This insight summarises the preliminary analysis and results from the first business case in the EPOS project. The potential synergy was detected at the UK Hull cluster and involves CEMEX South Ferriby and INEOS Hull.

**IS BUSINESS CASE (CEMEX & INEOS)**

The business case concerns the possibility for INEOS to send one of its liquid waste streams to CEMEX for energy valorisation.

INEOS Primary Liquid Fuel (PLF) respects the specifications for a stream to be burned inside a cement kiln:
- LHV > 16 MJ/kg
- No heavy metals such as lead or mercury (only trace amounts are permitted due to the very strict environmental constraints and permits)

It is anticipated that the synergy between CEMEX and INEOS can potentially reduce the global footprint of the local industrial activities. CEMEX has a permit to burn 100% waste as fuel in its cement kilns. Currently, only 80% of the fuels burned in the CEMEX kilns are based on waste. The liquid waste stream from INEOS can provide an opportunity for CEMEX to replace a portion of the remaining 20% of the energy needs currently provided by primary fuels; therefore, improving kiln operations by reducing costs and indirect emissions.

In such a setting, INEOS will stop sending the stream to its current utility provider and could thus negotiate a more favourable price for steam.
PRELIMINARY RESULTS

The CEMEX site is located in the wider periphery of the INEOS plant, at 28 km by road or 11 km by boat. Two means of transportation can therefore be used, namely by road or waterway (see Figure 3). In both cases, new infrastructure is needed for loading, storage and transport within the site (piping). INEOS already has a dedicated storage area onsite and a terminal at the riverside; therefore, the investment cost is expected to be lower for INEOS than for CEMEX.

Transportation by truck has been favoured due to the relatively small amount of PLF produced which is estimated to use approximately five truckloads per month. Barges are generally used for higher volumes.

It is assumed that the PLF stream will not directly impact the LSF stream currently used by CEMEX. The PLF only substitutes part of the remaining 20% of primary fuels still used by CEMEX.

The boundaries of the business case are defined by considering all stakeholders currently involved in addition to new actors that could take part in the future synergy (see Figure 2). To be practicable, the synergy must be profitable for all parties.

The stakeholders are: INEOS Hull, CEMEX South Ferriby, INEOS utility provider and CEMEX provider of Liquid Secondary Fuel (LSF) mixture.

Figure 2: EPOS Hull business case - Business as usual

Figure 3: EPOS Hull business case - Transport scenarios

Various synergy scenarios have been developed, considering transport, organisational & purification options and project timeline. They all have the same basic settings:

- Optimise the kiln waste fuel feed at CEMEX
- Use the PLF stream currently sent to INEOS utility provider
- Send the PLF stream totally/partially directly to CEMEX
Figure 4 illustrates the three scenarios considered for calculating the business case. These solutions are considered transferable to other sites in the same sectors.

1. **Scenario 1 (a)** – The PLF is directly sent to CEMEX.
2. **Scenario 2 (b)** – The PLF is split, with the addition of a new separation unit, into two fractions: organic (55%) and acid (45%), the latter being mainly composed of acetic acid. The acetic acid fraction can be internally valorised by INEOS while the organic fraction is sent to CEMEX.
3. **Scenario 3 (c)** – These scenarios account for the INEOS debottlenecking project planned for 2017. The two previously mentioned scenarios (1 & 2) were evaluated again considering a 40% increase in the PLF flowrate resulting from the INEOS investment at the Hull site in 2017. Scenario 3.1 includes the INEOS debottlenecking with the PLF directly sent to CEMEX; scenario 3.2 (not depicted) includes the debottlenecking followed by the PLF splitting. These scenarios increase the number of exchanged streams and enhances the feasibility of the project.
A fourth scenario is also possible once the information from CEMEX LSF provider is obtained. In this scenario (see Figure 5), the PLF is split into two fractions (as in scenario 2). Handling problems due to the acidic nature of the PLF could be avoided by allowing CEMEX LSF to recover the stream and mix it with the current LSF. This scenario has the advantage of avoiding investment for CEMEX and benefits from the provider expertise.

**MAIN CONCLUSIONS**

Thanks to the close collaboration of the INEOS and CEMEX teams in the EPOS project, very precise data have been collected to elaborate a preliminary economic analysis. It gives a first idea of the project feasibility, the required investment, benefits and payback times. If the project interest is proven (alternative options are welcomed) a further analysis involving the two other stakeholders could be done.

Table 1 introduces the study results. It is assumed that CEMEX will pay the total transport cost. This assumption could be reviewed in the future.

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Table 1: EPOS Hull business case - Preliminary results

The first results clearly indicate that the synergy has real economic potential for both companies. The initial scenario is generally more profitable for CEMEX, whereas the second scenario is more interesting for INEOS.

The study shows that INEOS could profit from recovering the acetic acid contained in the stream. In this case, the transport business model could be modified to balance the financial burden between the two parties.

After proving the project to be feasible economically, legal considerations should be accounted for. In order to use the stream as a fuel, CEMEX requires a new licence due to its hazardous waste status. This procedure lasts at least 26 weeks and must be considered in the planning of the project.

