



## **Bio-based PX for 100% bio-PET**

**International Conference on Sustainable Chemistry & Engineering**

*November 19<sup>th</sup> 2013*

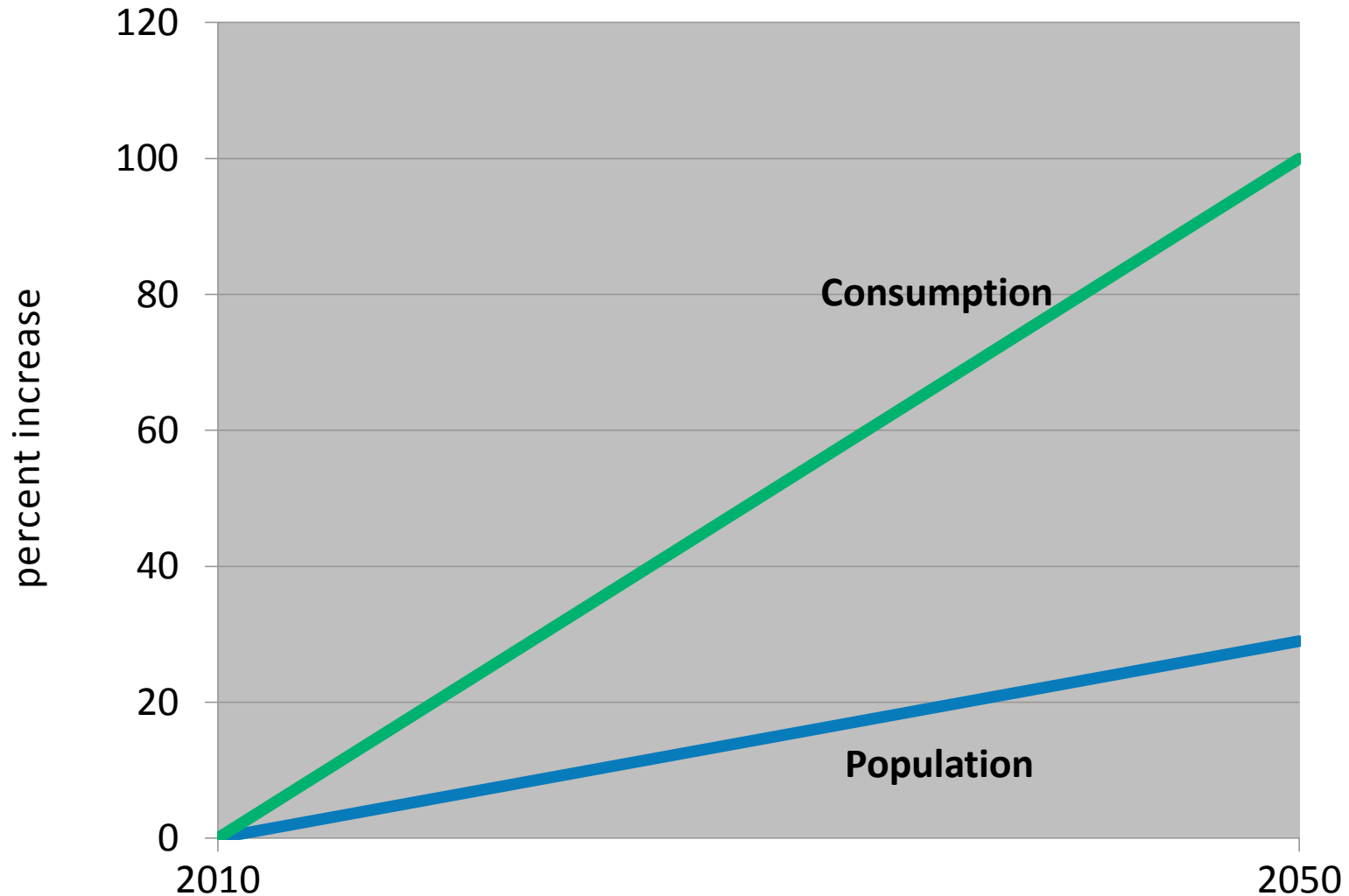
**ecochem**



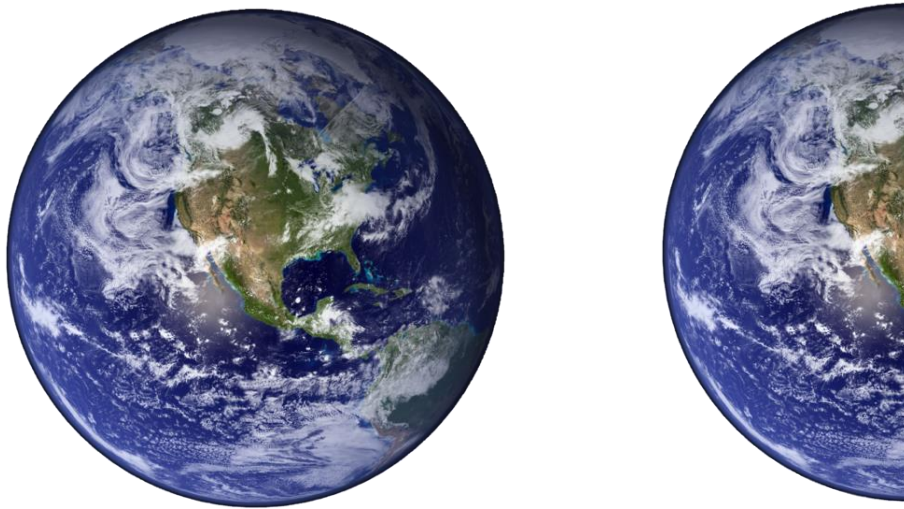
# Virent Vision



# Consumption outpacing population



# Consumption today



*We are consuming 1.5x the ability of the earth to supply resources sustainably...  
yet consumption will grow  
as we **increase quality of life***



