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LIFE CYCLE ASSESSMENT OF THE USE OF ALTERNATIVE FUELS IN CEMENT KILNS: A CASE STUDY

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Goal

- Evaluation of the environmental impacts of the use of alternative fuels (AFs) for 1 ton clinker production in the cement industry
- Selection of the most environmentally friendly fuel mixture using conventional fossil fuels (coal and petcoke) and different blends of alternative fuels (AFs)

In order to identify the best environmental option:

- Seven integrated scenaria for the production of 1ton clinker were developed and compared
- Scenaria include the use of fossil fuels and AFs
- A spreadsheet model was constructed
- Life Cycle Impact Assessment methodology was used, more specific: LCA software SimaPro 7.1 (CML 2 baseline 2000 and Eco-indicator 99 methodology)

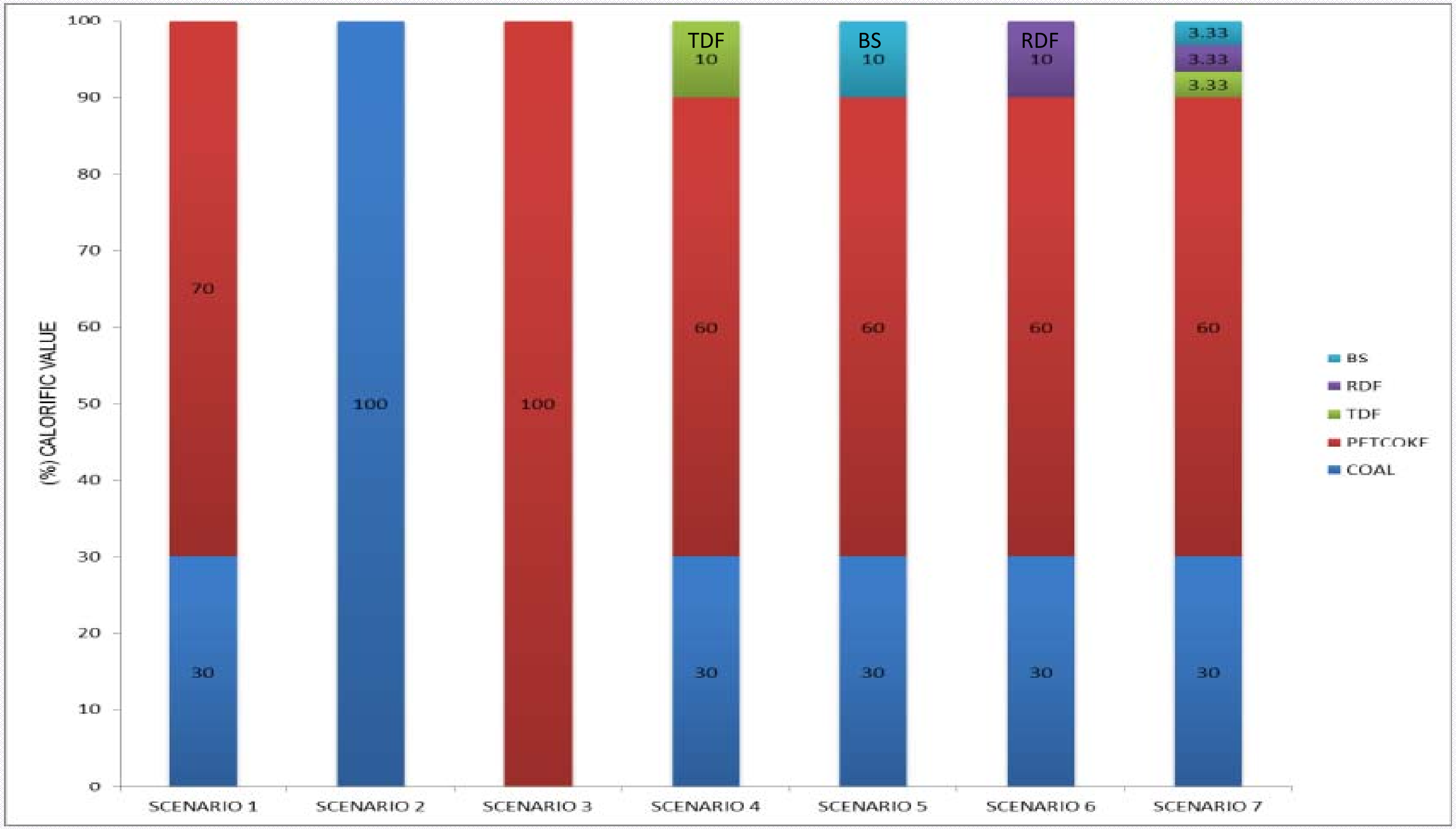
Alternative Fuels (AFs)

