Green chemistry - White biotechnology: (Bio-)Polymers and Ecocircularity – From Challenges to Opportunities

Transition towards sustainable chemistry: actor dynamics and prospective scenarios of green chemistry in Belgium

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In collaboration with

DNV·GL

Cogeneris

On behalf of FPS Health Food Chain Safety and Environment

service public fédéral
SANTE PUBLIQUE,
SECURITE DE LA CHAINE ALIMENTAIRE
ET ENVIRONNEMENT

Objectives of the study

- The mission was ordered at the end of 2016 and finalized in June 2017
- Its main objectives were:
  - Assess current state and future development of green chemistry in Belgium
  - Identify the main drivers and obstacles of green chemistry in Belgium
  - Identify actions to be taken by stakeholders (private, public, NGO) to promote green chemistry in Belgium
- Through scenarios, the study tries to assess the contribution of green chemistry to objectives of the 7th Environment Action Program of the EU
- Eventually, the study contributes to FPS's answer to UNEP request about the development of sustainable chemistry and its contribution to Agenda 2030 and SAICM (**S**trategic **A**pproach to **I**nternational **C**hemicals **M**anagement)

Research team

- The study was conducted by ICEDD in partnership with DNV GL and contribution of Cogeneris (Mr. Jacques de Gerlache)

- Active participation of various stakeholders through interviews and a participative workshop
  - Chemical companies
  - Retailers
  - Universities
  - Trade Unions
  - NGO’s

- The results of this study do not reflect the official position of the FPS. They are the sole responsibility of the Consortium (ICEDD, DNV GL and Jacques de Gerlache)

Methodological framework

- State of the art of green chemistry in Belgium
  - Which actors?
  - What understanding of green chemistry ?
  - What implementation level?
- Construction of 4 green chemistry scenarios following H. De Jouvenel method
  - *Important foreword: Prospective is not prophecy nor forecasts. Its purpose is not to predict the future but to help us building it. (H. De Jouvenel)*
    - The purpose is highlighting different possible futures and determining what will facilitate (or hinder) them.
  - Definition of the scope of the study
  - Identification of key variables acting on the system
  - Identification of interactions between variables and determination of key drivers
  - Narrative of scenarios (not too many scenarios, 4 scenarios is a good compromise)
  - Determination of levers of actions (for different actors)
- 'Impact assessment' of scenarios and necessary actions

What is green chemistry ?

The concept of green chemistry is not always understood. It is often mixed up with sustainable chemistry or bio-based chemistry
=> An useful reminder: the 12 green chemistry principles developped by Anastas and Warner in 1998,

12 Principles of Green Chemistry

1. **Prevention.** It is better to prevent waste than to treat or clean up waste after it is formed.
2. **Atom Economy.** Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemical Synthesis.** Whenever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing Safer Chemicals.** Chemical products should be designed to preserve efficacy of the function while reducing toxicity.
5. **Safer Solvents and Auxiliaries.** The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary whenever possible and, when used, innocuous.
6. **Design for Energy Efficiency.** Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.
7. **Use of Renewable Feedstocks.** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practical.
8. **Reduce Derivatives.** Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible .
9. **Catalysis.** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation.** Chemical products should be designed so that at the end of their function they do not persist in the environment and instead break down into innocuous degradation products.
11. **Real-time Analysis for Pollution Prevention.** Analytical methodologies need to be further developed to allow for real-time in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherently Safer Chemistry for Accident Prevention.** Substance and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

Anastas, P. T.; Warner, J.C. Green Chemistry: Theory and Practice, Oxford University Press,1998.

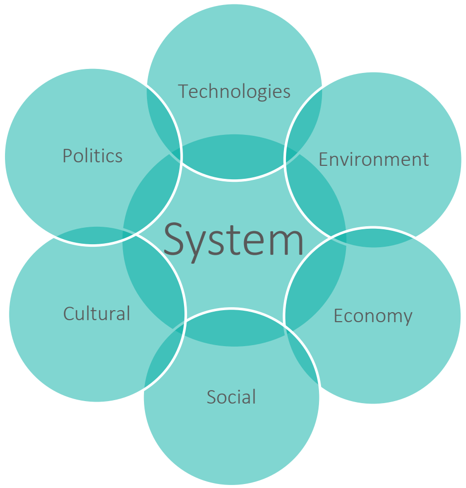
Implementation of green chemistry in Belgium

