Understanding our chemical accident risks

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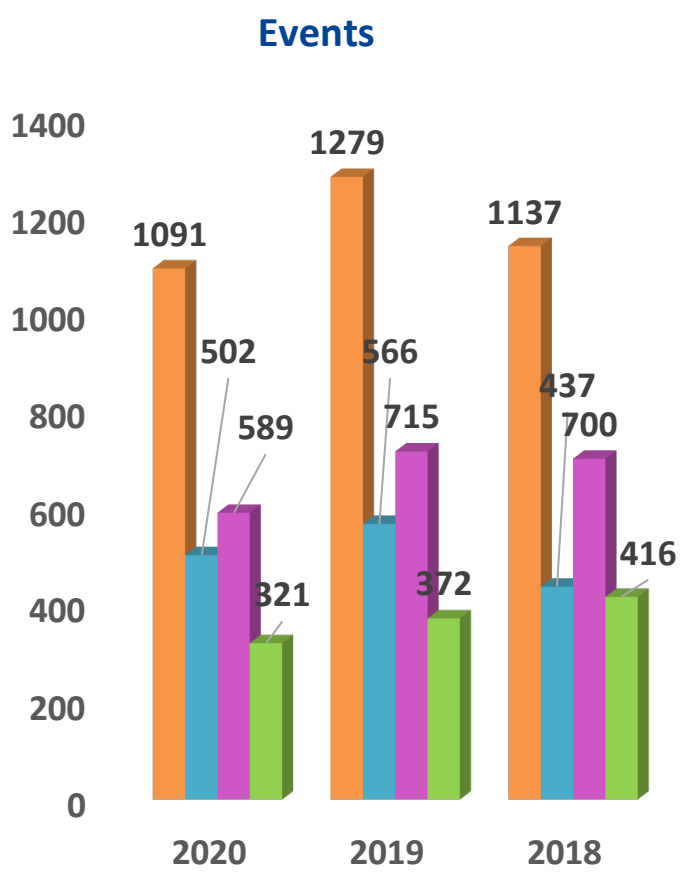
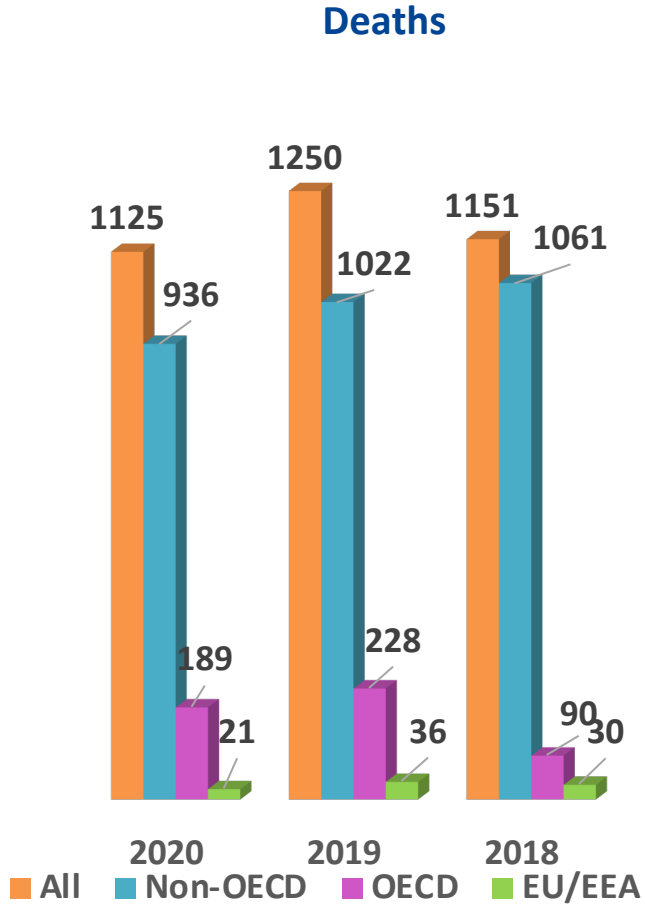
Outline of the presentation

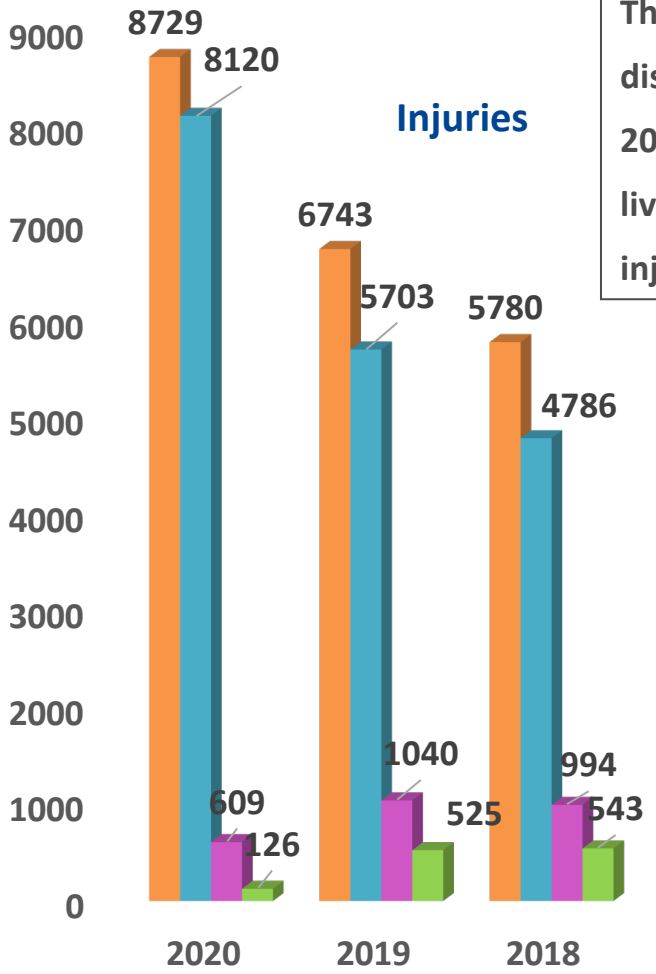
- Chemical accidents globally
- Chemical accidents in the EU
- Our current and future work

Significant chemical accidents and chemical accident trends in the EU and globally

