LCA comparative analysis of different technologies for functional coating in food applications

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Environment Park S.p.A. – Turin, Italy

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SUMMARY

- PROJECT FRAME AND AIMS
- LCA METHODOLOGY
- BOUNDARIES, F.U & INVENTORY
- RESULTS
- FINAL COMMENTS

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Environment Park S.p.A.

Environmental Scientific and Technological Park

Born by initiative of Regione Piemonte, Provincia di Torino, Comune di Torino, in a wide industrial dismissed area

Environment Park has been realized in the context of European Union Structural Funds and nowadays is an Joint Stock company receiving most of the capital from public organizations as: Comune di Torino, Finpiemonte S.P.A., SMAT, AMIAT, IRIDE ENERGIA, CCIAA di Torino, Unione Industriale, Provincia di Torino, Università di Torino

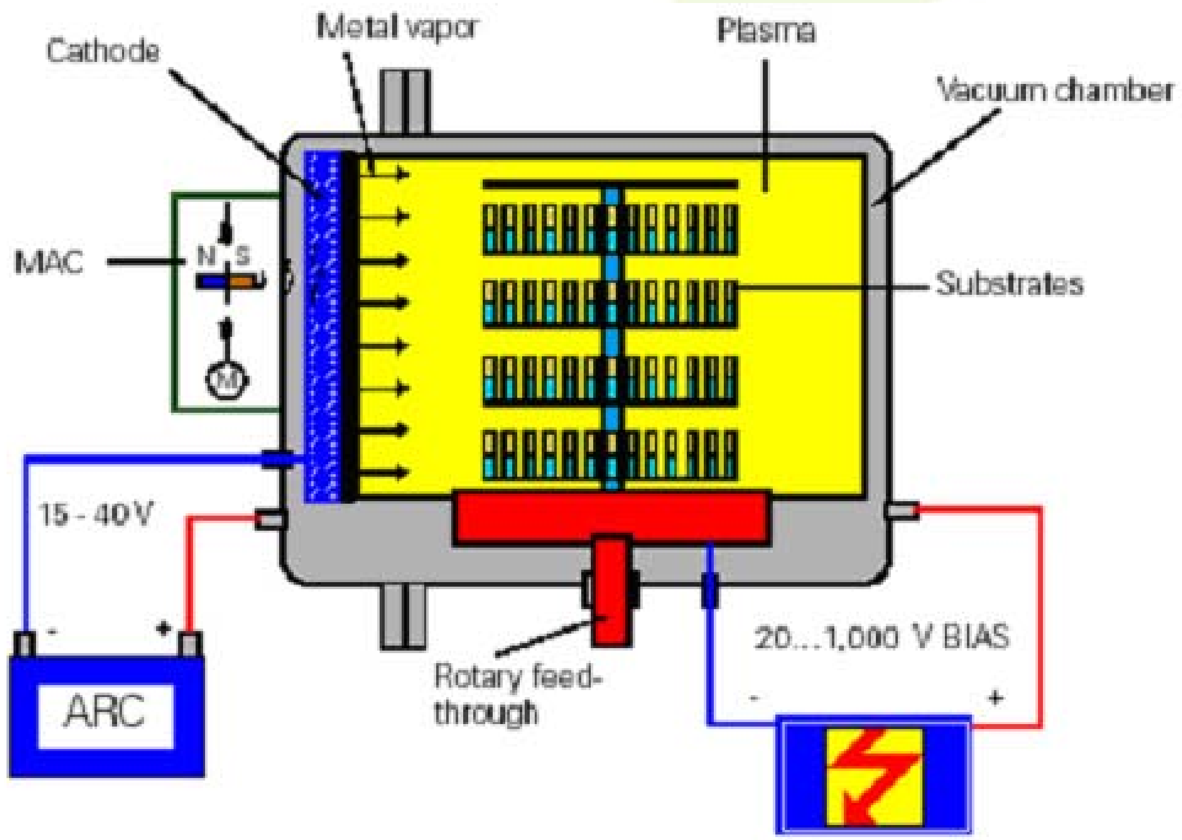
Environment Park site contains Research and Development organizations as well as companies working on eco–efficient and innovative technologies.

PROJECT FRAME

Clean NT Lab PVD deposition facilities

Plasma Vapour Deposition (PVD) Arc-DC facility for the development of innovative ceramics coatings to be deposited on conductive thermo-resistant metals and alloys – (process temperature >160°C)

SCHEMATICS OF PVD DEPOSITION SETUP



PROJECT AIMS

Investigate the available and future technologies for surface functionalisation to obtain anti corrosion properties, on a comparative basis with specific reference to their environmental life-cycle burden

Compare alternative technologies for surface functionalisation – process analysis

Estimate the overall environmental burden for each technology through LCA Analysis

