European Agency for Safety and Health at Work

Substitution of dangerous substances at workplaces

A training course for OSH practitioners

Participants´ manual – 2021 update

European Agency for Safety and Health at Work

Authors:

Isabella Banduch (Kooperationsstelle Hamburg IFE)

This training is based on a concept developed by Dolores Romano (2011): Alternatives Assessment and Training Guidance. SUBSPORT Substitution Support Portal - Moving towards safer alternatives

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Lothar Lieck (EU-OSHA)

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1. Introduction 

1.1 Goals

The overall goal of this training is to provide participants with basic concepts and tools to support the substitution of hazardous substances at work places.

Substitution of many substances of concern can be easier by getting inspired by the examples of others. There are many uses of hazardous chemicals that can be avoided by copying measures that others have already done. Once started or when dealing with more complex substitution cases, a more systematic approach may be needed.

The training seeks to help participants to get started in substitution processes, to understand the different stakeholders involved and their interests, which substances are of most concern, to find how and where to look for new ideas and alternatives and to get introduced to existing tools to assess alternatives.

1.2 Guidance structure and training planning

The trainer will decide which issues to cover taking into account the background and interests of the participants and/or the available time for conducting the training. The trainer will decide to arrange the **different training time frames: half a day, one day, two days and three days.**

The following modules are proposed for **one-day training.** The following agenda and time schedule is recommended:

- Introduction to the session (20 min)
- Substitution in the regulation (30 min)
- The substitution process (60 min)
- Identification of hazardous chemical agents at work (30 min)
- How and where to identify alternatives (60 min)
- Alternatives assessment (110 min)
- Cost assessment (40 min)

To carry out all activities at least 6 hours are needed.

Internet connections and a laptop should be available for the lecturer and for each group of participants (see chapter 1.4. Training method)

1.3 Guidance sections

The training guidance is divided in:

Activities: describing the goal and tasks to be carried out in each activity. In some cases, several options are possible in choosing activities. The trainer will decide on the activities to carry out considering the interests and background of the participants.

Complementary materials: to help participants carry out the activities included as annexes.

1.4 Training method

The training method is based on the Small Group Activity Method (see text box 1) which is focused on activities. Participants are divided in small groups to perform different tasks. The results are shared with the other participants in plenary sessions conducted by the trainer. The aim is to learn by doing and by sharing knowledge and experience with the other participants.

Taking in account possible time constraints or participants background, the trainer might decide to include some short oral presentations during the training.

Text box 1: The Small Group Activity Method

The Small Group Activity Method is based on activities. An activity can take from 30 minutes to an hour. Each activity has a common basic structure:

- Small Group Tasks
- Report-Back
- Summary

1. Small Group Tasks: The workshop always operates with people working in groups at tables. (round tables are preferable). Each activity has a task or set of tasks for the groups to work on. The idea is to work together, not to compete. Very often there is no one right answer. The tasks require that the groups use their experience to tackle problems and make judgments on key issues. Tasks often include looking at factsheets and reading short handouts.

2. Report-Back: For each task, the group selects a scribe whose job it is to take notes on the small group discussion and report back to the workshop as a whole. During the report-back, the scribe informs the entire workshop on how his or her group tackled the particular problem. The trainer records these reports on large pads of paper in front of the workshop so that all can refer to it. After the scribe's report, the workshop is opened up to general discussion about the problem at hand.

3. Summary: Before the discussion drifts too far and wide, the trainer needs to bring it all together during the summary. Here, the trainer highlights the key points and brings up any problems and points that may have been overlooked in the report-back. Good summaries tend to be short and to the point.

Adapted from: Worker and Environmentalist Green Chemistry Awareness Training Curriculum. The New England Consortium - University of Massachusetts Lowell (here)

2. Substitution in legislation 

2.1 Introduction

How to use the legislation section

- To get an overview of the presented legislation, go to the **legislation description** (see below the text boxes 2.1 - 2.6).
- To see the original document, go to **Link to the legal text** on the multilanguage site**,** for versions in all EU national languages or language versions specified on the original website.
- To see definitions of the used terms, go to the ***Glossary (chapter 8)***.

When using the legislation section, please note that:

- This section presents summaries of legislation that are meant for information only. The summaries have no legal value.
- The summaries are focused on provisions regarding substitution of hazardous substances. Therefore, information is not presented according to its general importance but to the relevance for the topic. To complete information please use the original documents.
- The selection of legislation is representative for the EU but should not be considered comprehensive, other laws may still have some relevance to substitution.
- Terms are used as defined in each legislation item. For a precise terminology definition, please check the original document.
- In this guidance only the term substitution is used (see definition in the **Glossary**) but other synonym words or equivalent expressions may be used by different legislative items.

2.2 Goals

The purpose of this activity is to help participants to:

- get an overview of the legal substitution approaches in the European Union, identify legislation that is relevant to substitution,
- have easy access to the original legislation text and to other related documents by providing links to them,
- decide if they have to comply with the described legislation,
- focus on direct information on substitution by presenting in detail those paragraphs containing such information,
- notice the relevance to substitution of the legal text.

2.3 Tasks

This section contains resumes of legislation that are relevant to substitution, whether they refer to it directly or are closely related. Links to the original documents are also provided.

Task1: In small groups (20 min)

Presentation: the OSH legislation on dangerous substances

There is a comprehensive legislative framework in the European Union to protect workers from the risks of dangerous substances in workplaces. The most relevant pieces of legislation at the EU level are the OSH Framework Directive, the Chemical Agents Directive and the Carcinogens and Mutagens Directive. These directives and their transposition into national law aim to reduce the exposure of workers to dangerous substances in workplaces.

Read text 2.1. OSH Framework Directive [*page 8*], text 2.2. Chemical Agents Directive *[page 9]* and Text 2.3. Carcinogens and Mutagens Directive *[page 9ff]* and discuss an assessment of relevance for substitution for each directive. Agree on one opinion and write it down as a group.

Text 2.1: OSH Framework Directive

Title

COUNCIL DIRECTIVE of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work (89/391/EEC) – OSH Framework Directive

Issued by / date / date of implementation

European Council / 12 June 1989 / 31 December 1992

Type of legislation

EU Directive

General purpose

The Framework Directive defines basic prerequisites for OSH in companies. This includes the delegation of responsible persons by the management/owner; the assignment of safety and health delegates or representatives, including their OSH education and training; the installing of the legally prescribed participatory and consultative processes on OSH, including committees if required; instructing and training workers; and performing mandatory risk assessments. Very basic technical OSH preconditions are regulated in the Directive on minimum requirements for workplace safety and health, e.g. building safety, fire safety, work spaces, temperature and ventilation (Directive 1989/654/EEC of 30 November 1989 concerning the minimum safety and health requirements for the workplace).

Substitution relevant paragraphs

Article 6

General obligations on employers

Paragraph 6-2: implementation of measures for prevention -> §6-2-(f):
„replacing the dangerous by the non-dangerous or the less dangerous"

Link to legal text

- Multilanguage site can be found here

Text 2.2: Chemical Agents Directive

Title

Protection of the health and safety of workers from the risks related to chemical agents at work

Council Directive 98/24/EC of 7 April 1998

Issued by / date / date of implementation

EU Council / 7 April 1998 / Not later than May 5 2001

Type of legislation

Directive, to be implemented by all EU Member States according to the subsidiary principle by their means. Individual directive in the frame of the OSH Framework Directive 89/391.

General purpose

Establishing 'minimum requirements for the protection of workers from risks to their safety and health arising, or likely to arise, from the effects of chemical agents that are present at the workplace or as a result of any work activity involving chemical agents.'

Substitution relevant paragraphs

Article 6

Specific protection and prevention measures

1. The employer shall ensure that the risk from a hazardous chemical agent to the safety and health of workers at work is eliminated or reduced to a minimum.

2. In applying paragraph 1, substitution shall by preference be undertaken, whereby the employer shall avoid the use of a hazardous chemical agent by replacing it with a chemical agent or process which, under its condition of use, is not hazardous or less hazardous to workers' safety and health, as the case may be.

Where the nature of the activity does not permit risk to be eliminated by substitution, the employer shall ensure that the risk is reduced to a minimum by application of protection and prevention measures, consistent with the assessment of the risk. Determination and assessment of risk of hazardous chemical agents should be made as presented in Article 4.

Link to the legal text

- Multilanguage site can be found here

Text 2.3: Carcinogens and Mutagens Directive

Title

Protection of workers from the risk related to exposure to carcinogens or mutagens at work Directive 2017/2398/EG (amending Directive 2004/37/EC from 2004)

Issued by / date / date of implementation

EUROPEAN PARLIAMENT AND EU COUNCIL / 12 December 2017/ 17 January 2020

Type of legislation

European Union Directive, to be implemented by all Member States by transposition of the legislation and enforcement with their means

General purpose

The aim of this Directive is to protect workers against risks arising from exposure to carcinogens and mutagens at work.

