Joint BioEnergy Institute

Life-Cycle Assessment of Cellulosic Biofuel Production with Ionic Liquid Pretreatment

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Overview

- Advanced biofuels research @ JBEI
- Ionic liquid (IL) pretreatment
- IL Process Configurations / Variations
  - Past, Present, and Future
  - Biocompatible ILs, Protic/Neutral ILs
- LCA results
  - Greenhouse gas emissions & Water intensity
- Conclusions

Advanced Biofuels Research @ JBEI

Lignocellulosic Biofuels:
Fuels derived from the solar energy stored in plants/biomass

Biorefinery
(Conversion Technologies)

Feedstock engineering → Deconstruction (Pretreatment & Hydrolysis) → Fuels synthesis

- **Efficient, economical and scalable technologies at each stage are necessary**
- **Focus is on drop-in biofuels**

Ionic Liquid (IL) Pretreatment

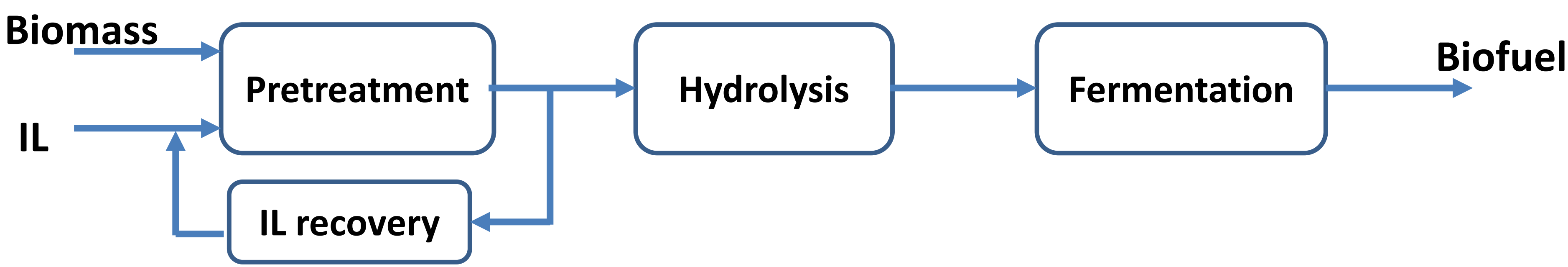
- **What are ILs?**
  - Essentially, salts in liquid phase at room temperature

- **Why ILs?**
  - Effective in reducing biomass recalcitrance
  - Facilitates efficient hydrolysis
  - Numerous options (cations / anions) → Tunable properties
  - Feedstock agnostic
  - Facilitate operation at milder conditions (low Temp etc.)
  - Lignin valorization possibilities

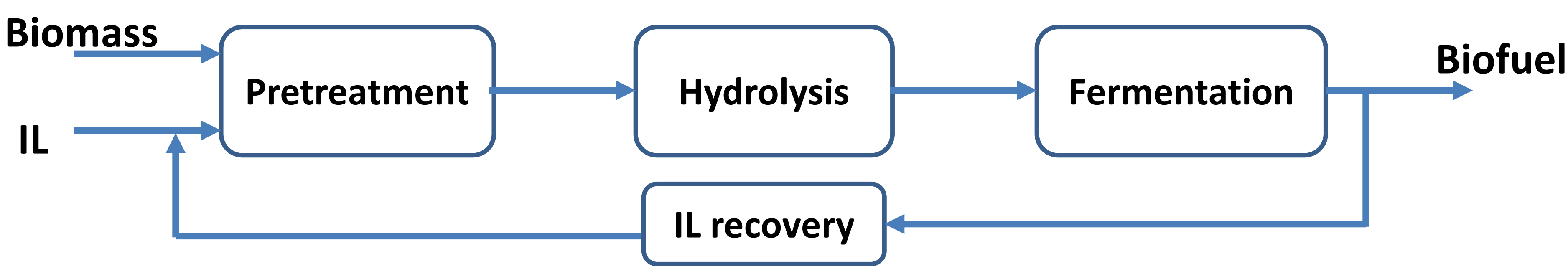
- **@ JBEI**
  - IL pretreatment technologies are being developed
  - With a focus on efficient, economical & scalable technologies

