



Footprints, Handprints, LCAs and Sustainability Myths

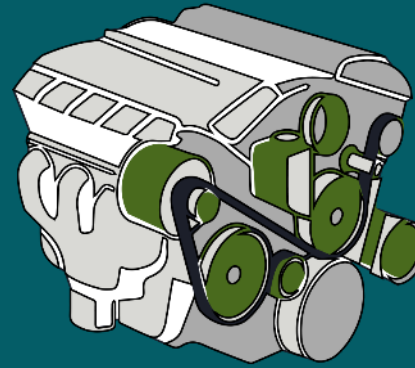
Lubricant Expo Dubai
Dr. Matthew Kriech

January 2026



Agenda

- Footprint, Handprint, and Avoided Emissions
- Building a Life Cycle Assessment (LCA)
FOOTPRINT for castor derived Estolides
- LCA Detailed Example
- Summary/Closing Thoughts



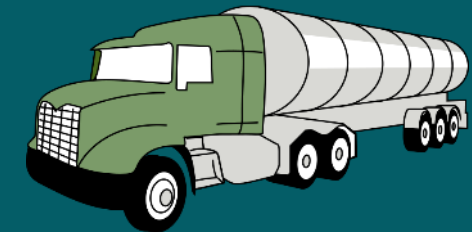
Performance



**Technical
Excellence**



Sustainability



**Commercial
Scale**

Footprint and Handprint *(Avoided Emissions)*

Product Carbon Footprint



A measure of the total greenhouse gas emissions required to produce a lubricant for use by a customer

Biogenic carbon, renewable energy, logistics optimization

= **Reduced Emissions**

FOCUS is to **MINIMIZE** Number

Product Carbon Handprint



A measure of the greenhouse gas emission reductions due to the use of a lubricant compared to a baseline

Higher Performing Lubricants reduce friction, reduce change out intervals, and reduce wear

