2. Environmental and economic assessment in INSPIREWATER

As part of the holistic approach followed during INSPIREWATER, indepth Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) analysis were conducted to evaluate the performance of the technologies from an ecological and economic point of view. Experts from industry, government and other organizations agree that conducting life cycle approaches is part of the way, how we design products, develop services, make policies and decide what to consume. Therefore, LCAs will help to halt and possibly reverse some of the damaging trends in our communities and environments. In the life cycle approach, based on scientific models, the emissions to the environment and the resources used for a product, a company, a service or a system are gathered all the way from resources to reuse, recycling or disposal. This is also called “from cradle to grave” (Fig. 6). This set of emissions and use of resources is then evaluated according to their environmental impacts. For the interpretation of the results a weighting of the different impacts leading to one single indicator is often necessary to come to a decision. Especially in studies dealing with WWT or technologies to reduce water consumption, a valuation of different environmental impacts are necessary, because in these cases mostly there is a benefit concerning the water, resources or pollutions, but higher burdens e.g. in climate relevant emissions. That is the reason why two single score methods considering water scarcity are used, i.e., in this point the report goes beyond the ISO Norm. The results of LCA can be used to detect hot spots, to find efficient optimization potentials as well as to evaluate different options according to their environmental effects. Furthermore, the results of an LCA can easily be combined with economic figures, allowing interpretation of the eco-efficiency of systems and to determine how money is best invested.

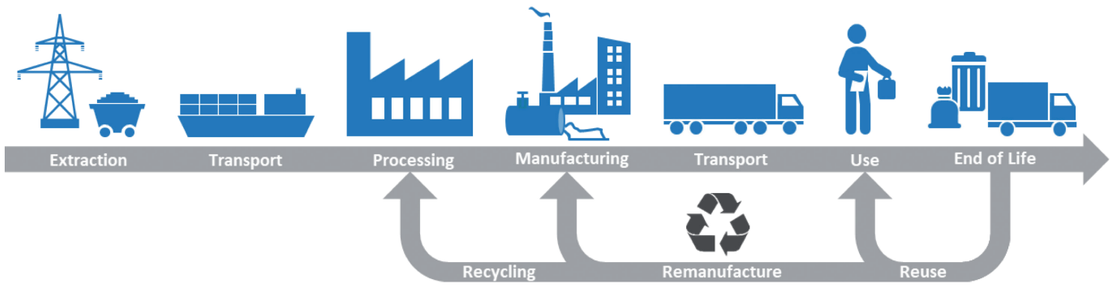

Figure 6: Life Cycle Assessment: the evaluation of environmental impacts from cradle to grave

To compare the ecological and economic impact of the INSPIREWATER technologies, an assessment of the current systems on the demonstration sites of the industry partners as a baseline scenario was carried out. This first LCA has shown that the relevant environmental impacts of the considered systems of the three case studies are quite different.

- At ArcelorMittal (AM), the fresh water and electricity used for the operation of the cooling water circuit have the main impact.
- The Sandvik case showed that the scarce element phosphorus and the disposal of wastewater containing heavy metals are of crucial importance.
- At Clariant, water consumption is dominant, as Tarragona is located in a region with severe water shortages.

Due to the different focal points, there is a need for different approaches for the applied solutions:

- At ArcelorMittal, energy-efficient technologies for the separation of solids in the wastewater of the direct cooling and the removal of salts for corrosion prevention in the case of water recycling of the blowdown are of particular importance.
- In the Sandvik case, the recovery of phosphoric acid is crucial.
- In the case of Clariant, the focus is on technologies for reducing fresh water requirements and recovering water, such as zero liquid discharge (ZLD) or using alternative water sources such as desalinated seawater.

The three pilot studies generated reliable and sufficient data, to perform an analysis of the different INSPIREWATER solutions, which enabled the comparison of its overall environmental impact to the baseline as well as to reference scenarios e.g. conventional treatment solutions. The conducted assessments allowed conclusions about the environmental and economic impact as well as the benefits for all three INSPIREWATER case studies.

For **ArcelorMittal**, different solid removal and corrosion inhibition scenarios were analyzed. Figure 7 shows that the INSPIREWATER solutions, especially the magnetic separator can clearly reduce the overall environmental impact of wastewater treatment with around 60% due to a water and energy efficient operation. The life cycle costs for scenario 6, the magnetic separator, are about a factor 3 lower than the current costs. This makes the INSPIREWATER technology to a truly eco-efficient solution.

