Drop-in biofuels in the AEO

EIA Biofuels Workshop

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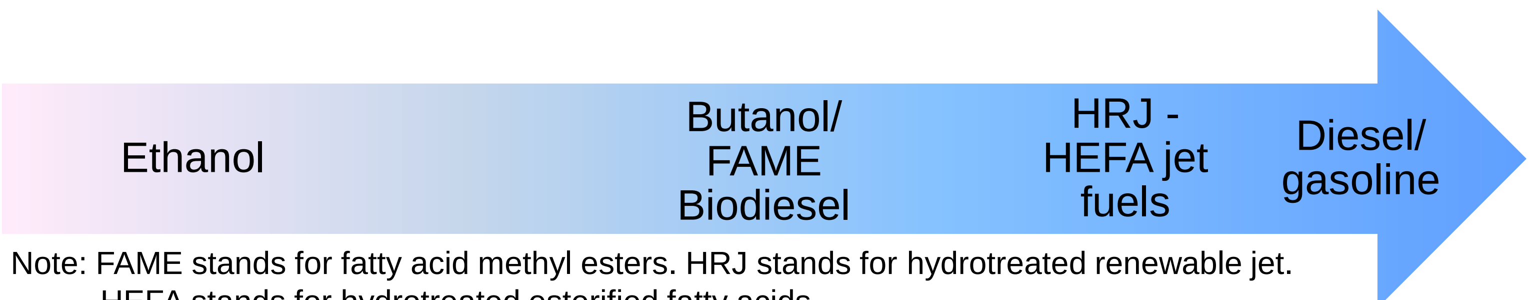
Overview

- What are drop-in biofuels?
- Technology assessment methodology
  - Technology descriptions
  - Process design review
  - Planned capacity
  - Production cost with learning
- Projections and implications
- Summary and look to the future

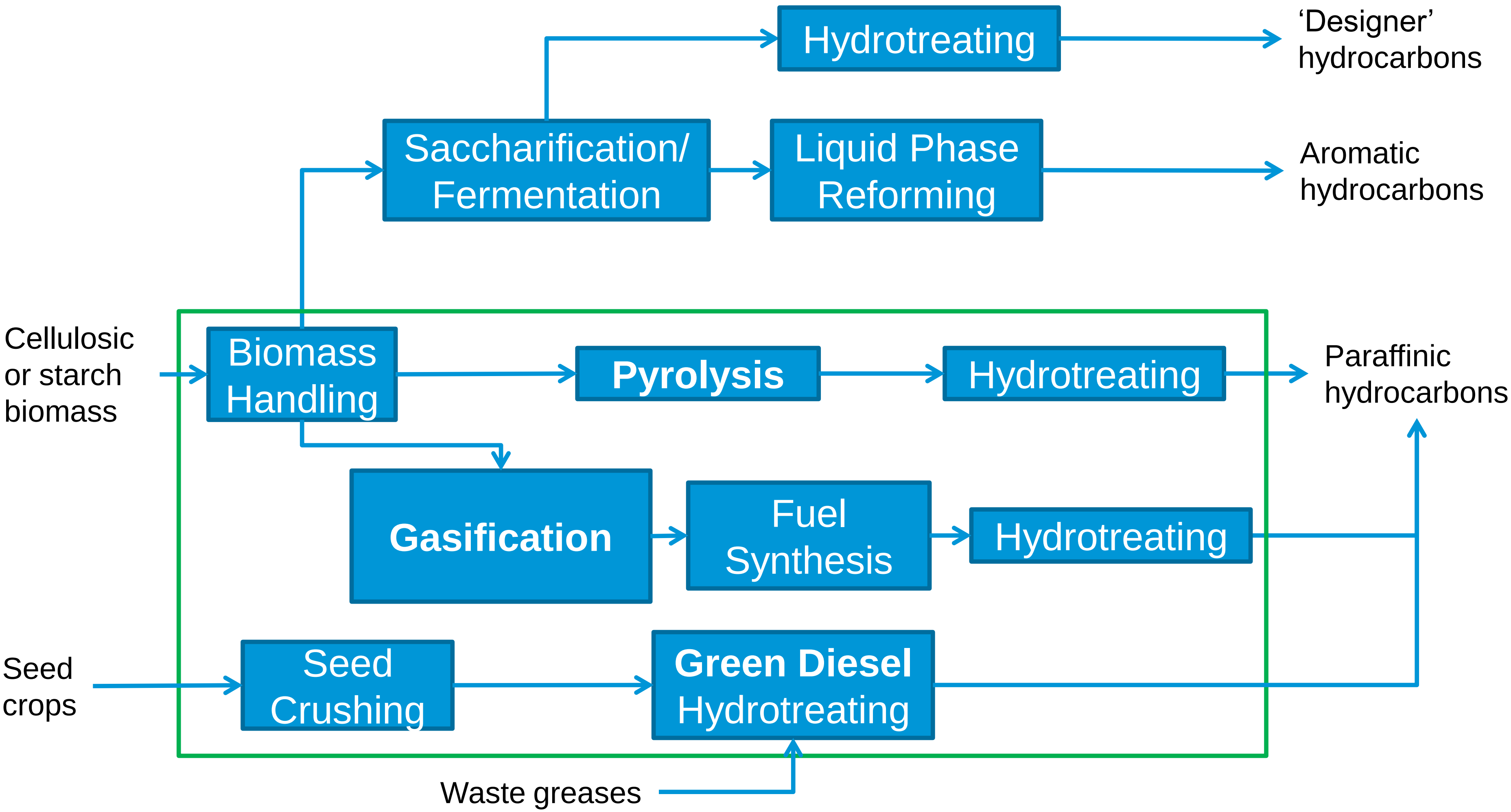
What are drop-in biofuels?

