

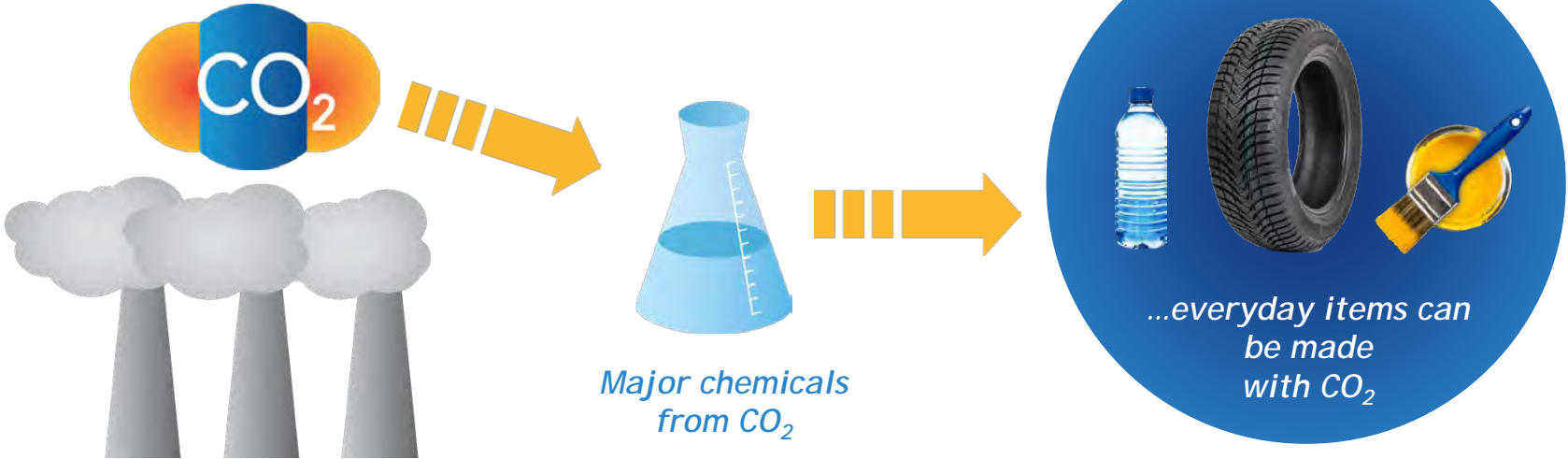


Electrocatalytic Conversion of CO₂ to Chemicals: Revenue enhancer for fermentation and other high CO₂ byproduct processes

15 May 2014

Making today's products with carbon dioxide

Using CO₂ benefits the economy *and* the environment



Large direct applications now; more later

Basic Chemicals (\$1 Trillion)



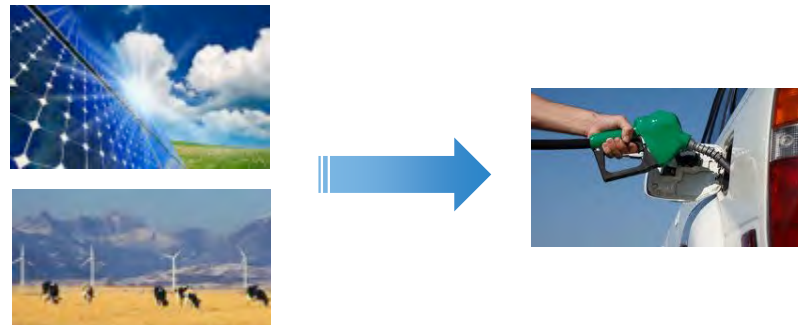
First product is ethylene glycol (\$27B)

Specialty Chemicals (\$800B)



Same technology also makes specialty chemicals

Renewable Chemicals and Fuels




CO₂ is the lowest cost feedstock for MEG




versus

Conventional




< \$80/t
(1.58t CO₂ / t MEG)


