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Workshop Report: Developing a Methodology to Quantify the Benefits of Regulations for Chemical Accidents Prevention, Preparedness and Response

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WORKSHOP REPORT:

DEVELOPING A METHODOLOGY TO QUANTIFY THE BENEFITS OF REGULATIONS FOR CHEMICAL ACCIDENTS PREVENTION, PREPAREDNESS AND RESPONSE

IOMC
INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS
A cooperative agreement among FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD

Environment Directorate
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FOREWORD

This document presents the main conclusions from an expert workshop the Working Group on Chemical Accidents organised on the Benefits of Regulations for Chemical Accidents Prevention, Preparedness and Response in Paris on 24 - 25 October 2016. The goal of this expert workshop was to discuss the possibility to develop guidance to support government officials and other interested parties in identifying and assessing the benefits of regulations for chemical accidents prevention, preparedness and response.

WORKSHOP REPORT

DEVELOPING A METHODOLOGY TO QUANTIFY THE BENEFITS OF REGULATIONS FOR CHEMICAL ACCIDENTS PREVENTION, PREPAREDNESS AND RESPONSE

Introduction

1. The OECD Working Group on Chemical Accidents organised an expert workshop on the Benefits of Regulations for Chemical Accidents Prevention, Preparedness and Response in Paris on 24 - 25 October 2016. The expert workshop was organised as a brainstorming meeting to discuss opportunities for assessing the benefits of regulations for chemical accidents prevention, preparedness and response.
2. Government agencies are increasingly being asked to justify proposed regulations and regulations amendments (including those related to management of chemicals) through analyses of expected costs and benefits. In addition to determining whether the proposals are efficient (meaning that benefits outweigh costs), these cost/benefit analyses help to determine whether proposed regulations are well-designed to achieve their desired objectives and whether there may be more efficient ways to reach the same results.
3. Assessing the benefits of regulations can be a difficult undertaking, in particular in the area of chemical accidents prevention. Challenges include difficulties in estimating how many, and what types of, accidents would occur if the regulations did not exist. There is a lack of available standardized data on chemical accidents and on their economic and environmental costs. Since significant chemical accidents are relatively rare events, statistical analyses and extrapolation may not be reliable. Furthermore, in most cases chemical accident regulations apply to a large number and wide variety of facilities and industries. Also, there are a range of potential benefits (direct and indirect) that should be taken into account and these could accrue to numerous different stakeholders groups including: the regulated industry, employees at hazardous installations, the communities in the neighbourhoods of such installations (public health, local economy, the environment), and society at large. In addition to the difficulty in identifying all of these benefits, there is also a problem with assigning a quantitative value to many of these.
4. The goal of this expert workshop was to discuss the possibility to develop guidance to support government officials and other interested parties in identifying and assessing the benefits of regulations for chemical accidents prevention, preparedness and response.
5. The expert workshop was composed of a number of sessions aiming to discuss specifically:

- The possible benefits (direct and indirect) of regulations for chemical accidents prevention, preparedness and response, and the related costs of such regulations;
- Those benefits that could be quantified and those that would rather be described in a qualitative way;
- The challenges in quantifying the benefits (and costs) of these regulations;
- Existing experience related to measuring the benefits and costs of these regulations.

6. The expert workshop was organised around expert talks and discussions, also a background paper was developed in preparation for the workshop to provide a "snapshot" on the opportunities and challenges of measuring the benefits, and an overview of relevant experience. This report summarises the main conclusions from the expert workshop as well as the main messages from the background paper.
7. In Annex A of the report are compiled examples of experience from countries in measuring the costs and benefits of regulations and impact of chemical accidents, collected through the workshop and background paper. In Annex B are the presentations made at the workshop of the workshop results.

Identifying Possible Benefits of Regulations for Chemical Accident Prevention, Preparedness and Response

8. The primary objectives of regulations for chemical accidents prevention, preparedness and response are to prevent accidents and reduce the impacts of any accidents that do occur. This includes effective emergency planning by both the companies and communities at risk. Thus, the largest group of benefits involves avoided costs from accident(s) that did not occur because of the regulations. These include both those that that can be quantified and those that by their nature can only be measured in qualitative terms. The workshop highlighted that being able to describe and value costs and benefits, when possible, would help decision making about regulation and the development of policy. It would also help demonstrating the economic impact of accidents to governments and help industry understanding the impact of their sites.

Classes of potential beneficiaries

9. One way to start this difficult undertaking of assessing the benefits of regulations is by identifying the classes of potential beneficiaries. The workshop background paper identified the following:

- the companies where the accidents might have occurred but for regulations[1] (*e.g.*, the costs of rebuilding, loss of profits, compensation for medical costs, lawsuits, fines, increased surveillance and many other direct and indirect expenses resulting from accidents);[2]

[1] Recognising that some companies will take action to reduce their risks even without the regulations.

[2] While it can be expected that some companies will invest in improvements that will reduce their costs in the event of an accident, other companies may not undertake the necessary audits and assessments to understand the nature and extent of risks their operations pose unless required to do

- employees at hazardous installations (*e.g.*, avoidance of death and injuries, enhanced working conditions, better morale);
- individuals in the communities where hazardous installations are located, including the local population and emergency responders (*e.g.*, avoidance of death and injuries, property damage, lost income);
- the local economy (including costs to other businesses in the area and costs paid by the government for response, clean-up and restoration);
- the wider economy (including knock-on effects in the supply chain);
- the environment near the hazardous installations (recognising that accidents can cause significant harm to soil, air and water adversely impacting agriculture and fisheries, as well as flora, fauna and recreational facilities);
- the industries targeted by the regulations (*e.g.*, avoiding loss of reputation, increased scrutiny);
- the general public and society more generally (which could include, for example, avoiding increased fuel costs that would be a result of a refinery accident).

