Algae: The Source of Reliable, Scalable, & Sustainable Liquid Transportation Fuels

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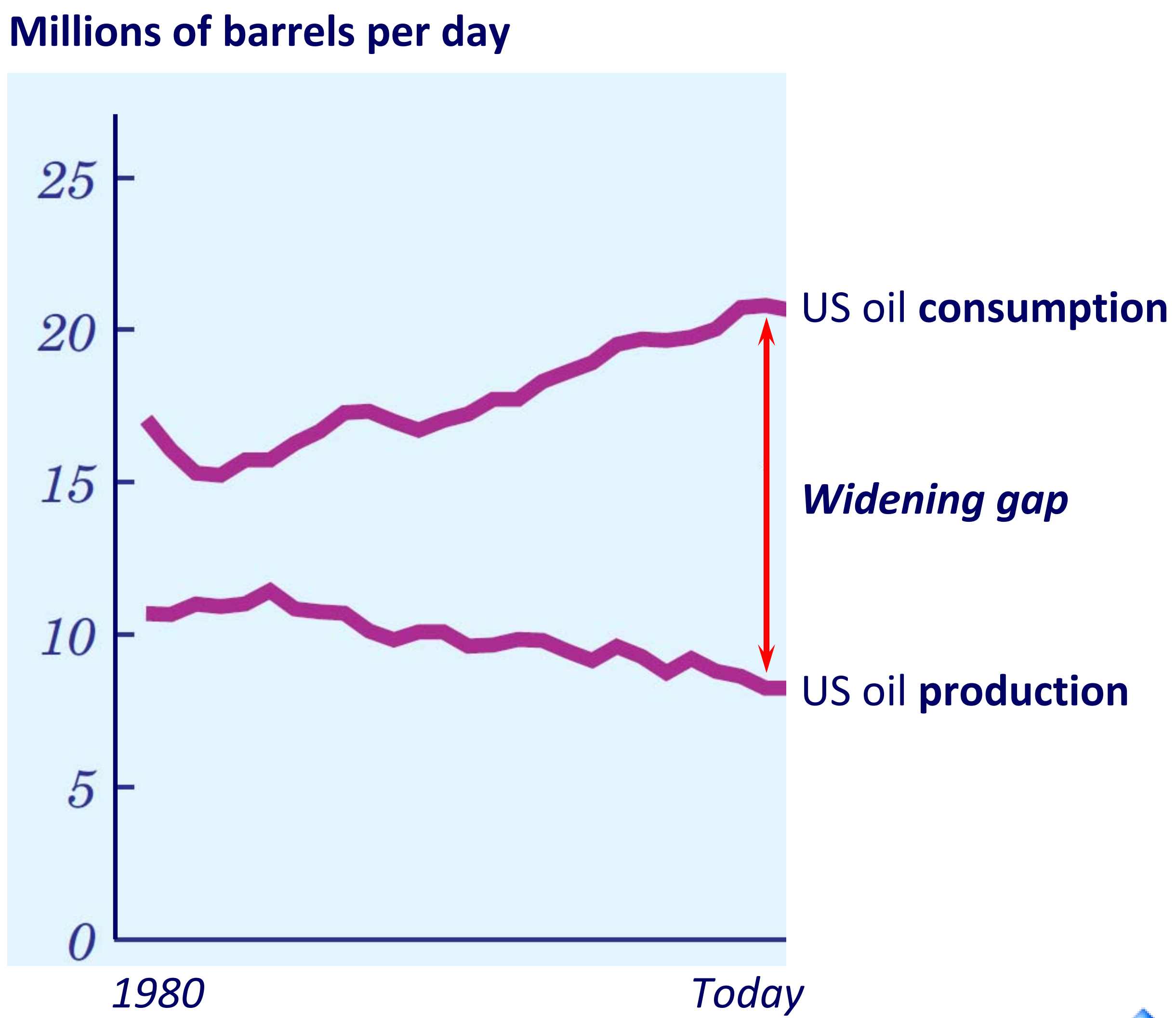
We have an enormous, and growing, problem



