



**SBE's Commercializing Industrial
Biotechnology**

Economic Realities and Opportunities

In Commercializing Industrial Biotechnology

September 28, 2015 Final

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- Introduction and background
- General project economics
- Illustrative biotechnology economics
- Expected future developments

Introduction and background

Why is industrial biotechnology important?



- Advanced ABE
- Acrylic Acid
- Algal oils/fatty acids
- BDO
- Butadiene
- CO-rich gas fermentation
- Farnesene
- Flavors and Fragrances
- Food substitutes
- Isobutanol/Isobutylene
- Itaconic acid
- MSW to RDF
- Non-food-based ethanol
- PHAs and derivatives
- Succinic Acid

Now



Later



What is important in industrial biotechnology economics?

- Productivity
- Yield
- Titer
- Energy balance
- Metabolics
- Specificity
- Recalcitrance
- Resilience
- Inhibition
- Etc., etc., etc.



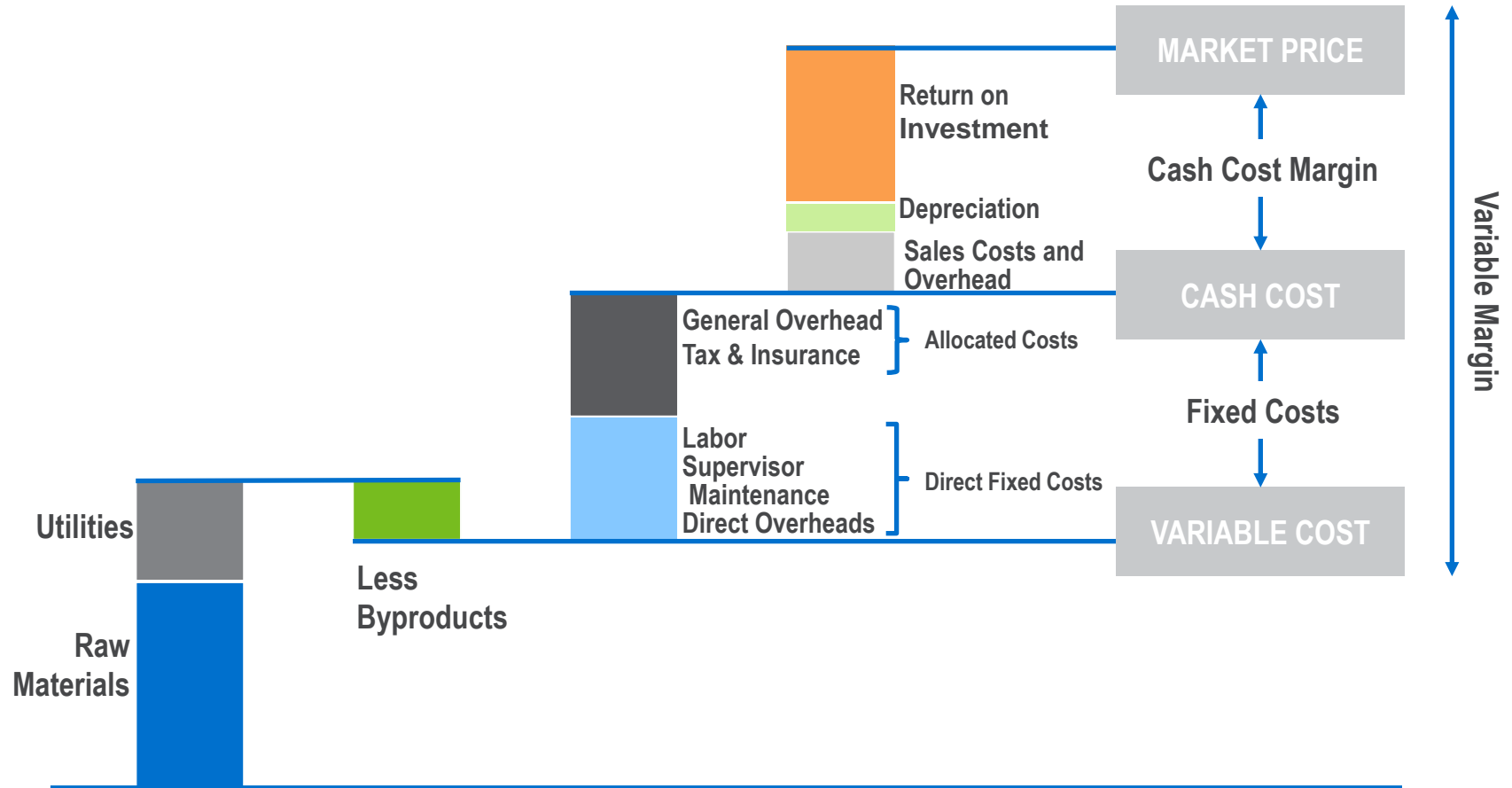
Cost

Volume

General project economics

Operating cost economics

Elements of the Cost of Production



Capital cost economics – ISBL and OSBL are the primary contributing sources to project capital expenditure

- **Inside Battery Limits (ISBL)**