= **Reduced Emissions**

FOCUS is to **MAXIMIZE** Number

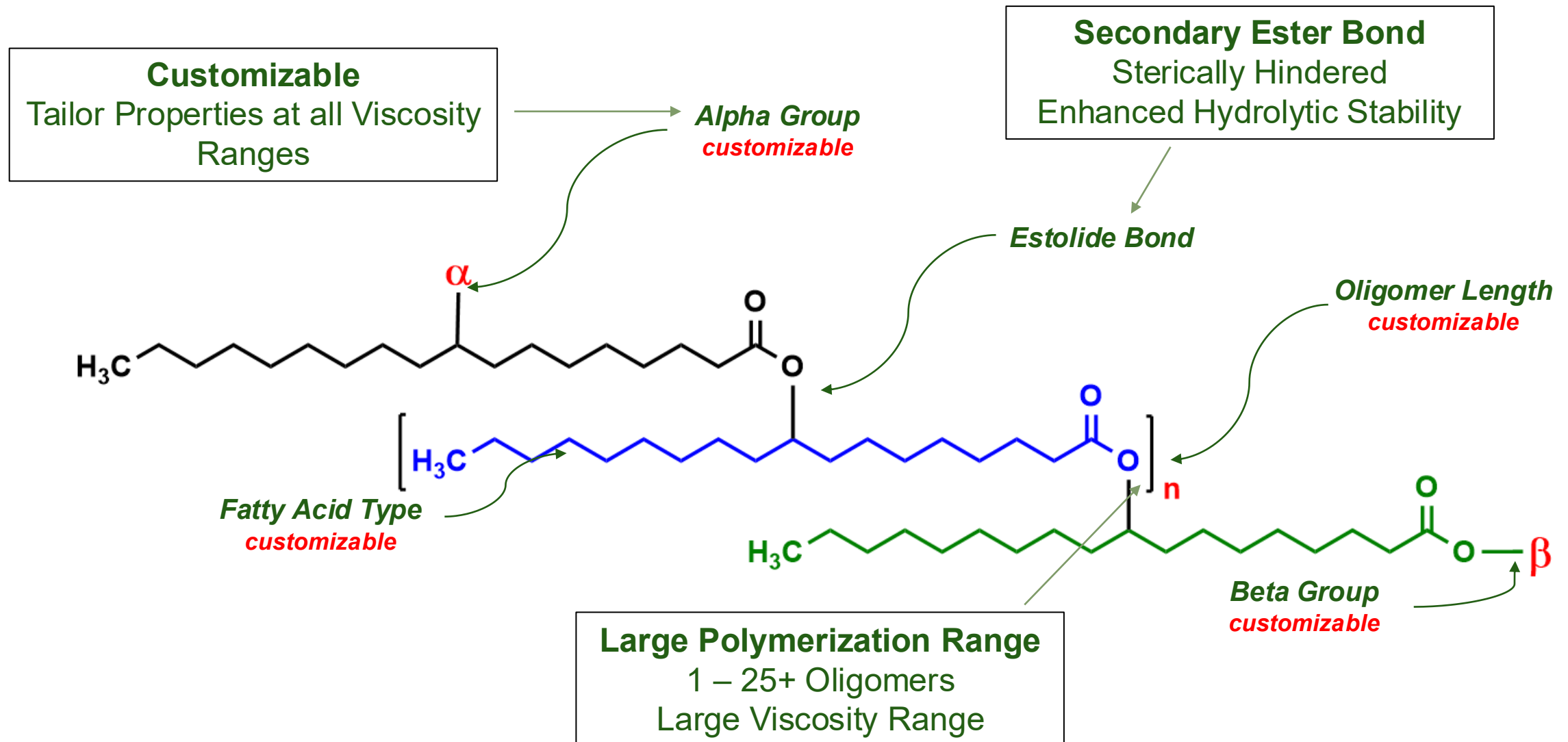
Life Cycle Assessments

- Footprint and Handprint are both part of a comprehensive LCA
- Cradle to Gate traditionally is considered the product's "Footprint"
- Cradle to Grave, or Cradle to Cradle includes a USE phase or "Handprint"
- Work together to provide complete sustainability picture



Life Cycle Assessment (LCA) for Castor Derivatives and Estolides

Biosynthetic Technologies – Estolide BASE OILS



BT Estolides for Industrial Applications



BIO-BASED

68%

(ASTM D6866)

BIO-BASED

86%

(ASTM D6866)

BIO-BASED

99%

(ASTM D6866)

BIO-BASED

94%

(ASTM D6866)

BIO-BASED

99%

(ASTM D6866)

GF6 Motor Oil Formulations

SAE	0W-20	5W-20	5W-30
Infineum P5907	8.85	8.85	8.85
Infineum SV265	5.43	2.26	7.11
Biosynthetic Technologies BT4	38.00	38.00	38.00
Safety Kleen RHT 120	-	19.79	46.04
Safety Kleen RHT 240	-	31.09	-
Puraglobe PureBase 4	47.72	-	-
KV100C, cSt	8.33	7.54	9.86
HTHS 150, cP	2.60	2.60	2.95
CCS @-TC, cP	6007 @ - 35C	4739 @- 30C	3864 @- 30C
NOACK, m%	10.90	7.90	10.30

