Model-based Analysis of Infrastructure Projects and Market Integration in Europe with Special Focus on Security of Supply Scenarios

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Brussels, 14 June 2010

Agenda

Part I – Model Approach and Scenarios

Part II – Results

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Part I – Model Approach and Scenarios

1. **Gas Infrastructure Model**
2. **Simulation Assumptions**
3. **Scenarios**

Part II – Results

TIGER In- and Outputs

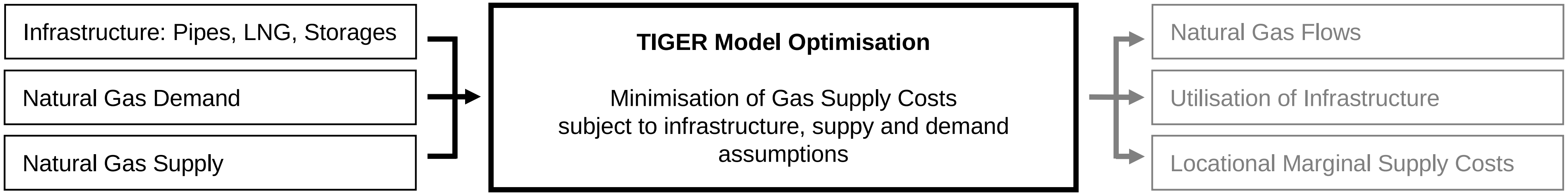
- Infrastructure: Pipes, LNG, Storages
- Natural Gas Demand
- Natural Gas Supply

TIGER Model Optimisation

Minimisation of Gas Supply Costs
subject to infrastructure, suppy and demand assumptions

- Natural Gas Flows
- Utilisation of Infrastructure
- Locational Marginal Supply Costs

TIGER Model Optimisation



Relevant assumptions:

- Minimisation of dispatch costs
- Results reflect efficient allocation, e.g. as obtained in a competitive market

  (prerequisite: efficient organisation of transport and storage market)
- I.e. results on gas flows assume that all efficient swaps have taken place

TIGER Inputs: Infrastructure Database

Infrastructure: Pipes, LNG, Storages

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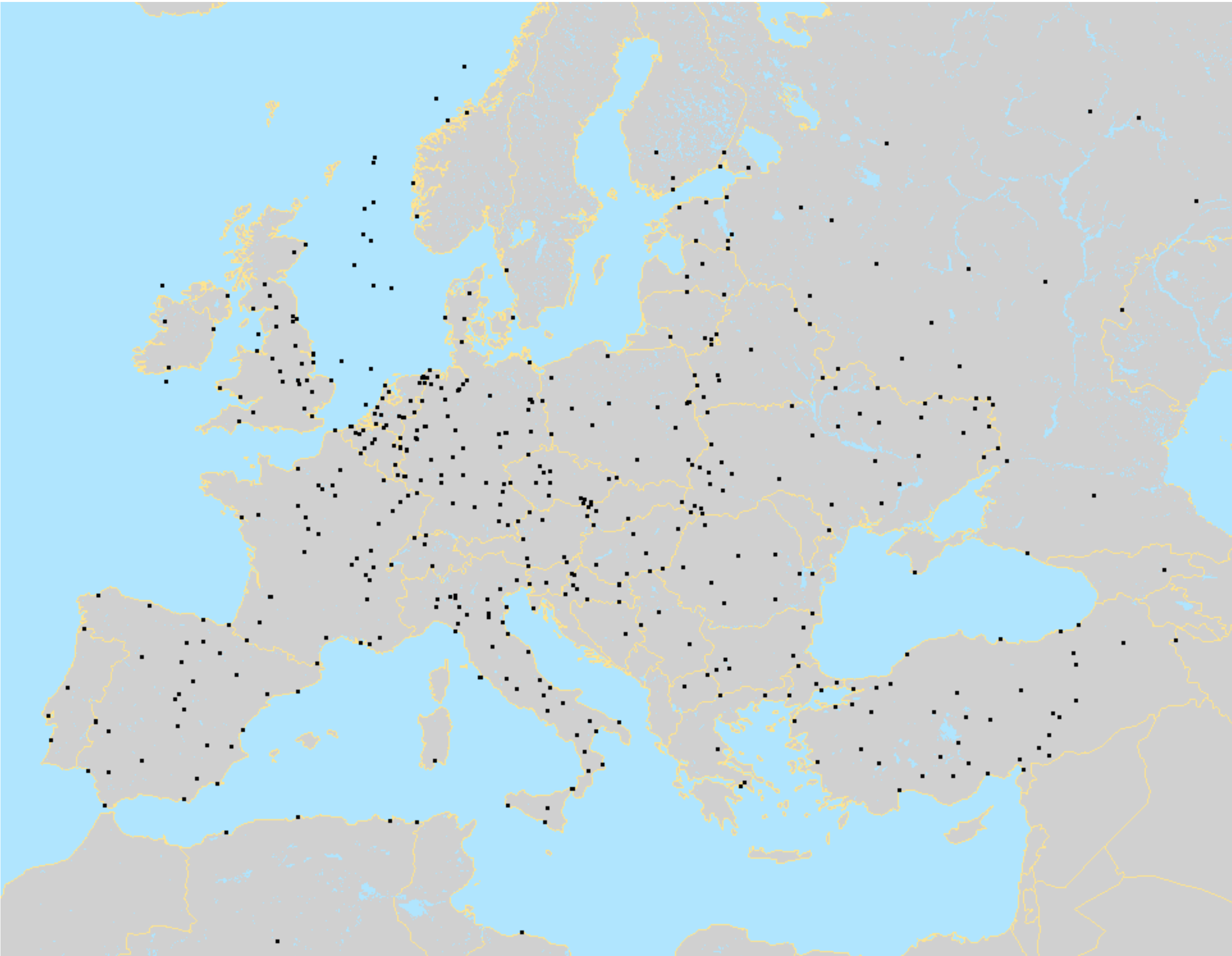

Geocoded Database:

Coverage >EU-27

>600 Nodes

TIGER Inputs: Infrastructure Database

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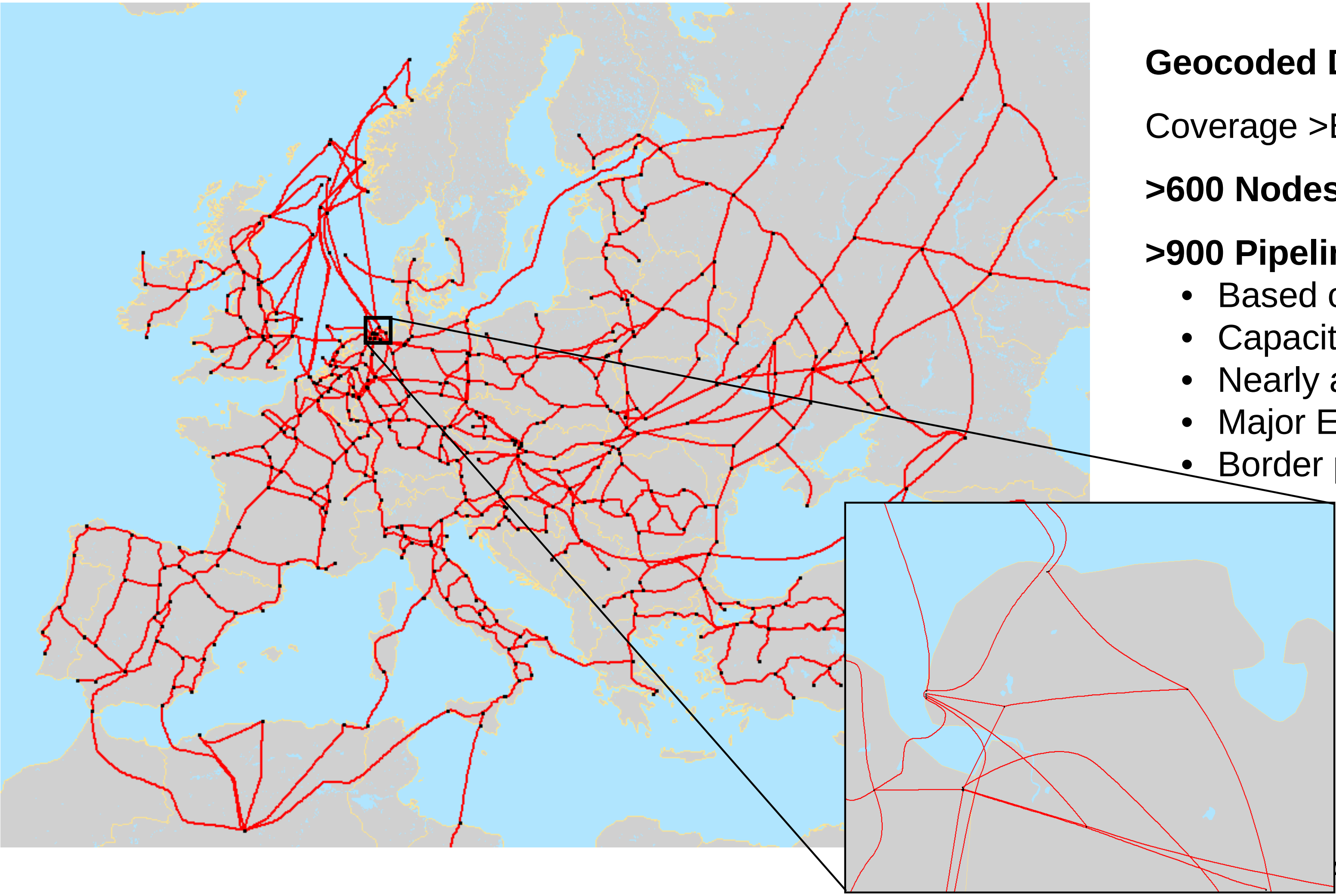

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>600 Nodes

>900 Pipelinesections*

- Based on TSO Maps
- Capacity / Pressure / Diameter
- Nearly all Entry-Points
- Major Exit Points
- Border point capacities

cts

TIGER Inputs: Infrastructure Database

Infrastructure: Pipes, LNG, Storages	**TIGER Model Optimisation**	Natural Gas Flows
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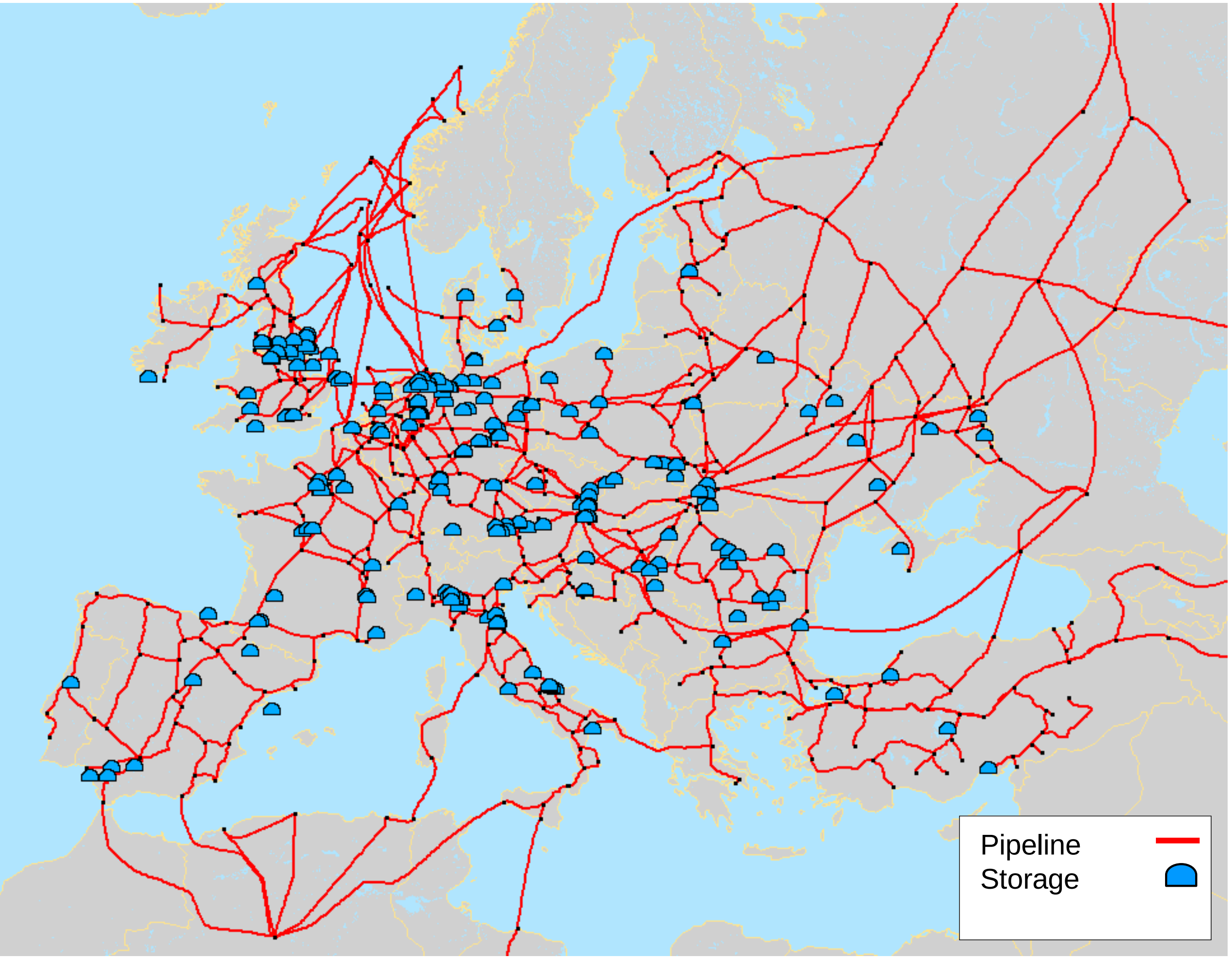

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>200 Storages*
- Type
- Max. injection / withdrawal
- Working Gas Volume

*including projects

TIGER Inputs: Infrastructure Database

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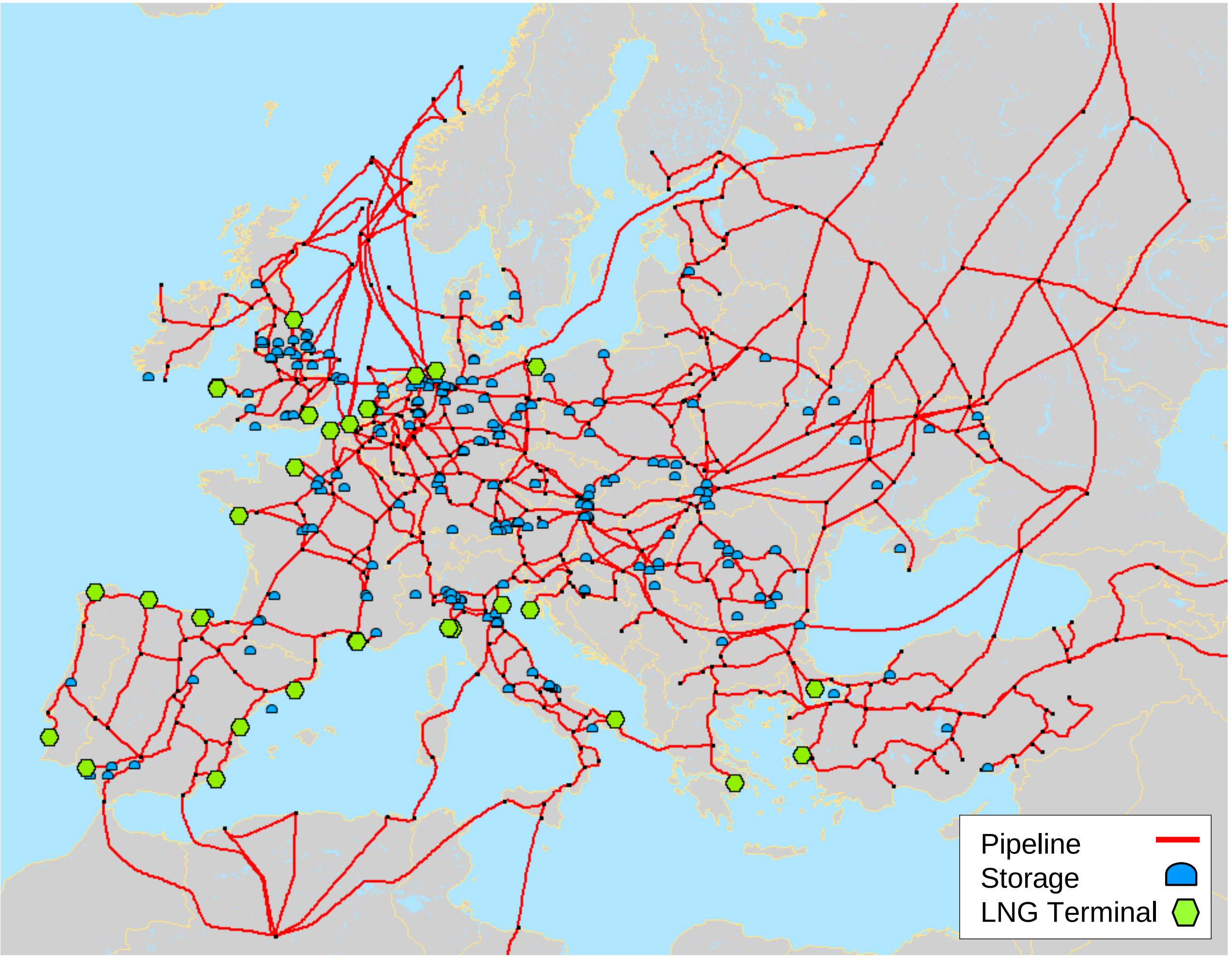