Source: IEA 2008 Energy outlook

We make up the difference by spending billions of dollars on foreign oil

Daily US imports of crude oil	
Canada	3.2 MBD
Mexico	2.0 MBD
Venezuela	3.4 MBD
Middle East	2.9 MBD
North Africa	1.0 MBD
Asia	2.5 MBD
Russia	0.6 MBD
Off-shore EU	1.3 MBD
Total	**17.0 MBD**

Avg price per bbl	Total annual imports ($billion)
$40	$248
$50	$310
$60	$372
$70	$434
$80	$496
$90	$558
$100	$621
$110	$683
$120	$745
$130	$807
$140	$869
$150	$931
$160	$993

Source: British Petroleum World Statistical Review, 2008

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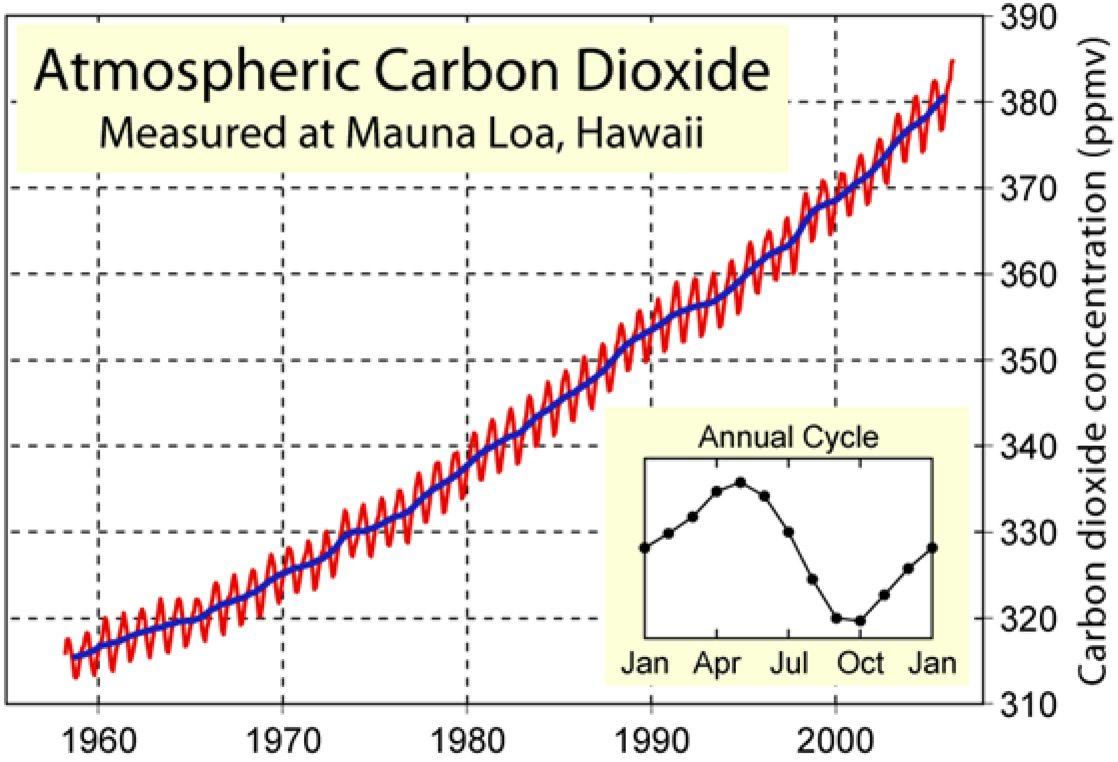
And the other costs?