API Approved Formulations



AMERICAN PETROLEUM INSTITUTE



Conventional Motor Oil



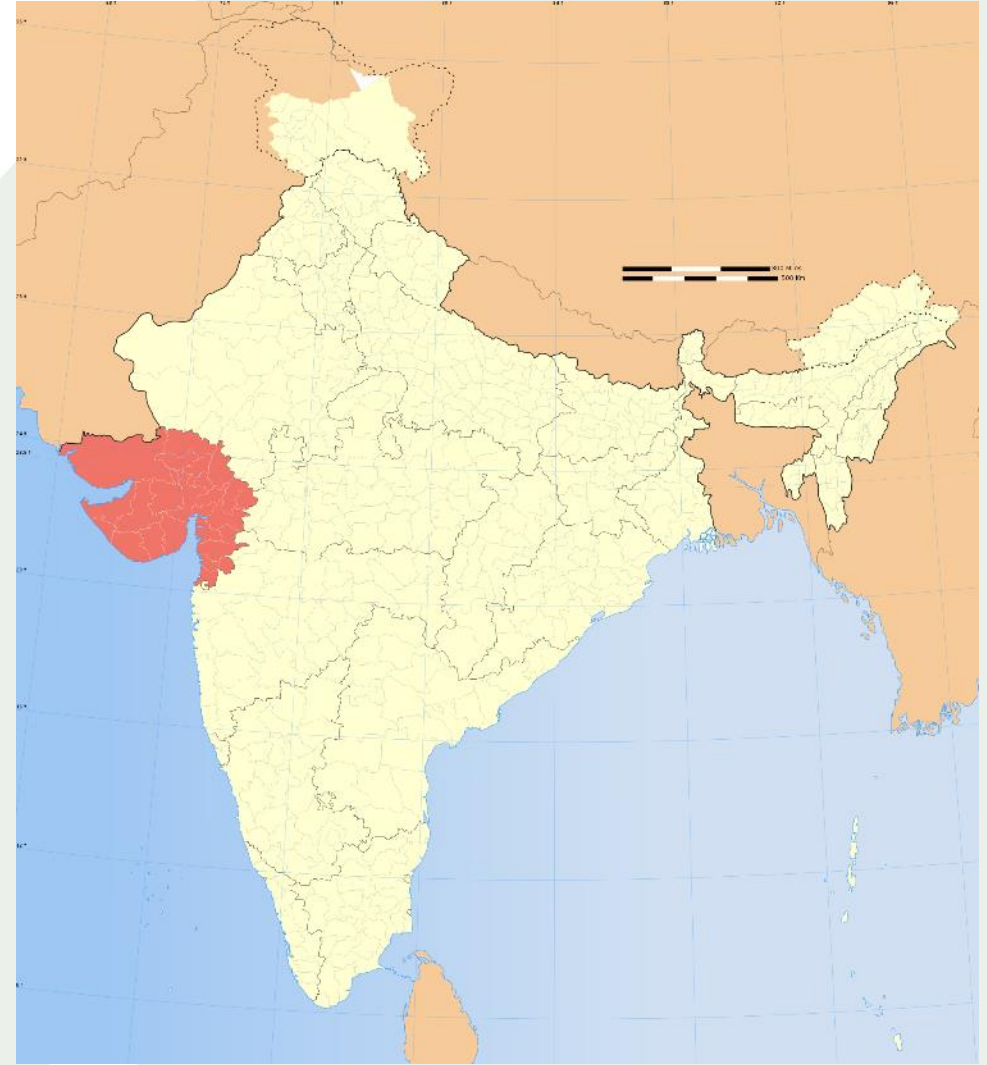
Estolide Motor Oil



Estolides from Castor

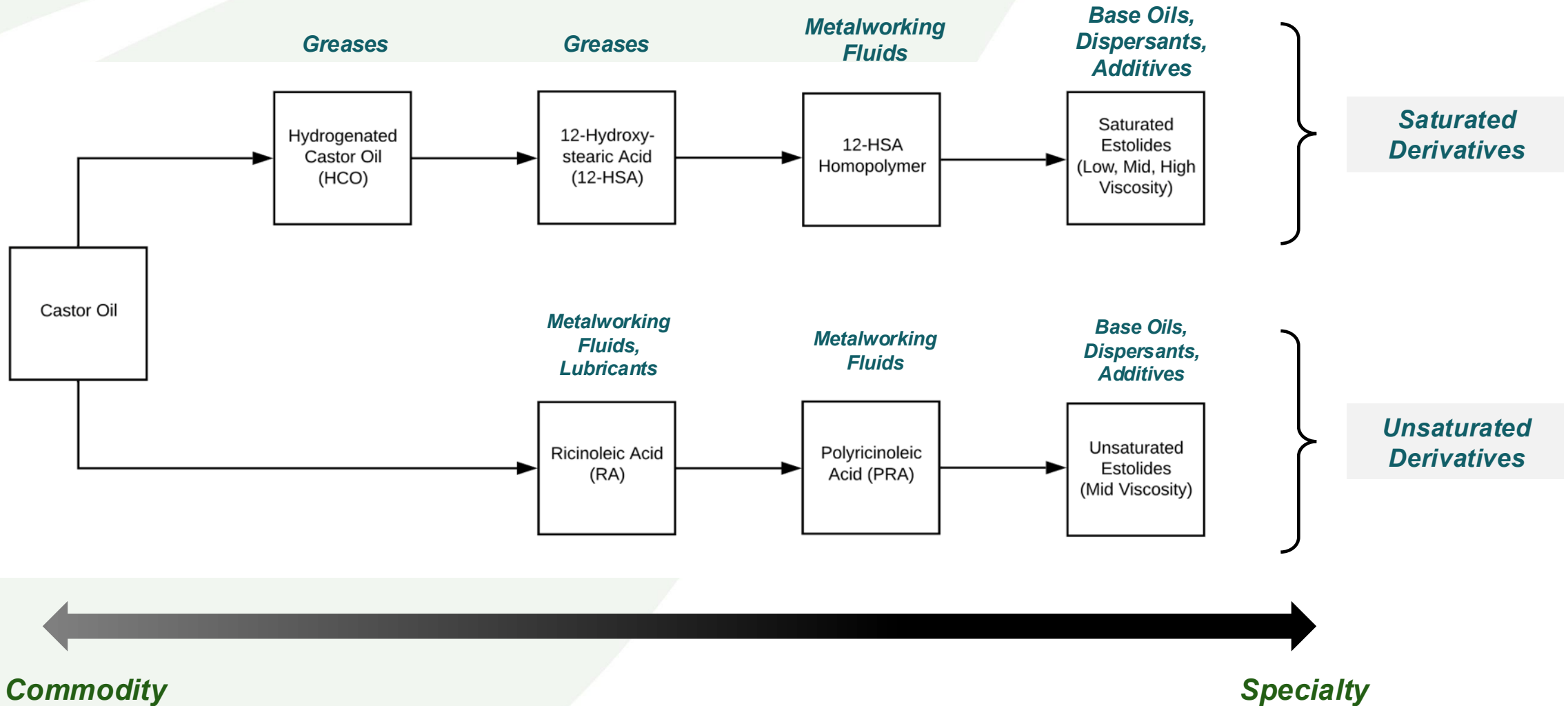


Castor Field in India



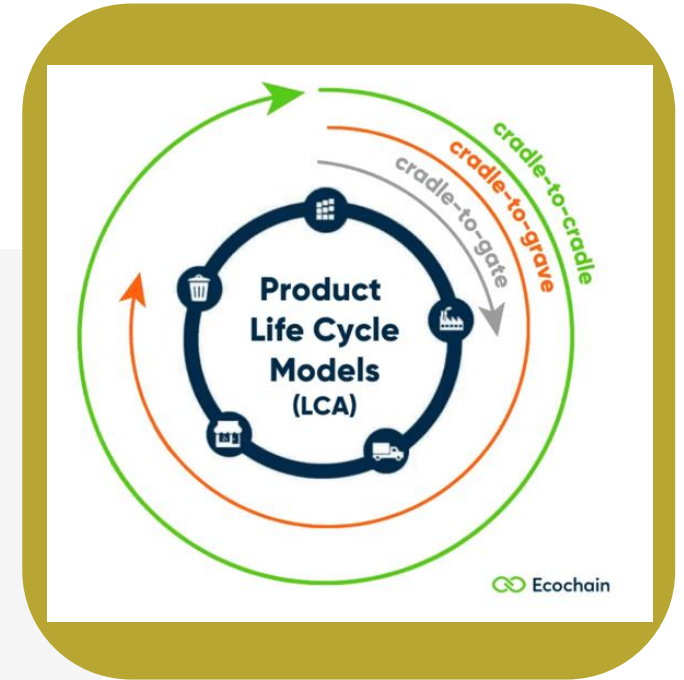
Gujarat Province India

Value Chain



LCA Scope Selections

- ISO 14040, ISO 14044, and ISO14067 Standards Followed
- 3 Party Critical Review Completed