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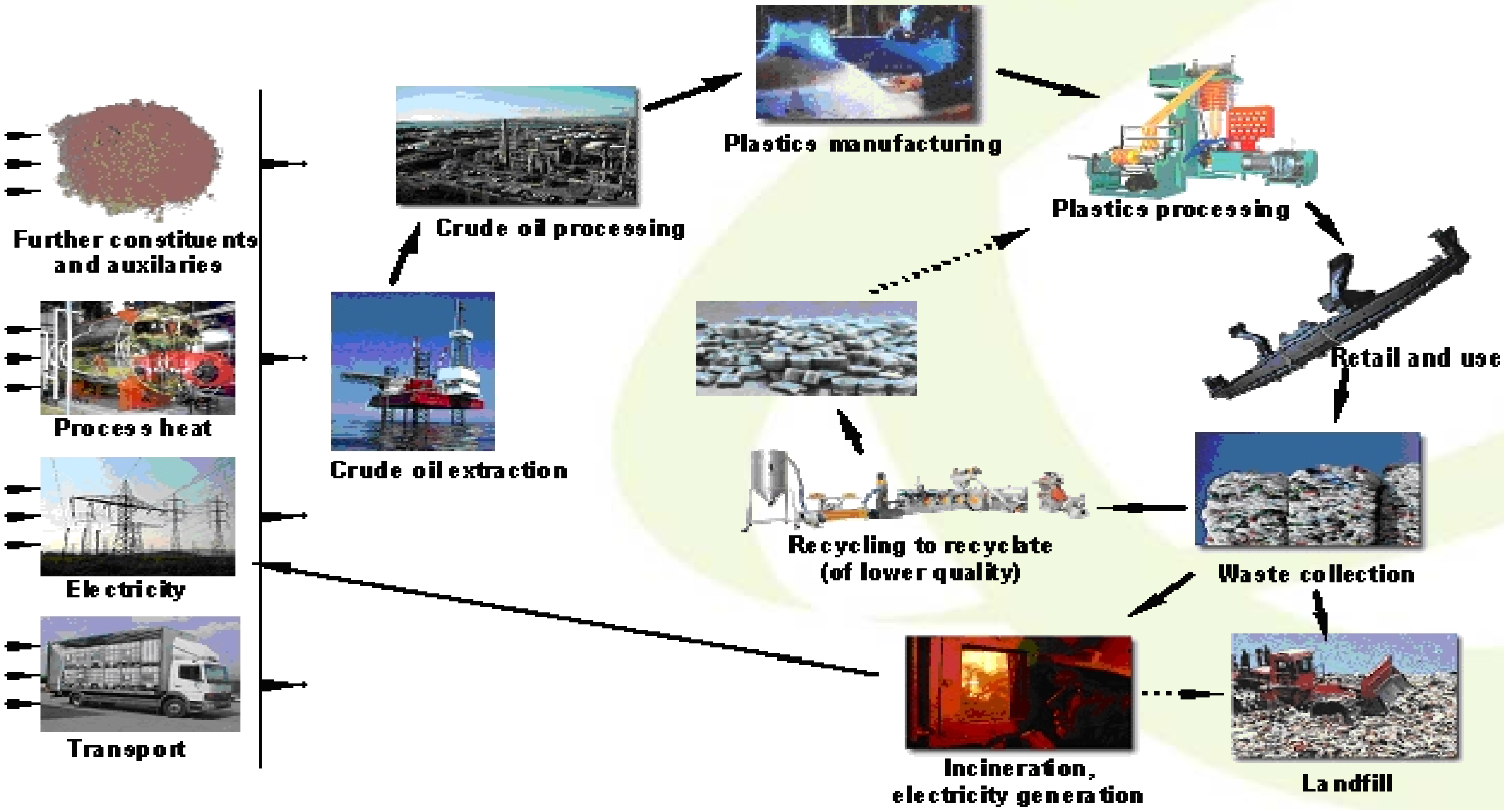
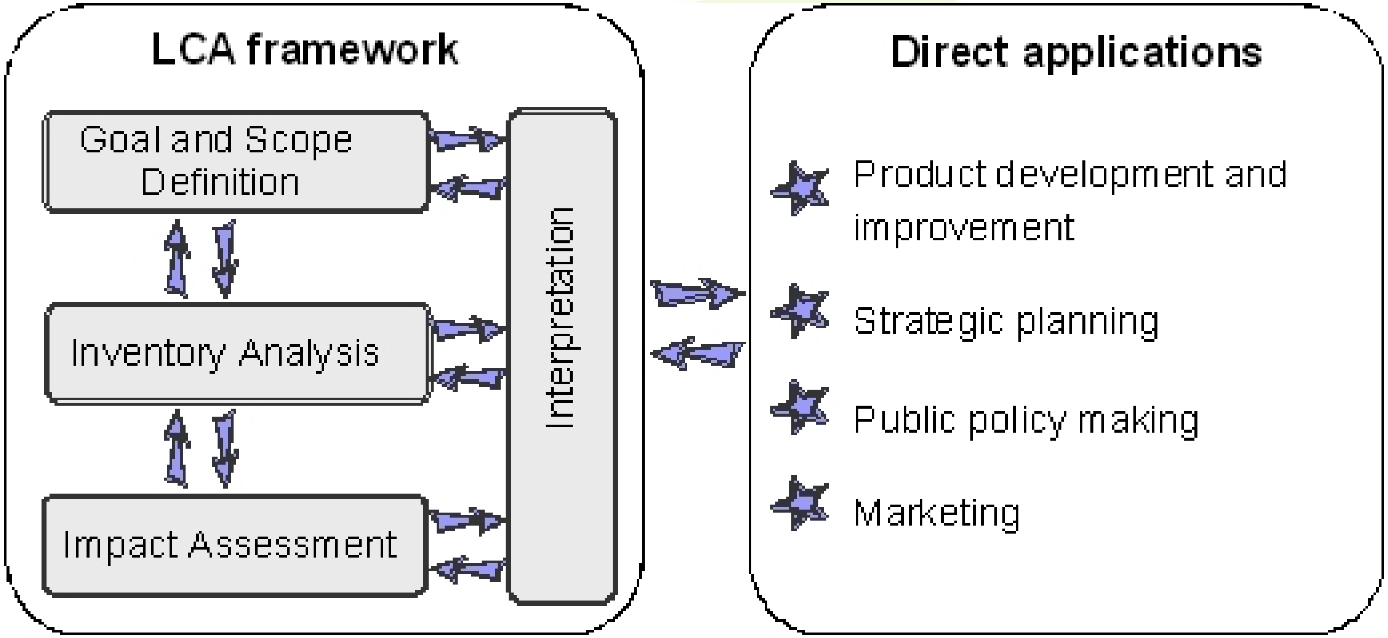
What is LCA? From cradle to…

