

The Direction of Research at BSEL: Bioproducts, Bioprocesses & Bioenergy

Making next generation
biofuels and chemicals
from biomass

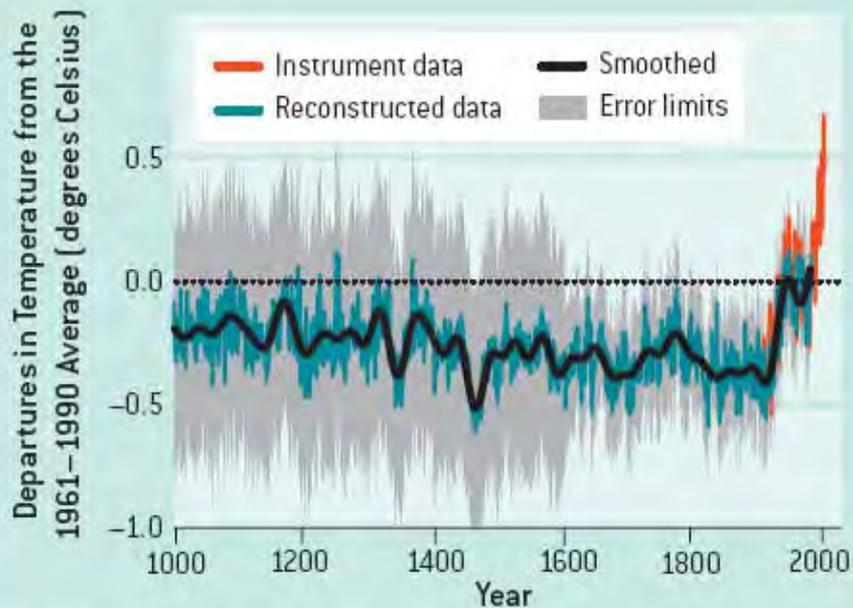
The BSEL Mission

1. To develop and transform abundant and renewable bioresources through targeted research, development, demonstration and commercialization of bioproducts, bioprocesses and bioenergy supported by a wide variety of public and private partnerships.
2. To provide a quality and rigorous education in the sciences and engineering required to conduct an active program of research, discovery and commercialization while integrating the teaching and research missions.



THE HEAT IS ON

A U.S. senator has called global warming the “greatest hoax” ever foisted on the American people. But despite persistently strident rhetoric, skeptics are having an ever harder time making their arguments: scientific support for warming continues to grow.



This “hockey stick graph,” from one of many studies showing a recent sharp increase in average temperatures, received criticism from warming skeptics, who questioned the underlying data. A report released in June by the National Research Council lends new credence to the sticklike trend line that traces an upward path of temperatures during the 20th century.



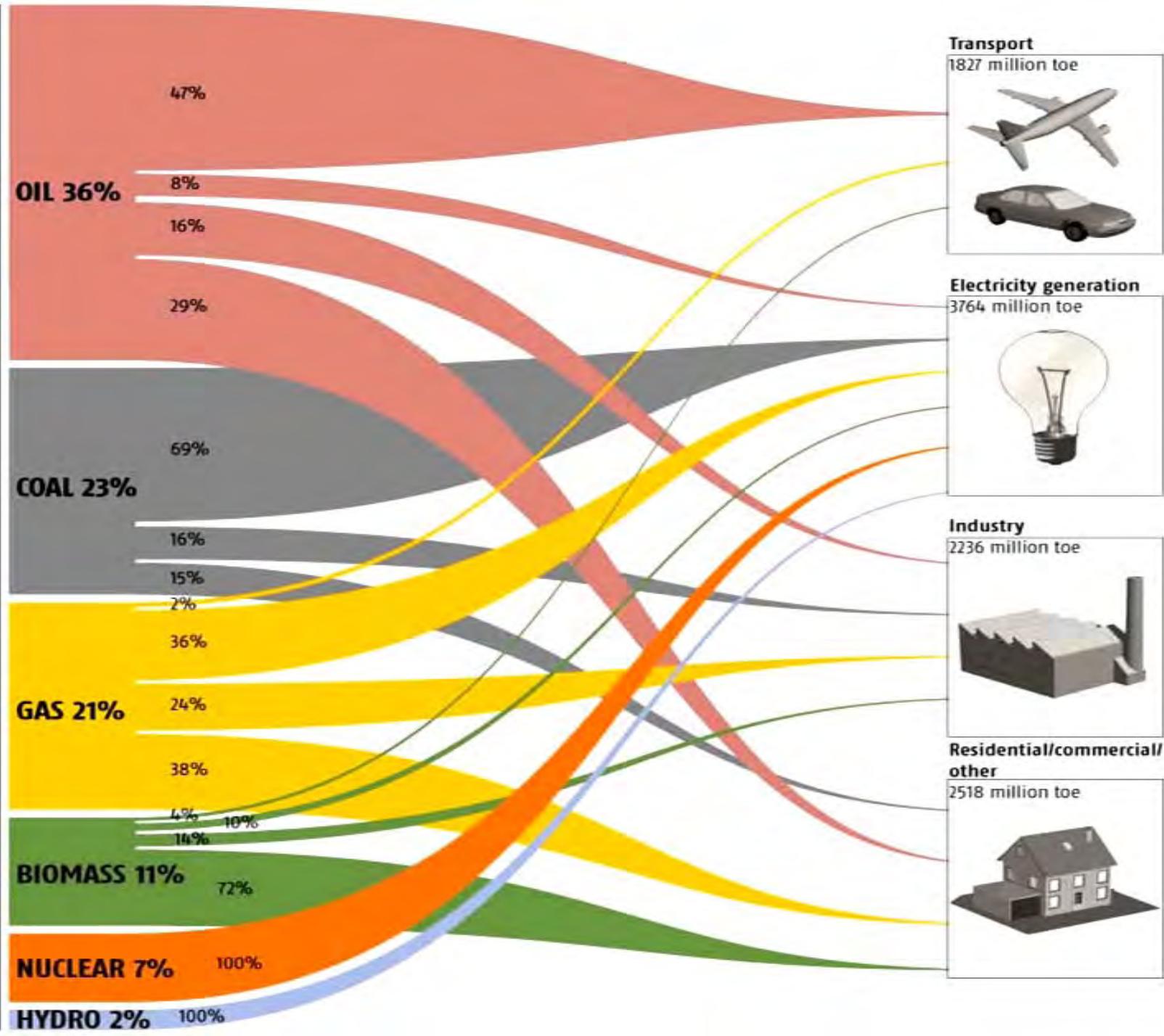
A line of SUVs symbolizes high per-capita U.S. energy consumption. But rising expectations pervade the developing world. Many Chinese dream of trading a bicycle for a car.





