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Risk and resilience assessment: key challenges from the European experience

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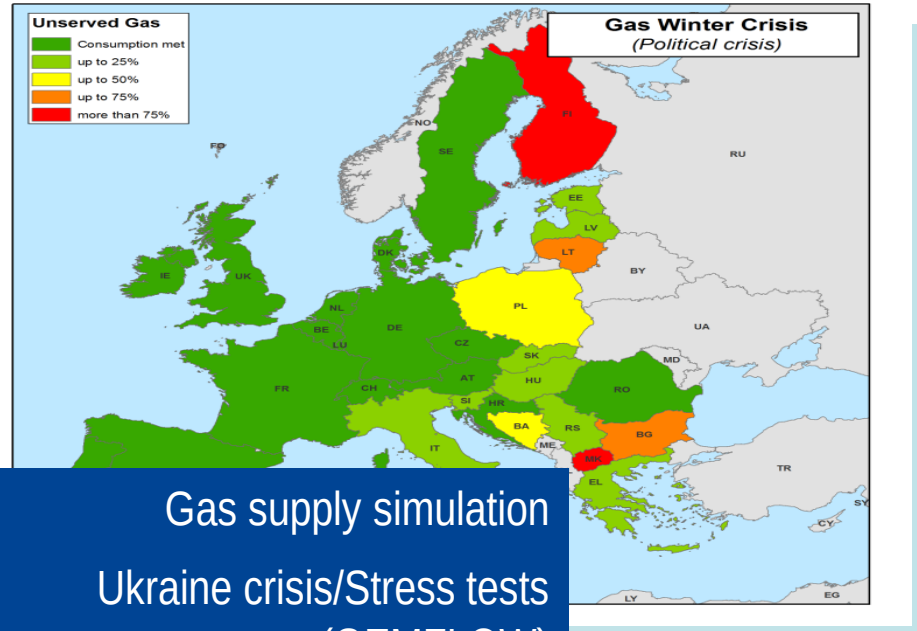
EGRD Workshop, System Resiliency and Flexibility, Vienna, 13-14 May 2019

European Commission

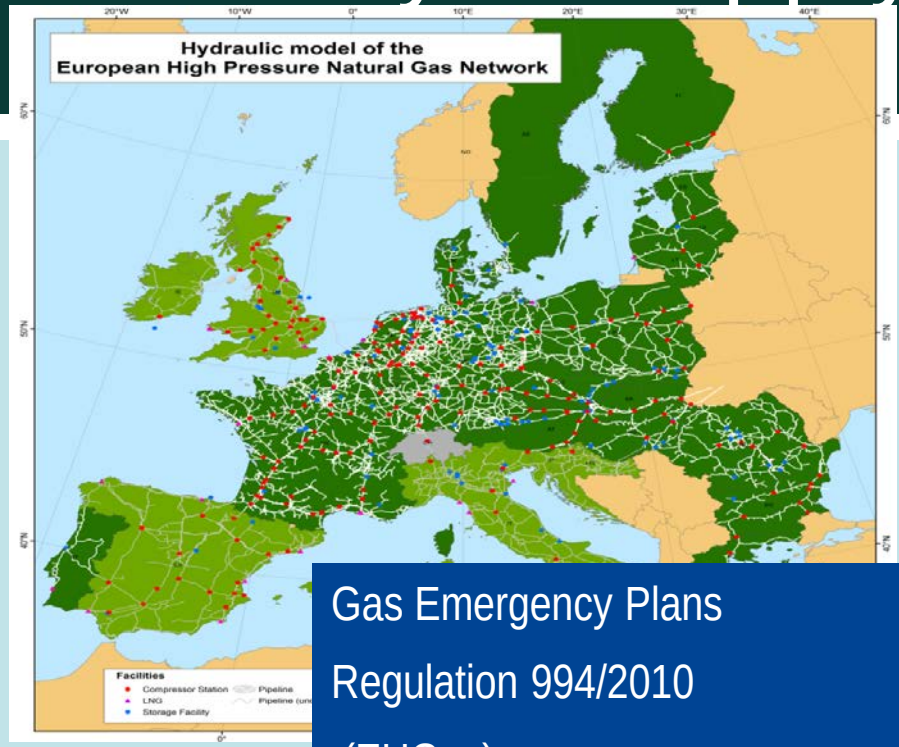
Contents

1. Risk assessment: gas security of supply



Gas supply simulation

Ukraine crisis/Stress tests (GEMFLOW)



Gas Emergency Plans

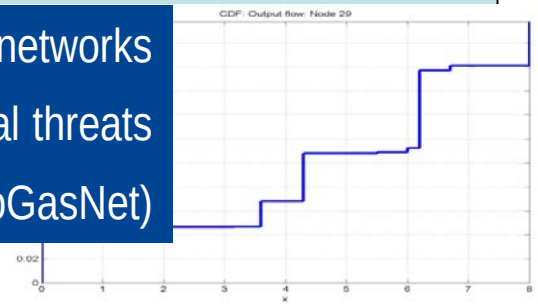
Regulation 994/2010

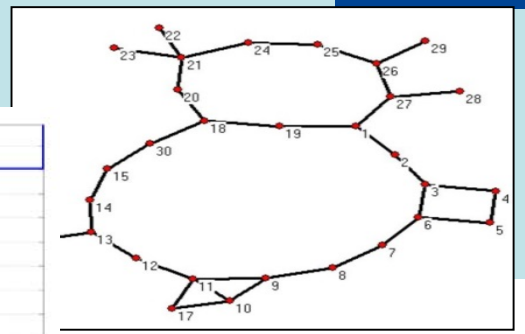
(EUGas)

Reliability of gas networks

Disruptions from intentional/accidental threats

(ProGasNet)





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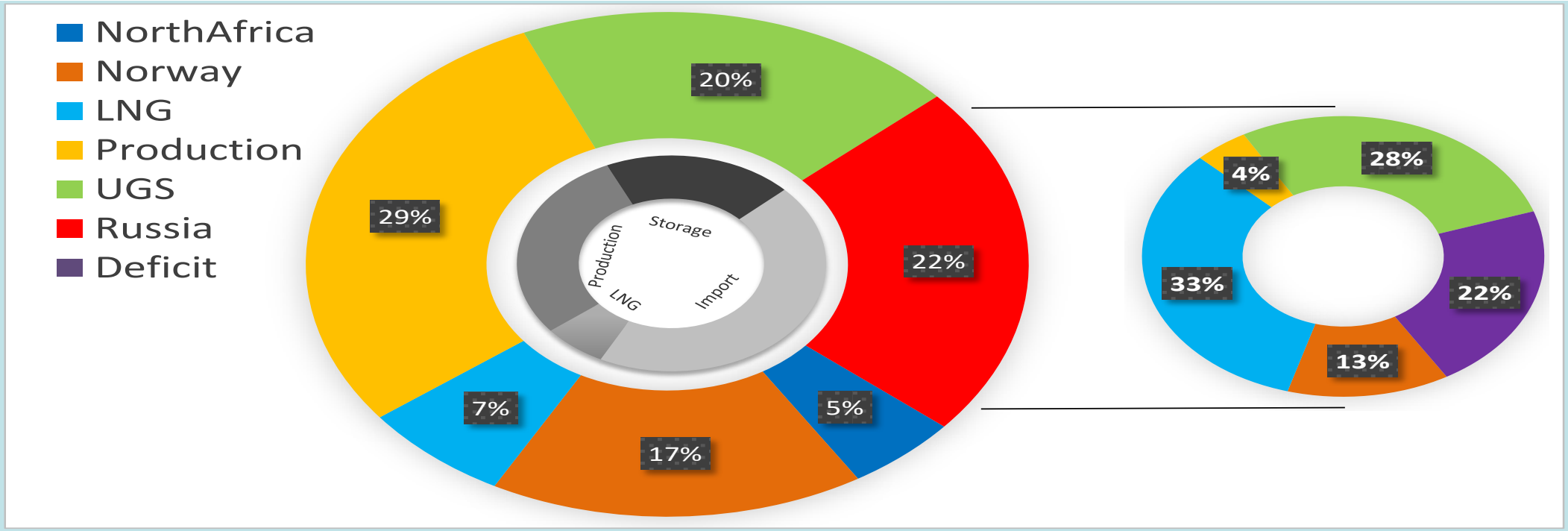
Support to the EU Gas Stress Test exercise



Double pies chart of the replacement of Russian gas in the 6-month Russian supply disruption scenario.

As appeared in “Preparedness for a possible disruption of supplies from the East during the fall and winter of 2014/2015” Brussels, 16.10.2014, COM(2014) 654 final

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EUGas model

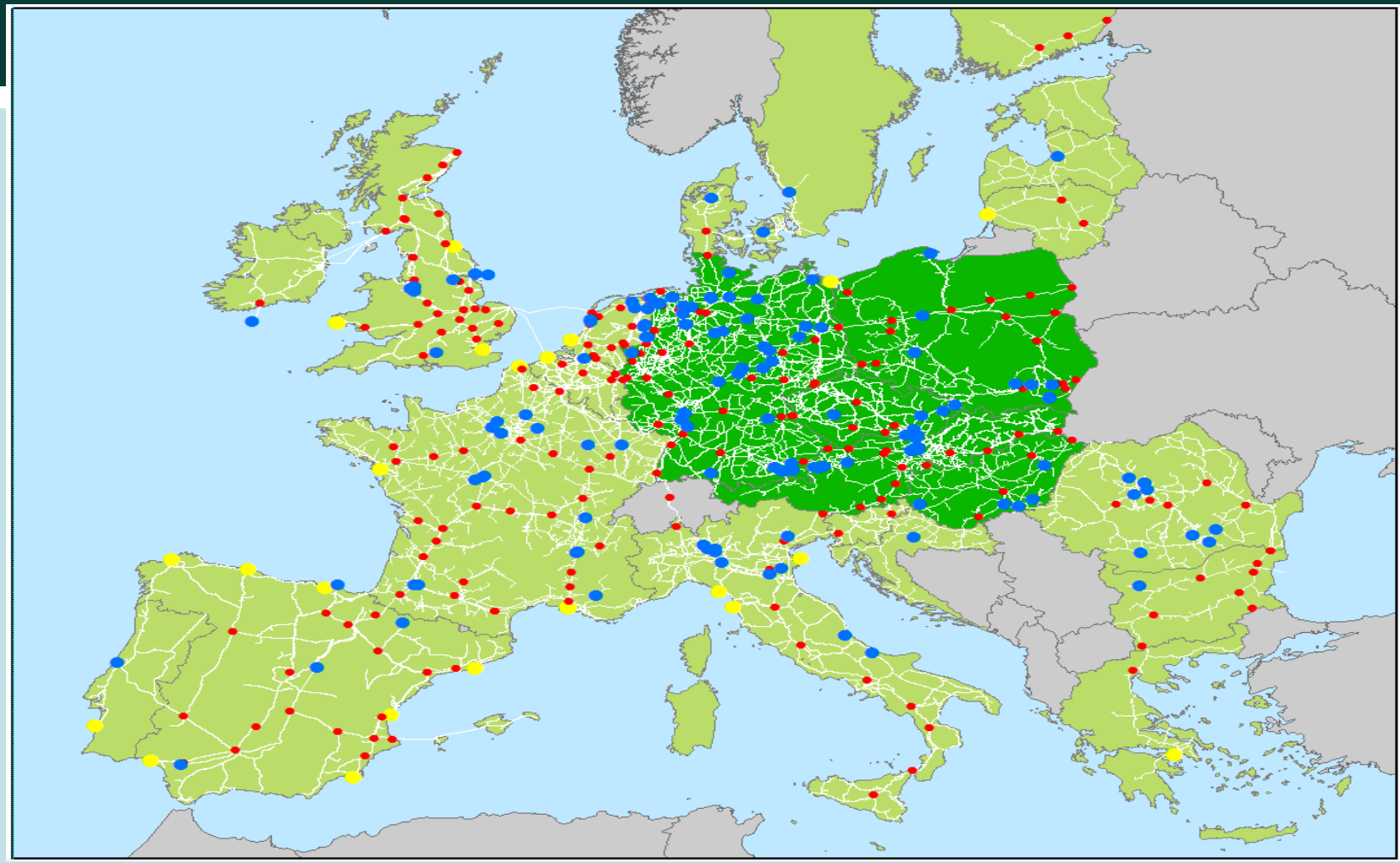
- *EU model (hydraulic, facility level)*
- *Extension to Ukraine, Turkey & Western Balkans*

