Annex C1-1:
Evaluation Report 1 from the demonstration phase after 6 months

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Evaluation Report 1 from the demonstration phase after 6 months – Monitoring and evaluation of pilot plant

The first evaluation report concludes the time period of May 1 – Dec 31 2015, so in reality 8 months. The 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

The first delivery of feedstock to the Etanolix-unit arrived on 11th May 2015. The delivery acted as a function test of the receiving station. From there on, the throughput of feedstock to the receiving station has increased over the time period, reaching 135 ton/month,see *Figure 1*.

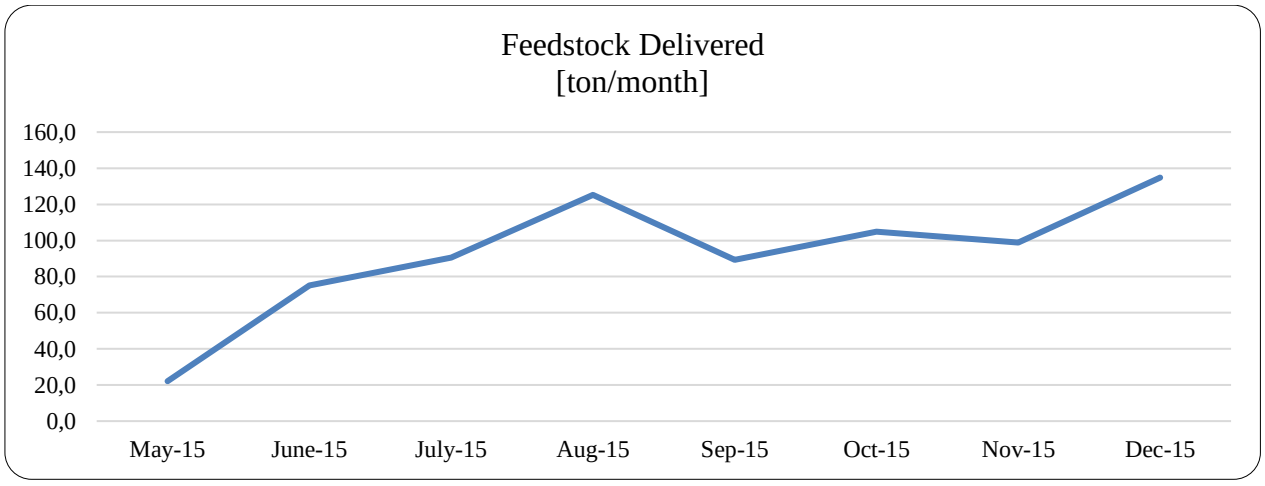

Figure 1. Delivered feedstock to the receiving station during May 1 – Dec 31 2015.

During the first months, it was observed that the quality of the feedstock was crucial for its ability to be processed from the receiving station to the next step. Items such as plastic bags and ropes that were mixed with the raw material made the screws in the bottom of the receiving container to get stuck (further described in *Issues and Solutions*). The amount of feedstock delivered to the receiving station, presented in *Figure 1*, can be compared with the planned throughput equal to approx. 1650 ton/month.

The capacity of the receiving container was limited in order to increase the total throughput. The container was too small, which meant that the raw-material got too packed and the screws did not manage to forward the raw-material to the next step (further described in *Issues and Solutions*).

During the period May-July, several test runs were made in order to optimizing the steps from the receiving station to the fermenters. Actions such as optimizing the capacity of the screws and changing the size of the screen before the hydrolysis step, in order to eliminating the risk of having plastics downstream the hydrolysis tank, were made. As the distillation step was not in operation, the stillage produced in May-July from Etanolix 2.0 was delivered to Borås Energi for biogas production. Most of the stillage during this period was sent for biogas production instead to animal fodder before it was ensured that the quality was good.

In beginning of July, feed from the fermenters was for the first time introduced to the distillation column. The first batches of distillation aimed for verifying the operation as well as instructing personnel of operating the distillation column in a good manner. Since the first test run in July until Dec 31, nine distillation campaigns were made with a total production time of 413 hours, leading to a cumulative ethanol production of 140 m^3, see *Figure 2*. The quality of the ethanol has still not been on specification due to too high acidity. The high acidity in the ethanol is probably due to dissolved CO_2 in the mash. A design where nitrogen is purged into the rectifying stage of the distillation column was introduced in the middle of December, in order to remove the CO_2. Test runs will be carried out in Q1 2016.