- **RDF** (Refuse Derived Fuel)
- **TDF** (Tire Derived Fuel)
- **BS** (Biological Sludge)

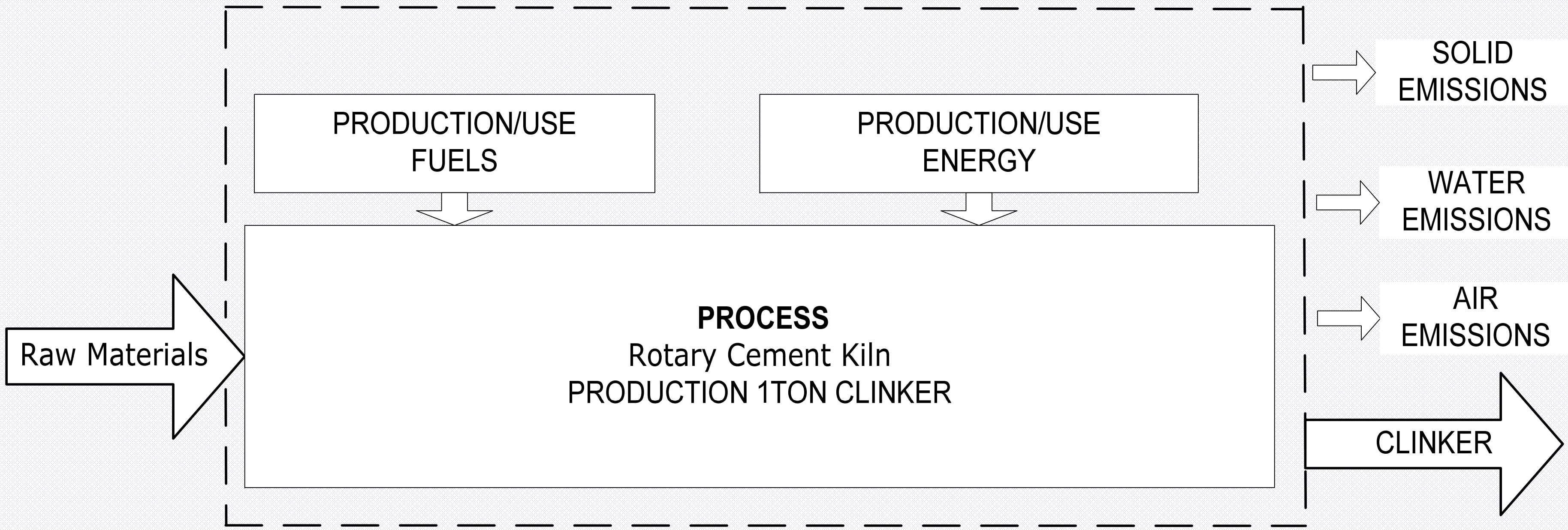
Fossil Fuels

- **Coal**
- **Petcoke**

Alternative Scenaria



System Boundary



Functional unit: 1 ton clinker

Assumptions

- The choice of AFs was based on the adequate (net) calorific value and biodegradable fraction
- It is assumed that AFs have low volatile heavy metal concentration
- The production of clinker takes place in a rotary, dry process, kiln
- The thermal demand for the kiln is about 1,700 to 1,800 MJ/ton clinker
- All resources consumed during the operation phase and activities carried out are included.
- The construction phase is considered negligible
- The life span of equipment is about thirty years

Assumptions

- The life cycle impact assessment includes the quality and quantity of raw materials, fossil fuels, AFs and energy inputs during the operation phase
- Extraction, production and transportation of raw materials, fossil fuels and electricity are included
- The AFs replace 10% of the total calorific value needed for the function of the kiln.