Key applications

- *Projects of Common Interest*
- *Risk Assessment of EU regions*
- *Gas quality issues*

Challenges

- *Gathering of reliable data*
  - *Network data (layout, capacities, demand per node etc.)*
  - *Non-Disclosure Agreements*



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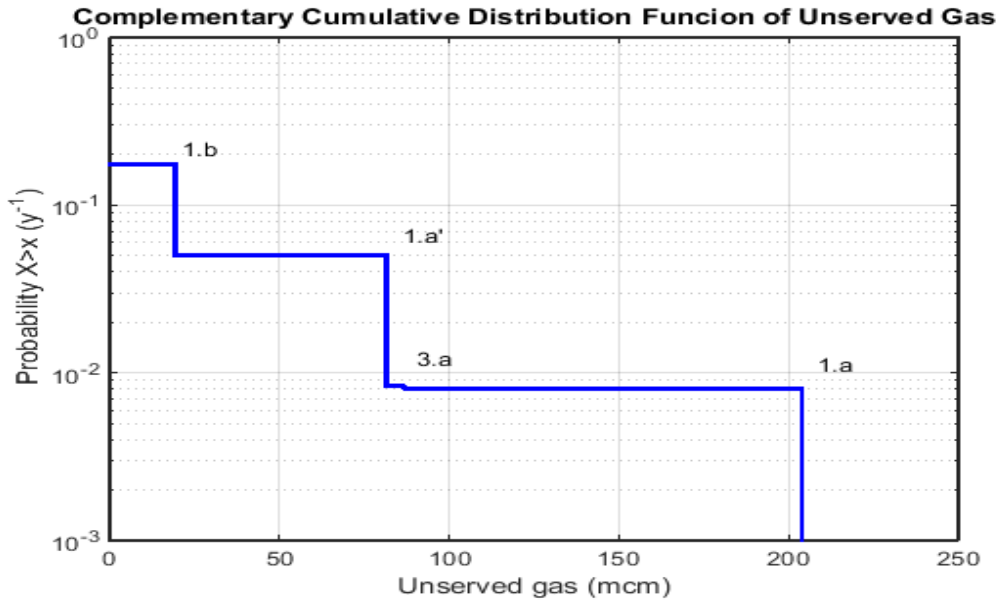
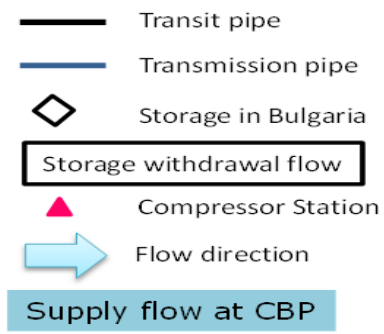
Regional Risk Assessment

Country	Gas Demand, mcm/d	Gas Deficit, mcm/d		Gas Sources, mcm/d			
				Isaccea	Kipi	Chiren UGS, send out at 52 bar	LNG Revithousa
			Peak demand situation (BCS)	68.9	2.3	3.7	9.6
Bulgaria	16.8	-12.5	Scenario 1.a	X	X	4.3	11.5
Greece	19.4	-7.9					
BG Transit	43.2	-43.2					





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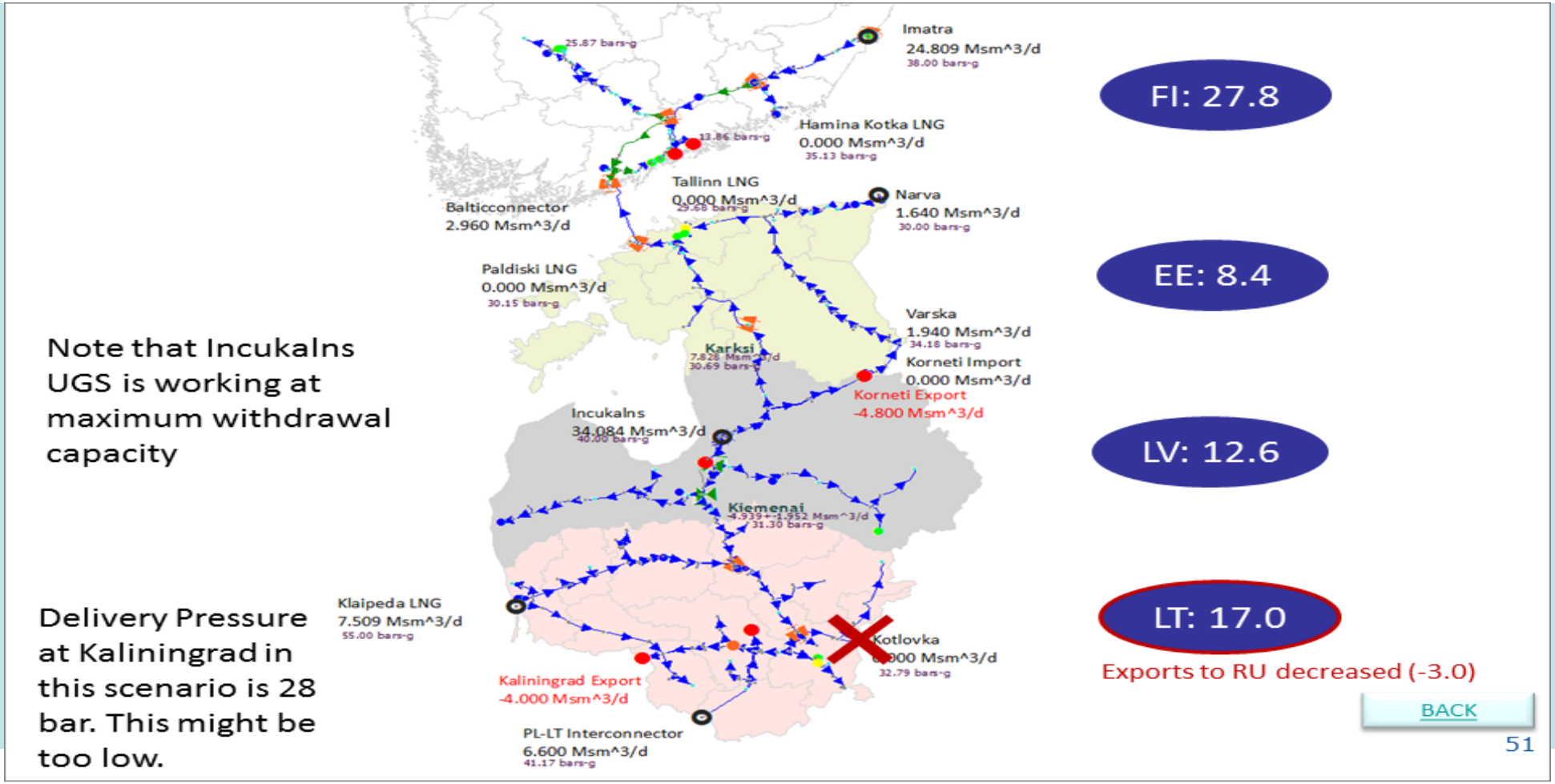
Regional Risk Assessment /2

Example of Baltic states & Finland

Scenario Regional N-1

Link to infrastructure investments



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2. Risk assessment: electricity supply

- New EU legislation requires "adequacy"

- *Adequacy:*
  - *measure of the ability of a power system to supply the aggregate electric power and energy requirements of the customers within component ratings and voltage limits, taking into account scheduled and unscheduled outages of system components and the operating constraints imposed by operations*

Adequacy: from long-term to short-term horizon from pan-European to national scope

Long-term adequacy

Resources adequacy.

- 10 years-ahead
- Investment planning

Medium-term adequacy

Seasonal outlooks

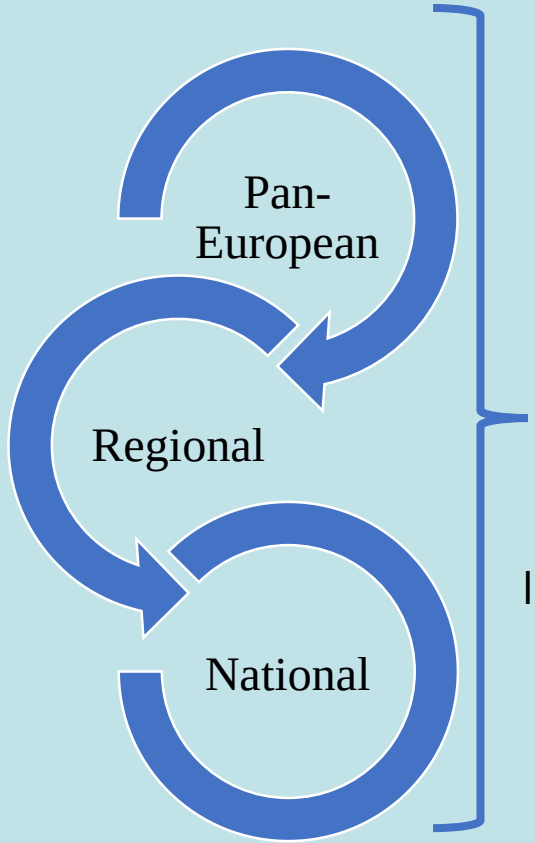
- Be prepared for the next season

Short-term adequacy

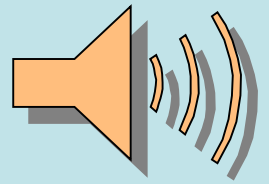
Month, week and at least day-ahead assessments.

