LIFE12 ENV/SE/000529

Final Report

Covering the project activities from 01/07/2013 to 01/07/2017

Reporting Date
24/05/2018

Etanolix 2.0 - Demonstration of Innovative Method for converting Industrial Waste to Ethanol in oil refinery for LIFE+

Data Project

Project location	St1 Refinery AB Gothenburg, Sweden
Project start date:	01/07/2013
Project end date:	01/07/2017
Total budget	€ 4 552 001
EC contribution:	€ 1 682 920
(%) of eligible costs	36,97

Data Beneficiary

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2 Executive Summary

2.1 General progress

This Final report presents the results achieved within the project *"Etanolix 2.0 for LIFE+"* (project no: LIFE12 ENV/SE/000529) covering the period from start 01/07/2013 up to its finalization 01/07/2017.

The projects main objective was to demonstrate how industrial food waste can be recycled into sustainable ethanol used for road transportation. The process was integrated with an existing oil refinery. The results and outputs were the following;

- 98-100% efficiency of recycling and re-use of industrial food waste was fulfilled according to grant agreement
- Production of sustainable ethanol (according to European standard EN 15376) – ethanol quality was as expected, the produced volumes was lower than expected according to grant agreement
- Production of stillage – the stillage quality was over expectations, but the produced volumes was lower than expected according to grant agreement
- Processing of industrial food waste – the amount of processed waste was lower than expected according to grant agreement
- CO_2-reduction – the CO_2-reduction was over expectations according to grant agreement
- Integration of the plant into an existing oil refinery infrastructure was performed according to expectations in grant agreement
- Help oil/gas companies to achieve more sustainable production was achieved according to grant agreement

Below the main results within the project activities are summarized.

A. Preparatory actions	
Action A1: *Planning and preparation*	All necessary planning and technical preparation for the following actions planned in the project were performed, including definition of responsibilities and interactions between suppliers, assigners, constructors, consultants and St1 regarding construction and installation as well as agreeing upon evaluation methods. This action started on time but there was a delay due to a more complex environmental permit application than expected and previously anticipated. The last deliverable was finalized on 28/08/2015, the action was fully completed on 30/08/2015. Status: Completed
Action A2: *Design of the pilot and Procurement*	Under this action the remaining technical issues were solved, and the remaining design work was completed for the final integration of the Etanolix technology into the production process at the refinery and a successful procurement for the construction of the pilot plant was performed. The action started one month before schedule, but there was a delay due to a more complex and time consuming design process than what had been expected by the designers. The action was fully completed on 30/06/2015. Status: Completed

B. Implementation actions	
Action B1:	Under this action the pilot plant was assembled. Some parts of the work could be performed in parallel with the preparatory actions based on the results reached under

Construction of pilot plant and installation/ integration with the refinery	those actions. Installation of all equipment aiming at integrating the Etanolix technology into the production process of the existing refinery was successfully performed. The action started on schedule and most of the milestones were reached on time or before schedule. Not previously anticipated, some additional civil and piping construction work as well as equipment design work contributed to longer procurement procedure and there was a late delivery of the receiving station gate from the supplier. As a consequence the action was finalized with a 5 month delay but the action was successfully completed on 31/05/2015. Status: Completed
Action B2: *Commissioning, start-up and performance verification*	This action aimed at putting into operation the Etanolix technology as installed and integrated into the production process of the existing refinery, ready for demonstration. The action started on schedule and the activities performed mostly run in accordance with the time schedule set out in the proposal. The action was finalized with almost no delay from the perspective of the milestones. Some unforeseen issues were encountered, and two sub-activities needed further attention. Therefore, the sub-activities: *Start ramping up the production units after the first tests; optimization of operation before commencing the demonstration* and *Fine tune operation* were moved to Action B.3. This adjustment did not however imply any change in the project objective. It is rather a measure taken to remediate any problems derived from mechanical, electrical or instrumental faults. By performing further testing is a measure to ensure a successful project implementation concerning technical as well as dissemination aspects. Status: Completed
Action B3: *Demonstration of pilot plant*	This action was performed according to time schedule and was finalized 31/01/2017. The goal was to test the integrated Etanolix technology and the refinery's production process and to present a solution to produce ethanol in a sustainable and energy efficient way. The demonstration period was initiated after the technique was verified, the unit was started up and the environmental parameters calculated, defined and agreed upon with the local authorities. The demonstration of operation and performance of the Etanolix technology (as integrated into the production process of the existing refinery) run in the beginning in parallel with Action B2. The demonstration of the fine tuning of the production and the integration included demonstration, testing and evaluation of the receiving station, demonstration of infrastructure functionality such as electricity, steam, water, piping system. Monitoring of defined key parameters, along with the demonstration of plant, has been documented. During the demonstration, some issues lead to modification in the receiving station which was not foreseen. The feedstock was compressed in the container for raw-material, which meant that the screws that drive the feed-stock forward in the bin did not manage to process the feed-stock to the next step. An improved design was made together with the supplier of the receiving station, and different technical parameters have been adjusted and tested during the demonstration period. Status: Completed

C. Monitoring of the impact of the project actions	
Action C1: *Monitoring and Evaluation of pilot plant*	This action was initiated on time and was finalized 01/07/2017 as set out in the grant agreement. During the monitoring and evaluation of the plant, the functionality under different conditions (outdoor equipment etc.), raw material and product quality and overall usability was monitored and evaluated. The demonstration plant has delivered products with good quality during the project period, 100 % of the ethanol produced has been used in gasoline products at the refinery, and stillage has been delivered to different customers. The integration with

	the existing refinery has also worked as planned, including efficient use of existing utilities. The challenges that occurred during the monitoring of the project was the functionality of equipment during different conditions. Some equipment and components had to be replaced during the demonstration period and replaced with other components more customized to outdoor conditions. The receiving station has not worked as planned and has been redesigned during the project period to be able to receive the expected amount of industrial food waste. Some improvements are still to be made after the project period, and when they are completed the full results are expected for the project. An LCA-study was also performed to verify the environmental impact of the Etanolix plant. The study shows a very good result for Etanolix compared to other production techniques. The environmental impact can be minimized even more by increasing the utilization rate, use only locally produced waste products and optimize the electricity comsumption. Status: Completed
Action C2: *Socioeconomic impact of the project action*	Action C.2 was finalized on time during spring 2017, and evaluated the socioeconomic impact of the Etanolix 2.0 project. Due to lack of time and own personnel, the study was performed by an external consultant with relevant experience from this topic. The study shows that the socioeconomic benefits from the project are several. Most of the benefits are direct and indirect employment, both during the construction and the operational phase. In the long term, the project generates employment growth both at the St1 Refinery and also outside the company within handling and packaging of waste, transport and logistics of waste, biogas and stillage and in the biogas/agricultural sector. The project also enhances activities in the renewable fuel sector and in food waste management industry, reduces CO_2-emissions and strengthens the knowledge regarding sustainable ethanol production from waste. Status: Completed

D. Communication and dissemination actions	
Action D1: *Communication and dissemination of project results*	Action D.1 was successfully performed and some of the progresses under this Action was over expectations. The project developed a *Dissemination plan* which was continuously updated and contained the strategy to conduct an extensive and intense dissemination of progress and results of the project to stakeholders and target groups. The main channel for dissemination of the project results is the *project website* that is running as a part of the St1 official website. Throughout the project duration the website provided more detailed information about the project, the progresses made, results obtained, deliverables and other data collected. To monitor the effectiveness, the number of web page visitors per month have been monitored. The dissemination activities also included *visits* such as the inauguration of the Etanolix plant which was a half day event where national, regional and local politicians together with other key stakeholders in the field of biofuels met. The project has also initiated the production of *information material*, printed illustrative infographic and EMAS reports to communicate with local stakeholders such as neighbors, people living in the area and other industries, local authorities and companies. Eight *seminars and conferences,* all with focus on biofuels, have been visited. There have been several *publications* about the Etanolix plant in newspapers and magazines as well as a TV-spot in the local news and an article at an international website about waste noticing the project. Two *Notice Boards* have also been erected; one outside the refinery reception and another one at one of St1's most visited retail stations. The activities were finalized in spring/summer

	2017 and when completed, a successful dissemination of the project's progress and results to the identified target groups and stakeholders across Europe was achieved. Status: Completed
Action D2: *Networking with other EU-projects*	Action D.2 started two months before schedule and it was completed according to the schedule in the Grant Agreement. In total, four networking meetings were performed, including three other EU-projects. The most important lessons learned is that the projects all have a large focus on environmental issues and sustainability focus, none of the project would have been realized without funding from Life+ and the dissemination activities really enhances the contacts, information and experience between different projects. Status: Completed
Action D3: *After LIFE+ Communication Plan*	This Action was implemented during spring 2017, according to the time plan agreed upon in the Grant Agreement. To receive a subsequent dissemination of the project results, feedback from the other dissemination activitites were used as basis for the After LIFE+ Communication Plan. Status: Completed

E. Project management and monitoring of the project progress	
Action E1: *Project management and monitoring of project progress*	The Project management has been running according to plan with the objective to perform a structured project management and to secure high quality in the project implementation, results and dissemination. The Project Management consisted of the following entities: Project Management Group (PMG), Project Manager (PM), Technical Work Group (TWG), Reference Group (RG) and Dissemination Group (DG) and is based on quick and efficient decision-making and open communication processes. To address the upcoming issues there has been ad-hoc meetings as well as scheduled ones. The main activities for the management group have been to define, start up and implement activities with the resources available. Each project member has been in close contact with each other, mainly through face to face meetings within the refinery, e-mail conversations as well as video- and telephone conferences to drive the activities forward. The role of the PMG is to inform the board of St1 of relevant issues regarding the project and how it proceeds, to delegate tasks within the project, to approve changes within the scope of the project. It also ensures that the project tasks are prioritized in the best order, to help the project in sorting out upcoming issues including the budget. The PM is responsible for the completion of the separate actions and has monitored that the implementation of the project has been executed in accordance to project objectives and pre-set plans and that all objectives have been fulfilled. The TWG had several technical meetings to review the on-going work and make suggestions of changes when needed. The DG is responsible for the dissemination activities. The group has had several meetings regarding the dissemination activities, developed a dissemination plan for the project and performed several communication activities including participation in conferences, organizing visit at the refinery etc. Taking together, the Project Management is working intensively to ensure a successful project. Status: Completed

2.2 Assessment as to whether the project objectives and work plan are still viable

The unforeseen issues related to a more complex permit procedure and technical issues have caused a delay compared to the time plan of some of the Actions, mainly Action A.1, A.2, B1 and B2.

However, the overall time plan of the project as well as the project objective, which is to demonstrate and evaluate an innovative technology and sustainable production of ethanol from

waste integrated with an oil refinery, has been achieved. The issues causing the changes in time plan have been dealt with in an efficient way and sorted out, and the project has been finalized successfully as planned according to the Grant Agreement.

3 Introduction

3.1 Background, problem and objectives

3.1.1 Environmental problems/issues addressed

Approximately 20% of the EU's total CO_2 emissions originate from road transport. The availability and sufficient quantity of renewable fuel for the transport sector is a crucial step towards reducing our dependence on fossil fuels, as well as stopping global warming and the increase in GHG emissions originating from this sector. *The project is addressing* this issue as well as the problem of food waste and presents an outstanding solution for "Waste to fuel" based on a wiser resource use, where food waste is seen as a resource for renewable fuel (ethanol) production.

3.1.2 Hypothesis to be demonstrated / verified by the project

The project´s main objective is to, for the first time ever, demonstrate a sustainable production of ethanol from waste integrated with an oil refinery. The project involves the demonstration of an energy integrated pilot installation which will be the first complete system for production of bioethanol using industrial residues as raw-material and based on the proximity principle. The project supports several EU legislation and policies, inter alia LIFE+ Regulation EC No 614/2007 (Article 3.2 b) by being a demonstration project for a new approach that contributes to Community environmental objectives. The project helps LIFE+ in achieving the results under: Climate change, Waste and Innovation.

3.1.3 Description of the technical / methodological solution

The ethanol plant will be a *prototype pilot installation*, built to enable integration with existing oil refinery processes, which means the synergies e.g. like heat and cooling from the refinery and water systems can be used from already existing processes. The ethanol will be used as a bio-component blended into fuels used in vehicles. Previous development and testing, notwithstanding this will be *the first complete midsized processing plant in the EU*. The size of the pilot will be approximately 80% of a full scale plant and will, during the project, be demonstrated under real life conditions. By doing so, the project could assist in the implementation of the Environmental Technologies Action Plan (ETAP) by testing and communicating an innovative and emerging technique that could be potentially considered as BAT.

3.1.4 Expected results and environmental benefits

The *main result* from the project will be the first integrated operational processing plant demonstrating how industrial food waste can be recycled into ethanol whilst integrated in the production system of an existing oil refinery to produce renewable fuel for the transport sector. The expected project results and environmental improvements (compared to state of the art) are:

- 98-100% efficiency of recycling and re-use of Industrial food waste.
- Production of ethanol (European standard EN 15376): 5000 m^3/year.
- Production of Stillage for animal feed: 25000 tons/year.
- Processing 15000-21000 tons/year of food waste as raw material.
- Sustainability fulfilment incl. CO_2 reduction compared to fossil fuel as CO_2 emissions are reduced by at least 90% of the portion constituting the ethanol.
- Integration with existing refinery infrastructure.

- Helps oil/gas companies' greening their production towards increased sustainability.

3.2 Expected longer term results

If successful, it is estimated that the potential and a wider implementation of the technology in other EU countries would, for example 5 years after the Etanolix project is finished, enable bioethanol produced from bio-waste across the Community to increase with more than 15% compared with the estimated 5.4 billion litres of bioethanol produced in the EU-27 in 2011.

4 Administrative part

4.1 Description of the management system

4.1.1 Project phases and activities

Below is a Gannt chart presenting the project phases and activities performed during the project.

Action		2013				2014				2015				2016				2017				2018			
Number	**Name of the action**	I	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
A. Preparatory actions																									
A.1	Planning and preparation			√	√	X	X		X																
A.2	Design of the pilot and procurement			√	√	X	X																		
B. Implementation actions																									
B.1	Construction of pilot plant and installation/integration to the refinery					√	√	√	√	X	X														
B.2	Commissioning, start-up and performance verification									√	√	X	X												
B.3	Demonstration of pilot plant											√	√	√	√	√	√	√							
C. Monitoring of the impact of the project actions																									
C.1	Monitoring and evaluation of the plant					√	√	√	√	√	√	√	√	√	√	√	√	√	√	√					
C.2	Socioeconomic impact of the project actions																		X	√					
D. Communication and disseminations actions																									
D.1	Communication and dissemination of project results				√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√					
D.2	Networking with other EU-projects					√	√	√	√	√	√	√	√	√	√	√	√	√	√	√					
D.3	After LIFE+ Communication Plan																	√	√	√					
E. Project management and monitoring of the project progress																									
E.1	Project management and monitoring of the project progress				√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√					

√ = submitted timetable in application
X = extended action

4.1.2 Project organization

One of the tasks of the project was to establish a structured project management to secure high quality in the project planning, implementation, result and dissemination.

