6TH AIEE ENERGY SYMPOSIUM
Current and Future Challenges to Energy Security

# Solidarity Measures: Assessment of Strategic Gas Storage Coordination Among EU Member States on EU Natural Gas Supply Resilience

**Marzia Sesini**
Climate Economics Chair
Université Paris-Dauphine

Co-Authors:
Prof. Adam Hawkes
Dr. Sara Giarola

Milan, 15.12.2021

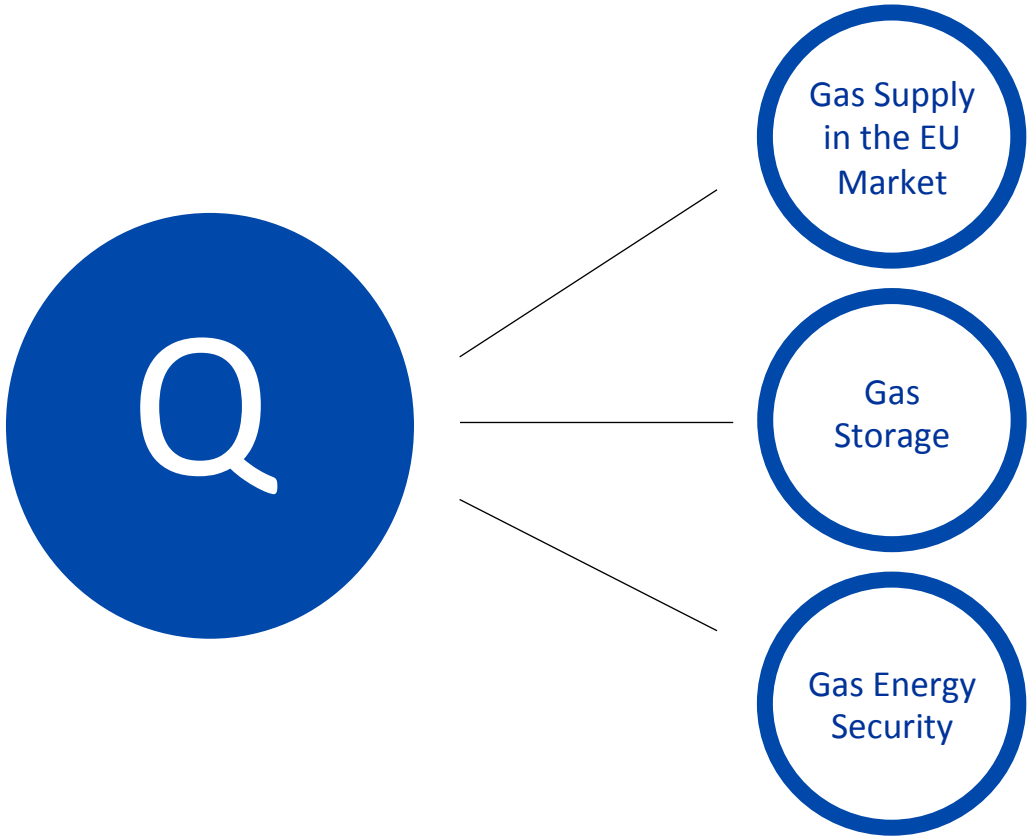
# INDEX

- Context
- Methodology
- Results and Conclusions

# Context

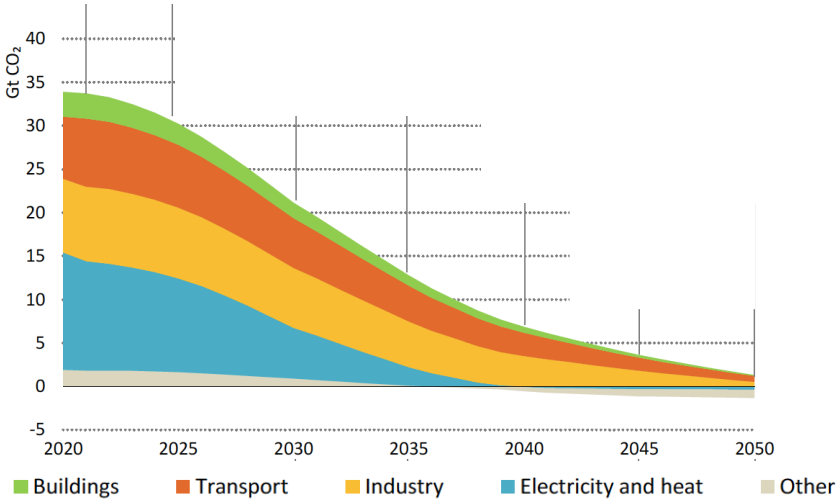
# Context

➢ **Can energy security be enhanced by solidarity among EU member states in response to natural gas supply crises?**