10. While the most direct and significant benefits accrue to the individual companies that avoid costs associated with accidents, and their surrounding communities, regulations can also have a number of indirect but still significant benefits for the regulated industry as a whole. For example, companies have noted unexpected improvements in efficiency (and, therefore, lower cost) operations. Improving process safety has also been shown to reduce worker accidents, as well as insurance and maintenance costs. It can also improve worker morale, resulting in lower turnover and the ability to attract better quality staff. Companies that have a safety culture will often have enhanced shareholder value and improved community relations. Companies perceived as safe will be welcomed by communities and will more easily get the support needed by officials and community leaders.[3] While enlightened companies could be expected to seek these results without regulation, for a number of companies the collateral benefits might not be sufficient to make investments without regulatory requirements.

11. From the perspective of the host countries, regulations provide a number of indirect benefits, for example, helping support compliance with international obligations and recommendations (including the OECD's Polluter Pays Principle) and helping promote a "level playing field" where companies must abide by the same rules

Categories of impacts

12. The workshop identified a number of categories of impacts that could be used as a framework to list the principal positive benefits that could be associated to regulations (direct and indirect benefits). They are the following:

- Impacts on infrastructures (*e.g.* protection of physical assets and reduction in damages);
- Impacts on health and safety of persons: immediate health consequences (fatalities, hospitalisations) versus longer terms ones. The workshop highlighted

so by regulation, or may simply conclude that accidents are sufficiently rare that they are willing to take the risk rather than incur the additional expenses.

[3] Other benefits include avoidance of indirect costs related to, for example, the damage to a sense of community and safety in the areas surrounding hazardous installations, loss of trust in government, and failure of the justice system to address losses.

existing tools for quantifying the impact of immediate health consequences (mortality risks and costs of illness), the longer terms health impact being more difficult to quantify;

- Impact on the environment: water, habitat destruction/biodiversity, wildlife, air pollution, agriculture, fisheries, forestry, heritage sites, tourism, social impact and cultural heritage. The workshop asked the question of valuation of ecological goods and the wide variation in accident impacts depending on its location.

13. Impacts could occur at various levels, including: country (economic disruption), local community (environmental damage and economic impacts), company (loss of assets and business), and individual (death and disability).

Identifying the costs of regulations

14. To put benefits into perspective, it is important to take into account costs associated with the regulations. These are generally easier to quantify and can include costs incurred by:

- Industry (including SMEs): costs associated with implementation including new technology, development of policies, hiring specialised personnel and consultants, additional training, audits, maintenance, and reporting;
- Governments: personnel, technology and other costs to implement and enforce the regulations (including local officials and response personnel);
- Employees: possible loss of jobs or increased responsibilities;
- Public: possible increased cost of products due to higher company production costs.

Benefits of Process Safety Management

15. The workshop highlighted the importance of looking at risk management programmes and process safety principles put in place by companies as a result and possibly as a complement to regulations: what are the categories of impacts that are being assessed to measure efficiency of these programmes by industry, and how those impacts/benefits are being measured?

16. The workshop background paper, for example, detailed a study published in 2006, by the Center for Chemical Process Safety (CCPS). The study focused on the benefits of process safety (defined as a management system implemented to prevent major incidents involving hazardous materials that focuses on three aspects: technology, facilities and personnel).[4] The CCPS study surveyed its member companies and reviewed data from other sources related to the implementation of process safety. The study concluded that their research "provides conclusive evidence that methodically implementing process safety provides four benefits essential to any healthy business," the first two quantitative and the second two qualitative:

- *Risk reduction*: a healthy process safety program significantly reduces the risk of catastrophic events and helps prevent the likelihood of human injury, environmental damage, and associated costs that arise from incidents. The number of less severe incidents is also reduced. In addition to the "windfall benefit" – the

[4] The Business Case for Process Safety. 2nd Edition (2006). Center for Chemical Process Safety. American Institute of Chemical Engineers. New York, N.Y.

income resulting from avoided accidents (lives saved, injuries reduced, property costs reduced) - this includes costs associated with business interruptions, loss of market share, litigation costs, incident investigation costs, and regulatory penalties. Furthermore, most companies participating in this study observed significant reductions in injury rates due to implementing high quality process safety programmes.

- *Sustained value*: process safety relates directly to enhance shareholder value. When properly implemented, it helps ensure reliable processes that can produce high quality products, on time, and at lower cost.[5] Furthermore, process safety supports quality management, environmental responsibility, industrial hygiene, worker safety and sustainable development.
- *Corporate responsibility*: displaying corporate responsibility which leads to the next benefit.[6]
- *Business flexibility*: companies that display responsibility through an effective process safety programme can achieve greater freedom and self-determination (from, for example: lower interest rates for financing; helping attract and retain high performance staff; and allowing managers to focus on sales and growth rather than accidents).

