Deriving value from wet and gaseous waste streams.

Assessing the real value of "higher value products" Setting realistic assumption and avoid common pitfalls

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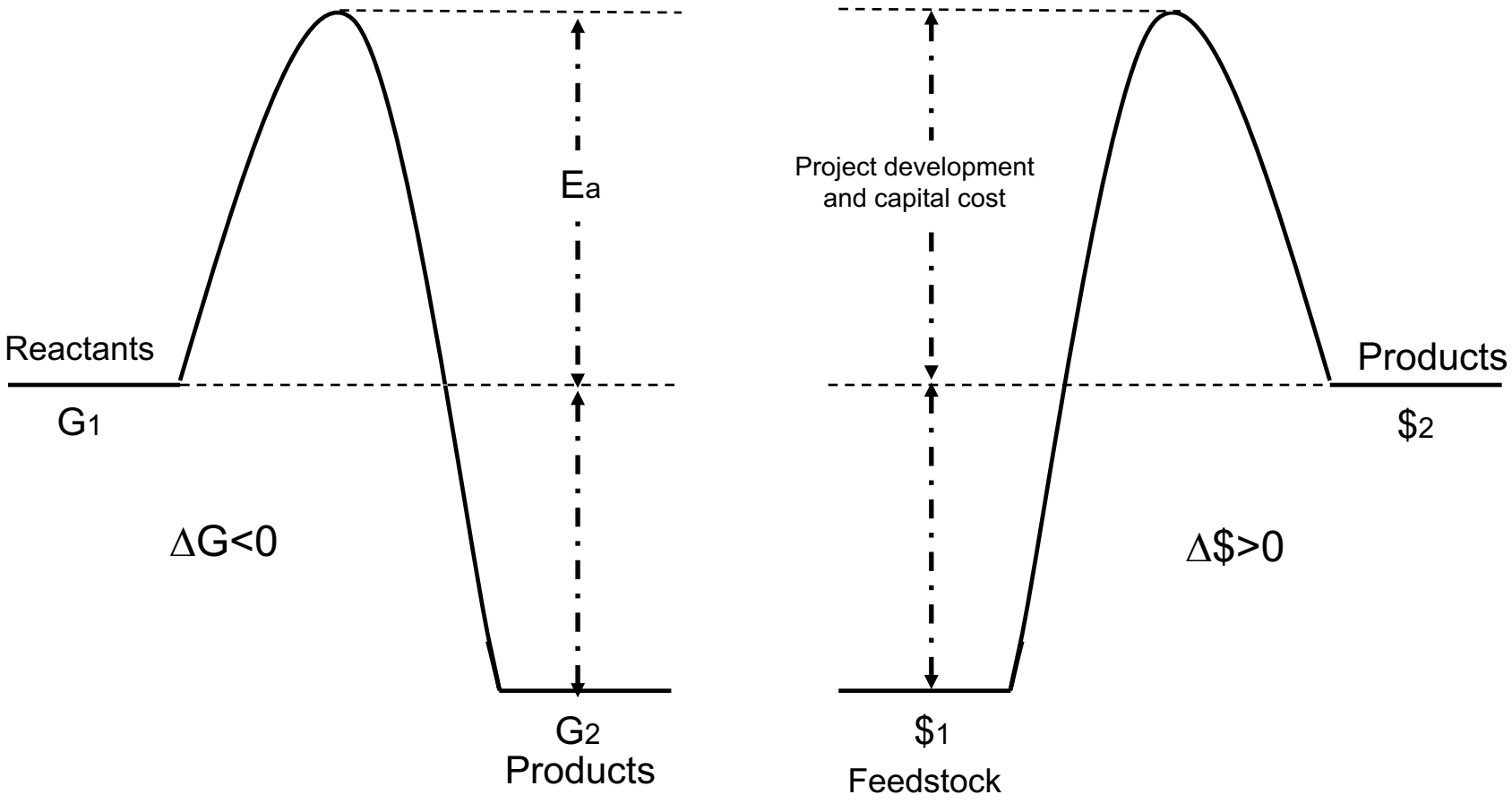
My technology works great and my feedstock is a no value waste!

Thermodynamics and process economics are not very different



It is never too early to think about economics!