- Share of resources, remedial actions

+



Increase awareness



Improve coordination

Methodological aspects

- *Factors:*
  - *Highly interconnected systems*
  - *Renewables increase variability and uncertainty*
  - *Aging generation fleet*
  - *Current deterministic approaches do not longer suffice*
- *New elements:*
  - *Demand response, storage, sector coupling (gas), increased uncertainty on demand…*
- *Challenge:*
  - ***system adequacy*** *(resources + transmission + distribution + demand + sector coupling)*

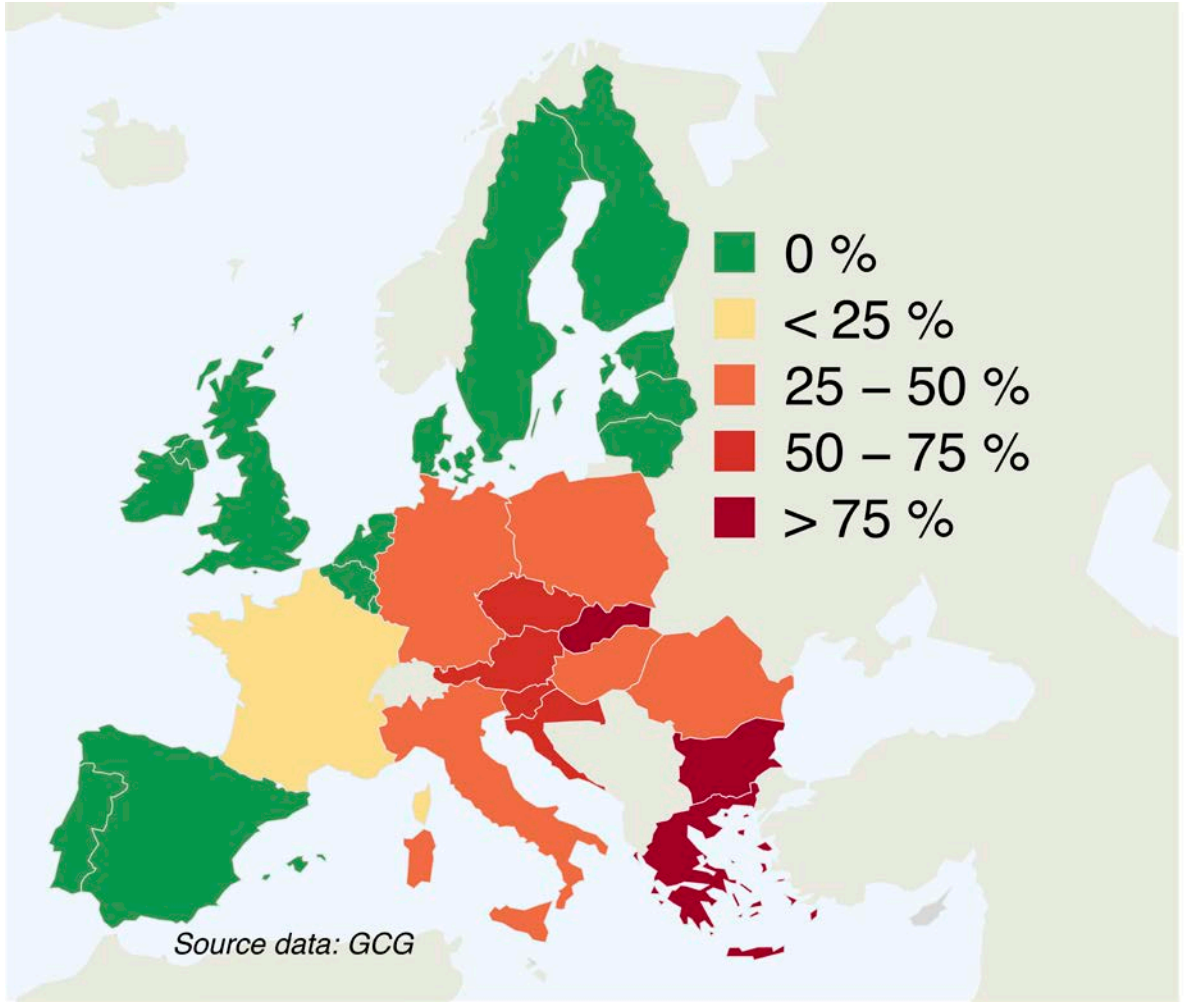
3. Resilience: application to gas crisis

- Context
- JRC framework selection variables
- Part I: Resilience to gas supply shock (outcomes)
- Part II: Impact signals from stock markets
- Conclusions

Context

- Ukraine-Russia gas disputes
- 1-21/01/2009:the supply from RU through UA stopped
- In EU, in 2009, NG from RU
  - 25% consumption (total ~416 Mtoe)*
  - out of which 80% through UA
- 5 bcm (4500 ktoe) not supplied
- NG available in the EU market
- Lack of infrastructure

worst affected : BG, SK, PL, HU
affected : RO, GR, AT, IT, SI, CZ, DE, FR



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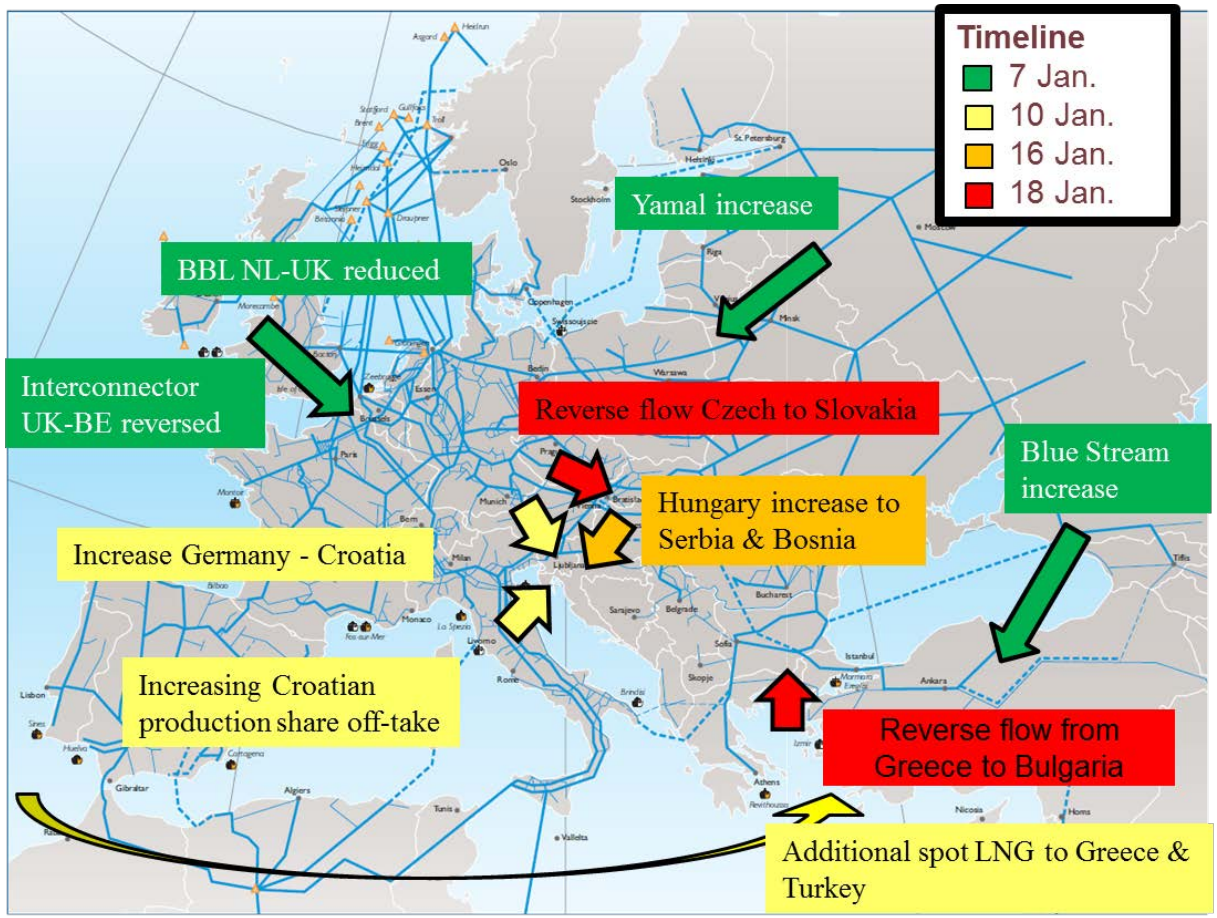
Context

- Substitution mechanisms
  - Increased supply from other countries / other routes
  - Production increase
  - Demand reduction
  - Fuel switching
  - Increase storage withdrawal
- Lessons learnt
  - Well-functioning market *
  - Diversification of supply sources
  - Improvement of the infrastructure



Source: IEA / OECD

* reacting to price and demand signals

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JRC framework selection variables

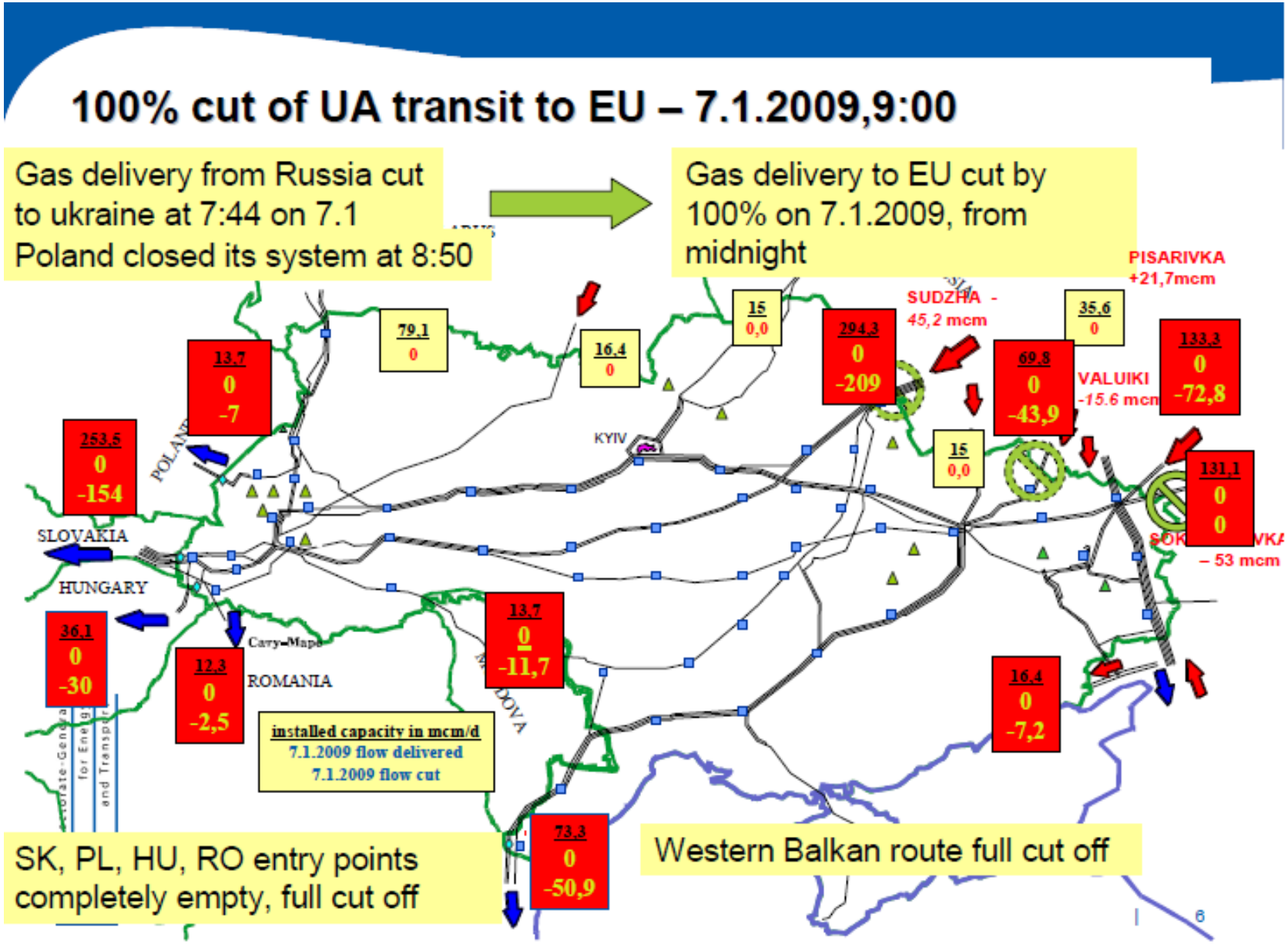
	ASSETS	ENGINE	OUTCOMES
CORE		**Financial market** Wholesale international gas prices (M, D) Wholesale DA market prices at EU hubs (D) *Wholesale DA market electricity prices (D)* Stock exchange indices in EU (D) Stock data for companies on EU stock exchanges (D) **Policy** N-1 indicator (A) **Infrastructure** Gas storage (A) LNG (A) *Pipelines (A)* *Interconnectors (A)*	**Consumption** *NG flow at entry points (D)* NG imports per source (M) NG imports per entry point (M) NG consumption, imports, exports, production (M) NG Storage capacity (A) NG use (A) Energy mix (A) NG share in GIC (A) Renewables share in GIC (A) NG Gross elec. Generation (A) Alternative fuels (oil, coal, elec.) (M) *Electricity consumption (D)*