 - Components directly responsible for product manufacture
 - Process equipment
 - Process unit/areas associated property
- **Outside Battery Limits (OSBL)**
 - Items required in addition to processing units
 - Storage, utilities, etc.
- **Other Project Costs**
- **Working Capital**

Scale-up is the practice of deploying innovative processes in commercial facilities

- **Scale-up is a challenge with any new technology**
- **A process has successfully scaled if it:**
 - **Is successfully started up and operated**
 - **Achieves design targets for titer, productivity and yield**
 - **Produces near the expected manufacturing cost**
- **Scale-up is not simply moving to larger scale units!**
 - **Scale-up is a process of building operational knowledge, de-risking operations, and working out the kinks in the process**
 - **An often under-estimated part of scale-up is the commissioning and start-up of a plant**
 - **It often gains (and indeed requires) operating improvements over smaller scale units**

Industrial biotechnology scale-ups have inherent challenges in dealing with living organisms and fermentative processes

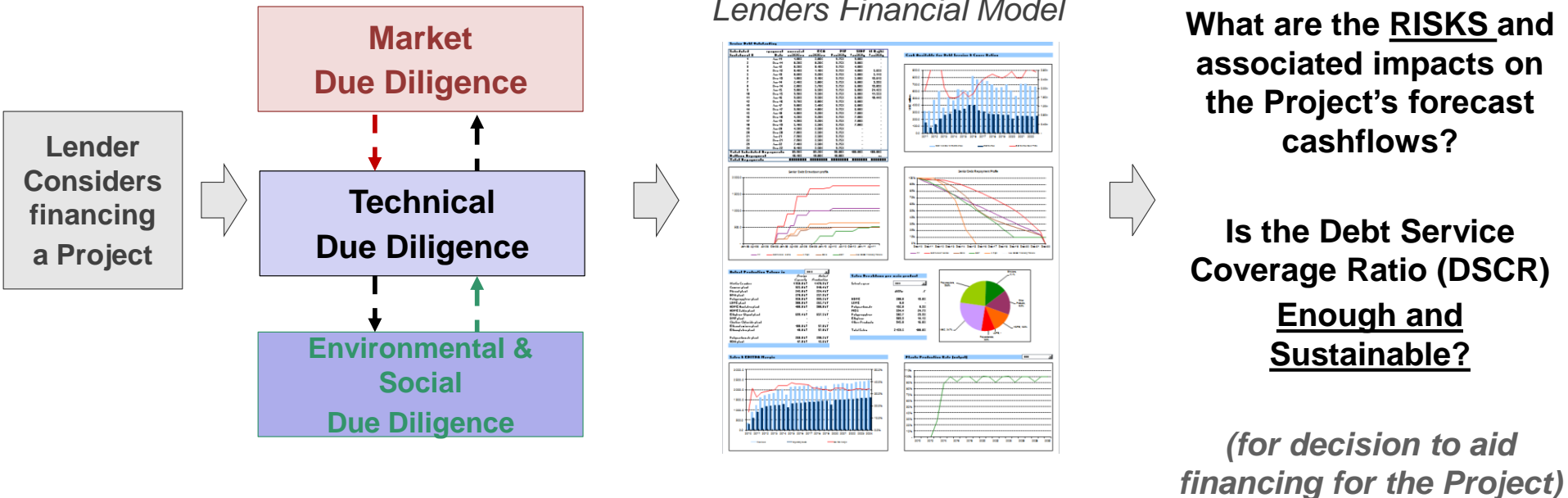
Financing a project is a “taxing” endeavor

