Eco-efficiency of technologies and products: Why is it needed? How can it be measured?

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EU sustainability challenges

- **Global warming:**

  current emission scenario -> temperature increase until 2100 around 3,5° .
  EU objective: CO2 emissions - 20 % 1990 – 2020
  IPCC recommendation and EC long term aim: not exceeding 2° ;
  corresponds to 50% reduction of CO2eq emissions worldwide, 70% in EU 1990-2050

- **Air pollution:**

  reduction of life expectancy per person ca. 3-6 months (esp. due to PM2.5);
  PM10 thresholds frequently exceeded

- **Use of non-renewable natural resources:**

  Resources become scarce and thus more expensive:
  e.g. rare earth metals, germanium, indium, platinum, gallium, tantalum, oil, gas, , lithium

Reduction of environmental pollution and resource use necessary (by a factor of 2-4)

World wide sustainability challenges

- **Population growth:**
  6 900 million 2010 -> 9 500 million 2050 (+ 38 %)
- **Poverty:**
  ‚happy life' possible from income of around 8 000€ per cap and year;
  richer people would not accept reduced income (OECD countries: 1150 million now, 1 300 million 2050)
  -> current GWP ($60*10^{12}$ US-$) has to increase by a factor of 3-4 until 2050 to be able to avoid poverty (around 3% -3,5% per year)

Substantial reduction of environmental pollution and ressource use per € of goods and services produced necessary (by a factor of 5-10)

But: what about the economic and social dimension of sustainability?

Especially end of pipe technologies, but also some process changes

- **might reduce GDP growth**
- **have a mixed influence on employment**
- **might increase inflation rate**
- **might incriminate poorer persons more than richer persons**

Employment effects of a 2.5 MW offshore wind energy plant

(Source: Bremer Energieinstitut)

People employed (in person-years)	In the 1st year	Over 20 years
Investment effect	57	57
Operation effect	1	22
Budget effect	-7	-142
Overall effect	51	-63

Assumption: Unelastic demand for electricity; reduced demand for other goods

But: what about the economic and social dimension of sustainability?

Especially end of pipe technologies, but also some process changes

- **might reduce GDP growth**
- **have a mixed influence on employment**
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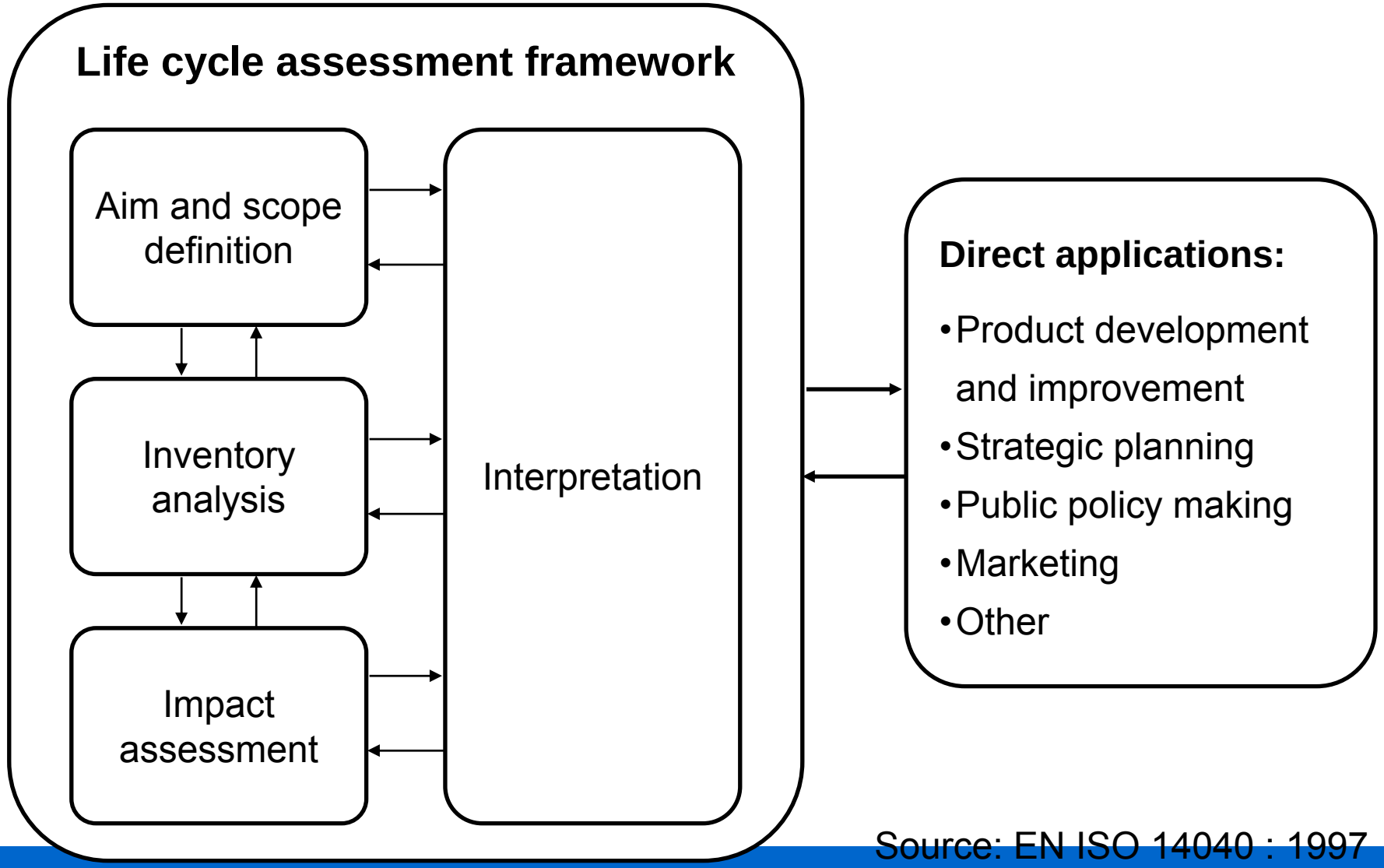
The Solution: eco-efficient products and processes