Sources : Platts, Eurostat, Bloomberg, ENTSOG , MS TSO or market operators, DG ECFIN, ENTSOE, IEA/OECD, IMF

JRC framework selection variables

	ASSETS	ENGINE	OUTCOMES
NON-CORE	**Human capital** Deaths by month (A) Healthy life years (A)	**Labour market** Unemployment rate (M) **Businesses** Number of bankruptcies index (Q) Economic sentiment indicator (M)	**Wellbeing** GDP (Q) Final consumption expenditure of households (Q) Imports of goods and services (Q) International trade (A) Harmonised index of consumer prices (M) Volume index of production (M)

Resilience to gas supply shock



Source : GCG meeting 9/1/2009

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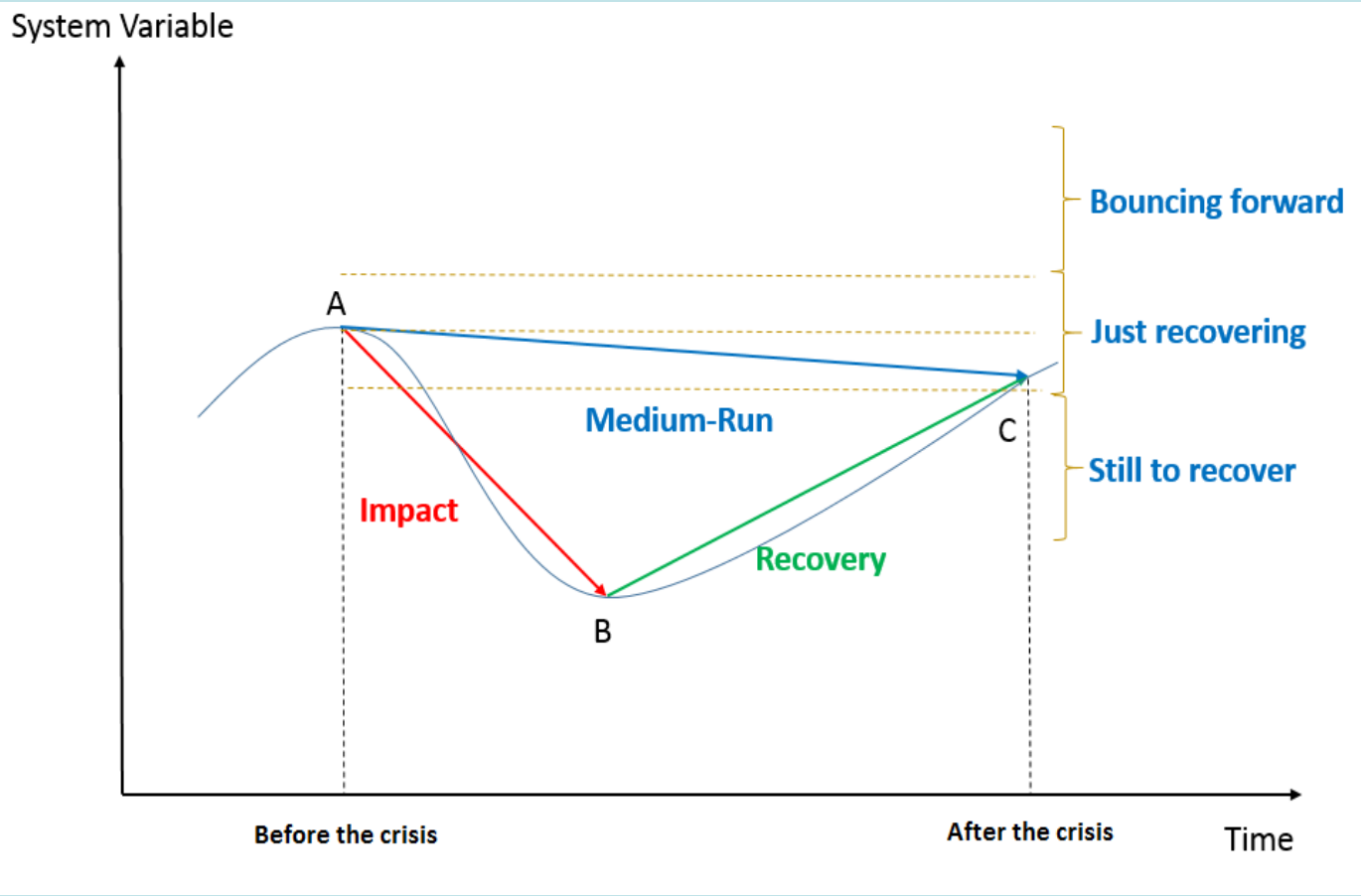
Resilience to gas supply shock

Metrics	Definition	Capacity
Impact of the crisis How much has the gas crisis affected European countries/sectors ?	Difference between the worst level and the pre-crisis level	Mostly absorption
Recovery from the crisis How much have countries recovered from the crisis?	Difference between the post-crisis level and the worst level	Absorption and adaptation
Medium-run performance What is the situation in the countries compared to the pre-crisis one?	Change between the post-crisis level and the pre-crisis level	Mostly adaptation



Source: Alessi, L., Benczur, P., Campolongo, F., Cariboni, J., Manca, A., Menyhert, B. and Pagano, A. (2018)

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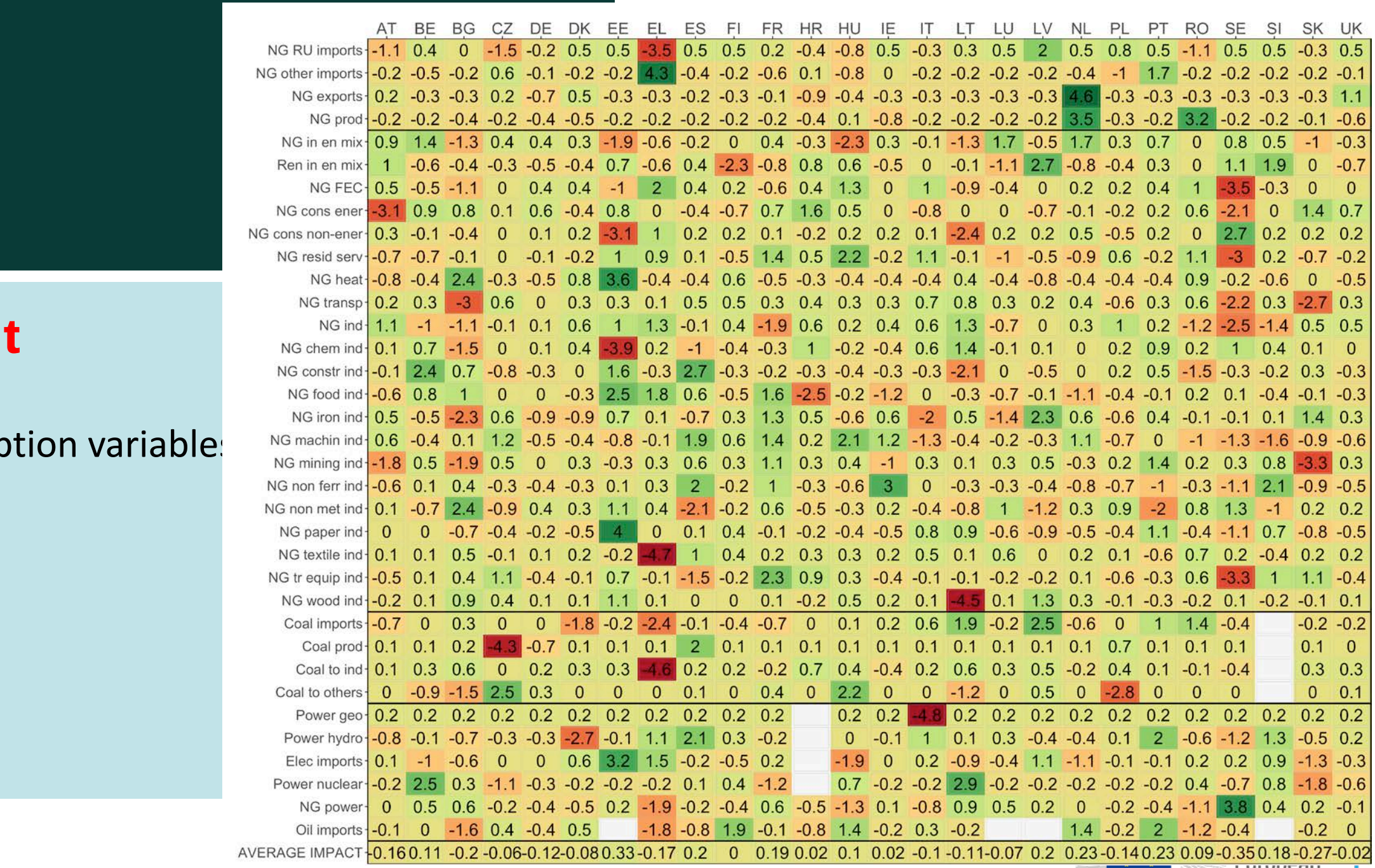
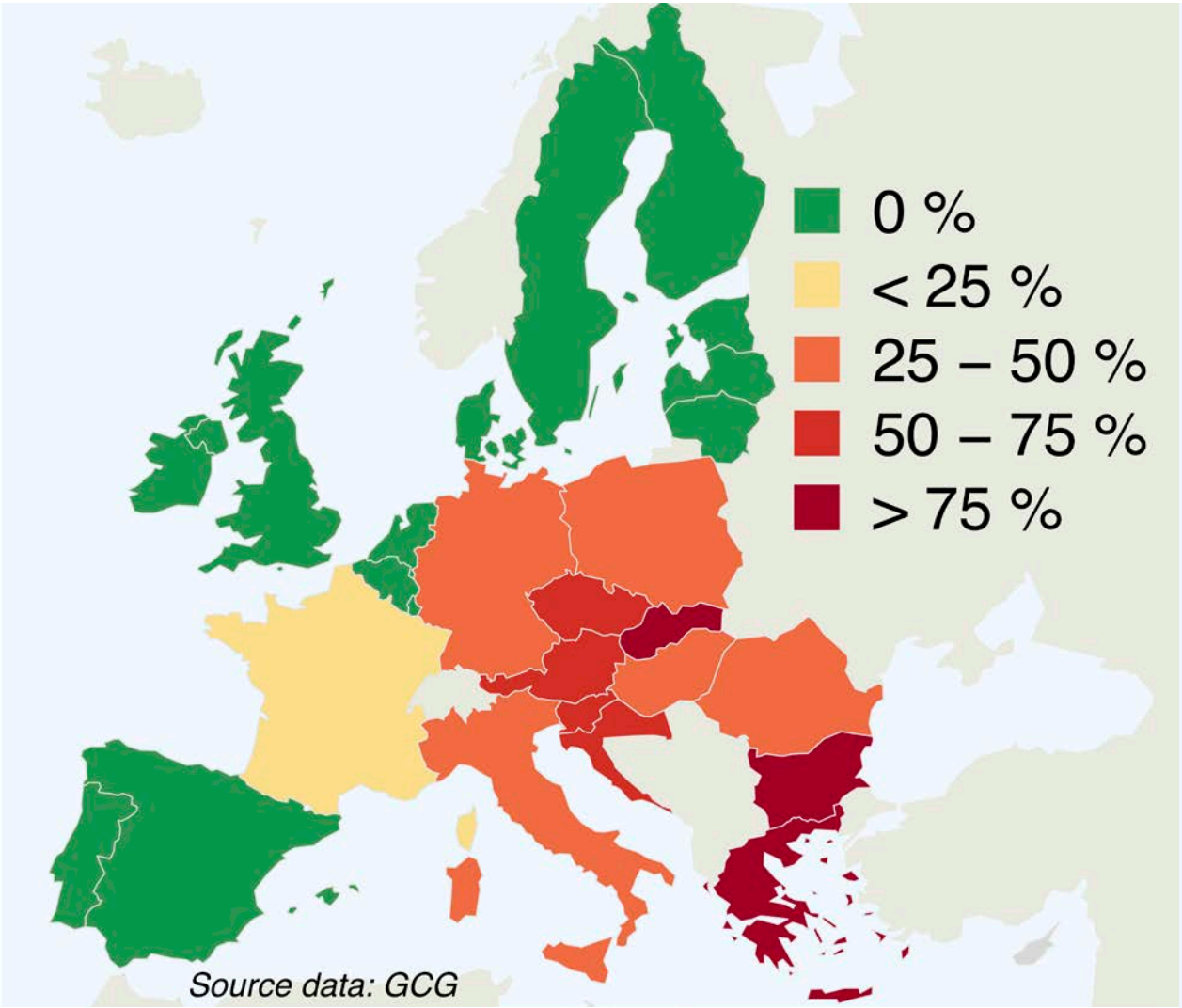
Impact

