Annex C1-4:
Final Data Evaluation Report including technical and economical report

Subject	Project acronym / Ref. No.	Date
Deliverable under Action C.1	Etanolix 2.0 for LIFE+ / LIFE12 ENV/SE/000529	24/05/2018

Issued by	Company / Department
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Final data evaluation report – Monitoring and evaluation of pilot plant

Final data evaluation report covers the period from December 31 2016 to July 1 2017. 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.

A large amount of the data from the startup to December 2016 have been evaluated in previous reports. The report contains the evaluation of the remaining data according to action C1.

Progress

Production of sustainable ethanol, waste handling and stillage as a by-product

Deliveries of feedstock to the Etanolix-unit has been steadily increasing during the period, from 490 to 615 tonnes/month, see *Figure 1*.

The work with finding suppliers, agreeing about contracts and arranging with logistics has been successful, and is to date considered to be more or less complete. There are contracts in place covering a feedstock rate up to 100% capacity, see forecast presented in *Figure 8.*

A new feed line for Etanolix to enable the use of wet feedstock, e.g. jam, porridge and other liquid suitable starch-rich feedstock was built during December. Supply of this type of feedstock was supposed to start during Q1 2017, but difficulties at the supplier's end has postponed this to Q3 2017.

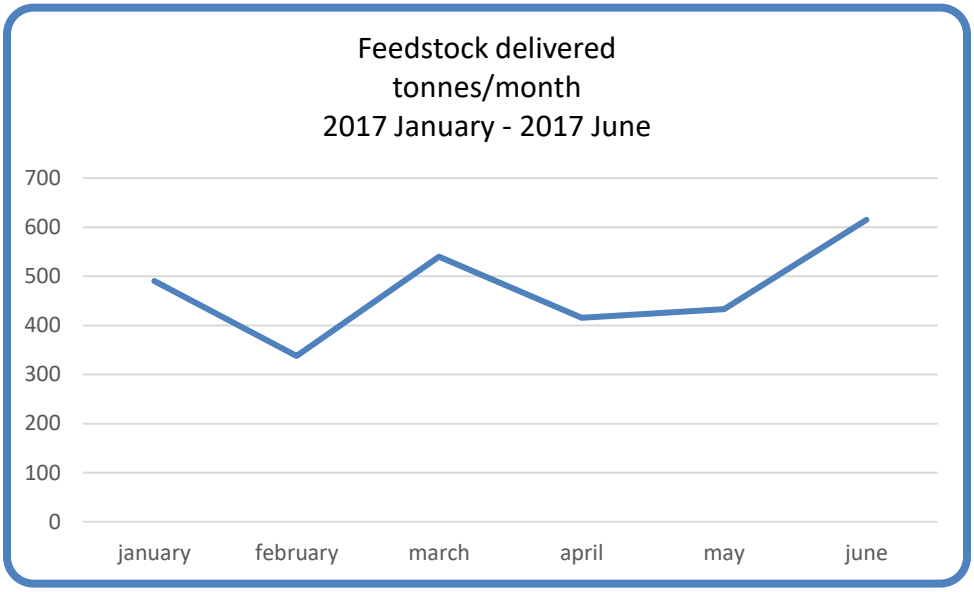

Figure 1. Delivered feedstock to the receiving station during January 1 2017 to June 30 2017.

The quality of the feedstock and eventual packaging is crucial for reaching a good processing pace of the unit.

Along with a steady increase in available feedstock, some suppliers of the most difficult materials have been deleted and replaced with more suitable feedstock. Processing disturbances still occur, but they are now mostly caused by individual mistakes in supermarkets, bakeries and such.

Perpetual training and information to suppliers and their staff about what and how to deliver the feedstock to 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 to the maximum (design) plant throughput equal to approx. 1 650 tonnes/month.

The receiving bin was partially redesigned during Q2 2017 in order to increase processing capability. Subsequent capacity tests revealed that the processing rate is less dependent of the amount of feedstock in the bin, but maximum processing rate is still well below design. With current feed rates, the capacity is sufficient but increases in feedstock deliveries up to 100% capacity during Q3 & Q4 2017 will show if more modifications are needed.