Specific obligations for the employer as well as other measures referring to health monitoring, record keeping and exposure limits are provided. In 2017 the Directive from 2004 was updated, there are now more substances covered by the Directive. Prevention measures according to this directive are stricter than under the Chemical Agents directive, e.g. there is a stricter requirement for substitution. More substances were added in further amendments in 2019 and 2020.

Substitution relevant paragraphs

Article 4.1.

"The employer shall reduce the use of carcinogens or mutagen at the place of work, in particular by replacing it, in so far as is technically possible, by a substance, preparation or process which, under its condition for use, is not dangerous or is less dangerous to worker's health or safety".

Link to the legal text (English and all EU-languages)

- Multilingual website: Directive 2004/37/EC
  Multilingual website: Directive 2017/2398/EG

Other Directives

There are some specific OSH directives that regulate, for example, workplace exposure to asbestos[1] or exposure limits for specific substances[2]. Other directives aim to protect specific groups, e.g. breastfeeding or pregnant workers[3], from certain substances.

Further details on the EU legislation can be found on the EU-OSHA website (https://osha.europa.eu/en/safety-and-health-legislation/european-directives) or on the EUR-Lex website (http://eur-lex.europa.eu/homepage.html).

Task2: Large group (10 min)

Each small group shares their opinion on the relevance of directives for the substitution of hazardous chemicals.

[1] **Directive 2009/148/EC (on exposure to asbestos at work)** of 30 November 2009 on the protection of workers from the risks related to exposure to asbestos at work (here)

[2] **Various directives on binding and indicative occupational exposure limit values,** available at https://osha.europa.eu/en/legislation/directives/exposure-to-chemical-agents-and-chemical-safety/

[3] **Directive 92/85/EEC (the Breastfeeding and Pregnant Workers Directive)** of 19 October 1992 on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding (here)

Task3: In small groups(20 min)

Presentation: Regulations on chemicals

There is also EU legislation on chemicals and related information requirements that contribute to safety and health in the workplace, including the CLP Regulation (on the classification, labelling and packaging of substances and mixtures). Furthermore, under the REACH regulation (REACH = Registration, Evaluation, Authorisation and Restriction of Chemicals), comprehensive information on chemical substances on the European market is available. Moreover, according to this legislation, substances and mixtures can be used only for defined purposes, and many substances are restricted in their use or completely prohibited.

Read text 2.4. REACH Regulation [*page 11 ff*], text 2.5. CLP Regulation [*page 14*] and Text 2.6. Biocides Directive [*page 15*] and discuss an assessment of relevance for substitution for each act. Agree on one opinion and write it down as a group.

Text 2.4: REACH Regulation

Title

Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006

Issued by / date / date of implementation

EU / December 2006 / July 2009

Type of legislation

European Union Regulation. A "regulation" is a binding legislative act. It must be applied in its entirety across the EU.

General purpose

REACH is the Regulation for Registration, Evaluation, Authorisation and Restriction of Chemicals. It entered into force on 1st June 2007 to streamline and improve the former legislative framework on chemicals of the European Union (EU). REACH places greater responsibility on industry to manage the risks that chemicals may pose to the health and the environment.

Registration: REACH requires manufacturers and importers of chemical substances (larger than or equal to 1 tonne/year) to obtain information on the physicochemical, health and environmental properties of their substances and use it to determine how these substances can be used safely. Each manufacturer and importer must submit a registration dossier documenting the data and assessments to the European Chemicals Agency (ECHA).

Authorisation: Authorisation will be required for the prioritised substances of very high concern (SVHC) that are included in Annex XIV.

Companies applying for authorisation will have to demonstrate that risks associated with uses of these substances are adequately controlled or that the socio-economic benefits from their use outweigh the risks.

Applicants will also have to investigate the possibility of **substituting these substances with safer alternatives or technologies, and prepare substitution plans**, if appropriate.

Restrictions: The European Union can impose restrictions and prohibit or set conditions for the manufacture, placing on the market or use of certain dangerous substances or group of substances when unacceptable risks to humans or the environment have been identified.

Substitution relevant paragraphs

Article 55

Aim of authorisation and considerations for substitution

The aim of Title VII Authorisation is to ensure the good functioning of the internal market while assuring that the risks from substances of very high concern are properly controlled and that these substances are progressively replaced by suitable alternative substances or technologies where these are economically and technically viable. To this end all manufacturers, importers and downstream users applying for authorisations shall analyse the availability of alternatives and consider their risks, and the technical and economic feasibility of substitution.

Article 60

Granting of authorisations

4. If an authorisation cannot be granted under paragraph 2 (referring to evidence that the risks are properly controlled), an authorisation may only be granted if it is shown that socio-economic benefits outweigh the risk to human health or the environment arising from the use of the substance and if there are no suitable alternative substances or technologies. This decision shall be taken after consideration of all of the following elements and taking into account the opinions of the Committee for Risk Assessment and the Committee for Socio-economic Analysis

(a) the risk posed by the uses of the substance, including the appropriateness and effectiveness of the risk management measures proposed;

(b) the socio-economic benefits arising from its use and the socio-economic implications of a refusal to authorise as demonstrated by the applicant or other interested parties;

(c) the analysis of the alternatives submitted by the applicant under Article 62(4)(e) (see below) or any substitution plan submitted by the applicant under Article 62(4)(f), and any third party contributions submitted under Article 64(2) (containing information on alternative substances or technologies);

(d) available information on the risks to human health or the environment of any alternative substances or technologies.

5. When assessing whether suitable alternative substances or technologies are available, all relevant aspects shall be taken into account by the Commission, including:

(a) whether the transfer to alternatives would result in reduced overall risks to human health and the environment, taking into account the appropriateness and effectiveness of risk management measures;

(b) the technical and economic feasibility of alternatives for the applicant.

Article 61

Review of authorisations

1. A holder of an authorisation granted in accordance with Article 60 shall submit an update of the analysis of alternatives referred to in Article 62(4)(e), including information about any relevant research and development activities by the applicant, if appropriate, and any substitution plan submitted under Article 62(4)(f) . If the update of the analysis of alternatives shows that there is a suitable alternative available taking into account the elements in Article 60(5), he shall submit a substitution plan, including a timetable for proposed actions by the applicant. If the holder cannot demonstrate that the risk is adequately controlled, he shall also submit an update of the socio-economic analysis contained in the original application.

2. Authorisations may be reviewed at any time if:

(a) the circumstances of the original authorisation have changed so as to affect the risk to human health or the environment, or the socio-economic impact; or (b) new information on possible substitutes becomes available.

3. In its review decision the Commission may, if circumstances have changed and taking into account the principle of proportionality, amend or withdraw the authorisation, if under the changed circumstances it would not have been granted or if suitable alternatives in accordance with Article 60(5) become available. In the latter case the Commission shall require the holder of the authorisation to present a substitution plan if he has not already done so as part of his application or update.

Article 62

Applications for authorisations

4. An application for authorisation shall include the following information:

(e) an analysis of the alternatives considering their risks and the technical and economic feasibility of substitution and including, if appropriate information about any relevant research and development activities by the applicant;

(f) where the analysis referred to in point (e) shows that suitable alternatives are available, taking into account the elements in Article 60(5), a substitution plan including a timetable for proposed actions by the applicant.

Annex XVII

Restrictions on the manufacture, placing on the market and use of certain dangerous substances, preparations and articles.

A substance that is restricted in Annex XVII must not in general be manufactured, placed on the market or used. There may be exemptions for substance used for scientific research and development.

Link to the legal text

- Multilanguage site and latest version can be found here
- EU-OSHA overview: here

Text 2.5: CLP Regulation

Title

Classification, Labelling and Packaging of Substances and Mixtures (CLP Regulation)

Regulation (EC) No 1272/2008 of the European Parliament and of the Council

Issued by / date / date of implementation

EC / 16 December 2008 /Titles II, III and IV applies for substances from 1 December 2010, for mixtures from 1 June 2015.

Type of legislation

Binding regulation directly applicable in all Member States

General purpose

Substitution relevant paragraphs

No paragraph in the Regulation refers directly to substitution but its classification is the background for substance evaluations

Link to the legal text

- Multilanguage site can be found here

Text 2.6: Biocides Regulation

Title

Biocidal Products Regulation (BPD) – Regulation 528/2012

Issued by / date / date of implementation

EU / May 2012 / Sept 2013

Type of legislation

Regulation to be applied by all EU Member States

General purpose

The Regulation has two major aims:

- Free movement of biocidal products within the Union
- Ensuring a high level of protection of both human and animal health and the environment. to harmonise the European market for biocidal products and active substances

Substitution relevant paragraphs (original text)

Article 23 (3)

The receiving competent authority or, in the case of a decision on an application for a Union authorisation, the Commission shall prohibit or restrict the making available on the market or the use of a biocidal product containing an active substance that is a candidate for substitution where the comparative assessment in accordance with Annex VI ('comparative assessment') demonstrates that both of the following criteria are met:

- for the uses specified in the application, another authorized biocidal product or a non-chemical control or prevention method already exists which presents a significantly lower overall risk for human health, animal health and the environment, is sufficiently effective and presents no other significant economic or practical disadvantages;

- the chemical diversity of the active substances is adequate to minimise the occurrence of resistance in the target harmful organism.