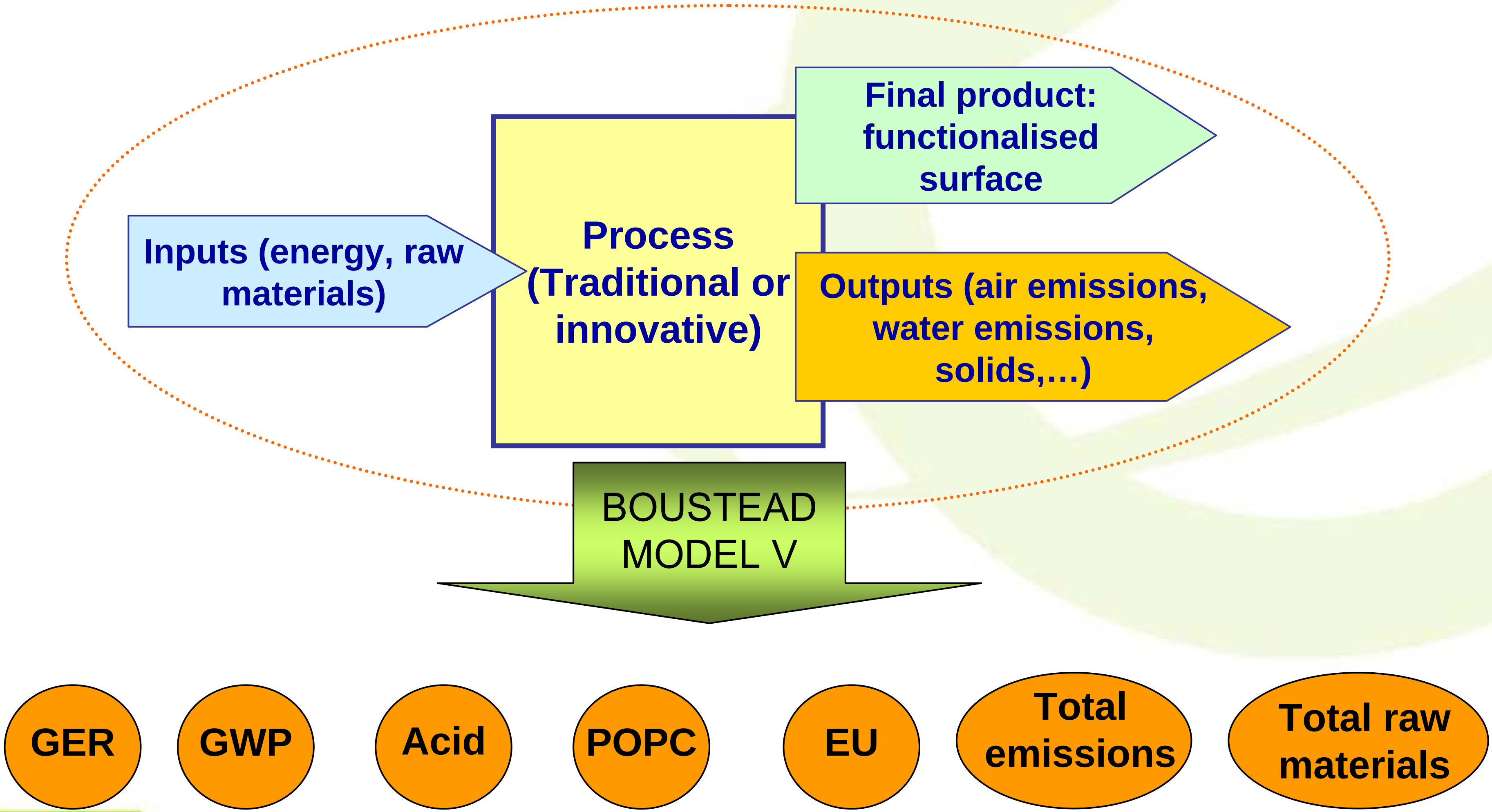


LCA is a technique for assesssing the environmental aspects and potential impacts associated with a product/process, by **compiling an inventory** of relevant inputs and outputs of a product system, **evaluating the potential environmental impacts** associated with those inputs and outputs, **interpreting** the results in relations to the objectives of the study.

LCA STEPS : ISO 14040- 44



LCA Methodology



LCA Methodology- glossary

- **Global Warming Potential in 100 years (GWP100):** index used to measure the global warming, that is the phenomenon, whereby CO2 in the atmosphere, along with others compounds, absorbs infra-red radiation emitted from the Earth's surface giving rise to an increase in temperature. In others words, GWP is the measure, based on concentration and on exposition time, of the potential contribute that a substance causes to greenhouse effect as to that caused by the same weight of CO2. The standardisation of global warming is made reporting the amounts of the inventoried substances to g of CO2-equivalents.
- **Acidification Potential (AP):** index used to measure the acidification impact into the atmosphere and water courses caused by the release of hydrogen ions. The standardisation of acidification is made reporting the amounts of the inventoried substances to g of H+equivalents.

- **Eutrophication Potential (EP):** index used to measure the nutrient enrichment (eutrophication), which in turn may result in algal blooms, caused by the release of sulphur nitrogen, phosphorous and degradable organic substances into the atmosphere and water courses. The standardisation of eutrophication is made reporting the amounts of the inventoried substances to g of O2equivalents.
- **Ozone Depletion Potential (ODP):** index used to measure the breakdown of the stratospheric ozone layer, which should protect from ultraviolet radiation, caused by the emissions of reactive substances mainly originated from Chlorofluorocarbons (CFC). The standardization of Ozone depletion is made reporting the amounts of the inventoried substances to g of CFC-11-equivalents.
- **Energy mix:** the balance between various sources of energy in primary energy consumption (i.e. France vs Italy)

- **GER:** is the Gross Energy Requirement, that is to say, the total amount of energy required by the process/product in study referred to direct energy,indirect energy, transport energy, feedstock energy.