The production of ethanol (*Figure 2*) during the period has steadily increased, with the exception of the end of April and most of May when different repair and rebuild work was performed. All ethanol produced during the period January 1 to June 30 2017, in total 569.8 m^3, has been according to quality specifications.
100% of the ethanol has been used in production of low blend gasoline.

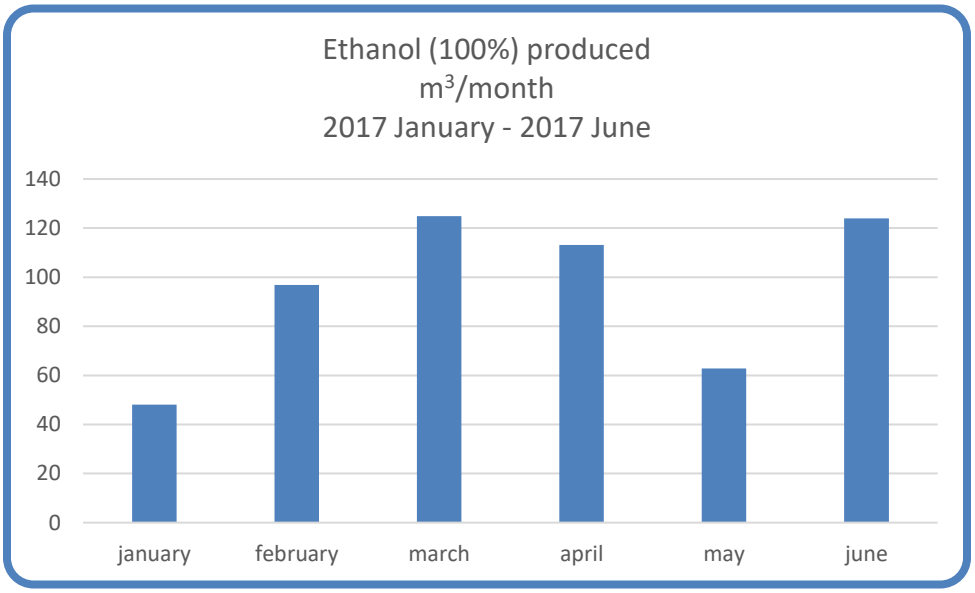

Figure 2. Produced ethanol from Etanolix 2.0 on a monthly basis.

The stillage production volume has followed the feedstock intake rate. The dry matter content in the product is continuously monitored and optimized. This is done because there is a lower limit on how diluted it can be, for being used as fodder. On the other hand, a too concentrated solution can cause problems in the distillation process. In total, 7 741 m^3 of stillage was produced during the period, compared to the maximum amount of 25 000 m^3. 3 578 m^3 was delivered as animal fodder and 4 162 m^3 as feedstock for biogas production, *see Figure 3.*

