

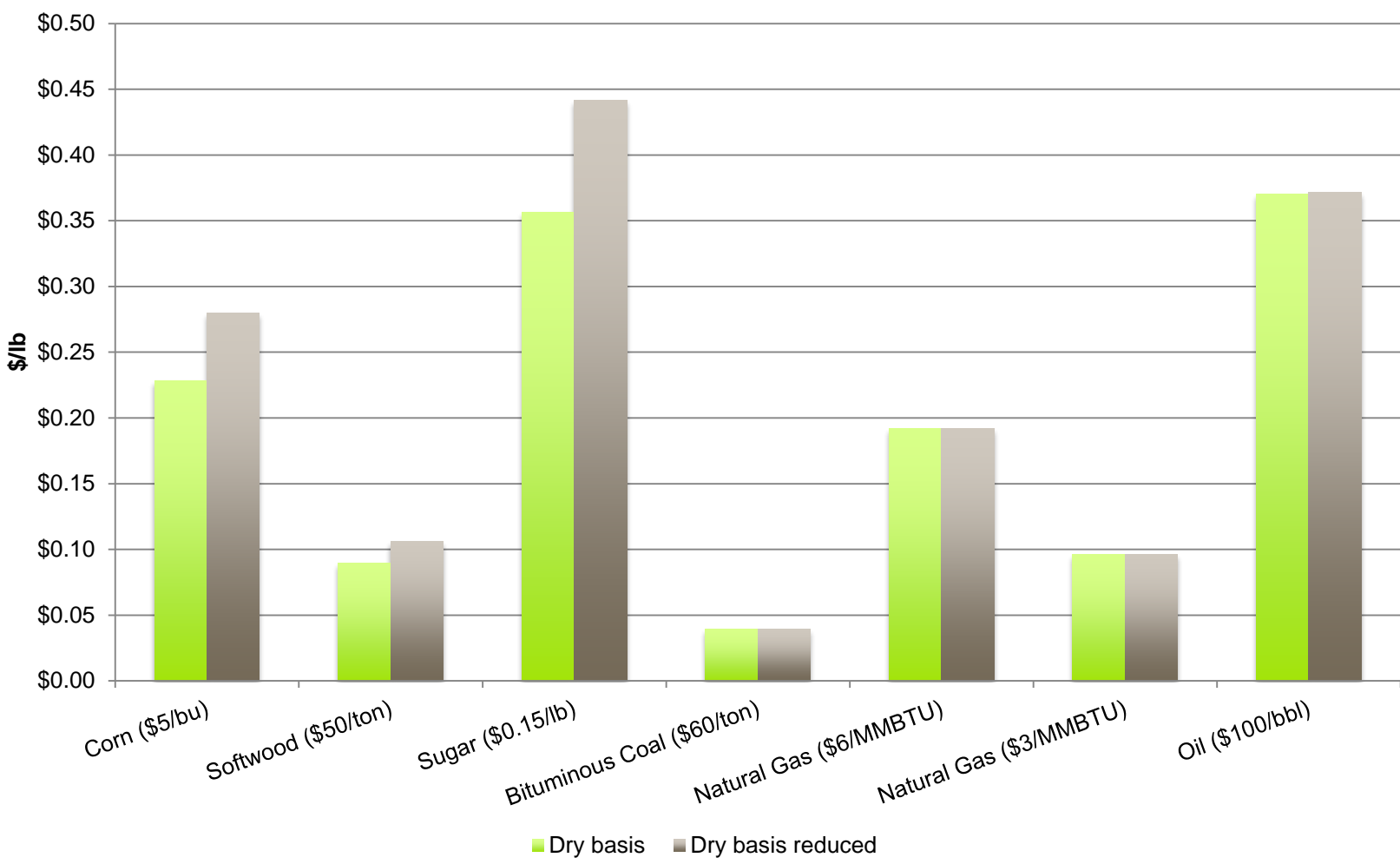
Bio-Based Chemicals and Materials From Woody Biomass