Process configurations (variations)

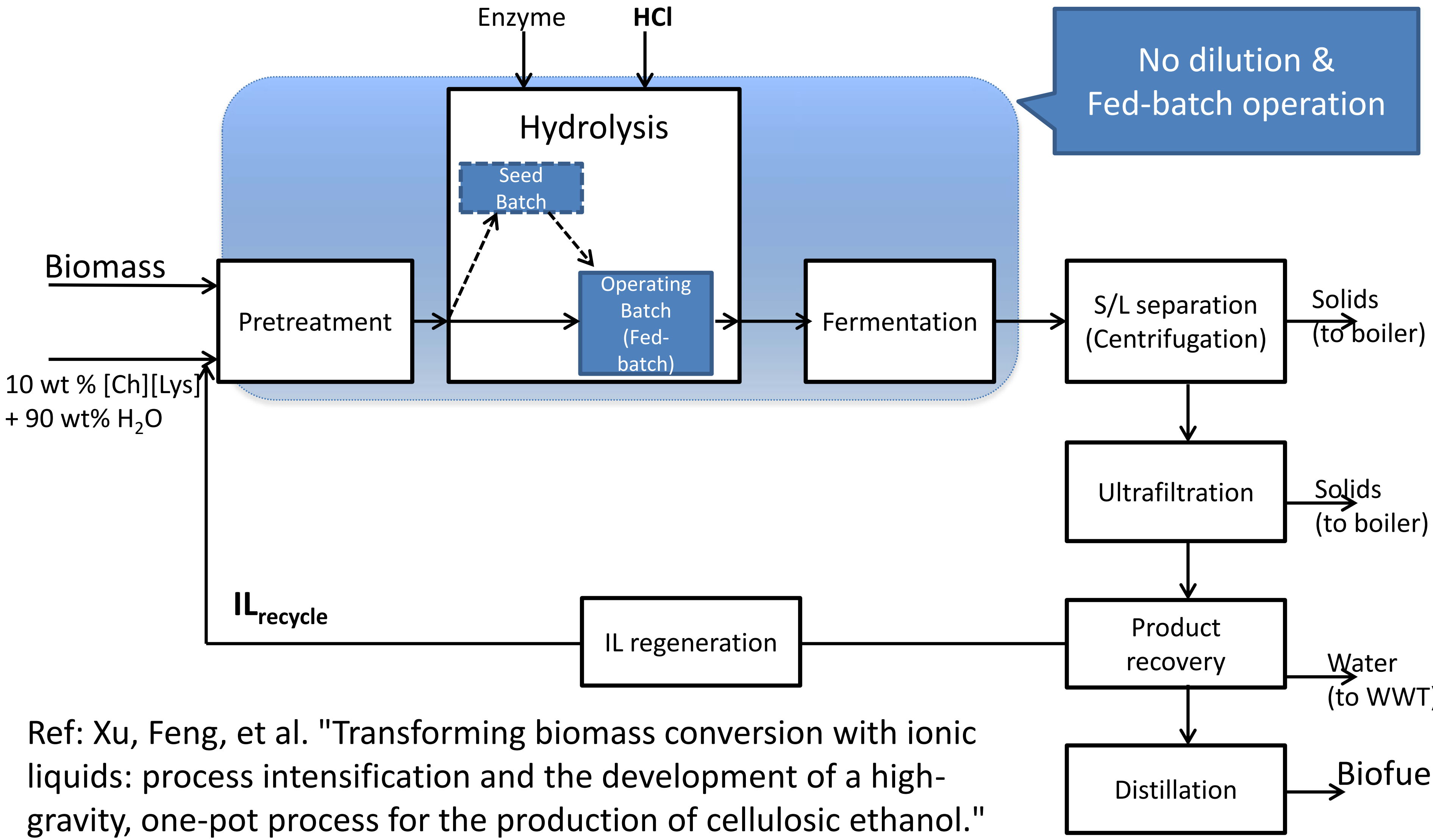
Water-wash route (tradonal)



