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Petroleum Refining Costs and Production Possibilities For Gasoline vs. Diesel Vehicles

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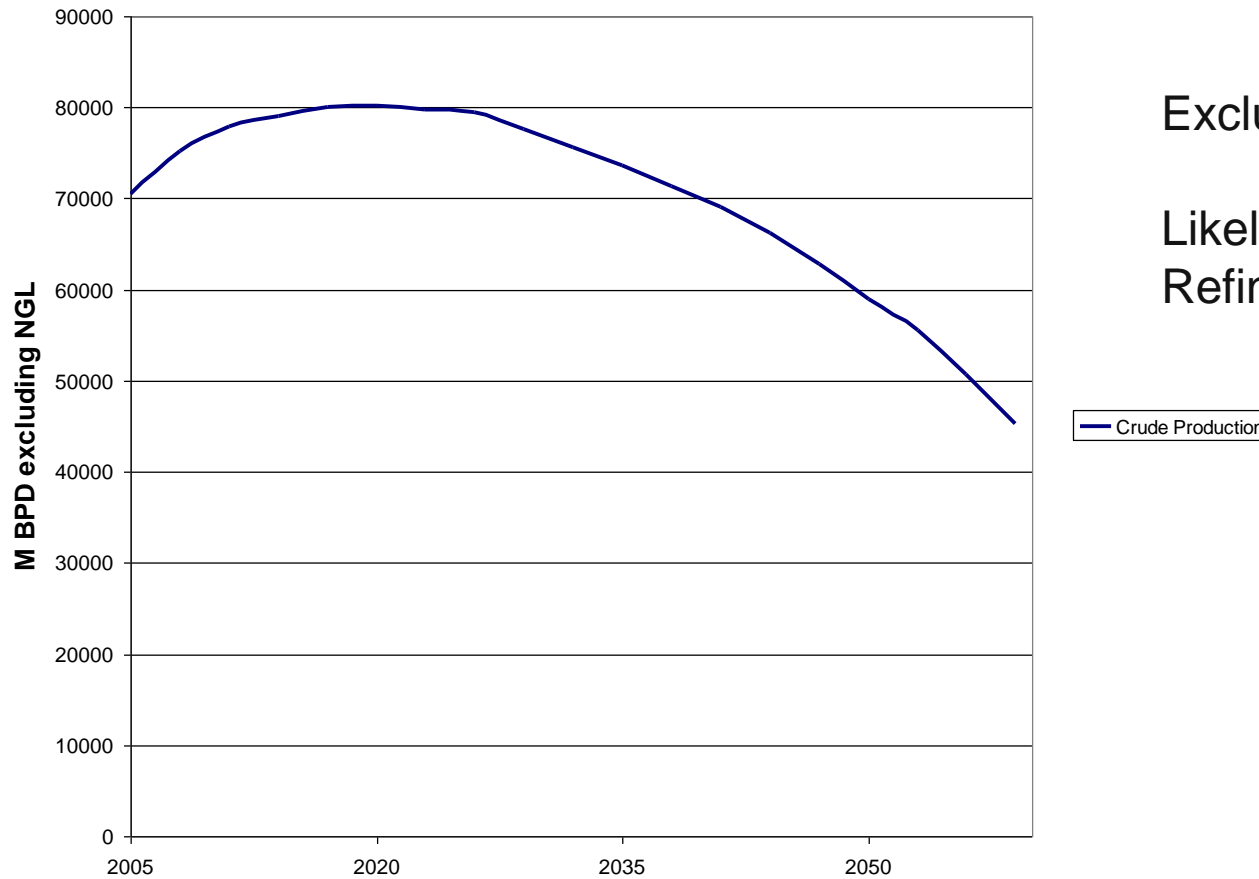
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Introduction

- This work is based on the MARS model
 - 25 refinery processes including CTL Fischer Tropsch liquids
 - 10 refinery products
 - 6 crude oil types
 - Other refinery inputs, utilities, and other costs
- Production of H₂ from steam methane reforming and pet coke gasification
- Demand for H₂ for hydrotreating, upgrading, and hydrocracking

Some Oil Industry Experts Expect Crude Oil Production to Peak by the Year 2020, even with Substantial Investment