Considerations for financing

SCOPE OF WORK

ECONOMIC ASSESSMENT

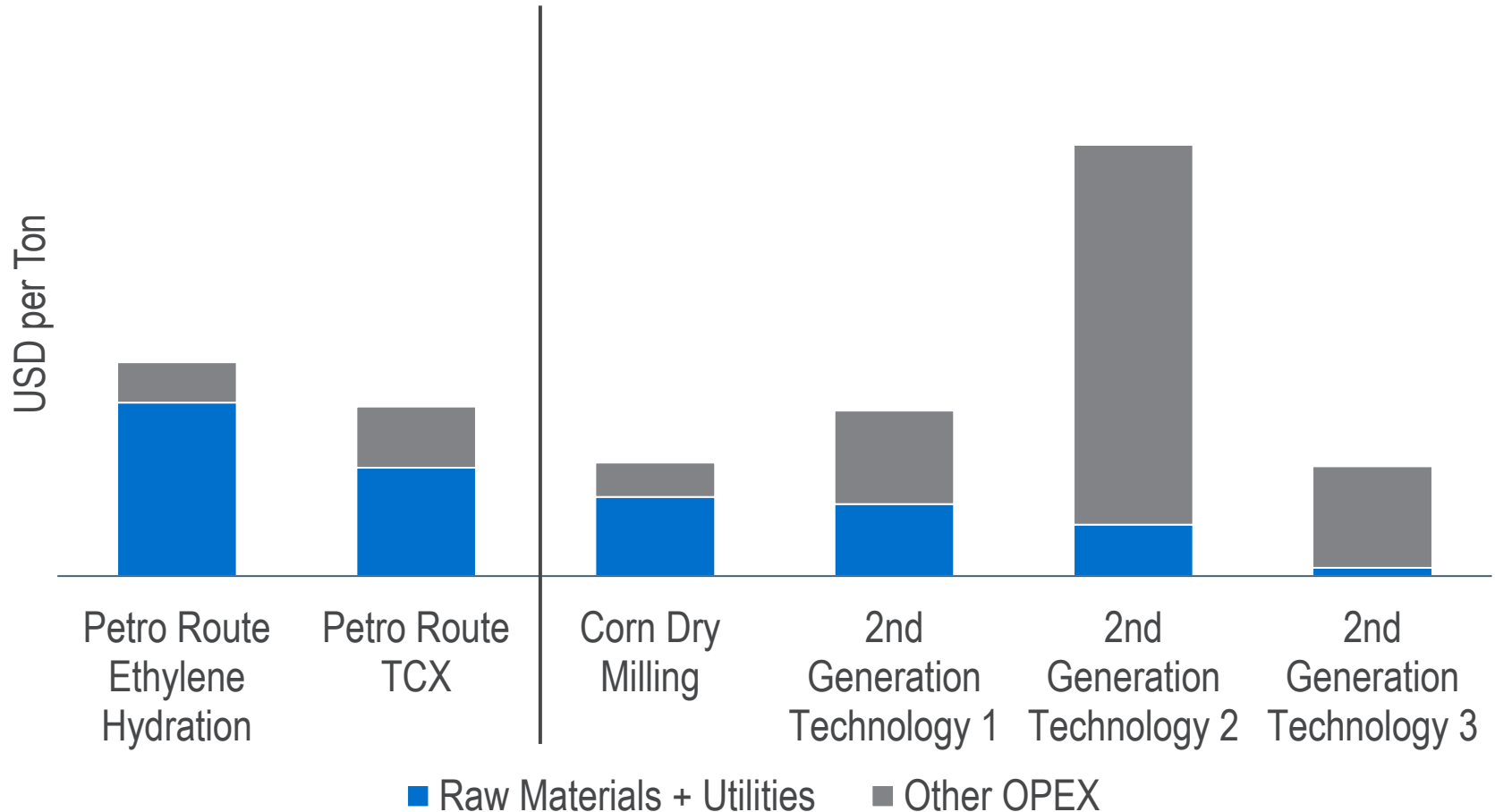
LENDER QUESTION



Illustrative biotechnology economics