What global media data show in 2020





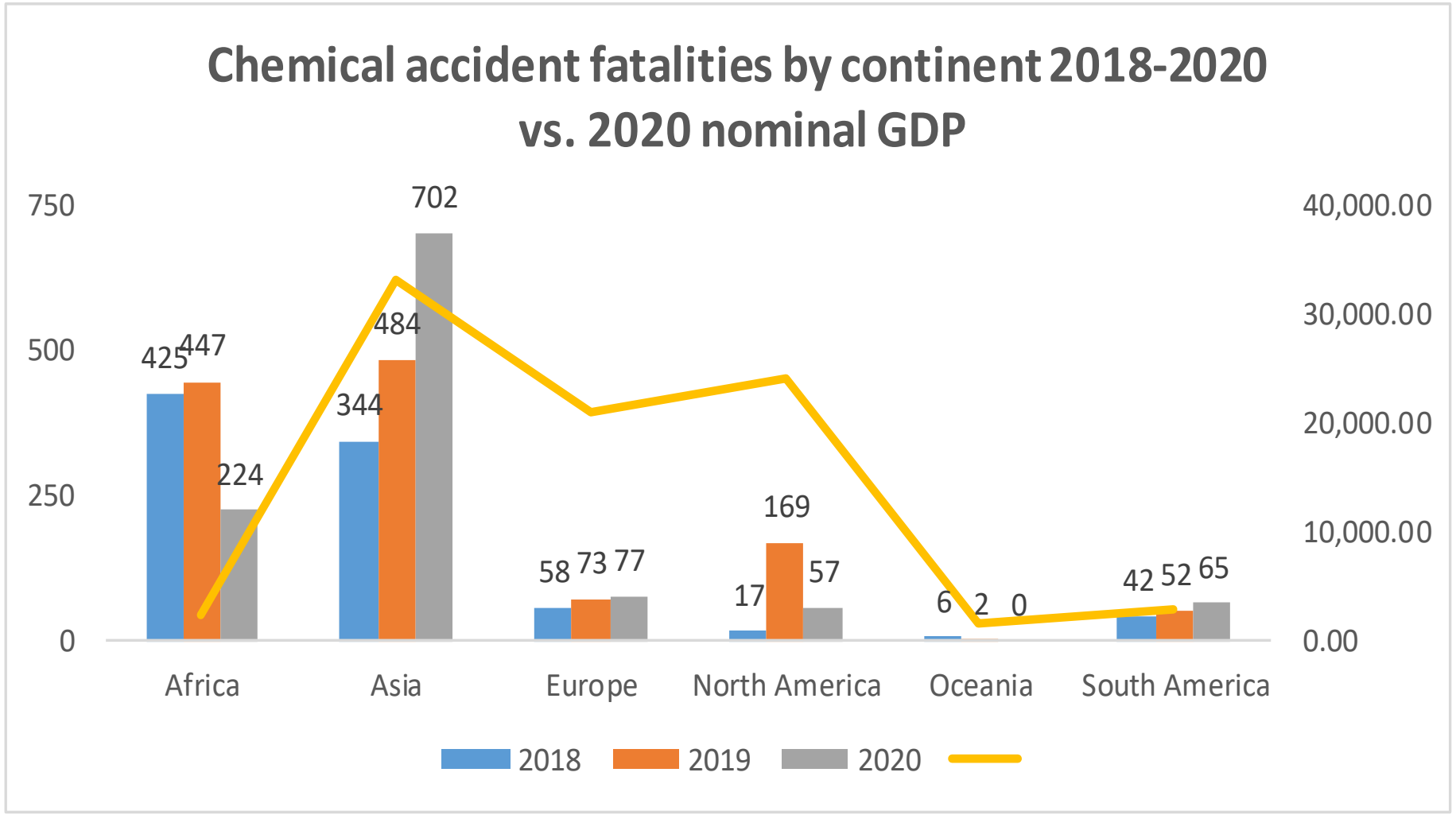


The Beirut, Lebanon disaster of 4 August 2020 claimed over 200 lives with 6,000 more injured

- In 2020 74% of deaths (852) and 90% of injuries occurred at **fixed facilities**
- **Downstream industries** ("non-chemicals") were responsible for 43% of the fatalities (485) and 75% of injuries (6,583). While the oil and gas industries caused 366 deaths (33%) and 571 injuries (7%)

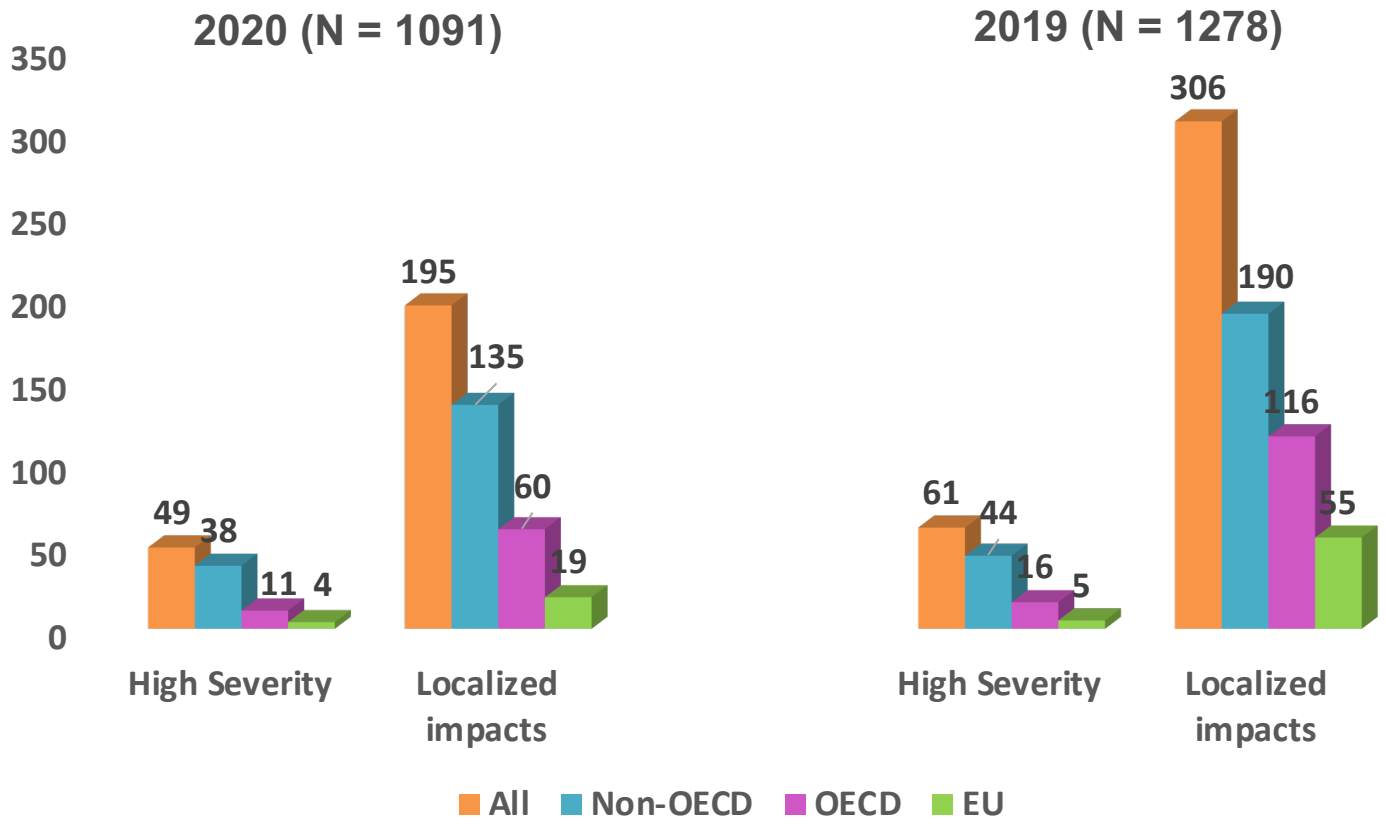
Chemical accidents reported in the global media in 2018-2020 (JRC GMI-CHEM database, 2021)

In Europe and North America, chemical accident frequency is not correlated with economic growth



European Commission

Serious chemical accidents and disasters in 2020 vs. 2019



High severity impact = EGL 5-6

Localized impact = EGL 3-4 plus 1 death accidents (EGL 2)

(EGL = European Gravity Scale for industrial accidents - Echelle européenne des accidents industriels gravité http://www.aria.developpement-durable.gouv.fr/)

2019 was a bad year in terms of volume of serious accidents, but **2020 had a far worse disaster (Beirut).**