GLOBAL ANNUAL ENERGY USE

10,345 million tonnes oil equivalent



Transport
1827 million toe

Electricity generation
3764 million toe

Industry
2236 million toe

Residential/commercial/other
2518 million toe

WEEKLY | NEWS IDEAS INNOVATION

THE BEST JOBS IN SCIENCE

NewScientist

7 July 2007

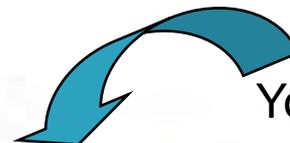
LIVING WITHOUT



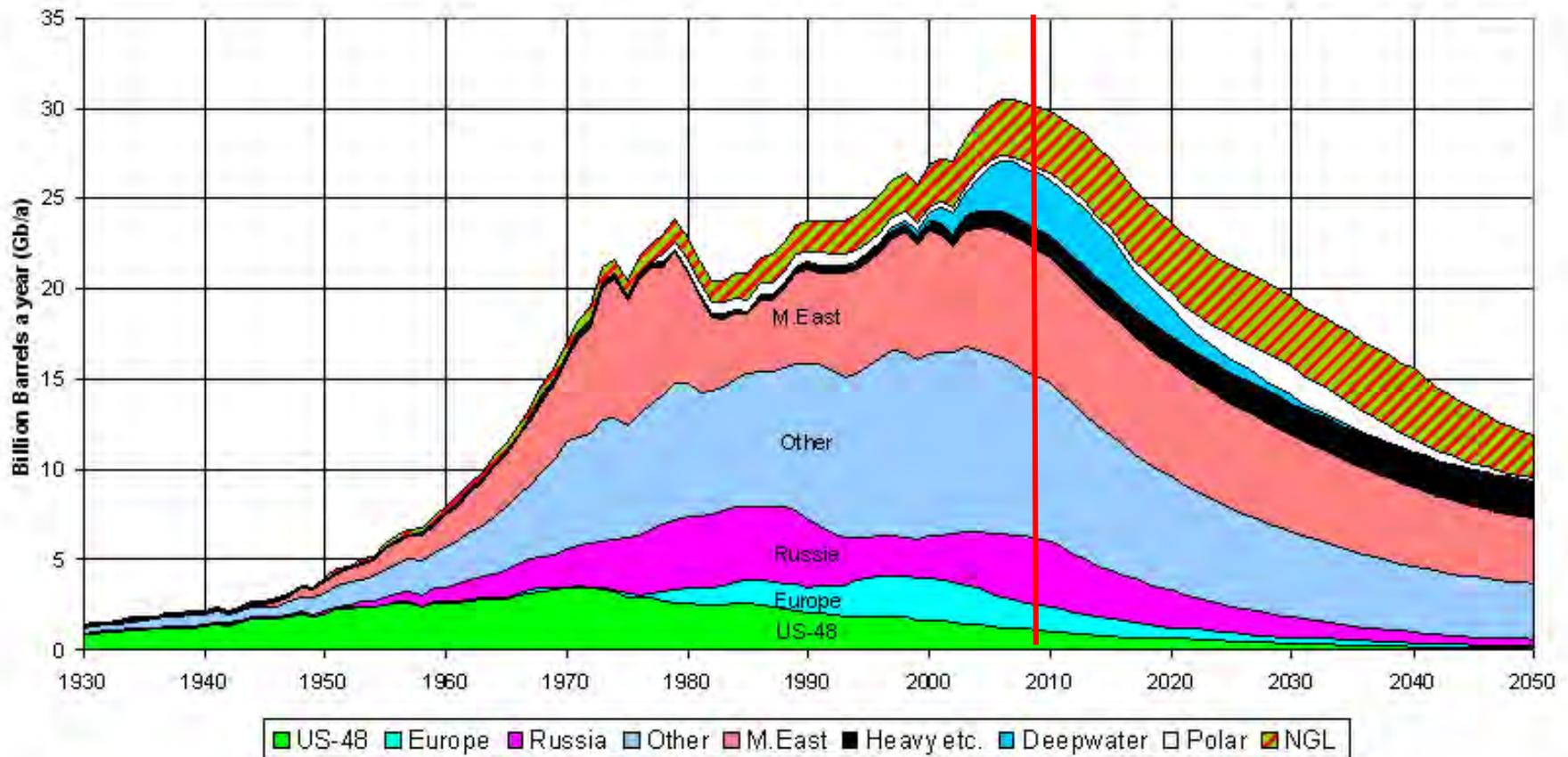
How civilisation will survive
once the black gold runs out

Oil and gas resources

2004 Scenario

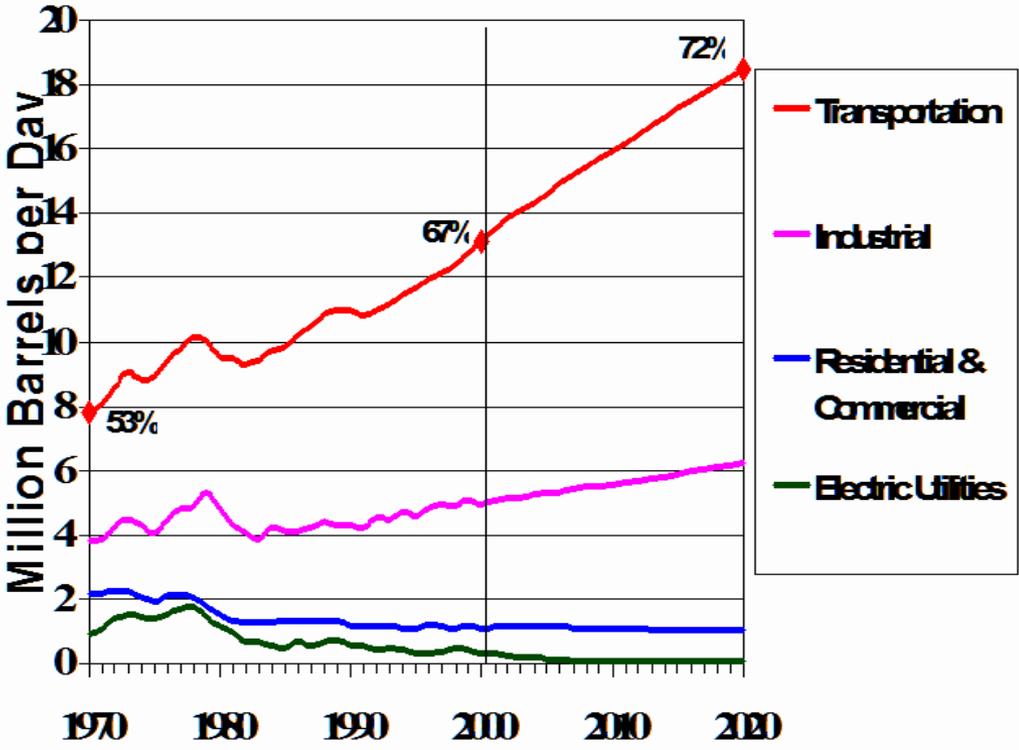


You are here





Oil use



Statement from US Department of Energy



U.S. Department of Energy
Energy Efficiency and Renewable Energy
Driving you a prosperous future where energy is clean, abundant, reliable, and affordable.

The Unique Role of Biomass

While the growing need for sustainable electric power can be met by other renewable, biomass is the only renewable that can meet our demand for carbon-based liquid fuels and chemicals.