# Consumption growth



# Sustainable Consumption

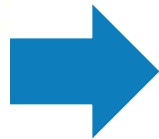


*We can increase the ability of the earth to sustainably supply the resources we need through efficiency, growth and **technology***

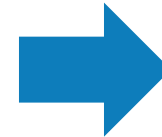


# Sustainable Consumption





**VIRENT**  
**BIOFORMING**





# Converting biomass around the world



...with Virent technologies and partners



# Virent at a glance

*The global leader in catalytic biorefinery research, development, and commercialization*

## Technology



**Catalytically converting plant-based feedstocks to fuels and chemicals**

## Partners & Investors

**Cargill**



*The Coca-Cola Company*

**HONDA**  
The Power of Dreams

## Location



**Madison, Wisconsin, USA**

## Infrastructure



**25x Development Pilot Plants**  
**2x Larger Demo Plants**



# Virent's BioForming® Technology

*Leading catalytic route to renewable hydrocarbon fuels and chemicals.*



*"Eagle" Virent's Biogasoline Demonstration Plant- Madison, WI*

## **Fast and Robust**

- Inorganic Catalysts
- Moderate Conditions
- Industry Proven Scalability

## **Energy Efficient**

- Exothermic
- Low Energy Separation
- Low Carbon Footprint

## **Premium Drop-in Products**

- Tunable Platform
- Infrastructure Compatible
- Fuels and Chemicals

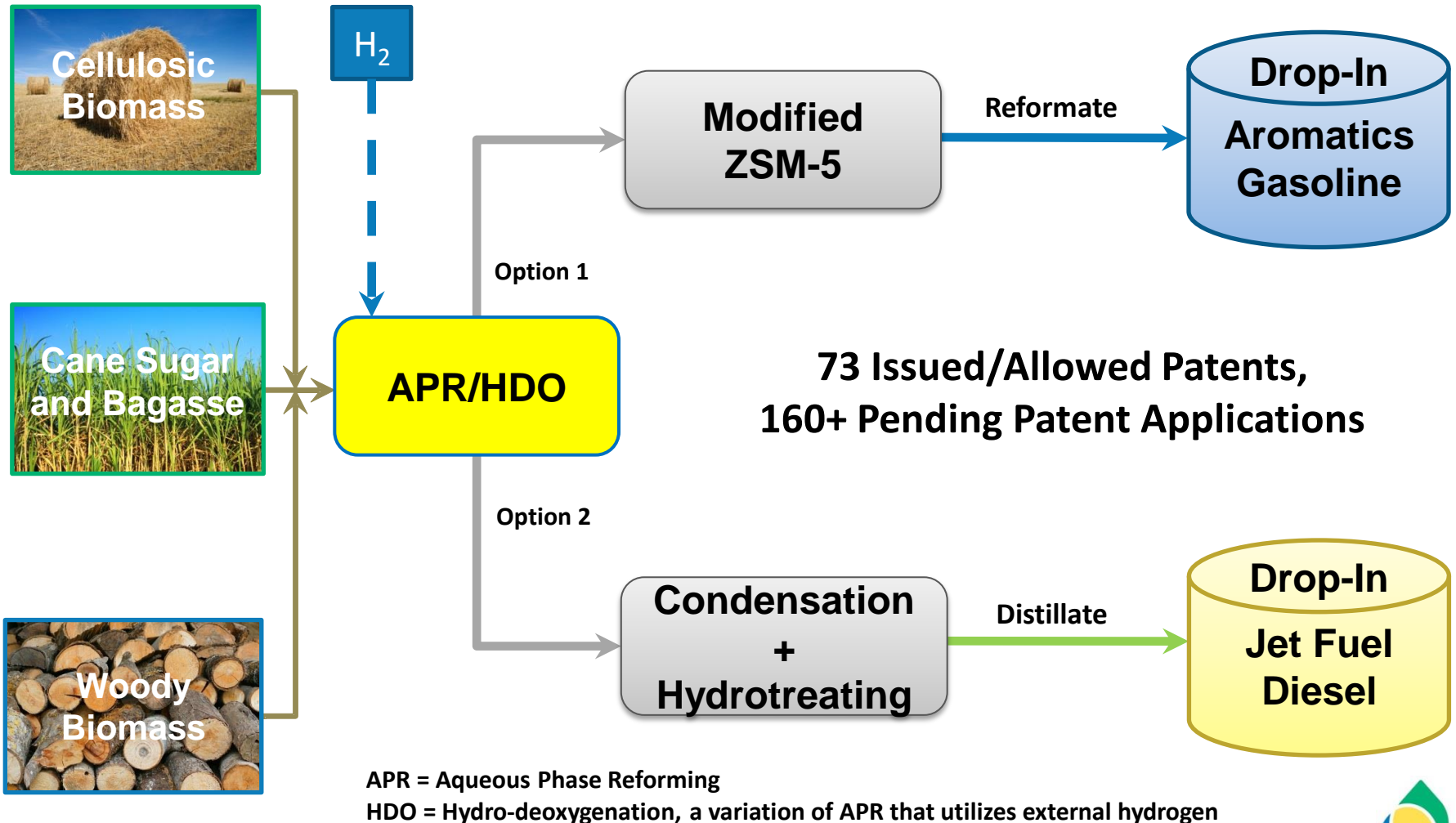
## **Feedstock Flexible**

- Conventional Sugars
- Non-Food Sugars



# The BioForming® Concept

*Bio-based feedstocks to direct replacement products*

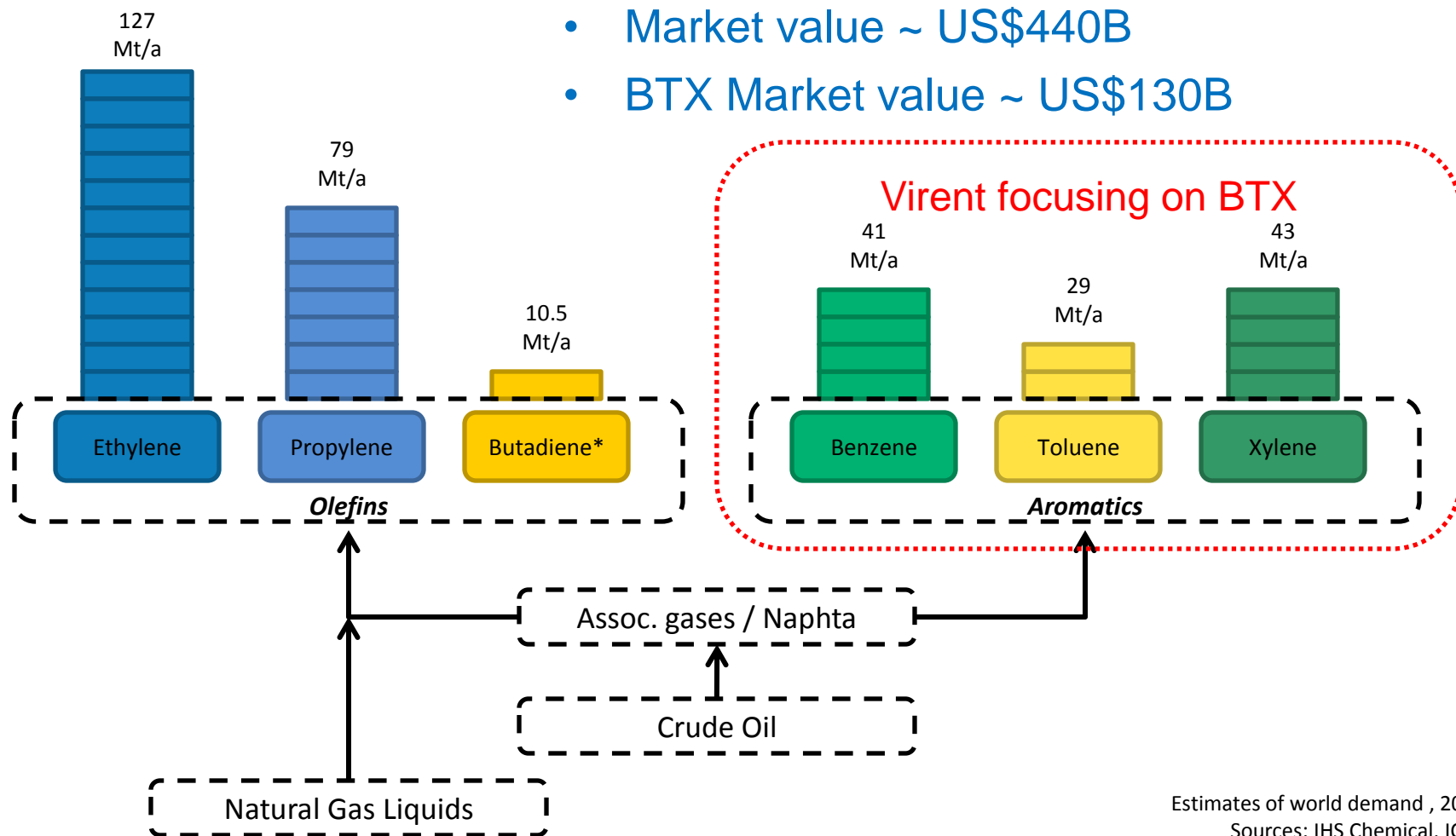


# Biobased Chemicals



# Global Petrochemical Market

- Approximately 330M tonnes in 2011
- Market value ~ US\$440B
- BTX Market value ~ US\$130B

