Fractionation of MSW:

What Can We Learn from Plant Biomass Biorefinery

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US DOE BETO Workshop on

Advancing Synergistic Waste Utilization as Biofuels Feedstocks: Preprocessing, Co-products, and Sustainability.

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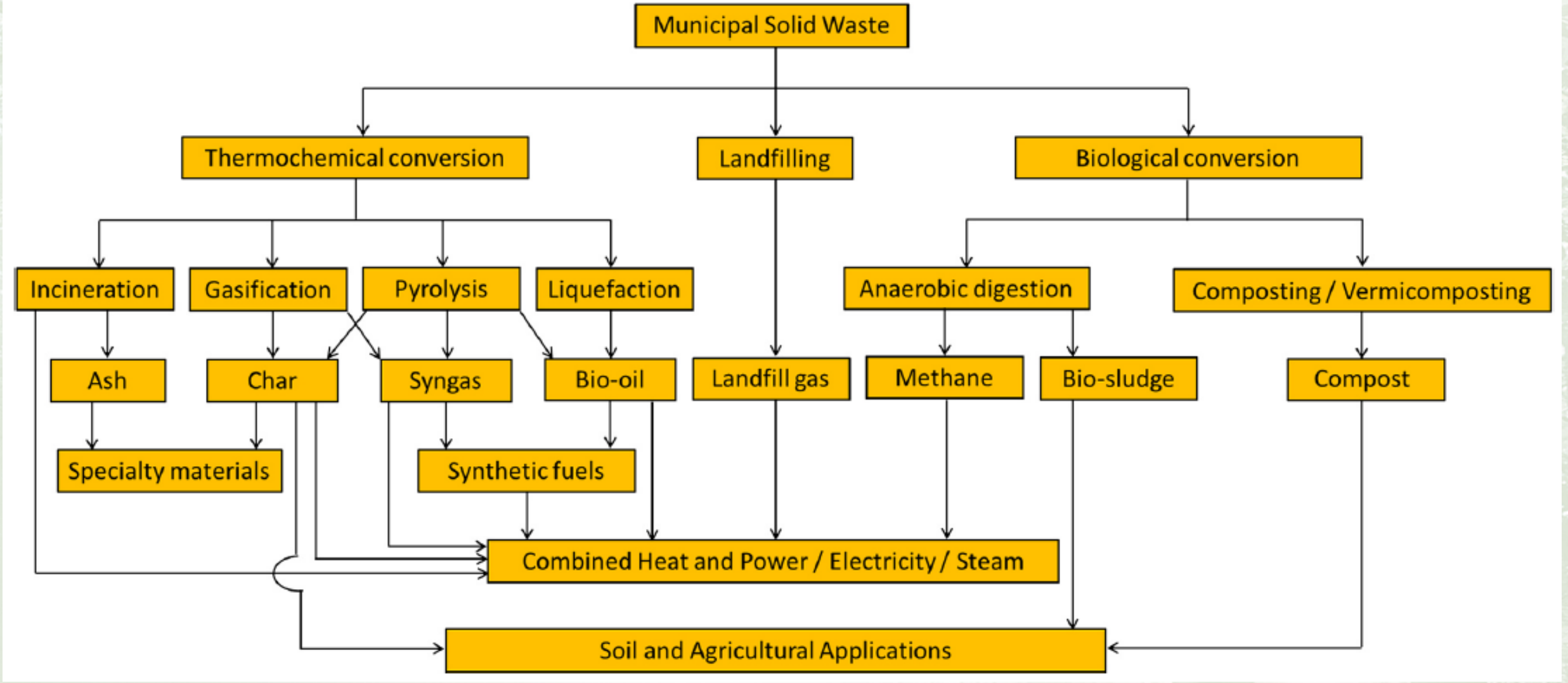
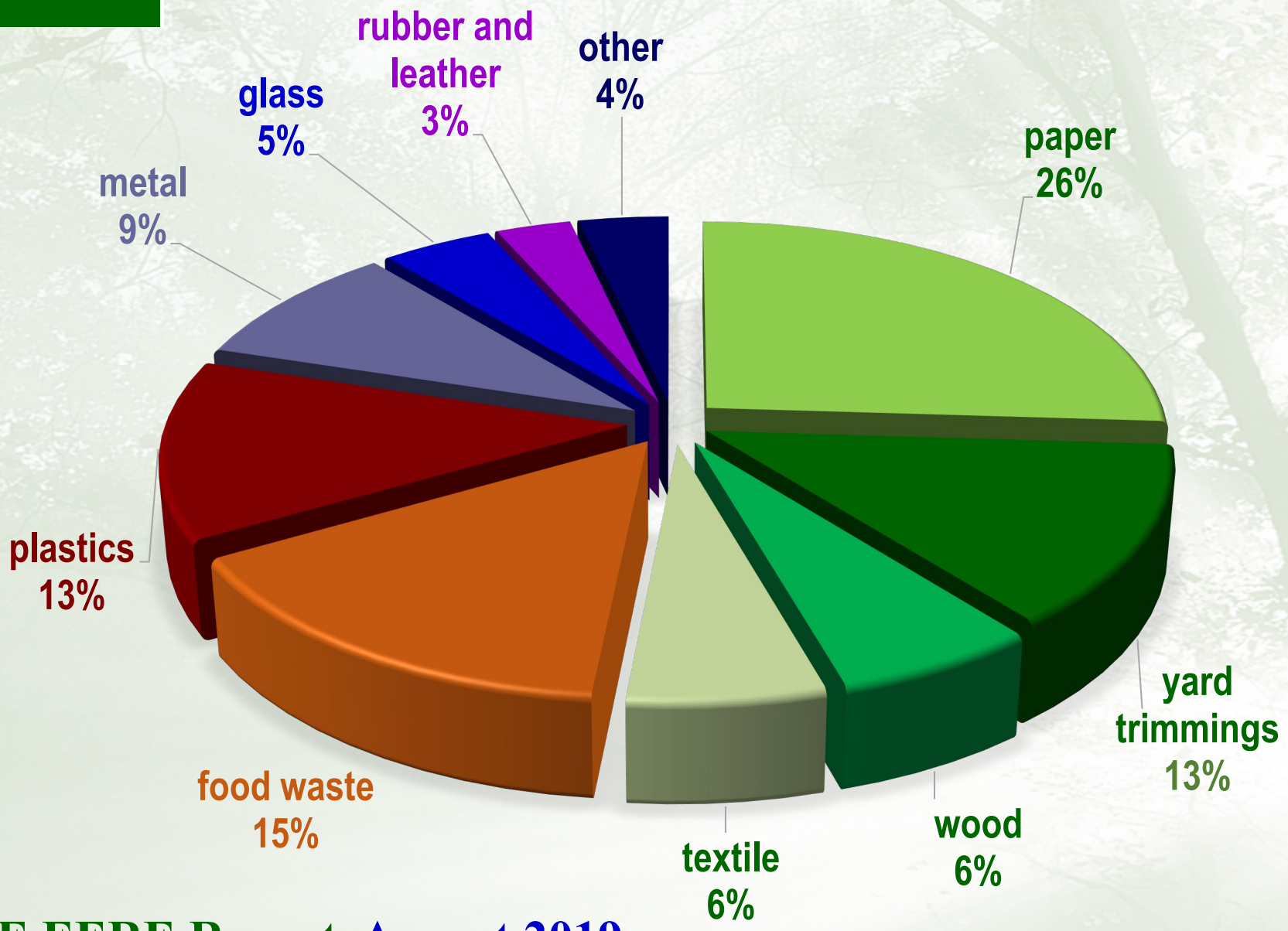
Current MSW to Energy Technologies