Challenges in Measuring Benefits and Costs

17. The workshop identified key challenges to valuing benefits of regulations. While it has proven to be very difficult to value benefits of environmental regulations generally, it is a particularly difficult challenge when it comes to regulations related to chemical accidents. A number of reasons were raised during the workshop and in the workshop background paper:

- One of the main issues raised during the workshop was the lack of available standardized data on chemical accidents and their economic impacts: there is a need for improving the collection of data across countries on accidents, in particular loss data, and for strengthening sharing of experience across countries. It is important to note efforts being made to collect data on chemical accidents. For example, the Major Accident Reporting System (eMars) is a comprehensive database compiling reports of chemical accidents and near misses provided to the

[5] The study identified ways companies can achieve a measurable increase in revenues and reduction in costs as a result of process management. These accrue from: productivity increases, production and maintenance cost decreases; lower capital budget and insurance premiums. For example, productivity is increased through: improved reliability and mechanical integrity of equipment; user-friendly, accurate operating procedures and safe work practices; improved team effectiveness through effective employee training programs; employee ownership of the systems to help ensure safety; enhanced troubleshooting capabilities; identifying and addressing safety, operability, and reliability issues before they occur; decreased turnaround time for minor repairs; extended intervals between major turnarounds and reduced turnaround time.

[6] Showing responsibility supports companies in a number of ways, for example: it helps fulfil companies' responsibilities to protect employees and the community; it enhances customer and supplier relationships; it helps to comply with regulations and conform to industry standards; it helps investors perceive a lower risk; it protects company reputation and shareholder value; it increases corporate image and brand; it reduces community concerns; and it engages employees by increasing morale, loyalty, and retention.

Major Accident Hazards Bureau (MAHB) of the European Commission's Joint Research Centre (JRC)[7].

The workshop highlighted the need to learn from each other experiences and progress in collecting data on the impact of accidents, across countries, also involving industry stakeholders;

- Some of the benefits associated to regulations cannot be quantified within the current state of knowledge (*e.g.* due to a lack of available and reliable data, the difficulty in building indicators of impacts for those benefits). However, as stakeholders are increasingly being aware of these challenges, the option is open for qualitative analysis to be used to describe those benefits in a more standardized manner. The workshop raised the need to use a common language across the community for developing qualitative analysis of these benefits that cannot be quantified;
- In addition to the direct costs of accidents, there are numerous indirect costs not only to the company and any people harmed by the accident, but also for the neighbouring community, the local environment, agriculture and fisheries in the area, and the industry at large. These are difficult to assess and can involve have very long-term impacts;
- There is a lack of available data for establishing causality between the non-occurrence of an accident and the implementation of a regulation. The primary objectives of regulations are to reduce the number of chemical accidents, and limit the severity of those that do occur. But it is difficult to estimate how many accidents would have occurred (and their related impacts) were it not for the regulations. Ad Hoc analyses and case studies might be able, to some extent, to help in linking accidents that did occur and the non-compliance to a regulation (or in linking how near-misses were arrested by regulatory processes or how actual accidents were prevented from getting worse by regulatory processes). However, these regulations typically comprise a number of elements (identifying risks, changes in policies and personnel, technology improvements, audits, information sharing, emergency planning) and it is difficult to discern which of these elements have an actual impact in reducing risk. It is also hard to separate out the aspects that management would have implemented even without the regulations.
- There is limited experience to date in assessing the costs of accidents and benefits of regulations for chemical accident prevention, preparedness and response (*see Annex A for a review of existing efforts to value costs of accidents and benefits of risk management policies*) and the existing analyses recognise limitations in their models and are challenged by the limited data available. Some challenges in these analyses:
  - The full impacts of accidents cannot be assessed (and thus the benefits of accidents avoided are undervalued). Some important benefits are not taken into account or are difficult if not impossible to quantify; some are not known for some period of time, or are subject to local factors that cannot be generalised in assessments.
  - There is limited information on the human impacts of acute exposure to many hazardous substances, as well as on their environmental impacts.

[7] For more information see, https://minerva.jrc.ec.europa.eu/en/emars/content/

  - In many cases, it is difficult to identify the potential for property loss and environmental damage and existing models most often do not include environmental effects;
  - Existing models have proven difficult to establish for the probability of an accident to occur and thus being able to link how this probability could be affected by regulations.
- Chemical accidents regulations tend to impact a number of different industries and sectors that use, produce and/or handle a wide range of hazardous substances. These include companies of different sizes with different types and quantities of substances. As a result, the nature of possible accidents and their associated impacts will vary greatly;
- Furthermore, these regulations may involve a variety of government agencies (*e.g.*, related to environmental protection, transportation, civil defence, health and safety) that might have different approaches to identifying and assessing benefits;
- Different communities within a country will make different judgements about costs and benefits. This could depend on the local economy, population density, the nature of the environment at risk, the types of nearby businesses, and the activities that would be impacted in the event of an accident;
- In some locations, the costs of infrastructure lost or damaged and the clean-up and compensation in the event of an accident may dwarf the monetised value of life lost. Yet for many people, a crucial part of the justification of regulations is the capacity to protect human life. In this regard, there are differences in the way countries establish values for life, human health and pain/suffering.

Even if information and knowledge is lacking to perform a full valuation of benefits of regulations, there is opportunity to strengthen collection and exchange of data and experience across countries. Using a combination of qualitative and quantitative analyses can allow for performing informative analyses within the current state of knowledge and data availability.

Conclusions from the workshop

18. Government agencies are increasingly being asked to justify proposed regulations and regulations amendments through analyses of expected costs and benefits. In addition to determining whether the proposals are efficient (meaning that benefits outweigh costs), these cost/benefit analyses help to determine whether proposed regulations are well-designed to achieve their desired objectives and whether there may be more efficient ways to reach the same results.

19. The workshop reiterated the difficulties of assessing the benefits of regulations for chemical accidents prevention, preparedness and response. Challenges include:

- The lack of available data on the occurrence of accidents and their economic costs across the range of possible impacts that should be considered;
- The difficulty in linking the non-occurrence of an event/accident with the implementation of a specific regulation;
- The identification of the range of potential benefits (direct and indirect) that should be considered;

- The challenge of identifying from these benefits, those that can be quantified and those that should rather be described in a qualitative way and how this description could be made;
- The range of possible methodologies that could be used to build indicators of impacts for each identified benefits.