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- Based on TSO Maps
- Capacity / Pressure / Diameter
- Nearly all Entry-Points
- Major Exit Points
- Border point capacities

>200 Storages*
- Type
- Max. injection / withdrawal
- Working Gas Volume

>30 Terminals*
- Max. hourly / annual capacity
- LNG Storage Capacity

**including projects*

TIGER Inputs: Demand Data

Infrastructure: Pipes, LNG, Storages

Natural Gas Demand

Natural Gas Supply

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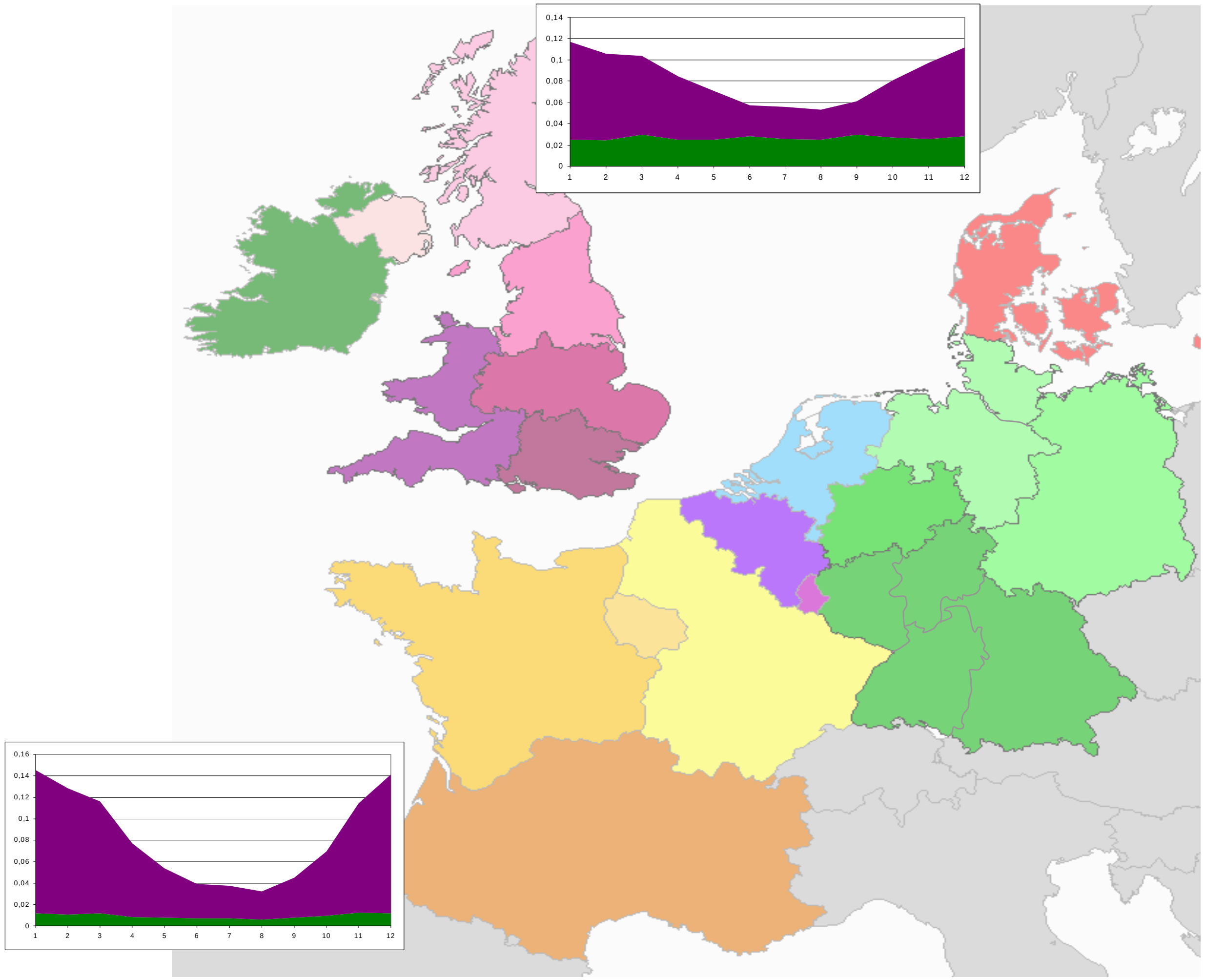

Detailed Demand Data:

58 European demand regions
- Share of total demand
- Individual sector distribution in each region

Monthly demand data
- 57 sector and country specific demand profiles for easy parameterization

Sectoral differentiation
- Typically Power / Households & Industry

Individual demand curves
- For sector and region

TIGER Input: Supply Data

Infrastructure: Pipes, LNG, Storages

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Natural Gas Supply

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Natural Gas Flows

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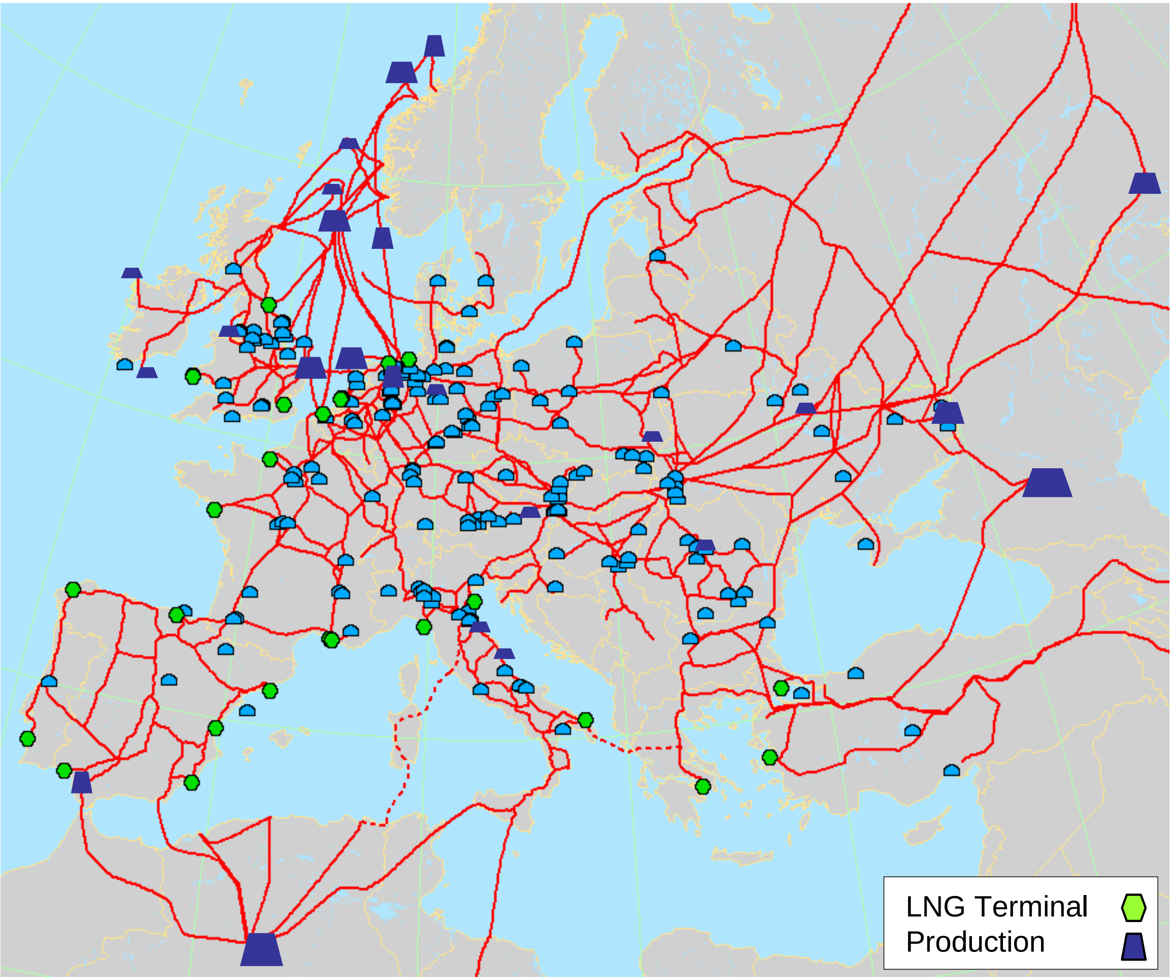

Incorporation of Gas Supply:

Production sites in and outside the EU

- Supply volumes and costs (production cost or border prices) for each production region
- Production flexibility capabilities taken into account
- Injection into grid at respective node or border point

LNG

- Regasified in LNG terminals
- Consideration of transport cost differentials to terminals
- LNG availability and costs can be specified

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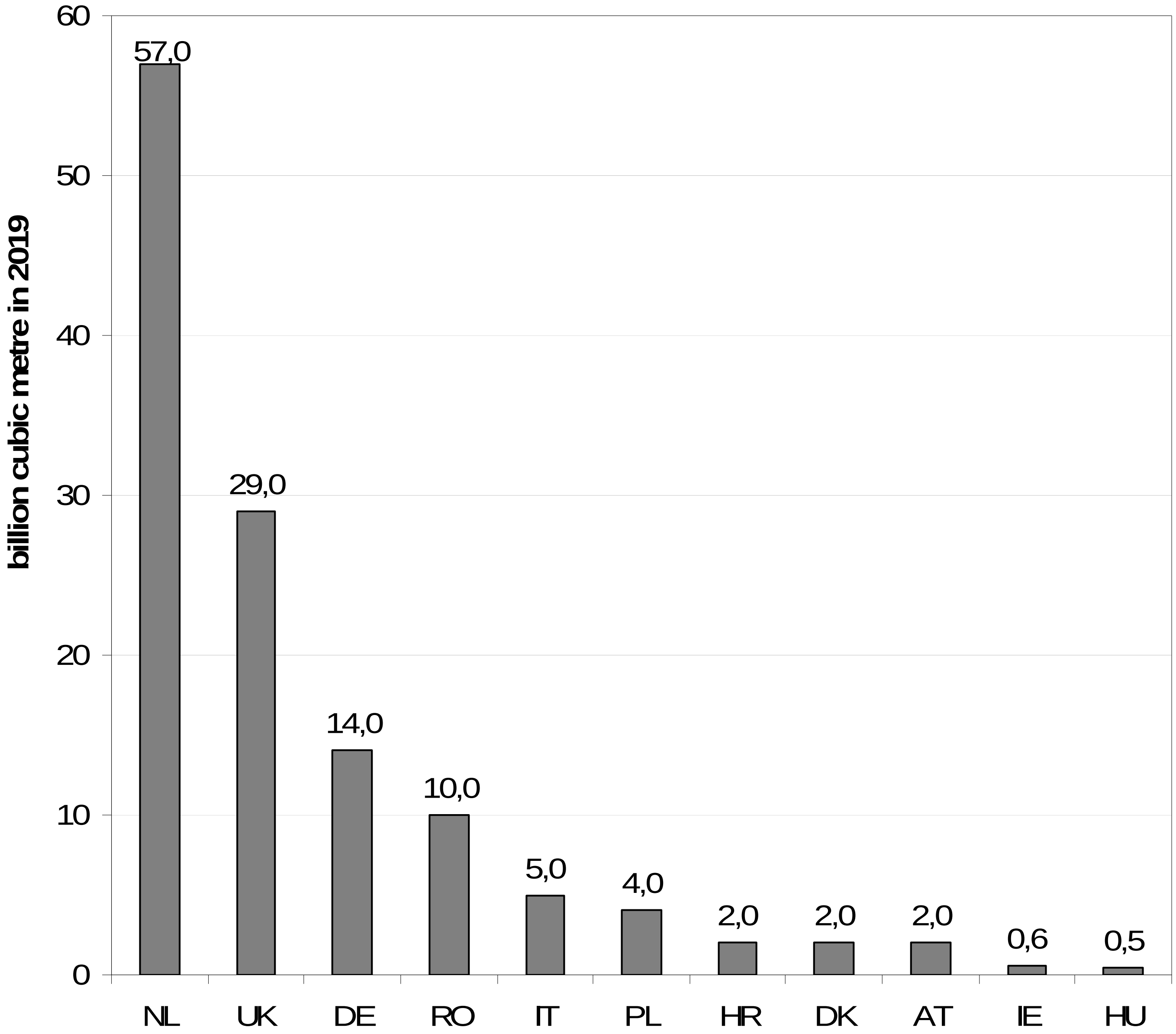
Part II – Results

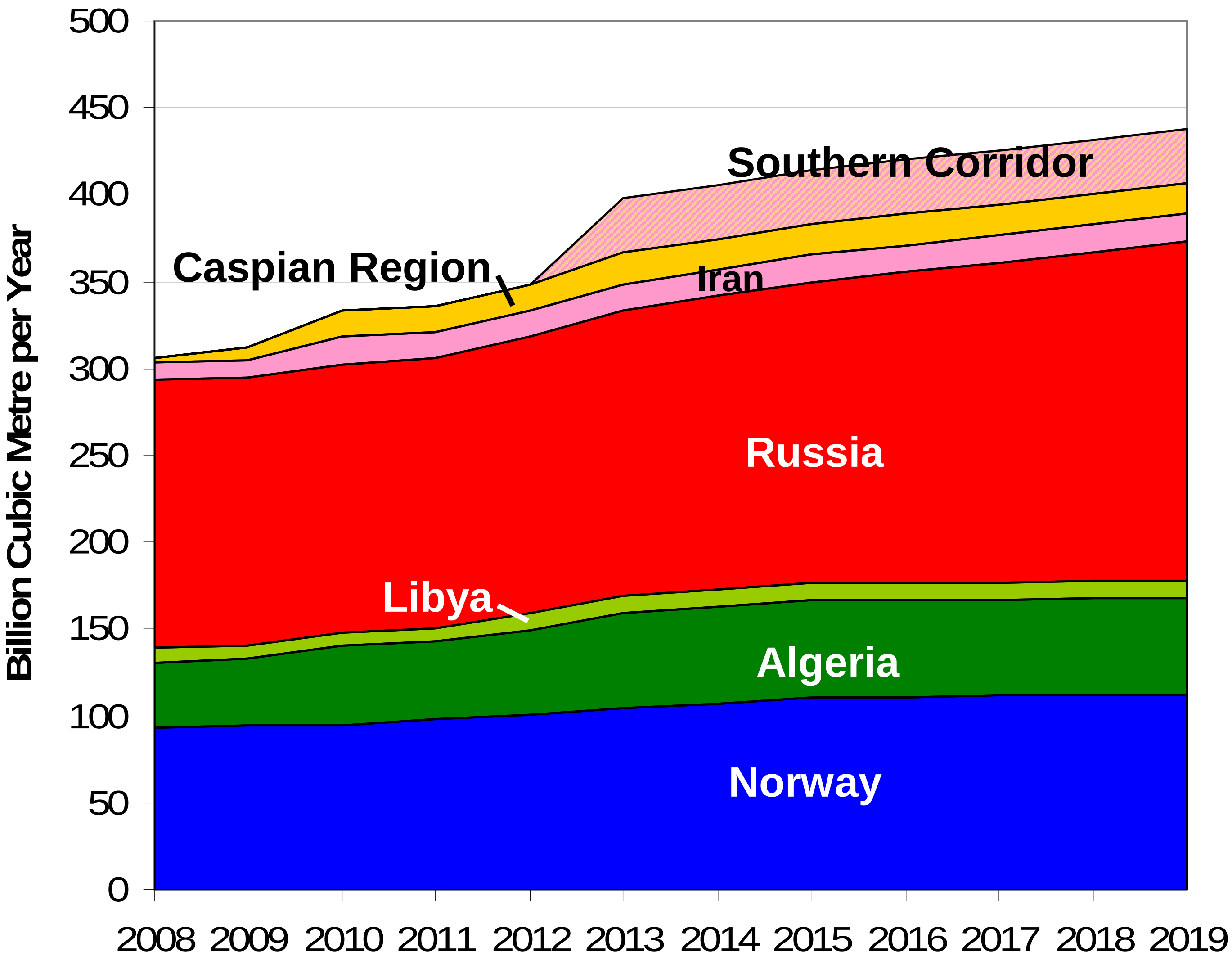
(1) General Supply Assumptions – EU production



- EU-27 production in 2019 according to ENTSOG assumptions
- Decline from 211 bcm in 2008 to 126 bcm in 2019 (-40 %)
- Largest absolute decline in UK
- Netherlands largest EU gas producer
- No Variations across Scenarios

Source: Own illustration based on ENTSOG (2009).