Nanda and Berruti (2021) *J. Hazardous Mat.* 403:123970

MSW Composition - US

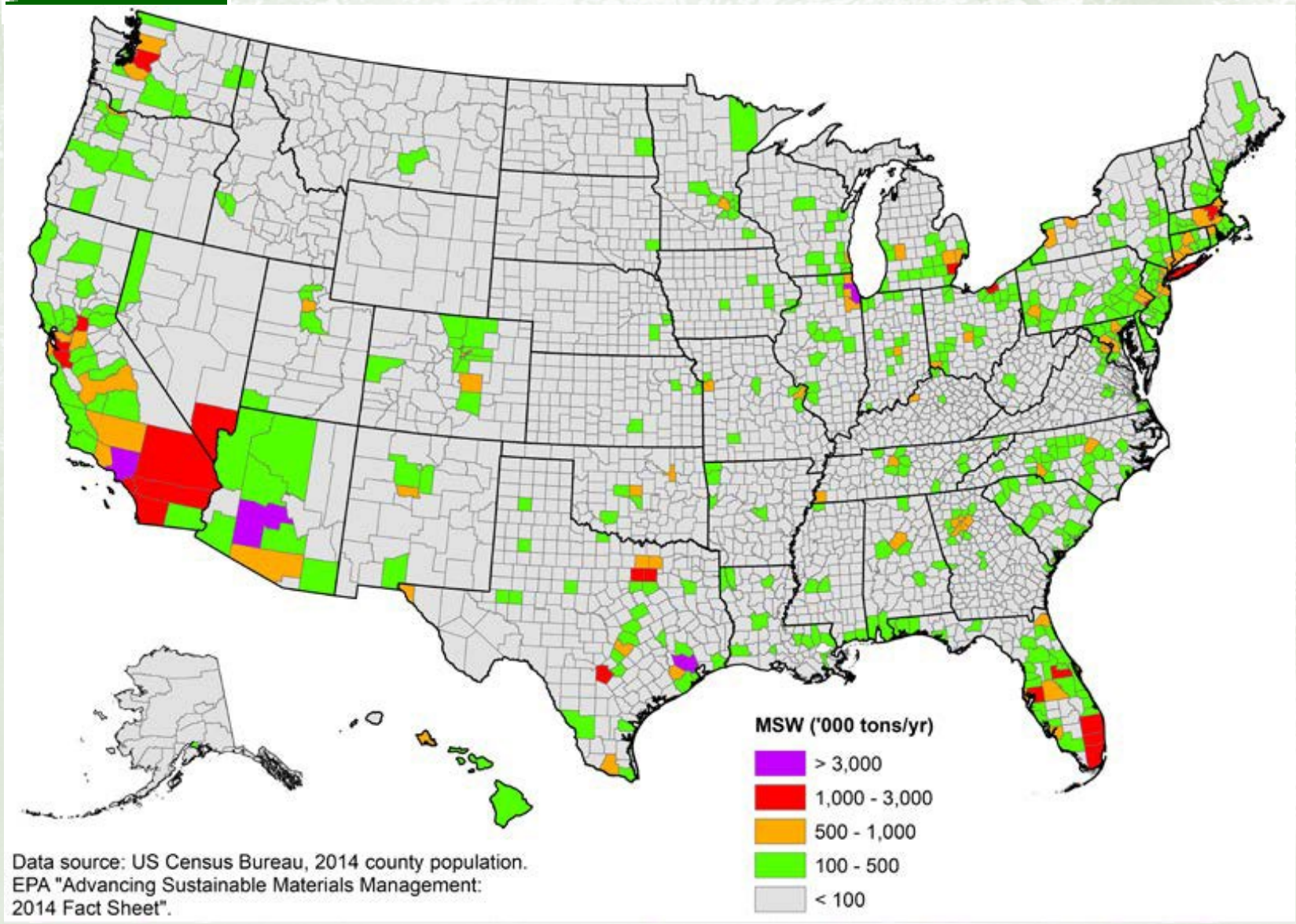


2015:
262 million tons
35% recycled;

2018:
292 million tons
32% recycled

DOE EERE Report, August 2019

Quantities of MSW - US



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262 million tons
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100K-500K/tons year:
300 – 1500 tons/day