20. As a first step, workshop participants highlighted the importance of listing all the main benefits that could be associated to regulations for chemical accidents prevention, preparedness and response, as a comprehensive list of this sort does not exist yet.

21. The workshop already identified categories of impacts, as below

- Impacts on infrastructures;
- Impacts on health and safety of persons: immediate health consequences (fatalities, hospitalisations) versus longer terms ones. The immediate impacts being easier to collect data on than the longer term ones;

Impact on the environment: water, habitat destruction/biodiversity, wildlife, air pollution, agriculture, fisheries, forestry, heritage sites, tourism, social impact and cultural heritage.

22. Impacts could occur at various levels, including: country (economic disruption), local community (environmental damage and economic impacts), company (loss of assets and business), and individual (death and disability).

23. Workshop participants agreed that, within the current state of knowledge and data availability, guidance could be developed that would provide a framework outline of agreed-upon quantitative and qualitative benefits. The guidance would include:

- A set of agreed-upon qualitative benefits that could be associated with these regulations. Each qualitative benefit should be described with a common messaging for supporting communication with decision makers in appreciating their value;
- A set of agreed-upon benefits that could be quantified according to current knowledge and experience. Each benefit should come with a description in general term of its impact and value as well as an indication of methodologies that might be applied to assign monetary value;
- A set of case studies illustrating how a regulation could have helped prevent an accident if applied or in place.

Annex A. COUNTRIES EXPERIENCE IN ASSESSING THE BENEFITS OF REGULATIONS FOR CHEMICAL ACCIDENT PREVENTION, PREPAREDNESS AND RESPONSE

24. There are a limited number of published reports related to assessing the benefits (and costs) of regulations for chemical accident prevention, preparedness and response. These efforts provide valuable experience but, as described below, each of these recognise the limitations of their analyses given the difficulty in quantifying, or even identifying, all the benefits of such regulations. The workshop highlighted recent experience from the UK for modelling the human and economic costs of major industrial accidents as well as a perspective from Canada for valuing chemical accident prevention. The background paper gave further examples from the United States and the United Kingdom.

United States Experience

CSB Study: The Cost-Benefit Hurdle for Safety Case Regulation.

25. In 2013, the US Chemical Safety Board (CSB) commissioned a study on *The Cost-Benefit Hurdle for Safety Case Regulation*.[8] Since 2011, US regulators have been subject to an Executive Order requiring them "to identify and use the best, most innovative and least burdensome tools for achieving regulatory ends. It must take into account benefits and costs, both quantitative and qualitative." The Executive Order recognises that each agency may consider values that are difficult or impossible to quantify, including equity, human dignity, fairness, and distributive impacts.

26. The CSB study states at the outset that for safety case regulations, quantifying the benefits - is impossibly difficult. Among the reasons given are: these regulations are designed to prevent "disasters" which are difficult to define; and it is difficult to estimate the number of disasters prevented. The fact that the numbers of disasters are rare, any projections or statistics are unreliable. Furthermore, some incidents do not rise to the definition of disaster simply because of fortuitous circumstances (*e.g.*, wind direction and the location of staff).

27. The paper goes on to discuss the European Commission's effort to introduce a safety case requirement for offshore petroleum production in 2011-2012. In support of the new regulation, the EC commissioned a detailed analysis that concluded that the benefits outweighed the costs, although not dramatically so. It was so controversial that a special expert review was commissioned. This review highlighted the difficulties involved in any attempt to carry out a cost/benefit analysis of safety case regulation. Its chair concluded: "In light of the inherent uncertainties … it is difficult … to evaluate the extent to which any analysis is or is not conservative. In essence, none of the analyses is wholly right or wrong. They reflect the effect of differing assumptions and approaches."

28. The Commission acknowledged numerous other problems in attempting to estimate the true cost of an accident and therefore restricted itself to "directly quantifiable

[8] The Cost Benefit Hurdle for Safety Case Regulation (US CSB 2013), http://www.csb.gov/assets/1/7/CBA_Hurdle_-_Hopkins.pdf

costs" – clean-up and compensation costs in the case of oil spills, and property costs in the case of infrastructure loss or damage. It noted that there were numerous technical difficulties involved in identifying even direct costs (for example, compensation paid may not reflect the full costs of all whose livelihoods have been damaged by a major accident such as an oil spill impacting fisheries and tourism in coastal communities).

29. Furthermore, the Commission recognised the failure to calculate significant indirect costs such as the effect on oil prices, the health of the oil industry, or the security of energy supply. Other important indirect impacts could include the potential loss of major corporate earnings, impacts on investments, and interruptions to other offshore sectors (wind farms, maritime transport).

30. After reviewing relevant experience, the CSB study concluded that it seems unlikely that a convincing safety case cost/benefit argument could be mounted in the United States. It goes on to point out that the requirement to justify new regulations on the basis of a cost/benefit analysis need not be an impediment to new regulations since the Executive Order recognises that there may be situations where the benefits are unquantifiable and therefore the analysis can integrate a qualitative assessment of benefits as well as reference to other values such as equity or human dignity. Finally, it notes that if one views major accidents as criminal incidents, then questions of justice need to be taken into account in ways that a cost/benefit analysis fails to do.

