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Biofuels Design Cases

DOE Office of Biomass Program

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Techno-Economic Analysis

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- Citable source for budget justification
- Setting R&D priorities
- Benchmarking
- Informing broader analytical activities (TEF, QTR)
- Track Program R&D progress against goals
- Identify technology process routes and prioritize funding
- Program direction decisions:
    - Are we spending our money on the right technology pathways?
    - Within a pathway: Are we focusing our funding on the highest priority activities?

Terminology and Concepts

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- Nth plant economics
  - Costs represent the case where several biorefineries with this technology have been built, which assumes lower contingency and other cost escalation factors
  - Assumes no risk premiums, no early-stage R&D, or start-up costs
- Learning curves
  - The factors applied to costs to adjust pioneer to nth plant costs to account for learning
- Pioneer plant
  - Costs represent a first-of-a-kind construction, where added cost factors are included for contingency and risk
  - Most closely represented by IBR projects
  - Few estimates available in the public domain
- Time value of money
  - Basis of time when comparing costs because of the changes in costs due to inflation
  - Currently 2007$

Terminology and Concepts

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- Design Case:
  - Detailed, peer reviewed process simulation based on ASPEN or Chemcad
  - Establishes cost of production at biorefinery boundary
  - Provides estimate of nth plant capital and operating costs
  - Based on best available information at date of design case
  - Scope: feedstock cost (harvest, collection, storage, grower payment), feedstock logistics (handling, size reduction, moisture control), conversion cost, profit for biorefinery
  - Excludes: taxes, distribution costs, tax credits or other incentives

- State of technology (SOT):
  - Assessment of the current state of development for a given technology pathway
  - Based on best available information from literature, bench scale tests, integrated pilot scale operations

Cost of Production for Hydrocarbon Biofuels

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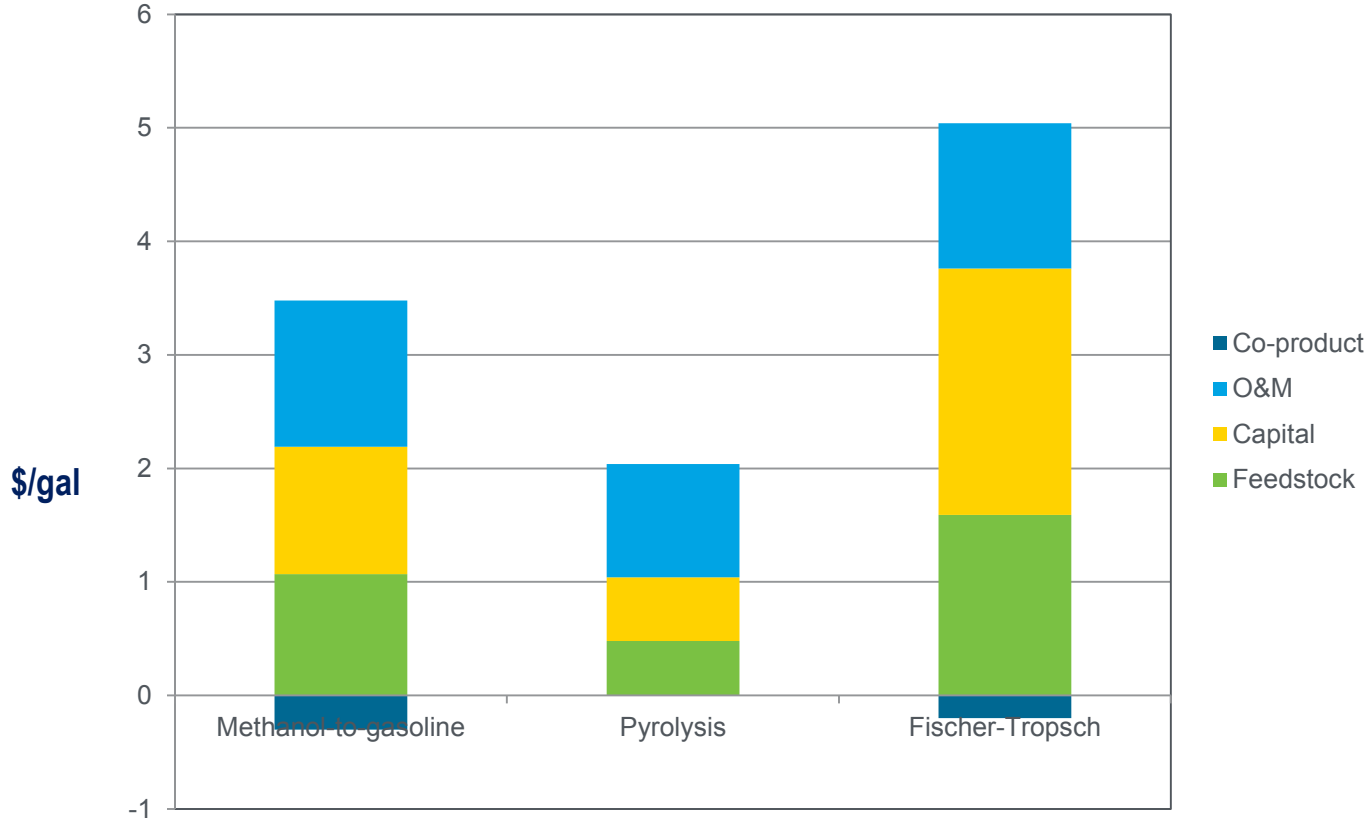