using consumption variables

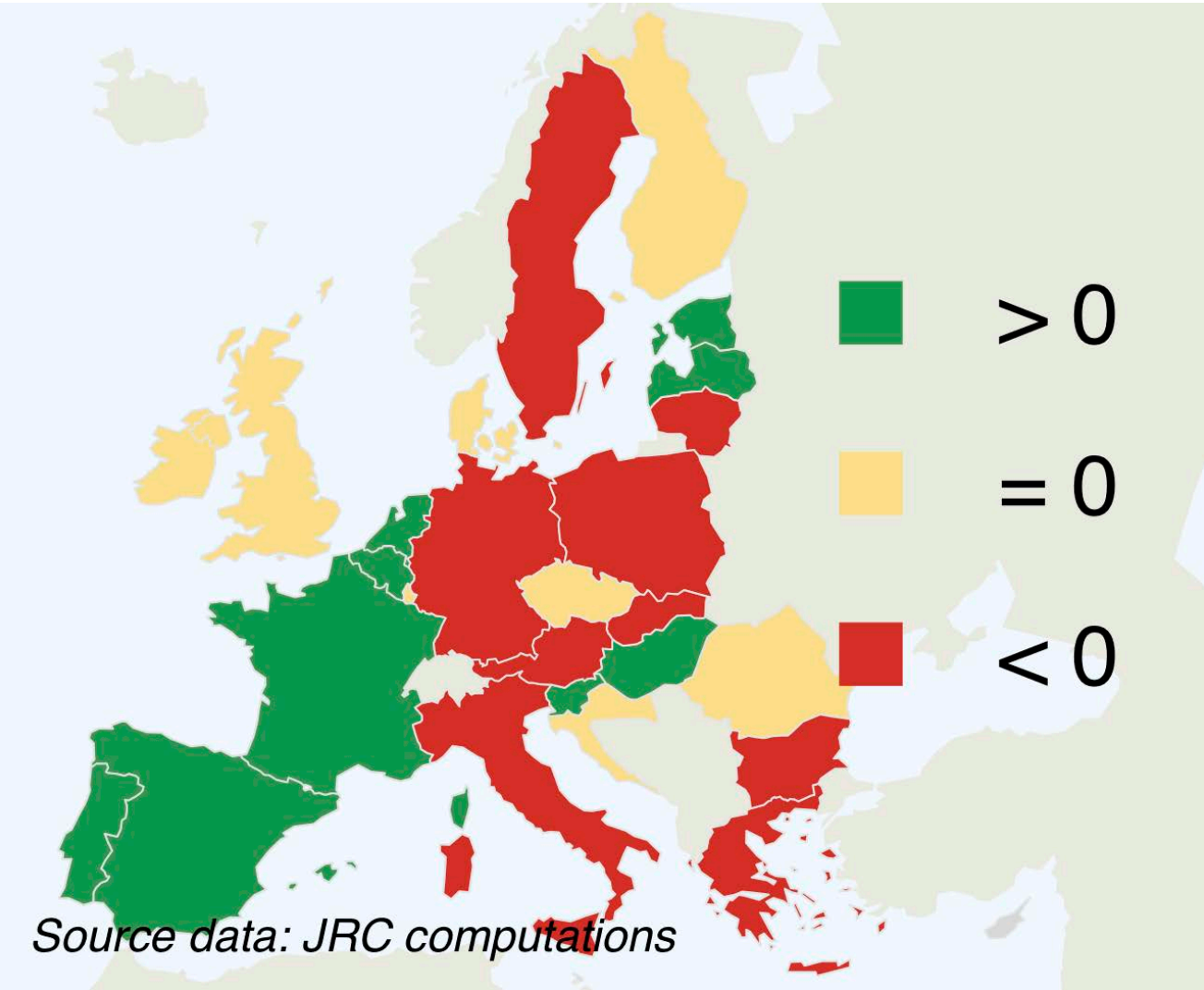


	AT	BE	BG	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK	UK
NG RU imports	-1.1	0.4	0	-1.5	-0.2	0.5	0.5	-3.5	0.5	0.5	0.2	-0.4	-0.8	0.5	-0.3	0.3	0.5	2	0.5	0.8	0.5	-1.1	0.5	0.5	-0.3	0.5
NG other imports	-0.2	-0.5	-0.2	0.6	-0.1	-0.2	-0.2	4.3	-0.4	-0.2	-0.6	0.1	-0.8	0	-0.2	-0.2	-0.2	-0.2	-0.4	-1	1.7	-0.2	-0.2	-0.2	-0.2	-0.1
NG exports	0.2	-0.3	-0.3	0.2	-0.7	0.5	-0.3	-0.3	-0.2	-0.3	-0.1	-0.9	-0.4	-0.3	-0.3	-0.3	-0.3	-0.3	4.6	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	1.1
NG prod	-0.2	-0.2	-0.4	-0.2	-0.4	-0.5	-0.2	-0.2	-0.2	-0.2	-0.2	-0.4	0.1	-0.8	-0.2	-0.2	-0.2	-0.2	3.5	-0.3	-0.2	3.2	-0.2	-0.2	-0.1	-0.6
NG in en mix	0.9	1.4	-1.3	0.4	0.4	0.3	-1.9	-0.6	-0.2	0	0.4	-0.3	-2.3	0.3	-0.1	-1.3	1.7	-0.5	1.7	0.3	0.7	0	0.8	0.5	-1	-0.3
Ren in en mix	1	-0.6	-0.4	-0.3	-0.5	-0.4	0.7	-0.6	0.4	-2.3	-0.8	0.8	0.6	-0.5	0	-0.1	-1.1	2.7	-0.8	-0.4	0.3	0	1.1	1.9	0	-0.7
NG FEC	0.5	-0.5	-1.1	0	0.4	0.4	-1	2	0.4	0.2	-0.6	0.4	1.3	0	1	-0.9	-0.4	0	0.2	0.2	0.4	1	-3.5	-0.3	0	0
NG cons ener	-3.1	0.9	0.8	0.1	0.6	-0.4	0.8	0	-0.4	-0.7	0.7	1.6	0.5	0	-0.8	0	0	-0.7	-0.1	-0.2	0.2	0.6	-2.1	0	1.4	0.7
NG cons non-ener	0.3	-0.1	-0.4	0	0.1	0.2	-3.1	1	0.2	0.2	0.1	-0.2	0.2	0.2	0.1	-2.4	0.2	0.2	0.5	-0.5	0.2	0	2.7	0.2	0.2	0.2
NG resid serv	-0.7	-0.7	-0.1	0	-0.1	-0.2	1	0.9	0.1	-0.5	1.4	0.5	2.2	-0.2	1.1	-0.1	-1	-0.5	-0.9	0.6	-0.2	1.1	-3	0.2	-0.7	-0.2
NG heat	-0.8	-0.4	2.4	-0.3	-0.5	0.8	3.6	-0.4	-0.4	0.6	-0.5	-0.3	-0.4	-0.4	-0.4	0.4	-0.4	-0.8	-0.4	-0.4	-0.4	0.9	-0.2	-0.6	0	-0.5
NG transp	0.2	0.3	-3	0.6	0	0.3	0.3	0.1	0.5	0.5	0.3	0.4	0.3	0.3	0.7	0.8	0.3	0.2	0.4	-0.6	0.3	0.6	-2.2	0.3	-2.7	0.3
NG ind	1.1	-1	-1.1	-0.1	0.1	0.6	1	1.3	-0.1	0.4	-1.9	0.6	0.2	0.4	0.6	1.3	-0.7	0	0.3	1	0.2	-1.2	-2.5	-1.4	0.5	0.5
NG chem ind	0.1	0.7	-1.5	0	0.1	0.4	-3.9	0.2	-1	-0.4	-0.3	1	-0.2	-0.4	0.6	1.4	-0.1	0.1	0	0.2	0.9	0.2	1	0.4	0.1	0
NG constr ind	-0.1	2.4	0.7	-0.8	-0.3	0	1.6	-0.3	2.7	-0.3	-0.2	-0.3	-0.4	-0.3	-0.3	-2.1	0	-0.5	0	0.2	0.5	-1.5	-0.3	-0.2	0.3	-0.3
NG food ind	-0.6	0.8	1	0	0	-0.3	2.5	1.8	0.6	-0.5	1.6	-2.5	-0.2	-1.2	0	-0.3	-0.7	-0.1	-1.1	-0.4	-0.1	0.2	0.1	-0.4	-0.1	-0.3
NG iron ind	0.5	-0.5	-2.3	0.6	-0.9	-0.9	0.7	0.1	-0.7	0.3	1.3	0.5	-0.6	0.6	-2	0.5	-1.4	2.3	0.6	-0.6	0.4	-0.1	-0.1	0.1	1.4	0.3
NG machin ind	0.6	-0.4	0.1	1.2	-0.5	-0.4	-0.8	-0.1	1.9	0.6	1.4	0.2	2.1	1.2	-1.3	-0.4	-0.2	-0.3	1.1	-0.7	0	-1	-1.3	-1.6	-0.9	-0.6
NG mining ind	-1.8	0.5	-1.9	0.5	0	0.3	-0.3	0.3	0.6	0.3	1.1	0.3	0.4	-1	0.3	0.1	0.3	0.5	-0.3	0.2	1.4	0.2	0.3	0.8	-3.3	0.3
NG non ferr ind	-0.6	0.1	0.4	-0.3	-0.4	-0.3	0.1	0.3	2	-0.2	1	-0.3	-0.6	3	0	-0.3	-0.3	-0.4	-0.8	-0.7	-1	-0.3	-1.1	2.1	-0.9	-0.5
NG non met ind	0.1	-0.7	2.4	-0.9	0.4	0.3	1.1	0.4	-2.1	-0.2	0.6	-0.5	-0.3	0.2	-0.4	-0.8	1	-1.2	0.3	0.9	-2	0.8	1.3	-1	0.2	0.2
NG paper ind	0	0	-0.7	-0.4	-0.2	-0.5	4	0	0.1	0.4	-0.1	-0.2	-0.4	-0.5	0.8	0.9	-0.6	-0.9	-0.5	-0.4	1.1	-0.4	-1.1	0.7	-0.8	-0.5
NG textile ind	0.1	0.1	0.5	-0.1	0.1	0.2	-0.2	-4.7	1	0.4	0.2	0.3	0.3	0.2	0.5	0.1	0.6	0	0.2	0.1	-0.6	0.7	0.2	-0.4	0.2	0.2
NG tr equip ind	-0.5	0.1	0.4	1.1	-0.4	-0.1	0.7	-0.1	-1.5	-0.2	2.3	0.9	0.3	-0.4	-0.1	-0.1	-0.2	-0.2	0.1	-0.6	-0.3	0.6	-3.3	1	1.1	-0.4
NG wood ind	-0.2	0.1	0.9	0.4	0.1	0.1	1.1	0.1	0	0	0.1	-0.2	0.5	0.2	0.1	-4.5	0.1	1.3	0.3	-0.1	-0.3	-0.2	0.1	-0.2	-0.1	0.1
Coal imports	-0.7	0	0.3	0	0	-1.8	-0.2	-2.4	-0.1	-0.4	-0.7	0	0.1	0.2	0.6	1.9	-0.2	2.5	-0.6	0	1	1.4	-0.4		-0.2	-0.2
Coal prod	0.1	0.1	0.2	-4.3	-0.7	0.1	0.1	0.1	2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.1	0.1	0.1		0.1	0
Coal to ind	0.1	0.3	0.6	0	0.2	0.3	0.3	-4.6	0.2	0.2	-0.2	0.7	0.4	-0.4	0.2	0.6	0.3	0.5	-0.2	0.4	0.1	-0.1	-0.4		0.3	0.3
Coal to others	0	-0.9	-1.5	2.5	0.3	0	0	0	0.1	0	0.4	0	2.2	0	0	-1.2	0	0.5	0	-2.8	0	0	0		0	0.1
Power geo	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2		0.2	0.2	-4.8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Power hydro	-0.8	-0.1	-0.7	-0.3	-0.3	-2.7	-0.1	1.1	2.1	0.3	-0.2		0	-0.1	1	0.1	0.3	-0.4	-0.4	0.1	2	-0.6	-1.2	1.3	-0.5	0.2
Elec imports	0.1	-1	-0.6	0	0	0.6	3.2	1.5	-0.2	-0.5	0.2		-1.9	0	0.2	-0.9	-0.4	1.1	-1.1	-0.1	-0.1	0.2	0.2	0.9	-1.3	-0.3
Power nuclear	-0.2	2.5	0.3	-1.1	-0.3	-0.2	-0.2	-0.2	0.1	0.4	-1.2		0.7	-0.2	-0.2	2.9	-0.2	-0.2	-0.2	-0.2	-0.2	0.4	-0.7	0.8	-1.8	-0.6
NG power	0	0.5	0.6	-0.2	-0.4	-0.5	0.2	-1.9	-0.2	-0.4	0.6	-0.5	-1.3	0.1	-0.8	0.9	0.5	0.2	0	-0.2	-0.4	-1.1	3.8	0.4	0.2	-0.1
Oil imports	-0.1	0	-1.6	0.4	-0.4	0.5		-1.8	-0.8	1.9	-0.1	-0.8	1.4	-0.2	0.3	-0.2			1.4	-0.2	2	-1.2	-0.4		-0.2	0
AVERAGE IMPACT	-0.16	0.11	-0.2	-0.06	-0.12	-0.08	0.33	-0.17	0.2	0	0.19	0.02	0.1	0.02	-0.1	-0.11	-0.07	0.2	0.23	-0.14	0.23	0.09	-0.35	0.18	-0.27	-0.02