 - Environmental Resource Management (ERG) – LCA Author
 - Dr. Matthias Finkbeiner (Technical University Berlin) – Critical Reviewer
- Cradle to Gate Analysis for Climate Change Emissions
- **Primary Data** collected on 1 year of Manufacturing Data in 2022 for all internally controlled processes
- Secondary Data supplied from Ecoinvent 3.8 Database
- Castor Oil Data supplied from GaBi 2020 Database
- SimaPro v9.4.0.2 Used for Software Simulation
- Measure Fossil, Biogenic, CO2 Uptake, and Land Transformation Emissions





Fossil Emissions

Emissions from
fossil-derived
carbon sources

Coal
Natural Gas
Heating Oil



Biogenic Emissions

Emissions from
bio-derived carbon
sources

Wood Pellets
Biochar
Castor Cake



CO2 Uptake

Emissions
captured by
biomass sources
(carbon sinks)

Crops
Trees
Algae



Land Transformation

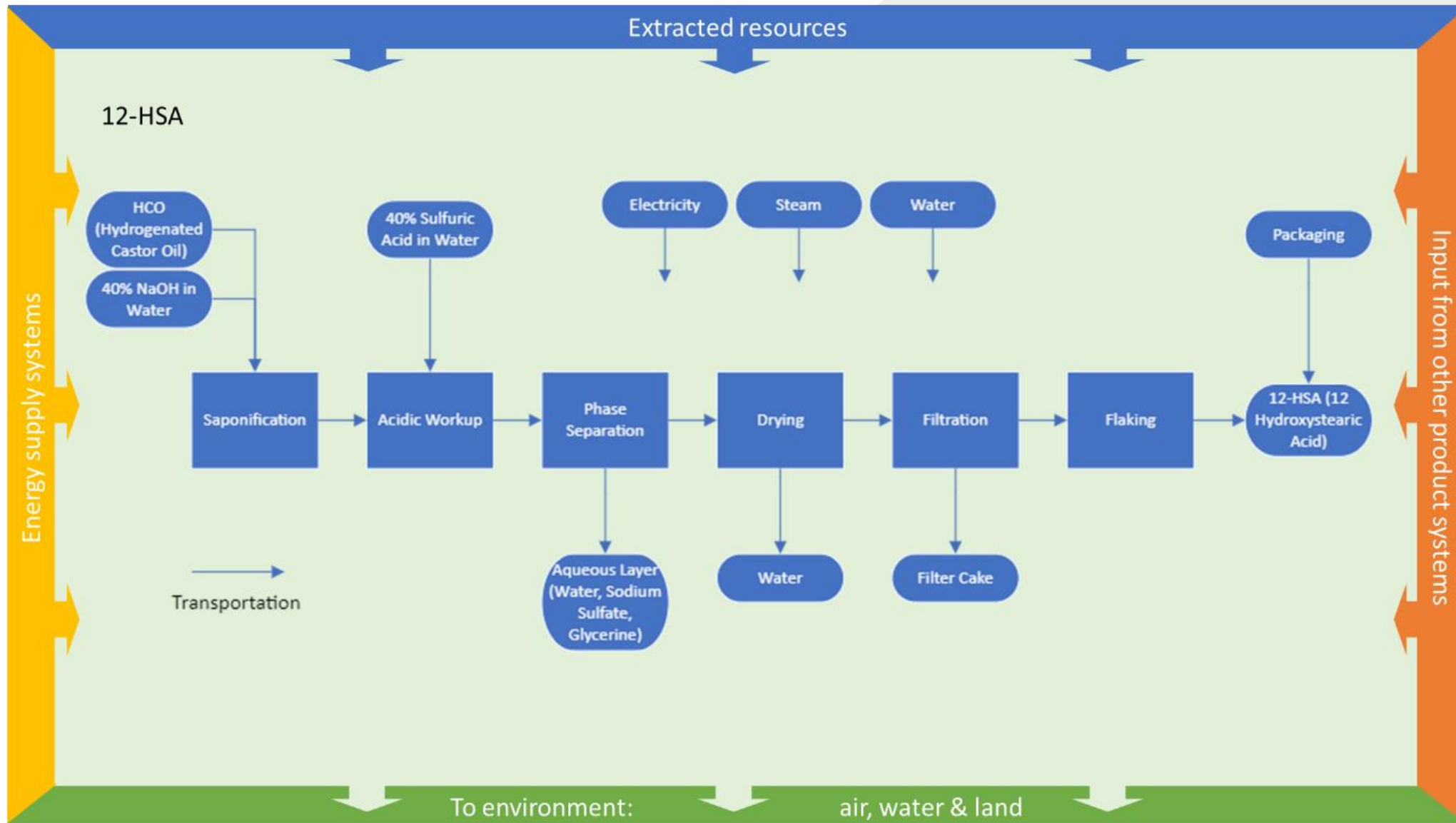
Emissions
associated with
land use change