(1) General Supply Assumptions – Pipeline Import Potential



*Only in Nabucco Scenarios

Source: Own illustration.

- Norway: based on IEA (2008)
- Algeria / Lybia: pipeline capacities (utilisation 90 %)
- Russia: growth path agreed with ERGEG: 195 bcm in 2019
- Iran*: contracted volumes (Turkey + EGL contract)
- Caspian region*: SC-pipeline expansion to 20 bcm (90 % utilis.)
- *in scenarios with Nabucco: increase of those volumes by 31 bcm per year

(1) General Supply Assumptions – Commodity Costs in 2019

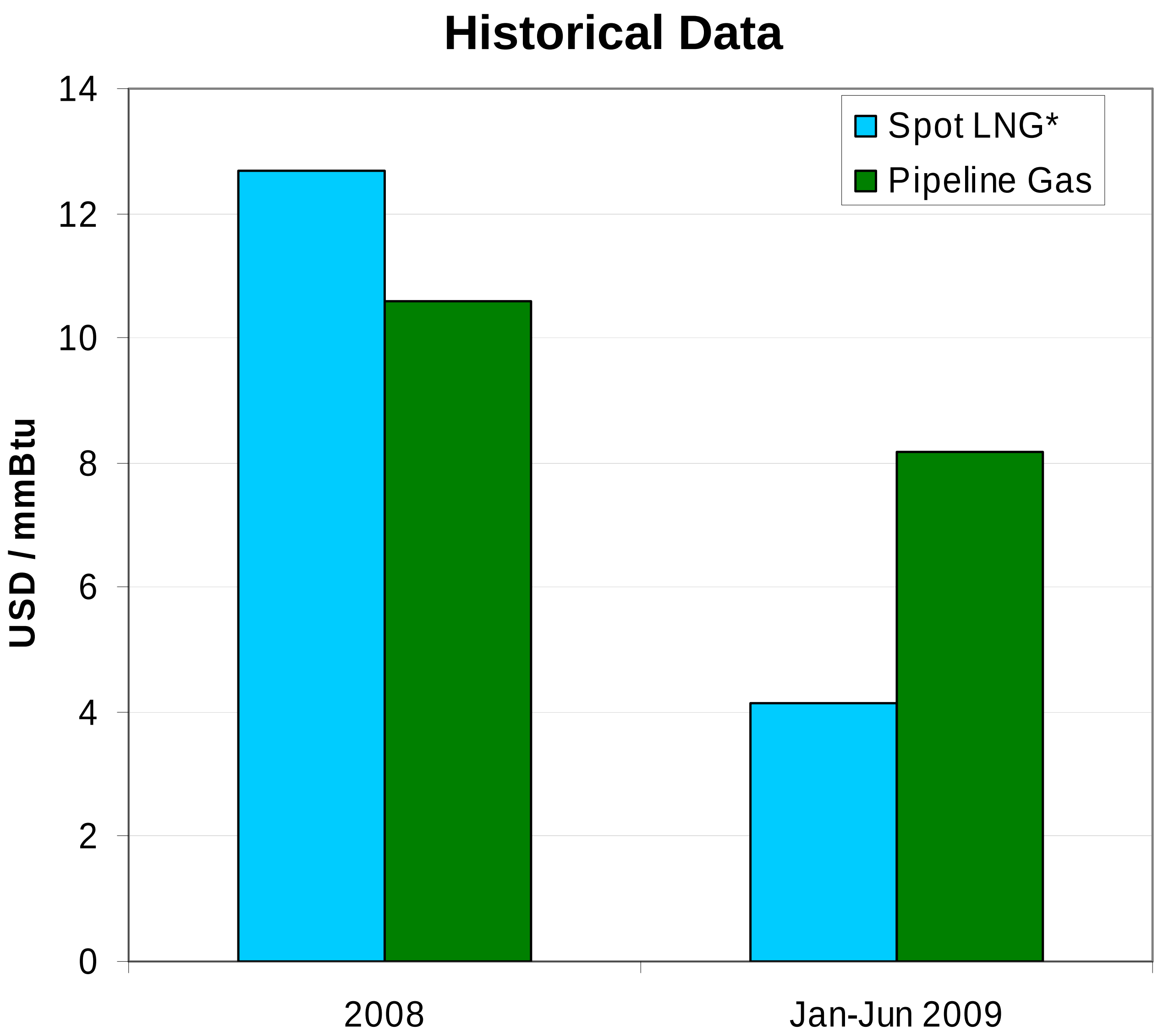
Supply Source	**Supply Cost at EU border** [EUR / MWh]
Pipeline supplies:	
Norway*	6,24
Russia	8,73
Azerbajian**	8,26
Iran**	8,06
Algeria	7,13
Lybia	7,51
LNG (cif to Europe):	
Global Marginal Supplier	19,78
LNG to Europe	6,21

*Supply Cost at field; **Supply Cost at Turkish border.

Source: Own calculations based on Lochner & Bothe (2009).

- Supply costs derived with EWI Global Gas Supply Model
- Volumes more important than costs for considerations in study
- LNG volumes considered with variation → higher or lower than pipeline supply costs

(1) General Supply Assumptions – LNG vs. Pipeline

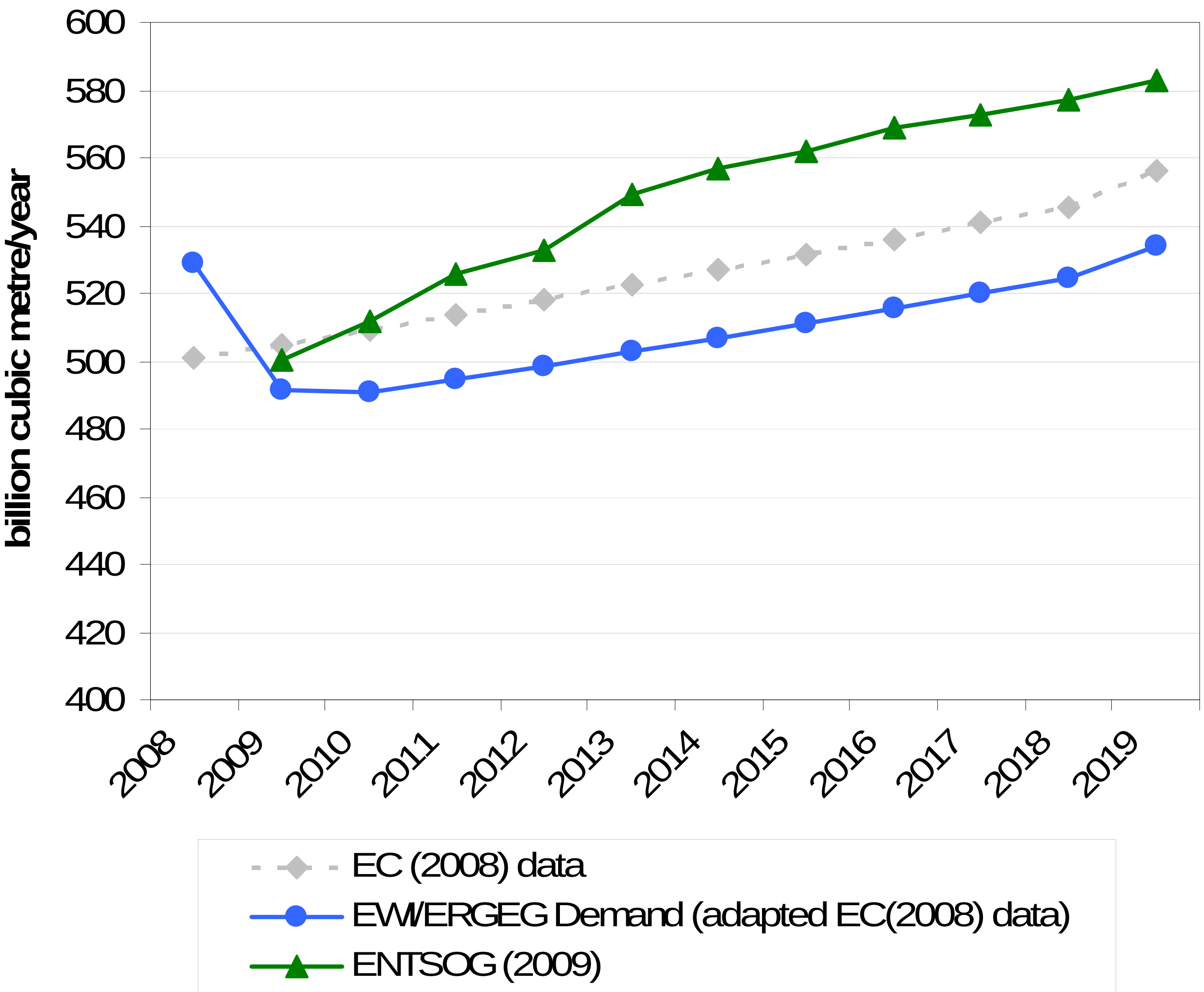


Source: EIA, IEA (2009); *Spot LNG reference Japan in 2008, US in 2009

2008 vs. 2009:

- Spot LNG prices potentially volatile
- 2008, tight market:
  - high prices in Japan / US, almost only contracted LNG to Europe
  - relative prices reflect relative cost structures
- 2009 buyer's market: lots of spot LNG volumes to Europe
- Uncertainty
- One additional LNG scenario

(2) Demand Assumptions & Scenarios



- EU (2008) data as recognised reference publication by EC
- Adjustment for economic crisis (2009/10 demand decline)

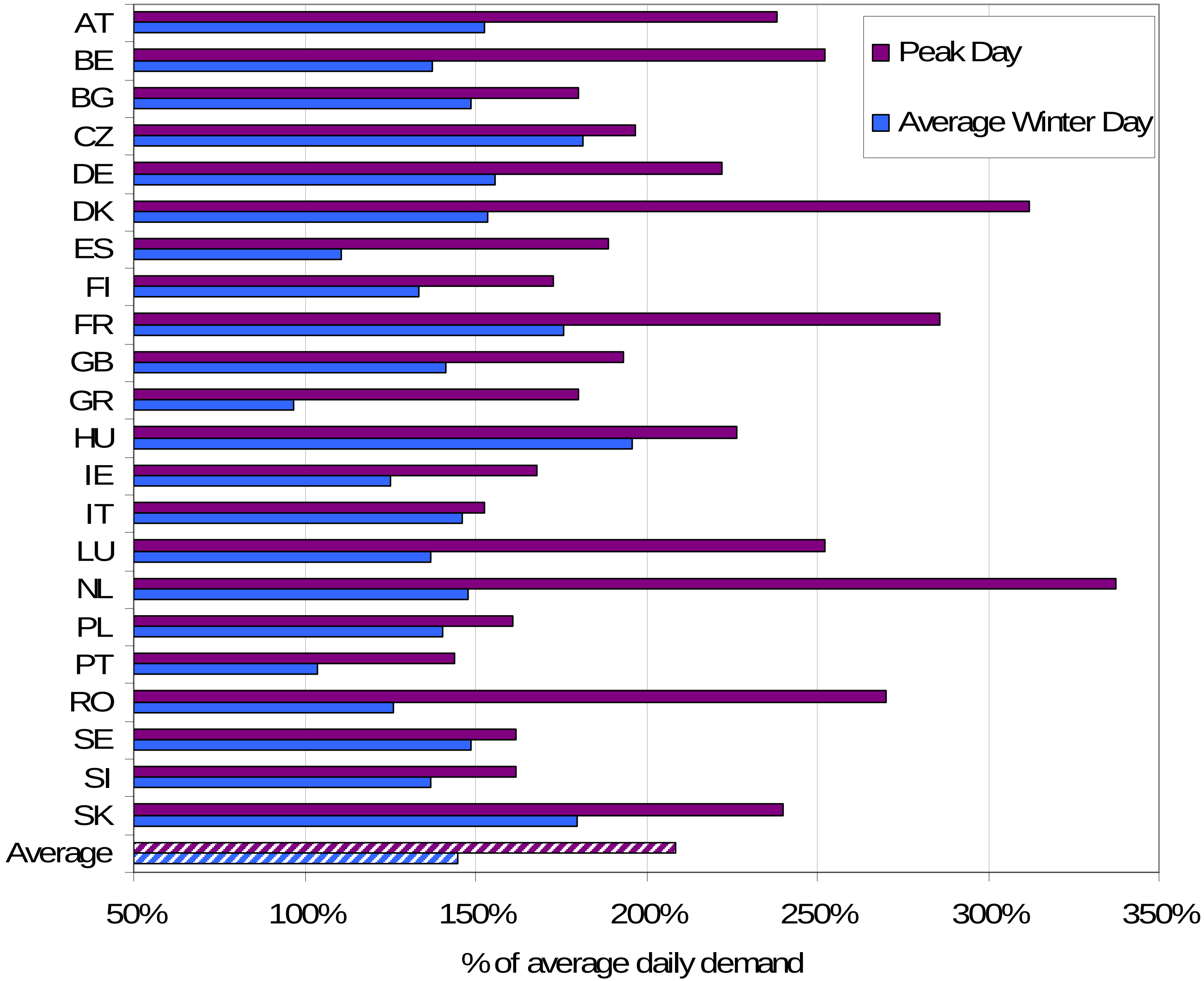
  >EWI/ERGEG Demand

- ENTSOG Demand case to ensure compara-bility and have high demand sensitivity

  >ENTSOG Demand

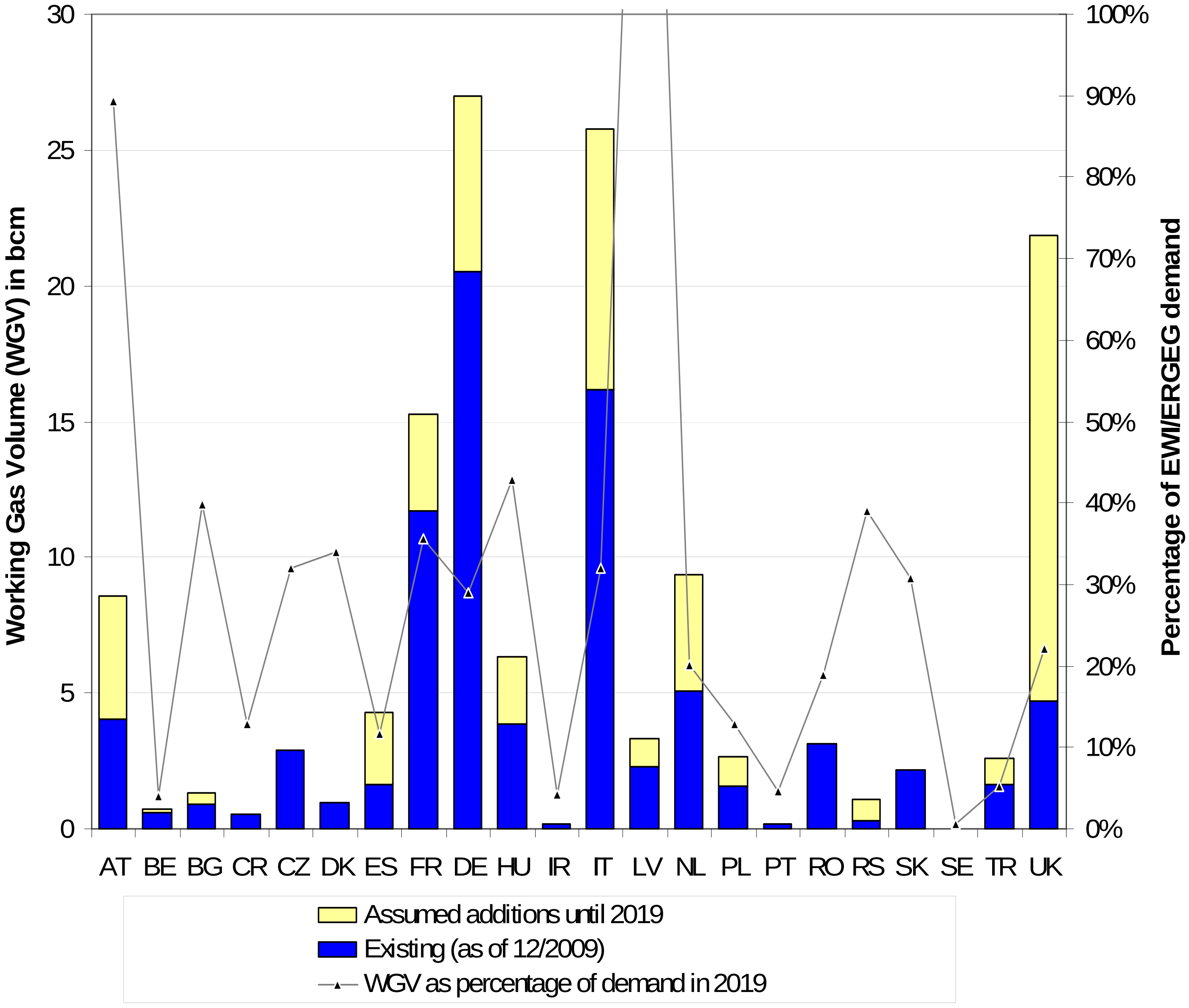
- (Additional Peak Day Simulations based on ENTSOG data)