Link to the legal text

Multilanguage site can be found here

Task4: Large group (10 min) 

Each small group shares their opinion on the relevance of these directives and regulations for the substitution of hazardous chemicals.

3. The substitution process

3.1 Introduction

The purpose of this activity is to introduce participants to different approaches to substitution. Several definitions of substitution will be analysed in order to identify shortcomings and reach a common definition to be used in the training. Different reasons (including the attitude of various stakeholders) that motivate or hamper companies or organisations to search for safer alternatives will be reviewed and discussed. Several frameworks for the substitution process will be discussed in order to identify the steps of most interest to participants and their main training needs. This activity will also be an opportunity for participants to introduce themselves and present their own experiences and interests on substitution.

3.2 Goals

- Establish a common definition of substitution that will be used during the training
- Get an overview of the substitution process
- Understand the variety of stakeholders that can influence a substitution process
- Identify main interests and drivers of participants towards substitution
- Identify participants' main training needs on the assessment of alternatives
- Understand participants' experience and interests in substitution

3.3 Tasks

Task1: In small groups(30 min)

Read text 3.1. Read the four definitions *[page 17]* and discuss the shortcomings of the different definitions of substitution. Choose the best option or establish your own definition.

Read text 3.2. Why do we want to substitute? [*page 18*] and discuss your organisation's main drivers for substitution. Who do you believe are the most important stakeholders in a substitution process?

In text 3.3. The substitution process [page 20] a systematic approach including seven steps is presented.

Agree on one opinion and write the results down as a group.

Task 2: Large group (30 min)

Each group shares their chosen definition of substitution, their main drivers for substitution and most important stakeholders in a substitution process.

Text 3.1 Definitions

A requirement for any discussion on substitution and its key factors is a broadly accepted understanding of what substitution is. The term "substitution" is used in legal documents but is hardly ever precisely defined in practical and policy terms. Some examples of definitions by various stakeholders illustrate the differences:

Substitution is *"...the replacement of one substance by another with the aim of achieving a lower level of risk."*

European Chemical Industry Association (CEFIC) [4]

"The Principle of Substitution states that hazardous chemicals should be systematically substituted by less hazardous alternatives or preferably alternatives for which no hazards can be identified."

Greenpeace [5]

1. *The employer shall ensure that the risk from a hazardous chemical agent to the safety and health of workers at work is eliminated or reduced to a minimum.*

2. *In applying paragraph 1, substitution shall by preference be undertaken, whereby the employer shall avoid the use of a hazardous chemical agent by replacing it with a chemical agent or process which, under its condition of use, is not hazardous or less hazardous to workers' safety and health, as the case may be.*

EU COUNCIL DIRECTIVE 98/24/EC of 7 of April 1998.[6]

"Substitution means the replacement or reduction of hazardous substances in products and processes by less hazardous or non-hazardous substances, or by achieving an equivalent functionality via technological or organisational measures."

Lohse / Lissner (2003) [7]

[4] CEFIC. Paper on Substitution and Authorisation under REACH, May 2005, Summary, http://www.cefic.be

[5] Greenpeace. *Safer Chemicals within Reach - Using the Substitution Principle to drive Green Chemistry*. Amsterdam: 2005, Greenpeace International.

[6] Council Directive 98/24/EC of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)". Official Journal of the European Communities L 131 (1998): 11-23.9.

[7] Lohse, J., Lissner, L., Substitution of hazardous chemicals in products and processes, Report compiled for the Directorate General Environment, 2003, (p94) http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.306.5104&rep=rep1&type=pdf

Text 3.2 Why we want to substitute

1/2 DAYS | 1 DAY | 2 DAYS | 3 DAYS

Although legislation enforcement is recognized by companies as the main driver, other factors contribute as well to substitution such as: suppliers' knowledge, management commitment, supply chain requirements, workers and environment protection costs, public pressure or workers' pressure, among others.

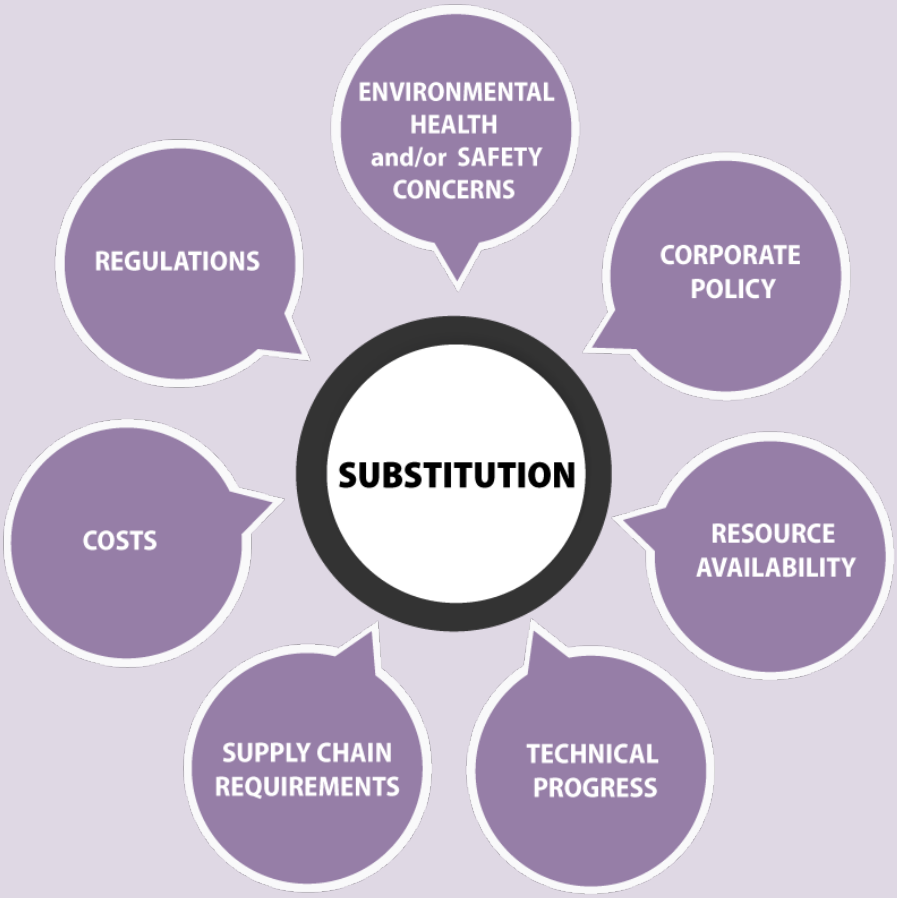


Figure 1. Substitution drivers

For small and medium-size companies/enterprises (SMEs) with very limited knowledge and information about chemicals, supplier assistance is an important factor. However, in general only specialized suppliers (e.g. of hair dyes or disinfectants) have the necessary knowledge to provide their customers with safer products and very often only producers have this knowledge. This substitution process led by suppliers is a common model in supplier-client arrangements where users have poor or no information on chemicals.

Substitution led by major users of chemicals can be found in many multinational corporations, e.g. in electronics, manufacturing and consumer products industry. Large players (large in respect to their sector's specific market power) develop substitution programmes and policies and compel their suppliers to ban or reduce certain hazardous chemicals.

Large companies that cooperate with other companies (including SMEs) and with the public sector on a regular basis (e.g. construction companies) have developed strategic approaches to avoid hazardous substances. The reasons for this are, on one hand the protection of workers, and on the other avoiding additional costs for extensive health and safety and environmental protection.

Large companies also tend to avoid incidents or critics that might affect their public reputation.