- Other economically viable technology routes for hydrocarbon biofuels exist, such as conversion of waste and plant oils, and sugar-to-hydrocarbons
- These costs are projected for the Nth Biorefinery Plant, after operation of initial commercial-scale Pioneer Plants

Sources:

1. Sue Jones et. al., "Production of Gasoline and Diesel from Biomass via Fast Pyrolysis, Hydrotreating and Hydrocracking: A Design Case", Pacific Northwest National Laboratory, PNNL-18284, available from http:/www.pnl.govFebruary 2009.
2. Sue Jones et. al., "Techno-Economic Analysis for the Conversion of Lignocellulosic Biomass to Gasoline via the Methanol-to-Gasoline (MTG) Process", Pacific Northwest National Laboratory, PNNL-18481, available from http://www.www.pnl.gov, February 2009.
3. Anex, R. A., et. al., "Techno-Economic Comparison of Biomass-to-Transportation Fuels via Pyrolysis, Gasification, and Biochemical Pathways", Fuel, July 2010.

Biofuel Production Costs
Example of renewable fuels via pyrolysis

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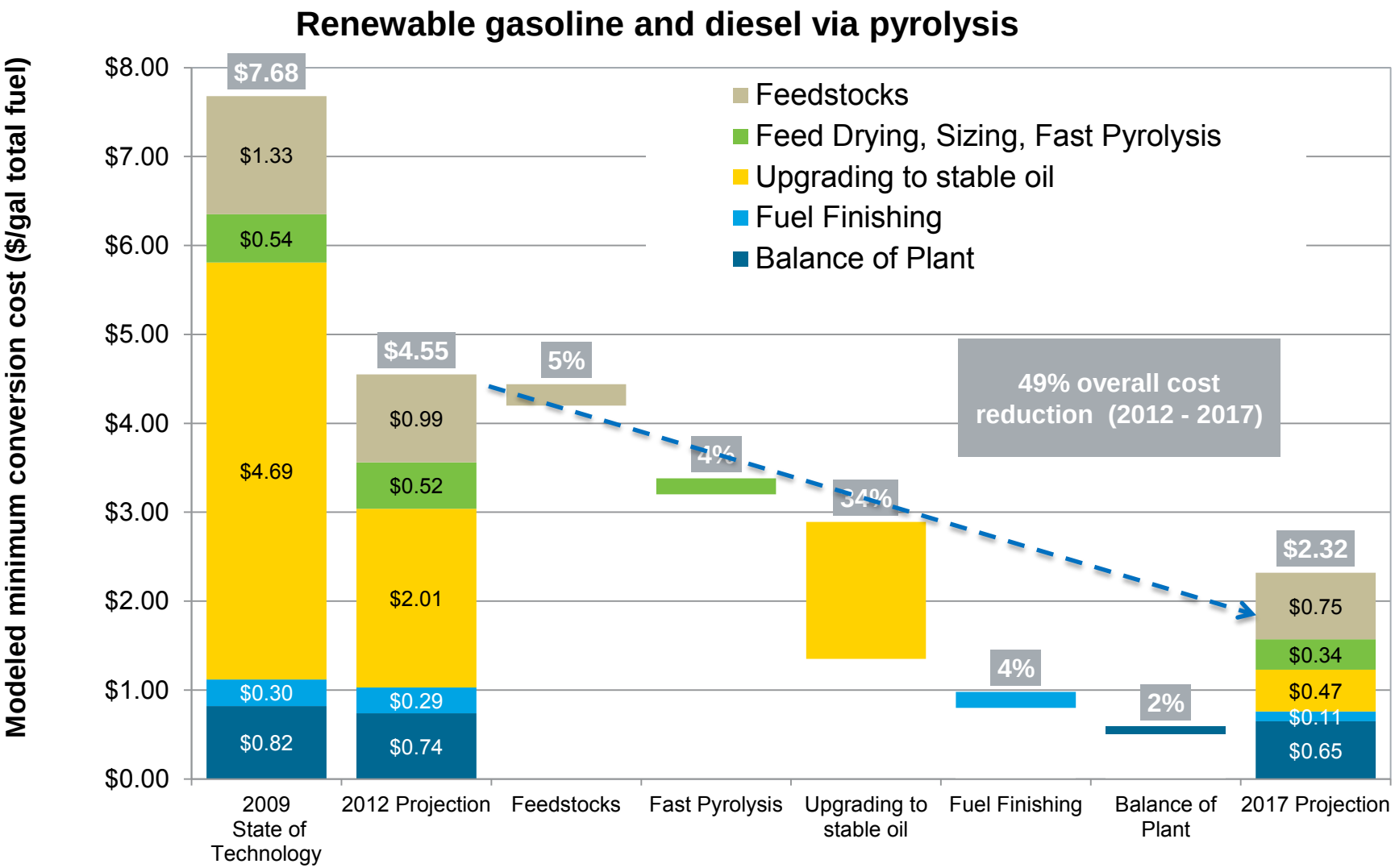
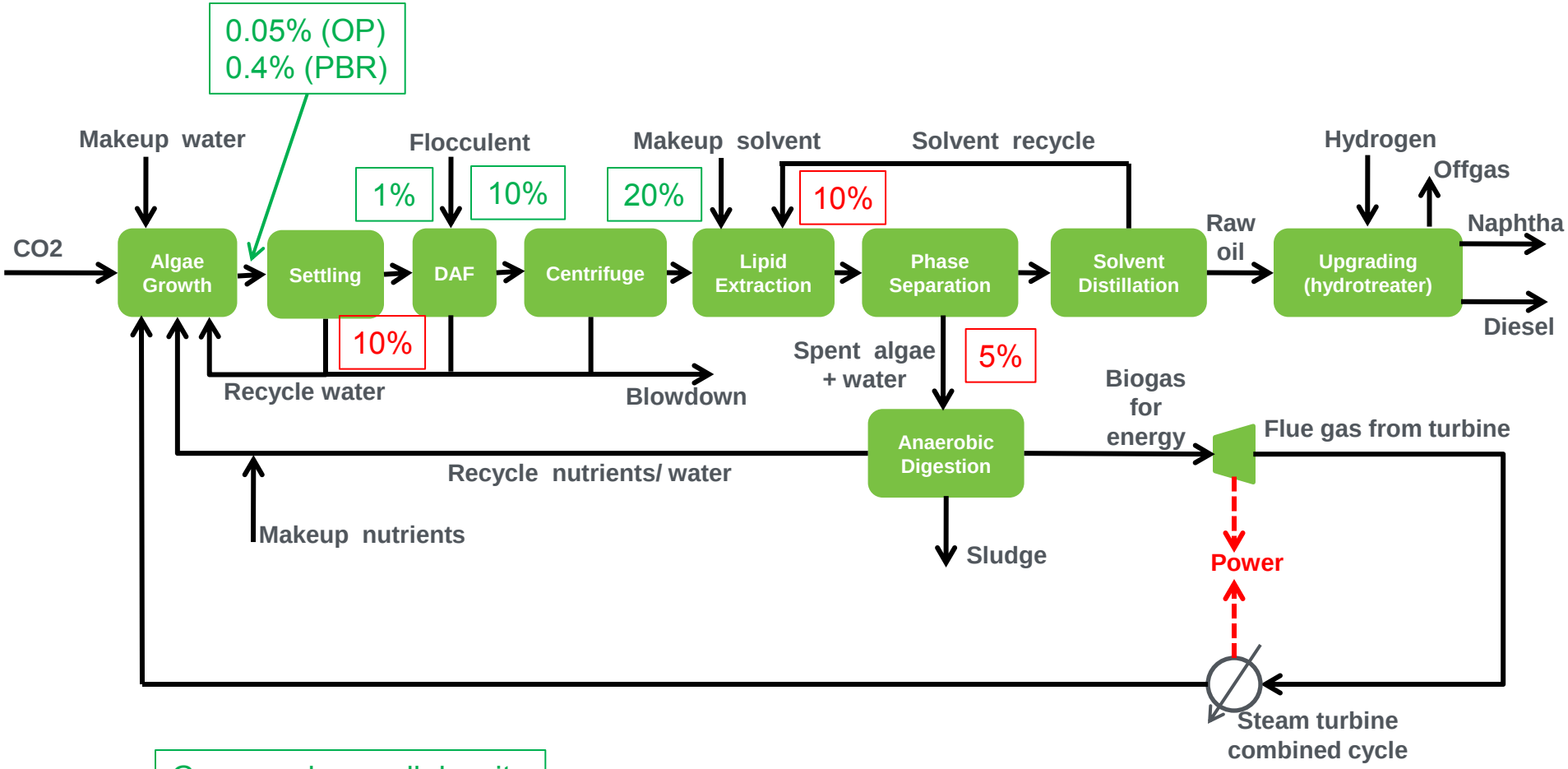