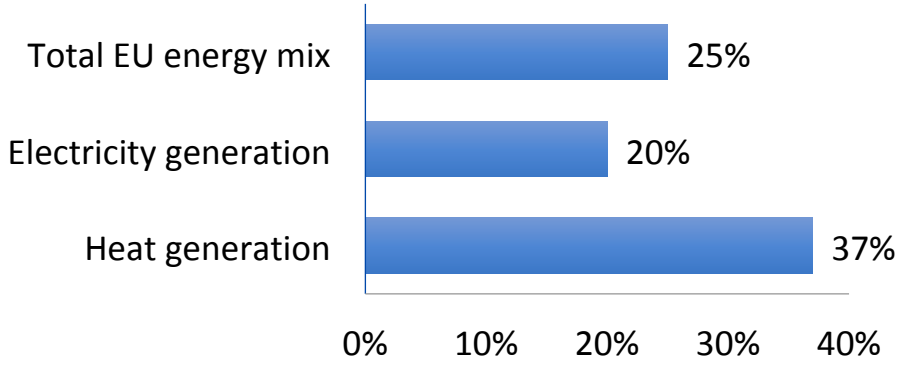


# Gas Supply in the EU Market

- **The EU goal of carbon neutrality by 2050 is going to require a significant system transformation.**
- **Natural gas today is the second largest-primary energy source in the EU.**



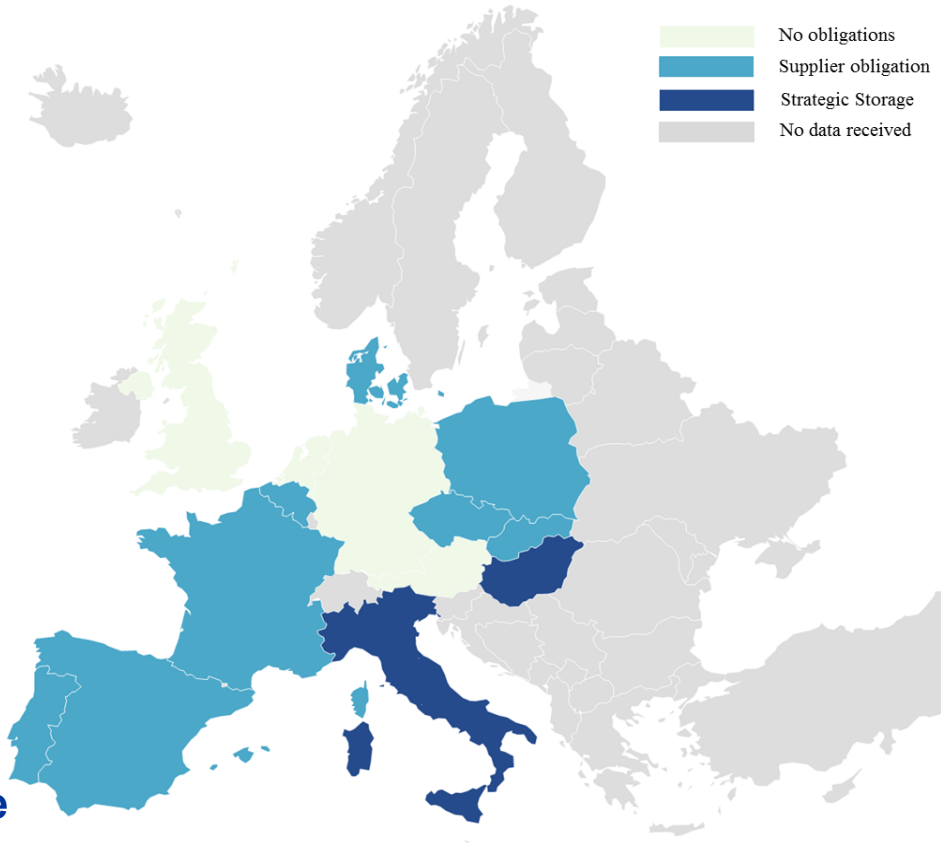

Pathway to net zero (Source: IEA, 2021)




Role of gas in the EU energy system in 2017 (Sesini et al., 2021)