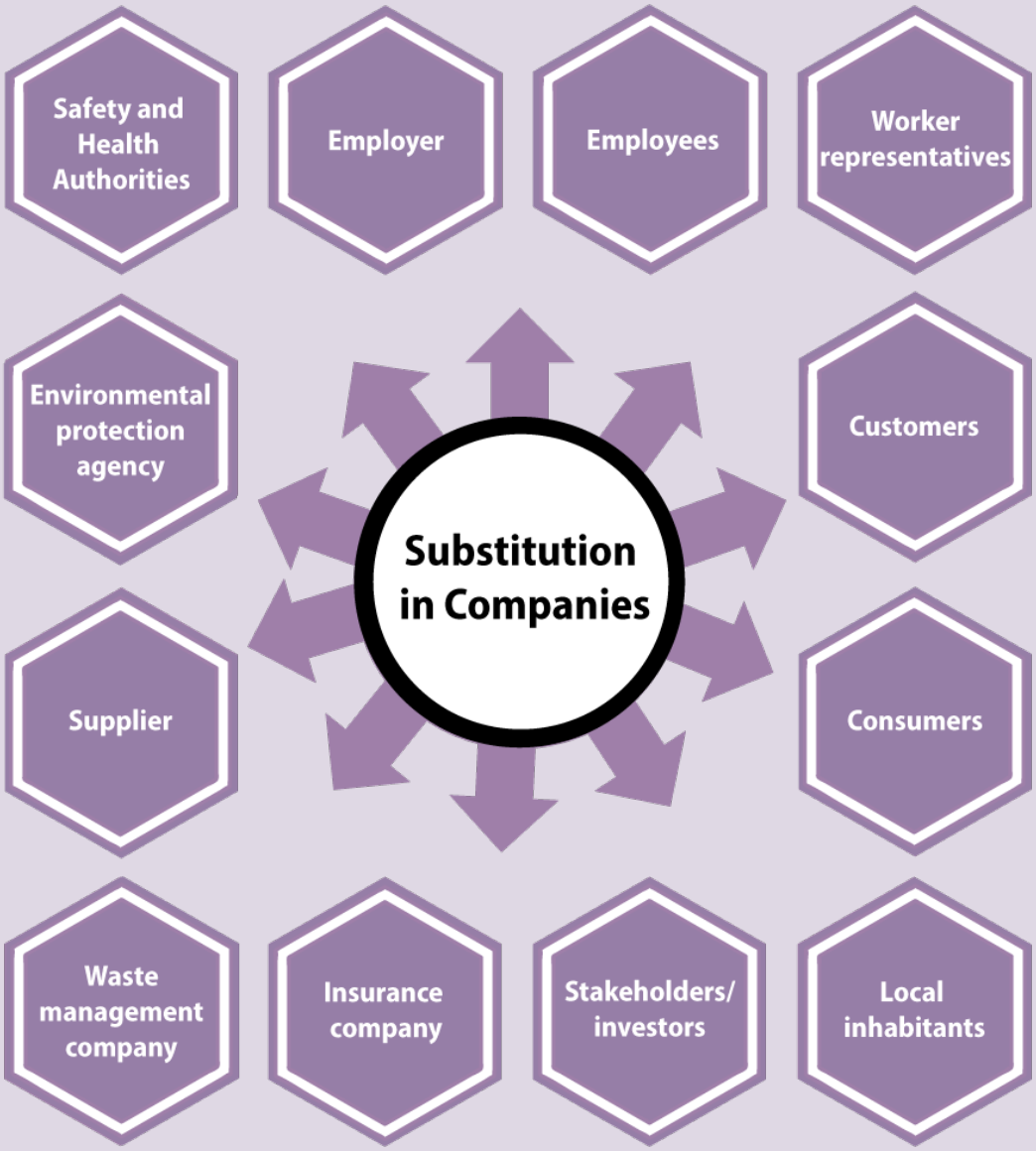


Figure 2. Stakeholders involved in substitution in a company (adapted from SWECO, earlier Grontmij S/A)

Companies producing consumer goods seem to be highly vulnerable to critics and have introduced strict rules to ban or reduce hazardous chemicals, for example in sportswear and shoes, furniture and clothes.

Another example is when several companies act together to find solutions for a specific substitution. The Safer Choice - US Design for the Environment programme hosts “partnerships” to find alternatives for specific uses, involving manufacturing companies, users and consumers or environmental organisations. The University of Massachusetts Lowell has broad experience in ‘Alternative Assessment’ and publishes substitution case studies. The pressure of safety representatives and trade unions has also forced companies to substitute hazardous substances that cause occupational health problems. Several examples can be found in companies that used asbestos or other carcinogens.

In addition, with the progress of REACH Regulation more information on hazardous effects of chemicals will be publicly available, and therefore it might become an important driver for future substitution processes.

Text 3.3 The substitution process 

Substitution may be carried out by looking to other companies' experiences for finding alternatives to hazardous substances. The SUBSPORT Plus Case Story Database or the OECD Case Studies Database for example present substitution case stories that may provide solutions or inspiration.

Afterwards or in more complex cases, you would need to implement substitution in a more systematic approach that generally includes the following steps:

Step 1. Organize a work group

Define all relevant stakeholders and their interests. Remember internal stakeholders like: workers, purchasing department, development department. Establish a work group – be sure to include workers they have practical knowledge, experience, network and ideas. Make a work plan including what and when to discuss with different stakeholders, resources for the work, who is responsible for the different actions, time limits, competence, economy, etc.

Step 2. Define the problem

Identify what you need to substitute and why! Prioritize substitution considering applicable legislation, policies of your company and interests of other relevant stakeholders (customers, public etc).

Describe both hazards and useful properties of each candidate to substitution, as regards the application considered. Ask your suppliers and/or use reliable sources to check hazards. Describe the function of the substance and analyse the production process. It is important to have a broad view of the function of the substance, so you may find not only alternative substances, but also alternative processes or even organisational changes that might avoid the need to use chemicals at all:

- What is the chemical/product used for?
- How does it work?
- What tasks is it used in?
- Why is it done that way?
- What are the risks it implies?
- Can tasks be performed differently? If so, what would happen?
- What do I use this product for? How does the product work?
- Can I use another product? If so, what would happen?
- Could we use other tools or technologies? If so, what would happen?

Step 3. Set substitution criteria

Set preliminary criteria to eliminate alternatives that are not safer or not safe enough. When establishing criteria check what substances are on a priority list or 'black list' of legal bodies or companies, or see which of the hazards you have identified were used by others in defining substances of concern.

Preliminary criteria will help eliminate unsuitable alternatives at an early stage and thus avoid useless efforts when searching independently or when asking for help.

Step 4. Search for alternatives

Search on internet, ask authorities, professional associations, NGOs and trade unions. Look for alternatives already elaborated and implemented, this may lower the innovation costs and risks. You may also ask your supplier to formulate a safer alternative.

Step 5. Assess and compare alternatives

This phase includes presenting all the alternatives found, comparing and assessing their usefulness, applicability and safety. The following aspects must be assessed:

1. **Environmental and health and safety impact:**
   This is an important first step since the driver of substitution is to get rid of hazardous substances, it is a key issue to assure that the alternative is actually safer for health and environment.
2. **Technical viability:**
   Assessing the functionality of alternatives to grant that they equal or excel the products they substitute. This includes research, and detailed technical examination by users and market analysis.
3. **Economic viability:**
   It must include a cost assessment and a cost/benefit analysis. Alternatives can sometimes be rejected when they imply a higher purchase cost, but it is necessary to include all costs and benefits associated with the product.
4. **Social impact:**
   It involves the impact of an alternative product on other workers, human rights, society, etc. The most used system is based on the assessment of corporate responsibility through the Global Reporting Initiative (GRI).

Step 6. Experiment on pilot

First try substitution on a smaller, pilot scale. Plan the technological and organisational changes needed. Pre-evaluate risks with an appropriate methodology. Assess substitution as regards functional performance, impact on workers, environment or consumers. Pay special attention to possible shift of risks and the necessary control measures. Consult with the employees.

Step 7. Implement and evaluate

Think what other measures would be needed when implementing substitution at full capacity. Re-examine the risk assessment and the health, safety and environmental protection measures. Update your supply chain and inform your downstream users. Collect extended feedback from workers and clients. Identify points to improve. Make known your achievements.

4. Identification of Hazardous Chemicals at Work

4.1 Introduction

The purpose of this activity is to introduce participants to the different criteria for defining substances of high concern that should be subject to substitution. Generally, the first criterion used by companies for prioritizing substances to be substituted is compliance with legislation. However, many companies and other organisations go beyond legislation.

4.2 Goals

- Introduce participants to the different criteria and definitions for substances of high concern.
- Provide participants with tools to establish their own criteria to define substances of high concern.
- Promote the exchange of experience on substances of concern subject to substitution among participants

4.3 Tasks

Task 1: In small groups (20 min)

To define your priority substances for substitution according to their intrinsic hazardous properties you can use different screening criteria for substances of concern (see Text box2). **The Screening criteria for substances of very high concern (SVHC) according to REACH Regulation Article 57** are placed in Text box 3 of this chapter.

Text box 2: Different lists and criteria for substances of concern

ChemSec: The ChemSec SIN List is an NGO driven project intended to identify Substances of Very High Concern (SVHC) based on REACH criteria. The aim is to push the legislative process and provide a tool that business and other actors can use to substitute hazardous chemicals with safer alternatives – ahead of legislation. SIN List

ETUI: Information about carcinogens and reprotoxins provided by the European Trade Union Institute (ETUI) Carcinogens and Reprotoxins

OECD: Substitution and Alternatives Assessment Toolbox - Regulations and Restrictions: http://www.oecdsaatoolbox.org/Home/Regulations

PHAROS: Provides 50 international 'Hazard Lists' (free access for one user after registration): Hazard lists

REACH: A dedicated webpage on Annex XVII of REACH. It includes all the restrictions adopted in the framework of REACH and the previous legislation, Directive 76/769/EEC. Substances restricted under REACH

SUBSPORTPlus: This database contains 35 lists of substances that are legally or voluntarily restricted or are recommended for restriction due to their hazards. Restricted and Priority Substances Database.