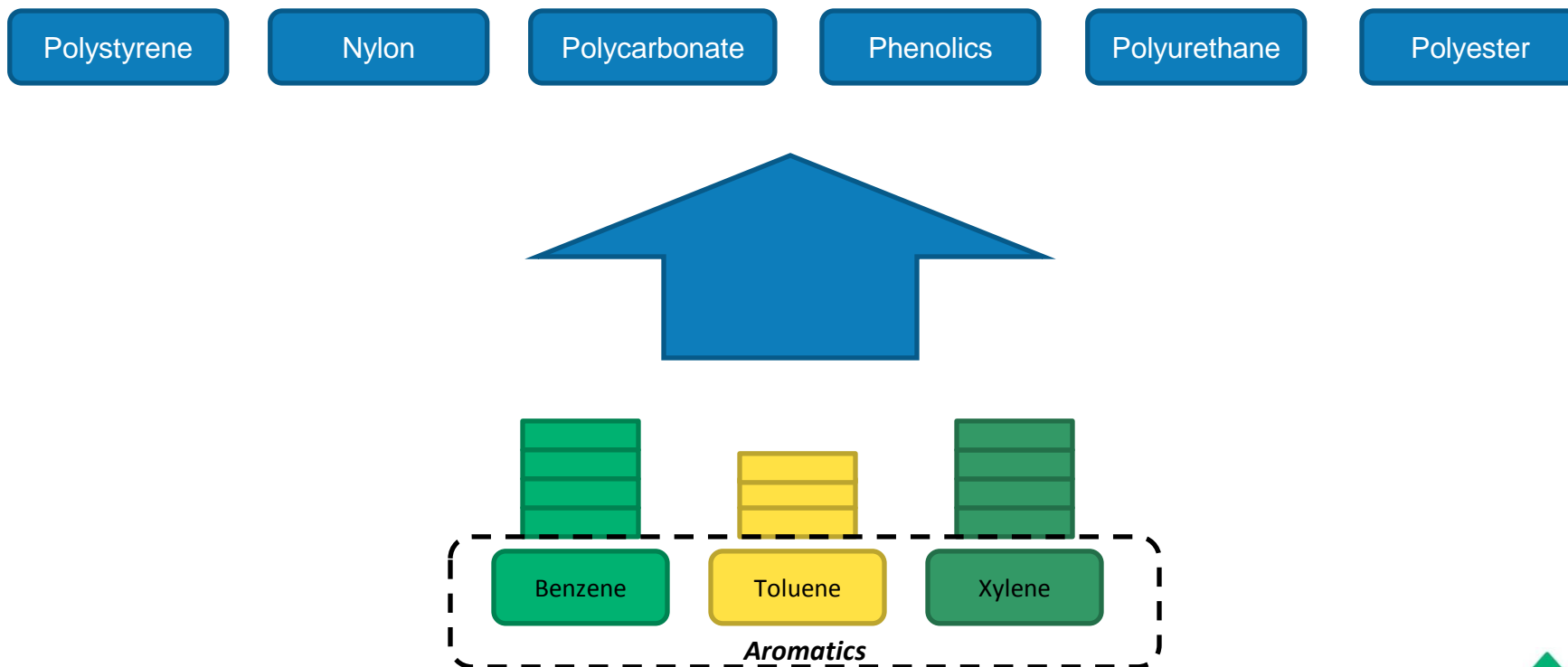


Estimates of world demand, 2011  
Sources: IHS Chemical, ICIS.

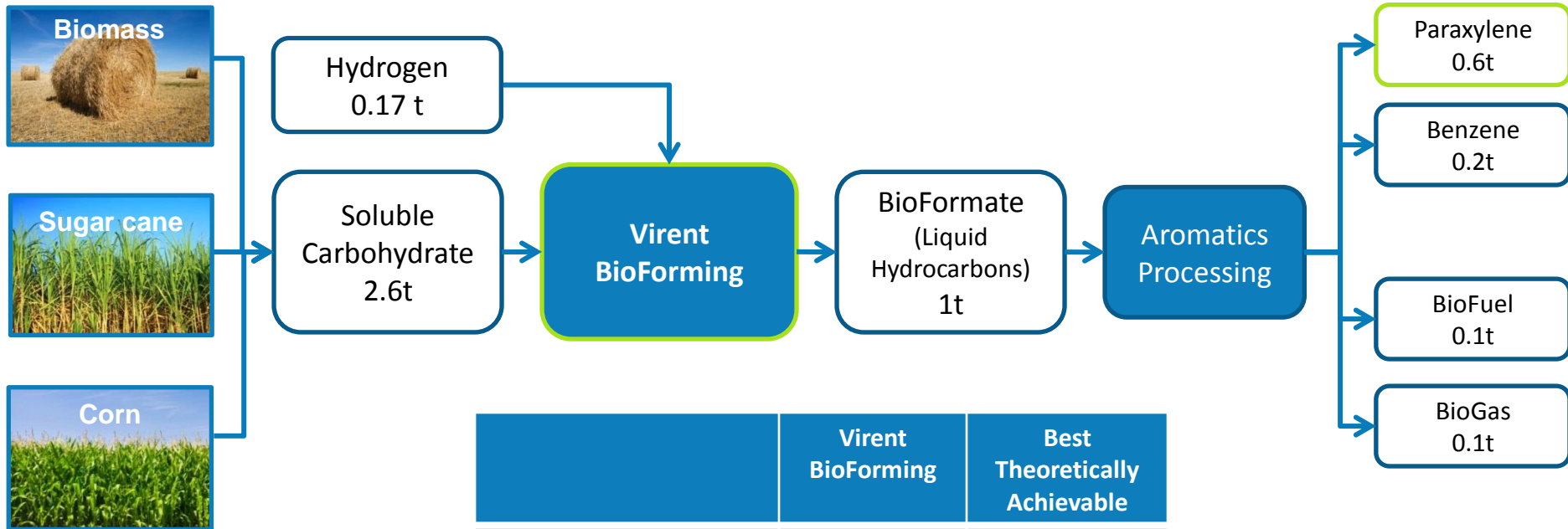


# Global Petrochemical Market

*Same polymers, same performance, same equipment*



# Mass Balance



	Virent BioForming	Best Theoretically Achievable
Specific Feedstock Consumption (mass carbohydrate per mass hydrocarbon)	2.6	2.3
Carbohydrate mass yield to liquid hydrocarbon	38%	43%





