Project Information Sheet

Producing sodium bicarbonate using carbon dioxide captured from the flue gasses of waste incineration (NaHCO3)

Programme area:	Recycling of materials
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Benefits (max. 150 characters incl. space):	An innovative technology for re-using carbon dioxide by capturing the product from the flue gasses of the Twence Waste-To-Energy (WTE) plant and using it for the production of sodium bicarbonate as a result of the alkaline reaction with soda. The sodium bicarbonate will be used for flue gasses cleaning purposes (removal of acid components), thus avoiding the current expensive purchase of the product.
Keywords:	Carbon dioxide capture + sodium bicarbonate production + re-use at incinerator for flue gas cleaning purposes
Sector:	Recycling
Type of solution	New technology
Duration:	01/07/2011 – 01/07/2014
Budget:	€ 2.044.412,-- (EU contribution: 42,76%)
Contract number:	ECO/10/277332

Summary

The increase of carbon dioxide emissions is the main reason for the global warming up causing disastrous environmental effects. In order to reduce the greenhouse gas emissions, several large-scaled carbon capture & storage (CCS) technologies and methods are in operation all over the world. The current techniques however have major technical and economic disadvantages. For example deficits in issues such as energy consumption, investment costs and consumption of absorbents. CCS is not the only option for reducing the greenhouse effects. Other options are mostly related to re-using the carbon dioxide. Recycling is likely to offer environmentally and financially sustainable responses to the global challenge of significantly reducing greenhouse gas emissions.

In this project Twence will demonstrate an innovative technology for re-using carbon dioxide by capturing the waste product from the flue gasses of the Waste-To-Energy (WTE) plant and using it for the production of sodium bicarbonate ($NaHCO_3$) as a result of the alkaline reaction with either sodium hydroxide (NaOH) or with soda (Na_2CO_3). The choice for the product to be used is largely depending on the price level and large-scaled availability of the raw materials. The sodium bicarbonate will be used at the incinerator for flue gasses cleaning purposes (removal of acid components), thus avoiding the current expensive purchase of sodium bicarbonate.

The overall objective of the project is to build an unique on-site carbon dioxide capture unit as well as a downstream sodium bicarbonate reactor geared to the future consumption of this flue gasses cleaning product by Twence. The production capacity of the demo plant is indicated at 8,000 tons of sodium bicarbonate on an annual basis. As a result the project will have major environmental benefits. The reduction of carbon dioxide consumption as a result of the innovative technology is calculated on more than 6,000 tons on an annual basis.

The main partial objectives of the demo project are:

- Demonstration of an unique carbon dioxide capture technology leading to lower investment costs, lower consumption of absorption liquids as well as lower operational costs;
- Demonstration of the re-use of the captured carbon dioxide for the on-site production of sodium bicarbonate to be used in the flue gasses cleaning system of the WTE plant;
- Evaluation of the concept of on-site production, storage and re-use of carbon dioxide;
- Review of the financial-economic perspective of the new technology.

The project has started on 1 July 2011. De duration of the demo is calculated on 36 months. The execution is structured according to work packages (WP), thus allowing for a structured approach of the activities.

Expected and/or achieved results

Expected results

The demo plant will initially aim at acquiring knowledge and know-how related to the proposed innovative technology in the shape of testing, validating and - if necessary - adjusting the production process. At the same time by realizing the installation the operational objective of the project is the production of the required volume of sodium bicarbonate to be used for flue gasses cleaning purposes at the Twence site.

The major results of the project to be expected are divided into know-how, technical and economic outcomes:

Know-how:

- Validation of the chemical, thermodynamic and physical properties of the system;
- Validation of the process models, model calculations and simulations;
- Validation of the effects of the process conditions on the product properties.

Technical deliverables:

- Detailed design of both the carbon capture plant as well as the sodium bicarbonate reactor;
- Construction of a demo plant with a capacity of 8,000 tons of sodium bicarbonate on an annual basis;
- Technical evaluation of both the carbon capture process as well as the re-use process;
- Integration of the demo plan with the regular WTE-plant (specifically with the flue gasses cleaning system).

Economic deliverables:

- Availability, volumes and prices on the raw materials;
- Evaluation of the storage, transport and recycling of raw materials and finished product;
- Business process evaluation (operational costs, level of investment and return-on-investment);
- Calculation of the market volume of the demonstrated technology.