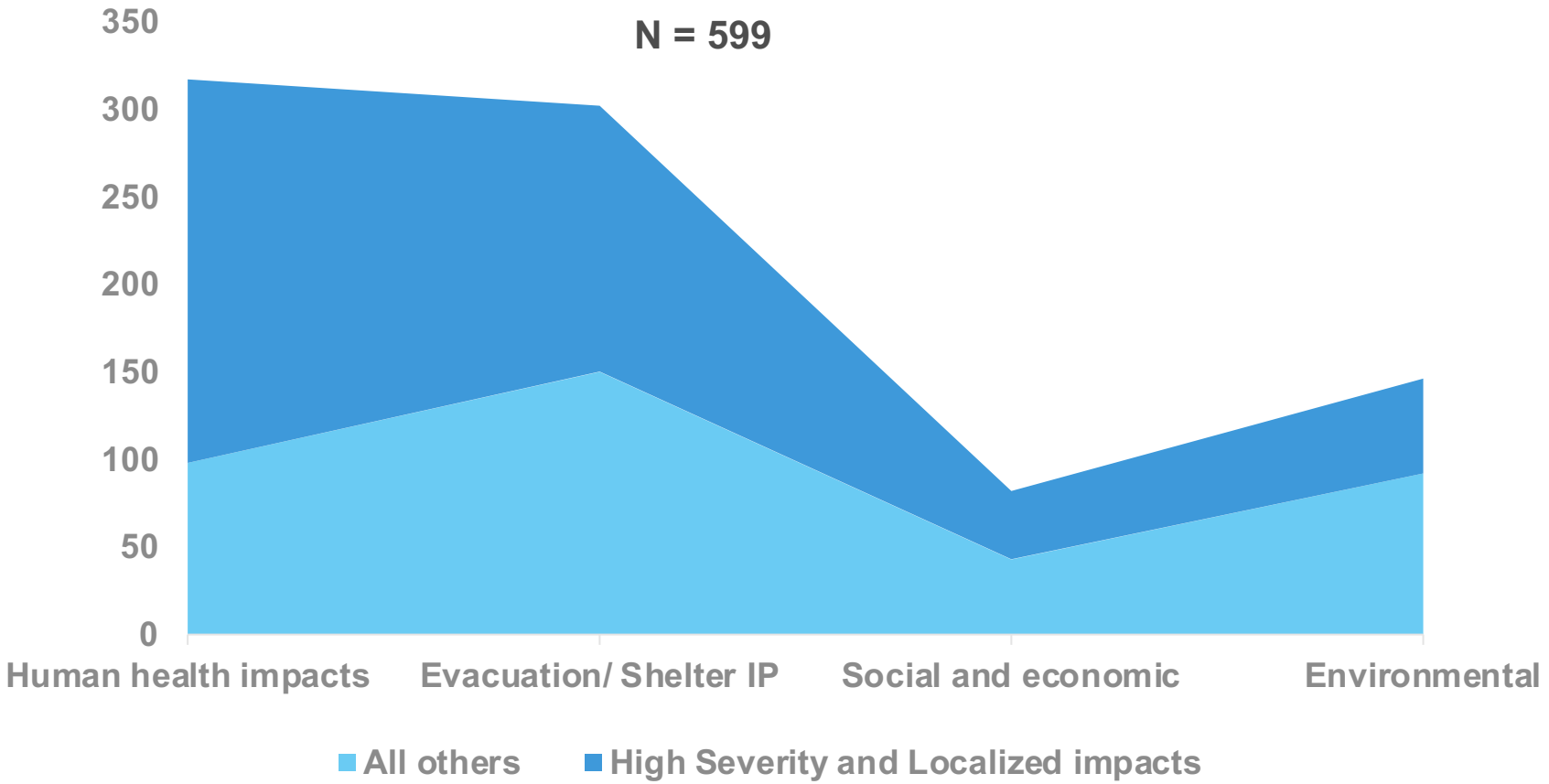
It is actually not the number of chemical accidents that count as much as how disastrous they are!

High severity events in 2019 were more than double those of 2018, and now have decreased somewhat in 2020

Events with substantial local impacts were 77% higher in 2019 compared to 2018, and are 36% higher than 2020.

JRC GMI-CHEM database, 2020

Around 50% of all 2020 OECD events were reported to have an impact of some kind (same as 2019)



Human health impacts dominate serious and disastrous events representing 75% of all such events and . 29% of events overall..

Social and economic impacts are also not insignificant, since **evacuation** and **shelter in place** as well as some **environmental** impacts also cause community disturbances. Evacuation or shelter-in-place occurred in 28% of all events.

Nearly 40% (307 out of 800) of "limited impact" events had health impacts reported (EGL Level 1-2 includes events with < 50 non-hospitalizing injuries).

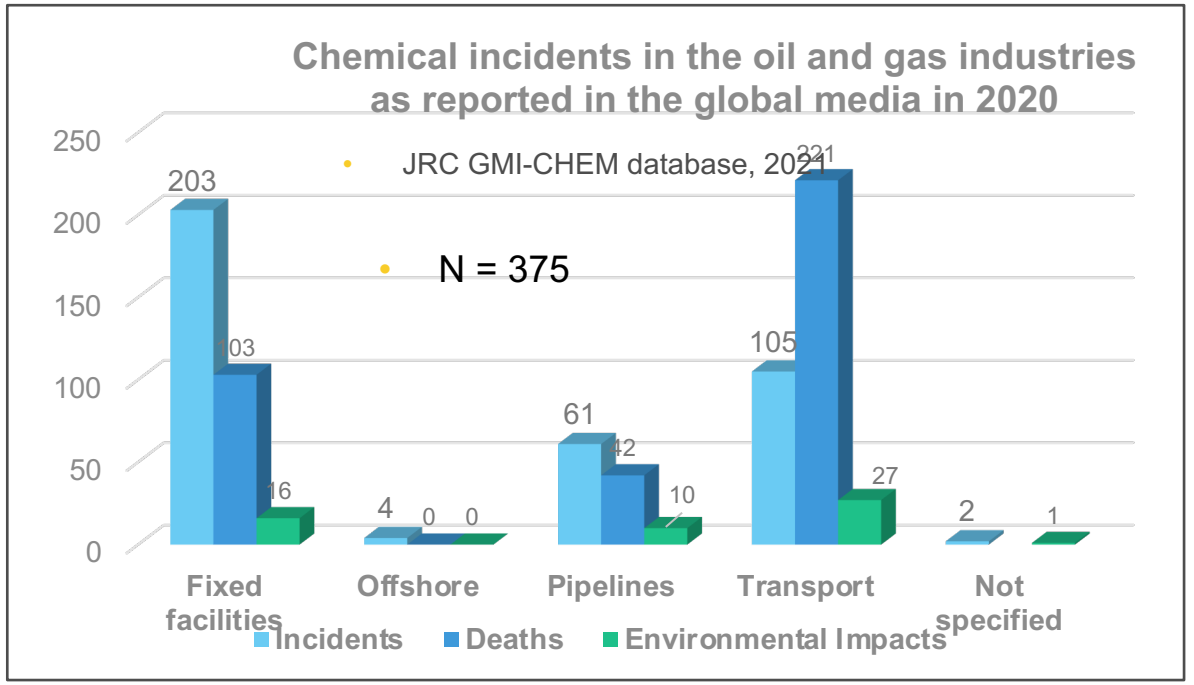
Social and economic impacts include property damage, business closures and loss of production, loss of utilities, closed schools and roads, etc.