PROJECT SCENARIOS

The main objective of this work is to calculate the energy and environmental burdens generated by ceramics PVD-, SiOx Plasma-. and Chromium electroplating- coating processes using different energy mixes.

In detail, data, calculation procedure and results refer to:

- PVD Arc DC ion-plating equipment;
- SiOx deposition from plasma experimental process carried
- Chromium electroplating process performed by typical electroplating process

LCA ANALYSIS - HYPOTHESIS

For the GER (Gross Energy Requirement) results it has been taken into account the values of the energy consumption referred to the European Energy Mix. When stated, it has also been considered the Italy Energy Mix and France Energy Mix

	Italy Mix	*Europe Mix*	*France Mix*
Coal	12%	27%	7%
Fuel	34%	8%	2%
Gas	34%	16%	1%
Hydroelectrics	10%	6%	7%
Nuclear	9%	39%	82%
Other sources	1%	2%	1%

LCA ANALYSIS - HYPOTHESIS

- Indirect energy for Natural Gas consumption have been considered using Italy scenario

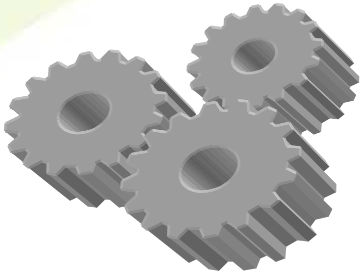
- All the values are referred to the established Functional Unit (F.U.)

- The analysis does not take into account the production of the substrates, tools and machinery for the process, nor industrial systems

- The results regard the environmental point of view. No budget considerations at that point.

More specific hypothesis are described for each case study

SUMMARY



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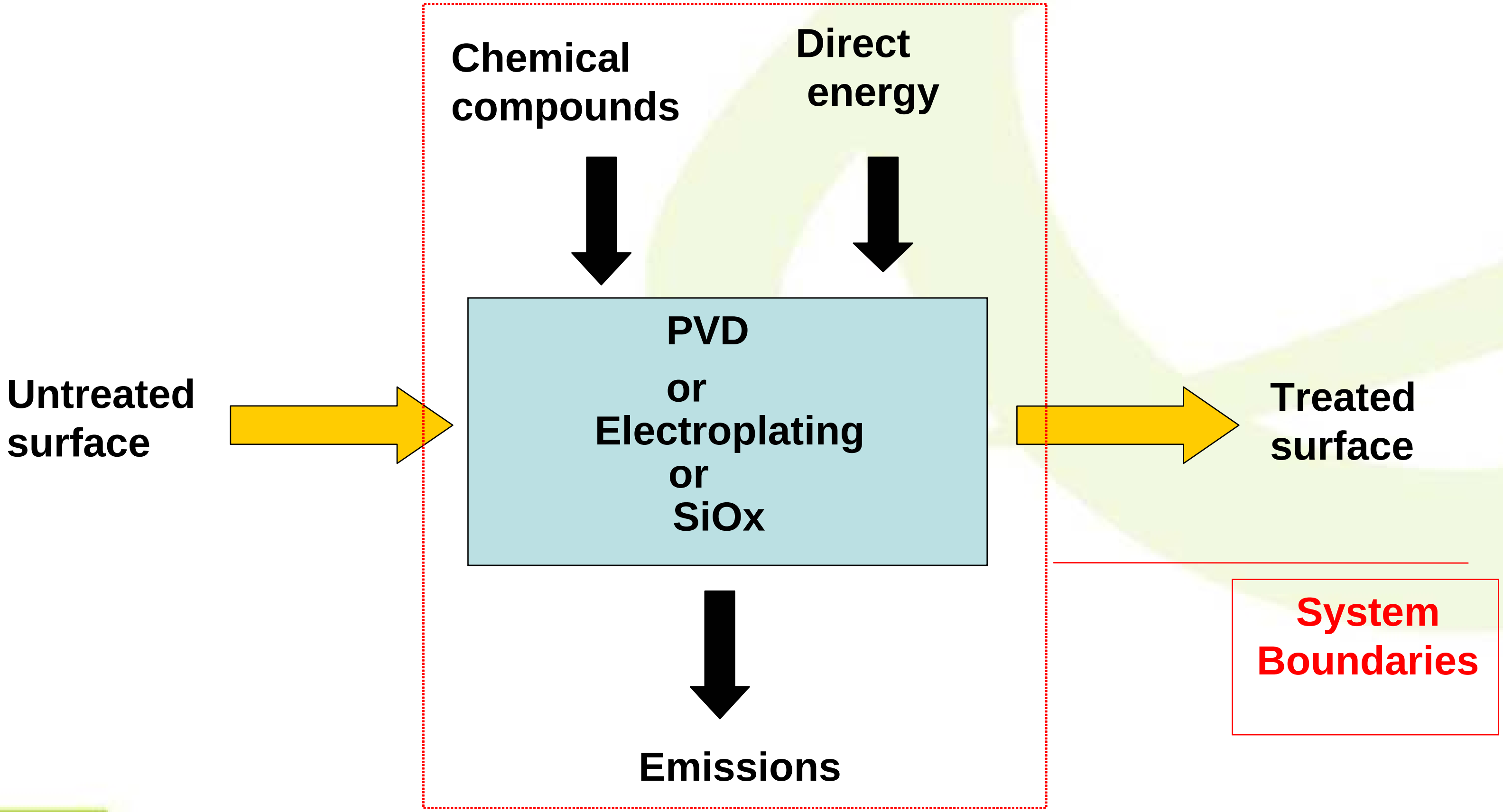
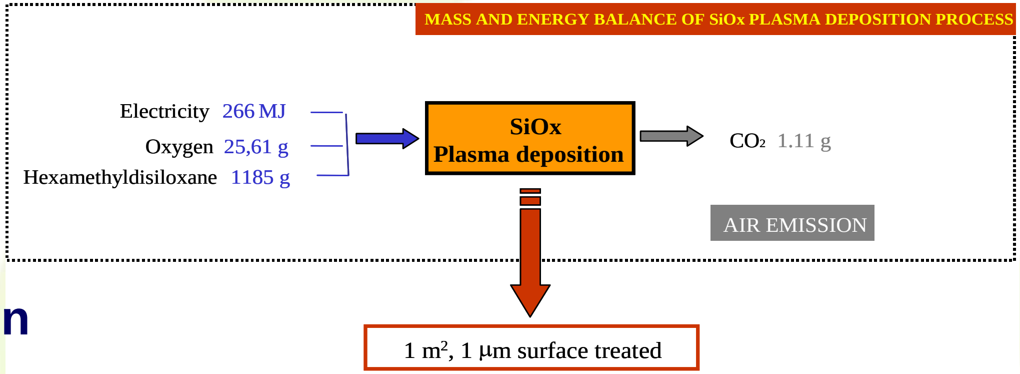
System Boundaries