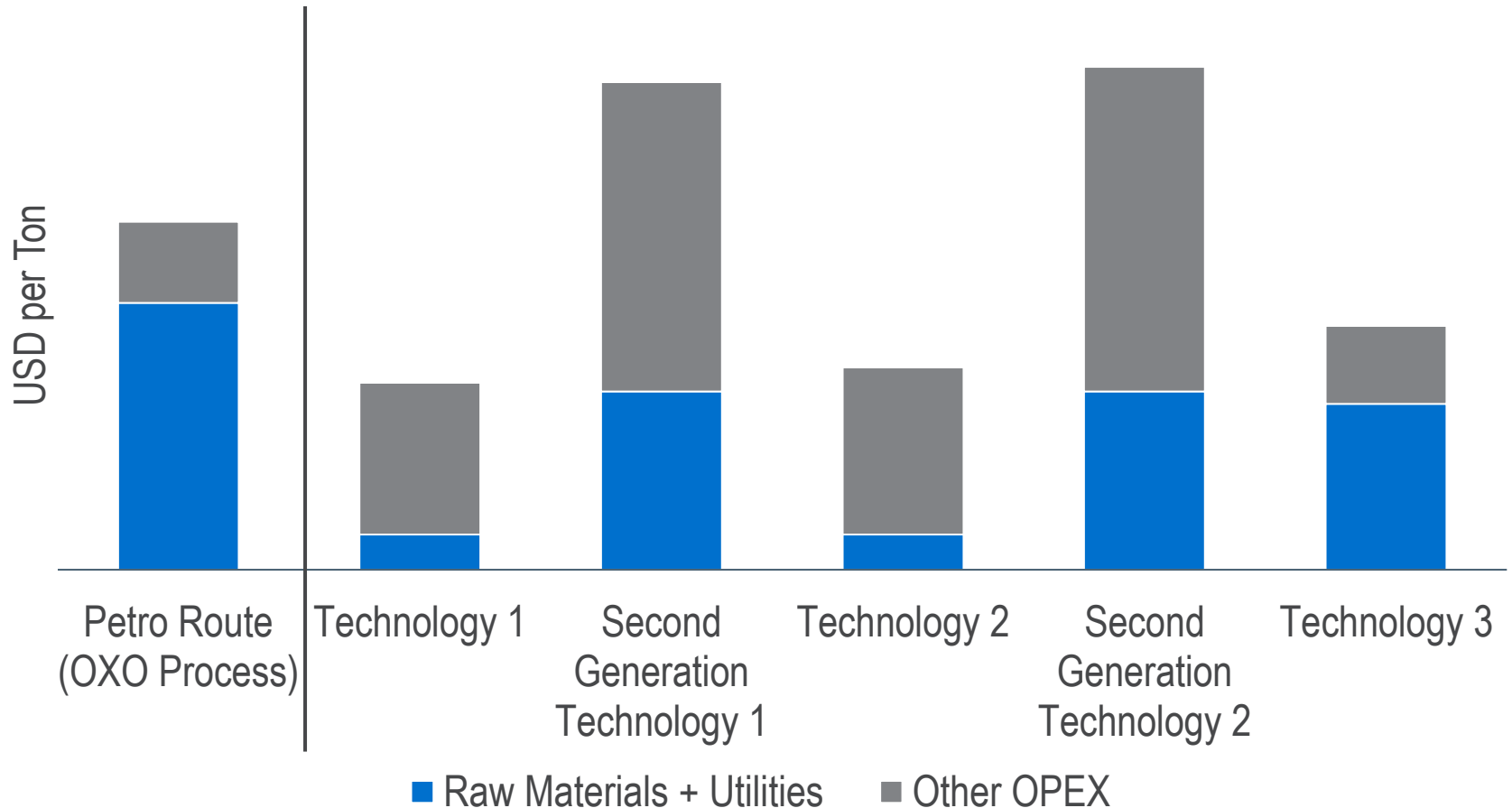
In ethanol operating costs, 1st and 2nd generation biotechnologies show lower costs than petro routes