	Principes	Majorité	Limité	Initié
1	Prevention	■		
2	Atom economy			■
3	Less hazardous chemical synthesis		■	
4	Designing safer chemicals		■	
5	Safer solvants and auxiliaries			■
6	Design for energy efficiency	■		
7	Use of renewable feedstocks			■
8	Reduce derivaties		■	
9	Catalysis		■	
10	Design for degradation			■
11	Real time analysis for pollution prevention		■	
12	Inherently safer chemistry	■		

According to interviews conducted by DNV GL in 2017

Scenario construction

- What are the main variables describing green chemistry in Belgium?



- Different kind of variables
  - Context variables (energy prices, geopolitical situation,…)
  - State variables (technological solutions, investment capacity,…)
  - Control variables (legislation, education,…)
- The variable list (39 variables) was identified during the first step of the study (through stakeholder interviews) and completed during the workshop

Interactions between variables

- Using the MicMac Method (Matrice d'Impacts Croisés - Multiplication Appliqués à un Classement) developed by Michel Godet
  - NB: The MicMac Method is an opensource tool available on the Internet
- Direct influences had to be assessed by each participant at the workshop (-2, -1 , 0, +1, +2)

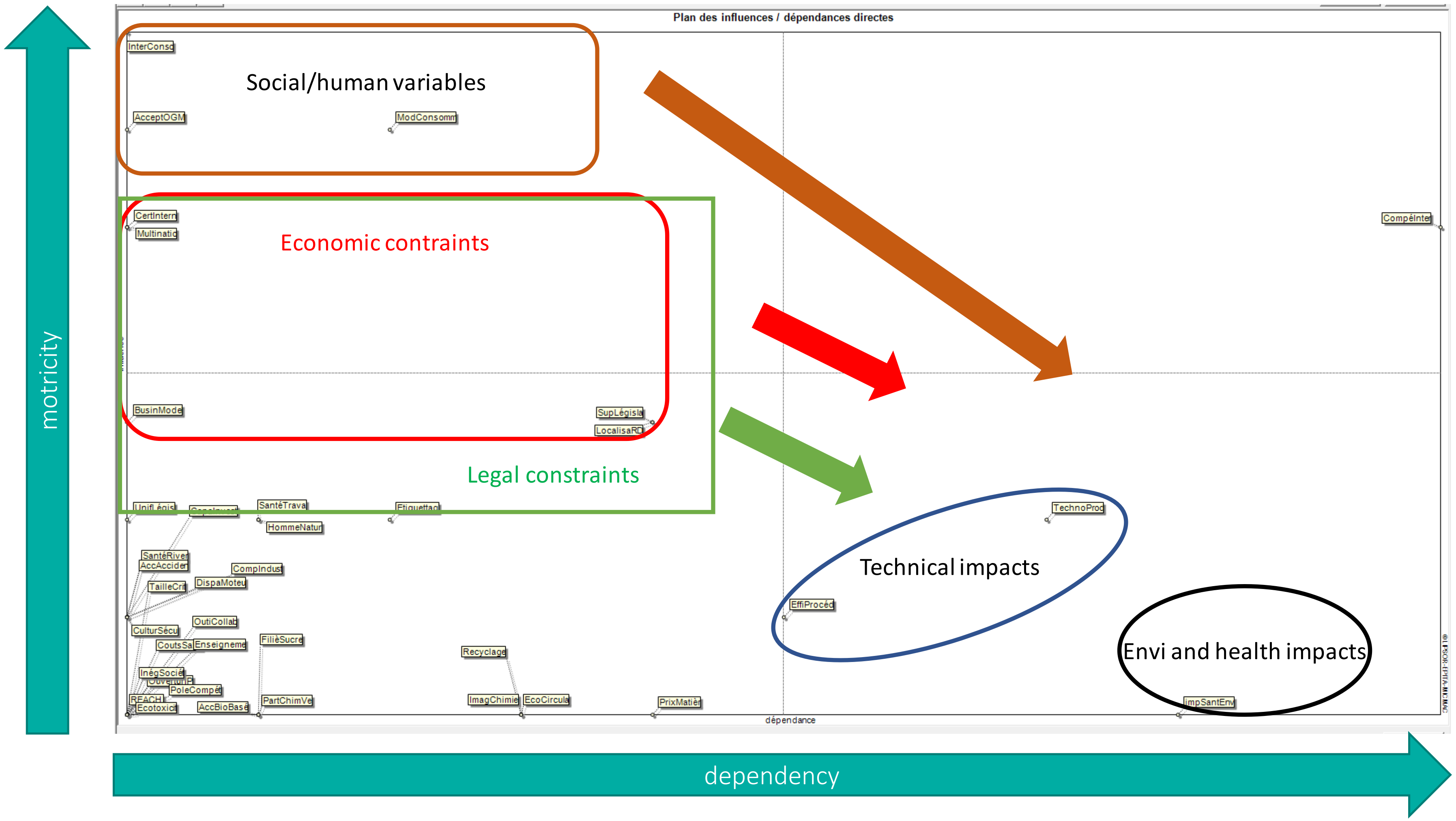
-1 : impact direct négatif modéré
-2: impact direct négatif fort

