

Modelling the cost of gas supply outages and their substitution as a way of assessing Security of Supply Measures

**Presentation to the 2nd AIEE Energy Symposium
“Current and Future Challenges to Energy Security”**

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Rome, 3 November 2017

Acknowledgments

- The paper is based on the methodological part of an empirical Study on “The role of gas storage in internal market and in ensuring security of supply”
- Carried out by ref4e (Italy), E-Bridge (Germany) and AF-Mercados (Spain) on behalf of the Energy Commission (DG Energy)
- Based on previous “Stress Tests” by ENTSO-G
- Full Study available on <http://ec.europa.eu/energy/en/studies>
- Full financial support of the European Commission is gratefully acknowledged
- Any responsibility is only with the author. The European Commission is by no means responsible for the methodology and results.

Security of Supply: from policy principle to practical assessment of Measures

- **Security of Supply, notably for natural gas, is one of the pillars of European energy policy and the subject of a (recently amended) EU Regulation (2017/1938)**
- **It can be pursued by several Measures:**
 - **Expansion of storage sites and inventories**
 - **Enhancement of reverse flow capacity**
 - **Construction of alternative pipelines or LNG terminals**
 - **Energy efficiency**
 - **Resort to alternative fuels**
- **Do benefits of Measures aimed at SoS enhancement outweigh their costs?**

Security of Supply: Benefits vs. Costs

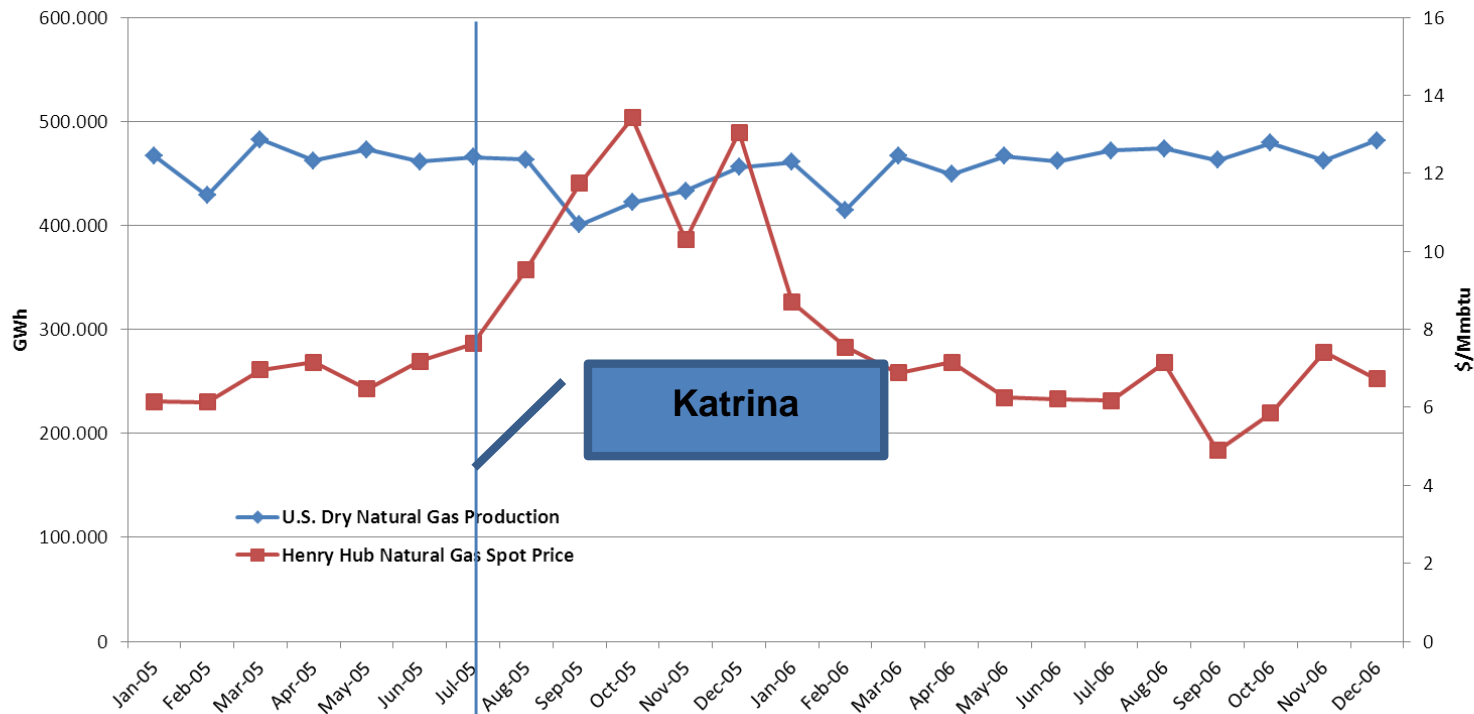
- The evaluation of costs of (infrastructure-related) measures can be performed by methodologies that are well known to companies and regulators
- Benefits of SoS Measures mostly amount to *avoided cost of disruptions*, which typically include :
 - purchase of spot supplies (mostly LNG);
 - resort to alternative, usually more costly and/or polluting energy sources (electricity, LPG, fuel oil, coal, fuelwood);
 - in extreme cases, the outage of energy supply, with industry activity halted and people left “in the cold”.
- **Traditional Cost-Benefit Analysis: Measures worth if:**
(Avoided cost of Outage) x (Prob. of Outage) > (Cost of Measures)