Integrated processes (novel approach)

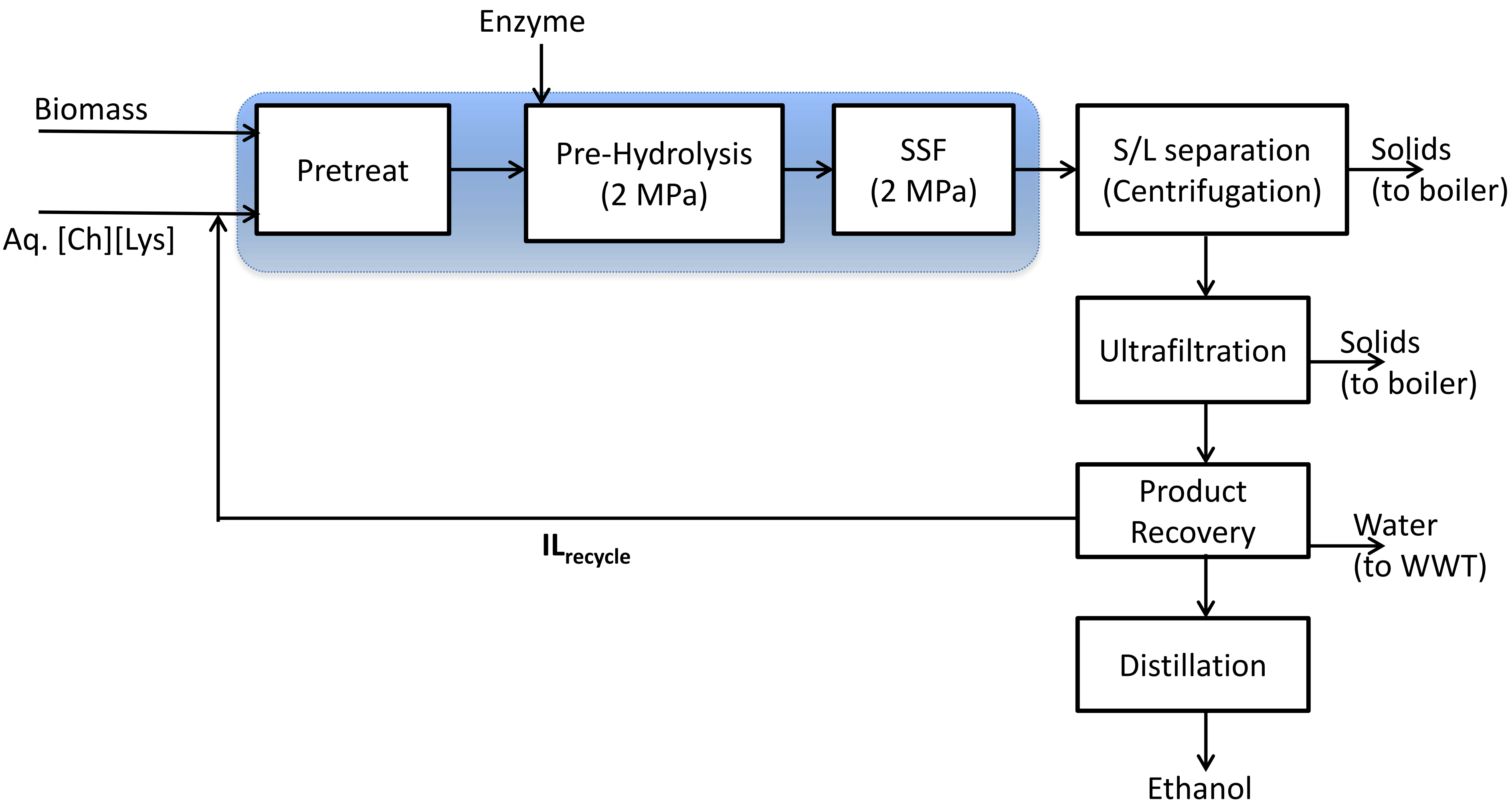


Integrated High Gravity Process (iHG-Current)



