Institute of Energy Economics at the University of Cologne

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

Study initiated by ERGEG

> Preliminary Results <

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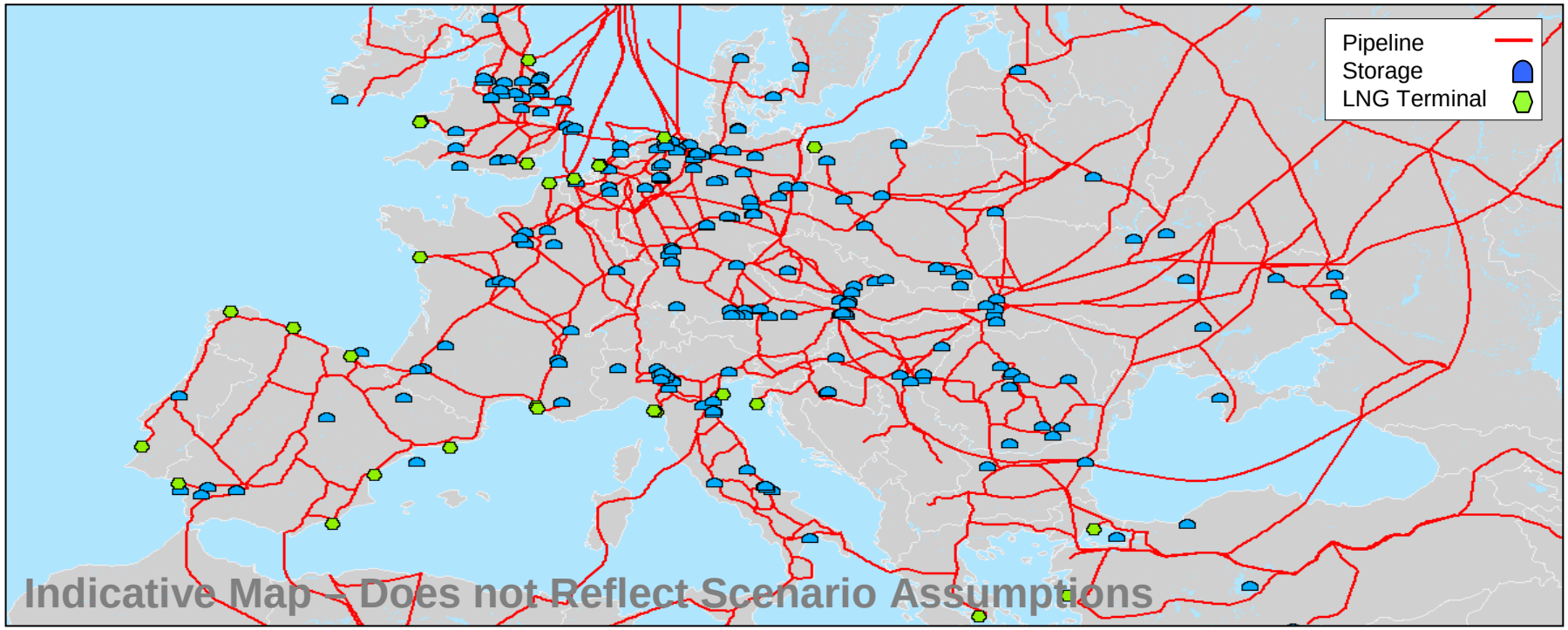
Brussels, 26 January 2010

Agenda

1. **Model Approach**
2. **Scenario Definition and Assumptions**
3. **Results**
    a. **Overview of Results**
    b. **Focus Security of Supply**
    c. **Focus Market Integration**
4. **Conclusion & Discussion**

TIGER – Overview



Gas Supply
- production/import volumes
- relative prices/costs

Gas demand
- by sector, regionalized

Infrastructure
- existing capacities
- assumptions on expansions, new projects

Linear Optimization

Objective:
Cost-minimal demand satisfaction, restricted by available capacities

monthly (daily) granularity

Gas flows in Europe

Infrastructure asset utilization data
(Pipelines, Storages, LNG)
- Volumes, flow directions, injection, withdrawals, ...

Locational Marginal Cost (Price) Estimator

Main Assumptions

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

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

A detailed description of the TIGER natural gas infrastructure and dispatch model can be downloaded from EWI‘s webpage:

http://www.ewi.uni-koeln.de/fileadmin/user/PDFs/TIGER.pdf

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Scenarios and Assumptions

Definition of assumptions with respect to:

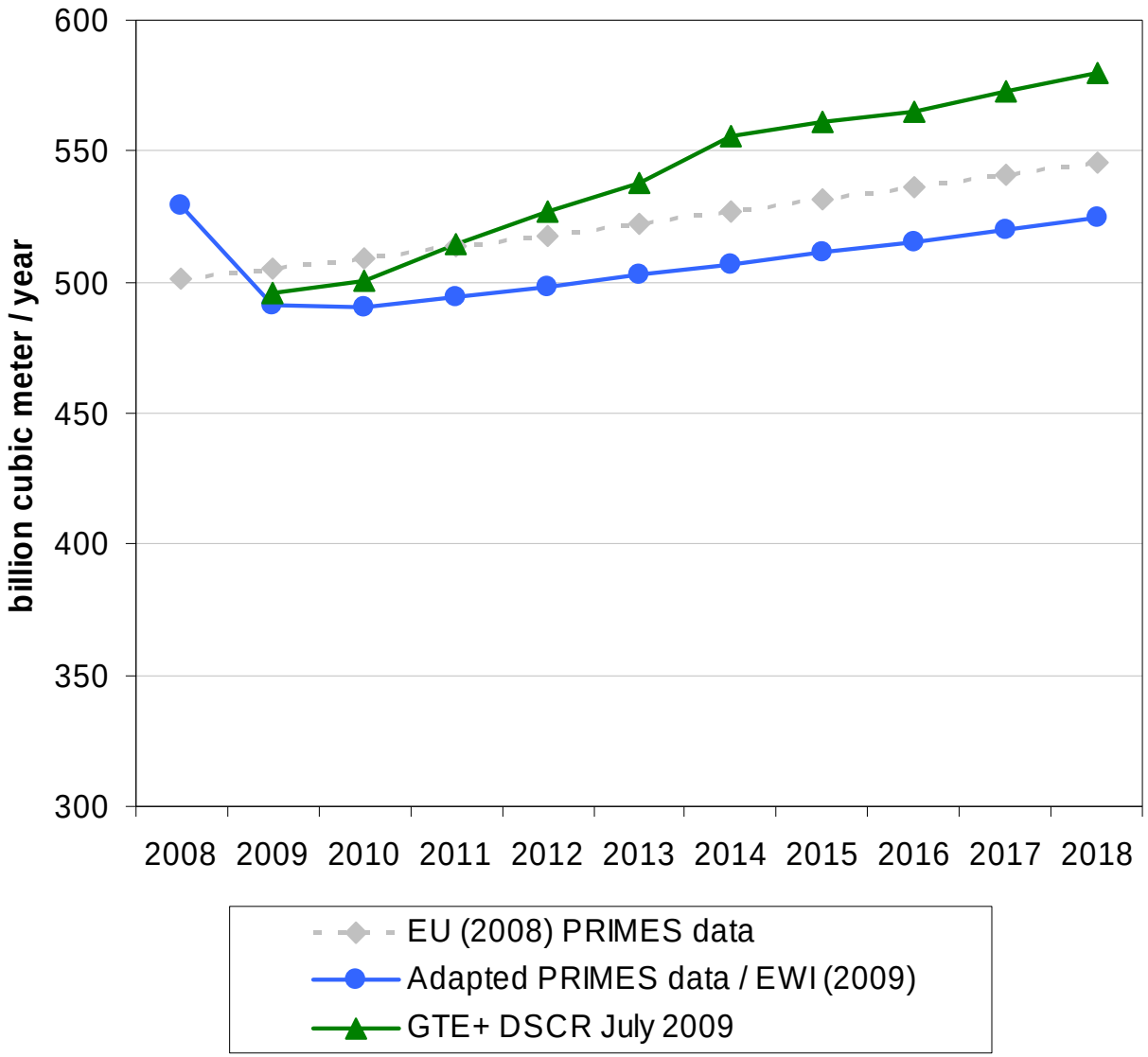
(1) Supply	(based on European Energy & Transport, Trends to 2030 (2008), IEA, own assumptions by EWI and ERGEG)
(2) Demand	(based on European Energy & Transport, Trends to 2030 (2008), EC Quarterly Report 2009, own assumptions by EWI and ERGEG)
(3) Infrastructure	Pipeline infrastructure scenarios LNG: 280 bcm import capacity in 2018 (+114 bcm) Storages: 141 bcm WGV in 2018 (+60.4 bcm)

Definition of scenarios (see also following slides):

Major variations of assumptions (scenario construction) regarding:

- Demand (Reference vs. High Demand)
- Infrastructure (variation of major import pipeline projects)

Demand Assumptions & Scenarios

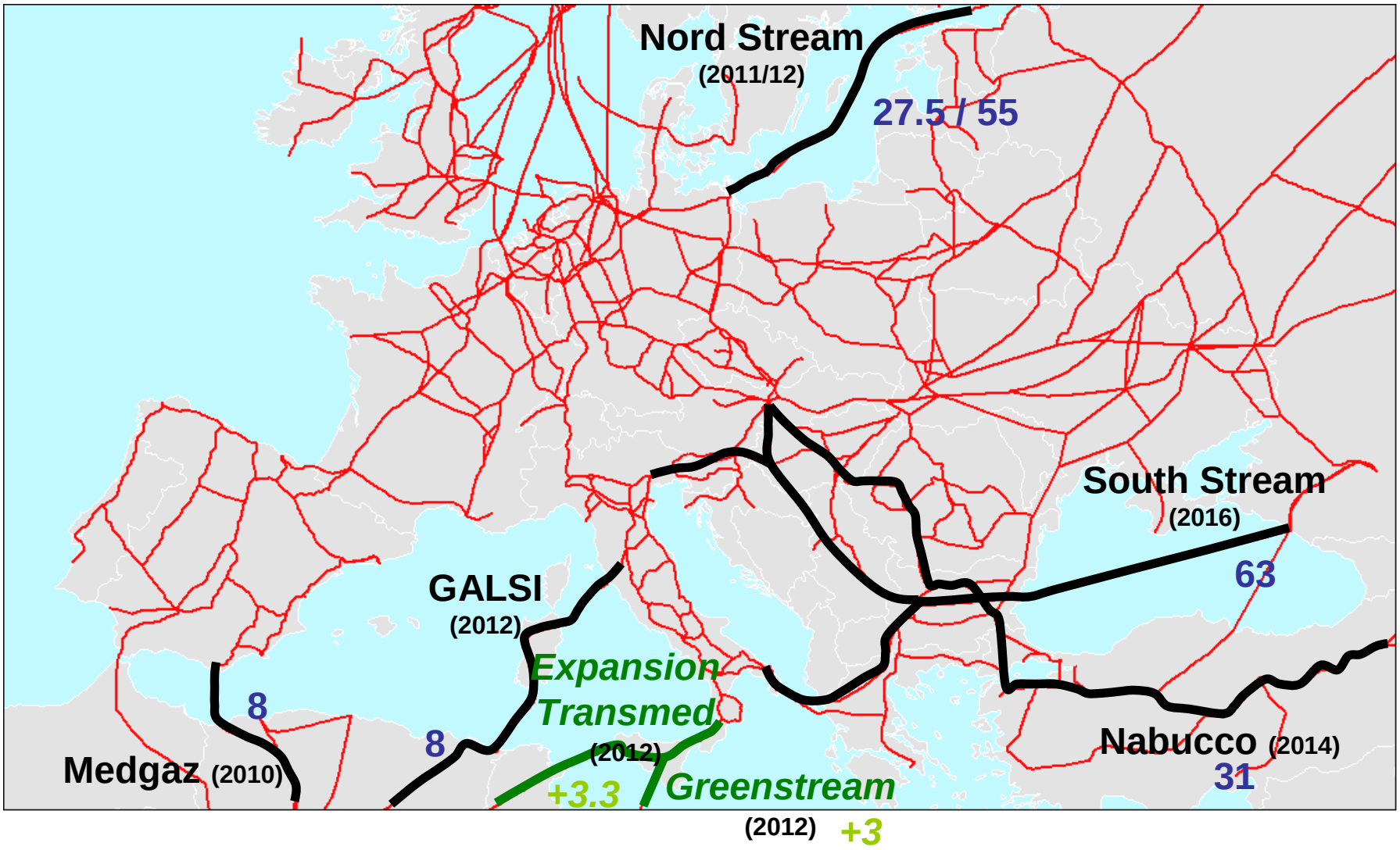


- EU (2008) data as recognized reference publication by EC
- Adjustment for economic crisis (2009/10 demand decline)

