European Commission

JRC Conference and Workshop Report

Training on methods for the implementation of the Regulation (EU) 2017/1938 on Security of Gas Supply and other related Regulations

Vienna,
24-25 April 2023

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2023

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Contents

Abstract

The Directorate C for Energy, Mobility and Climate of the European Commission Joint Research Centre (JRC) have organised together with the Energy Community a comprehensive training on "Methods for the implementation of the Regulation (EU) 2017/1938 on Security of Gas Supply and other related Regulations". This training was held in Vienna, Austria, on 24-25 April 2023. The objective of this training course, is to provide interested experts and organisations with the methods needed to implement the regulation. Specifically, the course provides practical guidelines to elaborate three important documents stemming from this regulation: the Risk Assessment, the Preventive Action Plan and the Emergency Plan. As a distinctive feature compared to previous editions, a description of the recently adopted regulations related to security of gas supply in the European Union has been presented. The training is very timely given that the Contracting Parties of the Energy Community should submit their respective Risk Assessments by 1 January 2024.

Acknowledgements

The authors are grateful for the help and active collaboration on the training on "Methods for the implementation of the Regulation (EU) 2017/1938 on Security of Gas Supply and other related Regulations" to the following experts:

— Mrs. Cegir Karolina, Senior Gas Expert of the Energy Community Secretariat.

— Mr. Grucijic Predrag, Head of Gas Unit of the Energy Community Secretariat.

— Mr. Florian Zink, Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology of the Republic of Austria.

— Mr. Andrii Prokofiev, Head of the Division of Cooperation with Clients of the Gas Transmission System Operator of Ukraine.

— Mrs. Ielyzaveta Badanova, Individual Consultant for the Ministry of Energy of Ukraine.

— Mr. Ronald Farmer, Senior Energy Expert & Crisis Coordinator at Energie-Control Austria (E-Control).

Last but not least, we would like to thank Mrs. Virginie Petitjean and Mrs. Dima Petrova, administrative assistants of the Unit C.3 of the Joint Research Centre of the European Commission, for their work devoted to the preparation of this training.

Authors

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Bolado Lavín, Ricardo (JRC C.3)

1 Introduction

The objective of this training course, is to provide interested experts and organisations with the methods needed to implement the Regulation (EU) 2017/1938 on Security of Gas Supply (SoGS) of the European Union (EU), hereinafter referred to as the Regulation. According to this Regulation, Member States have to develop a full *Risk Assessment* (RA) for their gas systems and to comply with Infrastructure and Supply Standards. Based on the results of both the RA and the Standards, Member States have to develop a *Preventive Action Plan* (PAP), to decrease the likelihoods and consequences of potential adverse events, and an *Emergency Plan* (EP), to manage adverse events once they occur.

The Contracting Parties of the Energy Community Treaty are also obliged to implement Regulation (EU) 2017/1938, with some modifications, which consist in removing some articles, particularly the ones related to regional cooperation and solidarity, and incorporating elements of the Regulation on gas storage (articles 6a to 6d of the Regulation as transposed by the Contracting Parties). The security of supply is part of the so-called “acquis communautaire” by which the Contracting Parties made legally binding commitments to adopt core EU legislation ([1]).

The course covers the main elements for implementing successfully the Regulation, namely the RA, the PAP, and the EP. In addition, it addresses, for the first time, aspects of legislation developed during 2022 in the SoGS field (Regulations (EU) 2022/1032, 2022/1369 and 2022/2576), although the only Regulation partially applicable to the Contracting Parties of the Energy Community is the new Gas Storage Regulation (EU) 2022/1032.

The training started with Mr. Predrag Grujicic, Head of Gas Unit at the Energy Community Secretariat, introducing the training and highlighting the perfect timing of the course because the national RA of the Contracting Parties of the Energy Community must be submitted by 1 January 2024, while the corresponding PAP and EP are due by 1 May 2024 ([2]).

Mr. Ricardo Bolado continued the training by introducing the political leadership of the European Commission (EC) and the Joint Research Centre (JRC), which is a directorate-general of the EC. Then, the purpose and priorities of the JRC were presented along with some relevant facts and figures.

The core of the training course started with an overview of the Regulation. Mr. Ricardo Bolado highlighted the importance of one of the first preceding directives, namely Council Directive 2004/67/EC. Later, the most important articles of the Regulation were briefly described along with two important definitions such as the one of protected customer, of utmost importance in case of emergency, and that one of competent authority, which must be designated by the Contracting Parties to ensure the correct implementation of the Regulation. The most important articles regarding the standards (infrastructure and supply), RA, the plans, and storage obligations (part of the transposed regulation by the Energy Community) were thoroughly described in subsequent sessions. Mr. Ricardo Bolado concluded the session by emphasising that (i) the Regulation (EU) 2017/1938 is a powerful tool to address SoGS, and (ii) it benefited from the accumulated experience of some crisis over the last 10 years. However, the Regulation is currently under revision by the European Commission because of the ongoing energy crisis started in the second half of 2021.

The training session about the gas RA in compliance with Regulation (EU) 2017/1938 established the minimum requirements and best practices to write a decent and well-organised RA. Mr. Ricardo Bolado referred to the Risk Management process ISO 31000:2018 as a guideline for the required RA since its structure fits well within the limits imposed by the Regulation when it comes to the elaboration of the RA. Hence, the very basic outline of this document is described in Annex V of the Regulation. It is proposed to structure it into four parts: (i) establishing the context, in which the system is described and the risk criteria are well-defined, (ii) risk identification, (iii) risk analysis, and (iv) risk evaluation. Two key ideas were conveyed to the audience. First, the roles and responsibilities should be clearly defined in advance. Second, it is desirable a quantitative risk analysis and evaluation over a qualitative one because the risks could be quantified without specifying fuzzy ranges.

Mr. Ricardo Bolado then explained in detail Articles 5 and 6 of the Regulation, which are devoted to the infrastructure standard (N-1) and supply standard, respectively. The infrastructure standard describes a simple arithmetic formula to provide one number which identifies whether the system could cope with a situation of peak demand and failure of the largest infrastructure. This number is referred to as N-1 and it

([1]) https://www.energy-community.org/legal/acquis.html.
([2]) https://www.energy-community.org/dam/jcr:55add297-389d-4367-9786-460c069db60b/19thMC_Decision15_GasSoS.pdf.

could be computed with market-based demand side measures and two different storage filling levels (at 100% and at 30%). The infrastructure standard does not capture internal network bottlenecks and it ignores physical aspects, therefore hydraulic simulations are presented as a solution to back up the resulting N-1 indicators. On the other hand, the supply standard safeguards the supply of gas to protected customers in three situations provided in the Regulation. Mr. Ricardo Bolado described then a potential methodology to estimate correctly the so-called Dmax ([3]) by using the Ukrainian system as a case study. The main idea to convey from this session is that the use of hydraulic simulations is of extremely importance to verify the correctness of the N-1 formula and that high-quality data should be utilised to implement them as accurately as possible.

Mr. Nicola Zaccarelli went through the basic concepts of probability and the design of scenarios. He stressed the difference between event and scenario, being the former the triggering cause of the latter. Then, Mr. Ricardo Bolado explained how to estimate probabilities for an RA. Sometimes, the estimation of probabilities may be simple when there are many available data (e.g. likelihood of a pipeline failure). However, one may resort to experts when there is (almost) no data (e.g. political-related events). Mr. Ricardo Bolado also emphasised that one should bear in mind the possible biased estimates of experts (cognitive, motivational and statistical). The session finished by reviewing some examples for estimating the probability of failure of a pipeline, compressor station or liquefied natural gas (LNG) regasification terminal. The main takeaways from the session are threefold: (i) a risk scenario is defined by two quantities, consequence and probability; (ii) a scenario is a combination of conditions (not an event); and (iii) probability estimation is essential albeit difficult for conducting a proper RA.

Mr. Ricardo Bolado followed the training by reviewing the main characteristics of a hydraulic gas transmission model in which pressures and flows are considered in the mathematical model. Two main types of models can be distinguished: steady-state in which variations over time are not accounted for in the mathematical formulation and unsteady-state or transient model in which such time variations are considered in the equations. Then, an application example of a scenario analysis with a hydraulic model was presented. The example was based on an already outdated gas system of Greece and Bulgaria ([4]). After that, Mr. Ricardo Fernández-Blanco gave a short introduction to mass balance models, which may deem useful when dealing with a large geographical coverage comprising several countries, or when including other energy carriers in the mathematical formulation. The main takeaway from this session is that hydraulic models are desirable when it comes to national RAs.

Another session was devoted to the last phase of an RA: risk evaluation. Mr. Ricardo Bolado deepened in the two possibilities available for completing this phase. One could resort to a qualitative risk evaluation by using the so-called risk matrix. However, as mentioned above, a quantitative risk evaluation is preferable because it is based on solid and knowledge-based risk estimates. In addition, quantitative assessments are recommended to indicate which measures must be implemented to decrease the risk below the pre-specified risk criteria.

After the RA, the two most important documents are the PAP and the EP. Mr. Nicola Zaccarelli presented the corresponding sessions for each of these two documents. The main goal of the former (PAP) is to identify preventive measures in order to feed them back to the RA so that the global risk could decrease. Mr. Nicola Zaccarelli emphasised the main contents of the PAP, which are part of Annex VI of the Regulation, as well as some general issues aroused from old PAPs (they are public documents).

The main goal of the EP is to describe the emergency management framework in case of need depending on the crisis level. Mr. Nicola Zaccarelli presented exhaustively the contents of the EP according to the Regulation by using good examples of old documents. As a main takeaway, the EP is an operational tool and therefore it should be clearly established who does what, what to do and when it should be done. For this very specific reason, a table-top exercise is recommended to clarify issues and identify potential gaps.

Two dedicated sessions were held by Mr. Ronald Farmer (Austria) and Mr Andrii Prokofiev and Mrs. Ielyzaveta Badanova (Ukraine) to explain their respective experiences in the implementation of the Regulation 2017/1938. Mr. Ronald Farmer explained in detail how Austria implements the main points of the Regulation. He started with the definition of protected customers, then he presented the infrastructure (N-1) and gas supply standard, and described the preparation of each one of the three documents (RA, PAP and EP).

Mr Andrii Prokofiev and Mrs. Ielyzaveta Badanova shared their experience on the implementation of rules of SoGS in Ukraine from the legal and technical perspectives. The timeline of this implementation dated back to

([3]) Dmax is the 1-in-20 daily peak demand.
([4]) This part has been excluded from the slides on purpose because it may contain sensitive information.

April 2015 when the law of Ukraine “On the Natural Gas Market of Ukraine” prescribed requirements of Regulation (EU) No 994/2010. They highlighted the Ukraine-JRC collaboration on this topic by which the RA has been prepared on an annual basis from 2016 until 2021 (together with standards of conduct and recommendations). This collaboration has been also materialised in the preparation of three table-top exercises for simulating a crisis scenario in the 2017-2021 period.

After revising thoroughly the main aspects of the Regulation (EU) 2017/1938, especially the three main documents for implementing it, i.e. the RA, the PAP, and the EP, Mr. Ricardo Fernández-Blanco presented the recently adopted regulations, which are to some extent related to the SoGS. In addition, one aspect of the Regulation that is typically forgotten in the PAPs of the EU Member States, i.e. the gas-electricity interaction, was also addressed in one of the last sessions.

Three regulations revolving around the Regulation on SoGS were adopted in 2022 as a consequence of the energy crisis. These legislative acts are (i) Regulation (EU) 2022/1032 amending Regulations (EU) 2017/1938 and (EC) No 715/2009 with regard to gas storage, (ii) Regulation (EU) 2022/1369 on coordinated demand reduction measures for gas, and (iii) Regulation (EU) 2022/2576 on enhancing solidarity through better coordination of gas purchases, reliable price benchmarks and exchanges of gas across borders. Mr. Ricardo Fernández-Blanco went over the contents of each one of these legislative acts and the impacts after their implementation in the European Union. Only the former regulation is applicable to the Contracting Parties of the Energy Community. For this reason, more implementation details were discussed in the oral presentation. The main takeaways of this session were: (i) the filling target trajectory should be provided by the countries themselves, and they should make sure that the trajectory is technically feasible, i.e. it fulfils the injection capacity curve; (ii) demand reduction is deemed a successful measure to mitigate risk of curtailment and face subsequent winters; and (iii) it seems that countries encounter challenges to attain a compromise about the solidarity agreements, although they are not applicable to the Contracting Parties of the Energy Community.

Mr. Ricardo Fernández-Blanco continued with a short introduction about the reasons why the electricity-gas nexus has been increasingly important in Europe. The Regulation recognises the increasing role of gas in electricity production by introducing the concept of critical gas-fired power plant. Mr. Ricardo Fernández-Blanco provided the regulatory framework of the critical gas-fired power plants, followed by a preliminary methodology proposal and an illustrative example with a synthetic electricity network. Lastly, the critical gas volumes, as presented in Regulation (EU) 2022/2576 on enhancing solidarity, were defined as the critical gas volume for electricity security of supply. The regulatory framework, the methodology proposed by the European Network of Transmission System Operators for Electricity (ENTSOE) and the results for the last winter 2022-2023 were briefly described.

The final session was devoted to presenting the transposition status quo in the Energy Community by Mr. Predrag Grujicic. He concluded the training course.

The document is organised as follows. Section 1 introduces the purpose of this training course and briefly explains each of the sessions. Section 2 provides the list of participants. Section 3 shows the programme of the training course. Section 4 provides the material of the training course. Finally, Section 5 highlights the main conclusions from this edition.

2 List of participants

Table 1 provides the list of participants to the training course including the organisers from the European Commission Joint Research Centre and Energy Community Secretariat.

Table 1. List of attendants, speakers and instructors.

#	Country	Last name	First name
1	Moldova	ANDRONIC	Ion
2	Serbia	ANTICC MIOCINOVIC	Olga
3	Bosnia and Herzegovina	ASONJA	Goran
4	Ukraine	BADANOVA	Ielyzaveta
5	North Macedonia	CELESKA	Maja
6	North Macedonia	DAMCHESKA-MAKSIMOVSKA	Ljupka
7	Montenegro	DJURANOVIC	Zarko
8	Albania	TRASJA	Eral
9	Bosnia and Herzegovina	FILIPOVIC	Belma
10	Ukraine	HORIUSHKO	Dmytro
11	Serbia	IVEZIC	Dejan
12	Georgia	KARDAVA	Nugzari
13	Bosnia and Herzegovina	KORDIC	Tanja
14	Georgia	MAKHARASHVIILI	Maia
15	Georgia	NALCHEVANIDZE	Otari
16	North Macedonia	NIKOLOVSKI	Goran
17	Moldova	NOLINA	Pomparau
18	Serbia	POPADIC	Aleksandar
19	Ukraine	PROKOFIEV	Andrii
20	Serbia	RISTIC	Snezana
21	Ukraine	SHYKERYNETS	Roman
22	Moldova	STRATULAT	Elena
23	Serbia	TUBIN-MITROVIC	Branka
24	Albania	GJERMANI	Ilia
25	Germany	ZACCARELLI	Nicola
26	Netherlands	FERNÁNDEZ-BLANCO CARRAMOLINO	Ricardo
27	Netherlands	BOLADO LAVÍN	Ricardo
29	Austria	FARMER	Ronald
30	Austria	ZINK	Florian
31	Austria	PREDRAG	Grujicic
32	Austria	CEGIR	Karolina

3 Programme of the training course

European Commission

Agenda

Monday, April 24th, 2023

REGISTRATION IN THE TRAINING COURSE

09:00-09:30 *Registration*

09:30:00-09:35 **Welcome by Energy Community Secretariat**

- P. Grujicic & K. Cegir

INTRODUCTION TO REGULATION 2017/1938

09:35 – 09:50 **Welcome presentation. EC DG-JRC overview. Scope of the training course.**

- R. Bolado (*European Commission; JRC, Directorate C)*

09:50 – 10:20 **Overview of Regulation 2017/1938.**

- R. Bolado (*European Commission; JRC, Directorate C)*

REGULATION 2017/1938; NATIONAL RISK ASSESSMENTS AND STANDARDS

10:20 – 11:05 **Gas risk assessment in compliance with Regulation 2017/1938. Minimum requirements and best practices**

- R. Bolado (*European Commission, JRC, Directorate C)*

11:05 – 11:20 Coffee break

11:20 – 12:05 **The Standards: Infrastructure standard (N-1) and supply standard**

- N. Rodriguez (*European Commission, JRC, Directorate C)*

12:05 – 12:30 **Questions and discussion**

- All

12:30 – 14:00: Lunch

Joint Research Centre

European Commission

MODELS FOR ESTIMATING CONSEQUENCES AND PROBABILITIES IN RISK ASSESSMENTS

14:00 – 14:45 **Scenario design and estimation of probabilities in a Risk Assessment**
- R. Bolado (European Commission, JRC, Directorate C)

14:45 – 15:30: **Modelling tools** (hydraulic models and other types of models)
- N. Rodriguez and R. Fernández-Blanco Carramolino (European Commission, JRC, Directorate C)

15:30 – 15:45 Coffee break

15:45 – 16:15 **Risk evaluation**
- R. Bolado (European Commission, JRC, Directorate C)

REGULATION 2017/1938; PLANS (PREVENTIVE ACTION PLAN & EMERGENCY PLAN) SESSION

16:15 – 16:45 **Preventive Action Plan according to Regulation (EU) 2017/1938**
- N. Zaccarelli *(Encoord)*

16:45 – 17:15 ***Day summary; questions and debate.***
- All (coordinated by K. Cegir and R. Bolado)

19:00 Social dinner

Joint Research Centre

European Commission

Tuesday, April 25th, 2023

09:00 – 09:30: **Emergency Plan according to Regulation 2017/1938**
- N. Zaccarelli (*Encoord)*

RELATED REGULATIONS

09:30 – 10:00 **Regulations (EU) 2022/1032, 2022/1369 & 2022/2576; links to SoS**
- R. Fernández-Blanco Carramolino and N. Rodríguez (*European Commission, JRC, Directorate C)*

EU NATIONAL EXPERIENCE SESSION

10:00 – 10:30: **Austria's experience implementing the Regulation; national peculiarities.**
- R. Farmer (*E-control)*

10:30 – 10:45 Coffee break

10:45 – 11:15: **Ukraine's experience implementing the Regulation; national peculiarities.**
- A. Prokofiev (*Gas TSO of Ukraine)*

11:15 – 11:45: **The interaction gas-electricity, insights, approaches and available models**
- R. Fernández-Blanco Carramolino (*European Commission, JRC, Directorate C)*

11:45 – 12:00 **Update on Energy Community last advancements**
- P. Grucijic (*Energy Community Secretariat, Austria*)

12:00 – 12:30 **Final discussion**
- All (coordinated by P. Grucijic and R. Bolado)

12:30 Training course closure
- R. Bolado (*European Commission, JRC, Directorate C)*

Joint Research Centre

European Commission

JOINT RESEARCH CENTRE
Directorate C for Energy, Mobility and Climate

Training on methods for the implementation of the Regulation (EU) 2017/1938 on Security of Gas Supply and other related Regulations

Date, Place and duration: April 24th – 25th, 2023, Energy Community Secretariat, Am Hof 4, VI floor, Vienna, Austria. 1 ½ days;

Deadline for application March 27th, 2023

Target deadline for results of selection March 29th, 2023

Participants profile: regulators, national energy administrations, transmission system operators, research institutes and academia

Funding
The Commission reserves the right to decide on a case-by-case basis - depending always on the available budget - the granting of such reimbursement of expenses. Participants may be entitled to reimbursement of their expenses in case they are directly (explicitly) invited by the organizer in order to contribute to the workshop's objectives.

Please send accompanying application, including a one-page CV (second page of the application form) to:
Virginie.petitjean@ec.europa.eu

For matters relating to content of workshop:
ricardo.bolado-lavin@ec.europa.eu –or- nuria.rodriguez-gomez@ec.europa.eu

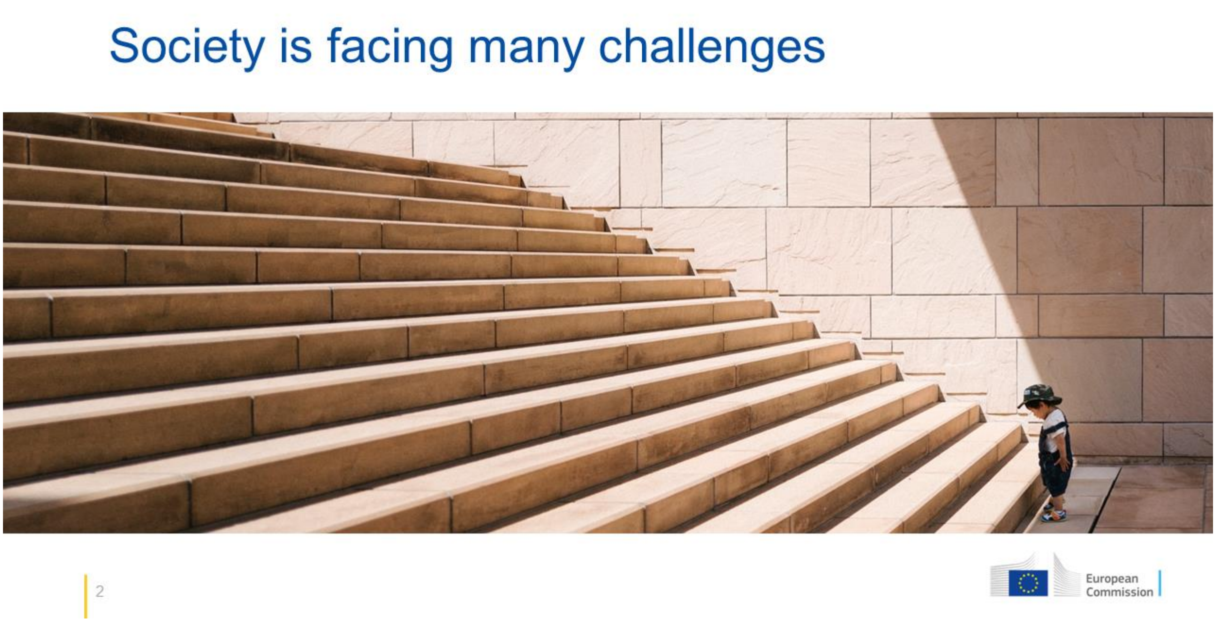
Joint Research Centre

4 Presentations

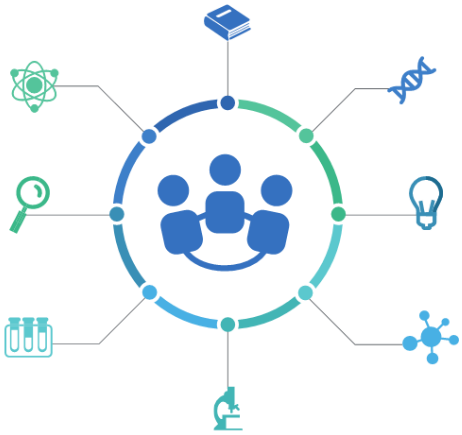
The following subsections provide the material of the training course.

4.1 Welcome presentation by the Joint Research Centre

Mr. Ricardo Bolado was the speaker of this session.



The need for evidence to inform policy



3

European Commission

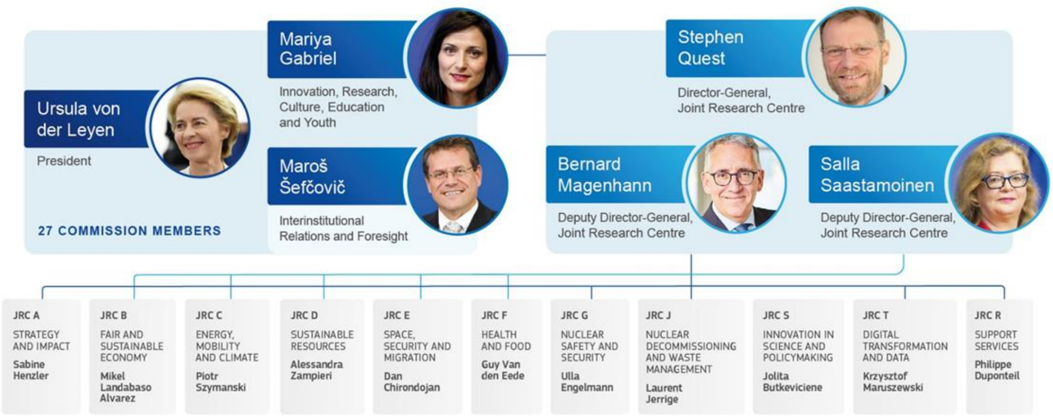
The European Commission’s political leadership

#Eustrivesformore #vdLcommission

4

European Commission

The Joint Research Centre within the Commission



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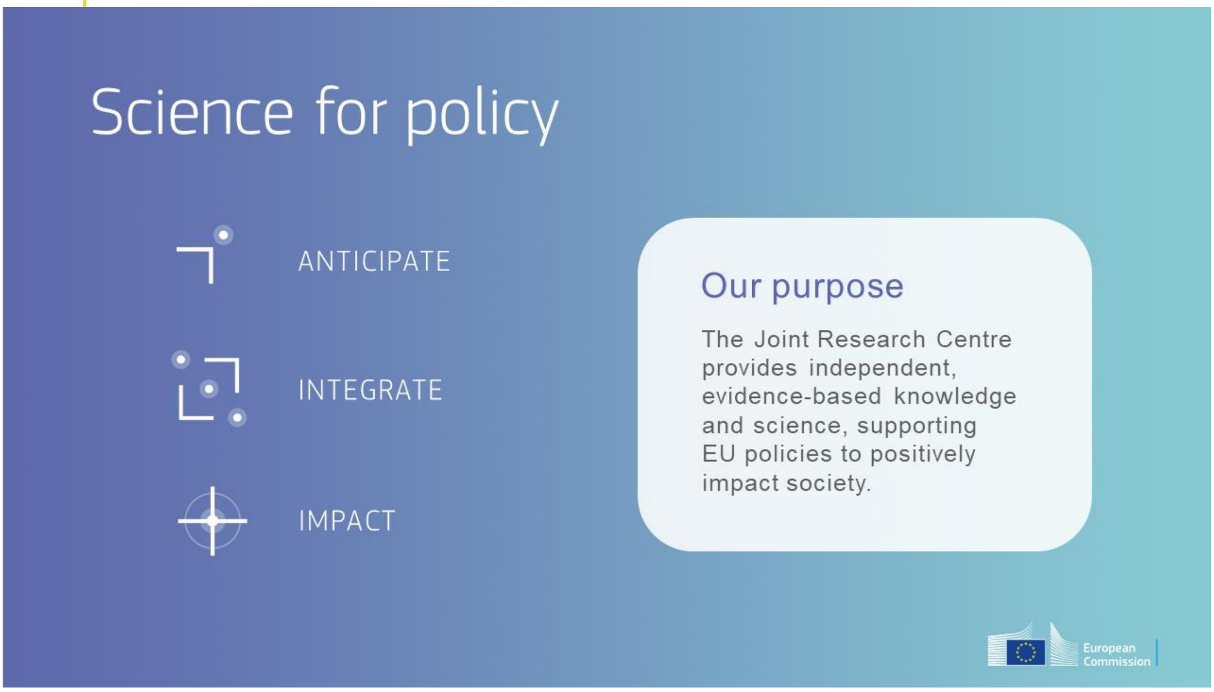

Our role

- **Independent** of private, commercial or national interests
- Works for more than **40 European Commission's policy departments**

European Commission

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JRC sites

Headquarters in **Brussels** and research facilities located in **5 Member States:**

- Belgium (Geel)
- Germany (Karlsruhe)
- Italy (Ispra)
- The Netherlands (Petten)
- Spain (Seville)

European Commission

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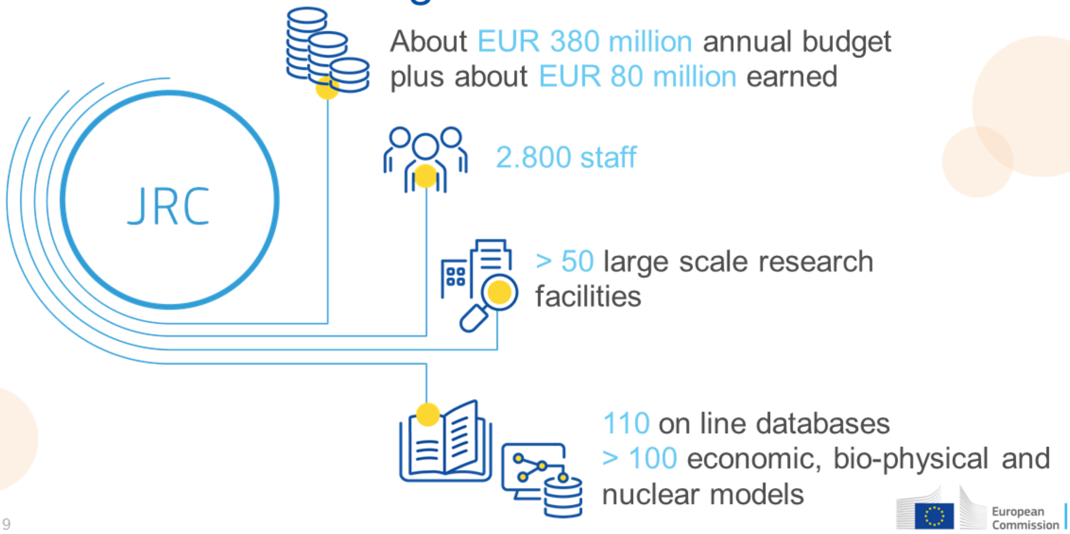
JRC – Facts and figures



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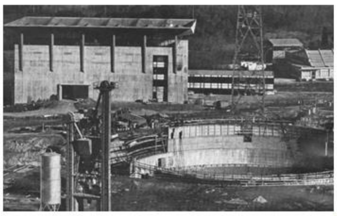
JRC History

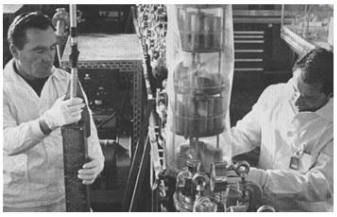
JRC: the birth

Ispra, 1962 – Euratom's Scientific Data Processing Centre: any nuclear installation requires electronic equiment.



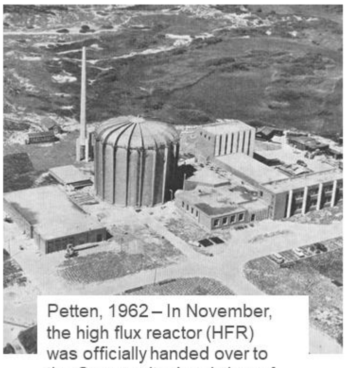
Ispra, 1963 – The ECO reactor and the ESSOR reactor construction site.

Ispra, 1966 – Decontamination of Ispra-1 reactor.

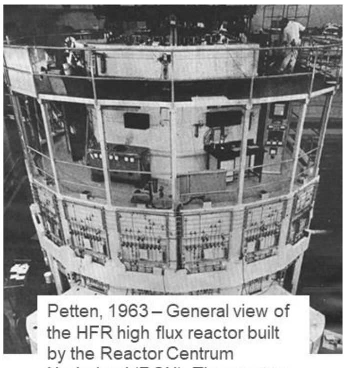


Ispra, 1967 – Metallurgy Department: two technicians placing uranium carbide in the special airtight containers.

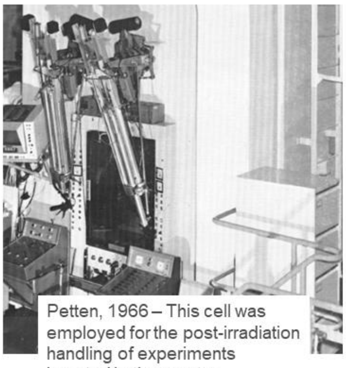
JRC: the birth



Petten, 1962 – In November, the high flux reactor (HFR) was officially handed over to the Community. Areal view of reactor and its auxiliary laboratories.



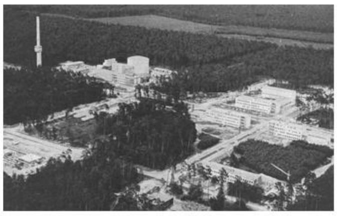
Petten, 1963 – General view of the HFR high flux reactor built by the Reactor Centrum Nederland (RCN). The reactor went into operation at the end of 1962.

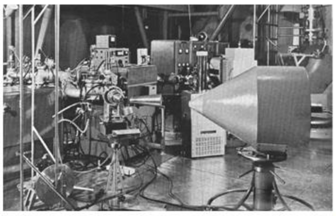


Petten, 1966 – This cell was employed for the post-irradiation handling of experiments inserted in the reactor.

JRC: the birth

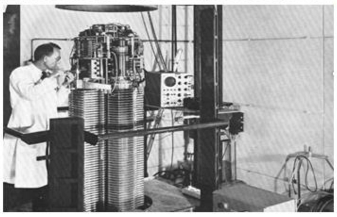
Karlsruhe, 1962 - The European Transuranium Institute building was to be built near the German nuclear research centre.





Geel, 1963 – Central Nuclear Measurements Bureau (CNMB). The hall of the Van de Graaff accelerator put into service at the end of 1963.

Karlsruhe, 1965 - This furnace was used chiefly for melting alloys of uranium or thorium with low plutonium contents, under vacuum at high temperatures.



Geel, 1969 – The accelerator was an essential piece of equipment used in the study of neutron data, knowledge of which was fundamental especially to develop fast reactors.

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European Commission

4.2 Overview of Regulation 2017/1938

The lecturer of this session was Mr. Ricardo Bolado.

Contents

- **Introduction**
- **Articles (23)**
- **Annexes (VIII)**

2

European Commission

Introduction; Council Directive 2004/67/EC

Clear acknowledgement of

- Importance of natural gas in the EU energy system
- Dependence on external gas suppliers

It was a Directive (transposed by MS into their national legislation); 5 pages.

