ECO-DESIGN : methodology and tools

Ecoconception GTPS Commission

European technical days of the GTPS

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Summary

- Introduction
- Ecodesign methodology
- EcoPyro: tool for pyrotechnics
- Optimisation

GROUPE DE TRAVAIL DE PYROTECHNIE

INTRODUCTION

Why ecodesigning?

GROUPE DE TRAVAIL DE PYROTECHNIE

- Taken into consideration short and long term effects on the environment when choosing materials and industrial process.
- Legislation :
  - ISO 14 001 – 2015 :
  - Chemical : REACh, ROHs, etc.
  - Recycling
- Economy :
  - Anticipate risk of obsolescence
    - Geopolitics : avoid use of European Critical Raw Materials
    - Reduction of costs and energy consumption
- Opportunities to increase environmental performance by developing new concept and innovation
- Necessity to be competitive worldwide :
  - Development of new products
  - Re-designing old components

Alysophil arianeGROUP Autoliv DGA DASSAULT AVIATION Davey Bickford Enaex EPC 2i Etienne Lacroix GROUP INERIS KNDS MBDA MISSILE SYSTEMS NOBELSPORT Roxel Propulsion systems THALES

WHICH TOOLS

GROUPE DE TRAVAIL DE PYROTECHNIE

- Life cycle assessment software with database : SIMAPRO, GABI

- Many data base :
  - Large scale : Eco-Invent
  - Big industries or specific areas: automotive, food, transport, agriculture
  - By governmental organizations specialized in environment such as ADEME

- But lacks of data
  - For chemistry
  - More specially for pyrotechnic

WHY DEVELOPING AN ECODESIGN TOOL FOR PYROTECHNICS?

GROUPE DE TRAVAIL DE PYROTECHNIE

- Introducing the environmental aspects at the beginning of the product conception, and during all steps of its life cycle to preserve performances and improve economic aspects.
- Have an open tool customised to the GTPS methodology
- Existing software or standards not directly suitable for pyrotechnics:
  - First studies took into evidence lack of data for energetic materials (pyrotechnic compositions, propellants …).

=> The most important impacts were due to the mechanical parts of the ammunition.

- Difficulties to implement existing database with energetic materials

=> Companies of the pyrotechnics join together to propose a methodology and a tool dedicated to the design of their products.

Commission Ecoconception du GTPS

Ecodesign group from GTPS

GROUPE DE TRAVAIL DE PYROTECHNIE

ECO-DESIGN METHODOLOGY

What do we need?

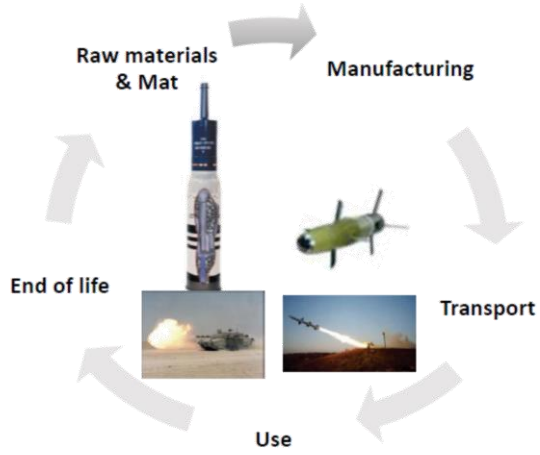
- Determine the environmental profile of pyrotechnic object to classify the impact on human and environment and get orientation to the designer to find best materials and process to decrease the environmental impact of his ammunition
- Free tool available for all the pyrotechnic companies
- Quick decision to improve the conception of pyrotechnics
- Take into account regulations on substances
- Identify environmental chemical markers

Guide and tool

Ecodesign GTPS Guide

GROUPE DE TRAVAIL DE PYROTECHNIE

- Process to decrease the environmental impact of ammunition over its life cycle:
  - Raw materials (**MP**): impact linked to the choice of all materials, components, … of the unpackaged ammunition;
  - Manufacturing (**F**): impact linked to the all processes needed for the manufacturing of the ammunition;
  - Transport and distribution (**T**): linked to the localization of suppliers, number of expeditions,
  - Use (**U**): linked to the use (chemicals emitted during firings)
  - End of life (**FV**): linked to the deconstruction and recyclability of the pyrotechnics object when not used.