Ethanol Operating Costs by Production Technology, USGC



In n-butanol, 1st gen biotechnologies are low cost but 2nd gen biotechnologies have a way to go

n-Butanol Operating Costs by Production Technology, USGC



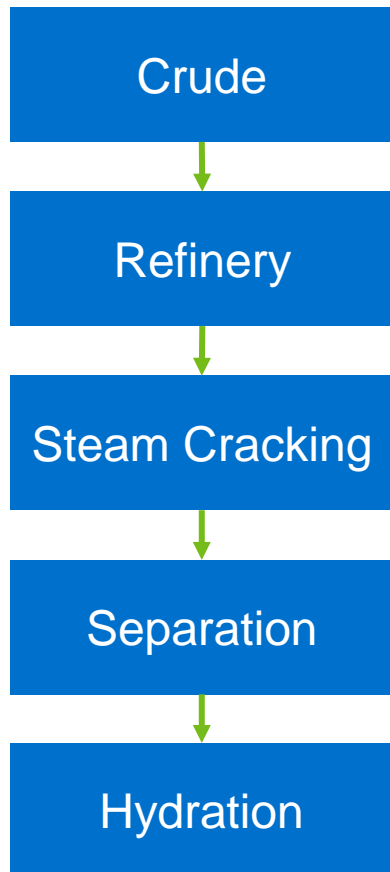
Feedstocks each have specific plusses and minuses

- Petro-based products tend to track oil through all its volatility
- Natural gas has decreased in price in the United States and is especially “available” when stranded or flared
- Coal has little oxygen, but needs hydrogen to make fuels and chemicals
- Biomass is costly to transport and process, although coal can be as well
- Biomass needs much oxygen removal to make fuels and chemicals

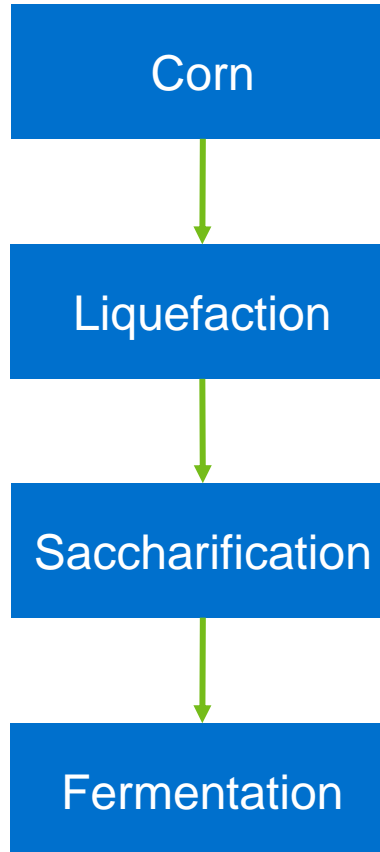
Economics depend on whether you make a hydrocarbon or an oxygenate

Conceptually, industrial biotechnology routes can be simpler and contain fewer steps than petro-based routes

