

# Water Footprint of Bioenergy Supply Chain

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## Overview of study

This study is focused on quantification of second generation bioenergy from corn stover into bioethanol through approach of life cycle assessment. Two main stage are included , agricultural stage and bioethanol refinery process. Moreover, in addition to direct water use, the indirect water consumption for energy use is also involved into this study during bioethanol production.

## LCA of corn stover into bioethanol

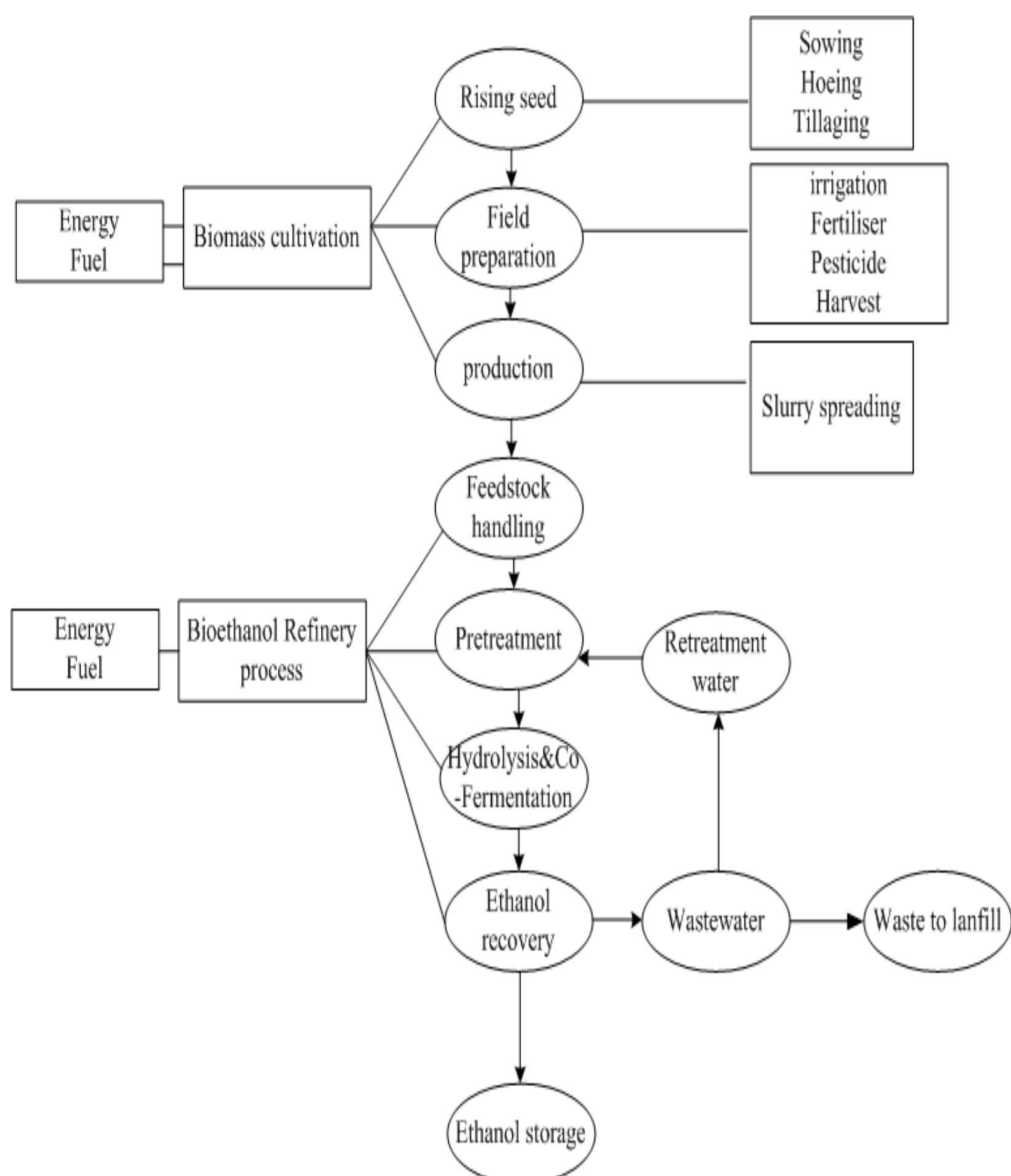


Fig 1. system boundary of LCA

In process of agricultural stage, the irrigation water consumption for biomass cultivation is given as direct water use, and the sub-phase of indirect water use includes sowing, hoeing, tillage, fertilizer, pesticide, harvest and slurry spreading as indirect water use in agricultural stage.

For bioethanol refinery process, both indirect and direct water use can be divided into five sub-stage: feedstock handling, pre-hydrolysis (also called pretreatment), hydrolysis & fermentation, ethanol recovery, and waste water treatment

## Water consumption

As Wisconsin of US is selected as example, the total water use during bioethanol production from corn stover can be obtained in Table 1 and the detailed water use in bioethanol refinery process is presented in Table 2. It is clear that in Wisconsin, to produce 1 kilogram ethanol from corn stover requires 30.65 L water in total.