Bioethanol – Production technologies



Current technology:

Starch-based ethanol

Biomass: Corn, grain, sugar



Technology under implementation:

Lignocellulose based ethanol

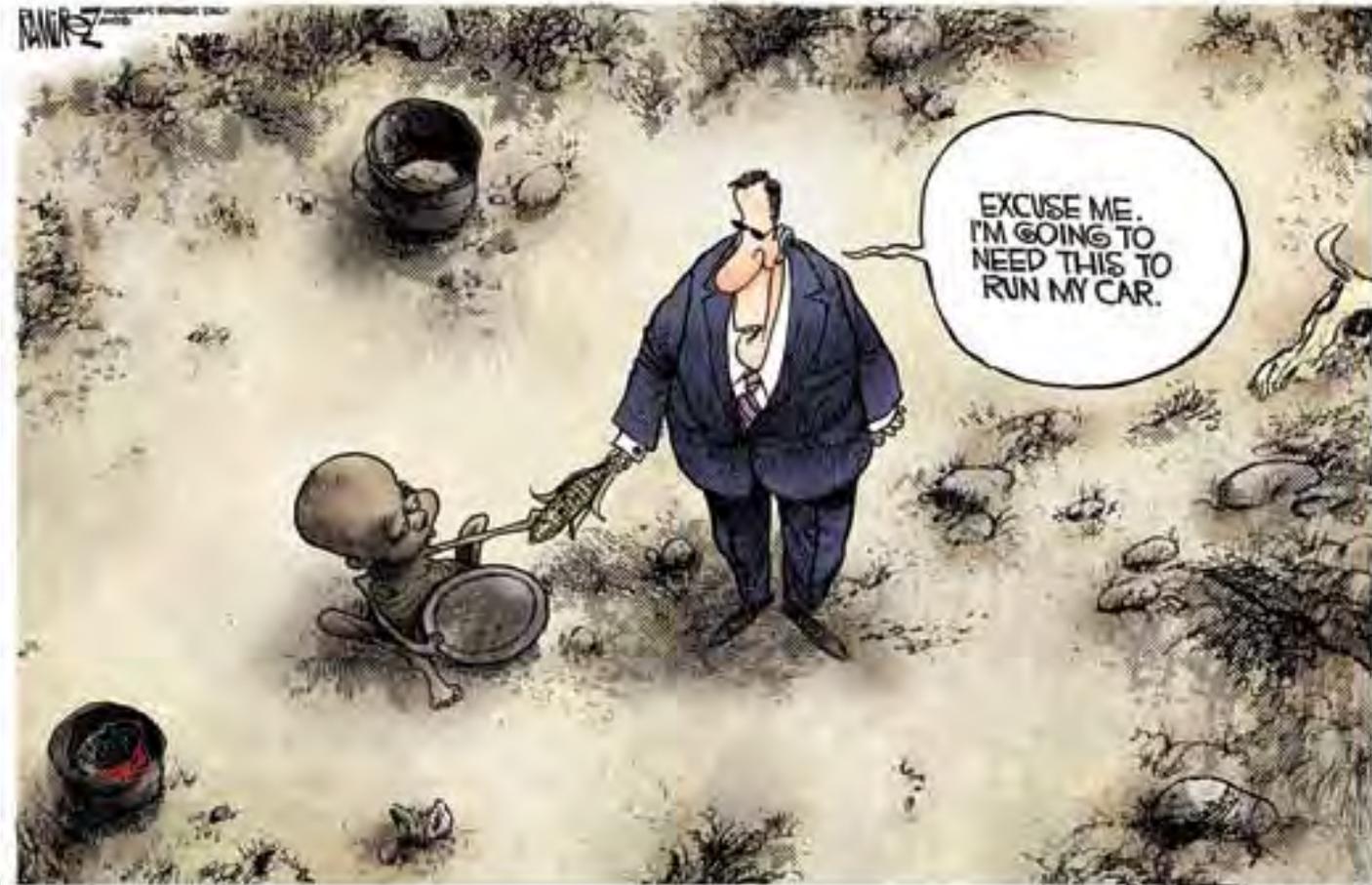
Residues and waste: Corn stover, straw, bagasse, wood, garden refuges etc.

1. Generation biofuels plant

Food/Fruit-based fuels made from sugar, starch, vegetable and animal oil.
Corn and grain based ethanol, rapeseed and palmoil based biodiesel.