Eco-efficiency: delivery of "competitively priced goods and services that satisfy human needs and bring quality of life while progressively reducing environmental impacts of goods and resource intensity throughout the entire life-cycle to a level at least in line with the Earth's estimated carrying capacity." World Business Council for Sustainable Development (WBCSD)

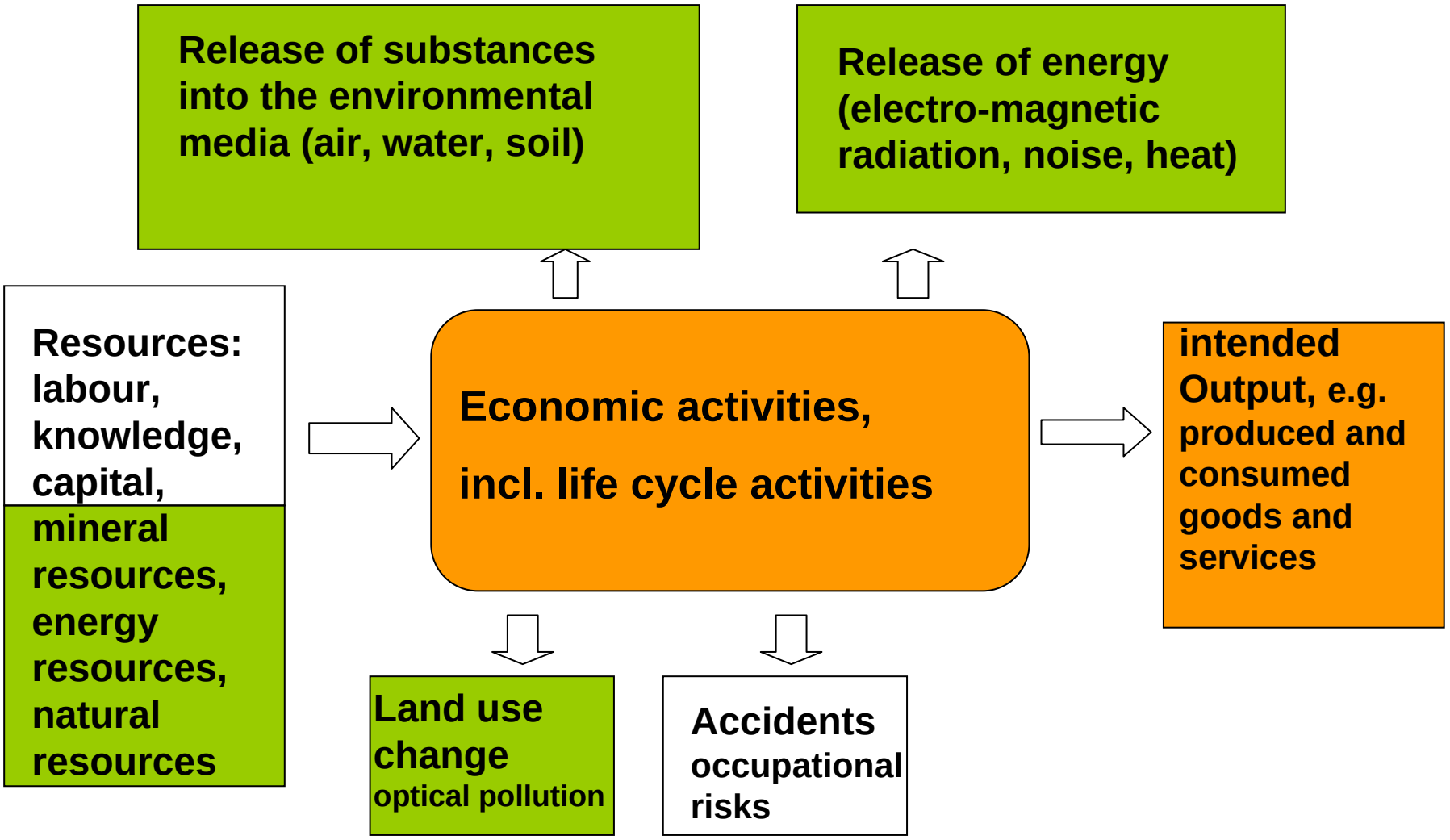
Eco-design: Ecodesign aims at designing a product with special emphasis on the environmental impacts of the product during its whole lifecycle

Eco-innovation provides 'new products and processes which provide customer and business value but significantly decrease environmental impacts'. P. James

Life cycle assessment framework

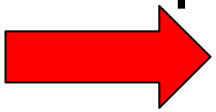


Source: EN ISO 14040 : 1997


Release of substances into the environmental media (air, water, soil)
Release of energy (electro-magnetic radiation, noise, heat)
Resources: labour, knowledge, capital,
mineral resources, energy resources, natural resources
Economic activities,
incl. life cycle activities
intended Output, e.g. produced and consumed goods and services
Land use change
optical pollution
Accidents
occupational risks