- Approved fuels
  - Meet ASTM specifications
  - Have received all necessary EPA approvals
- Infrastructure compatible
  - Can move in pipelines, trucks, and barges without equipment modification
  - Usable in existing fueling stations without modification
  - Usable by existing vehicle fleet without modification
- There is a continuum based on the above characteristics



Note: FAME stands for fatty acid methyl esters. HRJ stands for hydrotreated renewable jet. HEFA stands for hydrotreated esterified fatty acids.

How do you make drop-in biofuels?



Three pyrolysis technology options

- Non-catalytic fast pyrolysis
  - Produces 10% oxygen content product for sale to existing refineries
  - Used as process model for AEO2012
  - Several projects in Canada for producing food products, not fuels
- Biomass catalytic cracking (pyrolytic)
  - Produces zero oxygen content fuels for blending
  - Used as process model for AEO2013
  - Several planned projects by KiOR
- Integrated hydropyrolysis
  - Produces zero oxygen content fuels for blending
  - For consideration in future AEOs
  - No announced projects at this time

Process Design Review - Pyrolysis

Parameter	Units of measure	AEO 2012 'Pioneer Plant'	PNNL (2009)	Iowa State – 'Pioneer plant' (2010)	Iowa State – 'nth plant' (2010)	AEO 2013 'Pioneer plant'
Nameplate capacity	b/d	687	4,957	3,796	3,796	1,374
Overnight capital cost	$/bd	$78,726	$61,118	$154,087	$52,679	$158,507
Thermal efficiency	%	52	65	50	50	40
Capacity factor	%	90	90	90	90	90
Economic lifetime	Years	15	20	20	20	15
Construction lead time	Years	4	2.5	<2	<2	4
Feedstock						
Biomass	tons/day	438	2,205	2,205	2,205	1,128
Hydrogen	mcf/day	-	2,186	ND	ND	-
Electricity	MW	-	ND	ND	ND	-
Products						
Light ends	b/d	48	ND	ND	ND	-
Gasoline	b/d	618	2,073	ND	ND	652
Diesel	b/d	21	2,884	ND	ND	652

Two gasification technology options

- Fischer-Tropsch (FT) Synthesis
  - Used beginning in AEO2011 due to high quality diesel product
  - Recently there have been several project cancelations and decommissionings (e.g., Rentech, Choren)
- Methanol to Gasoline (MTG)
  - Produces light hydrocarbon product (~90% gasoline)
  - At least one new project has been announced
  - Co-integration of natural gas feedstock

Process Design Review - Gasification

Parameter	Units of measure	AEO 2013 'Pioneer Plant'	Wallace (Utrecht) – FT (2009)	PNNL – MTG (2009)	NREL – MTG (2011)
Nameplate capacity	b/d	3,143	1,882	2,609	3,235
Overnight capital cost	$/bd	$328,835	$350,434	$191,625	$61,694
Thermal efficiency	%	51	51	47	50
Capacity factor	%	90	96	96	96
Economic lifetime	Years	15	20	20	20
Construction lead time	Years	4	3	2.5	2.5
Process Inputs					
Biomass	tons/day	2,027	2,000	2,000	2,000
Natural gas	mcf/day	-	ND	ND	ND
Products					
LPG	b/d	-	ND	ND	463
Naphtha	b/d	864	ND	ND	ND
Gasoline	b/d	-	ND	2,609	2,772
Diesel	b/d	2,279	ND	ND	ND
Electricity	MW	32	51	32	0