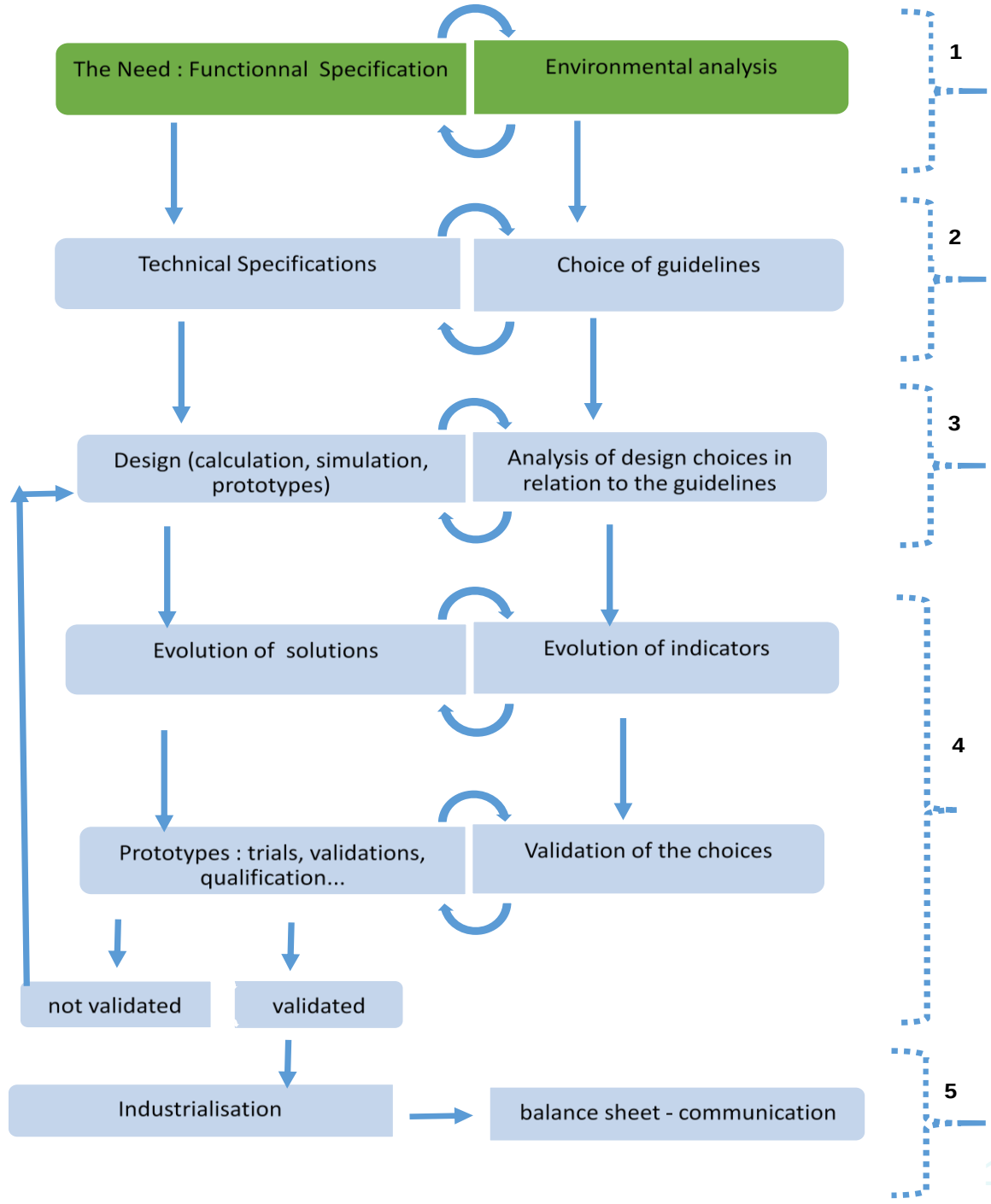


ECODESIGN METHODOLOGY

GROUPE DE TRAVAIL DE PYROTECHNIE

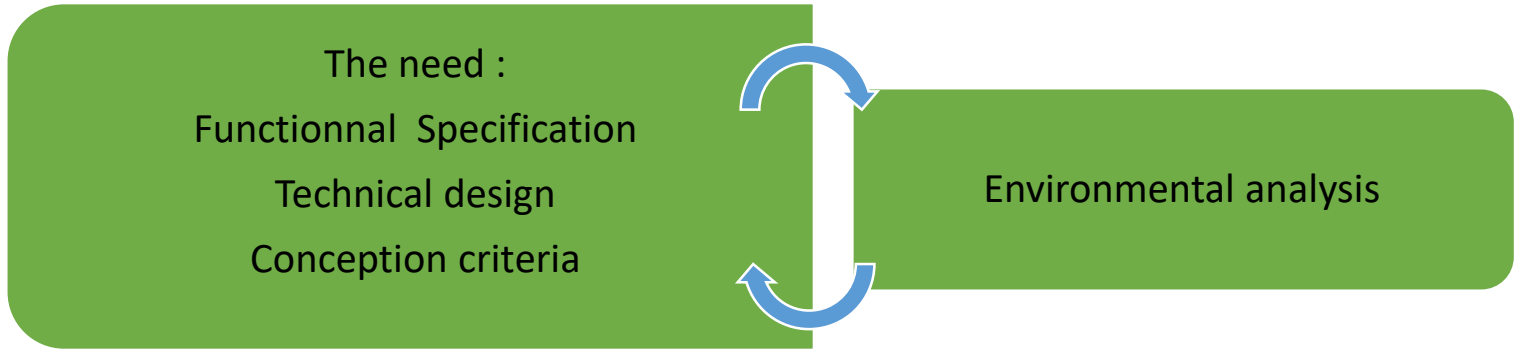
- Stage 1: determination of the environmental profile of a pyrotechnic object
- Stage 2: selection and organization into a hierarchy of guidelines
- Stage 3: choice of indicators adapted in touch with the pyrotechnic object
- Stage 4: follow-up of indicators
- Stage 5: balance sheet capitalisation

In the design Process : ***integration of the environment***:



ECODESIGN METHODOLOGY

- **Stage 1: determination of the environmental profile of a pyrotechnic object**



The need for an ecodesigned product:

- Lighter and smaller product
- Nontoxic substances in design
- Longer life time
- Easy reuse
- Controlled emissions

Input : Definition file

- Raw materials (**MP**)
- Manufacturing (**F**)
- Use (**U**)
- End of life (**FV**)
- Transport and distribution (**T)**
- Packaging (**Emb**)

Environmental analysis

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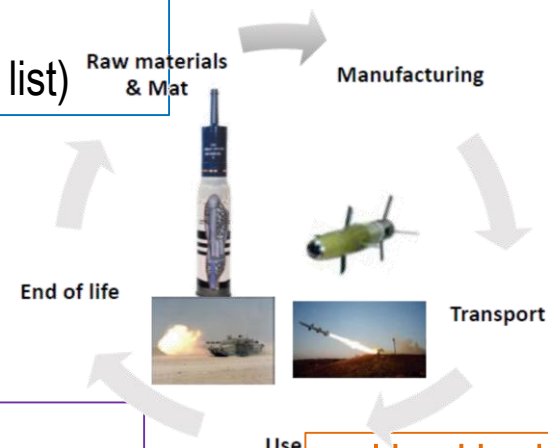
Raw materials MP