Ethane



\$360/t ethylene



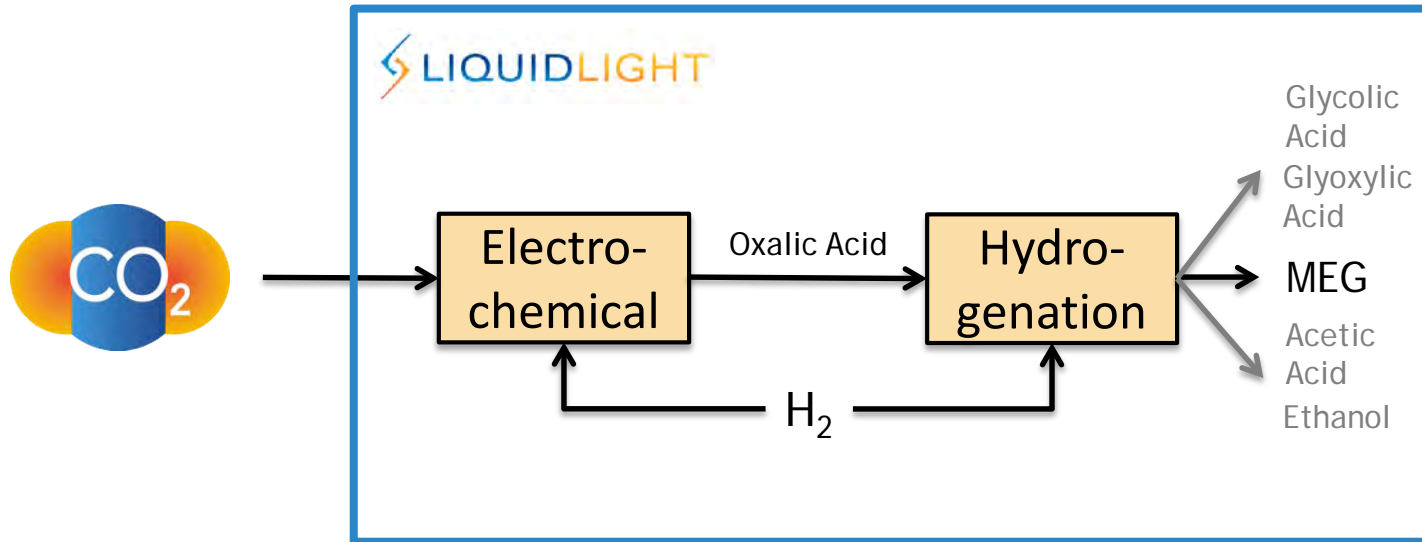
\$510/t ethylene



\$615/t ethylene

\$50/ton
feedstock to
make a \$1,200/t
product