GCG assessment



Impact indicator



European Commission

Recovery

using

consumption variables (M, A)

and without

- coal / oil
- NG exports and production

	AT	BE	BG	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK	UK
NG RU imports	1	-0.5	-0.4	1.9	0.1	-0.5	-0.5	2.1	-0.5	-0.5	-0.4	-1.1	-0.6	-0.5	0.2	-0.1	-0.5	3.3	-0.4	-0.1	-0.5	0.2	-0.5	-0.5	-0.6	-0.5
NG other imports	0	1.6	0	-1.1	0.1	1.1	0	-3.5	0	0	1.2	0.7	0.1	0.4	-0.1	0	0	0	-0.6	0	-2	0.1	0	0	0.6	1.2
NG in en mix	-0.2	-0.6	0.3	-0.3	-0.5	-0.4	-0.7	1.3	-0.6	-0.5	-0.3	0.6	0	0.2	-0.1	4.1	-1.1	0.6	-0.3	-0.2	0.5	0	-0.2	-0.7	-0.1	-1
Ren in en mix	-1.2	0.6	0.1	0.4	0.6	2.3	-0.4	0.6	0.9	0.8	-0.6	-1	0.4	0.3	-0.4	1.4	-0.5	-2	-0.3	0.4	1.4	-1.1	-1.8	-1.1	0	0.2
NG FEC	-0.4	0.2	1.1	-0.9	-0.9	0.5	0.6	0.2	1.9	0.4	-0.2	-1.3	-0.3	0.6	-0.7	2	0.5	-1.8	-0.3	-0.8	-0.6	-0.2	2.2	-0.6	-0.9	0
NG cons ener	1.8	0.1	-0.9	-0.6	0	-0.4	0	-0.9	-0.7	-1	1.4	-0.9	-2.2	-0.4	1.2	-0.2	-0.4	0.7	1.5	2	0.5	-0.3	0.9	-0.4	-0.9	-0.2
NG cons non-ener	-0.2	0.3	0.5	0	0	-0.2	-0.9	0.3	0	-0.1	-0.2	0.4	0.1	-0.2	-0.2	3.4	-0.2	-0.2	0.4	0.2	-0.2	0.2	-0.6	-3.3	0.6	-0.2
NG resid serv	-0.8	0	0.3	-0.1	-0.4	0.3	1	0.1	1.6	0.3	-1.3	-0.7	-0.4	-0.4	0.2	-0.5	0.2	-0.1	-0.8	-0.5	0.1	-0.2	1.7	2.6	-2.6	0.3
NG heat	0.1	0.3	-1.4	1.5	0.5	0.4	0.6	0.2	0.2	-0.9	0.1	0.1	1.4	0.2	0.2	-1.8	0.3	-2.7	0	0	0.2	-0.8	0.4	2	-1.3	0.4
NG transp	1.1	0.7	2.4	-0.3	-0.2	-0.3	-0.2	-0.6	-0.3	-0.5	-0.2	-0.4	0.8	-0.3	0.5	-1	-0.3	-0.3	-0.2	-1.3	-0.3	-1.2	3.3	-0.3	-0.2	-0.3
NG ind	0.5	-0.4	0	0.1	0.8	0.4	1.2	-0.6	0.5	0.4	0.8	-2	-0.3	1.2	-1.2	-1.6	0.8	-2.7	-0.2	-0.5	0.7	-0.1	0.5	1.1	0.8	-0.2
NG chem ind	-0.2	-2.6	1.8	-0.2	-0.2	0.1	-0.5	-0.5	2	0.2	2.1	-0.1	0.3	-0.2	-1.1	-0.6	0.6	0	0.4	0.5	0.4	0.1	-1.5	-0.2	-0.2	-0.5
NG constr ind	-0.2	-3.2	-0.1	-0.3	0	0.6	-0.8	0	-0.8	0	-0.2	0	0.2	0	2.4	0	0.1	2.5	-0.5	-0.4	-0.1	-0.1	0	0.7	0.3	0
NG food ind	0	1.6	-0.1	0.2	0.2	0	-0.6	-3.8	-0.8	0.3	1	0.6	-0.1	-0.6	0.2	0.7	0.4	1.2	0.7	-0.1	0.5	0.1	-0.8	-0.2	-1.2	0.7
NG iron ind	0.9	0.4	-1.4	0.2	0.5	0.2	0.1	-0.8	0.4	0.4	0.2	0.1	0.4	0.1	0.7	0.1	0	-4.4	0.2	0	0	0.4	-0.3	0.7	0.6	0.2
NG machin ind	-0.1	2.2	0.5	-1	-0.3	-1.1	2.5	-0.3	0.4	-1.1	0.1	0.2	-0.8	-1.9	-0.3	0.3	0	0.2	-1.6	-0.2	-0.8	0.4	1.1	0.8	0.4	0.3
NG mining ind	0.9	-0.4	-0.3	1.7	-1.3	0.3	1.8	-0.4	0.5	-0.4	0	0.5	-0.4	-1.2	0.8	-0.4	-0.9	0.3	1.8	1.2	-1.1	-0.4	0.2	-2.4	-0.2	-0.4
NG non ferr ind	-0.3	-0.1	-0.2	-0.2	-0.2	-0.2	-0.6	4.6	-0.4	-0.2	-0.3	-0.2	-0.1	1.3	0.2	-0.2	-0.2	0	-0.2	-0.2	-0.3	-0.2	-0.4	-0.8	-0.2	-0.2
NG non met ind	0	1.6	-0.7	-0.4	0.1	0.3	0	-2.8	0.2	-0.4	0.4	-1.2	-0.7	-0.1	0	0.3	-0.4	0.9	-0.5	-0.1	-0.8	0.4	2.8	0.9	0.6	-0.5
NG paper ind	-0.6	-1	0.4	0.8	-0.5	0.2	2.7	-1.6	-0.6	0.2	0.6	1.4	0.9	0.2	-0.6	0	0.4	0.5	-0.3	-0.2	1.4	-0.4	-0.9	-2.1	-0.6	-0.4
NG textile ind	0	1.4	-1.2	0.6	0.4	0.1	-0.5	-1.9	-1.1	-0.4	0	0.1	0.3	0.4	-0.5	1	-2.3	1.8	0.1	-0.1	-0.3	-0.7	-0.2	0.3	2.2	0.8
NG tr equip ind	0.4	0.4	0.5	1.5	0.6	-0.8	0.2	0.1	0.4	0.1	-0.7	-0.5	-0.1	0	0.1	-1	0.3	0.5	-0.6	-0.8	0.2	0	-1.7	-0.3	-2	3.3
NG wood ind	-0.6	0.1	0	0	-0.2	-0.2	-0.8	0	0.1	-0.3	-0.2	0.2	-0.1	-0.2	0	-1	-0.2	4.7	-0.2	-0.5	-0.1	0.2	-0.3	-0.2	-0.4	0.2
Power geo	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	4.7	-0.2	-0.2	-0.2		-0.2	-0.2	0.6	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
Power hydro	-0.2	-0.2	0.8	0.1	0	-2.1	-0.3	-0.2	-0.3	-0.9	-0.3		-0.2	-1.5	-0.4	0	0.8	1.6	-0.6	0	2.8	1.1	-1	0.5	1.1	-0.5
Elec imports	-0.3	0.8	-0.4	-0.6	0.1	-0.2	-1.2	0.1	0.1	0	0		-0.2	0.2	0.1	2.6	1.2	-2	0.3	-0.4	-0.8	-0.1	0.4	2	-2	0.2
Power nuclear	0.2	-0.3	0.3	0.5	0.3	0.2	0.2	0.2	0.1	0.1	0.3		0.2	0.2	0.2	-4.8	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.4	0.5
NG power	0	-1.1	-0.3	0.8	0.6	-0.4	-0.7	0.2	-1.7	0.4	-0.1	0.7	-0.1	-0.9	0.4	-1.2	-0.4	2.7	0	0.7	0.4	0.5	-2.3	0.1	1.6	0
AVERAGE RECOVERY	0.04	0.06	0.05	0.15	0	0	0.07	-0.11	0.04	-0.13	0.11	-0.15	-0.06	-0.11	0.08	0.04	-0.06	0.19	-0.08	-0.05	0.05	-0.08	0.04	-0.05	-0.16	0.11