- ✓ Environment : presence of dangerous substances with following risk mentions: H400 à H 402, H410 à H413 and H420 (ozone layer)
- ✓ Human: presence of dangerous substances with specific risk mentions (toxic,CMR type 1A, 1B or 2)
- ✓ Regulations concerning a substance : REACh, VOC, POP, vPvB, Biocide, Greenhouse effect, conflict mineral act list, ozone layer, ROHS
- ✓ Resources depletion: rare metals (GTPS commission list)

Manufacturing and transportation F materials, product and packaging

- ✓ Resource's consumption,
- ✓ Green warehouse effect GWP 100,
- ✓ Aquatic toxicity,
- ✓ Human toxicity

ADEME data base



End of life FV

- ✓ Disassembly capability: with or without specific tool (= not standard)
- ✓ Recyclability of its not made dirty components
- ✓ Treatment of its pyrotechnic part or its components made dirty

Use U : determination of emitted substances (test or thermochemical) and waste

- ✓ Effect on environment: : presence of dangerous substances with risk mention:
- ✓ Effect on the human: dangerous substances with mention of danger:
- ✓ VLEP : limited value authorise at working place

ECODESIGN METHODOLOGY

- **Stage 2:** selection and organization into a hierarchy of guidelines (GL)

Note E Enviromental criteria	0	1	2	3	4
	Non selected	GL poorly relevant	Moderately relevant GL	GL that can be selected	GL to be selected as a priority

Note T Technical/economic criteria	0	1	2	3	4
	GL not technically feasible – not compatible with client/internal requirements	GL does not create a technical conflict, but the improvement suggestions may encounter other significant constraints (heavy investments, qualifications/requalification, security, etc.).	Improvement suggestion is a priori feasible, but preliminary studies are necessary; medium to long term.	Existing technical solution; feasibility to be tested; non-negligible implementation cost.	Solution that can be implemented quickly and at an acceptable cost, or a solution already implemented by the company, or a feature of the product that the company wishes to promote.

Note S Strategic criteria	1	2	3
	Solution that conflicts with other strategic axes of the company or with market expectations.	Solution that is strategically neutral but interesting in terms of image.	Solution of prioritized strategic interest (regulation/specification/client demands, etc.).

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ECOPYRO TOOL FOR CONCEPTION AND COMPARISON

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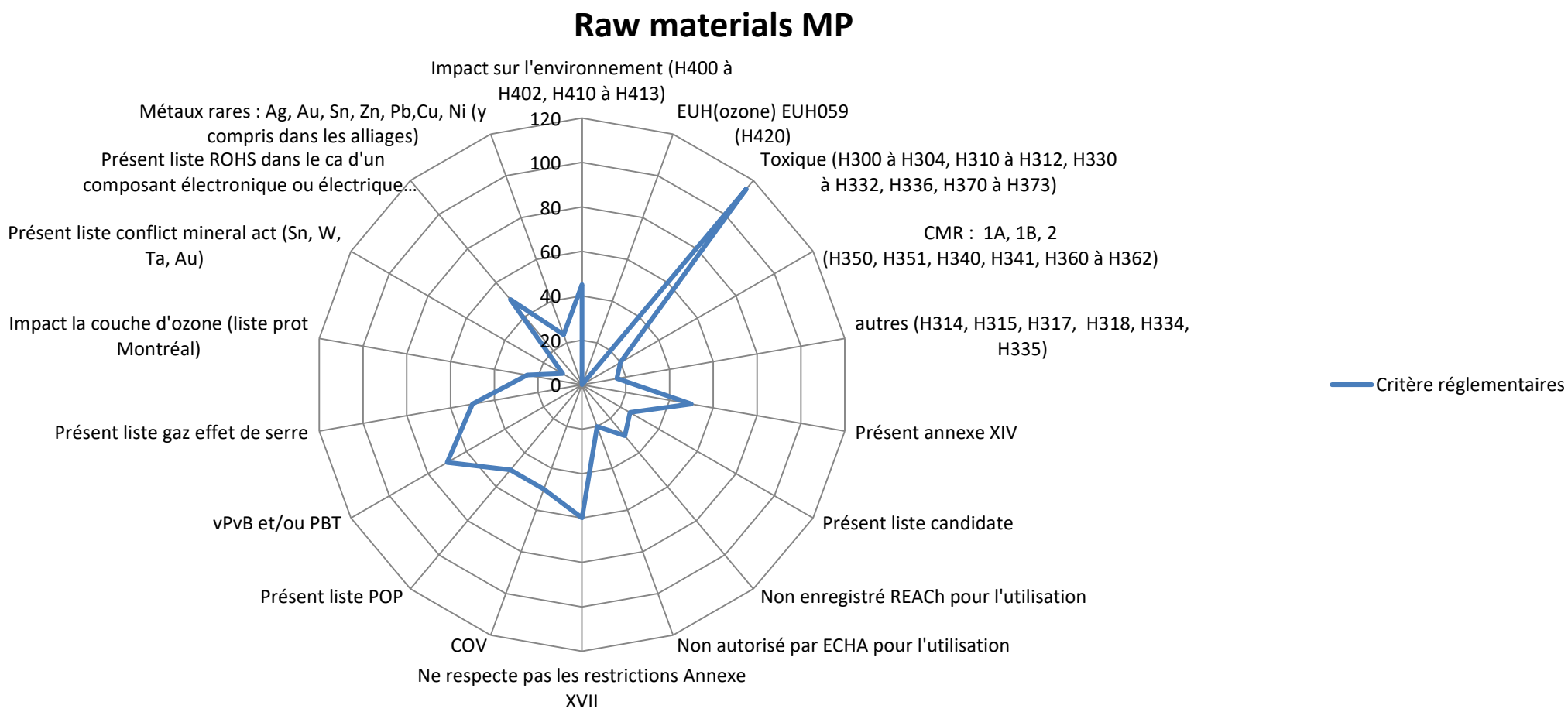
What is it for?

