BP Biofuels

a growing alternative

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Introduction

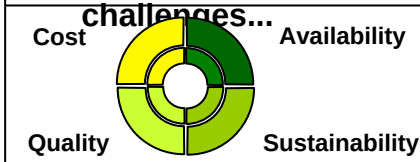
1 The long-term energy mix will change…

Regulatory Drivers
- Energy security
- Climate change
- Rural development

2 …with biofuels being a material component

Up to **30%** penetration by 2030

3 Today's biofuels face four main challenges...



4 …meaning industry growth is reliant on:

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- Shaper of an emerging industry
- Leadership position in the industry

1 The long-term energy mix will change…

Regulatory Drivers
- Energy security
- Climate change
- Rural development

Legislation is shaping the future demand mix of RTFs

ETHANOL EXAMPLE

Region	Demand type	Most likely demand (bgy)	Rationale
US	Mandate	30	Target of 36 b gals in 2022
EU	Mandate	4	Meet 10% target (in both ethanol and biodiesel)
Brazil	Economic	16	Ability of car fleet to absorb ethanol
China	Mandate	4	Current mandate: ~4 b gals in 2020, ~1 b gals in 2012, all from non-food feedstock. Mostly to be based on development of LC technology
India	Mandate	0.5	E10 in 2012-17
Japan	Mandate	1.7	E10 mandate for 2017
Other Asia	Mandate	1.2	Different mandates by country
ROW*	Mandate	3	Different mandates by country
TOTAL		~60 b gals	

* Includes Canada, Mexico, other Central and South America

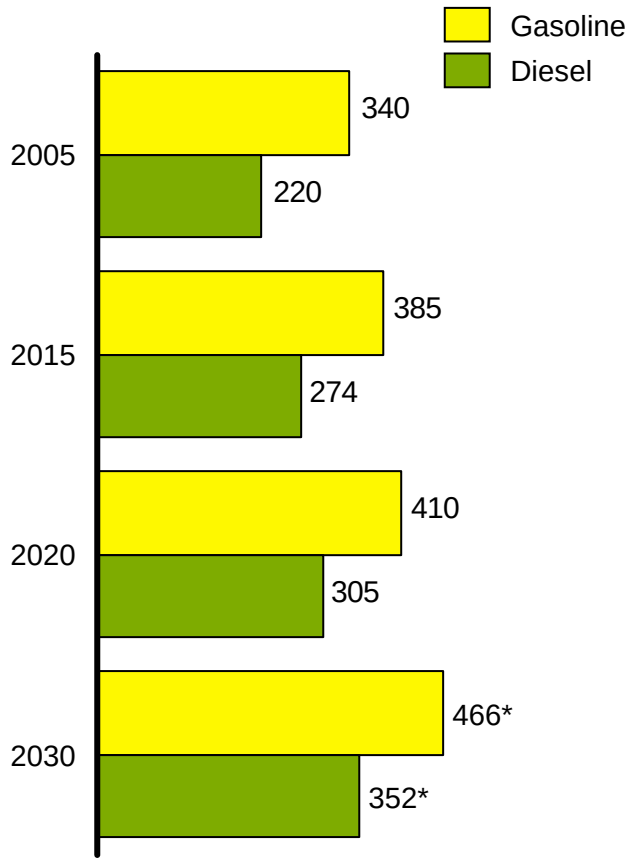
Source: Team analysis

2 …with biofuels being a material component

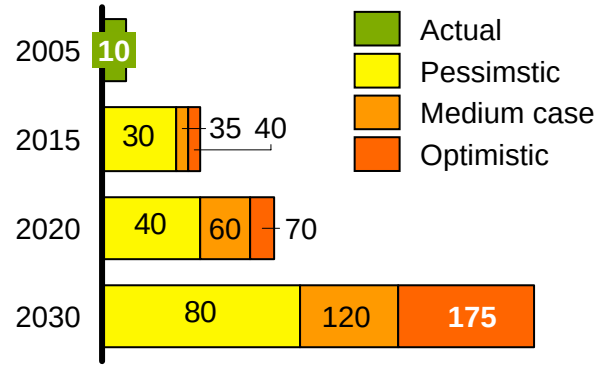
Up to **30%** penetration by 2030

Growing global energy use and regulatory drivers around energy security and climate change mean that biofuels could be very big

Expected Road Transport Fuel demand
Billion gallons of gasoline/diesel equivalent p.a.



