

# Sustainable Brewing Solutions:

## A Life Cycle Look at DuPont Brewing Enzymes



The benefits from the suite of DuPont brewing enzyme solutions are easy to see. Our enzymes secure more efficient mashing, improve filtration, and optimize the use of a variety of raw materials, which debottlenecks processes and improves throughput. Each solution provides brewing functionality which enables customers to Brew Uniquely.

In addition to enriching the brewer's bottom line, using DuPont enzyme solutions translates to enhanced sustainability. Yields are higher, meaning less raw materials per bottle of beer. Process steps can be avoided, and energy needs are reduced, leading to lower climate change impacts, non-renewable energy use, and water consumption.

### Enzyme impacts are minor

Life cycle assessment (LCA) screening has shown that the benefits of using our enzyme solutions comes without significant impacts from the enzymes themselves. Enzymes are proteins, manufactured via fermentation from renewable sources. Cradle-to-DuPont factory gate (CTG) LCAs show the climate change potential (CCP) and non-renewable energy use (NREU) for our brewing enzymes ranges from 1.6 - 3.4 kg CO<sub>2</sub> eq. and 28 - 47 MJ per kg of formulated enzyme solution, respectively.

**Enzymes provide high productivity at low use rates – which means the sustainability impact of the brewing enzymes is high whereas the amount of enzymes needed per hectoliter of beer is very low.**

But the key to enzyme sustainability is the bang for the buck, i.e. high productivity at low use rates. Most of our enzymes require less than 37 g enzyme solution per hl of beer, with several, including AMYLEX® and LAMINEX® offerings, requiring as low as 0.05 to 6 g. Figure 1 shows the range of impacts for our enzymes.

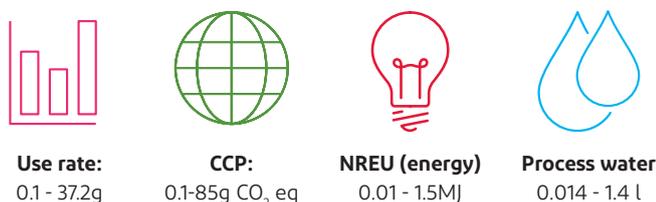


Figure 1: Use rates and impacts from enzymes per hl of beer.

### Perspective

Several LCAs have been performed, providing estimated impacts for beer [1,2]. Figure 2 shows a range of impacts associated with raw material production and the brewing process. These exclude impacts for bottling, distribution, and use.

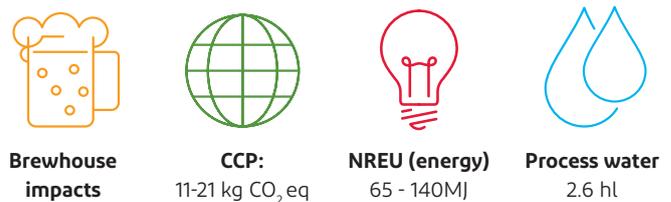


Figure 2: Brewhouse impacts per hl of beer.

Even at the higher use rates, our enzymes are just a small part of the overall brewhouse impacts; contributing less than 0.6% to water use, 0.4%-0.8% for CCP, and 1%-2.3% for NREU. For some enzymes such as our LAMINEX® offerings, the contributions to brewhouse impacts would be less than 0.1% for all three impact categories. In addition to having insignificant impacts relative to the brewhouse, enzyme use provides functional and environmental benefits which actually reduce the impacts of brewing.

### Enzyme benefits are substantial

DuPont has conducted screening LCAs for ALPHALASE® AP4 and LAMINEX® MaxFlow 4G, quantifying the potential environmental savings of our brewing enzyme solutions.

**Enzyme use provides functional and environmental benefits which reduce the impacts of brewing. DuPont conducted screening LCAs quantifying the environmental savings of ALPHALASE® AP4 and LAMINEX® MaxFlow 4G.**

<sup>1</sup>CCP Impacts per IPCC 4th AR, 100-yr basis; NREU impacts per Cumulative Energy Demand Method for non-renewable energy use include nuclear fuels from Ecoinvent report No.3, 2007.



## ALPHALASE® AP4



DuPont ALPHALASE® AP4 enzyme complexes supplement natural enzymes, enabling consistent mashing, particularly with un-malted barley or other adjuncts. Not only does the direct use of barley eliminate the need for the energy and water intensive malting process, it also significantly improves yields, meaning less overall barley is required. In conventional brewing, for every tonne of malt, about 79.5 hl of 5% ABV lager beer are produced from a 12 % Plato wort. Our screening LCA suggests that for each tonne of malt switched to barley brewing with ALPHALASE® AP4, a similar amount of water, 69 hl, can be saved across the life cycle, most of which are saved in the malthouse [3]. Energy and greenhouse gas savings are also evident. Figure 3 highlights the potential savings if 5% of the malt used in the European Union beer market is replaced with raw barley and ALPHALASE® AP4.

\*About 400 million hl beer are produced in the EU excluding countries not using exogenous enzymes

## LAMINEX® MaxFlow 4G



Performance is what has been driving the use of LAMINEX® MaxFlow 4G in breweries. The highly specific xylanases and  $\beta$ -glucanases improve mash separation and beer filtration, making it much easier and faster due to reduced wort viscosity. While the economic payback is evident through improved yield and higher throughput, DuPont has identified the environmental payback of using LAMINEX® MaxFlow 4G as well [4]. Water, energy, and climate change potential savings for using our enzymes are 63, 65, and 33 times greater than the impacts of their production, respectively. LAMINEX® MaxFlow 4G has potential for use in the entire EU beer market where exogenous enzymes are allowed, with potential environmental benefits as detailed in Figure 3.

### Savings potential with EU brewery adoption



Water savings:



Energy savings:



GHG savings:



Barley brewing with ALPHALASE® AP4

**696x**  
Olympic-sized swimming pools

**157,000 MWh**  
Enough to power 42,000 European households

**25x**  
Equivalent to savings from 25 wind turbines



Improved throughput with LAMINEX® MaxFlow 4G

**760x**  
Olympic-sized swimming pools

**86,000 MWh**  
Enough to power 23,000 European households

**11x**  
Equivalent to savings from 11 wind turbines

Figure 3

### References:

1. Amienyo, D., et al., "Life Cycle Environmental Impacts and costs of beer production and consumption in the UK," IJLCA V21, pp. 492-509 (2016);
2. De Marco, I., et al., "Life Cycle Assessment of Ale and Lager Beers Production," The Italian Association of Chemical Engineering Online, VOL. 49, 2016.
3. Krieger, T.M., "Sustainable Brewing Solutions: A Life Cycle look at DuPont Brewing Enzymes; ALPHALASE® AP4: An Enzyme Solution to Reduce Water Use through Barley Brewing," DuPont Nutrition and Biosciences, September, 2019.
4. Krieger, T.M., "Sustainable Brewing Solutions: A Life Cycle look at DuPont Brewing Enzymes; LAMINEX® MaxFlow 4G: Reducing Wort Viscosity and Environmental Impacts," DuPont Nutrition and Biosciences, September, 2019.