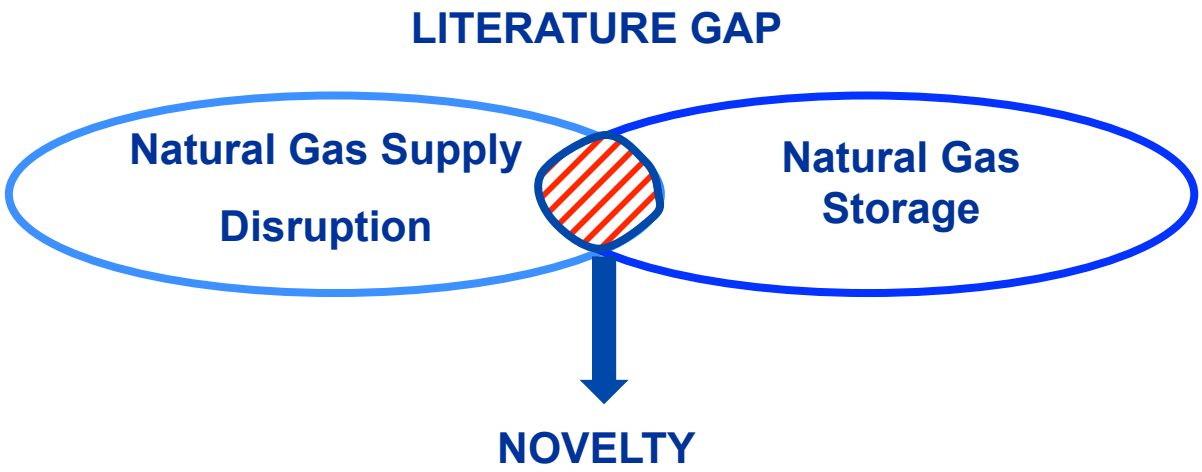
# Gas Storage in the EU

- **Dual role**
  - ✓ **Market value (flexibility)**
    - **Commercial storage**
      - ✓ **Declining indigenous production**
  - ✓ **Insurance value**
    - **Strategic storage**
    - **Storage Obligation (9 Member States) vs Strategic Storage (2 Member States)**
      - ✓ **Heavy import dependence**
      - ✓ **Little diversification of sources**




Mandatory storage security of supply interventions in the EU by type (Source: CEER, 2014)

# Research Goal

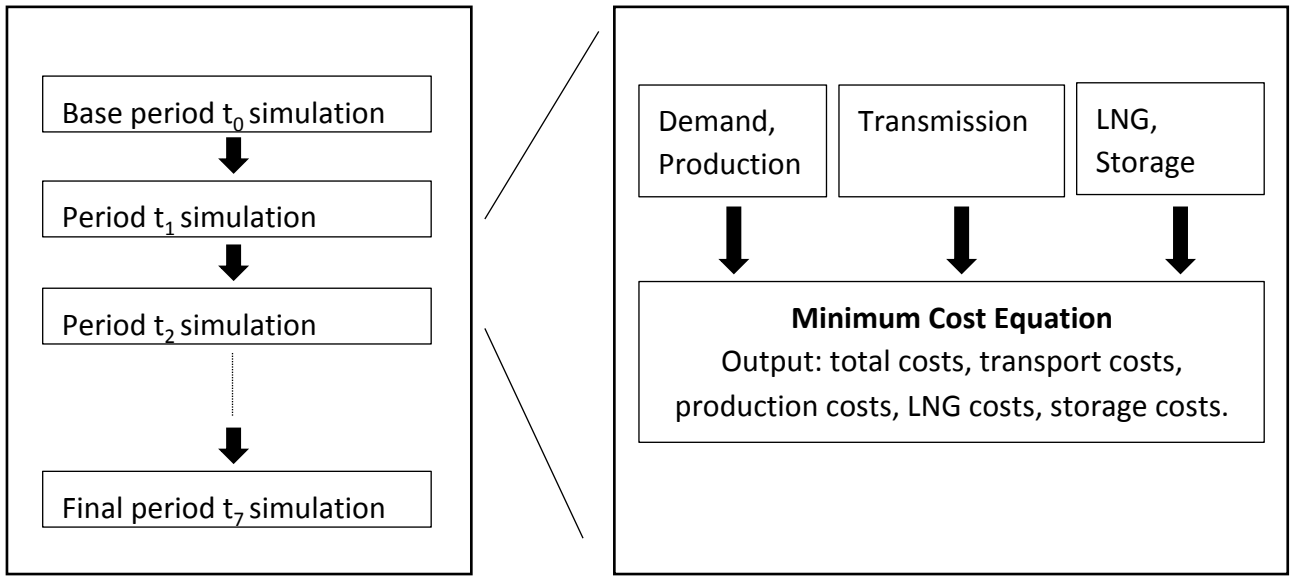



| Definition | Contribution |
|---|---|
| **HILP ("high-impact, low-probability" events):** mega-disasters where the market is unable to meet demand and policy intervention is required | **Absent in the literature** |
| **Strategic storage:** pre-fixed volume of gas taken out of the market | |
| **Solidarity:** cooperation of Regional Risk Groups | |
| **Resilience:** ability of supply chain to respond to unexpected events and maintain continuity of operations | **Absent in terms of strategic storage** |