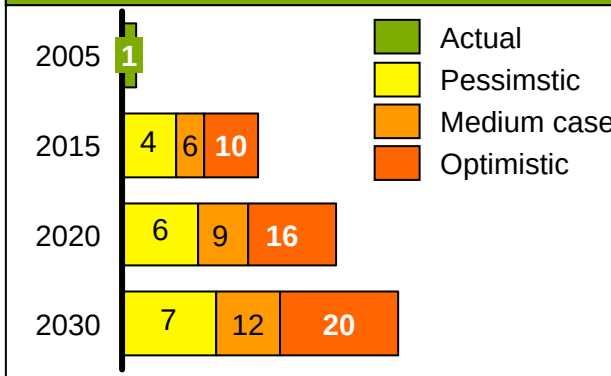
Potential gasoline replacement market
Billion gallons of ethanol equivalent p.a.



% of total conventional gasoline replaced

Year	Replacement ratio	% replaced
2015	0.8	8-10%
2020	0.8	7-13%
2030	0.8	13-28%

Potential biodiesel market
Billion gallons of biodiesel p.a.



% of total conventional diesel replaced

Year	Replacement ratio	% replaced
2015	0.92	1-4%
2020	0.92	1-5%
2030	0.92	2-5%

* Derived by applying IEA/WBSCD CAGRs to BP's 2020 numbers

** Volume of conventional fuel replaced by I gallon of relevant biofuel

Source: R&M 2020 world study; IEA/WBSCD Sustainable Mobility Project; Team analysis

3 **Today's biofuels face four main challenges...**

However, there are challenges in moving from carbohydrates to hydrocarbons today

- The biofuels industry is being created through the fusion of the two most important primary industries in the world – agriculture and energy

Petroleum Value Chain:

Exploration → Production → Transport → Refining → Blending/ Retail

Agricultural Value Chain:

Germplasm → Cultivation → Harvest → Process → Distribution

Biofuels Value Chain:

Germplasm → Cultivation → Harvest/ Transport → Processing/ Refining → Blending/ Retail