Sector or product related

Automobile industry: The IMDS (International Material Data System) is the automobile industry's material data system. Initially, it was a joint development of car producers. Further manufacturers have joined the community and IMDS has become a global standard used by almost all the global OEMs. IMDS

Disinfectants: The WIDES Database supports the safer choice of disinfectants. It contains information on the established effects of commercially available disinfectants and their ingredients as well as the properties of these products that are of relevance for occupational safety and environmental protection. City of Vienna Database for Disinfectants

Textile industry: ZDHC: MRSL

The Manufacturing Restricted Substances List (MRSL) is compiled by the Zero Discharge of Hazardous Chemicals Programme (ZDHC), representing a group of major apparel and footwear brands and retailers. It applies to chemical substances subject to a usage ban that are used in facilities processing textile materials and trim parts.

Text box 3: Screening criteria for substances of very high concern (SVHC) according to REACH Regulation Article 57

a) Carcinogenic category 1 or 2 in accordance with Directive 67/548/EEC;
b) Mutagenic category 1 or 2 in accordance with Directive 67/548/EEC;
c) Toxic for reproduction category 1 or 2 in accordance with Directive 67/548/EEC;
d) Substances which are persistent, bioaccumulative and toxic in accordance with the criteria set out in Annex XIII of this Regulation;
e) Substances which are very persistent and very bioaccumulative in accordance with the criteria set out in Annex XIII of this Regulation;
f) Substances – such as those having endocrine disrupting properties or those having persistent, bioaccumulative and toxic properties or very persistent and very bioaccumulative properties, which do not fulfil the criteria of points (d) or (e) – for which there is scientific evidence of probable serious effects to human health or the environment which give rise to an equivalent level of concern to those of other substances listed in points (a) to (e) and which are identified on a case-by-case basis in accordance with the procedure set out in Article 59.

Go to: source

Different criteria and their definitions that are most used by different sources to identify substances of concern can be found on SUBSPORTPlus. Other providers provide similar list screening offers, e.g. Pharos (free access for one user, https://pharosproject.net)

Use the screening criteria to decide which of the ingredients presented in table 1 below, used as disinfectants in cleaning products, would you prioritize for substitution taking in account their hazardous properties (H phrases from CLP).

Check which of the ingredients presented in table 1 below are included in one or more “black” lists. The type of organisation compiling a list and the number of lists that include a substance can help you to prioritize substances for substitution.

Discuss the results! Agree on one opinion and write it down as a group!

Table 1. Ingredients used as disinfectants in cleaning products

Substance	CAS	Hazard Statements – H-phrases
acetic acid	64-19-7	H226: Flammable liquid and vapour H314: Causes severe skin burns and eye damage
formaldehyde	50-00-0	H301+H311+H331: Toxic if swallowed, in contact with skin or if inhaled. H314: Causes severe skin burns and eye damage. H317: May cause an allergic skin reaction. H335: May cause respiratory irritation. H341: Suspected of causing genetic defects. H350: May cause cancer. H370: Causes damage to organs.
ethanol	64-17-5	H225: Highly flammable liquid and vapour. H319: Causes serious eye irritation.
sodium hypochlorite	7681-52-9	H290: May be corrosive to metals. H314: Causes severe skin burns and eye damage. H335: May cause respiratory irritation. H410: Very toxic to aquatic life with long lasting effects.

5. How and Where to Identify Alternatives

5.1 Introduction

The purpose of this activity is to introduce participants to different methods to identify alternatives. The first step is to define well the role of the chemical that will be substituted. The concepts of **use**, **function** and **need** will be discussed using three examples. Sources of information to help identifying alternatives will be presented and preliminary alternatives for three examples will be identified using SUBSPORT Plus Case Story Database or OECD Case Studies Database and ECHA Real life cases and EU OSHA Practical tools and guidance and other websites and databases.

5.2 Goal

The goal is to provide guidance on methods for identifying potentially feasible and safer alternatives to the chemicals of concern.

5.3 Tasks

Task 1: In small groups (15 min)

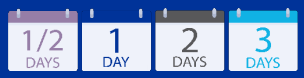
Read the text 5.1. Define use, function and need [page 27].

Discuss the use, function and need of the following chemicals and think about possible alternatives:

- **Phthalates** (e.g. BPA (CAS 80-05-7)) in toys for children
- **Trichloroethylene** (CAS 79-01-6) for degreasing of metal parts
- **Brominated flame retardants** (e.g. DecaBDE (CAS 1163-19-5)) in TV enclosures

Agree on one opinion and write the results down as a group.

Task 2: In small groups (25 min)



Search several database like the SUBSPORT Plus Case Stories, the OECD Case Studies Database, the Toxics Use Reduction Institute of Massachusetts websites, the ECHA reals life cases and other substitution websites and databases to look for possible alternatives to the above mentioned chemicals and discuss what you found. In addition, use also the “normal” browser search. Write the results down as a group.

You will find **search tips** provided in **textbox 4 and text 5.2 and 5.3** [*page 26/27*].

Text box 4: Useful sources of solutions and best practices

ANSES - *Substitution of CMR-Substances* (in French): https://www.substitution-cmr.fr/index.php?id=112

ChemSec - *Market place*: https://marketplace.chemsec.org/

EU OSHA - *e-tool Dangerous Substances* *(in English plus 8 languages):* https://eguides.osha.europa.eu/dangerous-substances/

EU OSHA - Practical tools and guidance Dangerous substances (1.000 resources): https://osha.europa.eu/en/themes/dangerous-substances/practical-tools-dangerous-substances

ISTAS - *Alternativas* (in Spanish): http://www.istas.net/web/index.asp?idpagina=3468

KEMI – *PRIO:* https://www.kemi.se/prioguiden/english/start

OECD *Substitution and Alternatives Assessment Toolbox* : http://www.oecdsaatoolbox.org/Home/CaseStudies

PHAROS / Green Screen (Available Green Screen assessments (free or priced): https://pharosproject.net/assessments

SUBSPORT Plus: https://www.subsportplus.eu/subsportplus/EN/Cases/Case-story-database/case-story-database_node.html

Swedish Centre for Chemical Substitution: https://www.ri.se/en/what-we-do/projects/support-centre-increased-substitution-hazardous-chemicals

TURI (Toxics Use Reduction Institute of Massachusetts): various sectors: https://www.uml.edu/research/lowell-center/, https://www.turi.org/ and hospitals: http://www.sustainablehospitals.org/

Université de Montreal - *SOLUB* (in French): http://irsst.qc.ca/solub/

US EPA - *Safer Choice*: https://www.epa.gov/saferchoice

Task 3: Large group (20 min)

Each small group shares how they defined function, use and need and the possible alternatives they have identified.

Text 5.1: Define use, function and need

In order to identify alternatives to a specific hazardous substance it is necessary to understand why this substance is being used and to know the specific function of the chemical in the process or in the product. For example, is it intended to dissolve materials (i.e. solvent), to preserve the product from microbiological degradation (i.e. biocide), to avoid oxidation during storage (antioxidant), to provide a scent (i.e. fragrance) etc.? We will also need to know the specific requirements for that use, like temperature, pH, and influence of other reagents etc. that are part of the application.

It is important to have a wider view and understand what the chemical was used for. If we have a broad view of the role of the substance we may find not only alternative substances, but also alternative processes or even organisational changes that might avoid the need to use chemicals at all. For example, the use of a degreaser satisfies the need to keep a surface clean from grease or oil. Perhaps we may find an organisational change that demands cleaner surfaces only for some applications - and therefore avoids degreasing. Quality norms may also be checked as many times the use of hazardous chemicals may be avoided if a lower quality is sufficient, for example when cleaning or painting.

Function refers to the intrinsic property of the substance that is technologically important to the specified **use** and to satisfy the specified **need**.

Use refers to the application of the function in a process/product.

Need refers to the ultimate benefit for the user. Needs may be reflected by norms (e.g. quality or safety norms) or may be inspired by customer/users' preferences or by the efforts to overcome competition. Needs, as defined here, may be stringent and compulsory (fire safety) or optional (bright finishing, fragrance).

These aspects may influence how we identify alternatives, as well as the type of alternative and the relation with the stakeholders that are most concerned/affected by the change.

Text 5.2: Tips for searching alternatives in databases

Look for:

- **substitution of** …… (name of the chemical to be substituted)
- **alternative to** …… (name of the chemical to be substituted)
- (name of the chemical to be substituted) …… **free** …… (name of the product, e.g. cleaner)
- Safe(r), green, healthy, ecological …… (name of the product e.g. cleaner)

Include in the search:

- **chemical name + use** of the substance: e.g. trichloroethylene degreaser
- specify as much as possible: **sector**, **process**, **product**, **function, task, occupation**
- look also for **synonyms and identification numbers** (CAS, EC etc.) of the chemicals

Text 5.3: Where can we find alternatives?