# Methodology

# HILP Model

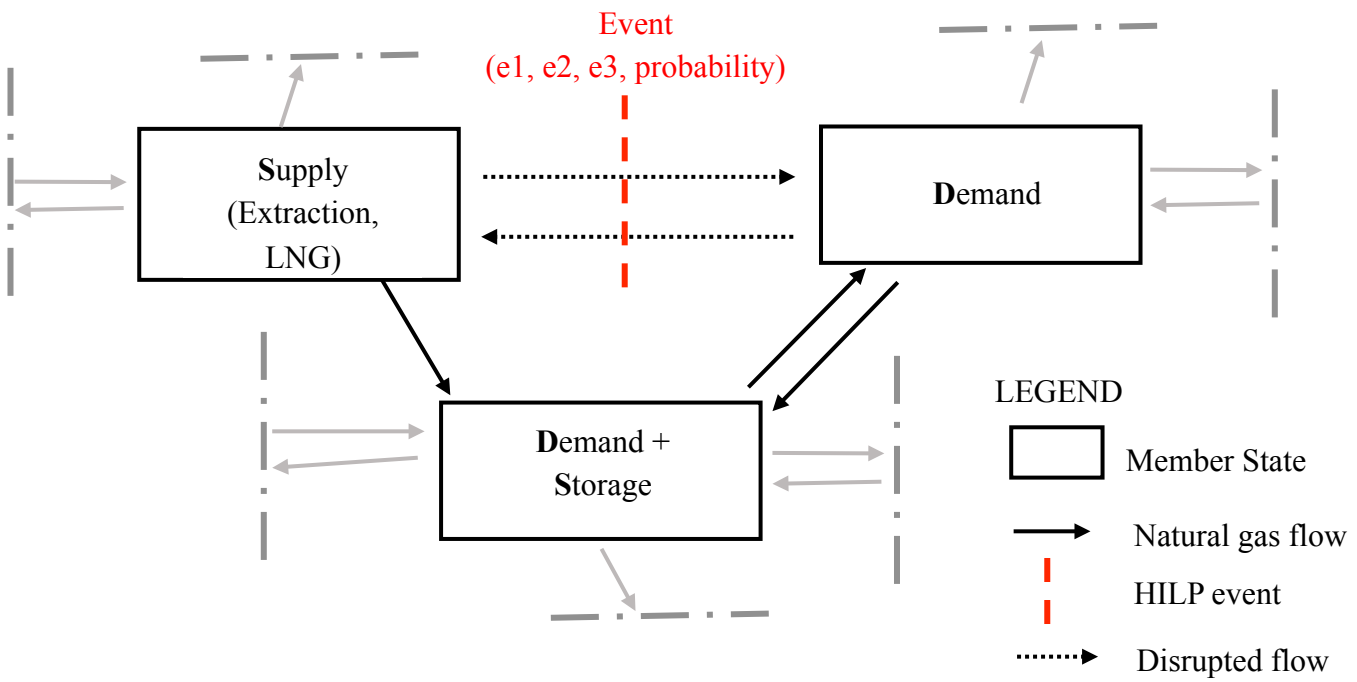
- **Linear programming optimization modelling the natural gas supply chain**
- **Stochastic approach with a short-term optimization framework (i.e., 7 days) based on real-world data (i.e., Burian).**