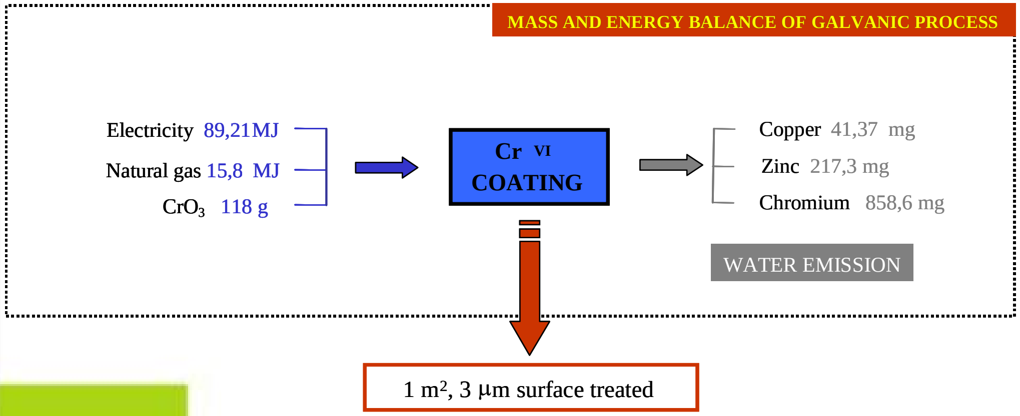


Anti corrosion coatings for food industry applications (traditional and SiOx deposition)

Comparing:

- Traditional Cr plating
- SiOx Plasma deposition
- TiN/TiCN PVD plasma deposition