Experience from the US OSHA

31. In 1992, the US Occupation Safety and Health Administration (OSHA) proposed new regulations focusing on the application of management controls to prevent the occurrence, while minimising the consequences, of catastrophic accidents involving toxic substances, as well as fires and explosions.[9]

32. The agency undertook to quantify the costs and benefits of the proposal. The agency identified the benefits, which included: the prevention of accidental fatalities, injuries and illnesses; the avoidance of property damage; enhanced productivity due to fewer process disruptions and accidental shutdowns; decreased labour turnover; more efficient utilisation of space, labour and equipment; an integrated approach to process design, construction, operation, and maintenance; reduced loss of raw materials and inadvertent waste generation; and increased product quality. In the analysis, OSHA also anticipated that many minor incidents would be prevented and there would be significant improvements in chronic health and safety problems -- including low-level exposure to toxic substances.

33. Based on an estimated 40 percent reduction in the number of fatalities and injuries avoided and other benefits measured against costs related to capital expenditures by companies as well as the personnel time needed to develop programs and procedures, train employees, and carry out inspection activities, the analysis concluded that the savings would be expected to exceed direct costs for most industry groups after the first five years.[10] However, it also stated that the estimate may understate the true cost savings,

9 https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=1043&p_table=PREAMBLES

10 OSHA determined that 24,939 establishments in 127 industry subgroups would be affected by the proposal - referred to as the process safety management or PSM standard. They noted that the extent of the impact will vary by industry depending on current practice, the number of processes, and the quantities of highly hazardous materials on site. OSHA estimated current practices

noting that insurance, administrative, and societal cost savings associated with accident prevention were not included in the assessment.

34. OSHA also noted that they expect that as PSM becomes widespread throughout American industry, the productivity benefits and other cost-savings resulting from the rule could improve the competitiveness of American businesses.

Experience from the US EPA

35. In 2016, EPA proposed amendments to its Risk Management Program (RMP) regulations seeking to improve chemical process safety, assist local emergency authorities in planning for and responding to accidents, and improve public awareness of chemical hazards at regulated sources.[11]

36. As required, EPA included an analysis of potential costs and benefits. It states that EPA anticipates that the implementation of this rule would result in a reduction of the frequency and magnitude of damages from releases and "(a)lthough we are unable to quantify what specific reductions may occur as a result of these proposed revisions, we are able to present data on the total damages that currently occur at RMP facilities each year" and that some portion of future damages would be prevented by the rule.

37. The analysis identified the types and numbers of facilities likely to be impacted by the revisions, based on the existing regulations. It identified the annualised costs of implementation (related to, *e.g.*, response exercises, public meetings, personnel, audits, investigations, etc.). With respect to benefits, EPA attempted to monetise values for both on-site and off-site damages that might be avoided from chemical accidents.[12] To do this, they reviewed the total damages from accidents that occur at RMP facilities each year (based on a 10-year baseline period). The analysis also notes that information disclosure improves the efficiency of property markets and allocation of emergency resources.

38. The agency admitted that their analysis omitted many impacts of accidents including lost productivity, the costs of emergency response, transaction costs, property value impacts, and environmental impacts. Furthermore, the costs did not include the impacts of non-RMP accidents and any potential impacts of rare high consequence

consistent with the provisions of the PSM rule using OSHA survey data, survey data compiled by a major chemical engineering magazine, and data in the rulemaking record.

In the summary of regulatory impact, OSHA simply stated that it anticipated that full compliance with the PSM standard will lead to fewer catastrophic fires, explosions, releases of hazardous substances and other types of serious accidents. Using data from its Integrated Management Information System database and applying an adjustment based upon the analysis of two consultants' reports, OSHA estimated the baseline number of fatalities and injuries/illnesses linked to the PSM standard for the period 1983-90. For the eight-year period, an average of 330 fatalities and 1,918 injuries/illnesses per year were associated with major accidents involving hazardous materials Using an average risk-reduction estimate of 40 percent for Years 1-5 implementation phase, OSHA estimated that 132 fatalities and 767 catastrophic injuries/illnesses will be avoided annually through compliance with the standard.

[11] Proposed RMP Rule and 2011 Executive Order requiring cost/benefit analysis

https://www.gpo.gov/fdsys/pkg/FR-2016-03-14/pdf/2016-05191.pdf

[12] The benefits identified included avoided property damage, fatalities, mitigation of health impacts, and emergency response costs. Avoided off-site costs involved sheltering in place, medical treatment, property damage, fatalities, evacuations, and hospitalisations.

catastrophes. Finally, it did not include the benefits to the potentially affected public of improved availability of information.

39. In light of the uncertainties - for example from costs that have not been identified, the wide range of possible outcomes, and the uncertainties associated with the estimates - EPA asked for further insights from the public.

Cost–Benefit Analysis of Proposed California Oil and Gas Refinery Regulations

40. In 2010, a report was prepared by the Rand Corporation assessing the costs and benefits of proposed California Process Safety Management (PSM) and California Accidental Release Prevention regulations designed to improve safety at oil and gas refineries in California. The proposed refinery PSM standard represented a significant change, to include new management system elements, a more carefully defined hazard analysis process, and provisions to expand employee participation and employee access to information. It would also require damage mechanism reviews for each process used in refinery operations and a hierarchy-of-hazard-control analysis for a wide range of refinery operations, planning, and engineering. This regulatory approach has some similarity to the regulations in the United Kingdom and Norway.