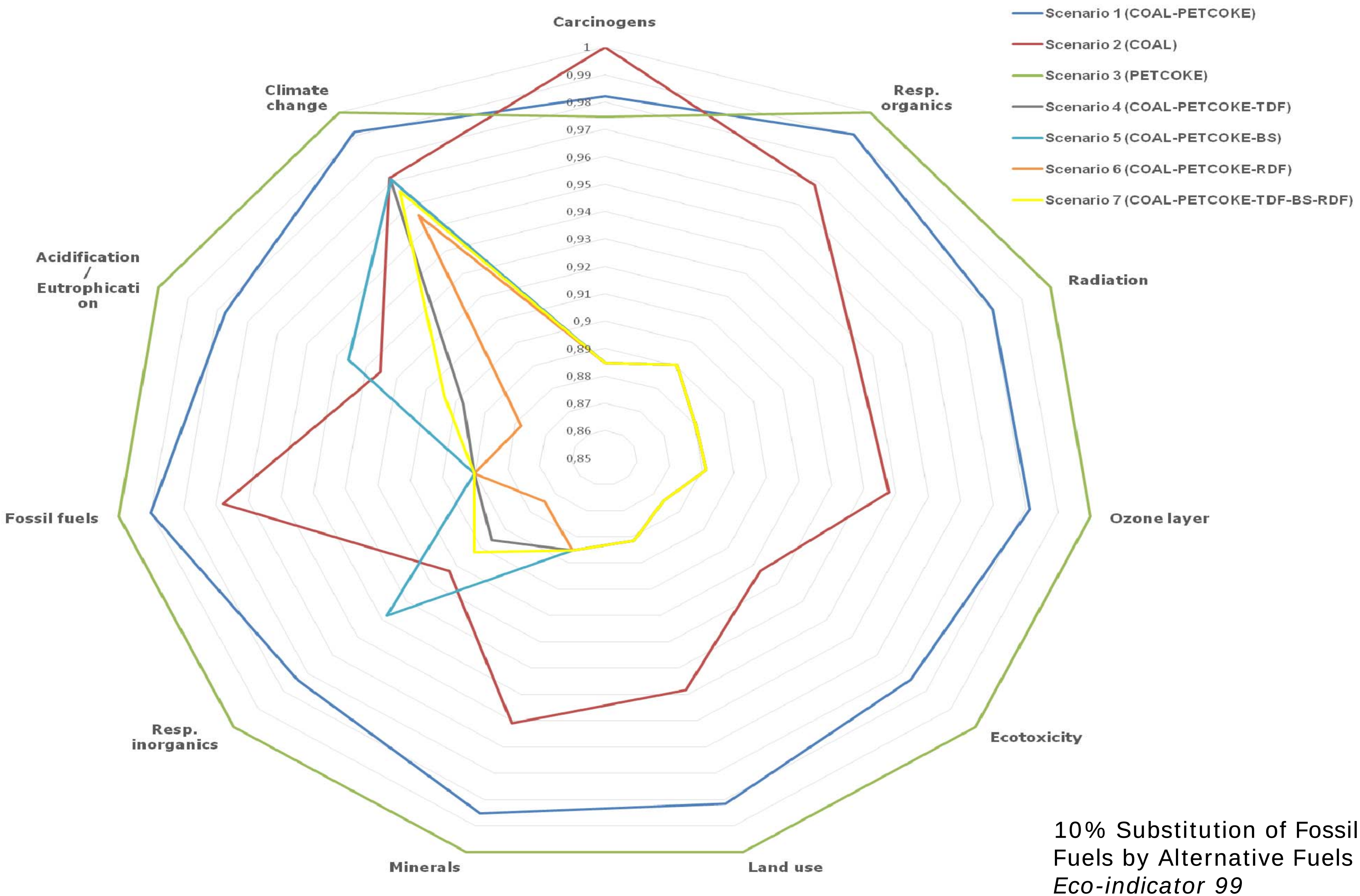
Inventory Data of Fossil and Alternative Fuels

	Conventional Fossil Fuels		Alternative Fuels		
	Coal	**Petroleum coke (petcoke)**	**Refuse Derived Fuel (RDF)**	**Tire Derived Fuel (TDF)**	**Biological Sludge (BS)**
NCV (kJ/kg dry fuel)	30000	33000	26000	32000	16000
Ultimate analysis mass % dry material					
C	7.50E+01	9.00E+01	5.30E-01	8.17E-01	4.05E-01
H	5.00E+00	3.74E-02	7.00E-02	7.84E-02	7.00E-02
O	8.00E+00	7.60E-03	2.10E-01	1.02E-02	3.26E-01
S	3.00E-01	4.34E-02	0.00E+00	1.81E-02	1.20E-03
N	1.00E-02	2.37E-02	1.00E-04	5.70E-03	8.40E-03
Cl	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-02
P	0.00E+00	0.00E+00	1.90E-01	7.06E-02	0.00E+00
Slag	9.84E+00	5.80E-03	0.00E+00	0.00E+00	1.79E-01
Emission factors per ton of fuel					
CO_2	2.76E+00	3.23E+00	1.94E+00	3.00E+00	1.49E+00
H_2O	5.97E-01	5.01E-01	8.11E-01	9.42E-01	7.92E-01
O_2	4.70E-01	5.37E-01	4.02E-01	5.79E-01	2.67E-01
NOx	9.28E+00	1.06E+01	7.93E+00	1.14E+01	5.27E+00
SO_2	9.05E-02	1.08E-01	5.00E-04	2.61E-02	3.84E-02
HCl	3.20E-03	4.88E-02	0.00E+00	2.04E-02	1.40E-03
P_2O_5	0.00E+00	0.00E+00	4.35E-01	1.62E-01	0.00E+00