World Crude Oil Production Scenario



Excludes NGLs

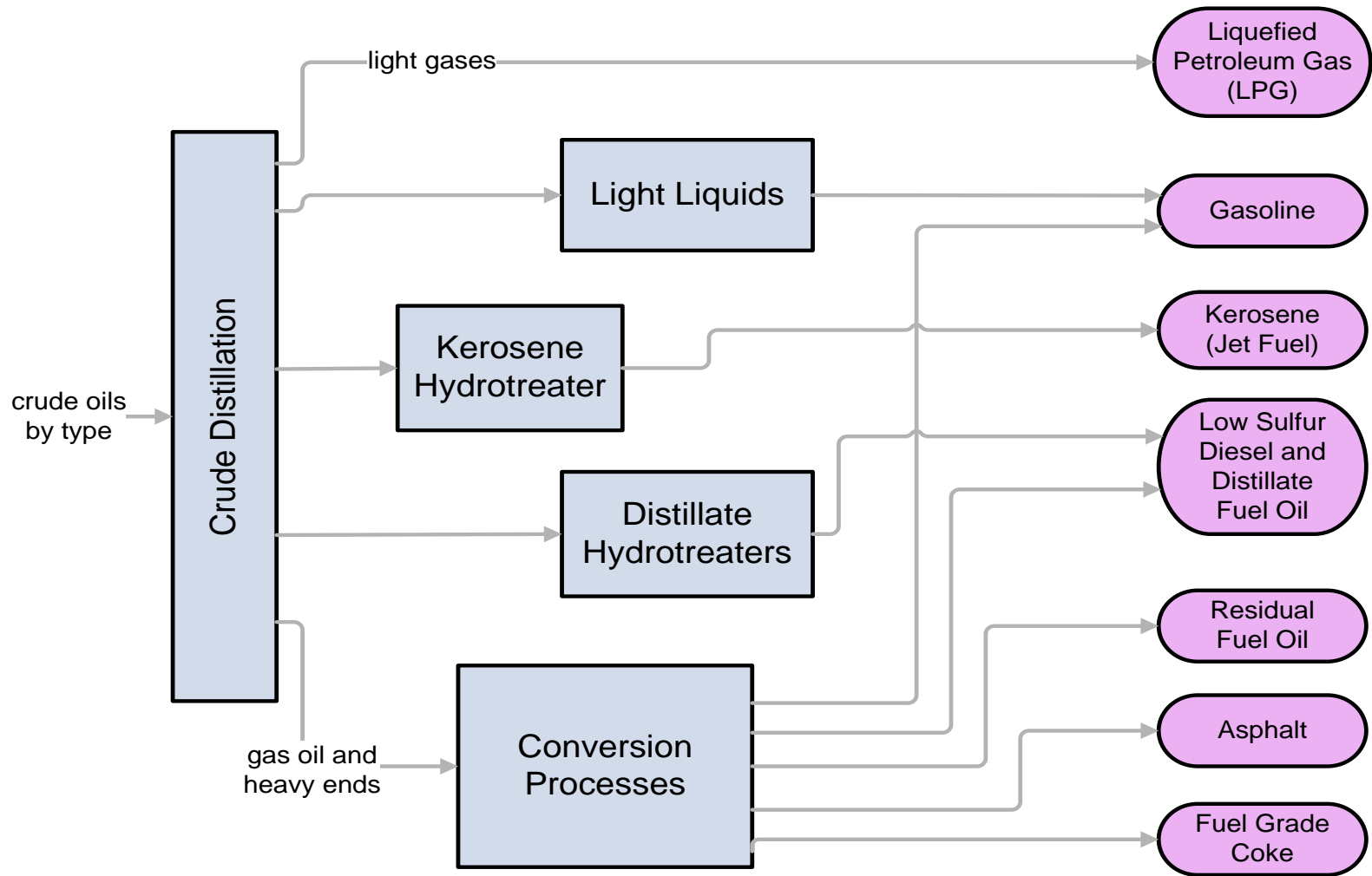
Likely Constrained By
Refinery Investment