Avoid disconnect between business and technology development

- What are the critical technical benchmarks?
- Is the process mass and energy balance correctly represented in the financial and business plan?
- Do we have an understanding of the impact of technical uncertainties and variability?
- Is the process able to delivery consistent product quality? Are the value assumption representative of the product quality? Do we really know what the market wants?
- Is the margin and return in line with the industry? How do we compare with industry benchmarks?
- Are we focusing to address the technical issues with the largest impact on the business?
- What are the key components of the capital cost?
- What are the trade offs between capital and operating costs?
- Are we using industry standards % to provide early estimate of unknown quantities?

If you are doomed to fail, fail fast!

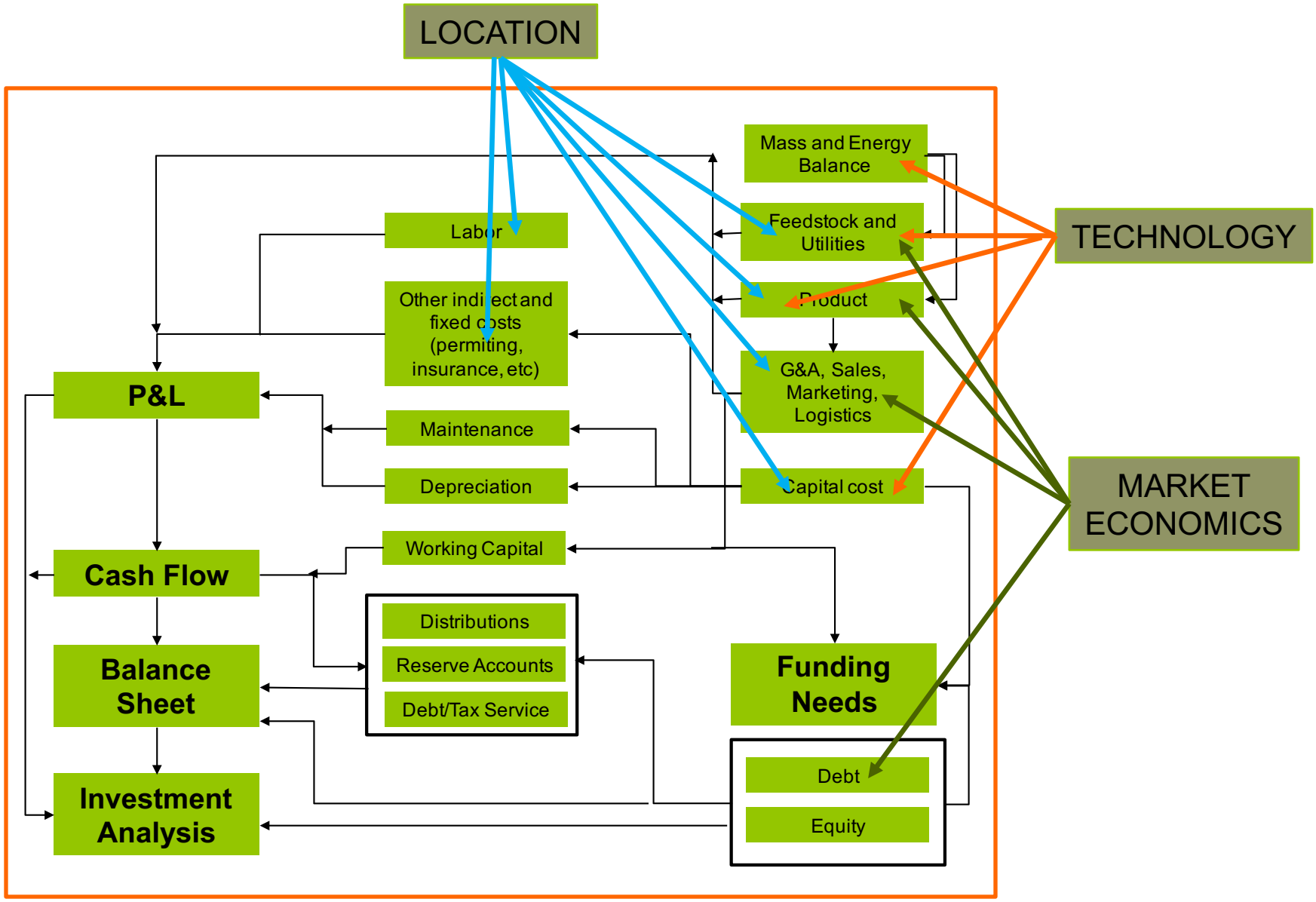
Have a RED team to challenge and attack your assumptions