Basic HILP model structure

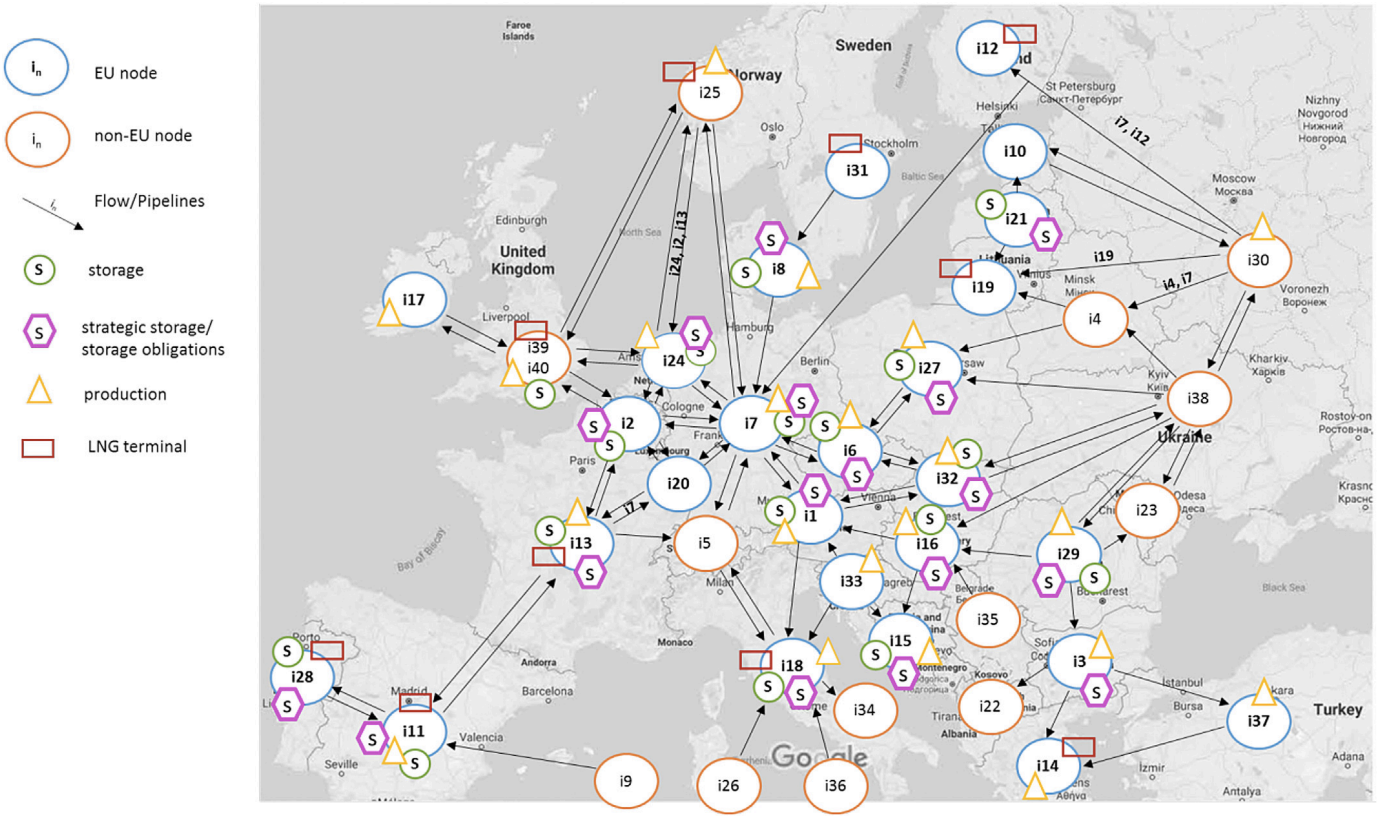
# HILP Model: Structure

- **Illustrative model structure:**



# HILP Model: Network Structure

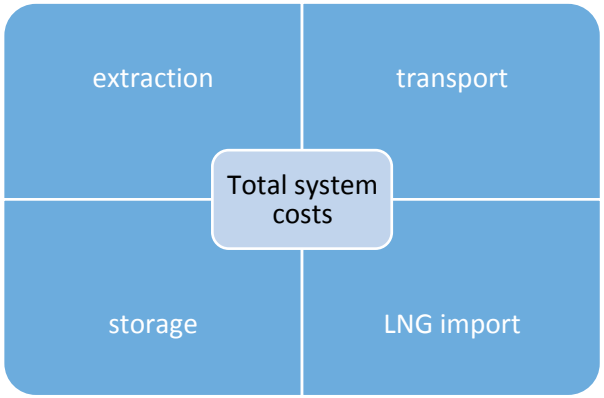
## ➢ Illustrative network structure:




Source: Sesini M, Giarola S, Hawkes AD. Strategic natural gas storage coordination among EU member states in response to disruption in the trans Austria gas pipeline: A stochastic approach to solidarity. Energy 2021;235:121426.

# HILP Model: Stochastic Formulation

**min** **total system costs**




**s.t.** **Constraints:**

- ✓ **Demand**
- ✓ **Resource availability**
- ✓ **Storage capacity**
- ✓ **Infrastructure capacity**
- ✓ **LNG port capacity**

| First stage variables | Second stage variables |
|---|---|
| Amount of stored natural gas | Natural gas transmission |
| | Natural gas production |
| Amount of natural gas withdrawn from storage | Natural gas supplied through LNG terminals |

# HILP Model: Applications

- Cold spell (validation)
- HILP
- **Solidarity**

**Focus: Coordinated strategic storage for energy security**

**Method: HILP model based on full Natural Gas Supply Chain Model**

Eastern gas supply risk group: 1 (a) Ukraine as in EU Regulation 2017/1938.
Includes: Bulgaria, Czech Republic, Germany, Greece, Croatia, Italy, Luxembourg, Hungary, Austria, Poland, Romania, Slovania, Slovakia

# Results and Conclusions

# Solidarity: Scenarios

- ✓ **Two-stage stochastic optimization-based linear programming minimum cost with increase temporal and geographical scope.**
- ✓ **Solidarity and Regional Risk Groups in case of HILP**