41. The study authors were provided with a list of costs and benefits to take into account in their study. These were identified in four categories: costs to industry (to implement the regulation), costs to society (pass-through of certain industry costs), benefits to industry, and benefits to society.[13]

[13] The following list outlines most of the costs and benefits considered in this study:

- costs to industry
  - conducting analyses required in the regulatory revisions
  - correcting deferred maintenance and making repairs that the new regulatory requirements make necessary
  - implementing management and programmatic changes to improve safety
  - implementing inherently safer systems and additional safeguards in some cases
- costs to society
  - pass-through of certain industry costs, including higher price of gasoline to California consumers
- benefits to industry: costs avoided
  - major incidents (including catastrophic events and upset events)
  - civil penalties
- benefits to industry: safety improvements
  - costs avoided—value of lost refinery production and sales
- benefits to society: costs avoided
  - costs to consumers of increased gasoline prices
  - health care costs
  - emergency services
  - medical claims
- benefits to society: improvements
  - fewer refinery-worker deaths
  - changes in employment
  - uninterrupted fuel supply
  - uninterrupted employment in the oil sector.

The study noted that they could not estimate some costs because of a lack of data. These include criminal liability charges, reputation damage, infrastructure impacts, air-quality damage, and property-value damage.

42. This situation presented a simpler challenge than evaluating draft regulations related to chemical accidents generally. The California proposal applied only to one industry (refiners) and impacted only twelve facilities. Furthermore, one county in the state already had more stringent regulations which provided a basis for evaluating how the proposed regulations might impact safety.

43. With respect to benefits to industry, the Rand study sought to quantify the money that could be saved for each refinery accident avoided. With respect to benefits to society, the study noted that the largest potential benefit in quantitative terms would be the avoided cost of fuel supply disruption that would accompany incidents. Reducing the number of refinery incidents also avoids health impacts for workers and the community, as well as costs to those living near afflicted refineries relating to, for example, emergency services, health care, reductions in property values, and reductions in local tax revenues. The study recognised that the regulations would also have indirect benefits, such as improving system reliability, community relations, labor–management relations, company reputation, and public image.

44. This study was able to quantify the costs of the proposed regulations to industry by surveying experts at each refinery in the state. It also identified significant costs to society from the increased price of gasoline as industry passed its expenses to the consumers.

45. The authors note that the benefits to industry of avoiding major accidents are complex and difficult to estimate because the refiners included in the study considered relevant cost data proprietary. For example, the study could not reliably estimate all refinery equipment repairs, company reputation damage, overseas production costs for reformulated gasoline, intermediate feedstock costs, or gasoline transportation costs without access to proprietary information. In addition, they recognised that the costs associated with accidents could differ significantly from one major incident to another. Furthermore, the study recognised but did not attempt to quantify the reduction in risk of death or injury in the event of an incident, nor the impact on worker safety and avoided environmental harm.

46. To compare the costs and benefits of the regulations, the authors used a break-even analysis framework, estimating that the break-even point for effectiveness of the proposed regulations to be about 7.3 percent. That is, given the frequency and cost of recent major incidents, the regulations costs can be justified if the frequency of major incidents is reduced by around 7.3 percent.

47. They concluded that safety gains of at least that magnitude are possible. And, to the extent that the comparison does not take into account “qualitative” benefits, such as avoided injury, avoided environmental harm and peace of mind, the study recognised that the analysis included a conservative estimate of the benefits. This had the effect of lowering the required break-even point and making the regulations easier to justify.

United Kingdom Experience

Impact evaluation of the Control of Major Accident Hazards (COMAH) Regulations (1999)

48. In 2006, the UK Health and Safety Executive undertook a study to review, retroactively, the costs and benefits of chemical accident regulations.[14] The COMAH regulations are the UK's implementation of the EU Seveso Directives and therefore the analysis done by the UK might be instructive for other European countries implementing Seveso Directives or similar regulations.

49. Specifically, the purpose of the UK study was to:

- estimate the costs and benefits of the COMAH Regulations including as far as possible the societal impacts;
- compare these with the estimates made in the Regulatory Impact Assessment (RIA); and
- identify additional work that may be required to establish further the impact of COMAH.

50. It was recognised that this would be a difficult task, for a number of reasons. The Regulations are principally aimed at addressing high impact but low frequency events which are inherently difficult to measure. The requirements of COMAH were phased in over a number of years, and companies might have implemented some of COMAH's elements even without legal requirements. In addition, it is very difficult to separate out the influence of one particular initiative against a background of a changing economic and regulatory environment. Furthermore, the nature of a company's culture may make it difficult to separate out the influence of a single driver of safety improvements. Finally, given that the regulations were relatively recent, many operators had little experience on which to assess their ongoing costs.

51. The study concluded that there were considerable uncertainties associated with both the estimation of costs and benefits. However, the authors found that the costs incurred by industry exceeded what was predicted by a significant margin particularly with respect to familiarisation and analysis, preparation of safety reports, and modifications to facilities.

52. It further stated that while it is clear that there are potentially very significant benefits to be obtained from the avoidance of major hazard accidents and their consequences, the study was unable to establish whether COMAH implementation was leading to a reduction in risks, and what the magnitude of any such reduction might be.

53. On the other hand, the study recognised that failings in management systems underpin many accidents. It is exactly these types of control that COMAH is aimed at addressing. So, while it is very difficult to quantify the benefits of COMAH after such a short period of time, the qualitative findings indicate that, in many cases, COMAH has had some early successes. Formalisation of safety procedures and a greater focus on safety were mentioned by many respondents as unquantifiable benefits of the COMAH Regulations.

[14] Impact evaluation of the Control of Major Accident Hazards (COMAH) Regulations (1999), http://www.hse.gov.uk/research/rrpdf/rr343.pdf

54. The analysis of possible benefits was based on the survey returns including operators' own assessment of the likely reduction in risks and their perceptions of intermediate and more qualitative impacts.