Assessment of alternative technologies

- **If all inputs and unintended outputs per unit produced decrease**



win-win situation

- **Otherwise, weighting of positive and negative impacts necessary**
- **non-monetary direct inputs and outputs (pressures, emissions), also the mid-points, can not be assessed/compared, only damages and benefits**
- **thus it is necessary to estimate the damages and avoided damages caused by the pressures to the environment (to human health, flora and fauna/ecosystems, crops, materials)**
- **damages depend on time and site of the release!**

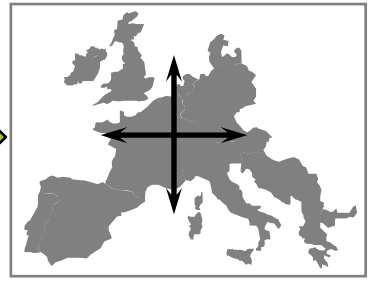
Impacts of air pollution from transport (years of life lost per 1000 t of emission) – country values

Pollutant emitted	NOx	NM VOC	SO2	PM2.5	PM2.5
Effective pollutant	O_3, Nitrates	O_3	Sulfates, Acid depos.	PM2.5	PM2.5
Local environment				urban	non-urban
Czech Republic	50	1	58	5 900	1 180
Finland	11	0,2	9	4 800	450
Belgium	57	1	81	6 200	1 470

ExternE Methodology: the Impact Pathway Appoach for Assessing Environmental Impacts, Step 1

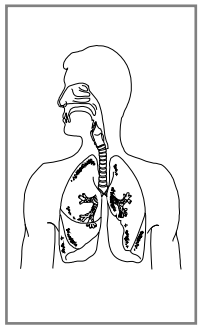
Pollutant/Noise Emission

Transport and Chemical Transformation in Air, Soil, Water, Food



Calculation is made twice: with and without project!

Differences of Physical Impacts



from scenarios of activities to pressures to damages

Examples of Concentration-Response-Relationships Used

(source: Torfs, Hurley, Miller, Rabl –NEEDS project)

Pollutant and corresponding Endpoint	CRF slope: impact per person per µg PM2.5 per m3	unit
Life expectancy reduction - YOLLchronic	6.51E-04	YOLL
net Restricted activity days (netRADs)	9.59E-03	days
Work loss days (WLD)	1.39E-02	days
Minor restricted activity days (MRAD)	3.69E-02	days

Endpoint	CRF slope: impact per person per µg PM10 per m3	unit
Increased mortality risk (infants)	6.84E-08	cases
New cases of chronic bronchitis	1.86E-05	cases
Respiratory hospital admissions	7.03E-06	cases
Cardiac hospital admissions	4.34E-06	cases
Medication use / bronchodilator use	4.03E-04	cases
Medication use / bronchodilator use	3.27E-03	cases
Lower respiratory symptoms (adult)	3.24E-02	days

Stressors considered include: PM10; PM2.5; ozone; NOx; SO2; NMVOC;NH3;CH4; N2O; CO; CO2; C14; heavy metals; pesticides; heat; fertilizers

Impacts included (I)

Impact Category	Pollutant / Burden	Effects
Human Health – mortality	PM_{10}	Reduction in life expectancy due to short and long time exposure
	SO_2, O_3	Reduction in life expectancy due to short time exposure
	Benzene, BaP, 1,3-butad., Diesel part.	Reduction in life expectancy due to long time exposure
	Noise	Reduction in life expectancy due to long time exposure
	Accident risk	Fatality risk from traffic and workplace accidents
Human Health – morbidity	PM_{10}, O_3, SO_2	Respiratory hospital admissions
	PM_{10}, O_3	Restricted activity days
	PM_{10}, CO	Congestive heart failure
	Benzene, BaP, 1,3-butad., Diesel part.	Cancer risk (non-fatal)
	PM_{10}	Cerebrovascular hospital admissions, cases of chronic bronchitis, cases of chronic cough in children, cough in asthmatics, lower respiratory symptoms
	O_3	Asthma attacks, symptom days
	Noise	Myocardial infarction, angina pectoris, hypertension, sleep disturbance
	Accident risk	Risk of injuries from traffic and workplace accidents

Impacts included (II)

Impact Category	Pollutant / Burden	Effects
Building Material	SO_2, Acid deposition	Ageing of galvanised steel, limestone, mortar, sand-stone, paint, rendering, and zinc for utilitarian buildings
	Combustion particles	Soiling of buildings
Crops	SO_2	Yield change for wheat, barley, rye, oats, potato, sugar beet
	O_3	Yield change for wheat, barley, rye, oats, potato, rice, tobacco, sunflower seed
	Acid deposition	Increased need for liming
	N, S	Fertilising effects
Global Warming	CO_2, CH_4, N_2O, N, S	World-wide effects on mortality, morbidity, coastal impacts, agriculture, energy demand, and economic impacts due to temperature change and sea level rise
Amenity losses	Noise	Amenity losses due to noise exposure
Ecosystems	Acid deposition, nitrogen deposition	Acidity and eutrophication (avoidance costs for reducing areas where critical loads are exceeded)