Crude Production

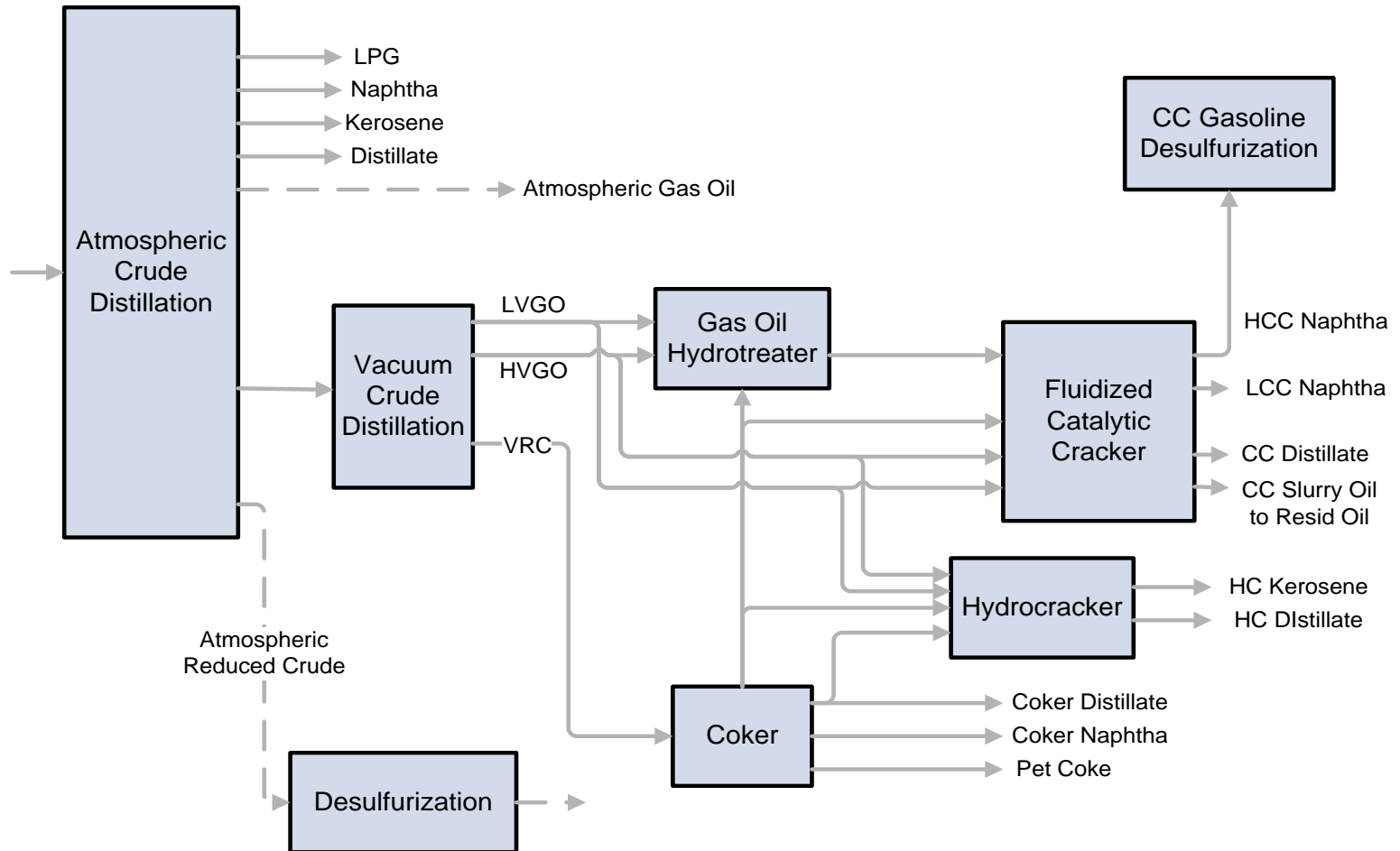
Potential Disruptions/Price Shocks for Diesel Fuel: the Fuels Production Side

- Refineries have sunk investment in gasoline capacity (fluid catalytic crackers)
- Slowing crude oil production will limit the economic potential to install diesel product capacity (hydrocracking)
- Refinery capacity will likely peak before oil field production potential would otherwise peak
- Limited cut point adjustments and blending changes to make diesel instead of gasoline in existing refineries