- But today's biofuels face 4 main challenges…

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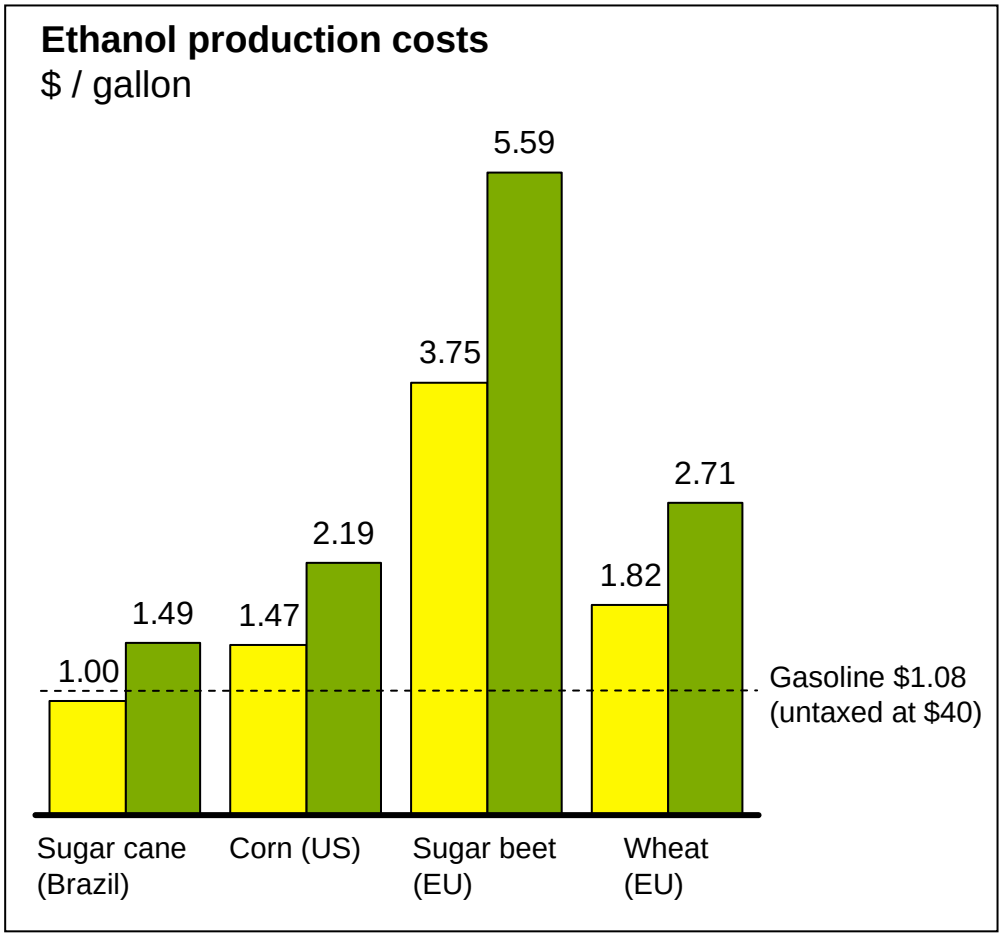
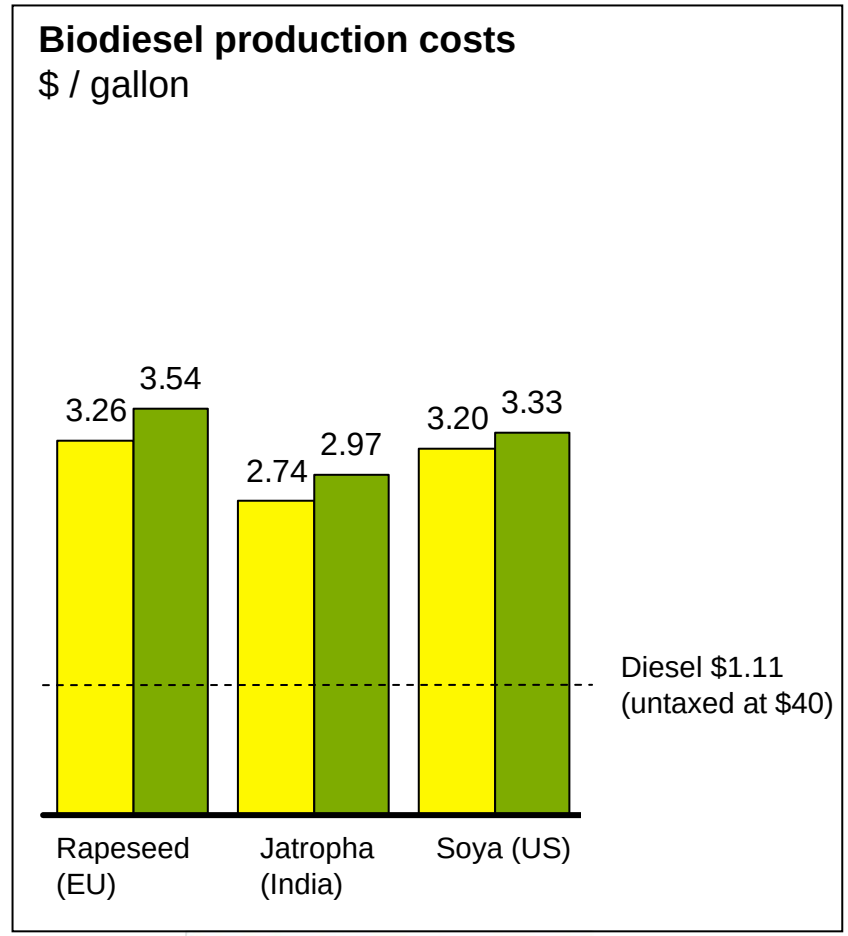
1 Cost: absent subsidies, biofuels need high oil prices in order to compete with their fossil equivalents

Equivalent volume basis
Equivalent energy content basis





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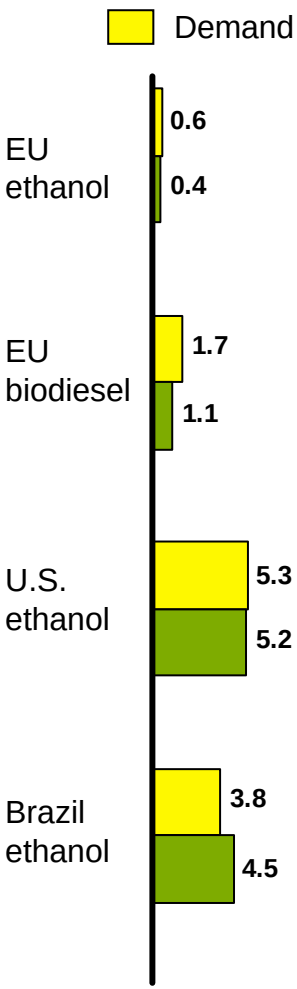
Availability: biofuels currently represent 2-3% of the transport fuel pool. Today, feedstocks limit penetration to around 5-7%