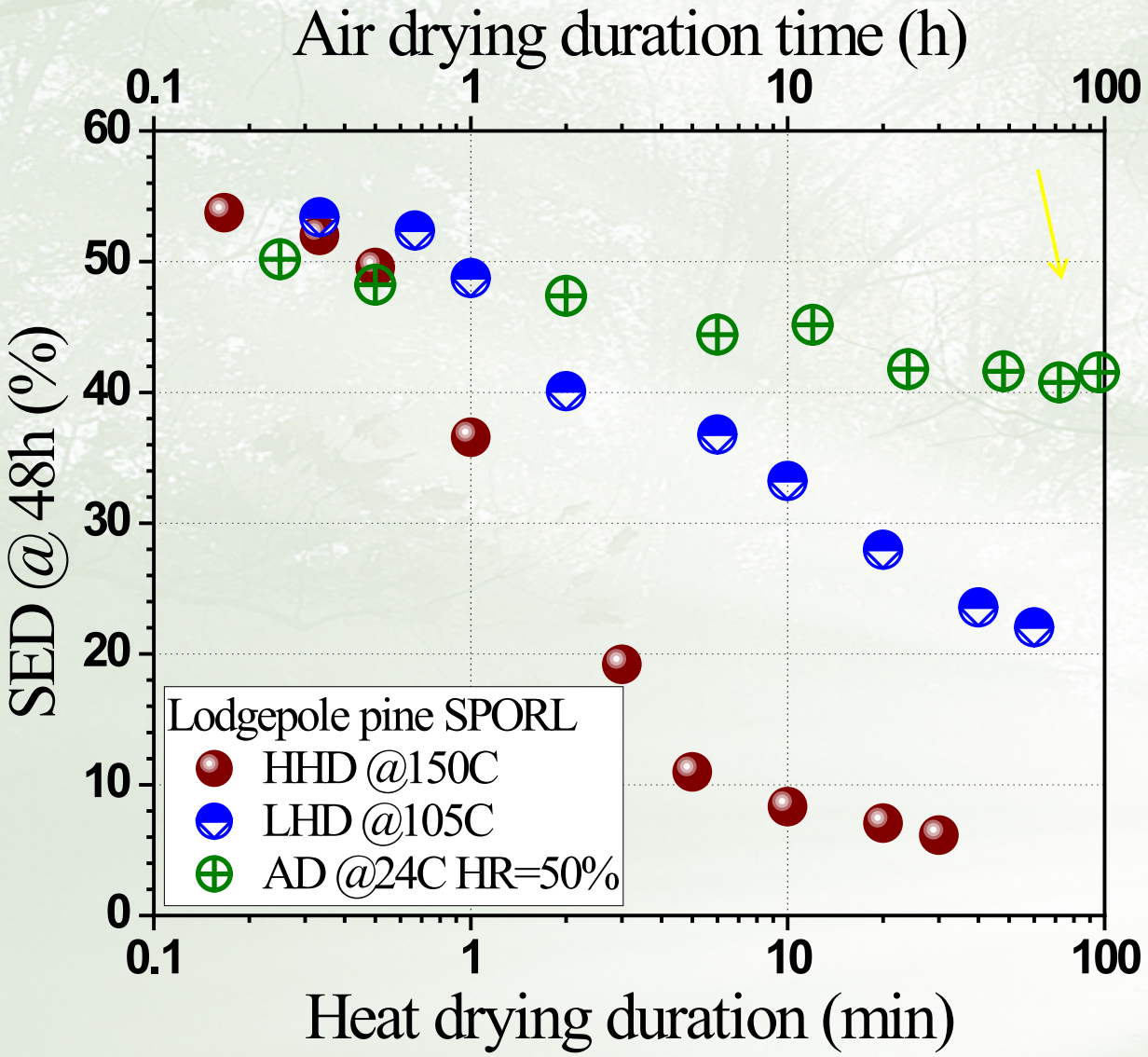
DOE EERE Report, August 2019

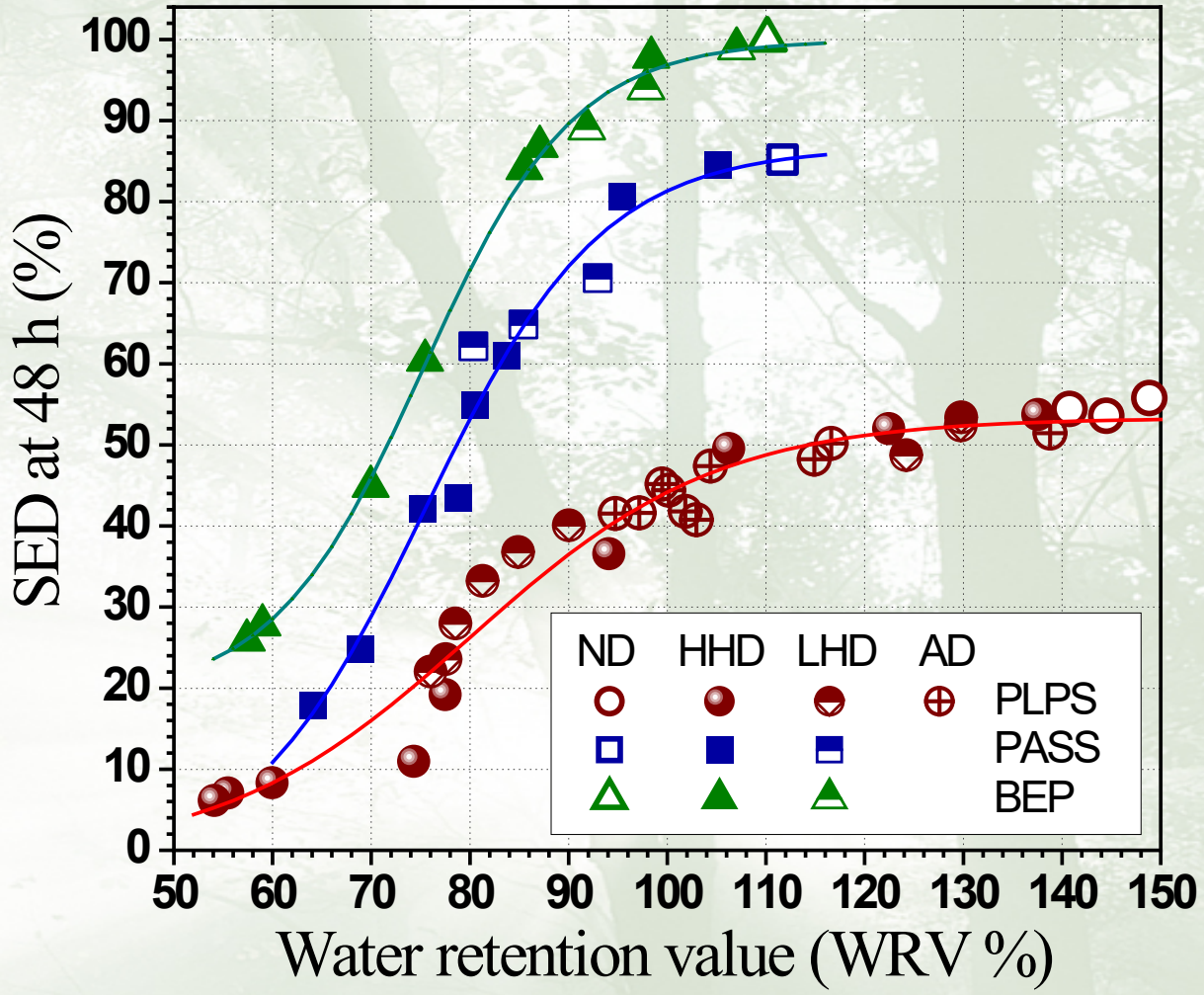
Enzymatic Sugar Production

- Biomass logistics issue is critical as typical biorefnery is at least 1000 ton/day. Co-processing with local plant-biomass sources is a sensible approach.
- Cellulose accessibility is a key technical barrier.
  - Paper products are dried and highly hornified even though they have been highly delignified
  - Wet compaction of the preprocessing may also affect cellulase accessibility.
  - Size reduction improves enzymatic saccharification
- Pretreatment/fractionation is the most-costly step. The technology adopted affects downstream processing.