Pyrolysis costs by unit and projected cost reductions through R&D

Algae Design Configuration



Green = algae cell density

Red = harvesting/extraction losses

FY11 Techno-economic Analysis: Algal Baseline Costs

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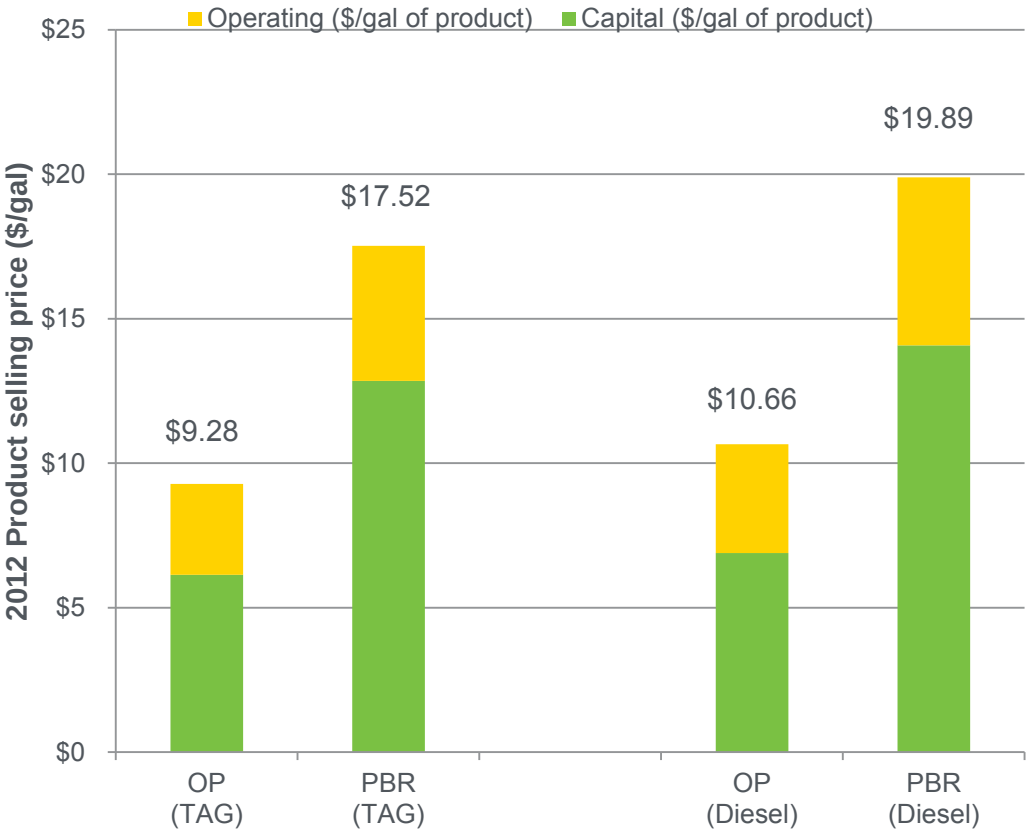
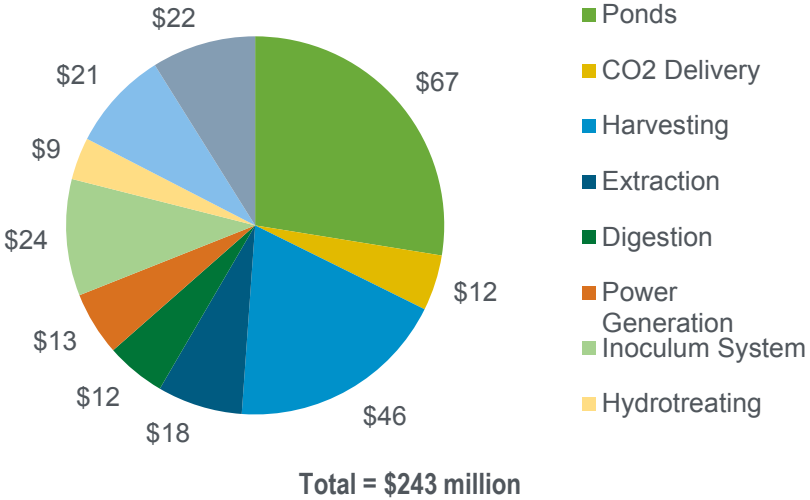
TAG/Diesel Selling Prices (OP vs PBR)