US Navy Aggressor Squadron

Goals of a techno-economic model

- It is never too early to structure a detailed techno-economic model.
  - Evolve from a conceptual tool to explore risk and uncertainty to a planning one.
  - Stand alone production enterprise
- Evaluate the economic impact of technology options.
  - Identify and assess the impact of uncertainties and/or lack of knowledge. Provide quantitative support in the design of mitigation strategies.
  - Identify critical drivers for the project success.
  - Identify realistic economic and financial goals.
- Assess the impact of external forces outside of the project developer control such as variability in commodities prices and other macro-economic impact factors.
  - Quantification of risk.
  - Avoiding funding pitfalls and providing realistic assessment of the enterprise ability to generate cash.
  - Align investors and founders expectations with those of the project developers.
  - Quantitatively support the business plan and provide clear project metrics to bankers and investors.
- Flexible on business model
  - Include royalties and licenses if you plan to license the technology. You need to make it sure that your licensor will have satisfactory returns.

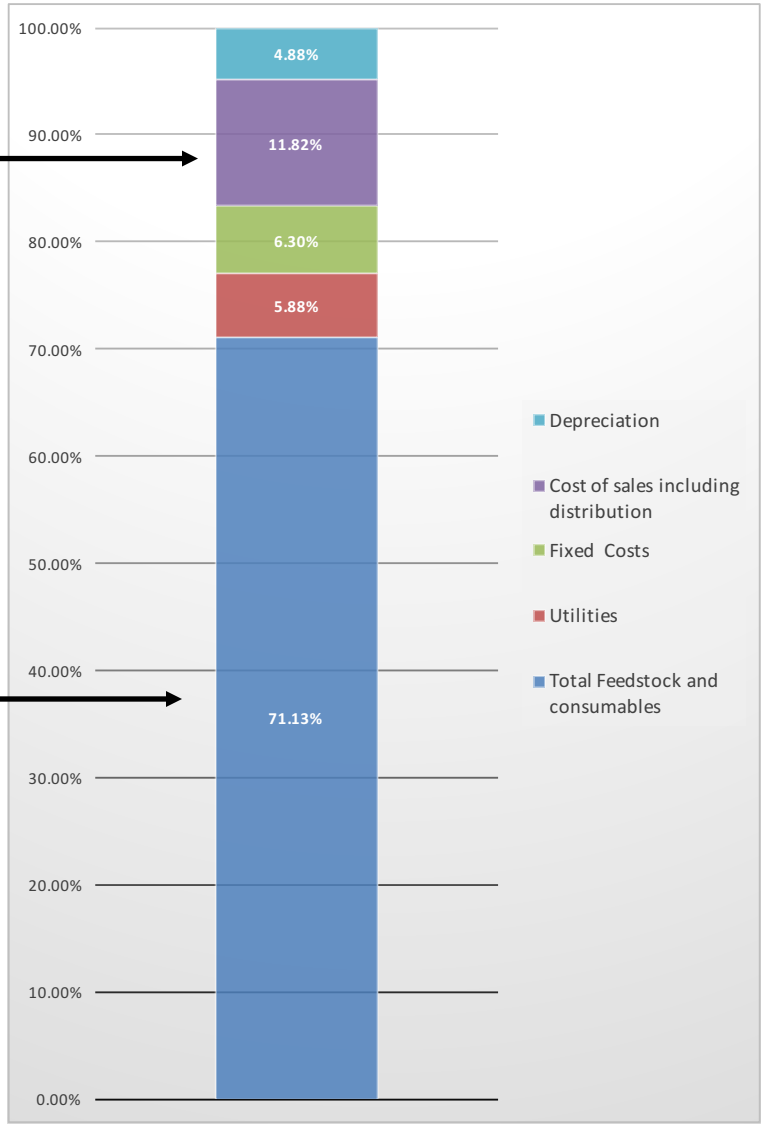
Structure of the model: external influences and sources of uncertainty