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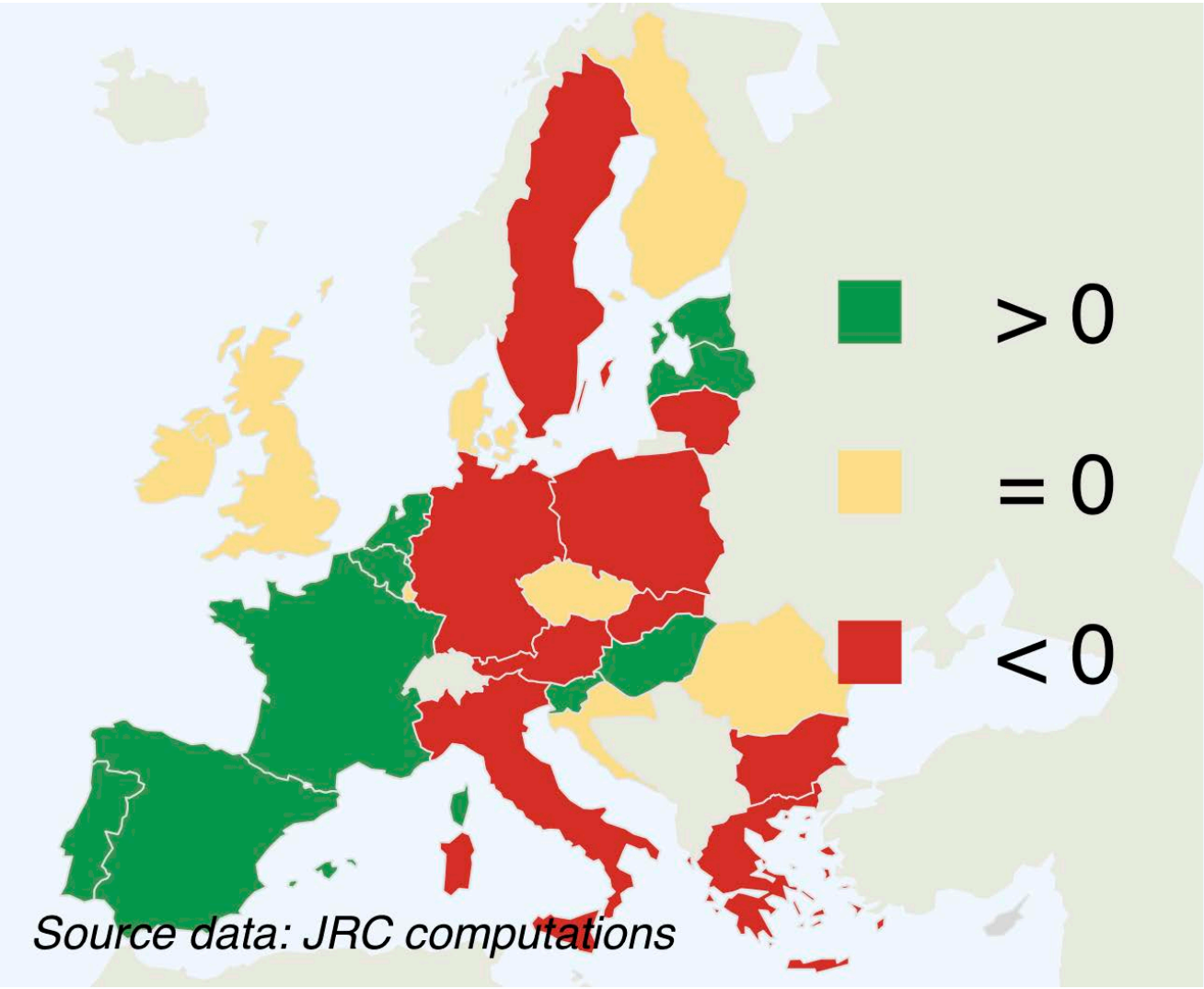
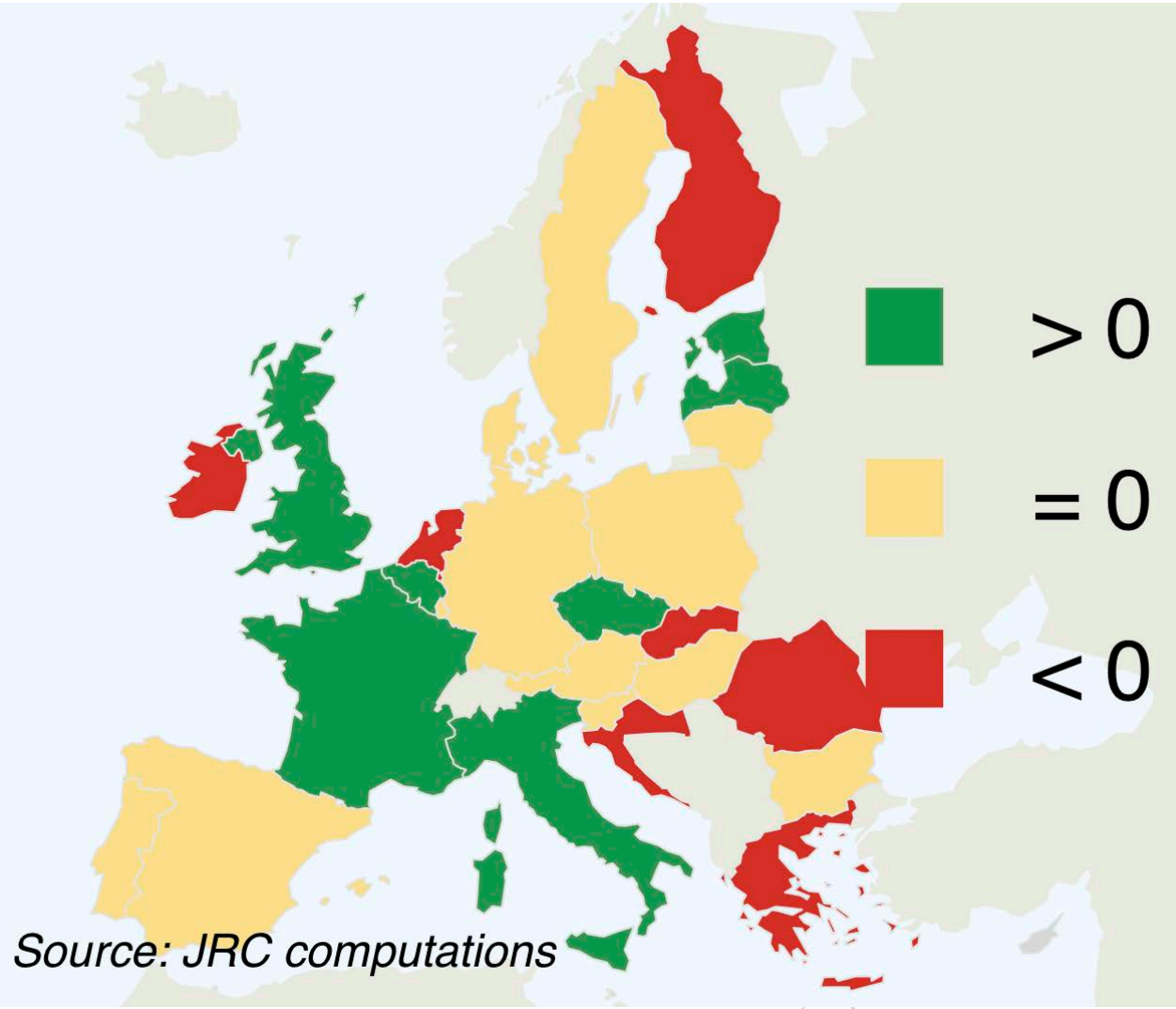
Impact indicator



[-0.35, 0.33]

Recovery indicator

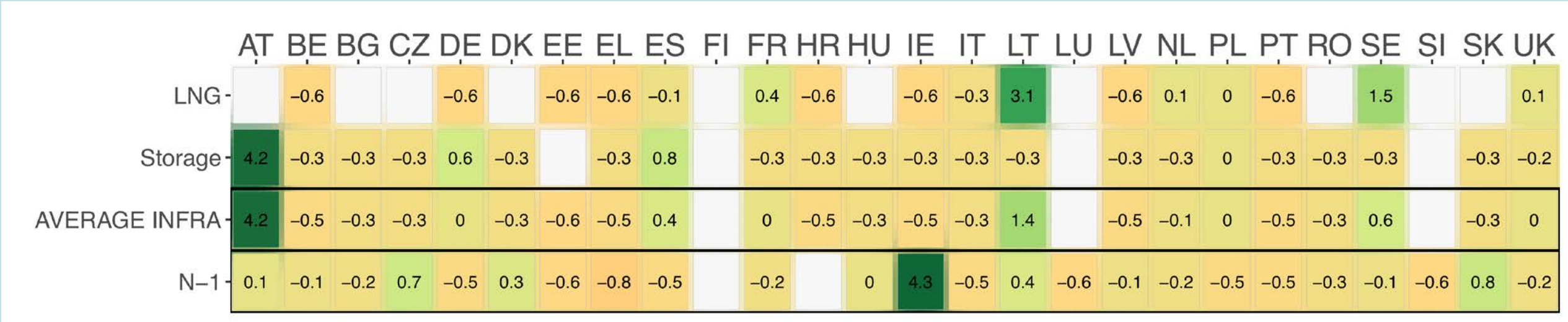


[-0.16, 0.19]