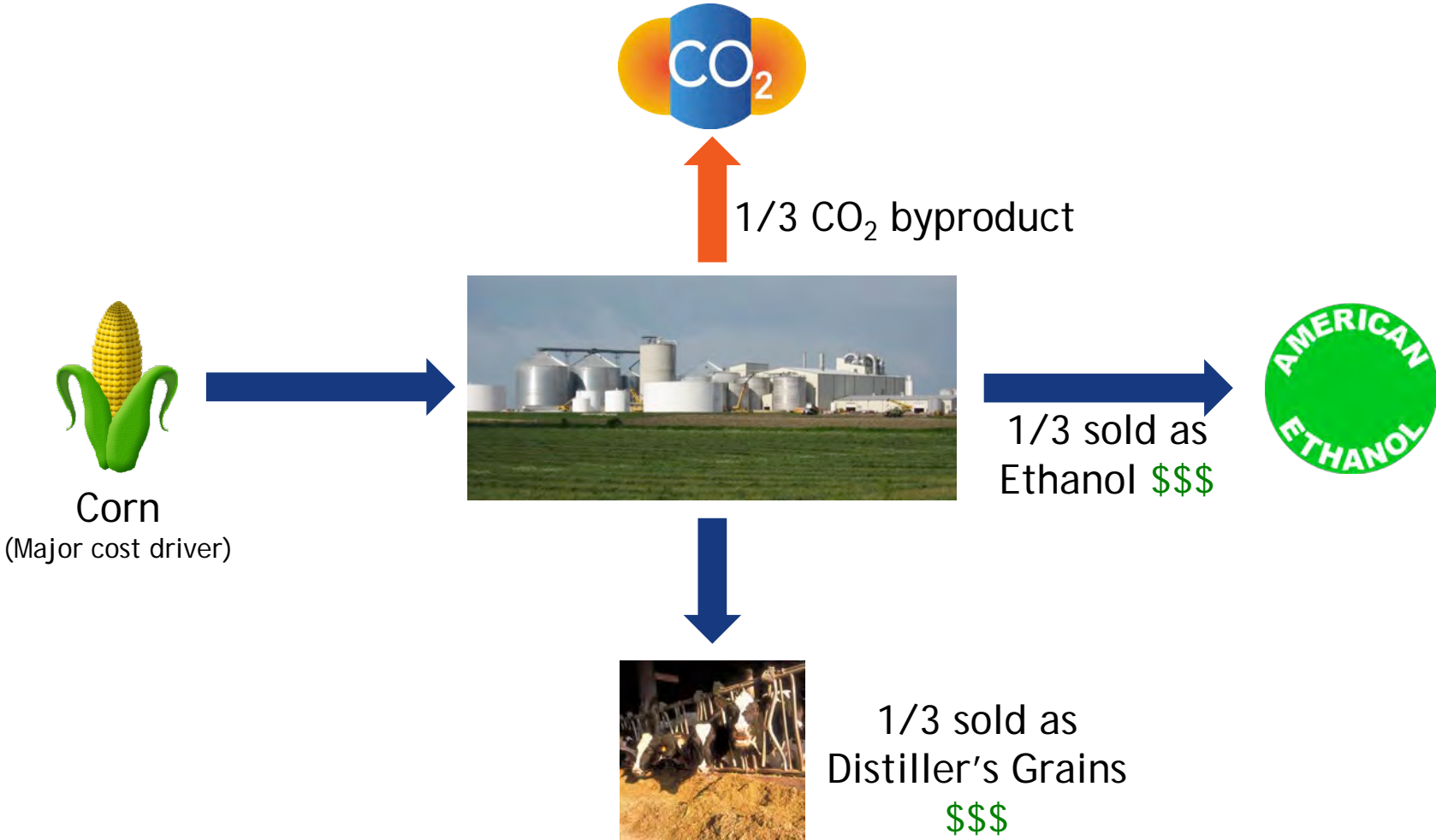
Getting value out of CO₂



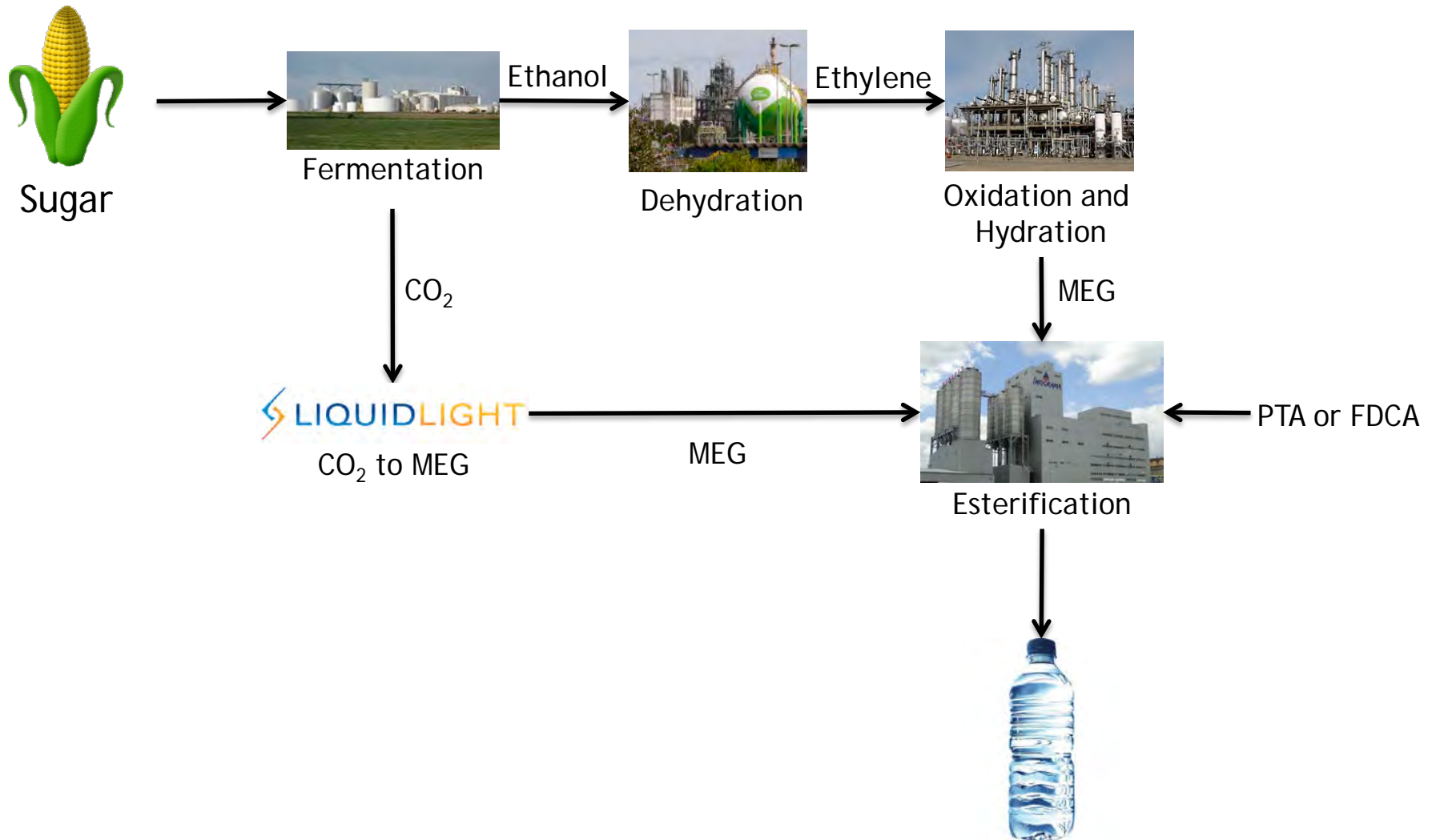
Get value from CO₂; add value to fermentation

