SisAl Pilot

SisAl Pilot Project
Innovative pilot for Silicon production with low environmental impact using secondary Aluminium and silicon raw materials

Enjoy reading the SisAl Pilot newsletter!

SisAl Pilot is making strides towards success!

Foreword of the coordinator

On behalf of the SisAl Pilot consortium, we are delighted to introduce the seventh newsletter. Throughout our third project year, the project partners have shown dynamic and productive collaboration both on the technical and non-technical side. We've had the privilege to meet in person on two occasions, first during the review meeting at NTNU in Trondheim followed by the plant visits at Hydro and Wacker in Norway and later at Reykjavik University in Iceland.

Over the past year, Fundiciones Rey has for the first time produced SisAl metal in their production rotary furnace with great success. The project partners have worked closely together with Mintek to prepare for the final large-scale SisAl trial that will take place during spring 2024. Also, Mytilineos has together with SiQAl and NTUA set up the acidic hydrometallurgical pilot at their site and they will conduct their last pilot trial in the beginning of 2024. Finally, a strong focus has been on optimizing the different SisAl business cases and linked environmental studies, which you will read more about in this news later.

We are planning to co-organise a clustering event titled “Industrial Symbiosis” with the Silicon for the chemical and solar industry conference which also has partnered up with CRU, the commodities Research unit on September 10th-13th 2024 in Trondheim, Norway (https://www.ntnu.edu/si-conference). We hope to see you there!

With kind regards,

Gabriella Tranell and Maria Wallin



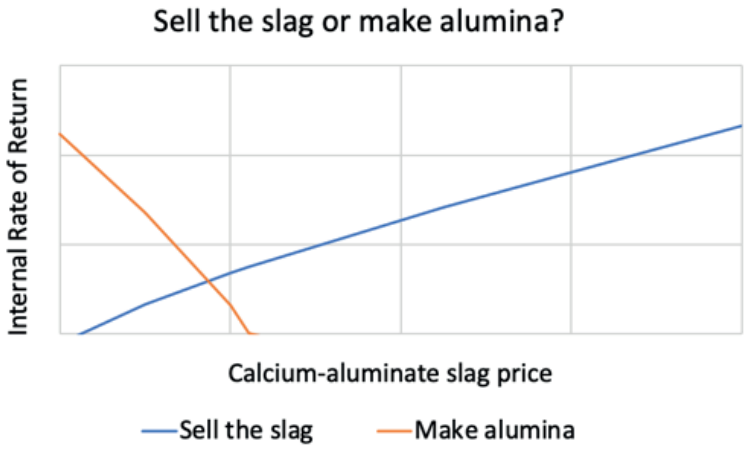

Main updates from the work package 4 – EXPLOITATION

The main aims of WP4 are to quantify the identified business cases and develop business plans relevant for the commercial/industrial stakeholders, as well as establish an innovation strategy that allows the consortium to identify new ideas and find ways to exploit them inside and outside the consortium.

It is dedicated therefore to the development of business models, detailed economic modelling, and exploitation activities, both commercial and non-commercial. To keep track of the development, a set of Key Exploitable Results (KER) was established at an early stage in the project, and these KER are regularly updated in line with the project progress.

