Annex C1-3:
Evaluation Report 3 from the demonstration phase after 18 months

Subject	Project acronym / Ref. No.	Date
Deliverable under Action C.1	Etanolix 2.0 for LIFE+ / LIFE12 ENV/SE/000529	31/01/2017

Issued by	Company / Department
Lars Olausson (Process Technical Department)	St1 Refinery AB / Technical Department

Evaluation Report 3 *from the demonstration phase after 18 months – Monitoring and evaluation of pilot plant*

Evaluation Report 3 concludes the period from July 1 2016 to December 31 2016. This report will cover progress, issues and solutions 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.

Progress

Deliveries of feedstock to the Etanolix-unit increased toward the end of the period, from 303 to 438 tons/month, see *Figure 1*.

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 those before starting the supply to Etanolix.

Agreements to reach 100 % of feedstock is ongoing and several big suppliers will start to deliver to Etanolix in the beginning of 2017. Contracts have been signed for >80% of the estimated maximum production., see forecast presented in *Figure 8.*

A new feed line for Etanolix to enable the use wet feedstock, e.g. jam, porridge and other liquid suitable starch-rich feedstock was built during December. Supply of this type of feedstock will start during Q1 2017.

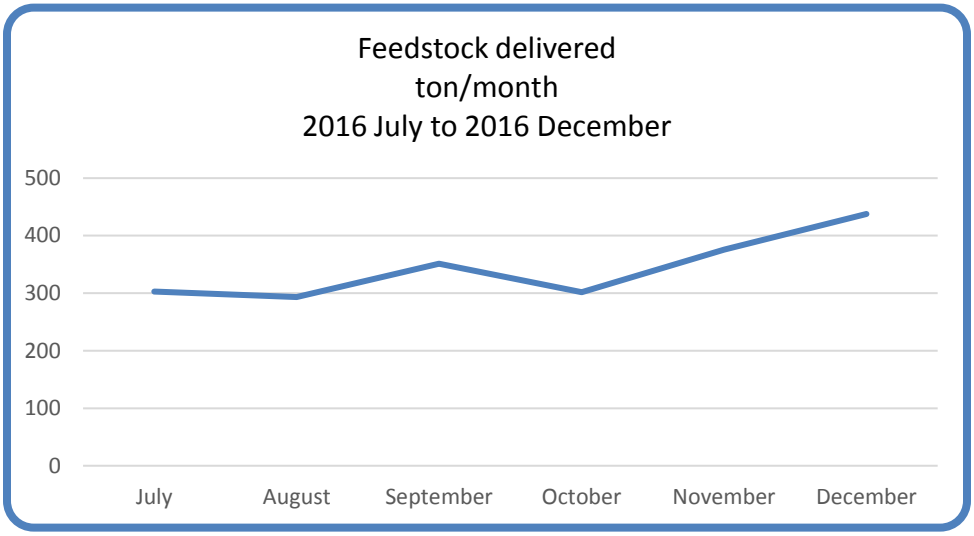

Figure 1. Delivered feedstock to the receiving station during July 1 2016 to December 31 2016.

The quality of the feedstock and its packaging is crucial for the unit to reach a good processing pace.
Most of the new suppliers have feedstock with suitable types of packing material and there are just a few transports per week where more difficult type of materials are present as big plastic bags and thick cardboard. The work together with manufacturer to get as clean feedstock as possible continues.

Perpetual training and information to supplier and their staff about what and how to deliver the feedstock into the refinery makes the processing of feed easier and faster. The amount of feedstock delivered to the receiving station, presented in *Figure 1*, can be compared with the maximum (design) plant throughput equal to approx. 1650 ton/month.

Testing which capacity the receiving container is able to handle have been done and is compared with earlier tests.
The volume of the container is fit for purpose to handle the design capacity full load of different sorts of feedstocks, but the processing rate of feedstock 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 speed is more or less unchanged during the period due to intermittent stops in receiving bin caused by jamming. The processing rate for the receiving bin is not yet up to design and demand further investigation and work.

The production of ethanol (*Figure 2*) during the period increased together with the feed from 80 m3/month to 127 m3/month accumulative to 570 m3 for the period *(figure 1)* and have been on specification.
100% have been transferred for production of low blend gasoline.