ExternE methodology: the Impact Pathway Approach

Pollutant/Noise Emission

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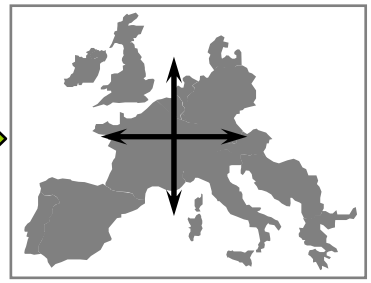

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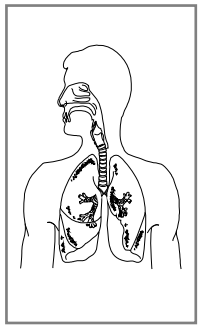


Monetary Valuation

Assessment of Damages

- **Step 1: the exceedance of essential thresholds should be avoided at any costs, safe minimum standards should be kept.**

- **Step 2: Assessment of impacts is based on the (measured) preferences of the affected well-informed population**

This implies:

Available information should be explained before measuring preferences

Increase of monetary values with time: income elasticity of 0.7-1.0

Weighting factors are expressed as monetary values **(e.g. €2010)** :

Not absolutely necessary, but has advantages:

->allows transfer of values, units are conceivable, direct use of results in CBA and for internalising via taxes possible

- ***-> however: 'utility points' would give the same results***

Valuation methods for non-market goods

Revealed Preference (RP)
behaviour (shown in the past)

Stated Preference (SP)
surveys (about future behaviour)

Indirect valuation

assesses costs or efforts that can be linked to the non-market good

- **Hedonic Price Method**
- **Averting Behavior Method (including past decisions about abatement policies)**
- **Travel Cost Method**
- **Contingent Behavior Method**

Direct valuation

- **Contingent Valuation Method (CVM)**
- **Attribute Based Choice Modeling (ABCM)**
- **Participatory approaches**
- **Surveys for preferences of public decision makers**

Benefit Transfer or Value Transfer

Adjustment and use of monetary values, that have been surveyed in another study, in the own analysis (even if other site, time, context).

Easiest possibility: use of same specific value (unit value transfer): hoever does not account for differences in income, culture, perception,..

Alternativ: income adjustment:

$$B_{neu} = B_{Original} * (Y_{neu} / Y_{Original})^{ß}$$

B= benefit ; Y = income per capity,

Usually PPP (purchase power parity) adjusted income is used.

Monetary Valuation: recommended central values for the EU

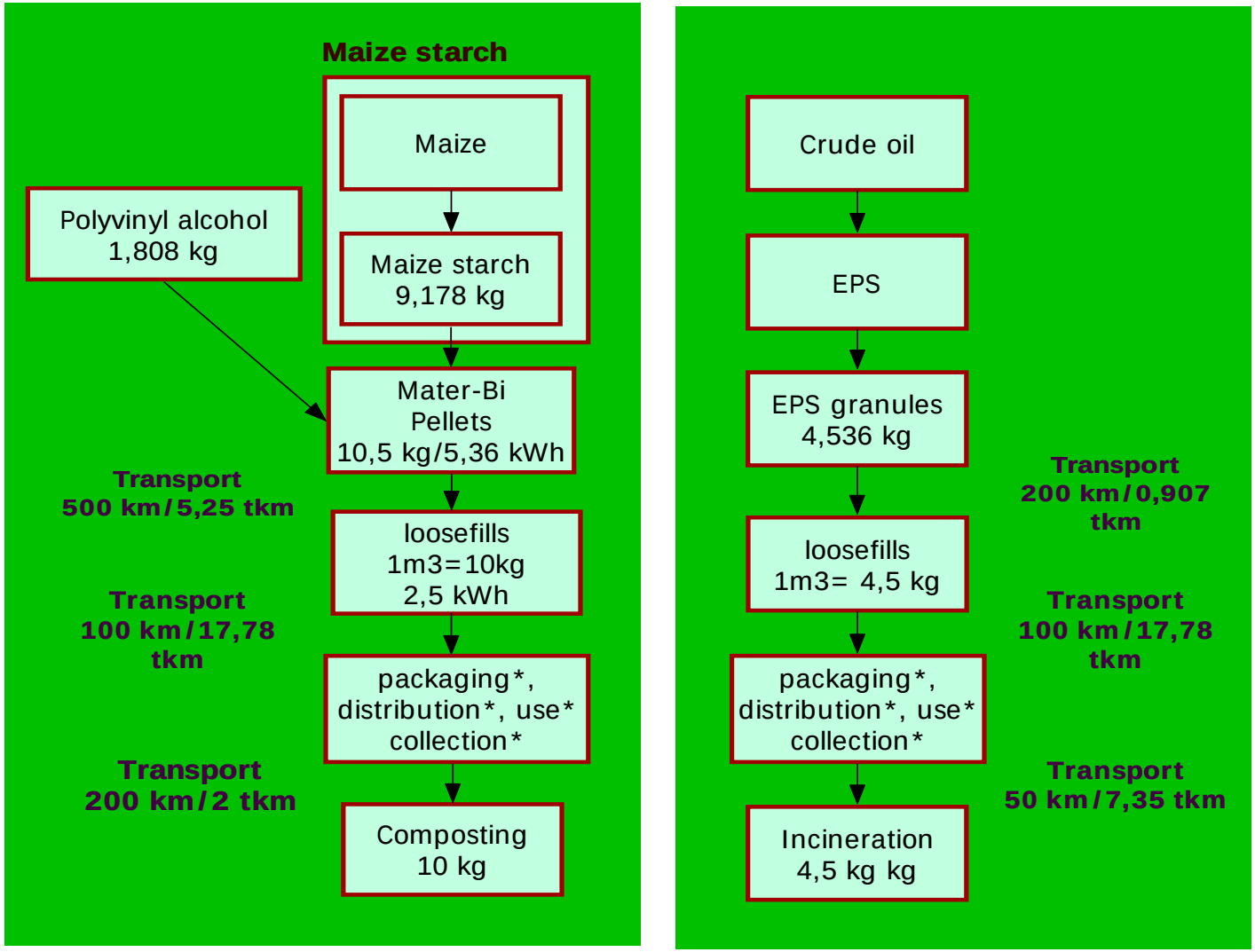
Health end-points	Euro per case / per YOLL
Increased mortality risk (infants)	3,000,000
New cases of chronic bronchitis	200,000
Increased mortality risk - YOLLacute	60,000
Life expectancy reduction - YOLLchronic	40,000
Respiratory hospital admissions	2,000
Cardiac hospital admissions	2,000
Work loss days (WLD)	295
netto Restricted activity days (netRADs)	130
Minor restricted activity days (MRAD)	38
Lower respiratory symptoms	38
LRS excluding cough	38
Cough days	38
Medication use / bronchodilator use	1