- To implement the ecodesign GTPS Guide
- To define the critical criteria parameters for a product/concept
- To compare different products/concepts
- To synthetize and present the results of criteria for a product/concept



How does it work?

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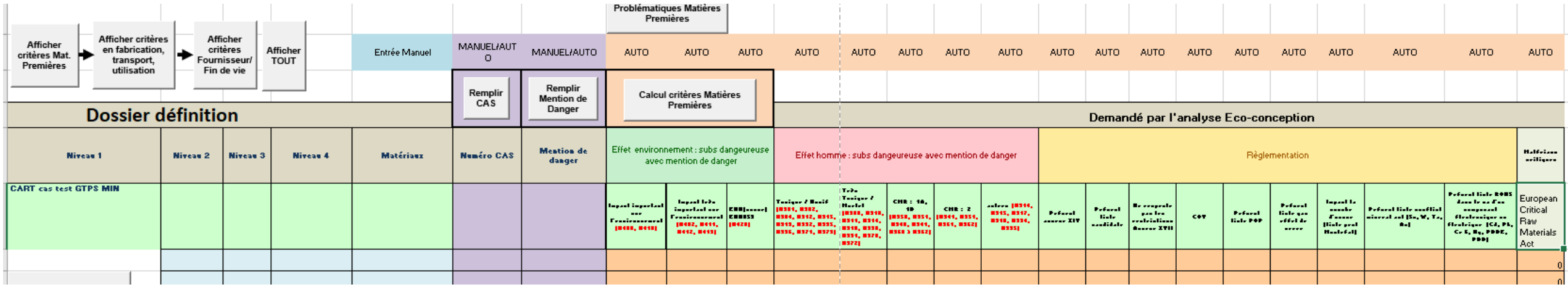
- Use of Microsoft Excel sheets, macros and library.

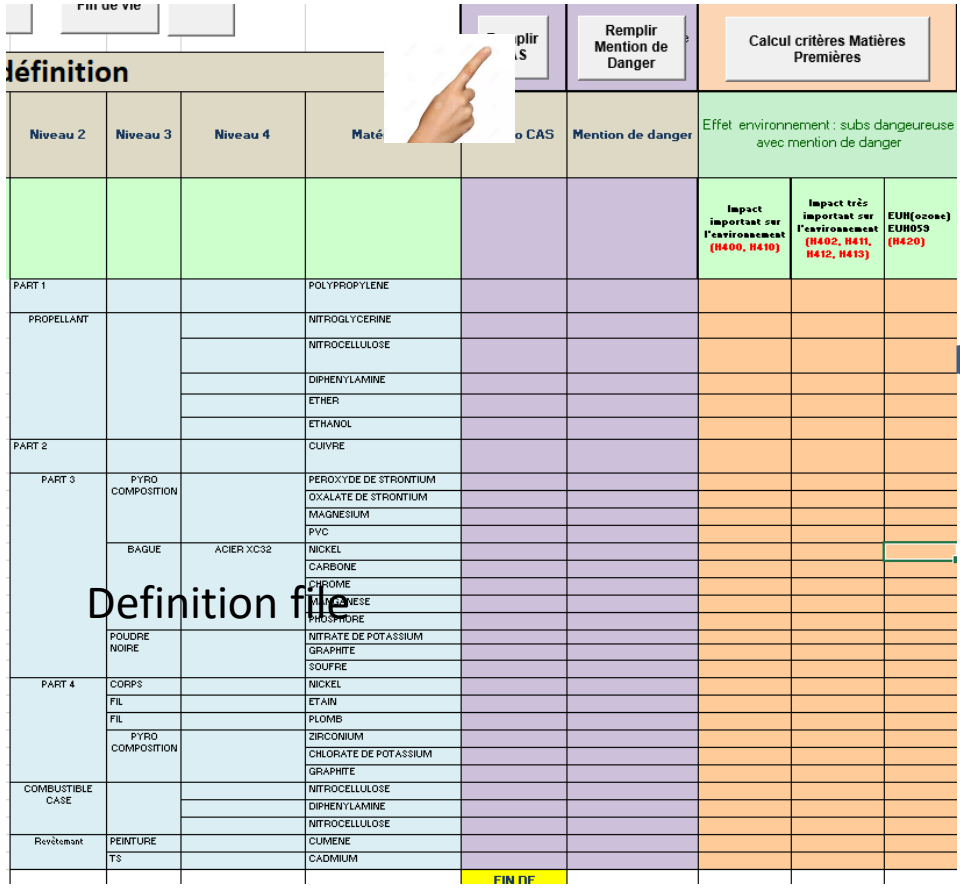


- Integration of database from GTPS EcoConception Guide appendixes
  - Reach data, CLP => ECHA site
  - VLEP : INRS tool
- Automatic calculation thanks to macro
- Analysis by criteria

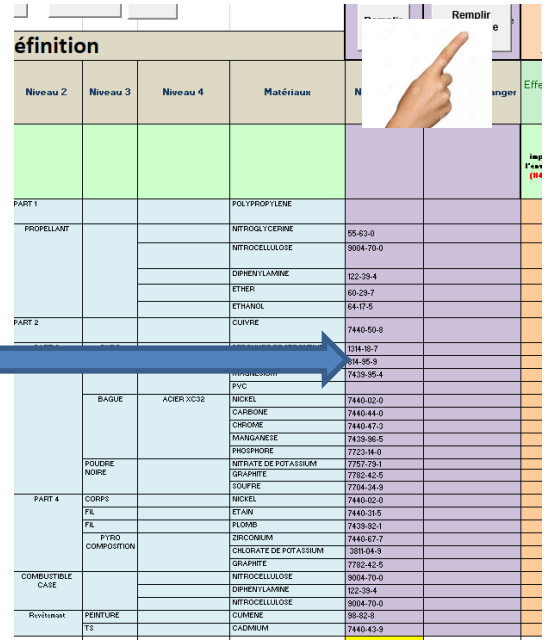
Which data for materials?