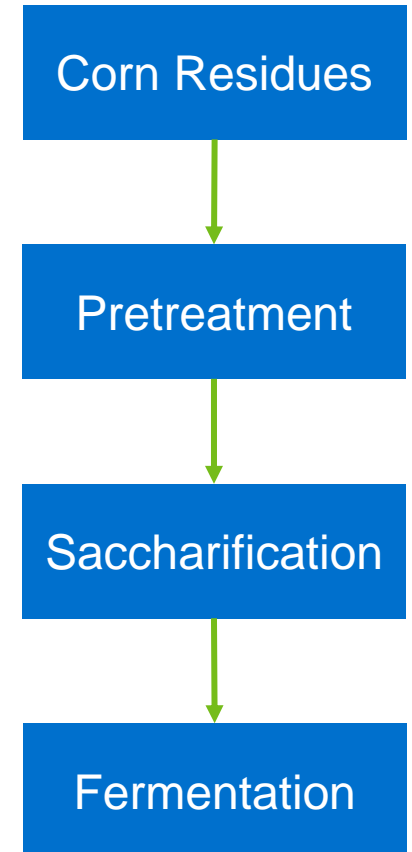
Petro-based



1st Generation

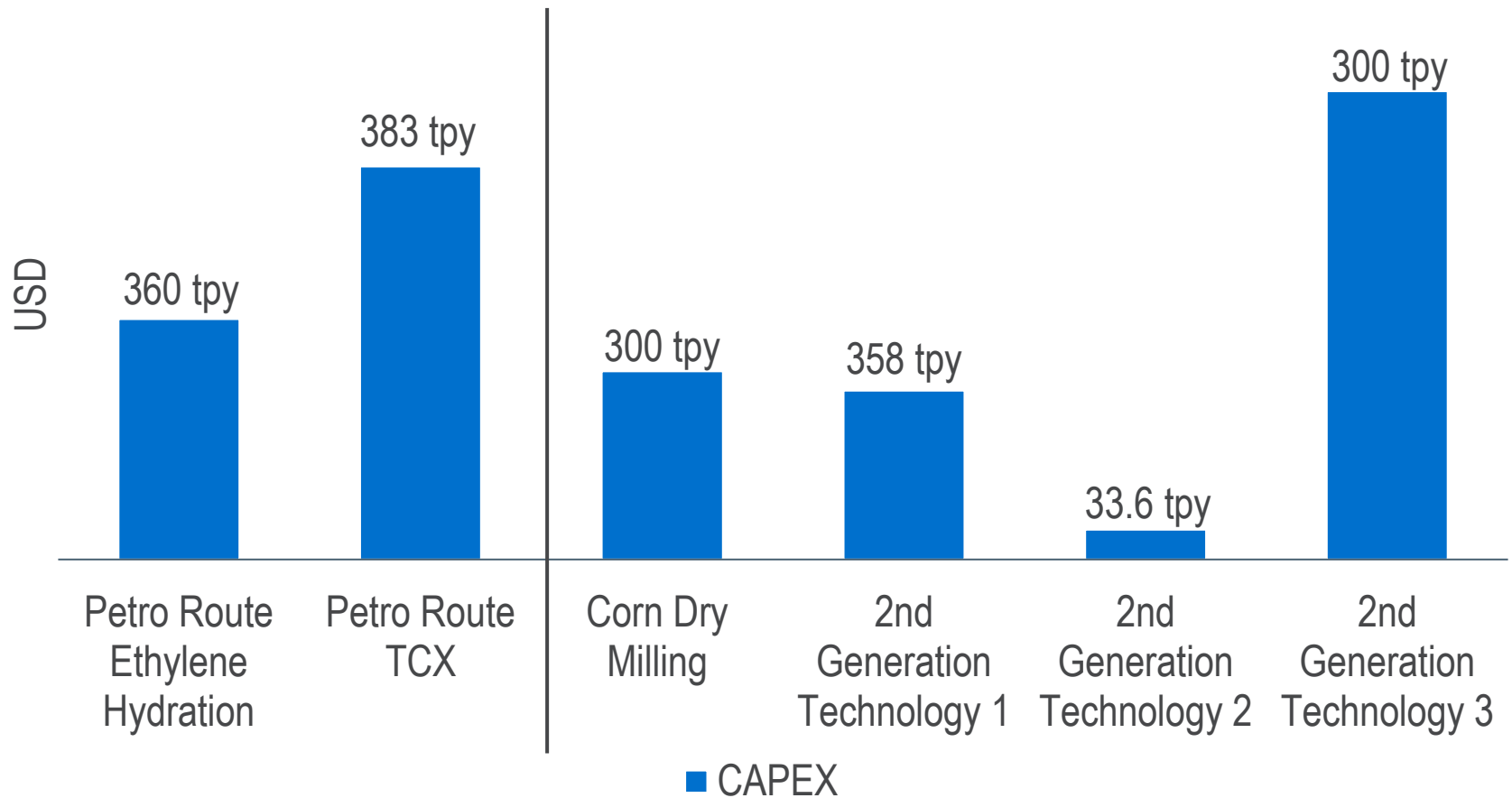


2nd Generation