The MARS Model Has Twenty-five Refining Processes

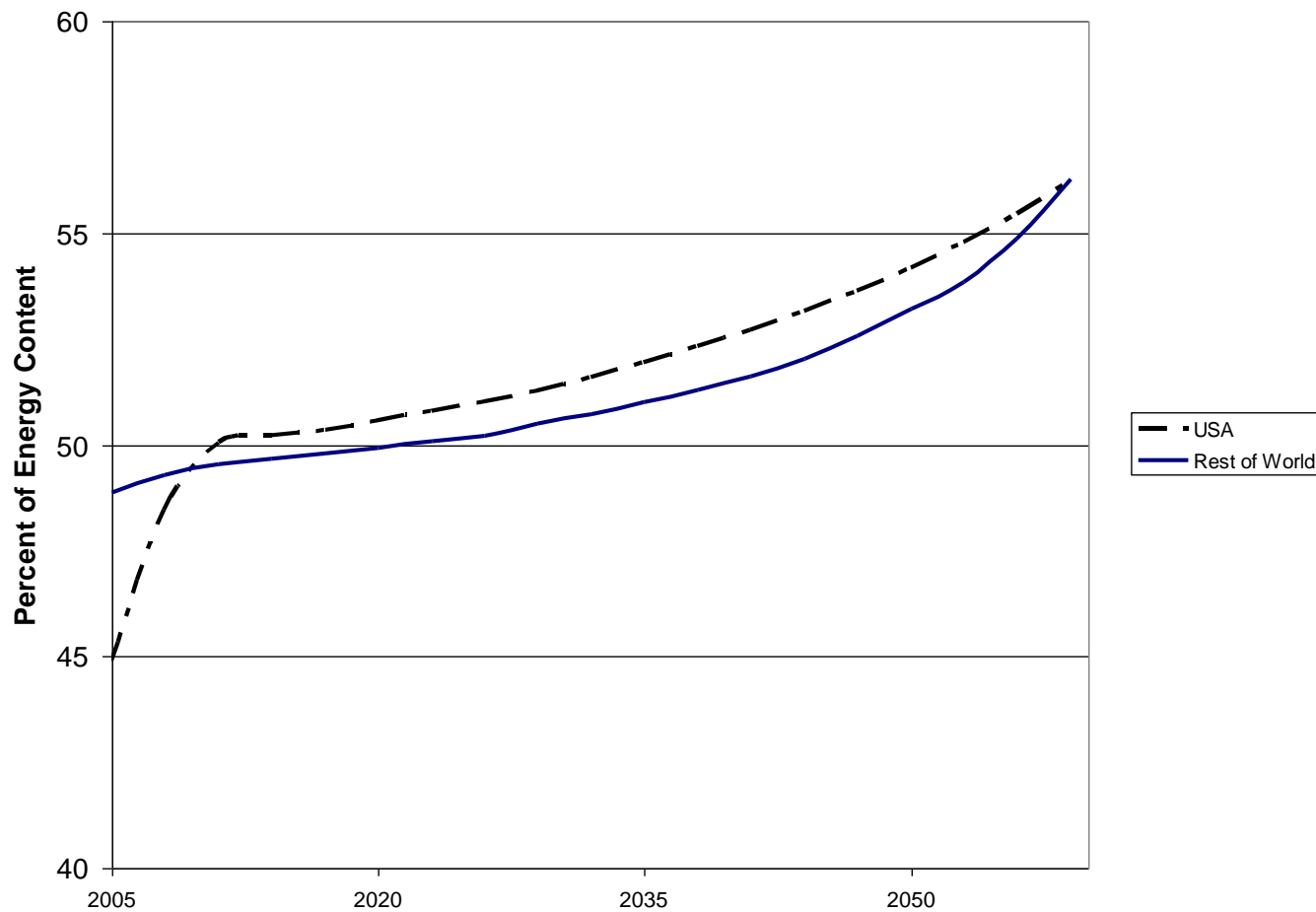


Heavy Oil Conversion to Lighter Products