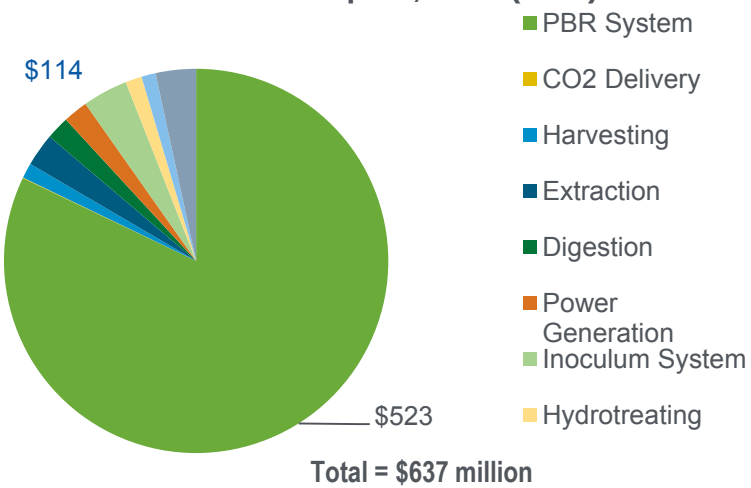


Source: Davis R et. al., "Techno-Economic Analysis of Autotrophic Microalgae for Fuel Production", Applied Energy 88 (2011) 3524 – 31.

Direct Installed Capital, $MM (Ponds)



Direct Installed Capital, $MM (PBR)



Projecting Future Algal Costs – How Can We Get There?