Drying on Enzymatic Saccharification

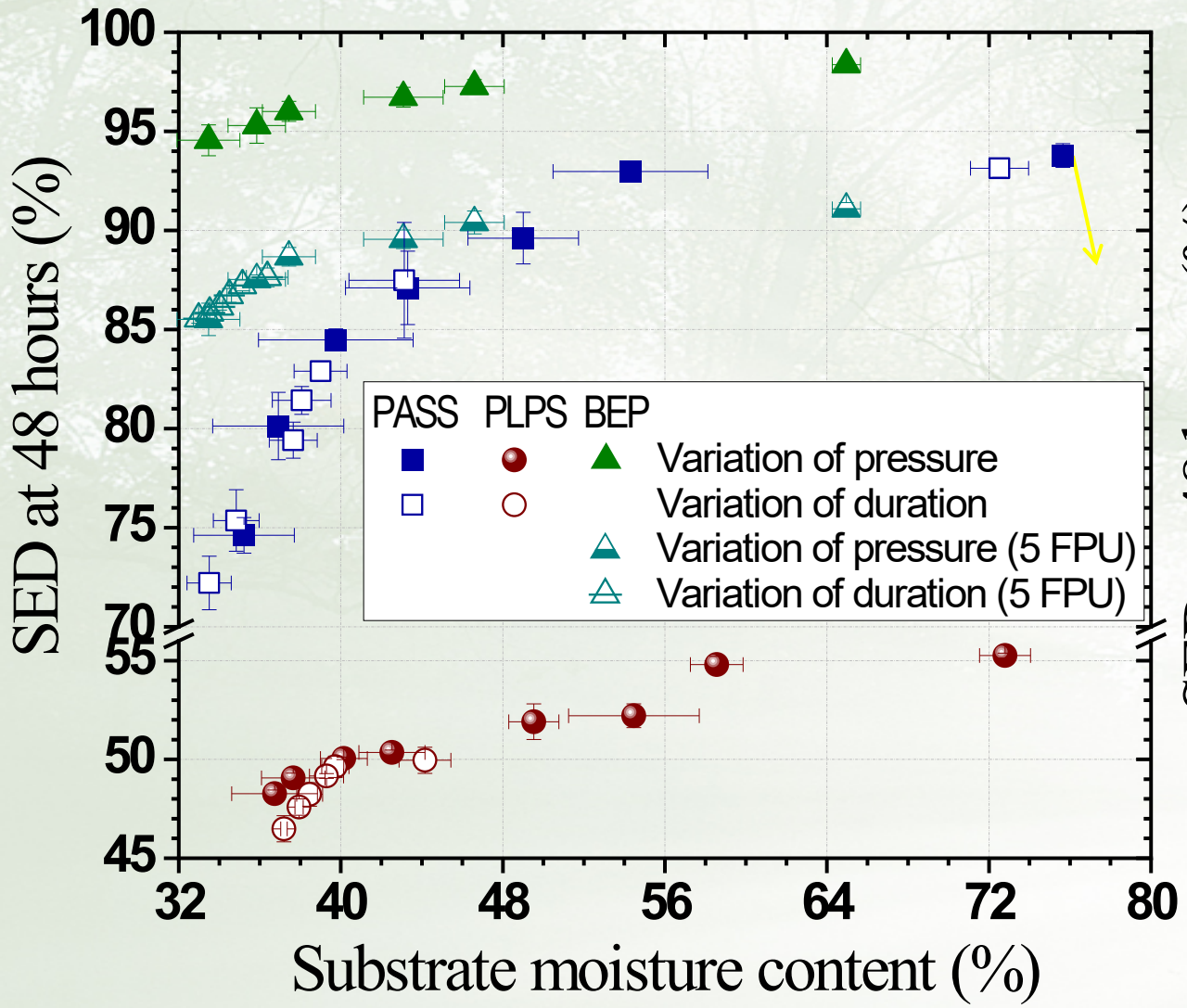
Luo and Zhu (2011) *Enzyme Microbial Technol.* 48:92-99