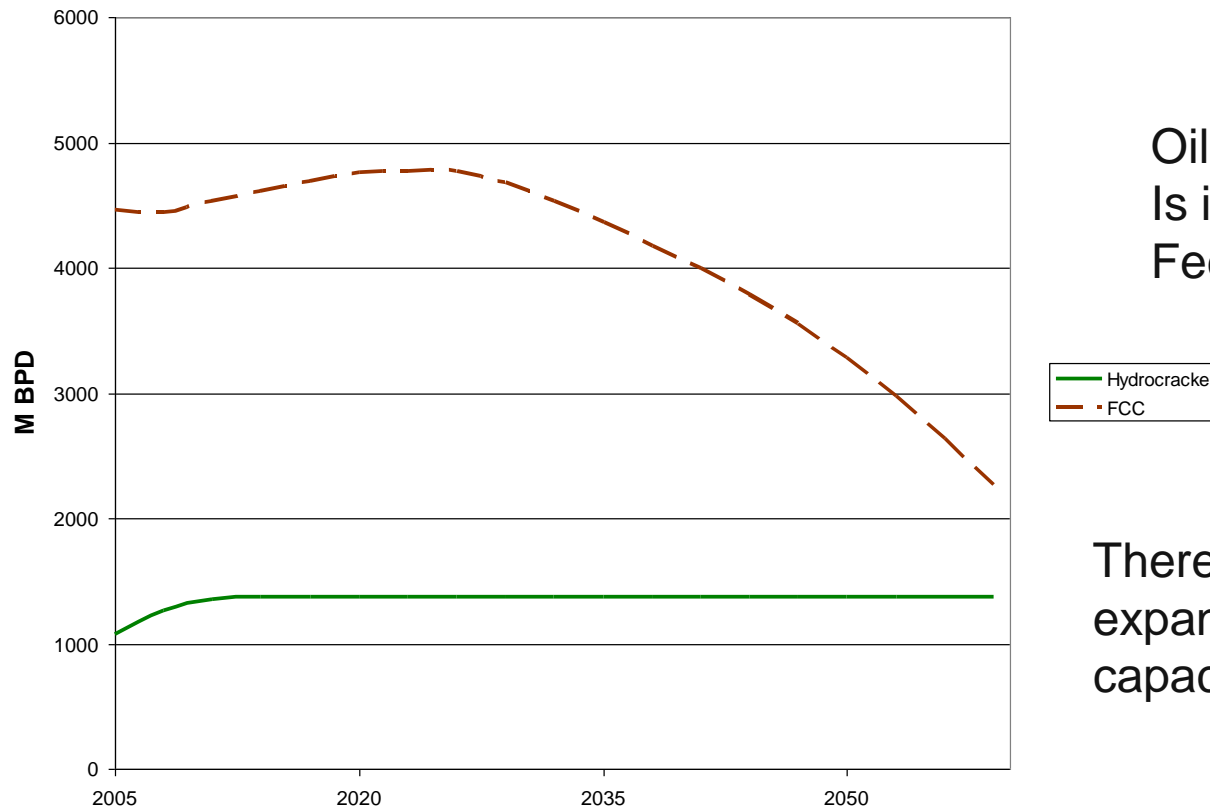
The Share of Distillate Product is Rising, Particularly in the USA

Ratios of Distillate to (Distillate plus Gasoline)