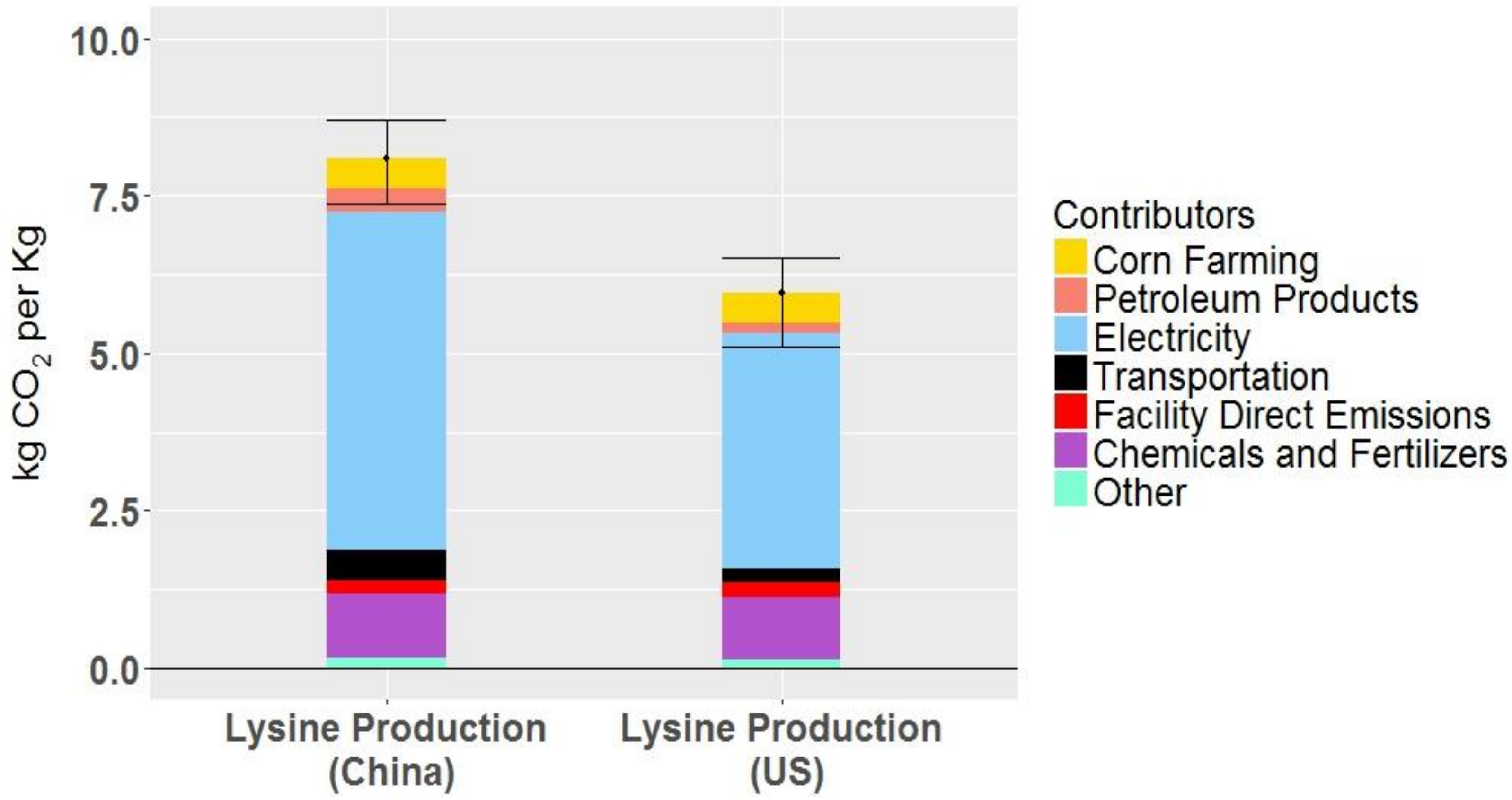
Ref: Xu, Feng, et al. "Transforming biomass conversion with ionic liquids: process intensification and the development of a high-gravity, one-pot process for the production of cellulosic ethanol." *Energy & Environmental Science* 9.3 (2016): 1042-1049.