(Re)Creating a Feedstock Platform

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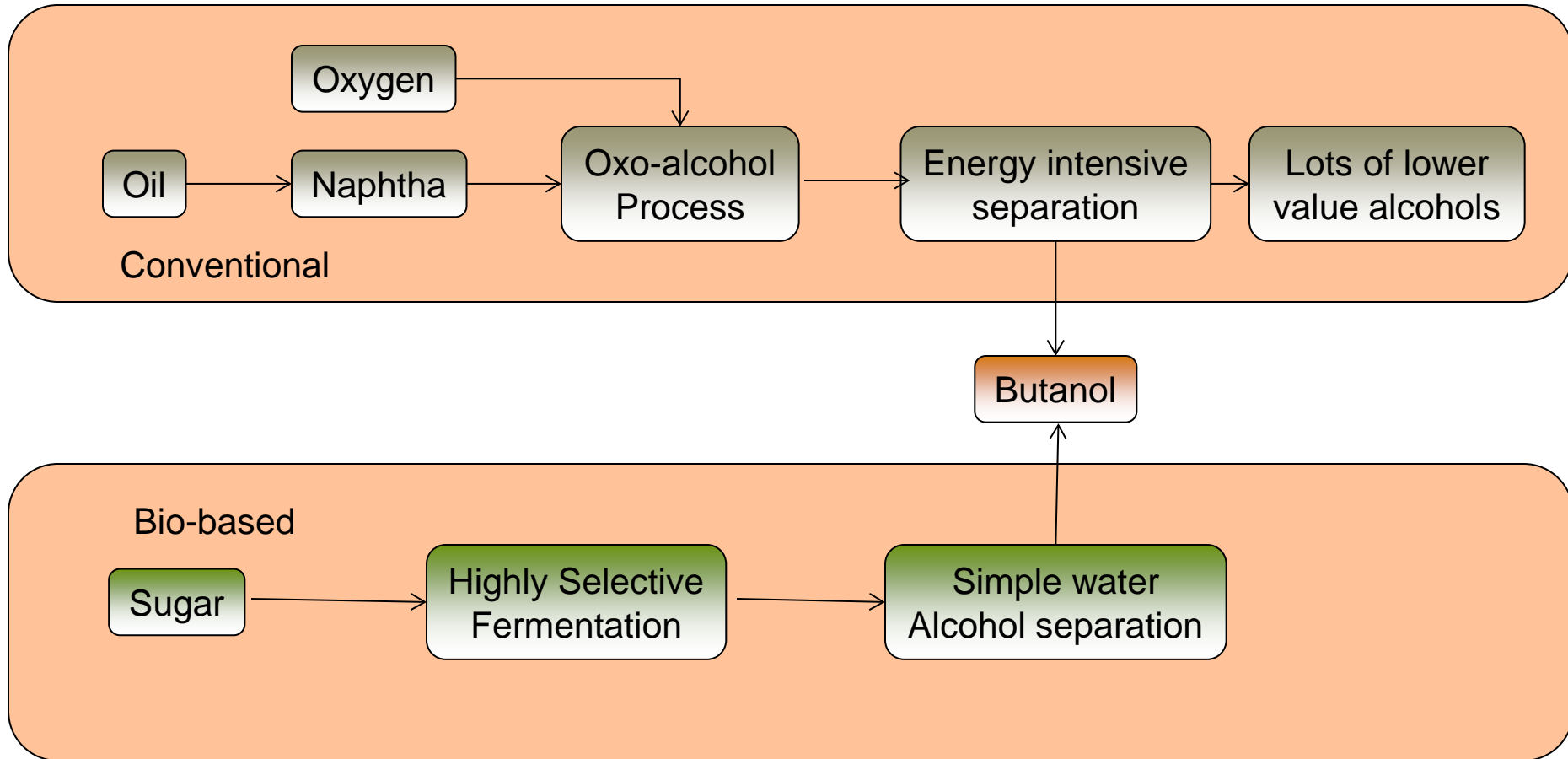