Achieved results

WP1 (project management)

The activities are in progress. In the course of the $NaHCO_3$ project the management has been strengthened. At first the project management consisted of two persons. Project director is Ir. H. Middelkamp (Manager Processes & Technology of Twence) and project manager is A. Roeloffzen Bsc (senior staff member Processes & Technology of Twence). The management has been strengthened by appointing an assistant project manager. Also recently more time as well as employees have been allocated to the $NaHCO_3$ project since the progress required a higher level of engagement in order to prevent unnecessary delay. The generated attention allowed for speeding up the project in previous months. More activities are performed and the tempo of these activities is also speeded up.

The International Advisory Board has also been completed. The board is monitoring the project and consists of three persons. Chairman of the board is J. Rooijakkers Msc (Chief Business Development of Twence). Other members of the board are Ir. G. Timmer (manager at Brewa GmbH in Bremen Germany) and Prof. G.F. Versteeg (manager of Procede Group in Enschede). The board advises the project management on activities to be performed and also acts as sounding board for the project staff involved.

WP2 (evaluation of the process plant design)
This WP is completed. In 2012 a study concluded that the original intended technology would not be feasible in financial perspective. The ROI-period would be long and the cost price of the sodium bicarbonate would exceed the actual market price. It was also concluded that both investment budgets as well as operational costs would exceed the original estimations. In reaction several adjustments were proposed. The first adjustment related to the use of 100% ('pure') carbon dioxide for the sodium bicarbonate production. The second adjustment consisted of eliminating drying the sodium bicarbonate and using slurries of the product. In the original plan the assumption was made that sodium bicarbonate will be unstable at high temperatures, thus leading to thermal decomposition. Due to several measurements the temperature will be reduced and as a result the drying process will be avoided as well as crystallising and sifting of the sodium bicarbonate.

It was decided that more information on the technical and financial implications of the proposed adjustments to use slurries of sodium bicarbonate instead of dried sodium bicarbonate was needed in order to be able to proceed with the NaHCO3 project. Following this decision a study regarding this subject was performed. The focus of the study was to be able to evaluate the effectiveness of using slurries for flue gas cleaning purposes instead of dried sodium bicarbonate. Using slurries of sodium bicarbonate must be effective in technical perspective, but must also result in reduced investment and exploitation costs (economic perspective).

The overall goal of the study was to realize a sodium bicarbonate slurry injection installation for the efficient removal of acid gas components (like HCl and SO2) from flue gas. The study was performed in the period from May until November 2012. In the study an extensive test program has been set up. The first part of the study concerned testing slurry injection at room temperatures and ambient conditions. The second part of the study concerned testing slurry injection at elevated temperatures in the actual flue gas of the WTE-plant. In the study the proposed innovative concept was investigated in detail in order to develop deeper understanding and faith in sodium bicarbonate slurry injection. Recently the results of the study focused on necessary technical modifications in the demo technology were discussed by the technical experts of Twence. The overall results of the study were evaluated positive and resulted in an adjusted technology for sodium bicarbonate slurry injection for the efficient removal of acid gas components from flue gas. The results were evaluated positive by Twence, thus leading to a complete oversight of all technical aspects related to the demo technology.

Following the technical evaluation also the financial implications of the proposed adjustments were investigated and evaluated. Price indications for the demo plant equipment (including integration with the operational WTE plant) were collected from potential contractors, thus resulting in detailed budget estimations for the investment. Based on the technical as well as financial input a revised business case was made up focused on the realization of a carbon dioxide capture plant in combination with a downstream sodium bicarbonate reactor with a capacity of 8,000 tons on an annual basis. The business case was evaluated positive by the project management and presented to the board of directors as well as the supervisory board of Twence. Final approval of these boards was received on June 13th 2013, thus enabling to complete this WP.

WP 3 (acquiring permissions)
The process of acquiring the permissions is also completed. It was investigated which permissions are required and what actions should be taken. It turned out that Twence is operating under the conditions set out by a framework environmental permission, resulting in degrees of liberty to act. In order to execute the possibilities to act stated by the framework an internal environmental audit was made focused on the effects of capturing carbon dioxide from the flue gas of the WTE plant and using it for the production of a slurry of sodium bicarbonate to be injected in the flue gas cleaning unit. The audit focused on the implications on emissions in the compartments soil, air and water. The audit report has been submitted for approval to the licensing authority. Since no obstacles were indicated approval of the Province of Overijssel was received on January 31st 2013.