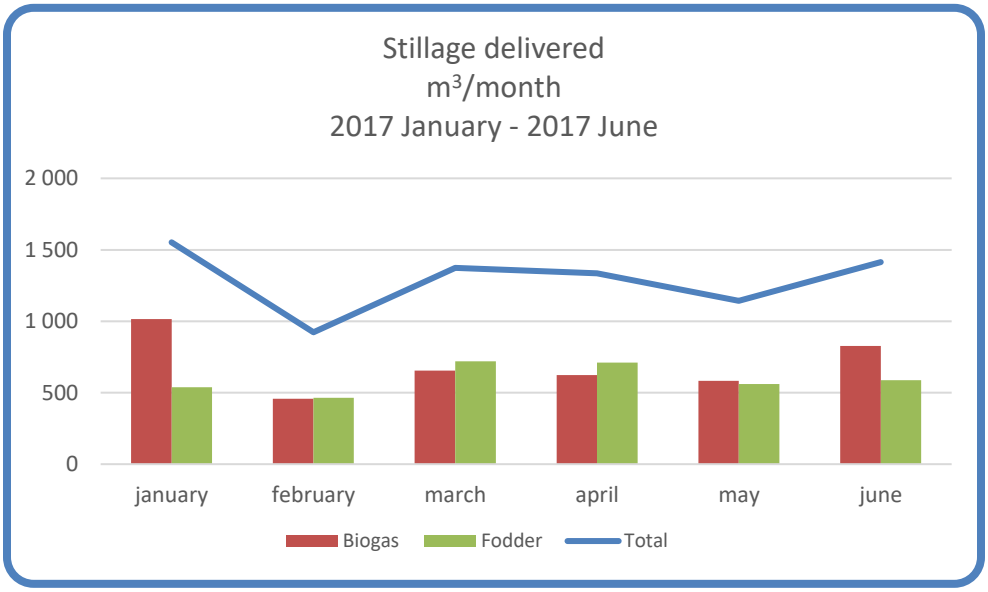

Figure 3. Stillage delivered from Etanolix 2.0 in January 1 2017 to June 30 2017.

As the total throughput of feedstock was still low compared to maximum design throughput, ethanol and stillage production was consequently relatively low, with 11.3% and 31.0% 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.

Unit efficiency

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 varied some during the period, this was caused by a few different hardware and control software issues, see *Figure 4*.

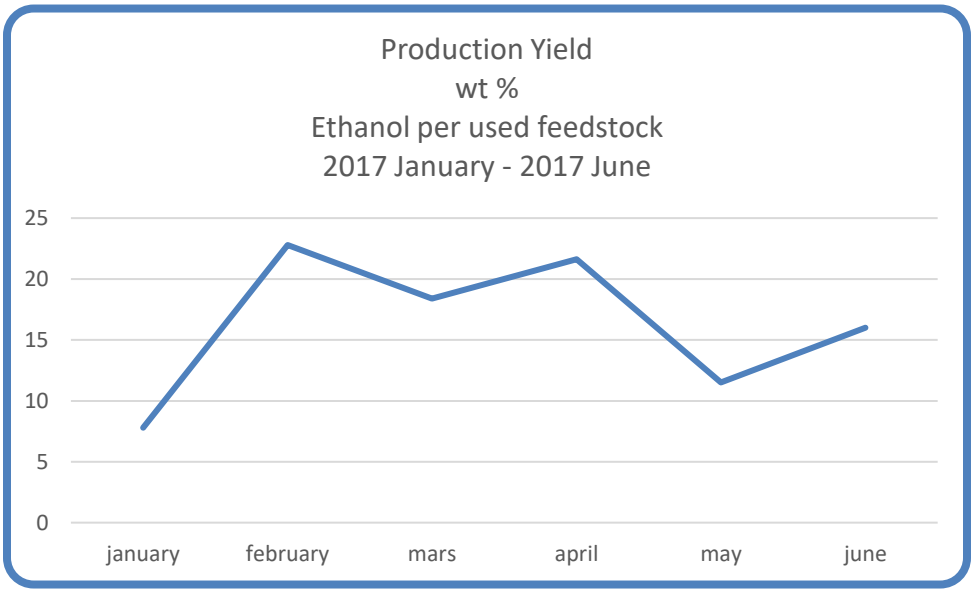

Figure 4. Ethanol yield

Refinery system and integration, including efficiency, cost effectiveness, environmental performance and sustainability

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

Energy consumption and environment

Due to lower than maximum throughput, the energy consumption was relatively low compared to design, which is 712.6 MWh/month. See *Figure 5*.

