

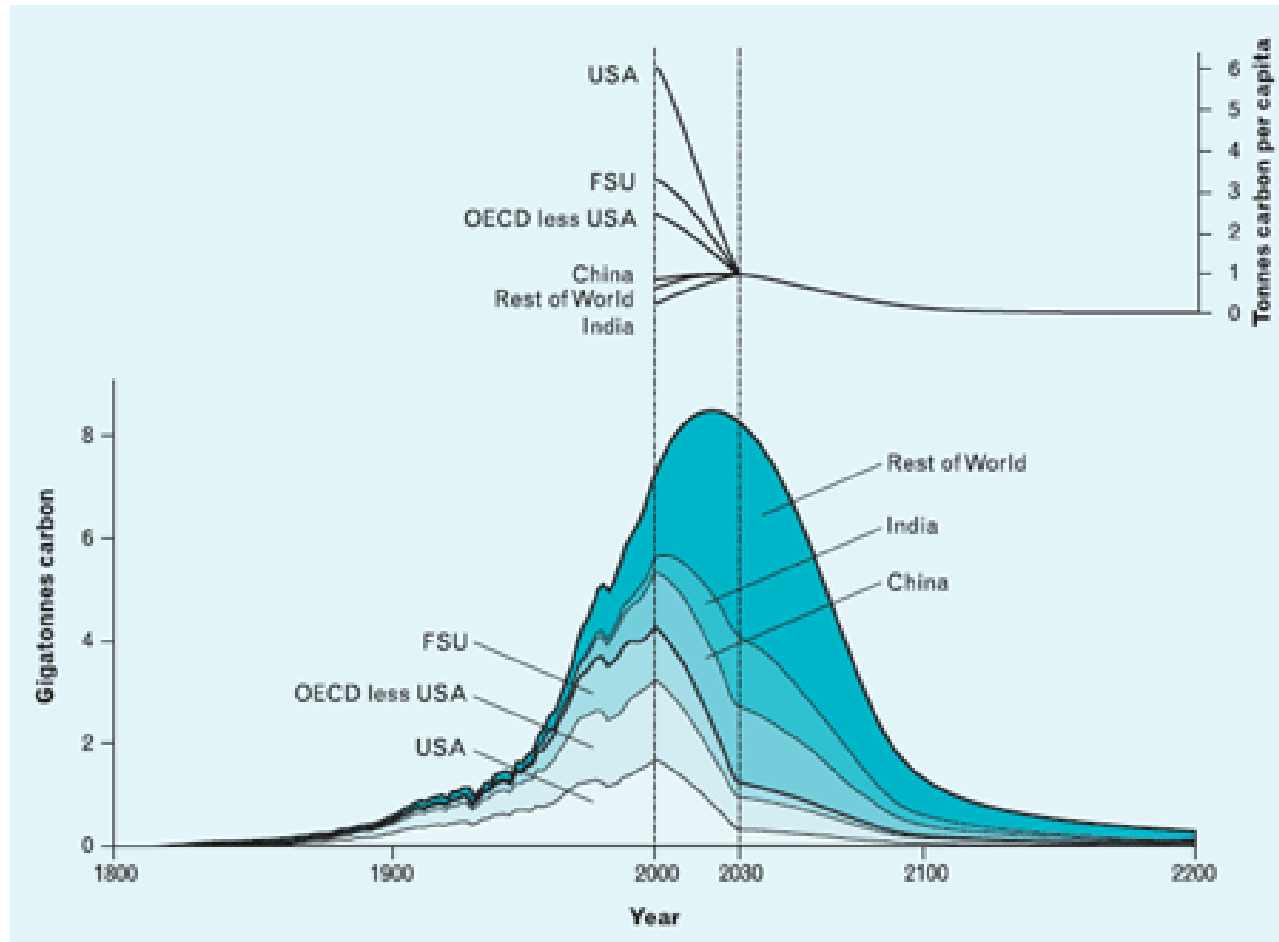
Biofuels and the Low Carbon Fuel Standard

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Climate stabilization is an enormous undertaking requiring a variety of actions



450 ppm example of “contraction and convergence” per the Global Commons Initiative

Source: www.cru.uea.ac.uk/tiempo/newswatch/comment060704.htm

Strategies

- Conservation
- Lower C energy
- Geoengineering (albedo)
- Air capture
- Adaptation
- (Failure)

Results

- Fossil energy use reduction
- More expensive energy
- Less use of physical goods
- Lifestyle changes
- Reallocation of wealth
- Change in status indicators

- NOT a reduction in GNP or economic growth; prices/tastes must change.