Disruption scenarios

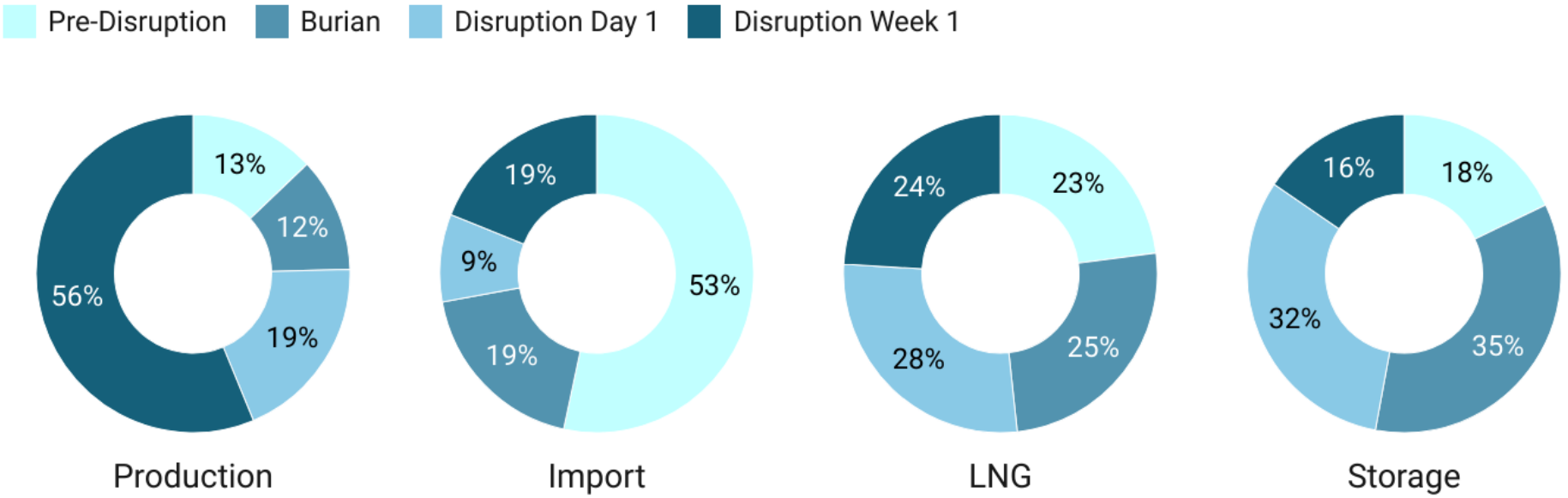
| **Scenario Assumption** | *Reference* Scenario | *Ukraine disruption* Scenario | *Russia disruption* Scenario | *Norway disruption* Scenario | *North Africa disruption* Scenario |
|---|---|---|---|---|---|
| **Origin of loss of gas transmission** | -80% from Russia | -100% from Ukraine | -100% from Russia | -100% from Norway | -100% from North Africa |
| **Destination of loss of gas transmission** | Germany and Italy | 1.Eastern gas supply (a) Ukraine - RR | 1.Eastern gas supply (d) North Eastern - RR | 2.North Sea gas supply (a) Norway - RR | 3.North Africa gas supply (a) Algeria - RR |
| **Gas reserve** | No strategic storage | With strategic storage | With strategic storage | With strategic storage | With strategic storage |

RR = EU Regional Risk Groups MS

Sesini M, Giarola S, Hawkes AD. Solidarity measures: assessment of strategic gas storage on EU regional risk groups natural gas supply resilience. Accepted in Applied Energy