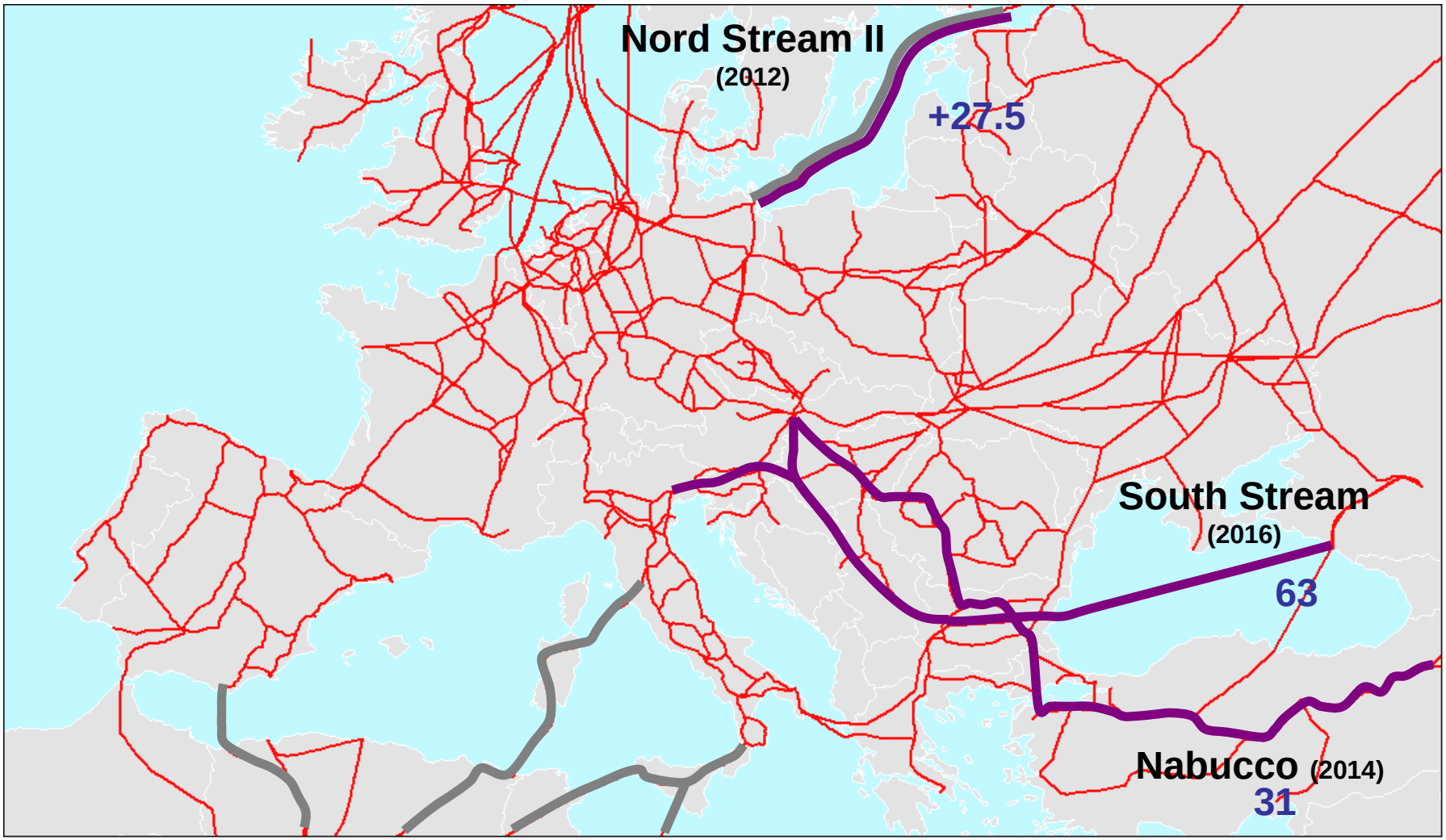
  >EWI/ERGEG Demand
- GTE+ Demand case to ensure compara-bility and have high demand sensitivity

  >GTE+ Demand
- (Additional Peak Day Simulations based on GTE+ data)

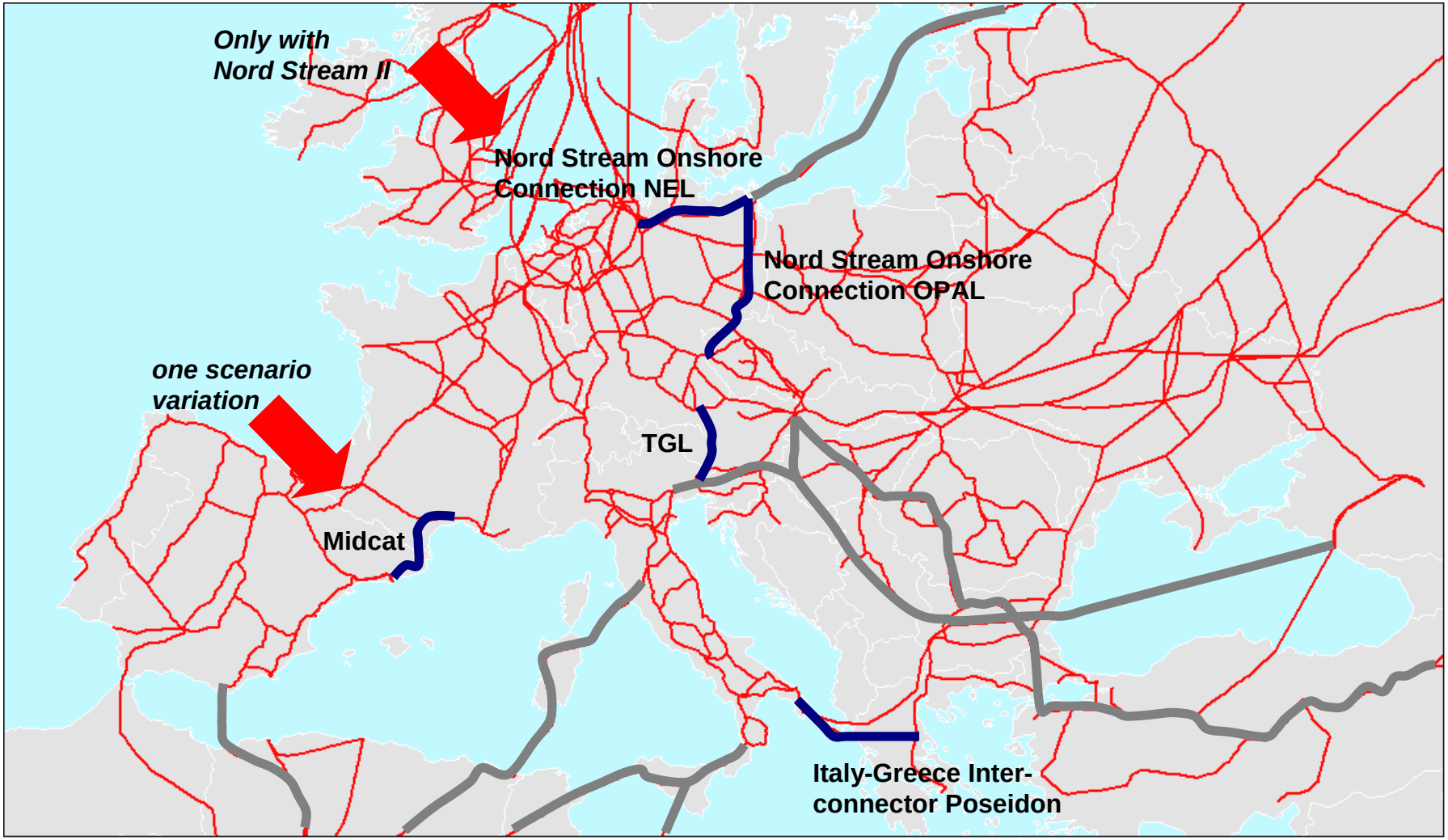
(4) Import Pipeline Projects



(4) Import Pipeline Projects – Scenario Variations



(4) Major Intra-European Pipeline Projects



Scenarios

Supply: No variation across scenarios (apart from LNG price and additional Nabucco volumes (*))

Demand: (i) **EWI/ERGEG** Demand (Adjusted EU 2008 projection)
(ii) **GTE+** Scenario (as higher demand alternative)

Infrastructure:

Scenario	**Pipeline Project included**				**"LNG price"**
	Nord Stream II	**Nabucco**	**South Stream**	**Midcat**	
Reference				YES	cost-based
Nord Stream II	YES			YES	cost-based
Nabucco		YES*		YES	cost-based
South Stream			YES		cost-based
DG TREN	YES	YES*		YES	cost-based
LNG Glut	YES	YES*		YES	low

- 12 Scenarios

  + Six Sensitivities Peak Day

  + Six Sensitivities Security of Supply Case (Disruption)

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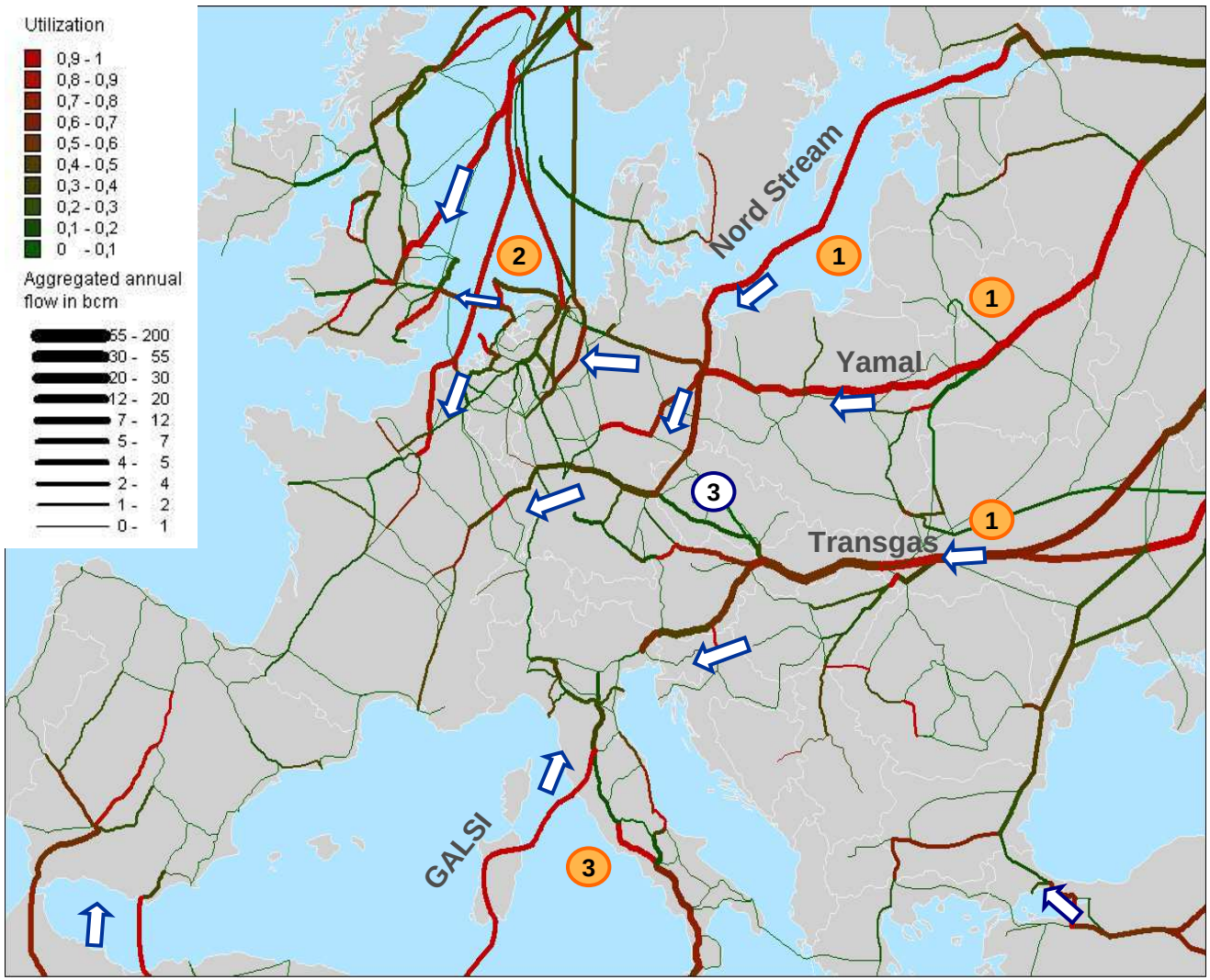
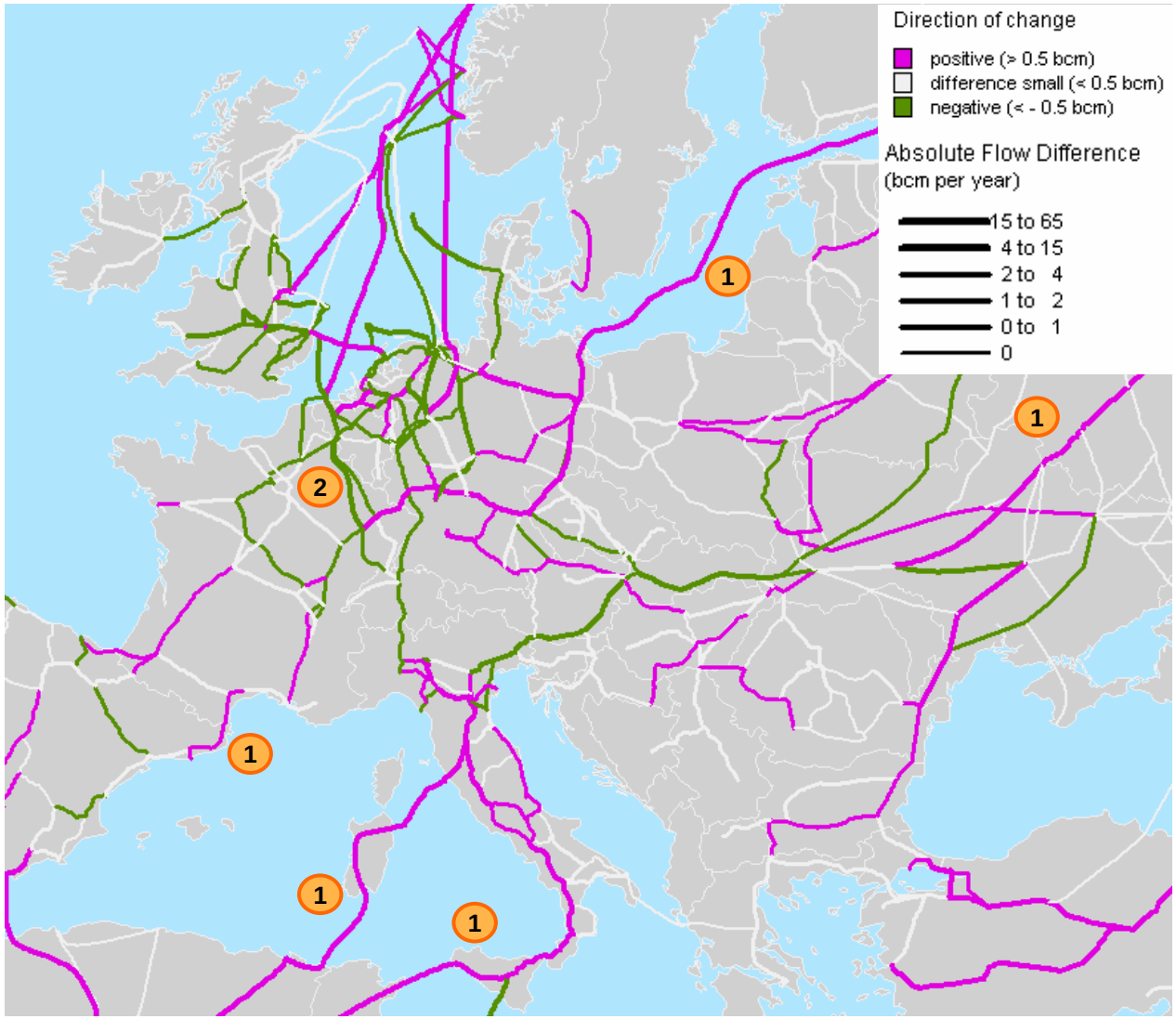
Annual Gas Flows 2018 – Reference Scenario (EWI/ERGEG Demand)