Example: Comparison of ”MATER-BI® with conventional expanded polystyrene loose-fill

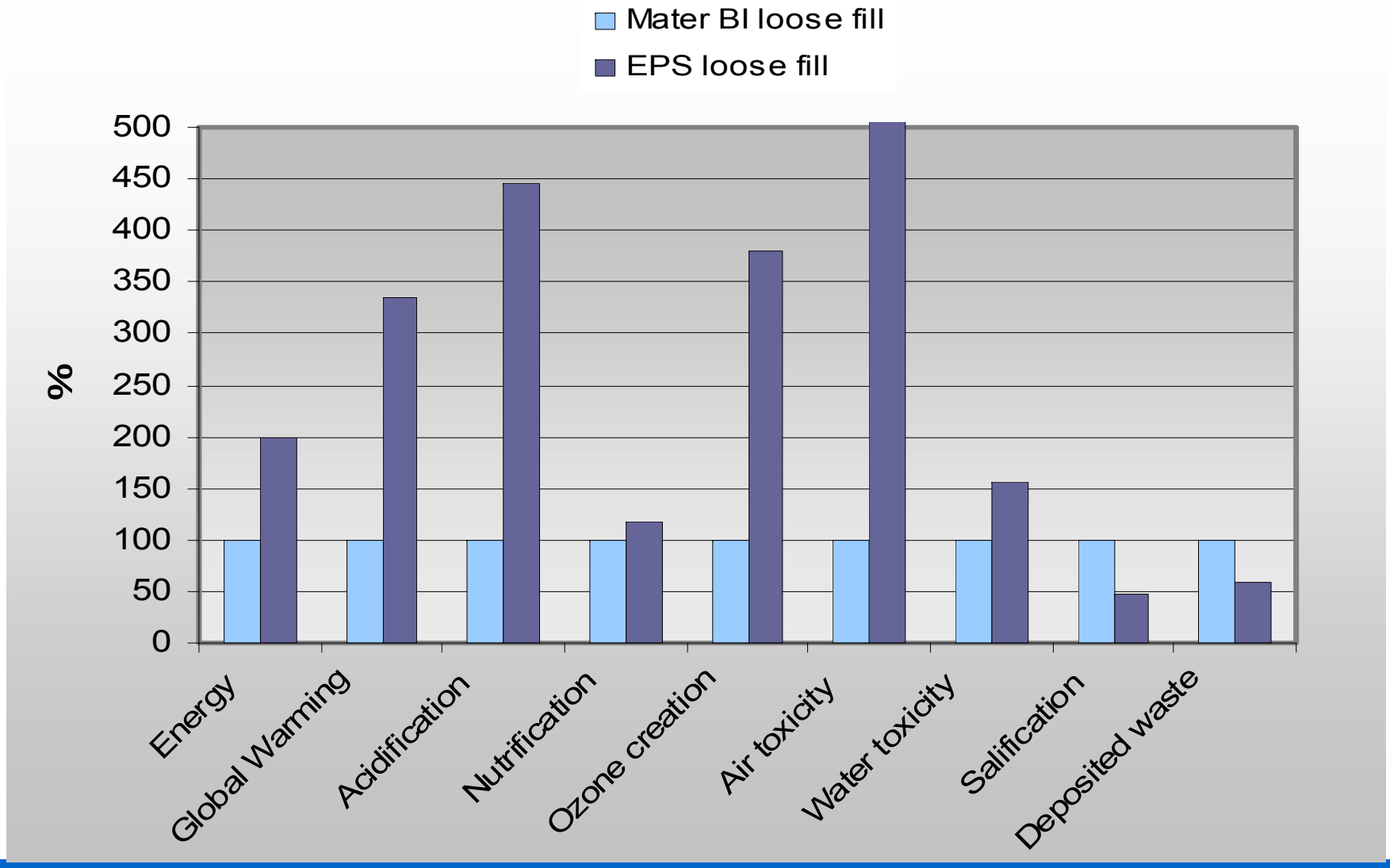
source: EC project ECOSIT, coordinator ISIS Rome,
producer of MATER-BI: Novamont SpA
LCA by Novamont SpA

