Conversion technologies for biomass transportation fuels

-Present and future scenarios

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Conversion of biomass to energy carriers: Solid, liquid and gas

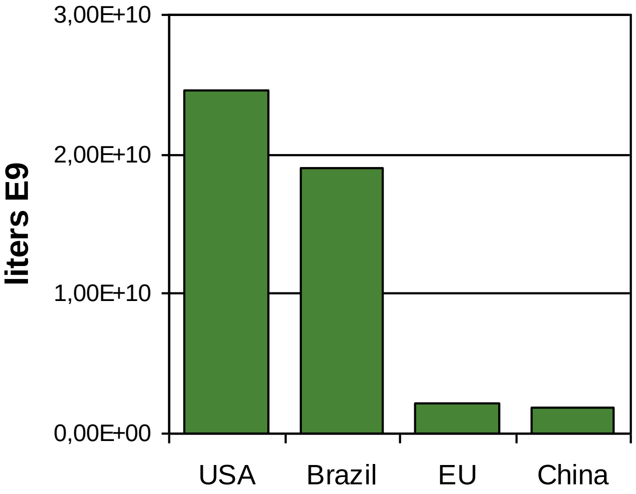
Solid fuels for
heat & power

Liquid fuels for
Transportation
Bioethanol, Biodiesel
New fuels

Gaseous fuels for
transportation and
heat & power
H_2, Methane

Bioethanol 1st generation

- Ethanol made from corn, sugarcane, wheat and sugar beet
- Rapid expansion in US and Brazil
- CO_2 savings vary from 30 to 80%
- Land area for corn and sugar cane approx. 15 mill ha.
- World production equals to 2 percent of gasoline consumption
- Feed by-products from corn and wheat



Biodiesel 1st generation

- Biodiesel made from oil palms, rape, soy and jatropha
- Jatropha biodiesel well suited as jet fuel
- Feed by-products from soy, rape and oil palms
- Larger area needed compared to bioethanol
- CO_2 savings can be negative for palm oil
- Major production in Germany and USA
- World production equals ~0,5% of diesel consumption

Bioethanol 2nd generation

- Ethanol made from non-food crops and residues
- Rapid technology development
- Large scale plants are expected to come on-line in 2009
- No major impact on the biofuel supply before 2014
- CO_2 savings vary from 60 to 90%
- Feed by-products are possible

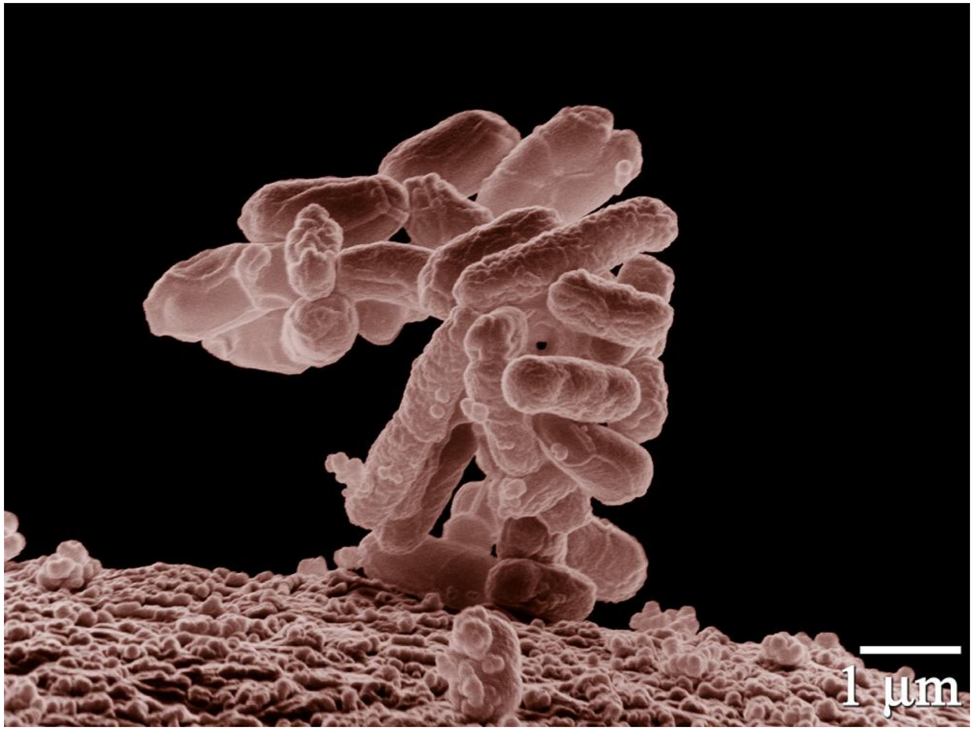
Biomass to liquids (BtL)

- Thermochemical conversion to diesel and gasoline (kerosene)
- Any type of biomass, but wood is preferred
- Rapid technology development
- Potential integration with 2nd generation bioethanol
- Main fuel is diesel
- Full-scale to come on-line in 2010?
- CO2 savings 70-85%
- No feed by-products