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

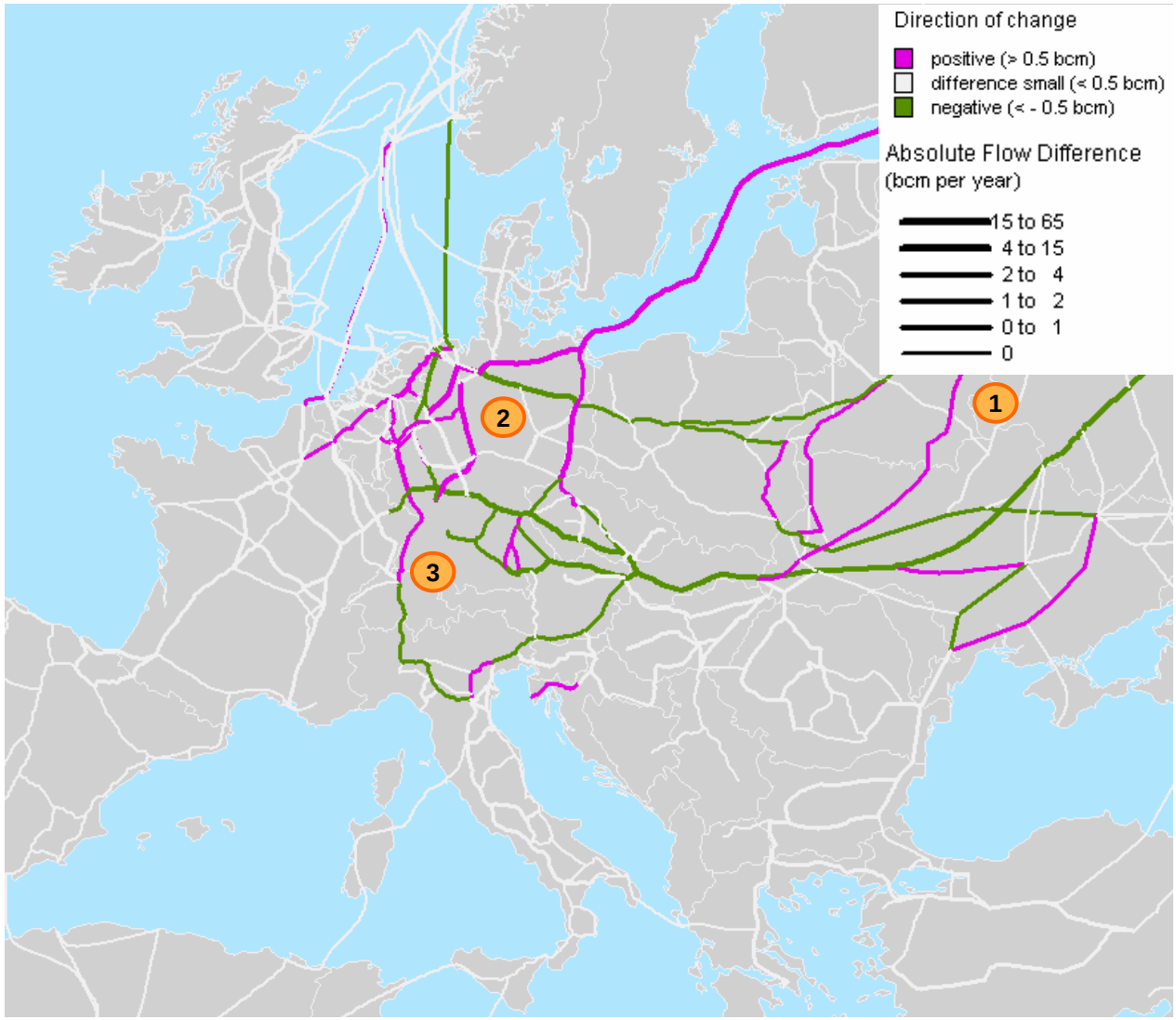
Absolute Change of Annual Gas Flows – Reference 2018 vs. 2008



1. Generally increase on all new and existing pipeline import routes except Transgas
2. Less inner European flows resulting from decrease of European production

- Increasing import dependency becomes obvious

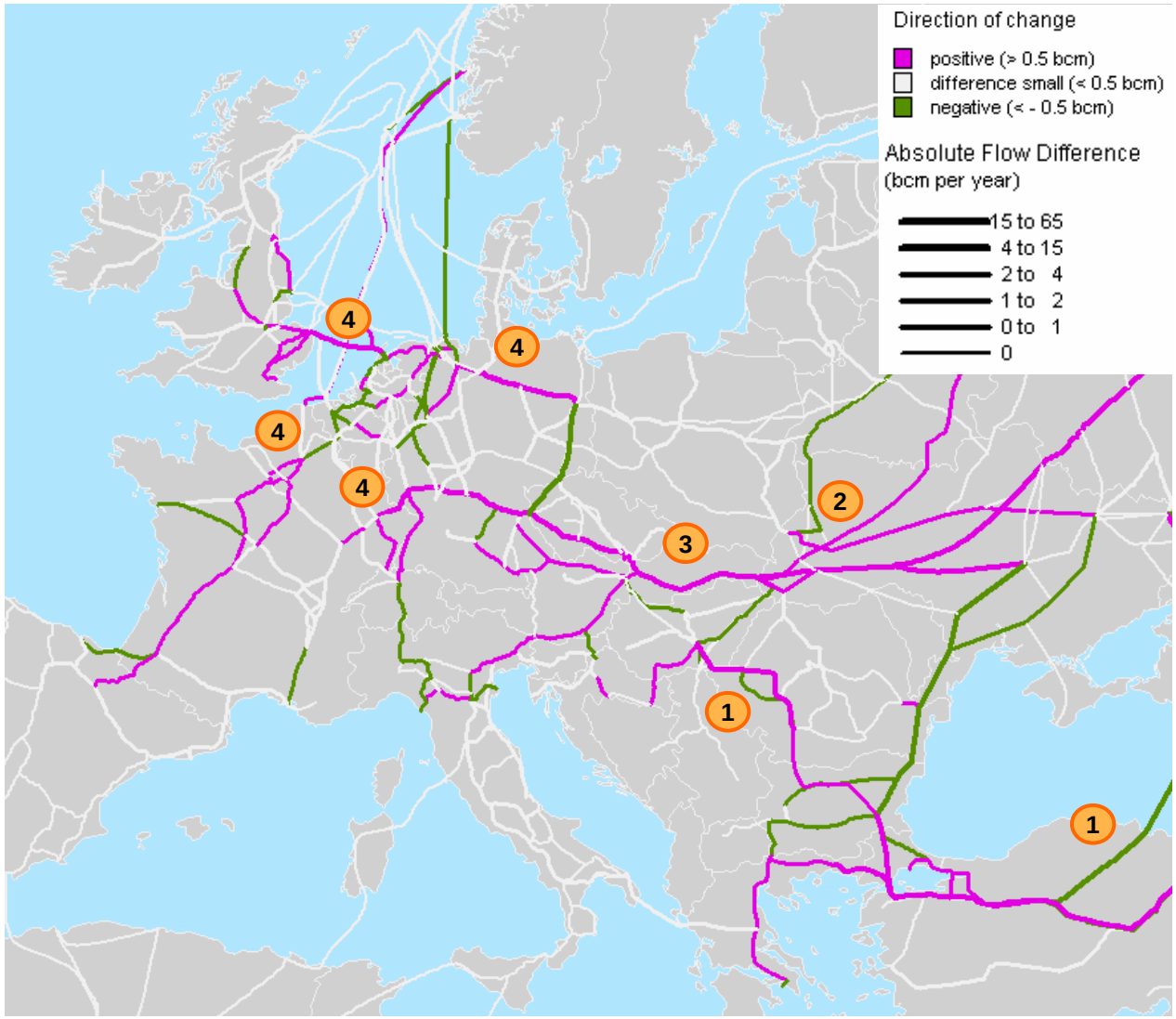
Absolute Change of Annual Gas Flows 2018 – Nord Stream II vs. Reference Scenario



1. Less imports on Yamal and Transgas to Italy and Germany
2. Increased flows to Belgium / Netherlands from Germany
3. Switzerland supplied increasingly from the North (instead of via Italy)

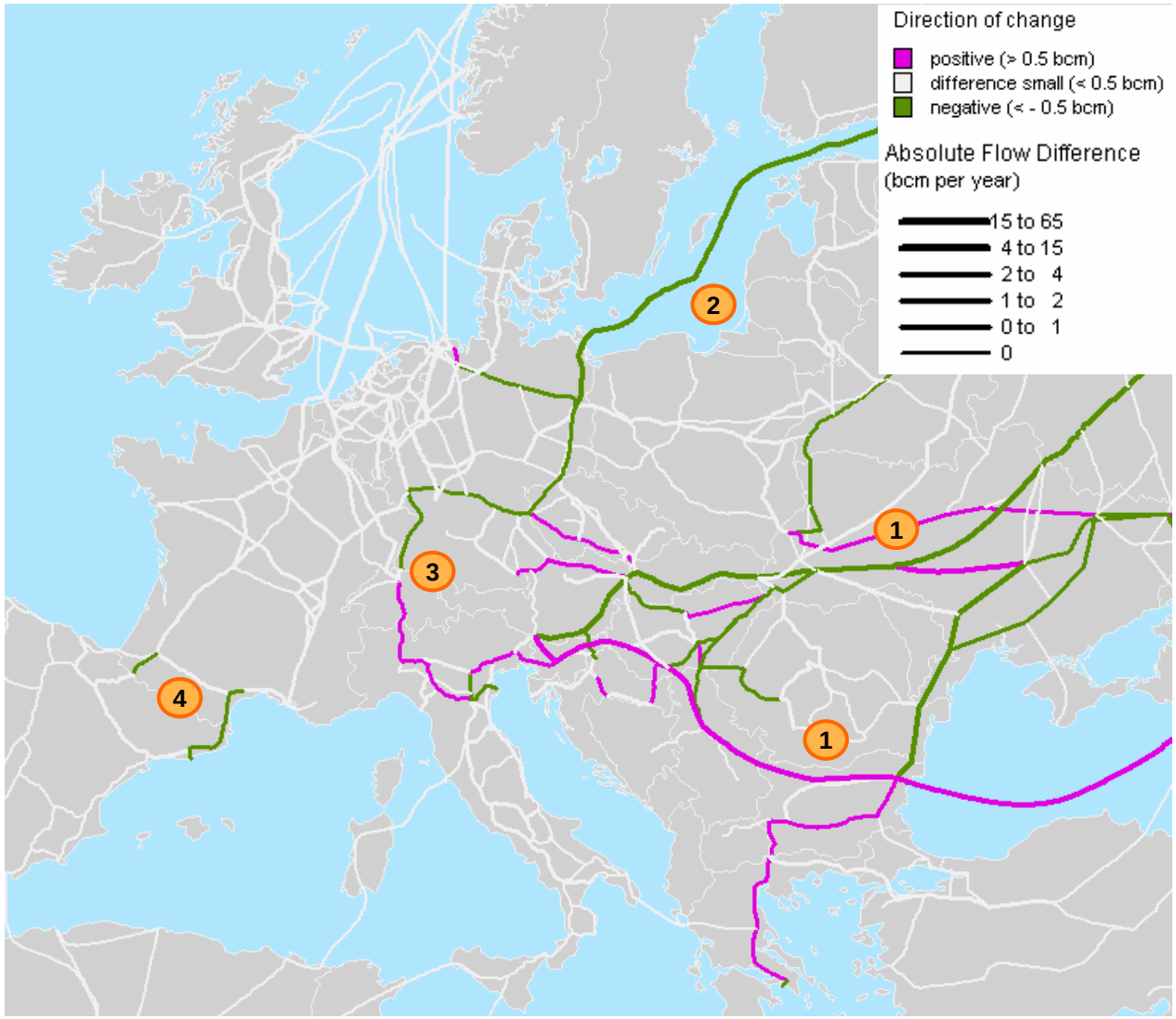
- Main effects in Central Europe (Germany, Austria, Italy, Benelux)
- No or small effects in Western and Eastern Europe (apart from transit flows)

