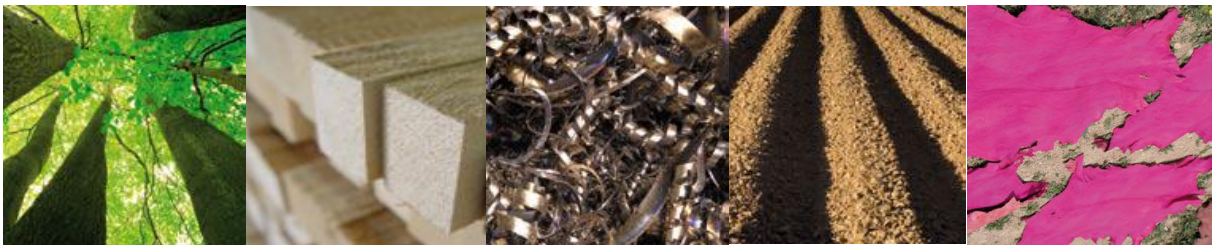

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$NaHCO_3$
Contract ECO/10/277332

Deliverable D10.1
Layman's report

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Initiator

Twence B.V. is a waste-processing company also generating energy (electricity, steam and heat). Twence processes waste originating from households and businesses located in The Netherlands, Germany and UK. The waste is sorted using state-of-the-art technologies, making it suitable for re-use, composting, energy production or - as a last resort - depositing. Over 95% of the waste is transformed into raw materials, building materials or/and energy. Twence processes over 1 million tons of domestic and industrial waste on an annual basis.

Twence offers a wide range of waste-processing options and guarantees high-grade waste processing in terms of its impact on the environment. Twence is an efficient and environmentally friendly link in the waste-elimination chain. Combustible waste that cannot be sorted or re-used is processed in the waste-to-energy (WTE) incineration plant. The WTE plant - consisting of three incineration lines - is one of the most modern plants in the world. At an average temperature of 1.000°C over 500,000 tons of waste is incinerated on an annual basis. The company generates enough electricity to meet about half the needs of the Twente region. Most of the electricity produced is supplied to the public electricity grid.

Incinerating waste inevitable creates flue gasses containing various chemical substances (gasses and/or fine particles) in concentrations harmful and damaging to the environment as well as to persons. To prevent flue gasses from being released in the environment cleaning is needed before leaving the chimney. Twence has a 'state of the art' flue gasses cleaning system at its disposal. The system is made up of a number of units. In the fabric filter the flue gasses cleaning process is performed by using absorbents such as sodium bicarbonate. The application of sodium bicarbonate has recently shown to be more effective and efficient compared to other chemicals such as carbon of calcium to remove elements like sulphur oxides and hydrogen chlorides. An increasing percentage of WTE plants had therefore switched to sodium bicarbonate in flue gas purification processes or is considering switching.

Problem

The increase of carbon dioxide emissions is the main reason for global warming, causing disastrous environmental effects. In order to reduce the greenhouse gas emission several large-scaled carbon capture & storage (CCS) technologies are worldwide in operation. Current technologies however have major technical and economic disadvantages. For example deficits in issues as energy consumption, investment costs as well as consumption of absorbents. Other options for reducing the greenhouse effects are mostly related to re-using carbon dioxide. Recycling is likely to offer environmentally and financially sustainable responses to the global challenge of reducing greenhouse gas emissions.

By recycling carbon dioxide new and prospective applications for the environmental harmful and damaging waste stream will be created as a result of which carbon dioxide can obtain a substantial economic value. An innovative technology for re-using carbon dioxide is demonstrated. The project demonstrates that carbon dioxide captured from flue gasses of Waste-To-Energy (WTE) plants can be used for the effective and cost-efficient production of sodium bicarbonate ($NaHCO_3$). As stated sodium bicarbonate is used by Twence in the flue gasses cleaning system and is currently purchased from chemical companies. Twence builds a demo carbon dioxide capture plant at her site to re-use the captured carbon dioxide for the production of sodium bicarbonate and demonstrates an innovative technology for re-using carbon dioxide by capturing the waste product from the flue gasses of the WTE plant and using it the production of sodium bicarbonate as a result of the alkaline reaction with soda.