GTPS
GROUPE DE TRAVAIL DE PYROTECHNIE

Definition file



Niveau 2	Niveau 3	Niveau 4	Matériaux	Numéro CAS	Mention de danger	Effet environnement : subs dangereuse avec mention de danger		
						Impact important sur l'environnement (H400, H410)	Impact très important sur l'environnement (H402, H411, H412, H413)	EUH(ozone) EUH059 (H420)
PART 1			POLYPROPYLENE					
PROPELLANT			NITROGLYCERINE					
			NITROCELLULOSE					
			DIPHENYLAMINE					
			ETHER					
			ETHANOL					
PART 2			CUIVRE					
PART 3	PYRO COMPOSITION		PEROXYDE DE STRONTIUM					
			OXALATE DE STRONTIUM					
			MAGNESIUM					
			PVC					
	BAGUE	ACIER XC32	NICKEL					
			CARBONE					
			CHROME					
			MANGANESE					
			PHOSPHORE					
	POUDRE NOIRE		NITRATE DE POTASSIUM					
			GRAPHITE					
			SOUFRE					
PART 4	CORPS		NICKEL					
	FIL		ETAIN					
	FIL		PLOMB					
	PYRO COMPOSITION		ZIRCONIUM					
			CHLORATE DE POTASSIUM					
			GRAPHITE					
COMBUSTIBLE CASE			NITROCELLULOSE					
			DIPHENYLAMINE					
			NITROCELLULOSE					
Revêtement	PEINTURE		CUMENE					
	TS		CADMIUM					
			FIN DE					



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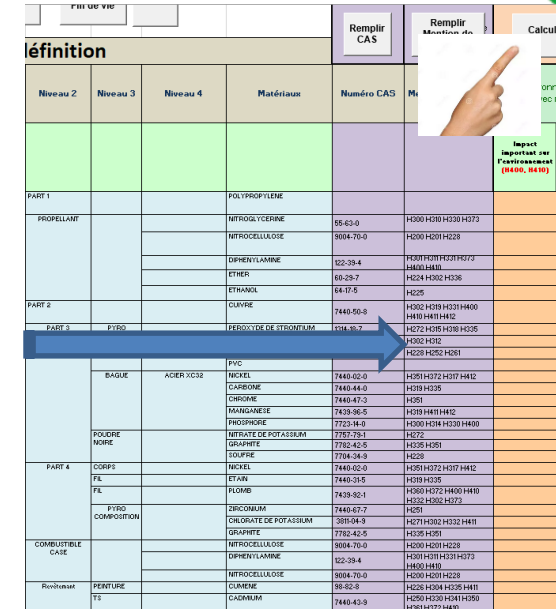
PART 1			POLYPROPYLENE					
PROPELLANT			NITROGLYCERINE	55-63-0	H300 H310 H330 H373			
			NITROCELLULOSE	9004-70-0	H200 H201 H228			
			DIPHENYLAMINE	122-39-4	H301 H311 H331 H373 H400 H410			
			ETHER	60-29-7	H224 H302 H336			
			ETHANOL	64-17-5	H225			
PART 2			CUIVRE	7440-50-8	H302 H319 H331 H400 H410 H411 H412			
PART 3	PYRO COMPOSITION		PEROXYDE DE STRONTIUM	1314-18-7	H272 H315 H319 H335			
			OXALATE DE STRONTIUM	814-95-9	H302 H312			
			MAGNESIUM	7439-95-4	H228 H252 H261			
			PVC					
	BAGUE	ACIER XC32	NICKEL	7440-02-0	H351 H372 H317 H412			
			CARBONE	7440-44-0	H319 H335			
			CHROME	7440-47-3	H351			
			MANGANESE	7439-96-5	H319 H411 H412			
			PHOSPHORE	7723-14-0	H300 H314 H330 H400			
	POUDRE NOIRE		NITRATE DE POTASSIUM	7757-79-1	H272			
			GRAPHITE	7782-42-5	H335 H351			
			SOUFRE	7704-34-9	H228			
PART 4	CORPS		NICKEL	7440-02-0	H351 H372 H317 H412			
	FIL		ETAIN	7440-31-5	H319 H335			
	FIL		PLOMB	7439-92-1	H360 H372 H400 H410 H332 H302 H373			
	PYRO COMPOSITION		ZIRCONIUM	7440-67-7	H251			
			CHLORATE DE POTASSIUM	3811-04-9	H271 H302 H332 H411			
			GRAPHITE	7782-42-5	H335 H351			
COMBUSTIBLE CASE			NITROCELLULOSE	9004-70-0	H200 H201 H228			
			DIPHENYLAMINE	122-39-4	H301 H311 H331 H373 H400 H410			
			NITROCELLULOSE	9004-70-0	H200 H201 H228			
Revêtement	PEINTURE		CUMENE	98-82-8	H226 H304 H335 H411			
	TS		CADMIUM	7440-43-9	H250 H330 H341 H350 H361 H372 H410			