- **Alternative loose-fill packaging product**
  i. **Made from starch grown in corn**
- **Advantages over conventional fillers;**
  i. **Fully renewable source**
  ii. **Totally biodegradable within ten days**

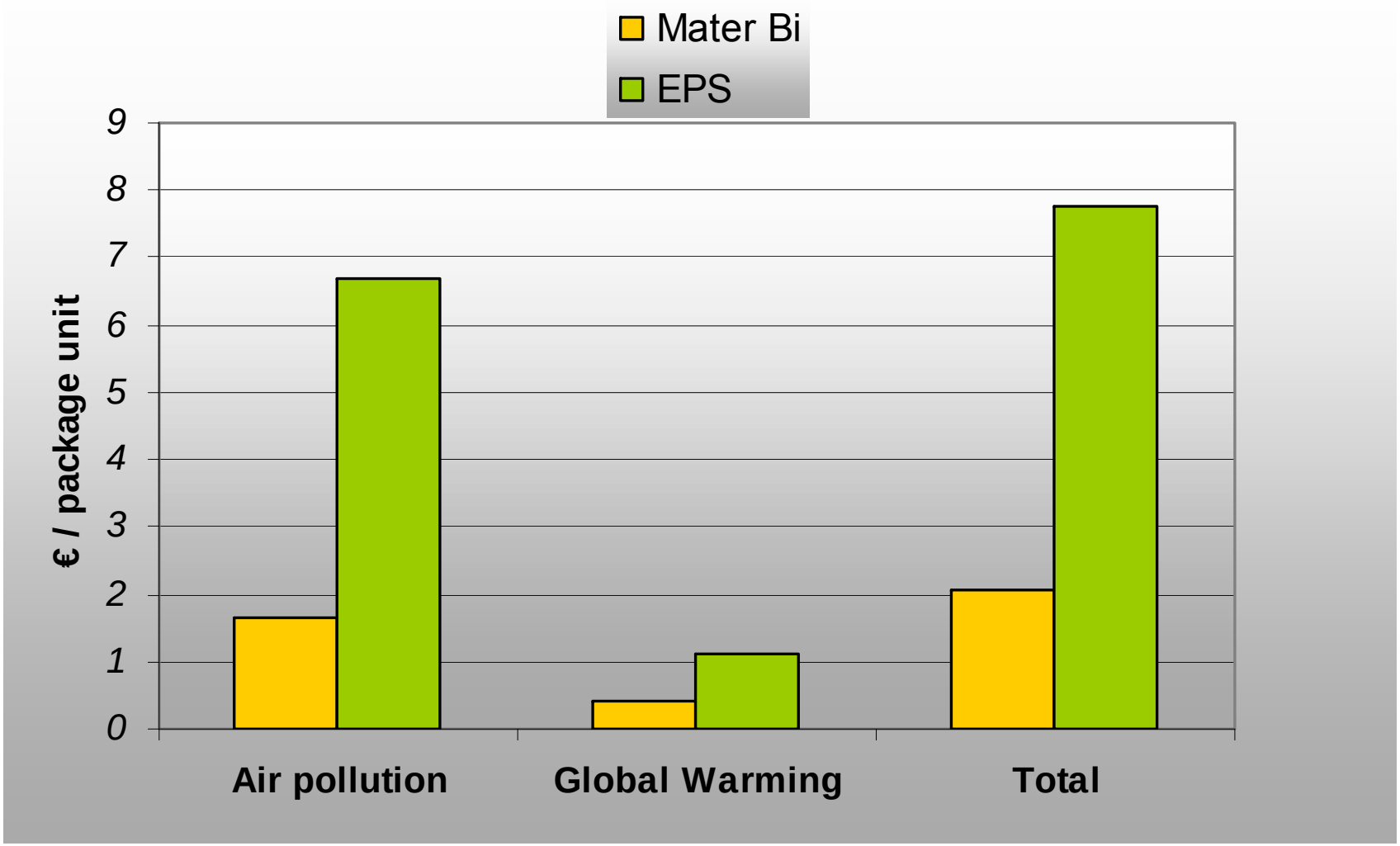
system boundaries for the LCA of Mater-BI® and EPS



relative performance of EPS against Mater-Bi® (for which values are set to 1).



External costs caused by Mater-Bi® and EPS production per package unit (1 m³)



Cost-Benefit-Analysis (prices and costs 2002)

source : EC DG research project ECOSIT, ISIS Rome, Novamont SpA

	Matter Bi®	EPS
Price per m^3	**20-22 €**	**14-17 €**
External costs per m^3	**2 €**	**8 €**
Sum	**22-24 €**	**22- 25 €**