Technology Description – Green Diesel

- **Process steps**
  - Fatty acids are mixed with hydrogen and begin their conversion to hydrocarbons. CO2 and water are produced as well and are separated by lowering the pressure.
  - The partially converted fatty acids are mixed with more hydrogen in a second reactor, removing the rest of the oxygen.
  - Hydrocarbons are then separated into LPG and distillate range material
  - Distillate range material is sometimes sent to a third reactor where it is isomerized for better fuel characteristics

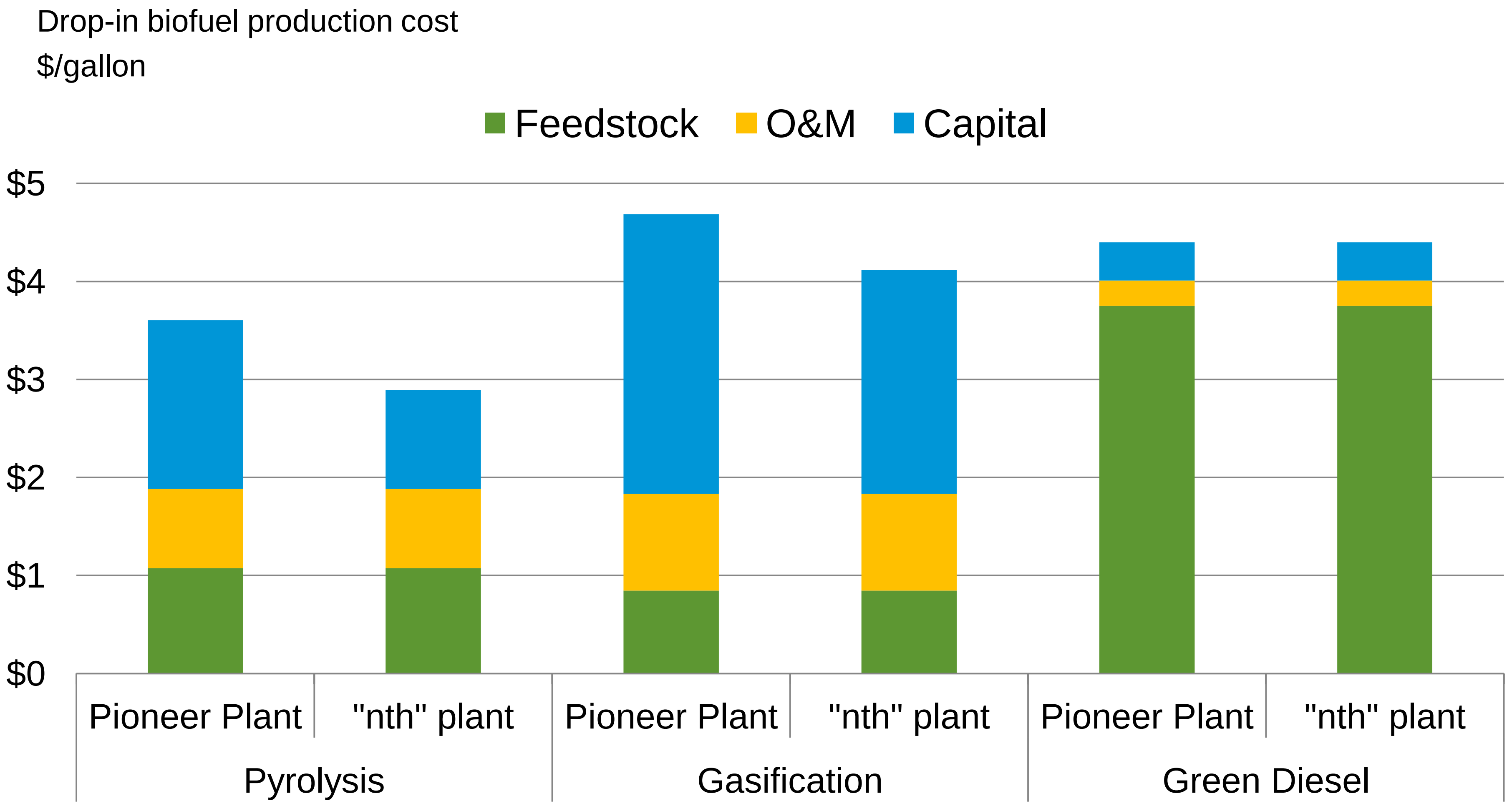
- **Process technologies**
  - Syntroleum (licensor for Dynamic Fuels)
  - UOP/Eni Ecofining (licensor for Diamond Green Diesel)
  - Neste NexBTL