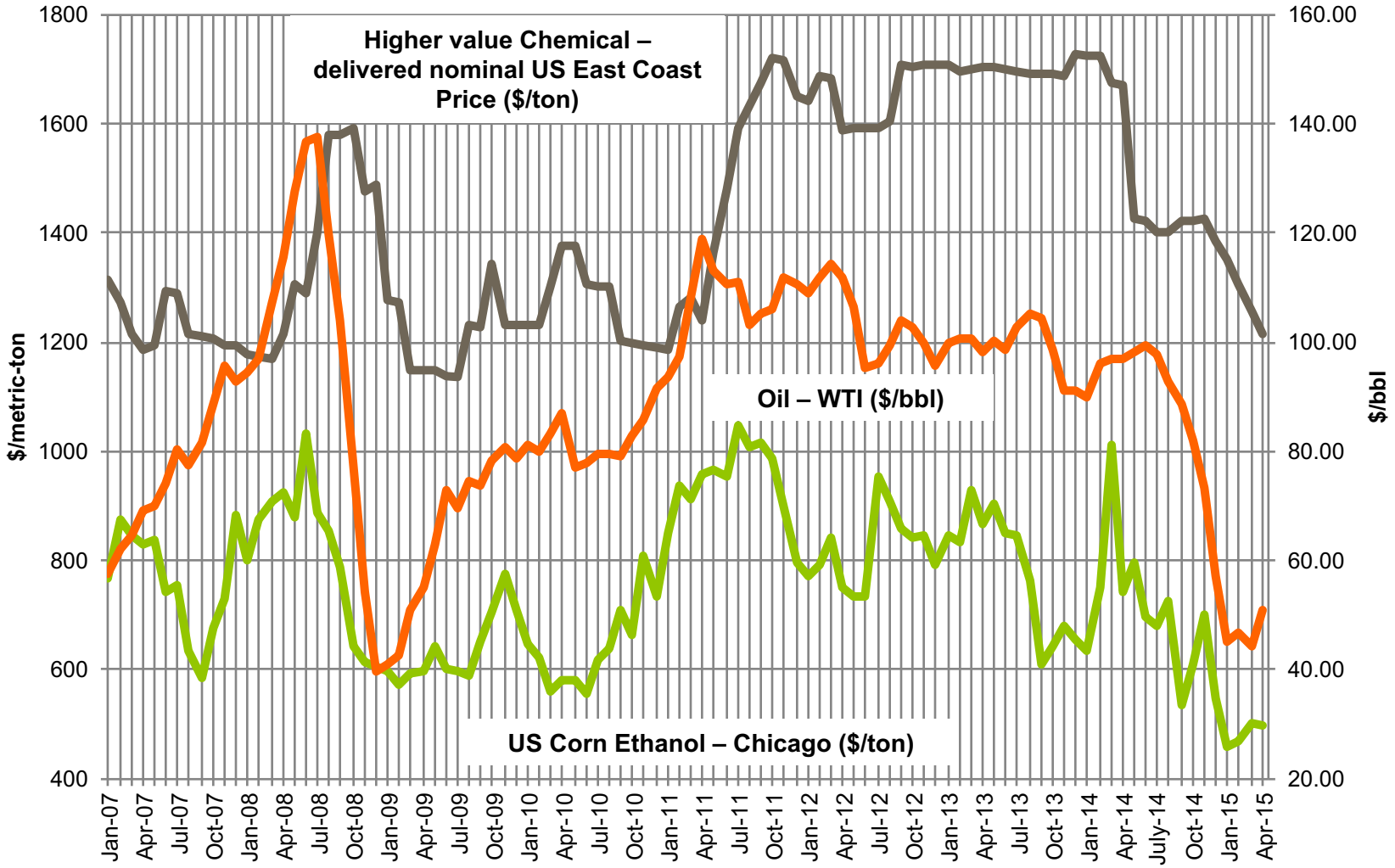
Typical production cost structure of chemical commodities with mature technologies

Often underestimated
or ignored in early evaluations

Cost of feedstock dominates process economics hence:
”Cracking Spread” in oil refining
and “Crush Spread” in corn-ethanol
PROCESS SPREAD



Spread Analysis. Ethanol to higher value chemical.