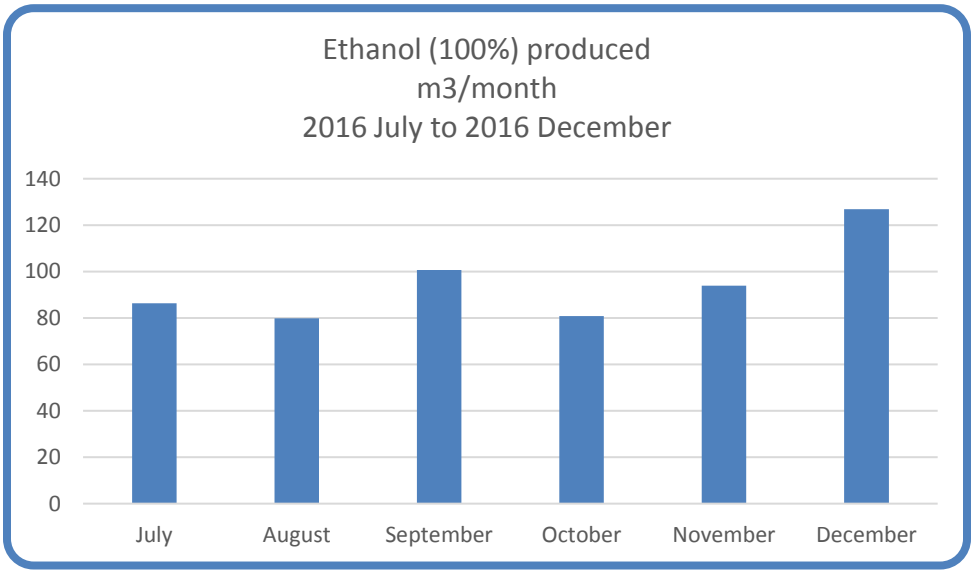

Figure 2. Produced ethanol from Etanolix 2.0 on a monthly basis.

The production of stillage follows the ramping of feedstock intake. The dry solid content in the production is continuously monitored and optimized.
This results in a stillage-product with higher nutrient-content which is better for the customers, and shows as a smaller volume of delivered stillage. In total, 5 751 m^3 of stillage was produced during the period, compared to the maximum amount of 25000 m^3. 2 813 m^3 was delivered as animal fodder and 2 938 m^3 as feed for biogas production, *see Figure 3.*

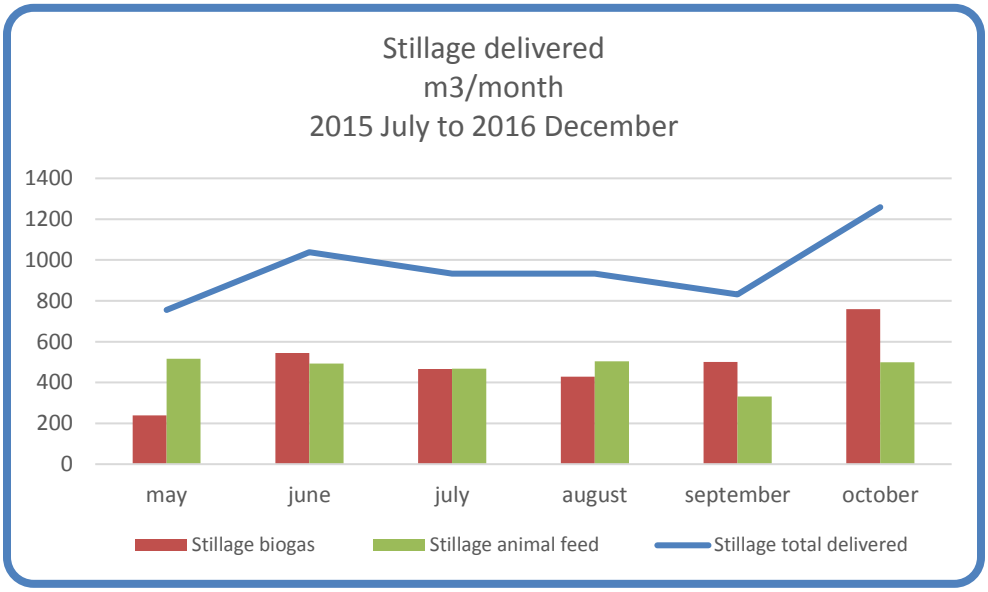

Figure 3. Stillage delivered from Etanolix 2.0 in July 1 2016 to December 31 2016.

As the total throughput of raw-material to the unit was low compared to maximum design unit throughput, consequently produced ethanol and stillage was relatively low with 11,3% and 11,5% respectively compared to the design.