Cost of carbon from different sources



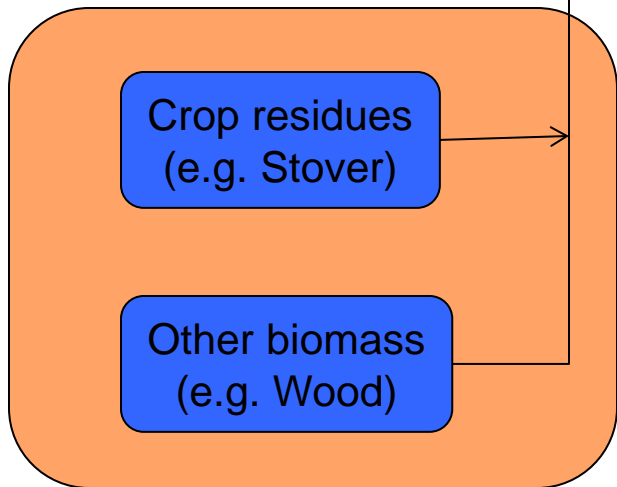
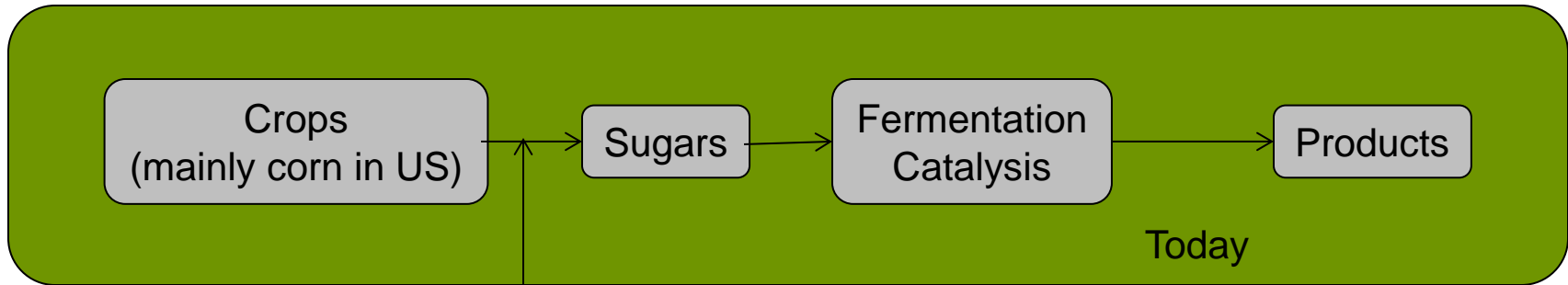
Reduced Products = Reduced Profit

How bio-based can compete with oil on some products?



Bio-based products can compete on a market basis with conventional chemicals because of process characteristics