1: impact direct positif modéré
2: impact direct positif fort

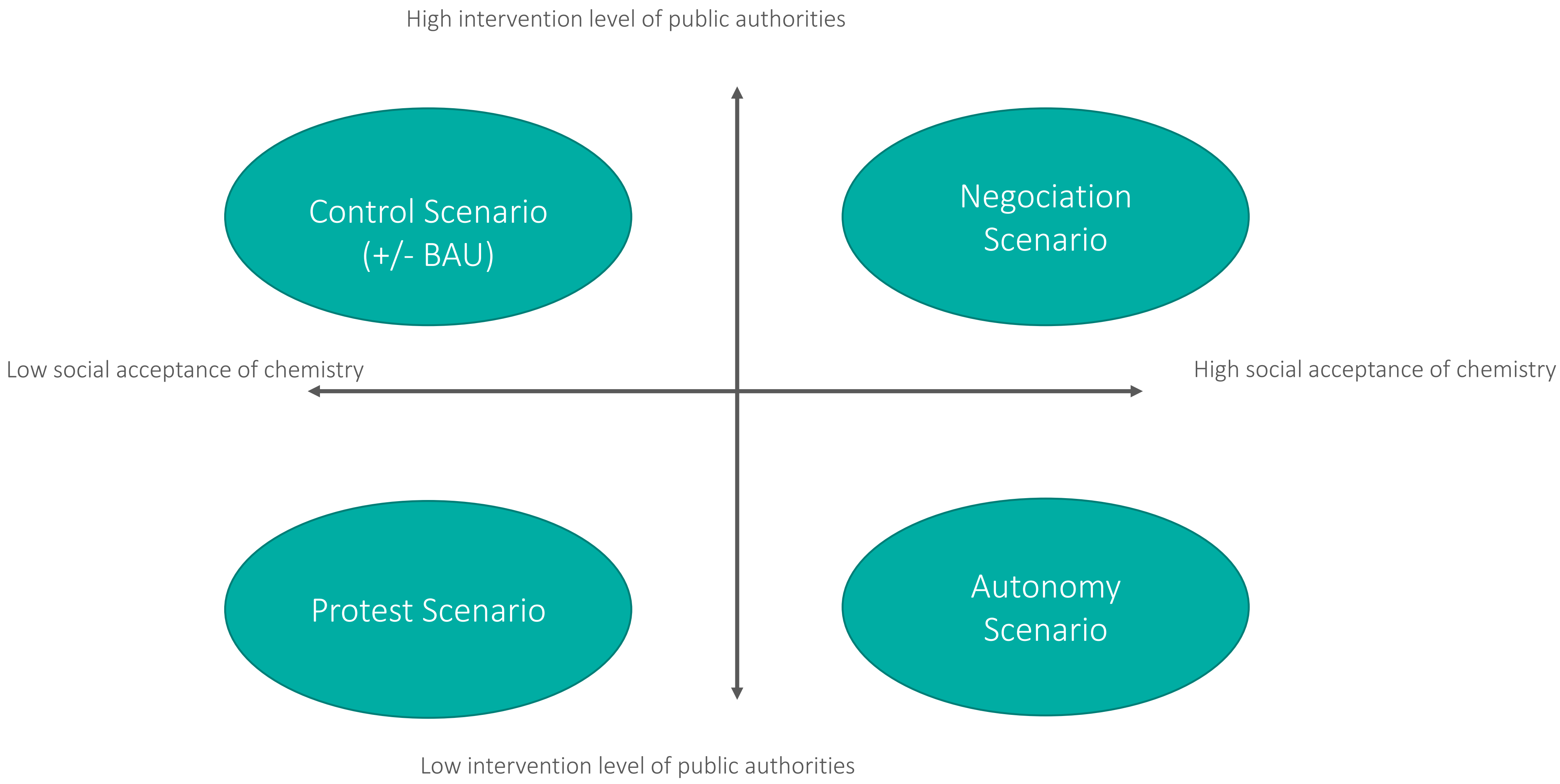
	Support et réactivité de la législation	Coûts salariaux	Compétition internationale - hors EU	Prix et disponibilité des matières premières	Uniformité des législations - contexte global	Localisation des centres de R&D	Contenu de REACH et procédure de mise en conformité	Obligation d'étiquettage	Tailles critiques de production	Disparition du moteur à explosion	Besoins et exigences des multi	Culture sé	Systèmes de			Eff
Support et réactivité de la législation		1						2								
Coûts salariaux			2			1			2						1	
Compétition internationale - hors EU		2														
Prix et disponibilité des matières premières																
Uniformité des législations - contexte global																
Localisation des centres de R&D			2												2	1
Contenu de REACH et procédure de mise en conformité																
Obligation d'étiquettage														2		
Tailles critiques de production																
Disparition du moteur à explosion																
Besoins et exigences des multinationales		2				2			1			1			1	1
Culture sécurité forte														1		
Systèmes de certification internationaux								2							1	
Intérêt du consommateur																
Nouvelles technologies de production																1
Efficacité des procédés d'épuration et de traitement des produits recyclés																
Ouverture des entreprises à l'échange de propriété intellectuelle						1										
Acceptation des produits bio-basés																
Acceptation des OGM's et de la biologie de synthèse																
Capacités d'investissement																
Filière de recyclage et de traitement de déchets																
Outils afin de faciliter la collaboration																