2006 current demand and production capacity (bn galls)



2006 to 2011

Europe constraints

- **Distribution** – need ethanol infrastructure for distribution, blending and retail
- **Ethanol –** max feedstock limit reached with 5.75% target.
- **Bio-diesel** – max limit from rapeseed will be 1.1ban galls short of target; B5 will limit further penetration

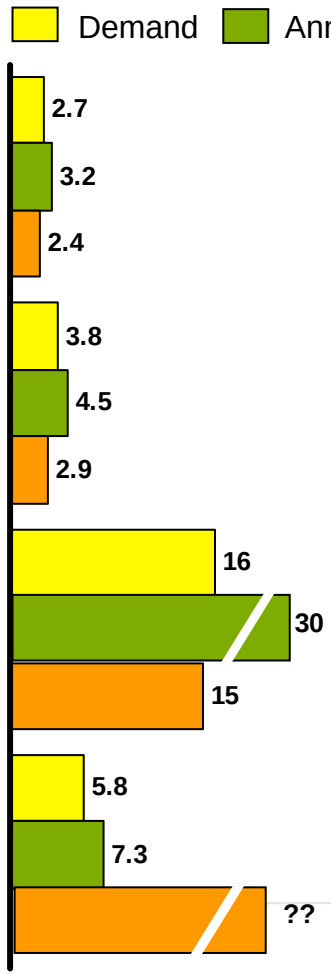
US constraints

- **Distribution** - rail car production capacity backlog of ~3 years
- **Growth** – limited by construction
- **Economics –** Increasing corn price will erode margin and limit growth to RFS and mandate volumes

Brazil constraints

- **Distribution -** Trucking is primary method, despite long distances and limited capacity resulting in high costs; limited port facilities
- **Risk management** – lack of paper market for hedging will limit exports

2011 predicted demand and maximum conventional feedstock supply (bn galls)



2011 forward

Europe constraints

- **Feedstock –** Limits include use of 50%set aside land and crop optimisation; Potential for 1.2 bn gall ethanol if cereal exports used; then LC required; increasing imports of veg oils for biodiesel
- **Capacity** – insufficient indigenous feedstock for announced capacity
- **Ethanol demand** beyond 10% - will require FFVs and E85 distribution

US constraints

- **Corn supply – max** 15-17 gallons then LC technology needed
- **Distribution** – river barge limited reach, ageing infrastructure
- **E85/FFVs** – to exceed 15 bn galls (10% vol) will require E85 distribution priced at energy parity and FFVs

Brazil constraints

- **Trade Policy –** Tariffs in demand markets will limit investment in exports
- **Domestic markets** – rapid growth in FFV's limit export volumes

3 Quality: conventional bio-components are essential to build the industry. A fuel chemist would not have started here!

	Ethanol – poor gasoline component	FAME - moderate diesel component
Fuel performance characteristics	– High octane (favours good performance) but… – High blend vapour pressure – Energy content approximately 1/3 lower than conventional gasoline – Water affinity and risk of phase separation when blended with gasoline	– Sulphur and aromatic free – Higher cetane value and improved lubricity properties vs. diesel – Low temperature and stability/deposit formation issues – Energy content 15% lower than conventional diesel
Suitability for use in premium products	• **Poor** – Energy content and water affinity mean that ethanol is not a good premium gasoline component	• **Poor** – Stability and energy content mean that FAME is not an ideal component for premium diesel
Blending limitations	• Corrosive effect as well as performance issues such as fuel economy limit the content of ethanol in standard grade gasoline (US 10%v/v, EU 5%v/v)	• Typically limited in standard grade diesel (e.g., 5%v/v max. Europe) • OEM concern over deposit formation in high pressure fuel injection systems used in modern diesel passenger vehicles
Supply chain implications	• **Poor** – can only be blended at the terminals, ethanol-containing blends cannot be moved by pipeline or ship and implies a segregated distribution network • **E85 –** issues around dispenser certification (safety)	• **Moderate** – low concentration blends (up to 5%) treated as fungible in many markets; higher blend levels may have impacts on pipeline contamination

