INDUSTRY

DHI CASE STORY

ENSURING SUSTAINABLE CELLULOSIC BIOETHANOL PRODUCTION

Using detailed process analysis to identify ways to reduce water consumption

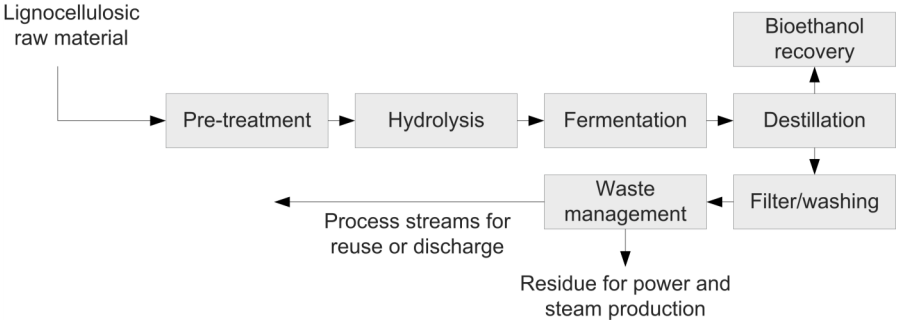
As the world's energy demands grow, cellulosic ethanol is increasingly seen as an important source of renewable energy. The production method behind cellulosic ethanol, however, can be water intensive. To address these concerns, Novozymes A/S asked us to determine how water consumption during cellulosic ethanol production compares to conventional gasoline production. We found that water consumption during cellulosic ethanol production is comparable to, or in some cases lower than, conventional gasoline production.

CELLULOSIC ETHANOL PRODUCTION – MEETING ENERGY NEEDS

Increasing demand for oil has also put mounting pressure on global energy resources. To address the world's growing energy needs, some companies are developing new sources of renewable energy, such as cellulosic ethanol production.

This method of energy production uses wood, grasses, and other inedible plant parts to produce biofuel. As it requires large amounts of water to produce, additional questions and concerns have been raised about the quantity of water consumed during the production process. However, only limited information about water consumption is available for current technologies in this field.

Novozymes is a world leading biotechnology company and one of the frontrunners in transforming the energy field from fossil-based to bio-based. Cellulosic ethanol is now starting to be produced on a large scale. As such, Novozymes wanted us to conduct a study to establish reliable, evidence-based data on how much water cellulosic ethanol production consumes.



Main process steps in second generation bioethanol production

SUMMARY

CLIENT

Novozymes A/S

CHALLENGE

Need to establish solid near- and long-term water consumption data for cellulosic ethanol production

SOLUTION

A detailed study to concretely establish how much water cellulosic ethanol production consumes

VALUE

Allows for the comparison of water consumption for cellulosic ethanol production and conventional gasoline production using reliable and evidence-based data

LOCATION / COUNTRY

Bagsværd, Denmark

ANALYSING WATER FOOTPRINT

The overall water consumption of a product is the volume of freshwater used to produce the product, measured over the full supply chain - including both direct and indirect water use. This is known as the product's water footprint. With the concept of water footprint in mind, we analysed water consumption during cellulosic ethanol production based on:

- data in existing literature
- information about commercially developed processes for cellulosic ethanol at the early stages of implementation

In order to establish concrete water consumption data for cellulosic ethanol that could be compared to reference data on water consumption for conventional gasoline, we analysed:

- direct water (fresh surface and groundwater) consumption during the fuel production process
- direct water consumption allocated to produce the raw material, such as crude oil for gasoline production and biomass for the cellulosic ethanol production
- indirect water saving allocated to the exported surplus electricity through saved public electricity production

Using a detailed process analysis, we examined the amount of water consumed during cellulosic ethanol production. We assessed water consumption for cellulosic ethanol using two data sources:

- a detailed process simulation study on corn stover (the leaves and stalks of corn) conversion conducted by the National Renewable Energy Laboratory (NREL) in the United States
- a commercial cellulosic bioethanol production during the implementation stage at Chemtex Italia S.R.I. (now Biochemtex), a large scale bioethanol production facility in Crescentino, Italy

FULL REPORT

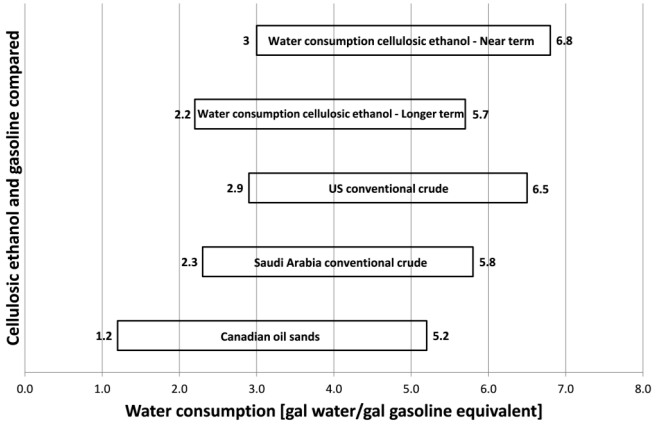
The full report is available online (in English): Water consumption study for cellulosic ethanol production.

WATER CONSUMPTION COMPARABLE TO GASOLINE PRODUCTION

We compared near- and long-term water consumption estimates for cellulosic ethanol production with currently accepted figures of water consumption in gasoline production. It was previously thought that bioethanol production used more water than conventional gasoline production. However, we found that water consumption during cellulosic ethanol production is comparable to, and in some cases lower than, conventional gasoline production in the long term. This is especially the case if water recovery and recycling through flue gas condensation is implemented.

In the near term, water consumption during cellulosic ethanol production would be 3.0-6.8 gallons of water per gallon of gasoline equivalent, if water recycling is implemented. By comparison, the conventional methods we investigated use 1.2-6.5 gallons of water per gallon of gasoline equivalent. Our initial analysis showed that the ethanol conversion process itself is not a significant water consumer. Instead, utility operations are the most water intensive processes, with cooling tower evaporation responsible for 90-95% of water use.

Cellulosic ethanol producers could achieve water savings in the long term by using measures such as air-cooling and flue gas condensate recycling. If additional water recovery and recycling through flue gas condensation is implemented, long-term water consumption during cellulosic ethanol production would be 2.2-5.7 gallon of water per gallon of gasoline equivalent. Flue gas condensate recycling seems like the most promising option, with a resultant water savings of 0.76-1.1 gallon of water per gallon of gasoline equivalent.



Water consumption for fuels included in the study

CLIENT TESTIMONIAL

> *We are very satisfied with the work DHI has done and with the high level of technical knowledge provided. We now have a well-documented study as a basis for the debate on water consumption for biomass-based bioethanol production.*
> *Per Henning Nielsen — Senior Manager — Novozymes A/S*

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