Deforestation
Soil Carbon
Land Use

System Boundary: Cradle-to-gate: Includes raw material extraction/harvesting, inbound raw material transport, packaging for inbound/outbound materials, manufacturing activities, waste management, associated energy use/water/steam

Included	Excluded
■ Raw material extraction/ harvesting	■ Capital goods and infrastructure
■ Inbound raw material transport	■ Employee commute
■ Packaging for inbound and outbound materials	■ Outbound distribution (i.e., after materials leave the factory gate in India)
■ Manufacturing activities	■ End of life
■ Waste Management	■ Consumer use
■ Associated energy use, water, steam	
■ Packaging and transportation of co-products to deliver them to beneficial reuse site	

Process Flow Diagrams – 12HSA as Example



Emission Results (kgCO₂e / MT Product)

Saturated Derivatives



Product	Castor Oil	HCO	12HSA	Low Vis	Mid Vis	High Vis
Fossil Emissions	1592	1835	1797	2627	2507	2469
Biogenic Emissions	33	360	636	924	1130	1156
CO ₂ Uptake	-2659	-2725	-2201	-1980	-2164	-2231
Land Transformation	386	385	301	383	329	318
Net Emissions	-648	-145	533	1954	1802	1712

Unsaturated Derivatives



Product	Castor Oil	RA	PRA	Mid Vis
Fossil Emissions	1592	1563	1952	2443
Biogenic Emissions	33	267	643	977
CO ₂ Uptake	-2659	-2134	-2204	-2129
Land Transformation	386	303	304	331
Net Emissions	-648	-1	695	1622