European Commission

Resilience to gas supply shock

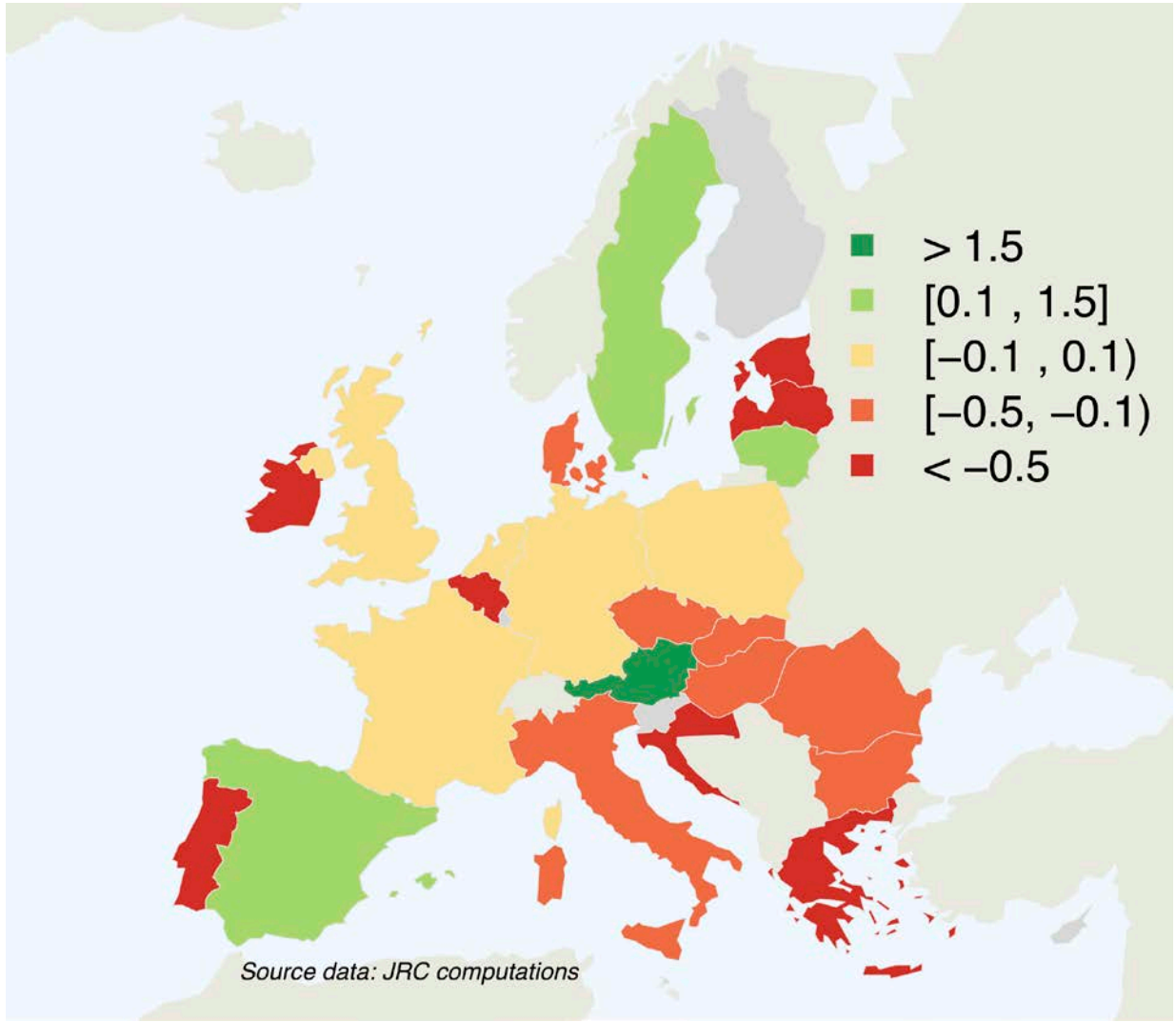
Medium-run indicator using
policy and infrastructure variables (A)



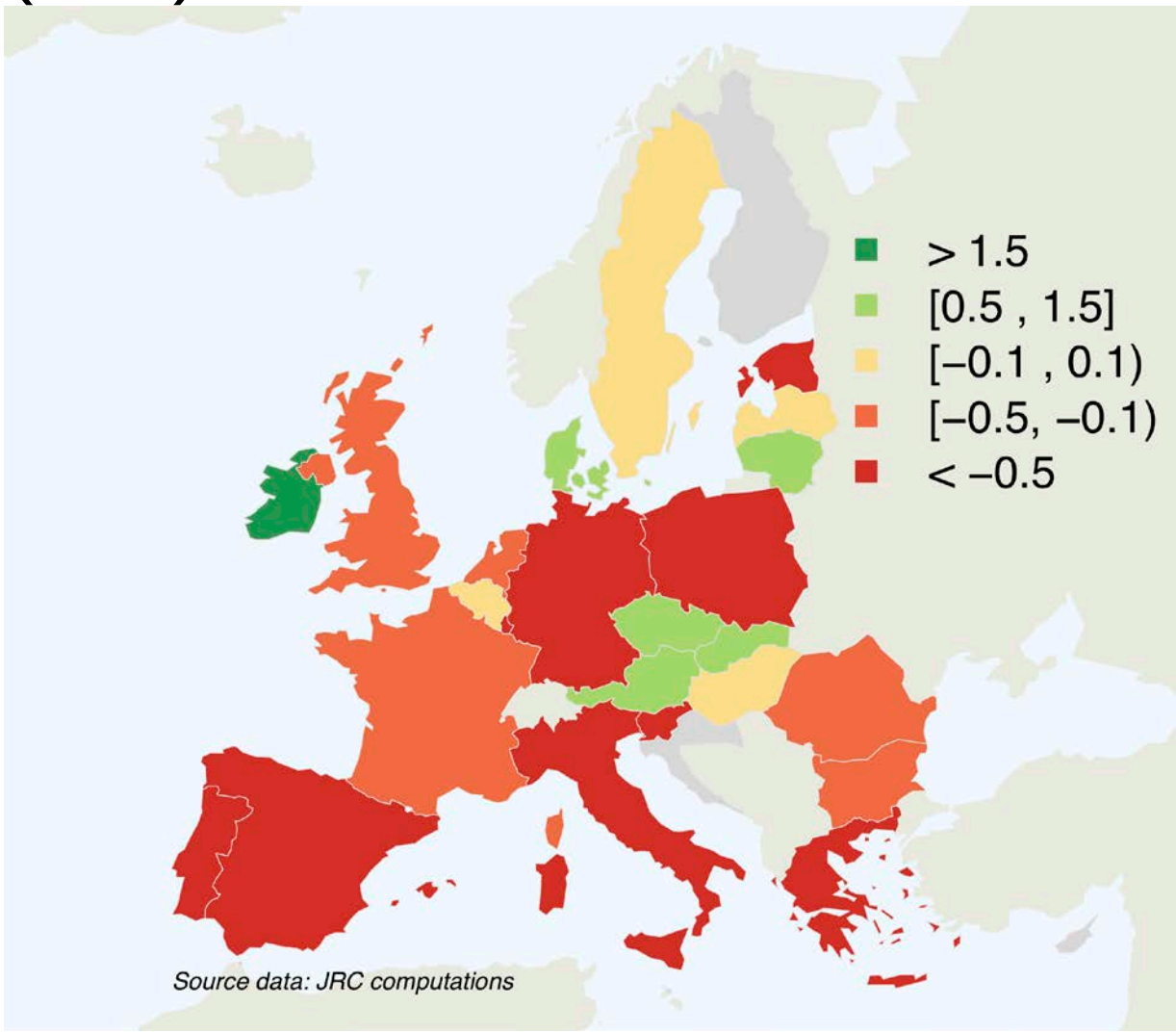
	AT	BE	BG	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	NL	PL	PT	RO	SE	SI	SK	UK
LNG		−0.6			−0.6		−0.6	−0.6	−0.1		0.4	−0.6		−0.6	−0.3	3.1		−0.6	0.1	0	−0.6		1.5			0.1
Storage	4.2	−0.3	−0.3	−0.3	0.6	−0.3		−0.3	0.8		−0.3	−0.3	−0.3	−0.3	−0.3	−0.3		−0.3	−0.3	0	−0.3	−0.3	−0.3		−0.3	−0.2
AVERAGE INFRA	4.2	−0.5	−0.3	−0.3	0	−0.3	−0.6	−0.5	0.4		0	−0.5	−0.3	−0.5	−0.3	1.4		−0.5	−0.1	0	−0.5	−0.3	0.6		−0.3	0
N−1	0.1	−0.1	−0.2	0.7	−0.5	0.3	−0.6	−0.8	−0.5		−0.2		0	4.3	−0.5	0.4	−0.6	−0.1	−0.2	−0.5	−0.5	−0.3	−0.1	−0.6	0.8	−0.2

European Commission

Medium-run indicator infrastructure



Medium-run indicator policy (N-1)



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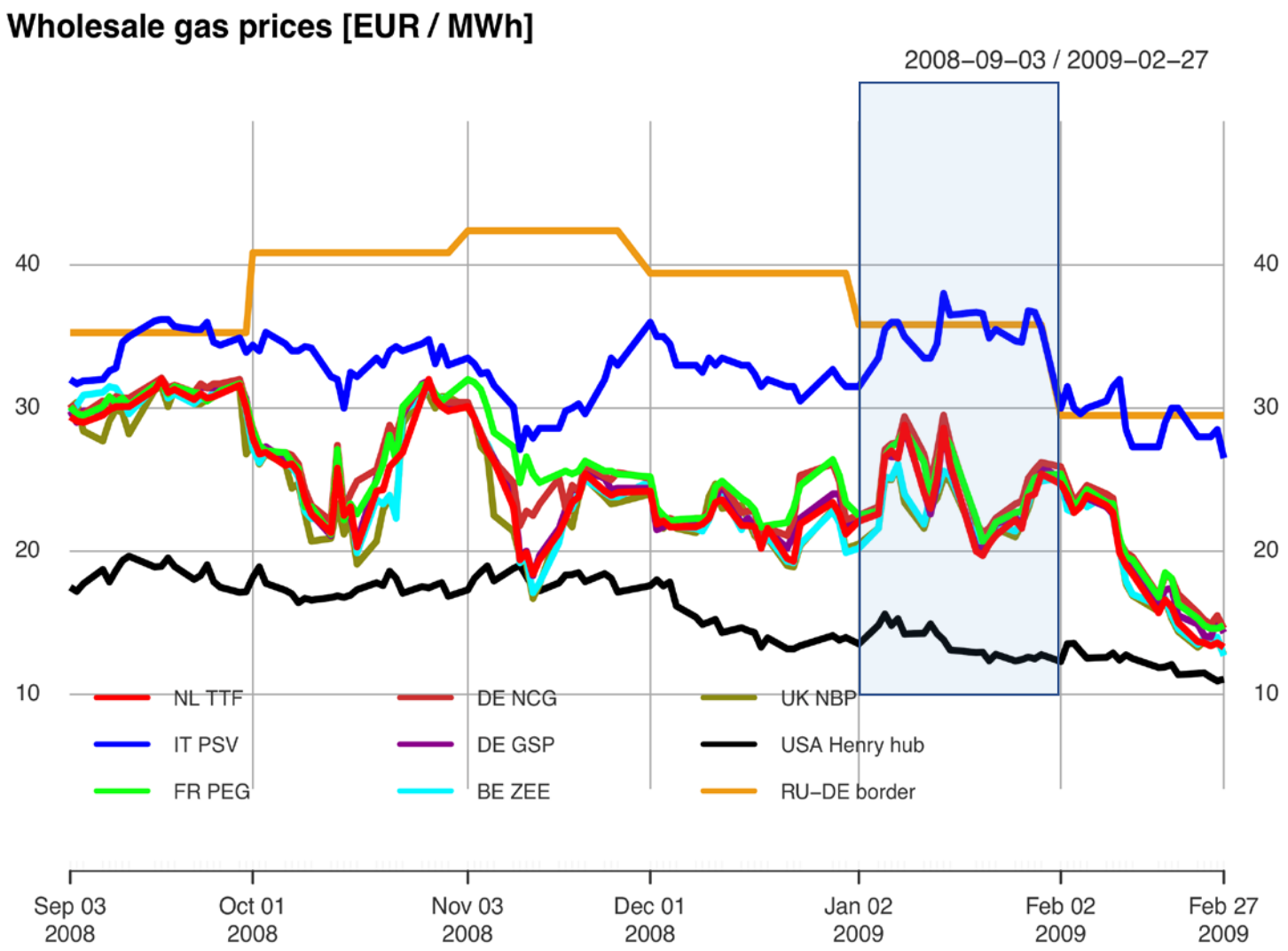
Resilience to gas supply shock

wholesale prices were stable (GCG, 2009)



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Concluding remarks

- Risk assessment of natural gas supply
  - Greatly evolved in last 10 years
- Risk assessment of electricity supply
- Resilience
  - Need to better understand concepts and derive analytic framework

Any questions?

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