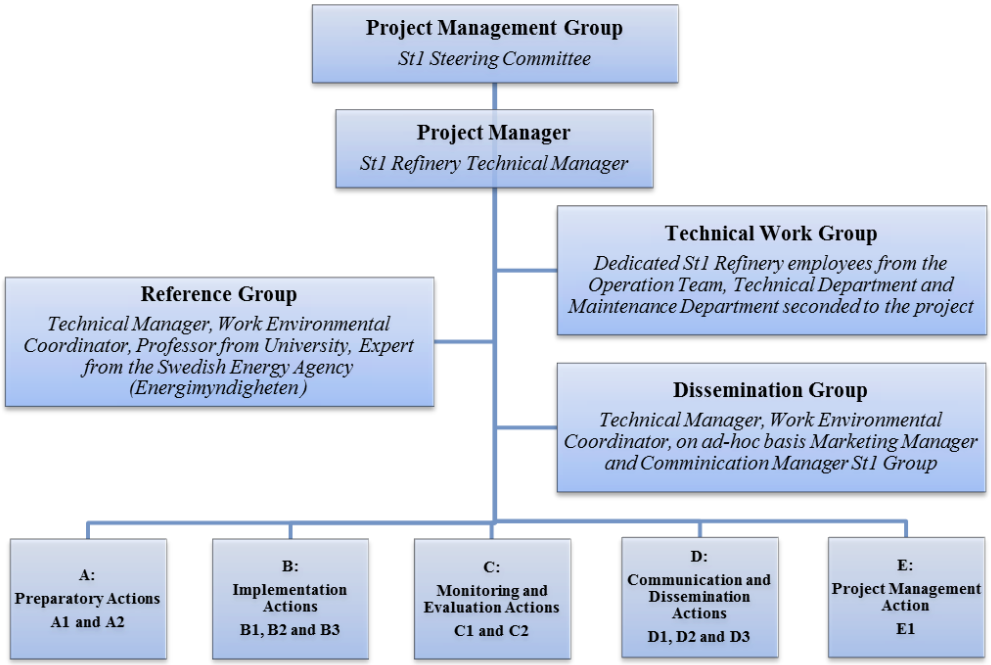


Figure 1: Organigramme of the project team and the project management structure

4.1.3 Project Management Group (PMG)

The PMG, (internally called Etanolix Steering Committee), consists of people from St1's management group and includes the Project Manager. The PMG consists of the Refinery Manager Bo-Erik Svensson, the refinery Technical Manager Linda Werner, representatives from the company Neot (supply of feedstock) Timo Huhtisaari and Henkka Talvitie, and representatives from St1 Biofuels (technical design of the unit) Risto Savolainen and Mika Aho. The group's role is to inform the board of St1 of relevant issues regarding the project and how it proceeds, to delegate tasks within the project, to approve changes within the scope of the project. The group's role is also to ensure that the project tasks are prioritized in the best order, to help the project in sorting out upcoming issues including the budget.

PMG meetings have been held 1-2 times per month during the preparatory and implementation actions. *See Annex E1-7 (Final monitoring report) and also Report from PMG meetings (Annexes E1-1, E1-3, E1-5 and E1-6).* During spring 2017 until the end of the project the PMG-meetings were held together with the DG-meetings.

During these meetings a number of key issues were discussed. The meetings have in general been attended by the entire management team to speed up the decisions and prepare for the next phase as fast as possible. After the meetings, the keeper of minutes has circulated the minutes of meetings, as a power point presentation, to the PMG (the Etanolix Steering Committee) members (the minutes are confidential, yet accessible during visits in Gothenburg, Sweden). The representatives in the Etanolix Steering Committee could thereafter in an efficient way delegate the actions and information further in the organization. This has been a successful way to engage easily with all the involved people and pass actions further in the organization To Whom It May Concern, e.g. the Technical Working Group or the Dissemination Group.

4.1.4 Project Manager (PM)

The PM originally appointed was Maria Frönell from the Technical department at St1. She had to take on other tasks within the refinery and was therefore replaced by Linda Werner, the refinery's Technical Manager. In the spring of 2017, Linda Werner ended her employment at St1 and was replaced by Anna Berggren (external consultant), to finalize the remaining work. Even though changes were made regarding the appointed PM, the PM's role and responsibilities did however not change. The PM's role is to make decisions within the scope of the project, to assess solutions during the on-going work, verify invoices, follow-up of the economy, handle documentation and report to the Project Management Group. The PM is directly responsible for the completion of the separate actions. Furthermore, the PM is in charge of the project planning, internal and external reporting and the documentation. The PM is coordinating the Project Management Group meetings.

Resource allocation is handled by the PM and the technical issues affected mostly the Technical Work Group. The PM is reporting on ad-hoc basis when required to highlight actions, but normally, on a monthly basis the project progress to the PMG. The PM is also responsible for the reporting to the European Commission.
See Annex E1-7 (Final monitoring report).

4.1.5 Technical Work Group (TWG)

The TWG consists of personnel from the St1's operation team, technical department and maintenance department. The TWG's role is to participate at necessary technical meetings and to review the on-going work and make suggestions of changes when needed. The TWG is steered by the Technology manager and meetings are held twice a year or ad-hoc if required to use the competence in severe trouble shooting etc. The TWG have had several meetings both planned and when the situation so required. Depending of intensity for each action e.g. the handling of environmental permit, meetings were held on a daily basis before the application was filed. Technical issues are handled face-to-face on a daily basis and during the commissioning and startup period, troubleshooting needed to be intense. This kind of meetings has not been formally documented.
See Annex E1-7 (Final monitoring report.)

4.1.6 Dissemination Group (DG)

The DG is responsible for dissemination activities and consists of the technical manager (Linda Werner) and the work environmental coordinator (from the HSE department, Carina Webjörn). Based on needs and requests, experienced marketing personnel at St1 and communication responsible from St1 Group have been involved in certain activities e.g. the inauguration. The DG have had monthly meetings discussing the progress of the dissemination actions. The dissemination plan has been updated after each meeting. The DG also developed a dissemination plan for the project, put up a website (02/2014), held meetings with the Reference Group, placed out 2 Notice Boards (02/2015) and performed several communication activities under 2014-2017 including several publications in magazines/newspapers, participation on

conferences, organizing visits at the refinery including the inauguration of the pilot plant (06/2015) etc. (for more information, please see section 5.2.2. under Action D.1).

See Annex E1-7 (Final monitoring report).

4.1.7 Reference group (RG)

The reference group was established in the beginning of the project period and meetings were held twice/year during the planning, construction and demonstration phase, to advise during the project. Following persons participated in the Reference Group.

Emmi Jozsa	Expert in sustainability at the Swedish Energy Agency
Willian Hogland	Professor in waste management and recycling at Linnaeus University
Marika Hogland	LundaHydro
Linda Werner	Technical manager ST1
Bo-Erik Svensson	Managing director ST1
Carina Webjörn	Health, safety and environmental coordinator, ST1

4.1.8 Amendments to the Grant Agreement

No changes have been made during the project period due to the Grant Agreement.

4.2 Evaluation of the management system

The Etanolix 2.0 project has a high priority within St1 and the experiences from previously successfully completed projects serve as a strong foundation for this demonstration project.
One of the main advantages for the project has been that the existing operational organization at the refinery, with long experience in process plants, has handled many of the operational parts of the Etanolix plant. In the end of 2016 and in the beginning of 2017, many of the project members ended their employment at ST1, (Maria Frönell went on maternity leave 2016-11-15, Linda Werner left ST1 2017-04-12, Lars Oluasson left ST1 2017-05-13 and Carina Webjörn left ST1 2017-05-21). To be able to finalize the project, Jonas Strandberg took the role as process engineer and external assistance (COWI) was hired for project management. Maria Ahlström at ST1 also joined the project organization for the finalization of the remaining activities.

From the technical and economical point of view, the project has required other working method for the organization than what they are used to. It involves many actors simultaneously working at the refinery site. The scope of the Etanolix 2.0 project is to upgrade an innovative technology including the receiving station and integrate it into the production process of the existing oil refinery. The ethanol production unit was delivered by someone else and the challenge was to tie-in the various units/systems together with a shared timeframe. Since the supplier of the inside battery limit part has not been used to work in a refinery area, with all the

additional safety standards to be followed, it was necessary to spend more time on discussions and on a kind of “internalization process” to ensure a common understanding.

When it comes to the communication with the Commission and the Monitoring team, there were some challenges in the beginning in understanding how and at what detail level the progresses made in the project should be reported. The internal standard procedures used for managing and reporting complex projects were reconciled with the expectations and project reporting from LIFE+-program perspective. Therefore, during most of the project duration it was important to have regular and ongoing dialogue with the Monitoring team and the Commission, to deliver a successful project. The Commission representatives and the Monitoring team was invited to visit the demonstration site, and a lot of effort was made to ensure that Commission will be satisfied with what has been achieved in the project.

5 Technical part

5.1 Technical tasks

5.1.1 A. Preparatory actions

5.1.1.1 Objectives

The project set out two planning and preparation actions (i.e. Actions A1-A2) in the proposal and Grant Agreement. The overall objective of the planning and preparation actions is to carry out all necessary planning and preparation, to solve the remaining technical issues, complete the remaining design work and perform a successful procurement and construction of the Etanolix plant. In short,

- *Action A1 – planning and preparation*, aims to perform all planning preparations for the actions to come
- *Action A2 – design of the pilot and procurement*, aims to solve the remaining technical issues and design work for the construction and integration of Etanolix technology

5.1.1.2 Action A1 – planning and preparation

5.1.1.2.1 Actions undertaken

Most of the planning and preparation work have been performed by the project manager and the technical manager at St1. To assist the St1 market department, a person with an established network from the food industry was hired to the refinery´s sister Supply Company named NEOT to help define all responsibilities between suppliers and assigners for the feed-stock as well as for the stillage.
St1 also hired a lawyer for expert assistance regarding the permitting procedure.

5.1.1.2.2 Results achieved

Deliverables	**Status**
Report on project plan *(Annex A1-1, submitted with the Mid-term report)*	*Finalized 31/12/2013*
Summary report on methods and evaluation tools *(Annex A1-2, submitted with the Mid-term report)*	*Finalized 21/08/2015*
Milestones	**Status**
Pre-decision on all permits	*Finished 2014/07/01*
Setting the final project management group	*Finished 2013/10/31*
Start-up meeting successfully conducted	*Finished 2013/10/31*
Successful finalization of the project plan and work program including risk mitigation	*Finished 2013/12/31*

Most of the activities were performed as planned according to time schedule and organization. The permit process turned out to be the most challenging part of this task, and took longer time than expected to finalize.

- *Final scheduling of all activities and related sub-activities:* Pre-planning and detailed planning of the different project parts and phases were carried out with different key

stakeholders within the organization. The Project Management Group was the sponsor of activities and economics etc. and the Technical Work Group in most cases has done a detailed planning and scheduling to enable the creation of timetable and defining details regarding activities including sub-activities. In *Annex A1-1 – Report on project plan* the activities are summarized briefly and examples of scheduled activities are given.

- *Constituting final project group:* A final project group was set up. External personnel, from other St1 companies and consultants, were active in the project organization in the Project Management Group and the Dissemination Group. For the Reference Group experts in the field of renewables, waste, sustainability were engaged. As a short summary report on methods and evaluation tools, please see *Annex A1-2 - Summary report on methods and evaluation tools*.
- *Final identification and classification of critical elements and how to solve these risks:* Identification of all possible foreseen risks has been performed, both from a business perspective and from the technical angle. One of the critical elements foreseen was to obtain the environmental permit. *Mark- och Miljödomstolen,* the decision-making court, granted the permit on 25/02/2014.
- *All responsibilities between suppliers and assigners were clearly defined:* In 2014 a person with an established network from the food industry was hired to the refinery´s sister Supply Company named NEOT to help define all responsibilities between suppliers and assigners for the feed-stock as well as for the stillage. This person explicitly dealt with activities related to contracting and procurement for the raw material, supply and logistics as well as stillage sales. An employee at St1 has researched the market and visited a lot of potential suppliers for bread, candy, cakes etc.
- *Clarification and development of tools for ensuring, measuring and reporting sustainability.* Tools and reporting systems have been developed for ensuring, measuring and reporting on sustainability (please also see *Annex A1-2 - Summary report on methods and evaluation tools*). The unit´s outcome will be fully verified in a later stage when the production is at steady state conditions. The environmental control framework has been defined and been agreed upon with the environmental authorities 07/07/2015.
- *Evaluation methods were finalized and agreed upon including design management quality systems for ethanol, stillage and the environmental parameters to be tested and reported.* To ensure product quality for the plant, evaluation methods, test methods and analyses programs have been developed (please see *Annex A1-2 - Summary report on methods and evaluation tools*). The quality controls will be carried out both during normal operation and for abnormal conditions to enable further development. A control framework for the quality parameters to be used is implemented and roles and responsibilities defined within the organization.

The most challenging part of the work was the permitting process. The obtaining of the environmental permit required more personnel involved than planned (both internal and external) and it was also received with a delay according to the original time schedule. This extended work did not imply for request of changes in the content of the action or the project, and even if the permit approval was delayed, it did not affect the overall project schedule to any large extent.

5.1.1.2.3 Modification of work plan

No modifications regarding the content of the project have been requested.

5.1.1.2.4 Major problems

No major problems were encountered when this action was executed.

5.1.1.2.5 Indicators of progress

Start-up meeting successfully conducted – completed
Setting the final project management group – completed
Successful finalization of the project plan and work program including risk mitigation – completed
Obtaining all permits – completed
Report on project plan – completed
Short summary report on methods and evaluation tools selected – completed

5.1.1.3 Action A2 – design of the pilot and procurement

5.1.1.3.1 Actions undertaken

The objective A2 – design of the pilot and procurement were to solve the remaining issues and to complete the remaining design work for a successful installation and integration of the Etanolix plant. The work was to a large extent performed by St1 internal staff and external consultants and managed by the project manager. Engineering specialists from St1 Biofuels also participated during the Basic design.