Existing and near-term planned capacity

	Project Parameters			Plant Location		Announced Technology Parameters		
Process	Company	Status	Online Year	City	State	Nameplate (bpd)	Million US$	$/bd
Pyrolysis (gasoline, diesel)	KiOR	Startup	2012	Columbus	Mississippi	717	215	$270,000
	KiOR	Construction	2014	Natchez	Mississippi	2,609	ND	ND
Gasification (gasoline)	Sundrop	Construction	2015	Alexandria	Louisiana	2,609	500	$191,625
Green Diesel	Dynamic Fuels	Complete	2011	Geismar	Louisiana	4,809	127	$25,959
	Diamond Green Diesel	Construction	2013	Norco	Louisiana	8,937	427	$47,778
	Emerald Biofuels	Development	TBD	Plaquemine	Louisiana	5,544	ND	ND

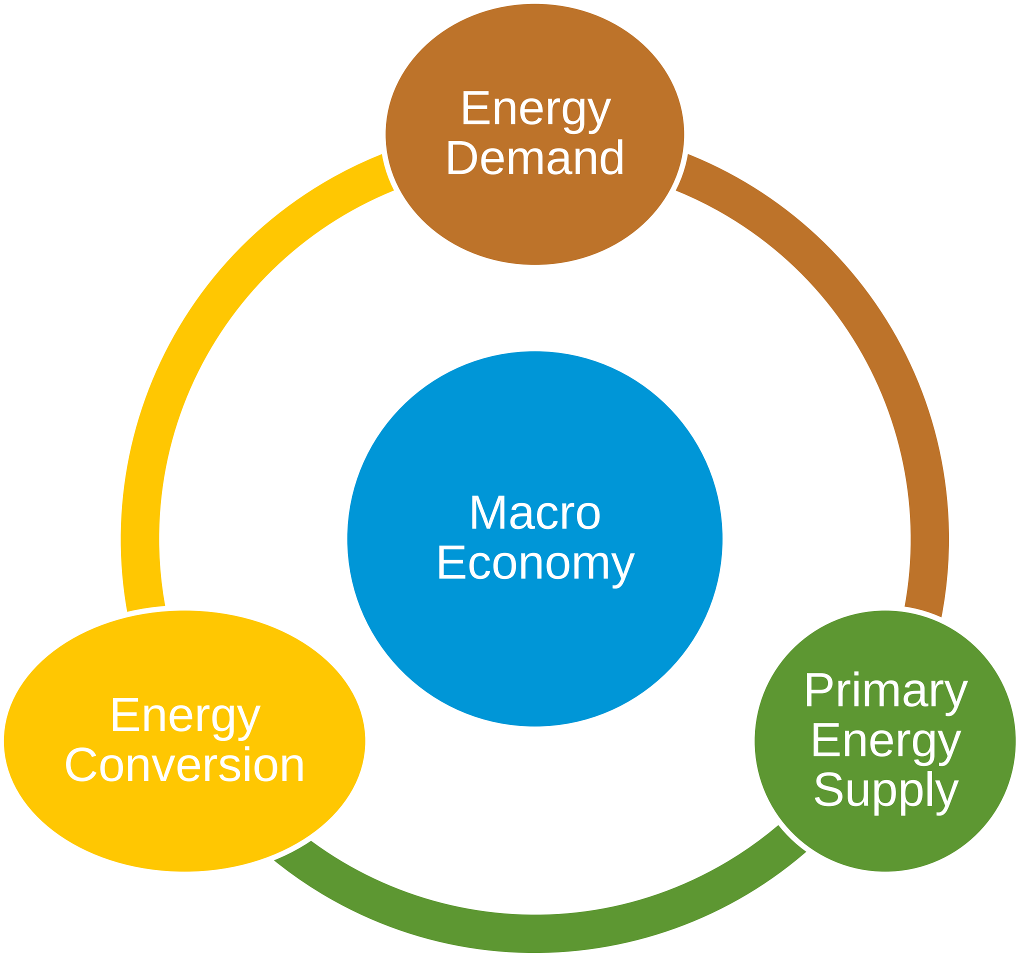
While no projects have yet been announced, CRI/Criterion (refinery technology company related to Royal Dutch Shell) is marketing a pyrolysis technology called Integrated Hydropyrolysis and Hydroconversion (IH2)

If significant plant builds occur, production costs for certain drop-in biofuel technologies could fall due to process learning