The bio-based supply chain: Replace food-based feedstock

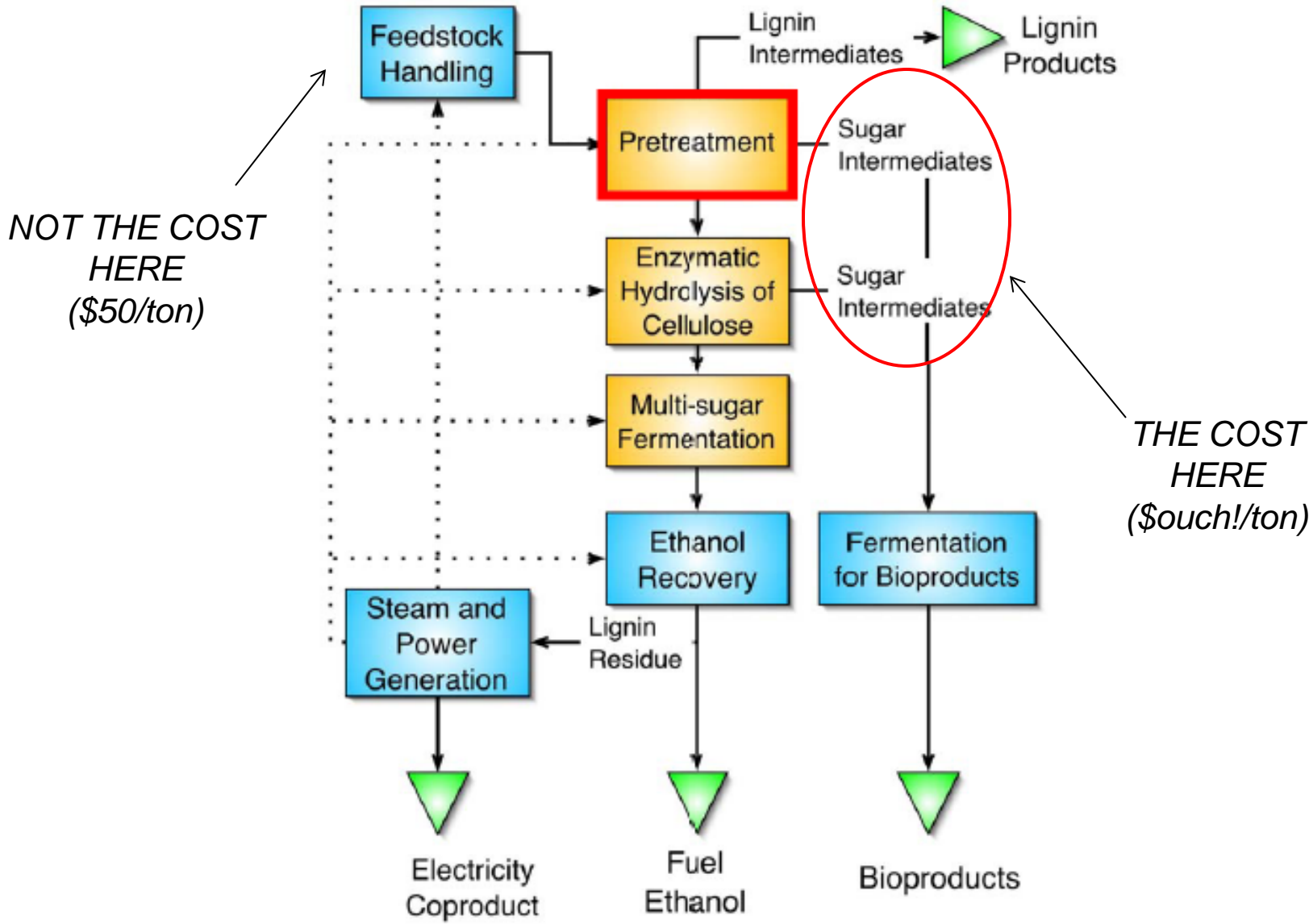


Vision: ligno-cellulosic feedstock

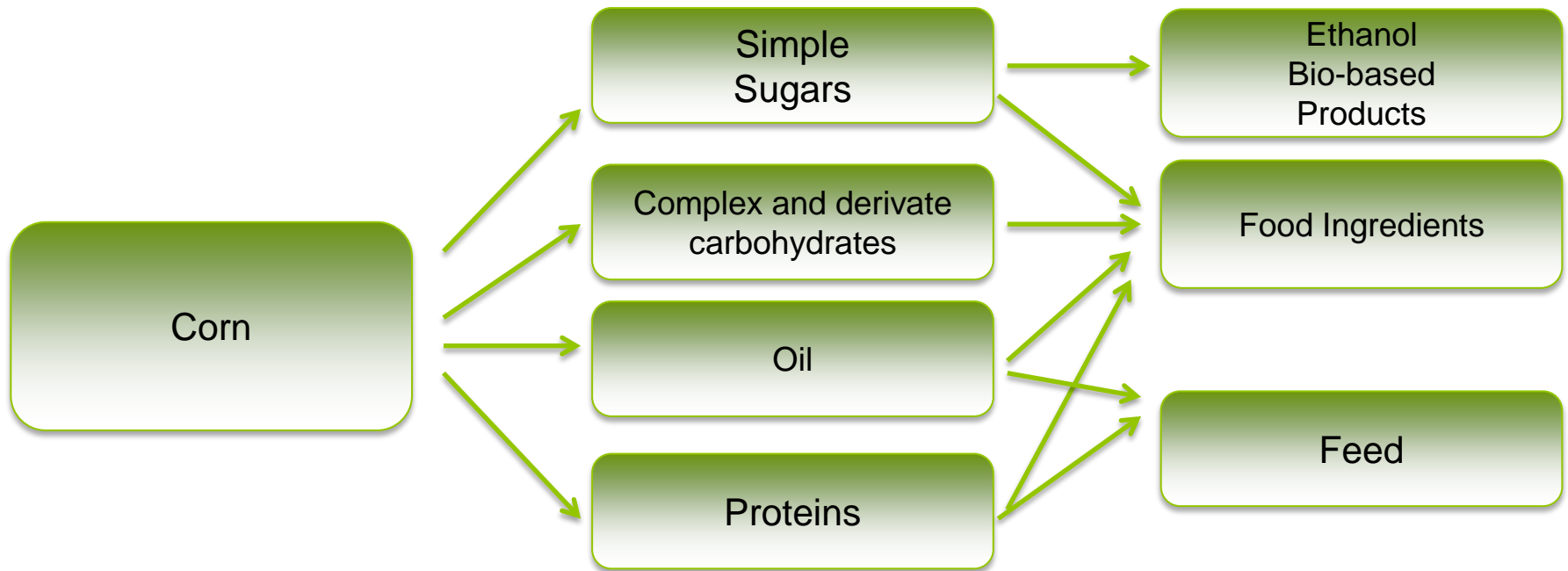
Challenges of ligno-cellulosic feedstock

- Supply/Chain Economics
 - Cost uncertainty. Not for wood though!
 - Scale/Aggregation
- Processing requirements
- Quality of sugars