(2) Peak Demand Day Assumptions



- Assumptions for the Peak Demand Day from ENTSOG (2009)
- Average peak demand day: 206 % of average daily demand (or +40 % higher than average winter day demand)
- Some countries with especially high relative peak demand days: NL, DK, FR, but also RO, BE, LU
- Only small relative peak demand days in IT, IE, PT, PL, SI

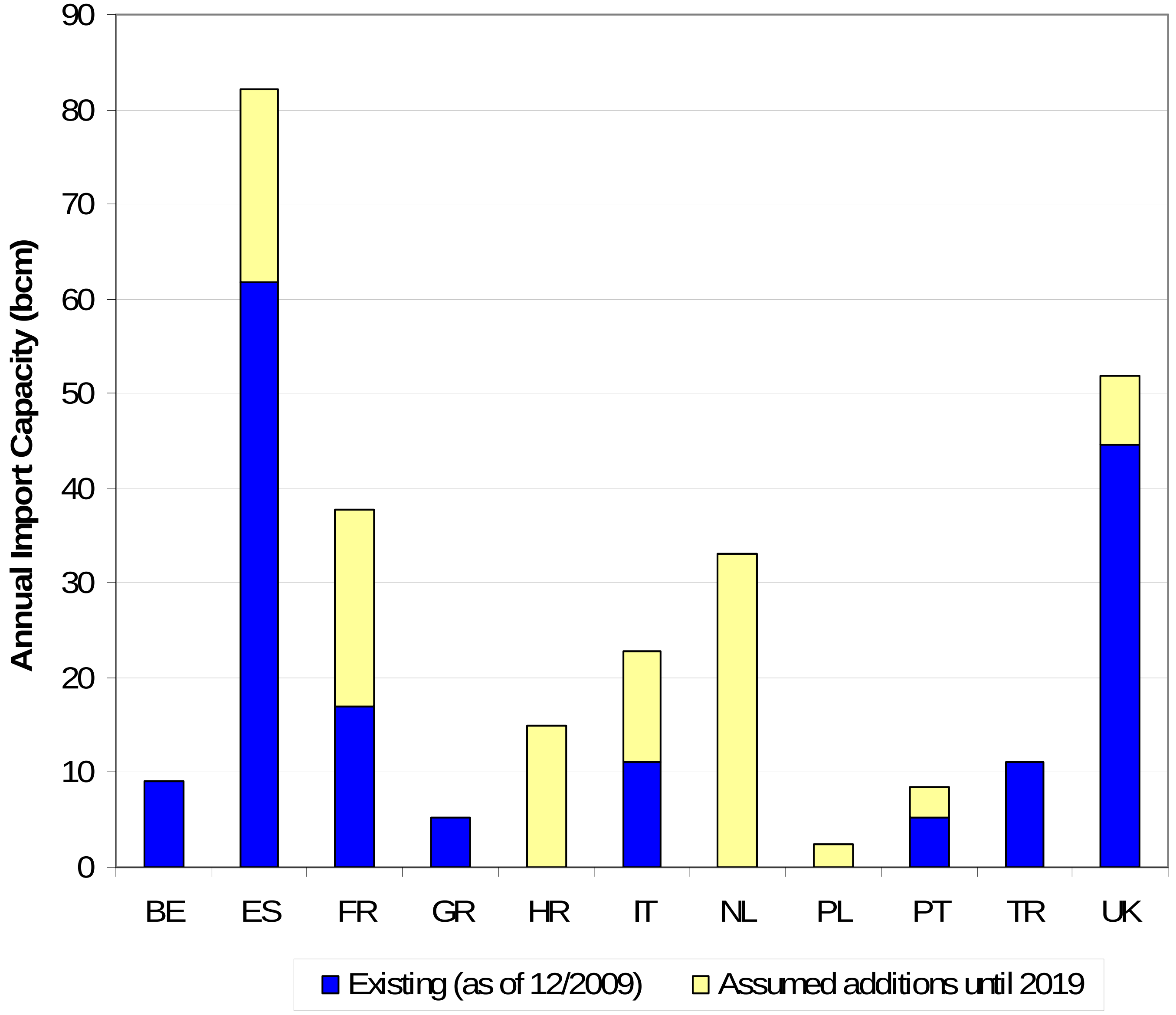
(3) Assumption Infrastructure – Storage Capacities



- Total storage working gas volume in Europe (all countries in study):
  - 85 bcm in 2009
  - additional capacities of 55 bcm until 2019 assumed (Total of 140 bcm)
- No variations across scenarios

Sources: Own illustration based on GSE, ERGEG (project steering group), IGU, storage operators.

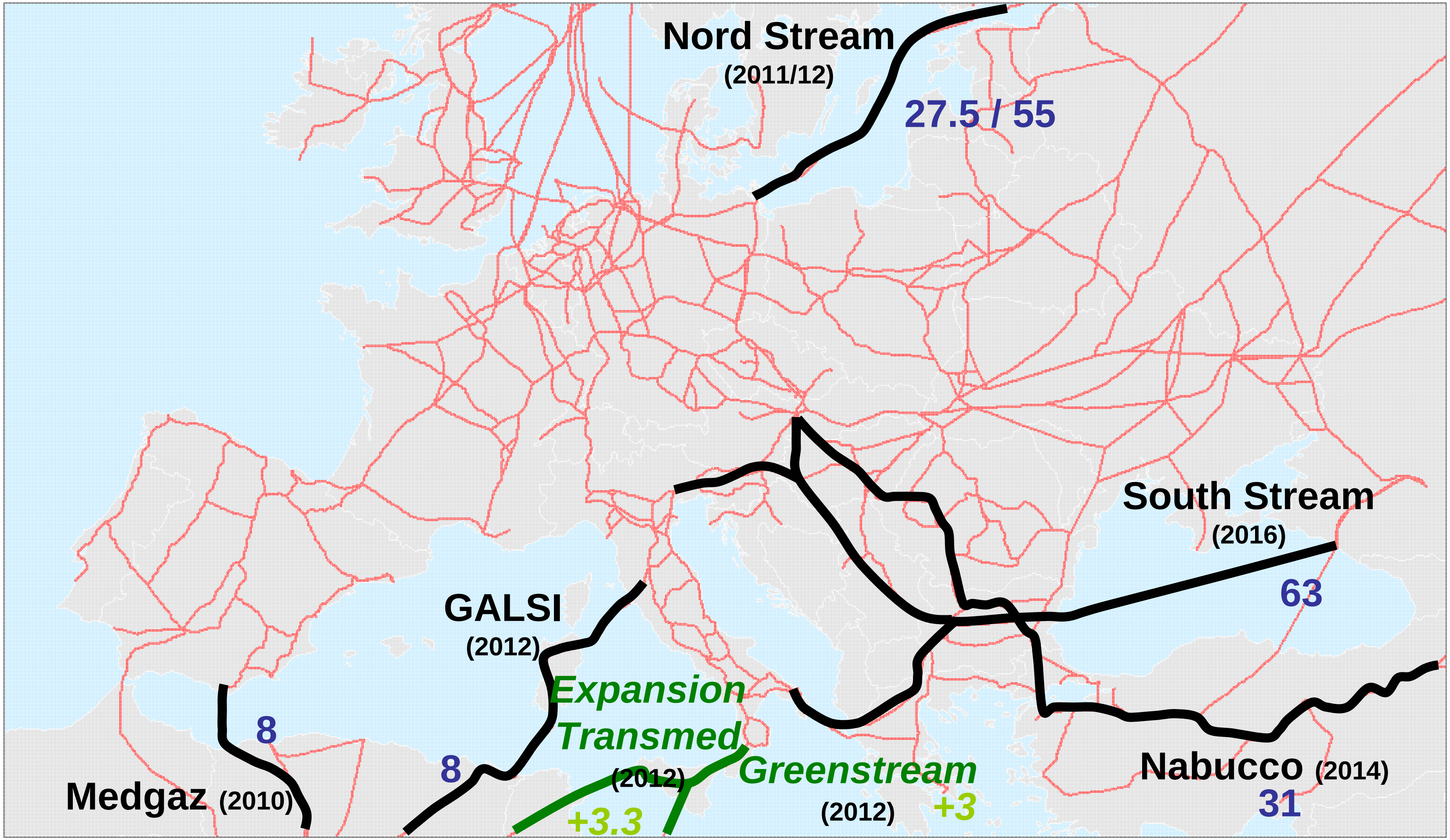
(3) Assumption Infrastructure – LNG Capacities



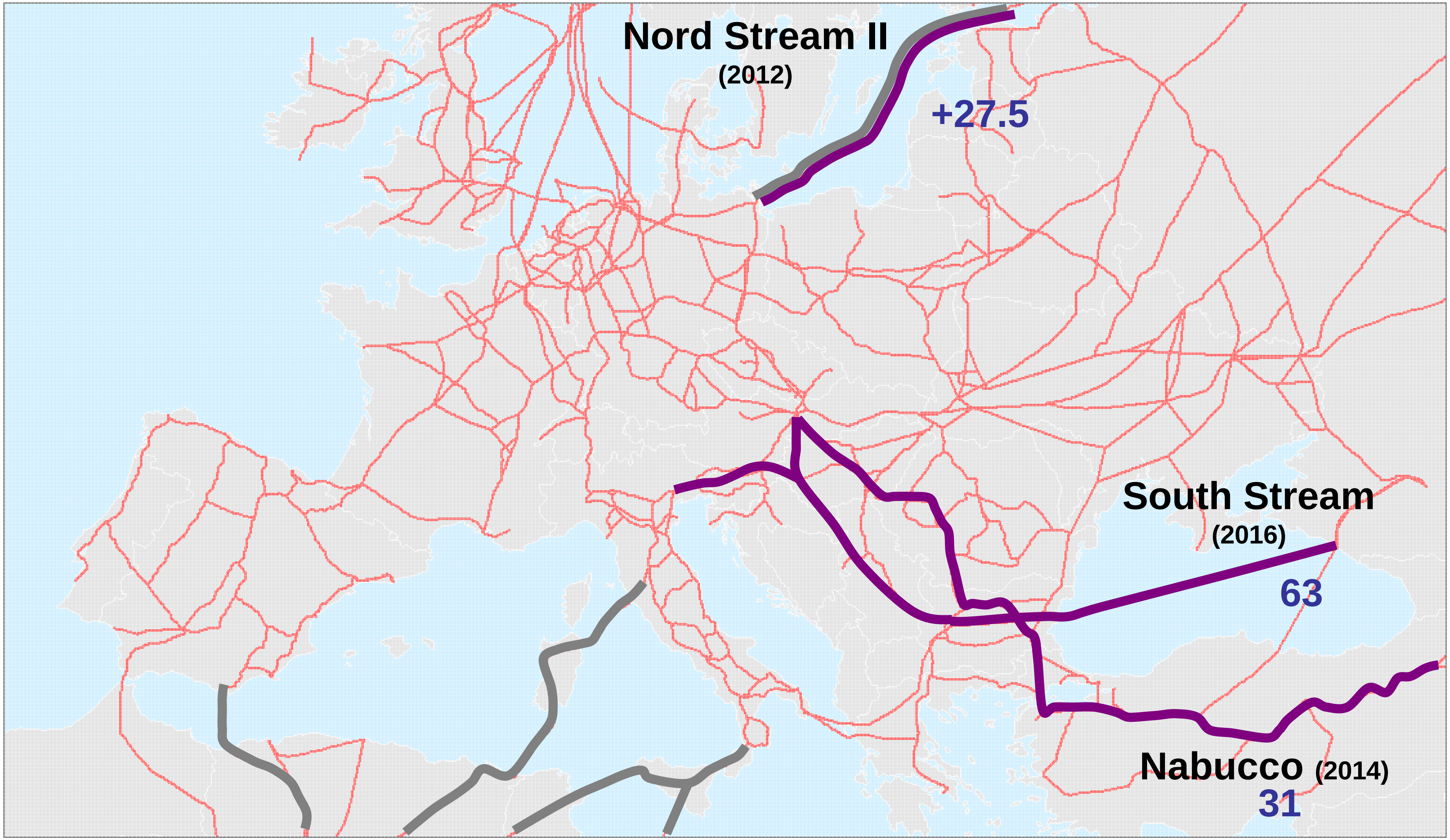
- Total import capacitiy in EU-27 plus Turkey and Croatia:
  - 165 bcm in 2010
  - additional capacities of 114 bcm until 2019 assumed (Total of 280 bcm)
- Largest additions in Netherlands, Spain, France
- No variations across scenarios

Sources: Own illustration based on GTE (LNG), ERGEG (project steering group).

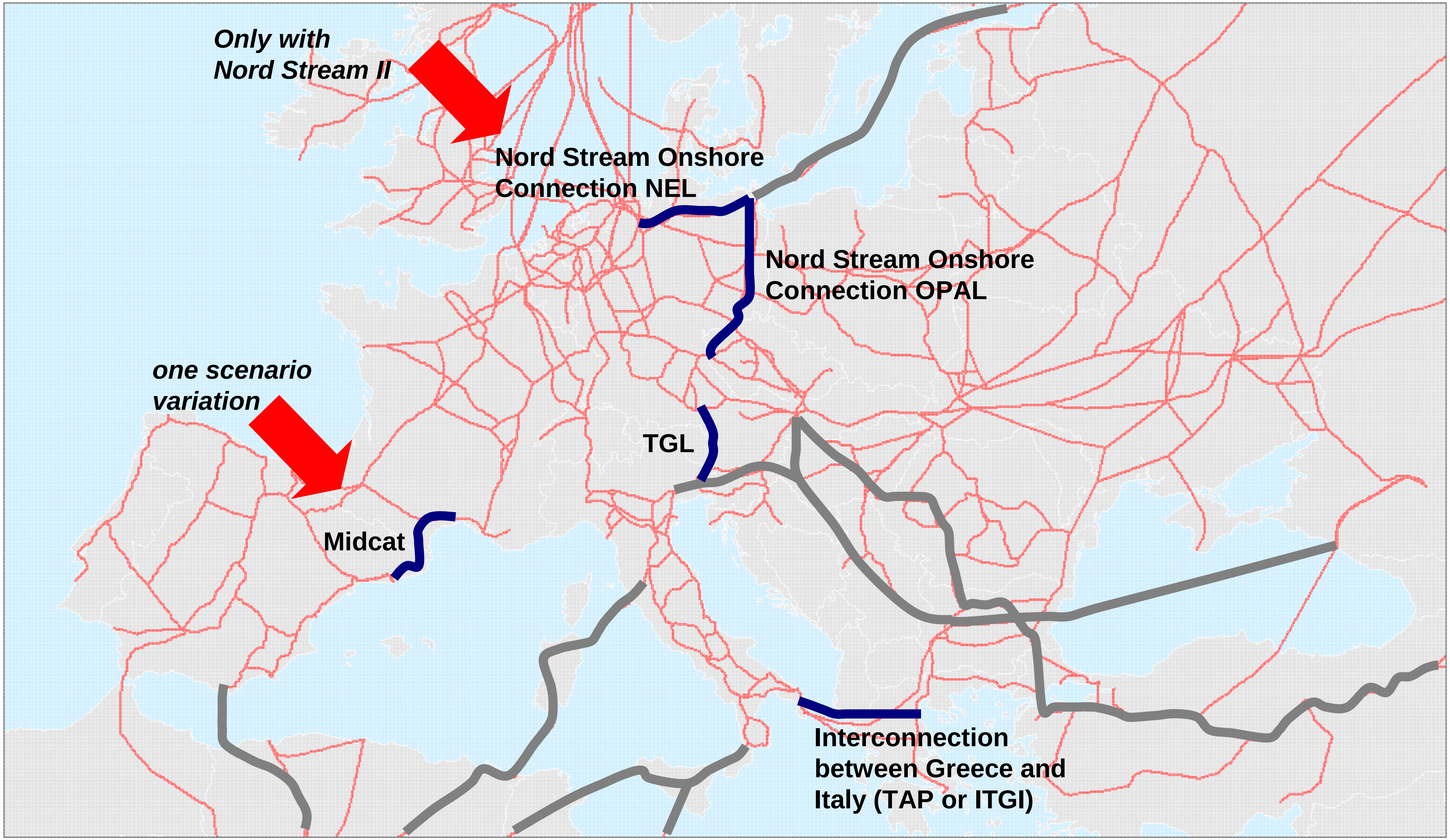
(3) Import Pipeline Projects



(3) Import Pipeline Projects – Scenario Variations



(3) Major Intra-European Pipeline Projects



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Scenarios

- Six infrastructure variations:

Reference	Midcat
Nord Stream II	Nord Stream II, Midcat
Nabucco	Nabucco, Midcat
South Stream	South Stream, **No Midcat**
DG TREN	Nord Stream II, Nabucco, Midcat
LNG Glut	Nord Stream II, Nabucco, Midcat, **low LNG costs**