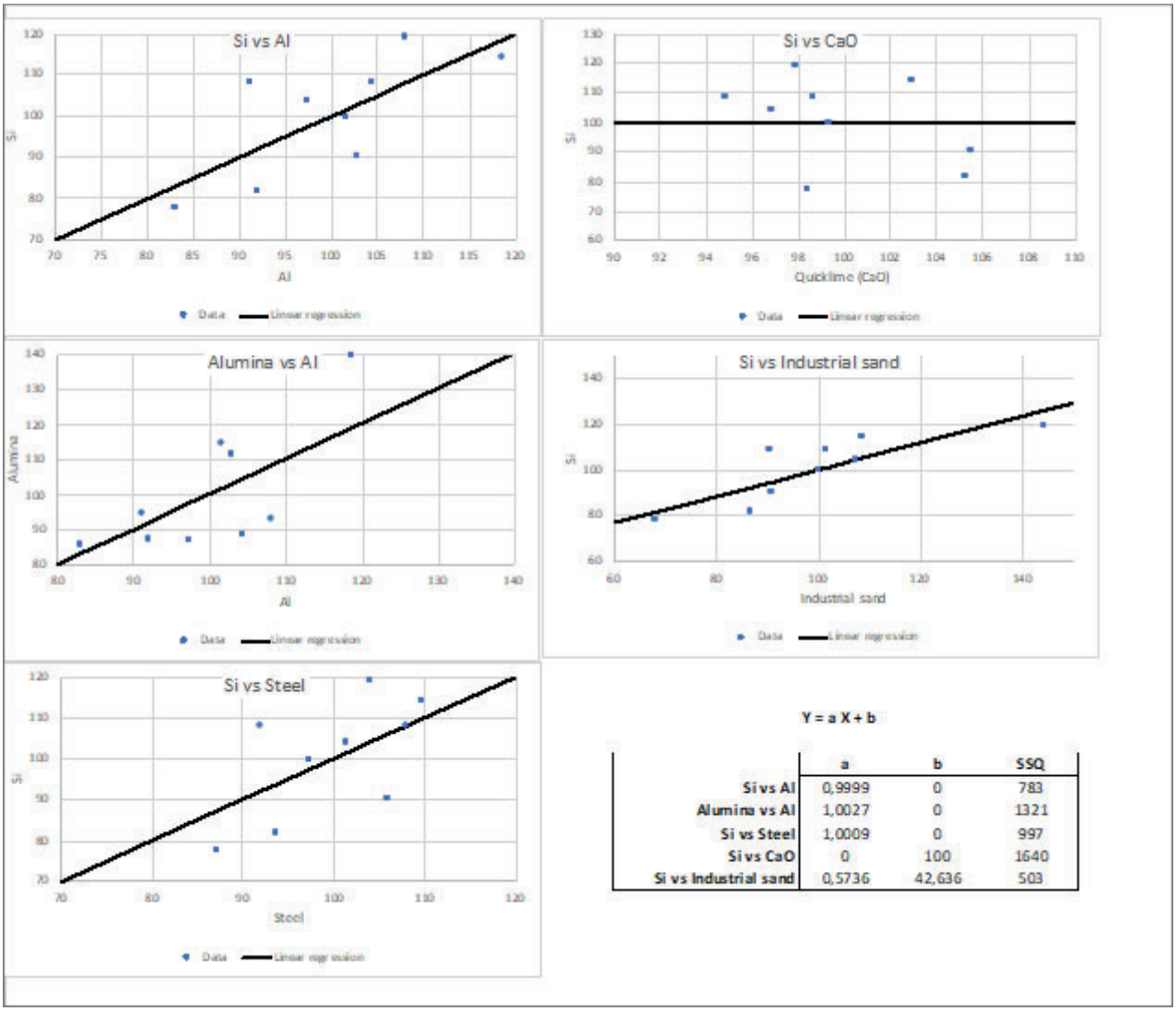
Valorizing secondary raw materials is a key feature of the SisAl concept, and business cases are being developed for specific European locations (such as Norway, Iceland, Spain and Greece) with favorable conditions regarding access to secondary raw materials. In this context secondary aluminium sources (scrap, dross) are vital, and the success of SisAl will depend on a synergistic interaction between the silicon- and aluminium industries. With the incumbent Submerged Arc Furnace (SAF) process for making silicon, there is a one-dimensional silicon supply chain, while the SisAl process represents a more circular supply chain, where the aluminium industry becomes both a supplier and an end user of materials.

In the full 3-stage SisAl process silicon and alumina are the end products. An alternative business opportunity is to omit the hydrometallurgical separation of calcium-aluminate slag and sell this slag directly on the market. Hence, a breakdown of the SisAl process has been done for the purpose of feasibility studies and business case assessments, by defining stage 1 (CaO-SiO2 slag making) and stage 2 (aluminothermic reduction and refining) as one industrial process, and stage 3 (hydrometallurgical separation of calcium-aluminate slag) as a separate process. A main aspect of this approach is to set a price for the intermediate calcium-aluminate slag, since the company that generates the slag might not be the one that does the hydrometallurgical separation. Also, even when the same company does all three process steps in-house, it makes sense to distinguish between process stage 1+2 and process stage 3, to be able to assess the performance of industrial processes that are indeed independent. Finally, it makes economic sense to assess whether it pays to refine this slag for making alumina or sell it on the market, as illustrated in the figure below, where profitability (Internal Rate of Return) is plotted vs the price of the calcium-aluminate slag. At high slag prices it makes sense to sell the slag to e.g. the steel industry, and vice versa at low slag prices.