Quantities of raw materials for the production 1 ton of clinker

Raw material	Quantity (ton)	Raw material	Quantity (ton)
Limestone	8.63E-01	Bauxide	2.30E-03
Slate	9.08E-02	Fly ash	1.80E-03
Flysch	5.00E-04	Fe source	1.82E-02
Sandstone	5.40E-03	Aggregates	2.00E-03

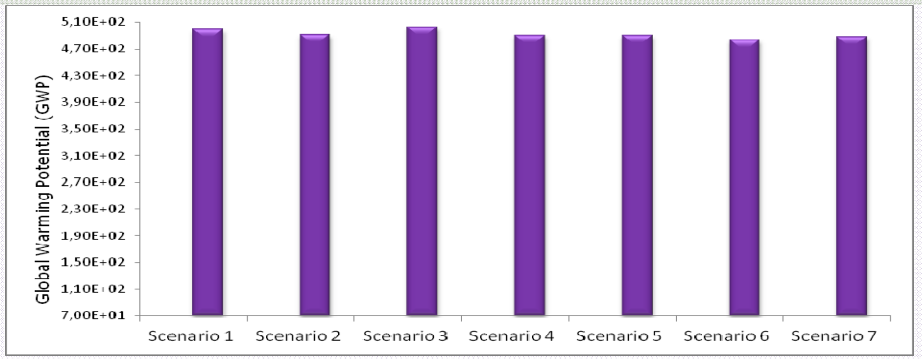
Results

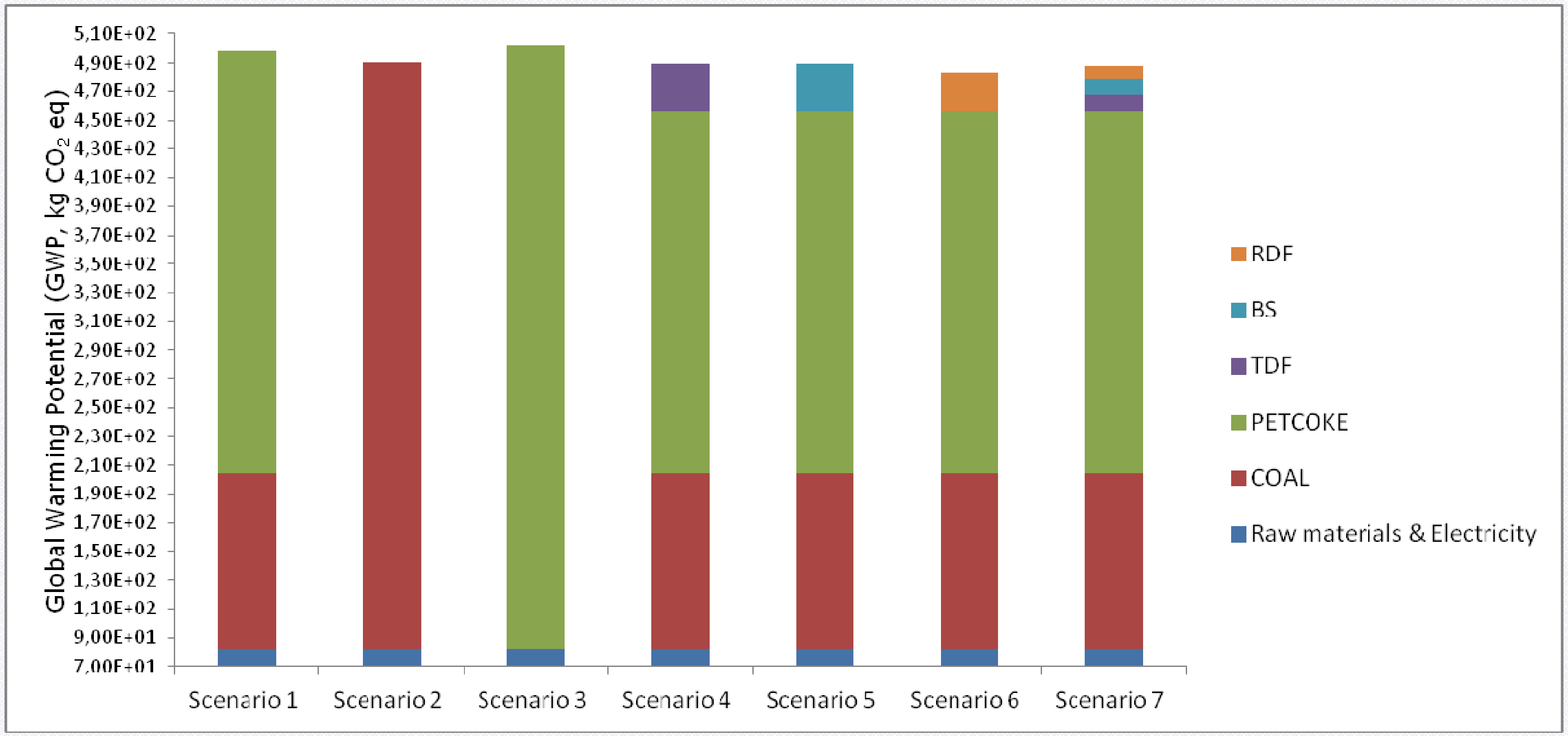


10% Substitution of Fossil Fuels by Alternative Fuels
Eco-indicator 99

GLOBAL WARMING

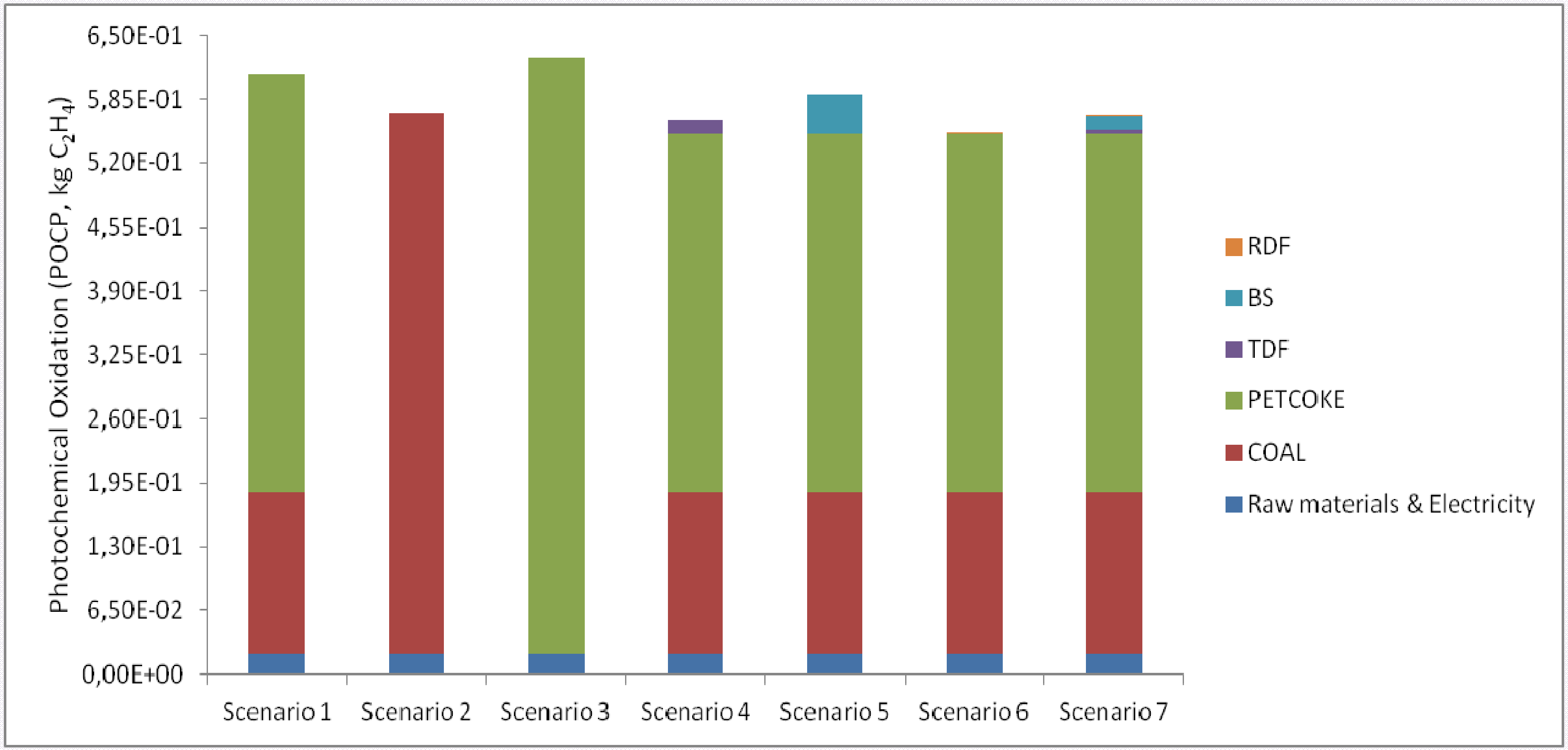
10% Substitution of Fossil Fuels by Alternative Fuels
CML 2 baseline 2000