5.1.1.3.2 Results achieved

Deliverables	**Status**
Report on Contract signed with subcontractors *(Annex A2-1, submitted with the Mid-term report)*	*Finalized 01/02/2014*
Report on Contracts signed with suppliers of raw materials and customers of stillage *(Annex A2-2, submitted with the Mid-term report)*	*Finalized 30/06/2015*
Report on Design of the pilot plant and refinery integration *(Annex A2-3, submitted with the Mid-term report)*	*Finalized 01/09/2014*
Report on risk assessment on plant *(Annex A2-4, submitted with the Mid-term report)*	*Finalized 28/11/2013*
Milestones	**Status**
Detailed design of the pilot plant and integration accomplished	*Finished 2014/12/31*
Tie-ins from process integration accomplished	*Finished 2014/07/31*
Hazop carried out for process safety reasons	*Finished 2014/01/31*
Contracts signed with subcontractors for construction	*Finished 2014/06/30*
Contracts signed with suppliers of raw materials and customers of stillage	*Finished 2014/12/31*
Project design accepted by independent inspector company	*Finished 2014/12/31*

- The *design prior to investment decision: predesign, feed, basic design, process design, safety and operability study* was carried out according to normal refinery procedures. The design parts were done mainly by the refinery's Project Department where the expertise is construction and civil engineering. Input to the design phases was required by the Process Technology Department. The safety and operability study was carried out by a team of experts from different departments in the refinery, e.g. HSE (health, safety and environment), process technology, operations, instrumentation department. In lead of these studies a coordinator is appointed normally from the Technical Department or an external resource leading the activity. In this case a process safety engineer acted as the coordinating party and compiled the report (please see *Annex A2-4-Report on Risk assessment on plant*).
- *Detailed engineering and procurement for construction* were carried out followed by the integration part to the refinery's ordinary processes where refinery staff carried out most of the task. (For more information please see *Annex A2-1-Report on Contracts signed with subcontractors*). The normal procurement procedure used within St1 is to send out the request for quotation to several companies when it comes to an amount above approximately 150,000 SEK. Tenders are opened as a formalized procedure by multiple people within the organization and an evaluation document is summarizing the outcome and the result is filed. If conditions change during the tender period, all the companies are notified about the changes.
- *Design of the integration scheme with the existing refinery.* The design and the scheme of the integration of the Etanolix within the existing refinery were done by the local refinery team together with the Finnish team who delivered the production plant. In addition, the so-

called tie-in points were defined. The integration into the refinery included connection points from the new unit into the existing refinery, e.g. the water, nitrogen, steam supply to the new unit, the connection of the new unit's effluent water to the refinery's biological water treatment, the electricity, the cables for steering the unit to the central control room etc. (For more information please see *Annex A2-3-Report of design of the pilot plant and refinery integration*)

- *Final integration* regarding how to sort the *logistical system for feedstock transport and reception* was done. The Etanolix plant is placed inside the refinery fenced area, an area which is a classified safety area with minimum criteria to be fulfilled (e.g. who is allowed to pass into the area, what training is required etc). In addition to the construction of new roads for heavy vehicle transportation including parking areas also new notification and development of procedures for suppliers of feed stock and stillage customers, entering the area via refinery reception, had to be taken care of.
- *Develop logistical options for ethanol in finished grades automotive fuels.* There have been discussions on how to best handle the ethanol and what options are best from a logistical point of view. The product is now pumped, in a piping system, to the refinery's west tank farm where it is blended into the mogas pool for quality test and delivery out in the market place. There are also some other options viable e.g. to transport the ethanol on train or truck out in the marketplace, however, these options go beyond the framework of this project. From a sustainable point of view the alternative chosen is the best option as existing infrastructure can be used except from the tie-in connection to the piping system and from some safety arrangements that are required.
- *Develop options for outlets and efficient infrastructure for further use of stillage and decide about preferred option.* Early in the project there were some thoughts to use the stillage internally to produce biogas for the transport sector. Building a bio digestion plant on-site was evaluated. There have also been discussions ongoing with the nearby local municipal waste water company about the possibilities to pump the stillage to their existing degasser and use the biogas in their *"circular economy loop"* for the transportation sector. After evaluating this option, it failed due to so called "revac criteria" and readiness of separating the digestate and therefore, this option would generate a too high cost for the project at the moment.
- *Contract management: all responsibilities between suppliers and assigners will be clearly defined, e.g. conclude agreements with feedstock suppliers for a sustainable co-operation for both parties:* Contracts were signed with approximately ten suppliers of feedstock. The volume contracted meet the demands and the ramping plan was 100% feedstock to the unit at 01/01/2016. Furthermore, contracts are in place with two customers for the whole volume of the stillage. Finally, contracts are in place for two logistical solutions. For long distance transports, contract is in place with a logistics company transporting goods out from Gothenburg and who usually return empty. For short distance transports and gathering of feedstock from stores there is an agreement with a garbage disposal company that uses dedicated vehicles for gathering and transporting feedstock to our unit. Due to commercial agreements, the exisitng contracts cannot be shared, but they can be seen at St1 Refinery if requested. The content of the *Report on Contracts signed with suppliers of raw materials and customers of stillage* is classified and therefore is not included in *Annex A2-2*, but it is available for examination at the refinery. In total and as a summary, 35 potential feedstock suppliers and 5 buyers of stillage were involved in the discussions. For the raw material

supply of feedstock 12 contracts are signed and for the stillage volumes 2 contracts are in place whereof one buyer takes 80% and the other party takes the rest.

- *A Risk assessment on plant* has been completed (28/11/2013). The risk assessment was an important activity during the permitting process (please see Action A.1) to identify and eliminate potential risks related to the project and operation of the Etanolix-plant as well as the integration of it into the existing oil refinery. (For more information please see *Annex A2-4-Report on Risk assessment on plant*).
- *Hazard and Operability Analysis (HAZOP)*: The risks identified with the ethanol plant and its connection to the refinery system is low in relation to the risks associated with the refinery's other activities. With the implementation of the identified action points in the risk analyzes, the risks are considered to be well taken care of, thereby creating good conditions for a safe and stable operation.

The Action A.2 started one month before schedule and was fully completed on 30/06/2015. The design process was more time consuming and complex than expected, and some of the milestones in the action was therefore delayed. However, the activities performed under Action A.2 enabled the project to successfully integrate the innovative technology and to optimize the production process thereby ensuring successful recycling and bioethanol production during the pre-industrial scale demonstration.

5.1.1.3.3 Modification of work plan

No modifications regarding the content of the project has been requested.

5.1.1.3.4 Major problems

No major problems were encountered when this action was executed.

5.1.2 B. Implementation actions

5.1.2.1 Objectives

The project set out three implementation actions (i.e. Actions B.1-B.3) in the proposal and Grant Agreement. In summary, the overall objective of the three implementation actions (Actions B.1-B.3) is to assemble the Etanolix plant, put it into operation including commissioning, start-up, verification and optimization. The implementation actions also include a demonstration period that demonstrates the production of sustainable ethanol integrated with the existing oil refinery. In short,

- *Action B.1. Construction of the pilot plant and installation/integration to the refinery* aims to translate the results reached in the planning and preparation actions into the final construction and integration of the pilot plant
- *Action B2 Commissioning, start-up and performance verification* aims to put the pilot plant into operation and to verify the performance of the installed equipment and integration
- *Action B3 Demonstration of pilot plant* aims to complete the operation and performance of the Etanolix technology

5.1.2.2 Action B1 – Construction of the pilot plant and installation/integration to the refinery

5.1.2.2.1 Actions undertaken

The aim with this action was to translate the results obtained in the planning actions A.1 and A.2 into the final construction of the integrated pilot plant. Action B.1 involved St1 staff, contractors and sub-contractors and the action was led by the Project Manager.

5.1.2.2.2 Results achieved

Deliverables	**Status**
Report on the construction of the pilot plant *(Annex B1-1, submitted with the Mid-term report)*	*Finalized 30/12/2014*
Report on the installation of the pilot plant *(Annex B1-2, submitted with the Mid-term report)*	*Finalized 30/12/2014*
Milestones	**Status**
Procurement on time	*Finished 2014/12/31*
Civil works completed	*Finished 2014/12/31*
Distillation tower installed	*Finished 2014/12/31*
Receiving station ready	*Finished 2015/03/31*
Safety training of staff	*Finished 2016/03/31*
Steel work finalized	*Finished 2014/12/31*
Tanks and fermenters installed	*Finished 2014/12/31*
Tie-ins to refinery finalized	*Finished 2014/12/31*

Action B.1 started on schedule (i.e. on 01/01/2014) and the majority of the milestones was reached on time or before schedule.

The activities performed under Action B.1 resulted in what was proposed in the application, i.e. an integrated and functional pilot plant capable of recycling industrial residue and transforming it to renewable fuel for the transport sector.

The performed activities under Action B.1 constituted two parts: construction/building of the ethanol plant and the installation/integration to the oil refinery. The activities and the results are summarized below:

- Construction and civil works were all finalized according to plan (please see *Annex B1-1-Report on the construction of pilot plant*). Construction of the Etanolix 2.0 has meant a lot of civil works for preparation of technical units; receiving station, pre-treatment, fermentation, distillation column, dehydration unit and tanks, intermediate tanks for the ethanol. The technical units were also equipped with an advanced control system and instruments. The work required special expertise of each category of contractors.
- The installation into the refinery meant connection into existing refinery for the use of heat, cooling, electricity and waste water system etc. This was done in parallel with the construction of the Etanolix plant. This activity involved many people and the St1 Safety department had an important role in ensuring that the activities were coordinated and planned so that potential/possible risks could be managed immediately (please see *Annex B1-2-Report on the installation of pilot plant*).
- All projects where checked by authorities (the Fire brigade) 13/05/2015. This means that the local fire brigade was visiting the Etanolix plant to see how in practice a fire will be extinguished. This was done together with the refinery Safety Manager and the civil engineer that had designed the system.
- Safety training of refinery staff has been performed, so the personnel will have enough awareness of the risks at the work location (confined space, heat, chemicals, hygiene). The training was performed by the unit responsible process engineer together with St1 Biofuels. The participants were refinery staff that will be involved in the operational, laboratory, maintenance activities of the new pilot plant. St1 Biofuels shared the knowledge from common ethanol plants, operating in smaller scale and not integrated to refineries. Even though the refinery in many years, due to the renewable directive, has been importing ethanol into refinery tanks the risk with operating a plant at refinery site introduces totally different risks that need to be considered and added competences are therefore needed.

Even though St1 has extensive previous experience of constructing technically complex systems and the staffs involved in this Action are leading experts in the field, two major issues were encountered. These issues delayed this action with approximately 5 months, and the issues are described below:

- Due to extended work scope, such as additional civil and piping construction work as well as equipment design work, St1 had to address this issue by extending the end-date for the procurement. The procurement was finalized at the end of October 2014. In addition, and to solve the encountered issues related to equipment design work, more personnel from St1 was involved as well as engaging some additional external assistance than previously anticipated and budgeted for.
- Due to late delivery of the receiving station gate from the supplier, the receiving station was not ready until 31/05/2015.

5.1.2.2.3 Modification of work plan

No modifications regarding the content of the project has been requested.

5.1.2.2.4 Major problems

No major problems were encountered when this action was executed.

5.1.2.3 Action B2 – Commissioning, start-up and performance verification

5.1.2.3.1 Actions undertaken

The objective of Action B.2 was to put the Etanolix technology into operation as installed and integrated into the production process of the existing refinery. When the action was finalized, the Etanolix technology was ready for demonstration. The action was led by the Operations Manager at St1, and involved several staff from St1, including members of the technical working group and staff from St1 Biofuels.

5.1.2.3.2 Results achieved

Deliverables	**Status**
Commissioning report produced and approved *(Annex B2-1, submitted with the Mid-term report)*	*Finalized 25/09/2015*
Documentation for the Etanolix technology and integration into the refinery completed *(Annex B2-2, submitted with the Mid-term report)*	*Finalized 31/05/2015*
Report on Verification of technique in operation with a satisfying operational performance defined in the pilot plant. *(Annex B2-3, submitted with the Mid-term report)*	*Finalized 31/01/2017*
Milestones	**Status**
Authority visit to agree on start-up	*Finished 2015/05/13*
Commissioning of plant	*Finished 2015/05/30*
Intake of raw material, waste feed stock	*Finished 2015/05/30*
Start-up of Etanolix 2.0	*Finished 2015/05/30*
Environmental parameters calculated and measured	*Finished 2016/12/31*
Etanolix waste water quality proven according to program, to ensure adoption in the refinery biological waste water treatment	*Finished 2016/12/31*
Ethanol and stillage quality parameters tested according to test program	*Finished 2016/12/31*
Training of operators completed	*Finished 2016/05/31*
Verification of technique in operation with a satisfying operational performance defined for the pilot plant	*Finished 2016/12/31*

The activities performed under this Action run mostly in accordance with the time schedule set out in the proposal. Even though some issues were encountered and some of them needed further attention, Action B.2 was finalized with almost no delay from the perspective of the milestones and a *Documentation for the Etanolix technology and integration into the refinery completed* (please see *Annex B2-2*).

In the Grant Agreement, several important tasks were proposed to be performed under Action B.2. These tasks were performed and the results are summarized below:

- *Training of staff*

A training program was established on16/09/2014 by the refinery's training officer together with the process engineer responsible for the plant. Several training visits to Finland were planned under Action B.2. Between 16-18/09/2014 the refinery's training officer and process engineer were in Finland to plan the training together with staff at St1 Biofuels in Finland as well as to visit Etanolix units and ethanol production units to study similar process and get a deeper understanding of objectives and key parameters to ensure successful implementation and fermentation process.

Training of staff started on 28/10/2014. Two laboratory staffs from St1 were in Finland between 17-18/11/2014 to get a deeper understanding on how they work at the local laboratory and how to use the laboratory equipment.
Staff training on safety regulations was also implemented in November and December, 2014. 150 persons were trained on 2-day course at seven times. The training was continuously implemented for new staff members. During 2016, 63 staff members were trained in safety regulations for the Etanolix plant.
Between 25-27/02/2015 two Etanolix field operators visited units in Finland for three days to learn how to operate the unit and carry out maintenance procedures. An instrumentation technician also visited Finland between 06-10/09/2014 for training regarding the control system to be installed in the control room at the refinery.

Most of the training has taken place at the refinery in Gothenburg, Sweden during the period of 28/10/2014 to 26/11/2014. During this period:

- 78 people from the Operations Department were trained for two days in the use of the ethanol unit including control and automation technology.
- 50 people from the Maintenance department and 10 people from the Laboratory were trained for one day in the use of the ethanol unit.

After that, training of Operation staff in the control room was performed by St1 Biofuels on how to run the process. The two Etanolix Field operators were also trained by St1 Biofuels out in the plant.

- *Commissioning and start-up of the new and integrated production process into the refinery*

The commissioning of the plant was performed in the end of December 2014. Thereafter, the Fire brigade (the competent authority) visited the plant on 15/02/2015 with the purpose to control that the plant was in accordance with the handling permit for flammable and explosive materials. The results from the inspection were without remark meaning that the plant could be put into operation.

A Commissioning report has been produced and signed off by the Technical department by the constructor and the civil engineer in lead for the project (please see *Annex B2-1-Commissioning report produced and approved*). In this document one can find the sign-off as confirmed finalized for all the defined tie-in points and infrastructure regarding the integration of the plant to the refinery. The commissioning of the plant was done by testing part by part of the plant and each discipline expertise in the refinery organization was handling over their area of responsibility to the Operations department according to normal refinery procedures. The commissioning is a part of a common refinery procedure named Management of Change which is always carried out for a project or a plant change within the refinery site.

The start-up was originally planned for in January 2015, but was postponed until May 2015. This because of a planned refinery shut down for maintenance and inspection. During a shutdown the Etanolix unit could not be operated due to the lack of energy source from the refinery.

- *Check-out of the unit accordingly to the St1 Project procedures on how to do a project*

Before start-up took place a so-called check-out was performed during the last week of April 2015, to make sure that e.g. instruments, electrical and mechanical parts were installed correctly. The check-out consisted of an audit of the integrated process and the receiving station. Documents collected from the check-outs are:

- Declaration of Conformity and plant inspections performed during spring 2015 (EU Declaration of Conformity for Etanolix®-plant, issued on 08/05/2015)
- System review and third party assessment (AFS 2005:2) issued on 06/05/ 2015
- Certificate of electrical installations issued on 24/04/ 2015
- Safety system test (SAT) reports for ethanol backflow protection and quench drum issued on 23/04/2015 and on15/04/2015
- Mechanical Completion Certificate issued on 18/05/2015

- *Performance verification*

The larger quantities of intake of raw-material to the receiving station occurred for the first time on 11/05/2015 aiming at performing a function test of the receiving container for raw-material.