In the **Sandvik** case study, the INSPIREWATER solution leads to a reduction of the environmental impact, mainly due to the recovery of phosphoric acid (Fig.8). Process optimizations increasing the recovery would further minimize the environmental impact. Due to new findings you can replace the sentence with:

In the **Clariant** case, different scenarios have been evaluated (Fig. 9) The FUTURE scenario is a simple post-treatment of the secondary effluent by a granular activated carbon (GAC) filter to meet the future legal compliances. Although regenerated GAC will be used the benefits of this post-treatment (lower environmental burdens from the effluent) are almost leveled by the additional burdens from the burdens of the GAC. The REFERENCE scenario, water recovery by reverse osmosis (RO) and evaporation of the RO concentrate, leads to a reduction of 40% and the INSPIREWATER solution, with RO, FO and evaporation leads to a reduction of more than 50%. When a production site is located close to the sea, another option to lower the environmental burdens would be to switch from river water to seawater. Two sub-scenarios are assessed: substitution only of the chlorinated water stream (i.e., about 29% of the water demand) and full use of desalination water. In the water scarce region of Tarragona this would lead to a reduction of environmental impacts of 25% or rather 80%. The LCC of the REFERENCE technology and INSPIREWATER will more than double the cost compared to the current water management practice on the site, but INSPIREWATER still costs about 40% less than the REFERENCE. If ZLD solutions are necessary or required, the INSPIREWATER solution is recommended, both from an ecological and economic point of view.

In conclusion, the INSPIREWATER project has pointed out that the conducted environmental and economic analyses are not only feasible, but also provide valuable information that would otherwise not have been available. Moreover, all three case study analyses have shown that the INSPIREWATER solutions have both environmental and economic advantages over the baseline and/or conventional technologies.

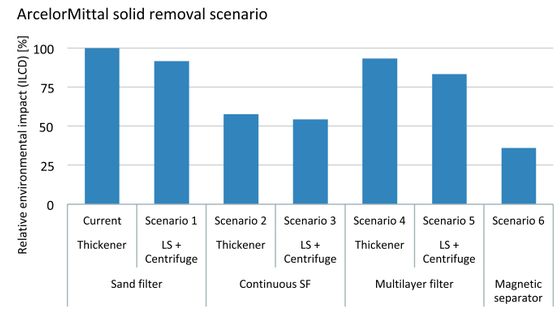

Figure 7: Relative environmental impacts according to ILCD of the scenarios for solid removal, related to the total environmental impact of the current solid removal scenario.

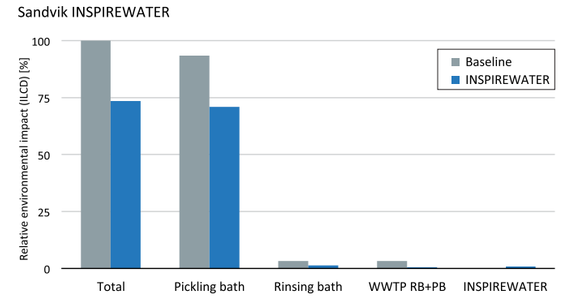

Figure 8: Relative environmental impacts according to ILCD for the current situation (baseline) compared to a INSPIREWATER scenario with 20% P acid savings, related to the total environmental impact of the current situation of the total pickling process

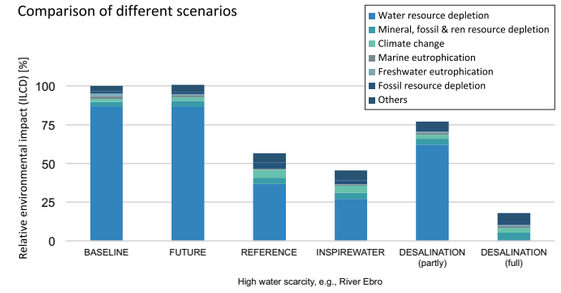

Figure 9: Comparison of the relative environmental impacts according to ILCD of the different scenarios for the Clariant case study, related to the total environmental impact of the current situation of the total water management at the Clariant site.

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