Real cost of feedstock

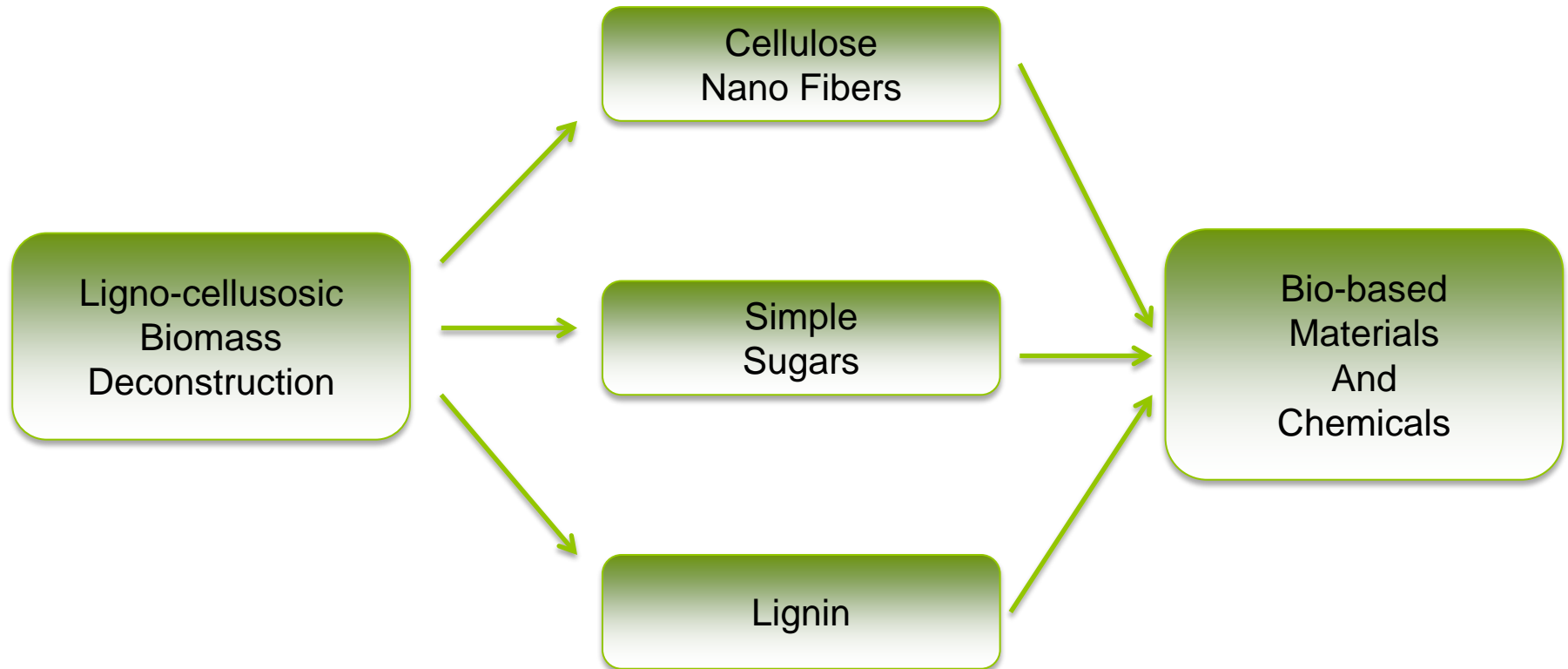


The other problem: corn is a platform



Net cost of corn carbohydrates is influenced by high value co-products in an established industry with largely paid fixed assets

We need to (re)make wood a platform as well





Wood could easily become a platform (over stover and other ligno-cellulosic feedstock):

- Clear supply chain economics
 - Existing industrial infrastructure
 - Absolutely no overlap with food crop agriculture
 - Potentially superior products on their own merit!
 - It is already happening!
- W
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Major pulp and paper companies see the opportunity...

Domtar Bio-Refinery Program Major Collaborations




Battelle
The Business of Innovation
Catalytic Fast Pyrolysis
Dryden, Ontario


- Blendable bio-fuels from available, low value wood streams
- With support from CRIBE

CelluForce 
Nano-crystalline Cellulose (NCC)
Windsor, Quebec

- First scale plant for manufacture of NCC
- Market and applications development.
- In partnership with FP Innovations, and supported by NRCAN and Quebec Provincial Government.


Power Generation
Kamloops, B.C.

- Upgrade boilers and optimize process steam
- Upgrade turbine generators
- Sell increased power generation to BC Hydro
- With support from PPGTP and BC Hydro

metso 
LignoBoost™ Technology
Plymouth, North Carolina

- De-bottleneck mill, increase production
- Start with Lignin as a bio-fuel for internal and external applications
- Use as a platform for new product and applications development
- Lignin – a new family of material?
- With support from USDA-NIFA BRDI program

- Several others in pipeline.
- Numerous smaller, application-type collaborations also in progress.

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Let's be done with the pun: You can do anything with lignin, but make money!