- Two demand variations:

EWI/ERGEG

ENTSOG

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4. **Security of Supply Sensitivities**

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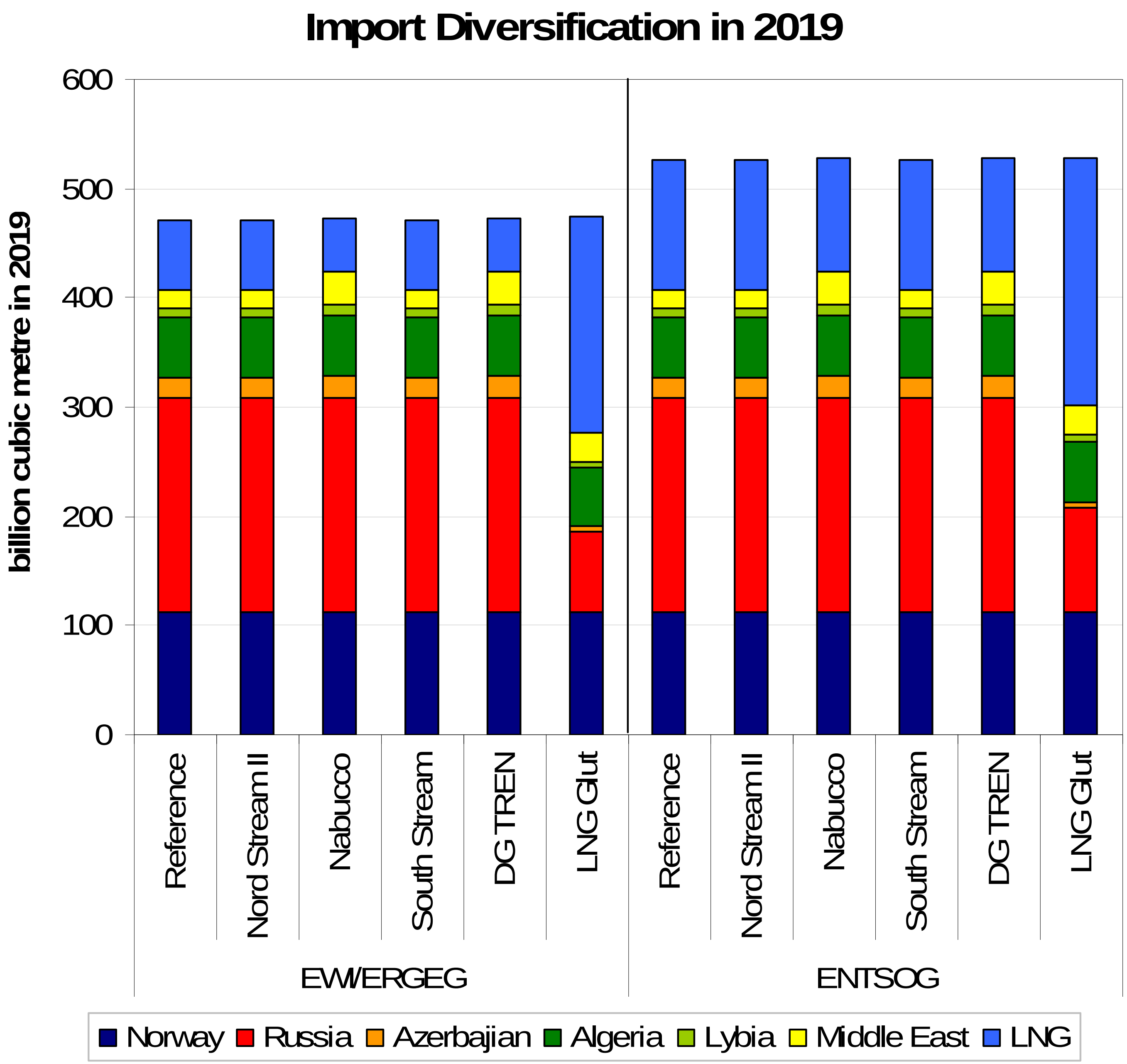
Summary of Results (I)



- Due to mostly fixed supply assumptions, no major impact of infrastructure scenarios – except for LNG Glut
- Additional Southern Corridor volumes replace some LNG
- In ENTSOG demand scenarios, higher demand covered by higher LNG imports

Summary of Results (II)

Reference Simulation

- Western Europe: No permanent bottlenecks (except Denmark)
- Eastern Europe: Significant bottlenecks (Hungary, Balkans)
- Ukraine Transit Disruption
  - Reverse Flow Projects allow additional West-to-East gas flows
  - not sufficient to eliminate all supply disruptions
- Algerian Export Stop
  - Supply Cost increases in many European countries
  - no supply disruptions to consumers (with sufficiently filled storages filled and efficient market reaction)

Summary of Results (III)

Nord Stream II

- cannibalizes other import routes from Russia
- no significant contribution to SoS due to remaining West-to-East bottlenecks

Nabucco

- improves integration in Eastern Europe
- improves SoS for Ukraine Transit Disruption, but additional volumes not sufficient to eliminate all supply disruptions in this case

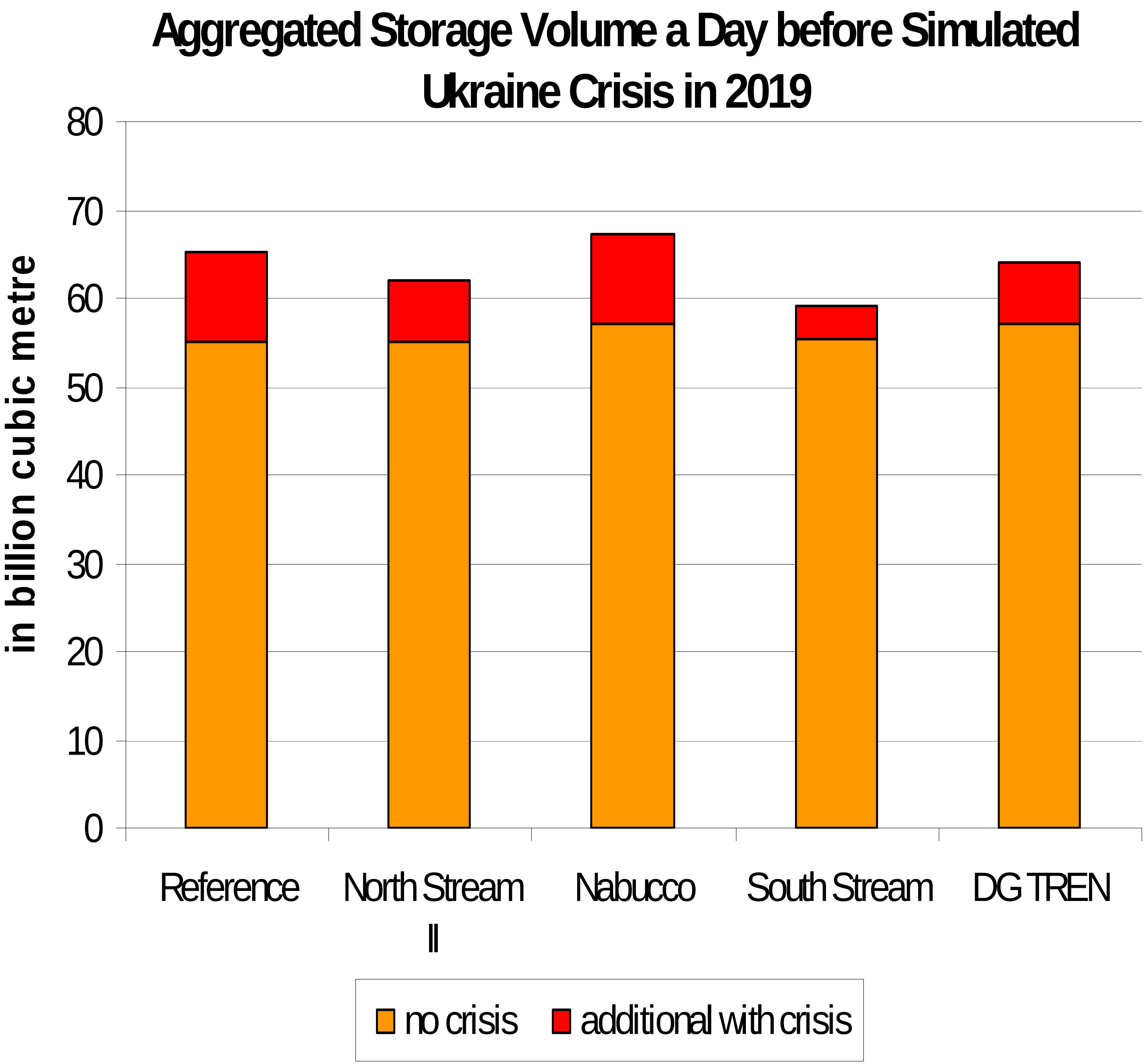
South Stream

- improves integration in Eastern Europe
- greatly enhances SoS for Ukraine Transit Disruption (alternative route to Ukraine -> redundant capacity and larger capacity than Nabucco)

LNG Glut

- Flow directions turning from East-to-West to West-to-East
- Additional congestion from Western to Central European countries

Summary of Results (IV): Role of Storage for SoS



- Perfect foresight: Crisis **known** to the model in advance
- **Model**: Additional gas volumes stored prior to crisis
- **Reality**: storage volumes depend on market expectations and regulatory requirements

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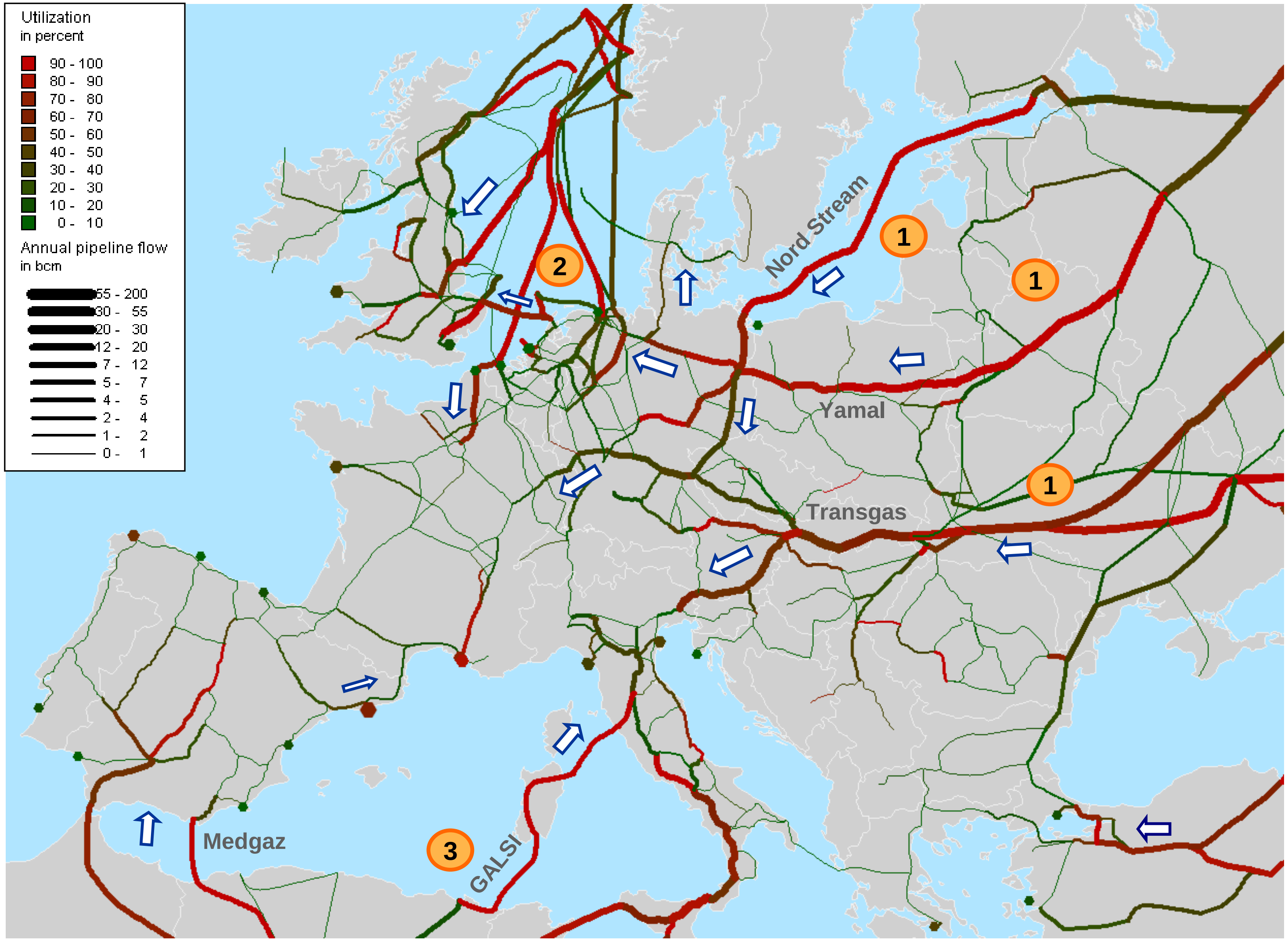
Annual Gas Flows 2019



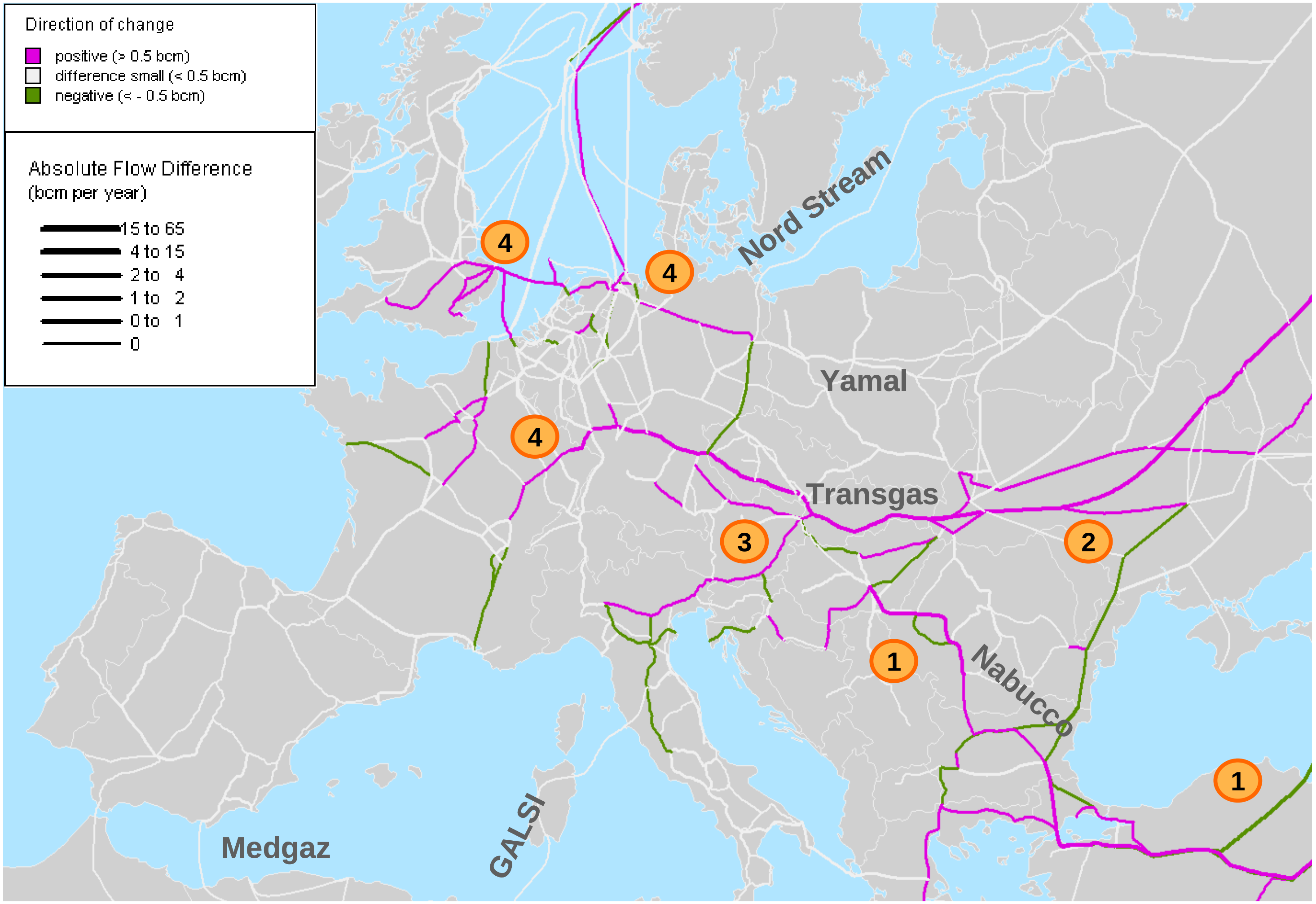
Infrastructure Scenario: **Reference**

Demand Scenario: **EWI/ERGEG**

Main routes to supply the European gas market:

1. Russian gas is imported via Nord Stream, Yamal and Transgas
2. Gas from Norway is transported to UK, FR, BE, DE/NL
3. Gas from Algeria to Italy and Spain

Absolute Change of Annual Gas Flows 2019



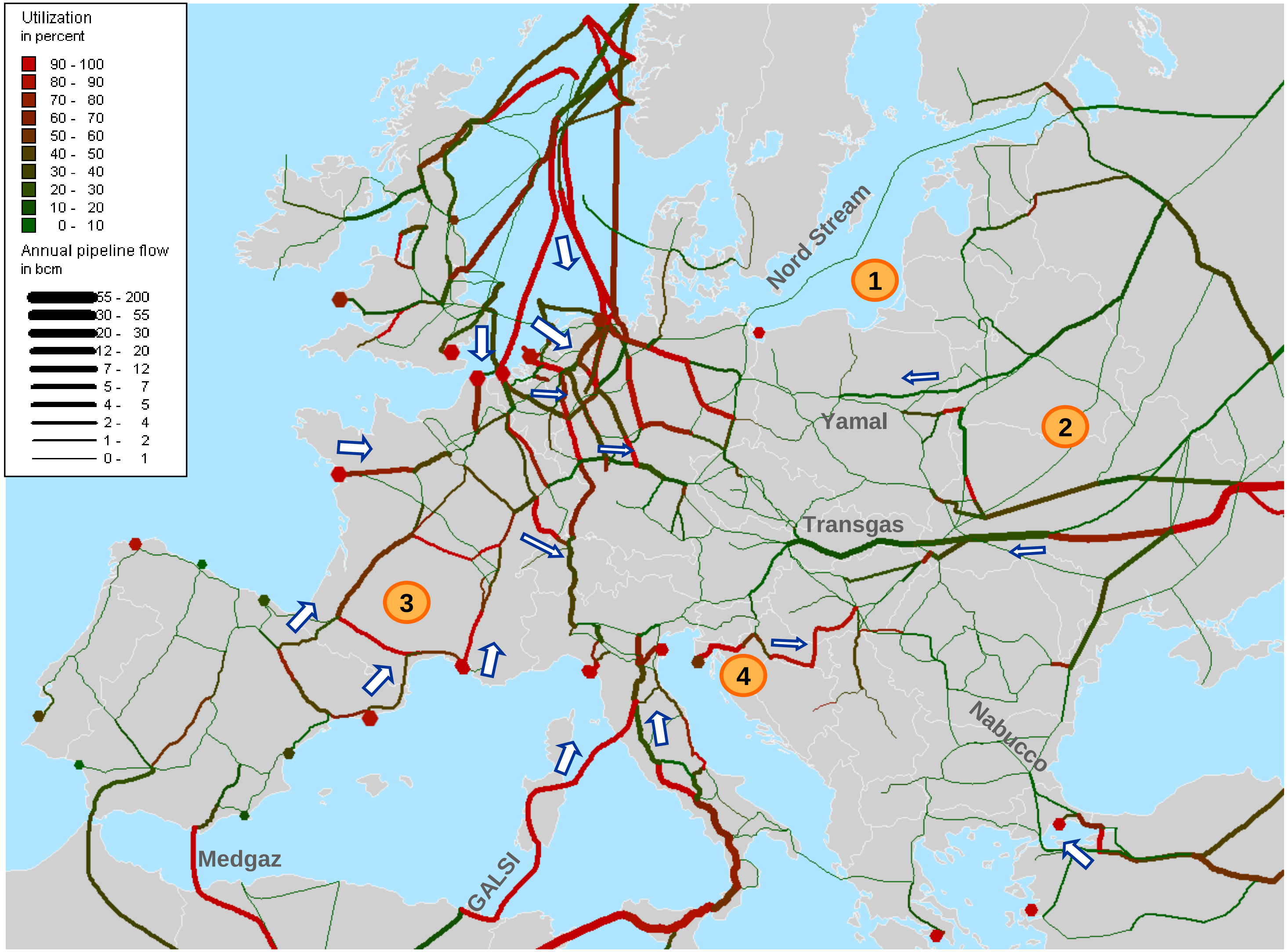
Infrastructure Scenario: Nabucco vs. Reference

Demand Scenario: EWI/ERGEG

1. Nabucco basically replaces Russian gas volumes in South Eastern Europe (Blue Stream, imports via Romania)
2. Indirect effects in Western Europe: less Russian gas to South East, more to Central and Western Europe
3. Transgas flows increase towards Germany, Italy, France
4.

- Pipeline gas volumes routed further West

Annual Gas Flows 2019 – LNG Glut (EWI/ERGEG Demand)



Infrastructure Scenario: LNG Glut

Demand Scenario: EWI/ERGEG

With temporally low LNG prices:

1. No gas via Nord Stream
2. Low utilisation of Yamal and Transgas
3. High utilisation of pipelines in France and Spain
4. High/full utilisation of pipeline in Croatia (from Krk terminal)

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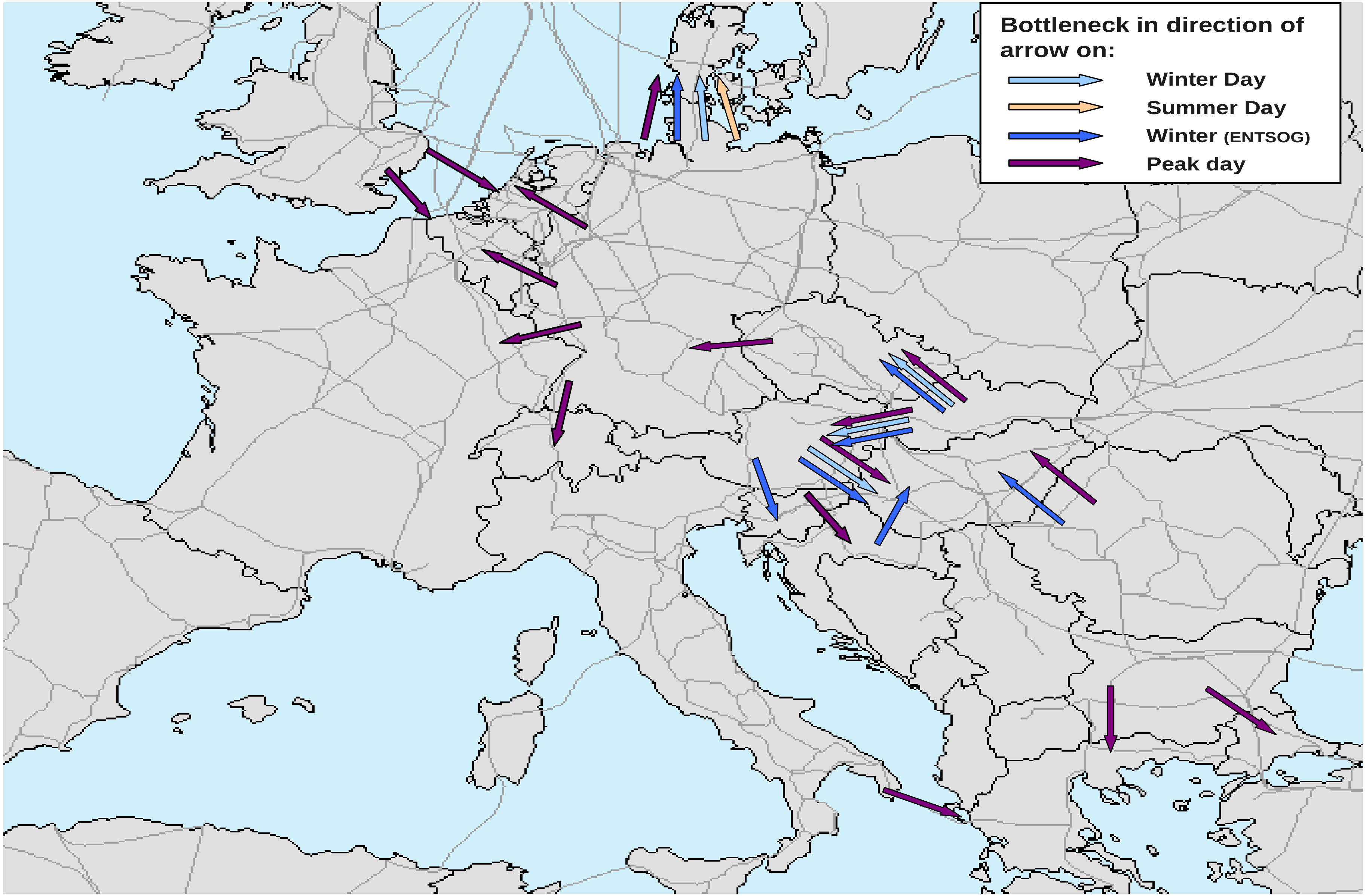
Identification of (economic) bottlenecks

- price differences vs. transport costs (between nodes)
- absolute value of price difference ≤ variable transport costs
  → no economic bottleneck
- absolute value of price difference > variable transport costs
  → economic bottleneck

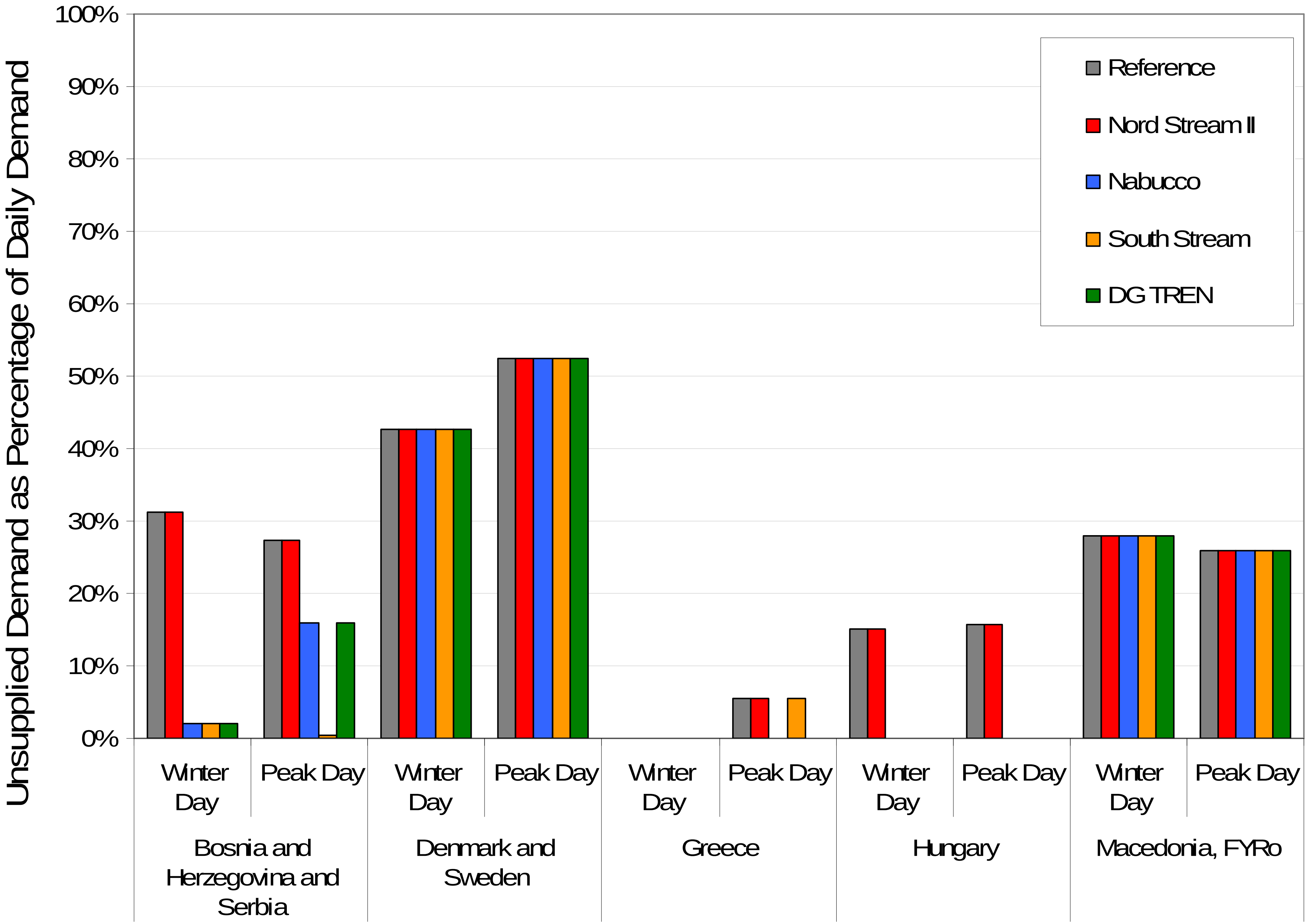
- For EWI/ERGEG demand: winter day → summer day
- For ENTSOG demand: winter day → peak day

Bottlenecks



Infrastructure Scenario: Reference

Unsupplied Demand due to bottlenecks



Main bottlenecks (I)

Denmark and Sweden

- All scenarios: demand in Denmark and Sweden exceeds import capacity plus domestic production (even on annual level)
- Persistent bottleneck: additional import capacity required

Eastern Europe

- Insufficient import capacity into Hungary if neither South Stream nor Nabucco in place, demand cannot be met (also true for Balkan countries)
- Some additional bottlenecks but with lower economic costs

Greece

- Import capacity insufficient on peak demand day (high demand in Turkey)
- Additional pipeline or LNG import capacity or storages might be necessary

Main bottlenecks (II)

Western Europe on peak demand day

- Benelux countries plus France: relative high peak demand day compared to average daily demand
- Relatively few storage sites or low withdrawal rates (Netherlands) compared to neighbouring countries (Germany, UK)
- On concurrent peak demand day → more gas transports from Germany and UK to this region would be economically viable

Low LNG Prices

- More transports from LNG terminals to central Europe possible if more west-to-east capacity were available
- Especially from UK to continent and from France to Germany and Switzerland
- Economic costs depend on relative LNG and pipeline gas prices and likelihood of very low LNG prices over time

Bottlenecks – Open Questions

Model results:

- Some bottlenecks identified (=physical bottleneck with economic cost)
- However, most of them depending on scenario and time of consideration (winter vs. summer vs. peak day)

Open questions:

- What degree of physical market integration is desirable?
- What is the efficient amount of capital investment?
- Does the economic cost of the congestion exceed the cost of physical integration?
- Are there any additional positive "external" effects of market integration (apart from economic efficiency gains)?