Evaluating costs of missing gas replacement ref4e

- **ENTSOG's 2014 Study showed that in the worst considered case (6-month all-Russian disruption):**
 - **42% replaced by domestic production, pipeline contract margins and storage, at low incremental costs**
 - **35% of missing gas replaced by (mostly spot) LNG;**
 - **22% gas deficit, mostly covered by alternative sources;**
- **However, LNG and other market-traded gas resources tend to “overshoot” in case of supply disruptions or demand shocks, as shown by past crisis cases**

Price impact of gas crisis: Katrina 2005

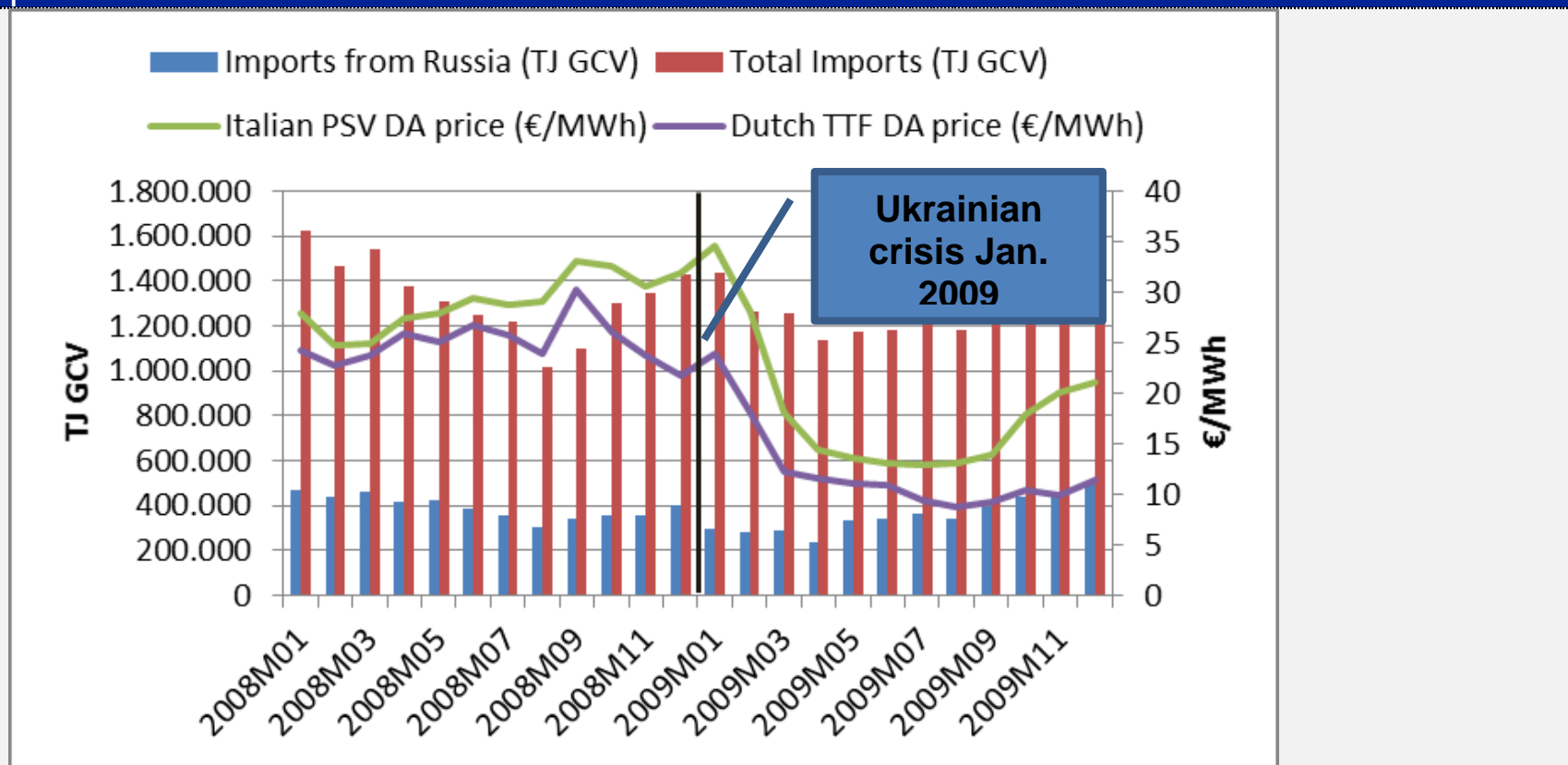
Figure 4.3.3. Evolution of US gas production and Henry Hub spot prices after the Katrina hurricane