# Solidarity: Supply Mix

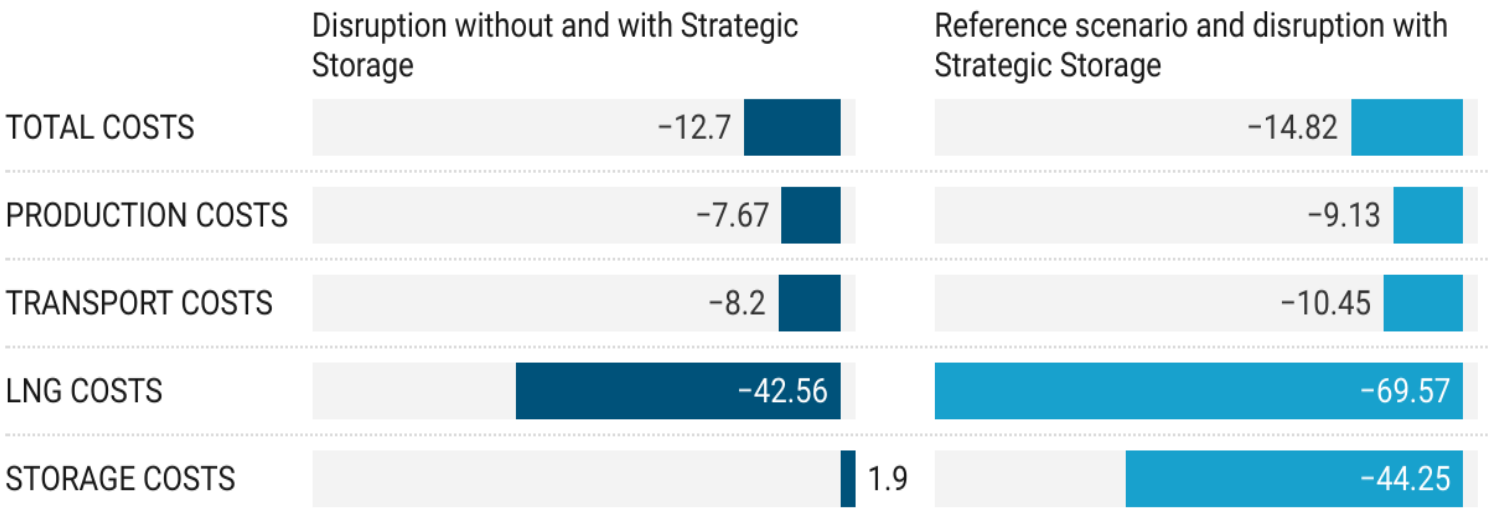
✓ Use of strategic storage is favoured




Natural gas supply mix at European level comparison (%)

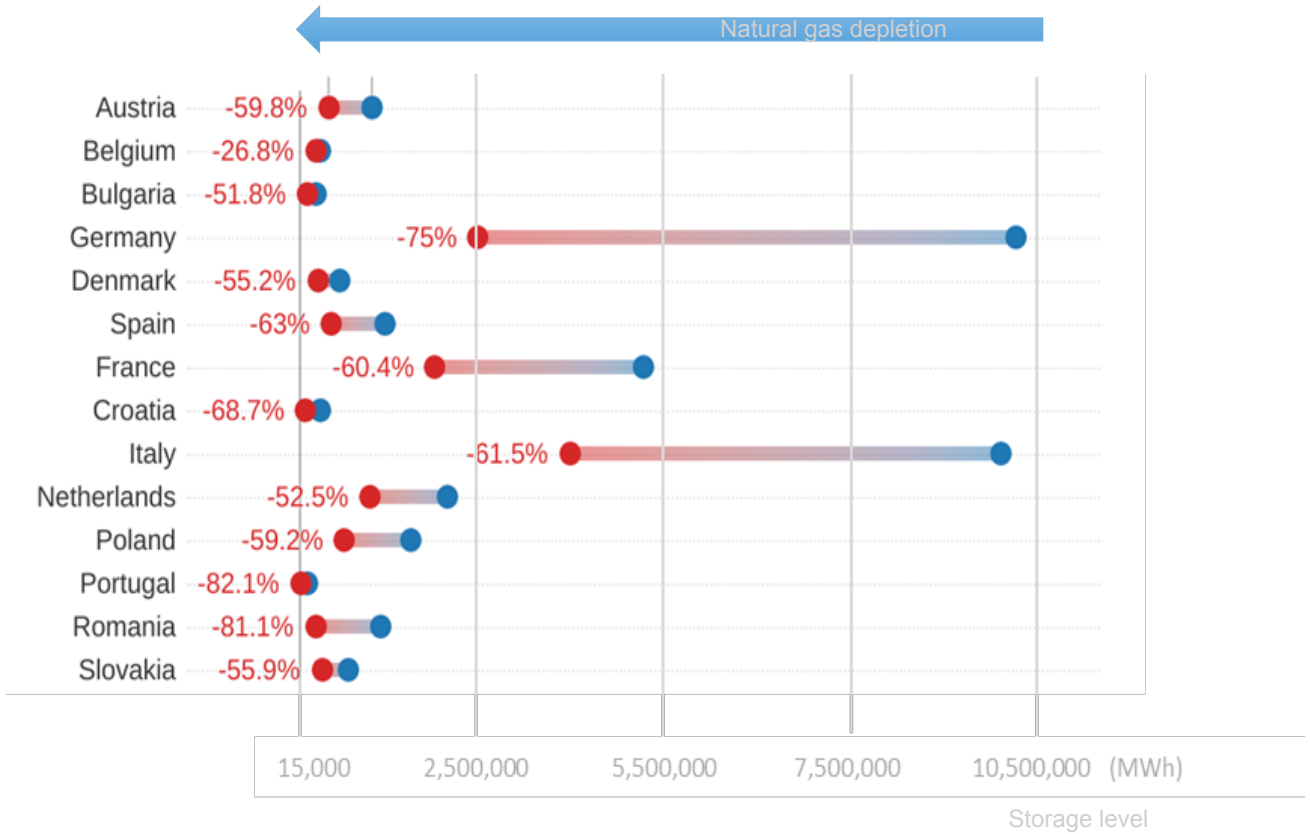
# Solidarity: Systems Costs

✓ Solidarity reduces up to 15% total system costs




Cost efficiency between scenarios without and with strategic storage at European level comparison at disruption week 1 (%).