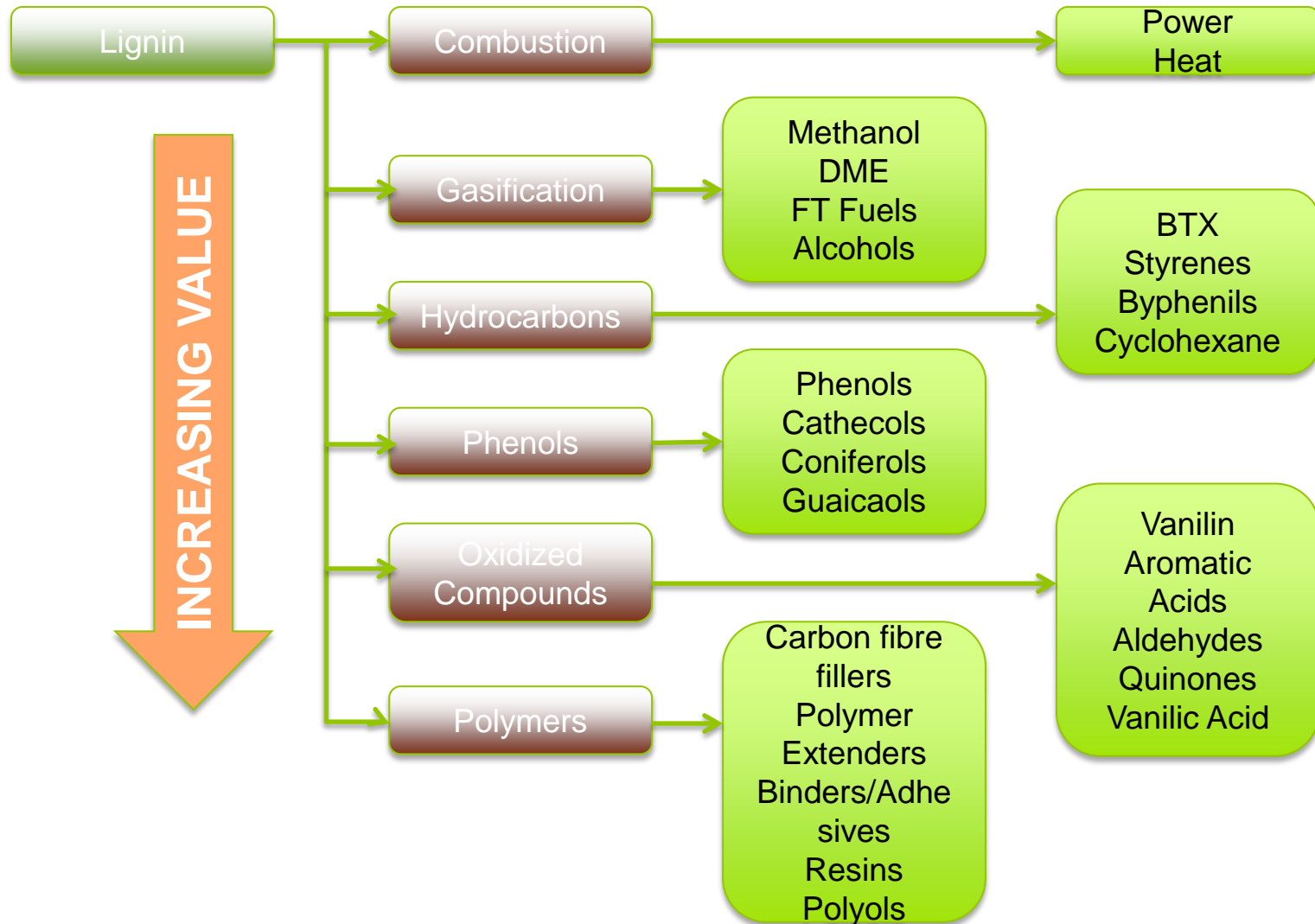
“Addressing markets worth more than 130 billion dollars, lignin could become the main renewable aromatic resource for the chemical industry in the future. The first opportunity could emerge as early as 2015 from the direct substitution of phenol in most of its industrial applications: phenolic resins, surfactants, epoxy resins, adhesives or polyester. The industry is just beginning to scratch the surface of lignin's potential. **It is the only renewable source for industrial aromatics production and is decoupled from the fluctuating price of oil.**”

Source:

“High Value Opportunities for Lignin”