Absolute Change of Annual Gas Flows 2018 – Nabucco vs. Reference Scenario



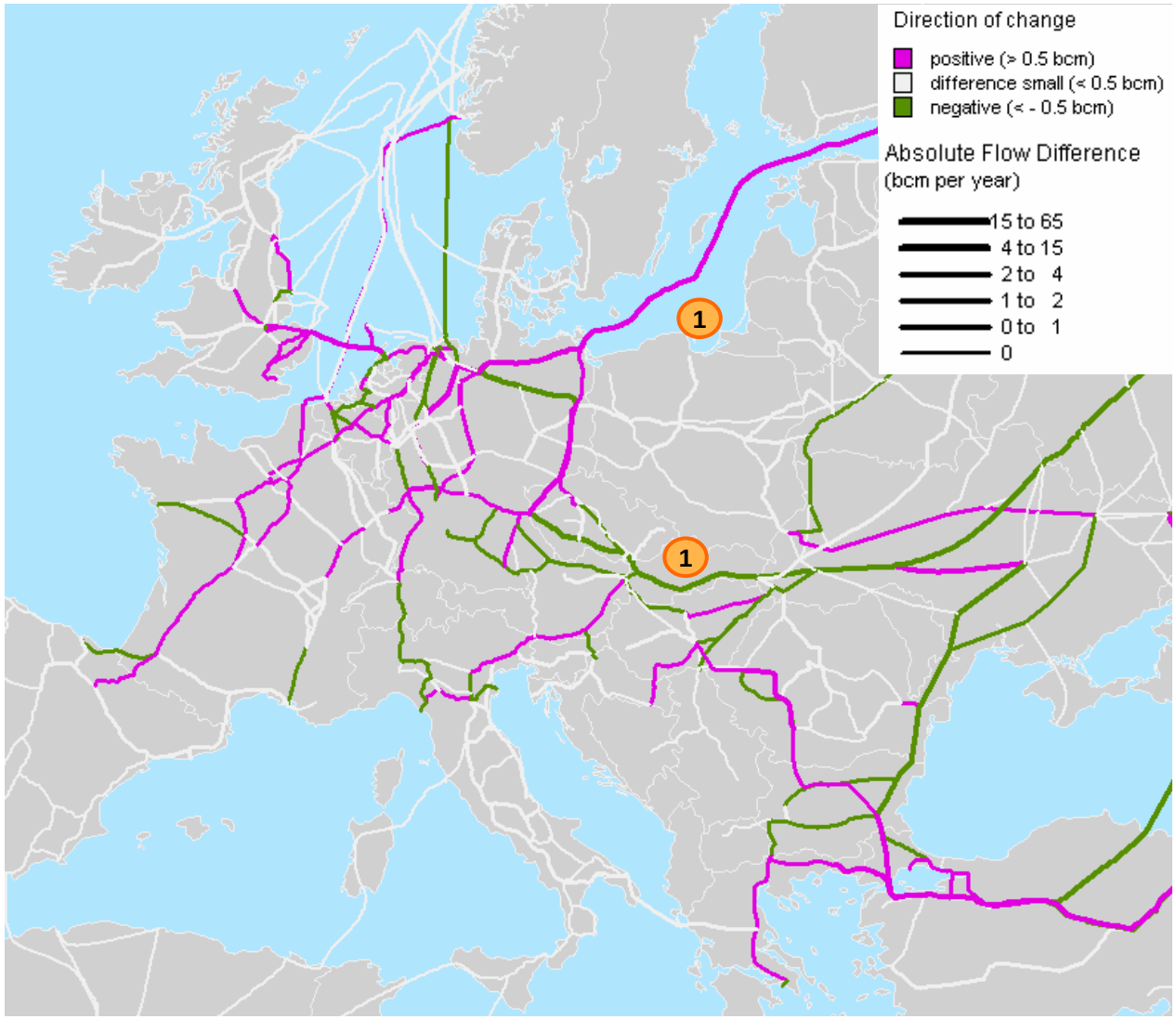
1. Nabucco basically replaces Russian gas volumes in South Eastern Europe (Blue Stream, imports via Romania)
2. Indirect effects in Western Europe: less Russian gas to South East, more to Central and Western Europe
3. Transgas flows increase towards Germany, Italy, France
4. Pipeline gas volumes routed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

Absolute Change of Annual Gas Flows 2018 – South Stream vs. Reference Scenario



1. South Stream takes over some volumes from Transgas for Italy and Croatia, Slovenia
2. South Stream takes over some volumes from Nord Stream
3. Switzerland supplied to increasing extend from the South and less from the North
4. Without Midcat, physical gas flows between ES and FR decline on Larrau pipeline as well

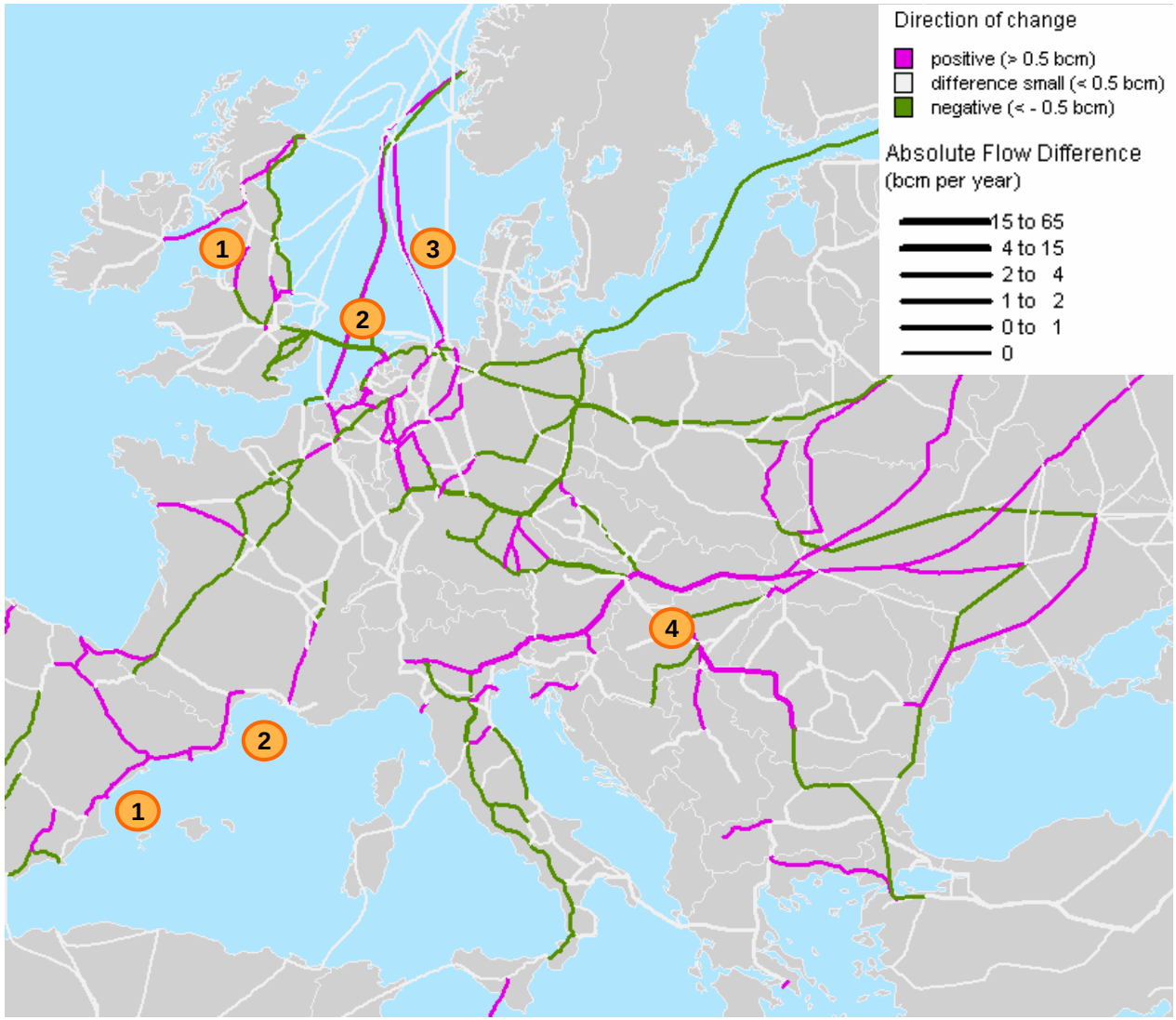
Absolute Change of Annual Gas Flows 2018 – DG TREN vs. Reference Scenario



- Combination of Nord Stream II and Nabucco effects:
- Russian gas losses market share in South-Eastern Europe

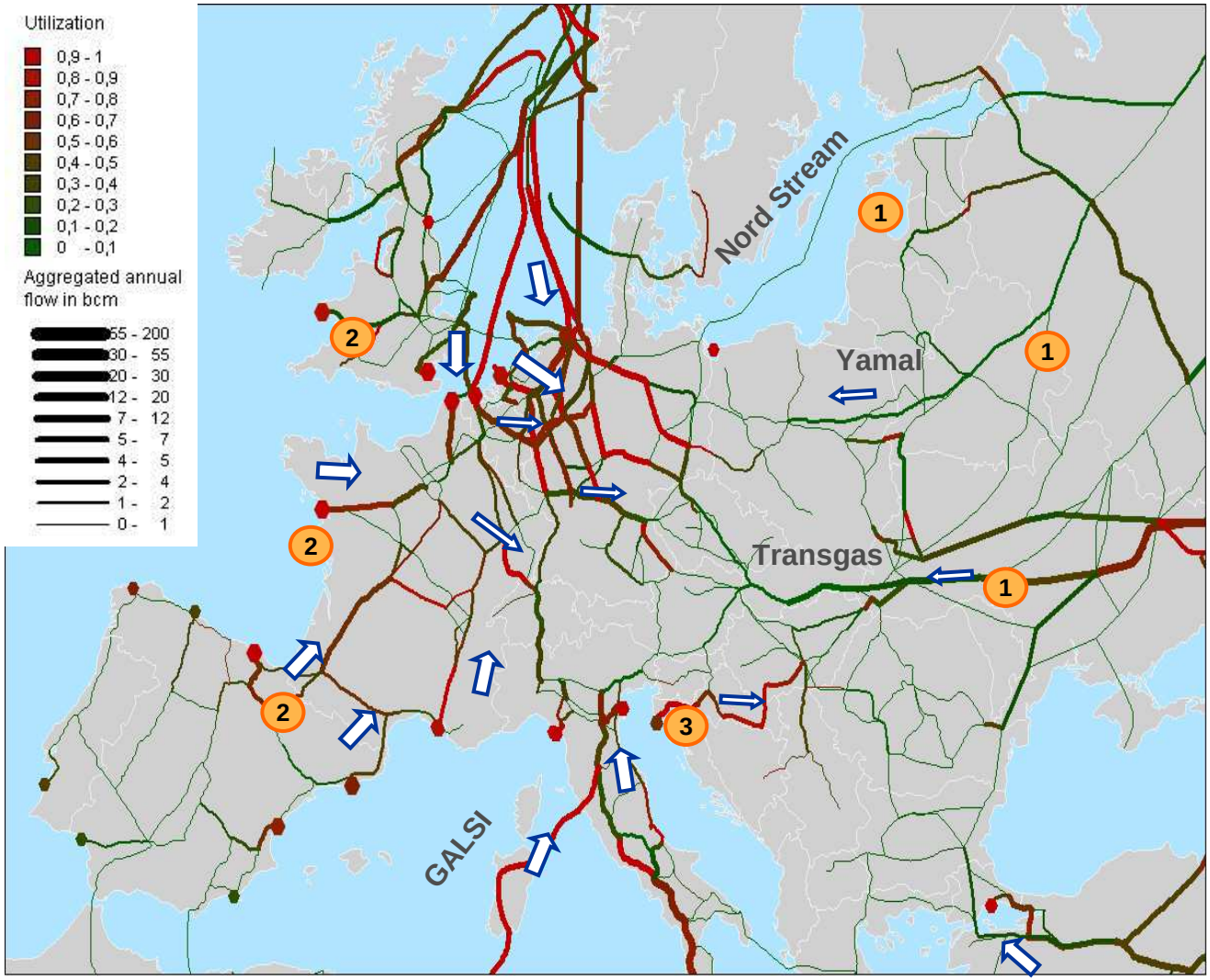
1 Increased Russian gas volumes in Central Europe but routed via Nord Stream II instead of Transgas

Absolute Change of Annual Gas Flows 2018 – DG TREN (GTE+ vs. EWI/ERGEG Demand)



1. More LNG in Spain, France, UK
2. Consequence: less pipeline imports to UK; more exports from Spain
3. Norwegian gas pushed further East from UK and France to Belgium and Germany, replaces some Russian gas
4. Russian gas routed to larger extent towards Italy or consumption in Eastern Europe

Annual Gas Flows 2018 – LNG Glut (EWI/ERGEG Demand)



Assumption of temporally low LNG prices and option to reduce contract minimum take obligations to zero (maximum LNG import scenario):

1. Significant reduction in pipeline imports, especially from Russia
2. LNG imports in Spain, France, UK increase and LNG volumes transported to Central Europe where possible
3. Also high utilization of Krk LNG terminals, supplying HR, HU, CS

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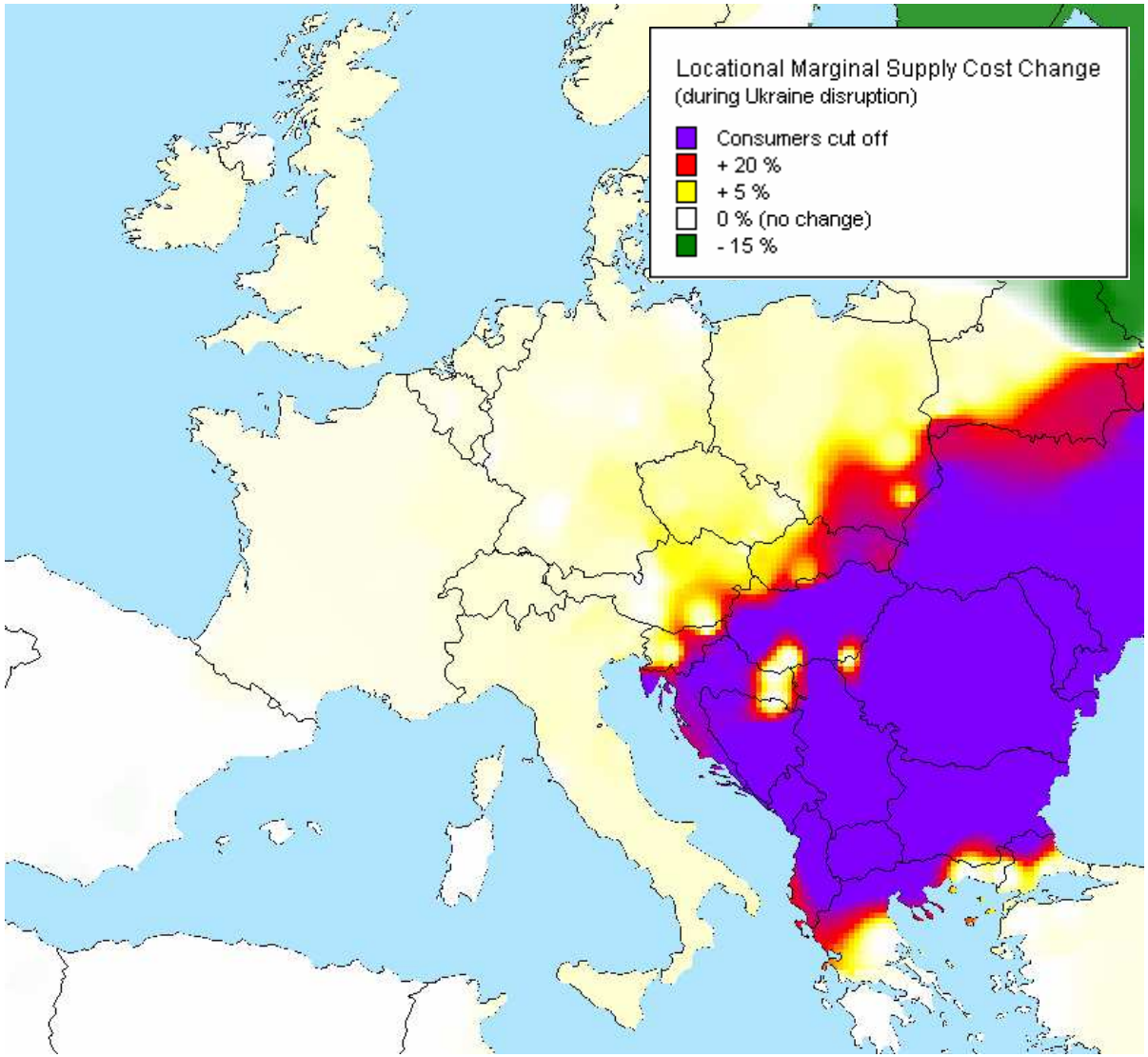
Definition of Security of Supply Sensitivity