Protic IL (PIL) process (iHG-Projected)

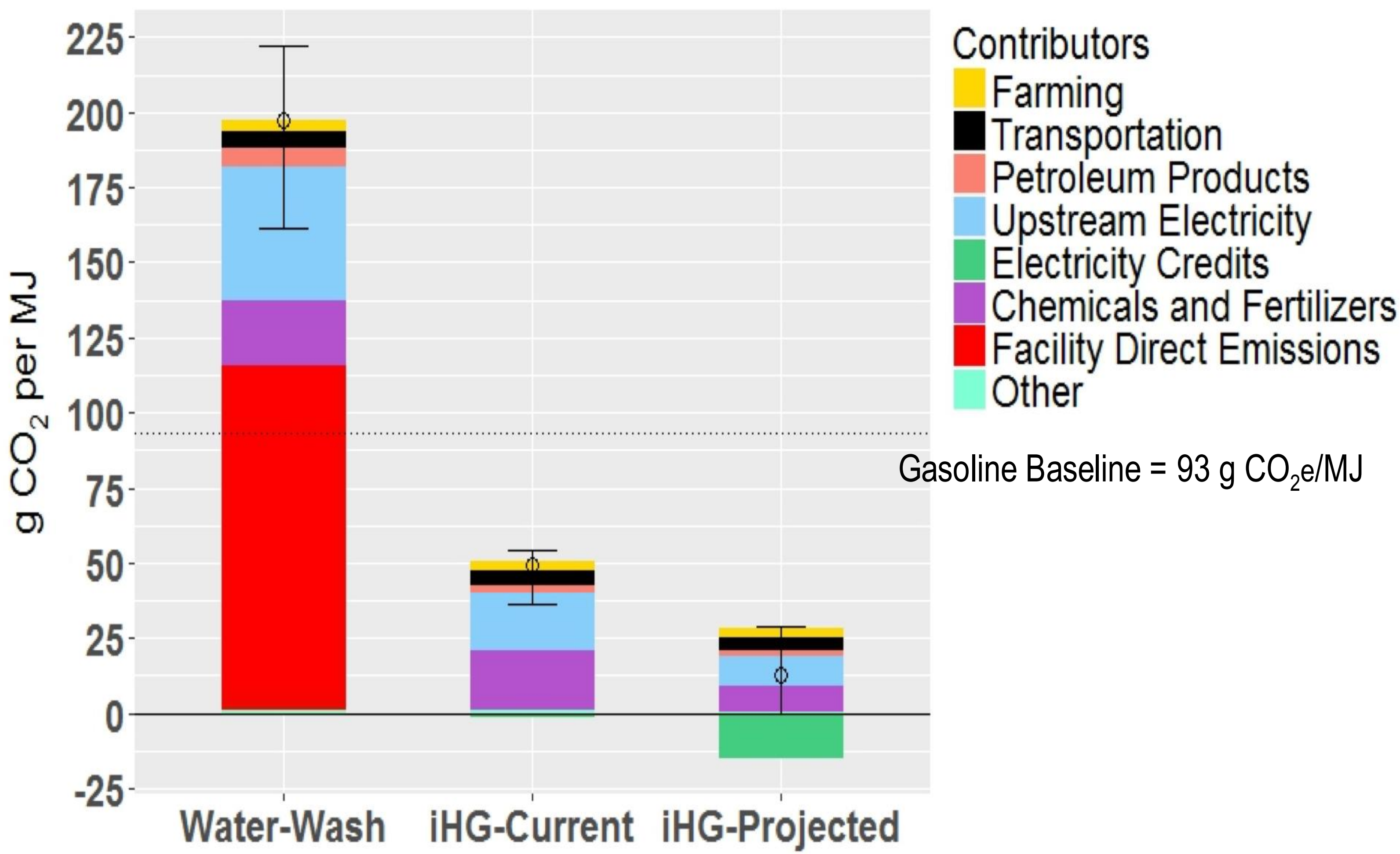


Ref: Sun, Jian, et al. "One-pot integrated biofuel production using low-cost biocompatible protic ionic liquids." *Green Chemistry* (2017).