4 **Sustainability**: fundamental to an enduring industry is the avoidance of harmful environmental and social impacts

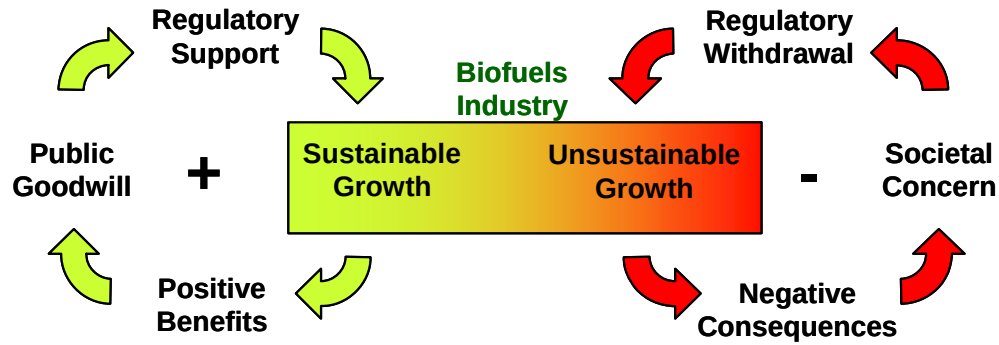
Issues (not exhaustive) include:

- Placing stress on the world's limited water resources
- Biodiversity
- Deforestation – the destruction of High Conservation Value Forest (HCVF)*
- Child and forced labour and other employment abuses
- Planting on peat soils
- Community conflict issues
- Land rights, including economic and physical displacement
- Effects of monoculture on local food production and local economies
- Pollution and environmental damage (water / soil / air), including related socio-economic impacts
- Net greenhouse gas balances resulting from land use change

* HCVF is technically defined according to principles defined by the WWF

4 …meaning industry growth is reliant on:

How regulators can help grow a sustainable biofuels industry



- **Market-based regulations that balance environmental, energy security and rural development goals that face communities around the world**
- **Encouragement of innovation at all stages of the value chain. It is important that regulation does not pick winners but instead allows the market to find solutions**
- **Policy that is geared to emissions reductions or the quantity of fuel energy replaced – rather than mandated volumes of a particular product.**
- **Regulatory mechanisms which apply equally to all and which maintain flexibility – for example avoiding fixed per gallon mandates.**
- **Support for guidelines for sourcing from sustainable and responsible production routes**

How technology has a major role to play

4 …meaning industry growth is reliant on:

Challenges	Technology Solutions
1 Cost	A Energy Crops
2 Availability	B Lignocellulosics
3 Quality	C Plant Modification
4 Sustainability	D Advanced Conversion

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Energy crops: non-food crops grown on marginal land reduce competition with food, especially in developing countries