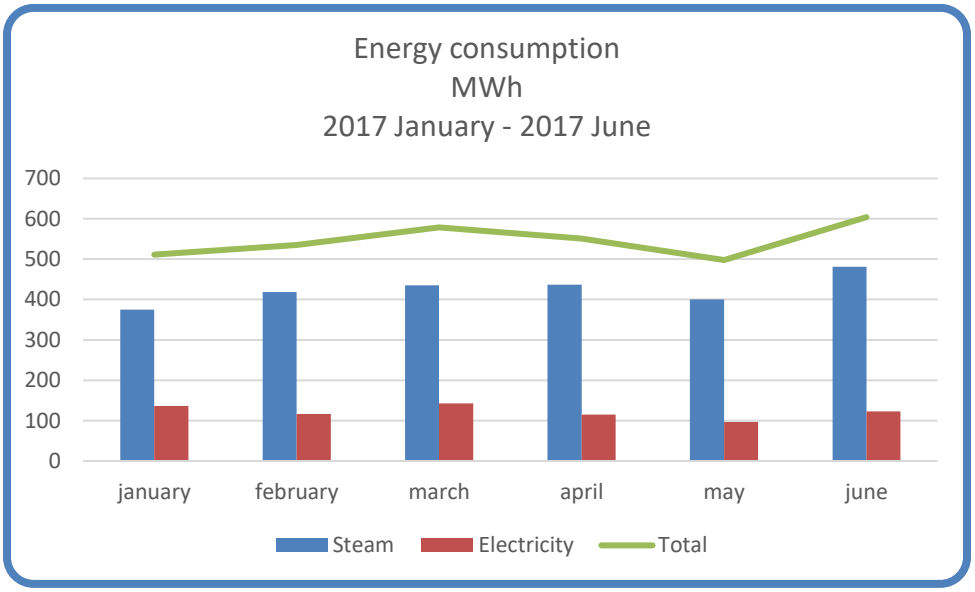

Figure 5. Energy consumption in the Etanolix 2.0 unit. The energy consumption is divided in the energy provided by excess steam from the refinery and electricity.

The use of energy is only partially comparable with the amount of feedstock and production. Equipment such as instrument, cooling pumps etc. is constantly 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.

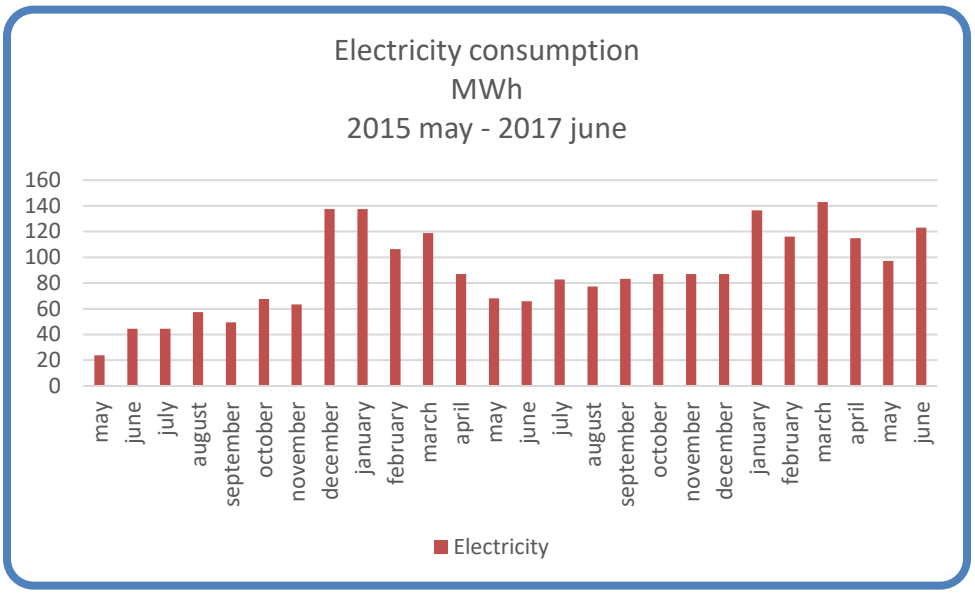

Figure 6. Electricity consumption since startup. It is clearly shown that consumption during the winter months is higher.