Several sources of information may help us to find alternatives:

Inside company knowledge: our own company may have the knowledge to find alternatives once we have identified the function of the hazardous substance in our product or process. Several departments may provide information: environmental, health and safety, quality or purchases.

Workers who carry out the tasks with chemical agents and know well their function may have proposals for alternatives.

Suppliers: in many cases suppliers can provide a less hazardous product. In particular if they understand that they may lose a client.

Databases: several databases compile cases stories and technical information on alternatives. The SUBSPORT or OECD Case Story Database provides a compilation of such examples/information. A search engine to access other databases can also be found on SUBSPORT.

Industry publications and websites provide information about what is currently being used in the market and may help identify companies that are using alternatives. Some company sites offer to collaborate for tailored solutions.

Scientific literature may provide information on chemicals that are being researched for the specific use or for similar uses that meet the same or similar requirements.

Technological institutes, clean production centres, e.g. the Swedish 'Support centre for increased substitution of hazardous chemicals'

Associations of interested partners: e.g. The Swedish National Substitution Group for Hospitals and Universities, EPA partnerships, etc.

Occupational, health and safety (OSH) consultants

Trade Unions and environmental NGOs working on pollution prevention or chemical risks publish materials on alternatives.

Internet search: in some cases a direct internet search may provide information on possible substitutes. Green chemistry websites, green chemistry awards, lists of certificated "responsible" products etc.

6. Assessment of Alternatives

6.1 Introduction

The purpose of this activity is to introduce participants to different methods to assess and compare alternatives. First, participants will be introduced to criteria to accept or to reject alternatives established by different organisations. Several alternatives assessment methods will be introduced to participants who will learn how to use two of them: Column Model and Green Screen. Pros and cons of these two methods will be discussed.

6.2 Goal

The purpose of this activity is to provide an overview on methods for the assessment of alternatives.

6.3 Tasks

Task 1: In small groups (80 min)

Read texts:

6.1. Define criteria [*page 29*]

6.2. Assess and compare alternatives [*page 31*]

6.3. The Column Model [*page 31*]

6.4. Green Screen for Safer Chemicals [*page 32*]

Assess and compare the alternatives of the **examples** in text 6.5. [*page 33/34*] using the Column Model and the Green Screen Method that are included as ***Annexes***.

Task 2: Large group (20 min)

Each small group shares the results of their assessment.

Text 6.1: Define criteria

In the same way we established criteria to identify chemicals of high level of concern, the next step is to determine which alternatives are not acceptable in any case or are preferable. Later during the assessment of alternatives, the hazardous properties of the chemical to be substituted will be compared to the properties of the alternatives we have identified and sifted according to our acceptance criteria.

SUBSPORT Plus has compiled criteria for the selection of alternatives used by different organisations and assessment methods (e.g. OECD, SUBSPORT Plus). The SUBSPORTPlus Restricted and Priority Substances Database, which includes lists published by different regulations, governments and organisations, can also be a reference for the sifting of initial alternatives.

Screening criteria for substances of very high concern (SVHC) according to **REACH Regulation Article 57 are presented in chapter 4.3** (p 11).

The following text box presents – as on example - criteria for the substitution of Persistent Organic Pollutants (POPs).

Other useful criteria for substances of concern can be found in Text box 2 [*page 22/23*].

Text box 5: Criteria for the substitution of Persistent Organic Pollutants (POPs)

According to the Spanish National Implementation Plan the following criteria had to be met in POPs substitution processes:

- Availability of information: information on the substance chosen as alternative must be sufficient to eliminate the possibility of unacceptable risks to human health and the environment considering the intended use of the substance.
- Avoid POPs precursors.
- Whenever feasible, choose mechanical or physical procedures instead of using of hazardous chemicals: many tasks related to cleaning, stripping, degreasing, cutting, welding, etc. have good mechanical and physical alternatives (scrapping, abrasion, blasting, etc.).
- Avoid substances and products with similar characteristics to POPs according to criteria of Annex D of the Stockholm Convention: persistence, bioaccumulation, long distance dispersion in the environment and adverse effects.
- Avoid carcinogens, mutagens, endocrine disruptors, reprotoxicants, neurotoxicants, sensitizers and similar chemicals and compounds of high concern.
- Choose simple and compatible products over complex mixtures and compounds if there is no information available about the effects of components on human health and the environment considering the intended use.

Text 6.2: Assess and compare alternatives

The assessment of alternative chemicals includes the analysis of their effects on human health and the environment, their effectiveness, economic viability and social impact.

Several methods [8]have been developed to carry out such evaluations but, in our view, they must be implemented when the substance has been identified, its hazard profile has been established and safer alternatives for humans and the environment have been sifted.

Alternatives assessment methods can be divided into two categories [9]:

- **Methods that compare data on hazards**: those that examine hazardous properties of chemicals to be compared in a matrix. Users must set their own rules to contrast the different alternatives. Several methods include hazard data and risk indexes for the comparison of chemicals.
  Methods in this category are:
  - **Column Model** (here)
  - **Pollution Prevention Options Analysis System (P2OASys)**

- **Sifting methods** are used to analyse chemicals based on previously prioritized hazards. They include recommendations to stop using chemicals of high level of concern. They also provide tools for decision making on alternatives.
  Methods in this category include:
  - **Green Screen** (here)
  - **PRIO** (here)

Many other useful methods for alternative assessment can be:found in the **OECD Substitution and Alternatives Assessment Toolbox** (here)

The strongest limitation for all assessment and comparing tools is the lack of data on certain hazards for many chemicals.

Alternatives assessment should be an interactive process, as the outcome of the assessment carried out actually may vary with new data on chemicals' properties.

Text 6.3: The Column Model

Elaborated by the "Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung" (IFA, Institute for Occupational Safety and Health of the German Social Accident Insurance) to provide industry with a practical tool for identification of alternative substances.

This is a simplified method to make a preliminary comparison between the risks of the different substances and products and offer a quick judgment on the convenience of substitution.

The model is based on 6 columns in which the following hazard categories are described:

- Acute health hazards
- Chronic health hazards
- Fire and explosion hazards
- Environmental hazards
- Exposure Potential
- Process hazards

[8] Rossi M, Tickner J, Geiser K. Alternatives Assessment Framework. Lowell Center for Sustainable Production, University of Massachusetts Lowell, 2006

[9] Edwards S, Rossi M, Civil P. Alternatives Assessment for Toxic Use Reduction: A survey of methods and tools. The Massachusetts Toxic Use Reduction Institute, University of Lowell, 2005.

Columns are divided into cells/boxes that contain the criteria to estimate the level of risk based on hazard phrases (H phrases), physical form of the substance, evaporation temperature, German classification of hazards for the aquatic environment and type of process (open, manual, etc.). Cells/boxes correspond to risk levels, ranked from Negligible to Very high. For detailed explanation see the column model documentation in the *Complementary material for participants*, here column 5 and 6 “Hazards from release behaviour (Exposure potential)” and “Process-related hazards”.

The hazards for the aquatic environment are based on the classification in the German Water Hazard class regulation (WGK) which contains a list of substances hazardous to water. A database on substance and mixtures (in English) is accessible here. Beside a no-hazard level (previously 0) three hazard levels exist:

- WGK 1: Low hazard to waters
- WGK 2: Hazard to waters
- WGK 3: Severe hazard to waters

Users can compare risk levels of the substance in use and the alternatives by placing/ assigning both agents in their respective boxes in the table. The necessary information to use this model can be obtained from Safety Data Sheets, and information on the process in which the given chemical is used.

Products and substances are compared by columns, i.e. by type of hazard. The acute health hazards and chronic health hazards must be evaluated jointly: products are only assessed for similar hazards. Conditions of product use must be considered. According to the hazard levels identified by this tool, the preferred substitute will be the one with the lowest hazard level.

However, an alternative will hardly have the lowest level in all the hazard endpoints, so users must set their own criteria to decide which alternative is preferable. Users must decide which potential hazards are more relevant for the workplace where the product is used taking into consideration the company’s possibilities to control or manage the different hazards. For instance, if an alternative substance has a lower level of toxicity than the product in use, but the environmental hazards are higher, the user must decide whether use conditions in the company allow an adequate control of environmental hazards or not, in order to choose that alternative.

The Columns Model includes criteria for the evaluation of hazards in case of lack of information on toxicity. The method advises against the use of substitutes for which there is no information about skin, toxic, mutagenic or sensitizing effects.

The Column Model can be found in the Complementary materials for participants, p 2 - 10.

Text 6.4: Green Screen for Safer Chemicals 

The Green Screen for Safer Chemicals, developed by the US-Based NGO Clean Production Action (CPA), is a hazard-based screening method that is designed to inform decision-makers in businesses, governments and individuals concerned with the risks posed by chemicals and to advance the development of green chemistry. The Green Screen defines four benchmarks on the path to safer chemicals, with each benchmark defining a progressively safer chemical:

- Benchmark 1: Avoid. Chemicals of high concern.
- Benchmark 2: Use but search for safer substitutes.
- Benchmark 3: Use but still opportunity for improvement.
- Benchmark 4: Safe chemical.