Investments in Hydrocracking and Diversion from FCC after Peak

Projected Gas Oil Feed to Hydrocracker vs. Fluid Catalytic Cracker:
USA



Oil sands syncrude
Is increasing FCC
Feed in US

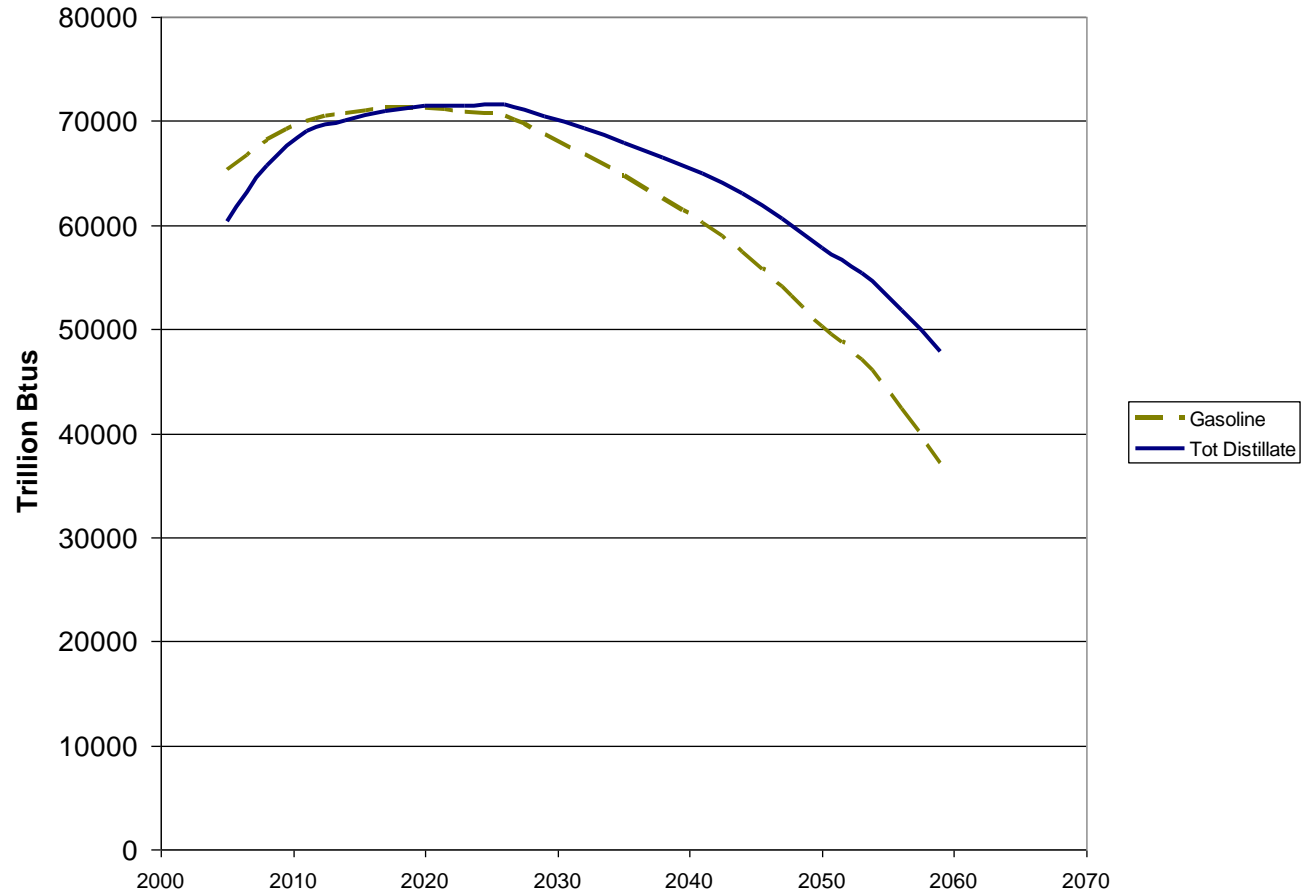
There is little room for
expanding hydrocracking
capacity

Potential Disruptions/Price Shocks for Diesel Fuel: the Market Side

- The major distillate fuel markets are fast growing world wide:
Heavy trucking/freight and jet aircraft travel
- Light duty vehicles (LDV) have been trending toward diesel engines
- Alternative transportation fuels are primarily gasoline substitutes:
for example, ethanol
- Bio diesel is very expensive. This should be a major research area
- Most efficiency opportunities are on the LDV side; freight engines are close to optimized already