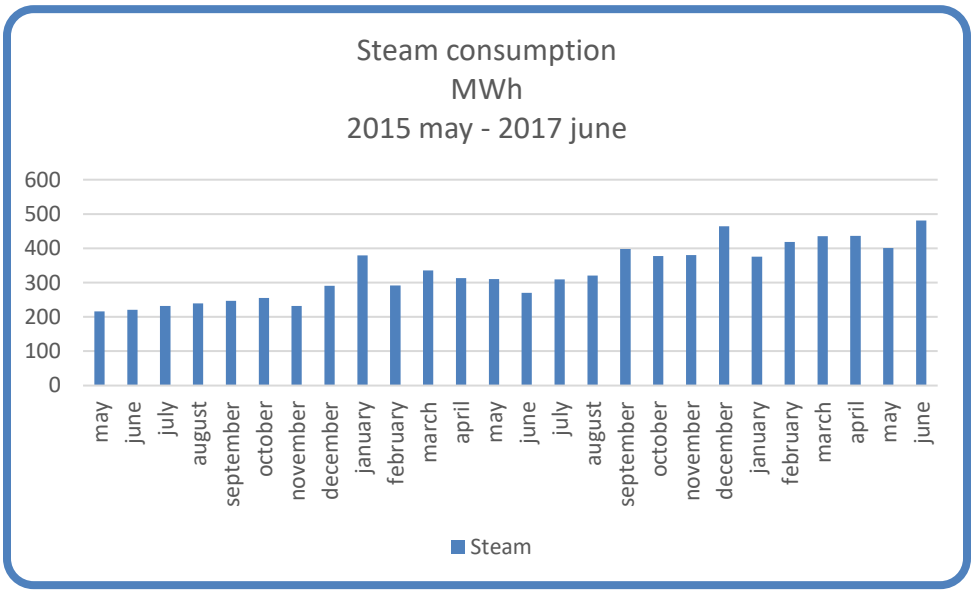

Figure 7. Steam consumption since startup. The steam demand does not show as much correlation with seasonal changes as the electricity does.

Operational costs and efficiency

The variable part of the total operational cost is highly affected by transportation costs. Both feedstock and stillage are transported on road by truck, and chemicals are delivered the same way.

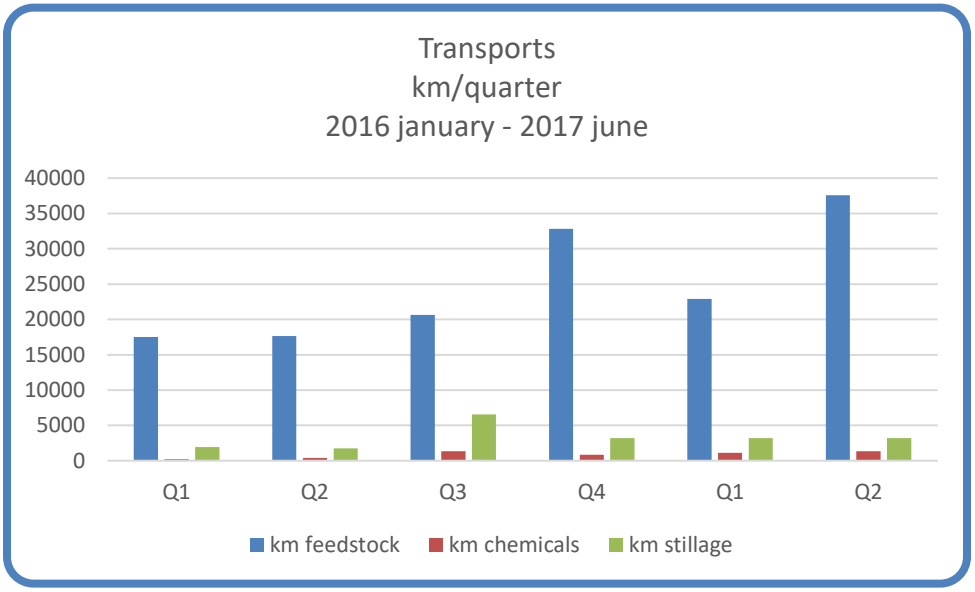

Figure 8. Transport distances since January 2016. They depend on total amounts av material transported, as well as on how far away the sources or destinations are located.

Along with the main focus on arranging for more feedstock deliveries, the aim has also been to reduce the number of cargoes with small loads and/or long distances in order to reduce the transport distance relative to amounts delivered.