Each benchmark includes a set of hazard criteria - including persistence, bioaccumulation, ecotoxicity, carcinogenicity and reproductive toxicity - that a chemical, along with its known and predicted breakdown products and metabolites, must pass.

Green Screen assesses chemicals on the basis of intrinsic hazards determined by their potential to cause acute or chronic human and environmental effects and on certain physical and chemical characteristics of interest for human health.

For a chemical to improve from benchmark 1 to benchmark 2, it must pass all the criteria of benchmark 1. And so on for going from 2 to 3 and from 3 to 4 all specific criteria must be met. Criteria become progressively more challenging in terms of human and environmental safety. Criteria in benchmark 4 represent the safest chemicals. Alternative chemicals are compared according to the benchmark they belong to.

An excerpt from the Green Screen for Safer Chemicals can be found in the ***Complementary material for participants***.

Text 6.5: Examples

Example A

A company searching for alternatives to their **metal parts degreaser (trichloroethylene)** has identified the following alternatives:

- Alternative products: DBE **dibasic esters**
- Alternative process: **Dry ice blasting**

Assess and compare the different alternatives using the Column Model. Discuss the results. Agree on one opinion and write it down as a group using the Column Model exercise table.

Complementary materials may be found in the Annexes:

- The Column Model,
- Material safety data sheets (MSDS [10]) of the products (Trichloroethylene, DBE dibasic esters, Carbon dioxide), and
- Description of the dry ice blasting process
- Column Model exercise table

Example B

A company using **formaldehyde** to elaborate adhesives for the manufacture of furniture has identified **two possible alternatives**:

- **Furfuryl alcohol**
- **Methyl methacrylate**

Compare formaldehyde and its possible alternatives using the Green Screen model and if time allows, use also the column model and the SDS. Compare and discuss the results of the two methods. Agree on one opinion and write it down as a group using the Column Model and the Green Screen exercise table.

These docs can be found in the *Complementary material for participants.* :

- Green Screen
- The Column Model
- MSDS of the chemicals (Formaldehyde, Furfuryl alcohol, Methyl meth acrylate) and
- Data on their hazardous properties
- Column Model exercise table
- GreenScreen® exercise table

[10] The term *Safety data sheets (SDS)* will be also used

Example C

Your company using hazardous substance XX for the manufacture of product YY has identified one or more possible alternatives.

Compare the hazardous substance XX and its possible alternatives using the Column Model and Green Screen. Compare and discuss the results of the two methods. Write the results down using the Column Model and the Green Screen exercise table.

Complementary materials may be found in the *Annexes*:

- The Column Model (p2 – p10)
- Green Screen (p11 – p31)
- Column Model exercise table (p97 – p98)
- GreenScreen exercise table (p99 – p100)

Text box 6: Additional information on hazardous properties of ingredients

- **ECHA** provides information on hazardous properties, classification and labelling, and safe use of chemicals): https://echa.europa.eu/information-on-chemicals
- **GESTIS** Substance Database (Information system on hazardous substances of the German Social Accident Insurance): https://gestis-database.dguv.de/
- **HazMap** (Database on the health effects of exposure to chemical and biological agents used in industry, on the job and at home (USA): https://haz-map.com/
- **RISCTOX** (Database of hazardous substances developed to provide clear, organized and concise information about health and environmental risks caused by chemicals contained in products generally used or handled by companies): http://risctox.istas.net/en/
  TOXNET (HSDB, integrated database system of hazardous chemicals, toxic releases and environmental health (USA)): https://pubchem.ncbi.nlm.nih.gov//

7. Cost Assessment 

7.1 Introduction

Companies and other organisations may reject the substitution of dangerous substances arguing that the price of the safer alternative is much higher than the product/chemical in use. However, not always an in-depth cost assessment including product price, operation, maintenance and repair costs and regulatory compliance, disposal and other liabilities are considered.

7.2 Goal

The goal is to understand the need to have a wide perspective when taking in account costs of alternatives.

7.3 Tasks

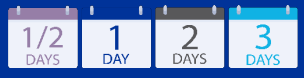
Task 1: Individually (5 min) 

Read the text 7.1. Brake cleaning with hot water washer [*page 36*].

Task 2: In small groups (15 min) 

Make a table comparing the costs of the product in use and the alternative and discuss the result. Discuss if there are other costs that have not been considered in this example.

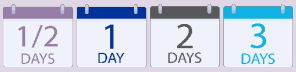
The German 'TRGS 600 – Substitution' [11] shows several criteria when taking in account costs of alternatives.

Task 3: Large groups (20 min) 

Each small group shares the result of their cost assessment.

[11] The cost categories were basically taken from the English version of the German Technical Rule for Hazardous Substances TRGS Nr 600 'Substitution' , p23

Text 7.1: Brake cleaning with hot water washer[12]



The thoroughly cleaning of car brakes is very important as the dirt can impair the functioning of brakes. In an average service station around 1500 brakes are cleaned per year. Of course the cost figures are only approximations and depend highly on local, regional and national factors.

A small and medium-sized (SME) car repair station substituted a typical brake cleaner (highly volatile hydrocarbons in spray cans) with a cleaning system using heated tap water. The heated tap water (90°C) applied by low pressure spraying is used to clean car brakes for repair and maintenance purposes from mud, dust and sand. The reasons for the change to cleaning with the hot water washer were safety and health concerns (fire and explosion risk, skin contact and inhalation of dangerous substances) and environmental concerns (emissions of VOC into the air). The investment costs for the hot water washer were 3,000 €. With regular maintenance (200 € / year) the equipment can be used for approximately 10 years.

Chemically, a typical recipe for the highly volatile hydrocarbons spray includes: 50%-80% special short chain hydrocarbons plus 20 - 40% Propan-2-ol. Some manufacturers use besides special fuel and alcohol up to 20% acetone. Around 0,125 litres spray are needed to clean one brake, which cost 1,50 € (i.e. one can for a car with four brakes), and cleaning takes around 2,5 min per brake. The sprayed cleaner dissolves the surface dirt, picks it up and flushes it away. The brake dust remains in the collection bin or on the ground. It is disposed of with a brush or by compressed air. The emission rate of the solvent is (apart from incomplete evacuation) about 100%. Employees suffer from inhalation exposure to hydrocarbon vapours and aerosols and skin contact with degreasing solvents.

In the alternative process the high-temperature water ensures the cleaning effect on deposits of accumulated oil, brake baked dust and at the same time a rapid drying of the brake. The brake dirt is bound by water and the washed dirt goes into a collecting tank where it settles and then is disposed of as sludge. According to garage technicians the small volumes of waste are disposed of with other wastes. The cleaning water is recirculated. Operating costs for water (3 litres/break) and power are estimated to 0,20 € per brake for water, and 0,20 € for energy. An advantage of the hot water washer compared to the conventional spray cans is the short cleaning time of 60 seconds per brake. Labour costs are calculated with 20 € per hour.

Cost category	Hydrocarbons (VOC)	Hot-water washer
Costs (1) **1500 break cleaning processes p.a.**	**Hydrocarbons (VOC)**	**Hot-water washer**
1. Input material costs Auxiliary materials and consumables		
2. Storage costs		
3.Transport costs, e.g. costs for packaging, freight tariffs, etc.		
4. **Disposal costs** e.g. recycling, waste, waste water		
5. Energy costs		
6. Insurance costs etc.		
Costs (1), annually		

[12] This case study has is based on information from repair stations, a manufacturer of hot water washers and a report (no. 297 44 906/2) for the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (German).

Costs (2)		
7. Research and development costs		
8. Investment costs Maintenance		
9. Personnel costs Direct costs		
10. Risk management costs Additional instructions and measures against fire risks / hot water risks		
11. Costs for occupational health care		
12. Costs of legal/certification requirements e.g. lists		
13. Additional costs to guarantee technical performance		
Costs (2), annually		
Total Cost		

Influencing factors	Hydrocarbons (VOC)	Hot-water washer
14. Public perception corporate image		
15. Employees satisfaction, motivation		
16. Advantageous product labelling		
17. Life cycle assessment		
18. Specific Case related factors		
Final evaluation	**Hydrocarbons (VOC)**	**Hot-water washer**
Alternative solution not suitable		
Substitution initiated		
Check until		
Free text		

Task 2: In small groups (15 min)

Fill the table!

Can you think of any other (hidden) costs?

Ideas and thoughts why hot-water washers are still a niche application?

8. Glossary

A

Article = Defined in article 3(3) of the REACH regulation: “An object which during production is given a special shape, surface or design, which determines its function to a greater degree than does its chemical composition.”
Examples of articles are toys or a mobile phones, a battery or a printer cartridge is regarded as borderline case, i.e. “combinations of an article functioning as a container or a carrier materia) and a substance/mixture”. (more here)**.**

B

Bioaccumulative = A property causing the substances to build up (accumulate) in the body. Such substances build up in fat tissue in the body and can not be excreted by the body.