Worldwide Supply and Use of Distillate and Diesel

Projected World Production of Refinery Gasoline and Distillate

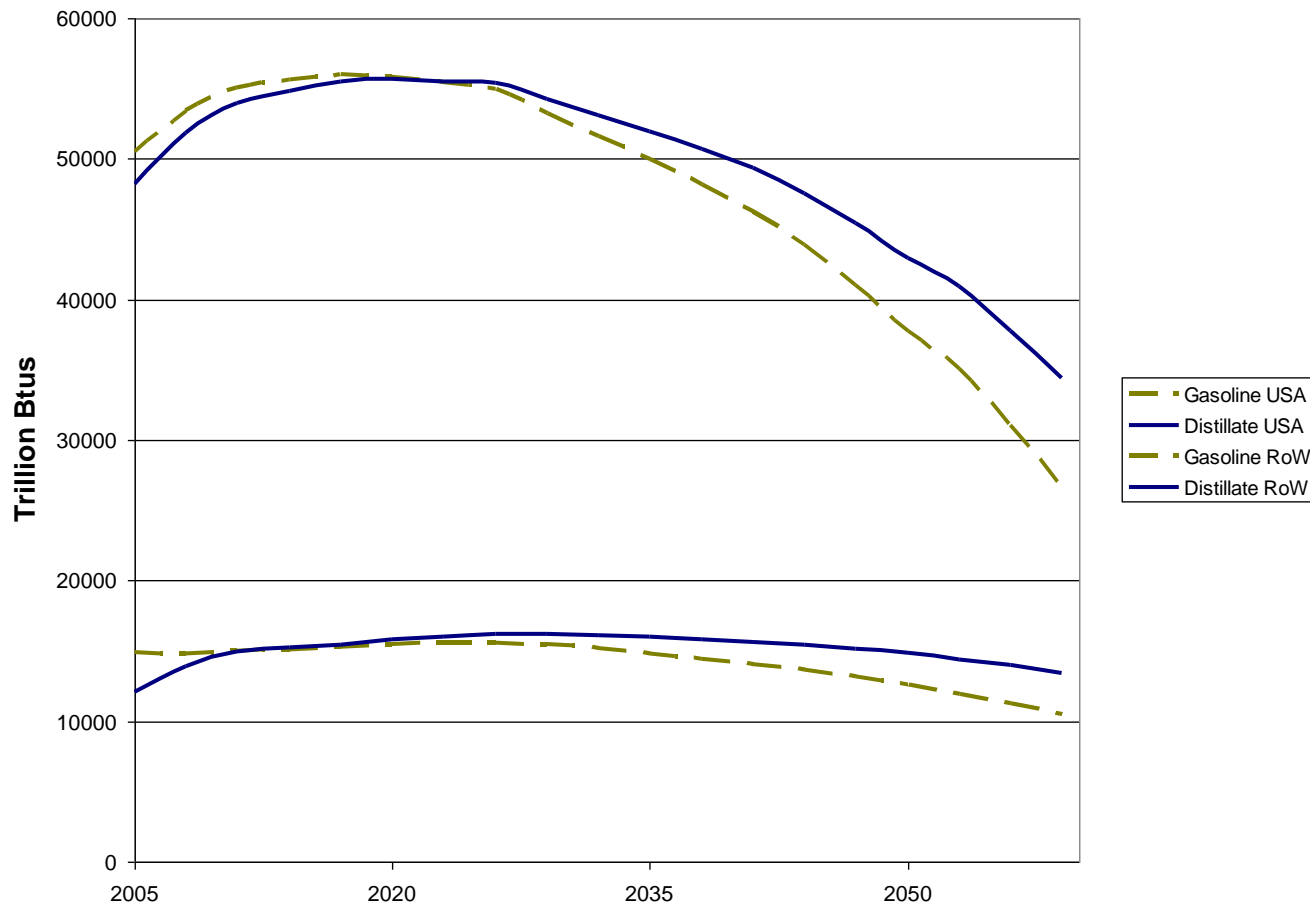


Scenario Assumption

- Regional refinery expansion is assumed to be located to meet regional diesel demand, the premium fuel
- Gasoline will become an international exchanged, tradeable commodity, priced at what it can get in the marketplace and heavily dependant on gasoline demand elasticity
- The remaining crude feedstock and other refining costs will be born by diesel prices (taking a credit for gasoline sales)
- With joint production, it is difficult to allocate costs to refinery products other than through the prices these products command in the market.