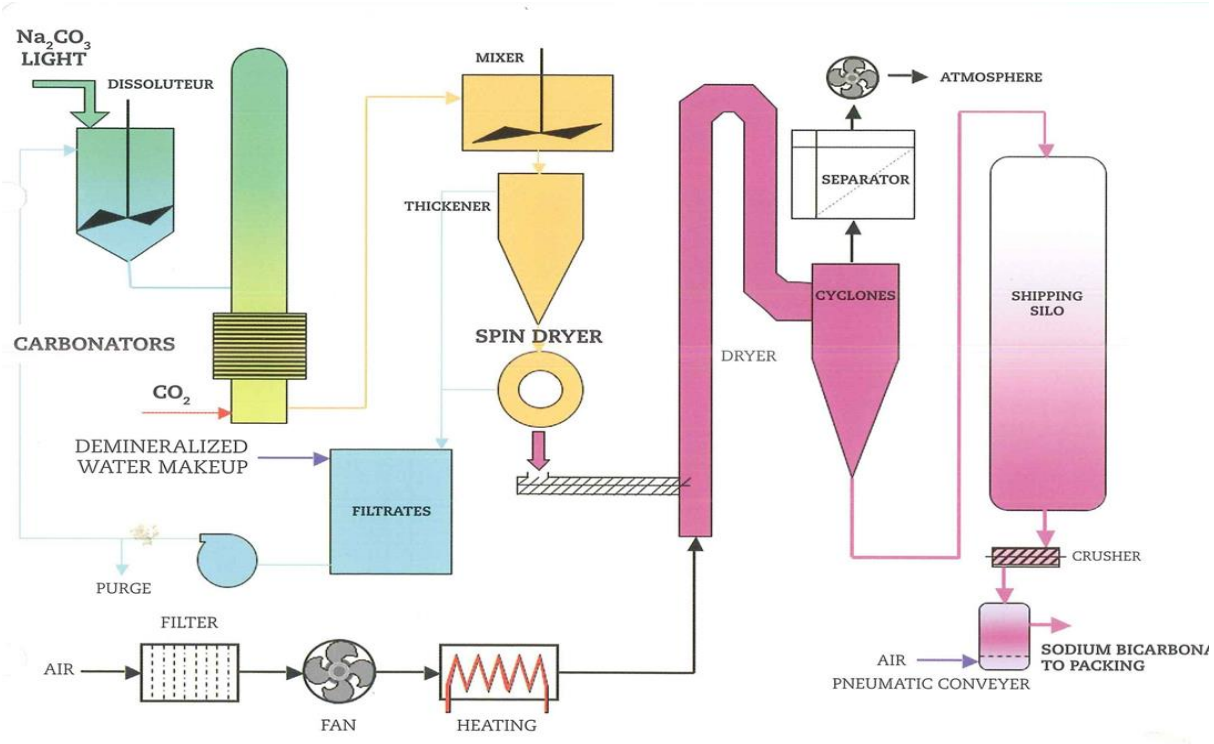
Objectives

The $NaHCO_3$ project demonstrates an innovative technology for the effective and cost-efficient production of sodium bicarbonate using carbon dioxide captured from the flue gasses of the WTE plant as well as the alkaline sodium carbonate. The overall objective is to build and demonstrate an unique on-site carbon dioxide capture unit and downstream sodium bicarbonate reactor with a capacity of 8,000 ton on an annual basis geared to the future consumption of this product by Twence for flue gasses cleaning purposes.

The main partial objectives of the project are:

- Demonstration of an unique carbon dioxide capture technology leading to lower operational costs (financial aspect) as well as lower consumption of absorption liquids (environmental aspect).
- Demonstration of the use of the captured carbon dioxide for the on-site production of sodium bicarbonate suitable to be injected into the flue gasses of the WTE plant.
- Evaluation of the concept of on-site production, storage and re-use of carbon dioxide as well as sodium bicarbonate on scale;
- Review of the financial-economic perspective of the new technology.

Figure 1: General process design for the production of sodium bicarbonate.



The reduction of carbon dioxide consumption as a result of the innovative technology is calculated on 2,0000 to 3,000 tons on an annual basis, based on capturing and re-using carbon dioxide as well as on the reduced need for transport and handling of the product.

Results

The demo plant initially aims at acquiring knowledge and know-how related to the innovative carbon dioxide capture technology as well as sodium bicarbonate production technology in the shape of testing, validating and adjusting the production process and equipment. At the same time by realizing the installation the operational objective is producing the required volume of sodium bicarbonate intended for the flue gasses purification at the Twence site.

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

Know-how:

- Validation of the 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 and sodium bicarbonate reactor;
- Construction of a plant with a capacity of 8,000 tons of sodium bicarbonate per year;
- Technical evaluation of both the carbon capture process as well as the re-use process.

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 (costs, level of investment and return-on-investment);
- Calculation of the market volume of the demonstrated technology.

Innovation

The project is focused on the concept of on-site producing sodium bicarbonate using carbon dioxide captured from the flue gasses of the WTE plant as well as the alkaline sodium carbonate. As a result both raw materials will obtain substantial economic value by means of an intensive valorisation process. The $NaHCO_3$ project is highly innovative. The demo technology consists of two innovative techniques not applied and/or documented previously.