Table 1. Total water footprint of biethanol in Wisconsin (L/ kg ethanol)

Agricultural stage		Bioethanol refinery process		Total
Direct	Indirect	Direct	Indirect	
7.17	6.72	13.17	3.59	30.65

Table 2. Water consumption in bioethanol refinery process(L/ kg ethanol)

sub stage	feedstock handling	Pretreatment	hydrolysis & fermentation	ethanol recovery	waste water treatment	total
direct	9.66	6.94	1.87	0.01	-5.3	13.18
indirect	0.09	1.67	1.19	0.57	0.07	3.59
total	9.75	8.61	1.87	0.58	-5.23	16.77

Figure 2 compares total water consumption of bioethanol from corn stover in three selected states ( i.e. Illinois, Wisconsin and South Dakota). With assumption of same water requirement in bioethanol refinery process and indirect water use in agricultural stage, the impact of irrigation water on total water footprint could be found .

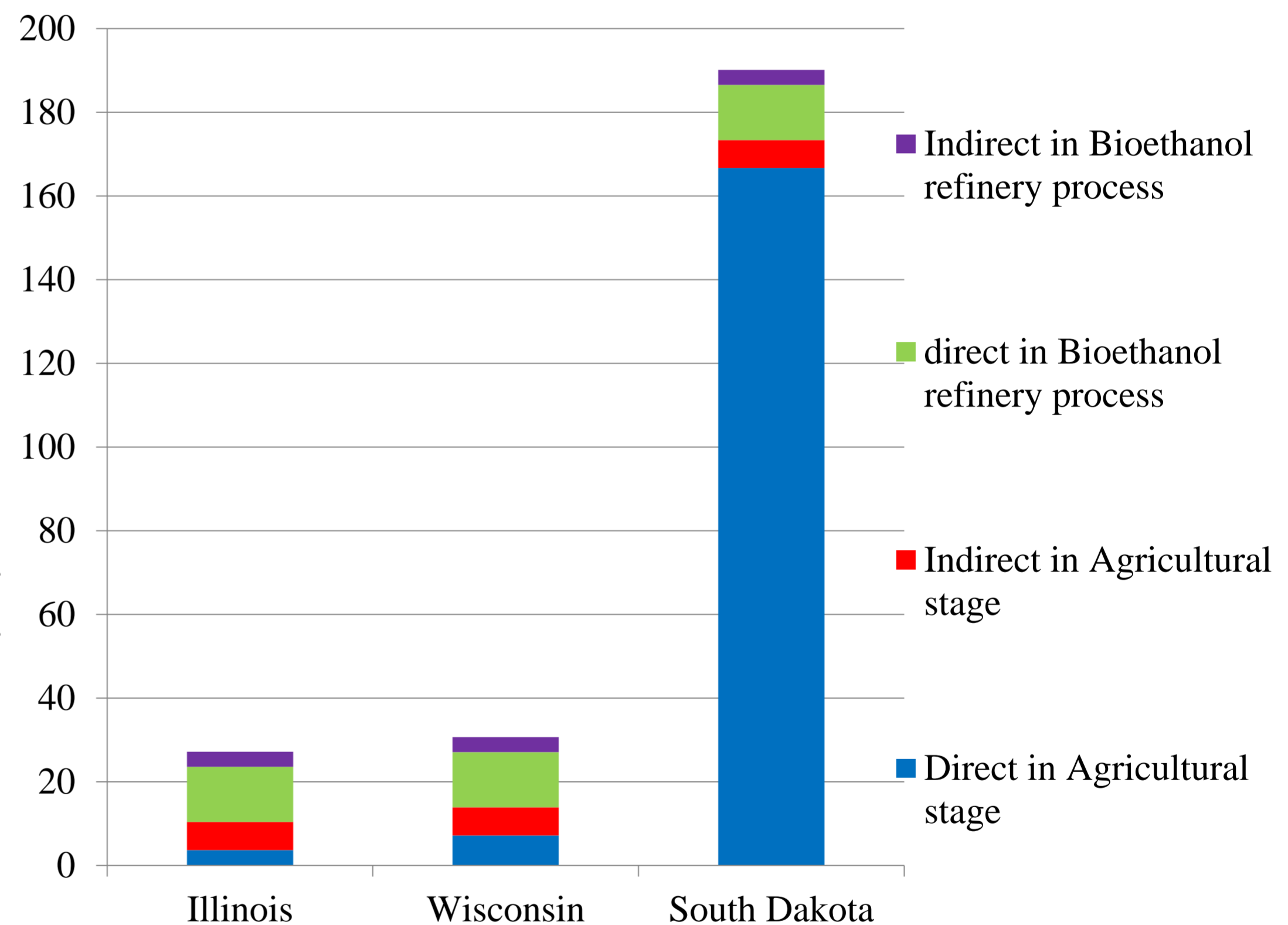


Fig 2. Comparison of water footprint of bioethanol between three selected states

## Conclusion

1. In Wisconsin, it needs **30.65L** water to produce 1kg ethanol from corn stover.
2. In conversion process, the sub-stage of feedstock handling consumes largest water **9.75L/kg ethanol** for bioethanol production.
3. In conversion process, direct water use is much more than indirect water consumption
4. Due to climate and soil moisture, direct irrigation water use in agricultural stage ranges largely, which has a significant impact on total water use result of bioethanol production.