Verification and test runs were performed on 2-3/07/2015 and the results were summarized in *Report document no. E02-P-10-REP-002*, distributed internally 24/07/2015. The verification of the operation, with a fully satisfying operational performance, was continued during the demonstration phase in Action B.3. For results, see *Report on Verification of technic in operation with a satisfying operational performance defined for the pilot plant* (*Annex B2*-3).

Since the unit was started up a laboratory test program have been put in place with analyses carried out on both ethanol and stillage. All quality parameters required to test that a product may be placed on the market will continuously be measured under this program. Results will be further presented under the Actions B.3 and C.1.

- *In a controlled way start feeding the process waste water into the refinery waste water*

Environmental parameters calculated and defined were approved by the environmental auditor responsible for the plant on 07/07/2015. The parameters are incorporated in an environmental control framework to be reported on regular basis to the authorities. Fully satisfying verification regarding measurements of the environmental and quality parameters will be presented in demonstration phase in Action B.3

Main issues during commissioning, start-up and verification was related to the Receiving station:

- The first delivery of bread contained a lot of packaging material why the feed-stock could not be used and was sent to a contingency container instead, according to the procedure for these kinds of situations. The feed stock suppliers were contacted and were informed to not send deliveries containing this kind of packaging material. Procedures are put in place to avoid issues like this to continue. Having to handle the volumes sent to contingency bin meant additional costs for waste handling. However, these costs will not be claimed on the project and therefore will not affect the budget.

- Another challenge was the frequencies of deliveries of feedstock. Supplies of bread need to come in a continuous flow to enable the weight in the receiving bin not to be too heavy and

thereby slow down the speed of the transfer equipment. Therefore, discussions are ongoing with the feed stock suppliers regarding the supply patterns and how it could be handled more efficiently. Continuous dialogue with the suppliers will be needed, which will also include the logistics companies involved. Even in the future, this has to be a continuous work and a never-ending work task since changes will always take place according to optimization of environmental and economic improvements and possibilities.

5.1.2.3.3 Modification of work plan

No modifications regarding the content of the project has been requested.

5.1.2.3.4 Major problems

No major problems were encountered when this action was executed.

5.1.2.4 Action B3 – Demonstration of pilot plant

5.1.2.4.1 Actions undertaken

The objective of Action B.3 was to complete the demonstration of operation and performance of the Etanolix technology as integrated to the existing production process of the refinery. The action was managed by staff at St1, mainly staff from the Technical Department and a Process engineer. The Technical Department has also been responsible for the action. The operational department has been responsible for the control and monitoring of the process units in the pilot plant. The refinery laboratory has also assisted the technical department in demonstrating the quality of the ethanol and by-products.

5.1.2.4.2 Results achieved

Deliverables	**Status**
Final report from demonstration completed *(Annex B3-1)*	*Finalized 31/01/2017*
Milestones	**Status**
Demonstration commences according to schedule	*Finished 31/01/2017*
Demonstration completed successfully	*Finished 31/01/2017*
Demonstration of complete ethanol production and the integrated production process into the existing oil refinery	*Finished 31/01/2017*

Demonstration time and Action B.3 were initiated after the technology was verified, the unit was started and the environmental parameters were calculated, defined and agreed with the local authorities (07/07/2015).

The demonstration of the fine tuning of the production and the integration was initiated in connection to the start-up (May 2015), and was finalized 31/01/2017. This included demonstration, testing and evaluation of the receiving station, demonstration of infrastructure functionality such as electricity, steam, water and piping system. Monitoring of defined key parameters, along with the demonstration of plant, has been started and documented, please see also Action C.1.

The general conclusion is that the unit is overall demonstrating an efficient way to gather waste from the food industry, an efficient way of handling feedstock for production of high-quality bioethanol for vehicle use. The result of the demonstration period is stated in *Annex B3-1, final report from demonstration completed*.

The following areas were covered during the demonstration:

- *Producing sustainable ethanol according to specification using a waste raw material as feed stock*
  a) Testing new technique in various climatic conditions

  The Etanolix plant worked overall well due to various climatic conditions. In the beginning of the demonstration period, some equipment needed to be upgraded or replaced to be more stable in outdoor conditions, and to increase the functionality of the plant.

  b) The plant operating and producing 5000 m³ of ethanol per year with the 30% yield

  The pilot plant was operated less hours and produced less ethanol and stillage than expected during the demonstration period. The main reasons were issues within the biological and

chemical processes in the plant (the biological process needed some time to stabilize and fine tuning of the chemical conditions was needed to create the most optimal environment for the biological process), and lower feedstock intake than expected. Process improvements were made during the demonstration period to increase the ethanol production, which includes work with the receiving station and adjustments of the process setup. The ethanol yield have varied during the period, the main reason is the issues within the biological and chemical processes. In the end of the demonstration period, the actual yield reached 28%, which is a good result.

Between January and July 2017, after the demonstration period but before the finalization of the project, the production capacity of ethanol increased steadily to 1600 m³/year *(see Annex C1-4).* The receiving station was optimized in spring 2017 to increase the capacity further.

Since the capacity is still below 50 % of the full capacity of the plant, the process is still operating in batch mode. Continuous operation is expected during second half of 2017. The optimization of the receiving station that was performed in spring 2017, will most likely enable continuous operation during 2017.

c) Ethanol produced was used in tank blends in the refinery

The produced ethanol was analyzed daily in the refinery laboratory, before being transferred to refinery tank farm. The results have been very satisfying. 100 % of the produced ethanol during the demonstration period has been used as low blend in the refinery gasoline products.

- *Waste handling*
  a) Demonstrating that the receiving station for raw material intake works as designed in order to obtain a well functional technical solution that does not require extensive manual handling/maintenance

  There have been some issues regarding the receiving station, which have limited the capacity of the waste handling. An improved design was made together with the supplier of the receiving station during summer 2015, to increase the capacity and the functionality of the station. Different settings of the transfer equipment (including patterns and speed) in the receiving station was also tested during the demonstration period to optimize the treatment of the feedstock.

  There were also challenges in the waste supply chain, to receive an even flow of feedstock. Improvements were made during the demonstration period to increase the capacity of waste handling, both regarding feedstock delivery, and improvements of the receiving station.
  The optimization work mainly consisted of changing minor components in the feedstock handling system, and also to increase the automation of the system. After the last rebuild in May 2017, the feedstock handling system works automatically. The optimization work has also included to increase the quality of the feedstock into the receiving station, and to avoid unwanted parts like tools, clothes and even furniture into the receiving station. A lot of discussions has been held with the suppliers and the quality of the feedstock has increased a lot during the project period.

  b) Demonstrating that 15,000-21,000 tons intake of waste from food per year to produce 5,000 m³ of ethanol/year

Due to the challenges regarding the receiving station and feedstock handling equipment, the intake of waste from food has not been as high as expected. A lot of effort was made during the demonstration period to optimize the function of the receiving station. The intake of feedstock increased during the demonstration period.

Between January and July 2017, after the demonstration period but before the finalization of the project, the intake of feedstock increased steadily, and in the end of the project period the intake of feedstock was over 600 tons/month, which is about 40 % of the expected capacity of the receiving station. The station was further rebuilt in May 2017, and a higher capacity is expected during the second half of 2017.
During the second half of 2017, the feedstock handling equipment will probably be able to handle 100% capacity. A ramp up in production during Q3 2017 will verify that. So far, the receiving station has handled up to 50% capacity without complications.

The main challenge during the second half of 2017 will be to receive full utilization of the feedstock agreements so the Etanolix plant can be used with full capacity. Since the receiving station has not worked properly, the feedstock agreements has not been fully utilized. A supply manager, Mikael Nilsson, was hired by ST1 in spring 2017 to work with the feedstock supply to the Etanolix plant, and his result is expected to supply the full capacity of feedstock to the Etanolix plant during the second half of 2017.

c) Setting up a supply structure that will allow continuous waste feed-stock intake giving 30% ethanol yield

Agreements regarding the amount of feedstock needed was not in place in the beginning of the demonstration period, which also contributed to the lower production rate. The logistic chain worked as expected during the demonstration period. Enough agreements with suppliers of industrial food waste were reached in the end of the demonstration period, but they have not been fully utilized due to lower capacity than expected of the plant. As stated above, Mikael Nilsson at ST1 has started to work with the feedstock supply aggrements to raise the intake of feedstock to the Etanolix plant.

- *Stillage as a by-product*

a) Testing of stillage maintenance routines, quality and logistics
b) Demonstration of stillage use as animal feed (25 000) tons

Stillage as a by-product was produced and its quality was been tested daily in the refinery laboratory before delivered to the customers, to secure the delivery of a high-quality product to the stillage customers. The amount of stillage produced was lower than expected, and the reasons were mainly the lower intake of feedstock and the lower ethanol production rate in the beginning of the period. The quality of the produced stillage has over expectations, and this means that all the produced stillage during the demonstration period has been used as animal feed (40 %) and biogas production (60 %). In the beginning of the demonstration period, there were some challenges in the logistic chain for the delivery of stillage to customers, mainly to receive a continuous delivery to customers to match the production rate of stillage. Since the Etanolix plant had production issues, the delivery of stillage was not

completely reliable. Discussions were held with the customers and in the end of the demonstration period the deliveries of stillage were made in a reliable way for both ST1 and the customers.

Between January and July 2017, after the demonstration period but before the finalization of the project, the stillage increased steadily, and in the end of the project period the production capacity was 15,000 tonnes/year (compared to full capacity 21,000 tonnes/year).

- *Integration into the refinery*

  a) Demonstration of the integration of steam for heating
  b) Use of cooling water from the existing refinery
  c) Demonstration of the Etanolix water balance
  d) Chemical consumption
  e) Blending ethanol into final fuel products

  The integration into the refinery's utility system and control room worked according to plan. The Etanolix plant uses the refinery´s existing systems and uses excess heat (steam) and the existing system for cooling water. The use of utilities, which are steam, cooling water and chemicals, has been a little higher than expected due to the fact that the use of utilities are not linear with the ethanol and stillage production rate. Calculations show that when ethanol is produced per design capacity, the amounts of utilities used will be as expected. This means also that the energy efficiency of the plant is high as expected according to the grant agreement.

  The Etanolix waste water quality was measured (e.g. pH, suspended solids) during the demonstration period to ensure adoption to the existing waste water treatment at the refinery. No negative effects have occurred during the demonstration period on the refinery's waste water treatment plant.

Overall, the pilot plant and the Etanolix technology works in a satisfying way and produces ethanol in a sustainable and energy efficient way.

When the demonstration was finalized, the Etanolix plant shows the following results;

Demonstration result for the Etanolix plant			
Result	**Predicted quantitative results**	**Actual quantitative results**	**Results Q1-Q2 2017**
Production of ethanol	5 000 m^3/year (yield 30%)	945 m^3 during demonstration period, actual yield 28%	1600 m^3/year
CO2-reduction	> 90%	95%	95%
Industrial food waste recycling and re-use as raw material efficiency of 98-100 %	98-100%	98-100%	98-100%
Intake of waste from food	15,000-21,000 tonnes per year	4,080 tonnes during the demonstration period	7,200 tonnes/year
Production of stillage	25,000 tonnes per year	11,060 tonnes during the demonstration period	16,000 tonnes/year
Re usage of sodium hydroxide	Approximately 2 m^3 per year	Approximately 2 m^3 per year	Approximately 2 m^3 per year
Ethanol blending into refinery products	85-95% of the ethanol produced	100%	100%
Use of excess steam	6760 MWh per year	6480 MWh for the demonstration period	-
Use of excess cooling water	9530 MWh per year	2242 MWh during the demonstration period	-

The table above shows that almost 100% of the used waste material can be recycled and produce ethanol and stillage of good quality. The integration and energy efficiency of the plant has also received expected results. The main challenge during the demonstration period has been the receiving station (the prototype). A lots of effort was made both during the demonstration period and also during the remaining project period. No more rebuilds are planned for the receiving station after the project finalization, and an increase in feedstock capacity will be performed to verify the designed capacity of the receiving station during the second half of 2017.

5.1.2.4.3 Modification of work plan

No modifications regarding the content of the project has been requested.

5.1.2.4.4 Major problems

The receiving station has been a challenge during the demonstration period, since it did not work as expected during the demonstration period. The problems that occurred did not change the overall time schedule for the project and the costs was not exceeded during the project.

5.1.3 C. Monitoring of the impact of the project actions

The project set out two monitoring actions (i.e. Actions C.1-C.2) in the proposal and Grant Agreement. In summary, the overall objective of the two implementation actions (Actions C.1-C.2) is to monitor and evaluate the demonstration activities from the environmental concerns targeted by the project, and to monitor and evaluate the socioeconomic impact of the project. In short,

- *Action C.1. Monitoring and evaluation of pilot plant* aims to monitor and evaluate the results from actions B1-B3
- *Action C.2 Socioeconomic impact of the project actions* aims to monitor and evaluate the socioeconomic impact on the local economy and population

5.1.3.1 Action C1 – Monitoring and evaluation of the pilot plant

5.1.3.1.1 Actions undertaken

The activities covered monitoring and evaluation of unit and process efficiency, evaluation of product performance and volumes produced, cost-effectiveness, sustainability and environmental performance (substantially decreasing CO_2 emission). The monitoring and evaluation has been performed by the operational department at St1, expert assistance, a process engineer in close cooperation with the refinery laboratory.

5.1.3.1.2 Results achieved

Deliverables	**Status**
Evaluation report 1 from the demonstration phase after 6 months *(Annex C1-1)*	*Finalized 31/01/2016*
Evaluation report from the demonstration phase after 12 months *(Annex C1-2)*	*Finalized 30/07/2016*
Evaluation report 3 from the demonstration phase after 18 months *(Annex C1-3)*	*Finalized 31/01/2017*
Final data evaluation report after the demonstration including the technical, environmental and economical evaluation *(Annex C1-4)*	*Finalized 08/08/2017*
LCA/LCC study produced *(Annex C1-5)*	*Finalized 15/06/2017*
Milestones	**Status**
First data evaluation completed	*Finished 31/01/2016*
Final data evaluation completed	*Finished 08/08/2017*
Successful monitoring and evaluation of the innovative etanolix technology and integrated sustainable ethanol production process at the oil refinery	*Finished 08/08/2017*

Action C.1 started on time (i.e. 01/01/2014) and the Action was be completed according to schedule (i.e. 01/07/2017) agreed upon in the Grant Agreement.

The technical monitoring and evaluation have mainly focused on:

- Functionality under different conditions (winter climate, outdoor equipment etc.)

- Raw material, production, throughputs, by-products, quality, energy, water etc.
- Overall usability in relation to existing production/process technology.