JRC GMI-CHEM database, 2020

Oil and gas industries are under pressure, especially from oil spills

2021 was a bad year for oil spills from pipelines, tankers and offshore

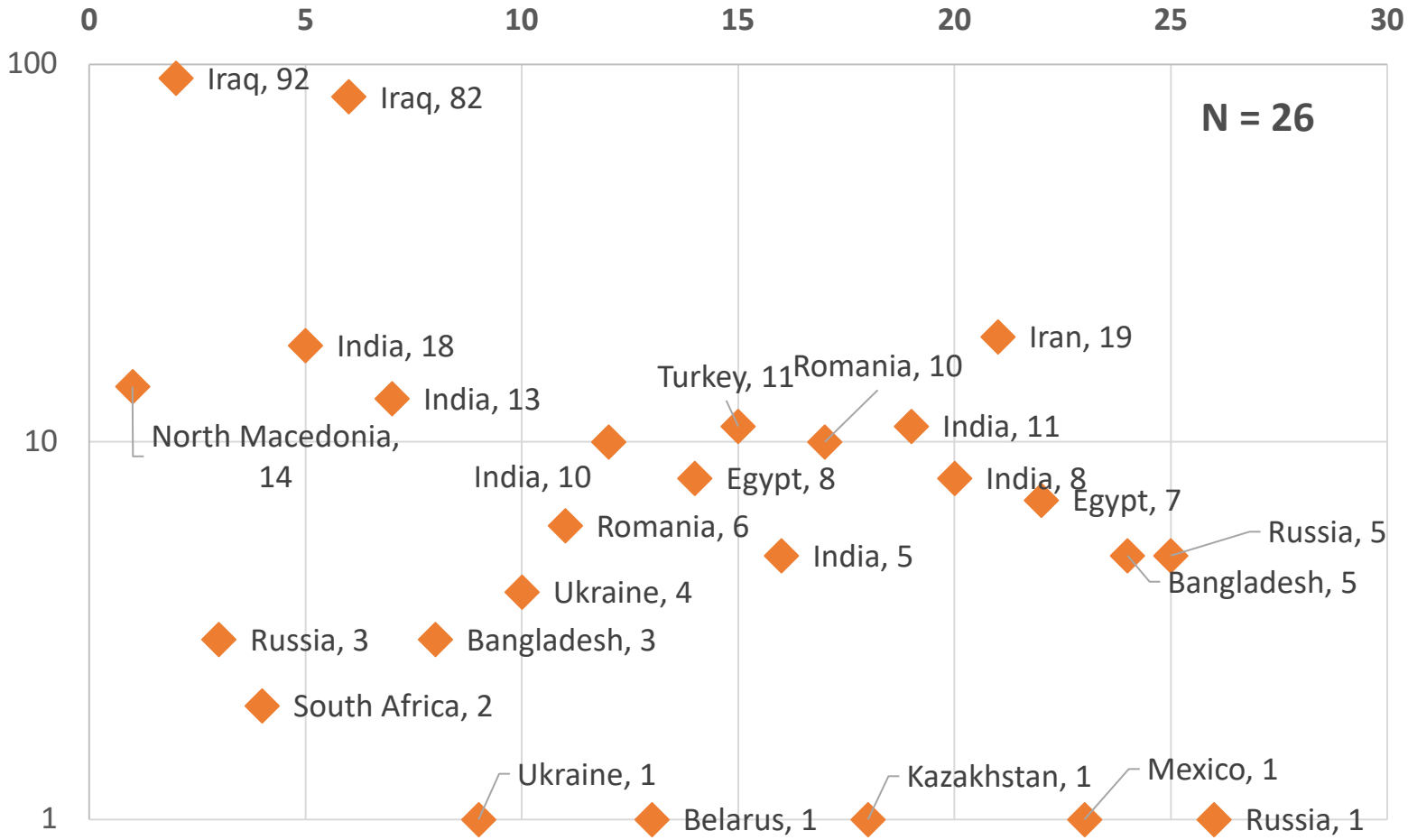
- California governor says offshore drilling is in the past after 144,000 litres of crude oil leak from a pipeline off the coast
- Tanker oil spill leads Israel to close beaches as it faces one of its 'most severe ecological disasters'
- Tanker fire leaves to massive oil spill and environmental disaster off the coast of Sri Lanka
- Five people killed and six injured in a fire at an offshore oil platform owned by Mexico's Pemex
- 7,000 people were evacuated from the vicinity of a burning oil well in northeast India in May-June 2020. 2 fire fighters died.



- Most fatalities occur in transport in developing countries.
- Few offshore incidents but those reported are often disasters

European Commission

Oxygen-related fires in Covid-19 hospitals increase >3000% during the pandemic



46 fires associated with Covid-19 oxygen therapy have occurred since May 2020, 26 of them have been fatal.

The MAHB alert* (Lessons Learned Bulletin) published in January 2021, but 18 incidents occurred in months after, 11 of them fatal.

14 people died in the most recent incident in North Macedonia in September.

Most incidents occurred in developing countries. Of 5 incidents in the European Union, two were fatal.

In April 2021, due to the JRC intervention, the WHO added oxygen risk management advice to its guidance and training.

*Co-authored by M. Wood, M. Hailwood and K. Koutelos

Notable chemical accidents in the EU

- Sulphur dioxide release at a pulp production site in Hallein, Austria on 2 June

One person was killed onsite. The accident highlighted once again challenges associated with **emergency planning** (especially **information to the public** and **crisis management**) and risk management and monitoring of **ageing equipment**.

- An explosion occurred on 27th July in the Waste Management Centre in Leverkusen, Germany, followed by a fire

7 persons were killed and 31 were injured. Preliminary investigations are focusing on the **conditions in which the waste was stored** and **associated control measures**.

The operator has invested effort in keeping the public informed about what happened and the ongoing investigation. https://www.currenta-info-buerrig.de/

- *Detailed reports on other major accidents in the EU are still pending …*

Recent incidents affected changes brought own by the Covid-19 pandemic

Four fatal accidents related to shutdown and startup because of Covid-19 lockdown/market change (2 in India, 1 in Italy, and 1 in South Africa)

Two incidents reported to eMARS associated with higher than normal volumes of production (an oxygen supplier and a disinfectant producer). The former qualified as a major accident.

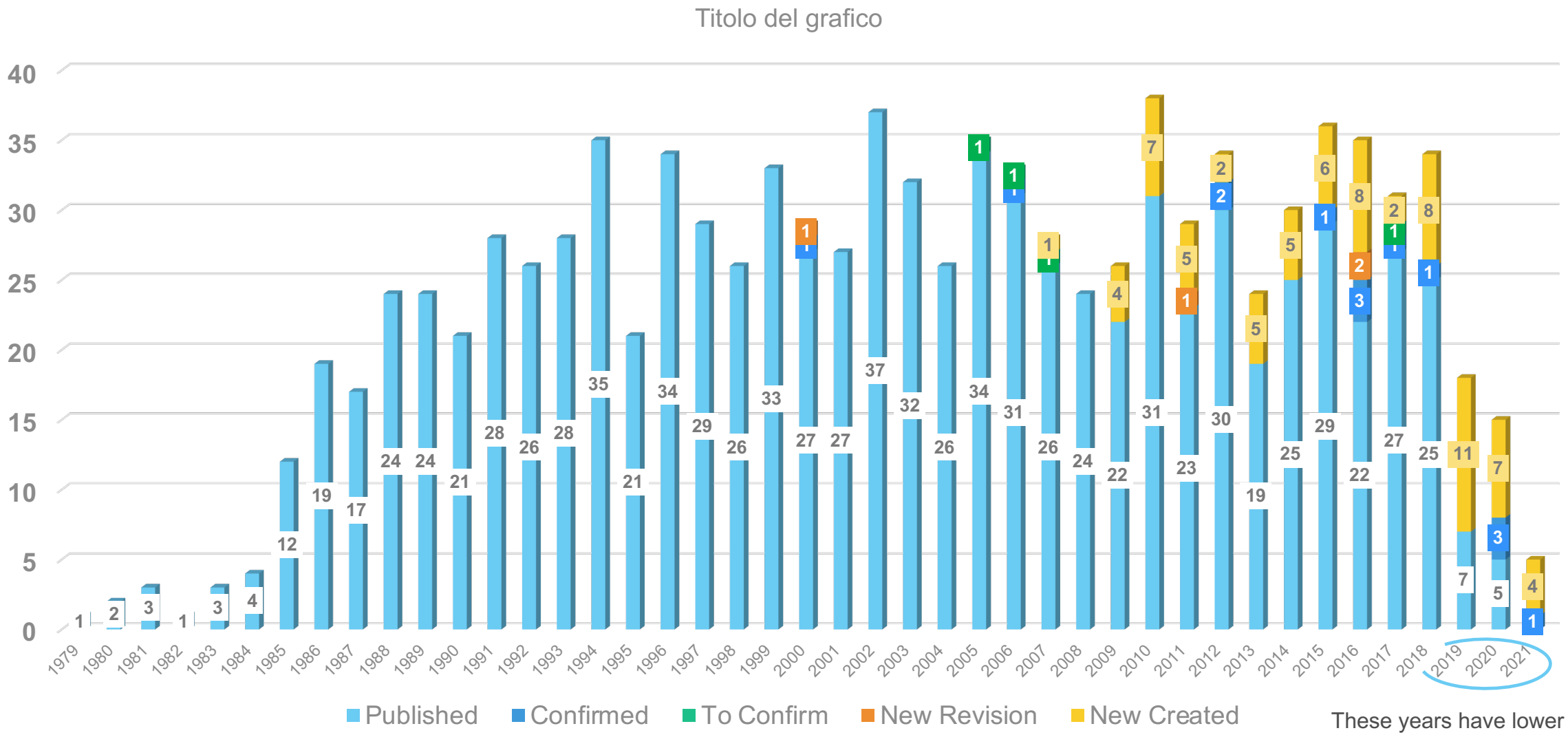
19 additional incidents reported in ARIA with Covid-19 measures as a contributing factor of which 11 are hazardous sites