Interactions between variables

- The interactions between variables could be plotted and classified as follow



Description of 4 contrasted scenarios



Autonomy scenario

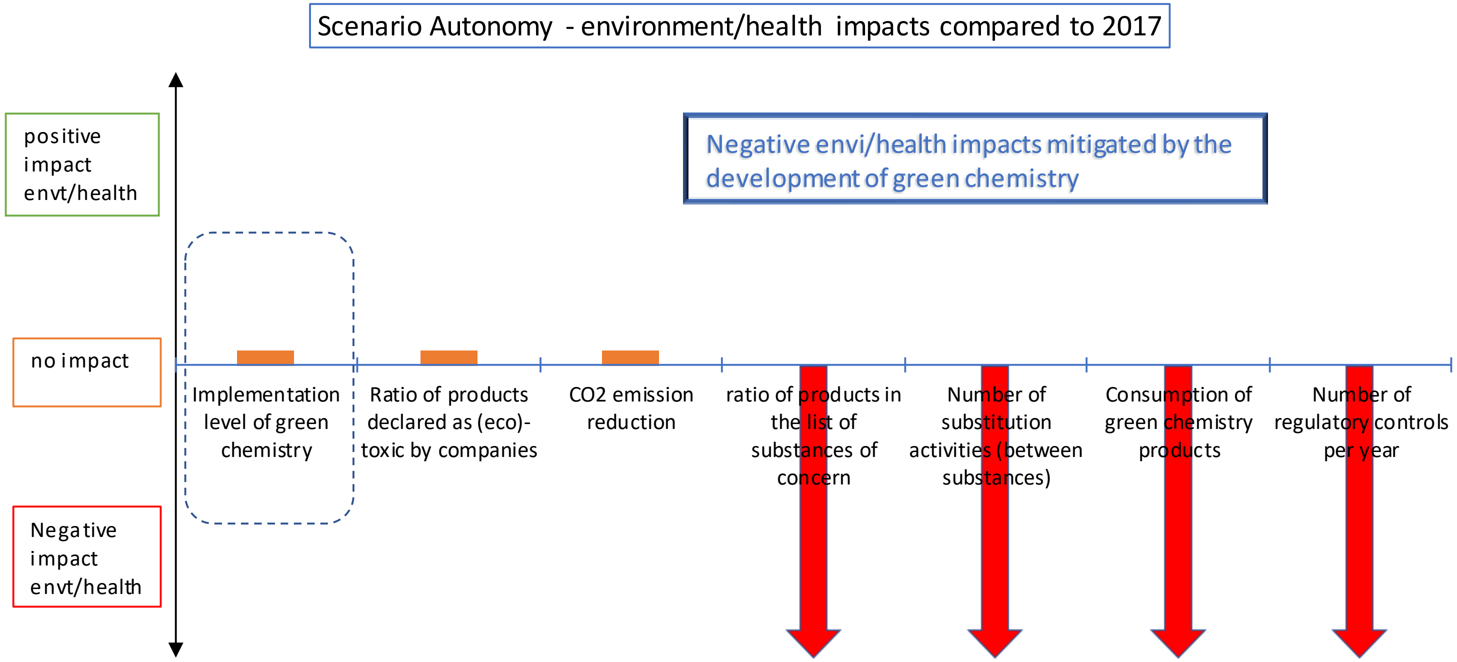
Key elements

- Economic crisis
- Lower attention to environment and health
- Job creation facilitating social acceptance of chemistry
- Development of pollutant activities in Belgium (need of job creation)
- Voluntary agreeement of private companies

Role of the actors