# 100% Bio-based Paraxylene



Virent Inc.  
3571 Anderson St  
Madison, WI 53704  
U.S.A

Date: 1/5/2012



ISO-17025 Accredited Testing Laboratory

PJLA ISOMECH 17025:2005 Testing Accreditation# 69423

Beta Analytic Inc.  
4965 SW 74 Court  
Miami, Florida 33155 USA  
Tel: 305-867-5167  
Fax: 305-863-0964  
info@betalabservices.com  
www.betalabservices.com

## Report of Biobased Content Analysis using ASTM-D6866-11

Submitter: Virent Energy Systems, Inc.  
Submitter Label: Virent #48389  
Laboratory Number: Beta-312393  
Material: Bio-liquid  
Date Received: December 16, 2011  
Date Reported: December 21, 2011

## CERTIFICATE OF ANALYSIS

Product name	BioFormPX
Product code	C0101D
Product description	Bio-based paraxylene

Lot number: C0101D-46880-00

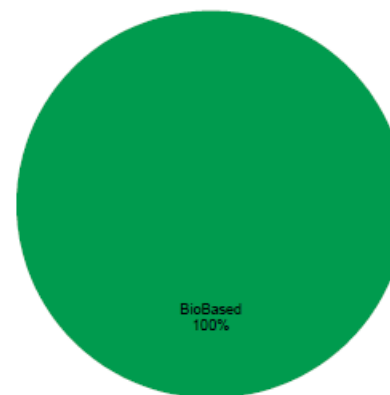
Property	Method	Provisional Specification	unit	Result
PX purity, minimum	modified ASTM D3798 <sup>(1)</sup>	≥ 99.7	wt%	99.98
Toluene, maximum	modified ASTM D3798 <sup>(1)</sup>	≤ 0.1	wt%	≤ 0.01
o-Xylene, maximum	modified ASTM D3798 <sup>(1)</sup>	≤ 0.1	wt%	≤ 0.01
m-Xylene, maximum	modified ASTM D3798 <sup>(1)</sup>	≤ 0.2	wt%	0.01
Ethylbenzene, maximum	modified ASTM D3798 <sup>(1)</sup>	≤ 0.2	wt%	≤ 0.01
Nonaromatic hydrocarbons, maximum	modified ASTM D3798 <sup>(1)</sup>	≤ 0.2	wt%	≤ 0.01
Appearance	ASTM D2090; Visual	(2)	NA	Pass
Color, maximum	ASTM D1209; ASTM D 5386	10	NA	Pass

<sup>(1)</sup> Modified (modifications available upon request)

<sup>(2)</sup> Clear, no sediment when between 18°.3C and 25.6°C (65 to 78°F)

Mean Biobased Result : 100 % \*

Proportions Biobased vs. Fossil Based indicated by 14C content





**M&A DRIVERS BANKERS SEE MORE ASSETS ON SELLING BLOCK UPDATE P14**

**ETHYLENE OXIDE**  
US EO supply is expected to be tight going into April and May after an active turnaround season **42**

**ASIA MDI**  
Further price hikes possible as producers face margin squeeze from benzene costs **43**



# ICIS Chemical Business

March 12-18, 2012

Periodicals Entry

## ANALYSIS OF CHEMICAL MARKETS



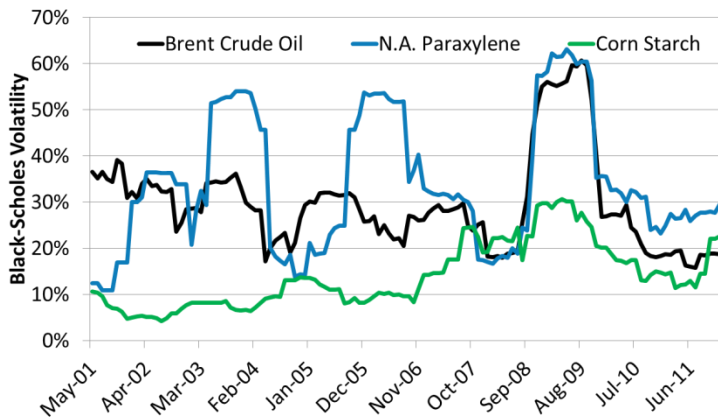
**GREEN CHEMICALS**

### BIO-PX HOLDS THE KEY

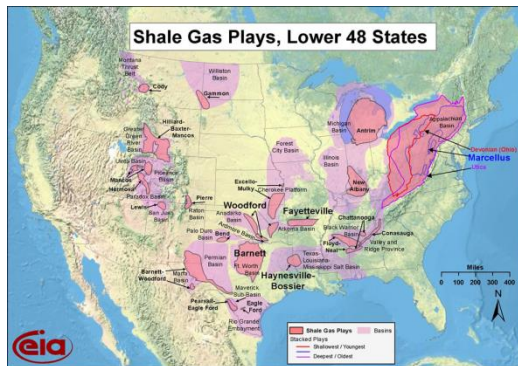
100% renewable PET bottles will need this component



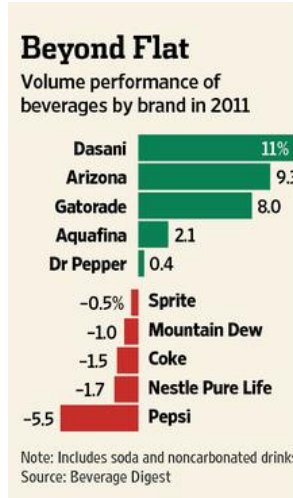
# Why are customers interested?