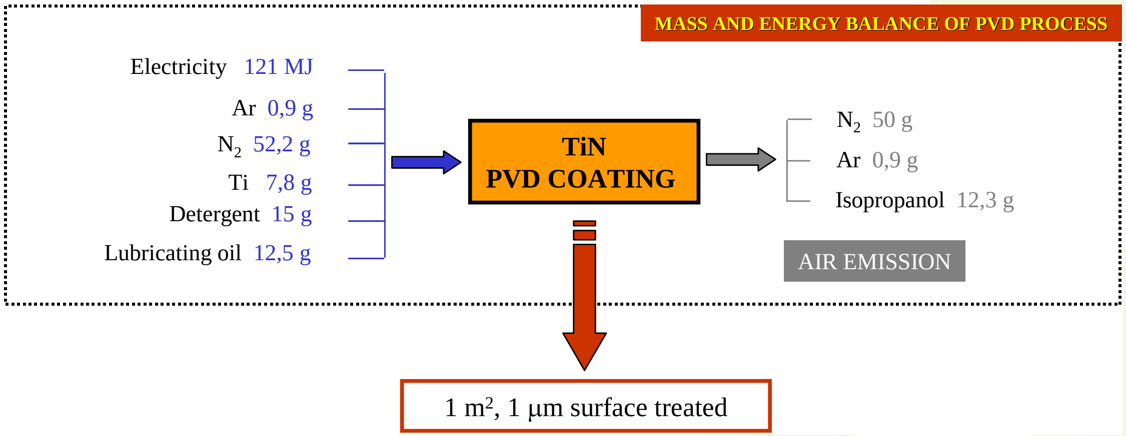


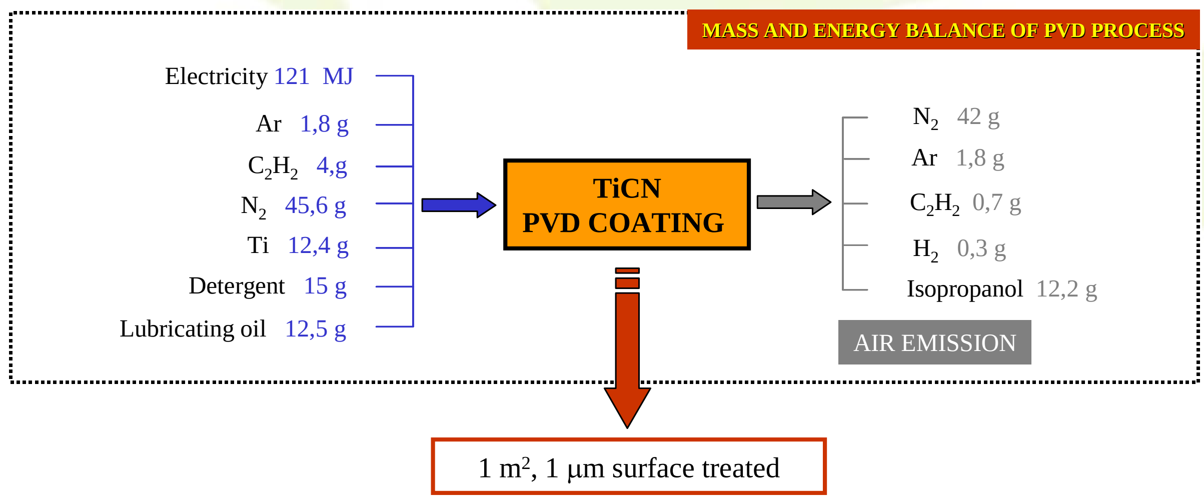


Extra hypothesis:

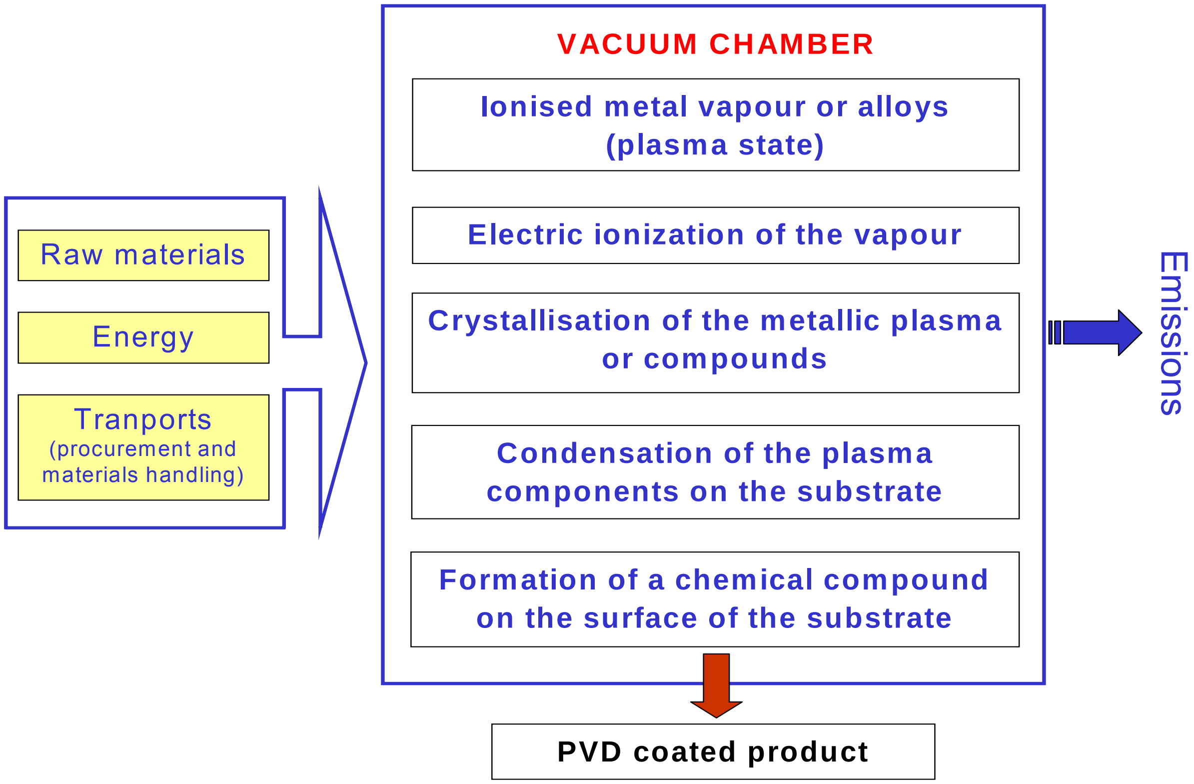
- Comparing 3 different energy mix (Italy, France, Europe)
- F.U.= 1 m2 x 1µm or 1m2 x 3µm

Case study - anti corrosion coatings for food industry applications- PVD deposition