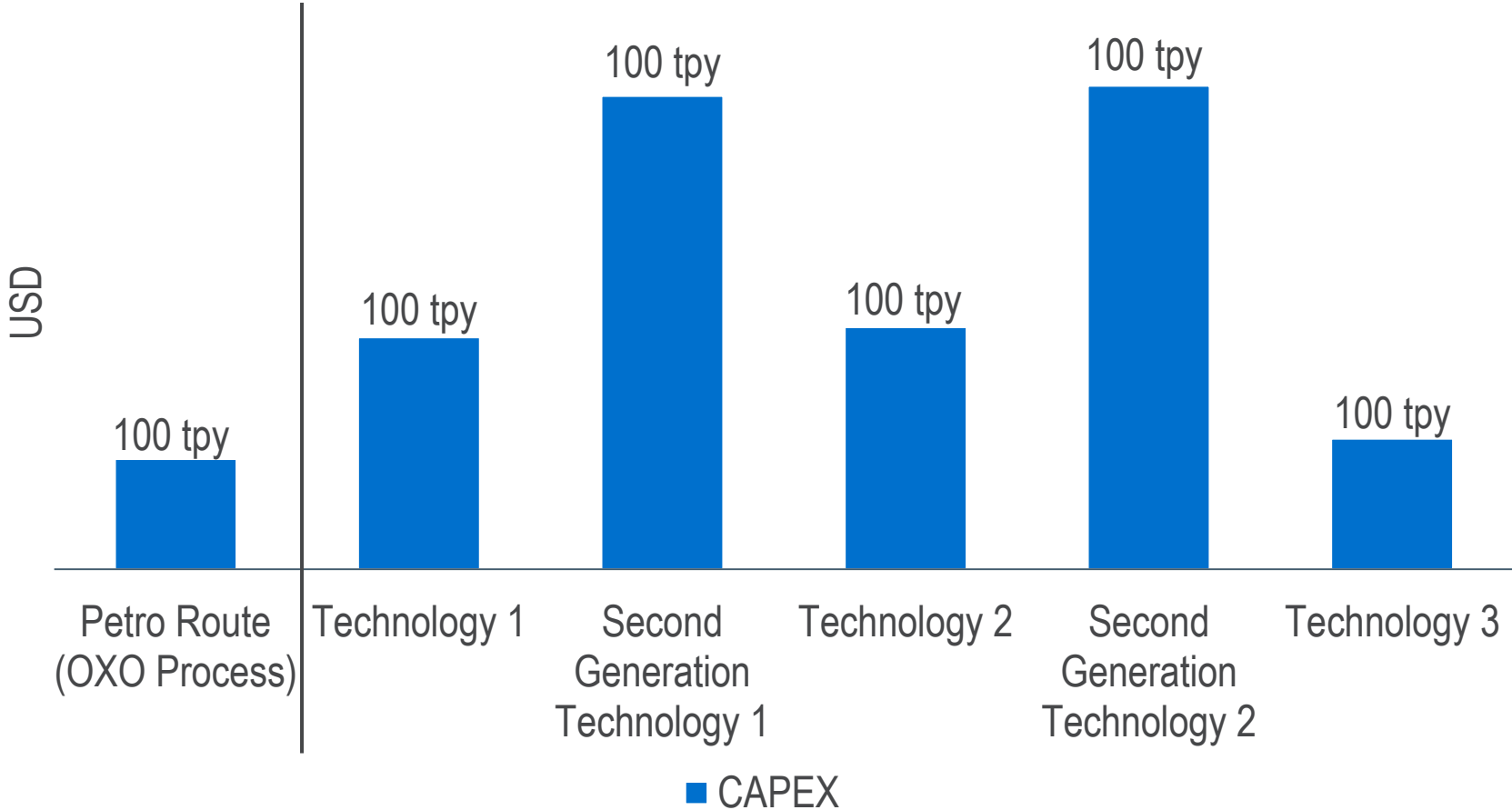
Cap ex for biotech ethanol plants are competitive with petro routes for similar scale plants