55. The top tier establishments[15] identified a number of benefits, mainly in the following areas:

- increased management and staff knowledge of process hazards;
- improvements in monitoring, detection and protection systems;
- engineering or process modifications;
- improved understanding of the business by local authorities and emergency services; and
- improved level of formal staff training and competency.

56. Other potential benefits that could not be quantified included: any benefits due to reductions in the numbers of near misses or non-major hazard accidents; reductions in inventories; and the "societal" value of avoiding long term harm to eco-systems. Although infrequent, large incidents can have far reaching, long-term impacts on the environment.

57. The study also contained recommendations on how future studies might improve understanding of the cost and benefits of COMAH (and presumably any regulations for chemical accidents prevention, preparedness and response).

58. For example, better evaluations might be promoted in the future by incorporating in the proposal stage consideration of how the regulation is going to be monitored and evaluated. This would allow systems to be adapted to endure that appropriate data is collected.

Modelling the economic impacts of an accident at major hazard sites

59. In 2015, the UK Health and Safety Executive issued a report that documents the development, implementation and results of a model to estimate the economic costs of accidents at major hazard sites in Great Britain.[16]

60. It was noted that HSE has an interest in the economic consequences of accidents to ensure that it can provide robust regulations and that the resources given to controlling risks are proportionate to the likely impacts. The report states that a method for estimating monetary costs of major accidents is necessary to demonstrate how the resources should best be deployed. It recognises the extent of non-financial costs of accidents, such as people's pain, grief and suffering. Quantifying the impact of accidents on people's health and well-being ensures that the full economic cost is revealed.

61. The report looks at 1900 major hazard sites - onshore only, excluding nuclear sites and pipelines. The model does not include environmental costs and domino effects. The model is looking first at the hazard component (i.e. toxic, fireball, overpressure), the vulnerability component (what around the site is vulnerable - people (injury and

[15] Top tier establishments are those where the quantities of dangerous substances used or stored exceed the higher thresholds in the COMAH Regulations, and are therefore subject to additional requirements.

[16] Modelling the economic impacts of an accident at major hazard sites, UK Health and Safety Executive (2015), http://www.hse.gov.uk/research/rrpdf/rr1055.pdf

fatalities/workers and non-workers), buildings (residential, non-residential), businesses) and then estimates economic costs.

62. In this study, the costs were broken down into the following components:

- harm to people (non-financial human costs and financial costs);
- evacuation (immediate and long-term);
- building damage (residential and non-residential);
- business disruption (loss of business and relocation); and
- emergency services.

63. Given the wide variation in the nature of sites, the study aimed to gather locally specific information for each site impacted by policy changes based on estimates of the *reasonable* worst-case scenarios. Here again the importance to collect extensive data on major hazard sites and surrounding area was raised.

Experience from Canada

64. In Canada chemical accident prevention, preparedness and response at fixed facilities is regulated at the federal level under the Environmental Emergency Regulations. There are also other federal instruments such as the Hazardous Products Act and Regulations that have established standards for workplace health and safety and separate regulations for emergency planning on major inter-provincial pipelines. Various provinces also play a role in regulation of chemical accident prevention, preparedness and response. The first Environmental Emergency Regulations were introduced in 2003, in which 174 chemicals were covered. The goal of these regulations was to promote the prevention of, preparedness for, response to and recovery from environmental emergencies at fixed facilities, from the accidental release of flammable or other hazardous substances. Any firm using a listed chemical substance over identified thresholds are now required to prepare an environmental emergency plan and report that action to the government. Both costs and benefits were considered. Benefits identified included enhanced safety for Canadians and their environment, avoided negative health and environmental impacts of accidents, and heightened awareness of the importance of safety measures.

65. At the federal level, Canada performs its regulatory analysis through the Treasury Board, which has a Cabinet Directive on Regulatory Management (CDRM)[17] requiring that a Regulatory Impact Analysis Statement (RIAS) be published for each regulation. The CDRM outlines requirements for the regulatory impact analysis, regulatory management, and roles and responsibilities.

66. The first amendments to the Environmental Emergency Regulations were made in 2011 with 41 individual substances added as well as different clarifications and exclusions. A specific approach was used to value benefits. For example, it was assumed that having an environmental emergency plan in place along with required testing would reduce accidents by 60%. The EPA damage estimated was used and scaled for Canada at 11% of US. More than 70% of benefits were from reduction in mortality risk.