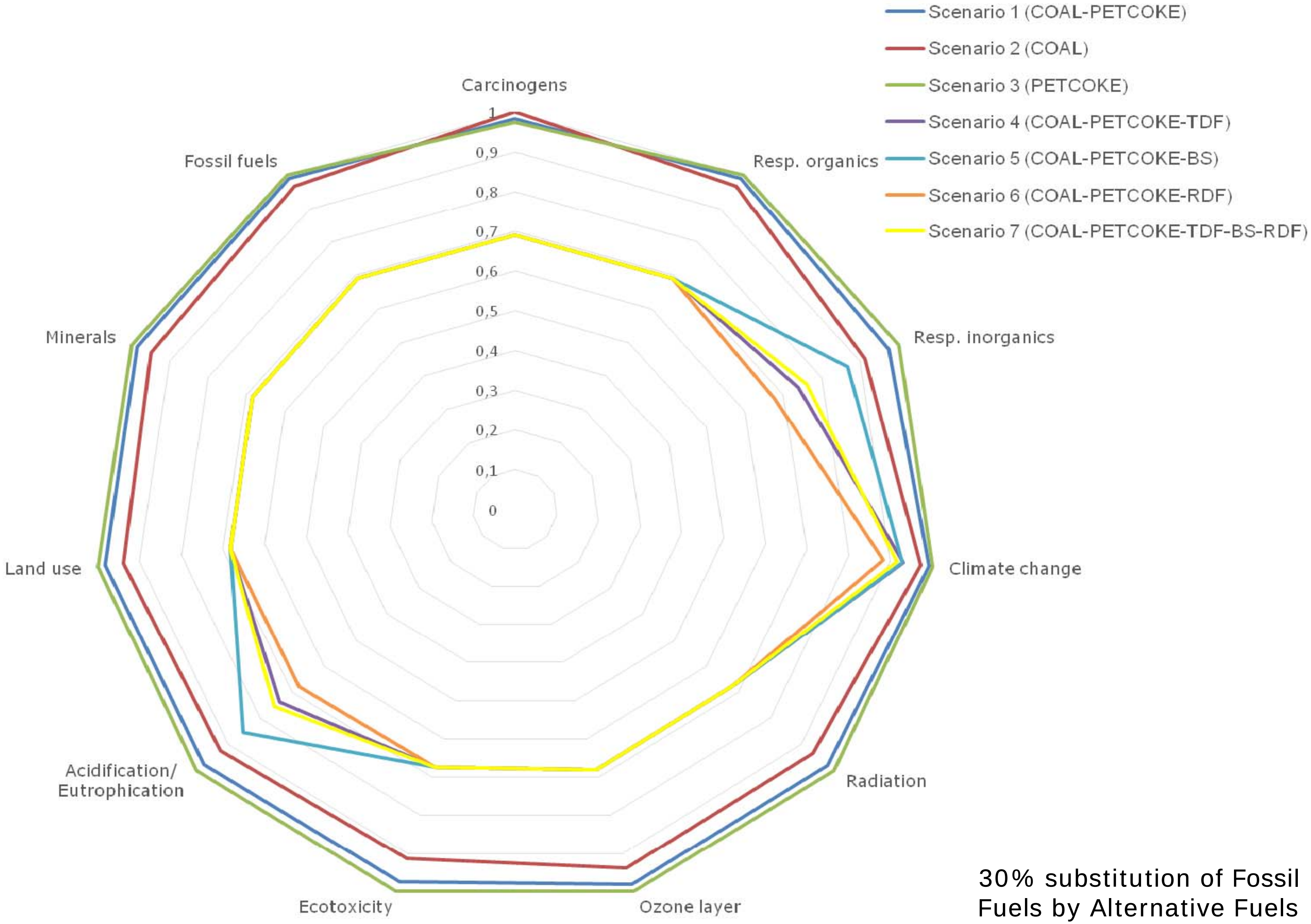


Photochemical Oxidation

10% Substitution of Fossil Fuels by Alternative Fuels
CML 2 baseline 2000