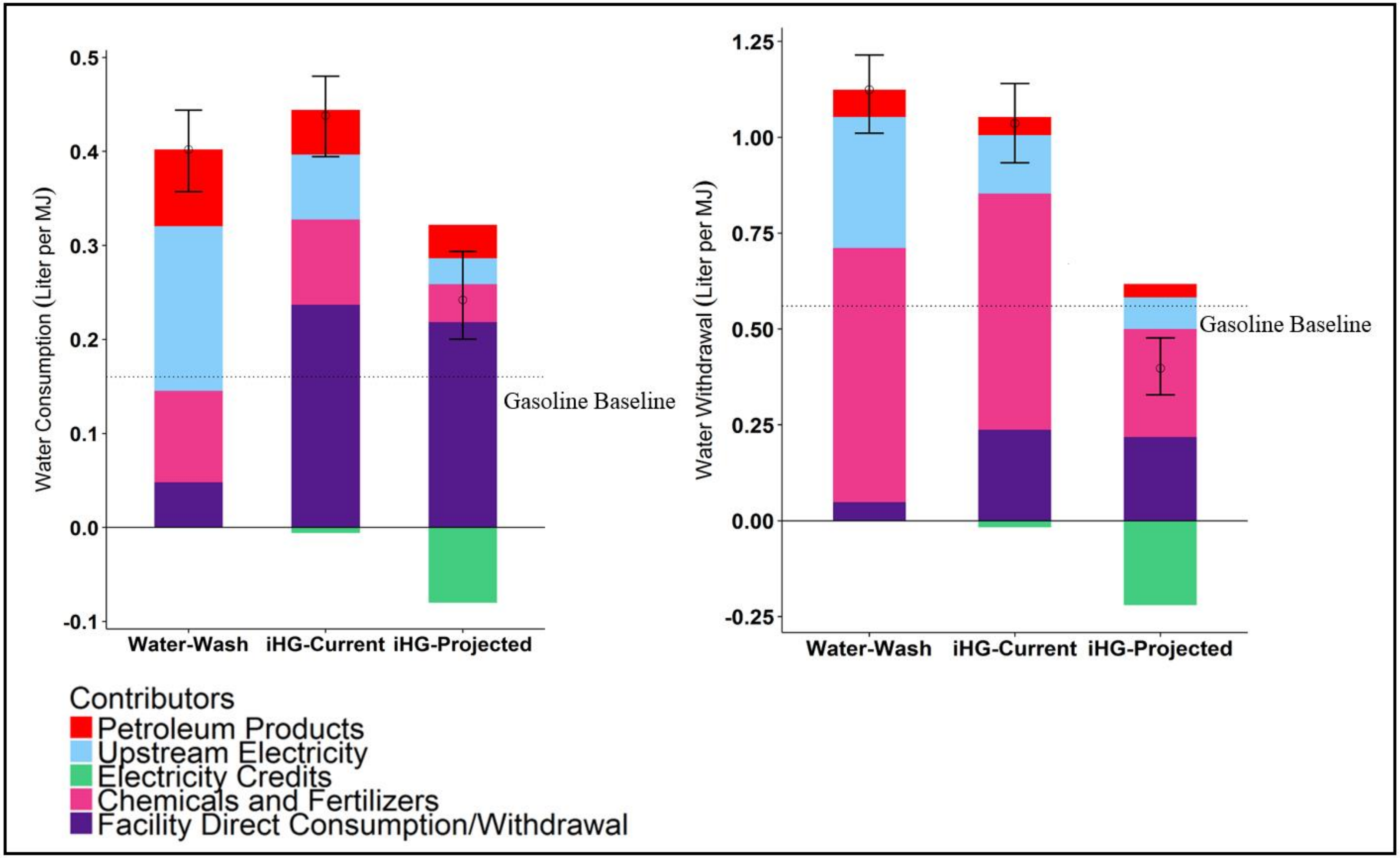
GHG footprint: [Ch][Lys] Production



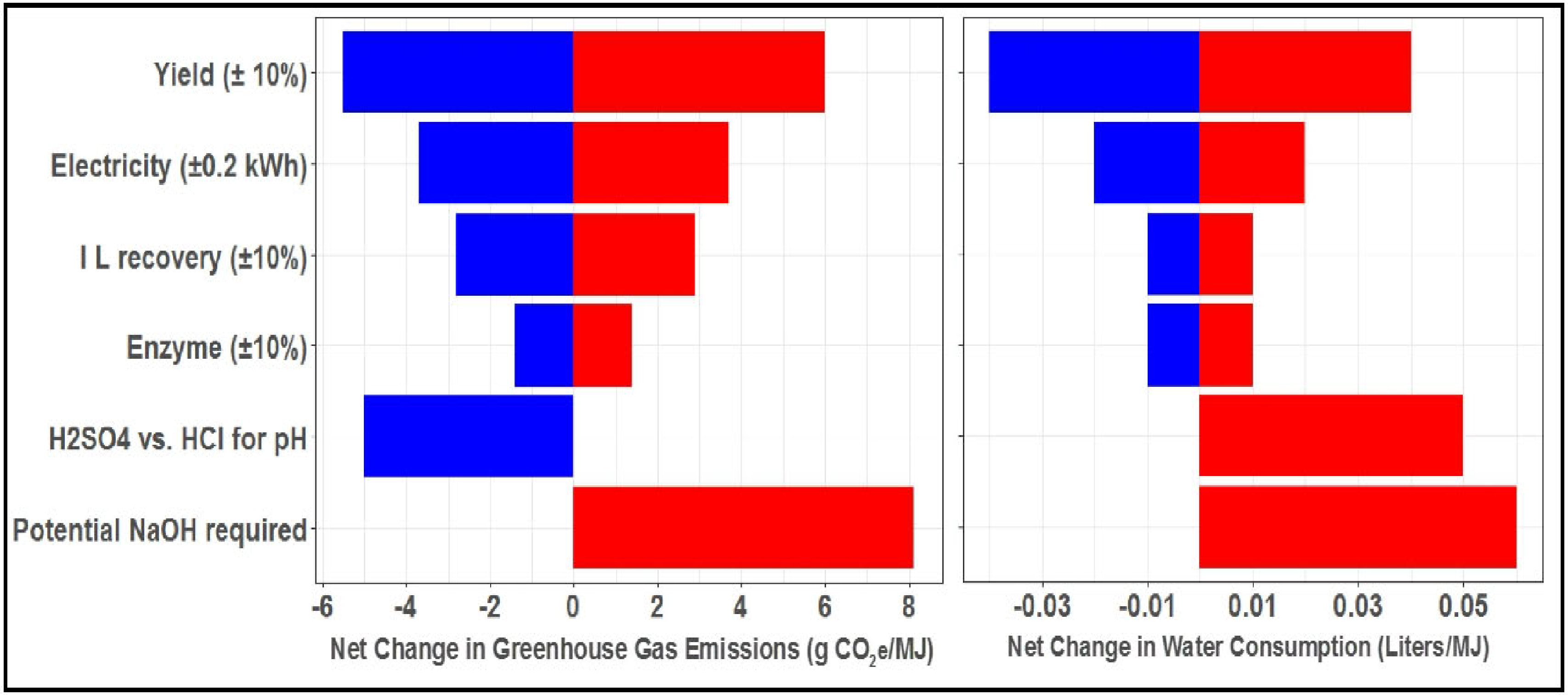
GHG footprint: Biofuel Production



Water intensity: Biofuel Production



Sensitivity Analysis



Concluding remarks

- Ionic liquid (IL) pretreatment facilitates efficient hydrolysis

- Life-cycle assessment has been performed (for the first-time)

- GHG emissions:
  - Water-wash (traditional) route is water/energy intensive → high GHG footprint
  - iHG processes have the potential to reduce GHG footprint significantly

- Water intensity (both consumption & withdrawal) can be comparable to other pretreatment technologies

- Sensitivity analysis highlights the potential impact of key yet uncertain parameters

Thank You!