BP Jatropha Nursery Plantation, Andra Pradesh State, India

BP – first oil major
to join the roundtable
on sustainable Palm Oil

Developing a framework
for sustainable production
of Jatropha oil

Crops like Jatropha offer improved sustainability in bio-diesel

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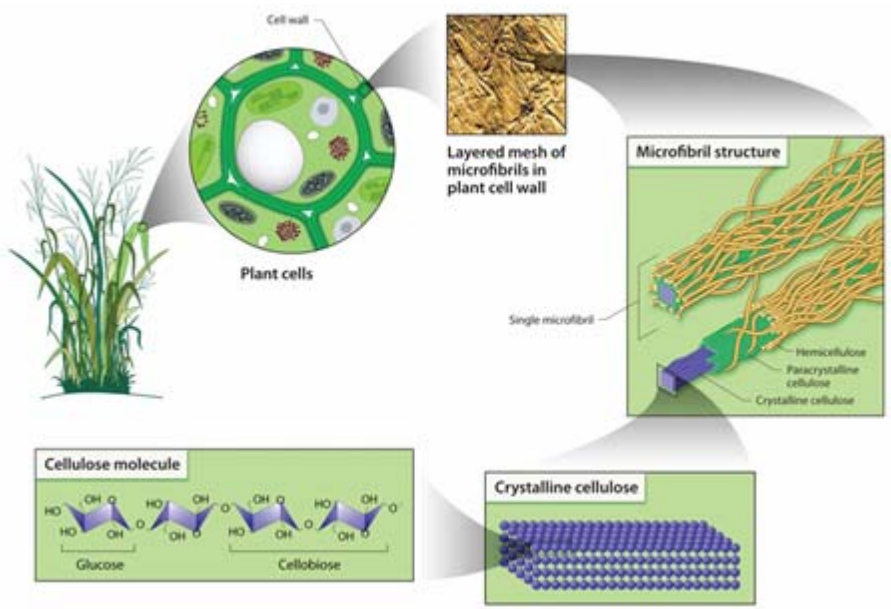
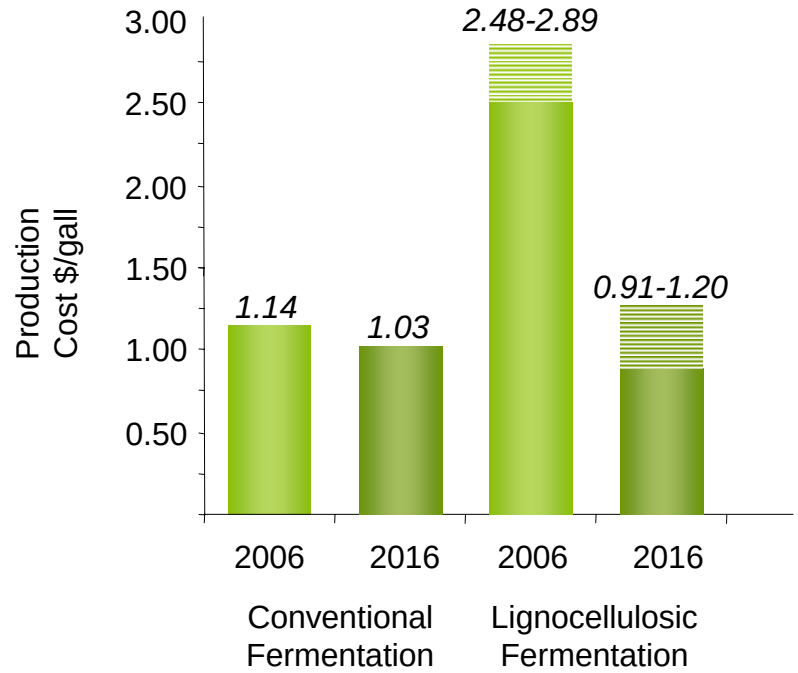
Lignocellulosics: 25-100% yield improvements* in 5-10 years. Brazilian sugarcane will remain competitive (economics & GHG)



ILLUSTRATIVE EXAMPLE – US CORN



Lignocellulose needs technology advances – BP EBI investment

* Corn example: 25% (fibre only); 100% (stover), with 50% of stover must remain in field to preserve ecosystem

Plant modification: improving economics and addressing sustainability by reducing the input intensity

- Some current generation technology can be input intensive e.g.
  - Water usage for plant growth
  - Acid usage in first generation lignocellulosic conversion
- Opportunities:
  - Genetically modified plants which are less thirsty
  - Plant decomposition triggered by UV-light

