

Annex B3:

Final Report from demonstration completed



Subject	Project acronym / Ref. No.	Date
<i>Deliverable under Action B.3</i>	Etanolix 2.0 for LIFE+ / LIFE12 ENV/SE/000529	31/01/2017
Issued by	Company / Department	
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Final Report from demonstration completed concludes the period from July 7th 2015 to January 31 2017. This report cover progress, issues, solutions and results with and within the unit, with a main focus on the receiving station of the Etanolix 2.0-unit and the integration to the refinery.

RESULTS

Action B.3 started on 07/07/2015 that is one week later than scheduled (i.e. 01/07/2015). This delay is not affecting the final delivery dates or targets for this action.

As described in Mid Term Report, the fine tuning of the production and the integrations continued until the end of this phase. The demonstration covered following areas:

- Producing sustainable ethanol according to specification using a waste raw material as feed stock
- Waste handling
- Stillage as a by-product
- Integration into the refinery

A general conclusion is that the unit is overall demonstrating an efficient way to gather waste from the food industry, an efficient way of pretreating feedstock with production of high quality bio-ethanol for vehicle use. The by-product is an efficient feed for biogas production and nutrients for animals. The integration to a fossil refinery's utility systems and control room works as expected, making the Etanolix a production unit with world-class CO₂ reduction possibilities.

The pilot plant has been operating less hours and produced less ethanol and stillage than expected during the demonstration phase. The lower production is due to issues both in the receiving station and within the so called Inside battery limit (where the biological and chemical reactions are taking place, not in the scope for the LIFE+ project). The issues have been mainly caused by equipment and material failure and have severely influenced the overall delivery results.

The issues with the receiving station, which is included in the LIFE+ project scope, and the time spent for modifications has not gained the throughput and therefore reduced the hours of production.



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Work has intensely continued during the demonstration phase resolving the issues. This work is ongoing until full performance is met.

The complexity of the issues has caused that we have not yet reached the targets on volumes of ethanol and stillage but we are confident that we will reach the set goal within an acceptable time.

Daily laboratory analyses and quality controls are made on production, stillage and ethanol.

Before ethanol and stillage are transferred or delivered to refinery tank farm and customer, respectively, complete analyses are made to ensure the correct quality of the product. 100 % of all ethanol that have been produced have been transferred to the refinery for use in low blend gasoline.

The integration with utilities supplied from the refinery has, during the whole period, worked according to plan.

The use of steam and electricity is not linear with the amount of feedstock. Cooling pumps, instruments, heat tracing etc. is using electricity regardless of the feed throughput. So the consumption will be comparatively high with lower amount of feedstock. Calculations show that the use of steam and electricity should be on specification when the unit is running according to design.

There has been no negative effects on the refinery's water treatment plant during the demonstration phase.

Air emission measures, from the CO₂-scrubbers located at the fermenters and the distillation column, have been performed and after optimization revisited and controlled; thereafter showing efficiency, of each scrubber, above 95%.

Performance parameters have been monitored during the whole phase. These parameters will be continuously monitored as KPIs for the unit.

For more information regarding the parameters please see *Annex C1 Evaluation reports (1-3) for 6, 12 and 18 month periods*. Compiled results from the demonstration is listed below:

- 1035 operational hours of feedstock (4080 tons) delivered into the receiving station. Receiving efficiency in the end of demonstration phase is approx. 28%.
- 50 distillation campaigns, production time 2443 hours, meaning a cumulative ethanol production of 945 m³.
- 44 batches of produced ethanol quality tested according to laboratory analysis program.
- The ethanol yield has increased and is stabilized above 20%.
- CO₂ reduction has increased during demonstration phase and is stabilized above 90%.
- Total production of high quality stillage during demonstration phase is 11060 m³ shared as animal feed and for biogas production.