- Public: economic support (subsidies, tax savings…)
- Private: Communication to reassure citizens (and to maintain social acceptance of chemistry)

Impacts on environment and health compared to 2017



Protest scenario

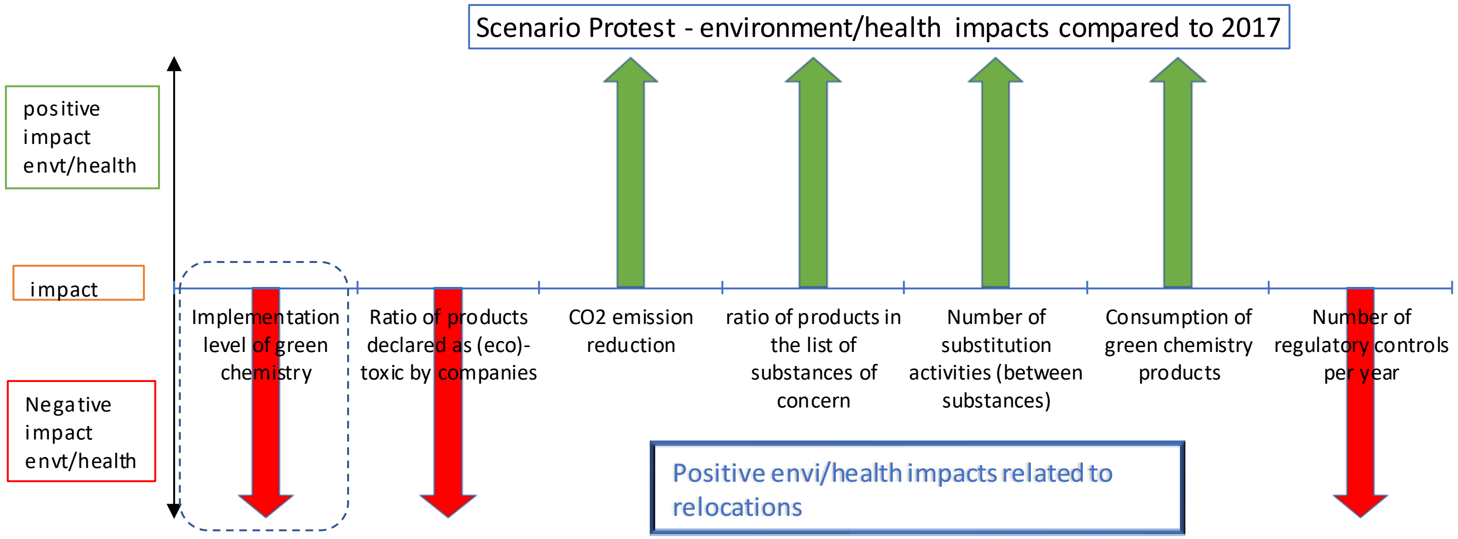
Key elements

- No need for regulation
- General distrust of
  - chemical facilities
  - Products
  - Even those following green chemistry principles
- Potential relocation of activities
- High level of (violent) protest
  - Not in court but in the street !