Factors related to Covid-19 measures include:

- Failure after startup
- Emergency response delayed
- Delays in housekeeping
- Tasks performed without adequate competence
- No eyes on the site and no detection system in place
- No second pair of eyes to check correctness of operations
- Non-urgent tasks delayed
- Excess ventilation increases worker exposure to a release

Statistics and findings from the reports to the EU’s eMARS database

Major accidents reported to eMARS (established 1984)



These years have lower numbers because many accidents have not yet been reported.

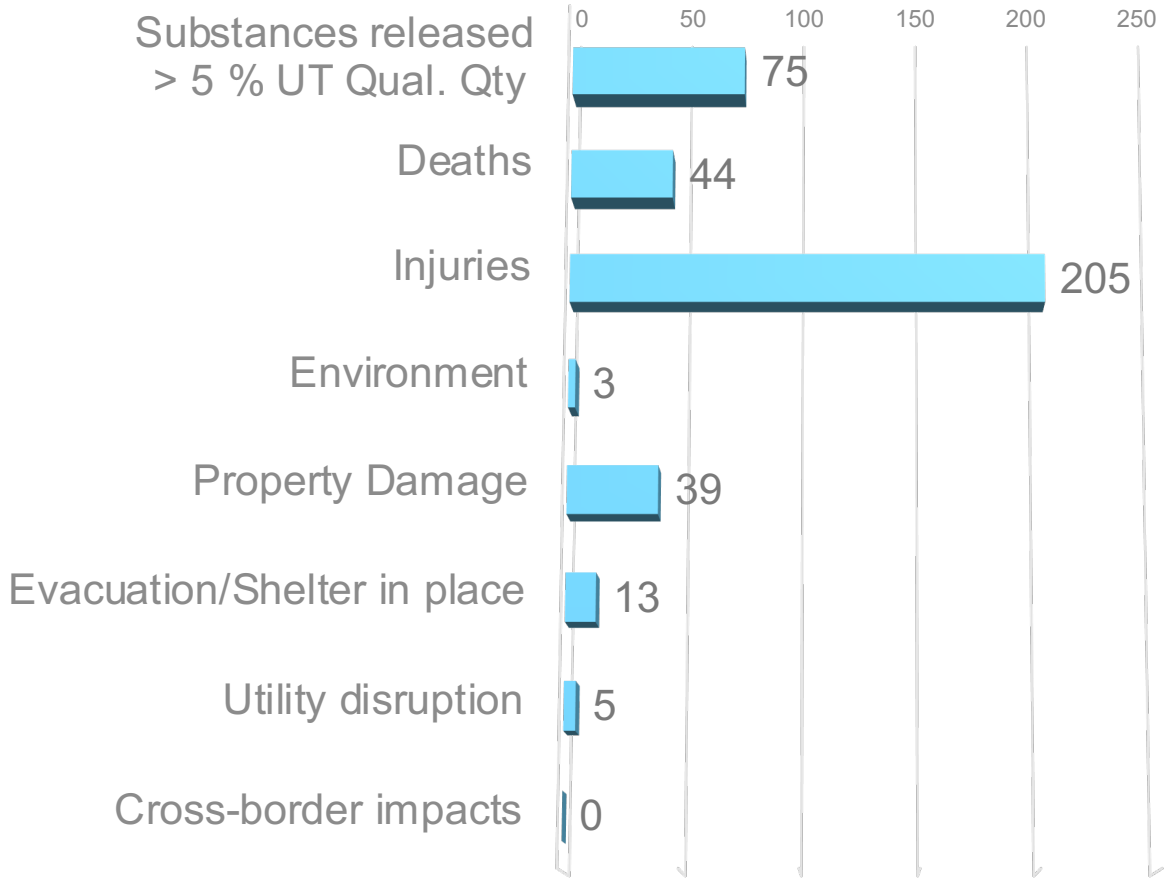
Latest 5 year average (2014-2018) is 33 major accidents per year.
(Reporting for 2019 - 2021 is still ongoing.)

European Commission

eMARS - EU and EEA major accidents for period 2016-2021 (as of 14.10.21)

140 (published and unpublished) reports of major accidents occurring on EU Seveso sites from January 2016 to October 2021. Of these 135 have consequences identified.

Most common reasons for reporting are volume of substance released (75), property damage (38), and human health impacts (37)



44 Fatalities in total (10 with multiple)

6 accidents with over 10 injuries, **205 injuries** in total

In 2019, one event **closed 237 schools in 12 communities** for 2 days

In 2016 a refinery fire cost nearly €800 million in damages and an explosion in a steel factory in 2016 cost €80 million

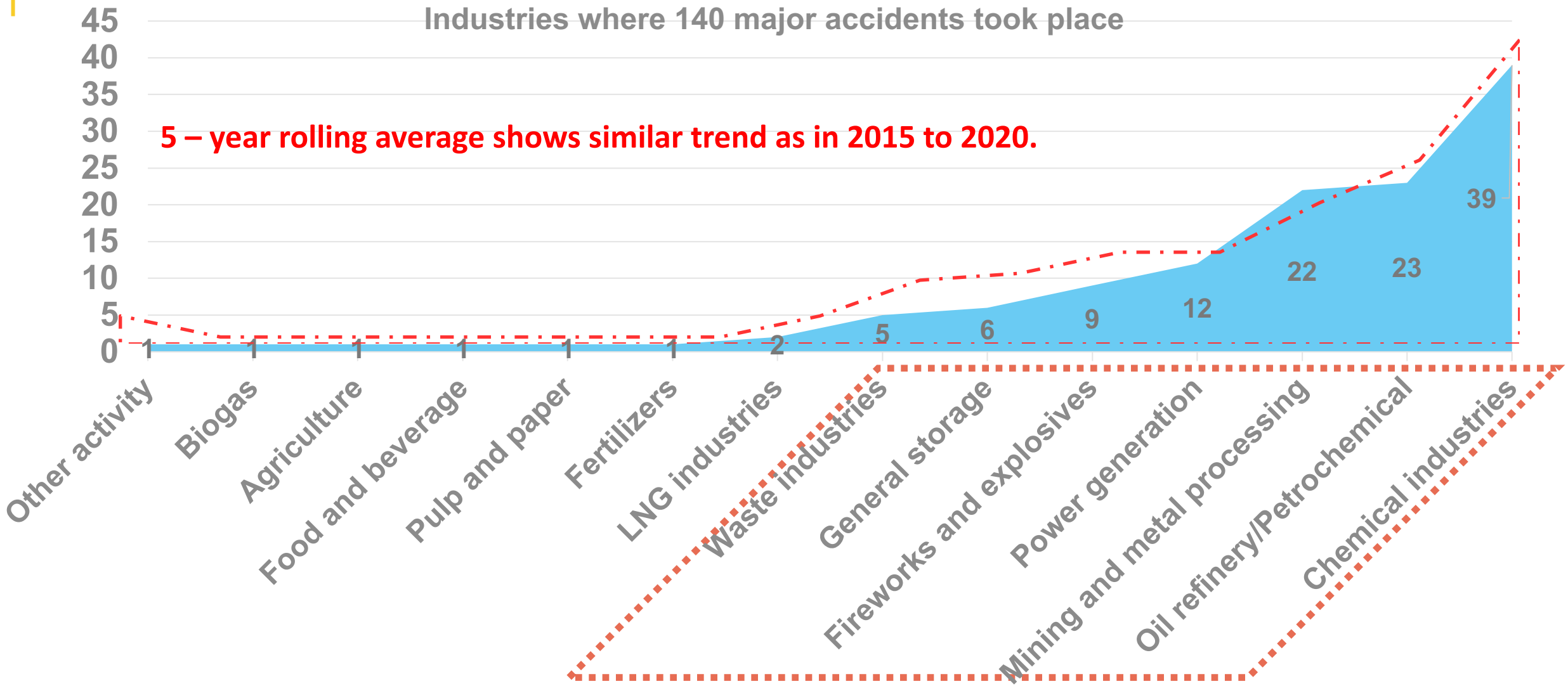
8 accidents ≥ € **10,000,000 in damages**