- Meet low carbon fuel standards
- Diversify product mix at an existing facility

Example: CO₂ byproduct of ethanol production



Shorter, lower cost value chain to bio PET



Example: “Bolt-on” MEG plant



82.5M gpy ethanol facility
Releases ~278,800 tons of high purity CO₂ annually

“Bolt-on” CO₂ to Ethylene Glycol

Capacity	175 kta
CapEx	\$280 M
OpEx	\$77 M/yr
Revenue	\$210 M/yr
15 yr NPV	\$200 M

Attributes of Liquid Light technology



Advanced Chemistry

- Smart catalysts
- Low energy
- Highly selective
- Builds multi-carbon chemicals

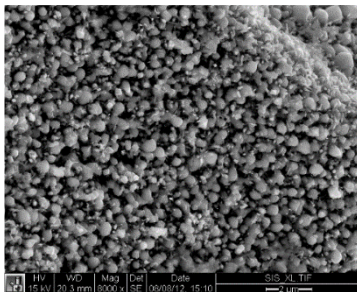


Process Technology

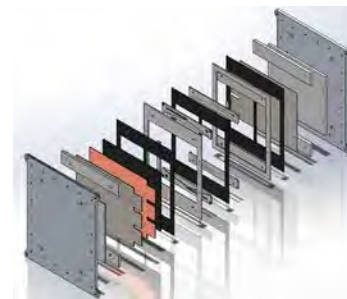
- Fewer steps
 - Simpler scale-up
 - 'Tunable' to make varied products
- First Process for MEG:*
- 25% lower cost of production



Cost
Advantage



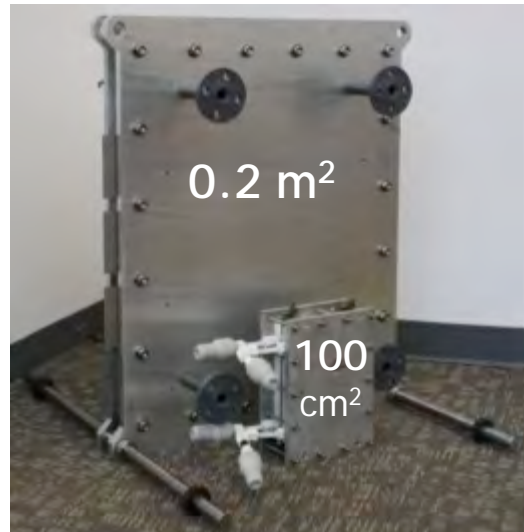
Catalysts



Reactor and Process
Design

Rapid progress; starting process development

	<u>Batch</u>	<u>Flow Reactors</u>		
Cell Size:	0.0001 m ²	.01 m ²	0.2 m ²	1-3 m ²
Production Rate:	1 g/day	0.2 kg/day	5 kg/day	50 kg/day
Scale Increase:	-	100x	20x	5 to 15x
	2011- 2012	2013	Q1 2014 1 st Gen Commercial Scale	2015-6 Next Generation



Technology to make major chemicals from carbon dioxide

Turn a potential liability into an asset

Increase the value of fermentation processes

Reaction chemistry validated; next step is process integration

Thanks!