NOAA, 2008; David Keeling, Scripps

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The ideal way we can fill this enormous – *and widening* – gap in liquid transportation fuels is by developing fuels which meet the following criteria

- Fuels that are **completely fungible** (100% “drop in solutions”) with
  - Existing oil and fuel movement infrastructure (e.g., pipelines, terminals)
  - Existing fleet of land and air vehicles (i.e., cars, trucks, jets)
  - Existing refining infrastructure
- Fuels that **do not compete** with agricultural products, agricultural land, or fresh water
- Fuels that have a **favorable life cycle** with respect to CO_2 compared to conventional petroleum
- Fuels that **can be scaled** to well over 1,000,000 barrels per day to meaningfully impact the widening gap between US fuel production and consumption

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Why Algae?

The most important chemical reaction on our planet

Ingredients | *Product*

Sunlight +

$$H_2O + CO_2 + \text{Nutrients} \rightarrow \text{“}CH_2O\text{”} + O_2$$

Water	Carbon dioxide	Nitrate NO_3 Phosphate PO_4 Iron Silica	“Organic matter”	Oxygen

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The most important chemical reaction on our planet was tailor made for algae

Ingredients			*Product*	
Sunlight +				
H_2O +	CO_2 +	Nutrients →	"CH_2O" +	O_2
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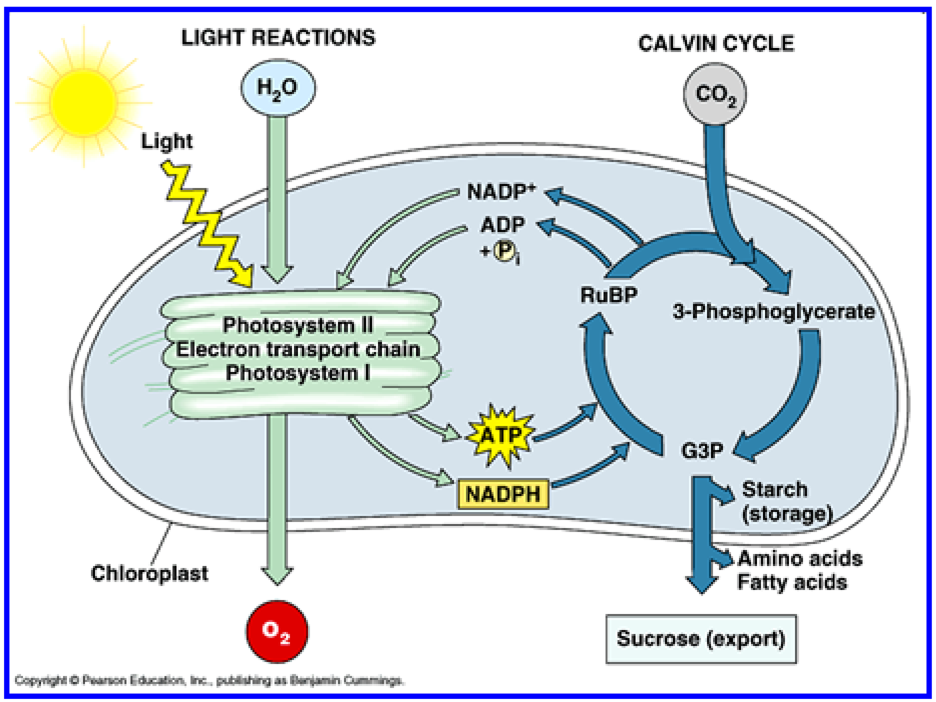

- Nearly all of the biomass of algae is concentrated in the chloroplast – the engine that turns sunlight and CO_2 into organic carbon (i.e., C-C and C-H bonds)
- Algae "waste" no time or energy making stalks, roots, leaves, or fruit
- The result is maximum hydrocarbon per unit area