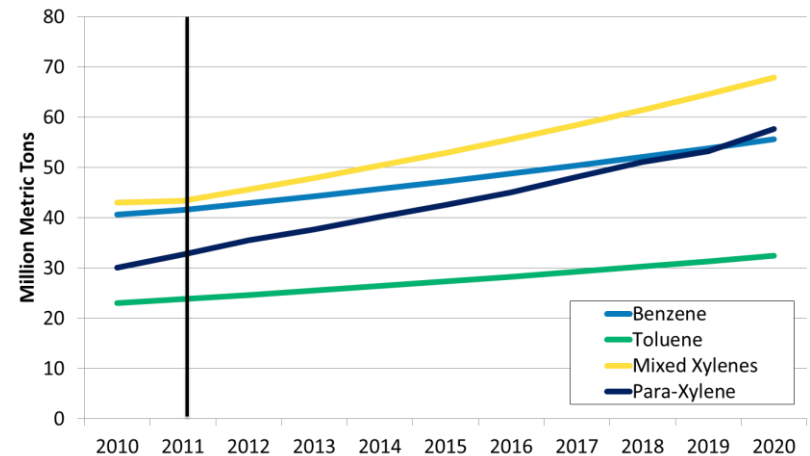
Diversifying supply & tackling volatility



Supply as co-product diminishing



Consumer interest and demands



Projected Strong Global Growth Rates



# Coca-Cola & Virent partnership

- Coca-Cola supporting the commercialization of Virent's BioFormPX™ for use in PlantBottle™
- Multi-million dollar, multi-year agreements with Virent
  - Joint Development Agreement
  - Supply Agreement
- Supporting Virent's plans for first chemicals plant