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.

The ethanol yield is affected by different components as carbohydrates, sugar content, starch and how easy they are to break down in suitable sugar components. Suppliers of feedstock are chosen, as far as possible, due to feedstock quality with high contents of above, volumes and suitable packaging. A good feedstock produces a high yield, examples is candy, cookies and white bread. A yield (ethanol produced/received feedstock) above 20% shows good quality feedstock for the production.

The yield was quite stabile during the period on 20-23 %.

The yield (*Figure 4*) was quite stable over the period.

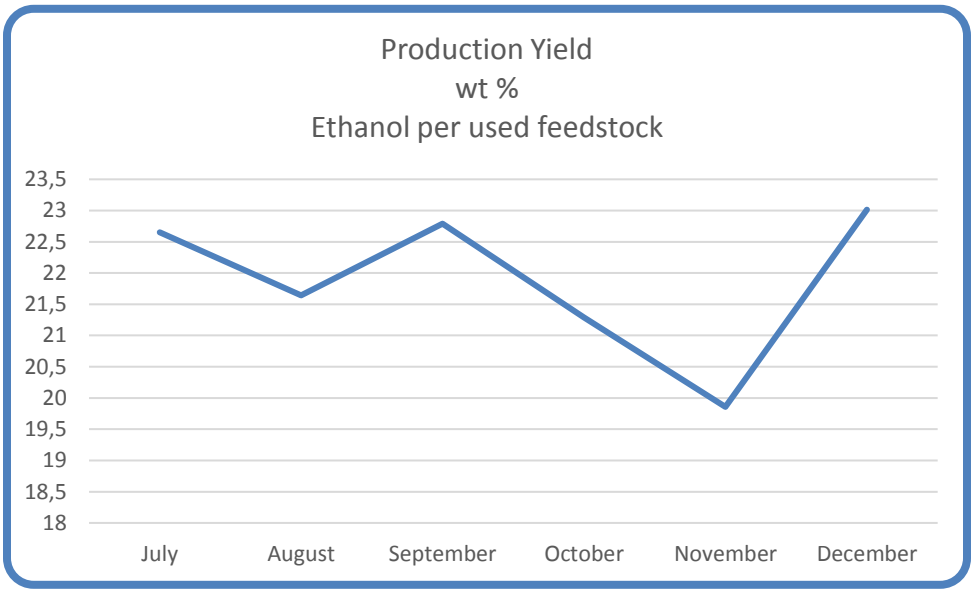

Figure 4. Ethanol yield

Refinery system and integration

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

Energy Consumption and Environment

Due to low throughput, the energy consumption was relatively low compared to design, that would expect 712.6 MWh/month, see *Figure 5*.

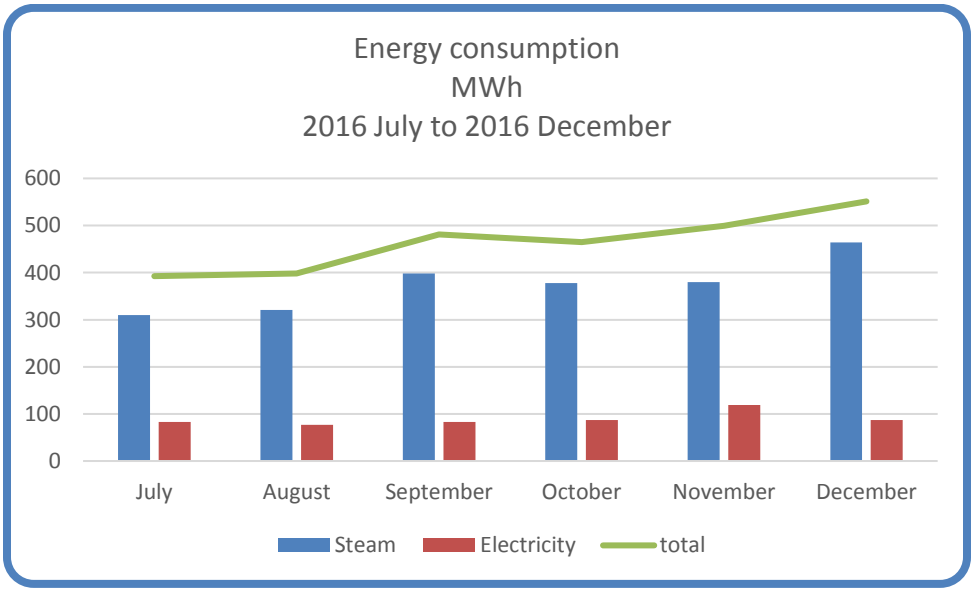

Figure 5. Energy consumption in the Etanolix 2.0 unit. The energy consumption is divided in the energy provided by excess steam from the refinery and electricity.