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					H302 H312	
					H228 H252 H261	
			PVC			
	BAGUE	ACIER XC32	NICKEL	7440-02-0	H351 H372 H317 H412	
			CARBONE	7440-44-0	H319 H335	
			CHROME	7440-47-3	H351	
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			PHOSPHORE	7723-14-0	H300 H314 H330 H400	
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PART 4	CORPS		NICKEL	7440-02-0	H351 H372 H317 H412	
	FIL		ETAIN	7440-31-5	H319 H335	
	FIL		PLOMB	7439-92-1	H360 H372 H400 H410 H332 H302 H373	
	PYRO COMPOSITION		ZIRCONIUM	7440-67-7	H251	
			CHLORATE DE POTASSIUM	3811-04-9	H271 H302 H332 H411	
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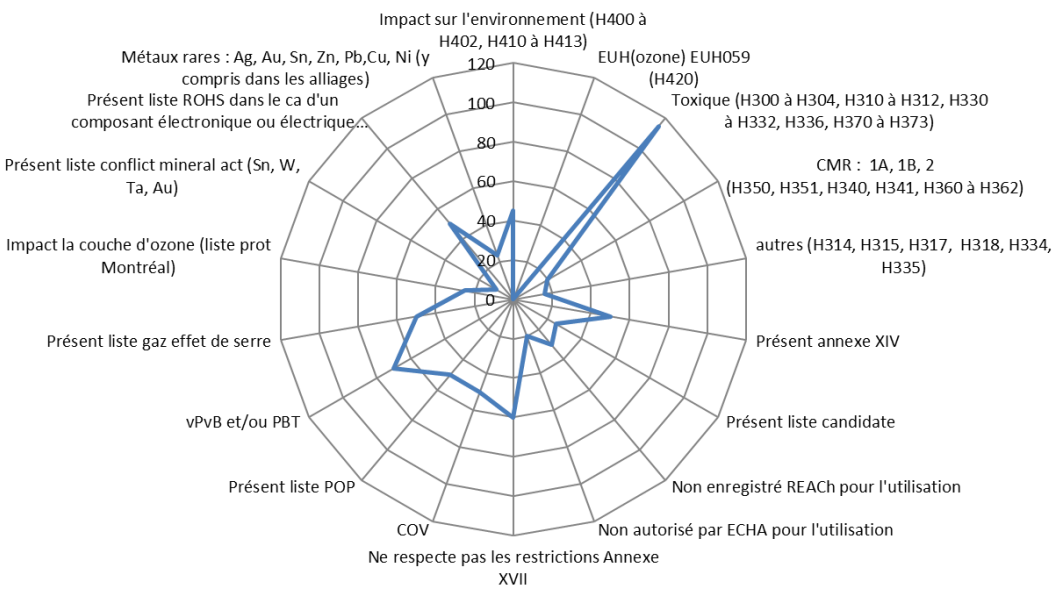
Revêtement	PEINTURE		CUMENE	98-82-8	H226 H304 H335 H411	
	TS		CADMIUM	7440-43-9	H250 H330 H341 H350 H361 H372 H410	

Raw materials MP



Which data for manufactoring?

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Excell file for production phase

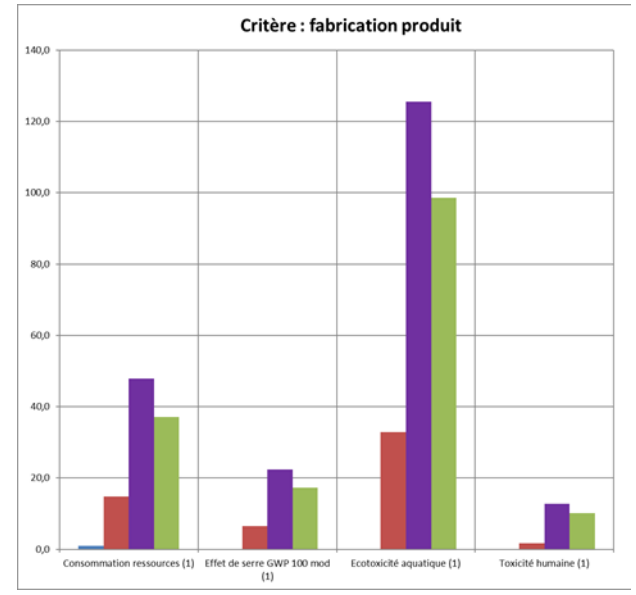
	Calcul critères cycles de vie			Calcul consommation énergétique		Calcul consommation eau			Calcul de l'impact environnemental suivant la méthodologie ADEME												Calcul de l'impact environnemental en utilisant les phrases de risques							
									COMPOSANT+EMBALLAGE-FABRICATION DES MATERIAUX						COMPOSANT+EMBALLAGE-FABRICATION DU PRODUIT						COMPOSANT+EMBALLAGE-TRANSPORT						UTILISATION DU PRODUIT ELEMENTS GENERES EFFETS SUR L'ENVIRONNEMENT / L'HOMME / EFFETS / SUR							
Matériaux	Masse [kg]	Quantité	Distance [km]	Composant-Emballage-Matériaux	Composant-Emballage-Fabrication	Composant-Emballage-Transport	Utilisation	Utilisation	Elément spécifié en utilisation - Mention de danger matière	Elément spécifié en utilisation - Nom du produit	Consommation ressources [MJ]	Effet de serre GWP 100 mod [kg]	Ecotoxicité aquatique [kg]	Toxicité humaine [kg]	Matériaux-Consommation énergie NR [MJ]	Matériaux-Consommation Eau [m3]	Consommation ressources [MJ]	Effet de serre GWP 100 mod [kg]	Ecotoxicité aquatique [kg]	Toxicité humaine [kg]	Fabrication-Consommation énergie NR [MJ]	Fabrication-Consommation Eau [m3]	Consommation ressources [MJ]	Effet de serre GWP 100 mod [kg]	Ecotoxicité aquatique [kg]	Toxicité humaine [kg]	Transport-Consommation énergie NR [MJ]	Transport-Consommation Eau [m3]	Impact impérceptible sur l'environnement : [H400, H410]	Impact très impérceptible sur l'environnement : [H402, H411, H412,	Impact sur la couche d'ozone : [H420]	CMR de type 1A et 1B : [H340, H350, H350i, H360]	CMR de type 2 : [H341, H351, H361, H362]	Mutagène et très toxique : [H300, H310, H311, H314, H330, H331,	Toxique à long terme : [H301, H312, H313, H315, H332,	VLEP UE ou VLCT réglementaire Union Française ou ou VLEP européenne
POLYPROPYLENE	28	2	50	PP	Injection	Conteneur					1,355941	0,278833	0,036556	0,004791	0	0	0,455983	0,189011	0,676414	0,04911	0	0	0,027462	0,013597	0,024768	0,003313	0	0	0	0	0	0	0	0	0	0	0	0
NITROGLYCERINE	248	1	100	NC	Extrusion	Fût					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NITROCELLULOSE																																						