In 2017 **~5000 people had to drink bottled water for 9 days** due to a bromine release to the water supply

Note: there are currently over 12,200 Seveso establishments registered in eSPIRS

European Commission

EU Seveso major accidents by industry type 2016 – 2021



eMARS accidents – 2016 – 2021

A quick look at the common initiating factors

Initiating Direct Causes (1)
97 major accidents and 39 near misses (eMARS 2016 – 2021)

#1 Wrong procedure (29) Hot work (7) -- (Several other cases where wrong procedure did not initiate the incident but failed to stop the sequence or caused a worse consequence.)

What are the underlying causes? Possibly many … One example

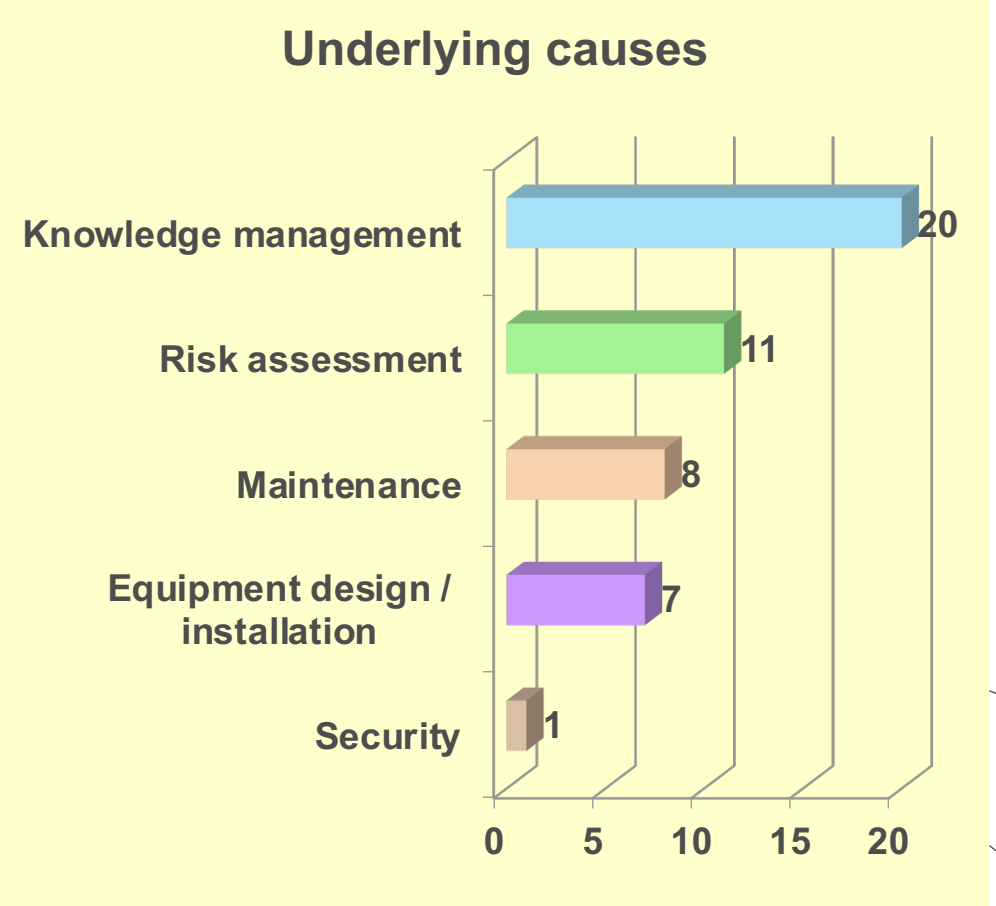
"**Lack of knowledge** and consequent assumptions about the end of the transhipment.
Lack of communication between the firm and the staff responsible for filling the tanks about the operation of the unloading gantry and storage tank.
Lack of awareness within the firm about good practice, or of noticing and being willing to speak out if good practice is not followed.

"**On the basis of the operator's documentation**, **it was not possible to determine whether the setup at the time of the accident corresponded to the original design** or whether a different metal fibre hose had been installed in the meantime. Although all participants in an on-site meeting were of the **opinion that the damaged installation did not meet the standards, nobody in the company (over a long period of time) had questioned the situation."**

Various reasons given across reports: Lack of training, lack of communication, design not documented, labelling error, lack of competency, ageing staff, safety culture, …

Small JRC study presented at Stockexpo (March 2021)

21 incidents involving tank storage



Acceptance of deviation
Wrong procedures
Lack of documentation/ historical knowledge
Poor training
Permit to Work failure

Management of change failure
Insufficient barriers to wrong procedure
Insufficient secondary containment
Lack of detection equipment

Inadequate maintenance
Inadequate inspection regime

Poor valve design
Poor design of tank
Poor design/installation of safety equipment
Poor design of loading equipment

Security failure

eMARS database 2016-2021

Initiating Direct Causes (2)
97 major accidents and 39 near misses (eMARS 2016 – 2021)

#2 Corrosion (12) / Mechanical integrity (18) / Error in maintenance (4)

Some common causes are **poor maintenance and inspection, excess wear and tear,** and **poor management of change.**

However, in many reports, **there is no reason given** for the equipment's condition. This might sometimes be a failure to report or a failure of the investigation, but it is also true that mechanical integrity cases are sometimes difficult to diagnose.

Should some of these cases be further investigated to understand technical of safety management causes?

It is hard for the analyst (me) to make that judgement, but it is a good question for the operator and the inspector to ask themselves.

Initiating Direct Causes (3)
97 major accidents and 39 near misses (eMARS 2016 – 2021)

#3 Process miscalculation (14) – That is, something went wrong in the process.

-It is often simply explained as an **unexpected heat or pressure increase**.
-**Higher than normal volumes** (increased demand), or **a change in ingredien**t sometimes cited.

Downstream events sometimes increased impact severity.
-For example, the **personnel conducted a wrong procedure** in response to the process failure
-Lack of downstream barrier, sometimes identified by Hazop, but not installed (e.g.,Tarragona, 2020)

Underlying causes are not always identified but here is a nice excerpt from one report that summarizes the many possibilities:

"-**Lack of barriers**. Some barriers (for example automatic temperature control on the tank) had been removed **without proper management of change** in earlier modifications.
-Inadequate risk assessment of changes and inadequate Hazop and follow up of Hazop.
-**Loss of competency, knowledge and understanding of risks** associated to the specific operation.
-**Personnel acceptance of deviations** as being "normal" (temperature alarms in control room not trusted, believed to be unreliable)"

Process design is another possible underlying cause for many of these incidents.

Initiating Direct Causes (4)
97 major accidents and 39 near misses (eMARS 2016 – 2021)

#4 Electrical ignition source (11) Unknown/unexpected ignition source (9)

In many cases, the ignition (electrical or not) appears to be unexpected and why it happened is not well understood even after investigation.

The following description of the cause is typical in these cases:

"The circumstances of the ignition have not been definitively determined. There was probably electrostatic accumulation. A flammable/explosive mixture formed inside the tank and, when an ignition occurred, caused the tank to explode."