Replication of 2009 January Ukraine Crisis in 2018:

- no transits via Ukraine
- duration of 13 days in mid-January

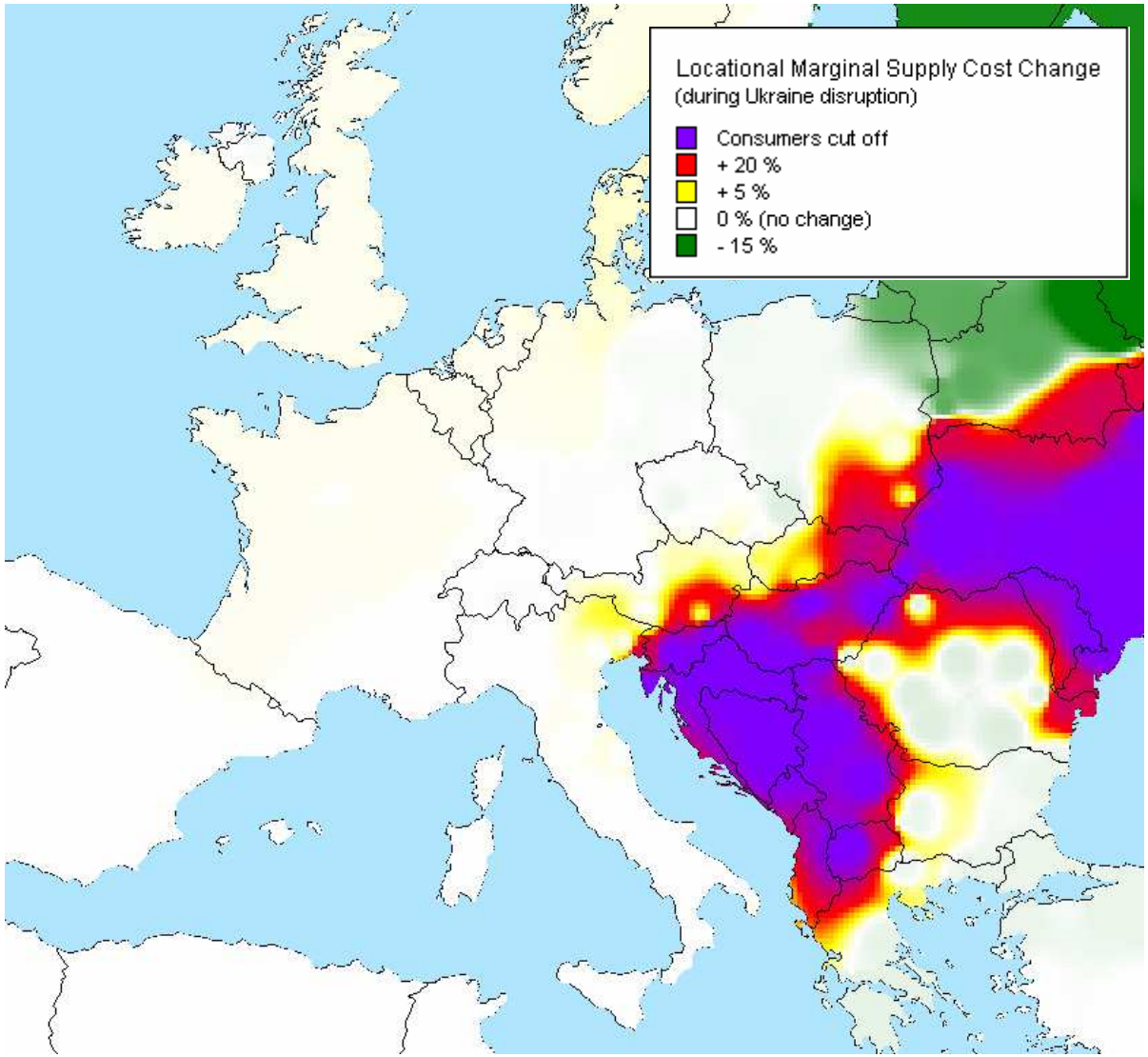
➢ Simulation for all five infrastructure scenarios

2009 Crisis revisited



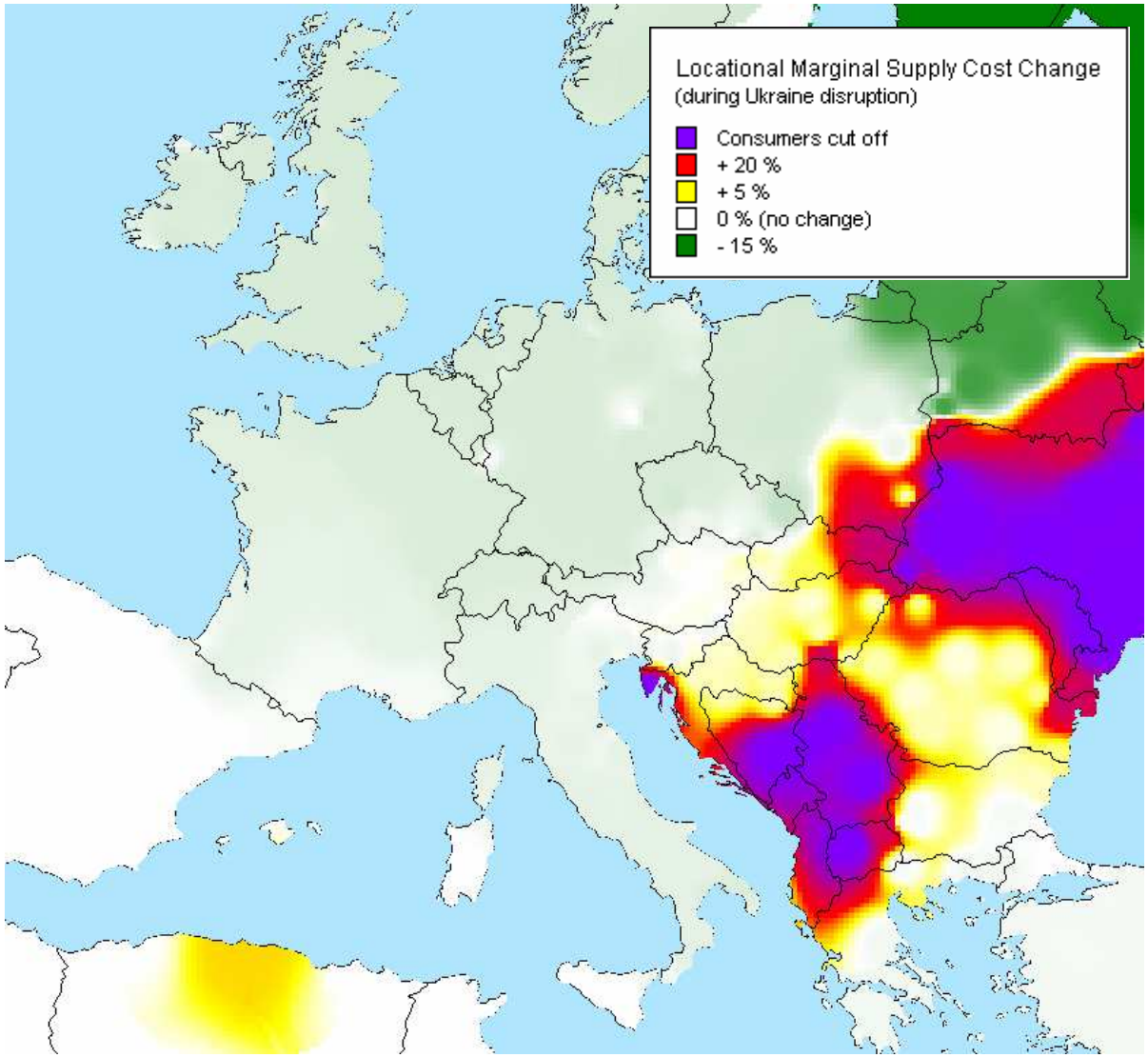
- Consumers can partially not be supplied in Bulgaria, Romania, Hungary, Balkan countries
- Increases in marginal costs significant in Slovenia, Austria, Czech Republic
- Small increases in Poland, Germany, Italy, also France, UK

Reference Scenario (GTE+ demand)



- Improved security of supply in similar crisis, esp. Bulgaria, Romania, Slovakia!
- Consumers can partially not be supplied in Hungary, Serbia & Montenegro, Bosnia & Herzegovina and Macedonia
- Price effects in other countries much smaller!
- Reason: Nord Stream as alternative route to Central and Western Europe

Nabucco Scenario (GTE+ demand)

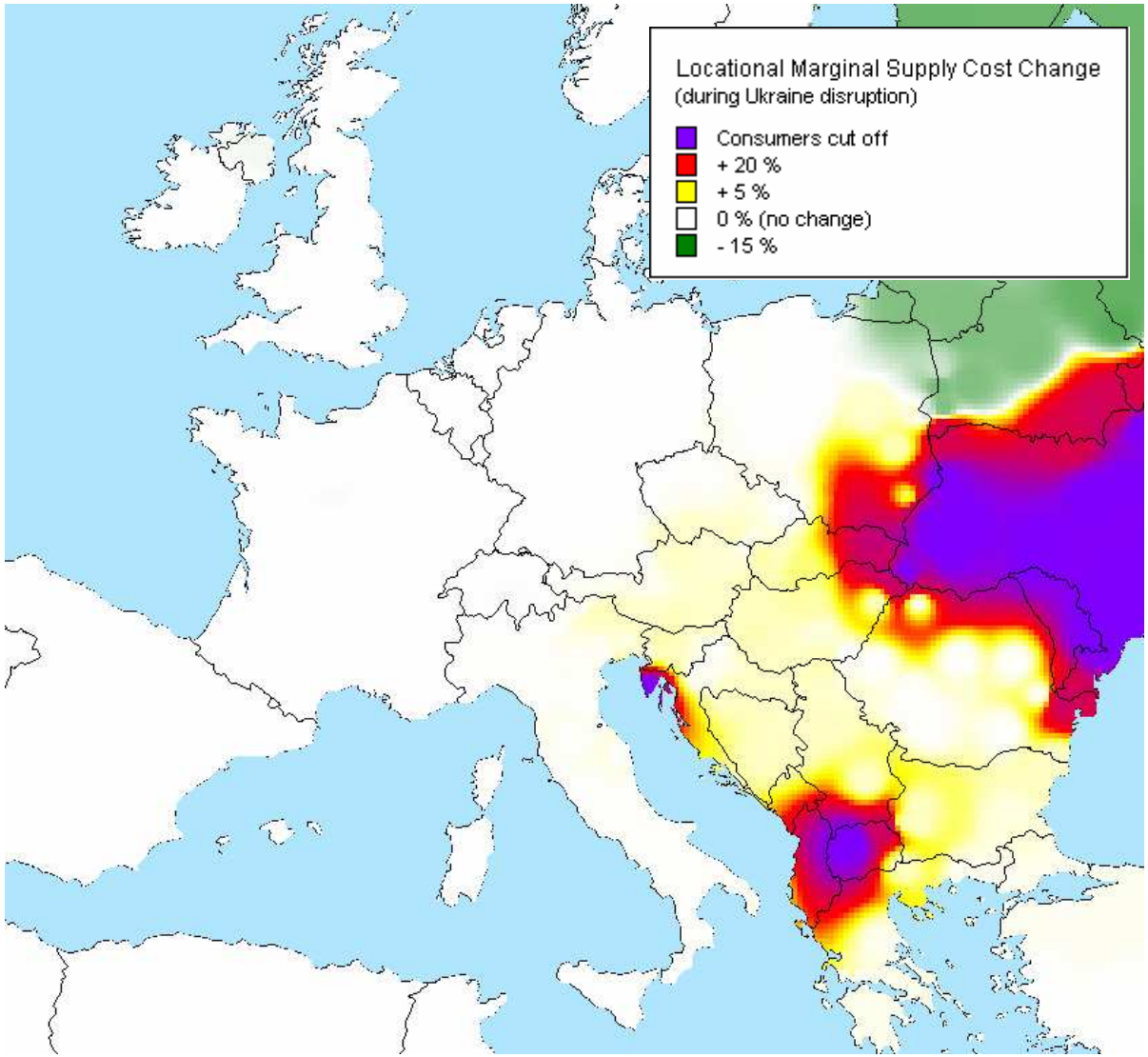


- As before, but Nabucco to Hungary also improves security of supply there significantly

  (no consumers switched off)