As a summary, the results regarding Actions B.1, B.2 and B.3 are presented as below:

- *Action B.1*

Already in the construction phase of the pilot plant and installation/integration to the refinery, monitoring and evaluation were important parts of the project. As action B.1 was finalized, reporting on progress and deliverables including costs have been done on a regular basis mainly to the Steering Committee (PMG) via the Project Manager. Reports as deliverables are to be seen as Annexes referred to under Action B.1's deliverables and Action E.1.

- *Action B.2*

During Action B.2, where commissioning, start-up and installation/integration to the refinery were done, monitoring and evaluation were performed to make sure that the activities were according to plan and budget was kept. Internally in the refinery organization staff from different departments have been engaged to make sure deadlines have been reached to meet e.g. authority requirements, get compliant certificates for construction, comply on committed training programs before start-up, ensure and arrange raw material in time to receiving station etc. Action B.2 is finalized and reporting has been done on a regular basis mainly to the Steering Committee (PMG) via the Project Manager. Reports as deliverables are to be seen as Annexes referred to under Action B.2's deliverables.

- *Action B.3*

All initiatives to enable evaluation and monitoring according to plan were taken when action B.3 started, containing the measuring, testing and analysis of ethanol production and the quality assurance. The feedstock handling e.g. received raw material and products produced from Etanolix 2.0 was under control as a result of the defined control frameworks/procedures implemented in the organization. Sampling, laboratory analysis and volume reporting etc. regarding stillage as a by-product were made according to procedure in the demonstration phase. Integration into refinery is evaluated as a functionality of efficiency. Parameters for this is defined and measurement and follow-up have started as an operational procedure to be monitored and reported on, on a daily basis or monthly basis depending on what has been agreed with the operational team and the external authorities.

Odour, emissions and noise have been monitored as a part of the environmental control program at St1, and are performed according to the Environmental permit for the plant. Control and monitoring of the plant show that the Etanolix process does not exceed any permitted limits regarding noise, odour or emissions.

Improvements and results made during monitoring of Action B.3:

- Process reports were produced to enable efficient day-to day operational follow up. These reports contain technical operational parameters and flows and throughputs for the Etanolix 2.0. The data in these reports are discussed in daily operative and maintenance meetings to alert people on progress and take actions, if changes are required. Responsible for this report is the process engineer, Lars Olausson.

- A steering document for the pilot plant and to evaluate also the implementation to the refinery has been developed to measure and report on raw materials, production, by-product, quality, energy, water etc. Responsible to collect data and analyze information and draw conclusions is the process engineer, Lars Olausson. This will be presented continuously internally at St1, as a key project in the organization, to the PMG to discuss in the Steering Group and to the Operations manager Johan Dahlberg and his team.
- To improve the possibilities for a better and easier documentation process. A computer was placed into the field operators local control room. This helps in a simpler/less time-consuming way to document e.g. the chemical consumption on a regular basis (monthly).
- The measuring of the cooling water flow was improved, since it initially was a too inaccurate figure (m^3) to enable any conclusions on energy efficiency on this stream. A method was developed to ensure that an accurate figure will be produced to the CO_2 calculation (Sustainability) for the units.
- To improve the capacity of the receiving station, a part of the transfer equipment was replaced in the feedstock handling process for larger ones. A plate was also installed to even out the feedstock load into the receiving station.
- Discussions were also held with the feedstock suppliers, to remove unsuitable material in the feedstock, such as stones, to improve the functionality and capacity of the feedstock treatment.
- Some quality improvements were necessary to perform during the project period, since some of the installed components appeared not to be for outdoor conditions.

When the project was finalized 01/07/2017, a lot of improvements had been made and the plant worked satisfying. The production rate of ethanol and the intake of waste increased during the project period. Data is presented in *Annex C1-4 Final data evaluation report.*

The evaluation of expected main results have mainly been described in Action B3. The technical data is found in *Annex B3-1 and C1-1 – C1-4*. Also, see a short summary below;

a) The CO2-reduction was measured during the project period and after the start-up period it was stabilized above 95 % during the demonstration period.

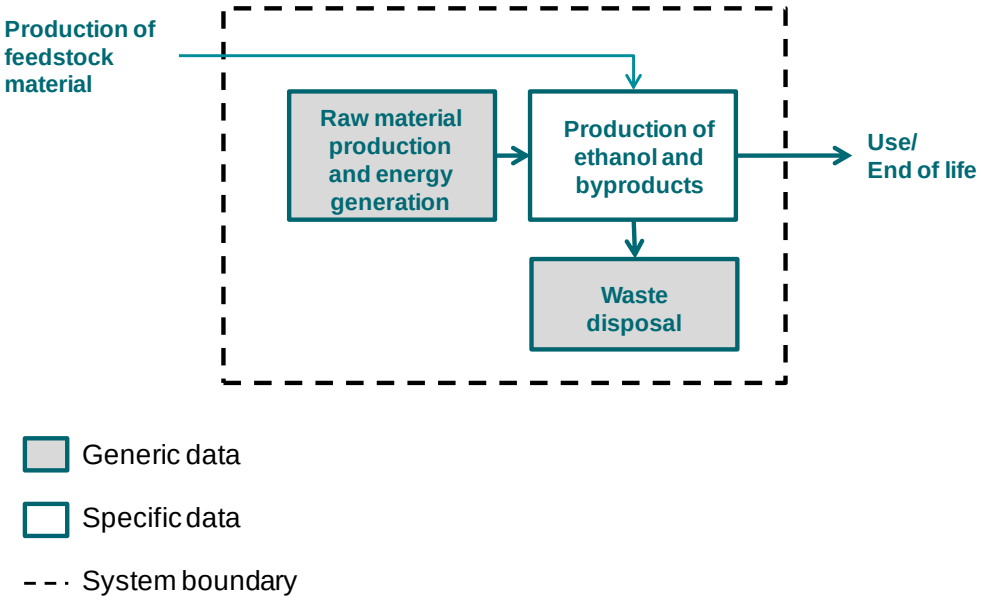
b) Ethanol quality tests was performed during the project with god results, all produced ethanol has been used as low blend in gasoline and sold to customers.

c) The stillage was measured during the project period according to the control program. The quality of the produced stillage has been over expectations, and the stillage has been sold to customers for biogas production or animal food.

d) The integration of the process plant has been monitored at a daily basis. Since the ethanol production has been lower than expected, the use of utilities has been higher than expected since the consumption of utilities are nor linear with the ethanol production rate.

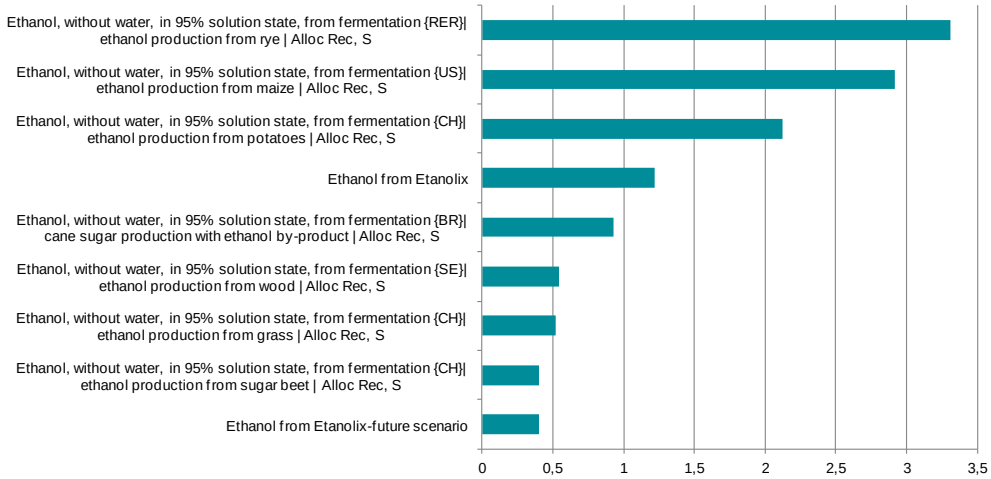
- *LCA/LCC report*

A Life cycle assessment was performed by an external consultant with specialist competence within the topic. The system boundaries for the study is presented below.



Data collection for regarding the etanolix technology was performed by Lars Olausson and Jonas Strandberg, both process engineers at ST1. The data used for modelling in the study is from quarter 1, 2017.

The detailed results are presented in *Annex C1-5*, and a summary is presented below. The environmental impact of produced ethanol from Etanolix is very low, and the study confirms the low expected environmental impact of the process.



The main conclusions are;

- To minimize the environmental impact from ethanol production, it is important to optimize the process in order to achieve a higher utilization rate. It is also important to minimize waste to incineration since today, much food residues that could have been utilized as ethanol production feedstock goes to waste.

- The choice of electricity has a large impact on the environmental impact. If the aim is to minimize environmental impact, a change to green electricity would be preferable.
- From an environmental point of view, local sourcing of raw materials is favourable.
- Enzyme production has large environmental impact. Therefore, it is important to optimize the use of enzymes.

5.1.3.1.3 Modifications of work plan

No modifications regarding the content of the project has been requested.

5.1.3.1.4 Major problems

No major problems were encountered when this action was executed.

5.1.3.2 Action C2 – Socioeconomic impact of the project actions

5.1.3.2.1 Actions undertaken

The Socioeconomic impact study was conducted by the environment, health and safety Coordinator at St1. It was performed in cooperation with expert assistance from an external consultancy company during spring 2017.

5.1.3.2.2 Results achieved

Deliverables	**Status**
Socioeconomic impact study produced *(Annex C2-1)*	*Finalized 09/05/2017*
Milestones	**Status**
Socioeconomic impact study completed	*Finished 09/05/2017*

The study was planned to be performed by own personnel at St1 from the beginning. Due to lack of time and resources, the study was performed by an external consultant with good experience in the topic.

The objective of Action C2 was to monitor and evaluate the socioeconomic benefits of the project actions. The full report is presented as *Annex C2-1*. This intends to clarify the financial effects of the project for the Municipality of Gothenburg and its socioeconomic impact that will partly form the basis for a decision for any further expansion in the region and as information material for external interests.

The benefits expected by the project according to grant agreement are:

- *Direct employment growth at St1 with 5 persons (in operation (Demonstration) phase of the Etanolix plant)*

The results shows that the direct growth at ST1 has been 3 persons at ST1.

- *Indirect employment growth at St1 with 50 persons (in operation (Demonstration) phase of the Etanolix plant)*

The results shows that the indirect employment has been 40 persons during the operational phase.

- *Improved market situation for the local and regional food waste management sector and agriculture and food production sector*

The results shows that the market situation has been improved, but it is difficult to quantify. The Etanolix plant shows that local waste can be used for ethanol production which reduces the transports needed for feedstock deliveries. It also stimulates sustainable development in regions by taking advantage of industrial waste.

- *CO_2 reduction > 90 %*

The CO_2-reduction has been as high as 95 %, which is over expectations.

The study shows that the socioeconomic benefits are higher than the costs. The total economic value for the benefits are 21,6 MSEK compared to the costs that are -12,3 MSEK.

A more detailed presentation is available in *Annex C2-1*. The majority of the socioeconomic benefits are due to the direct and indirect employment benefits, which constitutes around 85 % of the total estimated benefits. One crucial assumption is the cost of CO_2. The evaluation uses emissions costs in EUR per tons CO_2 and it has been assumed to attain a value of 11.02 EUR/ton.

5.1.3.2.3 Modifications of work plan

No modifications regarding the content of the project has been requested.

5.1.3.2.4 Major problems

No major problems were encountered when this action was executed.

5.2 D. Dissemination actions

5.2.1 Objectives

The project set out three dissemination actions (i.e. Actions D.1-D.3) in the proposal and Grant Agreement. In summary, the overall objective of the three dissemination actions (Actions D.1-D.3) is to disseminate the project's progress and results to identified target groups and stakeholders across Europe and to raise awareness about the project. In short,

- *Action D.1. Communication and dissemination of project results* aims at disseminating the project's progress and results through various means to the identified target groups and stakeholders across Europe.
- *Action D.2. Networking with other EU-projects* aims at ensuring efficient networking and information exchange activities with other relevant EU-projects.
- *Action D.3. After LIFE+ Communication Plan* aims at producing an After LIFE+ Communication Plan (at no additional costs for the EU).

5.2.2 Dissemination: Overview per activity

5.2.2.1 Action D1 – Communication and dissemination

5.2.2.1.1 Actions undertaken

The members of the communication and Dissemination Group (DG) are responsible for the communication actions associated with the project. The DG consists of Linda Werner (Refinery Technical Manager St1 Refinery AB), Erica Samuelsson (Marketing Manager St1 Sverige AB), Carina Webjörn (Work Environmental engineer St1 Refinery AB) and Alexandra Jerselius (Marketing Consultant). Meetings have been held regularly with the group to manage the communication and dissemination activities during the project.

There has been a large interest for the communication actions and for the project, which have resulted in a large number of participants at the study visits and visitors at the website etc. The publications regarding the project (see more below) have been only positive. The life+-logotype has been used on all communication material and in all dissemination actions.

Regarding the site visits, 10 visits was held to show the Etanolix plant and present the project during the project period. During the site visits, more than 200 people have seen the Etanolix plant and was told about the project. The visitors were mainly target groups, especially buyers of ethanol, food retailers, universities and institutes, European politicians and agencies, ethanol producers and other chemical companies. Additional site visits are planned during autumn 2017. For more details about the site visits, see section 5.2.2.1.2. below and *Annexes D1-3 – D1-12*.

5.2.2.1.2 Results achieved

Deliverables	Status
Project website online *(Annex D1-1)*	*Finalized 11/04/2017*
Dissemination plan *(Annex D1-2)*	*Finalized 07/03/2017*
Notice Boards *(Annex D1-24, submitted with the Mid-term report)*	*Finalized 08/02/2015*

Information material produced (*Annex D1-13*)	*Finalized 01/09/2016*
Report on study visits *(Annexes numbered below)*	*Finalized 2017/05/17*
Layman's Report (Annex D1-23)	*Finalized 2017/06/22*
Publications in journals and magazines	*Finalized 2017/07/01*
Milestones	**Status**
Website online	*Finished 2014/02/02*
Guided study visits at the demonstration facility	*Finished 2017/05/17*
Accomplished information event	*Finished 2017/05/17*
Participation at conferences, exhibitions, seminars and workshops	*Finished 2017/06/30*
Dissemination completed	*Finished 2017/06/30*

- Project website:

The main channel for dissemination of project results is the project website (please see *Annex D1-1)*. It has been running since 02/02/2014 and provides information about the project in both Swedish and English. The website has been continuously updated during the project and St1's Work environmental engineer is responsible for keeping the website up to date. To monitor the effectiveness, the number of web page visitors per month have been monitored. Since February 2014 until the project was finalized in July 2017, 11216 visits were registered on our Swedish and English websites, whereof 7351 visits on the Swedish and English websites were related to the key words: *Ethical ethanol, Etanolix, the LIFE+ project.* The rest of the visits (i.e. 1569) on these two websites, were related to the key words: *Latest news, Picture gallery, Media, Links* and *St1 contact.*

- Dissemination plan

A Communication and Dissemination plan including the earliest communicative actions was developed and finalized on 03/02/2014. The communication plan contains the strategy to conduct an extensive and intense dissemination of progress and results of the project to stakeholders and target groups. The planned communication and dissemination actions according to the original dissemination plan have taken place. The last update of the Dissemination is included as *Annex D1-2-Dissemination plan*.