The Policy Larder

	Incentives	Coercion
Market	Make Buy	Tax Subsidize
Information	Inform Implore	Oblige* Prohibit

*Rare, difficult

Transportation (25%)

- Vehicle efficiency standards
- Fuel taxes
- Fuel GHG content reduction
- Social pressure
- Carbon tax
- Stationary source emission caps
- Reduce VMT (land use)
- Complements of efficiency (public)

Fuel GHG content reduction

- Biofuel subsidies
- Fuel taxes
- **LCFS**
- Content requirements
- Carbon tax
- Cap and trade emission limits (on what?)
- Vehicle fuel standards

LCFS

“Mix ethanol into the gasoline” ...not so simple!

- Electric
 - Vehicles, distribution
- Diesel
 - Efficiency overcomes C content
- Biofuels
 - Which?
 - From where?
 - How?

LCFS basics

- **Carbon intensity must be measured on a lifecycle basis**
 - Average Fuel Carbon Intensity (AFCI) measured in gCO_{2e}/MJ
 - AFCI must decline by at least 10% by 2020
- **Stimulate technological innovation**
 - Use performance standard, with tightening over time
 - Measures desired outcome (GHGs), not a proxy (renewable)
 - Different fuels (electricity, biofuels, fossil, etc.) compete with one another, so government does not pick winners (or losers!)
- **Compliance by manufacturers or importers of fuels (mostly oil refiners)**
- **Additional to vehicle performance standards**
- **Overcompliance creates credits that can be traded in a market or banked for later use**
- **Default and opt-in approach (Thanks to the U.K.)**

Compliance through default and opt-in

- **Compliance is possible with many competing technologies:**
 - Lowering the carbon intensity of current fuels – e.g. refinery efficiency
 - Using new, low-carbon fuels – biofuels, electricity, hydrogen, etc.
 - Buying credits (or offsets)
- **Default: all fuel inputs are assigned a carbon intensity**
 - Fuel inputs must be categorized
 - Highest value in common use is the default value
 - Encourages opt-in and focuses management attention
- **Opt-in: certified data allow lower carbon intensity values**
 - Requires protocol development and data collection
 - Certifiers are needed
- **Default example:**
 - Gasoline: conventional oil, heavy oil, tar sands, coal
 - Diesel: conventional oil, heavy oil, tar sands, coal
 - Ethanol: U.S. corn, Brazilian sugar, U.S. switchgrass

The LCFS may become a complement to (or replacement for) biofuel mandates

- **United Kingdom:** Renewable Transportation Fuel Obligation (like a RFS) requires GHG monitoring in 2008
- **California:** LCFS regulations to be in effect 2010
- **Consideration by other states and provinces:** AZ, BC, CT, DE, MD, MA, MN, NH, NJ, NY, ON, OR, NM, RI, VT, WA...
- **Federal regulations:** Proposed CAFE + LCFS rule in Nov 2007
- **Federal bills:** Sanders-Boxer, Feinstein, Inslee, Boucher
- **European Union:** monitoring in 2009, reductions in 2011
- **Global Bio-Energy Partnership:** Oct 9-10 meeting on GHG emission monitoring