C

CAD

see: Chemical Agents Directive

Carcinogen = A carcinogenic substance causes cancer.

Carcinogens and Mutagens Directive = Directive 2004/37/EC (the Carcinogens and Mutagens Directive, CMD) of 29 April 2004 on the protection of workers from the risks related to exposure to carcinogens or mutagens at work, plus the update by Directive 2017/2398/EG

CAS number = Chemical Abstracts Services registration number. A unique number assigned to each substances submitted to CAS. Used world wide to positively identify chemicals.

Chemical = A chemical is another word for substance or compound. Identified by a unique CAS or EC number.

Chemical agent = This term is used in the basic OSH-legislation: *“'Chemical agent` means any chemical element or compound, on its own or admixed, as it occurs in the natural state or as produced, used or released, including release as waste, by any work activity, whether or not produced intentionally and whether or not placed on the market;"*

Chemical Agents Directive = Directive 98/24/EC (the Chemical Agents Directive, CAD) of 7 April 1998 on the protection of the health and safety of workers from the risks related to chemical agents at work (fourteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC).

Chemical article = *An object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition.* Typical examples are tyres, plastic furniture, electronic devices, textiles based on chemical fibres, cables

Classification, labelling and packaging plus the abbr. **CLP** = Regulation (EC) No 1272/2008 (CLP Regulation) of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.

CMR = The abbreviation for Carcinogenic, Mutagenic and toxic to Reproduction, chemicals with inherent properties which can cause cancer, alter DNA and damage reproductive systems. Part of the REACH Substances of Very High Concern.

Commission (if not specified otherwise) = **European Commission** is the executive body of the European Union responsible for proposing legislation, implementing decisions, upholding the Union's treaties and the general running of the Union. The Commission is divided into departments known as Directorates-General (DGs) e.g. DG Environment.

C&L Inventory = This database contains classification and labelling information on notified and registered substances received from manufacturers and importers. It also includes the list of harmonised classifications.

D

Dangerous substance (see also 'Hazardous substance') = the classification of dangerous substances is based on categories defined in the CLP Directive. These categories include physical hazards (explosive, flammable, instable etc.), health hazards (all aspects of short and long term harm to health) and environmental hazards (aquatic environment etc.).

Directive = Legislative act of the European Union, which requires Member States to achieve a particular result without dictating the means of achieving that result.

Downstream user =A user of a chemical produced by a manufacturer. This can be a formulator, article manufacturer or a consumer.

E

ECHA = The European Chemicals Agency in Helsinki, Finland, established to oversee and implement the REACH system.

Endocrine disruptor = A substance that disrupts or alters the hormonal systems in the body causing widespread effects throughout the organism. These effects can be observed at extremely low doses.

Equivalent level of concern = The safety net of the REACH regulation for substances which do not automatically fall into the categories CMR, PBT or vPvB, but is of equivalent level of concern in terms of the potential damage it may cause.

ETUI = European Trade Union Institute (ETUI)

Exposure = Exposure describes that a substance is present in the environment of a worker and can be either inhaled or taken up by contact with the skin (also eyes, ears) or through ingestion.

Contact of an organism with a chemical, radiological, or physical agent. Exposure is quantified as the amount of the agent available at the exchange boundaries of the organism (e.g. skin, lungs, gut) and available for absorption.

G

Globally Harmonised System About the GHS

H

Hazard = Intrinsic property of a substance which is always present. See also **Risk**.

Hazardous substance = see 'Dangerous substance' = *A substance which fulfils the criteria relating to physical hazards, health hazards or environmental hazards, laid down in Parts 2 to 5 of Annex I of the CLP Regulation, and classified in relation to the respective hazard classes provided for in that Annex.* The classification of dangerous substances is based on categories defined in the CLP Directive. These categories include physical hazards (explosive, flammable, instable etc.) health hazards (all aspects of short and long term harm to health) and environmental hazards (aquatic environment etc.). Often hazardous substances and dangerous substances are used like synonyms. There is no clear distinction, language preferences play a role.

HPV = High Production Volume chemical, manufactured/imported at more than 1000 tonnes/year.

I

IMDS = The IMDS (International Material Data System) is the automobile industry's material data system.

M

Manufacturing = Production or extraction of substances in the natural state

Manufacturer = Any natural or legal person established within the Community who manufactures a substance within the Community

MRSL - The Manufacturing Restricted Substances List (MRSL) is compiled by the Zero Discharge of Hazardous Chemicals Programme (ZDHC), representing a group of major apparel and footwear brands and retailers. It applies to chemical substances subject to a usage ban that are used in facilities processing textile materials and trim parts.

Material Safety Data Sheet (MSDS) see SDS

Mutagenic = Causes irreparable mutations in the DNA which will be transferred on to the next generation.

P

PBT = Substances that are Persistent, Bioaccumulative and Toxic are substances that do not easily break down, instead they build up in nature and in e.g. the fatty tissue of mammals, with a potential to cause serious and long-term irreversible effects. Part of the REACH Substances of Very High Concern.

POP = Persistent Organic Pollutant. POPs are organic substances which persist for a long time in nature. They are tackled globally through the provision of the Stockholm Convention.

Preparation = A mixture or solution composed of two or more substances.

R

REACH = Regulation for Registration, Evaluation, Authorisation and Restriction of Chemicals, the EU chemical regulation entered into force in 2007.

Regulation = Legislative act of the European Union that becomes immediately enforceable as law in all Member States simultaneously.

Reproductive toxicity = *Reproductive toxicity includes adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in the offspring.*

Risk = Combination of “Hazard”, probability and exposure. See also **Hazard**.

S

Safety Data Sheet (SDS) Safety data sheets provide the users of chemicals with information on chemical or chemical products supporting them to protect human health and the environment. Legal information can be found here Regulation (EC) No 1907/2006 - REACH and guidance from ECHA here ECHA guidance (see also MSDS = Material Data Sheet, the international term for such substance information sheets)

Sensitising = *Respiratory sensitiser means a substance that will lead to hypersensitivity of the airways following inhalation of the substance.*

Skin sensitiser means a substance that will lead to an allergic response following skin contact.

Substance = One single chemical substance identified by its unique Chemical Abstracts Services (CAS) or European Community (EC) registration number.

Substances of Very High Concern = The most hazardous substances according to article 57 of REACH. These are substances that are Carcinogenic, Mutagenic and toxic to Reproduction (CMR), Persistent, Bioaccumulative and Toxic (PBT), very Persistent and very Bioaccumulative (vPvB) or substances of Equivalent level of Concern.

SVHC = See **Substances of Very High Concern**

T

Toxic (acute) = From a legal point of view a chemical (substance, mixture) is acutely toxic if it fulfils these CLP criteria:
Acute toxicity means those adverse effects occurring following oral or dermal administration of a single dose of a substance or a mixture, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.

CLP differentiates between oral, dermal and inhalation toxicity.

Toxic (for reproduction) = A substance which is toxic for reproduction will impair the ability to get children or cause irreversible harm to the offspring itself.

Toxic (others) = Exposure to dangerous substances can lead to organ specific damages. The CLP differentiates between organ specific damages due to a single exposure or to repeated exposures.

Transposition = process by which the European Union's Member States give force to a directive by passing appropriate implementation measures.

U

Use = Any processing, formulation, consumption, storage, keeping, treatment, filling into containers, transfer from one container to another, mixing, production of an article or any other utilisation.

V

vPvB = Substances that are very Persistent and very Bioaccumulative but do not need to be toxic as defined today. However, they persist in the environment and accumulate in the food chain for such a long period of time that they are also considered to be Substances of Very High Concern according to REACH.

W

Weight of evidence = Considering the strengths and weaknesses of various pieces of information in reaching a conclusion concerning a property of the substance.

WGK = German Water Hazard class (WGK) The German Water Hazard class regulation (WGK) contains a list of substances hazardous to water. A database on substance and mixtures (in English) is accessible here. Beside a no-hazard level (previously 0) three hazard levels exist: WGK 1: Low hazard to waters; WGK 2: Hazard to waters; WGK 3: Severe hazard to waters.

Z

ZDHC = Zero Discharge of Hazardous Chemicals Programme (ZDHC), apparel and footwear brands and retailers. It works in combination with the MRSL (Manufacturing Restricted Substance List).

9. Annex: Complementary materials for participants

- The Column Model
- Excerpt from Green Screen for Safer Chemicals
- Material safety data sheet (MSDS): Trichloroethylene
- MSDS: DBE dibasic esters
- Process description: Dry ice blasting
- MSDS: Carbon dioxide (dry ice)
- MSDS: Formaldehyde solution
- MSDS: Furfuryl alcohol
- MSDS: Methyl methacrylate
- Hazardous properties of formaldehyde, furfuryl alcohol and methyl methacrylate
- Excerpt from TRGS 600 – Substitution
- Column Model exercise table
- GreenScreen® exercise table

Link