Definitions:

- ‘Long-term gas supply contract (Duration > 10 y)’
- ‘Major supply disruption’ (losses > 20% of gas supply from supply countries)

Introduction; Council Directive 2004/67/EC

Elements

Policies for securing gas (list of good practice)

Security of supply for specific customers

Member States (MS) shall ensure supply to households

- During partial disruptions of national gas supplies (duration to be determined by each MS)
- Extremely cold temperatures (nationally determined peak period)
- Periods of very high demand (1-in-20 years)

Reporting (periodic, on measures and their impact)

Creation of the Gas Coordination Group (GCG; MS, Industry, chaired by EC)

Development of National emergency measures

Community mechanism (suppor of GCG to MS in case of gas crisis)

Introduction; Early 2009 crisis

Start on 01-01-2009. Stop supply to Ukraine (UA) only (gas transit continues)

02-01-2009 – 06-01-2009. Increase of cuts of gas (mutual accusations GAZPROM - NAFTOGAZ)

07-01-2009. Full interruption of flows

07-01-2009 – 19-01-2009. Negotiations

20-01-2009. Deliveries resumed

Other measures

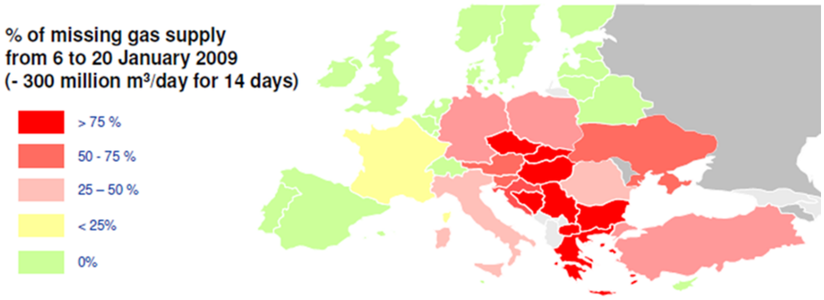
Storage

LNG (Atlantic basin glut)

Increase of Yamal & Blues Stream

Reverse flow CZ ➔ SK (+10 days)

Reverse flow UA (west to east)



5

Introduction; Lessons learnt from 2009 crisis

Council Directive 2004/67/EC proved to be **ineffective** to deal with this big gas crisis (largest ever gas crisis in the EU)

The Atlantic Basin was full of LNG vessels

There was a lot of gas in storage

It was just extremely difficult move it eastwards

Need of real coordinated effort

Good news:

In little more than 1½ year a Regulation (EU) 994/2010 was enacted, later replaced by Regulation (EU) 2017/1938

European Commission

6

Article 1; subject matter

This Regulation lays down rules for cooperation between Contracting Parties with a view to preventing, mitigating and managing gas crises in full regard for the requirements of a competitive single market for gas

European Commission

7

Article 2; definitions

5) **'protected customer'** means a household customer who is connected to a gas distribution network and, in addition, where the **Contracting Party** concerned so decides, may also mean one or more of the following, provided that enterprises or services as referred to in points (a) and (b) do not, jointly, represent more than 20 % of the total annual final gas consumption in that **Contracting Party**:

- a. a small or medium-sized enterprise, provided that it is connected to a gas distribution network;
- b. an essential social service, provided that it is connected to a gas distribution or transmission network;
- c. a district heating installation to the extent that it delivers heating to household customers, small or medium-sized enterprises, or essential social services, provided that such installation is not able to switch to other fuels than gas;

7) **'competent authority'** means a national governmental authority or a national regulatory authority designated by a **Contracting Party** to ensure the implementation of the measures provided for in this Regulation;

European Commission

Articles 3 & 4;

- **Article 3:** Responsibility for the security of gas supply
  - Natural gas undertakings
  - Contracting parties
    - Through Competent Authority (to be notified to EnC Secretariat)
      - Capacity of delegating tasks
  - EnC Secretariat

- **Article 4:** Security of Supply Coordination Group;
  - To be consulted by EnC secretariat
  - To be convened on regular basis

European Commission

Article 5; Infrastructure Standard

- **Mission:** Safeguard the supply of all gas customers in situation of peak demand and failure of largest infrastructure
  - N-1 formula
  - N-1 formula with market-based demand side measures
  - N-1 formula at 100% and at 30% gas storage levels
  - Importance of data availability / collection
  - Permanent bi-directional capacity
    - exemptions

10

European Commission

Article 6; Supply Standard + Storage obligation

- **Mission:** Safeguard the supply of gas to Protected Customers (PC) in case of
  - (a) extreme temperatures during a 7-day peak period occurring with a statistical probability of once in 20 years;
  - (b) any period of 30 days of exceptionally high gas demand, occurring with a statistical probability of once in 20 years;
  - (c) for a period of 30 days in the case of disruption of the single largest gas infrastructure under average winter conditions.
- Importance of data availability / collection
- Increased Supply Standard only under specific conditions
- **Mission**: Safeguard gas supply to all customers during winter.
  - Filling targets and filling trajectories + implementation
  - Storage arrangements and burden-sharing mechanisms
  - Monitoring and enforcement

11

European Commission

Article 7; Risk Assessment

- **Mission:** Assess gas system Risk
  - Infrastructure Standard
  - Take into account all relevant circumstances
  - Consider scenarios
  - Identify correlated risks
  - …
  - To be delivered by 01-01-2024
    - And every 4 years afterwards, …, unless more frequent updates be needed

12

European Commission

Article 8 - 11; The Plans

- **Mission:** Develop actions to decrease the gas system Risk
  - Preventive Action Plan (PAP)
    - Decrease the probability of undesired scenarios
    - Decrease the consequence of an scenario a priori
  - Emergency Plan (EP)
    - Decrease the consequence of an scenario when it takes place
  - Declaration of crisis
    - Three crisis levels:
      - Early warning (significant deterioration of the gas supply situation)
      - Alert (market based measures still enough to deal with the situation)
      - Emergency (need of deploying non-market-based measures)

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Rest of articles

- Information exchange (14)
- Professional secrecy (15)
- Monitoring (17)
  - Reporting
- Notifications (18)
- Derogation (20)
- Repeal (21)
- Entry into force (22)
- Review (23)
- Annexes

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European Commission

Conclusions

Regulation (EU) 2017/1938 is a powerful tool to address security of gas supply

This Regulation benefits from the experience accumulated over a long period (10+ years), several crises and quasi-crises included.

Tool under analysis by the EC

European Commission

4.3 Gas risk assessment in compliance with Regulation 2017/1938. Minimum requirements and best practices

The lecturer of this session was Mr. Ricardo Bolado.

Regulation (EU) 2017/1938 obligations

Identify Competent Authority

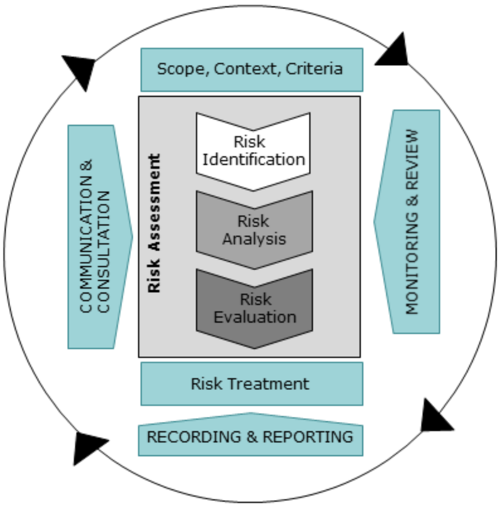
Define Protected Customers

Install bi-directional capacity on cross-border pipelines

Adhere to Infrastructure (N-1) and Supply Standards

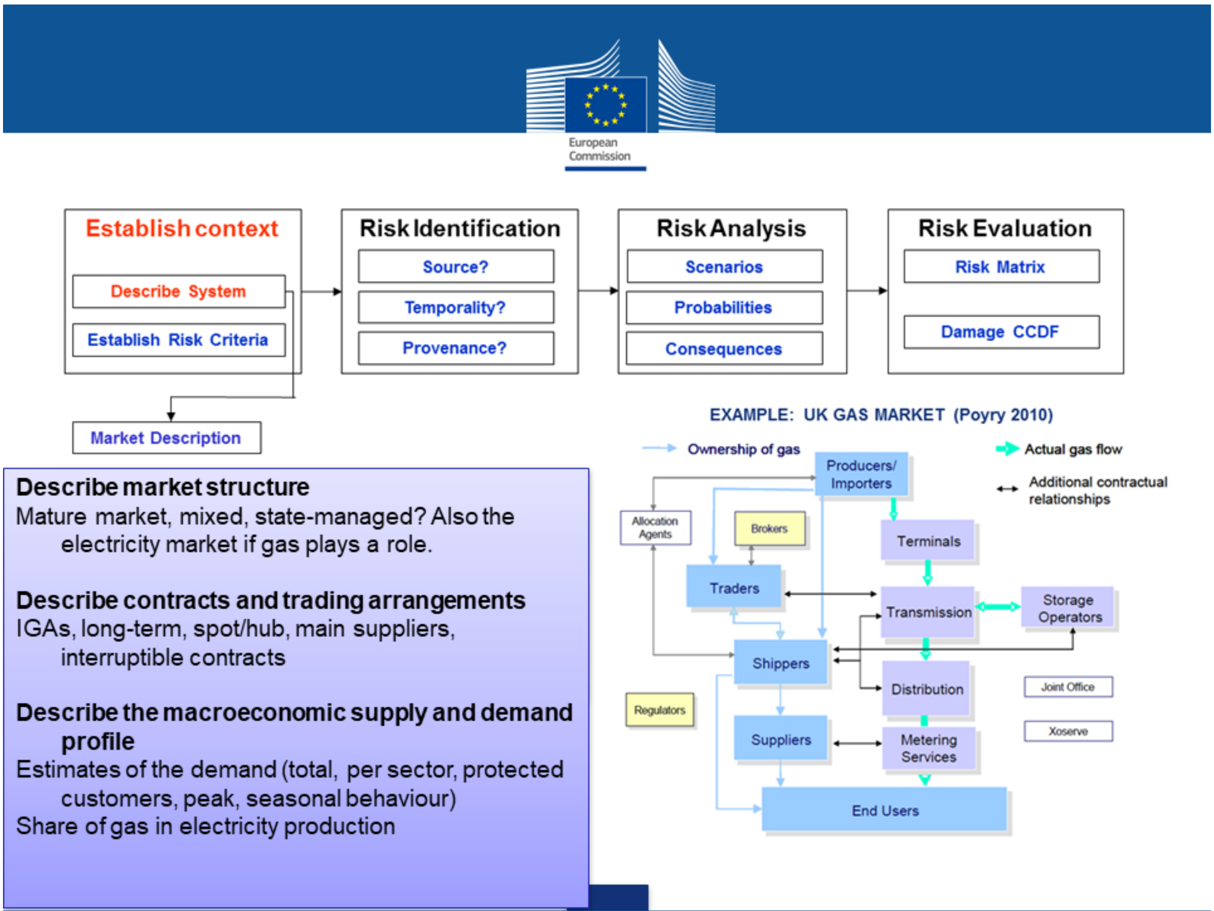
Carry out a Risk Assessment

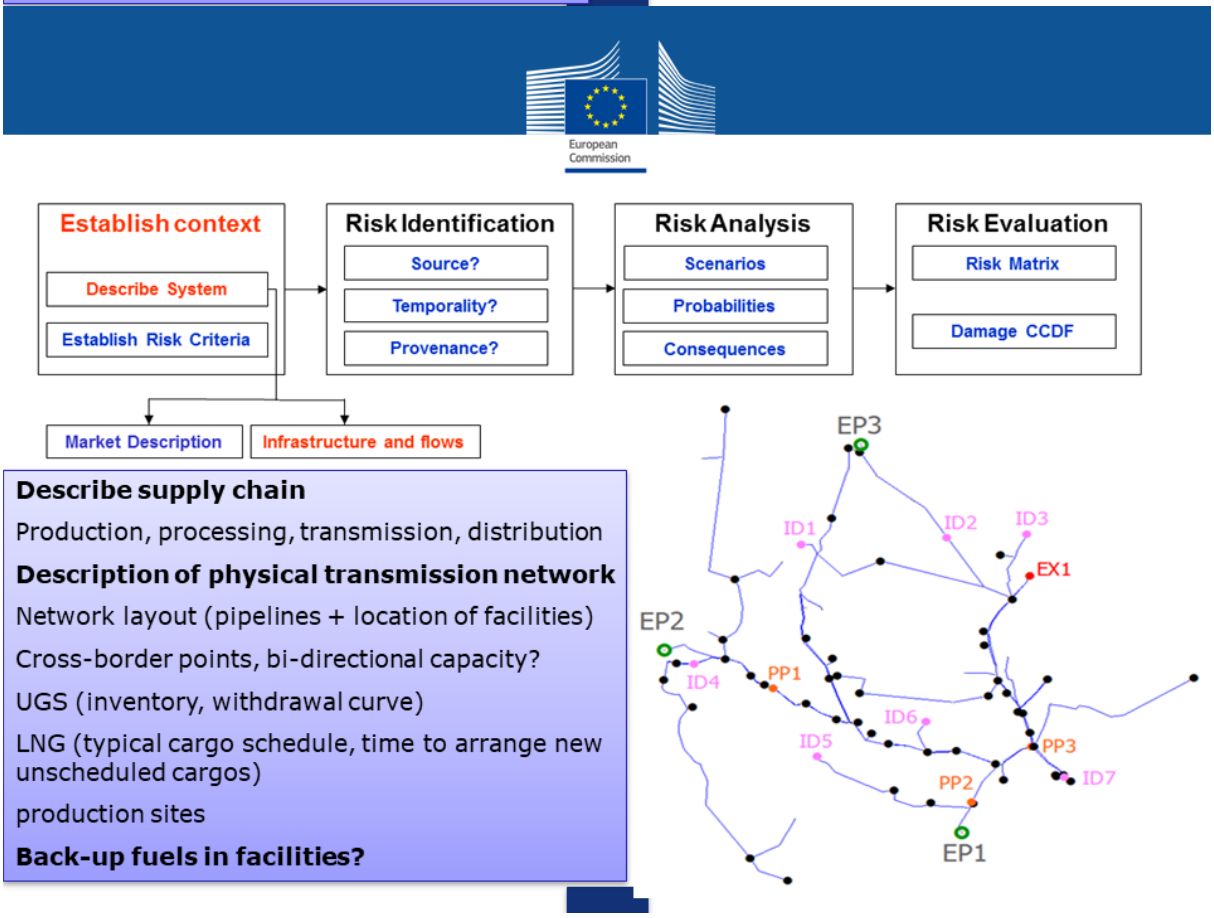
Formulate Emergency and Preventive Action Plan



Risk Management process ISO 31000:2018

4


European Commission
Establish context
Describe System
Establish Risk Criteria
Market Description
Risk Identification
Source?
Temporality?
Provenance?
Risk Analysis
Scenarios
Probabilities
Consequences
Risk Evaluation
Risk Matrix
Damage CCDF
Describe market structure
Mature market, mixed, state-managed? Also the electricity market if gas plays a role.
Describe contracts and trading arrangements
IGAs, long-term, spot/hub, main suppliers, interruptible contracts
Describe the macroeconomic supply and demand profile
Estimates of the demand (total, per sector, protected customers, peak, seasonal behaviour)
Share of gas in electricity production
EXAMPLE: UK GAS MARKET (Poyry 2010)
Ownership of gas
Actual gas flow
Additional contractual relationships
Producers/ Importers
Allocation Agents
Brokers
Terminals
Traders
Transmission
Storage Operators
Shippers
Distribution
Joint Office
Regulators
Suppliers
Metering Services
Xoserve
End Users


European Commission
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Infrastructure and flows
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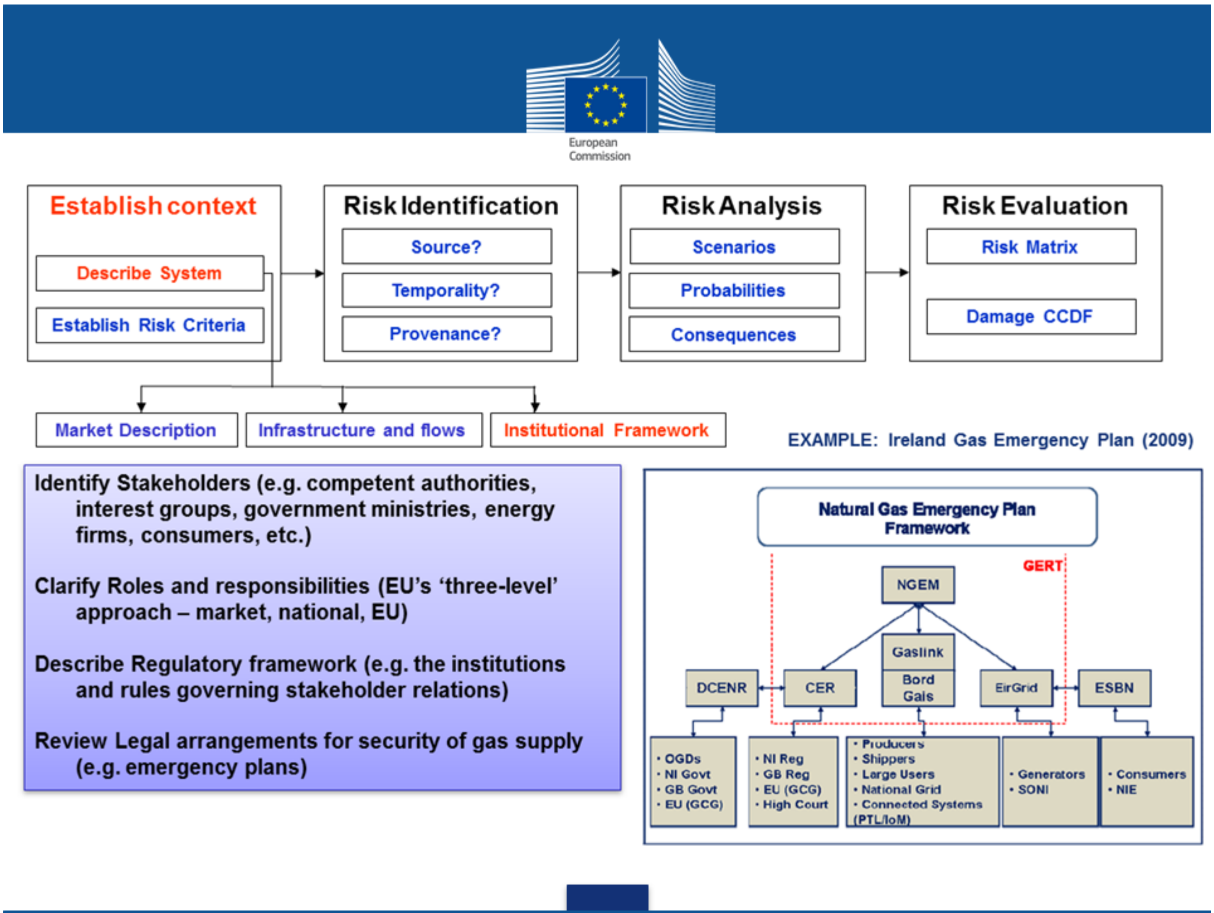
Describe supply chain
Production, processing, transmission, distribution
Description of physical transmission network
Network layout (pipelines + location of facilities)
Cross-border points, bi-directional capacity?
UGS (inventory, withdrawal curve)
LNG (typical cargo schedule, time to arrange new unscheduled cargos)
production sites
Back-up fuels in facilities?
EP3
ID1
ID2
ID3
EX1
EP2
ID4
PP1
ID6
ID5
PP3
ID7
PP2
EP1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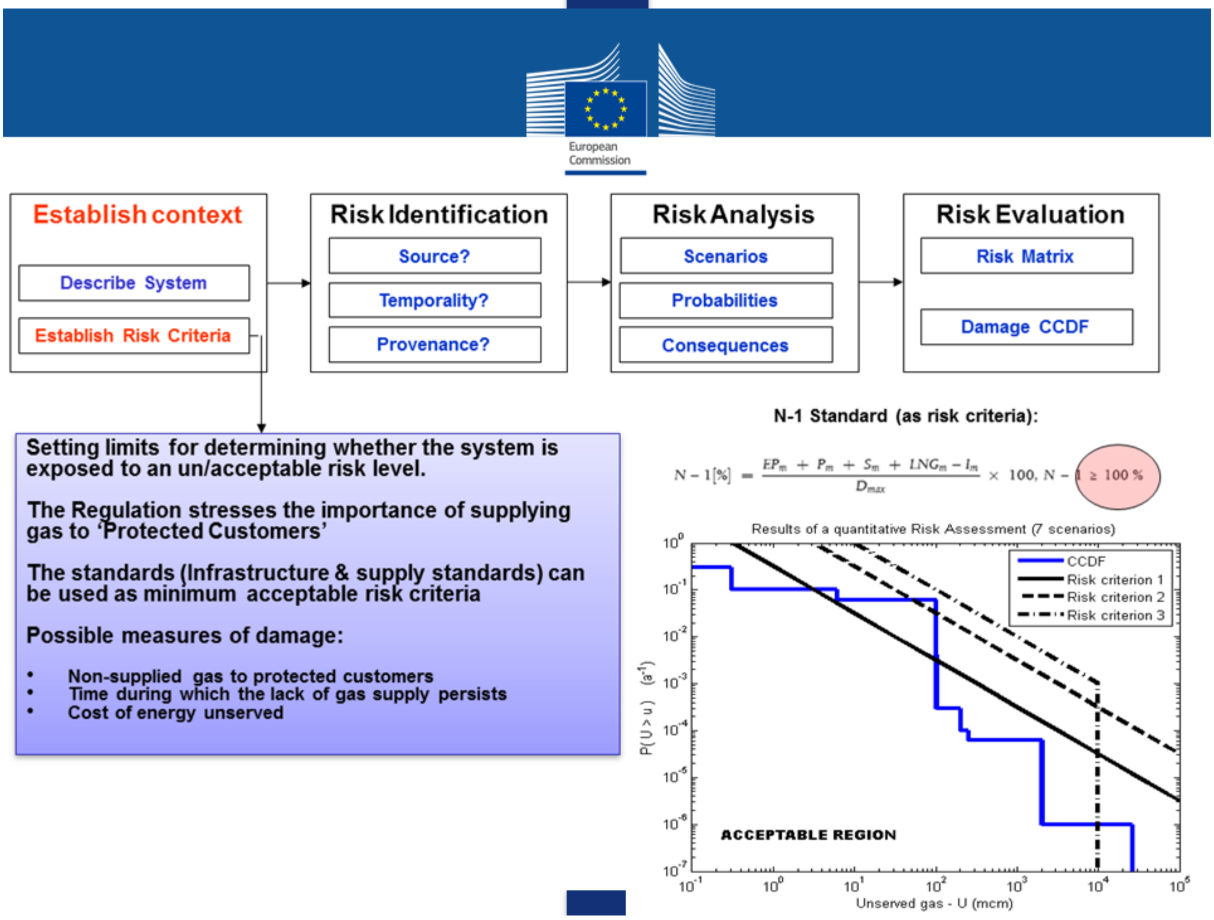
Market Description
Infrastructure and flows
Institutional Framework
Identify Stakeholders (e.g. competent authorities, interest groups, government ministries, energy firms, consumers, etc.)
Clarify Roles and responsibilities (EU's 'three-level' approach – market, national, EU)
Describe Regulatory framework (e.g. the institutions and rules governing stakeholder relations)
Review Legal arrangements for security of gas supply (e.g. emergency plans)
EXAMPLE: Ireland Gas Emergency Plan (2009)
Natural Gas Emergency Plan Framework
GERT
NGEM
Gaslink
Bord Gais
DCENR
CER
EirGrid
ESBN
• OGDs • NI Govt • GB Govt • EU (GCG)
• NI Reg • GB Reg • EU (GCG) • High Court
• Producers • Shippers • Large Users • National Grid • Connected Systems (PTL/IoM)
• Generators • SONI
• Consumers • NIE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Setting limits for determining whether the system is exposed to an un/acceptable risk level.
The Regulation stresses the importance of supplying gas to 'Protected Customers'
The standards (Infrastructure & supply standards) can be used as minimum acceptable risk criteria
Possible measures of damage:
• Non-supplied gas to protected customers
• Time during which the lack of gas supply persists
• Cost of energy unserved
N-1 Standard (as risk criteria):
$N-1[\%] = \frac{EP_m + P_m + S_m + LNG_m - I_m}{D_{max}} \times 100,\ N-1 \geq 100\,\%$
Results of a quantitative Risk Assessment (7 scenarios)
CCDF
Risk criterion 1
Risk criterion 2
Risk criterion 3
ACCEPTABLE REGION
P(U > u) (a⁻¹)
Unserved gas - U (mcm)

European Commission

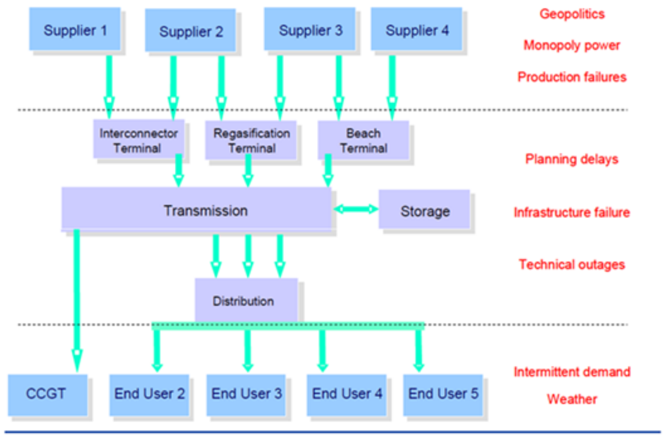
Establish context
- Describe System
- Establish Risk Criteria

Risk Identification
- Source?
- Temporality?
- Provenance?

Risk Analysis
- Scenarios
- Probabilities
- Consequences

Risk Evaluation
- Risk Matrix
- Damage CCDF

- Make an exhaustive identification of threats and hazards
- Avoid risk underestimation
- Common techniques:
  - Brainstorming
  - Structured and semi-structured interviews
  - Hazard and operability analysis (HAZOP)
  - Failure mode and effects analysis (FMEA)



European Commission

Establish context
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The set of scenarios should be exhaustive and mutually exclusive

Each scenario is a non-negligible combination of events and/or processes, together with a set of boundary conditions

Scenarios definition is based on expert judgement

EXAMPLE: EWI EU Energy Market Study (2010)

Scenarios

ewi

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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Establish context	Risk Identification	Risk Analysis	Risk Evaluation
Describe System	Source?	Scenarios	Risk Matrix
Establish Risk Criteria	Temporality?	Probabilities	Damage CCDF
	Provenance?	Consequences	

Two options: Quantitative & qualitative

1) Qualitative scales:
Very low; low; medium; high; certainty

2) Quantitative tools:
1. Classical inference methods
2. Bayesian inference methods
3. Expert Judgement
4. Event tree and fault tree analyses

1. Event likelihood ~ $P(E_i)$
2. Duration likelihood ~ $P(Du_i|E_i)$
3. Demand likelihood ~ $P(De_i|E_i \cap Du_i)$
4. Total likelihood ~ $P(S_i)$

$$P(S_i) = P(E_i \cap Du_i \cap De_i) = P(E_i)\, P(Du_i|E_i)\, P(De_i|E_i \cap Du_i)$$

European Commission

Establish context	Risk Identification	Risk Analysis	Risk Evaluation
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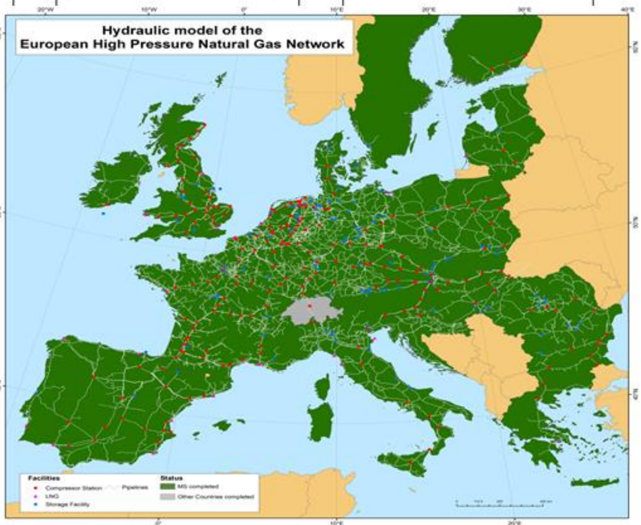
The assessment of consequences

Modelling energy security disruptions

Expert judgement (when models/data are unavailable or of poor quality)

The selection of scales (either quantitative or qualitative)

In some cases, uncertainty has to be explicitly acknowledged (possible use of Monte Carlo)



Establish context
- Describe System
- Establish Risk Criteria

→ Risk Identification
- Source?
- Temporality?
- Provenance?

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The assessment of consequences

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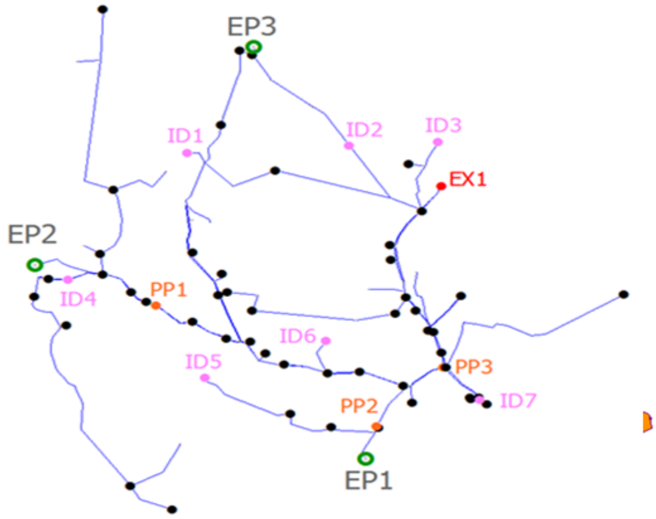

Establish context
- Describe System
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→ Risk Identification
- Source?
- Temporality?
- Provenance?

→ Risk Analysis
- Scenarios
- Probabilities
- Consequences

→ Risk Evaluation
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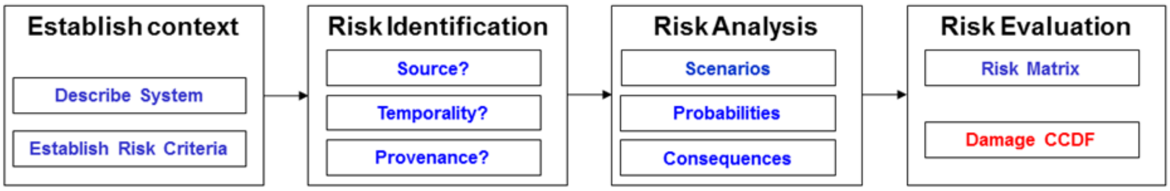
The Risk Matrix

Risks or threats of little consequence or remote probabilities are not further Considered (green)

Risks that are moderately probable or of some consequence are considered with low to moderate priority (yellow)

Risks that are probable and of serious (red) consequences should be treated first, in a preventive action and emergency plan.

probabilities \ consequences	1	2	3	4	5
5	0	0	0	0	0
4	44	8	0	0	4
3	55	38	0	3	11
2	84	41	1	2	18
1	45	26	0	2	9



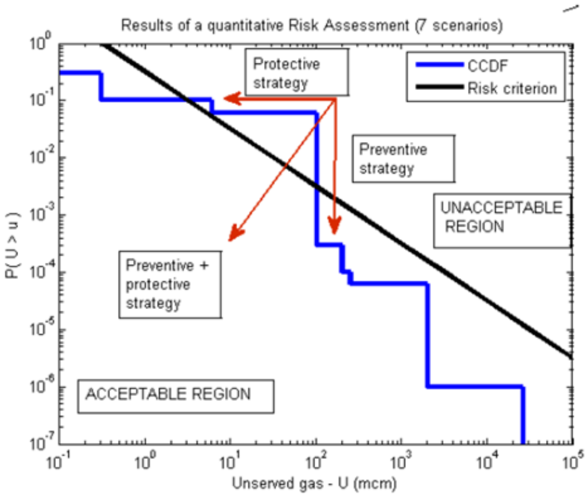


Table 1. Results of a hypothetical quantitative RA.

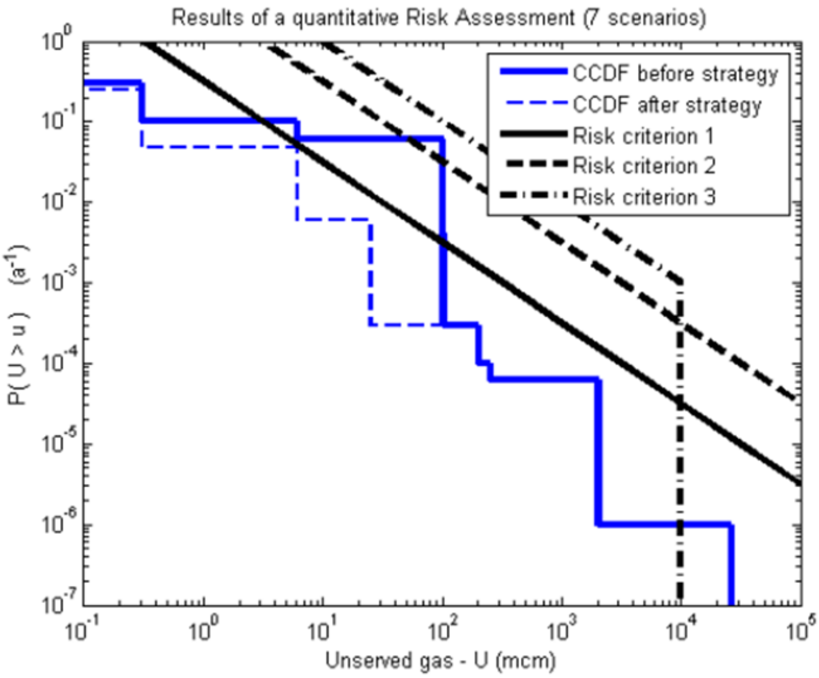
Scenario	Probability (a^{-1})	Unserved gas (mcm)	Expected Unserved gas (mcm/a)
SC1	$2 \cdot 10^{-1}$	$3 \cdot 10^{-1}$	0.060
SC2	$4 \cdot 10^{-2}$	$6 \cdot 10^{0}$	0.240
SC3	$6 \cdot 10^{-2}$	$1 \cdot 10^{2}$	6.000
SC4	$2 \cdot 10^{-4}$	$2 \cdot 10^{2}$	0.040
SC5	$4 \cdot 10^{-5}$	$2.5 \cdot 10^{2}$	0.010
SC6	$6 \cdot 10^{-5}$	$2 \cdot 10^{3}$	0.120
SC7	$1 \cdot 10^{-6}$	$2.6 \cdot 10^{4}$	0.026
Expected unserved gas			6.496

Preventive + protective action:

SC3:

Consequence:
100 mcm ➔ 25
Prob.:
0.06 ➔ 0.006

Expected unserved gas:
SC: 6 mcm/y ➔ 0.150 mcm/y



4.4 The standards: Infrastructure standard (N-1) and supply standard

The lecturer of this session was Mr. Ricardo Bolado.

Article 5; Infrastructure Standard

- **Mission:** Safeguard the supply of all gas customers in situation of peak demand and failure of largest infrastructure
  - N-1 formula
    - N-1 formula with market-based demand side measures
    - N-1 formula at 100% and at 30% filling level in storage
  - Backed-up by hydraulic simulation
  - Importance of data availability / collection
  - Permanent bi-directional capacity
    - exemptions

3

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Infrastructure Standard (art. 5)

$$N-1\,[\%] = \frac{Ep_m + S_m + P_m + LNG_m - I_m}{D_{max}} \times 100$$

- **Epm**: technical capacity of all entry points (in mcm/d) capable of supplying gas to the calculated area during the reference period;
- **Sm**: the sum of the maximum technical daily withdrawal capacity of all storage facilities which can be delivered to the system of the identified area (in mcm/d);
- **Pm**: the maximal technical production capability (in mcm/d) of all gas production facilities which can be delivered to the identified area;
- **LNGm**: the maximal technical send-out capacity at all LNG facilities in the identified area (in mcm/d);
- **Im**: the technical capacity of the single largest gas infrastructure (in mcm/d) with the highest capacity to supply the identified area;
- **Dmax**: is the 1-in-20 daily peak demand.

4

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Infrastructure Standard (art. 5); Demand side

$$N-1\,[\%]=\frac{Ep_m+S_m+P_m+LNG_m-I_m}{D_{max}\;-D_{eff}}\times 100$$

- **Deff**: Part of Dmax that can be sufficiently and timely and by means demand-side measures

Infrastructure Standard (art. 5); Storage at 30% capacity

$$N-1\,[\%]=\frac{Ep_m+S_{30\%}+P_m+LNG_m-I_m}{D_{max}}\times 100$$

- ***$S_{30\%}$***: the sum of the maximum technical daily withdrawal capacity of all storage facilities which can be delivered to the system of the calculated area (in mcm/d) when the facilities are at 30% capacity (volume);

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5

Why $S_{30\%}$?