Lessons Learned

Castor Farming
Fertilizer #1
Carbon
Emission

India Coal
Fired
Electricity #2
Carbon
Emission

< 1% of Carbon
Emission from
Waste in
Process

Castor Cake
Biofuel for
Steam
Generation

More
Processing
EQUALS Higher
Emissions

Castor Farming
Efficiency

IMPACT FOCUS: COAL POWERED EMISSIONS

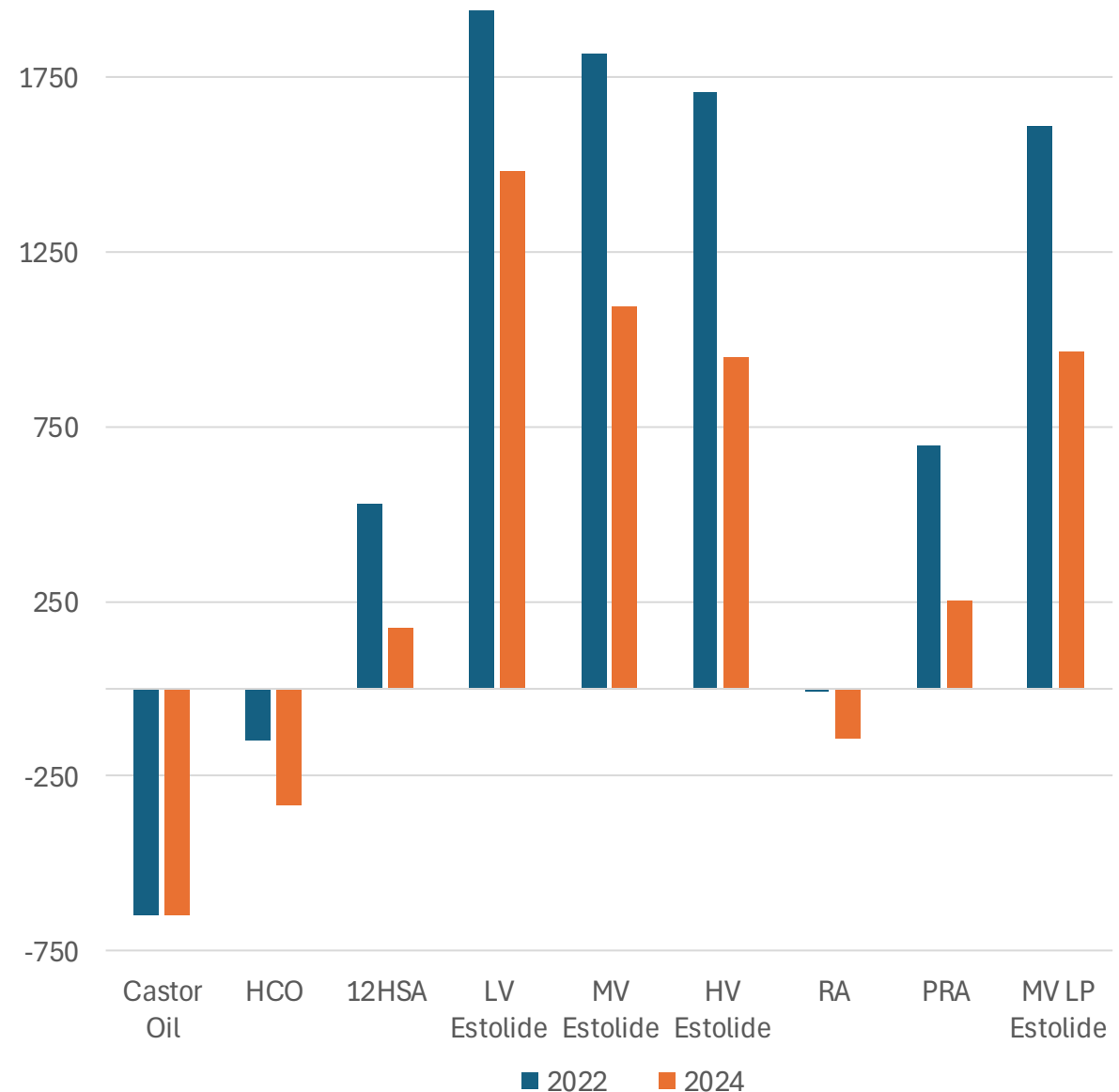
8 MW Solar Farm in India



IMPACT FOCUS: COAL POWERED EMISSIONS

- The 2022 LCA showed carbon emissions from coal-fired energy was the #2 source of Estolide emissions
- Average Energy Load for India-based production facility: ~3.0 MW
- **New Renewable Energy Installations**
 - Roof Top Solar: 2.1 MW
 - Wind Turbines: 2.2 MW
 - Total Renewable Energy: 4.3 MW
- **31% REDUCTION** in Fossil Emissions for 2024 LCA
 - This is a **modeled** scenario, real world numbers being collected
 - Some fossil emissions from castor farming and processing still remain
- Will need a full year of actual power usage to confirm model and allow for 3rd Party Critical Review per ISO standards