Frost and Sullivan Report 2012

The lignin value chain

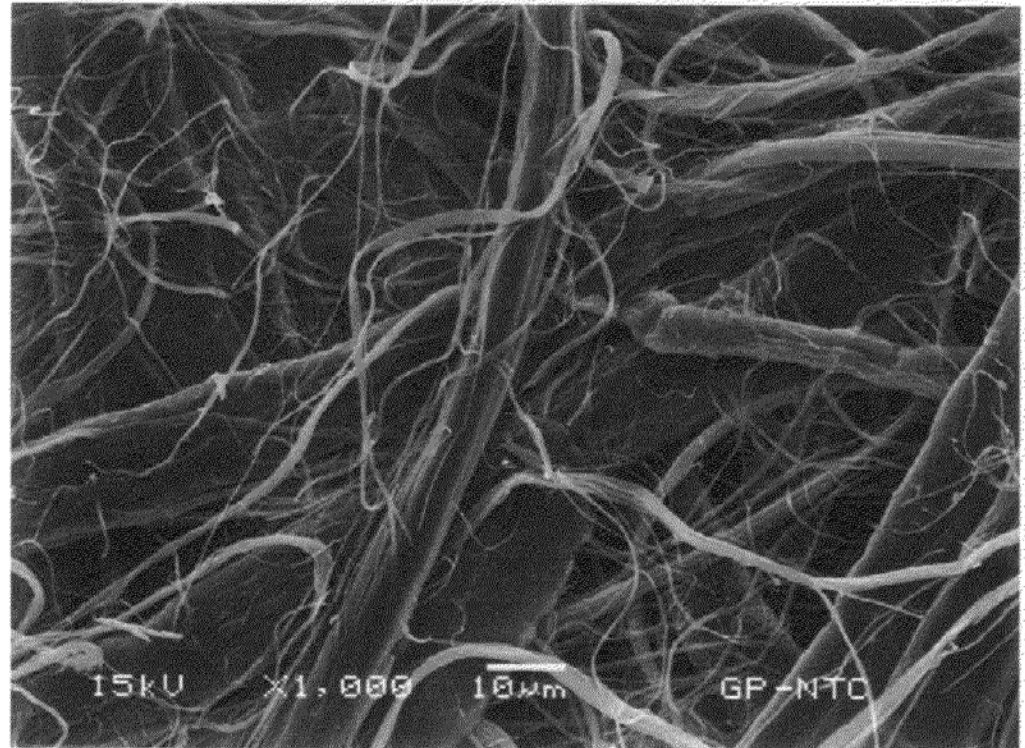


Cellulose microfibrils

Pure cellulose fibrils with length in the nano to micro meters scale

Can be used as reinforcing material in a variety of bio and non bio-blended composite materials

A superior product on its own!



Cellulose microfiber: A new wonder material

Table 1. Strength and stiffness of reinforcement materials*.

Material	Tensile strength (GPa)	Modulus (GPa)
Cellulose nanocrystals	7.5	150
Glass fiber	4.8	86
Steel wire	4.1	207
Kevlar	3.8	130
Graphite whiskers	21	410
Carbon nanotubes	11-73	270-970

1 GPa ~ 145,000 lbf/sft

Developing efficient biomass deconstruction technologies

- Requirements for a platform technology
 - Flexible
 - Stand alone or integrated
 - Feedstock flexibility
 - » Can use feedstock with (wood) or without (pulp) lignin
 - » High quality wood as well as waste wood
 - Low cost, common chemicals
 - Based on known unit operations and engineering concepts
 - Lowest chemical cost
 - Low energy consumption
 - Low carbon footprint
 - Easy to integrate with other assets
 - Scales down
 - Adapts to the reality of feedstock supply chain
 - Easy to delocalize
 - Transport higher value products for further processing
 - High quality lignin
 - High quality sugars
 - Enables efficient downstream processing

We have created a new company specifically focusing on this opportunity: SilvaNova

The Opportunity for Minnesota

- Strong, established forestry industry with a clear understanding of sustainable wood production, yet with declining demand for traditional products
- Excellent research and development facilities at the University of Minnesota
- Strong bio-based industry with world class leaders already operating in the state
- Receptive and supportive legislators
- Cooperative atmosphere:
 - BioBusiness Alliance www.biobusinessalliance.org
 - Bioeconomy Coalition of MN mnbioeconomy.org

Thank You!

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