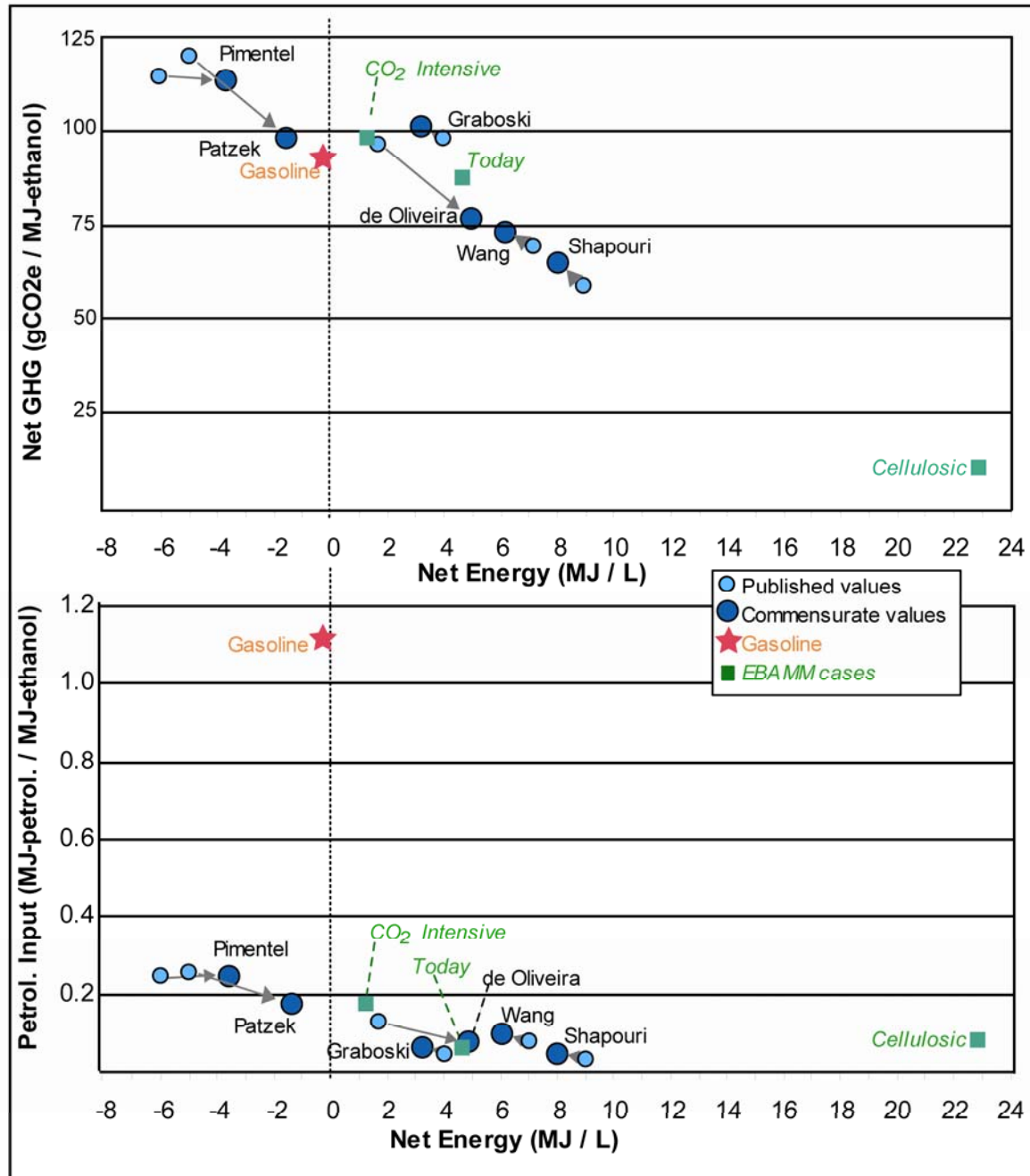
Policy challenges

- Diesel vs. gasoline
- State/nation/world - shifting
- Electricity vs. liquid fuels
 - Battery => mass burn
 - Current technology
- Biofuels assessment
 - “non-green ethanol”
 - Social consequences: will there be an “ethanol curse”?

Uncertainties

- Technology
 - Battery
 - Cellulosic
 - Which alcohol?
- GHG content/LCA
 - Lime etc. (small-medium)
 - Land use (big)
- Prices and elasticities
- Intereverything coordination