PVD process scheme



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RESULTS

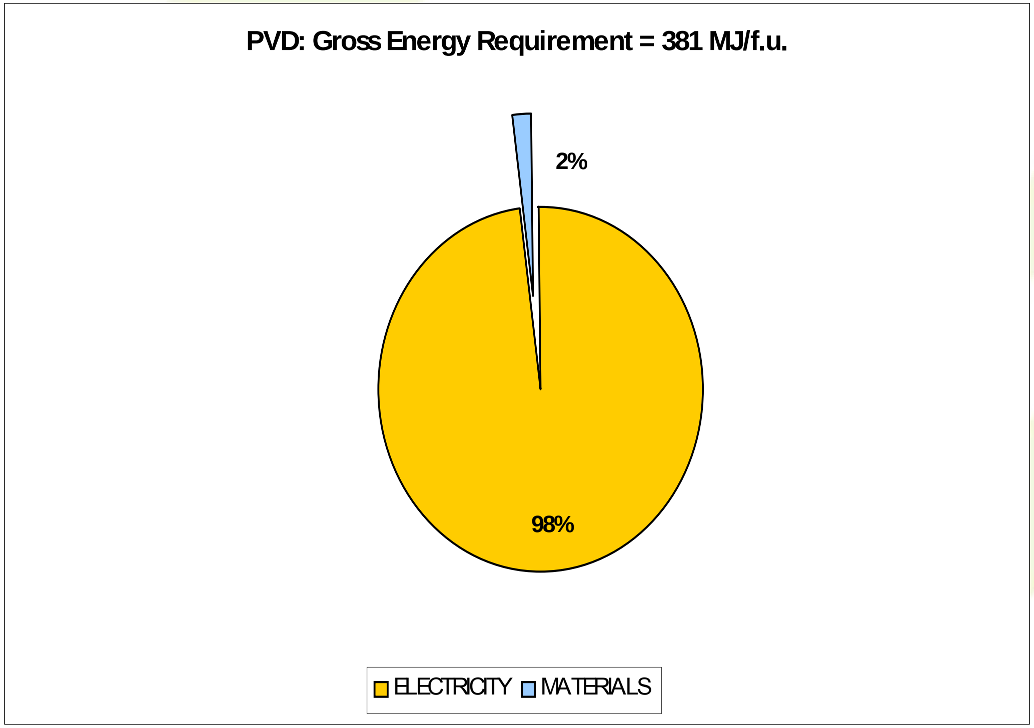
Energy consumption

Treatment GER[MJ/ f.u.]	Production energy	Energy Use	Transport energy	Feedstock energy	Total energy
PVD- TiCN Italy Mix	255	124	2	0	381
PVD- TiCN Europe Mix	248	124	2	1	375
PVD- TiCN France Mix	255	124	2	1	381
PVD- TiN Italy Mix	255	124	2	0	381
PVD- TiN Europe Mix	248	124	2	1	375
PVD- TiN France Mix	255	124	2	1	381
CrVI Galvanic Italy mix	187.3	115	2,5	0,9	306
CrVIGalvanic Europe mix	187,3	115	2,5	0,9	306
CrVI Galvanic France mix	182.3	115	2,5	0,9	300
SiOx plasma Italy mix	607	348	6	41	1002
SiOx plasma Europe mix	587	348	6	41	982
SiOx plasma-France mix	607	348	6	41	1002

Energy major consumption- contributors

Considering the contribution on the GER of the raw materials used in each process firstly it should be said that this is not significantly related to the energy mix. Respectively, the contributions of the raw material represent:

- 17 % of the GER in SiOx deposition process (hexamethyldisiloxane production)
- 1.5-2% of the GER in PVD process (titanium production)
- 4% of GER in Chromium electroplating process (production of CrO_3)