Example of Data for materials

Nom		Consommation ressources (1)	Effet de serre GWP 100 mod (1)	Ecotoxicité aquatique (1)	Toxicité humaine (1)	Consommation énergie NR (1)	Consommation Eau (1)
Electricité basse tension Europe	kWh	0,0432626	0,0199235	0,1031821	0,0065254	11,26770281	15723,00000000
Pallette européenne	unit	0,6427929	0,2179253	0,7733214	0,1962522	143,05317756	15723,00000000
Fibres de Carbone	kg	1,8410042	0,4483986	0,0000825	0,0236234	338,00000000	21411,00000000
Aluminium mix européen	kg	0,5161611	0,2966833	2,051	0,7211901	112,72744005	75937,00000000
Cuivre courant	kg	0,1483054	0,0671139	15,446071	2,5779751	28,84981277	75937,00000000
Caoutchouc synthétique	kg	0,4001883	0,0939573	0,2234964	0,0262611	89,23574038	21240,00000000
Glycerine vegetale	kg	0,0593295	0,0148185	0,0227725	0,0023892	13,26848015	573698,00000000
Graphite	kg	0,002069	0,0009982	0,0037289	0,0002485	0,50756151	282290,00000000
KClO4	kg	0,3842887	0,177548	1,1095	0,0681279	97,36705193	282290,00000000
Noir de carbone	kg	0,4082008	0,084306	0,0467071	0,0191829	88,81489335	282290,00000000
PCl3	kg	0,2993305	0,1190676	0,6478929	0,0410835	69,92690000	282290,00000000
Produits chimiques inorganiques (moyen	kg	0,1155753	0,065879	0,2464179	0,0205133	25,98549430	282290,00000000

Example of Data for process

Nom		Consommation ressources (1)	Effet de serre GWP 100 mod (1)	Ecotoxicité aquatique (1)	Toxicité humaine (1)	Consommation énergie NR (1)	Consommation Eau (1)
Fabrication moyenne en acier au chrome	kg	0,180156904	0,086302491	1,36125	0,325825933	38,92072801	42141,00000000
Fabrication moyenne en aluminium	kg	0,217322176	0,117213523	0,725214286	0,17582238	49,57111391	42141,00000000
Fabrication moyenne en cuivre	kg	0,133817992	0,065103203	3,766071429	0,597335702	30,53133962	42141,00000000
Laminage de profils acier	kg	0,009075628	0,007047687	0,055532143	0,001213215	1,89501710	42141,00000000
Perçage CNC acier	kg	0,262646444	0,128508897	1,309035714	0,144490231	52,08003647	42141,00000000
Soudage à l'arc acier	m	0,010387134	0,00437331	0,047446429	0,016232327	1,97961109	42141,00000000
Tournage CNC acier	kg	0,319309623	0,154633452	1,462678571	0,153451155	66,88904010	42141,00000000
Extrusion de profils aluminium	kg	0,077753138	0,036395018	0,204078571	0,020749556	18,58942726	42141,00000000
Injection	kg	0,113995816	0,047252669	0,169103571	0,012277442	26,89111173	42141,00000000
Nitration							2070,00000000



Data base ADEME 2011

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Optimization

Main activity of the commission : ECOPYRO updating

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- Updating data base for manufactoring
  - More recent data base
  - Compagny specific process