- Corinne Scown
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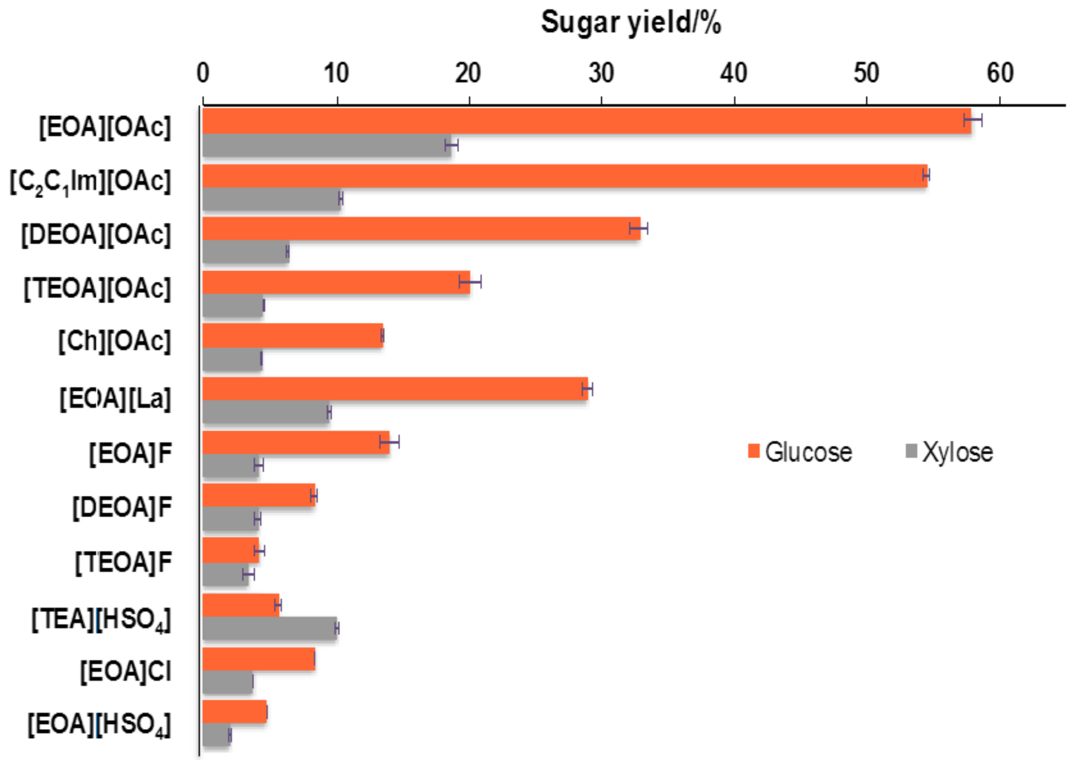
The role of biocompatible ILs (BILs)

- BILs eliminate the need for water-wash and/or other separation operations prior to hydrolysis/fermentation
  - Reduced water-usage and therefore lower costs (by eliminating or minimizing the need for subsequent IL dehydration)
  - Elimination of glucan/xylan losses in water-washing step

- Possibility to be used in aqueous form (e.g., 10% IL, w/w)
  - Reduced usage of IL
  - Enables higher solids loading
  - No further dilution required prior to hydrolysis and fermentation

Protic ILs (PILs)



- No pH adjustment during hydrolysis/fermentation
  - No mineral acids are used
  - No Need for IL regeneration
    - Improved recovery efficiency and reduced recovery costs

Sun J., Konda N.V.S.N.M. et al., (2017) Green Chemistry (accepted)