Waste water treatment

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

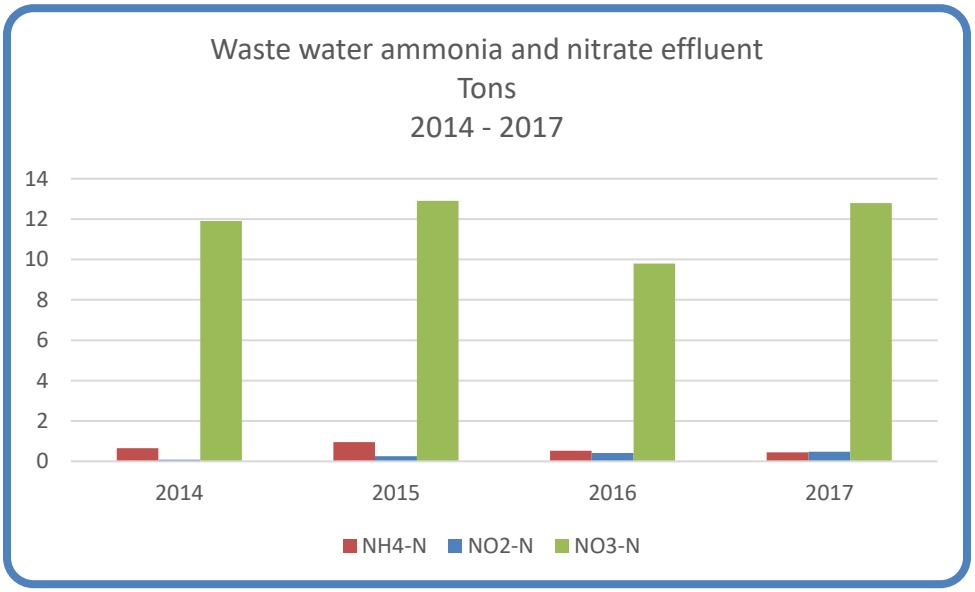

Figure 9. Total nitrogen effluents in water per year, since 2014. Etanolix has had no measureable influence on the effluent levels.

Green house gas calculations

Green House Gas (GHG) calculations for CO_2 reduction have been made accordingly to the Renewable Energy Directive. The reduction rate will, just as energy efficiency, increase with higher throughput. The CO_2 reduction for Q1 2017 was 89.52% and for Q2 2017 was 91.50%.

Distillation

The optimization of the distillation process is more or less complete. The unit starts up, runs and shuts down quite smoothly.

Waste

Waste generated from the unit consists of plastic bags and sludge from the CIP (Clean in Place) unit, see *Figure 10*. The plastic goes to a local facility for energy production and the sludge is delivered to a customer that is producing fertilizers. The accumulated waste amount during the period was 392.3 tonnes.

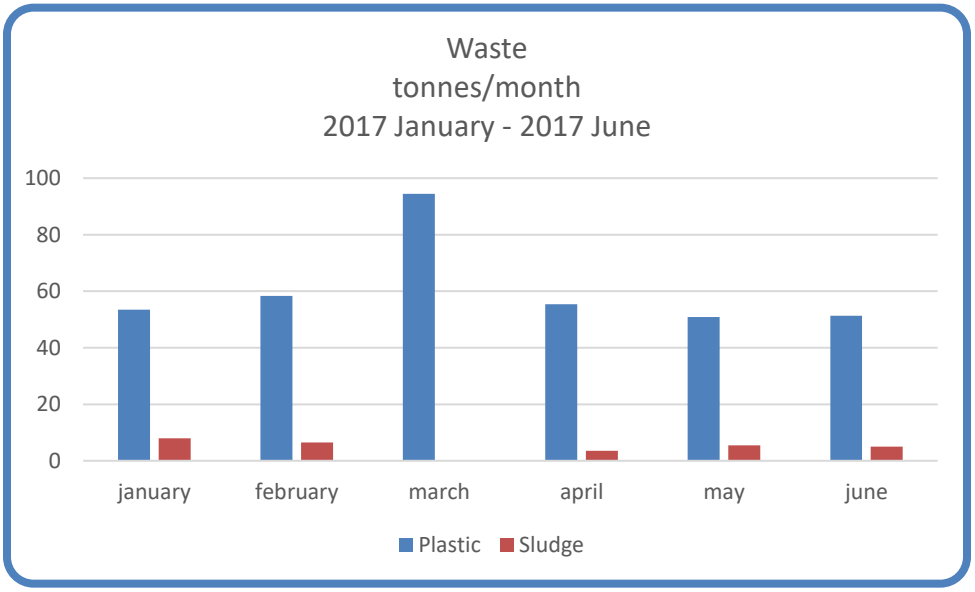

Figure 10. Waste from Etanolix 2.0.