The use of energy is only partially comparable with the amount of feedstock and production. Equipment such as instrument, cooling pumps etc. is always active using energy even if the unit does not run at full rate. During the winter period a lot of energy is used for heating the equipment. That means that the energy-efficiency/produced m^3 of product will be better with an increase amount of feedstock.

Waste water treatment

There have been no negative effects on the refinery's water treatment plant during the period.

Green house gas calculations

Green House Gas (GHG) calculations for CO_2 reduction have been made accordingly to Renewable Energy Directive. The reduction will just as energy efficiency increase along with higher throughput. The CO_2 reduction for quarter 3 2016 was 91,63%. The reduction calculation for quarter 4 is not yet performed.

Distillation

The optimization of the distillation process started in May have continued during the period and significantly increased the stability in the process and reduced downtime.

Waste

Waste generated from the unit consists of plastic from the packaging and sludge from the CIP (Clean in Place) unit, see *Figure 6*. The plastic goes to a local facility for energy production and the sludge is delivered to a customer that is producing fertilizers. Other is feedstock that has been rejected due to impurities, mold or foreign objects. The accumulative waste volume during the period was 431 tons.

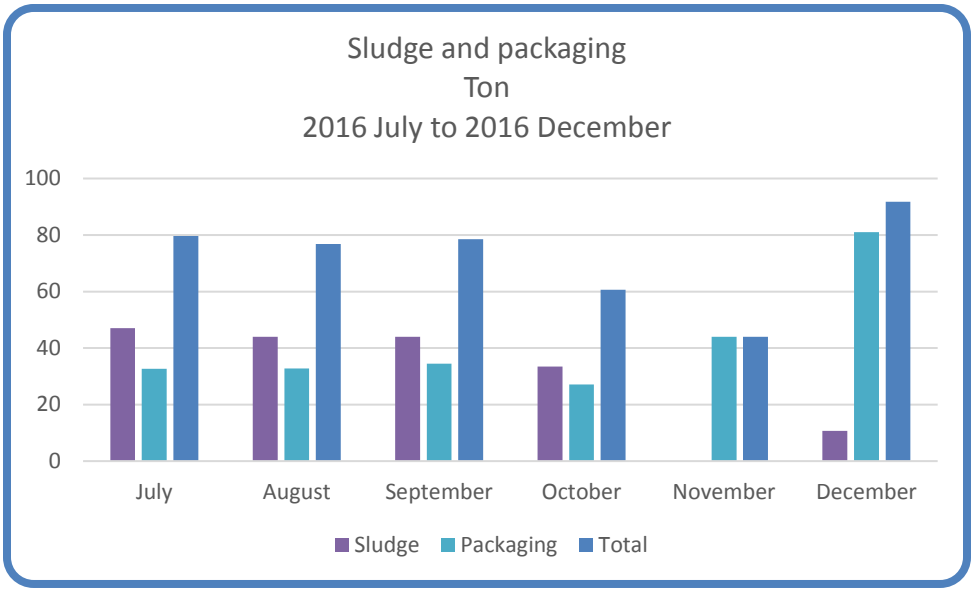

Figure 6. Waste from Etanolix 2.0.

Issues and Solutions

Receiving station / Prototype:
As reported earlier in Evaluation Report C1-2:
The receiving bins treatment speed and capacity is still restricted. Investigation is continuing by manufacturer PST for presentation of solution in beginning of 2017.
Maximum load can be increased depending on type of feedstock. Crumbs and chips is easier to treat and allows a heavier load than bread. In average, the maximum load is set to 12 ton.

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.

Even though the volume and the speed in the receiving station is almost up to specification, the limitation of just having a maximum of 12 tons in the receiving bin affects the logistic situation and can cause waiting time for the transporter of feedstock. For the moment there is no solution or plan ~~jet~~ on how to change this.

Feedstock:
The quality of the feedstock during the period have increased and loads that causing problem is now a small part of the total amount of delivered feedstock. This is still an important issue.
Having issues with the feedstock can in worse case also lead to "jamming of the screws" or the un-packaging machine leading to downtime of the unit.
There have also been load with unwanted materials. Those have been rejected and the customer have been notified.