WP4 (detailed engineering en dimensioning of the pilot plant)
The activities related to the engineering of the demo plant (including integration with the operational WTE incineration plant) were completed in the mid of 2013. The work consisted of the basic and detailed engineering (both mechanical and electrical) of the carbon dioxide capture plant in combination with a downstream sodium bicarbonate reactor. Specific attention was given to the unit and reactor design & configuration, specification of process equipment, control & safety aspects as well as process monitoring & analysis. Since slurries of sodium bicarbonate will be used special attention is also given to the integration of the demo plant with the operational WTE plant. In total 10 interfaces (SLIF's) between the pilot plant and the operational WTE plant are identified.

WP5 (tendering procedures)
In order to advance project activities the tendering procedure started before the revised business case was approved by the Twence management. The WP started by making up the procurement procedure and draft contract to select the best candidate for constructing the demo plant. The procurement instructions focused on engineering of the plant equipment as well as constructing and turn-key delivering of the plant. Integration with the WTE plant is partly included. Major integration systems will be realized by the general contractor and supporting systems will be realized by Twence. The general contractor is responsible for engineering and/or purchasing the equipment as well as for assembling the equipment into an operational demo plant. The contractor has the liberty to select subcontractors and suppliers.

The procurement instructions and contract were made public for interested and eligible contractors on June 17th of 2013 through the website www.negomatrix.com. The website was also to be used to submit a proposal. Final proposals were to be submitted before July 15th 2013. Based on the thorough evaluation of all proposals the construction contract was awarded to Bouman Proces Technologie since this company submitted the bid offering best value for money. The company has also extensive experience in the turn-key deliverance of process technology demo plants. Twence has positive references on this contractor in the recent past. On July 19th of 2013 the awarding decision was made public by Twence and on July 22th of 2013 the construction contract was signed.

It is decided that Procede Group will remain involved in the project as consultant. Procede Group will assist Twence in performing future project activities. Procede Group is selected since this agency was intensively involved in the process of evaluating and adjusting the demo technology (WP2) as well as the engineering of the demo plant (WP4). The activities consist of assistance in the process of selecting the eligible contractor, evaluating procurement offers, supporting the construction activities, setting up commissioning & trial tests etc.

The second part of WP5 includes the procurement procedure for soda to be used in the demo plant. These activities have not yet started due to the progress of the project up till now. It is intended to perform this procurement procedure in the remaining months of 2013. WP5 will be completed largely before starting-up the demo-plant. Selecting suitable soda suppliers will not be complex since the product is largely available at competitive market prices.

WP6 (construction of the demo plant)
Activities related to WP6 (equipment engineering, procurement, construction and assembling) have started almost immediately after signing the contract. The activities are performed by the contractor in cooperation with several subcontractors and suppliers. Also infrastructural activities will be performed by the contractor to realize an operational status and integration with the WTE plant. In August and September of 2013 Bouman Process Technology has focused on the detailed engineering of the equipment related to the demo plant based on the output of the engineering and dimensioning of the process design (WP4). In respect to the size of the plant this is an extensive task and will take time. A HAZOP study is currently performed by Twence and supervised by Arcadis. No deliverables are available yet.

Following the output of the actual equipment engineering & dimensioning process the procurement of the equipment will take place October and November of 2013. After receiving the equipment the actual construction of the demo plant can be performed by Bouman Proces Technologie and her subcontractors. It is planned that on 14th February of 2014 the third incineration line of the Twence WTE plant will be put out of operation for several days in order to be able to complete the installation and integration process of the demo plant. Based on the present knowledge no major obstacles are expected in performing this WP.

The start-up of the demo plant is expected on April 1st of 2014. At first a Pre-Factory Acceptance Test (FAT) will be performed. The objective of this test is to examine the demo plant on its completeness and compliance with the design specifications. Several mechanical, electrical, software and functional tests will be performed. After completion of the Pre-FAT the contractor will invite Twence for inspection to the demo plant to witness the performance of the Factory Acceptance Test (FAT). During the FAT procedure the contractor will also provide a training program to the operators of Twence. This training comprises introduction of and familiarization with the demo plant particularly the control sections. Relevant documentation related to the demo plant will also be presented to Twence in this WP.