Historical, long-term price co-variation for relevant materials is analysed, and for the commodity materials Si, Al, Al_2O_3 and steel there is an observed statistical 1:1 ratio with regards to relative price changes, e.g., when the Si price changes 1%, the Al price also changes 1%. This is not to be confused with short-term fluctuations, but rather as the long-term expected price co-variation. The linear relation is weaker for industrial sand (SiO_2), and for quicklime (CaO) there is no identified systematic co-variation. Correlations are shown in the figure below. The observed price correlations are applied in sensitivity analyses, and the overall effect is that Si price co-variation with other materials prices has a dampening influence on the economic performance of SisAl business cases. Overall, this reduces risk.

Price correlations between commodity materials, raw data from United States Geological Survey, USGS.



	a	b	SSQ
Si vs Al	0,9999	0	783
Alumina vs Al	1,0027	0	1321
Si vs Steel	1,0009	0	997
Si vs CaO	0	100	1640
Si vs Industrial sand	0,5736	42,636	503

At present there are several promising business cases, ranging from production of metallurgical grade silicon, high purity and solar grade silicon, aluminium-silicon alloys and high purity alumina.

In the final project period business case estimates will be refined, including assessment of lifecycle CO_2-e emission costs and a benchmarking of the SisAl process vs the SAF process for making silicon (cooperation between WP4 and WP5). Also planned large-scale pilot trials at MINTEK spring 2024 (WP2) are expected to give important information in relation to business cases.

Updates from the work package 5 - Environmental impact and sustainability assessment

The main objectives of the WP 5 are aiming at demonstrating the feasibility of the sub-processes and main products developed in SisAl with respect to environmental, economic and technical (EET) performance, and benchmark towards existing technologies and supply chains also with respect to exergy. It also wants to establish and maintain a database for collecting, compiling and curating the high number of analytical results and material streams expected during the development of the project, and to identify policy actions to establish a Social Licence to Operate.

The evaluation of environmental impact and sustainability assessment is currently under development and it has focused so far on:

- Modelling the SisAl Pilot process and the conventional silicon production.
- Environmental benchmarking of silicon produced in the SisAl Pilot with conventional silicon process, and improved life cycle assessment of conventional metallurgic silicon production.
- Assessing the influence of regional factors for the environmental benchmarking of silicon production, in market availability, logistics, energy supply, carbothermic reductant charges, and local environmental response.
- Improving our understanding of alternative recovery processes for aluminium-containing waste materials.

All the environmental evaluations apply life cycle assessment (LCA), with mass and energy balances developed through process simulation models. The work so far has been developed into several manuscripts, submitted or in preparation to international peer review journals.

Image: discussions during the project meeting at Reykjavik University.

The work in WP5 includes spatially explicit LCA wherein environmental impact is assessed for specific locations to evaluate the relative suitability of the different business cases of this project. This work won the student poster runner-up prize at the 11th International Conference on Industrial Ecology (ISIE) held in Leiden, the Netherlands – received by Elisa Pastor-Vallés.