*The Coca-Cola Company*

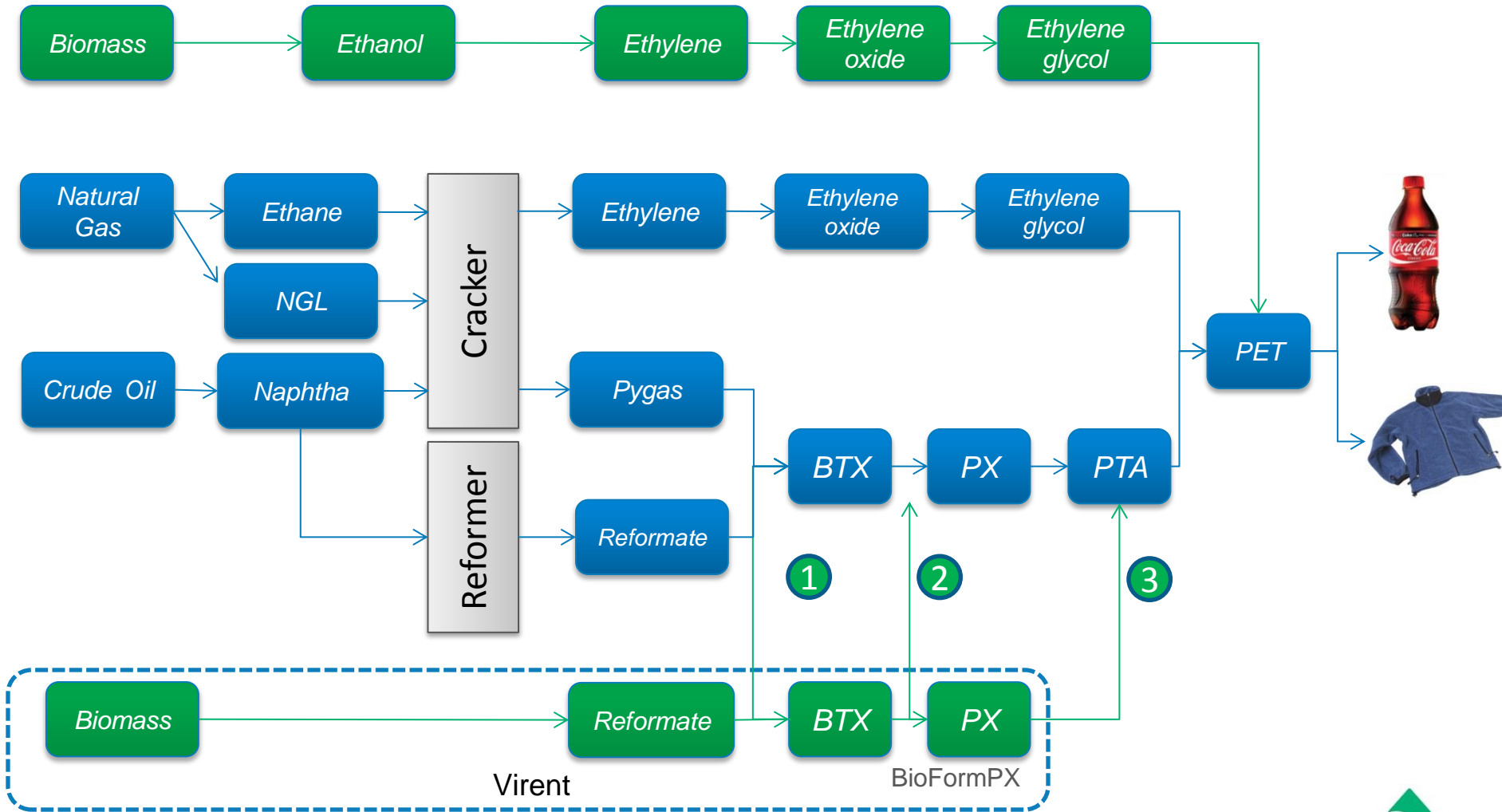


# Challenges

- Scaling and entering into a complex supply chain
- Raising capital for a novel technology
- Competing commodities (petro vs agro)
- Feedstock sustainability is a “moving target”