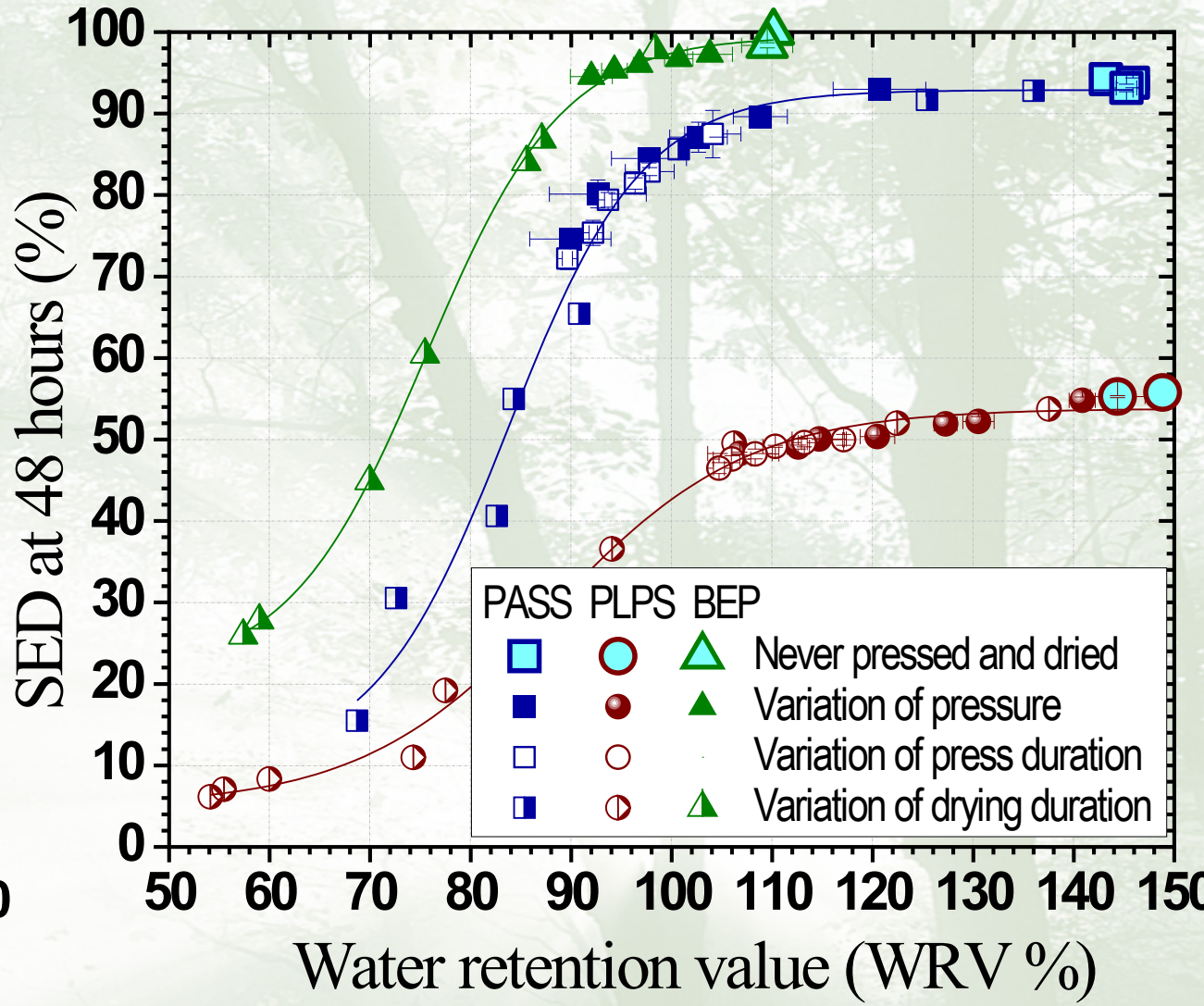




Wet Pressing on Enzymatic Saccharification

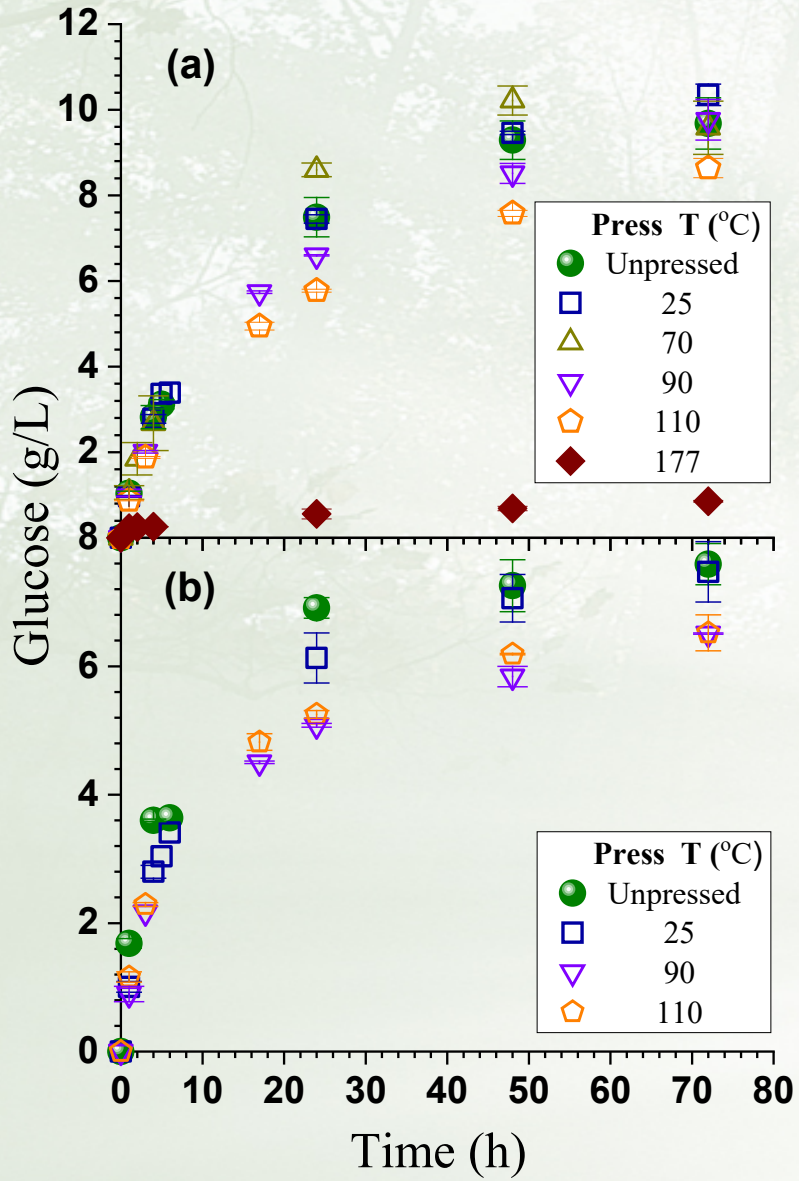
Luo et al. (2011) *Cellulose* 18:1055-1062

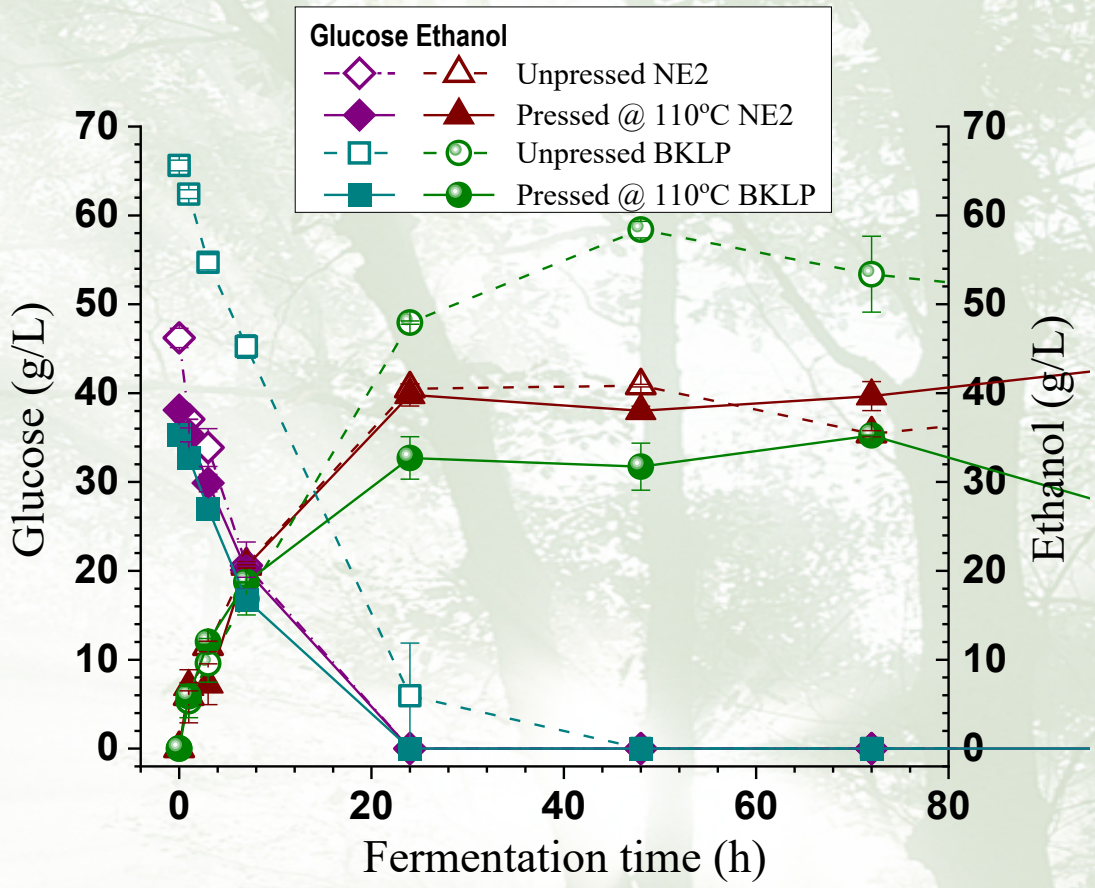




Effect of Pelletize (woody biomass)