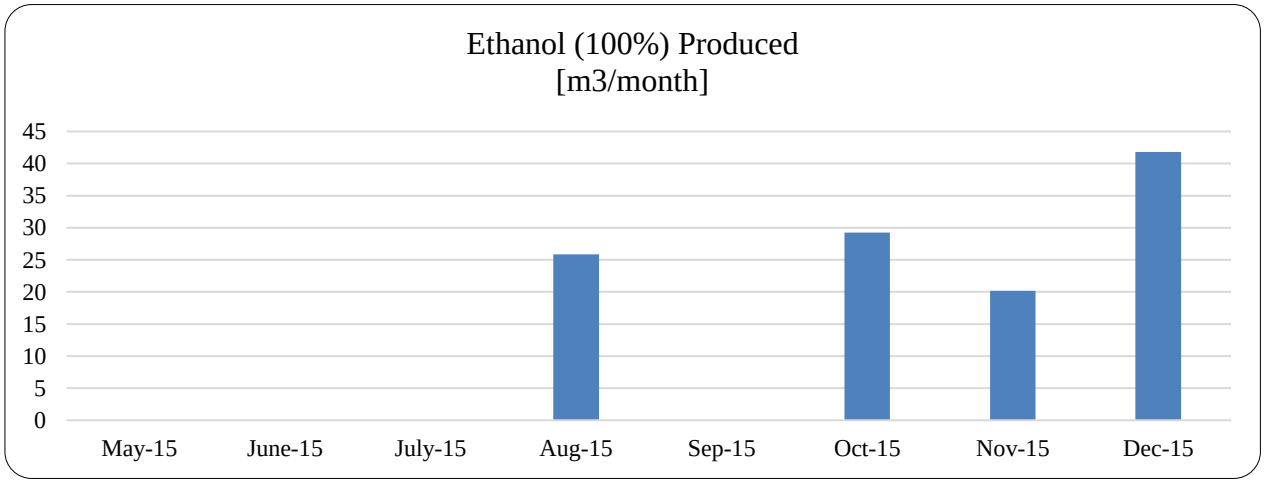

Figure 2. Produced ethanol from Etanolix 2.0 on a monthly basis.

As the unit was ramping up in throughput, more stillage was produced as well. In total, 1985 m^3 of stillage was produced during this period, whereof 550 m^3 has been accepted as animal feed quality, see *Figure 3*. The fraction of stillage being delivered as animal fodder has increased from October 2015 and forward. As the total throughput of raw-material to the unit was low compared to planned, consequently produced ethanol and stillage was low with 3.5% and 5.95% in relation to planned amounts, respectively.

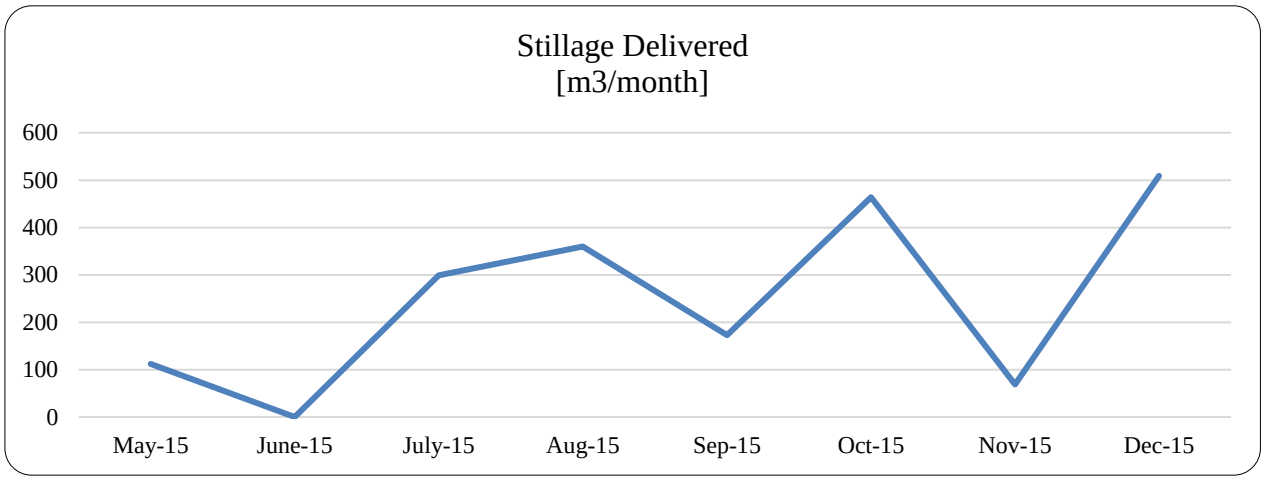

Figure 3. Stillage delivered from Etanolix 2.0 in May-Dec 2015.