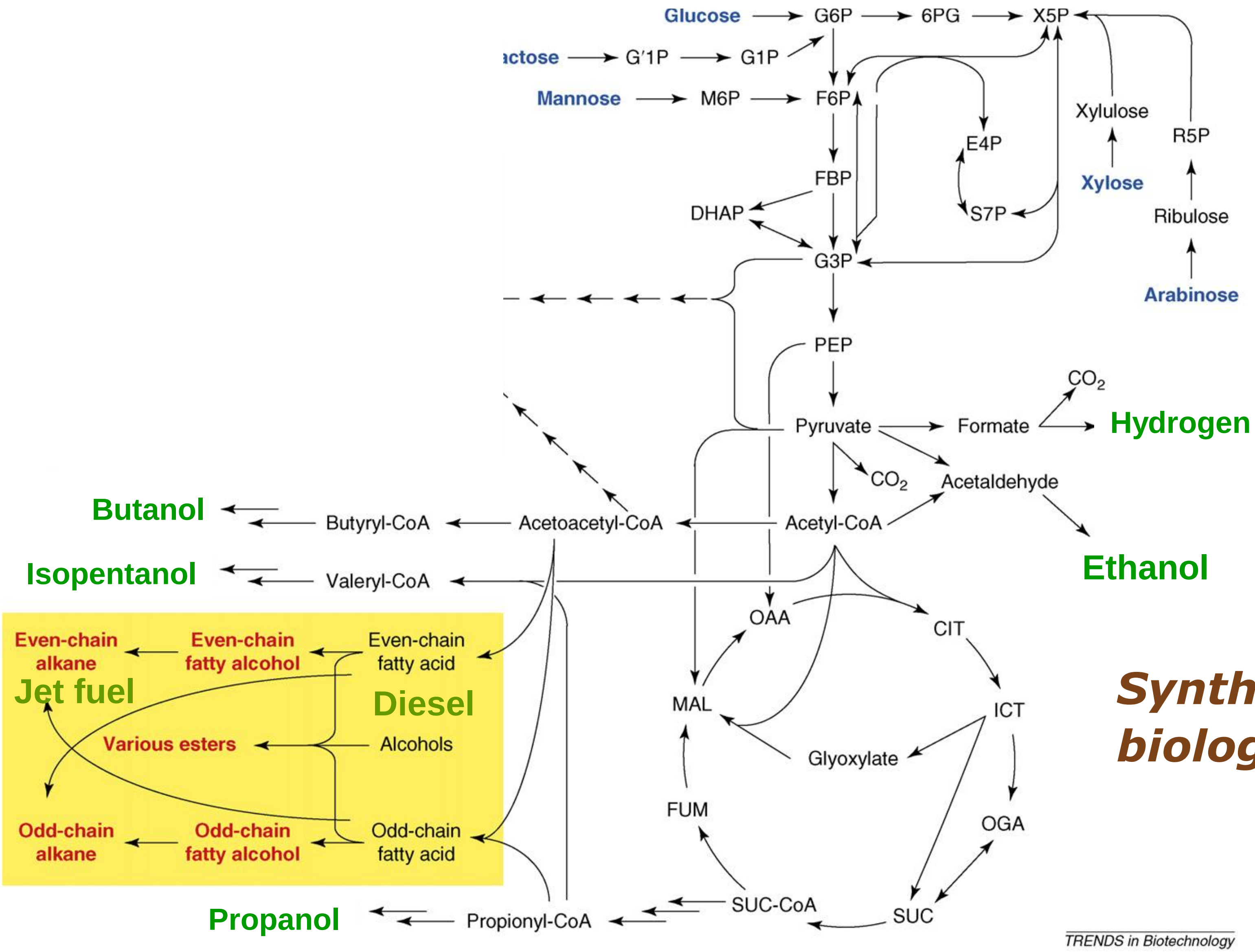
Biogas

- Based on manure, animal waste and energy crops
- Lowest yield from manure
- No feed by-products
- Already used in e.g. Sweden
- Removal of CO_2 and H_2S needed
- CO_2 savings 70-85% (not including CH_4)
- New opportunities for using MSW may increase potential

New Fuels
-exploring the microbiological well



The microbiological fuel pathways



Synthetic biology

Advanced biofuels

- Sugar derived i.e. compatible with bioethanol
- Lower yield ~30% compared to ethanol
- 4-18 carbon length chains
- 20-40% w/w higher energy content than ethanol
- Non (less)-miscible with water
- No destillation required
- Can be (and are) designed to existing engine technology
- 25-50% less steam required during processing.
- 100% GMO –restrictions on feed products
- Pilot-scale level

Blue biotechnology

- Algae and cyanobacteria has the potential of 2-3 times more efficient photosynthesis
- Could provide 100% decoupling food and bioenergy
- Only proven in lab-scale
- We have little experience with large scale production of algae biomass
- Still on the drawing board, but...

Artist's conception of growing algae in the desert

Biofuels of 2030

- Major biomass based transport fuels
  - Higher alcohols
  - Terpenes
  - Alkenes
  - CH4 –biogas
  - BTL diesel (?)

- Minor biomass based transport fuels
  - Bioethanol
  - Plant oil based biodiesel

- Challenges
  - GMO/feed issue
  - Adaptability to cellulosic feedstocks
  - Economic feasability?
  - Speed of implementation

Better fit with current engine technology, higher energy density and higher energy efficiency ~75%