Source: EIA

Price impact of gas crisis: Ukraine 2009

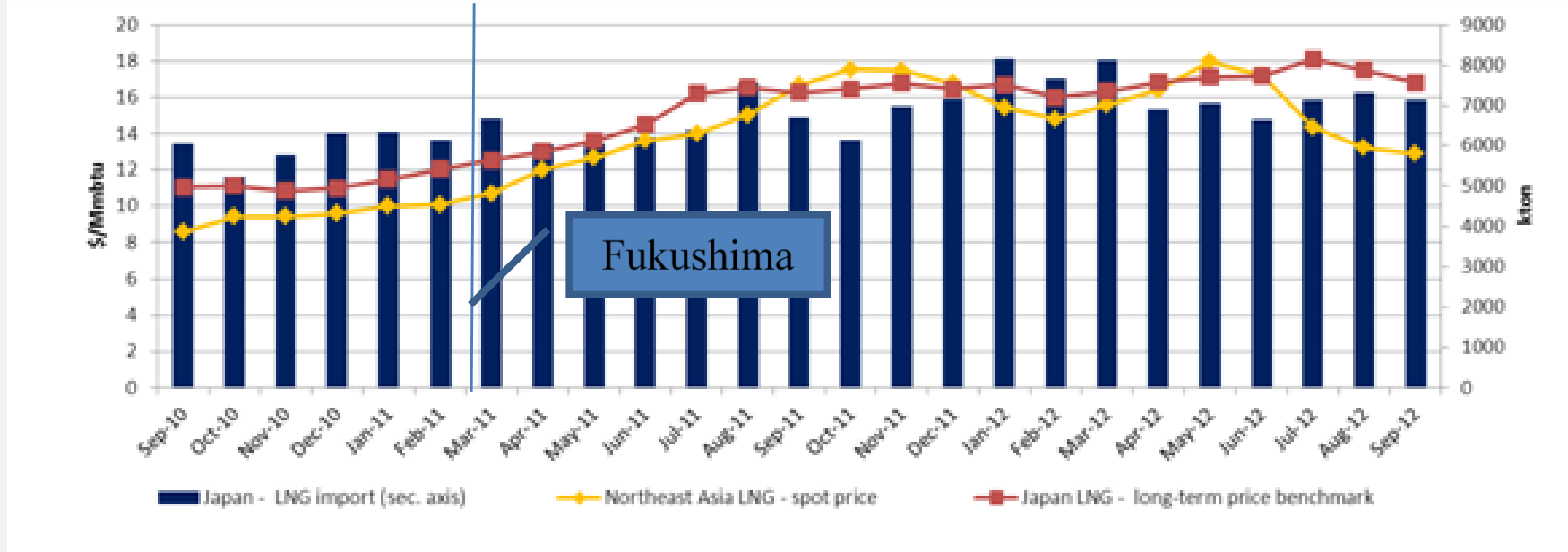
Figure 4.3.5. Evolution of monthly gas imports in EU27 and Dutch and Italian spot prices