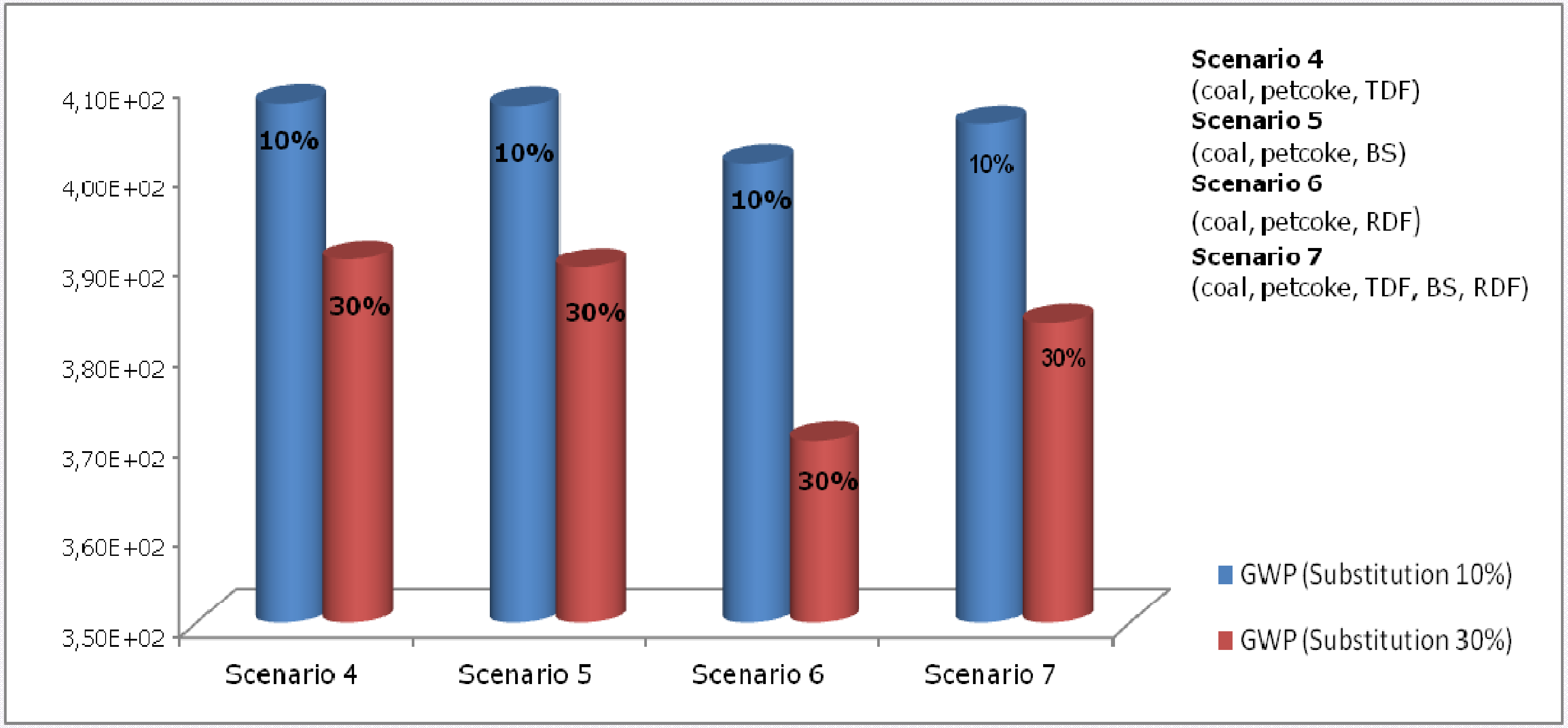


In the sequel, a 30% (instead of 10%) substitution of conventional fossil fuels by alternative fuels was examined.