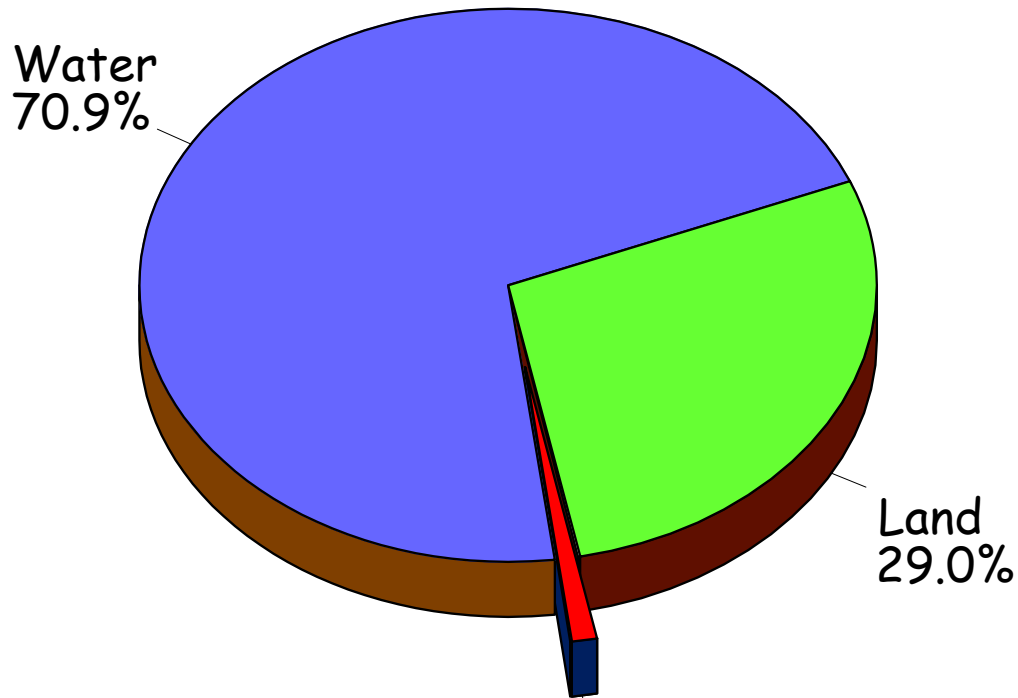
From Farrell et al,
Science 27/1/06



Types of biofuels

- Solid, burned directly
- Diesel
- Sugar to ethanol
- Cellulose to ethanol
- Cellulose to other

90,000 TW of energy arrives on the earth's surface from the sun



Amount of land needed for 13 TW at 1% efficiency
5% of land
650 MHa

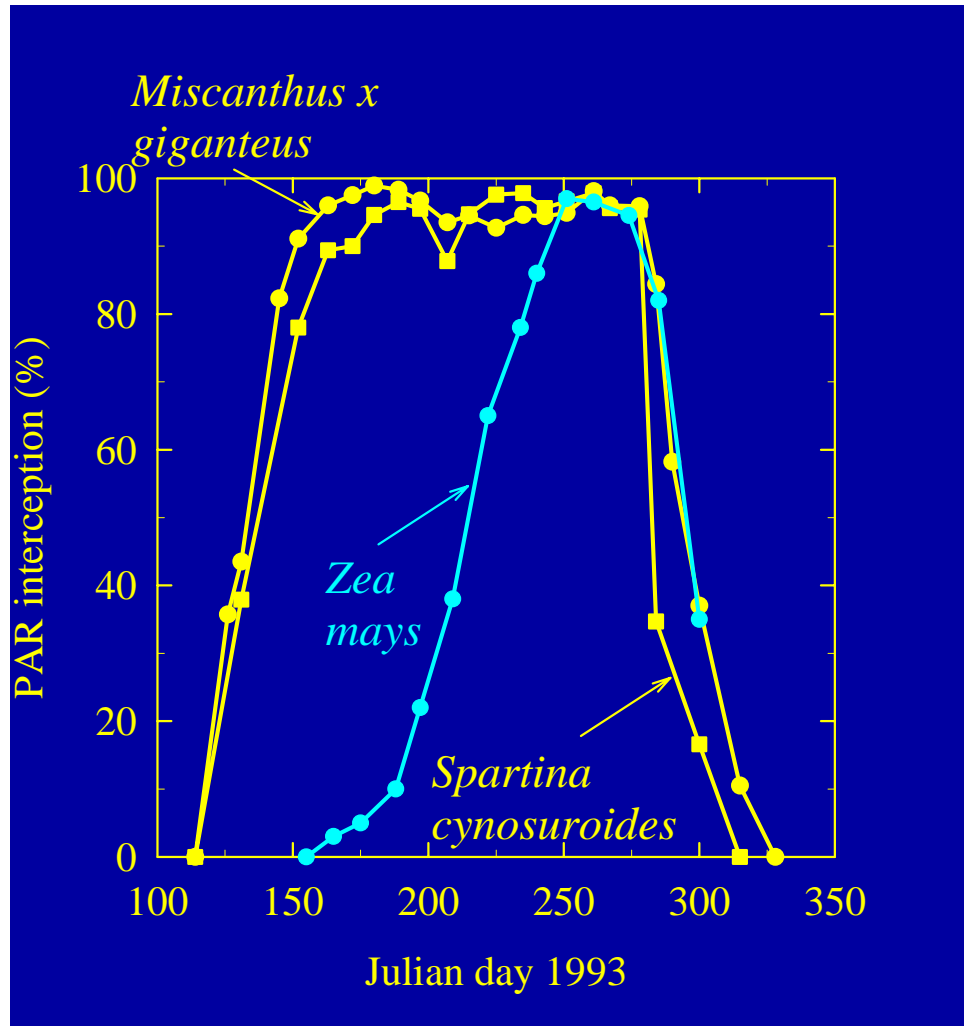
>2% yield is feasible

Yield of 26.5 tons/acre observed by Young & colleagues
in Illinois, without irrigation

Courtesy of Steve Long et al



Perennials have more photosynthesis



Courtesy of Steve Long, University of Illinois



BUT

- Biofuel crops are
 - Low labor input
 - Industrial monocrop agriculture
 - Land-hungry
 - Water-thirsty



Photo Alan Lodge

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