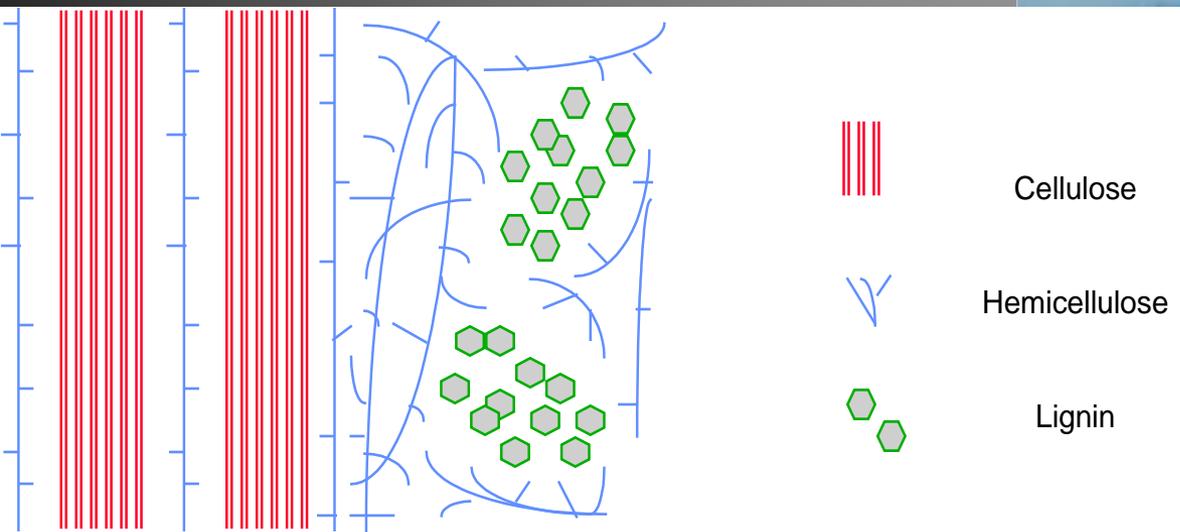
Competition with food





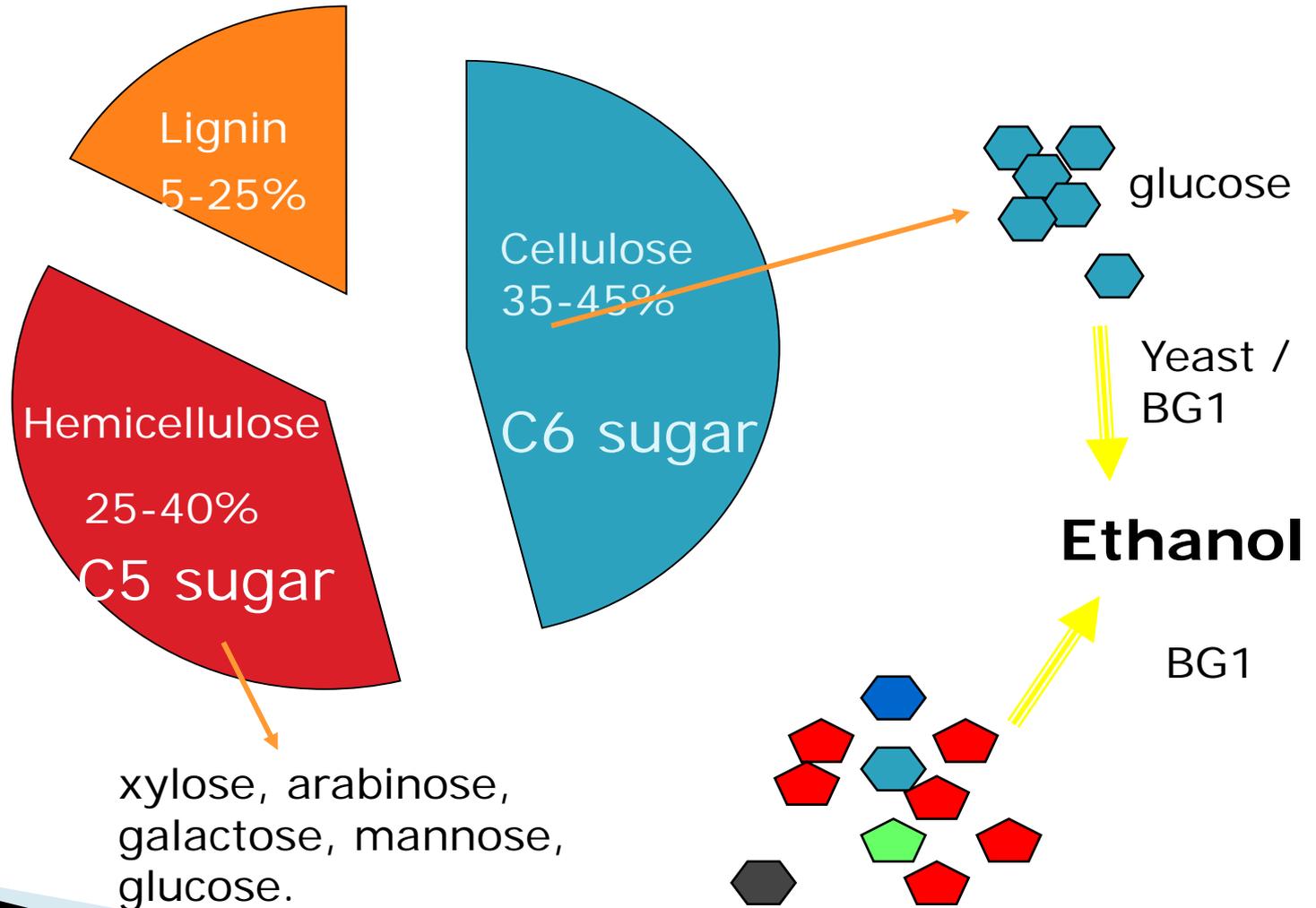
The lignocellulosic problem of 2nd generation biofuels