Country	Withdraw availability when working gas volume is at xx% level											
	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	1%	0%
AT	100%	99%	98%	97%	96%	95%	88%	80%	71%	63%	57%	0%
BEh	100%	100%	100%	100%	100%	100%	100%	20%	20%	10%	10%	0%
BGn	100%	100%	100%	100%	100%	100%	95%	85%	75%	66%	57%	0%
HR	100%	100%	100%	100%	100%	96%	80%	65%	48%	32%	14%	0%
CY	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CZ	100%	100%	100%	100%	100%	97%	80%	70%	50%	40%	20%	0%
CZd*	100%	100%	99%	98%	98%	98%	84%	70%	56%	41%	27%	0%
DK	100%	100%	100%	100%	100%	100%	100%	100%	85%	33%	25%	0%
EE	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FI	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fra	100%	95%	90%	85%	80%	75%	66%	57%	48%	39%	30%	0%
FRn	100%	96%	91%	87%	83%	78%	72%	65%	58%	49%	38%	0%
FRnL	100%	100%	100%	100%	100%	100%	100%	100%	100%	93%	85%	0%
FRs	100%	97%	94%	91%	88%	85%	79%	73%	66%	56%	27%	0%
FRt	100%	100%	100%	100%	100%	100%	91%	74%	57%	39%	22%	0%
DE	100%	100%	100%	99%	99%	99%	86%	74%	60%	46%	31%	0%
GR	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
HU	100%	100%	100%	100%	100%	97%	95%	84%	72%	52%	40%	0%
IE	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
IT	100%	100%	99%	98%	98%	98%	84%	70%	56%	41%	27%	0%
LV	100%	100%	100%	90%	80%	70%	50%	40%	25%	20%	20%	0%
LT	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NL	100%	98%	96%	95%	93%	91%	81%	70%	59%	48%	37%	0%
PL	100%	100%	99%	98%	97%	90%	84%	72%	65%	51%	29%	0%
PT	100%	100%	100%	100%	85%	85%	85%	85%	85%	85%	85%	0%
RO	100%	100%	99%	98%	98%	98%	84%	70%	56%	41%	27%	0%
RS	100%	100%	99%	98%	98%	98%	84%	70%	56%	41%	27%	0%
SK	100%	99%	97%	96%	93%	88%	82%	74%	65%	55%	44%	0%
SI	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
ES	100%	80%	72%	67%	63%	60%	55%	50%	45%	40%	40%	0%
SE	100%	100%	99%	98%	98%	98%	84%	70%	56%	41%	27%	0%
UK	100%	100%	99%	98%	98%	98%	84%	70%	56%	41%	27%	0%

* UGS Dolni Bojanovice located in Czech Republic but only connected the Slovak market

Table 3. - UGS deliverability curves.

6

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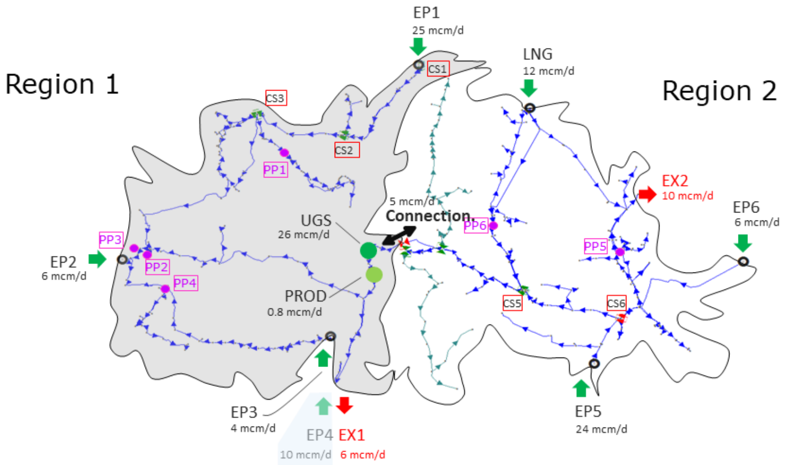
Case study network



130 off-take points 94 off-take points

Reference Hydraulic Scenario

Country 1	Pressure Range (bar)	Max. Capacity (mcm/d)
EP1	50-60	25
EP2	45-55	6
EP3	40-60	4
EP4/EX1	45-60	10/-6
UGS	50-60	26
PROD	55-65	0.8
CBP	40-60	5
Country 2	**Pressure Range (bar)**	**Max. Capacity (mcm/d)**
EP5	48-60	24
EP6	50-55	6
LNG	50-75	12
CBP	40-60	5
EX2	40-50	-10

- Dmax: 39.8 mcm/d in Region 1 and 24.4 mcm/d in Region 2;
- 30% Dmax in Region 1 is for PPs, 10% in Region 2. Minimum delivery pressure is set to 30 bar.

N-1[%] from Regulation

	Region 1	Region 2	Country
EPm (mcm/d)	50	35	75
Pm (mcm/d)	0.8	0	0.8
Sm (mcm/d)	26	0	26
LNGm (mcm/d)	0	12	12
Im (mcm/d) (Largest Infrastructure)	26 (UGS)	24 (EP5)	26 (UGS)
Dmax (mcm/d)	39.8	24.4	64.3
N-1 [%]	**128%**	**94%**	**137%**

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Article 5; Infrastructure Standard

- N-1 is just an indicator, an arithmetic formula; useful but with some real shortcomings:
  - It does not capture internal bottlenecks
  - It ignores important physical aspects (pressures, in particular)
- It is intuitive and easy to use
- Difficulty to estimate ***Dmax***

10

European Commission

Article 6; Supply Standard

- **Mission:** Safeguard the supply of gas to Protected Customers (PC) in case of
  - (a) extreme temperatures during a 7-day peak period occurring with a statistical probability of once in 20 years;
  - (b) any period of 30 days of exceptionally high gas demand, occurring with a statistical probability of once in 20 years;
  - (c) for a period of 30 days in the case of disruption of the single largest gas infrastructure under average winter conditions.
- Importance of data availability / collection
- Increased Supply Standard only under specific conditions
- Reliance on storage, in many cases.

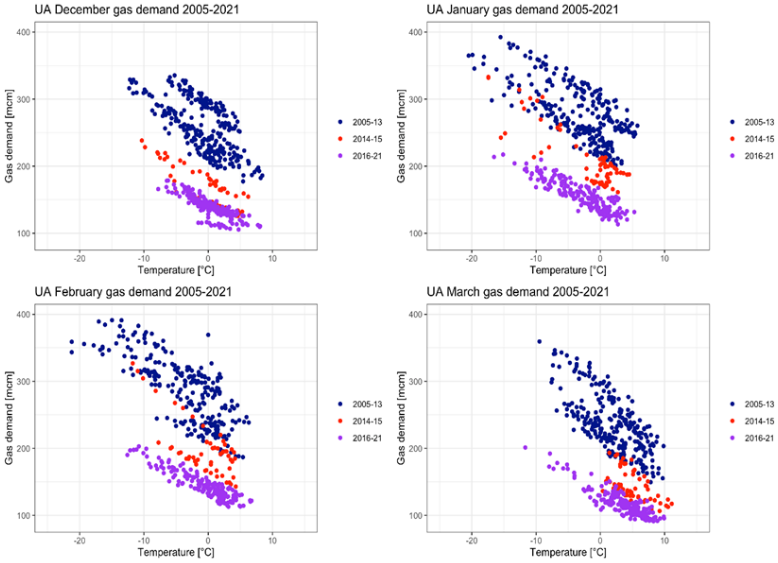
11 European Commission

Article 5; Infrastructure Standard

- **Estimation of Dmax;** possible methodology
  - Valid for weather controlled demand
  - Need of historical records
    - Study of the relation Temperature - Demand
    - Use of Extreme Theory Statistics
  - Case study

12 European Commission

Case Study: Ukraine



- **Data:** (weighted) Average national daily Temperature and Demand over the period 2005 – 2021.

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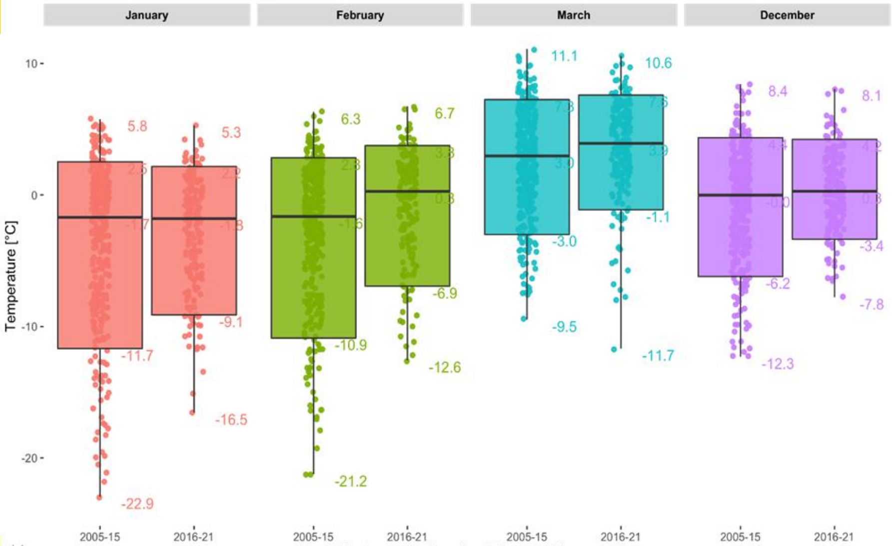
Case Study: Ukraine



top and bottom of the box: the 90th and 10th percentiles

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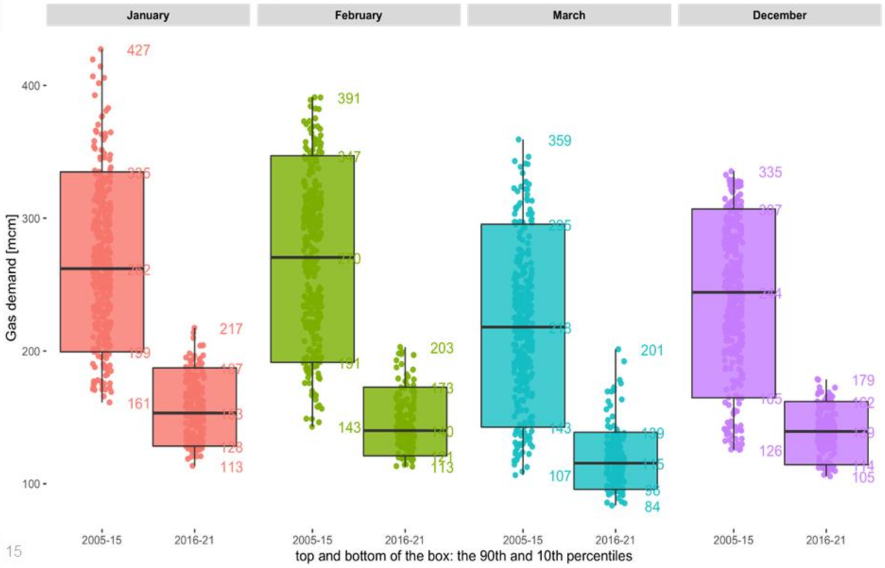
Case Study: Ukraine



top and bottom of the box: the 90th and 10th percentiles

Case Study: Ukraine

$$D_i = \beta_0 + \beta_1 T_i + \beta_2 T_{i-1} + \beta_3 M_i + \varepsilon_i \ , \qquad i = 1,2,\dots,n$$

where

- n is the total number of days in the data set
- D_i is the demand at day i
- T_i and T_{i-1} are the temperatures at days i and $i-1$ respectively
- M_i is a dummy variable for the month
- ε_i is the error term with an autoregressive structure AR(1): $\varepsilon_i = \phi\varepsilon_{i-1} + w_i$, and w_i are independent and identical distributed errors, following a normal distribution $N(0,\sigma^2)$.

Case Study: Ukraine

Model	Constant β_0	Temperature β_1	Lagged temperature β_2
January (n=183)	145.391	- 2.473	-1.228
t-statistics	(48.6)	(-14.0)	(-7.1)
February (n=170)	142.064	- 2.565	-1.518
t-statistics	(57.7)	(-17.9)	(-11.1)
March (n=183)	133,579	- 2.727	-1.875
t-statistics	(65.8)	(-14.6)	(-9.8)
December (n=183)	142.998	- 2.361	- 1.113
t-statistics	(83.0)	(-17.2)	(-8.0)

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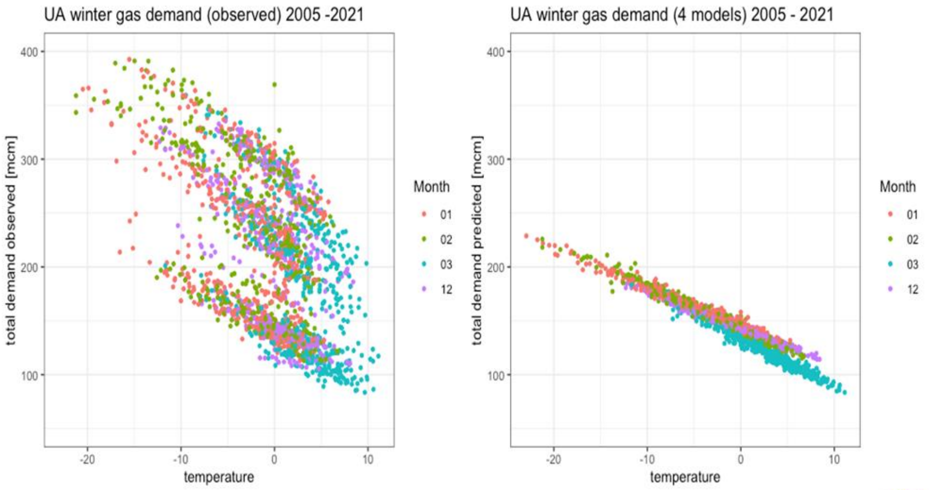
Case Study: Ukraine



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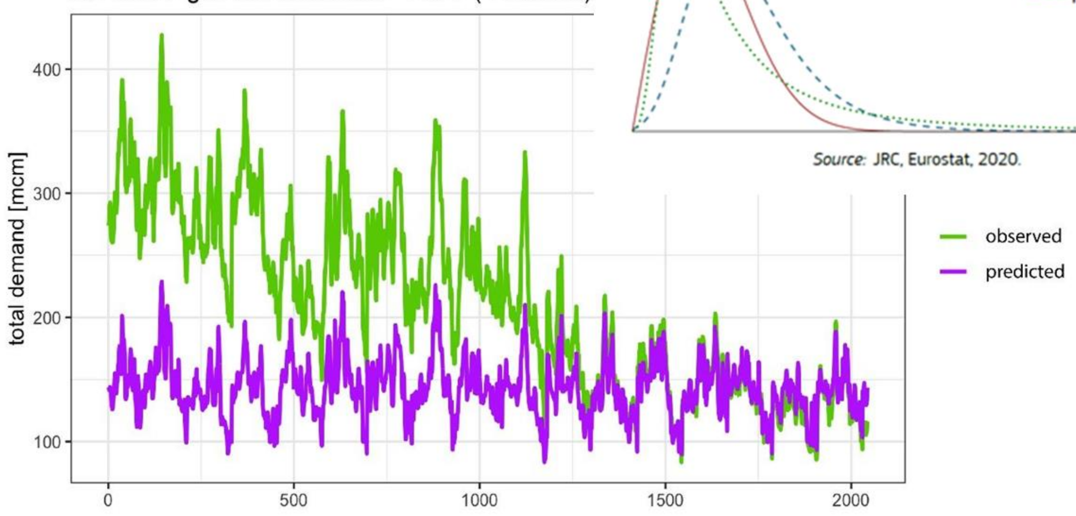
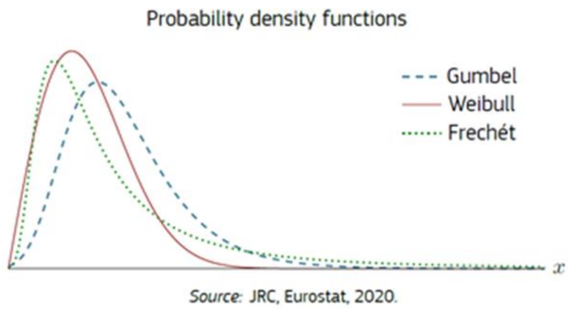
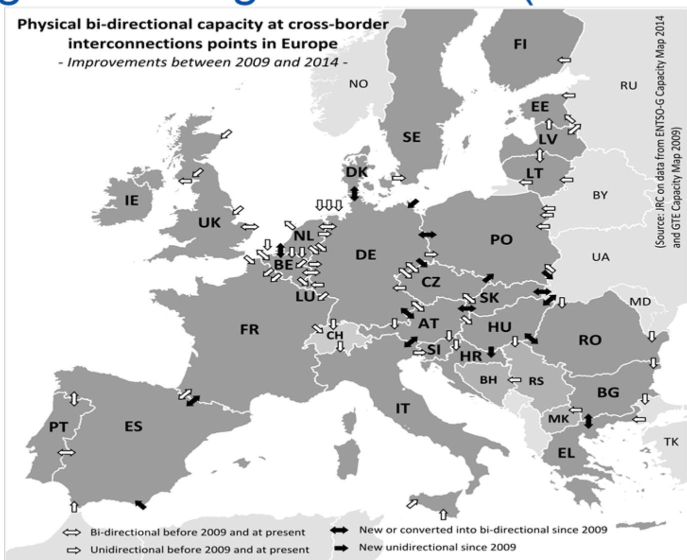
Case Study: Ukraine

UA winter gas demand 2005 - 2021 (4 models)





Changes in EU gas network (2009 - 2014)



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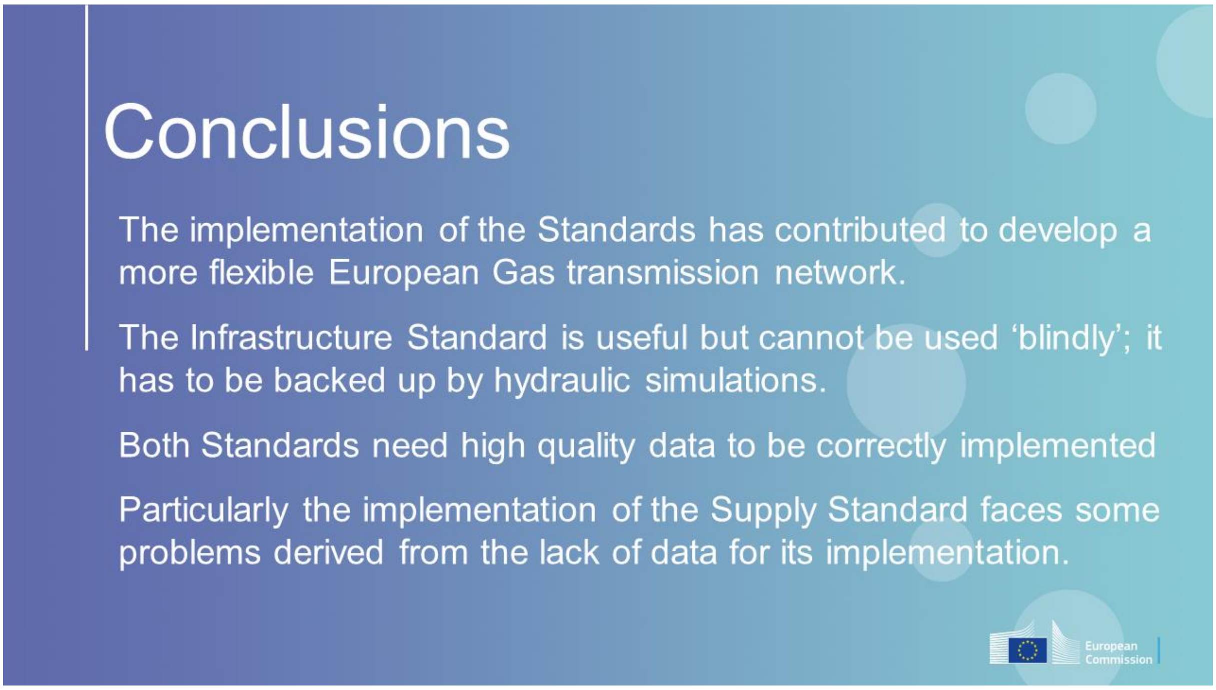
Conclusions
The implementation of the Standards has contributed to develop a more flexible European Gas transmission network.
The Infrastructure Standard is useful but cannot be used 'blindly'; it has to be backed up by hydraulic simulations.
Both Standards need high quality data to be correctly implemented
Particularly the implementation of the Supply Standard faces some problems derived from the lack of data for its implementation.
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4.5 Scenario design and estimation of probabilities in a Risk Assessment

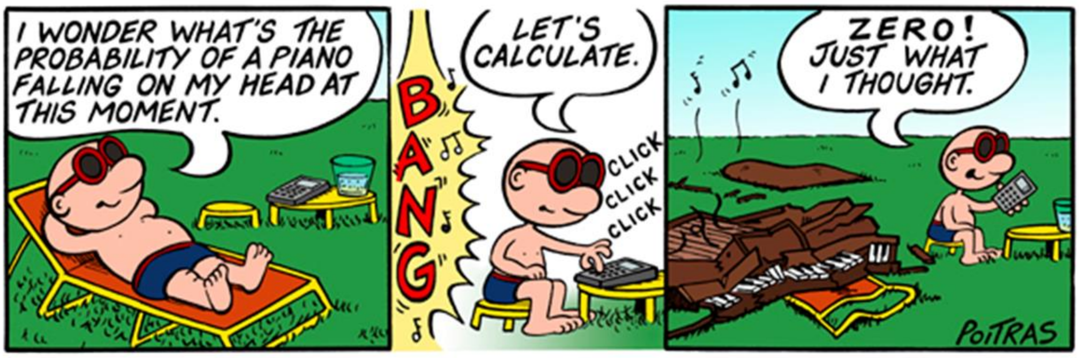
This session had two lecturers, namely Mr. Nicola Zaccarelli and Mr. Ricardo Bolado.

Reg. (EU) 2017/1938 requires estimating probabilities!

How can we estimate the probability of scenarios for:

- a commercial dispute?
- a geopolitical crisis?
- a pandemic?
- a pipeline failure?
- …

Certainly not an easy task but theoretical frameworks and methodologies have been developed (and commonly used in the Insurance sector, for example).



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What is probability (or likelihood)?

Probability defines the likelihood of the occurrence of an event.

The Kolmogorov axioms are the foundations of probability theory (1933):

1. P(A) is always a nonnegative real number, between 0 and 1 inclusive.
2. $P(\emptyset) = 0$, i.e., if A is the empty set $\emptyset$, then $P(A) = 0$.
3. $P(S) = 1$, i.e., if A is the entire sample space S, then $P(A) = 1$.
4. P is (countably) additive, meaning that if $A_1, A_2, \ldots$ is a finite or countable sequence of disjoint events, then $P(A_1 \cup A_2 \cup \cdots) = P(A_1) + P(A_2) + \cdots$

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Other basic concepts

Independent events: two events A and B are independent if $P(A \cap B) = P(A)\,P(B)$

Conditional probability: given two events A and B, with $P(B) > 0$, the conditional probability of A given B is equal to $P(A|B) = P(A \cap B) / P(B)$

Total likelihood: assume to have three aspects making up a risk scenario (i.e., aspect A, aspect B, and C). We can calculate the total likelihood as:

$$P(A \cap B \cap C) = P(A)\,P(B|A)\,P(C|A \cap B)$$

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How assign a probability to an event? (event ≠ scenario)

If the number we call “probability” follows the axioms, we have two types of approaches to selecting a value:

- we use some collected knowledge in the form of data/models (approach 1);
- we use knowledge based on experience (approach 2).

Both are correct if we follow the same set of axioms.

The experiment of the dice!

The experiment of the dice!

Take a dice (sorry I don’t have enough for everybody!). Examine the dice.

Now, answer the question: “*P(1)=? By throwing one time*”.

Approach 1: each of us throws the dice and based on the data we derive a probability.

Approach 2: each of us expresses his/her view of the probability by choosing a value, and an average is calculated. You have 25.000 euro, how much would you bet on getting 1 with one throw?

What is a scenario?

In Art. 7 (4.c) the Regulation states that a RA shall be carried out by:

running various scenarios of exceptionally high demand for gas and disruption of gas supply, taking into account the history, probability, season, frequency and duration of their occurrence and assessing their likely consequences, such as:

> *(i) disruption of the infrastructure relevant to the security of gas supply, in particular transmission infrastructure, storages or LNG terminals, including the largest gas infrastructure identified for the calculation of N – 1 formula; and*
>
> *(ii) disruption of supplies from third-country suppliers, as well as, where appropriate, geopolitical risks;*

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What is a scenario?

A scenario is a combination of a set of independent/conditional conditions selected by the expert.

The term "event" is better used to indicate the triggering cause of a scenario.

The probability of the scenario is derived by the probability of the conditions.

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How to create a scenario?

STEP 1: Define the list of conditions (e.g., triggering event, duration, demand level, export, import, UGS/LNG inventory, linepack, etc...).

STEP 2: Define the list of scenarios **and** specify the value of each condition.

STEP 3: Assess if the combination of conditions is independent or conditional.

This should be a participatory process, with a consensus on the final list of scenarios (which must cover the requirements of the Regulation).

Collect data -> Assign probability to independent events -> Estimate probability for conditional events -> Estimate the total probability.

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How to create a scenario?

Scenario:	S.5	Total likelihood: 1.96 x 10^{-3}
Likelihood	(y^{-1})	Notes
Event	0.05	Expert judgement on the likelihood of failure of the single largest infrastructure for the N-1 scenario.
Duration	0.95	Set because such duration is considered the most likely and it is part of the event.
Demand	0.05	Dmax demand.
Transit gas	0.931	Estimated based on historical data.
Supplying to Customer XYZ	0.99	Customer XYZ is supplied because of agreement.
Exports to Country A	0.95	Assumed to occur.
Imports from Country A	0.99	Imports are available.
Linepack correction	0.95	Most likely case.

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Sources of risk and probability estimates

For each scenario considered in the Risk Analysis, it is necessary to estimate

- Consequences
- Probability of occurrence of the scenario:
    * Probabilities of events/conditions
    * Four cases:
        A lot of data: classical estimation (approach 1)
        Few data: Bayesian estimation (approach 1)
        Almost no data or epistemic uncertainties: Expert judgment (approach 2)
        Models: event trees, fault trees (approach 1)

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Summary of natural hazards affecting EU (ESPON project)

1. Technological (internal)
2. Technological (external)
3. Political
4. Commercial / market / financial
5. Social
6. Natural
7. Common cause (correlated risks)

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Technological (int)

- Explosion
- Fires (internal to a given facility)
- Leakages
- Human errors
- Floods (internal event, leak leading to flood)
- Equipment malfunction (failure to start, failure during working time, etc.)
- Unavailability of staff (pandemic, accidents, etc.)
- Lack of electricity (or other energy source)
- ICT failure (hardware failure, software failure, internet, cyber-attack, SCADA problems, etc.)
- Lack of adequate maintenance
- Use of outdated technologies
- Unavailability of replacement components
- Low level of gas in Underground storage facilities

Technological (ext)

- Air contamination due to accident in nearby facility (chemical, nuclear)
- Aircraft impact
- Impact due to excavation works (digging, piling), ground works, etc.
- Coast pollution (ship accident/wreck, off-shore accident)

Common cause (CR)

- Gas disruption from Russia because of different reasons (commercial dispute, diplomatic incident, natural hazard, technical problem)
- Extreme weather conditions in a large region
- Lack of electricity in a large region

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	ASSET ->	Gas Infrastructure								ICT		Buildings			People
Risk	Source of Risk	*Compressor Station*	*Entry or Exit (from/to Countries)*	*Metering Station*	*Production Site*	*Underground Gas Storage*	*LNG Terminal*	*Block Valve Station*	*Pipeline*	*Process Control System*	*Data Communication System*	*Administrative building*	*Regional Support Centre*	*Gas Flow Control Centre*	*People*
Technological (internal)	Explosion														
	Fires (internal to a given facility)														
	Leakages														
	Human errors														
	Floods (internal event, leak leading to flood)														
	Equipment malfunction (failure to start, failure during working time, etc.)														
	Unavailability of staff (pandemic, accidents, etc.)														
	Lack of electricity (or other energy source)														
	ICT failure (hardware failure, software failure, internet, SCADA problems, etc.)														
	Unavailability for long period of facility for maintenance / improvements														
	Lack of adequate maintenance														
	Use of outdated technologies														
	Unavailability of replacement components														
	Low level of gas in Underground storage facilities/ Lack withdrawal capacity														
	Equipment aging (e.g., internal corrosion, mechanical wear out, etc.)														
	Decommissioning														
	Other risks: (specify)														

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Problem:
experts usually provide biased estimates

Cognitive biases	The way we process information and the way we reason is linked to a rational and experiential level.
Motivational biases	The way we distort our judgment due to our beliefs and ideology.
Statistical biases	Lack of capability to deal with statistical concepts.

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Bias of representativeness:
Misconception of chance

We expect that a sequence of events generated by a random process will represent the essential characteristics of that process even when the sequence is short.

For example: **1) HTHTTH** **2) HHHTTT** **3) HHHHTH**

People believe that option 1 is more likely than 2 and 3

Why?

People tend to expect the same behaviour in the short and in the long term: "Belief in the law of small numbers""

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Bias of availability

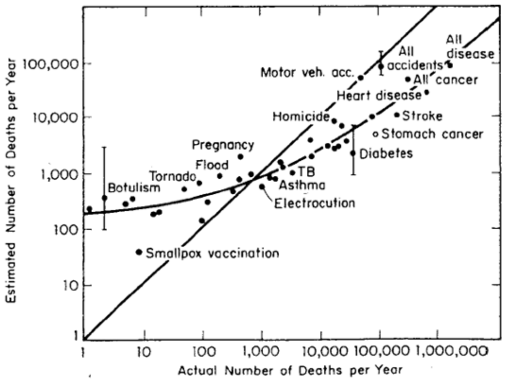
Perception of risk

People were asked to estimate the probability of death from various causes

Availability heuristic determine biases in the responses

Overestimation of less frequent/more "publicized" causes; ex: botulism

Underestimation of more frequent/less publicized causes; ex: stroke, cancer



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Bias of Anchor & Adjustment

Insufficient adjustment

Example 1:

In a study, groups of subjects were asked to estimate the percentage Q of African countries in the United Nations.

A number A was selected between 1 and 100 (firstly 10, then 65).

The subjects were led to believe that the result was a random number between 0 and 100.

After obtaining A, subjects were asked if Q was greater or less than A.

They were then asked to adjust their response up or down from A.

Result

The median percentage Q of African countries in the United Nations was 25 when A was 10 and was 45 when A was 65.

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Overconfidence & Calibration

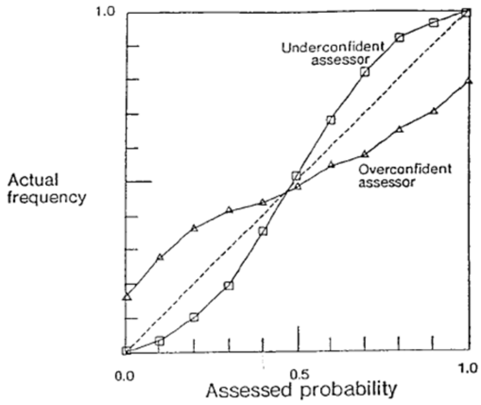
Anchoring can aggravate it. Overconfidence can express itself as poor calibration.

Calibration curve: assessed probabilities are plotted against actual frequency

Well calibrate judge: *curve near the diagonal*

Under confident judge: assessed probabilities nearer to 0.5 than they should be

Overconfident judge: assessed probabilities too near certainty (0 or 1)



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LACK OF CAPABILITY TO DEAL WITH STATISTICAL CONCEPTS: BIASES

Difficulties to distinguish means and medians

- many experts provide medians when asked for means (it is easier to compute a median than a mean: equal probability vs. integral or sum of a series)

Difficulties to evaluate measures of spread (standard deviations).

- Sometimes this problem is linked to the problem of overconfidence

Difficulties to use Bayes Theorem as the main tool to update information

Excessive tendency to fit opinions to the normal model

- Extensive use of this model in probability courses
- Uncertainty reducing mechanism (symmetry).