Zhang et al. *Bioenergy Res.*, 8:464-470, 2015





Pressed at 2.8 MPa for 10 min @ T

Steam Pretreatment –

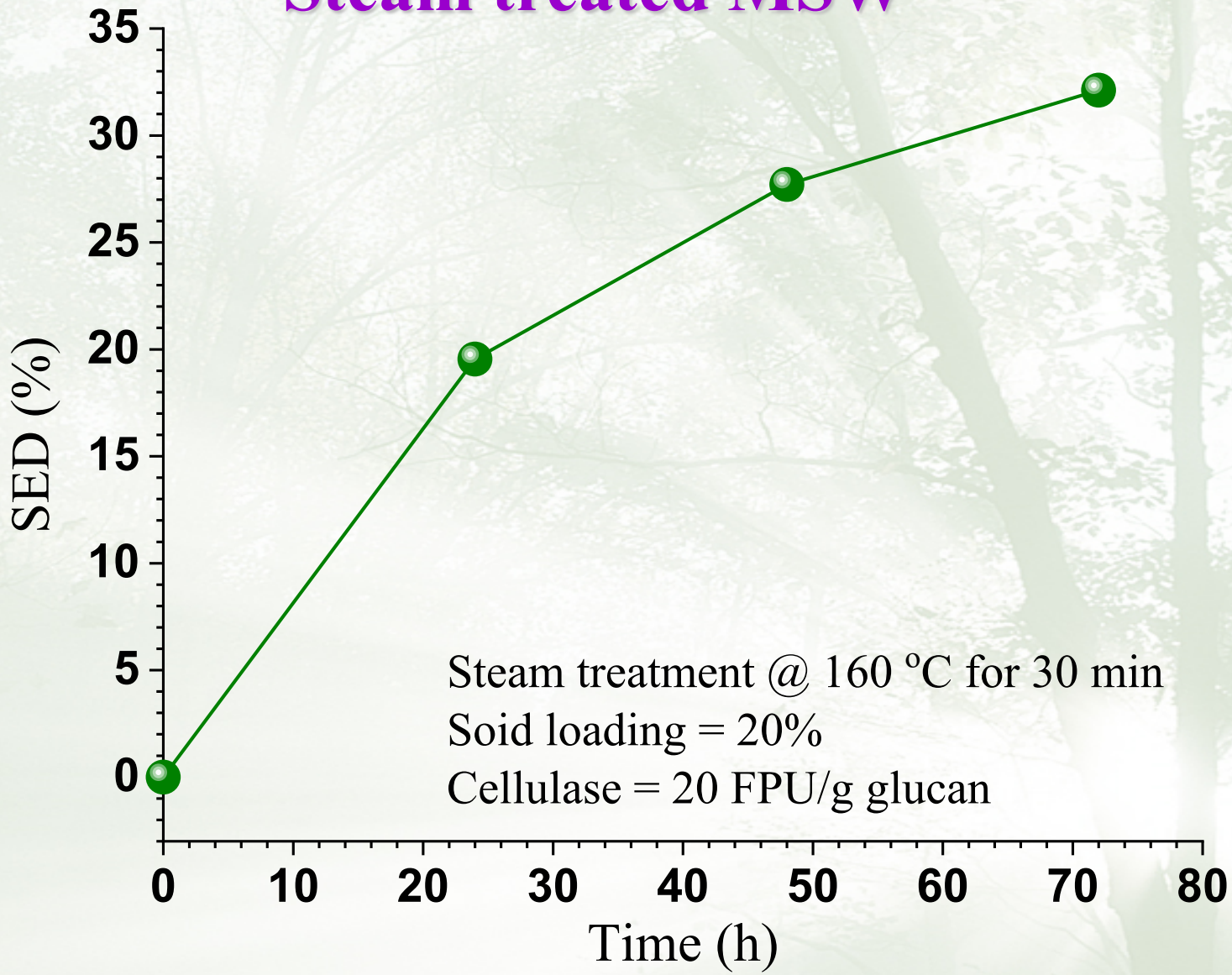
Active Hygienization

Condition 160 °C	Glucan (%)	Xylan (%)	Acid insoluble solids (%)	Ash (%)	Other (%)
5 min	37.5	5.8	24.6	18.0	14.1
10 min	37.6	5.0	29.1	17.9	10.4
20 min	40.2	5.0	21.9	17.7	15.3
30 min	41.9	5.2	22.6	13.9	16.4
50 min	43.9	5.5	23.1	14.3	13.2