Source: Platts and Eurostat

Price impact of gas crisis: Fukushima 2011

Figure 4.3.4. Evolution of LNG prices and LNG imports in Japan



Source: Analysis on World Gas Intelligence data

Gas price modelling

- **Study simulates price hikes, by means of an econometric model of gas hub prices**
- **Econometric models of hub prices already developed for U.S. markets (Brown & Yücel, 2008)**
- **Ref4e estimated similar models for TTF, PSV**
- **Main explanatory variables:**
 - **Oil prices**
 - **Storage changes**
 - **Temperatures (as degree-days)**
 - **Supply shocks (e.g. 2009 Ukraine crisis)**

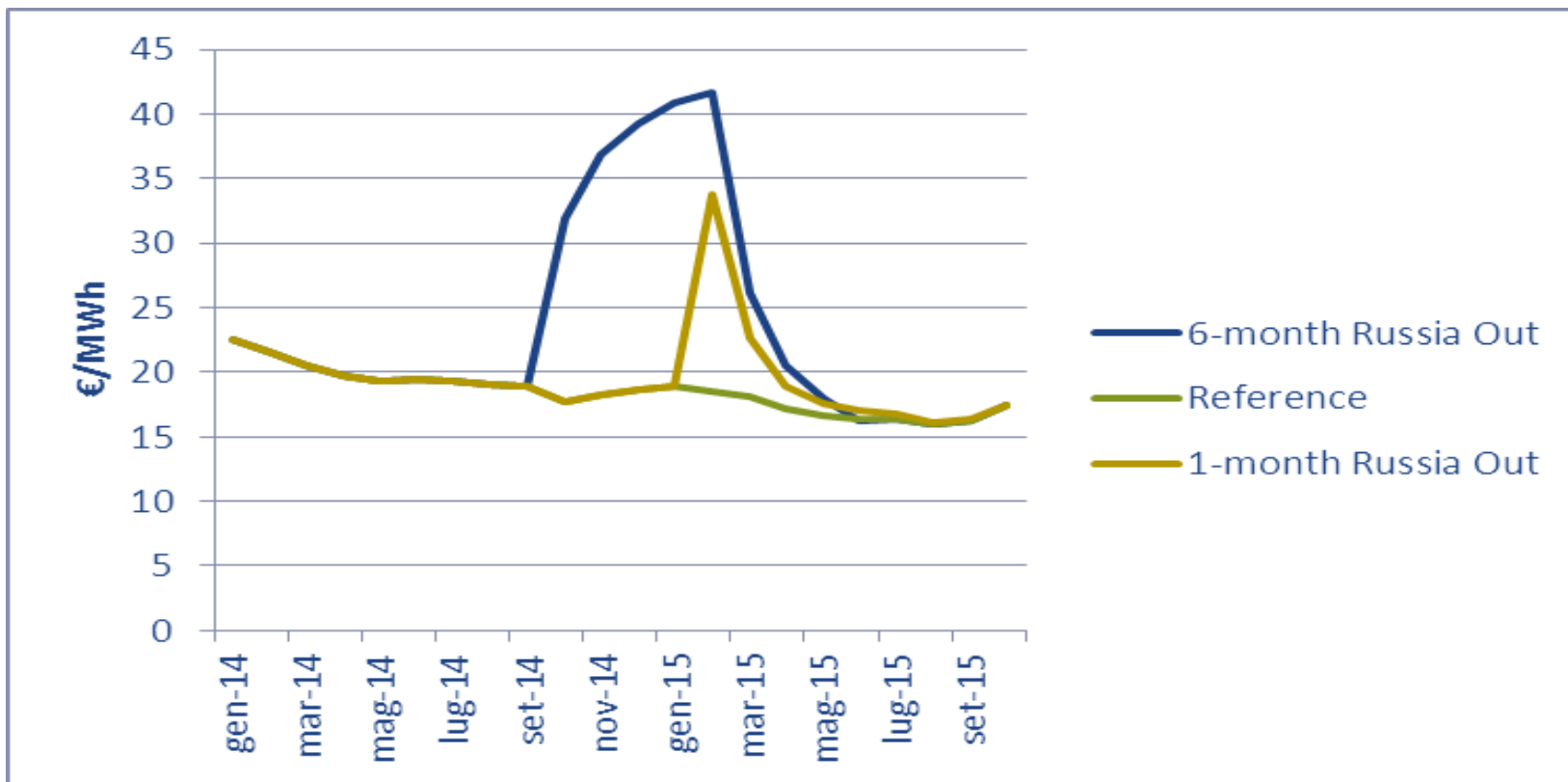
Gas price econometric model

Constant	2.702528
TTF Day Ahead Prices	0.247526
Brent price (lagged 3 months)	0.023917
Ukraine January 2009 crisis supply loss	-0.078791
12 th monthly differences of German storage filling level	3.171682
Average degree days (NW Europe)	0.005019

