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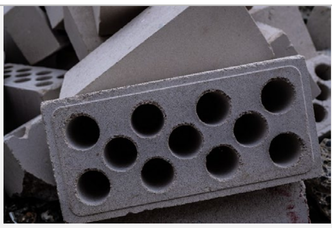
MEASURING DIRECT EFFECTS OF PEP TOKENS ON THE ENVIRONMENTAL PERFORMANCE OF INDUSTRIAL PRODUCTION

Goal and scope

Purchasing a carbon credit amounts to avoiding emissions of greenhouse gas (GHG) or the removal of carbon dioxide (CO_2) from the atmosphere. PEP focuses on avoiding GHG emissions in energy-intensive industrial sectors. When cleaner production measures are implemented to achieve such GHG emissions avoidances, **other environmental benefits can be accounted for**. Potential PEP token buyers should be aware of those co-benefits, as it may result in increasing attractiveness of PEP tokens.

We selected three important, energy-intensive industrial sectors and investigated by means of **life cycle assessment** (LCA) what other environmental benefits should be accounted for besides GHG emissions reductions. These industrial sectors also fall under the scope of PEP, as the latter aims **to reduce the use of fossil fuels in industrial production**. For each sector, we defined a functional unit (FU) and two scenarios achieving that functional unit: one with and one without **cleaner production measures to reduce GHG emissions**. We used life cycle data from the ecoinvent Association to model the environmental impacts of the base case and cleaner production scenarios, i.e., quantify savings achieved by the cleaner production scenarios. Next, we scaled GHG savings between base case and cleaner production scenarios to **1 ton of CO_2 equivalents** and noted the **savings in other environmental impact categories**.

Sector	**Alternative fuels and raw materials (AFRs) in cement industry**	**Electric-arc furnaces for steel production**	**Secondary sources for plastics**
			
Functional unit	Production of 1 kg of clinker	Production of 1 kg of low-alloyed steel	Production of 1 kg of polystyrene foam slab
Base case	Clinker produced exclusively with primary raw materials, e.g., coal and petcoke	Steel produced in a blast furnace-basic oxygen furnace (BF-BOF)	Polystyrene foam slab produced with 10% of input materials consisting of recycled plastics
Cleaner production	Clinker produced exclusively with primary raw materials, e.g., e.g., spent tires and sewage sludge	Steel produced in an electric arc furnace (EAF)	Polystyrene foam slab produced with 100% of input materials consisting of recycled plastics

Life cycle inventory

To enable a fair comparison of environmental impacts of virgin and secondary raw materials used in the cement, steel, and plastics industry, we used a **cut-off approach** (see Nordelöf et al., 2019 [1]) instead of the end-of-life recycling approach. Concretely, the environmental impacts of resource extraction, manufacturing, and use of materials used a second time (i.e., secondary war materials) are allocated to their first life, while end-of-life impacts are limited to collection. The ecoinvent datasets used are shown below:

Sector	Cement	Steel	Plastics
Base case	clinker production | clinker | Cutoff, U (Peru, with no AFR use)	steel production, converter, low-alloyed | steel, low-alloyed | Cutoff, U	polystyrene foam slab production, 10% recycled | polystyrene foam slab, 10% recycled | Cutoff, U
Cleaner production	clinker production | clinker | Cutoff, U (Switzerland)	steel production, electric, low-alloyed | steel, low-alloyed | Cutoff, U	polystyrene foam slab production, 100% recycled | polystyrene foam slab | Cutoff, U

Life cycle impact assessment

Environmental impacts assessed according to Recipe 2016:

Sector	Cement	Steel	Plastics
GHG emission reductions through cleaner production	12%	36%	90%
Co-benefits (savings) arising from 1 ton of CO_2 avoided	4 tons of pollutants toxic for terrestrial ecosystems (63%) Nearly half a ton of fossil fuels (57%) More than half a ton of pollutants toxic for humans (31%) 53 liters of water (76%)	10 tons of pollutants toxic for terrestrial ecosystems (57%) More than 200 kg of fossil fuels (33%) Nearly a ton of pollutants toxic for humans (30%) Almost 800 kg of metal and mineral resources (79%)	More than 700 kg of pollutants toxic for terrestrial ecosystems (58%) Half a ton of fossil fuels (94%) Some 200 kg of pollutants toxic for humans (76%) 20 liters of water (94%)

Interpretation

Cleaner production measures result in **significant co-benefits across major energy-intensive industries in almost the same four to five environmental impact categories**. Indeed, Recipe 2016 accounts for **18 environmental impact categories**.

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[1] Nordelöf, A., Poulikidou, S., Chordia, M., Bitencourt de Oliveira, F., Tivander, J., & Arvidsson, R. (2019). Methodological Approaches to End-Of-Life Modelling in Life Cycle Assessments of Lithium-Ion Batteries. Batteries, 5(3), 51.