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Need of structured protocols to get expert opinions / probabilities

History of structured use of expert opinions:
After WW II development of Delphi method & scenario analysis
(RAND Corporation)

Study WASH-1400
First attempt to use EJ in a large safety study (early 1970's)

Best known methodology in nuclear industry:
"NUREG-1150" Severe accident risks: an assessment for five U.S. NPP (1990)

Benchmark exercise on Expert judgement Techniques (EU Concerted action 1996-1998)
comparison of several approaches

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Probability of failure of pipelines

- Made of steel
- Located offshore
- Maximum Operating Pressure > 15 bar
- Located outside the fences of gas facilities

Parameters collected

- Diameter
- Pressure
- Year of constrcution
- Type of coating
- Cover
- Grade of material
- Wall thickness

EGIG

GAS PIPELINE INCIDENTS

9th Report of the European Gas Pipeline Incident Data Group
(period 1970 – 2013)

Comprising:

Gas Networks Ireland (Ireland)
DGC (Denmark)
ENAGAS, S.A. (Spain)
EUSTREAM (Slovak Republic)
Fluxys (Belgium)
Gasum (Finland)
GRT Gaz (France)
National Grid (UK)
Gasunie (Netherlands / Germany)
NET4GAS (Czech Republic)
Gasconnect (Austria)
Open Grid Europe (Germany)
Ren Gasodutos S.A. (Portugal)
Snam Rete Gas (Italy)
Swedegas A.B. (Sweden)
SWISSGAS (Switzerland)
TIGF (France)

Doc. Number EGIG 14.R.0403
February 2015

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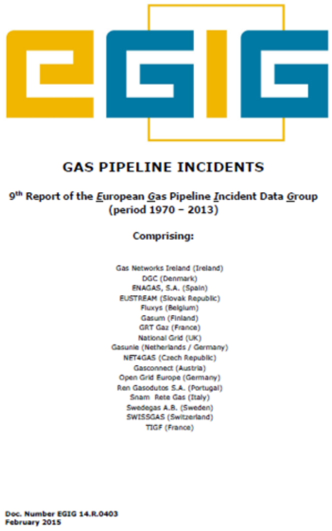
Additional specific information about incidents / accidents

- **Leak size**
  - Pinhole / crack (Diameter < 2 cm)
  - Hole (2cm < Diameter < Pipeline Diameter)
  - Rupture (Diameter > Pipeline Diameter)
- **Initial cause of the incident / accident**
  - External interference
  - Corrosion
  - Construction defect / material failure
  - Ground movement
  - …
  - Unknown
- **Occurrence of ignition (or not)**
- **Consequences**
- **…**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February 2015

Total cumulative experience (total exposure) of 3.98 million km . year

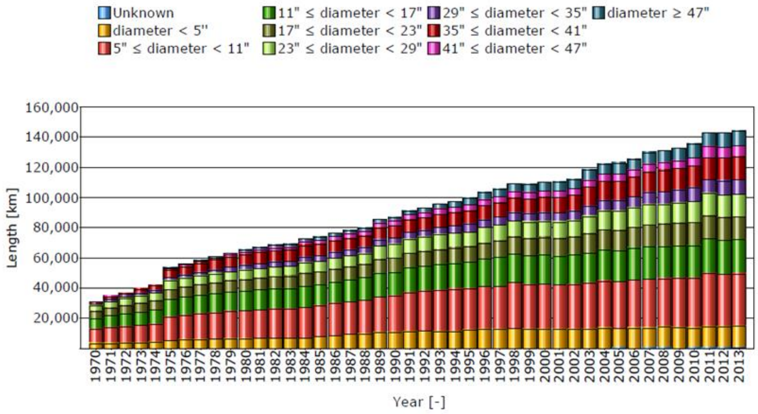
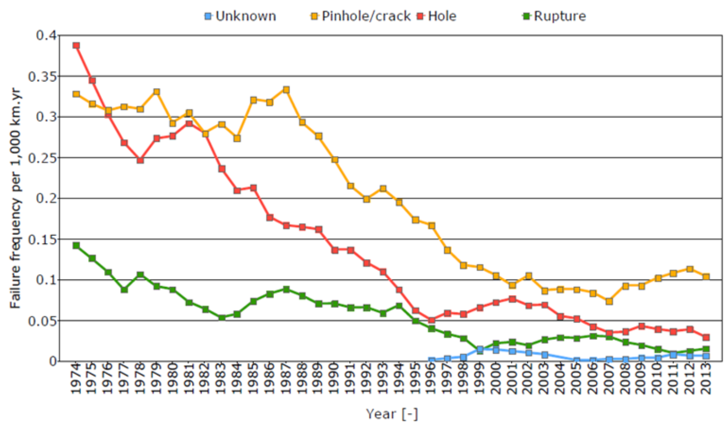


Figure 2: Total length per diameter

Evolution of Failure frequency over time (decrease + stabilisation)



27 Figure 13: Primary (5-year moving average) failure frequency as a function of leak size

Estimation of probability of failure of a pipeline per year

Primary failure frequency per 1,000 km . Year X Length of the pipeline

Leak size	Primary failure frequency per 1,000 km·yr	95% LL Primary failure frequency per 1,000 km·yr	95% UL Primary failure frequency per 1,000 km·yr
Pinhole/crack	0.105	0.082	0.132
Hole	0.030	0.019	0.046
Rupture	0.016	0.008	0.028

Table 9: Primary failure frequencies per leak size (period 2009–2013) and their 95% confidence intervals

If Length = 300 Km ➔ P= (0.105+0.030+0.016) X 0.3 = 0.0453 Year (-1)
(it will happen once every ~ 20 Years)

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Compressor stations

Need of knowing

- **Taxonomy**
- **Different damage states**

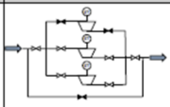
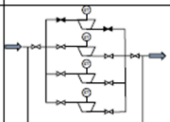
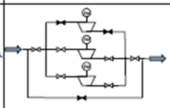
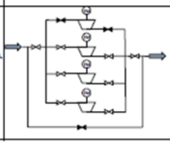
  Reduced capacity
- **Several parameters corresponding to each damage state**

  Unavailability (Q; fraction of the time in that Damage Class)

  Expected number of failures per year (Occ. Per year)

  Down time (Hours per year)

  Average Down time (hours)

TYPICAL	SKETCH	DAMAGE CLASS				
		0% flow	33% flow (Nominal Pressure)	50% flow (Nominal Pressure)	66% flow (Nominal Pressure)	By-pass
1-N-TUCO-RP (3 compressors gas turbine driven, 1 spare)		X		X		X
1a-4-TUCO-RP (4 compressors gas turbine driven, 1 spare)		X	X		X	X
2-N-MOCO-RP (3 compressors electric motor driven, 1 spare)		X		X		X
2a-4-MOCO-RP (4 compressors electric motor driven, 1 spare)		X	X		X	X

Compressor stations

Need of knowing

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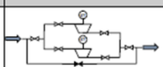
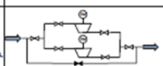
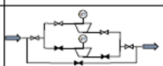
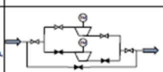
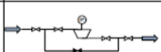
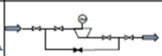
  Unavailability (Q; fraction of the time in that Damage Class)

  Expected number of failures per year (Occ. Per year)

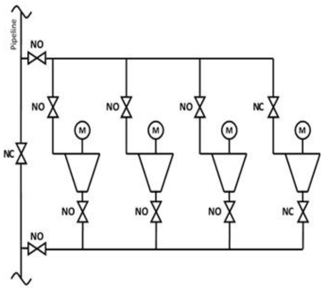
  Down time (Hours per year)

  Average Down time (hours)

TYPICAL	SKETCH	DAMAGE CLASS				
		0% flow	33% flow (Nominal Pressure)	50% flow (Nominal Pressure)	66% flow (Nominal Pressure)	By-pass
3-2-TUCO-RN (2 compressors gas turbine driven, no spare)		X		X		X
4-2-MOCO-RN (2 compressors electric motor driven, no spare)		X		X		X
5-2-TUCO-RT (2 compressors gas turbine driven, 1 spare)		X				X
6-2-MOCO-RT (2 compressors electric motor driven, 1 spare)		X				X
7-1-TUCO-RN (1 compressor gas turbine driven, no spare)		X				X
8-1-MOCO-RN (1 compressor electric motor driven, no spare)		X				X

Results for different compressor stations

Type 2a 4-MOCO-RP



Typical	Parameter	Damage Class (nominal flow percentage) 66%	50%	33%	"By – pass"	0%
1-N-TUCO-RP	Q	X	3,46E-02	X	1,39E-03	6,58E-06
	ENF [occ/year]	X	5,07E+00	X	2,65E-01	1,31E-03
	Down Time [hr/year]	X	3,03E+02	X	1,22E+01	5,76E-02
	Average Down Time [hr]	X	5,96E+01	X	4,59E+01	4,39E+01
1a-4-TUCO-RP	Q	5,52E-02	X	1,32E-03	1,08E-03	4,76E-06
	ENF [occ/year]	8,12E+00	X	3,65E-01	1,67E-01	7,35E-04
	Down Time [hr/year]	4,84E+02	X	1,16E+01	9,46E+00	4,17E-02
	Average Down Time [hr]	5,96E+01	X	3,17E+01	5,67E+01	5,67E+01
2-N-MOCO-RP	Q	X	3,67E-03	X	6,96E-04	3,07E-06
	ENF [occ/year]	X	4,99E-01	X	1,06E-01	4,69E-04
	Down Time [hr/year]	X	3,21E+01	X	6,09E+00	2,69E-02
	Average Down Time [hr]	X	6,44E+01	X	5,76E+01	5,73E+01
2a-4-MOCO-RP	Q	5,94E-03	X	5,09E-05	7,72E-04	3,38E-06
	ENF [occ/year]	8,06E-01	X	1,32E-02	1,14E-01	5,01E-04
	Down Time [hr/year]	5,20E+01	X	4,46E-01	6,76E+00	2,96E-02
	Average Down Time [hr]	6,46E+01	X	3,38E+01	5,93E+01	5,91E+01
3-2-TUCO-RN	Q	X	1,31E-01	X	5,77E-03	2,54E-05
	ENF [occ/year]	X	7,44E+00	X	4,94E-01	2,16E-03
	Down Time [hr/year]	X	1,14E+03	X	5,06E+01	2,22E-01
	Average Down Time [hr]	X	1,54E+02	X	1,02E+02	1,03E+02
4-2-MOCO-RN	Q	X	4,24E-02	X	1,14E-03	5,02E-06
	ENF [occ/year]	X	2,56E+00	X	1,40E-01	6,14E-04
	Down Time [hr/year]	X	3,72E+02	X	1,00E+01	4,39E-02
	Average Down Time [hr]	X	1,45E+02	X	7,15E+01	7,15E+01
5-2-TUCO-RT	Q	X	X	X	1,70E-02	9,54E-05
	ENF [occ/year]	X	X	X	2,52E+00	1,42E-02
	Down Time [hr/year]	X	X	X	1,49E+02	8,35E-01
	Average Down Time [hr]	X	X	X	5,92E+01	5,87E+01
6-2-MOCO-RT	Q	X	X	X	2,31E-03	1,22E-05

Corrective + Preventive Maintenance – 24 hr Logistic Delay Time

Results for different compressor stations (2)

Corrective + Preventive Maintenance – 24 hr Logistic Delay Time

Typical	Parameter	Damage Class (nominal flow percentage) 66%	50%	33%	"By – pass"	0%
	ENF [occ/year]	X	X	X	3,33E-01	1,77E-03
	Down Time [hr/year]	X	X	X	2,02E+01	1,07E-01
	Average Down Time [hr]	X	X	X	6,06E+01	6,05E+01
7-1-TUCO-RN	Q	X	X	X	6,81E-02	3,06E-04
	ENF [occ/year]	X	X	X	3,80E+00	1,66E-02
	Down Time [hr/year]	X	X	X	5,96E+02	2,68E+00
	Average Down Time [hr]	X	X	X	1,57E+02	1,61E+02
8-1-MOCO-RN	Q	X	X	X	2,19E-02	9,64E-05
	ENF [occ/year]	X	X	X	1,36E+00	5,94E-03
	Down Time [hr/year]	X	X	X	1,92E+02	8,45E-01
	Average Down Time [hr]	X	X	X	1,41E+02	1,42E+02

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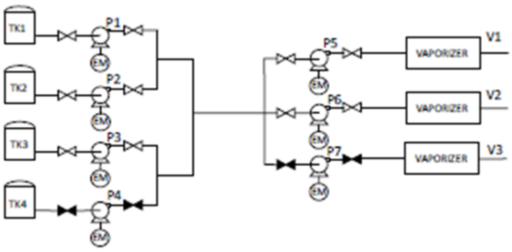
Results for an LNG regasification terminal

LNG Storage	Q	3,48E-03	1,12E-02	1,95E-05	X	3,08E-04
	ENF [occ/year]	2,54E-01	2,13E+00	2,73E-03	X	5,40E-02
	Down Time [hr/year]	3,05E+01	9,83E+01	1,71E-01	X	2,70E+00
	Average Down Time [hr]	1,20E+02	4,61E+01	6,25E+01	X	5,01E+01



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Take home messages

- A **risk** scenario needs to be properly defined to estimate consequences and probabilities;
- A scenario is not an event but a combination of conditions:
- Probability estimation is a difficult task, but it is necessary for a proper risk assessment.
- There is no "correct" probability, but only a correct way of estimating a probability.

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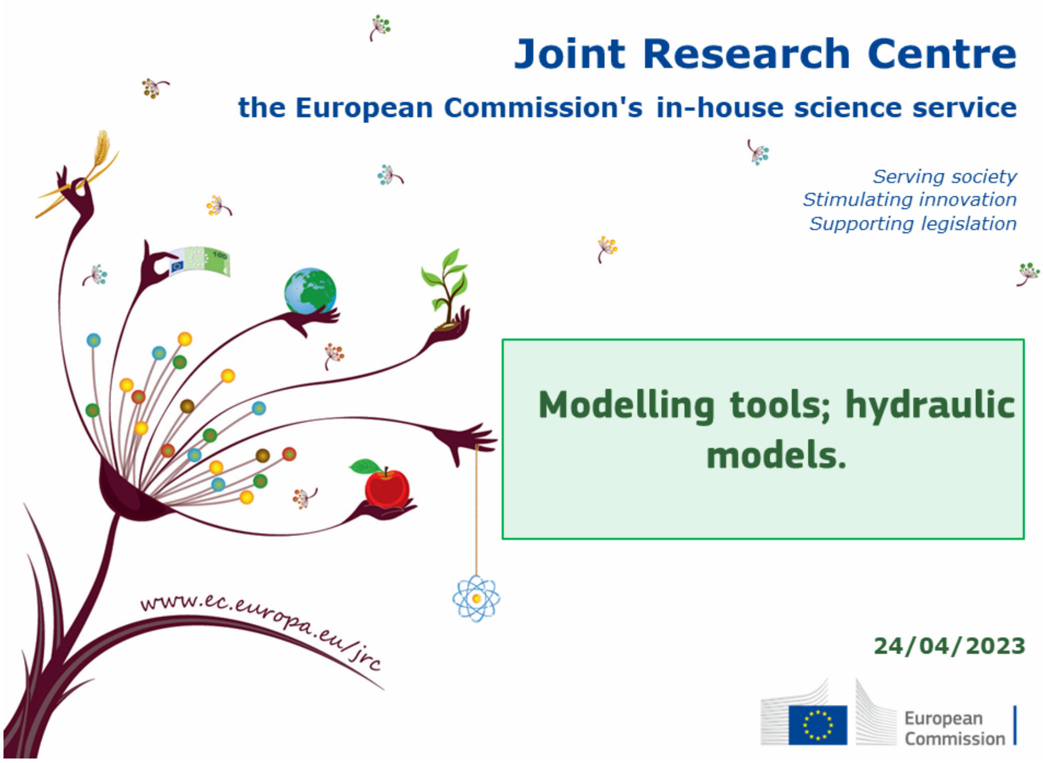
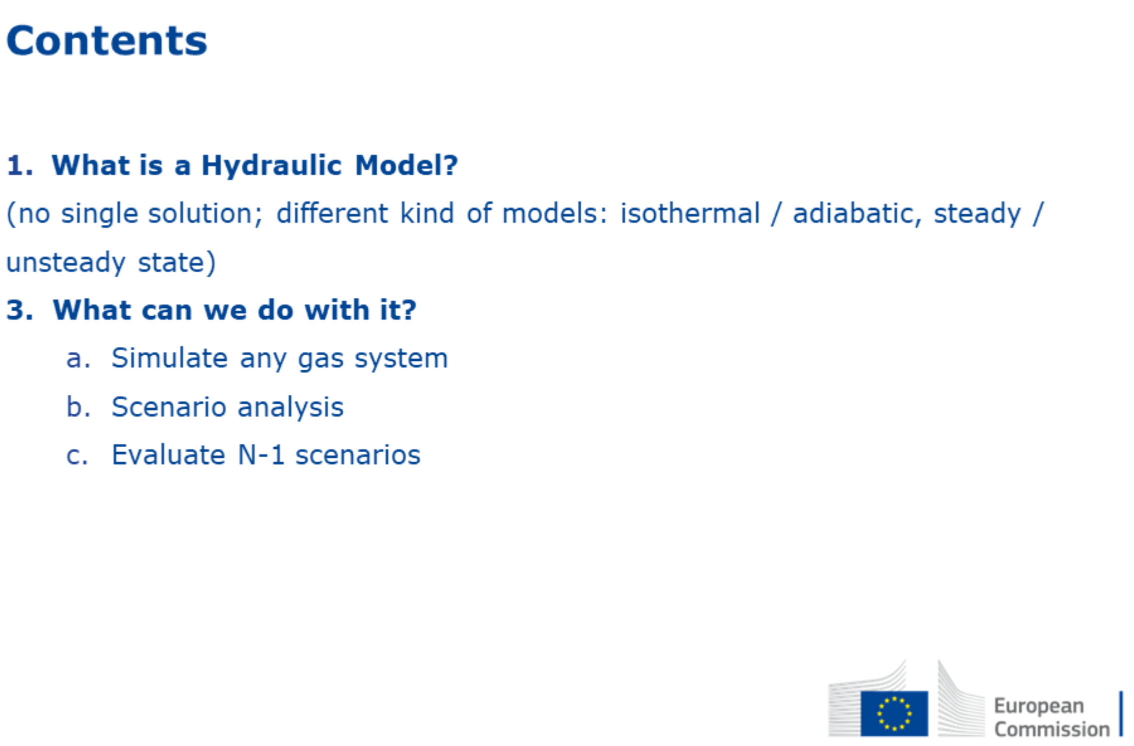
4.6 Modelling tools: hydraulic and mass balance models

This session was split into two parts. Mr. Ricardo Bolado was the lecturer of the first part, which was related to hydraulic modelling tools, while Mr. Ricardo Fernández-Blanco was the speaker of the second part related to mass balance models.

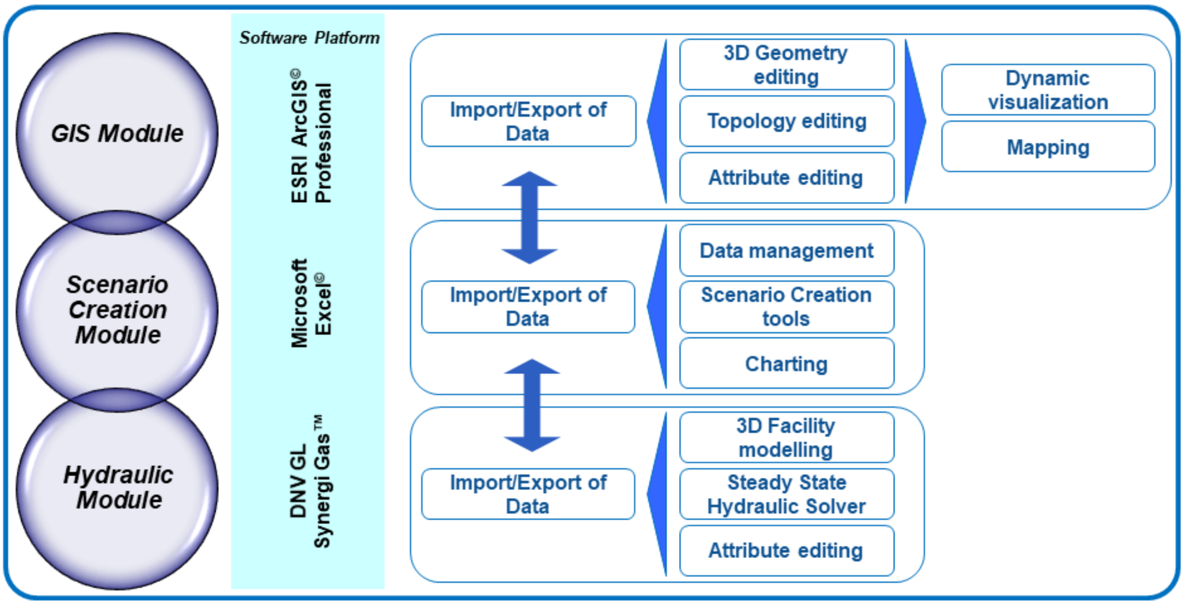




What it is a Hydraulic Model of a gas network?

- Describes the transport of gas in a network taking into account the topology of the grid and the physical characteristics of its components.
- A gas network is a complex physical system ruled by several variables.
- A hydraulic model is defined by mathematical equations that gather all the variables that govern the behaviour of gas in a network.

EUGas (hydraulic model) Architecture



What EUGas models:

Infrastructure

- Pipelines
- Compressor Stations
- Underground Gas Storages
- LNG Terminals
- Production Sites
- Regulators
- Blending Stations

Nodes

- Cross-border points
- Domestic / Commerce off-take
- Industry off-take
- District Heating off-take
- Electricity Production off-take

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EUGas: a geographic view

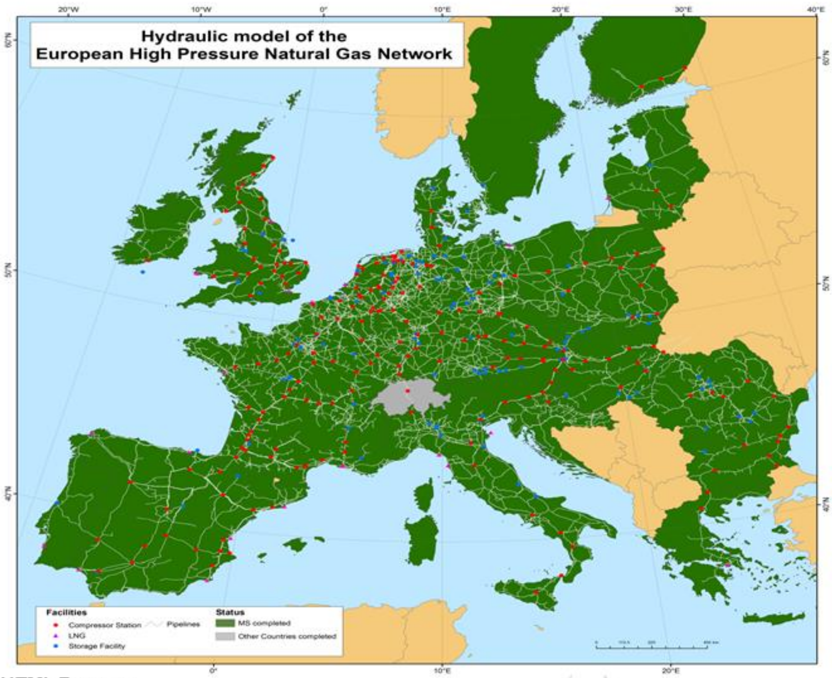
146 UGS

217 Compressor Stations

LNG

~16.500 Pipeline segments

~180.000 km of pipelines



HTML Browser

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Types of Hydraulic Models

1. **Non-Steady State models (or Transient models): gas flow characteristics' variations over time are considered**

2. **Steady State models: the mathematical equations do not take into account the gas flow characteristics' variations over time.**

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Types of Hydraulic Models

	isothermal ($T = T_a = const.$)	adiabatic ($\dot{\Omega} = 0$)
steady state ($\partial/\partial t = 0$)	$\frac{\partial(\rho u)}{\partial x} = 0$ $\frac{\partial(p + \rho u^2)}{\partial x} + \frac{2f\rho u\lvert u\rvert}{D} + \rho g sin\alpha = 0$ $u\frac{\partial u}{\partial x} + g sin\alpha = \frac{\dot{\Omega}}{\rho u A}$ $\frac{p}{\rho} = ZRT$	$\frac{\partial(\rho u)}{\partial x} = 0$ $\frac{\partial(p + \rho u^2)}{\partial x} + \frac{2f\rho u\lvert u\rvert}{D} + \rho g sin\alpha = 0$ $\frac{\partial}{\partial x}\left[c_v T + \frac{p}{\rho} + \frac{1}{2}u^2\right] + g sin\alpha = 0$ $\frac{p}{\rho} = ZRT$
unsteady state ($\partial/\partial t \neq 0$)	$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} = 0$ $\frac{\partial(\rho u)}{\partial t} + \frac{\partial(p + \rho u^2)}{\partial x} + \frac{2f\rho u\lvert u\rvert}{D} + \rho g sin\alpha = 0$ $\frac{\partial}{\partial t}\left[\frac{1}{2}\rho u^2 A\right] + \frac{\partial}{\partial x}\left[\frac{1}{2}\rho u^3 A\right] + \rho u A g sin\alpha = \dot{\Omega}$ $\frac{p}{\rho} = ZRT$	$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} = 0$ $\frac{\partial(\rho u)}{\partial t} + \frac{\partial(p + \rho u^2)}{\partial x} + \frac{2f\rho u\lvert u\rvert}{D} + \rho g sin\alpha = 0$ $\frac{\partial}{\partial t}\left[\left(c_v T + \frac{1}{2}u^2\right)\rho A\right] +$ $\frac{\partial}{\partial x}\left[\left(c_v T + \frac{p}{\rho} + \frac{1}{2}u^2\right)\rho u A\right] + \rho u A g sin\alpha = 0$ $\frac{p}{\rho} = ZRT$
	Typically transmission	**Typically distribution**

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Transport of gas in a pipeline

Capacity Q is function of:
- Pressure inlet: Pi
- Pressure outlet: Po
- Diameter of pipe: D
- Length of pipe: L

} 4 most important parameters

$$Q \sim \sqrt{\frac{Pi^2 - Po^2}{L}} \times D^{2.5}$$

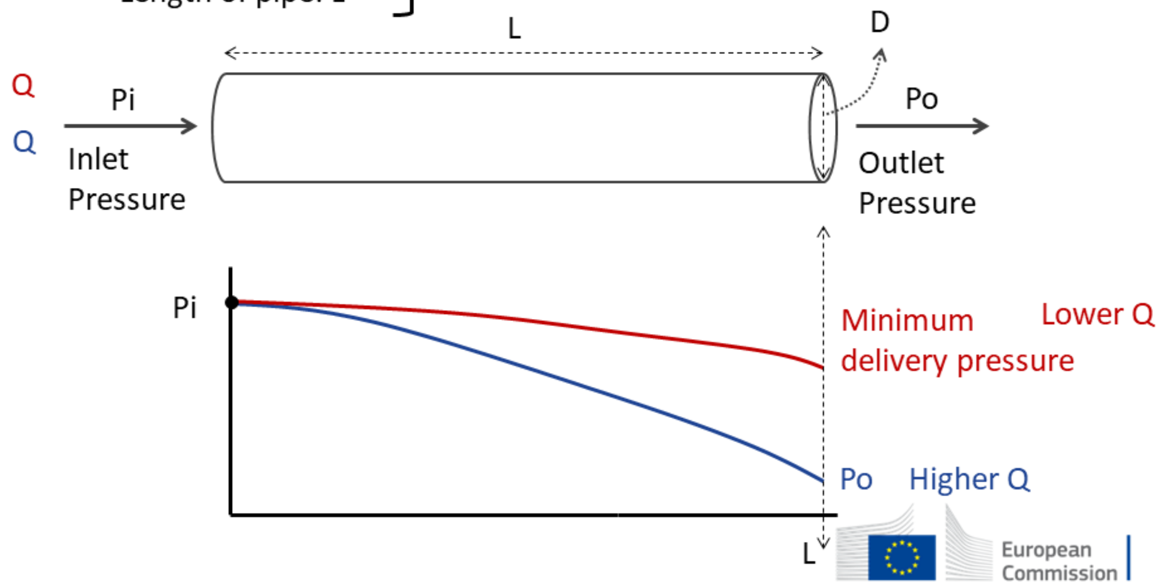
Other parameters include:
- Temperature of gas
- Pipe friction factor
- Relative density of gas
- Gas compressibility factor

Transport of gas in a pipeline

Capacity Q is function of:
- Pressure inlet: Pi
- Pressure outlet: Po
- Diameter of pipe: D
- Length of pipe: L

} 4 most important parameters

$$Q \sim \sqrt{\frac{Pi^2 - Po^2}{L}} \times D^{2.5}$$



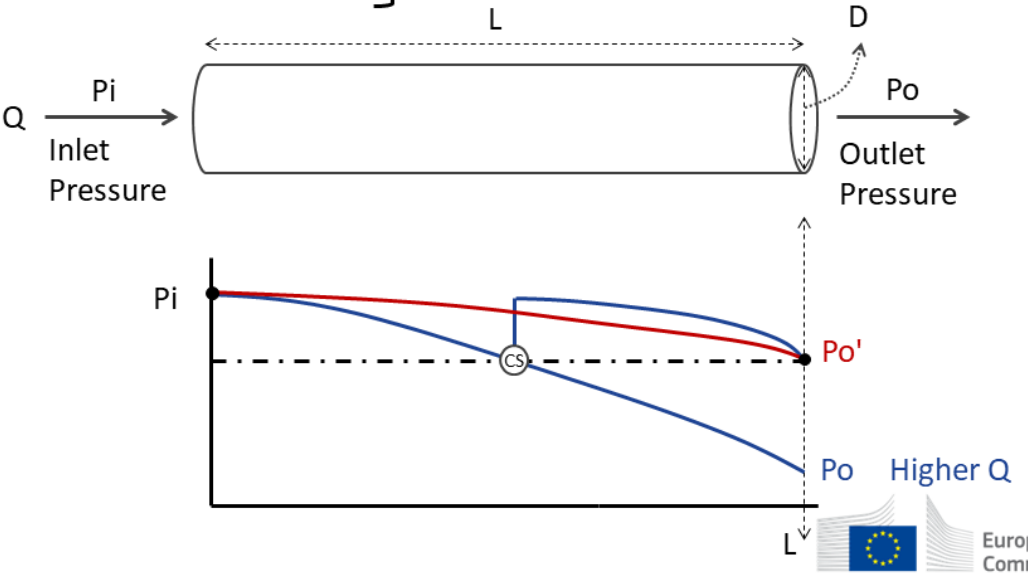
Transport of gas in a pipeline

Capacity Q is function of:

- Pressure inlet: Pi
- Pressure outlet: Po
- Diameter of pipe: D
- Length of pipe: L

4 most important parameters

$$Q \sim \sqrt{\frac{Pi^2 - Po^2}{L}} \times D^{2.5}$$



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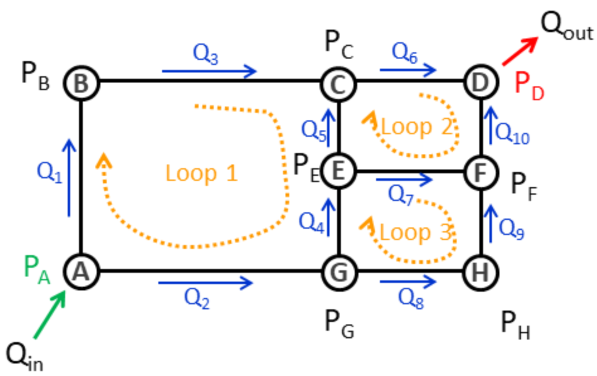
Gas Network



The steady-state flows on the network must satisfy two conditions:

First Kirchhoff's law (law of conservation of mass): The sum of flows at any node is zero

Node A: $Q_{in} = Q_1 + Q_2$

Node C: $Q_5 + Q_3 = Q_6$

Second Kirchhoff's law (law of conservation of energy): The pressure drop around a closed loop is zero

Loop 1: $(P_A-P_B)+(P_B-P_C)=(P_A-P_G)+(P_G-P_E)+(P_E-P_C)$

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- Capacity and pressures are always linked in a gas network
- Changes in capacity or pressure in one node of the grid will propagate through the grid
- Off-take points for different customers have different requirements of capacity and delivery pressure
- The solution of a scenario with a hydraulic model allows to know if the gas available in the system is able to reach all the delivery points at the right conditions
- For the same scenario it is possible to obtain different solutions based on different operating conditions

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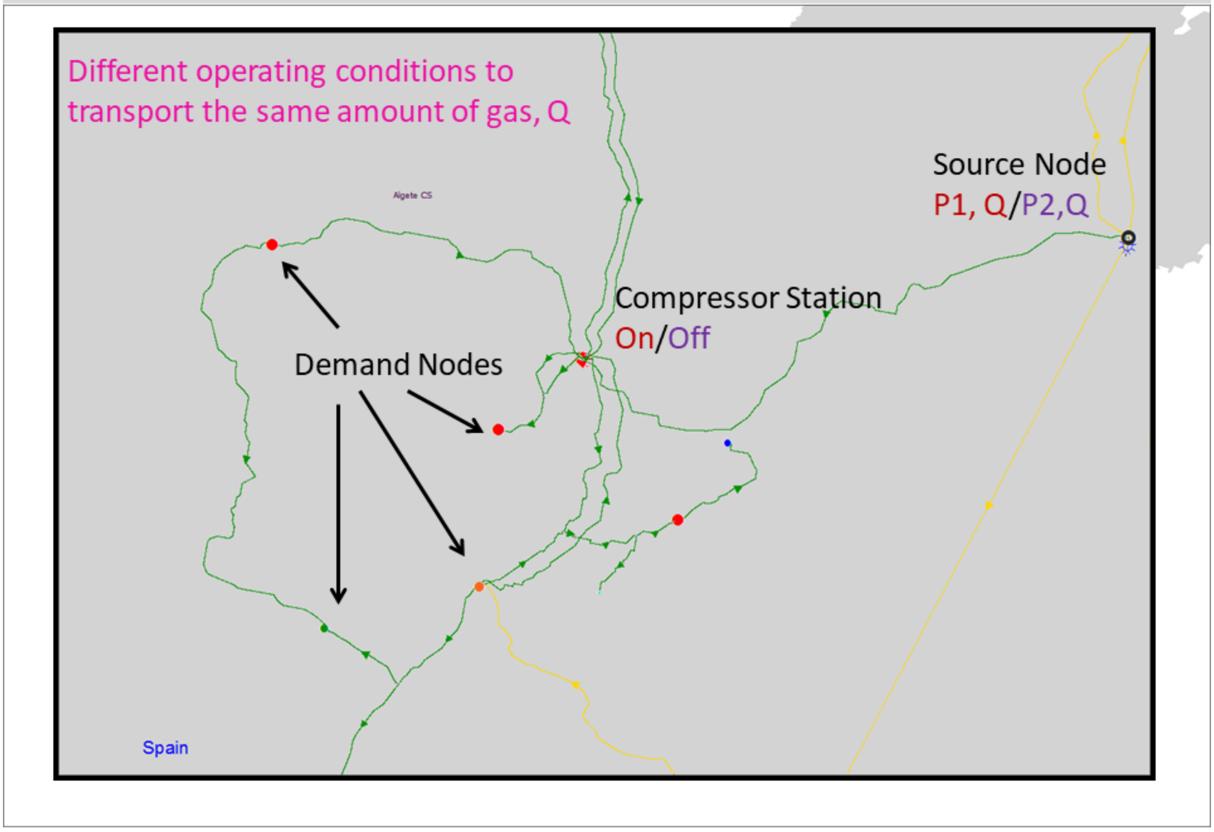
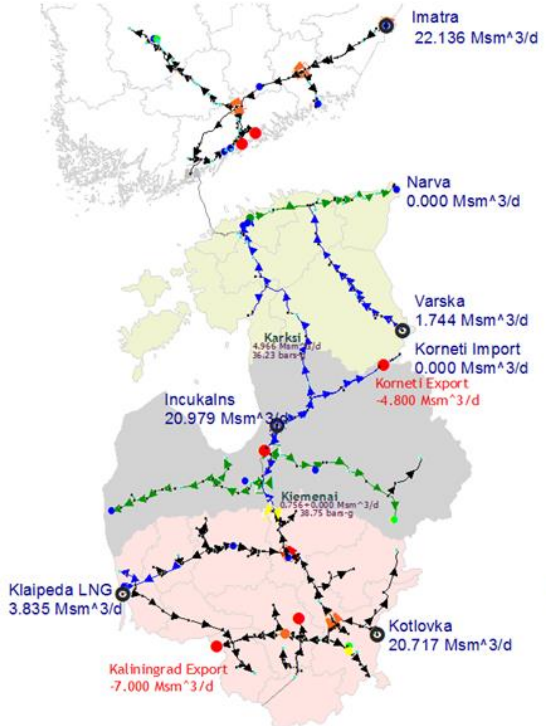
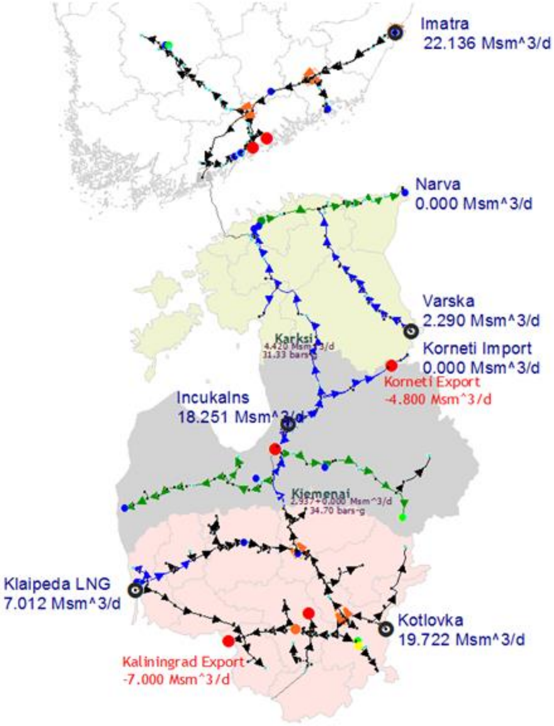
Gas Transmission Network of Iberian Peninsula



Two different solutions to the same operation





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APPLICATIONS FOR HIDRAULIC MODELS

Scenario analysis

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Mass balance models

Application to security of gas supply

Ricardo Fernández-Blanco Carramolino
25 April 2023

Joint Research Centre

Mass balance models

- Mass balance models could be complemented by considering techno-economic characteristics
- Optimal distribution of sources is attained when minimising the system-wide costs
- Strategic storage behaviour could be analysed by a techno-economic model in which an energy balance is considered in the set of constraints
- Typically these models are characterised as linear programming problems (or even mixed-integer programs)

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When should we use a mass balance model?

Geographical coverage
- Too large comprising several countries

Methodological challenges
- Interaction gas and electricity
- Custom constraints

High impact high probability risks
- Global overview
- Easy to analyse hundreds/thousands of scenarios

Data needs
- Lack of data
- Privacy considerations

Research/policy question
- This will guide the assessment and the method to be used

3

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Which tools can we use?

Commercial software	METIS	GEMFLOW	Customised models	Pypsa
Plexos, SAInt	Energy system and market model	Designed to analyse supply disruptions	GAMS, Python	Python-based energy system and market model
Energy system and market models	Policy oriented model	Tailored to the EU gas system	Mathematical problem easily modelled	Solver license is needed as in customised ones
Modelling aspects up to the software		Monte Carlo approach	Flexibility to include custom constraints	

4

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How can we use a mass balance model?