LCA CO2 kg eq per 1 MT of Product



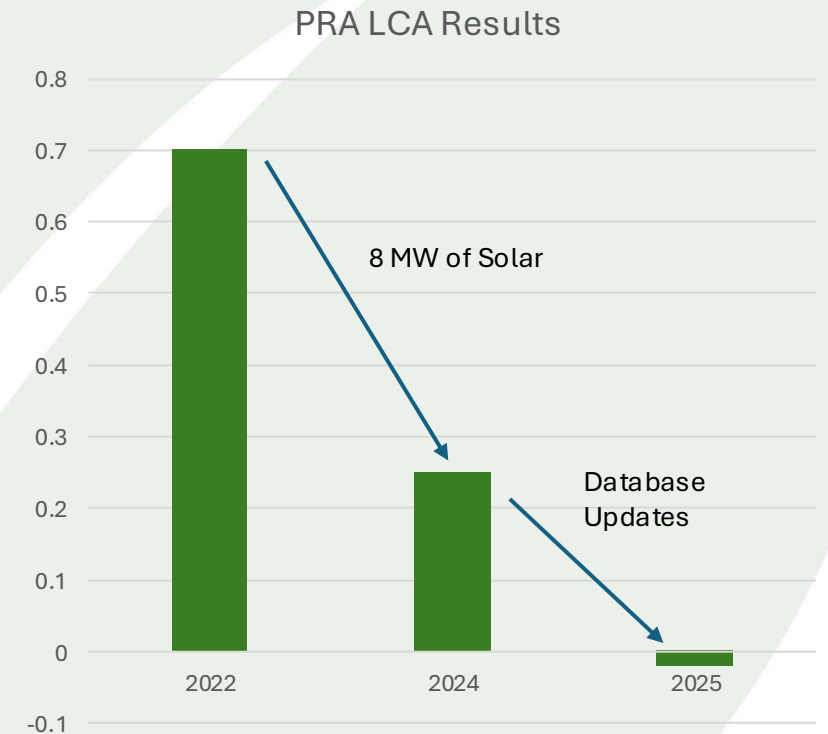
IMPACT FOCUS: CASTOR FARMING

- LCA Data needs to be used to make smart and rational decisions that can realistically impact emission using data/science
- The only Carbon Emission item that can still be significantly improved in the production of Estolides is Castor Farming itself
 - Lower Fertilizer/Herbicide Use
 - Higher Yield per Acre
- Biosynthetic Technologies is a member of the World Castor Sustainability Forum to work on the largest remaining carbon emission in our value chain



LCA – Lost in the Details

- Databases are constantly evolving, meaning LCA numbers are almost always in a constant state of flux (sometimes for the good, sometimes for the bad)
- Ecoinvent 3.8 to Ecoinvent 3.11
- GaBi 2020 now Sphera
- SimaPro v9.4.0.2 to SimaPro v10.2.0.2
- Database change is as big as solar addition!



Closing Comments

- The methodology to produce high-quality LCA/PCF data exists for the Lubricant Industry
- Transparent and open use of the process, boundary conditions, and critical review should build trust in the numbers/data being generated
- Don't treat the results as a competition, use them to make smart choices that have real world impact to your emission numbers
- Share this data with your customers so their LCA/PCF data can be updated for accuracy
- Be open to your results and let it challenge previously held assumptions
- Evolving databases eventually will pose a problem when comparing LCA values



Questions and Thank You!!!

Dr. Matthew Kriech
mkriech@biosynthetic.com

January 2026