Ballesteros et. al. (2010) *Appl. Biochem. Biptechnol.* 161:423-431

Enzymatic Hydrolysis –

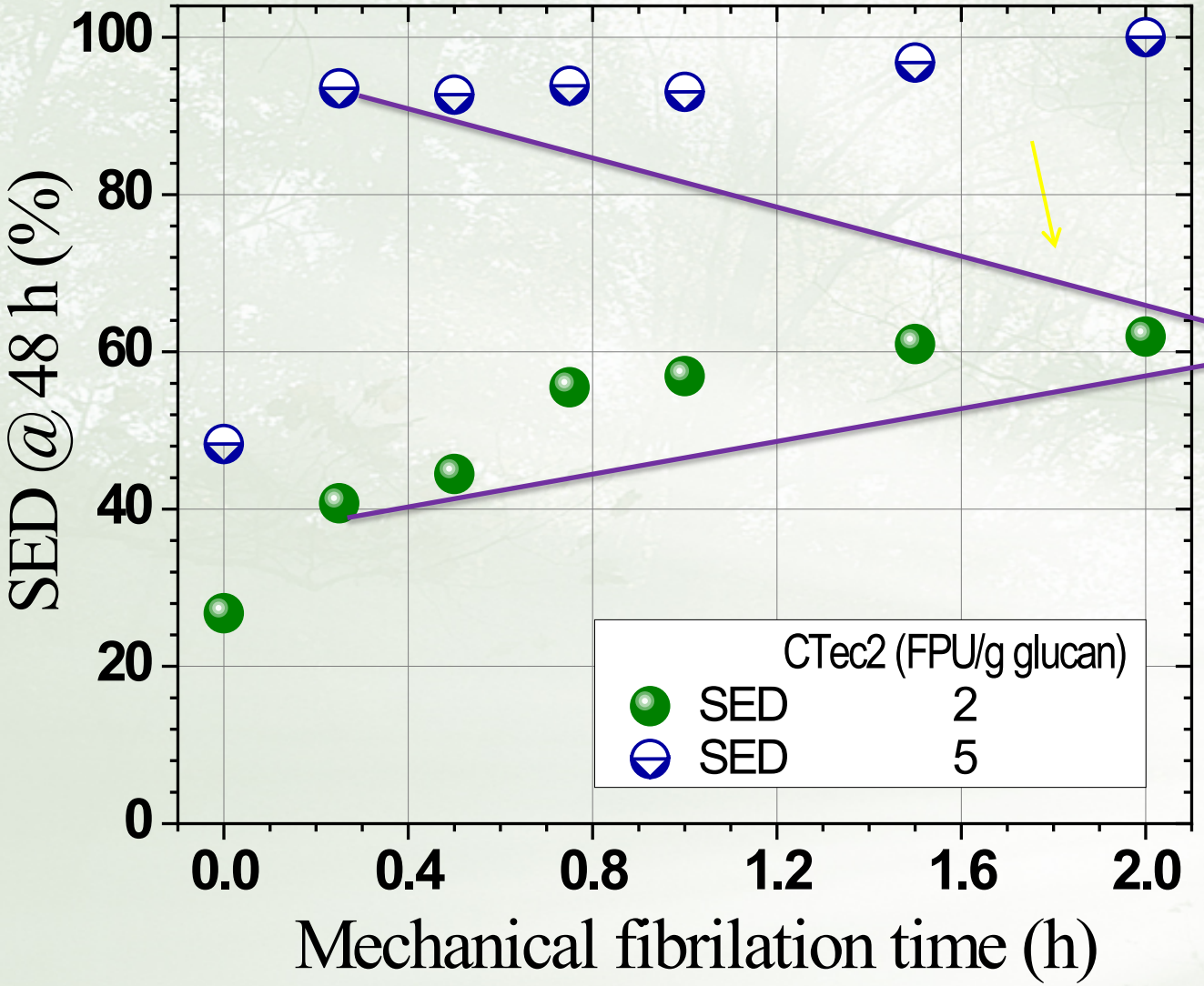
Steam treated MSW



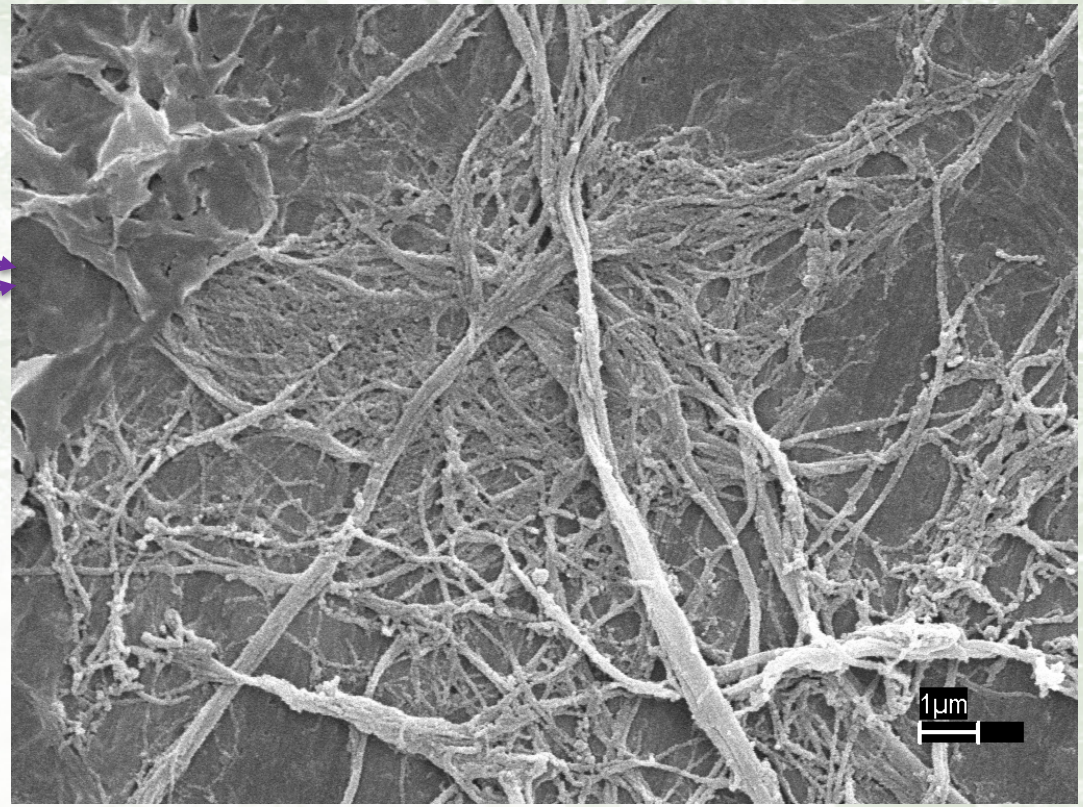
Ballesteros et. al. (2010) *Appl. Biochem. Biptechnol.* 161:423-431