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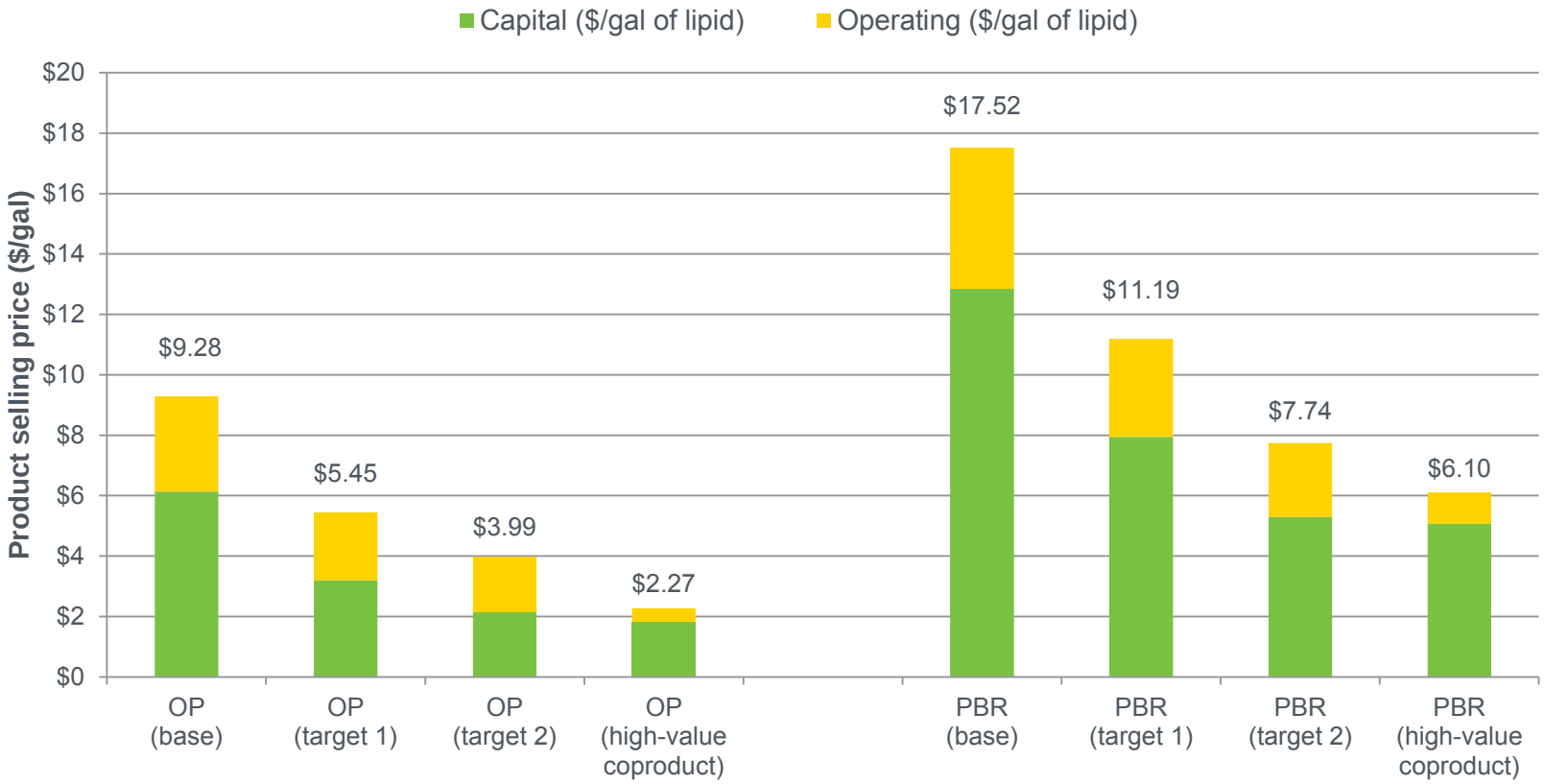

Growth rate	25 g/m²/d	25 g/m²/d	30 g/m²/d	30 g/m²/d		1.25 g/L/d	1.25 g/L/d	1.5 g/L/d	1.5 g/L/d
Lipid content	25%	40%	50%	50%		25%	40%	50%	50%
Harvesting cost	Base	Cut by 50%	Cut by 50%	Cut by 50%		Base	Cut by 50%	Cut by 50%	Cut by 50%
Extraction cost	Base	Base	Cut by 50%	Cut by 50%		Base	Base	Cut by 50%	Cut by 50%
Spent biomass utilization	AD	AD	AD	Sell @ $500/ton		AD	AD	AD	Sell @ $500/ton

Future Design Cases

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- Continued reliance on design cases for many needs
- FY13: more design cases, expansion of scope, quicker
- Expansion and integration
  - Pioneer plant costs and nth plant costs
  - Lifecycle greenhouse gas emissions
  - Water footprint
- A design case report should encompass the entire supply chain from biomass to fuel blend-stocks

Program Needs

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- Pioneer plant cost in addition to nth plant
- Pioneer plant cost could be estimated from ASPEN process simulations based on higher contingency, Lang factor, and IRR
- Update to current year$ (2011)
- Goal dates: 2017, 2022 (RFS), 2030
- Design cases should be fully integrated across entire supply chain
- Multiple ‘design cases’ will be needed
- Sustainability metrics – GHG and water

Potential Pathways for Hydrocarbons from Biomass

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- Pyrolysis
- Gasification followed by Fischer-Tropsch conversion
- Heterotrophic algae
- Microbial bioconversion of initially clean sugars to hydrocarbon precursors
- Hydrogenation of triglycerides
- Butanol
- Ethanol to jet