- Visits:

The site visits have been planned by the dissemination group and the Technical work Group at St1.
A number of study visits have been held for different stakeholders to see the facility, and to receive information regarding the project and the technology. Our most important visit was the inauguration of the Etanolix plant the 5th of June 2105, with approximately 100 people attending and the main speaker was the Swedish Energy Minister, Ibrahim Baylan. In addition to the inauguration, the following site visits have been performed for the project stakeholders;

2015-04-22; Seminar for student in Chemistry, from Chalmers University of Technology *(please see Annex D1-3)*
2015-06-05; Inauguration of the Etanolix plant *(please see Annex D1-4)*
2015-12-01; seminar for students in chemistry, from Chalmers University of Technology *(please see Annex D1-5)*
2015-05-25; Seminar for ST1 retail personnel *(please see Annex D1-6)*
2015-09-01; Study visit by Lidl AB, *(please see Annex D1-7)*

2015-10-29; Study visit by Oljehamnsgruppen *(please see Annex D1-8)*
2016-08-19; Study visit by finnish family firms *(please see Annex D1-9)*
2016-11-30; Study visit by students from Chalmers University of Technology *(please see Annex D1-10)*
2017-02-22; Study visit by Purac AB and Läckeby AB *(please see Annex D1-11)*
2017-05-17; Study visit at Advanced Biofuels Conference *(please see Annex D1-12)*
The target groups have been reached at through the site visits, but also others, such as students.

- Information material:

Information material regarding the project has been produced in different ways. The work has mainly been performed by the Dissemination Group (DG). An infographic has been distributed at conferences and visits to stakeholders. The refinery Health, Safety and Environmental coordinator has been responsible for the infographics. 200 Swedish and 100 English infographics has been printed for this purpose *(please see Annex D1-13)*. In addition to the printed infographics, it has also been available digitally at the St1 Etanolix project website for downloading.

200 copies for each year of St1's EMAS (Eco Management and Audit Scheme) report for 2013, 2014, 2015 och 2016 were printed for St1. One part of the report contains information about the Etanolix project and the contribution from LIFE+. The refinery Health Safety and Environmental coordinator is responsible for the compilation and printing of the report. EMAS report is a tool to communicate with local stakeholders such as neighbors, people living in the

area and other industries, local authorities and companies. This information is also very valid to distribute at study visits, when attending conferences, exhibitions, seminars and workshops etc. The EMAS report has also been available digitally for downloading at the St1 Etanolix project website. *(please see Annex D1-14).*

- Conferences, exhibitions, seminars and workshops:

St1 has participated in the following seminars, conferences and workshops in Sweden and European countries during the project;

2014-06-04; PulPaper Seminar in Helsinki *(please see Annex D1-15)*
2014-11-06; World ethanol and biofuels conference in Budapest, Hungary *(please see Annex D1-16)*
2015-01-21; Lignofuels in Madrid, Spain *(please see Annex D1-17)*
2015-04-16; Twin town meeting and Green Energy Conference, Denmark *(please see Annex D1-18)*
2015-05-29; Biofuels seminar at Lunds university *(please see Annex D1-19)*
2015-07-05; Almedalsvecka between 2015-06-28 until 2015-07-05
2016-11-23; International conference at the Linnéuniversitetet 22-23 november 2016 *(please see Annex D1-20)*
2017-05-17; Svebio (Swedish Bioenergy Organization) arranged an International Bioenergy Conference in Gothenburg. A site visit to the Etanolix plant was a part of the programme, and ST1 presented the project results for the visit participants *(please see Annex D1-21).*

St1 has been represented by personnel from the Technical department at St1 Refinery or the Marketing department at St1 Sweden and Sales department at St1 Biofuels in Finland. One of the seminars was in Almedalen Gotland (2015) in Sweden, which is a one week yearly event with open debates, speeches, seminars and political activities for anyone to attend; this is considered as an important activity to communicate about how to reach the climate targets for Sweden and Europe.

A seminar about the Etanolix unit was held in December 2015 at the refinery for chemistry students from Chalmers University of Technology, working with a sustainability concept project which shall be related to a company in the chemical and process industry.

- Publications:

There have been several publications about the Etanolix plant in newspapers and magazines during the project. In the project plan and in the Grant Agreement, 3 articles were to be published. We experience a great interest for the project and so far, 6 articles, in different newspapers and magazines, have been published. In addition, there has also been a TV-spot in the local news *"Västnytt"* and an article at an international website about waste noticing the project. Below, please find a list of links to the publications:

2015 http://www.biofuelsdigest.com/bdigest/2015/06/06/st1-completes-waste-to-ethanol-etanolix-project-in-sweden/

2015 http://www.gp.se/ekonomi/1.2737835-gammalt-brod-blir-till-bilbransle

2015 http://www.st1.se/documents/10180/17541/di_bilagan+n%c3%a4ringsliv+oktober+2014/d098d3f7-d272-47f7-9d81-71f403e41388?t=1415026279190

2015 http://waste-management-world.com/a/bakery-waste-to-carbo-load-bioethanol-production-in-sweden

2014 http://www.st1.se/documents/10180/17541/artikel+om+etanolixfabriken/54e1feb3-202a-4637-85b7-08b7480c6104

2014 http://www.expressen.se/gt/bullar-och-godis-ska-bli-bransle-i-goteborg/

2014 http://www.transport.se/Transportarbetaren/Start/Nyheter1/Omvandlat-godis-i-tanken-/

2014 http://www.svtplay.se/klipp/2355599/bullar-blir-etanol

During 2016 and 2017, no articles regarding the Etanolix was published in media. The main reason is probably that the biggest interest was in the beginning of the project, and also during the inauguration of the plant.

- Notice Boards:

As set out in the Grant Agreement, two notice boards have been erected; one outside the refinery reception and another one at one of St1's most visited retail stations located 10 km outside the center of Gothenburg (please see *Annex D1-22- Notice Boards)* presenting photos on Notice Board 483 and Notice Board 579). There is not a geographical proximity to the Etanolix plant but the retail station is accessible to a lot of people in the process of using the Etanolix product.

- Layman Report

The Layman report was evaluated during spring 2017 by Carina Webjörn (Health safety and environmental coordinaor at ST1), as planned in the Grant Agreement. It is already available at St1 Etanolix project website, and 100 paper copies are available for distribution. Layman report is available as *Annex D1-23*.

- Indicators of progress
- Project website online as planned - completed
- Dissemination plan developed as planned - completed
- Guided study visits performed 10 visits in three years as planned - completed
- Participation at conferences as planned - completed
- Information material produced as planned - completed
- 2 notice boards placed out at strategic locations as planned - completed
- Layman report produced as planned - completed
- Dissemination completed - completed
- Accomplished information event performed -completed

5.2.2.2 Action D2 – Networking with other EU-projects

5.2.2.2.1 Actions undertaken

Network meetings was held during the Etanolix project execution with other EU-projects. From St1, the Technical manager (Linda Werner) and process engineers (Mikael Öberg, Mattias

Fredriksson and Lars Olausson) from St1 technical team has participated in the different network meetings.

5.2.2.2.2 Results achieved

Deliverables	**Actual Deliverable date / prognosis**
Report 1 on networking meeting *(Annex D2-1)*	*Finalized 30/09/2015*
Report 2 on networking meeting *(Annex D2-2 – D2-4)*	*Finalized 23/06/2016*
1 presentation on experience received on networking (Annex D2-5)	*Finalized 01/09/2016*
Milestone	**Actual Milestone date / prognosis**
Networking completed	*Finalized 2017/06/30*

Networking meetings has been held with the following projects;

- Life+-seminar, "Green week conference", Brussels 3-5th June 2014 *(See Annex D2-1).* The seminar was visited by the Technical Manager from St1. The total amount of visits was around 2,500 people and a lot of networking, presentations and discussions took place. During the conference, two other Life+-project were identified and contacted for future networking activities in the Etanolix 2.0-project.

- Network meeting with project BIOMethER, Bologna (Italy) 30th May 2016 *(See Annex D2-2).* The project was very similar to Etanolix 2.0, using waste material for biofuel (biomethane) production.

- Network meeting with project SludgeisBiofuel, Skellefteå (Sweden) 23rd June 2016 *(See Annex D2-3).* The project main objective is a Phosphorus recycling in combination with an economically feasible and sustainable solution to dry and incinerate sewage sludge, manure or other suitable sludge's.

- Network meeting with project AlgaEnergy SA, Madrid (Spain) 23rd June 2016 *(See Annex D2-4).* AlgaEnergy's Life+-project, CO2AlgaeFix), is based on carbon dioxide (CO_2)-fixation by using microalgae.

Lessons learned and experience from the network meetings are summarized in presentation Lessons learned *(See Annex D2-5).* The main conclusions from the networking meetings with other EU-projects are that all projects have a really strong focus on sustainability and minimizing CO_2-emissions. The meetings held have given lots of input that has been valuable for the implementation of the Etanolix 2.0-project. None of the networking projects would have been realized without contribution from the EU Life+ programme.

5.2.2.2.3 Indicators of progress

- One presentation lesson learned from contacted projects - completed
- Two reports (one for each project contacted) on network meetings – completed
- Two additional reports from other network meetings – completed

5.2.2.3 Action D3 – After Life+ Communication Plan

5.2.2.3.1 Actions undertaken

To secure the continued communication of the project results when the project has been finalized, an After LIFE+ communication plan *(See Annex D3-1)* was developed by the St1 Market Manager and the Project Manager during spring 2017. In addition, an information slide to be used in all kinds of presentations has been prepared to ease future communication activities *(See Annex D3-2)*.

5.2.2.3.2 Results achieved

Deliverable	**Actual Deliverable date / prognosis**
After LIFE+ Communication Plan (please see Annex D3-1 and Annex D3-2)	*Finalized 01/07/2017*
Milestone	**Actual Milestone date / prognosis**
After LIFE+ Communication Plan completed	*Finalized 2017/08/01*

In accordance with the proposed Action D.3, the *After LIFE+ Communication Plan* was finalized according to our application and Grant Agreement. The plan has been produced in both English and Swedish and is available in both electronic and paper format.

The aim with the after Life+ communication plan is to disseminate the results of the project, including lessons learned and the result of the continued improvements that will be made after the project has ended. A lot of contacts has been received during the project implementation to the afterlife target groups and future potential customers.

5.2.2.3.3 Indicators of progress

- Successful completion of the After LIFE+ Communication Plan - completed

5.3 Evaluation of Project Implementation

The project benefitted from a strong project team, with mainly in-house personnel. The personnel involved has lots of experience from large and complex industrial projects and a wide spread of competences that were necessary for a successful implementation. The change of project manager has been a challenge during the project, but since the rest of the organization remained, the overall time schedule of the project could be held during the implementation. Since all project groups had the possibility to work close together at the refinery, the work has been performed in an efficient way.

The existing project experience was used during planning and preparation of the project. Most of the planning activities were performed as planned. The main challenge during the planning phase was the authority process which also was highlighted as a potential risk in the grant application, due to the uncertainty of the process. The project management team set high focus on this task and the permitting process was managed without any delay for the overall project.

The work with the contacting of feedstock suppliers and also customers for stillage worked fine during the project. The number of contracts has been satisfying and has not affected the production capacity of sustainable ethanol or stillage. Due to the local presence, discussions could easily be held regarding feedstock related issues. Issues that affected the functionality of the receiving station could be effectively solved.

The design of the pilot included up-scaling of a new developed process needed close cooperation with St1 Biofuels, who has developed the process. This cooperation worked satisfying, and the fact that much of the design work was done at the St1 Refinery in Gothenburg, both by own personnel and external assistance, the best design for this specific site was performed. The challenges in the design and construction work were the feeding station and the adaption to outdoor conditions, since there is not so much experience available for this kind of installation. The functionality of the receiving station was the most challenging part of the project, and during demonstration and monitoring, the receiving station has not reached the full capacity that was planned.

The integration with the existing refinery has been implemented successfully. The use of excess steam, cooling water and the existing water treatment has improved the cost efficiency of the production of sustainable ethanol. The integration has also led to the fact that the Etanolix-plant became a natural part of the refinery as soon as it was build, which enabled an effective monitoring and evaluation of the plant, since the Etanolix-plant was completely integrated in the refinery routines and systems.

The dissemination activities of the project were successfully implemented. The interest regarding the Etanolix 2.0 plant has been high, with a large amount of visitors at the performed study visits, many conferences has showed interest of the project. The dissemination activities required cooperation with ST1 Refinery, NEOT and ST1 Biofuels.

Task	Achieved	Evaluation
A1. Preparatory actions	All preparatory actions were performed as planned. The permitting process took longer time than planned, which caused a change in the time schedule for this action.	The preparatory actions were performed successfully, lesson learned is that the permitting issues needs to be very well planned before the project starts.
A2. Design of the pilot plant and procurement	The design and procurement of the plant was performed successfully with some time delay.	The existing experience of the project team managed to perform the work in a good way, and the planned results were achieved. Some design of the plant was more challenging than expected, and needed extra time and resources to be solved.
B1. Construction of the pilot plant and installation/integration to the refinery	The construction of the pilot plant and the installation/integration to the refinery was performed according to grant agreement with some time delay.	The installation/integration to the refinery was successfully performed as planned. The challenge during the construction of the plant was that more civil and piping work than expected was needed and that the receiving station was delayed. Even if ST1 has great experience of project execution, the receiving station was a new item for the organization and required more work than other items in the plant to receive the right quality for the process plant.
B2. Commissioning, start-up and performance verification	The commissioning, start-up and verification of the Etanolix-plant was performed according to grant agreement and according to time schedule with good results.	The objectives of this action was successfully performed. The existing routines at the ST1 Refinery could be implemented for check-out, training of staff and other activities related to this action with good results. The challenges that occurred was the quality and the delivery frequency of the bread feedstock. However, these issues were solved during the start-up and the performance verification.
B3. Demonstration of pilot plant	The demonstration of the pilot plant was	The biggest successes during the demonstration was the quality of

	performed according to grant agreement.	the products from the plant and the integration to the existing refinery. The plant produces ethanol with very good quality, of which 100% has been used as fuel. The stillage has also been of good quality and has been sold to satisfied customers. The demonstration period proves that the Etanolix technology development is successful and produces high quality products. The integration to the existing refinery, which is important for the sustainability and efficiency aspects of the project has also been successful. The challenges have been mainly the receiving station and the effects of outdoor conditions, and this experience should be available as lessons learned in coming projects.
C1. Monitoring and evaluation of pilot plant	The monitoring and evaluation of the pilot plant was performed according to grant agreement.	The work with the receiving station will continue after the Life-project has ended. The full capacity of the receiving station will probably be achieved in the end of 2017. The environmental impact from Etanolix when it has reached its full production rate is very low.
C2. Socioeconomic impact of the project actions	The socioeconomic impact was studied as planned according to the grant agreement.	The study was performed and completed as planned and is delivered together with the final report. The study concludes that, as expected, the social benefits from the project are higher than the costs.
D1. Communication and dissemination of project results	The activities in this objective were successfully performed as planned according to grant agreement.	• Website – the website was implemented and has been updated during the project implementation. The site had a certain number of visitors during the project. • Study visits – the planned number of visits has been performed, with higher

		interest than expected for the project • Publications – the interest for the project has been high, which is shown in the large amount of publications in newspapers, television and industry related journals that has paid attention to the project. • Conferences – the project has been presented at relevant seminars and conferences as planned, with good experience and interest for the project • Information material has been produced as planned. The distribution of printed information material has not been as large as expected during the project. The presentations at conferences and similar, the study visits and the web based information seems to have been more effective for the dissemination of the project. • Notice boards – the notice boards were produced and placed at strategic places as planned. The result is difficult to quantify, but the locations for the boards are carefully chosen to receive as much attention as possible. • The Layman-report was produced as planned and is available at the ST1 website for the Etanolix project.
D2. Networking with other EU-projects	Networking with other EU-projects was performed as planned according to grant agreement.	The networking meetings with other EU-projects was appreciated and rewarding. Many conclusions from execution the projects were

		common and the meetings have been supportive for the Etanolix-project.
D3. After Life+ communication plan	The After Life+ communication plan was produced as planned and delivered with the final report.	The planned results were achieved.
E1. Project management and monitoring of the project progress	The project was managed and monitored during the project implementation according to grant agreement.	The project was successfully implemented and no delay of the total time schedule occurred. The challenges were managed during the implementation. The unexpected change of project manager did not affect the overall implementation of the project but caused some increase in project management costs, which was difficult to avoid.