Issues and solutions

Receiving station / Prototype:

The receiving bin has been modified and average performance has increased. It is still questionable whether the PST screw conveyors are able to handle 100% capacity. A ramp up in production during Q3 2017 will show that. So far, the receiving station has handled up to 50% capacity without complications, but it is probable that new bottlenecks will show at higher throughputs.

Feedstock:

The quality of the feedstock has increased during the period. As previously mentioned, deliveries of the most troublesome feedstocks have been completely removed and the contracts terminated. This has led to a significant decrease in downtime on the receiving station.

It still happens that loads with different amounts of unwanted materials arrive. The majority of those have been rejected, but some have been discovered after the load has been dumped in the receiving bin. Sometimes just one item of unprocessable material has been hidden in a container of otherwise perfect feedstock. Examples of such items has been tools, tires, clothes and furniture. They are discovered when they cause blockages somewhere in the process stream.

Future work

Upcoming work is to continue with optimizing throughput of feedstock at the receiving station. A forecast on throughput is presented in *Figure 11*. 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. Due to decreased production during summer (the bread consumption in Sweden is lower during the summer months), the predicted increase in deliveries with start in June hasn't been realized.

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.

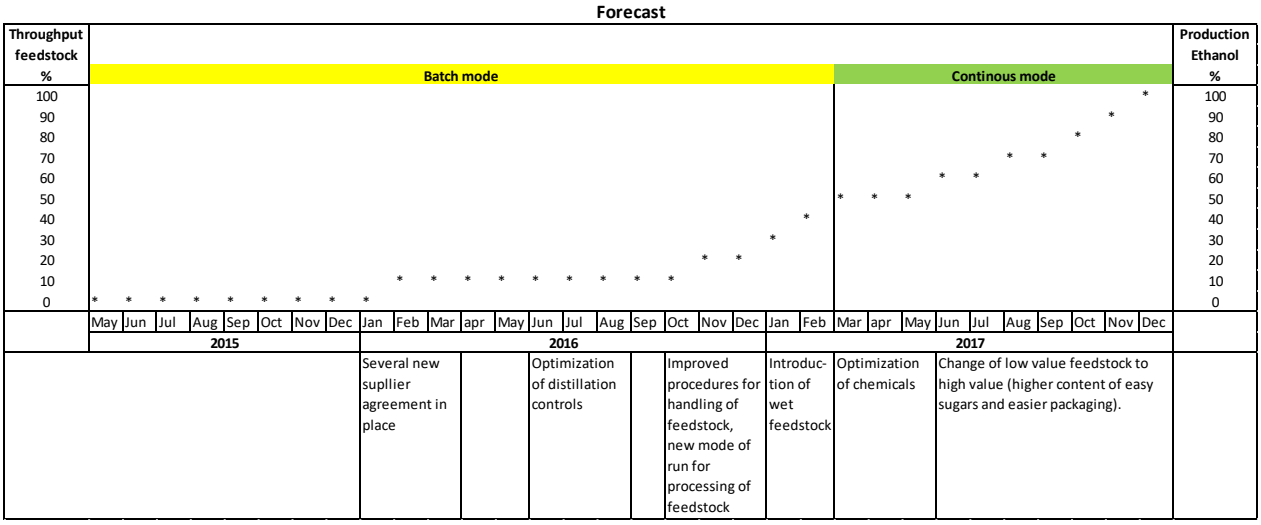

Figure 11. Forecast and plans for Etanolix 2.0 during the time period 2015-2017

Results

- 650 operational hours of feedstock accumulated to 2 831 tonnes was delivered into the receiving station.
- 26 distillation campaigns, production time 1 420 hours, meaning a cumulative ethanol production of 570 m^3.
- 17 batches of produced ethanol quality tested according to laboratory analysis program.
- Total production of stillage is 7 741 m^3 (whereof 3 578 m^3 have been delivered as animal feed).
- The ethanol yield varied considerably during the period between 8-23%.
- 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 392 tonnes 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 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.