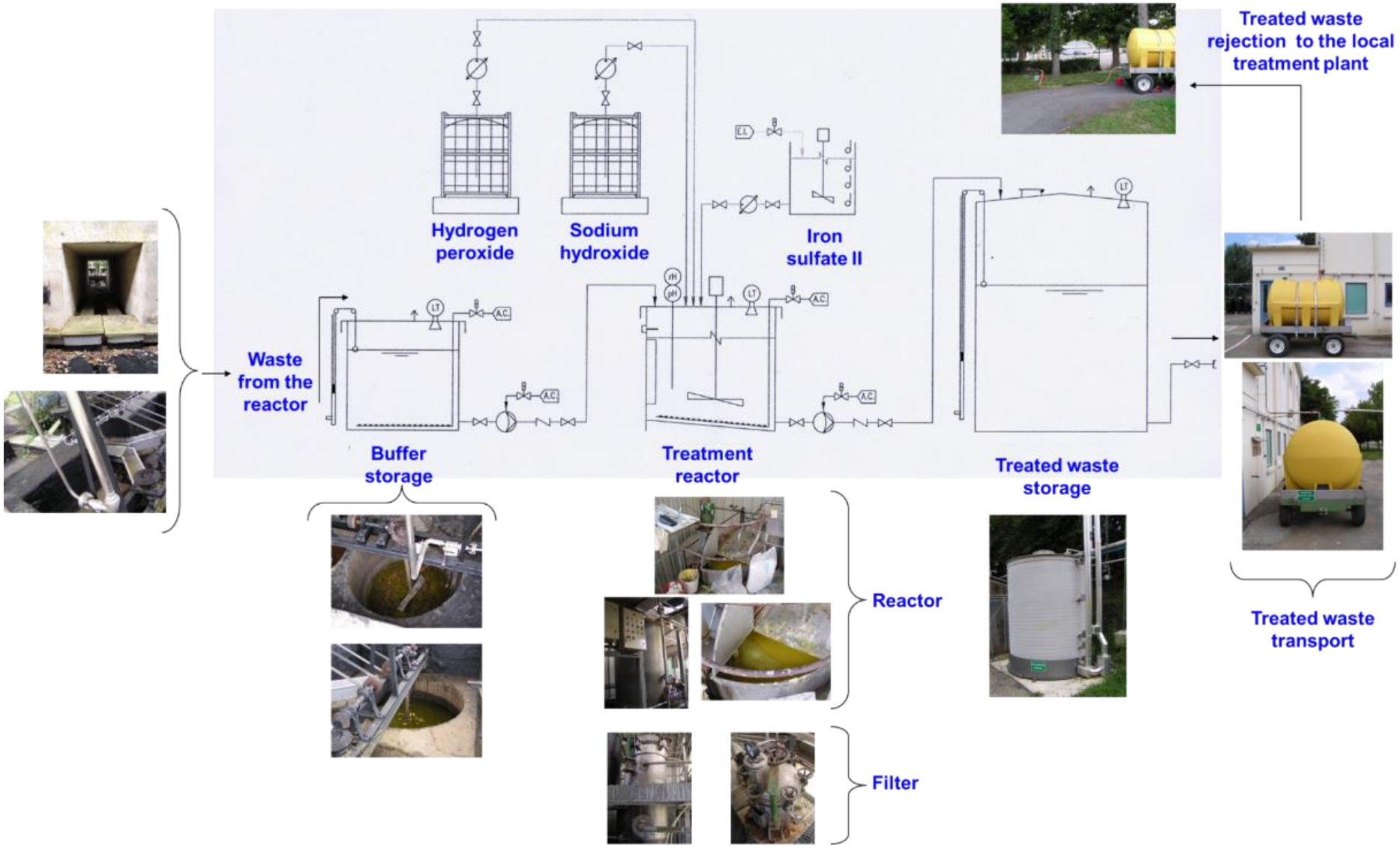
- Perform end of use :
  - Pyrotechnics : burning => impact calculated like U phase
  - Metallic parts :
    - Recycling after depollution if in contact with pyrotechnic (burning)
    - Direct recycling if no contact with pyrotechnic
  - Plastic :
    - Recycling if no contact with pyrotechnic
    - Destruction in case of contact with pyrotechnic

→ - Take into account new process
- Company RETEX

Implementation data base by DAVEY BICKFORD

GROUPE DE TRAVAIL DE PYROTECHNIE

- **Primary explosive synthesis: liquid waste treatment [EUROPYRO 2019]**
  - Data for waste treatment :analysis of process and energy consumption



Implementation data base by LACROIX

➢ Implementation of a fixed fee for activities carried out internally by Lacroix

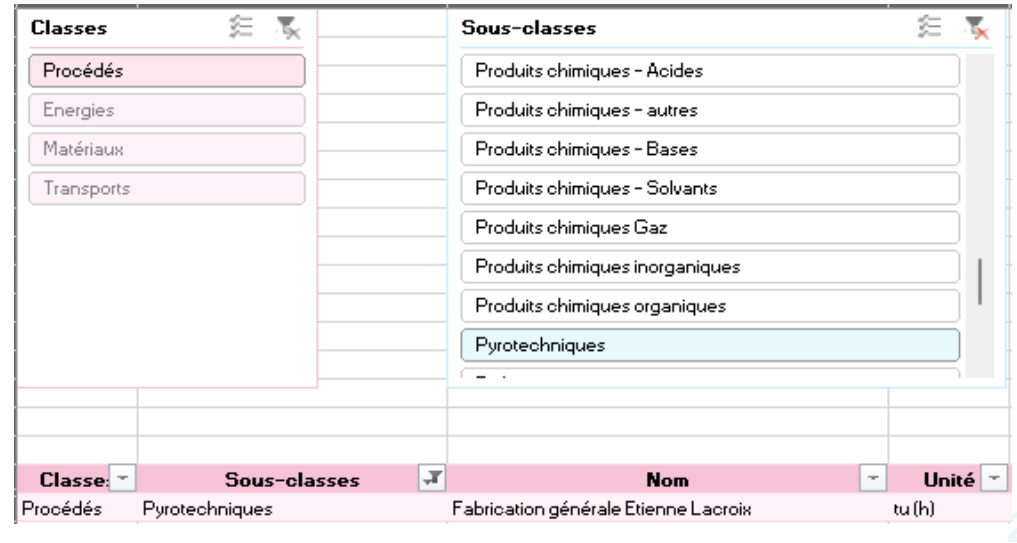
Study of consumptions (1 year)

Analysis of production (1 year)

Fixed fee / 1h

LACROIX

Addition to the Eco-pyro database



The methodology will be detailled by Camille ESCANDE/LACROIX tomorrow afternoon

Implementation data base by KNDS Ammo France

➢ Process analysis following manufactoring data

Energy, water, time for one production of x ammo => data for 1 ammo

	Malaxage	Coulée
Electricity comsumption (electric power * time)/number ammo)	48,71 W	2389,11 W
Water consumptions	2,64 dm^3	
Wastes (soiled rags)	0 ,2 kg	

➢ Process from literature

- RDX : Procédé BACHMANN :

4 HNO3 + 2 NH4NO3 +6 CH3CO2 + Hexaméthylène tetramine => RDX +12 CH3COOH

Hexaméthylène tetramine : 6 formaldéhyde + 4 NH3

- TNT : 3 steps according to the Schmid-Meissner process : mononitration, bi and trinitration

Masse (g)	Quantité	Distance (km)	Composant +Emballage- Matériaux
214,2	214,2	50	H2SO4
88,2	88,2		HNO3
12,6	12,6		Toluene
400	0,3087	50	Eau potable au robinet
20	2		Electricité nucléaire France

GROUPE DE TRAVAIL DE PYROTECHNIE

Conclusion

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- Commission Ecoconception from GTPS
  - Ecodesign methodology
  - Ecodesign tool EcoPyro specific for pyrotechnics