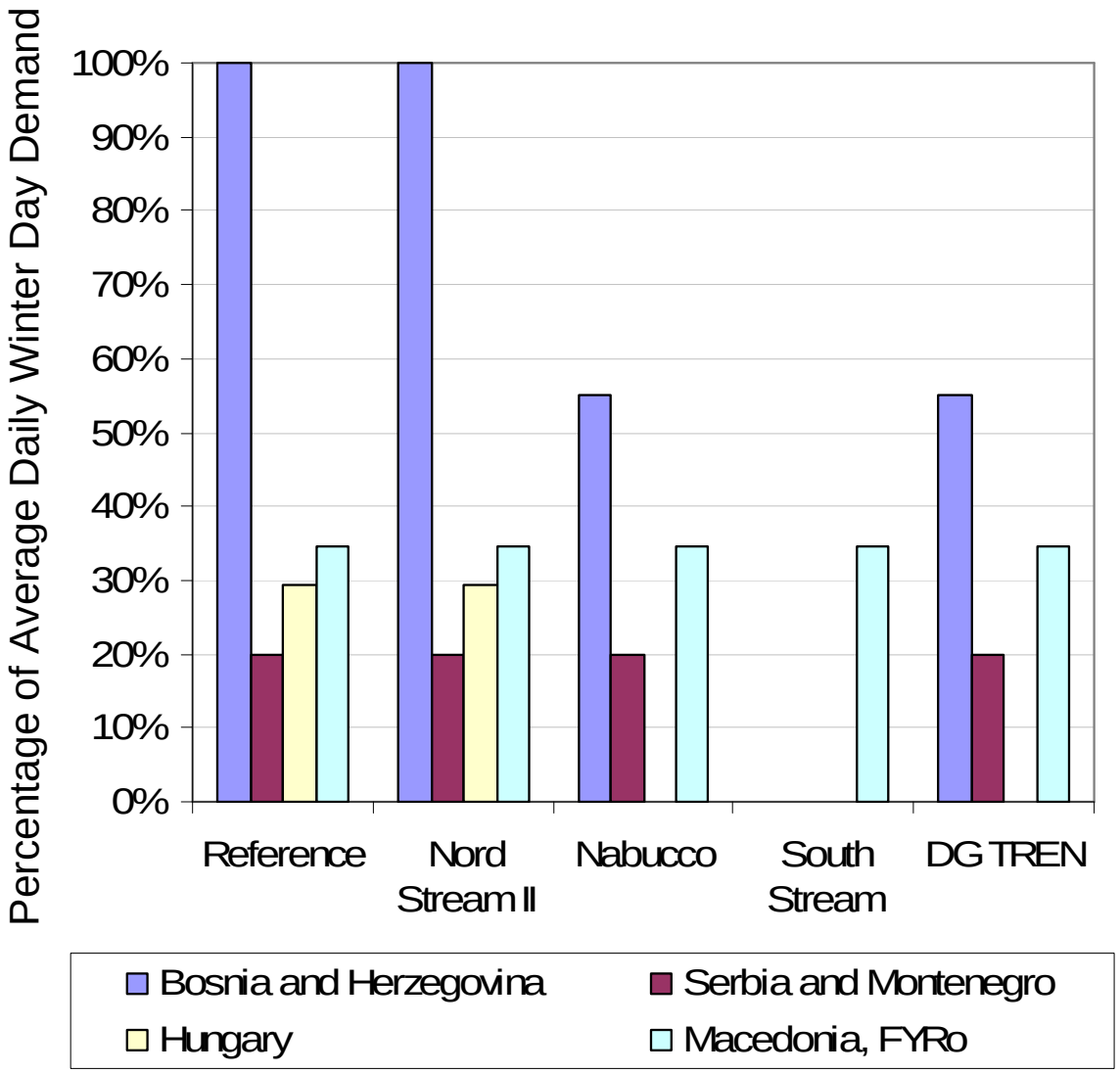
- Diversion of Russian gas to Central Europe actually increases availability of gas!
- Still small disruptions to consumers in Serbia & Montenegro, Bosnia & Herzegovina and Macedonia

South Stream Scenario (GTE+ demand)



- As before, but South Stream to Serbia also improves security of supply in Serbia & Montenegro, Bosnia & Herzegovina significantly (no consumers switched off)
- Still small disruptions to consumers in Macedonia

Quantities to consumers switched off



- Disruptions “only“ in a limited number of countries
- System very resistant to such a crisis
- Significant Disruptions in Hungary (in volume terms) -> still possibly problems when there is neither South Stream nor Nabucco being built

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Analysis of Market Integration

What is market integration?

Economic Theory / Finance Theory:

- “Law of One Price“ must hold
- Cross-market arbitrage opportunities can be exploited
- No impediments to trade

➢ Without transport and transaction costs, perfect correlation of prices between markets

Analysis of Market Integration

Natural Gas Markets:

- Transport costs > 0 (Law of One Price distorted)
- Grid-bound commodity -> availability of the infrastructure potential physical barrier to trade (which might prevent market integration)
    - No arbitrage if gas cannot be transported from market with low to market with high price
    - I.e. a bottleneck in the system prevents an otherwise economically viable activity from taking place

- ➢ Competitive market: if price difference between markets A and B exceeds the cost of transporting gas from B to A, traders would buy in B and sell in A until the price difference is equal to (or lower than) the cost of transportation.
- ➢ This would be replicated in EWI model simulations.
- ➢ Hence, if large price differences persists, this is the consequence of a physical bottleneck and non-integrated markets.

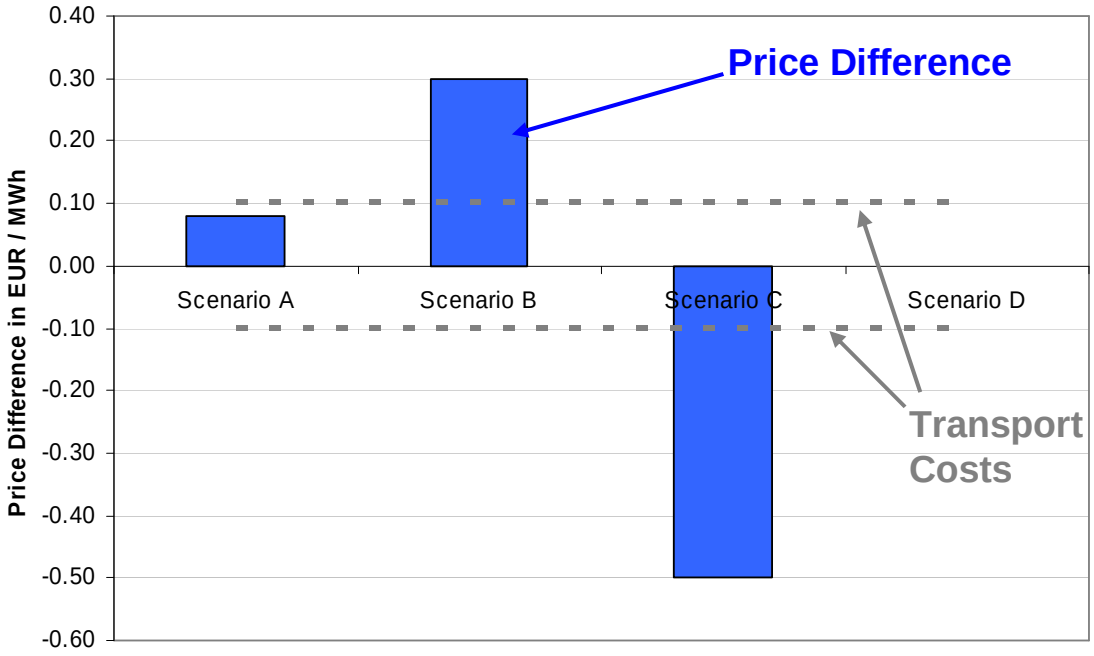
Analysis of Market Integration

Approach:

- Comparing price differences between nodes in countries over the scenarios and with the transport costs
- Absolute value of Price Difference <= Variable Transport Costs

  -> no economic bottleneck
- Absolute value of Price Difference > Variable Transport Costs

  -> economic bottleneck



Price in A minus Price in B

Scenario A: small positive price difference, no bottleneck from B to A

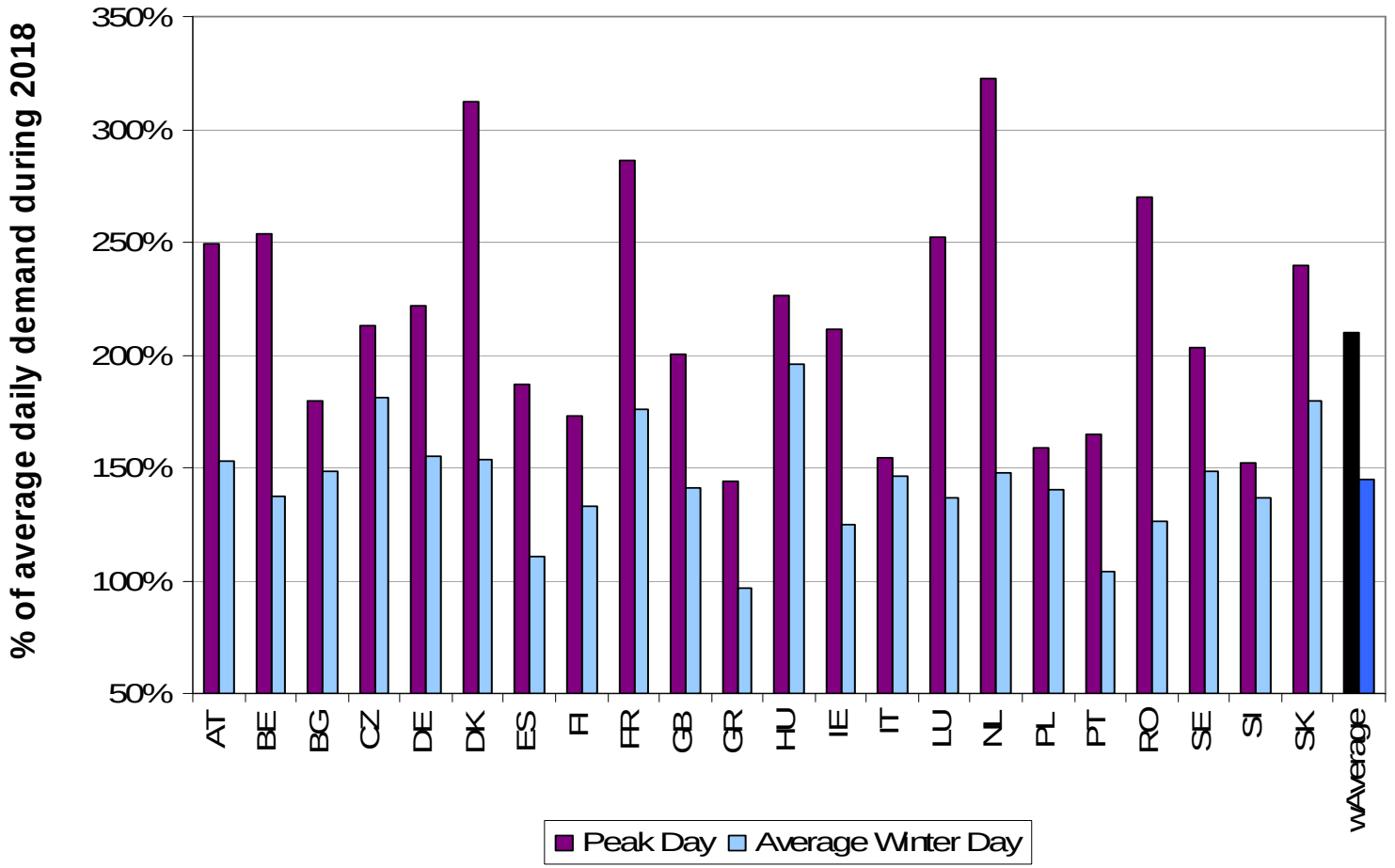
Scenario B: positive price difference exceeds transport costs -> bottleneck from B to A

Scenario C: negative price difference exceeds transport costs -> bottleneck for reverse flow from A to B (higher price in B but not enough flows from B to achieve price convergence)

Scenario D: no price difference, no economic bottleneck

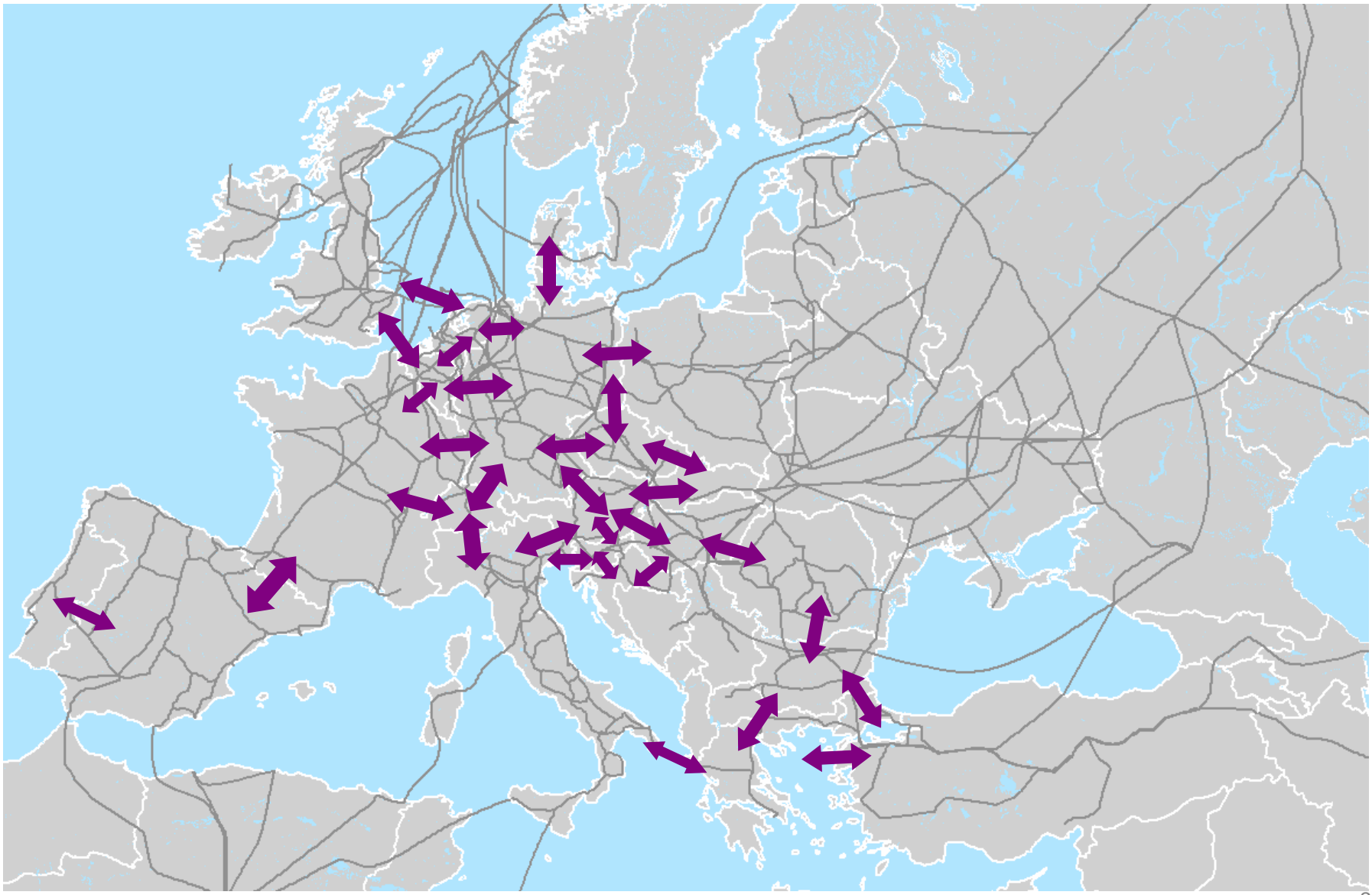
GTE+ Peak Demand Day Assumptions

Additional simulation of peak day (assuming concurrent peak day in ALL countries) based on GTE+ data:



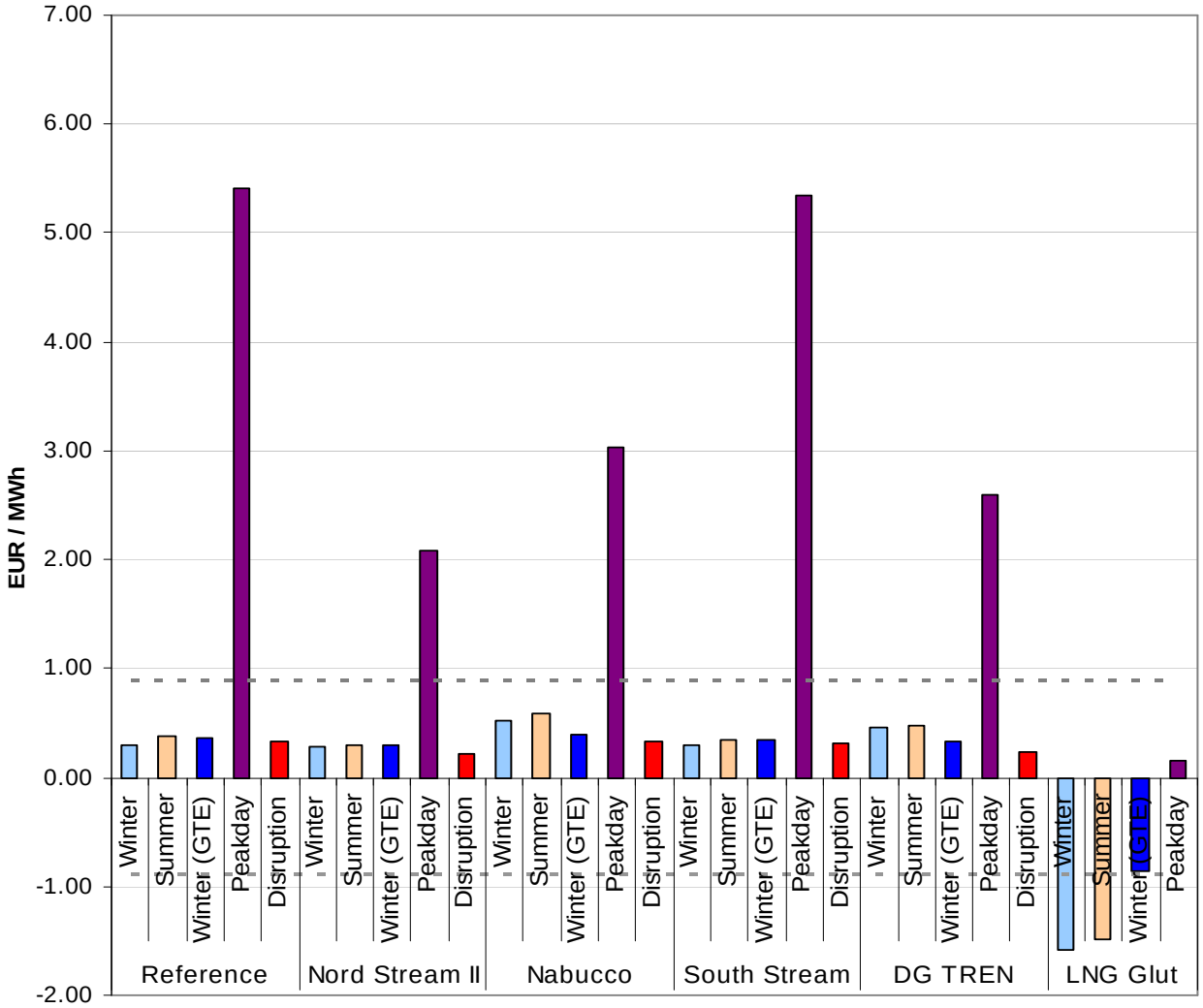
Source: own chart based on GTE+ Demand Scenarios vs. Capacity Repor t (July 2009)

Country-by-Country Analysis of Market Integration



Selected results: Germany to France

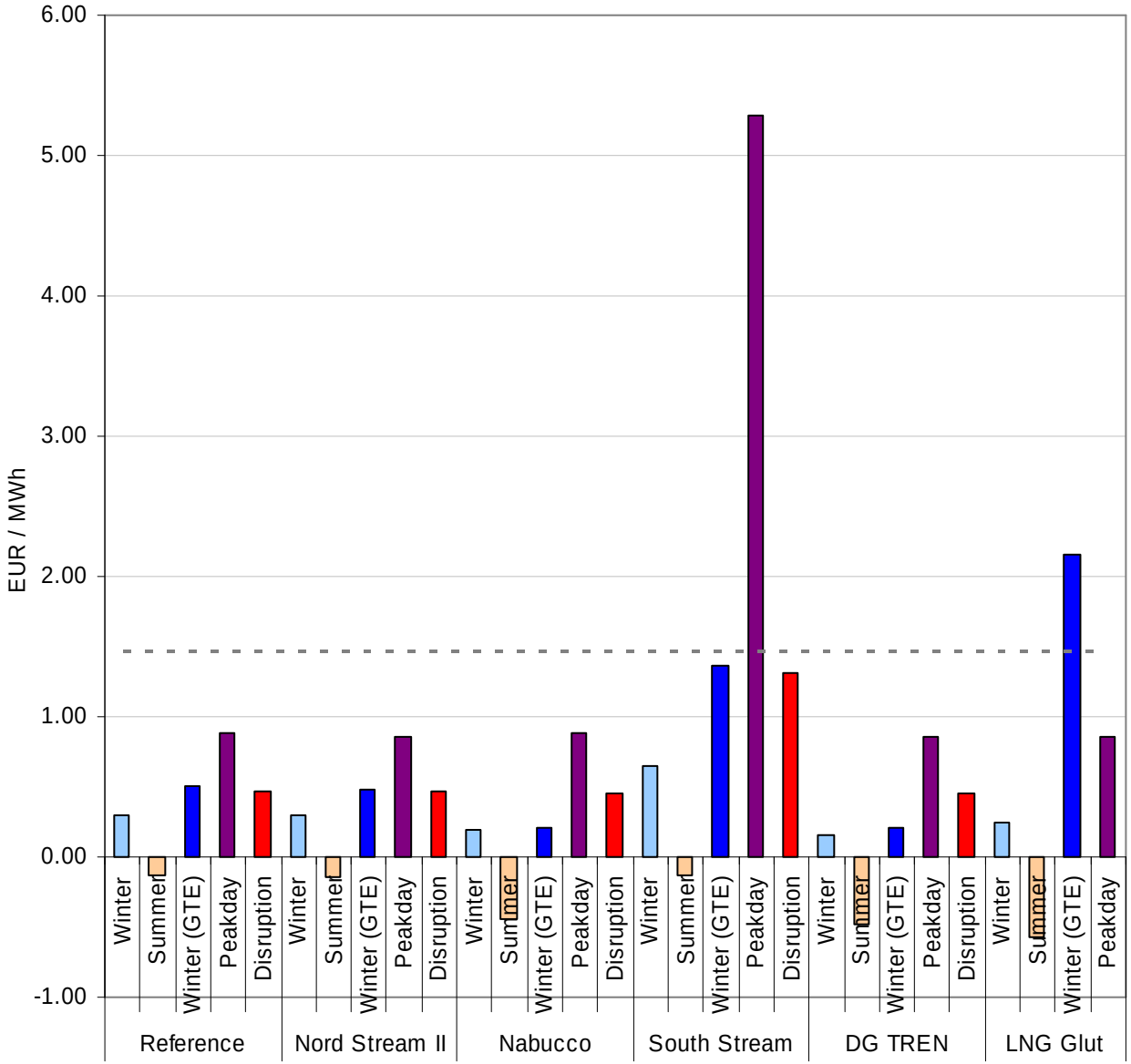
Germany to France means: marginal cost (France) minus marginal cost (Germany) = difference: (*)



- Price spread between France and Germany never only exceeds variable transport costs on peak days (see before)
- Cost of constraint however slightly lower than in the case of DE to BE / NL
- Low LNG prices: economic bottleneck in direction France -> Germany

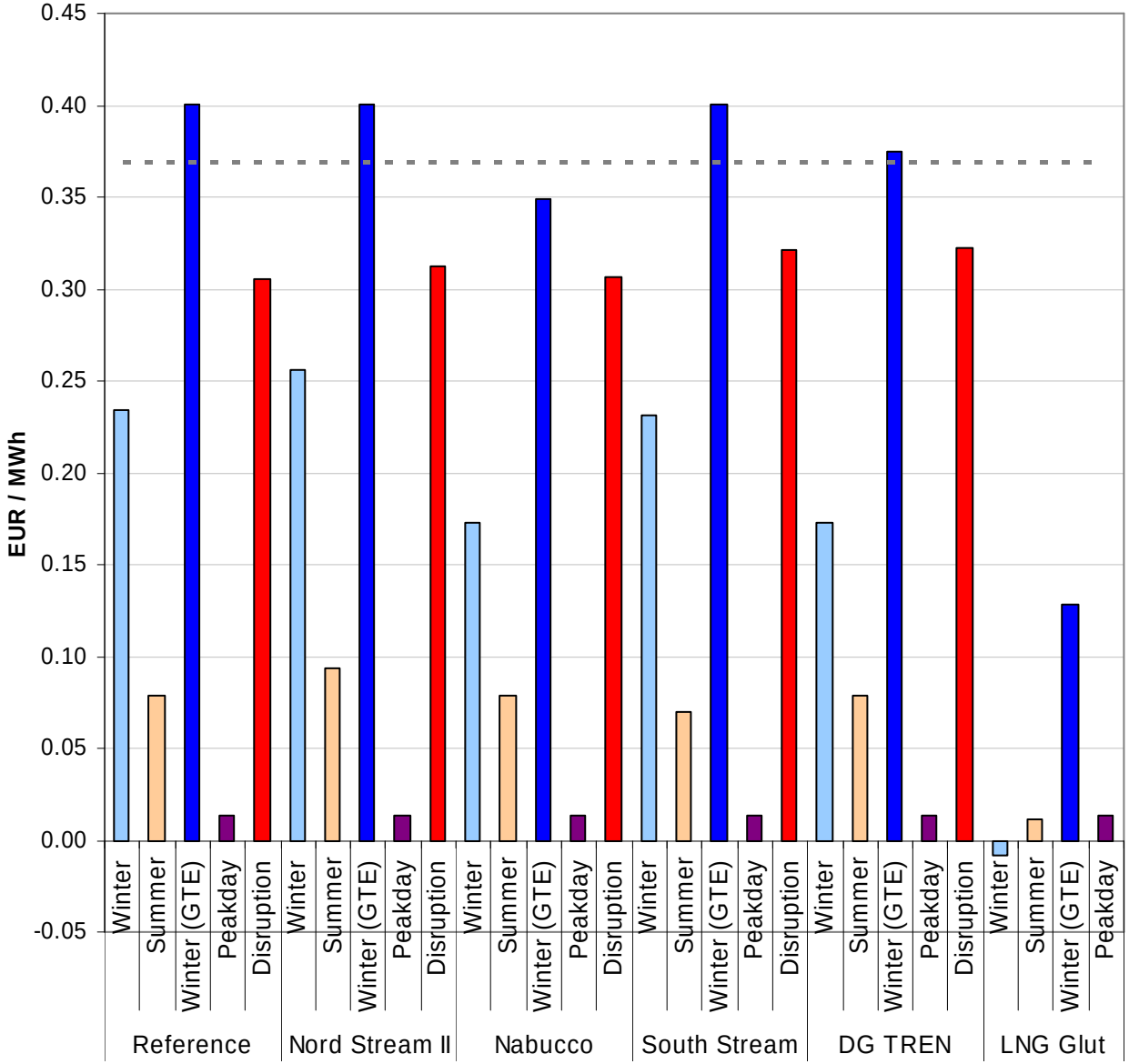
(*) Same labeling for all following slides.