Genetic technologies are important in biofuels development

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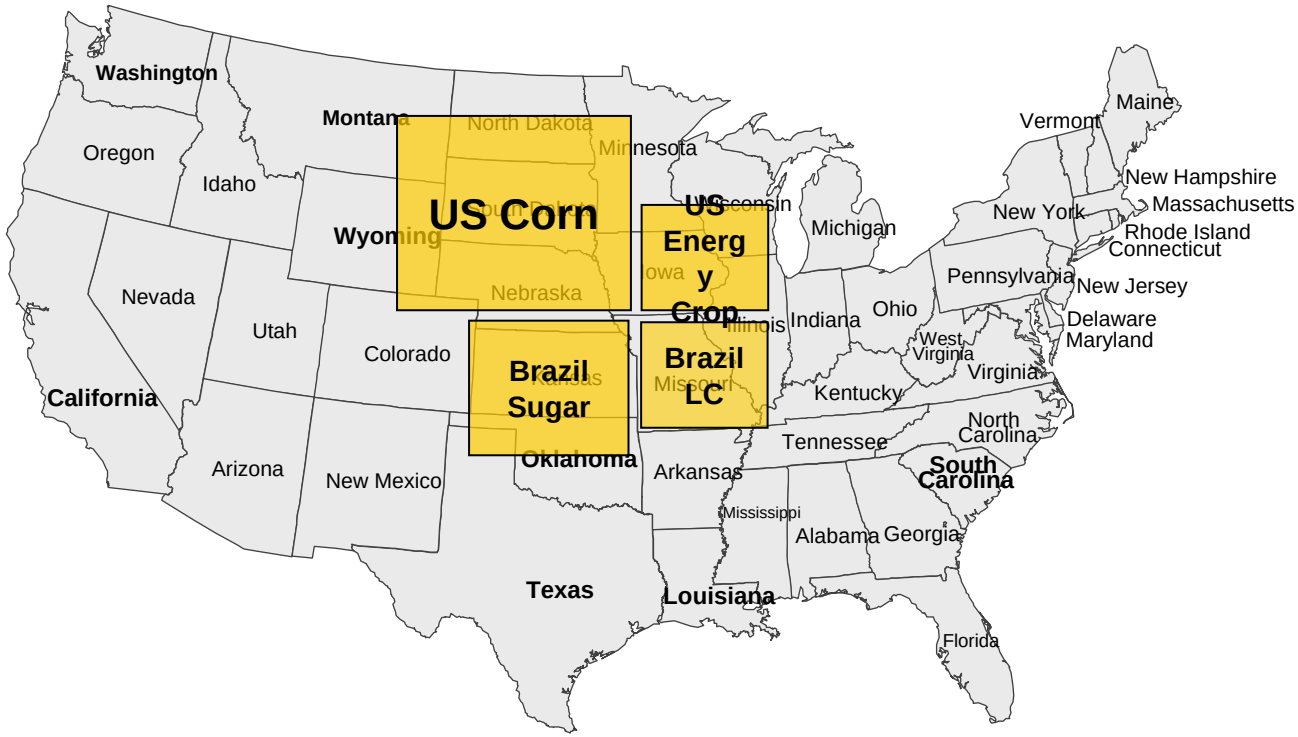
US example: land area required to replace 30% of the 2006 gasoline market



Legislation driven by objectives is required rather than legislation driven by technologies

2006 US gasoline market =140 bn galls.

30% v/v replacement adjusted for lower energy content of ethanol

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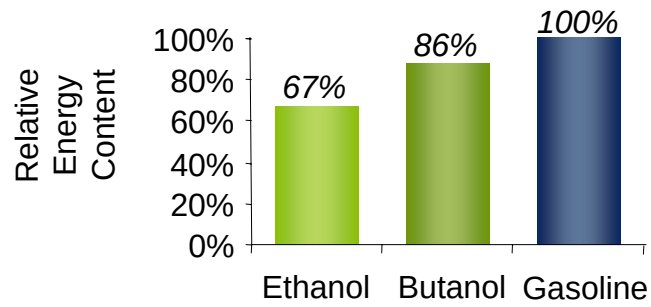
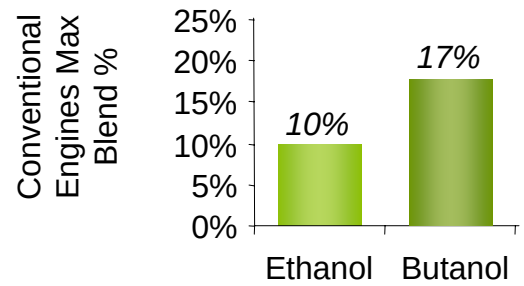
Advanced conversion: developing better quality molecules which can also increase penetration

- Butanol offers advantages over conventional biofuels (e.g. ethanol)
- Benefits:
  - Not corrosive – can use in higher concentrations
  - Low water affinity – no risk of phase separation; can pipeline
  - Easier to blend – no RVP issues
  - Higher energy content – better for the environment; better for the consumer (fewer fills)





Butanol allows deeper market penetration by biofuels giving higher total CO_2 savings

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- Shaper of an emerging industry
- Leadership position in the industry

BP is committed to the sustainable growth of the biofuels industry

"BP is building a Biofuels business underpinned by the exploitation of proprietary technology and ownership of advantaged assets, logistics and feedstocks."

- Investment in Ethanol with ABF & DuPont – Hull, UK
- Investment in sustainable diesel – with D1 Oils
- Energy Biosciences Institute – Berkeley/University of Illinois
- Crop development – investment in Mendel inc.
- Butanol development programme with DuPont
- Butanol Pilot Plant in Hull, UK

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