Pinus longaeva
5000 years

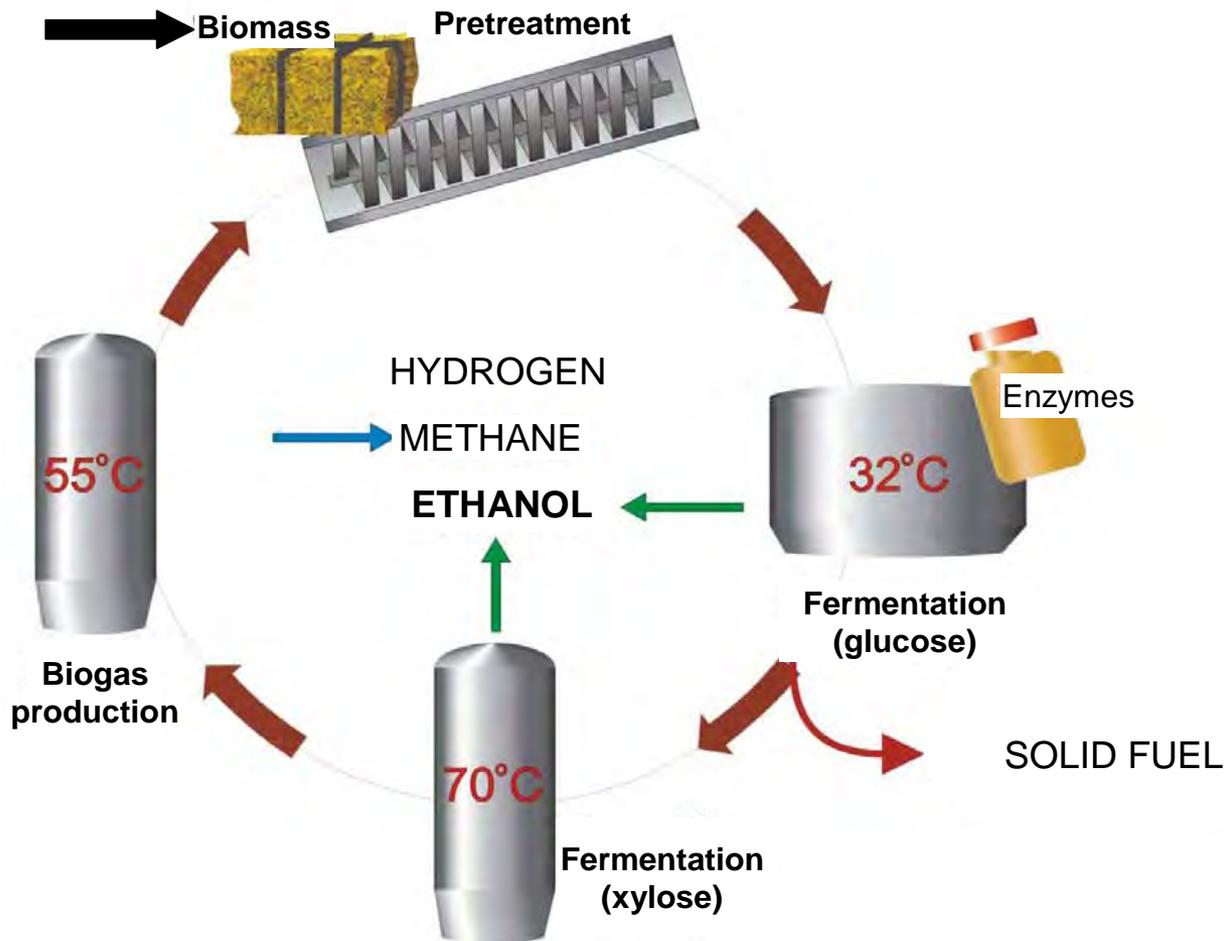


Feedstock

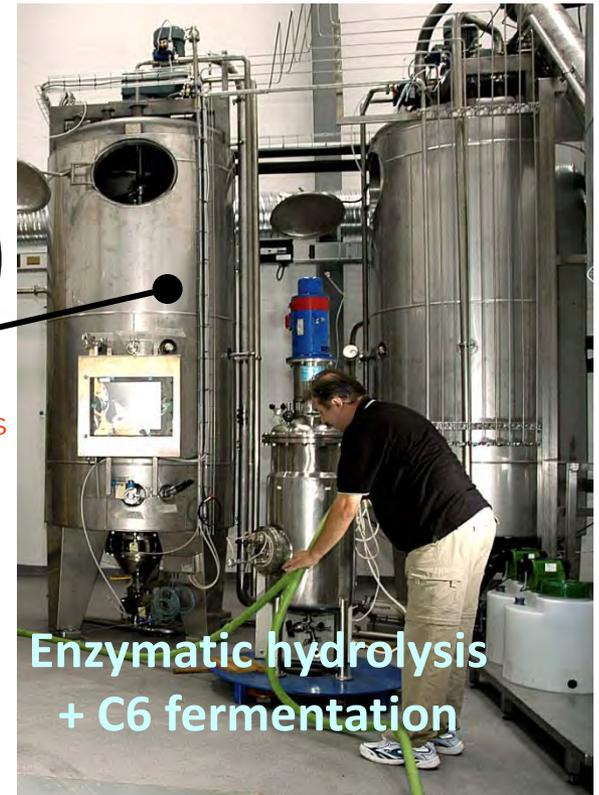
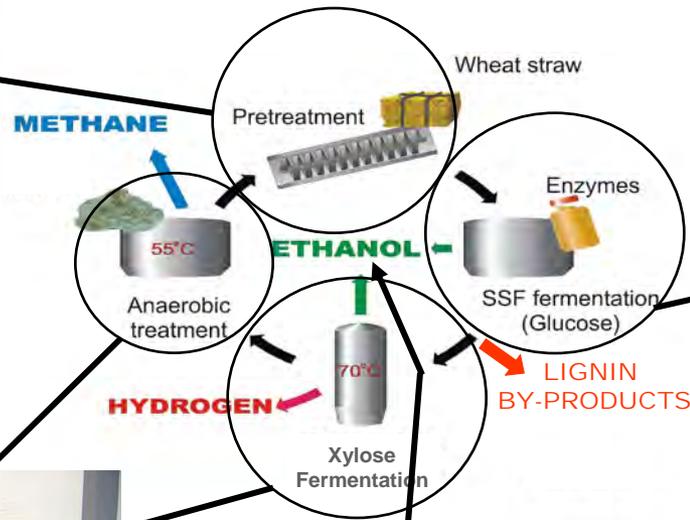
- Three major components



The BioGasol Concept : The carbon slaughter-house

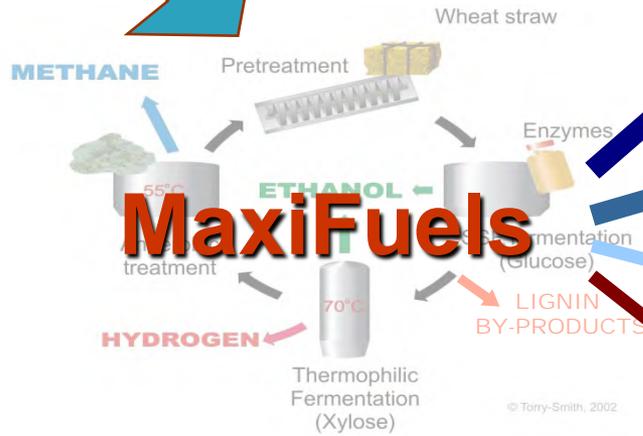


MAXIFuels pilot plant – started September 2006 – Abandoned July 2008



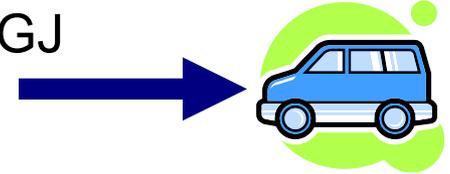


1 tonne
straw =
15 GJ



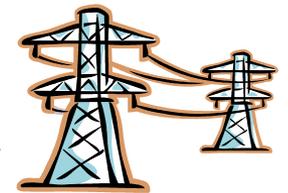
230 kg Ethanol

= 6.8 GJ



47 kg Methane

= 2,6 GJ

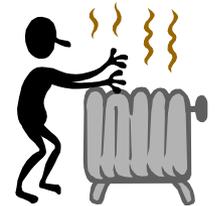


2.9 kg Hydrogen

= 0,4 GJ



Heat/electricity



200 kg Fibers

= 3,7 GJ



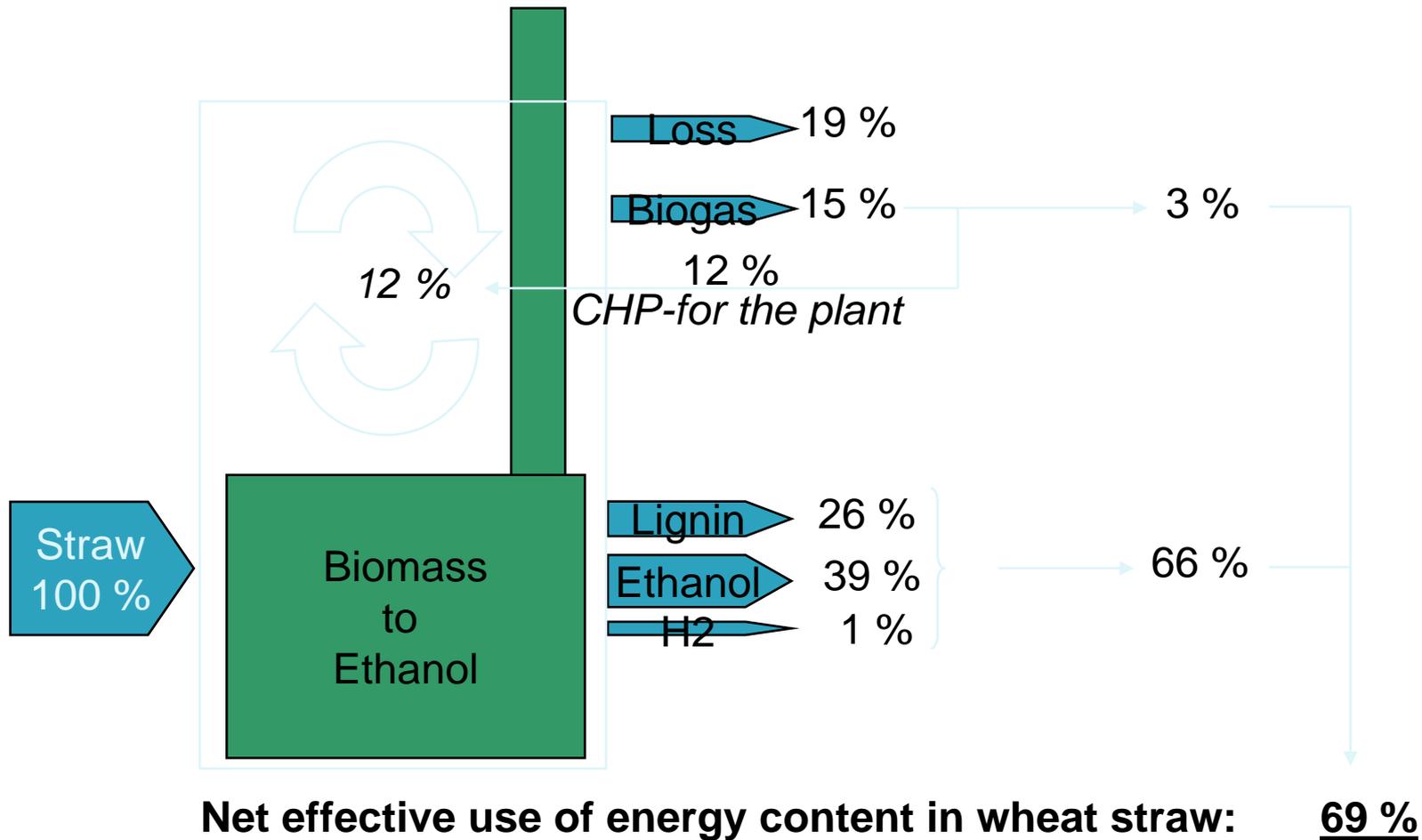
Chemicals/fuels



What do we get out
of Maxifuels???