5.4 Analysis of long-term benefits

1. Environmental benefits

The demonstration of Etanolix 2.0 technology shows that other EU-countries has the possibility to use food waste for bioethanol production, to increase with more than 15% compared to the estimated 5.4 billion liters of bioethanol produced in the EU-27 in 2011.

The integration to the refinery installation could be applied to many different refinery/petrochemical plants in other countries, and this means effective use of existing utility systems at the existing process plants, no new land areas has to be explored for the bioethanol production and the energy efficiency is high for the plant.

2. Long-term benefits and sustainability

Results from the Etanolix project shows that the environmental impact is up to 85% lower than other bioethanol production methods *(se Annex C1-5)*. The main reason are as follows;

- Food waste material can be used instead of produced raw material for bioethanol production. Food waste is generated almost everywhere and the Etanolix plant shows that different kind of food waste (like old bread, jam and cookies) can be used as feedstock for ethanol production.

- The Etanolix plant uses effluent energy resources from the refinery as well as the refinery's water treatment. The integration to an existing refinery gives many environmental advantages, especially when it comes to energy use. It also lowers the total investment for the plant which increases the possibility to build more plants at other refineries.

- Another reason is the lower amount of long distance transports needed, since food waste can be collected locally near the plant location. *Annex C1-5* shows that the CO_2-emissions are lowered with 4,500 tons/year due to the fact that the Etanolix plant is located close to the feedstock suppliers.

Another sustainability aspect is the fact that the use of food waste does not create any conflict in terms of biodiversity.

The main socioeconomic benefits are direct and indirect employment, both during the construction and the operating phase of an Etanolix plant. Employment is needed both in the operation of the plant, handling and packaging of raw material (feedstock) and also transport and logistics of raw material and stillage. Other socioeconomic benefits are reduced CO2-emissions, which will lead to better climate for citizens in the long-term, and improved waste management.

3. Potential for technical and commercial transfer of application

Taking into account the use of natural resources and also waste management, the project enables local production of ethanol from residual waste; reuse of waste in an environmentally friendly and energy efficient way. It also allows the creation of sustainable production and consumption, a local disposal of waste products that do not become waste, promoting local ethanol production and a decrease in imports from other parts of the world.

One example of successful transfer of the application, is that in January 2017, ST1 and Ubon Bio Ethanol in Thailand signed a Memorandum of Understanding regarding development bioethanol production in Thailand. The ethanol will be produced from Cassava waste, which is a good feedstock for the Etanolix-technology and is available in large amounts in Thailand. There is a potential for up to 20 Etanolix plants in Thailand, that uses mainly cassava waste as feedstock. Ethanol is used in large amount as transportation fuel in Thailand. Important experience from the Etanolix 2.0-project will be used as input to the development of ethanol production by Cassava-waste in Thailand.

4. Best practice lessons

The project includes a lot of successful elements. Even if some challenges have occurred during the project period, the Etanolix plant produces good quality sustainable ethanol that is used as transportation fuel. 100 % of the produced ethanol has been used as fuel, which is above expectations and gives a good opportunity to construct additional plants according to the Etanolix concept.

The distribution chain and the delivery of stillage to customers has also worked well, and the stillage has been used both as feedstock for biogas production and as animal food. The projects states that available food waste is a good feedstock for sustainable ethanol production.

The CO_2-reduction has been above the expected 90 % for the plant.

The integration of the plant with an existing refinery gives not only a cost efficient and sustainable solution but also access to personnel that possesses the best suitable knowledge and experience of handling process plants, including the technical challenges that occurred during the construction and demonstration of the Etanolix plant.

The parts of the project that will require higher attention during the planning phase for the next project will be the receiving station and to verify the design and the materials used. Material selection to manage outdoor conditions is another improvement that will be implemented in the next project.

5. Innovation and demonstration value

Major innovations are the:

- design of the receiving station
- collecting and handling facilities for feed stock
- process pre-treatment step for waste feedstock

One of the main advantages compared to existing plants lies in the integration in the refinery energy flows, both related to heating and cooling. For heating, the required temperature levels is designed to fit with the temperature level of a surplus energy stream from the refinery.

For cooling, existing water systems is used within the refinery processes. The overall project serves as an example of how to integrate renewable and non-renewable production resources and facilities to achieve the most optimal energy use. To achieve this, it is necessary to identify the suitable segments of both processes that can be integrated and this type of work and methodology will need to be further explored to enable more utilization of energy resources in existing industrial production complexes.

This project and the demonstration of the innovative technology contribute to a decreasing of CO_2 emission in Sweden with 4 500 tons per year. With the potential of starting up 3-5 Etanolix would mean a reduction of 23 000 ton CO_2 per year. For Europe, with 150 Etanolix, the reduction of CO2 will be 850 000 tons per year.

The target of this project to integrate a cost effective and sustainable technology, to produce renewable fuel (ethanol) from industrial food waste and moreover, greening existing refineries, is a crucial step to mitigate climate change and waste management. This is of high relevance for the EU and its environmental goals. Since food is wasted at all stages (by producers, processors, retailers, caterers and consumers) the European Parliament's call for a coordinated strategy to tackle food wastage as a matter of urgency.

6. Long term indicators of the project success

- Bioethanol production plants using different kinds of food waste as feedstock
- Bioethanol production plants integrated to refineries with high energy efficieny as a result (reduced utility consumption)
- Lower transportation of food waste and produced raw material for bioethanol production and reduced CO_2-emissions as a result
- Less new grounds exploited for new process plants (since the plants are built at existing refineries)

6 Comments on the financial report

6.1 Summary of Costs Incurred

This report includes an overview of costs incurred, information about the accounting system and an allocation of the costs per action.

PROJECT COSTS INCURRED				
	Cost category	Budget according to the grant agreement*	Costs incurred within the project duration	%**
1.	Personnel	888,680	724,875	81
2.	Travel	100,050	9,216	9
3.	External assistance	837,000	493,809	59
4.	Durables: total non-depreciated cost			
	- *Infrastructure sub-tot.*	1,370,000	1,365,440	99
	- *Equipment sub-tot.*	317,320	155,224	49
	- *Prototypes sub-tot.*	650,000	656,049	101
5.	Consumables	91,756	6,647	7
6.	Other costs	77,000	26,595	35
7.	Overheads	220,195	163,356	74
	TOTAL	**4,552,001**	**3,601,390**	

*) If the Commission has officially approved a budget modification indicate the breakdown of the revised budget Otherwise this should be the budget in the original grant agreement.
**) Calculate the percentages by budget lines: e.g. the % of the budgeted personnel costs that were actually incurred

6.1.1 Comments to costs incurred per category

The deviations in actual cost compared to budget in grant agreement is more described in section 6.5.

6.1.1.1 Personnel

The personnel costs were in total below budget (approximately 19 %). The personnel costs for some actions were above budget (A1, A2 and B1), mainly according to a more extensive permitting and design process. The personnel costs for actions B3, C1, C2, D1 and E1 were below budget. The main reason was that the commissioning and monitoring of the plant was effectively included in the daily operations of the refinery. Also, personnel costs in Actions C2 and E1 were changed to external assistance.

6.1.1.2 Travel

The travel costs were in total well below budget (9 % of the budget in the grant agreement was spent). One of the reasons is that a large part of the dissemination actions was done at the

ST1 refinery. There was a large interest in visiting the site and less travels than expected was needed.

6.1.1.3 External assistance

The external assistance was in total below budget (57 % of the budget in the grant agreement was spent). Action A2 and B2 was underspend because more work than expected was performed by own personnel at ST1. During the construction phase, B3, more external assistance than expected was needed. Action C2, the socioeconomic study, was made by external assistance instead of own personnel at ST1 according to lack of time and resources, and therefore the cost for Actiosn C2 was higher than expected in the grant agreement. More external assistance than expected was needed in Action E, and this actiosn was also overspend.

6.1.1.4 Durables

6.1.1.4.1 Infrastructure

The costs for infrastructure durables was on budget.

6.1.1.4.2 Equipment

The costs for equipment was below budget (approximately 50% of the budget in the grant agreement was spent). Competitive bidding according to the grant agreement and also an experienced purchasing organization at ST1 have worked during the project with the procurement. A smaller part than expected in the budget was built according to ATEX-regulations, which resulted in actual lower equipment costs.

6.1.1.4.3 Prototypes

The cost for prototype durables was on budget.

6.1.1.5 Consumables

The consumables was well below budget (only 7 % was spent), the costs that occurred in this category is special analyses during the commissioning of the Etanolix-plant. A larger part than expected of the planned analyses could be performed at the refinery´s own laboratory.

6.1.1.6 Other costs

Other costs was also below budget, due to less other costs than expected. Other costs are mainly cost related to requirements during the permitting process and other requirements during the dissemination of the project.

6.2 Accounting system

St1 is an incorporated company, its accounting and reporting is regulated by Swedish cooperate laws, and the Etanolix project will be part of it. Thus, St1 is obliged to follow Swedish tax legislation and accounting standards. The accounting- and reporting system is called IBS. It is based on “International Financial Reporting Standard for Small and Medium-sized Entities (IFRS for SMEs)”. The annual report is audited by *PriceWaterhouseCoopers AB.*

6.2.1 Durable goods

Since the Etanolix project is a pilot project never incorporated in a refinery before, it is estimated to have a shorter life span than normal and the depreciation will be during four years.

As all projects in the refinery the Etanolix 2.0 LIFE+ has a dedicated project number - R0213R90 - that is used as identification in the accounting system. All costs and revenues associated to the project are accounted for using this project identification number. It is further divided into:

R90	Concrete and Construction
R61	Instrument
R96	Piping
R62	Service, Painting, Isolation, Scaffolding
R84	Electrical work
R52	Cranes, lifts misc.
R94	Safety personnel
R71	Engineering
R88	Mechanical objects
R64	Sheds, other equipment

<u>Subcontractors selected by Competitive bidding</u>
Durable goods – Infrastructure:
SFF AB, Konstruktionssvets AB, Veidekke entreprenad AB, Empower AB and Caverion Sverige AB

Durable goods – Equipment:
Konstruktionssvets AB

Durable goods – Prototype:
Nakkila Works, Raison valmisasennus oy, Plåt & spiralteknik i Torsby and Ventab i Göteborg AB

<u>Subcontractors selected from Framework agreement</u>
Durable goods – Infrastructure:
Midroc ställningar AB and PEAB Anläggning AB

Durable goods – Prototype:
Metso endress+hauser oy, Assa abloy entrance systems, Atritor limited and Forssan levy oy

6.2.2 Time reporting

Working hours are the actual hours worked and based on each action. A time reporting sheet explicitly for Etanolix 2.0 LIFE+ has been developed and is based on the time sheet supplied in the *Financial Report.* A dedicated person from the refinery's Human Resource department Maria Ahlström coordinates this work.

Due to confidentiality, all figures regarding salary information are being kept separate. In the LIFE+ project and for this reporting only the refinery Human Resource department is able to work on this data. The excel sheet "*Personnel*" in the *Financial Report* is protected by password and will be opened for the European Commission, only for the purpose to be transparent with the Personnel costs incurred.

Please find an explanation of the methodology that is used for the calculations of the annual gross salaries, in Annex – Cost calculations personnel.

Comments:

- When the project application was filed the personal salary, figures were given as approximately figures. This was estimated as daily rate in Euro and linked to the actions and roles planned for staff within the refinery organization Some full-time employees in the refinery organization has changed since the application was filed.

- The average personnel salary given as assumption as daily rate in Euro in the Grant Agreement is differing for some personnel compared to the actual salary as reported in the financial report (please see Financial reporting_2013 to 2017_LIFE12 ENV-SE-000529.xls.) In total 50 employees in the St1 refinery organization has reported time in the project, whereof 6 persons per roles were not planned for from start but needed during the project development. Comments on each role and action differing more than approx. 20% are given below each action under section 6.5.
- Calculating the total salary per personnel, in the financial spread sheet, the eligible pension cost is not included to the total salary cost. Since the Swedish pension system makes it very complicated to extract the eligible pension cost on an individual basis, however it could be done on each staff level by the refinery's Human Resource department, if requested.

6.3. Partnership arrangements (if relevant)

Not relevant.

6.4. Auditor's report/declaration

Audit of the Etanolix-project was performed in the end of 2016, and also at the end of the project in 2017 by PriceWaterhouseCoopers (PwC Sweden). The name of the auditor is Monica Hedberg. The auditor's report is presented in Annex F1-3.

6.5 Summary of costs per action

This table should present an allocation of the costs incurred per action. It should be presented in both paper and Excel format.

Action no.	Short name of action	1. Personnel	2. Travel and subsistence	3. External assistance	4.a Infra-structure	4.b Equip-ment	4.c Prototype	6. Consumables	7. Other costs	TOTAL (% of budgeted)
A1	Planning and preparation	90873	0	30765	0	0	0	0	10388	**132026 (182 %)**
A2	Design of the pilot and procurement	27350	0	235876	0	0	0	0	0	**263226 (36 %)**
B1	Construction of the pilot plant and installation/integration to the refinery	111377	407	77625	825787	11608	656049	0	0	**1682853 (97 %)**
B2	Commissioning, start-up and performance verification	44335	3783	2810	539654	143617	0	6647	0	**740846 (86 %)**
B3	Demonstration of pilot plant	169329		0	0	0	0	0	0	**169329 (44 %)**
C1	Monitoring and evaluation of pilot plant	118807		9456	0	0	0	0	0	**128263 (65 %)**
C2	Socioeconomic impact of the project actions	3991	0	19076	0	0	0	0	0	**23067 (640 %)**
D1	Communication and dissemination of project results	17585	901	0	0	0	0	0	16207	**34693 (25 %)**
D2	Networking with other EU-projects	5174	4124	0	0	0	0	0	0	**9298 (67 %)**
D3	After LIFE+ Communication Plan	0	0	0	0	0	0	0	0	**0**
E1	Project management and monitoring of project progress	133550		118199	0	0	0	0	0	**251749 (130 %)**
Over-heads										**163356**
	TOTAL	**724875**	**9215**	**493809**	**1365441**	**155255**	**656049**	**6647**	**26310**	**3601390 (78 %)**

Comments to the summary above;

Action A.1
Overall the budget for Action A.1 was exceeded with approximately € 60 000.