- Country-specific hydraulic simulations
- System-wide mass balance simulations

5

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Modelling aspects (I)

- Modelling accurately **Underground Gas Storages (UGS)** is key in mass balance models when analysing security of supply issues
- Mass balance models are typically linear
- UGS withdrawal/injection capacity curves may be non-convex

Non-linear UGS model

- Binary variables are needed
- Computational complexity increases ✗

Piecewise linear UGS model

- One segment ✗
- Typically two segments ✓

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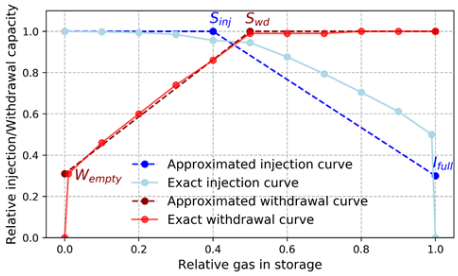
Modelling aspects (I)

- These curves may be represented by two-segment function by defining four parameter
- ENTSOG provides capacity curves with 10 segments for aggregated storages per country



- Withdrawal rate when storage is empty (W_{empty})
- Storage level in the inflexion point (S_{wd})
- Injection rate when storage is full (I_{full})
- Storage level in the inflexion point (S_{wd})

- We have developed an optimisation model to create the approximated piecewise linear functions based on user-defined number of segments -> Powertech conference 2023

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Modelling aspects (II)

Refinement of modelling aspects

Transmission network

- Transmission bottlenecks
- Conflicting capacities
- Contractual constraints

Demand-side

- Consumption prioritisation
- Cooperation and solidarity

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8

Applications in the field of security of supply

1. (Strategic) behavior of underground gas storages
2. Interplay between LNG, pipeline flows and storage facilities
3. Fast sensitivity analysis on a number of weather-dependent parameters or geopolitical factors
4. Impact of solidarity or cooperation arrangements among countries

9

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Thank you

10

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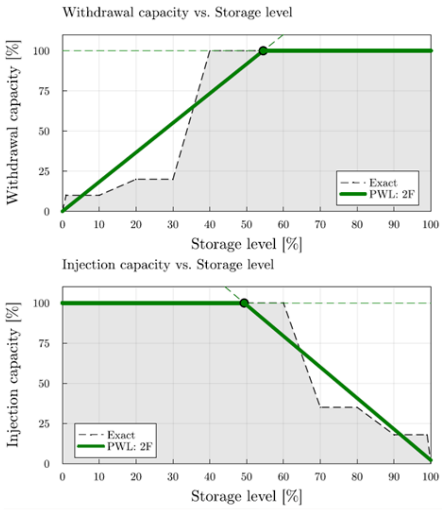
Modelling aspects (I)



- ❑ Assessment of the impact of the number of segments considered in the piecewise linear approximation -> Powertech conference 2023
- ❑ This is the case of Belgium with 2 segments

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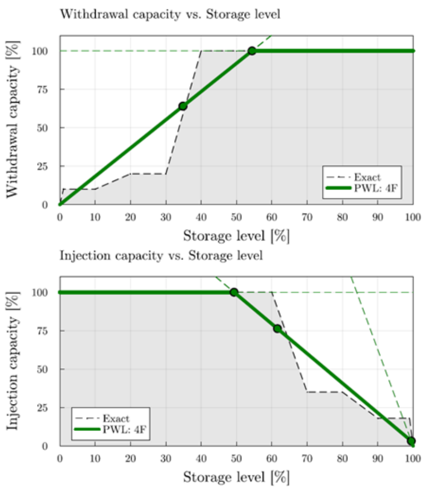
Modelling aspects (I)



- ❑ When considering more than two segments, the approximated curve is almost identical to the one with two segments

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Modelling aspects (I)

Country	Case	e@10 [%]	e@20 [%]	e@60 [%]	1pPWL [days]	1pExcact [days]
BE	0F	90.00	80.00	0.00	0.48	1.14
	1F	21.61	19.21	-30.39	0.85	
	2F	8.37	16.74	0.00	0.77	
	2FYB	10.00	20.00	0.00	0.73	
	3F	8.37	16.75	0.00	0.77	
	4F	8.38	16.76	0.00	0.77	
NL	0F	52.00	41.00	7.00	0.52	0.66
	1F	7.86	1.77	-12.62	0.71	
	2F	-1.93	-0.95	-0.14	0.67	
	2FYB	-2.54	0.09	7.00	0.64	
	3F	0.00	0.00	-0.12	0.66	
	4F	-0.01	0.00	0.00	0.66	
ES	0F	60.00	55.00	37.00	1.64	2.88
	1F	-1.36	-0.85	3.19	2.84	
	2F	-1.08	-0.62	3.24	2.83	
	2FYB	-3.92	7.06	37.00	2.13	
	3F	-1.08	-0.62	3.24	2.83	
	4F	-1.08	-0.62	3.24	2.83	
EU	0F	54.46	41.92	6.21	0.56	0.71
	1F	9.21	1.71	-13.90	0.76	
	2F	-1.63	-1.25	-0.19	0.71	
	2FYB	-2.09	-0.48	6.21	0.69	
	3F	0.29	-0.30	-0.18	0.71	
	4F	0.10	-0.21	-0.04	0.71	

Performance metrics

- **e@X**: Withdrawal capacity approximation error in % at X level of gas in storage
- **1pPWL**: Average number of days for extracting 1% of storage capacity when using the approximated curve
- **1pExact**: Average number of days for extracting 1% of storage capacity when using the exact curve

Cases of approximated functions

- XF: X refers to the number of segments
- 2FYB: special case in which inflexion point is always at 50% of capacity

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Modelling aspects (I)

Country	Case	e@10 [%]	e@20 [%]	e@60 [%]	1pPWL [days]	1pExcact [days]
BE	0F	90.00	80.00	0.00	0.48	1.14
	1F	21.61	19.21	-30.39	0.85	
	2F	8.37	16.74	0.00	0.77	
	2FYB	10.00	20.00	0.00	0.73	
	3F	8.37	16.75	0.00	0.77	
	4F	8.38	16.76	0.00	0.77	
NL	0F	52.00	41.00	7.00	0.52	0.66
	1F	7.86	1.77	-12.62	0.71	
	2F	-1.93	-0.95	-0.14	0.67	
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	3F	0.00	0.00	-0.12	0.66	
	4F	-0.01	0.00	0.00	0.66	
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	2F	-1.08	-0.62	3.24	2.83	
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	3F	0.29	-0.30	-0.18	0.71	
	4F	0.10	-0.21	-0.04	0.71	

Remarks

- Two line segments are a good compromise to reduce errors in most of UGSs
- Using more segments does not improve the approximation in general (see 1pPWL)
- In some extreme cases (BE) where UGS capacity curves are highly non-convex, modeller should decide on the importance of representing them precisely
- Flexibility in the inflexion point is important (2F vs 2FYB)

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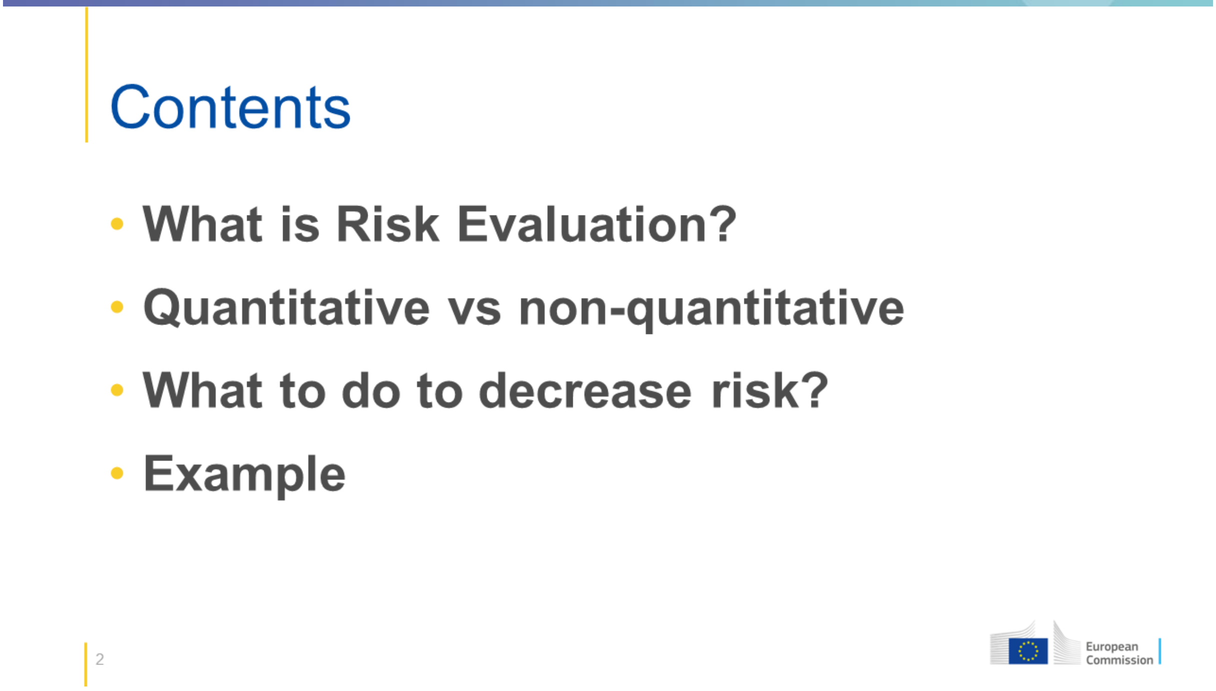
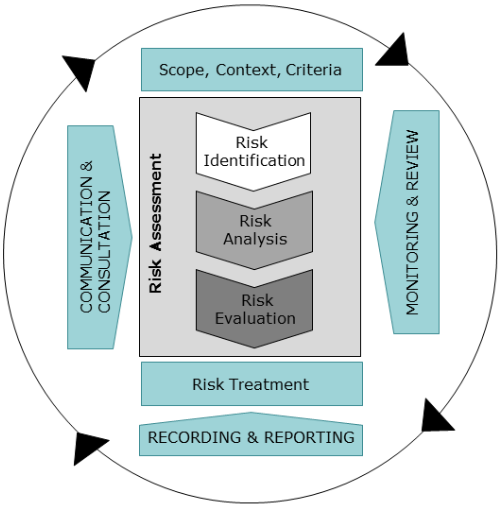
4.7 Risk evaluation

The lecturer of this session was Mr. Ricardo Bolado.



What is Risk Evaluation?



Risk Management process ISO 31000:2018

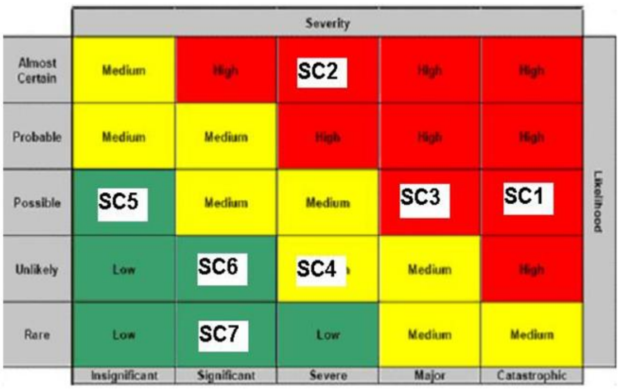
Putting together all what has been done to make sense of it.

Putting together Scenarios, probabilities and consequences

Quantitative vs non-quantitative

Table 1. Results of a hypothetical quantitative RA.

Scenario	Probability (a^{-1})	Unserved gas (mcm)	Expected Unserved gas (mcm/a)
SC1	$2 \cdot 10^{-1}$	$3 \cdot 10^{-1}$	0.060
SC2	$4 \cdot 10^{-2}$	$6 \cdot 10^{0}$	0.240
SC3	$6 \cdot 10^{-2}$	$1 \cdot 10^{2}$	6.000
SC4	$2 \cdot 10^{-4}$	$2 \cdot 10^{2}$	0.040
SC5	$4 \cdot 10^{-5}$	$2.5 \cdot 10^{2}$	0.010
SC6	$6 \cdot 10^{-5}$	$2 \cdot 10^{3}$	0.120
SC7	$1 \cdot 10^{-6}$	$2.6 \cdot 10^{4}$	0.026
Expected unserved gas			6.496



Quantitative

Table 1. Results of a hypothetical quantitative RA.

Scenario	Probability (a^{-1})	Unserved gas (mcm)	Expected Unserved gas (mcm/a)
SC1	$2 \cdot 10^{-1}$	$3 \cdot 10^{-1}$	0.060
SC2	$4 \cdot 10^{-2}$	$6 \cdot 10^{0}$	0.240
SC3	$6 \cdot 10^{-2}$	$1 \cdot 10^{2}$	6.000
SC4	$2 \cdot 10^{-4}$	$2 \cdot 10^{2}$	0.040
SC5	$4 \cdot 10^{-5}$	$2.5 \cdot 10^{2}$	0.010
SC6	$6 \cdot 10^{-5}$	$2 \cdot 10^{3}$	0.120
SC7	$1 \cdot 10^{-6}$	$2.6 \cdot 10^{4}$	0.026
Expected unserved gas			6.496

What is the probability of incurring unserved gas larger than a given value?

P(U>= 26 bcm) = 0.000001

P(U>= 2 bcm) = 0.000061

P(U>= 0.25 bcm) = 0.000101

P(U>= 0.20 bcm) = 0.000301

P(U>= 0.10 bcm) = 0.060301

P(U>= 6 mcm) = 0.100301

P(U>= 0.3 mcm) = 0.300301

5

Quantitative vs non-quantitative

P(U>= 26 bcm) = 0.000001

P(U>= 2 bcm) = 0.000061

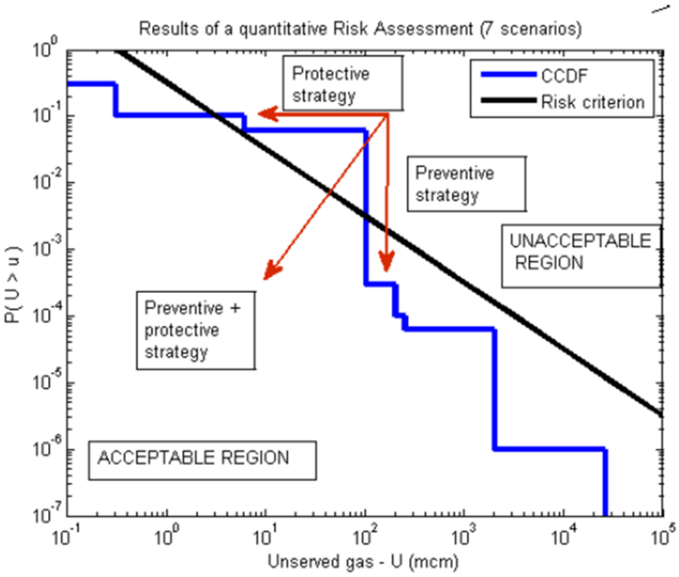
P(U>= 0.25 bcm) = 0.000101

P(U>= 0.20 bcm) = 0.000301

P(U>= 0.10 bcm) = 0.060301

P(U>= 6 mcm) = 0.100301

P(U>= 0.3 mcm) = 0.300301



6

What to do to decrease Risk?

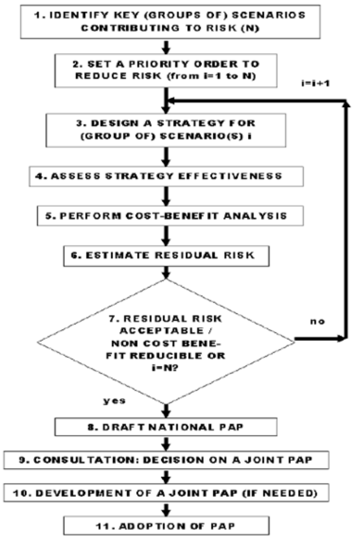


Table 1. Results of a hypothetical quantitative RA.

Scenario	Probability (a^{-1})	Unserved gas (mcm)	Expected Unserved gas (mcm/a)
SC1	$2 \cdot 10^{-1}$	$3 \cdot 10^{-1}$	0.060
SC2	$4 \cdot 10^{-2}$	$6 \cdot 10^{0}$	0.240
SC3	$6 \cdot 10^{-2}$	$1 \cdot 10^{2}$	6.000
SC4	$2 \cdot 10^{-4}$	$2 \cdot 10^{2}$	0.040
SC5	$4 \cdot 10^{-5}$	$2.5 \cdot 10^{2}$	0.010
SC6	$6 \cdot 10^{-5}$	$2 \cdot 10^{3}$	0.120
SC7	$1 \cdot 10^{-6}$	$2.6 \cdot 10^{4}$	0.026
Expected unserved gas			6.496

Risk reduction

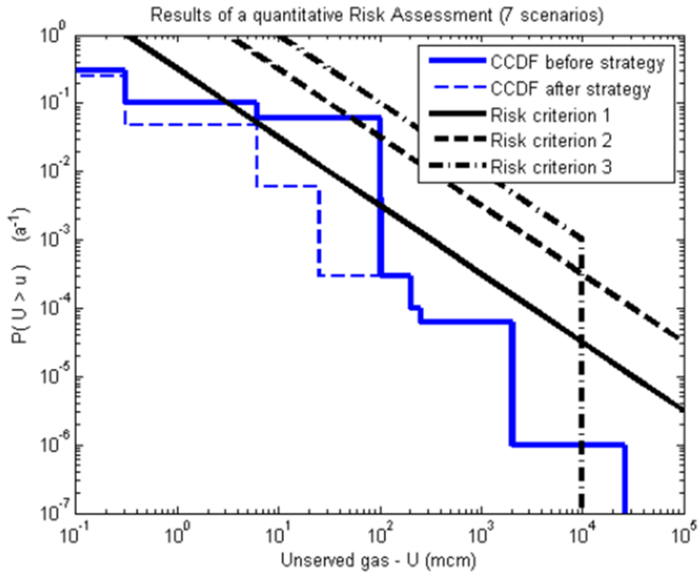
Preventive + protective action:

SC3:

Consequence: 100 mcm ➔ 25 mcm
Prob.: 0.06 ➔ 0.006

Expected unserved gas:
SC: 6 mcm/y ➔ 0.150 mcm/y

Global risk:
6.496 ➔ 0.646 mcm/y



8

Example

Risk analysis of a gas region

- 8 scenarios / contexts considered
- Monte Carlo: Each scenario 6 times (climatic scenarios
- Consequences: unserved gas in the region during winter
- Mitigation strategy: gas demand reduction

9

European Commission

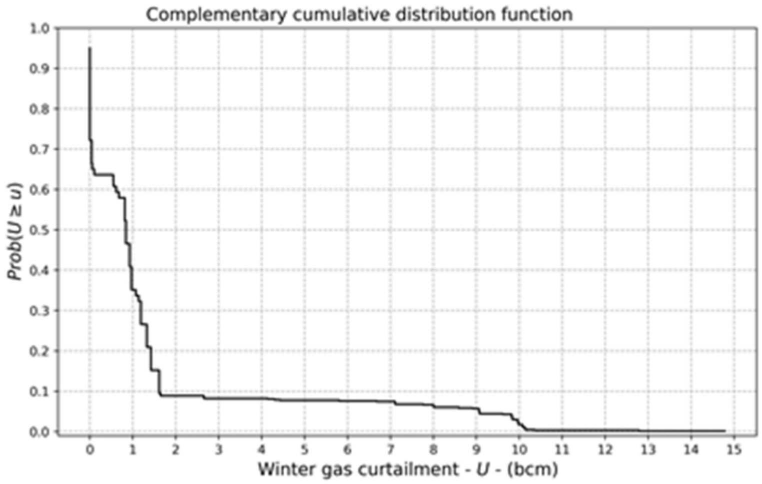
Example

Context	Impact (bcm)	Probability	Risk (bcm)
CB0	0.7	0.342	0.2
CB21	8.1	0.038	0.3
CC0	0.8	0.342	0.3
CC21	8.1	0.038	0.3
NB0	0.4	0.086	0.0
NB21	8.2	0.01	0.1
NC0	0.4	0.086	0.0
NC21	8.2	0.01	0.1
Expected Risk	-	-	1.3

10

European Commission

Example



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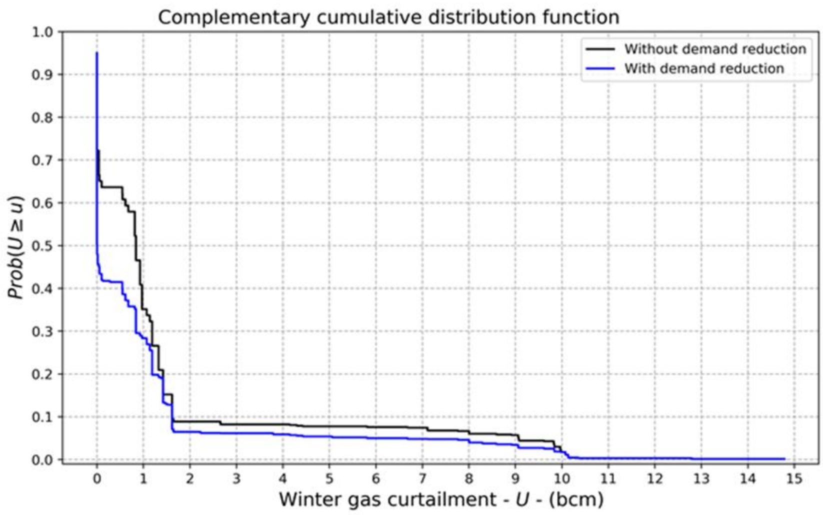
Example; after demand reduction



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Example; after demand reduction

Context	Impact (bcm)	Probability	Risk without Demand Reduction (bcm)	Risk with Demand Reduction (bcm)
CB0	0.7	0.342	0.2	0.0
CB21	8.1	0.038	0.3	0.1
CC0	0.8	0.342	0.3	0.3
CC21	8.1	0.038	0.3	0.3
NB0	0.4	0.086	0.0	0.0
NB21	8.2	0.01	0.1	0.1
NC0	0.4	0.086	0.0	0.0
NC21	8.2	0.01	0.1	0.1
Expected Risk	-	-	1.3	0.9

13

Commission

Conclusions

Risk evaluation consists in putting all results together and draw lessons on how to decrease the global risk

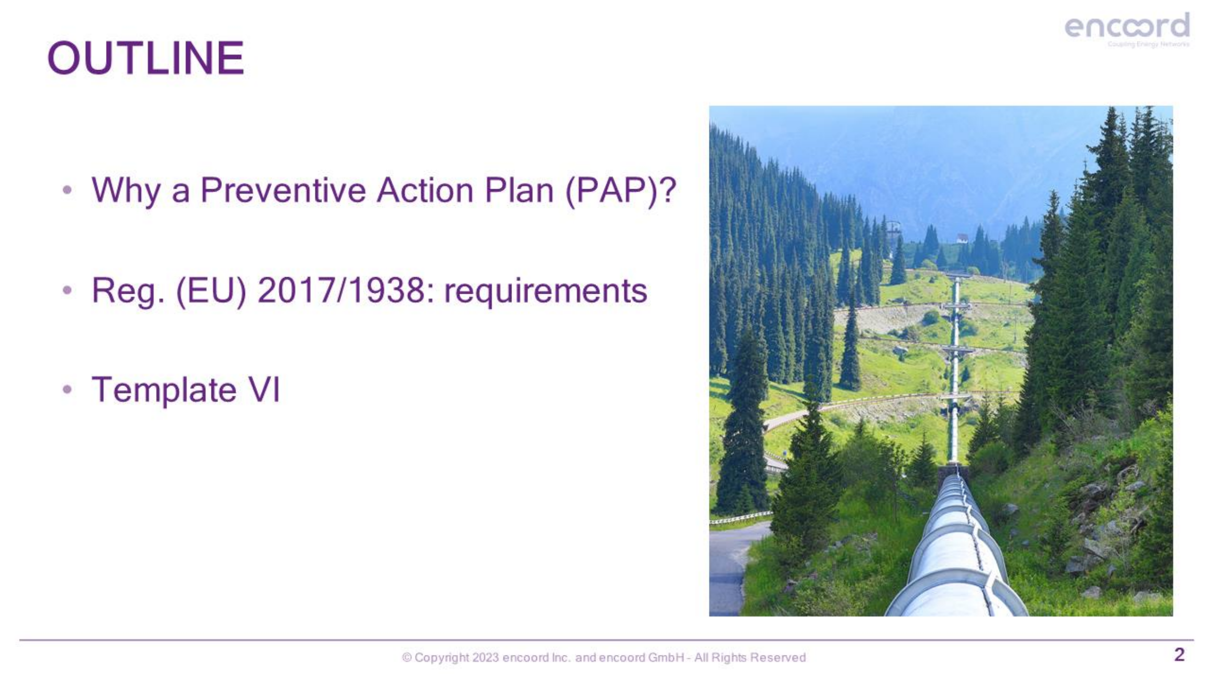
Risk evaluation should preferably be based on solid, knowledge based, quantitative Risk estimates.

Risk Assessments are iterative; include incremental steps.

European Commission

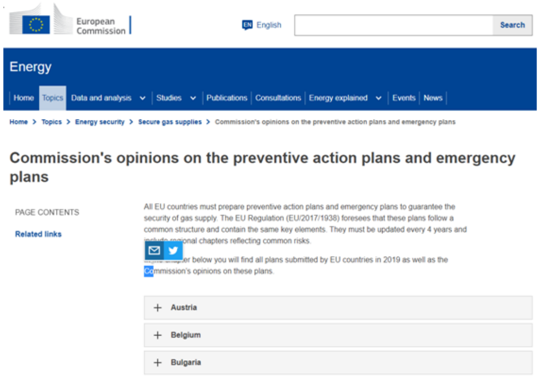
4.8 Preventive Action Plan according to Regulation (EU) 2017/1938

The lecturer of this session was Mr. Nicola Zaccarelli.



REMINDER

- The Preventive Action Plan is a PUBLIC document assessed by the European Commission (EC)
- The EC issues an OPINION

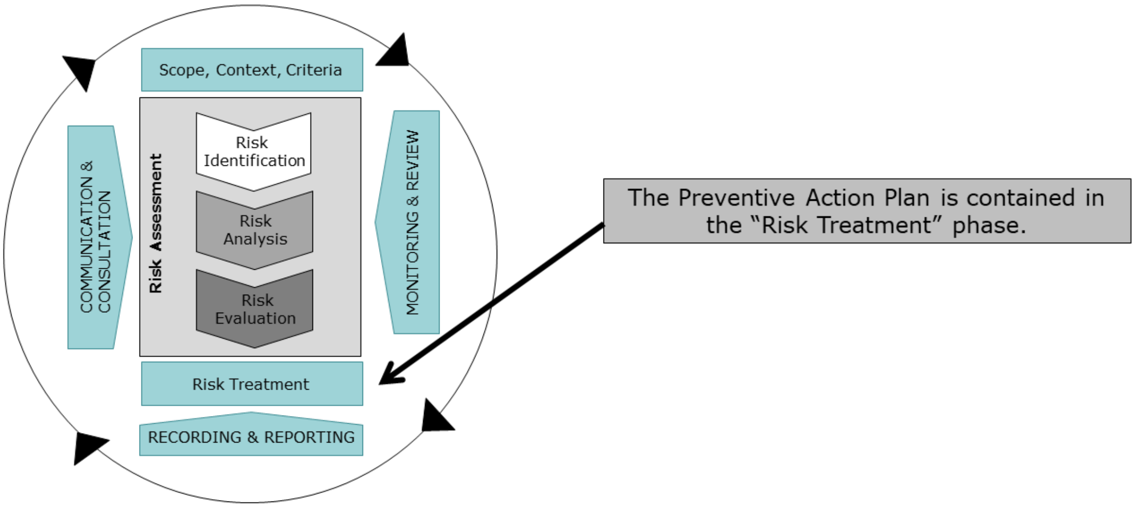


The plans and opinions are at

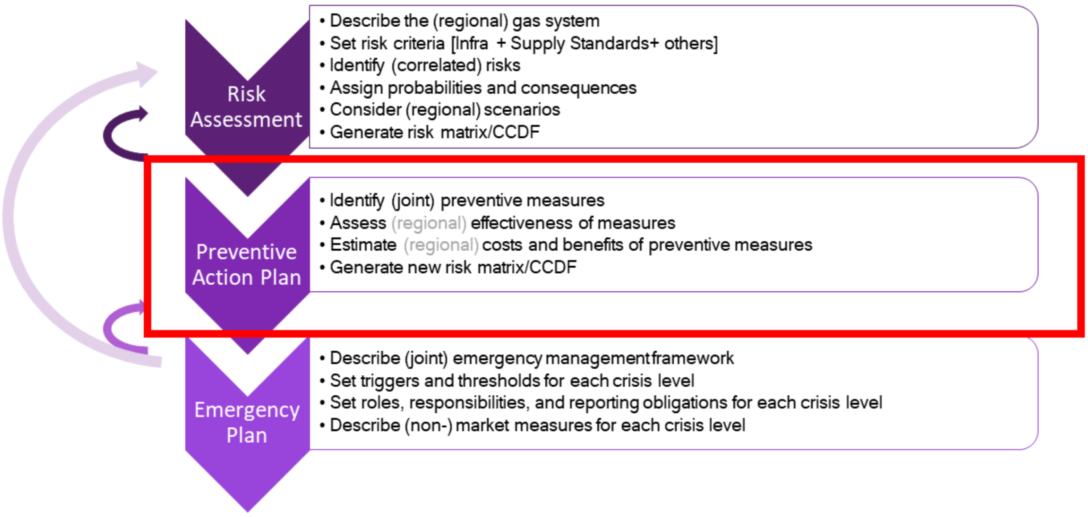
[Secure gas supplies (europa.eu)](https://energy.ec.europa.eu/topics/energy-security/secure-gas-supplies_en)

[https://energy.ec.europa.eu/topics/energy-security/secure-gas-supplies_en]

Risk Management process ISO 31000:2018



Simplified Structure of RA/PAP/EP Process



Reg. (EU) 2017/1938

Article 8 - Establishment of preventive action plans and emergency plans

1) Measures in the plans must be "*[...] clearly defined, transparent, proportionate, non-discriminatory and verifiable, shall not* ***unduly distort competition*** *or the effective functioning of the internal market in gas and shall not* ***endanger the security*** *of gas supply of other Member States or of the Union*".
2) **Consultation** of gas undertakings and other Authorities (e.g., electricity TSO)
3) Must contain "regional chapters" for each Risk Group and "regional measures"
4) Report to "Gas Coordination Group" for "regional" measures, updates, and cooperation mechanism

Reg. (EU) 2017/1938

Article 8 – Establishment of preventive action plans and emergency plans

5) **Follow the template of Annex VI**
6) Consultation and draft exchange with Risk Groups
7) It is a **public** document
8) **Commission provides an opinion** on the plan
9) Member State to amend the plan or explain why not
10) Procedure for new non-market based measures
11) Confidentiality of commercially sensitive information
12) Reg. (EU) 994/2010 PAPs are still valid till new ones are approved (every 4 years).

Reg. (EU) 2017/1938

9 - Content of preventive action plans (1/5)

Content of preventive action plans

1. The preventive action plan shall contain:

(a) the **results of the risk assessment** and a **summary of the scenarios** considered, as referred to in point (c) of Article 7(4);

(b) the **definition of protected customers** and the **information described in the second subparagraph** of Article 6(1); (i.e., the supply standard)

(c) the **measures, volumes and capacities** needed to fulfil the infrastructure and gas supply standards, including demand-side measures, single largest infrastructure, gas by category of protected customers and scenarios, (compliance) increased supply standard and temporally reduction mechanisms.

Reg. (EU) 2017/1938

9 - Content of preventive action plans (2/5)

(d) **obligations** imposed on natural **gas undertakings, electricity undertakings**, and **other relevant bodies** likely to have an impact on the security of gas supply, such as obligations for the safe operation of the gas system;

(e) other **preventive measures** designed to address the risks identified in the risk assessment, such as those relating to the need **to enhance interconnections** between neighbouring Member States, to further improve **energy efficiency**, to **reduce gas demand** and the possibility to **diversify gas routes** and **sources** of gas supply and the regional utilisation of existing storage and LNG capacities, if appropriate, in order to maintain gas supply to all customers as far as possible;

(f) information on the **economic impact, effectiveness and efficiency** of the measures contained in the plan, including the obligations referred to in point (k); (i.e., public service obligations)

Reg. (EU) 2017/1938

9 - Content of preventive action plans (3/5)

(g) a description of the **effects** of the measures contained in the plan on the **functioning of the internal energy market as well as national markets**, including the obligations referred to in point (k);

(h) a description of the **impact** of the measures **on the environment** and on **customers**;

(i) the **mechanisms** to be used **for cooperation** with other Member States, including the mechanisms for preparing and implementing preventive action plans and emergency plans;

(j) information on **existing and future interconnections and infrastructure**, including those providing access to the internal market, cross-border flows, cross-border access to storage and LNG facilities and the bi-directional capacity, in particular in the event of an emergency;

(k) information on **<u>all</u> public service obligations** that relate to the security of gas supply.

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Reg. (EU) 2017/1938

9 - Content of preventive action plans (4/5)

Content of preventive action plans

2. take into account the **Union-wide TYNDP** elaborated by ENTSOG;

3. based primarily on **market-based measures** and shall not put an **undue burden** on natural gas undertakings, or negatively impact on the functioning of the internal market;

4. **preventive non-market-based measures compliant** with protected customers, principles of a PAP, internal market and flow;

5. and 6. states to make public measures of 4. and EC impact assessment;

7. This point details the content of the impact assessment.

Reg. (EU) 2017/1938

9 - Content of preventive action plans (5/5)

Content of preventive action plans

8. and 9. describe how the EC and the notification/opinion on the measures consider the assessment;

10. describes amendment procedure;

11. Timing of the plan update: every 4 years from 1 March 2019 or more frequently if the circumstances so warrant or at the Commission's request.

Reg. (EU) 2017/1938

PAP general issues (1/4)

When reading critically old PAPs and checking them against Art. 9 some issues may arise:

- Gas - electricity interaction: not properly addressed (⇒ need more experience)
- Bottlenecks: hidden or not considered
- Origin of gas (Risk Assessment): not clear (⇒ not possible)
- Historical - estimation: wrong view on the 1-in-20 concept (cfr. Risk Assessment)

Reg. (EU) 2017/1938

PAP general issues (2/4)

- Only a few countries provide a **comprehensive correlation** between risks identified and measures, and make a sufficiently detailed quantitative analysis of the risks identified (e.g. likelihood and impact) and measures proposed (how they contribute to mitigating the risks)
- Market vs. non-market based measures (Classification of state-EU financed infrastructure developments)
- **Environmental and economic impacts of emergency and preventive measures, as well as the quantitative evaluation of the efficiency of the measures are almost always missing.**

Reg. (EU) 2017/1938

PAP general issues (3/4)

The infrastructure standard (defined in the RA):

- Different approaches to estimate Dmax;
- Different considerations regarding transit;
- Technical abilities vs. contractual circumstances;
- Deff is rarely considered and clarified.

Reg. (EU) 2017/1938

PAP general issues (4/4)

The supply standard lacks:

- complete definition of protected customers (PC) and of their gas demand.
- consistency in the assumptions to estimate the different figures required by the Regulation (e.g., quantification of gas demand for PC as an annual average instead of peak winter conditions).
- Not only calculating but also the confirmation of supply.
- The technical feasibility of prioritizing protected customers in practice is a challenge.

Reg. (EU) 2017/1938

ANNEX VI – Template for a preventive action plan

The structure of the template is:

Name of the competent authority

1. Description of the system
2. Summary of the risk assessment (scenarios, assumptions, conclusions)
3. Infrastructure standard (Article 5)
4. Compliance with the supply standard (Article 6)
5. Preventive measures (**impact**)
6. Other measures and obligations (e.g. safety operation of the system)
7. Infrastructure projects
8. Public service obligations related to the security of supply
9. Stakeholder consultations
10. Regional dimension

Reg. (EU) 2017/1938

ANNEX VI – Template for a preventive action plan

- The TEMPLATE indicates the minimum information necessary. More can be added.
- What it is bounding is the content described in Art. 9. Not the templates.
- The EC uses the templates as a checklist.
- Templates facilitate comparison and communication and should not be considered an extra burden.

TAKE HOME messages

- A Preventive Action Plan MUST build on the Risk Assessment
- In its core is a Before-After-Control-Impact (**BACI**)
- It requires numerical analyses of measure impacts

Plan the Energy Future!

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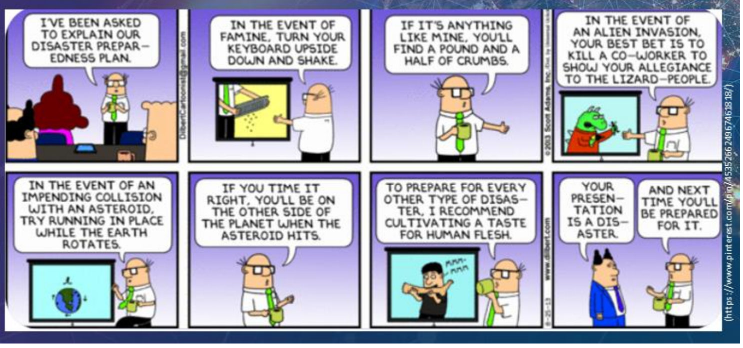
Any questions?