There is a risk if unwanted material enters the collecting bins and reaches the receiving station. It is a part of normal routine that the Etanolix-operators check all deliveries before they accept the truck to deliver material into the receiving station.

Future work

Upcoming work is to continue with optimizing throughput of feedstock at the receiving station. A forecast on throughput is presented in *Figure 7.* This is a combination of more incoming feedstock and a higher treatment speed in the receiving bin.

Once the throughput of feedstock reaches approx. 45-50% of maximum, it will be possible to run the distillation continuously instead of batch mode as it is today.

Work will continue to engage suppliers with good quality of feedstock to ensure deliveries of at least 100% of the calculated maximum amount of feedstock.

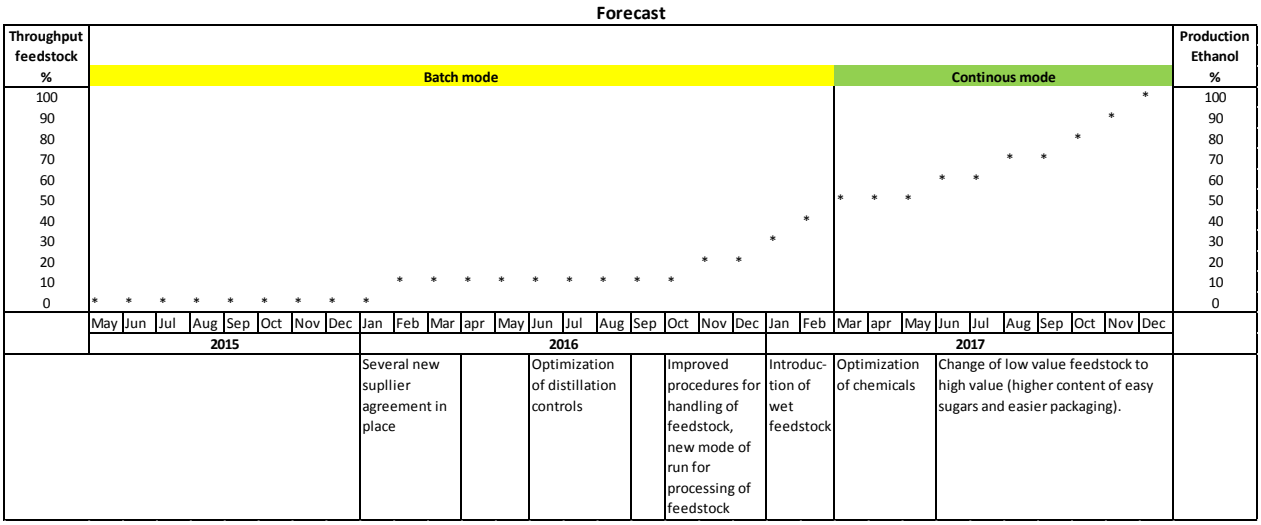

Figure 7. Forecast and plans for Etanolix 2.0 during the time period 2015-2017

Results

- 580 operational hours of feedstock accumulated to 2062 tons was delivered into the receiving station.
- 25 distillation campaigns, production time 1420 hours, meaning a cumulative ethanol production of 568 m3.
- 15 batches of produced ethanol quality tested according to laboratory analysis program.
- Total production of stillage is 5751 m3 (whereof 2813 m3 have been delivered as animal feed.
- The ethanol yield was stable during the period on 20-23%.
- Integration into refinery such as water and cooling system, steam, electricity, infrastructure (piping and tank connections), waste water system etc. is functioning as planned.
- Chemical uses are measured by quantity. At this stage, how much has been purchased rather than how much is required in the plant.
- Accumulative waste for the period was 431 tons that have been sent for burning and heat recovery.
- 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. Nevertheless, since we are in the demonstration phase period and that the production until now has been irregular (not continuous as planned for) and that only small amounts of waste water were produced compared to the final goal, this area will be an important issue to keep close track of as the demonstration goes forward since it is also linked to the refinery’s environmental permit.
- Environmental parameters e.g. odor has been considered acceptable ~~already~~ at this stage of the demonstration phase. At present, not all environmental parameters such as CO_2 and other air emissions have been calculated and measured due to the aforementioned reason under the previous point (i.e. Etanolix waste water quality). The operation must be more frequent and loads higher in order to obtain representative results.