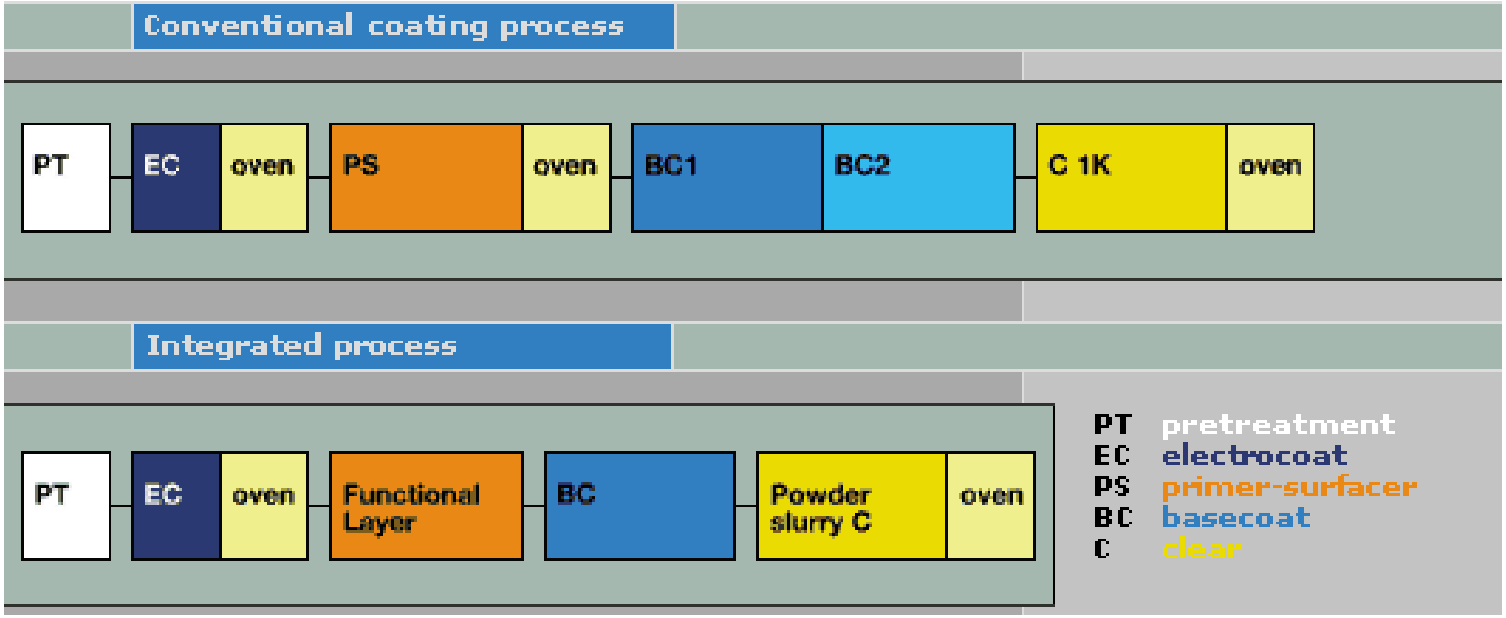
Example for a process: Coating of a car (Daimler: Mercedes A-class)

Innovations:

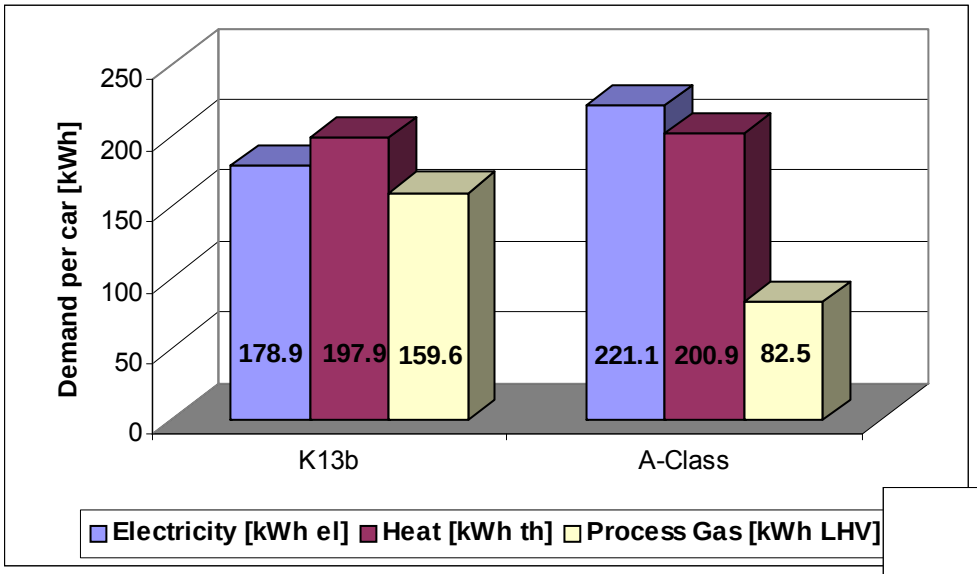
Wet in wet coating

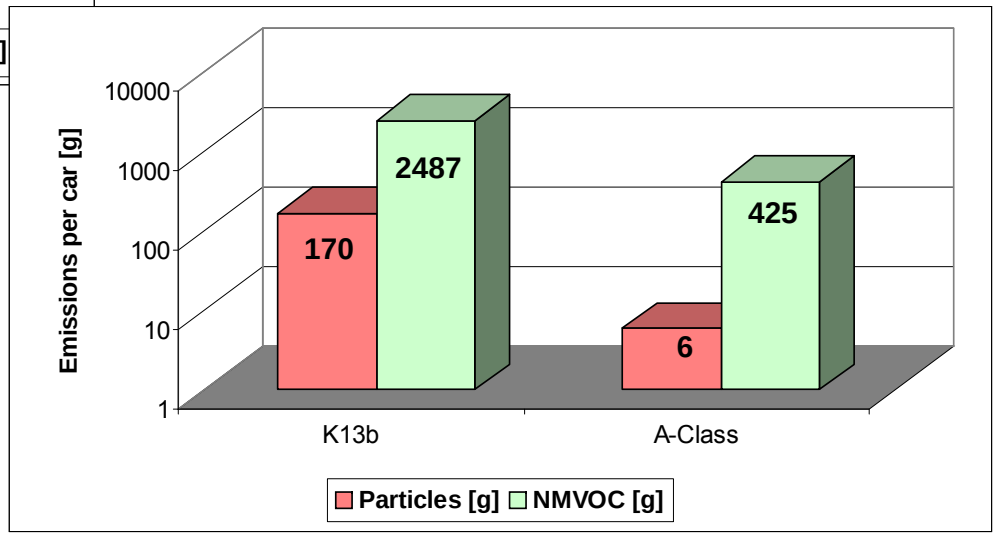
Use of powder slurry and water-based paints