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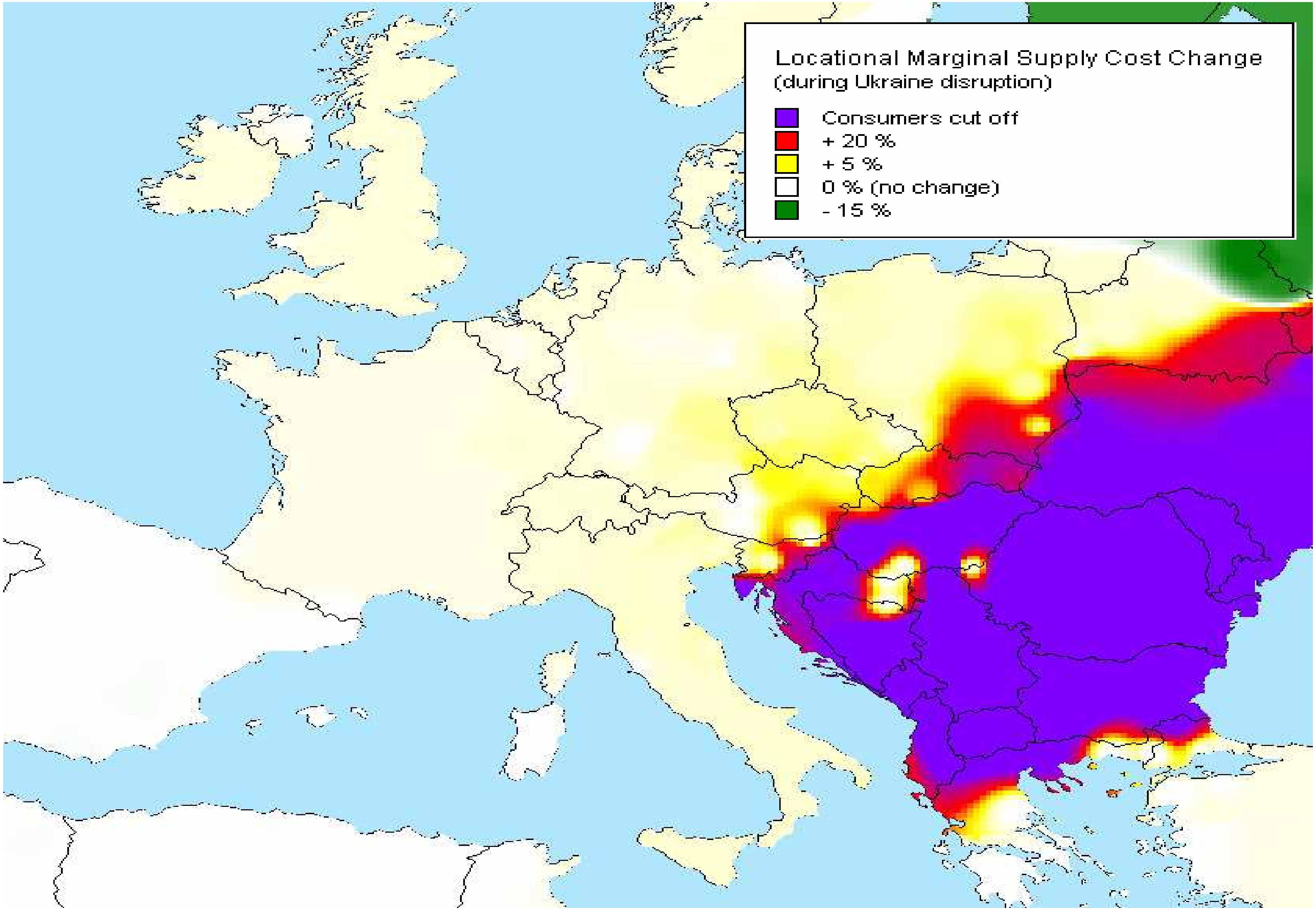
2009 Crisis simulated

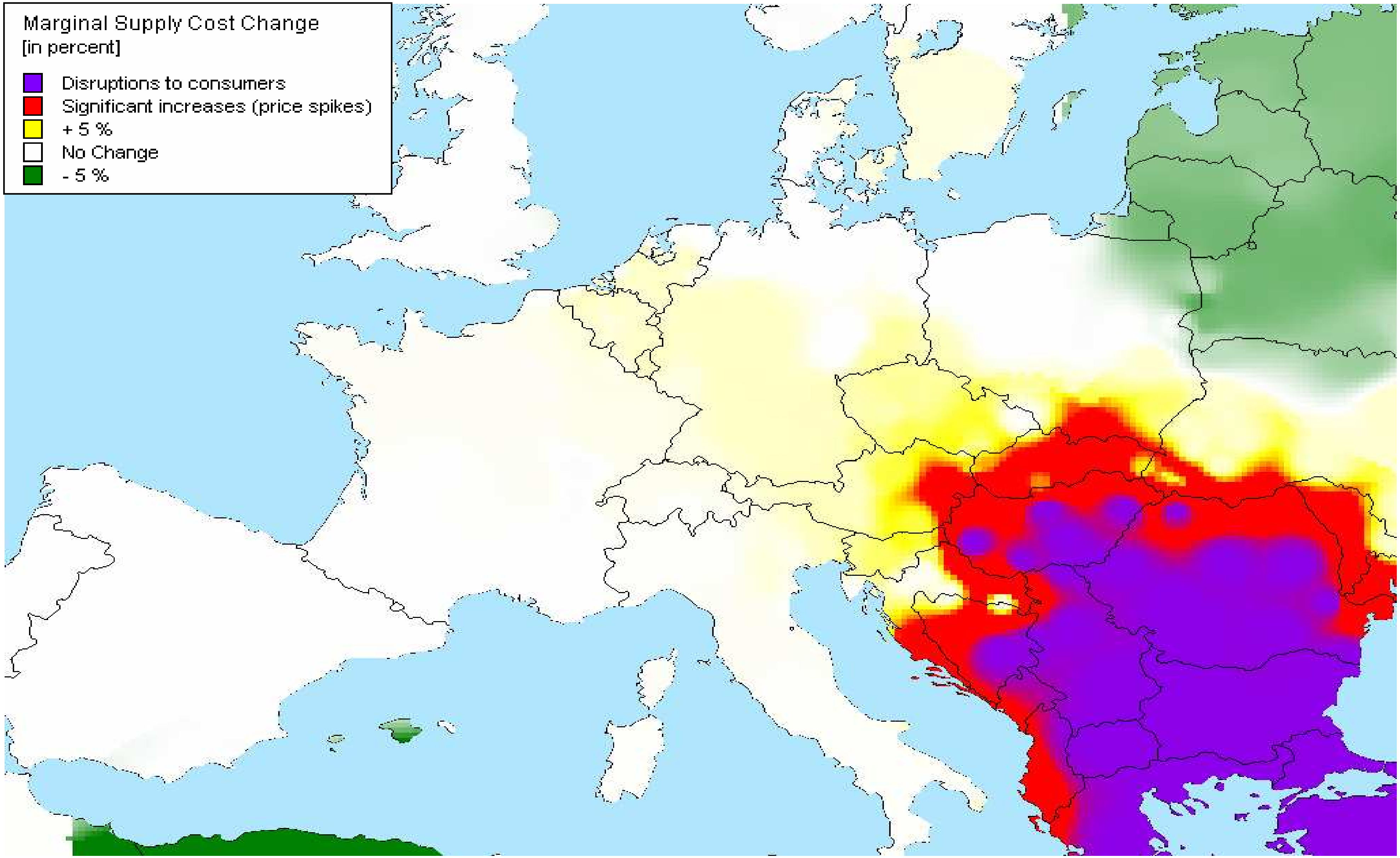


Hypothetical Ukraine Crisis

Assumptions

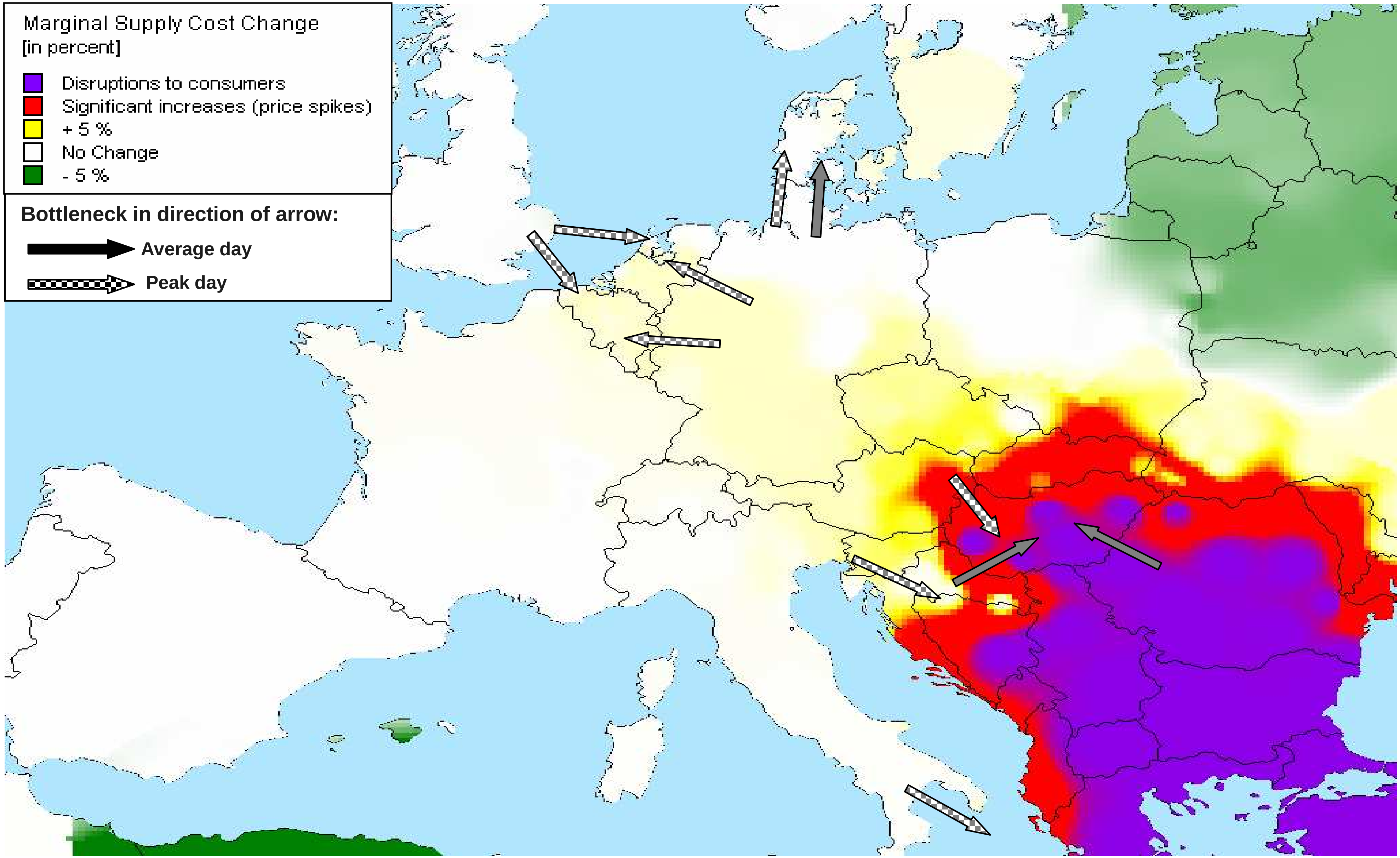
- No transits via Ukraine
- Duration of 28 days in mid-January (including the peak demand day)