Maxifuel Energy Balance

$\eta=0.69$

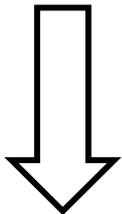


Tested with success in the laboratory



1 tonne
wheat
straw

An oval containing the text "1 tonne wheat straw". A red arrow points from the bottom of the wheat straw image to this oval.

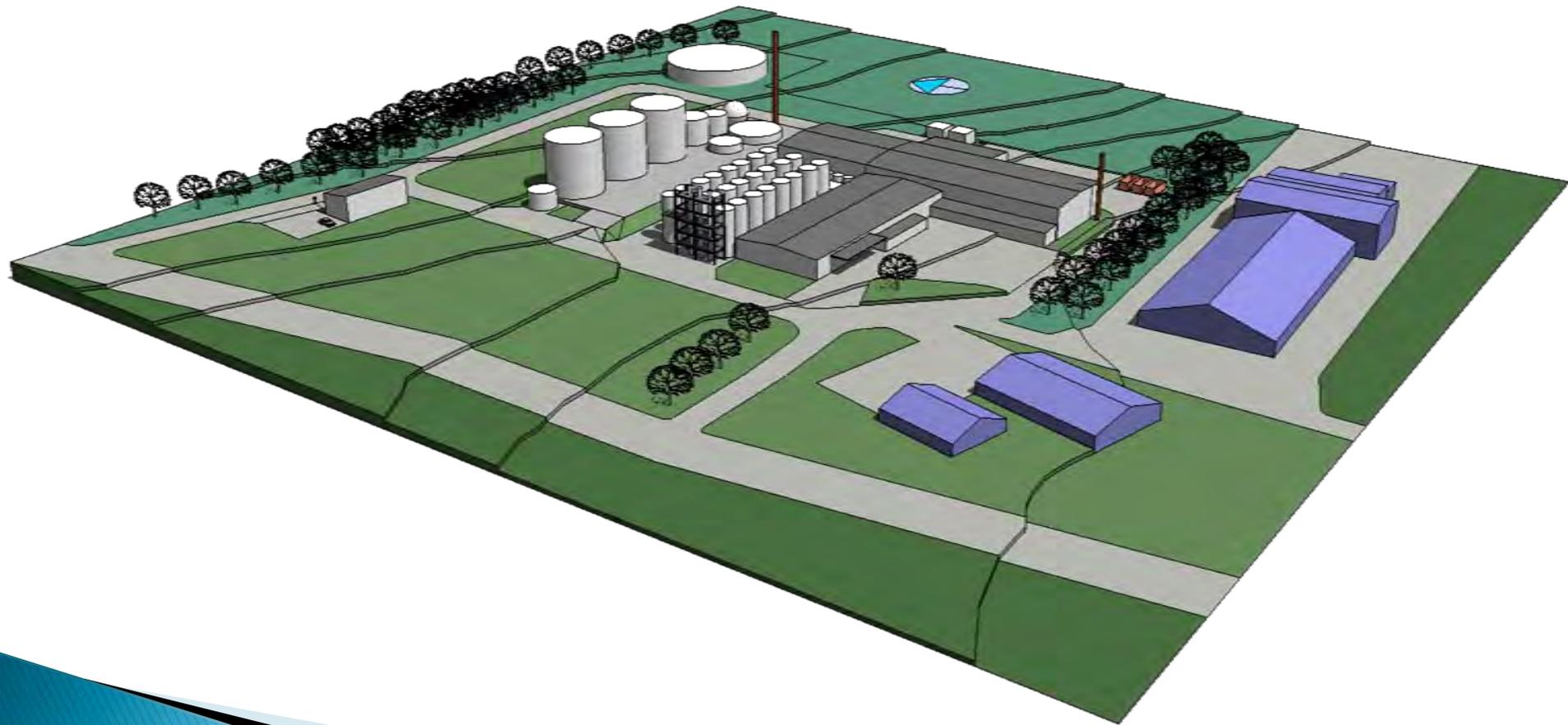


270 liters of ethanol

A rectangular box containing the text "270 liters of ethanol".



BornBioFuel



The biofuel family

1. **Generation:** Food-based fuels made from sugar, starch, vegetable and animal oil.
2. **Generation:** Non-food based fuels made from lignocellulosic wastes, other wastes, and energy crops.
3. **Generation:** Biomass-free biofuels produced directly by photosynthetic algae and bacteria.
4. **Generation:** Synthetic or genetically engineered microorganisms producing biofuels directly from CO₂ (biomass-free).

3. Generation biofuels. Biomass-free biofuels produced directly by photosynthetic algae and bacteria.

Algal biodiesel production



Photobiological
Hydrogen production



SYNDUSTRY

The news of "Synthia," the world's first human-made species, is just the latest from a rapidly growing artificial life industry. Synthetic biology (or "Syn Bio") aims to profit from the design and construction of industrially useful life-forms.

THE EMERGING SYNTHETIC BIOLOGY INDUSTRY

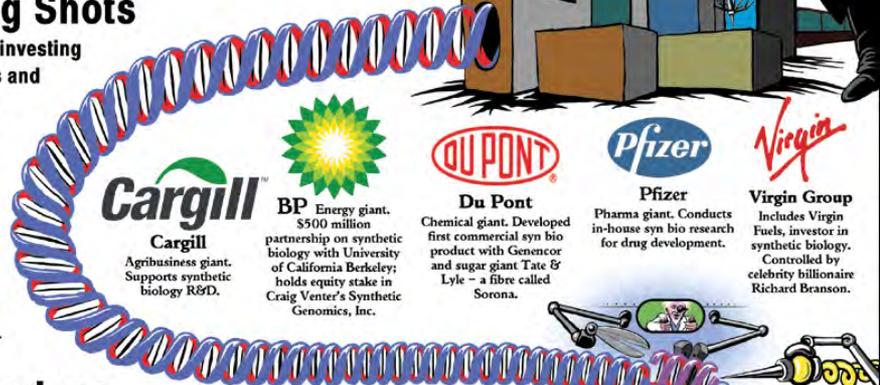


4. Generation biofuels
Synthetic biology
Hydrocarbons, alcohols
- you name it.

Syn Bio's Big Shots

Global corporations are investing in synthetic biology labs and partnering with start-up companies.

"Over the next 20 years synthetic genomics is going to become the standard for making anything." - Craig Venter



Cargill
Agribusiness giant. Supports synthetic biology R&D.

BP Energy giant. \$500 million partnership on synthetic biology with University of California Berkeley; holds equity stake in Craig Venter's Synthetic Genomics, Inc.

Du Pont
Chemical giant. Developed first commercial syn bio product with Genencor and sugar giant Tate & Lyle - a fibre called Sorona.

Pfizer
Pharma giant. Conducts in-house syn bio research for drug development.

Virgin Group
Includes Virgin Fuels, investor in synthetic biology. Controlled by celebrity billionaire Richard Branson.

Synthetic Startups

A bevy of 'pure play' syn bio companies is attempting to design synthetic microbes for fuel, chemicals and drugs. Many are university spin-offs.

gevo (USA) Developing synthetic biofuels with support from Virgin.

Mascoma (USA) Developing synthetic biofuels.

Synthetic Genomics (USA) Constructing synthetic life forms for biofuels and carbon sequestration.