This suggests both **a design error** and **a risk assessment error**.

In two cases, the cause appeared to be a **wrong procedure** (including **improper precautions for hot work**). (There can be more than one initiating direct cause in some cases.)

Initiating Direct Causes (5)
97 major accidents and 39 near misses (eMARS 2016 – 2021)

#5 Power failures (11)

7 of the power failures were caused by a defect in the onsite power supply system (poor maintenance, animal interference, etc.)

One power failure occurred on startup, one during an emergency shutdown, and another because the public power supply was cut.

In another case**, maintenance of the UPS** went wrong and tripped the entire power supply at the plant.

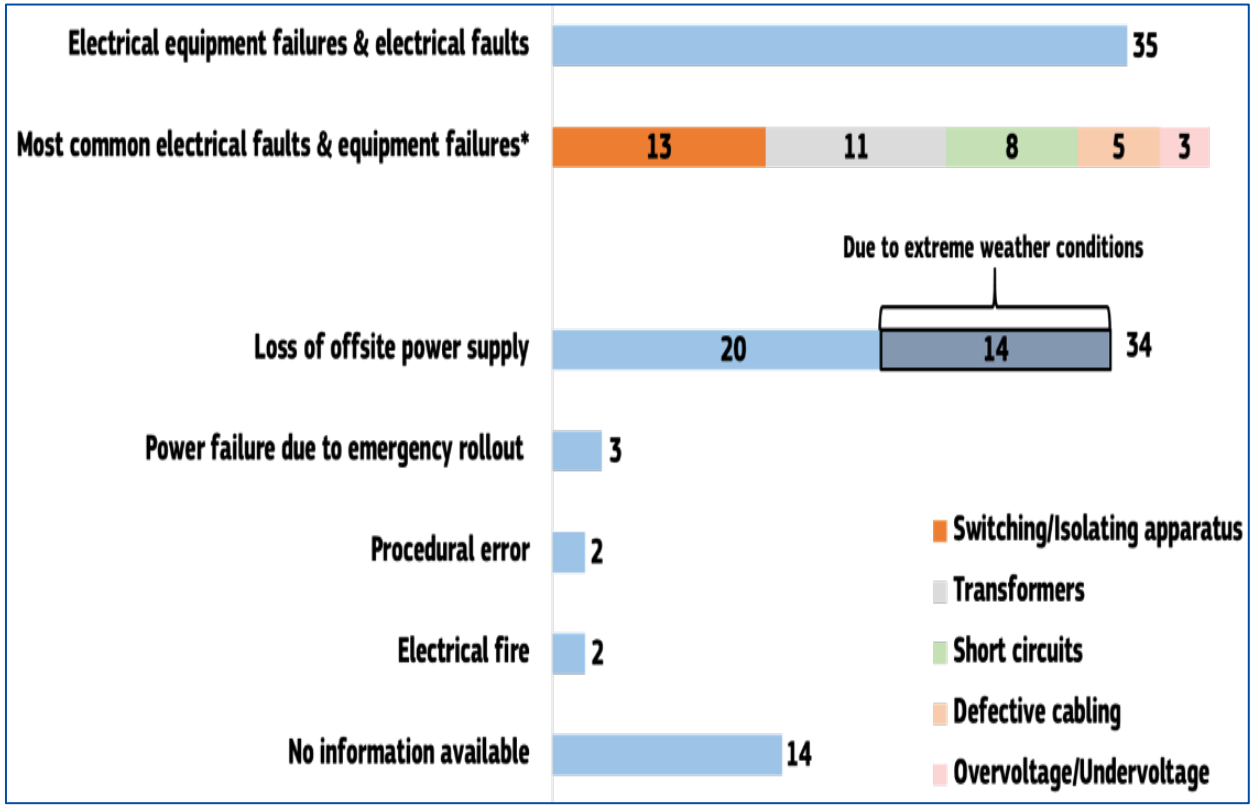
For this causal factor, **maintenance and housekeeping** appear to be an important underlying issues.

Lessons learned bulletin from chemical accidents involving power failures

Study of 99 accidents involving power failures in EU and OECD countries that occurred since 1981.

Power failures:

- Are often unpredictable
- Can affect multiple units and equipment
- Can affect most industries with one or more unintended consequences.
- May destabilize units and compromise process safety
- Can have delayed impacts if process consequences are not recognized & controlled.
- Can have worse impacts when poor process safety practices have weakened resilience.
- Can have significant impact on utilities even without loss of containment, e.g., loss of product, plant shutdown, and damage to equipment and buildings.



Causes of primary power supply failure (N=90) (JRC, 2021) (*Some cases have more than one failure)

Most electrical equipment failures were related to electrical switching/isolating apparatus, transformers failing, short circuits, defective cabling, under or over voltage.

Initiating Direct Causes (6)
97 major accidents and 39 near misses (eMARS 2016 – 2021)

 # 6 Natech (11)

9 events were caused by very strong winds (mainly from storms or hurricanes), and one event involved a lightning strike and another release was caused by flooding

In all cases, the main factor was considered to be either **equipment that was insufficiently resilient**, or **the failure to check that equipment or infrastructure (e.g., a tank roof) had been adequately secured** prior to the natural hazard event.

 # 7 Waste management (6)

The main initiator in 4 cases appears to be in the hand-off of waste by the owner to the waste treatment operator. In 3 cases, the composition of the waste was not fully understood and in a 4th case, the operator overfilled the container.

2 other cases were linked to unexpected ignition.

Initiating Direct Causes (7)
97 major accidents and 39 near misses (eMARS 2016 – 2021)

#8 Detection system failure (4)

A **logical programming error, mislabeling**, and **sensor failure** were cited for 3 incidents, respectively.

-In a fourth case there were three detection failures: 1) The high level alarm was turned off
2)The very high alarm was not adapted to the position of the overflow valve
3) the temperature detector in the bund did not detect the substance overflow (in the wrong place?)

JRC publications and activities

JRC publications – recent and upcoming

https://minerva.jrc.ec.europa.eu/en/shorturl/minerva/publications

Recently published work

Seveso Inspections Series

- Common Inspection Criteria (CIC) – **Maintenance of primary containment systems** (published)
- Common Inspection Criteria (CIC) – **Training of Personnel**
- Good Practice Report – **Risk management and enforcement of ageing hazardous sites**

Accident analysis

- **Lessons Learned Bulletin on chemical accidents involving power failures**
- **Reducing the risk of oxygen-related fires and explosions in hospitals treating Covid-19 patients** (Article and Lessons Learned Bulletin)

Natech

- **Thinking the unthinkable: A perspective on Natech risks and Black Swans** (Article)
- **Natech risk management in Japan after Fukushima – What have we learned?** (Article)

Upcoming paper themes

Product Stewardship - Are current product stewardship strategies capable of meeting macrolevel challenges?*

- How prepared are future customers for new uses of dangerous substances (e.g., renewable fuels) or dependence on technologies that use dangerous substances in new ways?

Lessons Learning – A never ending task - Investing in lessons learning beyond reporting chemical accident investigation findings*

- Nowadays there is an ample supply of chemical accident information within large corporations as well as in the public domain. Corporate leaders must invest in development of analytical tools and competency to exploit learnings from past accidents and guarantee the fruition of a lessons learning culture.