Hypothetical Crisis: Ukraine Transit Disruption



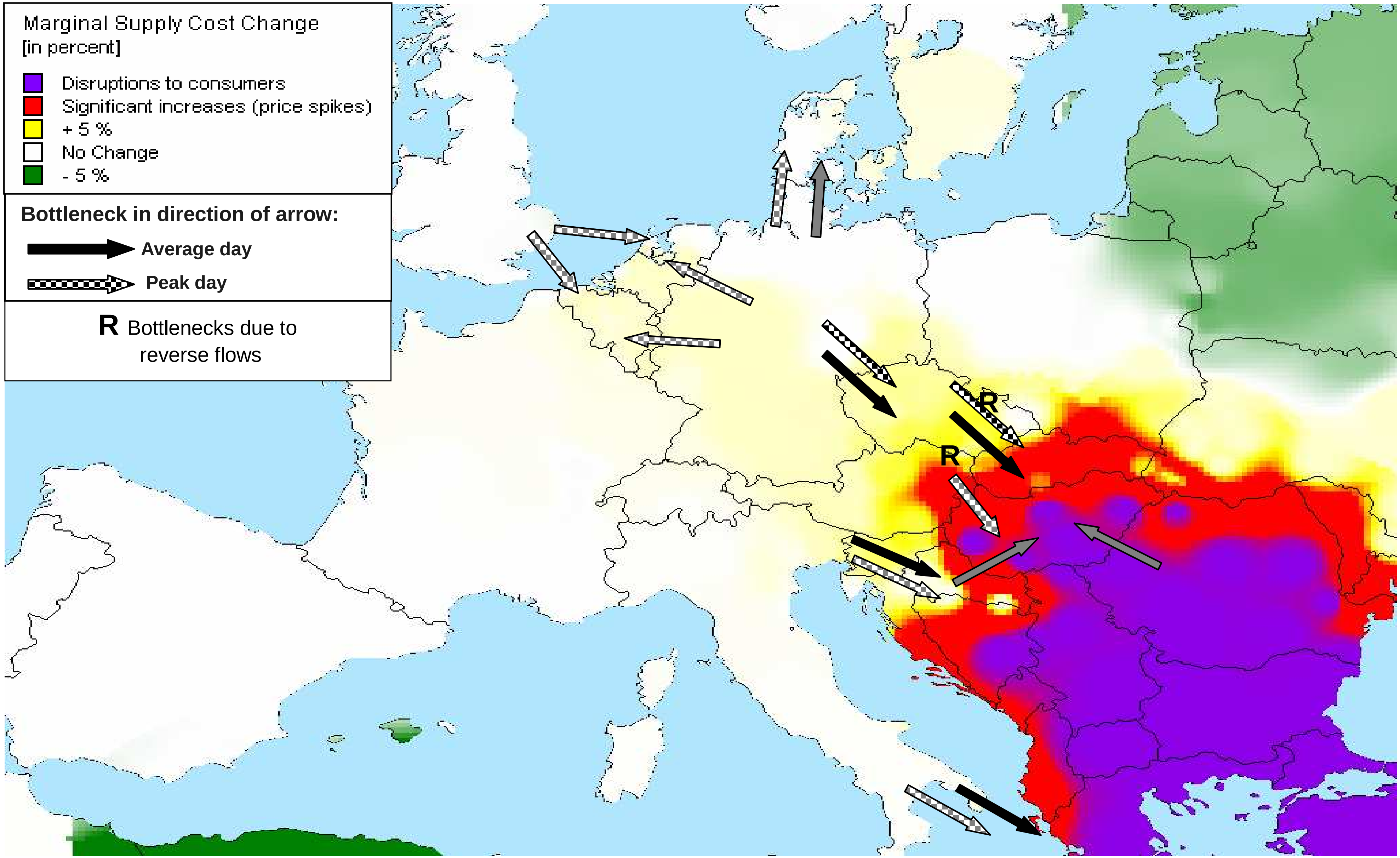
Infrastructure Scenario: Reference

Hypothetical Crisis: Ukraine Transit Disruption



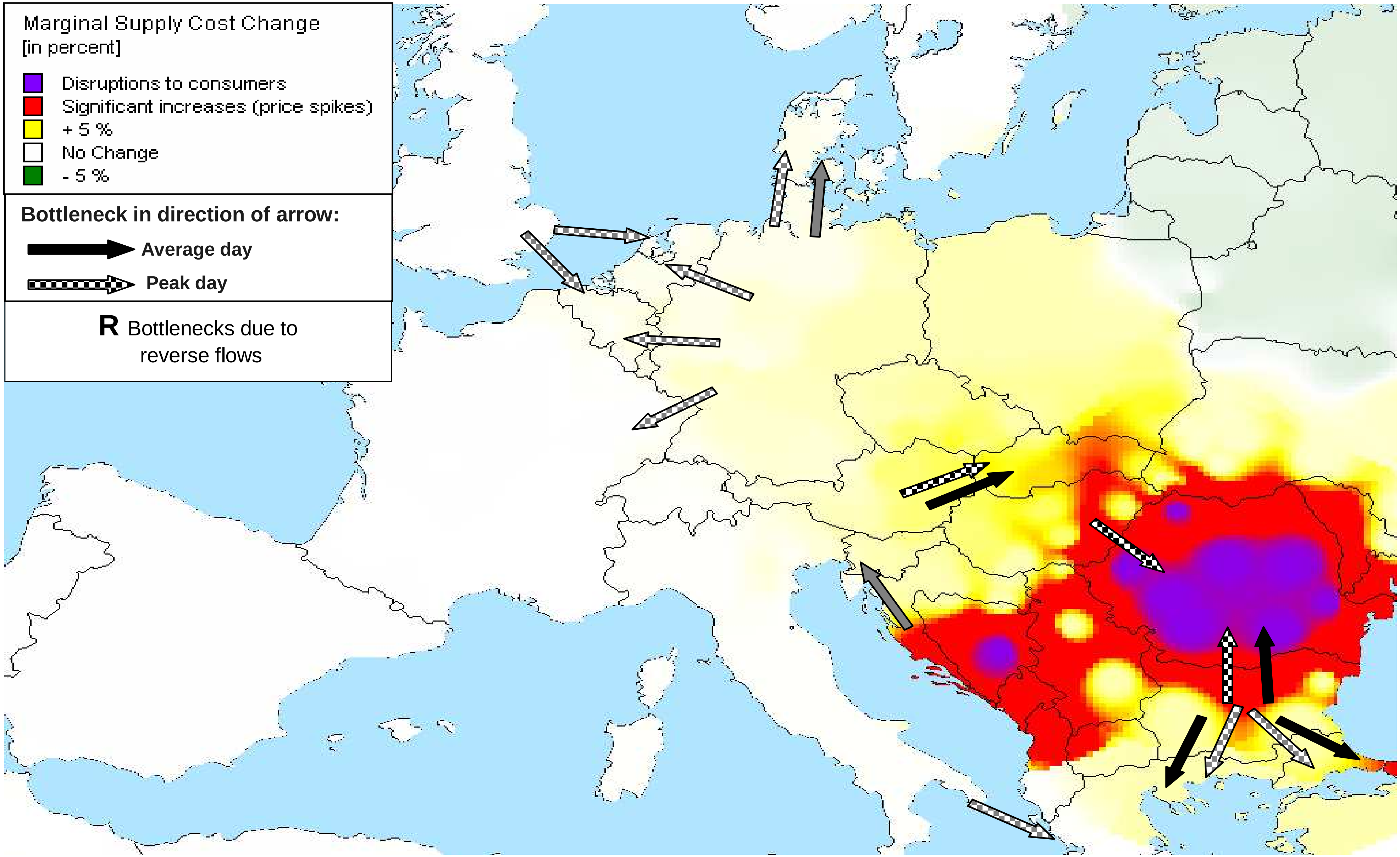
Infrastructure Scenario: Reference

Hypothetical Crisis: Ukraine Transit Disruption



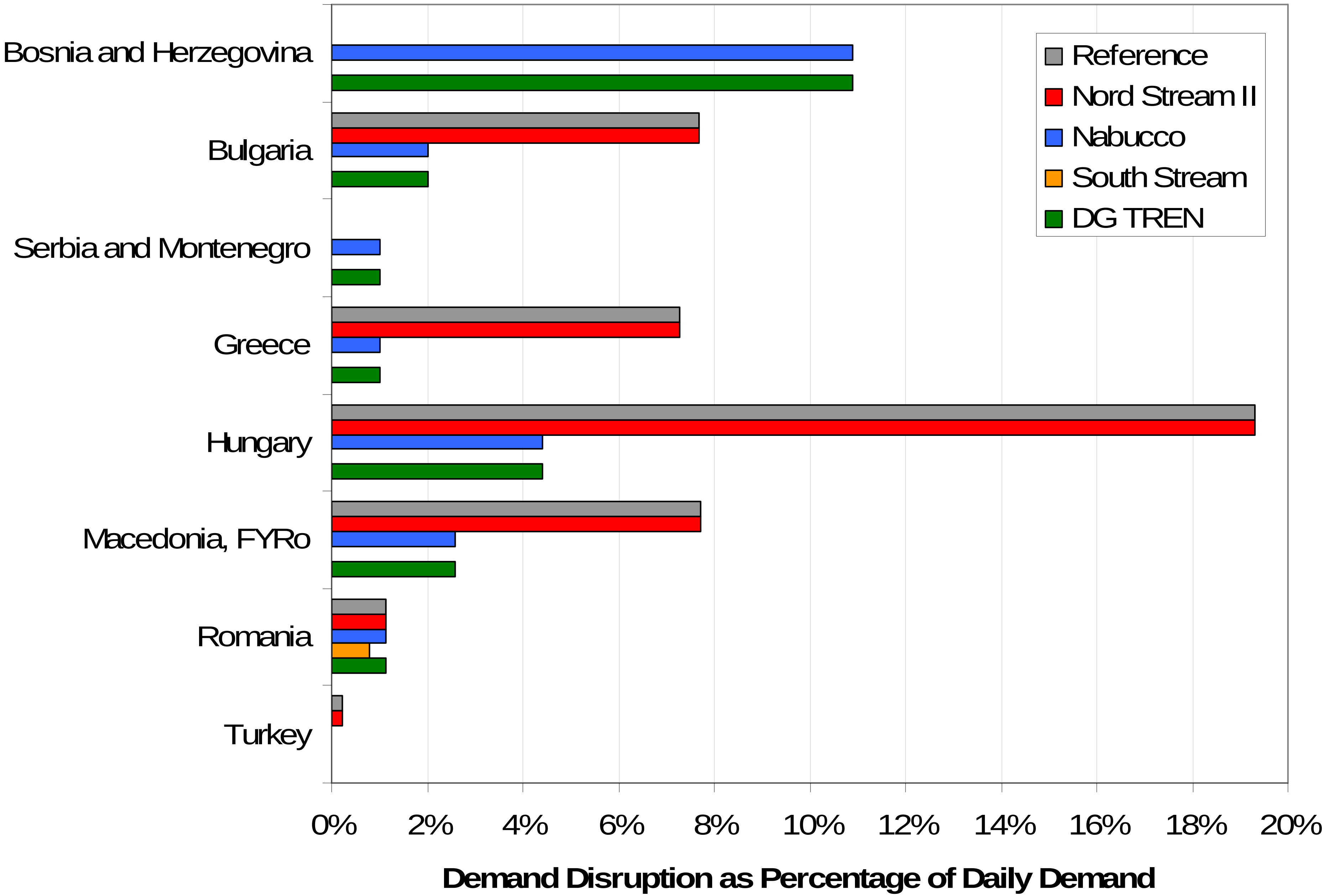
Infrastructure Scenario: Reference

Hypothetical Crisis: Ukraine Transit Disruption



Infrastructure Scenario: South Stream

Quantities to consumers switched off



Security of Supply Sensitivities

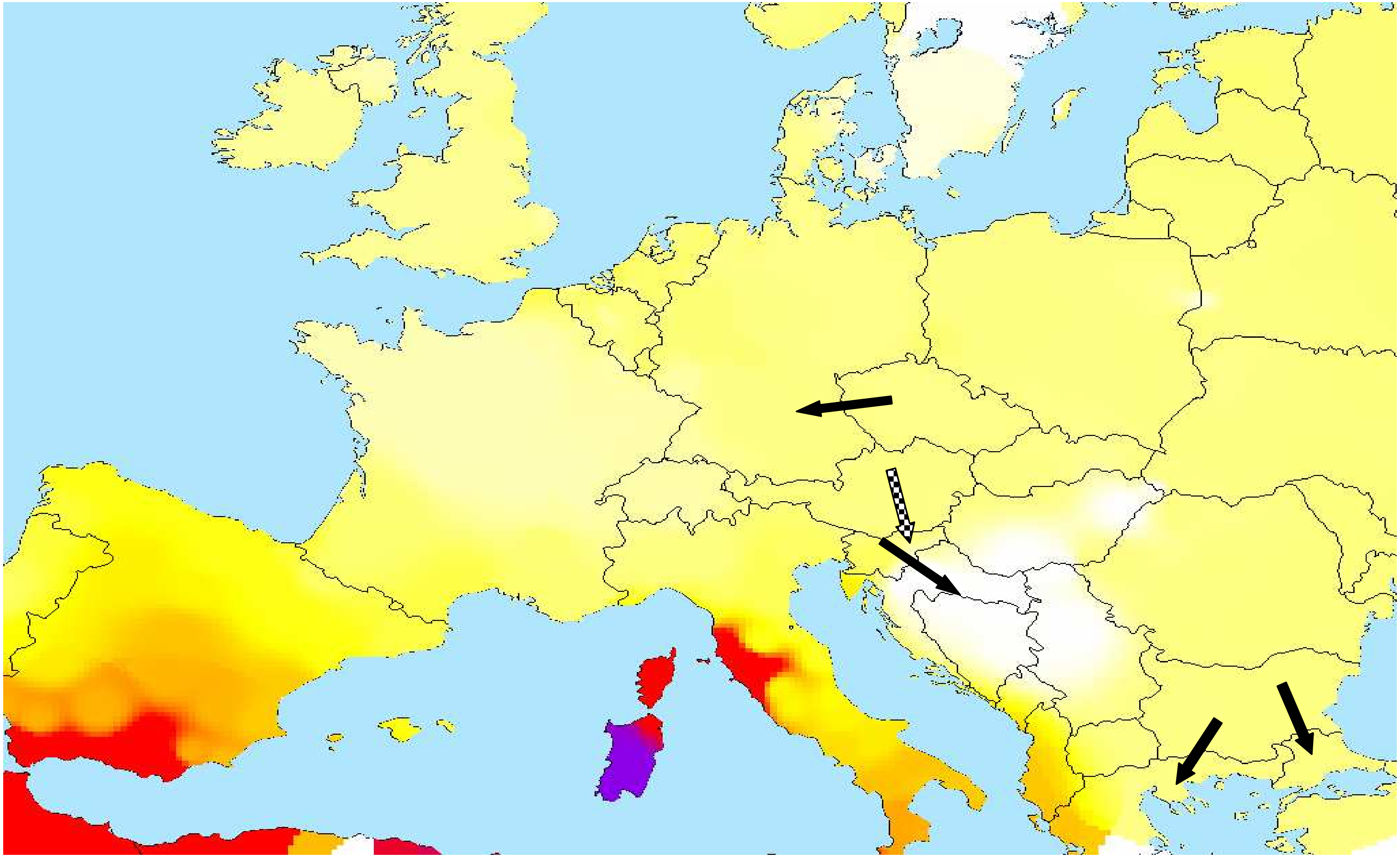
(1) Replication of 2009 January Ukraine Crisis

- No transits via Ukraine
- Duration of 28 days in mid-January (including the peak demand day)

(2) Algerian export stop

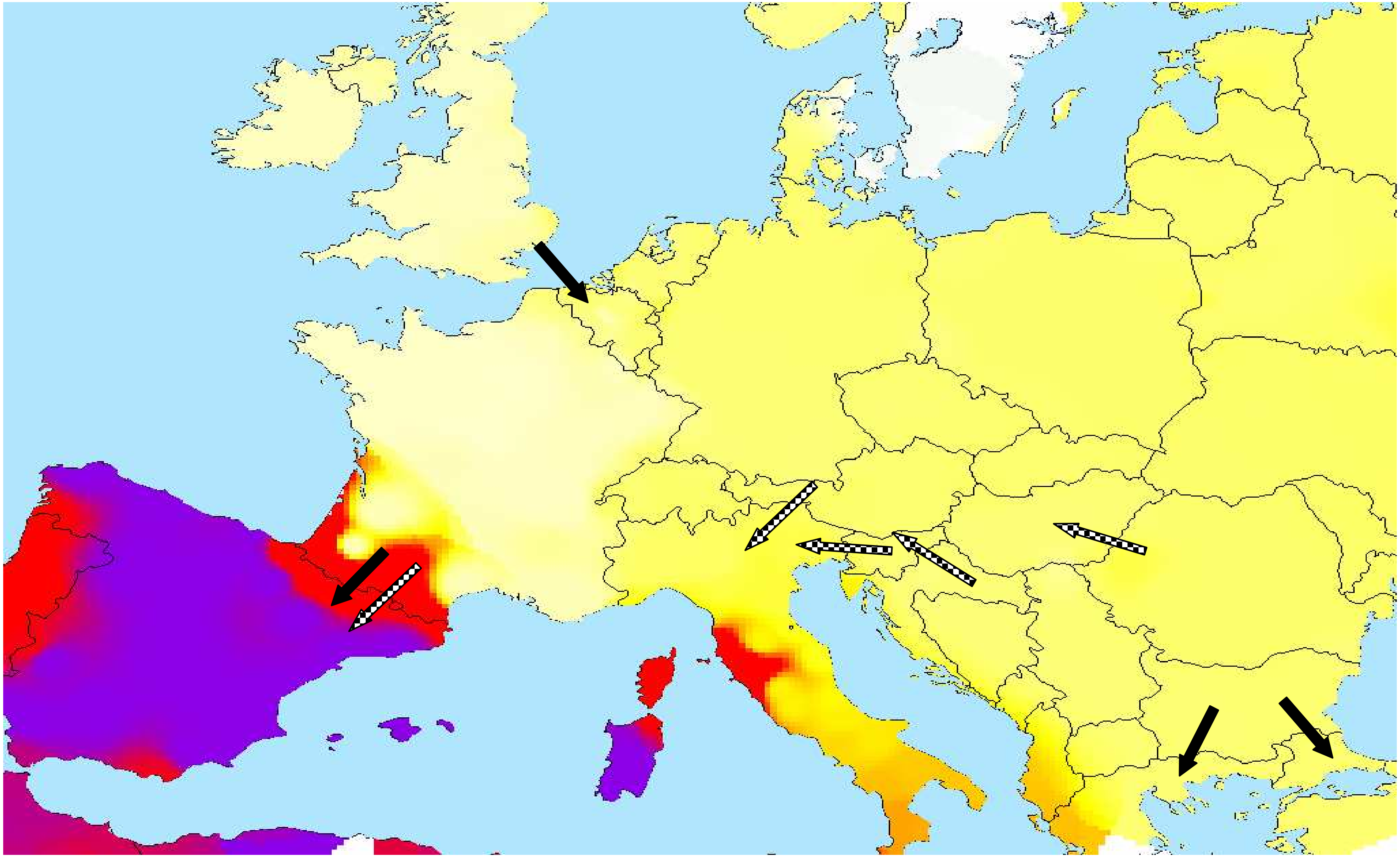
- No exports by pipeline from Algeria for 28 days in mid-January (including the peak demand day)
- Reduction of total available LNG volumes to the EU by 25 percent during this time period
- Diversion of LNG ships from one EU country to another is assumed to be possible, albeit only after a several day reaction time period

Hypothetical Crisis: Algeria Suppy Disruption



Infrastructure Scenario: Reference

Algeria Suppy Disruption – “Without MidCat“ Scenario



Infrastructure Scenario: South Stream

Overview: Additional bottlenecks in SoS simulations

	Ukraine stress scenario										Algeria stress scenario									
Countries	Refer-ence		Nord Stream II		Nabucco		South Stream		DG TREN		Refer-ence		Nord Stream II		Nabucco		South Stream		DG TREN	
ES and FR																				
GB and BE																				
CZ and DE-S*																				
CZ and DE-E*																				
AT and DE																				
AT and IT					R				R											
AT and SI																				
IT and SI																				
HR and SI																				
HU and RO																				
AT and SK																				
CZ and SK	R	R		R	R	R				R										
BG and RO																				
BG and GR																				
BG and TR																				
GR and IT																				

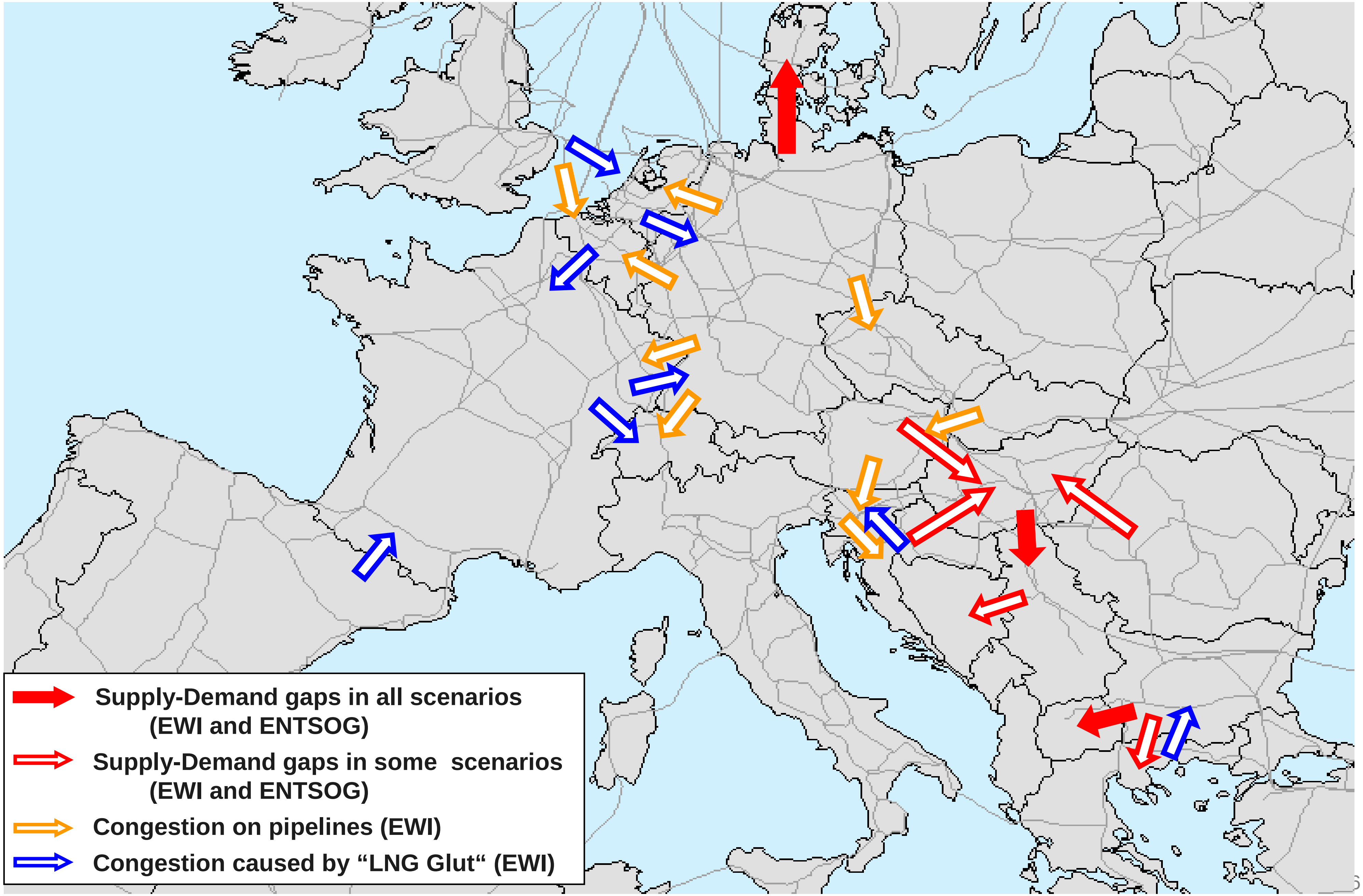
**Czech border with south (Waidhaus) and east Germany (Olbernhau) respectively*

Ukraine crisis - bottlenecks:
on average winter day
on peak demand day

Algeria crisis - bottlenecks:
on average winter day
on peak demand day

bottlenecks in reverse direction **R**

Conclusion: Summary of Bottlenecks in EWI Study and ENTSOG (2009) Study Comparison



Thank you for your attention!

The full study is available for download at the website of ERGEG.

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