Selected results: Spain to France



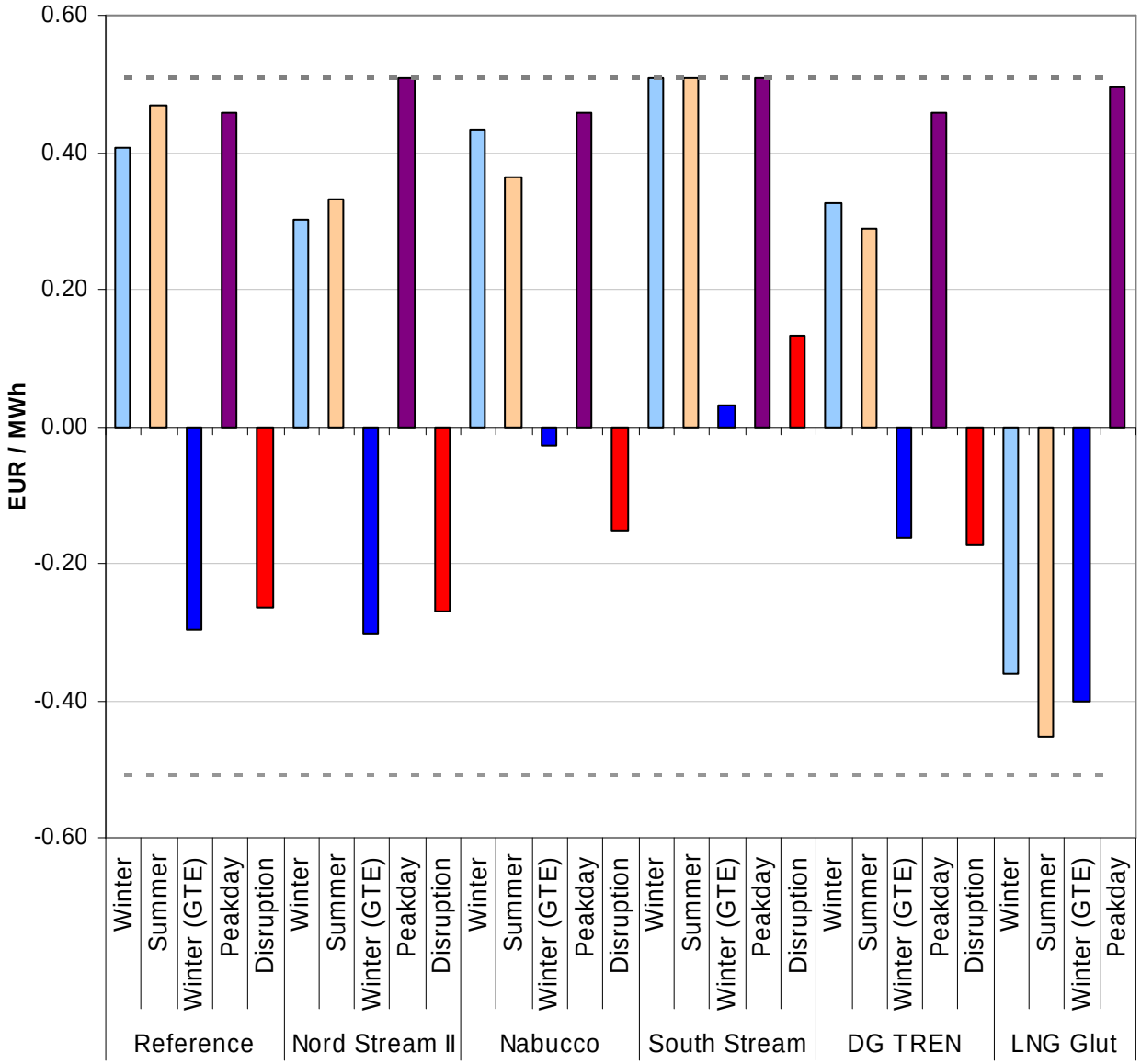
- High integration with Midcat and Larrau expansion except South Stream scenario (no Midcat)
- In summer flow direction France to Spain
- Economic bottleneck in direction to France only on peak days
- When high GTE+ demand and low LNG prices: economic bottleneck in winter even with Midcat

Selected results: Netherlands to Belgium



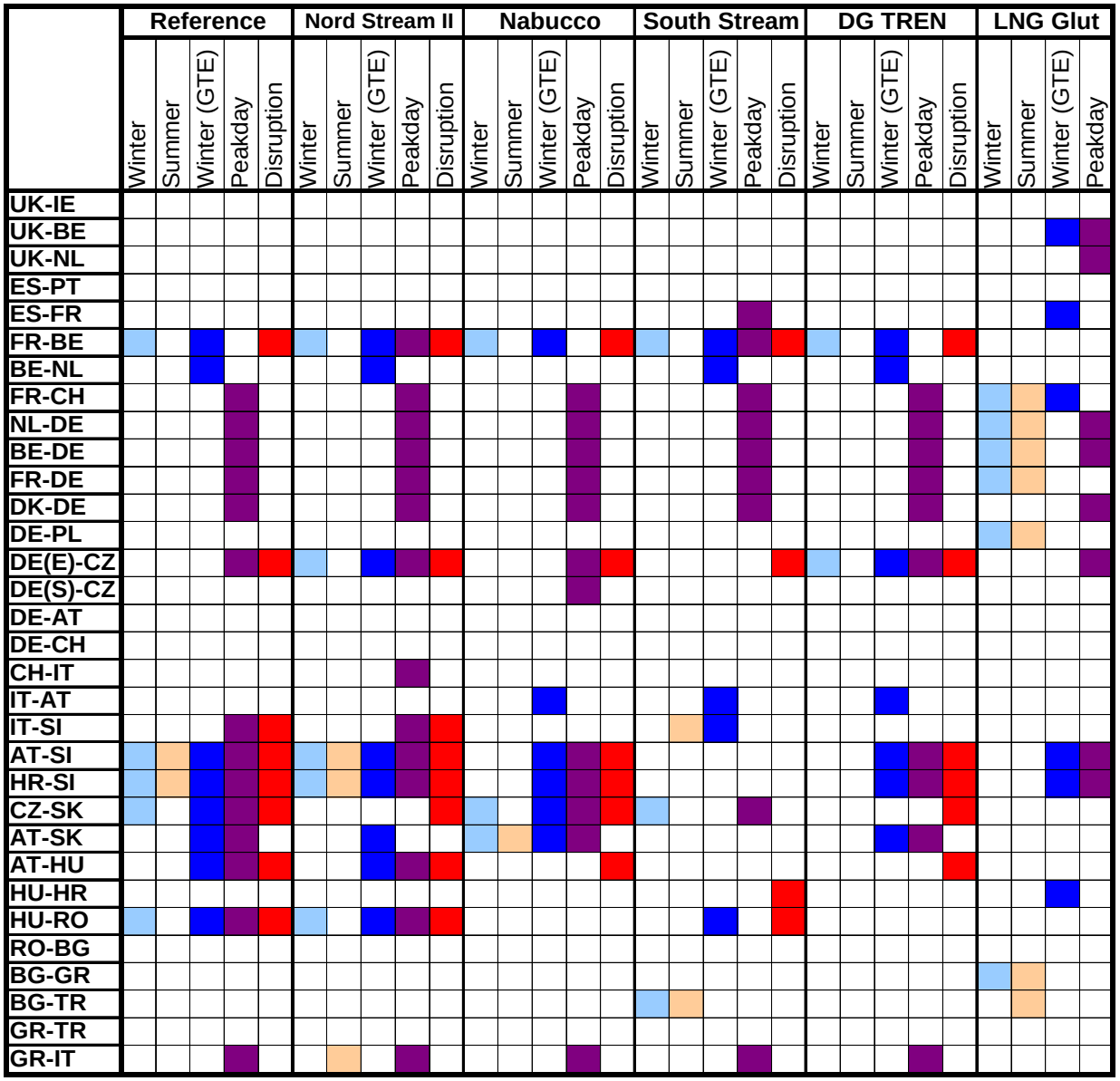
- Only very small economic bottlenecks between Netherlands and Belgium in GTE+ demand scenario winters

Selected results: Italy to Switzerland



- Price spread between Italy and Switzerland never exceeds variable transport costs
- Flows directions vary between scenarios
- Especially with low LNG prices increasing flows from South to North, but sufficient capacity available

Summary of bottlenecks



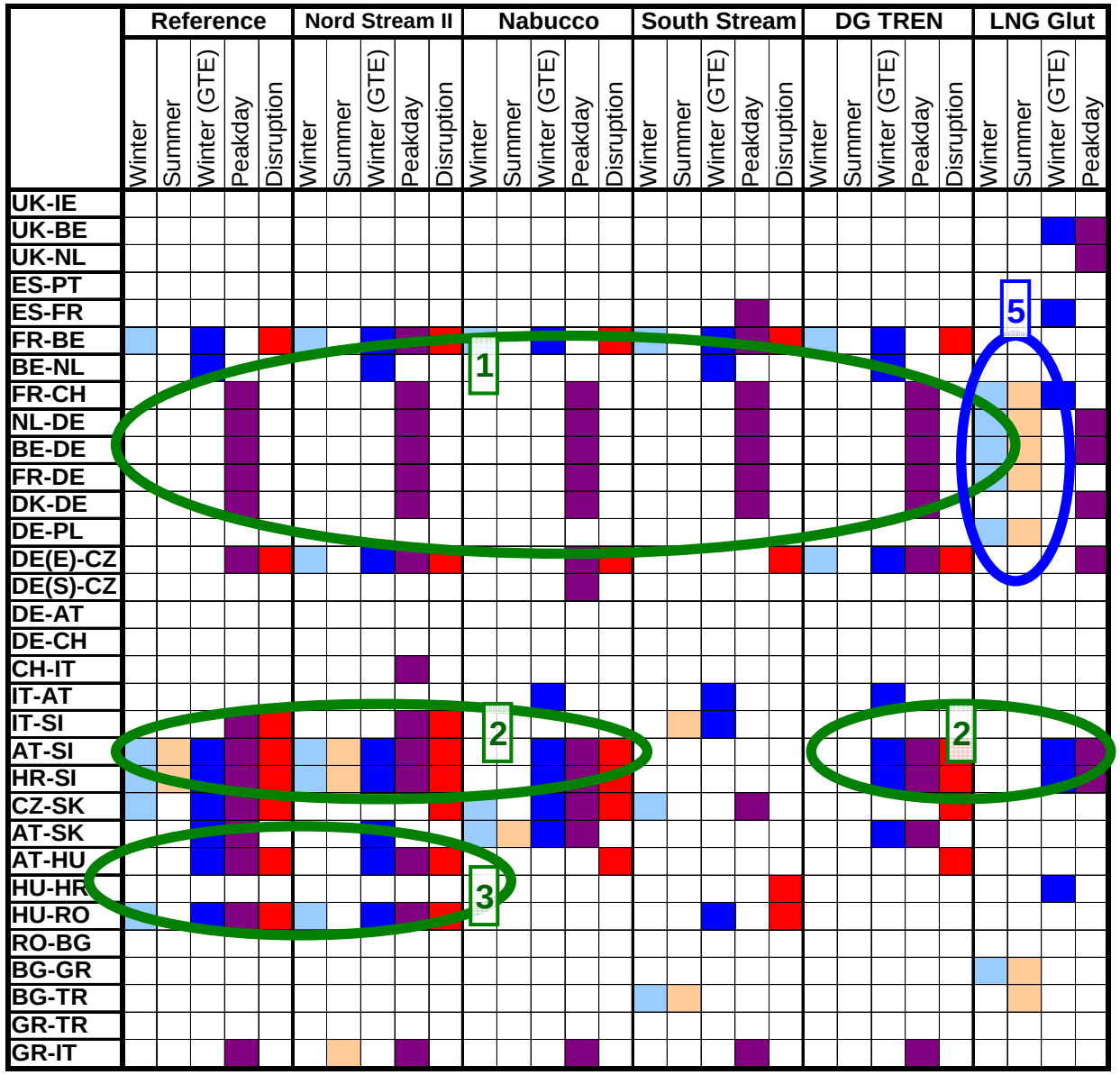
Bottleneck in/on:

- Winter (EWI/ERGEG)
- Summer (EWI/ERGEG)
- Winter (GTE+)
- Peak Day
- Disruption

No Bottleneck:

- *(white)*

Summary of bottlenecks



Bottlenecks:

1. On peak day between Central and Western Europe
2. Slovenia and neighbouring countries
3. Hungary and neighbouring countries
4. Czech Republic to Slovakia and v.v.
5. Low LNG Prices: Western to Central Europe in summer and winter

Summary of bottlenecks

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

What degree of physical market integration is desirable?

- Removing bottlenecks / increasing integration requires capital investment
- Efficient amount of investment:
  - marginal capacity cost should equal the cost of congestion
  - (options to invest: pipelines and storages)
- Hence, especially for temporal bottlenecks, it might be efficient to have a not-perfectly integrated markets as the cost of physical integration exceeds the economic cost of the congestion.
- Postitive external effects of market integration (apart from economic efficiency gains):
  - Larger market -> more players, more competition

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Main findings

Infrastructure projects:

- Nabucco volumes stay to a large extent in Turkey and South Eastern Europe; but significant impact on gas flows all over Europe
- South Stream imports much larger gas volumes to Central Europe, but effects largely confined to Eastern and Central Europe (cannibalization of gas flows on other routes)

Security of Supply:

- “Reverse Flow Study“ projects increase physical integration in Eastern Europe significantly; Nord Stream increases availability of volumes in Central Europe
- Some issues remain (Hungary)

Market Integration:

- With all incorporated projects: high degree of physical market integration
- Some issues on peak days / high demand; in Eastern Europe during disruptions

Way Forward

- Some additional parameterization updates for Balkan region (based on discussions with Energy Community)
- Parameterization updates on EU indigenous supply and peak day demand based on ‘ENTSOG European Ten Year Network Development Plan 2010 – 2019’ (December 2009)
- Focus on year 2019 (instead of 2018)
- Simulation of additional security of supply sensitivtiy

Thank you for your attention!

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Appendix: Selected EWI publications

- Lochner, S. (2009). Nodal prices, capacity valuation and investments in natural gas markets - Overview and Analytical Framework. EWI Working Paper 09/2.
- Bettzüge, M.O.; S. Lochner (2009). Der russisch-ukrainische Gaskonflikt im Januar 2009 – Eine modell-gestützte Analyse. In: *Energiewirtschaftliche Tagesfragen* 59 (2009), No. 7, pp. 26-30.
- Lochner, S.; D. Bothe (2009). The development of natural gas supply costs to Europe, the US and Japan in a globalizing gas market - Model-based analysis until 2030. In: *Energy Policy*, 37 (2009) No. 4 pp. 1518-1528.
- Lochner, S.; C. Dieckhöner (2008). Analyse von Grenzkostenpreisen im Europäischen Gasmarkt. EWI Working Paper 08/5.
- Bothe, D.; S. Lochner (2008). Erdgas für Europa: Die ewiGAS$_{2008}$ Prognose. In: *Zeitschrift für Energiewirtschaft* 32 (2008) No. 1, pp. 22-29.
- Lochner, S.; D. Bothe (2007). Nord Stream-Gas, quo vadis? Analyse der Ostseepipeline mit dem TIGER-Modell. In: *Energiewirtschaftliche Tagesfragen* 57 (2007) No. 11, pp. 18-23.
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- Bothe, D.; M. Lienert; S. Lochner (2007). Analysing the Sufficiency of European Gas Infrastructure - the TIGER Model. Conference Paper presented at ENERDAY 2007, Dresden.
- Seeliger, A. (2006). Entwicklung des weltweiten Erdgasangebots bis 2030 - Eine modellgestützte Prognose. Schriften des Energiewirtschaftlichen Instituts, Band 61, München.
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