A screening assessment shows that the synergy presents potential benefits from an environmental perspective. Figure 6 shows potential greenhouse gas (GHG) emissions savings, approximately 4.1 kt CO₂ eq/year, when comparing the business-as-usual case and scenario 2b. The main savings come from the avoided impact of producing acetic acid and solvent; these chemicals would no longer need to be purchased by INEOS as they can be recovered from the acid fraction of the PLF and reused internally.
CURRENT CHALLENGES

The following challenges were identified:

- **Level of investment**: the CAPEX requirements demand a board level decision.
- **Payback time**: all scenarios have a generally higher payback time than is common in industry (ca. 2 years); thus, financial incentives should be taken into account.
- **Waste stream**: currently, expert opinion suggests that it is not possible to blend the liquid waste stream with the fuel mix that is currently used by CEMEX, hence new logistic options and new investments are needed.
- **By-product**: when leaving an industrial site as a by-product, a registered hazardous waste stream should be redefined and accepted as an additional product; however, this presents a legislative hurdle.
- **Transport**: dangerous goods transported by road or waterway require special permits. This should be taken into account when choosing the third party that would be responsible for transporting the stream.
- **Cement kiln**: problems with the cement burner are anticipated due to the high flammability of the PLF stream; thus, new technologies might be required such as adsorption on activated carbon.
- **Licences**: the burning licence must be modified.

RECOMMENDATIONS

The following recommendations emerge from the challenges faced during the preliminary analysis of the business case. They are based on the 5 LESTS aspects.

- **Legal / policies**:
  - A review of the current waste legislation is recommended - whether or not linked to the ongoing revision of the waste frame directive - in order to allow waste streams, even when hazardous, to be reused as a resource and thus contribute to the circular economy and boost industrial symbiosis.
  - Modifications to permits and licences for infrastructure or activities that help to close industrial loops, such as the licence for the cement burner in this case, must require less administration and lag time.
• **Economical / instruments:**
  › The creation of new specific stakeholders for resources should be explored. In this case, the possibility to treat acid wastes from chemical plants for use in cement or steel plants. Suppliers of waste-derived fuel, as in the Hull case, often focus on one sector and do not offer treatment services for waste streams from other sectors. In the case presented here, the supplier only treats alkaline wastes and thus cannot treat the liquid waste stream originating from INEOS which is acidic in nature.
  › Support mechanisms and incentives should be increased, with a focus on investment aid to finance joint infrastructure, facilitate shared services, reduce taxes and penalties, etc. when a positive environmental and social impact is anticipated.

• **Spatial / planning:**
  › From a high-level perspective, spatial planning can stimulate clustering so as to optimise industrial interactions and exchanges in clusters to reduce the environmental and social impact.
  › A multi-modal transport network is recommended as the next best thing to promote (cross-)sectorial collaboration, particularly in the field of resource efficiency.
  › A truck or barge for transporting the waste stream from INEOS to CEMEX will require a permit, the application for which should be flexible and facilitated.

• **Technical / engineering:**
  › Development and promotion of technical tools for detecting symbiosis across industries should be enforced.
  › Investment in technologies to purify and split streams for (partial) reuse should be supported. Such circular technologies must be considered to be as relevant as raw material extraction and treatment technologies.

• **Social / responsibilities:**
  › Although NISP is highly active in the UK, the cross-sectorial match in the above case was not spotted. Not only is it recommended to support subscription to waste trading platforms, it is also needed to encourage cross-sectorial knowledge-building to enable collaboration with other, often unknown, process sectors. To promote knowledge platforms is thus one of the most important and highest-impact recommendations drawn from this case.
  › For the Hull case, such a platform can provide new opportunities for INEOS and CEMEX to reduce the costs of connecting both sites and may help to explore other possibilities of IS. There is no doubt that IS cultivates the seeds for further collaboration between industrial partners. This IS activity will have a long term positive effect; not only to both industries involved but for the wider Humber region.
  › Finally, it is recommended to facilitate engineering consultancy services for assessing symbiosis opportunities. LESTS consultations added with overall environmental footprint calculations are longer-term additions to the basic (economically-driven) cross-sectorial engineering synergies that deserve to be further exploited.
CASE PROGRESS

Below are the most recent developments for the industrial symbiosis potential identified in the Humber Region:

• From the options provided in Table 1, scenario 3.2 was selected.
• In order to accomplish this, INEOS first considered using liquid-liquid extraction technology, though this proved to be insufficient due to high impurity concentrations in the stream.
• An alternative option that may prove feasible is distillation. This will allow two fractions to be used by INEOS and one fraction to be sent to CEMEX.
• Laboratory testing has thus far yielded positive results for the use of distillation. Industrial scale trials are set to begin.
• Once the industrial scale trials are finished, these results will be shared with CEMEX for further discussions.
• The CAPEX for INEOS is estimated at 1 200 000 £, the OPEX at 750 050 £/y, with a PBT of 2 years.
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