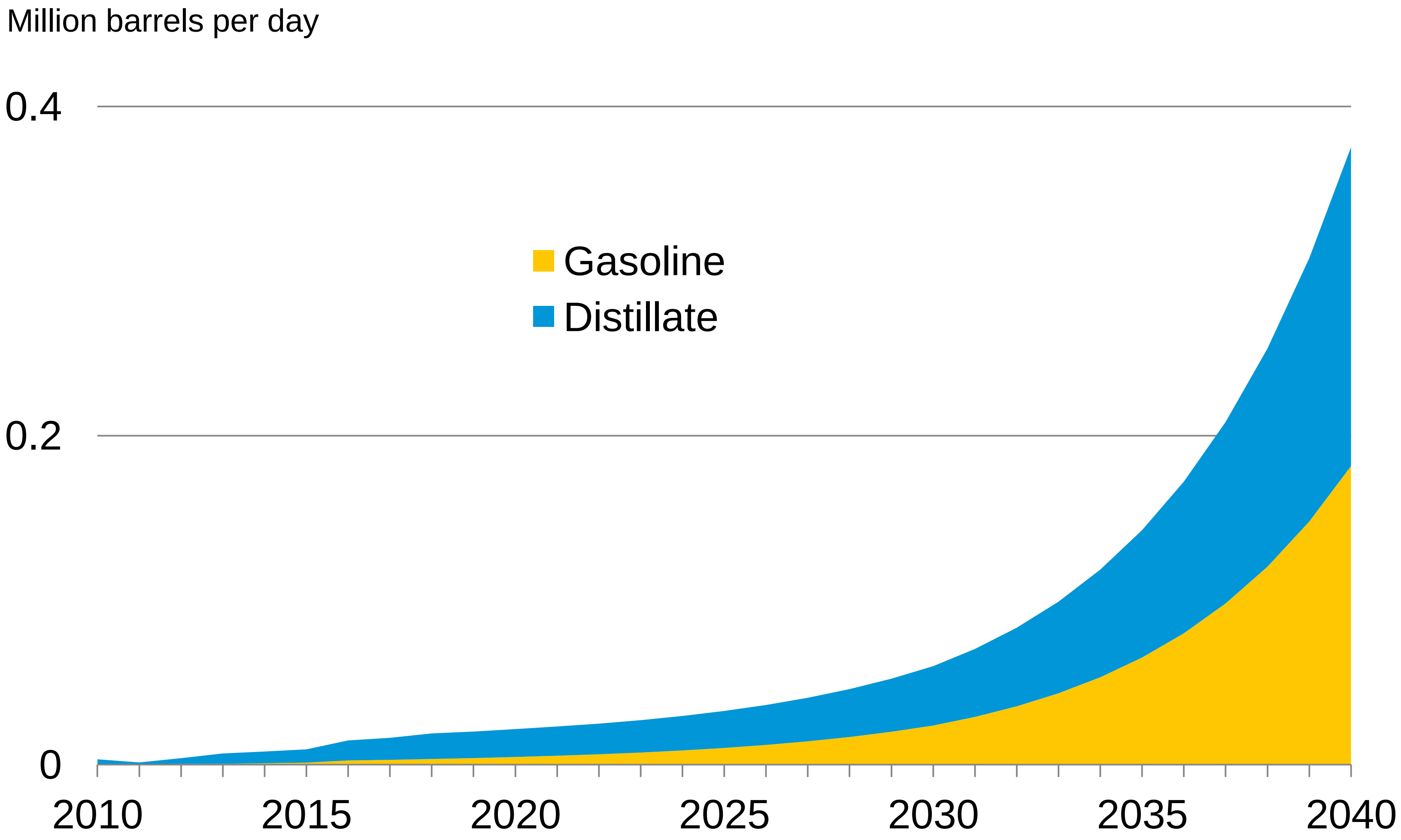


Notes: Feedstock costs assumptions are $0.50/lb for renewable oils and $50/ton for cellulosic biomass.

With NEMS, we transition from production cost point estimates to projections over time



Current projections indicate rapid growth of drop-in biofuels after 2030 as petroleum prices move higher than biofuel production costs



Source: EIA, AEO2013 Early Release

Summary and look to the future

- The biofuels industry is dynamic
- Potential technology changes for future AEOs
  - Update gasification and pyrolysis models
  - Conversions of ethanol plants to butanol plants
  - Improved yield, energy efficiency, and water use
- Potential competition between fuels and chemicals

For more information

U.S. Energy Information Administration home page | www.eia.gov

Short-Term Energy Outlook | www.eia.gov/steo

Annual Energy Outlook | www.eia.gov/aeo

International Energy Outlook | www.eia.gov/ieo

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