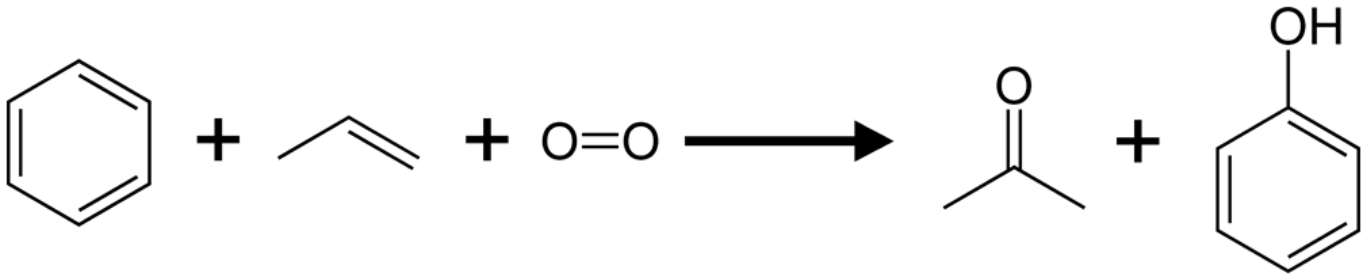
Low oil is not killing the opportunity, but beware of feedstock producer economics!

Values adjusted for inflation. Sources: EIA-DOE, ICIS, Platts

Understanding the market

- New vs. drop-in molecule
  - Product sold on performance vs. specifications
    - Specification pitfalls
  - Performance improvement of new molecule needs to sufficient to justify the cost of adoption
  - What is the value proposition across the supply chain?
  - Realistic market development time
- Market size
  - Overall market size
  - Impact of new production
  - Market balance
  - Market disposition
    - Consumers/Users profile
    - How the market is being served
  - Competitive dynamics and how they affect the price
  - Incumbent economics
- Impact of logistics, sales and distribution cost
  - Location
  - Domestic vs. Import
  - *Net back price = Sale price – **cost of sales – distribution** – end buyer discount.*
- Feedstock dynamics
- No “green” price premium but ”green” marketing advantage is possible
- Unlike fuels, chemicals are typically not sold in transparent over the counter cash markets, hence the determination of realistic market price is often not trivial

Incumbent economics: what drives their business and margin structure



- Example: Acetone production.
  - **MARGINAL ECONOMICS**: Acetone is co-product of phenol in the Cumene process. Phenol drives the economics which means that acetone producers can sell at **75% of propylene** price and go break-even.
  - **IMPACT OF PORTFOLIO**: Because phenol is the profitability driver, they could push the price below current market value to keep market share.
  - **CAPITAL COST ADVANTAGE**: Fully depreciated plants or sunk capital

Waste economics. MSW example

- Is the landfill diversion opportunity really worth $30/ton?
- Not necessarily because landfill margins may allow to reduce the tipping fee to a level to make the diversion not competitive
  - This is the reason why many MSW to Power project eventually failed.

As soon someone can make money out of it is not really a waste. It becomes a commodity!

Market fragmentation. Same molecule. Delivered in many volumes and containers

Several medium consumers 5000 to 1000 tpa Truck, and IBC containerS, small delivery

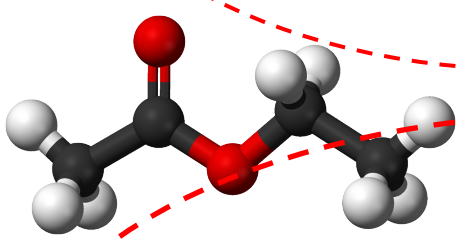
Adhesives
4.1%

Pharmaceuticals
15.3%

Few large and medium consumers > 5000 tpa Railcar, truck, and ISO container delivery

Other (food, packaging, industrial solvents)
9.9%

Paints and Coatings
51.1%



Cosmetics
4.1%

Printing Ink
15.7%

Many small consumer <<1000 tpa IBC containers. 55 gals drum Very small deliveries