Gas price modelling of crises: simulation

- In Europe, over 90% of non-Russian gas is now priced at hubs
- World LNG market not perfect → regional spikes possible

Model simulation of September-February and February only disruptions of all Russian supplies 2014-15



Valuation of missing gas (lost load)

- 1. End user price as a measure of gas value**
 - Includes gas transmission and distribution cost → 50 €/MWh
 - “Floor” evaluation: does not include consumer surplus
- 2. Value of alternative fuels (e.g. light fuel oil, electricity)**
 - Consumers typically use them where gas is not available
 - Adjusted by (differential) environmental cost → 90-300 €/MWh
- 3. UK Contingent Valuation Study of VOLL for electricity**
 - On a per/kWh basis, adjusted by per capita income and national consumption level → 200-700 €/MWh

The probability of disruptions

- **Costs of SoS Measures are certain, but disruptions are not**
- **Balance of benefits and costs depends on the probability of disruption**
- **Historically, unplanned disruptions are limited and rare (less than 0.5% of expected supplies from outside EU)**
- **Probability can be “weighted” by adding risk aversion or by more sophisticated approaches to probability**
 - **Beyond scope of presentation, not common in CBA**
- **Otherwise, researchers may calculate break-even probability, yielding $pB = C$**

Example: Assessment of storage based Measures

- **Based on ENTSOG results @ EU level (+CH-Baltics)**
- **Simulation: LNG & hub prices to follow model forecasts, based on average Brent prices of last 15 years**
- **Simulating generalization of different levels of Mandatory inventories or Strategic storage**
- **Assuming replacement of missing gas in case of crisis by:**
 - **LNG+Norway (estimated by econometric model of hub price or oil-related)**
 - **Alternative fuel (coal or light fuel oil, LFO) in power stations, where generation capacity is available (based on ENTSO-E data)**
 - **Coal/LFO cost corrected by (differential) environmental cost and transformation efficiency → @ 2014 prices: 87-101 €/MWh**
 - **For any further missing gas, load loss cost estimated at 150-350 €/MWh (income & climate-adjusted from a UK Study)**

Estimated Costs of Supply Replacement

Replacement Option	Potential role (ENTSOG 2014 Study)*	Evaluation approach	Average cost of simulated year (€/MWh)
EU production	4%	Market price	24.5
Pipeline imports	10%	Contract price	23.3
Storage	28%	Market price before crisis	21.4
LNG spot	35%	Market price	24.5
Light fuel oil	22%	Market price + external cost diff.	87
Coal	..	Market price + external cost diff.	99
No replacement	..	Cost of lost load UK adjusted by per capita GDP	150 - 350

(*) Based on worst **scenario**: 6-month Russian supply disruption, September-February, average winter condition with a 14-day cold spell in February

Assessment of storage based Measures:

Main Results

- **Balance of benefits and costs depends on the probability of disruption, prudently assumed at**
 - **2% : 6-month all Russian supplies followed by cold spell**
 - **10%: 1-month Russian supply transit through Ukraine**
- **Costs of generalised Storage Measures are always larger than probability weighted benefits @EU level**
- **Benefit-costs balance even worse for increased strategic storage**
- **Generalisation of strategic storage (as currently required in Italy and Hungary) would be cost-effective only with a 26% probability**

Thank you for your attention!