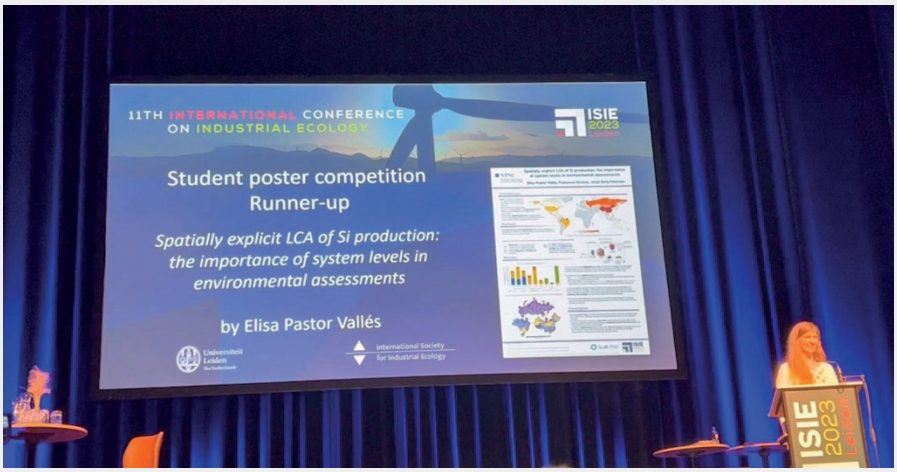
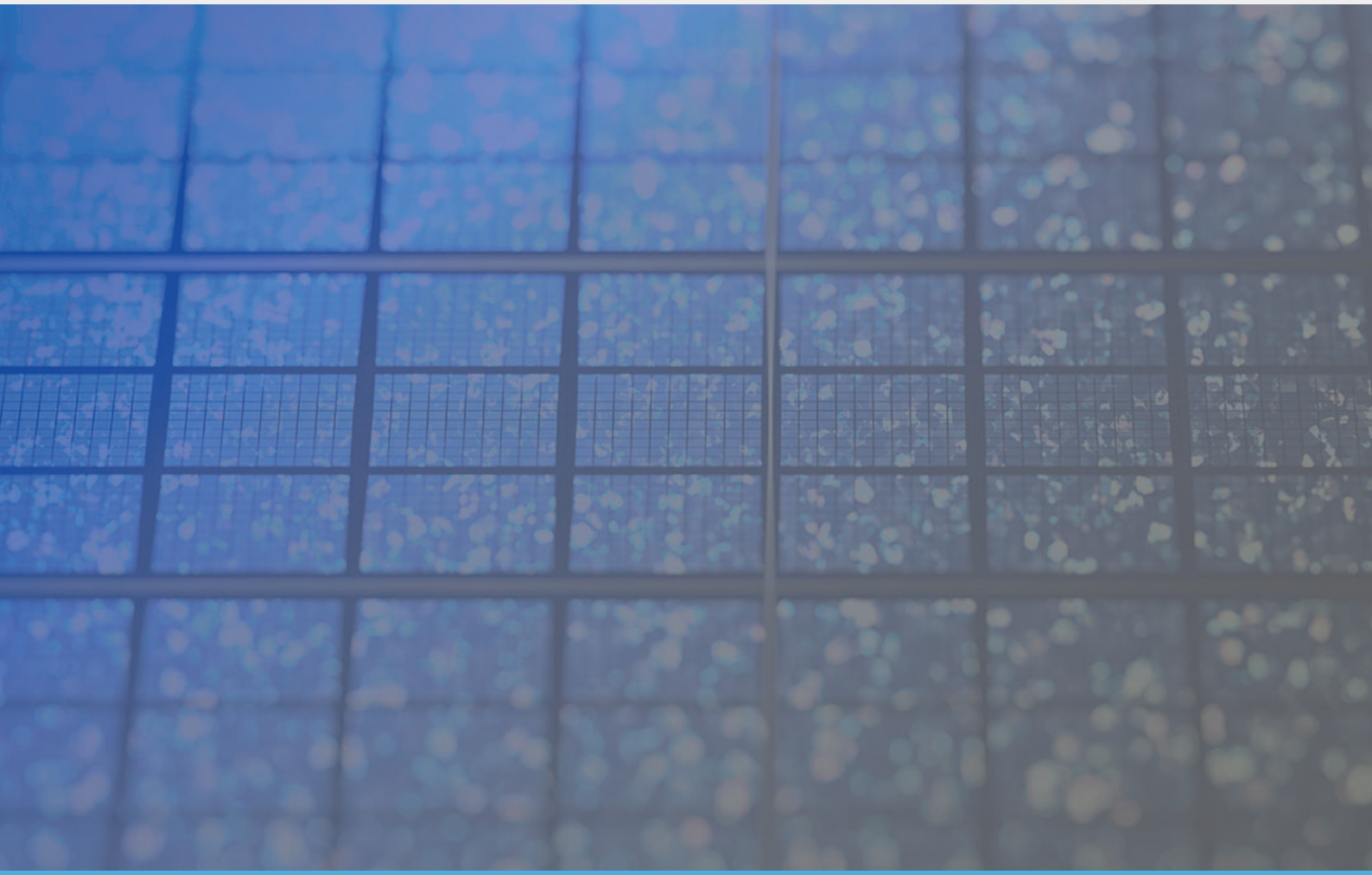


Image: student poster competition runner-up in the ISIE2023 Conference.



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