Role of the actors

- Public: Low level of intervention except for security
- Private : communication to minimize protests

Impacts on environment and health compared to 2017



Control scenario (+/- BAU scenario)

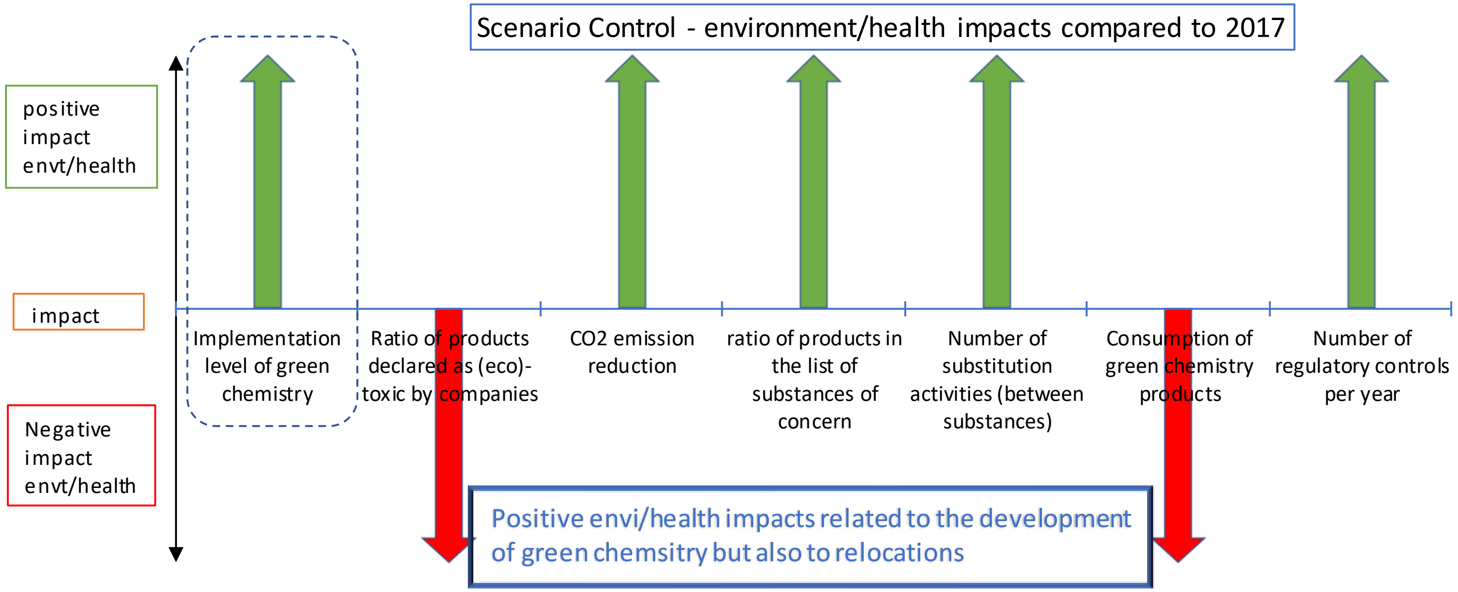
Key elements

- More restrictive regulations
- Trade off between eco/envi/health interests
- 'Institutional' protest against chemistry (in court)
- Low incentive level to innovate
- Difficulties to highlight the positive impact of green chemistry
- Bad reputation of chemistry even for green chemistry

Role of the actors

- Public: arbitrate between divergent interests
  - Impose controls to garantee label, traceability
  - Education/sensibilisation
- Private: communication to civil society, application of regulation to minimize environment and health concerns

