# Theoretical Ethanol from Cellulosic Biomass (2G)

Theoretical ethanol per tonne of dry biomass from its cellulose (glucan) and hemicellulose (xylan) by hydrolysis and fermentation stoichiometry, with process yields.

**Method:** Hydrolysis glucan → glucose (×1.111); xylan → xylose (×1.136); 3 $C_5H_{10}O_5$ → 5 $C_2H_5OH$ + 5 $CO_2$ and Gay-Lussac stoichiometry $C_6H_{12}O_6$ → 2 $C_2H_5OH$ + 2 $CO_2$ with IUPAC atomic masses; ethanol density 789.24 kg/m³ at 20 °C (OIML R 22) (as in the US DOE/NREL theoretical ethanol yield method)

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Cellulose (glucan) % dry biomass | 40.000 | % |
| Hemicellulose (xylan) % dry biomass | 25.000 | % |
| Glucose release and fermentation yield | 100.00 | % |
| Xylose release and fermentation yield | 100.00 | % |
| Ethanol density at 20 °C | 789.24 | kg/m³ |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Ethanol from cellulose per tonne | 288.00 | L/t |
| Ethanol from hemicellulose per tonne | 184.09 | L/t |
| Total ethanol per tonne of dry biomass | 472.10 | L/t |

**Notes for this case**

- Theoretical maximum: pretreatment, enzyme and pentose fermentation losses lower real yields.

## Formula and method

$$y_C = C\,\frac{M_{Glc}}{M_{Glc}-M_{H_2O}}\,\frac{2M_{EtOH}}{M_{Glc}}\,\frac{\eta_C}{\rho_e},\quad y_X = X\,\frac{M_{Xyl}}{M_{Xyl}-M_{H_2O}}\,\frac{5M_{EtOH}}{3M_{Xyl}}\,\frac{\eta_X}{\rho_e}$$

### Variables

| | | |
|---|---|---|
| $C$ | Cellulose (glucan) % dry biomass | - |
| $X$ | Hemicellulose (xylan) % dry biomass | - |
| $\eta_C$ | Glucose release and fermentation yield | - |
| $\eta_X$ | Xylose release and fermentation yield | - |
| $\rho_e$ | Ethanol density at 20 °C | kg/m³ |
| $y_C$ | Ethanol from cellulose per tonne | m³/kg |
| $y_X$ | Ethanol from hemicellulose per tonne | m³/kg |
| $y$ | Total ethanol per tonne of dry biomass | m³/kg |

### Method and standards

Stoichiometry.

### Assumptions and limits

- Dry basis.
- All hemicellulose is treated as xylan ($C_5$ sugars); its mannan, galactan ($C_6$) and arabinan parts get the xylan factor, a small difference in the result.

### References

- Hydrolysis glucan → glucose (×1.111)
- xylan → xylose (×1.136); 3 $C_5H_{10}O_5$ → 5 $C_2H_5OH$ + 5 $CO_2$ and Gay-Lussac stoichiometry $C_6H_{12}O_6$ → 2 $C_2H_5OH$ + 2 $CO_2$ with

IUPAC atomic masses; ethanol density 789.24 kg/m³ at 20 °C (OIML R 22) (as in the US DOE/NREL theoretical ethanol yield method)

## Report details

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|---|---|
| Report reference | FCC-S63D-6HT5 (the same inputs always give the same reference) |
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| Method last reviewed | 13 November 2026 |
| Software release | FireCAD Calc, release of 17 November 2026 |
| Release checks | 2 reference cases of this calculator, computed independently, are checked on every release |

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

### This calculator online

https://calc.firecad.com/sugar-ethanol/ethanol/cellulosic-ethanol-theoretical

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.