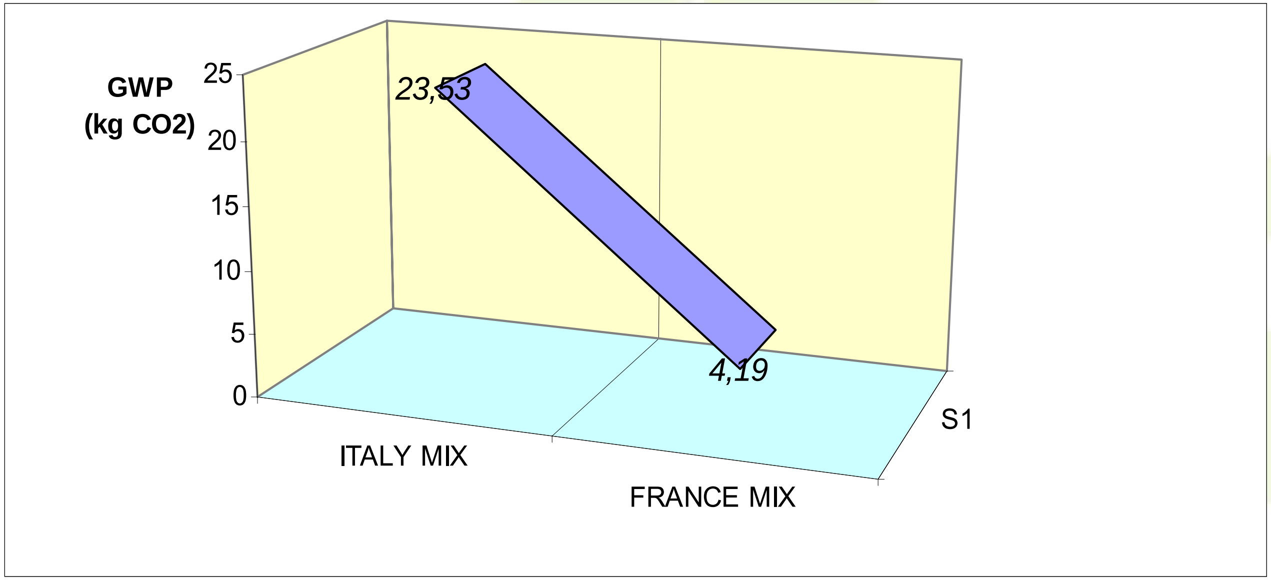
RESULTS

Anti - corrosion treatments
Environmental Paramters

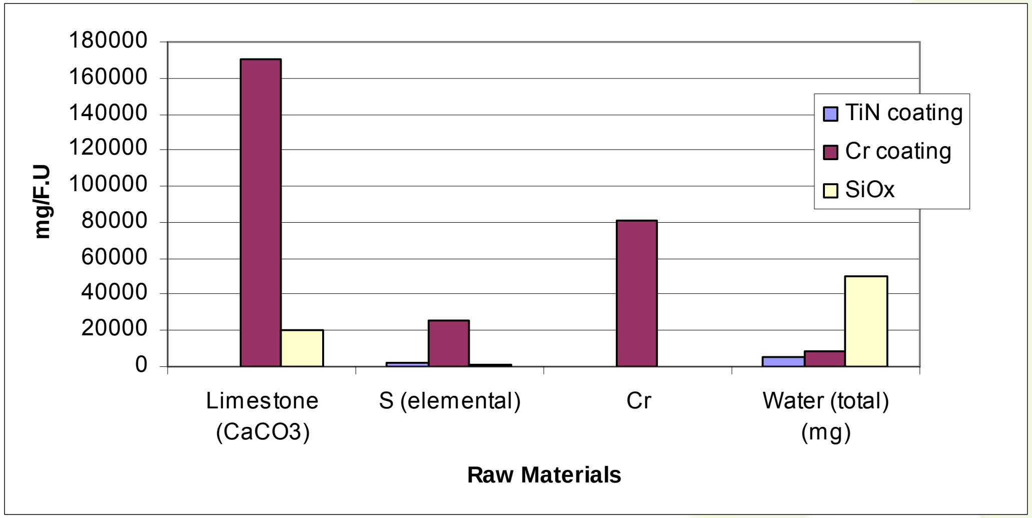
TREATMENT	GWP (kg CO2)	AP (g eq SO2)	POPC (g C2H4)	EU (g PO43)
PVD - TiCN Italy Mix	23,53	276,79	32,75	8,76
PVD - TiCN Europe Mix	17,36	140,63	15,32	5,98
PVD - TiCN France Mix	4,19	38,88	7,45	1,71
PVD- TiN Italy Mix	23,39	245,47	32,38	8,71
PVD- TiN Europe Mix	17,22	139,32	14,95	5,93
PVD- TiN France Mix	4,05	37,6	7,08	1,66
CrVI Galvanic Italy mix	18.93	210.52	22.44	6.92
CrVI Galvanic Europe mix	14.38	110.13	9.59	4.86
CrVI Galvanic France mix	4.76	35.68	3.60	1.73
SiOx plasma Italy mix	59,78	718,75	75,99	22,92
SiOx plasma Europe mix	46,21	419,44	37,66	16,8
SiOx plasmaFrance mix	17,38	197,35	20,54	7,46

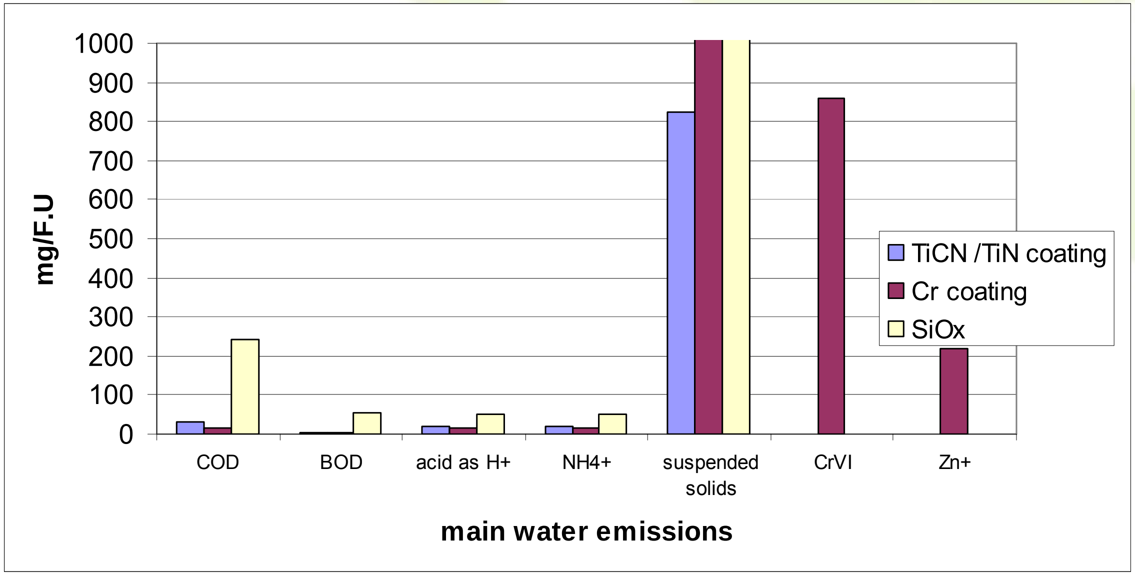
Energy mix contribution to GWP

The energy mix cleary affects the GWP parametrer.



Raw materials consumption and water emissions





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Chromium plating process determines a huge local or localised environmental burden while PVD and plasma deposition of SiOx determine a greater environmental burden on global scale.

− The energy mix does not affect significantly the energy consumption for the same process

− Cr coatings requires less process (direct) energy (115 MJ/f.u.) respect to the PVD/plasma processes (124 MJ/f.u.) and 348 MJ/f.u. This is especially relevant for the electricity consumption: the Cr process requires only 89.2 MJ el/f.u. while the PVD process 122 MJ el/f.u and SiOx 288 MJ/f.u .

−The energy mix to produce electricity is therefore relevant to define the environmental burden of the two systems.

− In the case of PVD, the use of renewable electricity sources and the increment of the process efficiency could be a good way to improve the environmental performances.

FINAL COMMENTS

- From a local environmental point of view, the PVD process avoids the direct emissions of metals (Cr, Zn and Cu in particular) but it generates an indirect contribution from the electrical power plant.
- Furthermore, it should be remarked that input data used for Chromium electroplating are very conservative, as it has not been considered that for a productive process of technical galvanisation the concentration of CrO_3 in the electrolytic bath is in average a 30% higher than for the process considered here.
- PVD coating technology eliminates the need, risk and relevant cost of post processing since there is no emission in water and main direct emission source to air is Nitrogen. So no additional technical complexity or extra cost for by products post-treatments are required.

Thank you for your attention!

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