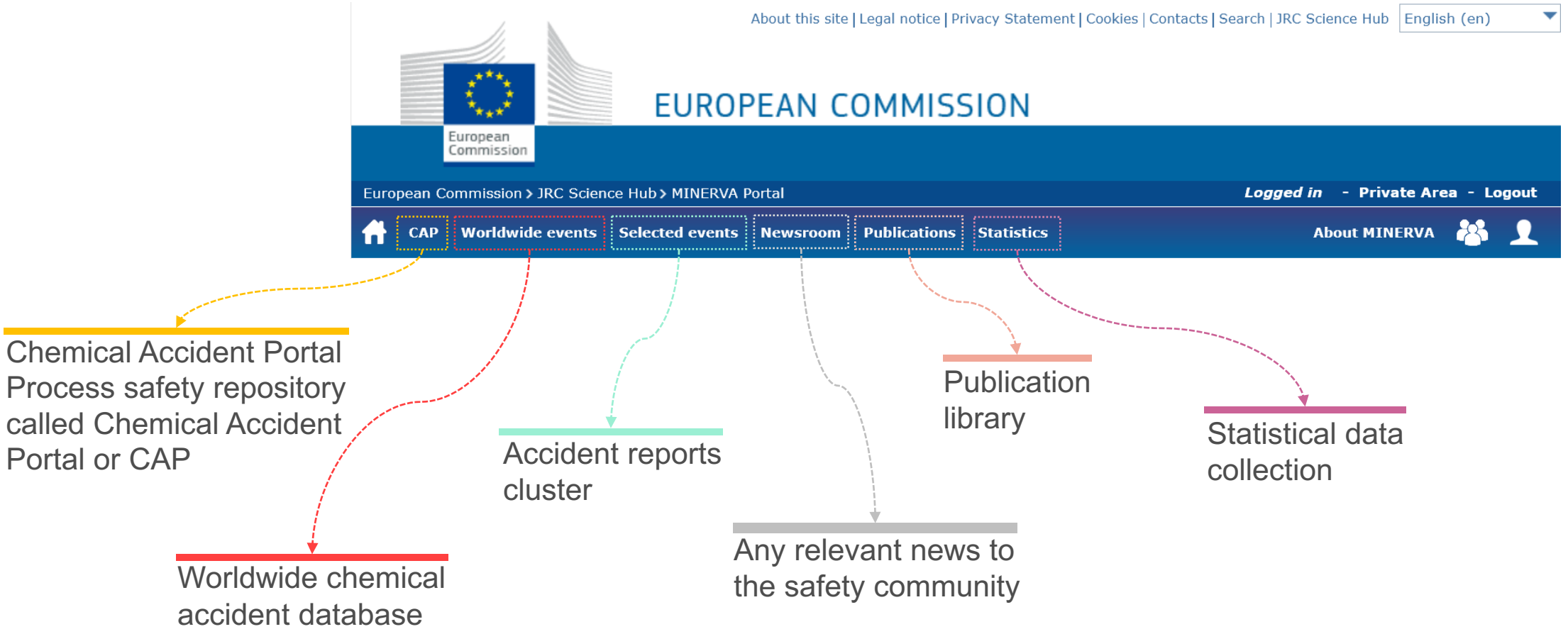
Technological risk governance – Is there a risk of "Drift into failure" when resources shift to new policies?**

- Climate change policy creates an opportunity to talk about how governments balance technological risk with other priorities.

*With Mark Hailwood and Konstantinos Koutelos

**With Mark Hailwood

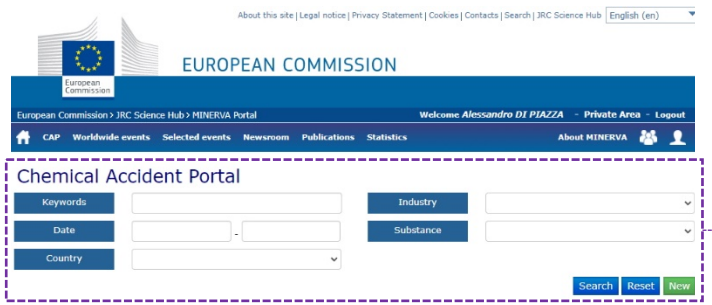
Chemical Accident Portal – a process safety repository under development by MAHB

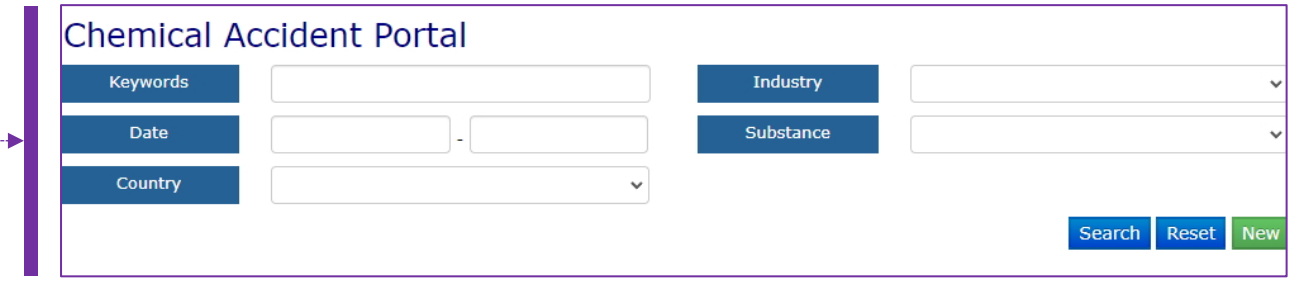


CAP is a MAHB concept still under design and development

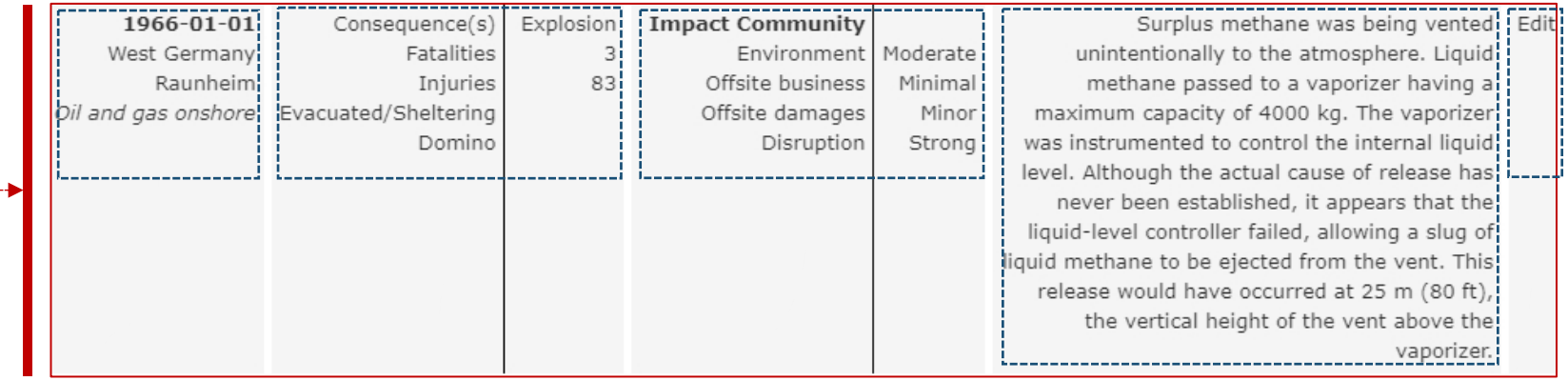
Worldwide events page – version 1 draft

Search functions of the worldwide chemical events repository





Event details



Characteristics of event

General information event

Effects / impacts of event

Brief description of event

Edit mode

European Commission

Ongoing projects and upcoming publications

- **Industrial safety measurement indices** - An Online Tool for Measuring Progress in Implementation of the EU Seveso Directive and the UNECE Industrial (collaboration with UNECE)
- **Accident Investigation and Analysis Handbook** for inspectors
- **Seveso Inspectors ("Mutual Joint Visit") workshop on Information to the Public**
- **Common Inspection Criteria on Internal Emergency Planning**
- A **lessons learned bulletin on chemical accidents in warehouses and distribution centres**
- **Chemical accident information portal**
- **Good Practice Report** – Summarising results of the JRC webinar and survey on **experiences and practices on managing chemical accident risk during the Covid-19 pandemic**.
- **Papers on product stewardship, lessons learning, and governance of technological risk**
- **JRC input to UNDRR (in collaboration with UNECE)**

Thank you

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