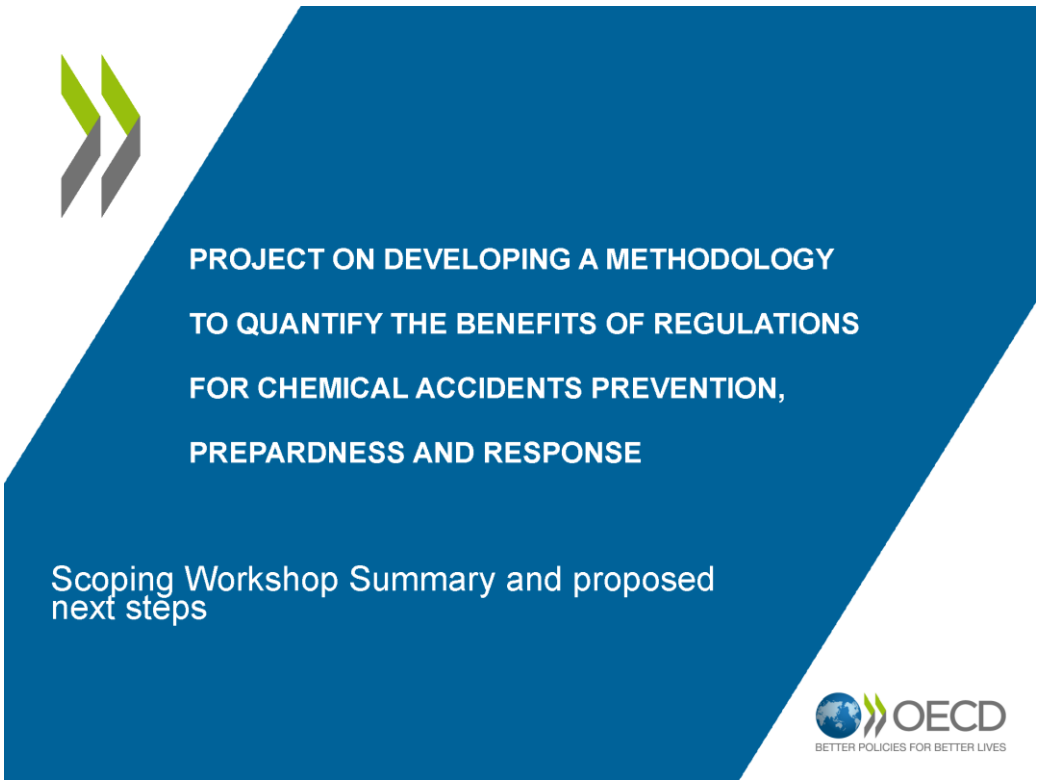
67. The most recent amendments to the regulations were proposed in 2016. These amendments include the addition of new hazardous substances, additional public

[17] https://www.canada.ca/en/treasury-board-secretariat/services/federal-regulatory-management/guidelines-tools/cabinet-directive-regulatory-management.html

notification and emergency planning requirements, additional reporting and the inclusion of uncontained substances. Costs were estimated based on an estimation of industry administrative and compliance costs. Benefits were qualitatively described.

68. Interesting elements from Canada's experience include the use of qualitative analyses of benefits when those are too difficult to quantify and its acceptance by the government. It also reiterates the need for more data on accidents and more information in general on the benefits of associated regulations.

Annex B. POWER POINT PRESENTATION OF THE WORKSHOP RESULTS



Scoping Workshop – 24/25 October

- Aim to gather information on countries' approaches to measuring the benefits of regulations for chemical accidents;
- Discuss the benefits (direct and indirect) that could be associated with those regulations,
- And, agree on a path forward for the project.

Draft Programme

National Experiences in Measuring the Benefits and Costs of Chemical Accidents Prevention, Preparedness and Response

– ***Experience from Canada***

Joe Devlin, Senior Economist , *Canada*

– ***Experience from the United Kingdom***

Kyran Donald, Health and Safety Executive, United Kingdom

OECD work on the costs of disasters and benefits of risk management policies

Role of environmental insurance after chemical accidents

Judith Golova, Environmental Risk Specialist, Marsh, United Kingdom

A Corporate Risk Management Approach to Chemical Accident Prevention

Bill Gulledge, Senior Director, American Chemistry Council

Summary of Discussions – Categories of Impacts

Benefits on infrastructures

- Key prerequisites for chemical accident regulations:
  - Design, construction, operation (as prevention);
  - Identification of safety critical components;
  - Process safety management;
  - Corporate knowledge of systems;
  - Adaptive feedback loops for operation and maintenance;
  - Land-use planning (complementary consideration; within other authorities);
  - Planning for 'normal' and reasonable worst-case scenarios based on pillars of prevention, preparedness, response, recovery; reporting of near-misses and chemical accidents; polluter pays (as a principle);
  - Enforceable regulations and an inspection regime; identification of facility sites; Other?

Summary of Discussions

- *Framework for potential benefits**
  - Set of qualitative benefits –
    - loss of company reputation; loss of industry sector reputation; loss of government regulator reputation; litigation impacts; loss of community reputation; loss of country reputation
  - agree on how these would be described to decision makers
  - Set of quantitative benefits – what exists; what are the gaps for countries; which countries could fill the gaps
    - Loss of assets; loss of production; loss of market; market disruption; knock-on in the supply chain;
  - What motivates the business – very corporate governance base – each company would define what their top priority would be; different sectors, different perceptions

*Refer to background paper for lists of benefits

Summary of Discussions

Health impacts categories:

- Immediate health consequences versus longer term ones;
- Immediate impacts easier to collect data on (i.e. fatalities, hospitalisations) than longer term ones.

Summary of Discussions

Environmental Impacts Categories:

- Water (ground water and surface water),
- Habitat destruction/biodiversity,
- Wildlife,
- Air pollution,
- Agriculture, fisheries, forestry,
- Heritage sites,
- Tourism.
- Social impact, cultural heritage.

Potential Next Steps

- Case studies – look at 6 or 7 sectors; Trace the failures (e.g. Weak regulation? Company issues? Could that happen here? Were there compliance and/or safety management failures?)
  - Use this as example of how the regulations would have helped, had they complied.
  - If we didn't have the regulations, there could be more of these types of accidents.
- Webinars– Further detail some quantitative benefits and who can share info?
- Partnerships
  - US Chemical Safety Board; CEFIC; ACC
  - Insurance sector

Potential Next Steps

End product – OECD Brochure publication documenting **framework outline of agreed-upon quantitative and qualitative benefits** to include and **common messaging for qualitative components**:

- common-language for communication with decision makers on both the impacts that can be quantified and those that would rather be analysed in a qualitative way;
- Including case studies that will test the framework.