Since the unit was started, a laboratory test program has been put in place analyzing both ethanol and stillage. The test program involves all necessary analyses required in order to make the products enabled for the market. As the distillation is in operation, daily analyses are made, which acts as a support for the process engineer to optimize the process.

Before ethanol and stillage is transferred or delivered to refinery tank farm and customer, respectively, a complete analysis is made to ensure the correct quality of the product.

Even though throughput was lower than expected, the ethanol yield shows a positive trend. The trend in *Figure 4* shows that the production in the plant is running smoother. The main reason of achieving this trend was better control of incoming raw-material. Fewer impurities in the feedstock made the screws in the receiving container running without interruption, meaning that less raw-material was discarded in the contingency container. Ethanol yield up to 25% was reached during the period.

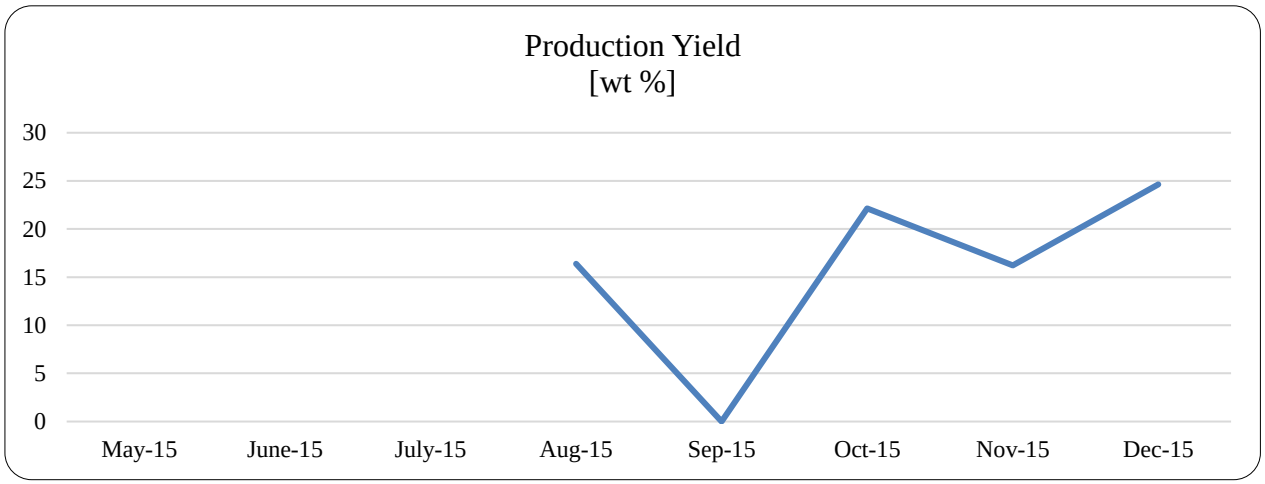

Figure 4. Ethanol yield

It is worth noting the variations in the production yield. This is due to infrequent distillations, meaning that some feedstock received in e.g. September was distilled in October. More trustworthy yields will become reality when the distillation step is running continuously.

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

Energy Consumption and Environment

Due to lower throughput than planned for, the energy consumption is also lower than expected, see *Figure 5*.