Mechanical Size Reduction

Bleached softwood kraft dry lap pulp



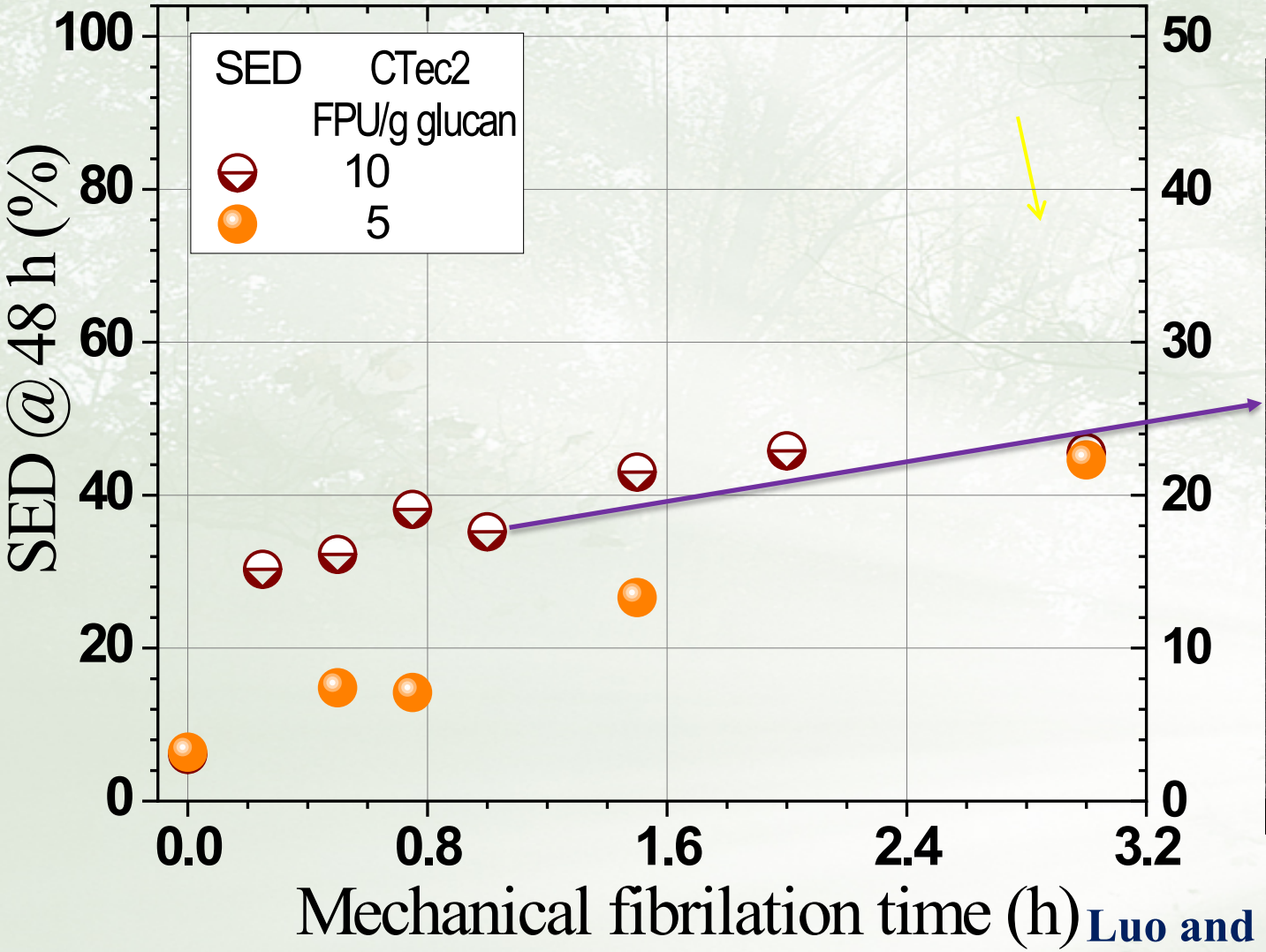
15 min milling



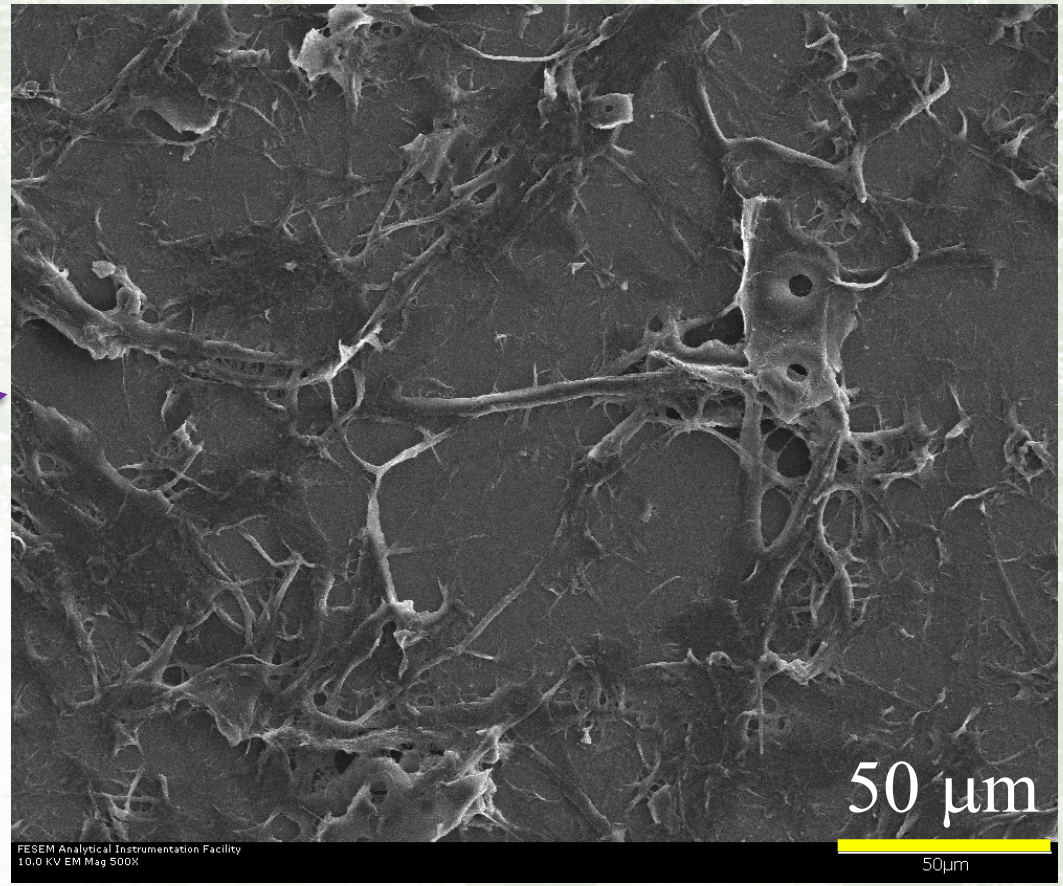
Hoeger et al. (2013) *Cellulose* 20:807-818

Effect of Size Reduction

Mechanical wood fibers



1 h milling



Luo and Zhu (2011) *Enzyme Microbial Technol.* 48:92-99

Summary

- MSW contains cellulose rich materials with cellulose content as much as 40%.
- From feedstock logistic point of view, co-processing MSW with local biorefinery makes a lot of sense as most areas provides MSW 300-1500 ton/day
- Sorting/separation of cellulosic rich materials from plastics is the key.
- Fiber hornification caused pore collapse makes cellulosic materials in MSW highly recalcitrant to enzymatic processing for sugar production
- Steam and physical size reduction may offer the most economical treatment for MSW bioconversion to biofuels.