Carbon dioxide capture:

Capture of carbon dioxide is in itself an existing technology applied in several industrial processes. Most of the (post-combustion) technologies are based on absorption/desorption using conventional amines as absorption liquid. This however is not effective and cost-efficient with regard to WTE plants. New generations of solvents have to be applied to solve existing limitations. For example deficits in issues as energy consumption, investment costs and consumption of absorption liquids. Capturing and compressing carbon dioxide requires large volumes of energy. Regular amines have high volatility and show rapid degradation. They also have limited absorption capacity as well as operational stability. Handling these amines will increase the costs. Conventional amines are also damaging for the environment.

The carbon capture technology applied in this project uses innovative solvents able to tolerate higher percentages of pollution and consuming reduced amounts of energy for the regeneration of carbon dioxide. Main characteristics of these solvents are environmentally friendly, biodegradable, no vapour pressure, high stability and low costs. By applying these innovative solvents evens multiple components will be captured at the same time. The energy consumption is less than 2 MJ/kg carbon dioxide captured (conventional technology requires 3.5 MJ/kg). In addition low-valued residual heat is suitable for the technology.

Sodium bicarbonate:
The use of carbon dioxide captured from the flue gasses of the WTE plant as raw material for the production of sodium bicarbonate is also highly innovative. Up till now there are no similar initiatives known to the initiator. Almost all sodium bicarbonate is synthetically produced as a side-product made available during the production of sodium carbonate using the ammonia-soda process (Solvay process). In this process salt (sodium chloride) and limestone (calcium carbonate) are used as raw materials. Using carbon dioxide for producing sodium bicarbonate has been avoided up till now since conventional capture methods are expensive and show limited results, thus resulting in an economically non-interesting technology. It can also be stated that sodium bicarbonate is only recently used by WTE plants for flue gasses cleaning purposes. Until recently other techniques were used for this purpose (e.g. alkali scrubbing). These techniques however show major limitations.

Realization
The demo plant consists of 4 main subsystems (soda dissolving system, CO_2 capture plant, sodium bicarbonate production plant and injection system). The main utilities are steam injection, cooling water and heat recovery.