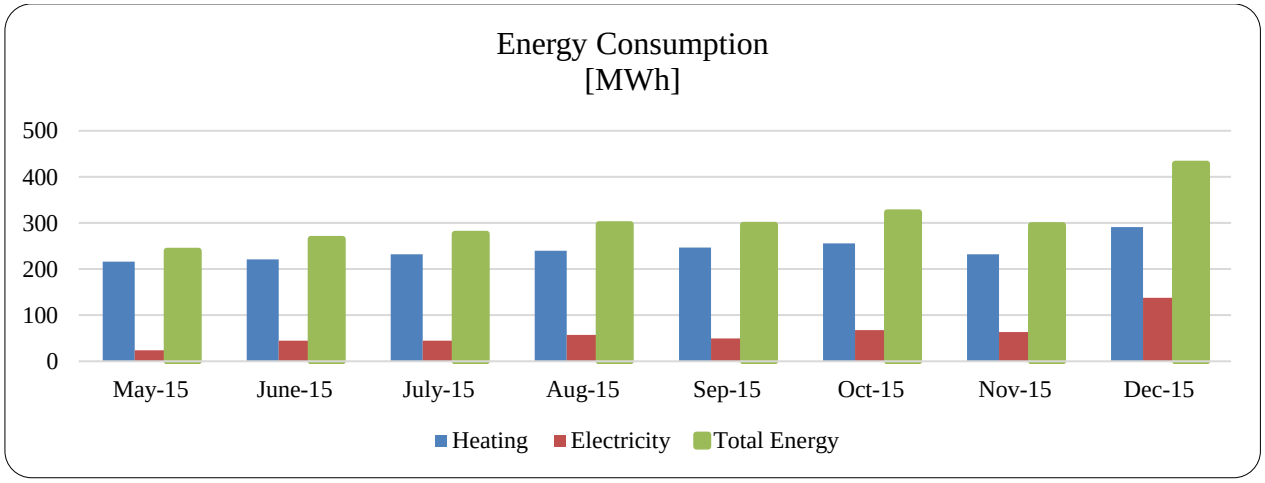

Figure 5. Energy consumption in the Etanolix 2.0 unit. The energy consumption is divided in the energy provided by excess steam from the refinery and electricity.

The energy consumption has increased with increasing throughput and number of distillation campaigns. At maximum production rate, it is estimated that 712.6 MWh/month will be supplied. As the throughput increase, the unit will become more energy efficient based on MWh/processed ton raw-material.

Waste water produced from the unit has been analyzed rather infrequent due to the irregularity of the run time of the distillation. However, the quality (e.g. pH and suspended solids) of the waste water has been considered accepted and according to plan.

At this moment, no CO_2 and other air emissions measurements have been carried out due to the, already mentioned, irregularity of the process. However, the plan is make measurements during Q1 2016 and will be presented in the second evaluation report.

Issues and Solutions

As mentioned in the beginning of the report, the receiving container was, at an early stage, considered to be too small. This affected the throughput into the unit as well as the efficiency of the receiving station. As the receiving container was too small, the feedstock was too tightly packed making the rotating screws in the bottom of container jam. An improved design of the receiving container was carried out during June and July, making it possible to increase the throughput to up to 20 ton per loading. The container was lowered and the upper part was widened. When the revised container was back in operation in September 2015, it was soon thereafter clear that the rotating screws did not manage to move that amount of raw-material at the same time. One screw broke due to mechanical stress. Thereafter, several test runs have been carried out in order to optimize the operation of the screws. By the end of this period a rotation guard was designed. The rotation guard prevents the same screw from rotating at different speed, and thereby reducing the risk for mechanical stress. The protection for the screws will be installed during Q1 2016 and, thus, covered in the second evaluation report.

The quality of the feedstock was also a crucial problem, mainly in the beginning of the period. Packaging material such as plastics and ropes were mixed with raw-material leading to jamming the screws. The feedstock in the receiving container was several times discarded in order to remove the impurities that got stuck in the screws. The suppliers of the feedstock were informed with clear instructions on what type of feedstock that was acceptable. Also, Etanolix-operators were informed what to look for once a delivery came to the receiving station. In this way, it has been possible to increase the throughput month by month.

Future work

The main focus for upcoming months will be to increase throughput into the unit. More suppliers will start deliver raw-material by the start of Q1 2016. The rotation guard (*Issues and Solutions*) will be installed during Q1 2016, where the aim is to decrease downtime in the receiving station due to mechanical problem.

As the throughput increases, more and longer distillation campaigns will be possible leading to the possibility of optimizing the operation of the whole unit. Also, the problem with too high acidity in the ethanol would be possible to solve as the number of distillations increases.

Environmental (air and water) measurements will be carried out during Q1 2016 for the Etanolix-unit.

Results

- 125 operational hours of feedstock accumulated to 740 tons was delivered into the receiving station.
- 10 short distillation campaigns, production time 273 hours, meaning a cumulative ethanol production of 140 m3.
- 10 batches of produced ethanol quality tested according to laboratory analysis program.
- Total production of stillage is so far in the demonstration phase 1985 m3 (whereof 550 m3 have been accepted as animal feed quality).
- The Ethanol yield increased during the period reaching 25% best month.
- 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.
- The Etanolix waste water quality has been demonstrated for e.g. pH, suspended solids and this has been so far proven according to program to ensure adoption in the refinery's biological waste water treatment. Nevertheless since we are in the early phases of the demonstration 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.