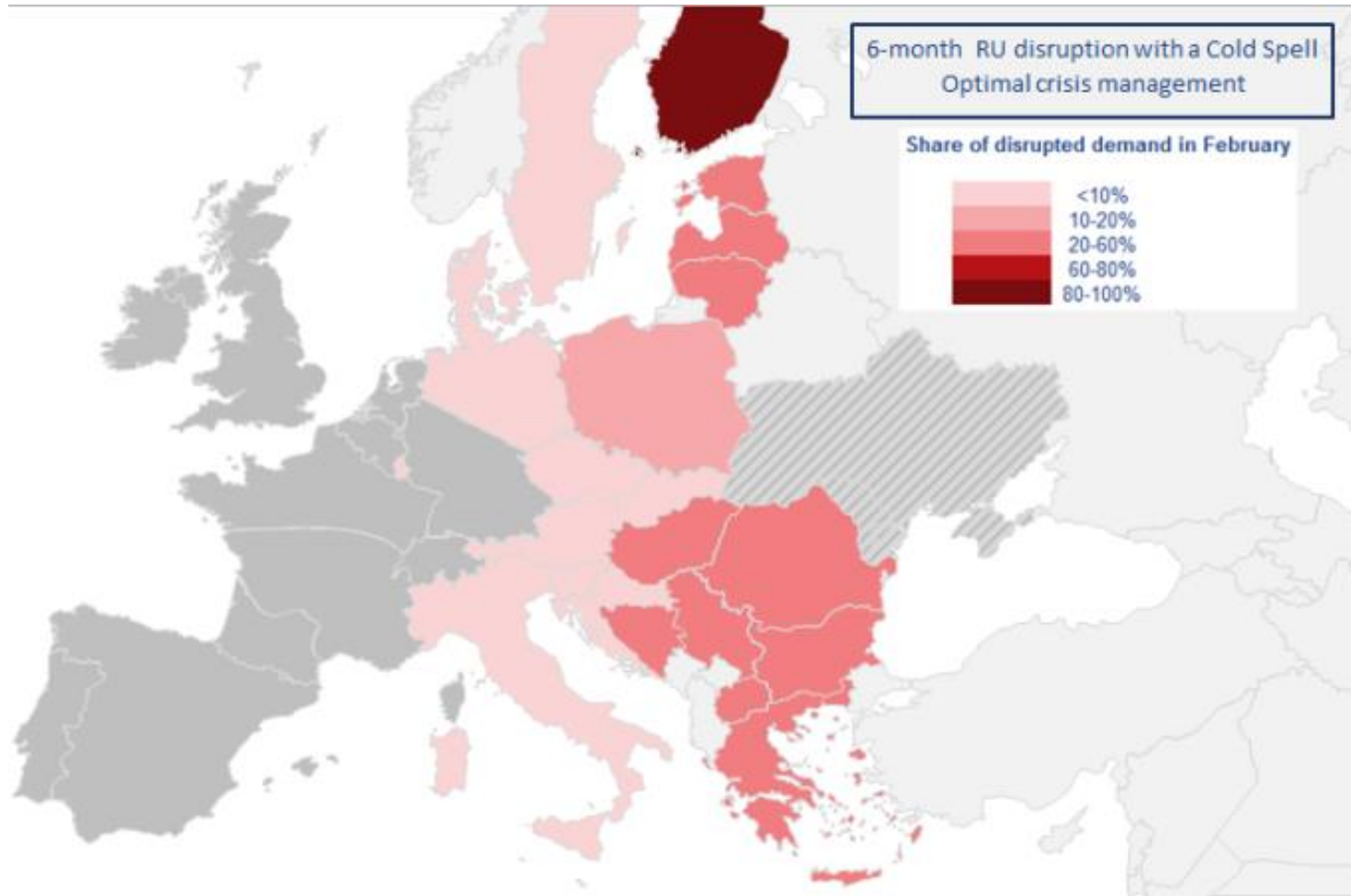
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Back-Up: Which Measures?

- **In principle a general energy market model should be employed to assess the role of each alternative**
- **High cost of modelling and limited model precision**
- **In fact, reliable results can be obtained by cost-based ranking of substitutes to missing supplies**
- **Significant cost differences entail that it is unlikely that the role of each alternative can be subject to major changes in the short term**
 - **purchase of spot supplies (mostly LNG);**
 - **resort to alternative, usually more costly and/or polluting energy sources (electricity, LPG, fuel oil, coal, fuelwood);**
 - **in extreme cases, the outage of energy supply, with industry activity halted and people left “in the cold”.**

ENTSOEG Stress Tests: expected deficit under worst scenario



Backup: Gas price modelling for legacy contracts

- **LNG and pipeline supply (Norway, partly Russia) in competitive and liquid markets to follow hub prices**
- **LNG & pipeline prices oil-related in other markets (estimated by Ref4E econometric models)**
- **Mix of oil- and hub-related prices used for each supply point, in line with best known information (IGU and research information)**
- **Oil prices unaffected by gas disruption scenarios**