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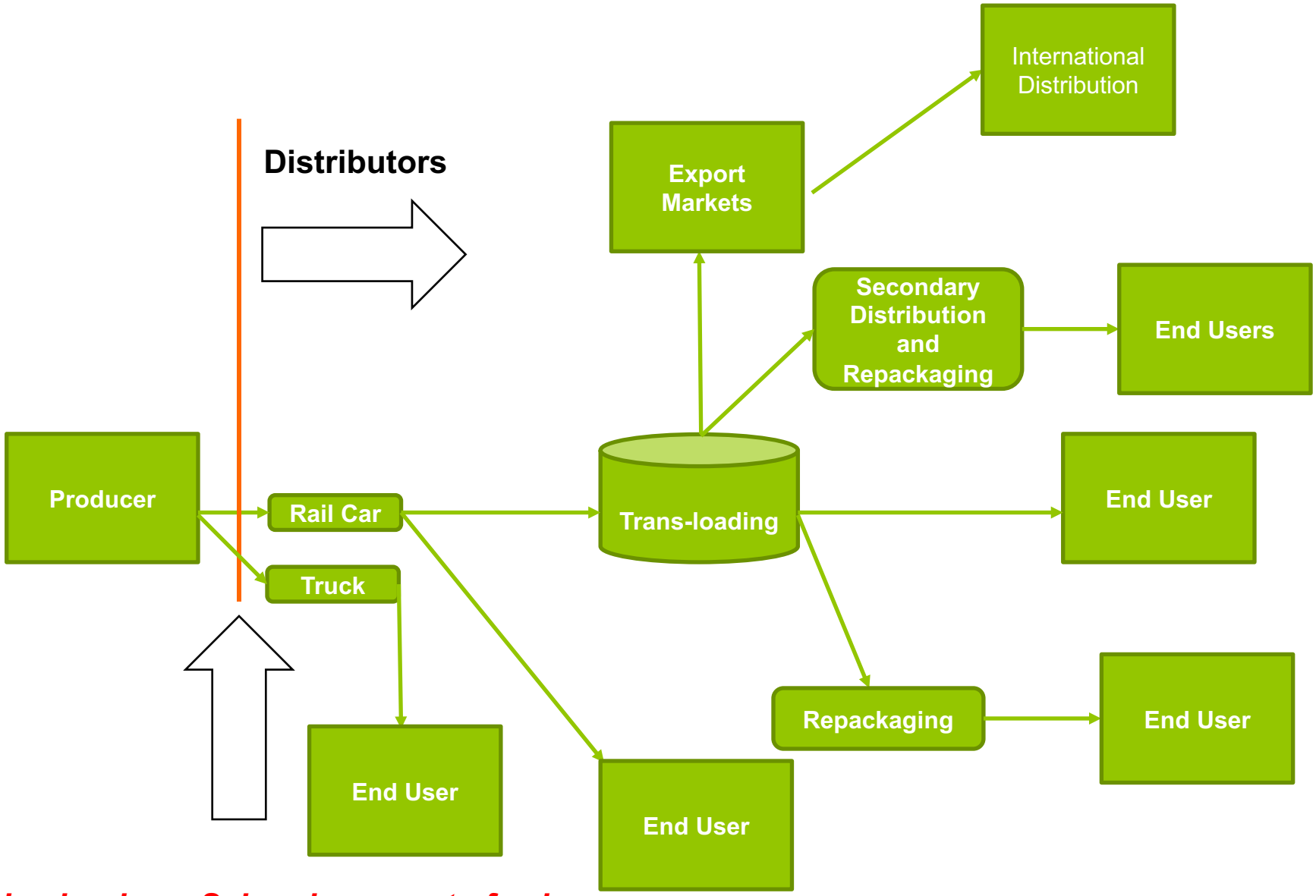
Chemical Distribution in a Nutshell



Net back price = Sale price – cost of sales – distribution cost – end buyer discount.