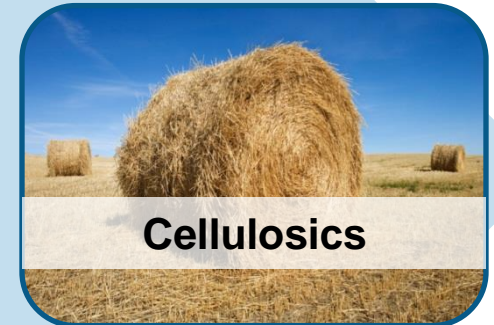
# Bio-PET Supply Chain



# Feedstocks



# Feedstocks





# Cellulosics

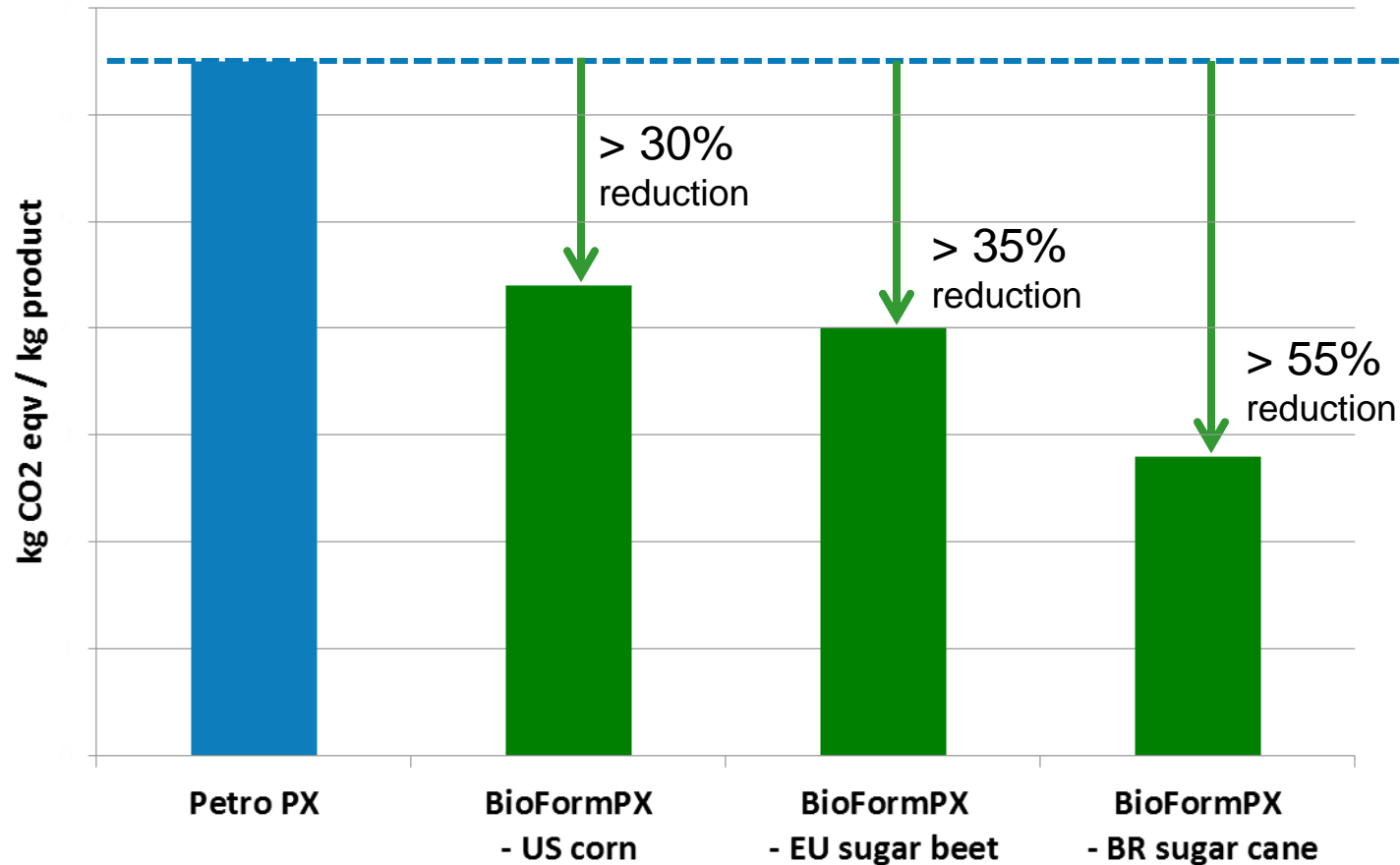


# Sustainability



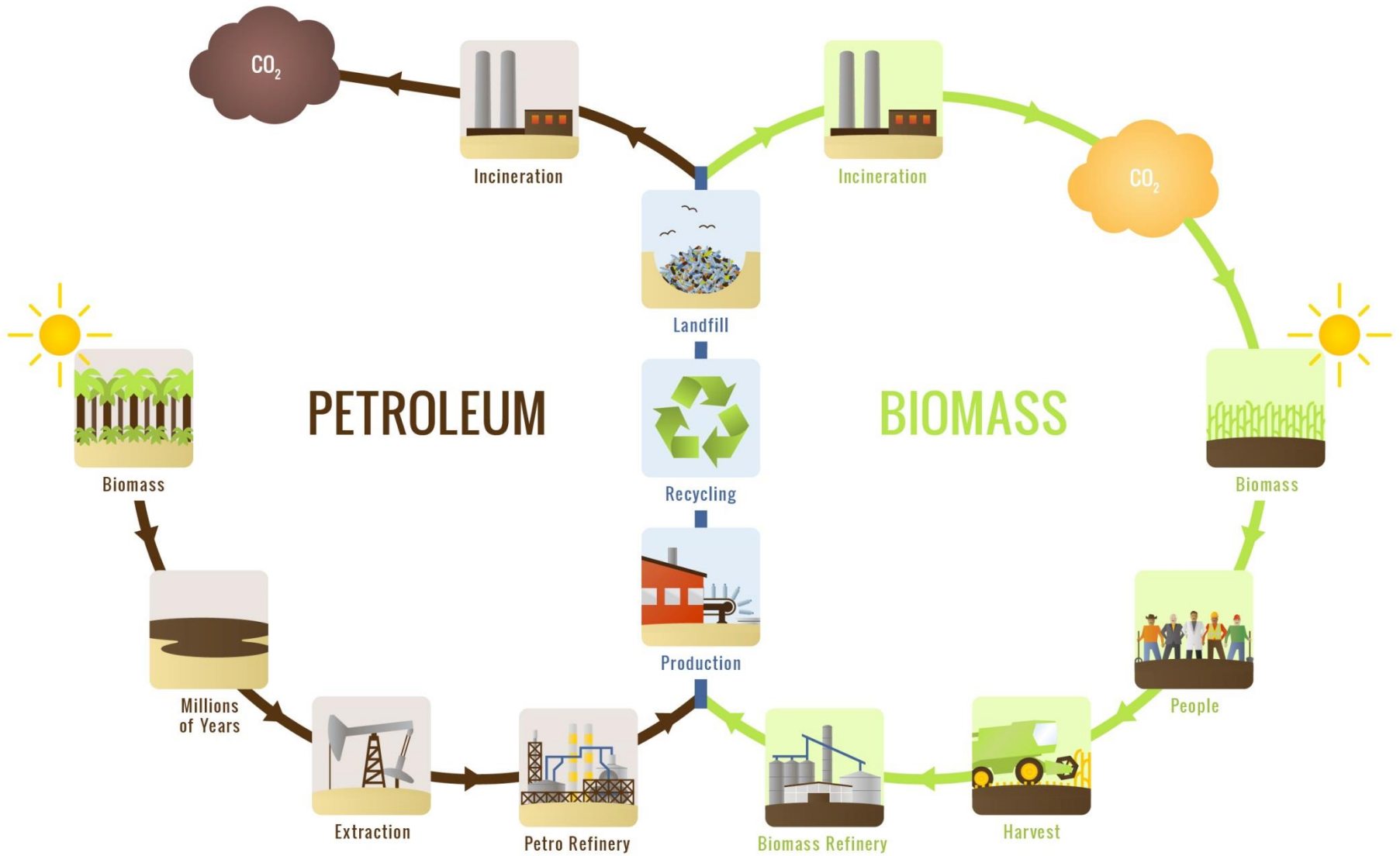
# Green House Gas (GHG) Emissions

## Cradle To Grave Analysis



- Initial Virent internal GHG estimates conducted for one potential commercial plant configuration
- GHG emissions calculated based on economic allocation methodology (5 yr. price average)
- Utilized EcolInvent and GREET data in conjunction with GaBi software for GHG analysis.
- Does not include any transportation effects post-gate.





# Summary

- Leading technology for catalytic conversion of plant matter to direct replacement hydrocarbons, including aromatics.
- Strong strategic partnerships (e.g. The Coca-Cola Company, Royal Dutch Shell, Cargill, Honda).
- First commercial deployment will be bio-PX for the production of biobased PTA and PET.
- Initial deployment for bio-PX will use ethanol as a feedstock for more rapid, lighter capital project
- Growing demand for bio-based aromatics due to
  - Consumer demands and desire for differentiation
  - Shifts in petrochemical supply dynamics and fears
  - Tackling volatility with a portfolio approach
- Developing pathways to advance integration with cellulosic feedstocks and lignin.
- Sustainability is critical and must account for biogenic carbon





# Thank you.

Virent converts plant-based sugars into 100% renewable chemicals and fuels. Our bio-based products are identical to those produced from petroleum—direct replacements that utilize today’s processing, storage and transportation infrastructure.

Kieran Furlong, Director Chemicals Business Development

**[kieran\\_furlong@virent.com](mailto:kieran_furlong@virent.com)**