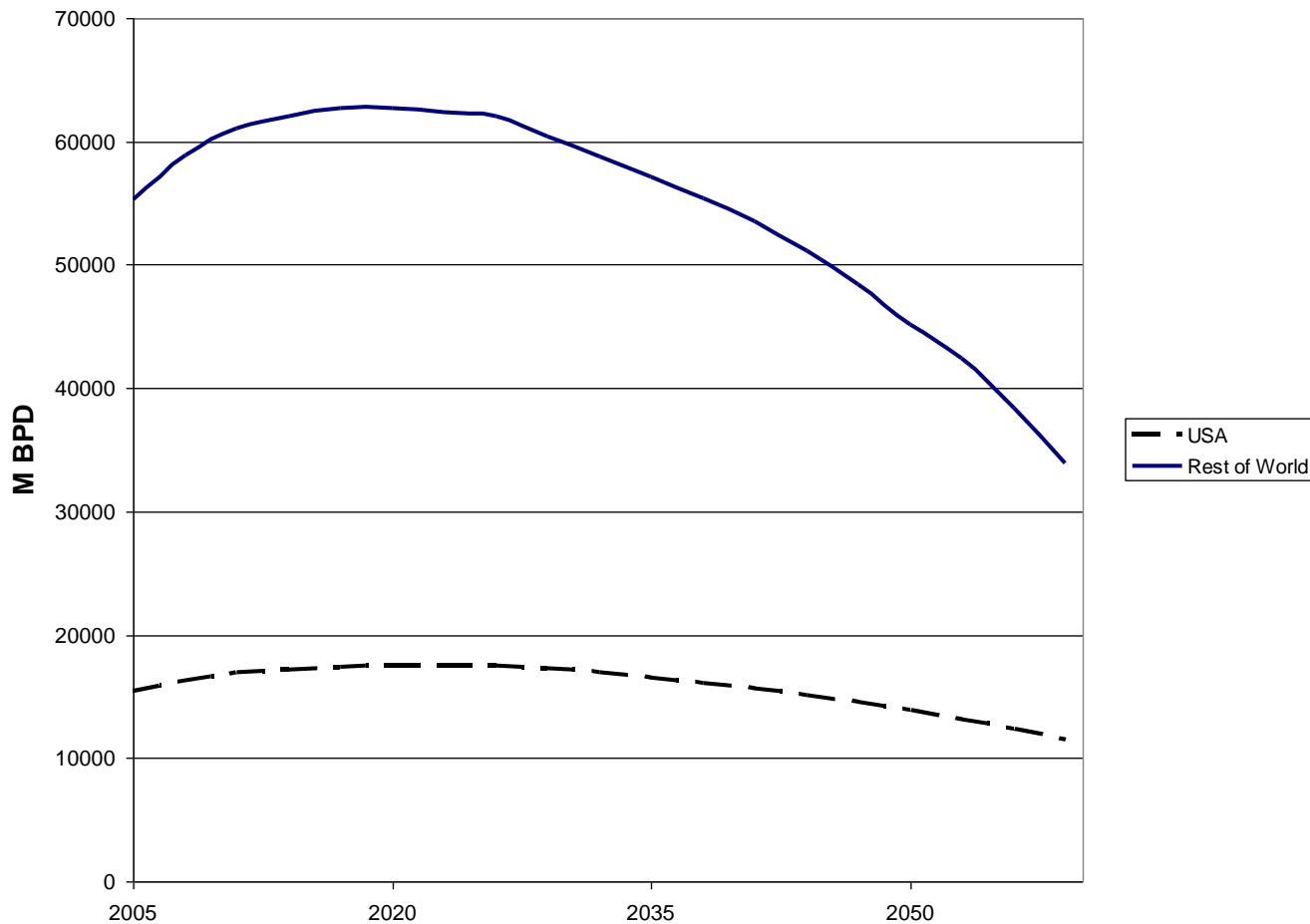
Major Product Output from Refineries in the US and Rest of World

Major Product Production in US and Rest of World



The US will likely Gain in World Refining Share as it Exports Gasoline Product to the Rest of the World

Crude Oil Refinery Input (excluding NGL)



Technical Notes

- The range for the distillate fraction increases over time as more hydrocracking capacity is put in place and gasoline production capacity is retired
- Hydrocracking is based on cracking heavy oils into lighter ones by adding hydrogen (increasing the hydrogen-carbon ratio in the molecule)
- Gasoline production from fluid catalytic cracking is a thermal process in which excess carbon atoms are burned off (creating CO₂ emissions)
- However, hydrogen currently is produced mostly from steam methane reforming, which also produces large CO₂ emissions

CO2 Emissions Will Depend on Future Processing Changes

US Refinery 2005 Mt CO2	Fuel Source	Description
101	Still gas	Process Heat
13	Steam coal & oil	Steam generation
51	Natural gas	Cogen, Heat, Hydrogen
53	Petroleum & catalyst coke	Heat & gasification for H2
218	Total	