Electrostatic paint application

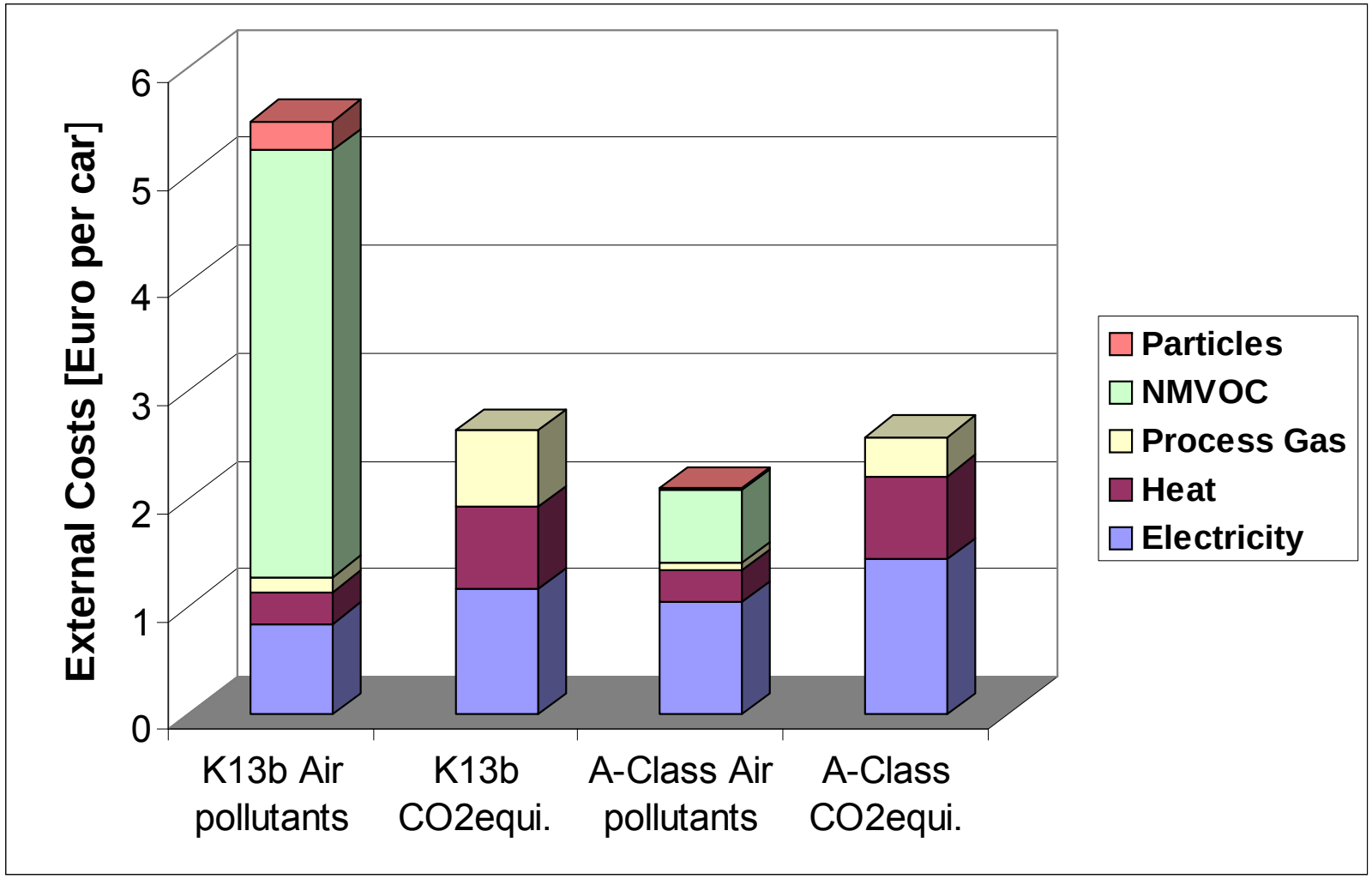


Comparison of conventional painting process and A-class painting process





External Costs of a conventional laquering process and A-class process



Conclusions

- **Substantial reductions of greenhouse gas emissions, of releases of toxic substances and of using natural resources are necessary to achieve a more sustainable development**
- **However these improvements should be reached with limited use of economic resources – eco-efficient production processes and products are needed**
- **Eco-efficiency of a process or product can be assessed by using the ExternE methodology for assessing environmental pressures**

  more information: www.ExternE.info, www.integrated-assessment.eu
- **Eco-efficieny is reached through eco-design and eco-innovation**