LS9 (USA) Developing synthetic biofuels and industrial chemicals.

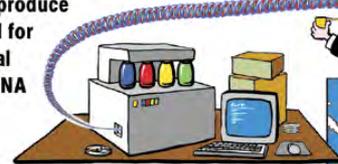
AMYRIS BIOTECHNOLOGIES (USA) Developing cellular factories to produce drugs, fuels and industrial chemicals.

ProtoLife (Italy) Developing synthetic living systems.

DNA Synthesis Foundries

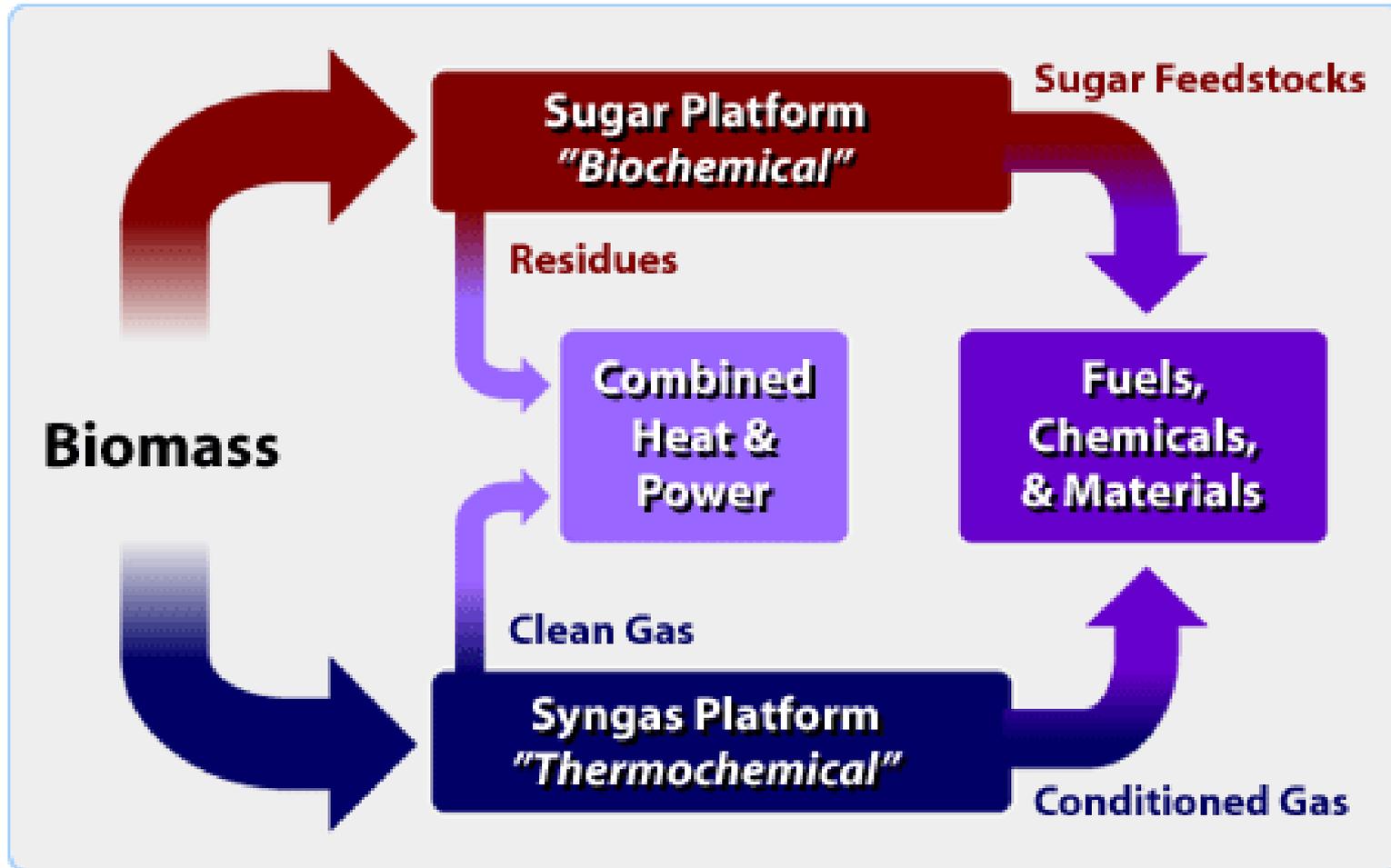
DNA foundries produce the raw material for creating artificial life: synthetic DNA (sDNA).

Over 70 DNA foundries worldwide manufacture sDNA for genetic engineers and synthetic biologists. The market for sDNA already exceeds a billion dollars annually. Even long DNA sequences - entire genes, for example - can be ordered over the Internet and delivered within two weeks. The speed of producing accurate DNA sequences is doubling every two years and costs are halving even faster.



Some Commercial DNA Synthesis Companies

Biorefinery Concept

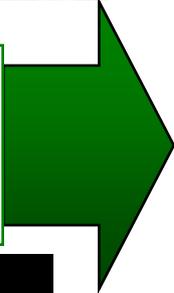




Biomass will constitute an inevitable resource for carbon-based fuels and chemicals



Biomass Feedstock



Conversion Processes



- Trees
- Grasses
- Agricultural Crops
- Algae
- Agricultural Residues
- Animal Wastes
- Municipal Solid Waste

- Enzymatic Fermentation
- Gas/liquid Fermentation
- Acid Hydrolysis/Fermentation
- Gasification
- Combustion
- Co-firing

USES

Fuels:

- Ethanol
- Renewable Diesel
- Hydrogen

Power:

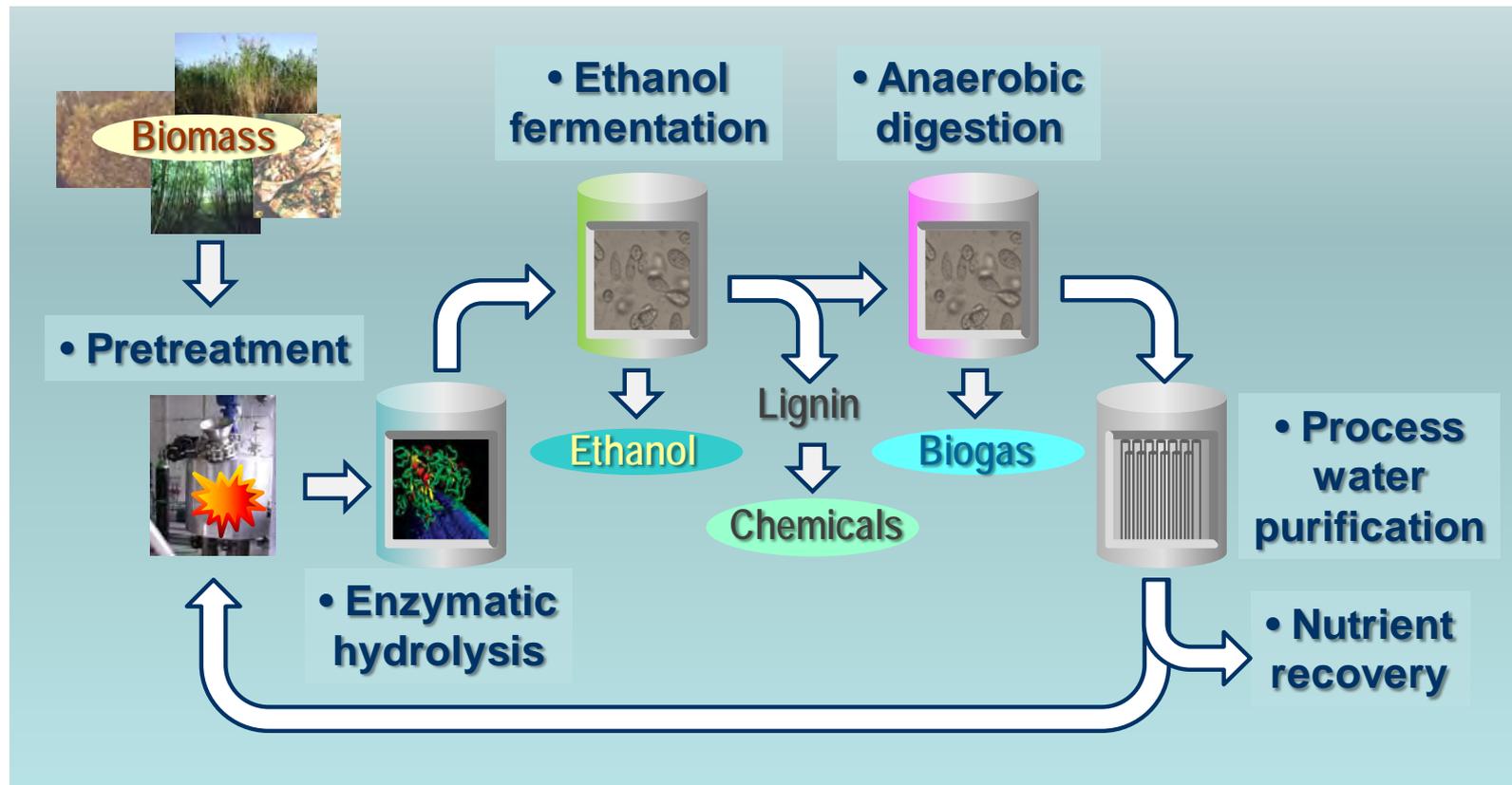
- Electricity
- Heat

Chemicals

- Plastics
- Solvents
- Chemical Intermediates
- Phenolics
- Adhesives
- Furfural
- Fatty acids
- Acetic Acid
- Carbon black
- Paints
- Dyes, Pigments, and Ink
- Detergents
- Etc.

Food and Feed

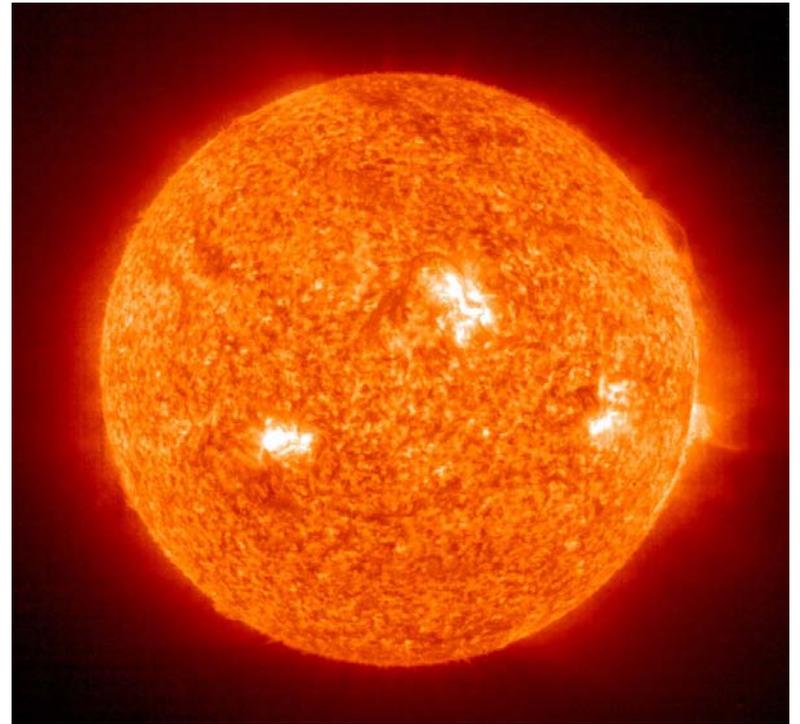
Identifying Streams for Chemical Products



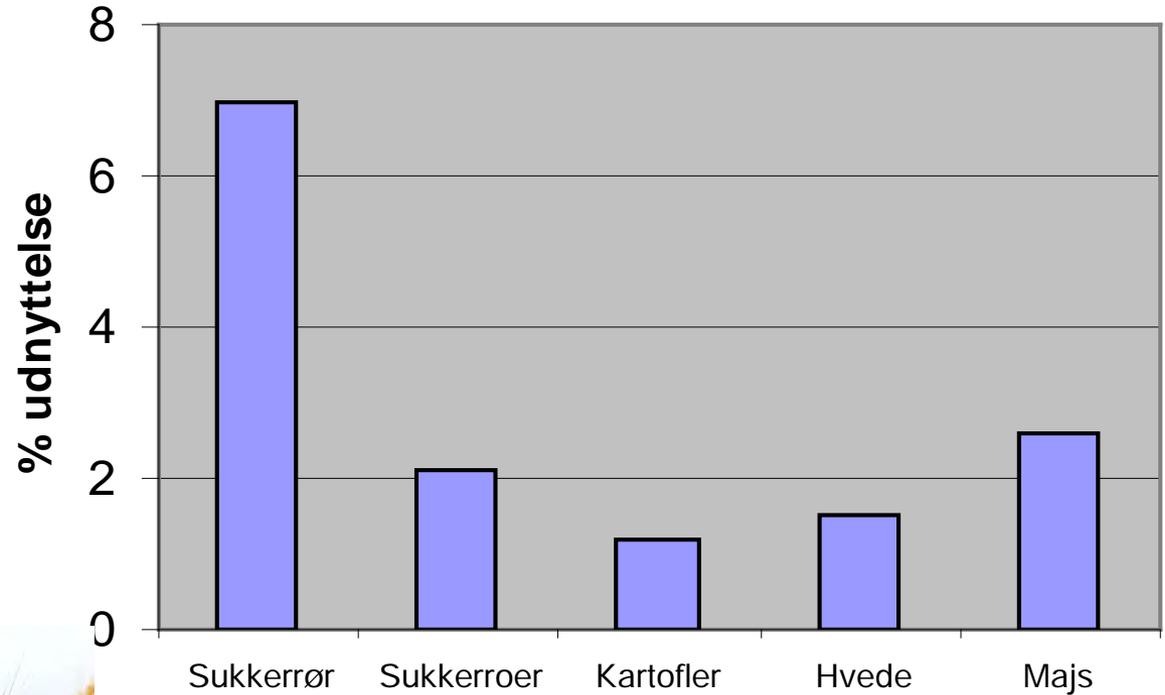
...to support lignocellulosic and algal biorefineries

Plants convert sun light, water and CO₂ into new plant material: biomass

One hectare
receives 10000
Mwh input of sun
light per year



What you harvest depends on what you grow



Grasses like sugar cane has high efficiency for harvesting sun light

Energy crops



The aviation problem

- Density
- Energy density
- Freezing point
- Sulfur and particle generating content
- Availability
- Prize



The Biorefinery concept