Ethanol Production Technologies, USGC



Biotech routes to n-butanol generally require higher capex for the same size plant

n-Butanol Production Technologies, USGC



Expected future developments

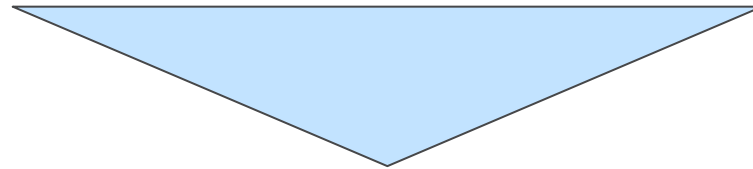
Expected future developments focus on broad, large-scale commercialization of industrial biotechnologies

- **Efficiency/yield/titer increases**
- **Evolution/deployment**
- **Further efficiency/yield/titer increases**
- **Size/economies of scale increases**

Increasing scale will improve both the economics and the attractiveness of financing



- Operating efficiency
- Yield and titer
- Size, economies of scale



DRIVE LOWER



- Cap ex/unit
- Op ex/unit
- Challenges of financing commercialization

Commercializing industrial biotechnology offers opportunities that are checked by realities

■ Opportunities

- Less price volatility than petro-based products
- More direct routes, on-purpose production of anything
- Meet growing demand for “good” products, driven by megatrend

■ Realities of small denominators – economics depend on spreading capital&operating costs across large volumes, but:

- 2nd gen biotech tend to be, at least for now, smaller volumes
- And if not operating at capacity, denominator is smaller and costs per unit are higher
- Getting a full scale commercial biotech plant to work has been likened to a symphony

A symphony requires simultaneously clicking on all cylinders

“Every instrument is precious and adds to the complex beauty of the symphony”

Joseph B. Wirthlin

Nexant provides expertise across the energy and chemicals value chain

Nexant proposition		Differentiation
Transaction Support	<ul style="list-style-type: none"> Project finance: Lenders' independent market, technical and environmental consultant M&A (corporates and private equity): Commercial, technical and environmental due diligence support Buy-side due diligence and vendor due diligence 	High-quality risk and value focused evaluation based on real market and technical insight
Technology Assessment	<ul style="list-style-type: none"> Technology and operational benchmarking Cost of production modelling and benchmarking Technology evaluation and screening 	Strong team of engineers with deep understanding of chemicals process technology
Strategic Planning	<ul style="list-style-type: none"> Corporate strategy development and business plan review; master planning Portfolio analysis and market segmentation studies, feasibility studies Strategic options and screening, innovation strategy, market entry, company and product acquisition screening, corporate vision development, management workshops 	Deep industry knowledge Able to identify commercially viable strategic options
Commercial Analysis	<ul style="list-style-type: none"> Supply / demand, trade-flows, price and margin forecasts, and value chain analysis Competitor analysis, market research, interview programs (customer, competitor & suppliers) Financial modelling and valuations 	In-house database with a proven methodology – accepted by Boards and banks
Independent Expert	<ul style="list-style-type: none"> Expert advisor Litigation support 	<ul style="list-style-type: none"> Highly experienced and credible

Nexant has considerable experience serving client needs in biotechnology

- **Biotechnology is a particular area of specialization for Nexant in which it has completed a wide variety of client engagements**
 - **Independent/Owner's Engineer, due diligence, and feasibility studies for the design and construction of biotechnology plants**
 - **Assessment/commercialization of hydrolysis and fermentation technologies to produce biochemicals/fuels**
 - **Market assessments and cost competitiveness evaluations of proposed biotechnology plants**
- **Nexant offers:**
 - **Vast experience gained over many years in evaluating the full range of biotechnologies across the world**
 - **Track record of being involved in planning and implementing many successful projects at all stages of development**
 - **A global team of highly qualified experts**

Contact information

Eric Bober

Principal

Nexant

44 South Broadway

White Plains, NY 10601

EBober@Nexant.com

+1-914-609-0302 (office)

+1-914-310-4281 (mobile)



www.nexant.com

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