You can find me nicola@encoord.com
Or visit https://www.encoord.com/



4.9 Emergency Plan according to Regulation (EU) 2017/1938

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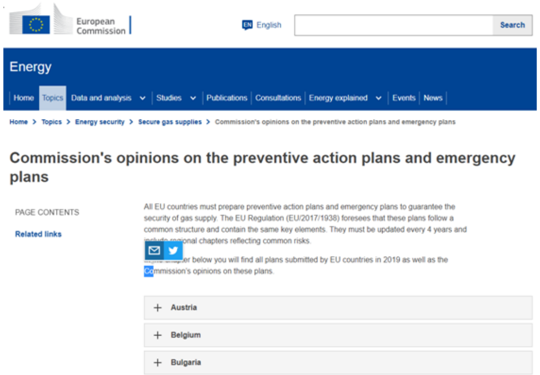
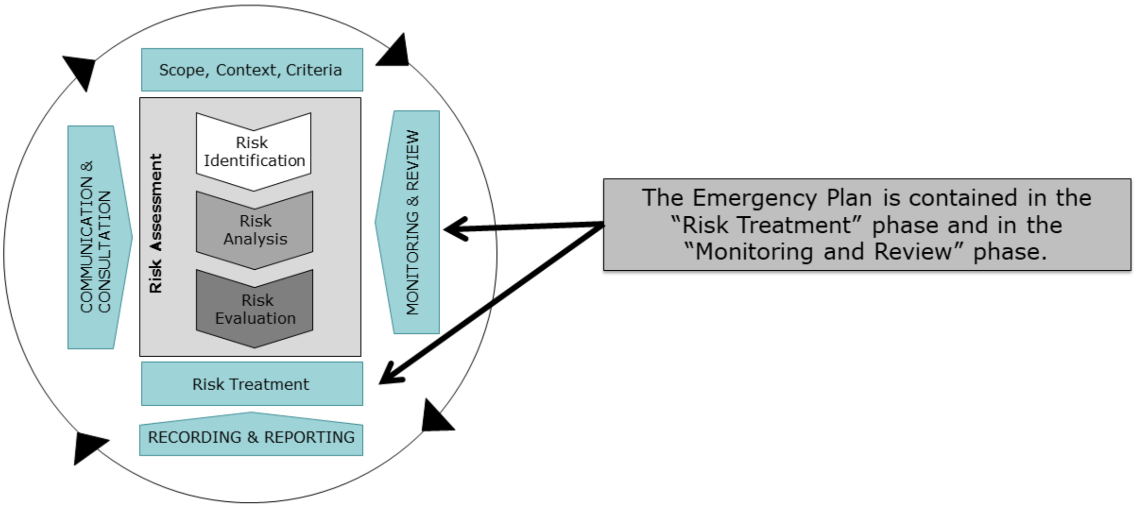


[https://energy.ec.europa.eu/topics/energy-security/secure-gas-supplies_en]

TAKE HOME messages

- An Emergency Plan is an OPERATIONAL TOOL
  - **Must be very clear!**
  - **Who does what! What to do! When it is done!**
- Consultation of neighbouring Countries and gas undertakings
- It requires numerical analyses of:
  - **Crisis levels**
  - **Contribution of measures**
- **Needs of** (“solidarity”) **protected customers**
- **[Check for exceptional situations: war (Act of God)]**

Risk Management process ISO 31000:2018



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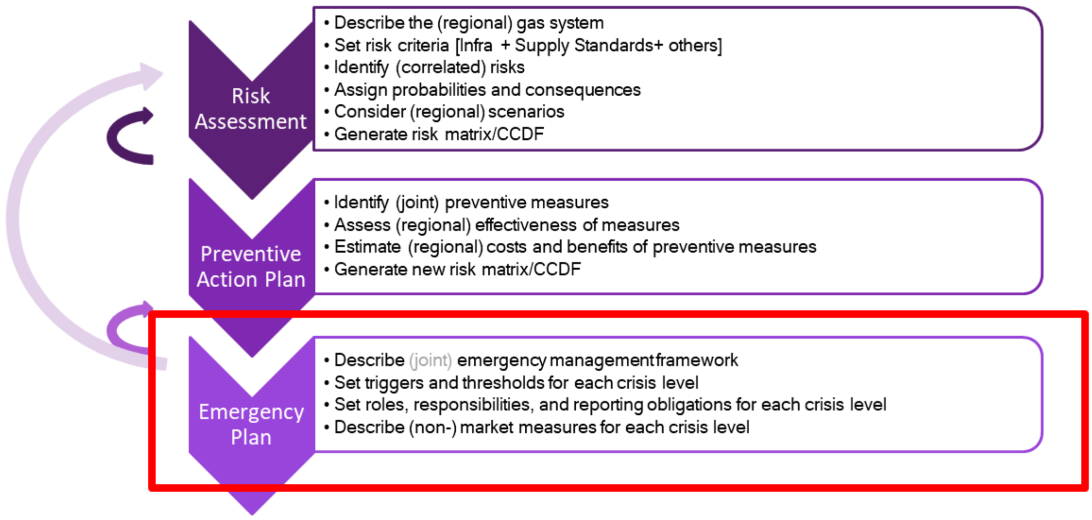
Simplified Structure of RA/PAP/EP Process



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Reg. (EU) 2017/1938

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12) Reg. (EU) 994/2010 emergency plans are still valid till new ones are approved

Reg. (EU) 2017/1938

10 - Content of emergency plans (1/5)

Content of emergency plans

1. The emergency plan shall:

(a) **build upon the crisis levels** referred to in Article 11(1);

-> Who declares the crisis level [either Competent Authority and/or TSO]

-> Define crisis levels and provide numerical indicators / thresholds

Transmission System Operators [TSO] have indicators for crisis situations:

- **e.g., Bulgartransgaz three regions for use of linepack!**
- **e.g., Emergency Plan of Serbia clear list of triggering conditions and numbers**

Reg. (EU) 2017/1938

10 - Content of emergency plans (1/5)

6.11. Crisis events and grades in Hungary

Infrastucture	Crisis event	Early warning level	Alert level	Emergency level
Baumgarten – Mosonmagyaróvár line	Pressure at the border is <38 bar		x	
	No gas flow for 4 hrs and consumption is 70-80 mcm/d		x	
	ditto, plus consumption is >80 mcm/d			x
	ditto, plus consumption in last 3 days is >70 mcm/d			x
Beregovo-beregdaróc line	Pressure at the border is <40 bar	x		
	No gas flow for 4 hrs and consumption is 60-70 mcm/d	x		
	ditto, plus consumption is >70 mcm		x	
	ditto, plus consumption in last 3 days is >60 mcm/d		x	

(as of 2019)

Reg. (EU) 2017/1938

10 - Content of emergency plans (1/5)

Crisis Level 2 - alert is declared in the event that one of the following circumstances has occurred:

1) when there is a shortage of more than 10% of the nominated volumes, over a period of time that is equal or greater than two consecutive days during December, January and February;

2) when there is a shortage in the amount of 40% of the nominated volumes over a period of time that is equal or greater than two consecutive days in any other period of the year except January and February;

3) total available volumes of natural gas in the Banatski Dvor underground storage facility are less than 150 million m3, regardless of the season;

4) the volumes of natural gas in the Banatski Dvor underground storage facility held by the Public Enterprise Srbijagas are less than 18 million m^3;

5) the demand for natural gas exceeds 130% of the nominated volume, over a specified period of more than or equal to two consecutive days;

6) compressor station failure;

7) interrupted supply from the Banatski Dvor underground storage facility;

8) the inability to meet daily demands for natural gas for 20,000 to 50,000 system users;

9) the total unmet demand of priority customers for natural gas are greater than 500,000 m^3/day;

(as of 2019)

Reg. (EU) 2017/1938

10 - Content of emergency plans (2/5)

Content of emergency plans

1. The emergency plan shall:

(a) **build upon the crisis levels** referred to in Article 11(1);

(b) **define the role and responsibilities of natural gas undertakings, transmission system operators for electricity** if relevant and of **industrial gas customers** including relevant electricity producers, taking account of the different extent to which they are affected in the event of a disruption of gas supply, and their interaction with the competent authorities and where appropriate with the **national regulatory authorities** at each of the crisis levels referred to in Article 11(1);

(c) define the **role and responsibilities of the competent authorities** and of the other bodies to which tasks have been delegated as referred to in Article 3(2) at each of the crisis levels referred to in Article 11(1);

Reg. (EU) 2017/1938

10 - Content of emergency plans (2/5)

EP of Belgium: Table with actors, roles, and responsibilities

3.3. Roles and responsibilities

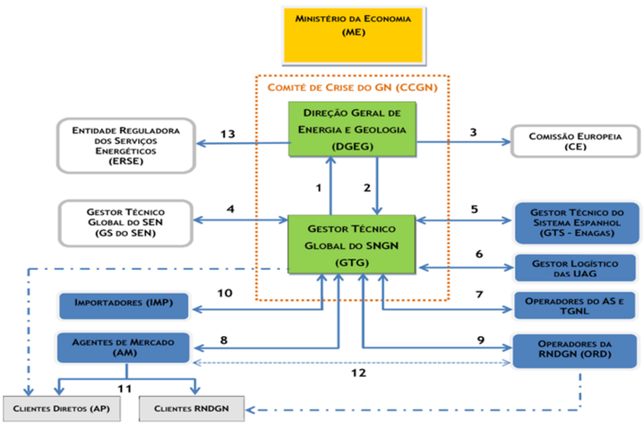
Organisation	Role and responsibility
NESO	Lead government body during a gas emergency responsible for drafting the NEP and procedures to be followed by each of the stakeholders. In certain circumstances, the NESO may decide to deviate from the NEP and propose additional measures.
Crisis Cell home affairs	Assists the NESO with the coordination of the actions to take on a local level, with the local and regional resilience teams. Takes over the facilitating role in an emergency if the gas emergency has an impact on the civil protection or creates a safety hazards.
Bureau of Civil Contingency	The internal crisis cell of the Federal Public Service Economy, P.M.E., self-Employed and Energy which will be in contact with the crisis cell of the department of home affairs.
Fluxys Belgium	The transmission system operator has the responsibility to manage the response to a national gas emergency and is the first one to give instructions to the shippers and suppliers to adjust the gas flows as foreseen in the specific emergency plan.
CREG	Regulates the gas market and provides information on the operation of the

(as of 2019)

Reg. (EU) 2017/1938

10 - Content of emergency plans (2/5)

EP of Portugal: Diagrams addressing actors, relationships and responsibilities



(as of 2019)

Reg. (EU) 2017/1938

10 - Content of emergency plans (3/5)

(d) ensure that natural **gas undertakings and industrial gas customers** including relevant electricity producers are given **sufficient opportunity to respond** to the crisis levels referred to in Article 11(1);

(e) identify, if appropriate, the **measures and actions** to be taken to mitigate the potential impact of a disruption of gas supply on **district heating** and the supply of **electricity generated** from gas, including through an integrated view of energy systems operations across electricity and gas if relevant;

(f) establish **detailed procedures and measures to be followed for the crisis levels** referred to in Article 11(1), including the corresponding schemes on **information flows**;

(g) designate a **crisis manager** and define its role;

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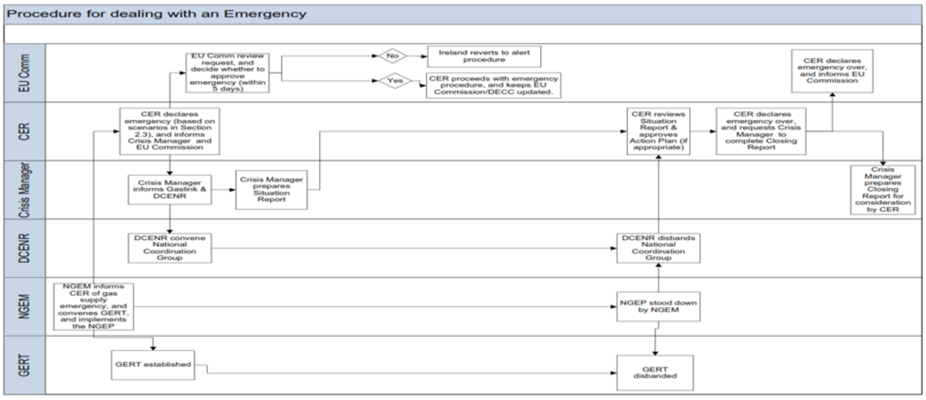
10 - Content of emergency plans (3/5)

Flow chart from the EP of Ireland

Appendix 4: Emergency Flow Chart



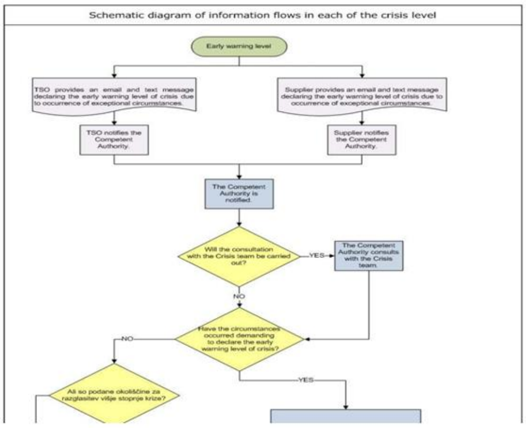
(as of 2019)

Reg. (EU) 2017/1938

10 - Content of emergency plans (3/5)

Flow chart from the EP of Slovenia

Annex 1: Schematic diagram of information flows in each of the crisis level



(as of 2019)

Reg. (EU) 2017/1938

10 - Content of emergency plans (3/5)

Establish measures for each crisis level - Croatia

			CRISIS LEVELS (applicable / on the basis of and implementation method)		
			1.EARLY WARNING Declared by the Minister following the proposal from the Crisis Team	2. ALERT Declared by the Minister following the proposal from the Crisis Team	3. EMERGENCY Declared by the Croatian Government following the Minister's proposal
MARKET	1	Increase natural gas production	***YES*** */ Order of the Crisis Team to the energy undertaking*	***YES*** */ Order of the Crisis Team to the energy undertaking*	-
	2	Increase natural gas imports	*Energy undertakings*	***YES*** */ Order of the Crisis Team to OVT**	-
	3	Reduction or discontinuance of supply – use of other fuels	***YES*** */ Order of the Crisis Team to the customers*	***YES*** */ Order of the Crisis Team to the customers*	-
	4	Safeguard sufficient gas stock	***YES*** */ Order of the Crisis Team to the energy undertakings*	***YES*** */ Order of the Crisis Team to the energy undertakings*	-
	5	Other measures contributing to security of supply	*Energy undertakings coordinated with the Crisis Team*	*Energy undertakings coordinated with the Crisis Team*	-
NON-MARKET	1	Maximal increase in the natural gas production	*NO / -*	***YES*** */ Croatian Government's decision*	***YES*** */ Order of the Crisis Team*
	2	Limit natural gas exports	*NO /*	***YES*** */ Croatian Government's decision*	***YES*** */ Order of the Crisis Team*
	3	Increase natural gas imports	*NO /*	***YES*** */ Croatian Government's decision*	***YES*** */ Order of the Crisis Team*
	4	Maximal withdrawal of gas from storage	*NO /*	***YES*** */ Croatian Government's decision*	***YES*** */ Order of the Crisis Team*
	5	Reduction or discontinuance of supply – levels 1 to 11	*NO /*	*NO /*	***YES*** */ Order of the Crisis Team*

OVT* supplier in the wholesale market pursuant to the Gas Market Act („Official Gazette« 28/13, 14/14)

(as of 2019)

Reg. (EU) 2017/1938

10 - Content of emergency plans (4/5)

(h) identify the **contribution of market-based** measures for coping with the situation at alert level and mitigating the situation at emergency level;

(i) identify the **contribution of non-market-based measures** planned or to be implemented for the emergency level, and assess the degree to which the use of such non-market-based measures is necessary to cope with a crisis. The effects of the non-market-based measures shall be assessed and procedures for their implementation defined. Non-market-based measures are to be used only when market-based mechanisms alone can no longer ensure supplies, in particular to protected customers, or for the application of Article 13;

Reg. (EU) 2017/1938

10 - Content of emergency plans (4/5)

Spanish EP

contribution of market-based

(as of 2019)

Tabla 2: Medidas aplicadas en situación de operación normal y alerta temprana

	ORDEN DE ACTUACIÓN	MEDIDAS DISPONIBLES	VALORACIÓN	OBSERVACIONES
OPERACIÓN NORMAL	1	Operaciones de BRS	-	Diferencia entre el flujo físico total y la suma de las nominaciones de los usuarios. Existen tres niveles de BRS (0, 1 y 2) en función de las causas que lo justifican (Protocolo de Detalle PD-11 de las NGTS). Estas diferencias quedan reflejadas diariamente en los informes de BRS publicados en la web de Enagás-GTS.
	2	Operación conjunta en conexiones internacionales (VIP IBÉRICO/ PIRINEOS)	-	Capacidad para operar conjuntamente las conexiones internacionales con un mismo Estado Miembro. Esta flexibilidad viene dada por la existencia de acuerdos operativos entre Enagás-GTS y REN/TIGF.
	3	Acuerdo de asistencia mutua entre Enagás-GTS y TIGF	-	Apoyo hasta alcanzar una OBA máxima acumulada, mediante la elaboración de un programa conjunto de asistencia, en situación de operación excepcional debidamente justificada. Medida reflejada en el cómputo diario de las operaciones de BRS-0.
		Acuerdo de asistencia mutua entre Enagás-GTS y REN-GTG	-	Apoyo hasta alcanzar una OBA máxima acumulada, mediante la elaboración de un programa conjunto de asistencia, en situación de operación excepcional debidamente justificada. Medida reflejada en el cómputo diario de las operaciones de BRS-0.
	4	Mecanismos de colaboración activa entre el Gestor Técnico del Sistema y empresas comercializadoras de gas natural	-	Colaboración activa entre agentes del sistema para evitar desbalances y situaciones de riesgo (reprogramación logística de buques, reprogramacion en CI, activación interrumpibilidad comercial, etc.)
ALERTA TEMPRANA	5	Reordenamiento de la logística de buques	-	El GTS junto con los comercializadores, ubicará adecuadamente los suministros en el Sistema para garantizar el adecuado funcionamiento de las instalaciones dentro de la operación segura. Se optimizarán las operaciones de descarga/carga en las terminales de GNL, facilitando la entrada al Sistema de buques metaneros no programados procedentes del mercado spot que contribuyan a la seguridad del suministro
	6	Incremento extracción en AASS	máx: [183-238] GWh/día mín: 0 GWh/día	Diferencia entre la capacidad máxima de extracción disponible y la suma de las nominaciones de los usuarios. Este margen se puede concretar y cuantificar una vez declarado el nivel de crisis. Con la consolidación de los nuevos almacenamientos de Yela y Marismas, la capacidad de extracción seguirá incrementándose a lo largo de los distintos ciclos de inyección/extracción.
	7	Uso de existencias de GNL y/o AASS (PAI)	≈ 2.000 GWh (inv. 2014-2015)	Reserva operativa disponible en tanques de GNL y/o AASS durante el periodo invernal en virtud de la Regla 1ª del Plan de Actuación Invernal. En el invierno 2014-2015 continúa vigente el Plan Invernal aprobado en la Resolución de 8 de octubre de 2013, de la DGPEyM. La reserva de existencias de la citada Regla 1ª, equivalente a 2 días de la capacidad contratada en las terminales de regasificación y cistemas más 2 días de la contratación en CCII y yacimientos, se valoran en al menos 2.000 GWh.
	8	Promover el flujo máximo de entrada por CI	-	Colaboración entre operadores y comercializadores para: - en CI unidireccionales, impulsar la utilización de la capacidad nominal de la infraestructura (a cuantificar una vez declarado el nivel de crisis). - en CI bidireccionales, reprogramación máxima variable en función de la capacidad nominal de entrada y el saldo resultante de la suma de las nominaciones de los usuarios, teniendo en cuenta las nominaciones bajo contratación interrumpible. Avanzar en los acuerdos de asistencia mutua para incrementar las cantidades de apoyo
	9	Potenciales medidas de mercado aplicadas a la oferta	-	Por ejemplo, las derivadas de la implantación del mercado organizado (Hub Ibérico)

Reg. (EU) 2017/1938

10 - Content of emergency plans (4/5)

(h) identify the **contribution of market-based** measures for coping with the situation at alert level and mitigating the situation at emergency level;

(i) identify the **contribution of non-market-based measures** planned or to be implemented for the emergency level, and assess the degree to which the use of such non-market-based measures is necessary to cope with a crisis. The effects of the non-market-based measures shall be assessed and procedures for their implementation defined. Non-market-based measures are to be used only when market-based mechanisms alone can no longer ensure supplies, in particular to protected customers, or for the application of Article 13;

(j) describe the **mechanisms used to cooperate with other Member States** for the crisis levels referred to in Article 11(1) and information exchange arrangements between the competent authorities;

(k) detail the **reporting obligations** imposed on natural gas undertakings and, where appropriate, electricity undertakings at alert and emergency levels;

Reg. (EU) 2017/1938

10 - Content of emergency plans (5/5)

(l) describe the technical or legal arrangements in place to **prevent undue gas consumption of customers** who are connected to a gas distribution or transmission network but not protected customers;

(m) describe the technical, legal and financial arrangements in place to apply the **solidarity obligations** laid down in Article 13;

(n) **estimate the gas volumes** that could be consumed **by solidarity protected customers** covering at least the cases described in Article 6(1) (i.e., supply standard);

(o) **establish a list of predefined actions to make gas available** in the event of an emergency, including commercial agreements between the parties involved in such actions and the compensation mechanisms for natural gas undertakings where appropriate, taking due account of the confidentiality of sensitive data. Such actions may involve cross-border agreements between Member States and/or natural gas undertakings.

Reg. (EU) 2017/1938

13 - Solidarity

Def: '**solidarity protected customer**' means a household customer who is connected to a gas distribution network, and, in addition, may include one or both of the following:

(a) a district heating installation if it is a protected customer in the relevant Member State and only in so far as it delivers heating to households or essential social services other than educational and public administration services;

(b) an essential social service if it is a protected customer in the relevant Member State, other than educational and public administration services;

Art 13 is composed of 16 points covering the application of the "solidarity principle".

This article is relevant for EU Member States.

Reg. (EU) 2017/1938

10 - Content of emergency plans

2. The emergency plan **shall be updated every four years** after 1 March 2019 or more frequently if circumstances so warrant or at the Commission's request. The updated plan shall reflect the updated risk assessment and the results of the tests carried out in accordance with paragraph 3 of this Article. Article 8(4) to (11) shall apply to the updated plan.

3. The measures, actions, and procedures contained in the emergency plan **shall be tested at least once** between its four-year updates referred to in paragraph 2. In order to test the emergency plan, the competent authority shall simulate high and medium impact scenarios and responses in real time in accordance with that emergency plan. The results of the tests shall be presented at the GCG by the competent authority. [-> Table-Top Exercises!]

4. The emergency plan shall ensure that cross-border access to infrastructure in accordance with Regulation (EC) No 715/2009 is maintained as far as technically and safely possible in the event of an emergency and shall not introduce any measure unduly restricting the flow of gas across borders.

Reg. (EU) 2017/1938

ANNEX VII – Template for an emergency plan

The structure of the template is:

Name of the competent authority responsible for the preparation of the present plan.

1. Definition of crisis levels
2. Measures to be adopted per crisis level
3. Specific measures for the electricity and district heating
4. Crisis manager or team
5. Roles and responsibilities of different actors
6. Measures regarding undue consumption by customers who are not protected customers
7. Emergency tests
8. Regional Dimension

Reg. (EU) 2017/1938

ANNEX VII – Template for an emergency plan

- The TEMPLATE indicates the minimum information necessary. More can be added.
- What it is bounding is the content described in Art. 10.
- The EC uses the templates as a checklist.
- Templates facilitate comparison and communication and should not be considered an extra burden.

Plan the Energy Future!

encoord

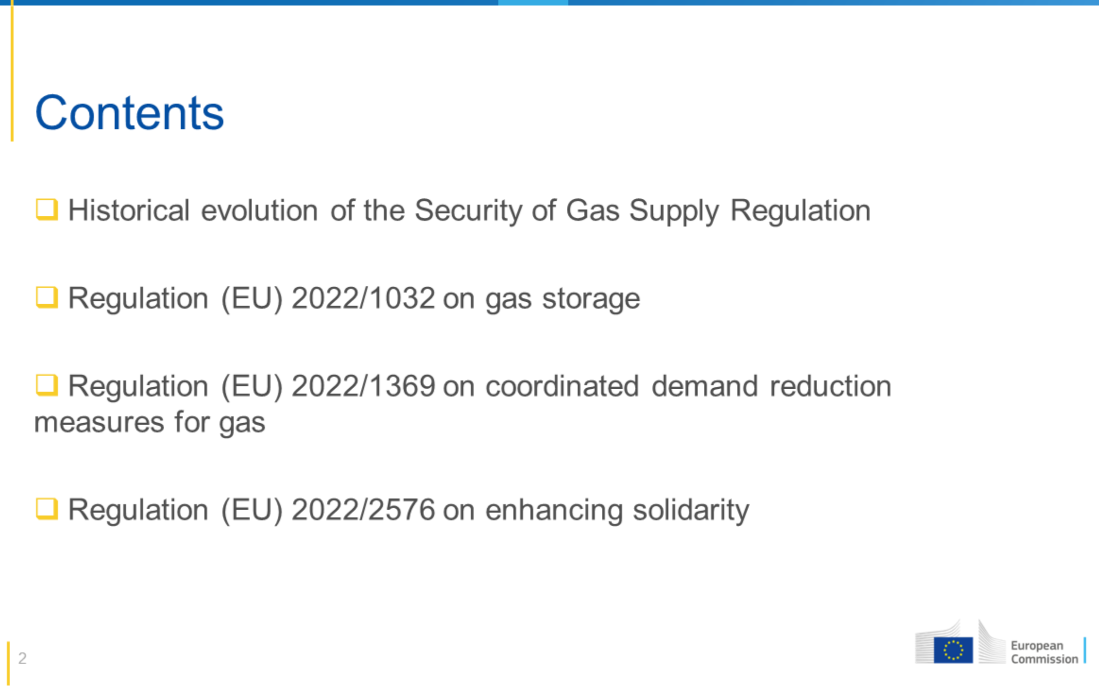
Any questions?

You can find me nicola@encoord.com
Or visit https://www.encoord.com/

(Source: http://dilbert.com/strip/2000-08-15)

4.10 Regulation (EU) 2022/1032, 2022/1369 & 2022/2576

The lecturer of this session was Mr. Ricardo Fernández-Blanco.



Evolution of the Security of Gas Supply Regulation

European Union

Evolution of EU policies on energy security

EU POLICIES ON ENERGY SECURITY

The 1990s	The 2000s	The 2010s	The 2020s
First Gas Directive 98/30/EC	**Second Gas Directive** 2003/55/EC **Third Energy Package** (Directive 73/2009; Regulations 713 and 715/2009)	**Gas Regulation** 994/2010 **Energy Security Package** 2016 **Regulation 2017/1938**	**Regulation 2022/1032** **Regulation 2022/1369** **Regulation 2022/2576** **Regulation 2022/2578** **Hydrogen and decarbonised gas market package**
Completion of the **internal gas market** and creation of an **internal competition** (unbundling)	Shifting role of **security of supply** from MSs to EU Creation of regulators (ACER)	Towards a converging **energy security supranational society**: cooperation, coordination, solidarity	**Enhancement** of specific security and solidarity measures Rules for new **low-carbon gases**

4

Source: Sesini et al. (2022)

Recent energy security policies in the EU

Regulation 2022/1032	29 June 2022	Strengthen security of gas supply from a **supply perspective**
Regulation 2022/1369	5 August 2022	**Demand-side measures** to increase security of gas supply
Regulation 2022/2576	19 Dec. 2022	Improving **coordination** of gas purchases, reliable price benchmarks and cross-border gas exchanges
Regulation 2022/2578	22 Dec. 2022	**Market Correction Mechanism** to limit extreme gas prices
Hydrogen and decarbonised gas market package	15 Dec. 2021	**Amending some provisions on security of gas supply** (EU-wide Risk Assessment, extension to low-carbon gases and hydrogen) -> Still proposal

5

Regulation (EU) 2022/1032

amending Regulations (EU) 2017/1938 and (EC) No 715/2009 with regard to gas storage

European Commission

Regulation (EU) 2022/1032 on gas storage

❑ ***Why has this regulation been adopted?***

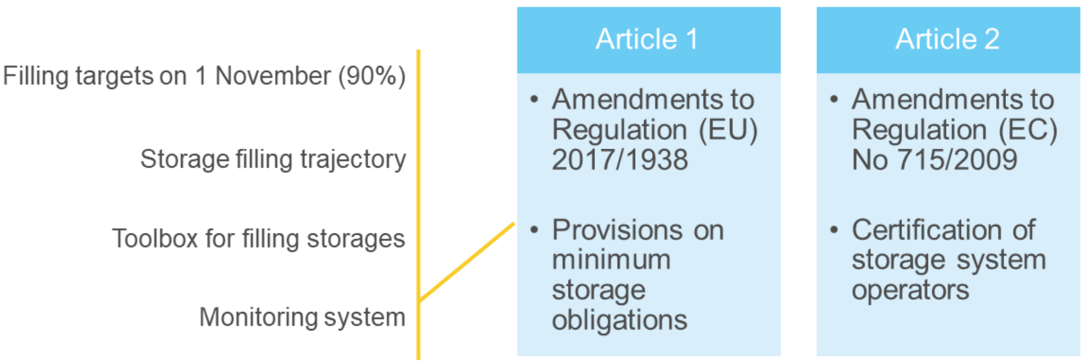
❖ Existing security of supply rules not adapted to sudden major changes (supply shortages, price peaks)

❖ Intentional major events, not only failure of infrastructure or extreme weather conditions

❖ Underground Gas Storages (UGSs) play an insurance role (not only market or operational)

Regulation (EU) 2022/1032 on gas storage

❑ ***Contents of the Regulation***



Some definitions

Article 1

Filling trajectory	Series of intermediate targets for the underground gas storage facilities. For 2022, targets on Aug., Sep., and Oct. For 2023, targets on Feb., May, Jul. and Sep.
Filling target	A binding target for the filling level of the aggregated capacity of the underground gas storage facilities

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European Commission

Regulation (EU) 2022/1032 on gas storage

❑ ***How can this be achieved?***

- Obligation on gas suppliers to store *minimum volumes* (UGS or LNG)
- Obligation on TSOs to purchase *strategic stocks*
- Obligation on SSOs to *tender capacities* to market capacities
- *Coordinated platforms* to purchase LNG to maximise its use
- Voluntary mechanisms for the *joint procurement of natural gas*
- *Financial incentives* (e.g. contracts for difference or compensation mechanism)
- Use it or lose it clauses, discounts on storage tariffs, etc

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European Commission

Overview of implementation details

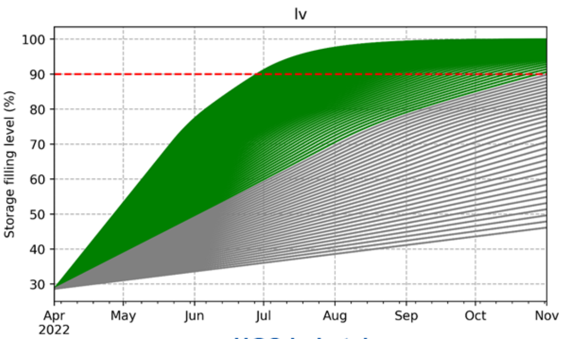
- Main objective: 90% filling target at EU level on 1 November
- There are some rules and derogations in MS' targets

Article	Content
Article 6(a).2	35% average annual gas consumption
Article 6(a).3	Third-country exports
Article 6(a).4	Storage ownership
Article 6(a).5	LNG storages may be added to fulfil targets
Article 6(a).10	5 percentage point margin
Article 20	Derogation
Article 6(c).1	MSs without UGS, burden-sharing 15% average annual gas consumption, alternative fuels
Article 6(c).3	MSs without UGS but with UGS in the PCI list, LNG stocks can be used to fulfil obligations
Article 6(c).5	MSs without UGS but with access to neighbouring UGS to fulfil their obligations

European Commission

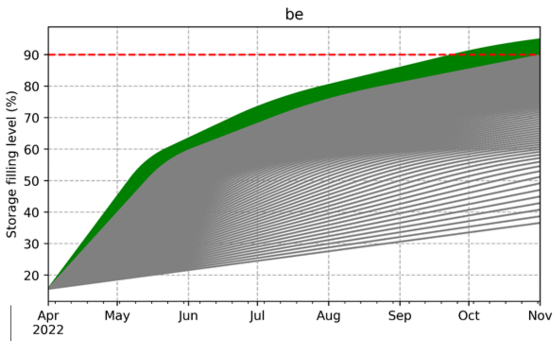
Filling trajectories with flexibility

- The filling trajectory will depend on the filling level and the individual injection curve



UGS in Latvia

UGSs with higher degree of flexibility (multiple possible trajectories that allow reaching the target)



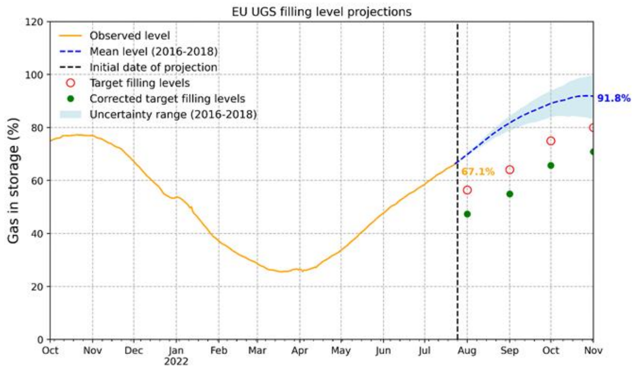
UGS in Belgium

UGSs with less flexibility (trajectory might not be totally linear)

European Commission

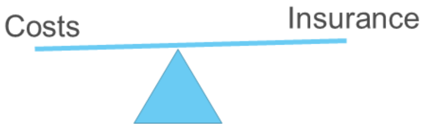
Projected levels and monitoring

- Storage projections may be useful for monitoring purposes
- Historical data or model-based trajectories
- Corrected targets < regulation-defined targets
- How could targets per MS be estimated?



Estimation of MS intermediate targets for next year

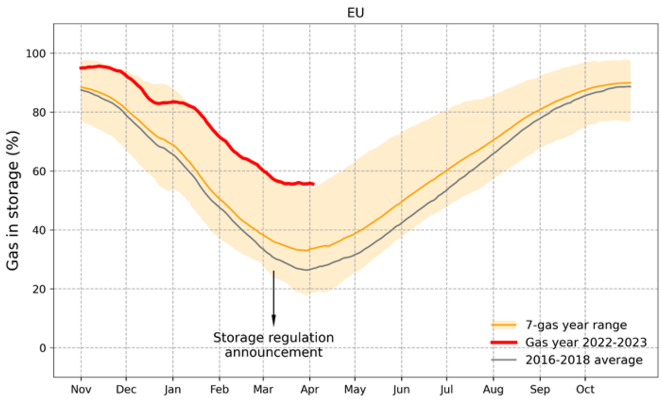
- New targets for 2023 and following years (Feb., May, Jul., Sep.) to be submitted *by each country* to the Commission
- When should they be communicated? *15 September*
- Cost-benefit analysis



- Too stringent targets -> high market intervention (market distorsion)
- Too loose targets -> risk of not fulfilling the final target

Impact of this regulation in winter 2022-2023

Operational viewpoint



- 80% target in November was reached by far in the EU (>90%)
- High filling level + mild winter => EU filling level at maximum records during winter (except Dec 2022 and mid Jan 2023)
- Filling targets met by all countries w/o issues

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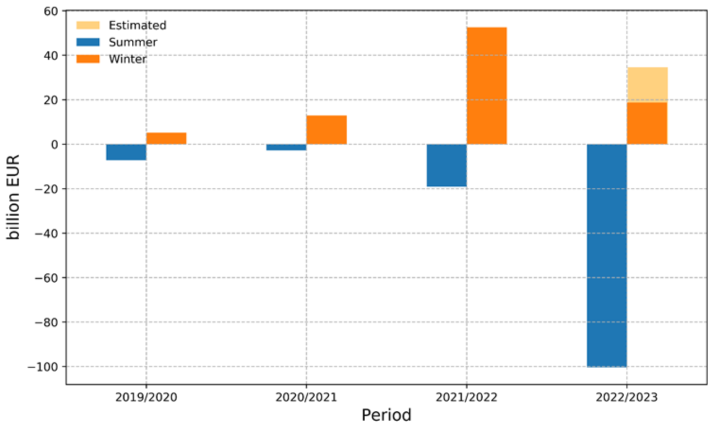
Impact of this regulation in winter 2022-2023

Economic viewpoint



(*) Figure made originally by ACER and replicated by JRC

- Cost/revenues from UGS by using TTF prices
- Overestimation (long-term contracts may have lower prices)
- 100 billion EUR is the estimated cost of injection
- Insurance value? Which would have been the cost in case of gas curtailment?