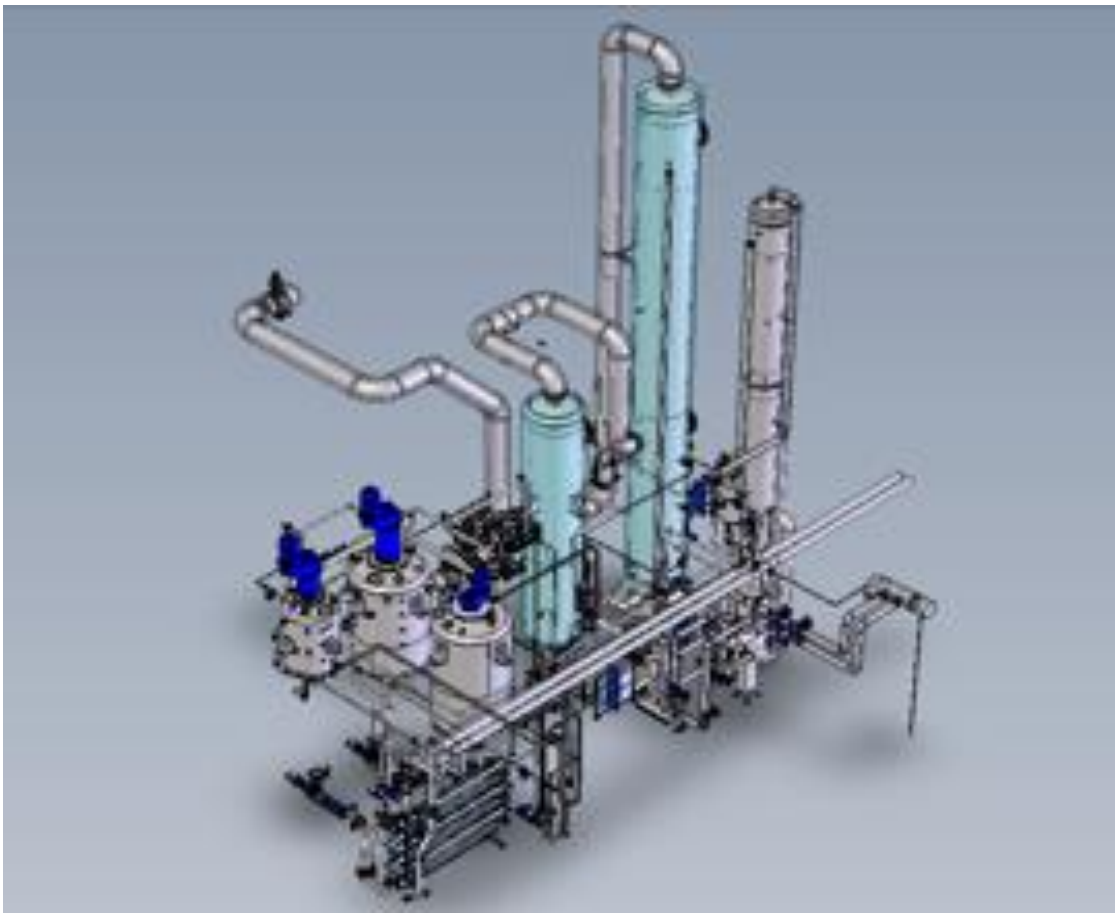


Photo 1: carbon capture pant and sodium bicarbonate reactor.

Environmental benefits

The main environmental benefits of the demo technology for producing sodium bicarbonate using carbon dioxide captured are:

- Purchasing sodium bicarbonate from chemical manufacturers will be avoided, leading to voluminous reductions in material use, energy consumption and purchasing costs.
- By re-using the environmental harmful and potential damaging carbon dioxide the gas shall obtain substantial economic value by means of valorising the waste stream.
- The additional production and emission of carbon dioxide will be avoided since the conventional production of sodium bicarbonate requires large volumes of fossil natural gas. In addition the conventional production technology for sodium bicarbonate has an efficiency loss of circa 30%, thus leading to the emission of additional carbon dioxide
- The carbon dioxide emitted by the WTE plant is mainly of biomass origin (over 50% of the waste streams is of biomass). As a result no additional carbon dioxide is produced.
- Sodium bicarbonate can be produced on-site, thus leading to advantages related to the handling, transport and distribution of the product. As a result no substantial carbon dioxide emissions will occur related to these activities.

Market

Market uptake and replication will not be a problem. Twence is one of the 11 WTE plants located in The Netherlands. At a European scale at the moment circa 450 WTE plants are in operation. WTE plants heavily invest in sophisticated filtering devices to minimize the emissions into the atmosphere. Since the use of sodium bicarbonate has shown to be more effective and efficient compared to other chemicals for flue gasses cleaning purposes an increasing percentage of the WTE plants recently switched to using this product or is considering switching. Sodium bicarbonate is expected to become the standard solvent in filtering devices in the WTE sector in the near future. It is expected that within 5 years 25% of the European WTE plants will use sodium bicarbonate for flue gasses cleaning purposes.

By far the largest potential market potential is related to the application of carbon dioxide capture in other industries and sectors. For example in electricity power plants, steel industry, refineries and the (petro)chemical industry. At the moment no effective and cost-efficient technologies for the large-scaled carbon dioxide capture are commercially available. The available and currently used carbon capture technologies show major disadvantages at various points. For example deficits in issues such as energy consumption, investment costs and the consumption of absorption liquids. Recent developments seem to have the potential for effective and cost-efficient carbon dioxide capture with lower energy consumption and reduced investment costs, thus allowing more application possibilities.

European added value

The innovative technology to produce sodium bicarbonate has clear and substantial European added value. The environmental challenges described are not of local, regional or national origin, but have a widespread international character. In all European countries waste is regularly processed by incineration plants. Waste-to-Energy (WTE) plants thermally treat waste that remains after waste prevention, re-use and/or recycling by generating energy (electricity, steam and heat) from it. Twence is one of the 11 WTE plants located in The Netherlands incinerating in total circa 5,7 million tons of waste on an annual basis. At a European scale over 450 WTE plants are in operation. The CEWEP (Confederation of European Waste-to-Energy Plants) represents almost 90% of the plants in Europe.

The European WTE plants annually treat over 75 million tons of waste that remains after prevention, re-use and recycling. By doing so the WTE sector is helping to reduce carbon dioxide emissions and aiming at reaching the objectives set out in the Kyoto-protocol. There is a close link between the sustainable management of natural resources and energy recovery. The European WTE sector produces over 40 billion kWh of electricity and 70 billion kWh of heat on an annual basis. As a result millions of tons of fossil fuels (gas, oil, hard coal and lignite) is substituted annually, preventing the emission of millions tons of carbon dioxide. Replacing the fossil fuels WTE plants can supply annually about 15 million inhabitants with electricity and heat. This is equivalent to the population of Denmark, Ireland and Latvia.

Contact information

For more information on the $NaHCO_3$ project please contact the coordinator:

Organisation
Twence B.V.
Boldershoekweg 51
7554 RT Hengelo
PO Box 870
7550 AW Hengelo
The Netherlands

Project director
Mr. Andy Roeloffzen Bsc
Tel: +31 - 74 - 240.44.44
E-mail: a.roeloffzen@twence.nl
Website: www.CO2SBS.eu

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