We encountered a more complex environmental permit application resulting in longer time to obtain all permits than expected and previously anticipated. In addition, due to the extensive activities related to the environmental permit, the budget related to this matter and this Action has been exceeded. The exceeded costs are primarily related to the involvement of much more internal personnel as more competencies/expertise from different disciplines within the refinery was needed to solve the upcoming issues than previously anticipated and budgeted for. This does not imply a request for more community contribution or changes in the content and objectives of the project. All cost exceeding the budgeted overall project cost will be covered by St1.

During this hectic period, it was not possible to travel as much as planned for. This reflects the budget with having spent less money on travels and subsistence compare to what was defined in the budget.

Personnel costs differing from Grant Agreement

Additional roles:
A Terminal manager (Egon Karlsson) was added as a resource to the project to ensure planning and preparation for refinery tank farm activities was taken care of. The refinery's Process Technology manager (Karin Lundqvist) had to attend as a senior process engineer competence. Electricity engineer (Peter Andersson) was added to the project for the competency requirement. Electrical manager (Per Åkeflo) was not planned to attend in this phase but was needed also in the planning. Health Advisor (Carina Webjörn) Safety engineer (Ulla Frejmyr) were helping within the environmental permit process, but were originally not planned to attending the project in this action.

More time spent:
The Refinery Manager (Bo-Erik Svensson), Technical Manager (Linda Werner), Civil Engineer (Carl-Sixten Ullgren), Process safety Engineer (Charlotte Lind) and HSSE coordinator (Marianne Risel) had all to spend more time on the environmental permit than expected. Construction Engineer (Greger Nilsson) and Civil Engineer (Carl-Sixten Ullgren) had to work more intense on the planning and preparation part of the project than originally estimated

Salaries different from what was presented in Grant Agreement:
The salaries for the Refinery Manager (Bo-Erik Svensson), the Civil engineer (Carl-Sixten Ullgren) and the Construction engineer (Greger Nilsson) were underestimated compared to actual budget.

Action A.2
Overall the budget for Action A.2 was not fully spent, approximately € 460 000 less than budgeted in grant agremmetn.

During Action A.2 we encountered some issues due to a more complex and time consuming design process than what had been expected by the designers. Therefore, personnel from St1 had to be more involved in the design work and used much less external assistance than previously anticipated and budgeted for.

Personnel costs differing from Grant Agreement

More time spent:
Purchaser (Maria Nyegre), Process Safety Engineer (Charlotte Lind) and Civil Engineer (Carl-Sixten Ullgren) spent more time on the design of the pilot and procurement than originally planned for.

Salaries different from what was presented in Grant Agreement:
The salaries for the Civil engineer (Carl-Sixten Ullgren) was underestimated compared to actual budget.

Action B.1
In total the budget for Action B.1 was well estimated in the budget application and especially with regards to cost categories: Infrastructure and Prototype. The outcome was approximately € 50 000 below budget.

Nevertheless, due to extended work scope such as additional civil and piping construction work as well as equipment design work we had to involve more personnel from St1 as well as engaging some additional external assistance than previously anticipated and budgeted for.

The estimated travel budget during this period was not spent as planned for since the personnel was occupied and focused on the internal project activities.

Personnel costs differing from Grant Agreement

Additional roles:
The refinery's Operations Training Manager (Svante Sjölander) was added as a resource to the project to ensure training and competency assurance was done according to refinery standards. A dedicated Laboratory Engineer (Maria Streck) was appointed to start preparation for analysis to be performed, methods and procedures to be developed to ensure a fit for purpose evaluation and quality assurance for process and products. This role was originally planned for to start at a later stage, but discovered to be needed earlier to make sure all details could be covered and prepared upfront Commissioning, start-up and verifications where the laboratory will have an important role.

More time spent:
Also in this action, construction and integration/installation to the refinery, the Civil Engineer (Carl-Sixten Ullgren) and the Construction Engineer (Greger Nilsson) had to be more involved and engaged in the project than originally estimated. The Process Engineer (Lars Olausson) was also heavily involved and to a larger extent than planned for, with the same tasks as plan, but more time-consuming. The Instrument Engineer (Johan Andersson) spent more time on the project than estimated in the project budget. The Safety Engineer (Ulla Frejmyr) had to work more on the field with contractor management and safety inspections than anticipated in the

Grant Agreement. This not to any issues or injuries, but the time to be spent was underestimated compare to actuals.

Salaries different from what was presented in Grant Agreement:
The Civil engineer (Carl-Sixten Ullgren) and the Construction engineer (Greger Nilsson) were underestimated compared to actual budget.

Action B.2
Not the whole budget defined for the project's Commissioning, start-up and performance verification phase was spent in Action B.2, approximately € 120 000 less than expected.

Not all verification tests have been able to perform yet since there has not been enough throughput of raw material in the pilot plant to test for the design case. These tests, when the pilot plant will be ramped up in capacity, will have to be moved into Action B.3. For the same reason, also the fine-tuning and optimization will have to take place in the demonstration phase (Action B.3). By these adjustments, the costs related to these sub-activities will be incurred under Action B.3 instead.

Personnel costs differing from Grant Agreement

Additional roles:
Due to organizational changes within the Technical Department (Mikael Noring) had to act as a temporary Inspection Manager in the project. The Inspection manager originally appointed to the project changed job. The involvement from the Inspection Department wasn't planned for during action B.2 but further competences in the area of asset integrity was required during the Commissioning, start-up and verification phase than first anticipated and the role needed in the project.

Action B.3
The overall budget for action B.3 was not fully spent, approximately € 220 000 less than expected according to grant agreement. The demonstration of the Etanolix pilot plant was integrated in the daily work and routines for the personnel at ST1 refinery. It enabled a more efficient handling of the demonstration work.

Action C.1
The overall budget for action C.1 was not fully spent, approximately € 68 000 less than expected according to grant agreement. The monitoring and evaluation of the Etanolix pilot plant was integrated in the daily work and routines for the personnel at ST1 refinery. It enabled a more efficient handling of the monitoring and evaluation.

Action C.2
The budget for action C2 was exceeded with € 19 000 more than expected according to grant agreement. The main reason is that external assistance was needed to perform the socioeconomic study, due to lack of own resources at ST1 when the study was planned to be

performed. The result of the socioeconomic study is also of large value for the project, and the work required more discussions and evaluation than planned in the previous budget.

Action D.1

The overall budget for action D.1 was not fully spent, approximatelt € 105 000 less than expected according to budget in grant agreement, even if all planned dissemination activities were performed. During action D.1, a large part of the dissemination actions were arranged in combination with site visits at ST1 Refinery and the Etanolix plant, which have improved the cost efficiency of the action.

Action D.2

The overall budget for action D.2 was well estimated in the budget application. The budget for travel costs was not fully spent.

Action D.3

No budget is assigned for this action.

Action E.1

The budget for action E1 regarding external assistance was exceeded with € 60 000 compared with the budget in the grant agreement. This is caused by change management in the organization when the Project Manager originally appointed had to take on other tasks and the Technical manager was appointed instead. For a period in the beginning, right after the change, an external assistance was helping out coordinating the project not as the Project Manager, but as an administrator. In January 2017, when the Technical Manager ended her employment at ST1, an external resource (from COWI AB) was hired as Project Manager to finalize the remaining work.

7 Annexes

7.1 Administrative annexes

Annex E1-1-Report 1 from PMG meetings *(submitted with the Mid-term report)*
Annex E1-2-Inception Report *(submitted with the Mid-term report)*
Annex E1-2-Inception Report (sent to EC) *(submitted with the Mid-term report)*
Annex E1-3-Report 2 from PMG meetings *(submitted with the Mid-term report)*
Annex E1-4-Mid-term Report *(submitted with the Mid-term report)*
Annex E1-5-Report 3 from PMG meetings *(submitted with the Mid-term report)*
Annex E1-6-report 4 from PMG meetings
Annex E1-7-Final monitoring report
Annex E1-8-Answers to comments on the Midterm-report

7.2 Technical annexes

Annex A1-1-Report on project plan *(submitted with the Mid-term report)*
Annex A1-2-Summary report on methods and evaluation tools *(submitted with the Mid-term report)*

Annex A2-1-Report on Contracts signed with subcontractors *(submitted with the Mid-term report)*
Annex A2-2-Report on Contracts signed with suppliers of raw materials and customers of stillage *(submitted with the Mid-term report)*
Annex A2-3-Report on Design of the pilot plant and refinery integration *(submitted with the Mid-term report)*
Annex A2-4-Report on Risk assessment on plant *(submitted with the Mid-term report)*

Annex B1-1-Report on the construction of pilot plant *(submitted with the Mid-term report)*
Annex B1-2-Report on the installation of pilot plant *(submitted with the Mid-term report)*

Annex B2-1-Commissioning report produced and approved *(submitted with the Mid-term report)*
Annex B2-2-Documentation for the Etanolix technology and integration into the refinery completed *(submitted with the Mid-term report)*
Annex B2-3-Report on Verification of technic in operation with a satisfying operational performance defined for the pilot plant *(submitted with the Mid-term report)*

Annex B3-1-Final report from demonstration completed

Annex C1-1-Evaluation report from demonstration phase after 6 months
Annex C1-2- Evaluation report from demonstration phase after 12 months
Annex C1-3-Evaluation report from demonstration phase after 18 months
Annex C1-4-Final data evaluation report after the demonstration including the technical, environmental and economic evaluation
Annex C1-5-LCA/LCC study

Annex C2-Socioeconomic impact study

7.3 Dissemination annexes

7.3.1 Layman report

Layman report is attached as Annex D1-23-Layman Report.

7.3.2 After Life+ Communication plan

The After Life+ Communication Plan is attached as the following annexes;

Annex D3-1-After Life+ Communication Plan_swe
Annex D3-1-After Life+ Communication Plan_eng
Annex D3-2 Presentation slide after life+ communication_swe
Annex D3-2 Presentation slide after life+ communication_eng

7.3.3 Other dissemination annexes

Annex D1-1-Project website online
Annex D1-2-Dissemination plan
Annex D1-3-Students from Chalmers visit
Annex D1-4-Inaguration of the Etanolix plant
Annex D1-5-Students from Chalmers visit
Annex D1-6-St1 Retail visit, incl presentation
Annex D1-7-LIDL visit
Annex D1-8-Oljehamnsgruppen visit
Annex D1-9-Finnish family firms visit
Annex D1-10-students from Chalmers visit
Annex D1-11- Purac and Läckeby water visit
Annex D1-12-Study visit at Advanced Biofuels Conference
Annex D1-13-St1 Infographic (in English and Swedish)
Annex D1-14-EMAS report 2015
Annex D1-15-PulPaper seminar 2014
Annex D1-16-Seminar Budapest 2014, incl list of delegates
Annex D1-17-Seminar Madrid 2015, including presentation and list of participants
Annex D1-18-Seminar Denmark 2015, including presentation and list of participants
Annex D1-19-Seminar in Lund 2015, including presentation
Annex D1-20-Seminar Linneus University, including speakers and photos
Annex D1-21-Advanced biofuels conference
Annex D1-22-Notice Boards, *(submitted with the Mid-term report)*

Annex D2-1-Report 1 on networking meeting
Annex D2-2-Networking meeting with BioMether
Annex D2-3-Networking meeting with SludgeisBiofuels
Annex D2-4-Networking meeting with AlgaEnergySA
Annex D2-5-Experience from networking meetings

7.4 Final table of indicators

7.4.1 Part 1-3 – LIFE+ Environmental Policy and Governance

The Output indicator tables related to the *LIFE+ Environmental Policy & Governance* is applicable for this specific project and is presented below. In Table 1 to Table 3 output indicators during the project are reported.

Table 1: *Preparatory issues*

Types of preparatory actions	No	Budgeted cost (€)
Feasibility studies		
Legislative reviews	1	10,000
Cost-benefit studies		
Market analysis		
Permit studies	1	20,000
Permit applications	3	5,000
Permits obtained	3	
Environmental impact assessment studies	1	10,000
Scientific studies		
Detailed engineering studies	2	723,000
Monitoring actions		
Action plans	1	20,000
Management plans	1	10,000
Inventories and studies	2	-
Ex ante environmental monitoring		
Ex post environmental monitoring		
Other (specify)		
Total budgeted cost (€)		798,000

Table 2: *Main project deliverables*

Deliverable	No	Budgeted cost (€)
Prototypes	1	650,000
Pilot plants	1	2,337,000
Techniques/methodologies developed	1	N/A
Software		
Successful implementation of demonstration actions	1	2,597,000
Monitoring techniques developed	1	390,000
Monitoring performed	1	197,000
Guidelines		
Manuals		
Others (specify)		
Total budgeted cost (€)		6,171,000

Table 3: *Training*

No of training sessions	Total no. of persons trained	Budgeted cost (€)
4	138	6,360

7.4.2 Part 4-7 - Awareness raising and communication

The Output indicator tables related to the *Awareness raising and communication* is applicable for all Life+ projects and is presented below. In Table 4 to Table 7 output indicators during the project are reported.

***Table 4**: Workshops, seminars and conferences*

Target audience:	General public			Specialised audience (e.g. decision-makers)			Very specialised audience (e.g. experts, academics)		
Number of participants:	Local/ Regional	National	EU/ International	Local/ Regional	National	EU/ International	Local/ Regional	National	Local/ Regional
0-25 participants	3				5				
25-75 participants						1			
75-100 participants				1		1			
>100 participants					2	4			
Total budgeted cost (€)	89 500								

***Table 5**: Media and other communication and dissemination work*

Type of media	No.
Project website: average number of visitors per month	*
Press releases made by the project	0
General public article in national press	3
General public article in local press	2
Specialised press article	2
Internet article	0
TV news/reportage	1
Radio news/reportage	0
Film produced	0
Film played on TV	0
Film presented in events/festivals	0
Exhibitions attended	7
Information centre/Information kiosk	0

Project notice boards	2
Other	0
Total budgeted cost (€)	7400

**No information about languages in the Grant Agreement.*

***Table 6**: Publications*

Type of publication	No. published	No. of copies	Languages
Layman's report	100	0	Swe, Eng.
Manuals	0	0	N/A
Leaflets	1000	0	*
Brochures	0	0	N/A
Posters	0	0	N/A
Books	0	0	N/A
Technical publications	0	0	N/A
Other (please specify)	0	0	N/A
Total budgeted cost (€)	15000		

***Table 7**: Educational activities*

Establishment involved	No. of students
Kindergartens/Primary schools	0
Secondary schools	0
Higher education establishments	0
Total budgeted cost (€)	0

8 Financial report and annexes

Annex F1-1 Financial report (Financial_reporting_2013 to 2017_LIFE12 ENV-SE-000529.xls)
Annex F1-2-Cost calculations personnel
Annex F1-3-Independent Audit report