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Regulation (EU) 2022/1369

on coordinated demand reduction measures for gas

Subject matter and scope

Aim Coordinated demand-reduction measures

- Situation of severe difficulties in the supply of gas
- Safeguard Security of Gas Supply
- Spirit of solidarity

Structure Non-permanent regulation (*one year*)

- 10 articles
- To be reviewed by May 2023 (extended!)

Subject matter Article 1 (*temporary* rules, mechanisms, measures)

- Improved coordination
- Monitoring of and reporting on national gas demand-reduction measures
- Declaration of a Union alert as a Union-specific crisis level

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Voluntary or mandatory reduction?

Articles 3-5

Voluntary demand reduction

- Reduction target = *15%* compared to reference average consumption
- When? From *1 August 2022 to 31 March 2023*
- Member states should use their *best efforts*

Declaration of Union Alert

- *Significant deterioration* of the gas supply situation in the EU
- Reasons: i) substantial risk of severe gas supply shortage or ii) exceptionally high demand for gas.
- Voluntary gas demand is not sufficient but no need to resort to non-market-based measures
- Also, if *five or more* competent authorities declare an *alert at national level*

Mandatory demand reduction

- Previous reduction target becomes mandatory if Union Alert is declared
- There are multiple derogations to the mandatory target

European Commission

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Extension of the regulation

Objectives

- Provide flexibility to the market for refilling storages
- Ensure SoS for winter 2023-2024
- Contain gas price volatility

Main changes

- Starting date: 1 April 2023
- Spread reduction over one year to relieve pressure for storage injection
- One year reference period
- End date: 31 March 2024 (review by 1 March 2024)
- Improved monitoring and reporting of gas consumption (monthly frequency + reliable data)

European Commission

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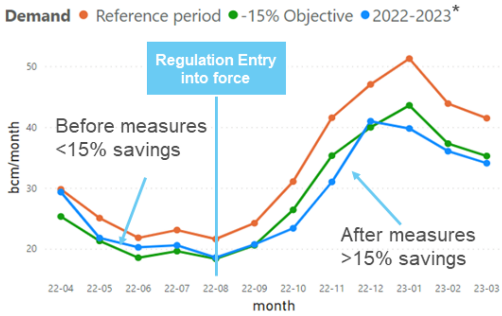
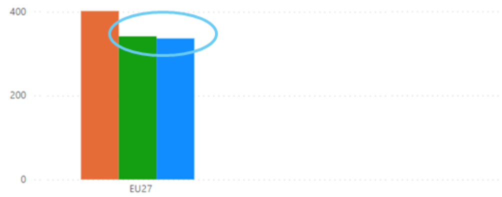
How well did it go?

42 bcm saved between 1 August and 31 January

Share in Demand Reduction





*Values for February and March are projection based on previous months

** Source: DG ENER B.4

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Regulation (EU) 2022/2576

on enhancing solidarity through better coordination of gas purchases, reliable price benchmarks and exchanges of gas across borders

European Commission

Structure and subject matter

Aim Enhancing solidarity

- Better coordination of gas purchases
- Reliable price benchmarks
- Exchanges of gas across borders

Structure Non-permanent regulation (*one year*)

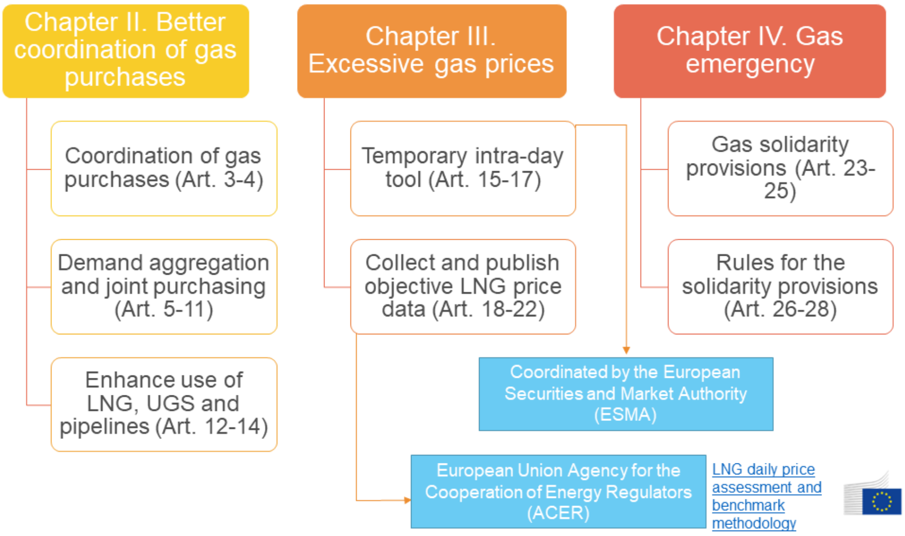
- 31 articles, 5 chapters and 2 annexes
- To be reviewed by October 2023

Subject matter Article 1 (*temporary* rules, mechanisms, measures)

- Demand aggregation and joint gas purchasing, secondary capacity booking and transparency platforms for LNG and UGS, and congestion management
- Temporary intra-day volatility management and an ad-hoc LNG benchmark
- **Gas emergency case: critical customers and cross-border solidarity**

23 European Commission

Contents of the chapters



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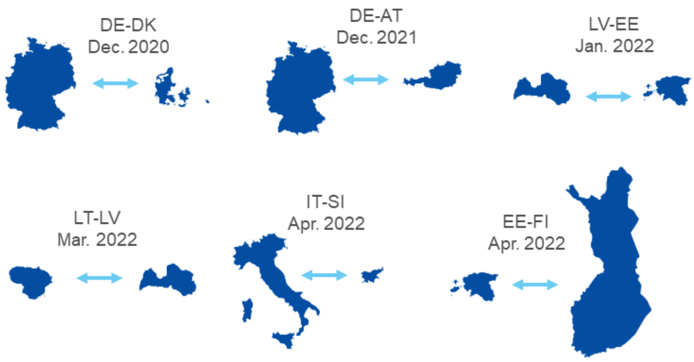
Signed bilateral solidarity agreements



- Six bilateral agreements so far
- Most of them signed in 2022
- There are still many agreements to be signed among EU countries
- These bilateral arrangements are at the core of the provision of **solidarity gas!**

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European Commission

Thank you

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European Commission

4.11 Dedicated session for the experience of implementing the Regulation 2017/1938 in Austria

Mr. Ronald Farmer was the invited speaker for this dedicated session.

Regulation (EU) 2017/1938 („SoS Reg.“)

Main points

E-CONTROL
Unsere Energie gehört der Zukunft.

- Definition of Protected Customers
- Evaluation of the Infrastructure Standard (N – 1)
- Evaluation of the Gas Supply Standard
- Preparation of a Risk Assessment
- Preparation of Preventive Action and Emergency Plans
- Declaration of a Crisis Level
- Implementation of Solidarity among Member States
- Provisions on Information Exchange

3

Protected Customers in Austria

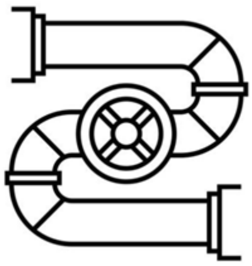
E-CONTROL
Unsere Energie gehört der Zukunft.

- Households, which are connected to the gas distribution system
- Essential social services, other than educational and public administration services and connected to the gas distribution system
- District heating installations in so far as they deliver heating to households and essential social services other than educational and public administration services and where no fuel switch is possible

4

National Infrastructure Standard (N-1)

Anlagenbezeichnung	Techn. Kapazität [Mio. Nm³/d]	Definition & Erläuterung
Baumgarten (GCA, WAG, TAG)	140,34	Exit Slowakei
Oberkappel	21,95	Minimum aus Exit NCG und WAG Kap OK-->BM
Überackern	0	in Oberkappel integriert
Arnoldstein	17,29	Exit Italien
Freilassing & Laa/ Thaya	0,87	ausgewiesene Standardkapazität
EPm	**180,45**	**Techn. Kapazität von Einspeisepunkten**
Produktion OMV	1,99	gebuchte Standardkapazität
Produktion RAG	0,36	gebuchte Standardkapazität
Biomethan Produktion	0,06	gebuchte Standardkapazität
Pm	**2,41**	**Max. techn. Produktionskapazität**
Speicherpool OMV	23,39	bei Speicherstand von 30% Arbeitsgasvolumen
Speicherpool RAG	14,20	bei Speicherstand von 30% Arbeitsgasvolumen
7Fields Fernleitung	0	nur unterbrechbare Kapazität
7Fields Verteilergebiet	6,49	bei Speicherstand von 30% Arbeitsgasvolumen
Haidach Verteilergebiet	0	in Österreich nicht angeschlossen
Sm	**44,07**	**Max. techn. Ausspeisekapazität**
LNGm	**0**	**Max. techn. Kapazität der LNG-Anlagen**
Im	**140,34**	**Techn. Kapazität der größten einzelnen Infrastruktur**
Dmax	**50,31**	**Max. tägliche Gasnachfrage** Baseline Szenario Max. der nächsten 10 Jahre
N - 1	**172%**	



Source: AGGM, KNEP 2022

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National Gas Supply Standard

- Supplier of Protected Customers must take measures to ensure the gas supply in each of the following cases:
  a) extreme temperatures during a 7-day peak period occurring with a statistical probability of once in 20 years;
  b) any period of 30 days of exceptionally high gas demand, occurring with a statistical probability of once in 20 years;
  c) for a period of 30 days in the case of disruption of the single largest gas infrastructure under average winter conditions.

- Yearly evaluation by E-Control is sent to all Supplier of Protected Customers beginning in summer for the following winter period
  - Cases a) and b) can be proven by providing OTC contracts, storage contracts or futures contracts on the exchange
  - Case c) can only be proven by providing storage contracts and relevant gas quantities in the storage

6

Preventive Action Plan
Content Overview

- Risk Groups (Ukraine, Baltic Sea, Algeria, Libya)
- System Description
- Risk Assessments
  - Regional and National
- Infrastructure Standards (N-1)
  - Regional and National
- Gas Supply Standard
- Preventive Measures
  - Infrastructure Planning and related Projects
  - Monitoring and Market Model Development

7

National Risk Assessment
Input

- Elaborated in a Cooperation between the Federal Ministry for Energy, the Market Area Manager and E-Control
- Investigation of 41 Risk Elements, such as International Gas Flows, Interconnection Points, Compressor Stations, Storage Facilities, Domestic Production and more
- The Risk Elements result in 60 Subsystems, where each of them can be subject to several Interruption Threats, such as political issues (e.g. terror), natural events (e.g. earthquake) and technical issues (e.g. electricity supply failure)
- Combined we identified 484 potential Interruption Risks for the Austrian main gas infrastructure and supply

8

National Risk Assessment
Output

E-CONTROL Unsere Energie gehört der Zukunft.

- Risk Matrix

Probability of Occurence [Occasions/Year]							
5	very high: E ≥ 1	39	4	0	0	5
4	high: 0,1 ≤ E < 1	0	2	2	0	0
3	moderate: 0,03 ≤ E < 0,1	41	25	1	1	13
2	low: 0,01 ≤ E < 0,03	195	52	6	0	45
1	very low: E < 0,01	28	14	1	1	9
		low	moderate	significant	serious	very serious
		1	2	3	4	5
		Severity of Impact				

Probability of Occurence

very high: E ≥ 1	yearly or even more
high: 0,1 ≤ E < 1	once in 1 to 10 years
moderate: 0,03 ≤ E < 0,1	once in 1 to 30 years
low: 0,01 ≤ E < 0,03	once in 30 to 100 years
very low: E < 0,01	less than once in 100 years

Severity of Impact

low	No countermeasures necessary
moderate	Supply of all customers secured with technical measures and the market
significant	Supply of protected customers secured with market-based measures
serious	Supply of protected customers secured with non-market-based measures
very serious	Supply of protected customers not secured

- Risk Overview

Possible Interruptions in relation to the Risk Elements / Subsystems	Number	%
Low Risk	402	83,1%
Moderate Risk	64	13,2%
High Risk	18	3,7%
Sum	484	100,0%

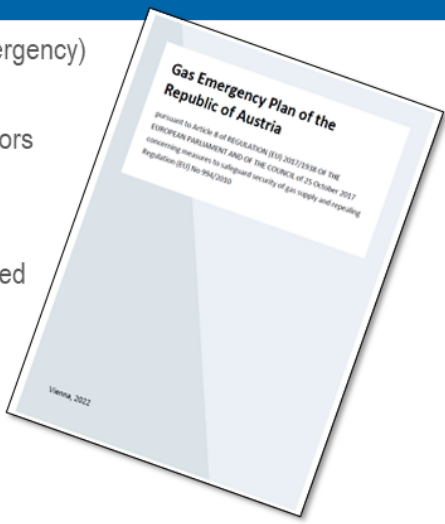
All of them have only local or regional relevance (within Austria)

9

Emergency Plan
Content Overview

E-CONTROL Unsere Energie gehört der Zukunft.

- Determination of the Crisis Levels (*Early Warning*, Alert, Emergency)
- Measures to be taken in the individual Crisis Levels
- Special Measures for the Electricity and District Heating sectors
- Crisis Manager and Crisis Team
- Tasks and Responsibilities of various actors
- Measures in case of Unjustified Consumption by non-protected customers
- Emergency Tests
- Regional Dimension
  - Mechanisms for Cooperation
  - Solidarity between Member States



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Potential Market-Based Measures
No Ranking

No.	Measure	Who?	Basis
1)	In the event of a threat to grid stability, MDAM cuts back those balance groups that contribute to this grid instability with their high imbalances on the basis of a ranking, predominantly at the relevant points.	MDAM	General Terms and Conditions (GTC) AGGM-BGR V 4.0, item 10.1
2)	Short-term creation of additional capacities from interruptible natural gas supply contracts or interruptible network access as well as from free capacities in the transmission system, from storage facilities and production. Information with the collected data to all BGR with the request to use them for additional offers at the exchange, combined with the MDAM offer to support the handling of the additional transports.	Balance group representatives (BGR) / network operators / storage facilities / production / MDAM	Section Section 14 (1) no. 8 and section 18 (1) no. 23 GWG 2011 Interruptible natural gas supply, storage and production contracts and network access contracts, respectively.
3)	Measures to eliminate short- or medium-term capacity bottlenecks (Section 25 Action Plan).	MDAM, natural gas company	Section 25 GWG 2011 Section 14(1) Z8 GWG 2011
4)	Call for offer submission (order submission) on the day-ahead as well as within-day market of the gas exchange (in the market area east) on request MDAM for the maintenance of the balancing energy calls.	Virtual trading point operator (VTP operator), MDAM	

Emerg

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Potential Market-Based Measures
No Ranking

5)	Call for offers on the Merit Order List (MOL) for standard and flexibility products by the Balance Group Coordinator (BGC) at the request of the market- and distribution area manager (MDAM).	Balance group coordinator (BGC) = AGCS Gas Clearing and Settlement AG, A&B Ausgleichsenergie & Bilanzgruppen-Management AG, MDAM	Section Section 29(2) line 2 Gas Market Model Ordinance (GMMO-VO 2020) GTC-BGC (AGCS, A&B) Annex Balancing Energy Management V 1.0 Section 3
6)	Call-off of physical balancing energy in the following order 1) standardized products at the Natural Gas Exchange at the Virtual Trading Point (VTP) 2) MOL standard products 3) MOL flexibility products Access to the respectively next priority level, if no corresponding offers are available in the respective priority level for a time period classified as relevant by the MDAM or if location-dependent or short-term products are required by the MDAM to maintain trouble-free operation in the distribution area (DA).	MDAM	Section Section 28(2) GMMO-VO 2020 GTC-BGC (AGCS) Annex Balancing Energy Management V 1.0 Section 3
7)	Execution of balancing energy calls from MOL deviating from the MOL call order.	MDAM	GTC-BGC (AGCS) Annex Balancing Energy Management V 1.0 Section 3

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Potential Market-Based Measures
No Ranking

8)	Simultaneous call-offs of balancing energy supply and balancing energy purchase offers with the possibility of using them at different locations.	MDAM	GTC-BGC (AGCS) Annex Balancing Energy Management V 1.0 Section 3
9)	Execution of market maker auctions in case of insufficient or completely missing balancing energy offers at MOL.	BGC, MDAM	GTC-BGC (AGCS) Annex Balancing Energy Management V 1.0 Section 3
10)	Execution of a tender procedure at the request of the Federal Minister for Climate Action by the BGC for the storage of gas quantities to ensure security of supply. Gas is held in storage facilities that can be used for release to the market areas. Storage for the market areas Tyrol and Vorarlberg can also take place in storage facilities that are connected to neighboring market areas. The total quantity of gas to be held in reserve shall be specified in the request by the Federal Minister for Climate Action, taking into account the current and forecast storage levels and imminent or already occurring impairments or disruptions to security of supply.	BGC	Section 87(6) Natural Gas Act 2011 (GWG 2011)
11)	Shortage management in the distribution grid shall prioritize transports for end-customer supply over other transports (note: in particular over transports to storage facilities).	MDAM	Section Section 18(1) no. 20 GWG 2011 (Natural Gas Act)

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Potential Non-Market-Based Measures
No Ranking, Overview

Possible instructions can be roughly divided into two areas

1. Provision of additional quantities that can be activated
2. Restriction of the consumption of end-user(group)s

- Instructions to balance group representatives, storage companies and producers
- Dispositions of storage quantities and, if necessary, cushion gas
- Restriction of final consumers and large consumers (incl. producers with CHP plants and district heating companies)
- Instruction for substitution of natural gas by alternative energy sources
- Mandatory Bidding on the Merit Order List
- Release of Quantities from the Strategic Gas Reserve (Section 18a ff GWG 2011)

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National Measure to increase SoS: Implementation of a Strategic Gas Reverse

E-CONTROL Unsere Energie gehört der Zukunft.

- Overall 20 TWh in different storage locations.
- Procurement is carried out by the Market Area Manager with federal funds within the framework of a market based, transparent, non discriminatory and public tendering procedure.
- The strategic gas reserve can only be released by Ordinance of the Federal Minister for Energy in accordance with the Energy Intervention Powers Act 2012.
- The volumes of the strategic reserve should come from non Russian sources, taking into account availability on the market.

15

National Measure to increase SoS: Bringing Gas Storage Facility Haidach to the Market

E-CONTROL Unsere Energie gehört der Zukunft.

- In response to the challenges posed by the Haidach storage facility situation, which is located in Austria, but only directly connected to German gas grid, two legislative amendments were implemented:
  - Use-it-or-lose-it rule for storage capacities
  - Mandatory direct connection of Austrian gas storage facilities to the Austrian gas network

Source: astora GmbH

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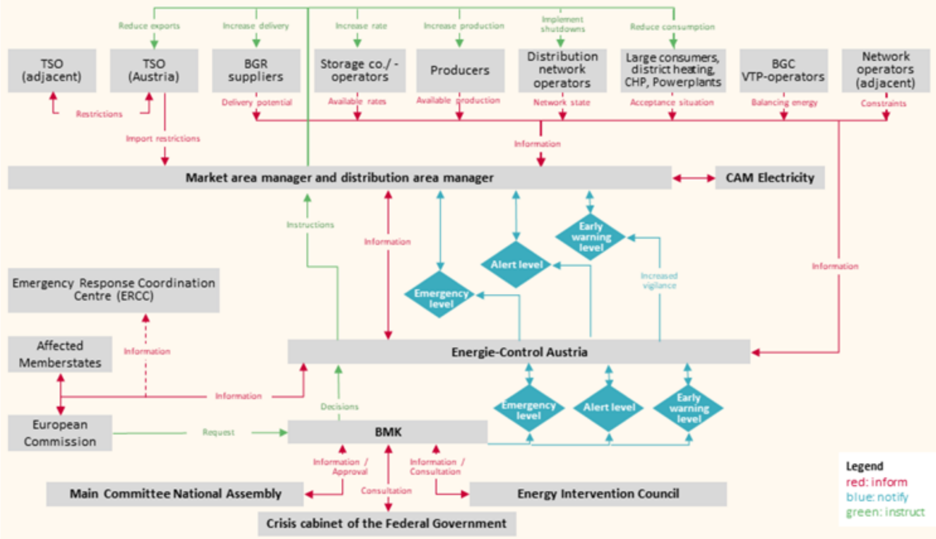
Tasks and Responsibilities of various Actors



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Tasks of E-Control in relation to an Energy Crisis
A Selection

Preparation for and Coordination in the Crisis

1. Claim Data – Analyze Data – Evaluation and Calculation of Scenarios
2. Preparation and Execution of Crisis Exercises
3. Preparation of Special Rules for large End-Users
4. Communication Platform for national and international Stakeholder
5. Preparation of the Surplus-Consumption-Fees-Ordinance
6. Collaboration in the Preparation and Implementation of the Energy Interventions Measures Ordinance of the Ministry and the Crisis Plans

18

Austrian Measures to Support Customers

- Energy cost compensation for consumers (150 € per household)
- Financial support for the payment of electricity bills ("Stromkostenbremse")
- Various general tax and social policy measures
- Climate bonus
- Energy subsidy for energy-intensive companies
- No surcharge on electricity bills to support renewable energy (100 €/year)
- Reduction of energy taxes

Legal Framework in Austria

Selection of Amendments since Februarv 2022

Titel	Inhalt	Wo	Wann
Novelle GWG 1	Einführung der Regelungen zur strategischen Gasreserve	BGBl. I Nr. 38/2022	Seit 8.4.2022
Novelle EnLG 1	Entschädigungsrecht, „Immunisierung" von Selbstvorrat, EnL-Beirat	BGBl. I Nr. 68/2022	Seit 8.6.2022
Novelle GWG 2	Market Maker für Versorgungssicherheit	BGBl. I Nr. 67/2022	Seit 8.6.2022
Novelle GWG 3	Speicheranschlusspflicht, UIOLI Speicherkapazität, Ermächtigung zu Übereinkommen Speichermengenhaltung	BGBl. I Nr. 94/2022	Seit 1.7.2022
GasdiversifizierungsG (GDG)	100 Mio. für Umrüstung von Gasanlagen Richtung Bivalenz	BGBl. I Nr. 95/2022	Seit 1.7.2022
Novelle GDG 1	Möglichkeit zusätzl. Mittel, auch für stillgelegte Anlagen möglich, auch Kosten der Kohlebeschaffung erfasst	BGBl. I Nr. 107/2022	Seit 20.7.2022
EnLD-VO Gas Novelle 1	Zusätzliche Informationen in Krise bzw. zur Vorbereitung ab 1.8.2022	BGBl. II Nr. 274/2022	Seit 9.7.2022
VO strategische Reserve	Ausdehnung der strategischen Reserve von 12 > 20 TWh, kein russisches Gas	BGBl. II Nr. 262/2022	Seit 30.6.2022
EnLD-VO Strom	Zusätzliche Informationen in Krise bzw. zur Vorbereitung ab 1.8.2022	BGBl. II Nr. 282/2022	Seit 19.7.2022
EnLD-VO Gas Novelle 2	Zusätzliche Informationen iZm Speichermengen-Zweckwidmung, Speicherlokation, Sekundärmarktspeicherkunden	BGBl. II Nr. 347/2022	Seit 23.9.2022
Förderrichtlinien für GDG	Konkretisierung der Förderungen für Umrüstung gemäß GDG	EU-Kommission	Seit 4.7.2022
GMMO-VO 2020 Novelle 2	Verpflichtende Registrierung auf der FlexMol Verschärfung der Pflicht zur Ausgeglichenheit der Bilanzgruppe im Notfall Instrumente für physikalische Ausgleichsenergie im Notfall	BGBl. II Nr. 357/2022	Seit 27.9.2022

Contact

E-CONTROL
Unsere Energie gehört der Zukunft.

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***Energy** for our future.*

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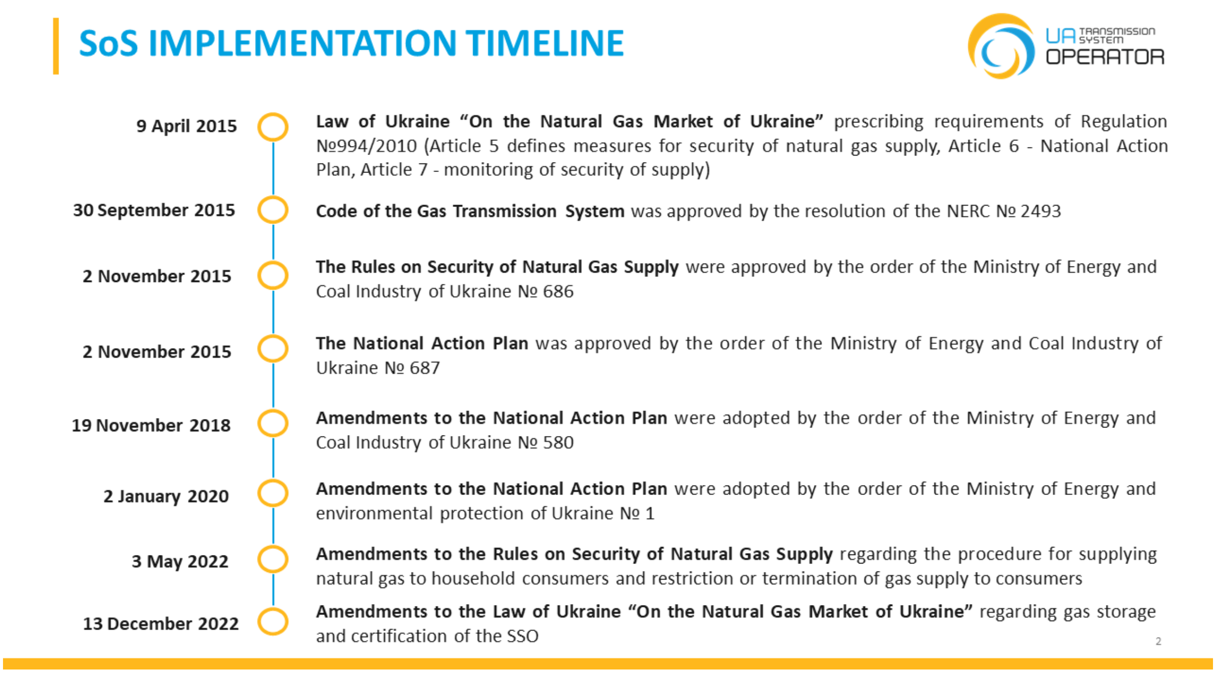
4.12 Dedicated session for the experience of implementing the Regulation 2017/1938 in Ukraine

Mrs. Ielyzaveta Badanova and Mr. Andrii Prokofiev were both invited speakers for this dedicated session.



RULES ON SECURITY OF NATURAL GAS SUPPLY

The Rules on Security of Natural Gas Supply, approved by the order of the Ministry of Energy and Coal Industry of Ukraine № 686 of 02.11.2015, determine:

- protected consumers;
- measures that are mandatory for natural gas market participants (except consumers) to ensure the security of natural gas supply for natural gas suppliers and gas infrastructure facilities;
- identification and classification of the main risks to the security of natural gas supply (risk assessment);
- measures necessary to reduce the impact of identified risks, in particular, the scope of responsibilities of natural gas market participants and the timing of their implementation (preventive measures);
- the form and procedure for submitting a report of natural gas market entities (except for consumers) on the status of implementation of measures in accordance with these Rules;
- responsibilities of the authority for the security of natural gas supply.

PROTECTED CUSTOMERS:

- household consumers connected to the gas distribution system;
- enterprises, institutions, organizations that provide important public services and connected to the gas transmission or gas distribution system;
- heat energy producers for the needs of such consumers or enterprises, institutions, organizations, provided that the production of heat energy for the needs of such consumers or enterprises, institutions, organizations is carried out with the help of objects not adapted to the change of fuel and connected to the gas transmission or gas distribution system.

Natural gas suppliers shall ensure a sufficient resource of gas for the needs of their protected customers in the following cases:

1) extreme temperature conditions during the 7-day peak period, the statistical probability of which occurs once every 20 years (**Standard 1**);	**2)** any period lasting 30 days or more during which there is an extremely high demand for natural gas, the statistical probability of which occurs once every 20 years (**Standard 2**);	**3)** failure of one main gas pipeline under normal winter conditions for a period of 30 days (**Standard 3**).

NATIONAL ACTION PLAN DEFINES

- **Levels of crisis:**

• **early warning crisis** (an early warning crisis situation arises when the projected demand for natural gas in Ukraine is equal to the supply potential, but the pressure in the gas transmission system is at a critical level, which may worsen the natural gas supply situation);

• **crisis of the warning level** (a crisis of the warning level arises when the projected demand for natural gas in Ukraine is higher than the supply potential but lower than the maximum supply potential, the pressure in the gas transmission system is at a critical level, which can complicate the natural gas supply situation);

• **crisis at the level of emergency** (an emergency crisis arises when the projected demand for natural gas in Ukraine is higher than the maximum supply potential, the pressure in the gas transmission system is at a critical level, which may further complicate the situation and the need for temporary precautionary measures, including non-market).

- **For each level of crisis:**

• a system of response measures to eliminate or reduce the overall negative impact of the crisis;

• responsibilities and tasks of the authority to participate in overcoming the crisis;

• responsibilities of natural gas market participants, taking into account the impact of the crisis on them;

- **Conditions of activity of the Crisis Committee;**
- **Mechanisms of international cooperation;**
- **Priority measures to be implemented in order to restore the supply of natural gas.**

5

UKRAINE-JRC COLLABORATION

Subject of collaboration: Further refinement of Ukrainian security of gas supply legislation.

Articles 5 of the Law of Ukraine on the natural gas market:

- Risk Assessment of the gas year ahead
- Standards of Conduct
- Recommendations

Delivered in 2016-2021 on annual basis

Table-top exercise

- Simulation of a crisis:
  - gas flows
  - random events (weather, infrastructure failures, market issues, etc.)
  - implementation of NAP:
    - ✓ actors (including crisis committee)
    - ✓ information flows
    - ✓ decisions and their effects
- Results analysis:
  - Identification of weaknesses in the NAP
  - Proposal of NAP modification if needed

Conducted three times in 2017-2021 period

6

ENERGY COMMUNITY ANNUAL IMPLEMENTATION REPORT 2022

UA TRANSMISSION SYSTEM OPERATOR

Ukraine
Gas

SECURITY OF SUPPLY	100%

Ukraine has a well-established regulatory framework for the security of gas supply, based on elements of Regulation (EU) 2017/1938, such as risk assessment and preventive and emergency action plans, which still need to be aligned to a full extent with the gas acquis. Ukraine started with the transposition of the Storage Regulation (EU) 2022/1032 and the level of gas in the storages overpassed the target. However, the security of supply situation is endangered due to the loss of some domestic production sites and the destruction of the network.

8

COOPERATION AND INFORMATION EXCHANGE

UA TRANSMISSION SYSTEM OPERATOR

Energy Community

The Security of Supply Coordination Group (SoSCG) provides an institutional and procedural framework for coordinating national security of supply measures at the Energy Community level. Ukraine as Contracting Party participates in this Group.

\+ entsog

GTSOU participates in ENTSOG ReCo **operational meetings** on regular basis and takes part in the events held by ENTSOG. GTSOU submits information to the **ENTSOG Transparency Platform**.

European Commission

Ukraine maintains regular communication with European Commission.

9

UKRAINIAN SSO CERTIFICATION

UA TRANSMISSION SYSTEM OPERATOR

NAFTOGAZ UKRTRANSGAZ

Ukrtransgaz JSC provides operation of Ukrainian UGS facilities. The company now operates **11 underground storages**, located all over Ukraine. Their active volume is **31 bcm** that is proportionate to UGS facilities of Italy, France, Hungary and Austria put together. 1 UGS currently is located in a temporarily occupied territory.

7 April 2023

The NEURC has made a final decision on Ukrtransgaz certification in accordance with the European gas supply security regulations.

Ukrtransgaz is the 2nd storage system operator in Europe to successfully pass the certification and prove its right to carry out gas storage activities in accordance with the updated regulations in the European Union and the Energy Community.

Ukrtransgaz certification gives a right to **engage Ukrainian gas storages** for implementation of energy security measures in Europe, as provided for by the EU Gas Supply Security Regulation, including storage of non-resident customers reserves, as well **as reserves** for the countries that do not have their own gas storages or gas volumes jointly purchased by countries **for crisis situations.**

10

ACTUAL USE OF NAP PROVISIONS IN UKRAINE

UA TRANSMISSION SYSTEM OPERATOR

2018

March gas crisis

Gazprom returned Naftogaz's prepayment for gas to be supplied in March 15 min before expected start of the flow. Severe weather conditions, low import, storage on maximum capacities. National action plan provisions launched. Crisis Committee declared the crisis situation of emergency level, included list of actions to be followed by market participants, prescribed educational establishments shutdown, decrease consumption of large industrial and medium-sized consumers by 10%, increase of import, decrease of temperature, decrease of consumption. Joint web-conference with the EC monitoring group was held.

2021-2022

Assistance to Moldova

In October 2021 energy crisis in Moldova was declared. GTSOU increased OBA for IP Grebenyky and IP Oleksiivka at the request of Moldovatransgaz (solidarity principle applied). Due to the fact that Ukraine actually lent natural gas to Moldovan side to balance the Moldovan gas transportation system, Moldovatransgaz was able to maintain the efficiency of the system during the crisis period.
In November 2022 Moldova started using Ukrainian UGS for gas stocks.

2022-...

Starting from 24 February 2022 Ukraine`s gas market is functioning in crisis at the level of emergency

We cannot disclose much details on that now (because of ban on publication of sensitive data) but the main takeaways is the possibility of Competent Authority to take quick decisions to regulate market in form of Ministry orders. Some examples, especially in March-April 2022, but without details: gas export ban and allowing of reexport.

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Thank you for your attention!

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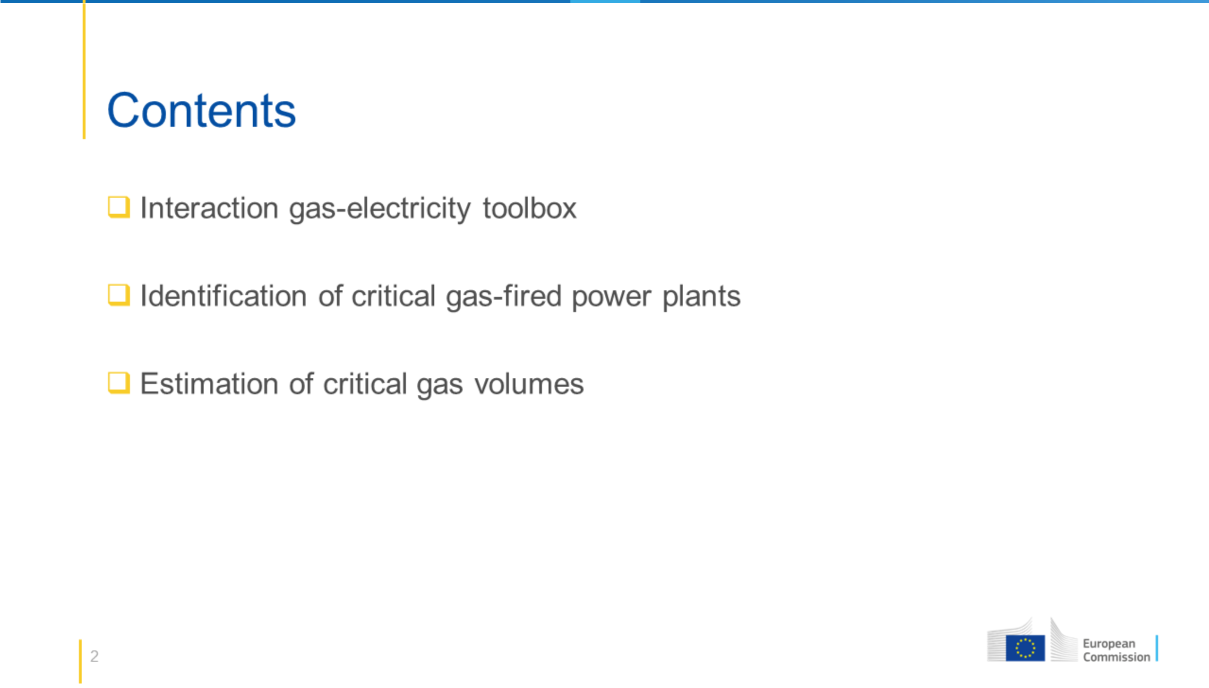
4.13 The interaction gas-electricity, insights, approaches and available models

The lecturer of this session was Mr. Ricardo Fernández-Blanco.