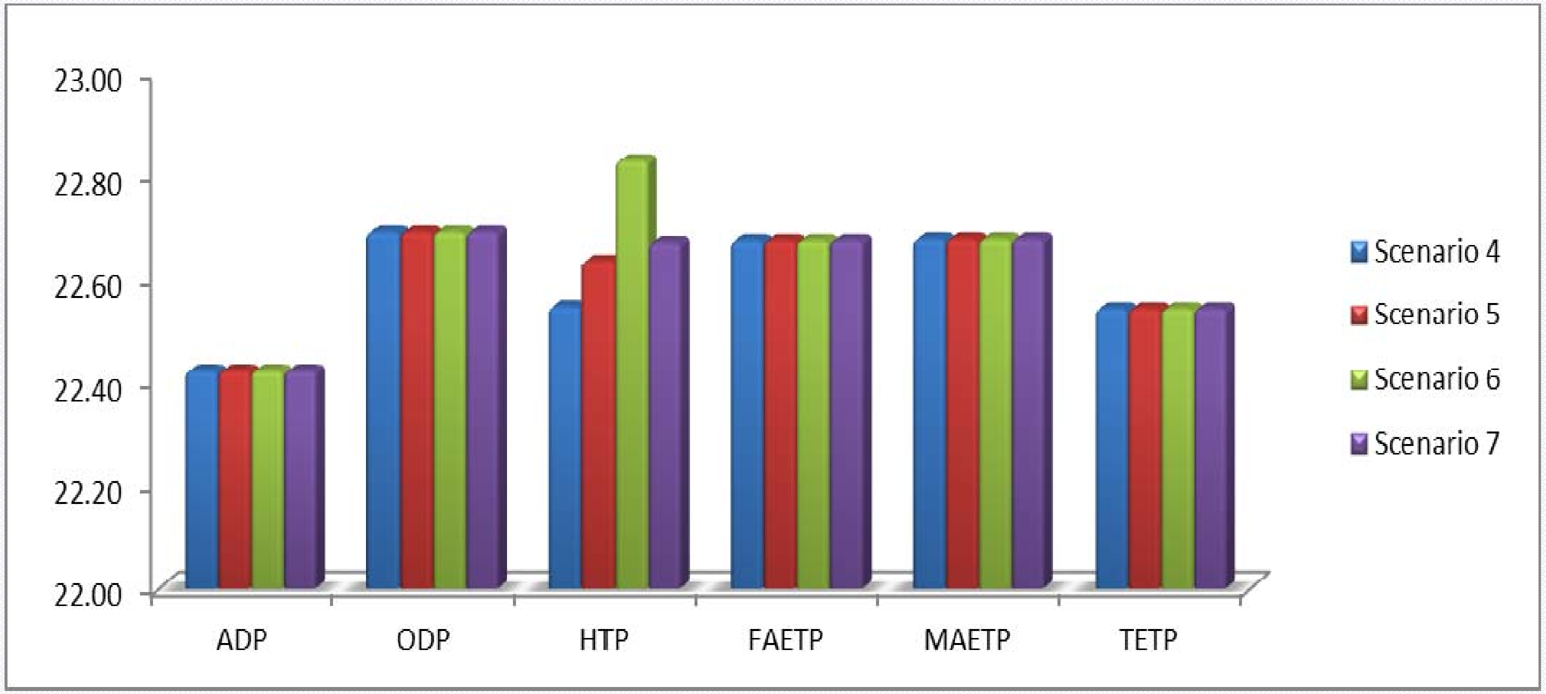


30% substitution of Fossil Fuels by Alternative Fuels Eco-indicator 99

Contribution of Scenaria 4, 5, 6 and 7 to the Impact Category Global Warming Potential (GWP) for 10% and 30% substitution of fossil fuels by alternative fuels



Impact Percent reduction of scenaria 4, 5, 6 and 7 to the categories of CML baseline 2000 methodology when substitution is increased from 10 to 30%



Conclusions

- The use of **fossil fuels** results in environmental pollution in all impact categories
- In addition the use of petcoke results in harmful environmental impacts

- The use of **AFs** *reduce the environmental impacts of all* impact categories
- AFs are more environmentally friendly

  BS *→ has the highest environmental impact in the life cycle of the process*

  RDF *→ is the most environmentally friendly prospect*

Thank you for your attention!