Producer price determination

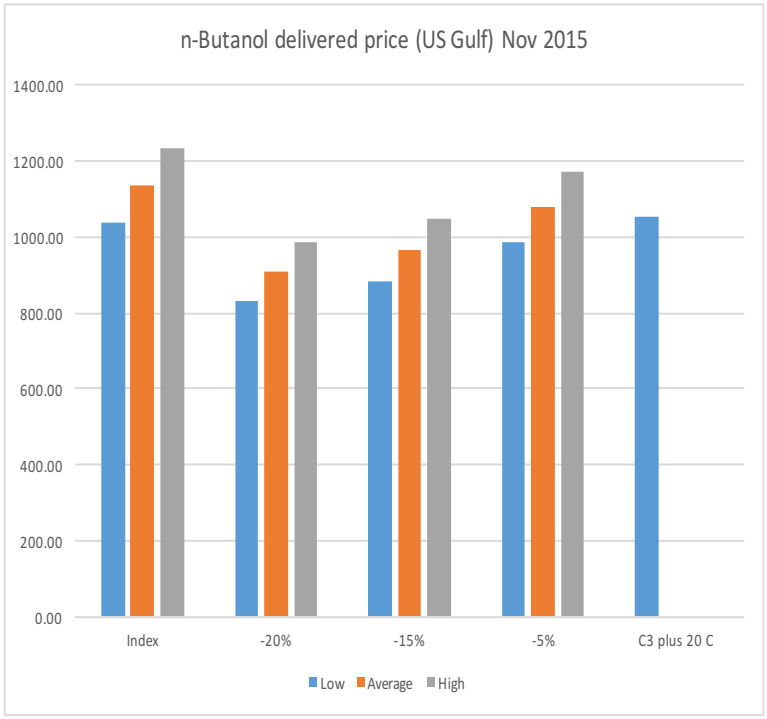
- Use an index as a basis, e.g. ICIS when exist and detract.
  - Index prices are at best indicative of short term spot delivery
  - Index prices from market consultants are typically very optimistic
  - Different index may exist for different products
    - e.g. cost plus when tied to a more transparent commodity
- Cost of sale
  - Commission paid to distributors
  - Typically either a discount on an agreed market price (7% to 10%) or a percentage of the actual gross sale price (4% to 8%)
- Distribution cost
  - Freight and logistics at least $80/ton on average
    - US rail freight typically $50-70/ton
    - Trans-loading costs $20-$40/ton
  - Higher for truck transportation and for smaller delivery systems
  - Repackaging, storage, demurrage, duties, insurance, interests, L/C, RTC leases....
- End user discount
  - Depends on volume and length of contract
    - Large users (>5000 ktpa at least 12 month contract): index minus 20% to 30%
    - Medium users (5000-1000 ktpa): index –15%
    - Small users (<1000 ktpa): index flat to -10%

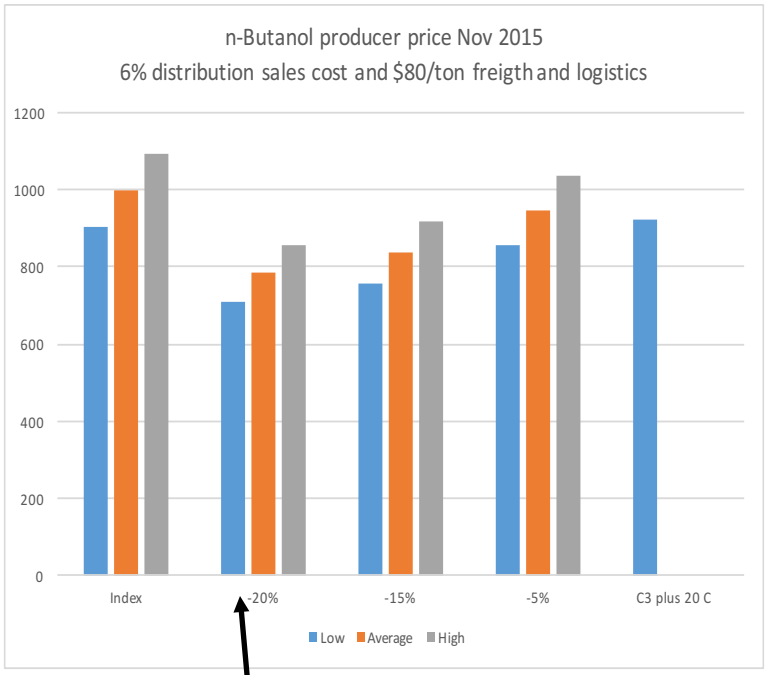
Example: n-Butanol pricing

We conducted a thorough market study for n-Butanol. In general, there are various price tiers within the n-Butanol market. The very large consumers buy at a C3+20 cts/lb feedstock formula or a substantial discount of 20%+ from the ICIS publication. Medium-sized consumers are around ICIS-15% and smaller ones anywhere between ICIS flat and -15%, depending on how much they buy and ***how informed*** *they are.*

VP of large ($9billion) chemical distributor

ICIS published price: >$1200/ton
Real net back as low as $650/ton





Index: ICIS contract price, 11/15
Propylene price: ICIS chemical grade avg. contract 11/15

Do the economics work here?

Thank you for your attention!

Voyages of discovery are not made by seeing new place but by having new eyes

Marcel Proust