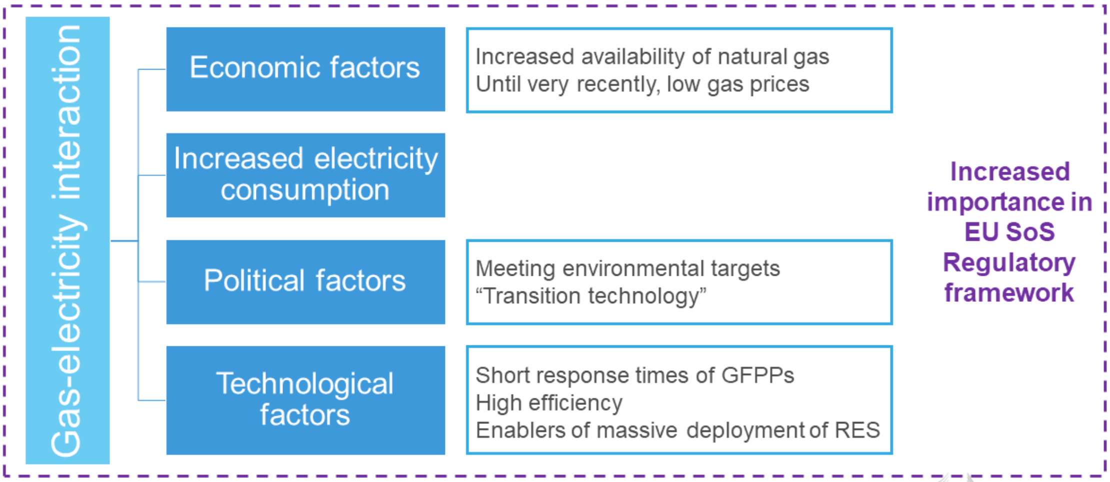


Interaction gas-electricity toolbox

Jung, D., Fernandez Blanco Carramolino, R., Yusta Loyo, J.M. and Bolado Lavin, R., Interaction gas-electricity toolbox, EUR 30935 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-45991-0, doi:10.2760/62982, JRC123982.

European Commission

Gas-electricity nexus



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European Commission

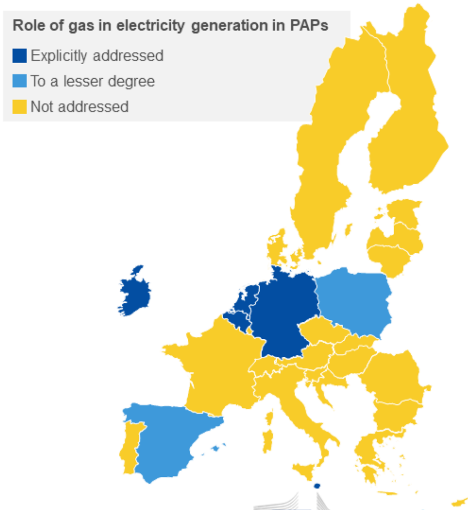
Although there is growing attention on this nexus…

❑ In practice, did any country address it in their Preventive Action and Emergency Plans? Are the concerned articles of the regulations properly taken into account?

❑ Critical Gas-Fired Power Plants (CGFPPs) only in DE, NL, and PL

DE	“Systemically relevant” GFPPs with a nominal capacity above 50 MW
NL	Four criteria to determine if power plant is critical
PL	List of critical GFPPs and combined heat and power plants

Poorly addressed in PAPs in general and methodology not outlined!



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Gas-electricity interaction toolbox (report)

Toolbox

- Identification and quantification of interaction mechanisms
- High-level indicators for dependence of electricity on gas

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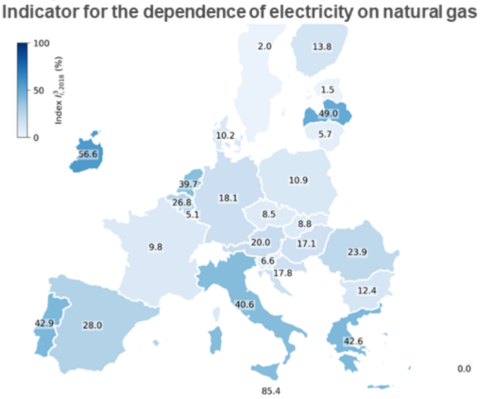
Gas-electricity interaction toolbox

- Compound indicator based on Eurostat
- Role of gas in the production of electricity and role of electricity production in total gas demand
- Benefits
  - High-level analysis
  - Screening tool
- Disadvantages
  - Disregarding physical constraints
  - Identification of CGFPPs impossible

Example:
Indicator for the dependence of electricity on natural gas



Source: JRC, based on Eurostat (2020). Data year: 2018

Gas-electricity interaction toolbox (report)

Toolbox

- Identification and quantification of interaction mechanisms
- High-level indicators for dependence of electricity on gas

Modelling is key

- Particular regions
- More detailed analysis
- Physical and operational constraint (network layout, system parameters, internal bottlenecks, ...)

Critical gas-fired power plants

Regulation (EU) 2017/1938

Regulatory framework – Critical gas-fired power plants

Regulation (EU) No 2017/1938 on the Security of Gas Supply

- Article 11(7)

During an emergency and on reasonable grounds, upon a request of the relevant electricity or gas transmission system operator a Member State may decide to prioritise the gas supply to certain **critical gas-fired power plants** over the gas supply to certain categories of protected customers, if the lack of gas supply to such critical gas-fired power plants either:

(a) could result in severe damage in the functioning of the electricity system; or
(b) would hamper the production and/or transportation of gas.

- Article 13(1)

In exceptional circumstances and upon a duly reasoned request by the relevant electricity or gas transmission system operator to its competent authority, the gas supply may also continue to certain **critical gas-fired power plants** as defined pursuant to Article 11(7) in the Member State providing solidarity if the lack of gas supply to such plants would result in severe damage in the functioning of the electricity system or would hamper the production and/or transportation of gas.

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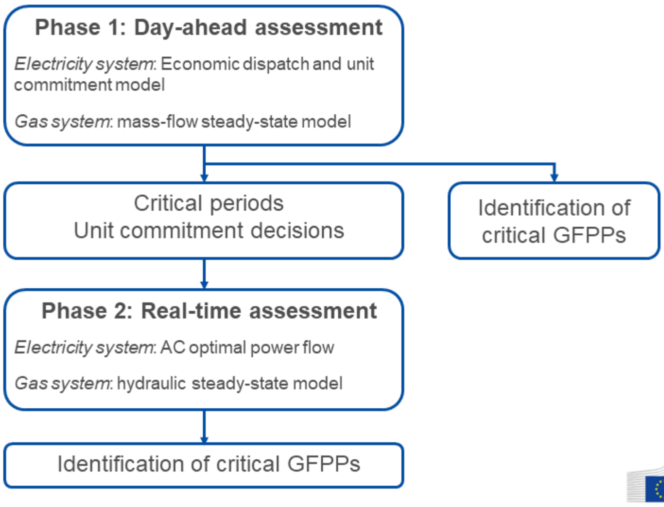
Overview of the methodology



Identification and ranking of critical GFPPs

❑ *Joint optimisation* of electricity and gas systems modelled in *Plexos*

Gas-fired power plants (GFPPs)

Electricity system

- **Unit commitment and economic dispatch problem**
- Minimise Operation Cost + Load Shedding cost
- Subject to:
- DC load flow model
- Operational constraints (ramps, minimum up/down times, startups)
- Binary decision variable declaration for commitments
- Custom constraints

Gas system

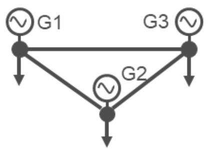
- **Optimal mass-flow steady-state model**
- Minimise Operation Cost + Gas Shortage cost
- Subject to:
- Gas volume nodal balance constraints
- Contract volume limits
- Storage limits
- Pipeline storage/transportation limits
- Custom constraints

Gas and electric consumption of households

Identification and ranking of critical GFPPs

- Scenarios for the gas and electricity systems must be defined: Gas disruption scenarios, failure of elements, etc.
- Risk metric: Energy not served (ENS)
- Critical GFPPs: GFPPs that provide the best mitigation of consequences

Scenario-based assessment



G1	G2	G3	ENS
ON	OFF	OFF	10
OFF	ON	OFF	5
OFF	OFF	ON	7

G2 is the critical GFPP

Optimisation-based assessment

$$u_1 + u_2 + u_3 \leq k$$

u defines the ON/OFF status
k defines the number of critical GFPPs

Custom constraints in Plexos

European Commission

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Synthetic case study

- IEEE Three-Area Reliability Test system (*RTS-GMLC*)

Advantages

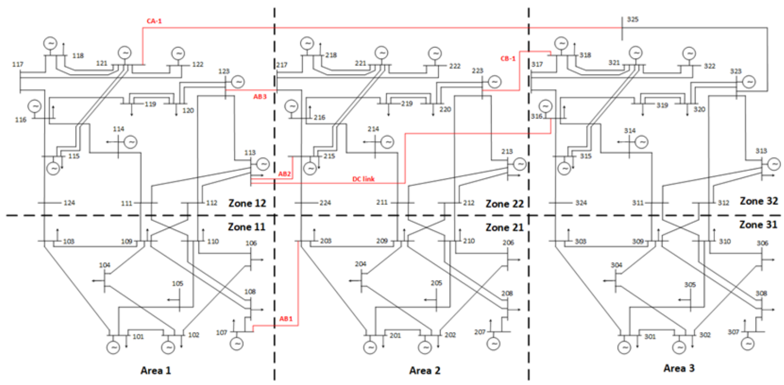
- Well-known system in the power system community
- Availability of data
- Possibility to analyse the cross-border dimension

73 buses

121 lines

5 AC cross-border interconnectors

One 100-MW DC link



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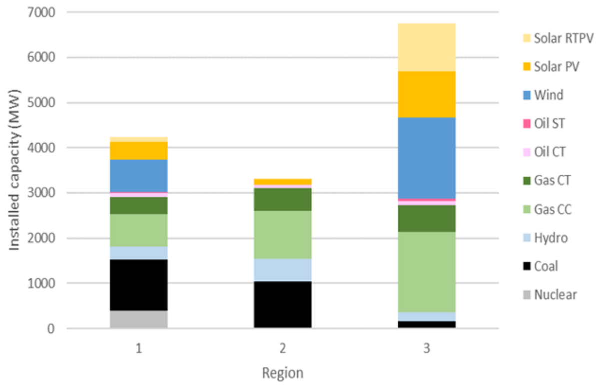
Regional installed capacity



*Region 2 also includes a concentrating solar power (CSP) storage at bus 212
**There is a 50-MW battery energy storage located at bus 313

- Region 3 is the one with a higher capacity of GFPPs and renewable generation
- Region 2 is characterised by low renewable generation
- Region 1 has the lowest gas-fired generation capacity

European Commission

Gas-fired power plants (GFPPs)

Bus	GFPP type	Number	Capacity (MW)	
107	CC	1	355	Region 1 (1095 MW)
113	CT	4	220	
118	CC	1	355	
123	CT	3	165	
207	CT	2	110	Region 2 (1560 MW)
213	CC, CT	3	465	
215	CT	2	110	
218	CC	1	355	
221	CC	1	355	
223	CT	3	165	
301	CT	2	110	Region 3 (2380 MW)
302	CT	2	110	
307	CT	2	110	
313	CC	1	355	
315	CT	3	165	
318	CC	1	355	
321	CC	1	355	
322	CT	2	110	
323	CT	2	**710**	

- 10 natural gas-fired combined cycle (CC) generators with an installed capacity of 355 MW
- 27 natural gas-fired combustion turbines (CT) generators with an installed capacity of 55 MW
- We assume GFPPs aggregated per bus

European Commission

Assumptions

- Case study: RTS-GLMC
- Period of the simulation: 24-30 August 2020
- We focus on the electricity system and assume that the gas is scarce

- Robust solution: Ideally the identification of CGFPPs must account for all credible hazards under a shortage of gas

Scenario 1: Congestion is key

- Scenario-based assessment
  - For each scenario, we assume that the GFPP identified as critical may be able to consume as much gas as needed
- Three different scenarios are defined:

Scenarios		Case	Electricity network
SC1	SC 1.a	Reference	Yes
	SC 1.b	Congested	Yes, cross-border line capacities are reduced by half
	SC 1.c	Congested	Yes, SC1.b + capacity of intra-zonal lines are reduced to 100 MW

Scenario 1.a. Reference

Scenario	Capacity (MW)
107	355
113	220
118	355
123	165
207	110
213	465
215	110
218	355
221	355
223	165
301	110
302	110
307	110
313	355
315	165
318	355
321	355
322	110
323	710

Note: Scenario X means that only the GFPPs in node X are treated as invulnerable

Assumption: GFPPs in the same bus are grouped

Which one would be the critical GFPP?

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Scenario 1.a. Reference

Scenario	Total ENS (GWh)	Capacity (MWh)
323	75.4	710
213	94.3	465
107	104.7	355
118	104.7	355
218	104.7	355
221	104.7	355
318	104.7	355
321	104.7	355
313	104.7	355
113	118.9	220
223	125.1	165
123	125.1	165
315	125.2	165
207	131.5	110
215	131.5	110
307	131.5	110
302	131.5	110
322	131.5	110
301	131.5	110
No gas	144.8	

Note: Scenario X means that only the GFPPs in node X are treated as invulnerable
Assumption: GFPPs in the same bus are grouped

The GFPP with the highest capacity is the CRITICAL GFPP!

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Scenario 1.a. Reference

- The previous result stems from the fact that the cross-border lines are not congested
- Let us consider regions 1, 2, and 3 as three different countries

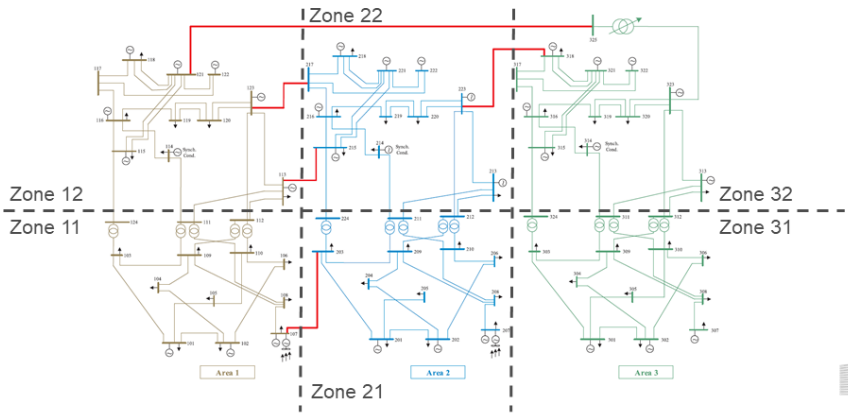
Scenario	ENS (GWh)				Capacity (MWh)
	Region 1	Region 2	Region 3	Total	
323	**23.4**	**18.5**	**33.4**	**75.4**	710
213	26.9	25.1	42.3	94.3	465
107	31.7	25.5	47.4	104.7	355
118	34.2	22.5	48.0	104.7	355
218	28.5	31.1	45.1	104.7	355
221	32.1	23.1	49.5	104.7	355
318	28.8	24.3	51.6	104.7	355

GFPPs of regions 2 and 3 are more critical for region 1 than the GFPP located at 118!

European Commission

Reduced cross-border and intra-zonal flows

- On top of the reduced cross-border capacities, we reduce the capacities of the lines connecting two zones to 100 MW



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Scenario 1.b. Reduction of cross-border capacities

Scenario	Region 1	Region 2	Region 3	Total	Capacity
323	23.3	27.0	**26.9**	**77.1**	710
213	21.1	24.2	50.1	95.4	465
313	30.0	33.3	42.3	105.6	355
221	25.4	**23.9**	56.3	105.6	355
218	21.2	31.1	53.2	105.6	355
321	29.3	34.6	41.8	105.7	355
318	27.6	34.1	44.0	105.7	355
118	17.5	30.6	61.3	109.4	355
107	**12.7**	46.2	50.6	109.6	355
113	27.9	31.7	60.6	120.2	220
123	24.4	37.9	60.3	122.6	165
223	33.1	31.7	60.7	125.4	165
315	35.2	36.9	53.6	125.8	165
207	30.9	39.2	61.8	131.8	110
215	35.1	34.0	62.8	131.8	110
307	35.1	36.1	60.9	132.1	110
322	38.1	37.5	56.5	132.1	110
302	35.9	38.6	57.6	132.1	110
301	36.2	38.6	57.3	132.1	110
No gas	39.5	41.0	64.8	145.2	

Each region identifies its own critical GFPP within their own fleet of gas-fired generators

The intraregional congestion may be very low!

European Commission

Scenario 1.c. Reduction of intra-zonal capacities

Scenario	Region 1	Region 2	Region 3	Total	Capacity
107	**16.2**	77.7	50.5	**144.4**	355
213	30.4	**69.8**	48.7	149.0	465
221	29.0	76.9	46.3	152.2	355
218	27.9	78.8	46.3	153.0	355
313	26.6	87.2	40.2	154.0	355
323	18.1	88.5	48.4	155.0	710
321	28.1	91.8	37.0	157.0	355
318	27.8	92.6	**37.0**	157.3	355
113	23.0	87.2	50.1	160.2	220
118	27.0	84.7	51.2	162.9	355
207	37.6	76.6	53.4	167.6	110
315	32.1	94.8	43.5	170.3	165
307	36.7	94.3	41.2	172.2	110
302	36.5	95.5	40.5	172.4	110
301	36.7	95.4	40.4	172.5	110
215	33.4	89.6	50.5	173.5	110
223	30.0	96.8	47.1	173.8	165
322	34.0	95.6	45.7	175.3	110
123	42.0	84.9	49.4	176.3	165
No gas	37.0	95.9	52.7	185.7	

Critical GFPPs at bus 107!!

Even within region 3, GFPPs at bus 323 are no longer critical

Transmission congestion plays a role in the identification of critical GFPPs!!

European Commission

Scenario 2: Optimisation is important

- Only electricity grid
- Optimisation-based approach
- Parameter k indicates the number of critical GFPPs that can be identified per time period

Scenarios		Case	Electricity network
SC2	SC 2.a	Reference	Yes, k=1
	SC 2.b	Reference	Yes, k=2
	SC 2.c	Congested	Yes, SC1.c, k=1
	SC 2.d	Congested	Yes, SC1.c, k=2

European Commission

Scenarios 2.a and 2.c (reference case)

- For both approaches, the criticality is linked to the size of the GFPP when the network is uncongested
- In the congested case, the two most critical GFPPs are identical regardless of the assessment method, however the optimisation-based one leads to an optimised decision (10% reduction in ENS)

(a) Scenario-based results

Scenario 1.a (reference case)		Scenario 1.c (congested case)	
Ranking	Total ENS (GWh)	Ranking	Total ENS (GWh)
323	75.4	107	144.4
213	94.3	213	149.0
107	104.7	221	152.2
118	104.7	218	153.0

(b) Optimisation-based results (k=1)

Scenario 2.a (reference case)		Scenario 2.c (congested case)	
Ranking	Operating hours	Ranking	Operating hours
323	156	107	74
213	8	213	49
		323	31
		313	14
Total ENS = 75.4 GWh		Total ENS = 129.6 GWh	

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Main takeaways

- *Optimisation*: The methodology can provide the required number of critical GFPPs in a single shot and its temporal identification
- *Topology*: Electricity network congestion plays a crucial role in the identification of critical GFPPs
- *Sector coupling*: Gas network may change the degree of criticality of GFPPs
- *Protected customers*: Linking gas and electrical customers may help optimise the dispatch and commitment of power plants, although we have not observed an impact on the identification of critical GFPPs
- *Fuel-switching capabilities*: Criticality will change when accounting for alternative fuels

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Critical gas volumes

Regulation (EU) 2022/2576

Regulatory framework – Critical gas volumes

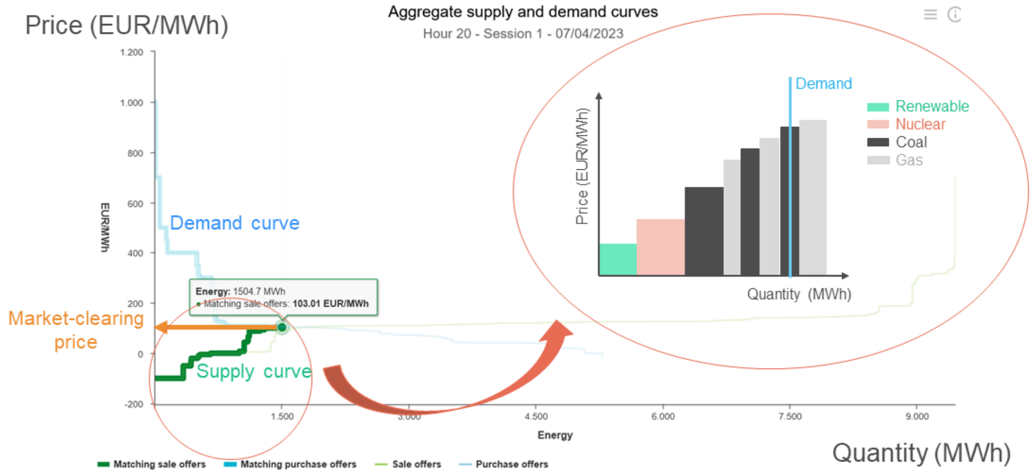
Regulation (EU) No 2022/2576 on enhancing solidarity

- ❑ Article 2 defines critical gas volume (CGV)

  ‘***critical gas volume for electricity security of supply***’ means the maximum gas consumption needed in the power sector to ensure adequacy in a worst-case scenario simulated in the winter adequacy assessment.

- ❑ Article 23 extends solidarity protection to CGV for electricity security of supply
- ❑ Annex I provides tables for maximum CGV per Member State:
  - (a) for the winter months (individually) December 2022 to March 2023 and,
  - (b) one monthly value for April 2023 to December 2023

Basics of electricity markets



Source: [OMIE, 2023]

Critical gas volume – Methodology (ENTSOE)

Definition

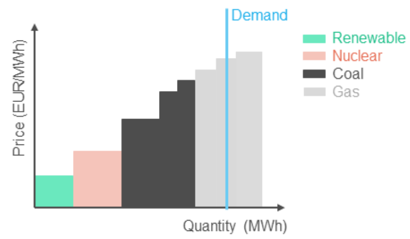
- Lowest volumes of gas absolutely needed for electricity generation using all market resources in the most adverse combination of climate conditions and outages

Key elements

- Gas is considered as the last profitable resource in the merit order
- Must-run gas-fired units are the exception

Consequences

- Gas is most likely the price setter always in the market
- Electricity adequacy is ensured even in the most adverse scenarios



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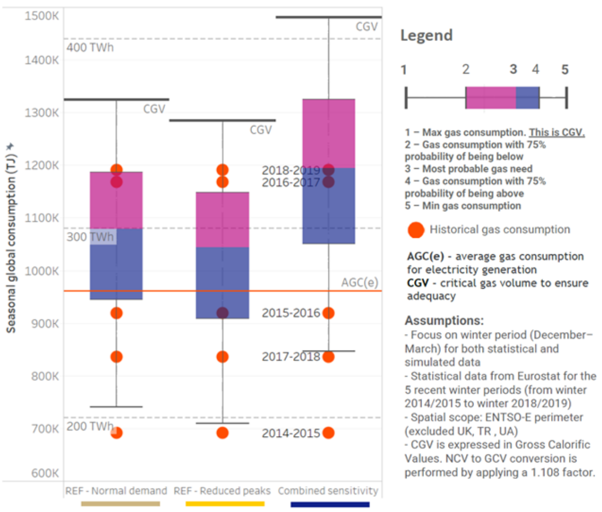
Critical gas volume in the EU – ENTSOE

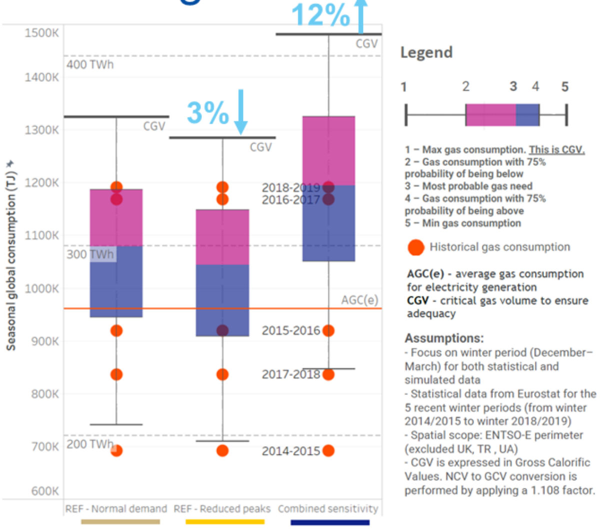


Source: ENTSOE Winter Outlook 2022-2023

Scenarios

- ❑ *REF – Normal demand*: Best estimates for the analysed winter
- ❑ *REF – Reduced peaks*: Identical to first one but demand reduction by 5% at peak hours
- ❑ *Combined sensitivity*: Limitation of fossil fuel-based generation + prolonged unavailability of nuclear plants

Critical gas volume in the EU – ENTSOE



Source: ENTSOE Winter Outlook 2022-2023

Remarks

- The CGV for winter 2022/2023 exceeds historical records
- CGV could represent one third of the working gas volume of the EU gas storages
- Lowering demand helps mitigate the gas dependence of the power system and therefore mitigate adequacy risks (not shown in this presentation)

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4.14 Update on Energy Community last advancements

Mr. Predrag Grujicic was the speaker of the last session about an update on Energy Community last advancements.

Competent Authorities

Contracting Party	Formal notification	Competent authority
Albania	Yes	Ministry of Infrastructure and Energy
Bosnia and Herzegovina	No (tacit)	Ministry of Foreign Trade and Economic Relations (MOFTER)
Georgia	Yes	Ministry of Economy and Sustainable Development
Kosovo*	Yes	Ministry of Economy
North Macedonia	Yes	Ministry of Economy
Montenegro	Yes	Ministry of Capital Investment
Moldova	No (tacit)	Ministry of Infrastructure and Regional Development
Serbia	No (tacit)	Ministry of Mining and Energy
Ukraine	No (tacit)	Ministry of Energy

Protected customers

Contracting Party	Formal notification	Protected customers – definition	Estimated Annual Consumption in mcm	Percentage of total consumption
Albania	Yes	household customers, SMEs, essential social services, DHC - heating to the abovementioned customers	0	0
Bosnia and Herzegovina	No (tacit)	Entity level -	Est. 105	Est. 42%
Georgia	Yes	household customers, SMEs, essential social services, DHC - heating to the abovementioned customers	1407.2	55%
Kosovo*	Yes	household customers, SMEs, essential social services, DHC - heating to the abovementioned customers	0	0
North Macedonia	Yes	households; essential social services, zoos		Est. cca 2%
Montenegro	n/a	n/a	0	0
Moldova	No (tacit)	household customers, SMEs, essential social services, DHC - heating to the abovementioned customers	Est. 362 (Moldova proper)	Est. 37.5%
Serbia	No (tacit)	households; heat energy producers; grid operators, essential social services; facilities in which the delivery of gas would cause permanent damage to production facilities	Est. 900 (needs confirmation)	Est. 34%
Ukraine	No (tacit)	Ministry of Energy	Est. (2021): 16 000-18 000	Est. (2021): 60-65%

Regulation (EU) 2022/1032 („the Storage regulation“)

Energy Community

Entered into the force for the Contracting Parties on **1 October 2022**

1. Amendments to Regulation (EU) 2017/1938

<u>Storage filling targets and filling trajectories</u>

- Determination of intermediary targets
- Measures to reach the targets
- Monitoring of filling targets / Reporting

<u>Storage arrangements and burden-sharing mechanisms</u>

2. Amendments to Regulation (EU) 715/2009

<u>Certification of the storage system operators</u>

<u>Possible tariffs discount at entry/exit storage points</u>

Intermediary targets for 2023 – state of play

Energy Community

The decision based:

- On basis of the technical information and draft filling trajectory with intermediate targets submitted by each Contracting Party (No Contracting Party sent official data)
- On the average filling rate during the preceding five years
- On the basis of an assessment of the general security of the gas supply situation and the development of gas demand demand-supply in the Energy Community and individual Contracting Parties
- Taking into the assessment of the **Security of the Supply Coordination Group**

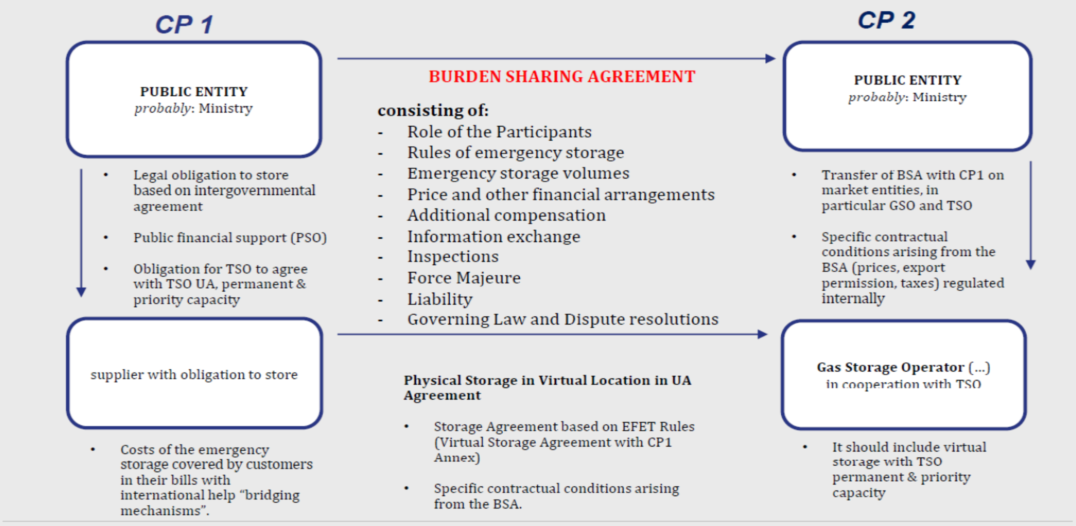
ECS adopted the decision on filling targets on 15 November 2022

February targets surpassed in both CPs

Contracting Party	February 1st	May 1st	July 1st	September 1st
Serbia	50%	15%	45%	70%
Ukraine*	33%	23%	47%	58%

* the intermediate targets of the filling trajectory shall be reduced accordingly by 35% multiplier

Storage arrangements and burden-sharing mechanisms



Energy Community Secretariat

Storage Report – by 1 June 2023

Article 17(a) of Regulation (EU) 2022/1032 defines the content of the report:

(a) an overview of the measures taken by the Contracting Parties to fulfil the storage obligations,

(b) an overview of the time needed for the certification procedure, set out in Article 3a of Regulation (EC) No 715/2009 as adapted and adopted by the Ministerial Council Decision 2011/02/MC-EnC

(c) an overview of the measures requested by the Energy Community Secretariat in order to ensure compliance with the filling trajectories and the filling targets;

(d) an analysis of the potential effects of this Regulation on gas prices and potential gas savings in relation to Article 6b(4).

Energy Community Secretariat

Certification of storage system operators

Energy Community

Ukraine

December 2022 the Law on the certification of Gas Storage Operator was adopted to implement the Gas Storage Regulation

In January - Procedure for the certification of the Gas Storage Operator was approved by the NRA
January 27, 2023 Ukrtransgaz, Ukrainian Gas Storage Operator, submitted to NEURC an official request for certification

Draft preliminary decision notified to the Secretariat on 3 March 2023
ECS Opinion – 31 March 2023: no SoS risk currently identified

Final decision by NEURC – 7 April 2023 – UTG is the second certified SSO in the whole Europe

Serbia - ECS shared proposed amendments to Serbian law to enable certification of storages in Serbia (Gazprom owns 51% of shares)

Energy Community Secretariat

Energy Community

Energy Community Secretariat

5 Conclusions

The training course on “Methods for the implementation of the Regulation (EU) 2017/1938 on Security of Gas Supply and other related Regulations” held in Vienna on 24-25 April 2023 covered primarily the fundamentals of the Regulation (EU) 2017/1938 of the European Parliament and of the Council of 25 October 2017 concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010. The Contracting Parties of the Energy Community Treaty are also obliged to implement the Regulation (EU) 2017/1938 with some modifications. The modified regulation removes the provisions related to regional cooperation and solidarity. In addition, it incorporates newly security of supply policy elements of Regulation (EU) 2022/1032 of the European Parliament and of the Council of 29 June 2022 amending Regulations (EU) 2017/1938 and (EC) No 715/2009 with regard to gas storage.

The Joint Research Centre (JRC) of the European Commission has the required competences and experience for organising a dedicated training on the implementation of the regulations for security of gas supply. This is backed by the experience gained along these years by supporting Member States of the European Union in the correct implementation of the Regulation (EU) 2017/1938, especially in performing national and common risk assessments (Bolado Lavin, et al., 2012; Zeniewski & Bolado Lavin, 2012). The trainers have accumulated years of technical and mathematical knowledge in the area of security of supply and they have also acquired a deep knowledge of the current regulations revolving around the Regulation (EU) 2017/1938 (Jung, Fernandez Blanco Carramolino, Yusta Loyo, & Bolado Lavin, 2022; Fernández-Blanco Carramolino, Rodríguez-Gómez, & Bolado-Lavín, 2023).

As in previous years, more than 20 participants involving experts from almost all Contracting Parties of the Energy Community have attended the training in Vienna (Austria). The course has been a good opportunity to discuss practical implementation details such as the application of the N-1 formula for the countries with transit gas, the computation of the peak demand, or the contents of the national risk assessments.

This edition of the training course is very timely as the national risk assessments of the Contracting Parties of the Energy Community are due by 1 January 2024. Right after that, the Contracting Parties should submit their corresponding preventive action plans and emergency plans not later than 1 May 2024. The training course has provided valuable information to prepare each of these documents, which are crucial for implementing the Regulation (EU) 2017/1938 on security of gas supply, in a practical and effective manner.

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Bolado Lavin, R., Gracceva, F., Zeniewski, P., Zastera, P., Vanhoorn, L., & Mengolini, A. (2012). *Best Practices and Methodological Guidelines for Conducting Gas Risk Assessments.* EUR 25227 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2012. JRC68735.

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Zeniewski, P., & Bolado Lavin, R. (2012). *Preventive Action Plan and Emergency Plan Good Practices: A Review of EU Member State natural gas preventive action and emergency plans.* EUR 25210 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2012. JRC68736.

List of abbreviations and definitions

EC	European Commission.
ENTSOE	European Network of Transmission System Operators for Electricity.
EP	Emergency Plan.
EU	European Union.
JRC	Joint Research Centre.
LNG	Liquefied natural gas.
PAP	Preventive Action Plan.
RA	Risk Assessment.
SoGS	Security of Gas Supply.

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