# Solidarity: Resilience

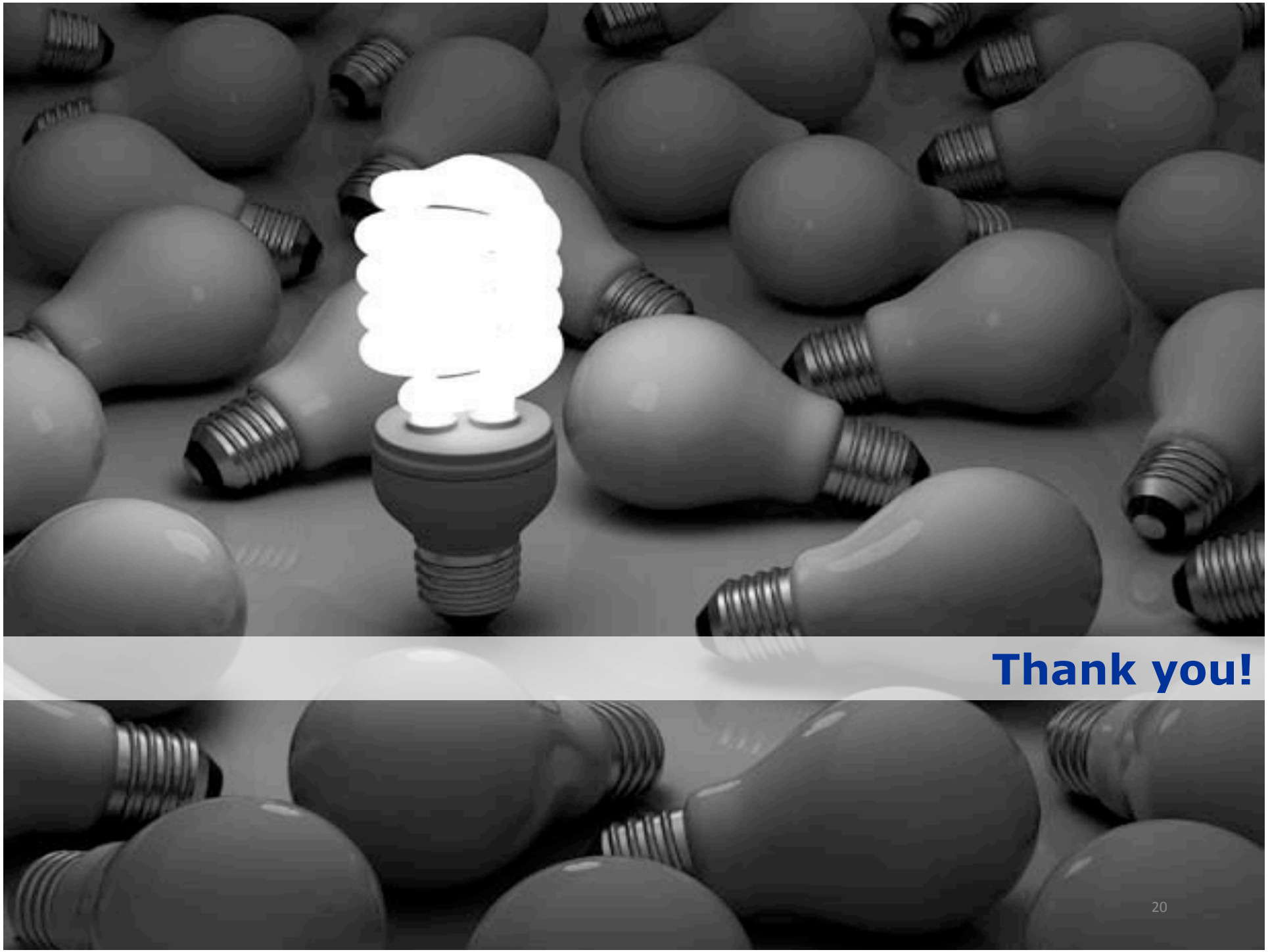



Strategic storage depletion during a seven-day emergency at European level (%).

# Conclusions

- ✓ **There is a strong interplay between LNG and storage during emergencies.**
- ✓ **Non-market based measure could be a cost-effective alternative to market-based ones, highlighting the reliability and insurance value of strategic storage benefitting overall system costs.**
- ✓ **Solidarity among member states during HILP significantly lessens the impact of the event in terms of costs and increases system resilience.**

**Hence, it points out how in an increasingly interconnected EU energy market and system, the role of strategic storage and solidarity should gain traction in the path towards an Energy Union.**



# Thank you!