Impacts on environment and health compared to 2017



Negociation scenario

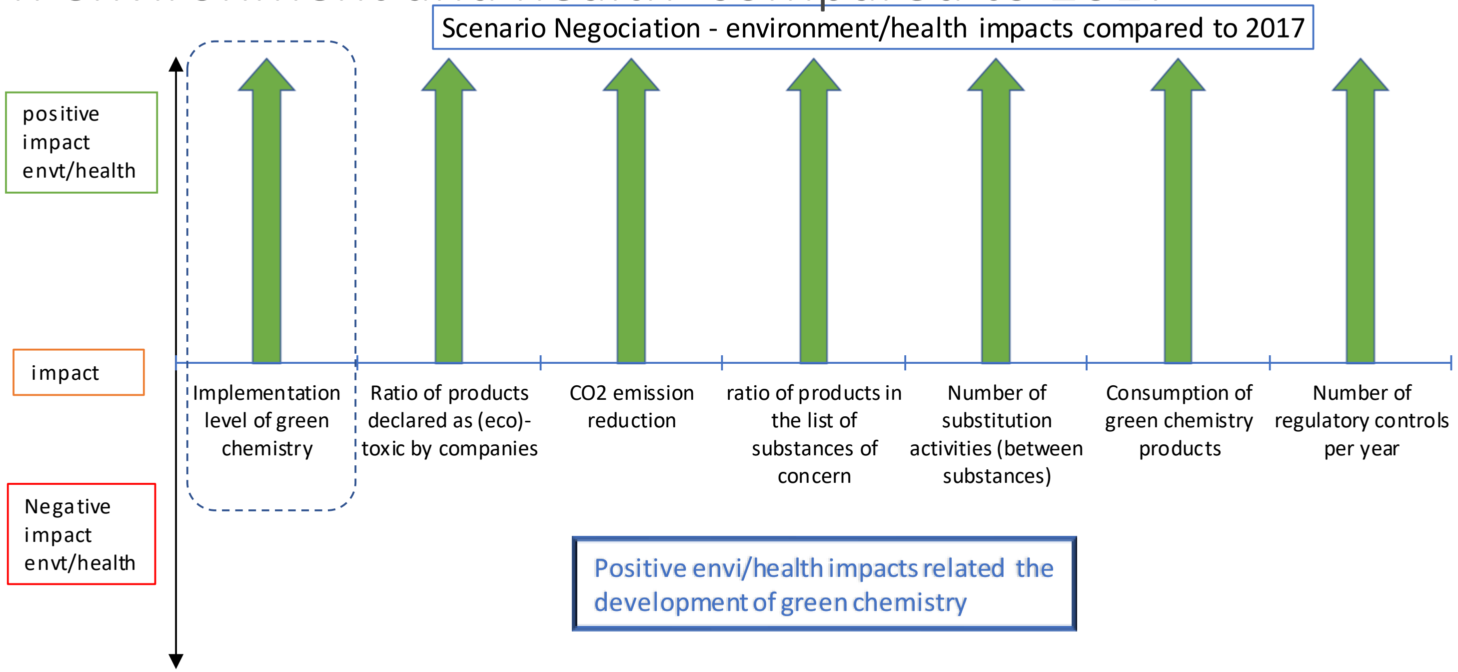
Key elements

- Green chemistry is understood and accepted
- Chemical products and facilities are accepted
  - Since pros and cons are discussed and negociated
- New ways of consultation
  - Large green chemistry forums
  - All chemistry questions are discussed
    - → including the relevance of some research, products, facilities

Role of the actors

- Public: Facilitator of consultation process
- Communication, transparency, education,…
- Private: communication,
- Companies and citizens debate all critical concerns

Impacts on environment and health compared to 2017



Some conclusions

- These are just scenarios !
  - They do not give a correct picture of the future. The future will not look like one of them !
- Their purpose is helping us to ask the right questions
  - What are the key drivers facilitating green chemistry?
  - What are the role of public and private actors?
- The study intiated a debate between different actors (public, companies, NGO’s) about green chemistry and its role in Belgium
- Some environment and health impact indicators were defined. They could be useful for FPS to evaluate the development of green chemistry
- The study was only a first step. It would be useful to carry on the dialogue between actors.

Thank you for your attention

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