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- Integration into refinery such as potable water, cooling system, steam, electricity, infrastructure (piping and tank connections), waste water system etc. is functioning as planned.
- Use of steam for this phase is for 2016 6480 MWh and electricity 1700 MWh.
- Cooling water used for this phase 2016 is 2242 MWh.
- Chemical uses are measured by quantity. At this stage, how much has been purchased rather than how much is required in the plant.
- The Etanolix waste water quality has been demonstrated for e.g. pH, suspended solids and this has been proven according to program to ensure adoption in the refinery's biological waste water treatment.
- Environmental parameters e.g. odor has been considered acceptable during the demonstration phase.

ISSUES and SOLUTIONS

Receiving station / Prototype:

As reported earlier in *Annex C1 1 to 3 Evaluation Report*:

Receiving container was, at an early stage, considered having capacity problems. An improved design of the receiving container was carried out during June and July 2015, making it possible to increase the throughput to up to 20 tons per loading. The container was lowered and the upper part was widened.

Maximum load is depending on type of feedstock. Crumbs and chips is easier to treat and allows a little bit heavier load than bread. In average, the maximum load is set to 12 tons.

It has not yet been possible to ramp up and process the design volume of bread of 80 tons/day, as will be the main target.

The receiving bins treatment rate and capacity is restricted. The rate of throughput is limited by the weight of incoming raw material.

If the receiving container capacity is exceeded, the processing rate is decreased or could even cause a stop to the production.

The rate is more or less unchanged during the demonstration phase due to above reason together with intermittent stops in receiving bin caused by jamming.

Tests during the demonstration phase have been performed with different settings of the screws in the receiving station. Several types of patterns and speed have been tested and an optimum setting for the present situation is in place.

Investigation is continuing during the demonstration phase by manufacturer PST for presentation of a solution for enhancing speed and weight capacity in beginning of 2017.



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New tests for optimizing screw pattern and force will be conducted together with implementing the new solution.

The work with finding suppliers, agreeing about contracts and arranging with logistics have been successful but takes time and involves a lot of people. Big suppliers often have agreements in place for the feedstock and must await end of that before starting the supply to Etanolix.

Contract to reach 100% is agreed upon but due to mentioned reasons above together with technical bottlenecks in the unit will realize the design throughput in the later part of 2017 or beginning of 2018.

There is also a bottleneck in hydrolysis that restrict maximum speed due to a restricted heat exchanger. This will be investigated when the problem with the receiving bin treatment speed has been solved.

The quality of the feedstock during the demonstration phase have a clear impact on the performance of the receiving unit's throughput. Items that have caused problems can be sorted in the categories:

- Not allowed feedstock as meat, vegetables, mold etc...
- Food containers as glass, metals, thick cardboard.
- Unwanted items as stone, papers, clothes, metal objects, wood etc.

Depending on the situation, the unwanted loads been discarded for waste handling.

This is still an important issue and thus, every delivery is monitored by the operators.

Having issues with the feedstock can in worst case lead to "jamming" of the screws or the un-packaging machine leading to downtime of the unit. Perpetual training and information to supplier and their staff about what is preferred feedstock and how to deliver the feedstock to the refinery have improved the quality.

During 2016, there have been problem with sand in the feedstock. The sand causes erosion in pipes and pumps which has lead several leaks in pipes. Investigation found that one deliverer had gravel and sand in the container together with the feedstock. The amount of sand decreased after discussion with the deliverer, but there is still some amount of sand causing problems.

Investigation of a solution for restriction of sand is ongoing during 2017.

In summary, the above mentioned issues and the measures taken to address the unforeseen issues will ensure a successful demonstration of the unique Etanolix technology and the first preindustrial



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pilot installation of integrated production process of sustainable ethanol in a fossil fuel refinery in operation.

ENVISAGED PROGRESS

The work after the demonstration phase will proceed until we reach the planned production of ethanol and stillage. Improved technical solution and a continuous improved tuning of the unit will together with new suppliers ensure high production with good quality products. The primary aim is to achieve production according to design and fulfill set target such as ethanol production, raw material, waste, stillage and KPIs.

St1 are confident that the project will result in an integrated production process performed under real life conditions to produce sustainable bio-ethanol with lowest possible CO₂ impact, allowing us to evaluate the technical and economic viability of the proposed concept.