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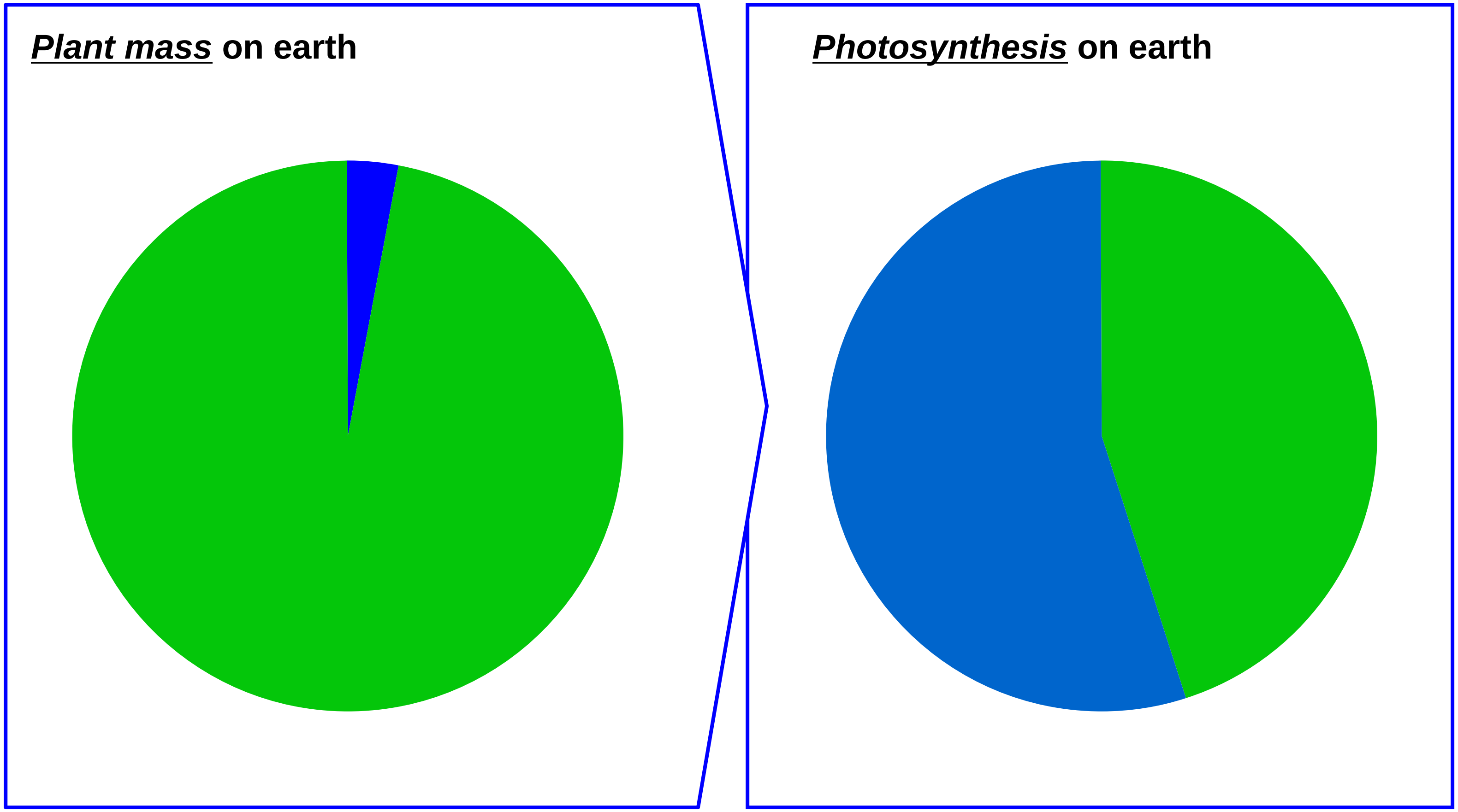
Algal oil production dwarfs that of all terrestial plants because of the enormous advantage they have converting CO_2 to hydrocarbons



Algae are 40x more efficient at converting sunlight to hydrocarbon than terrestial plants

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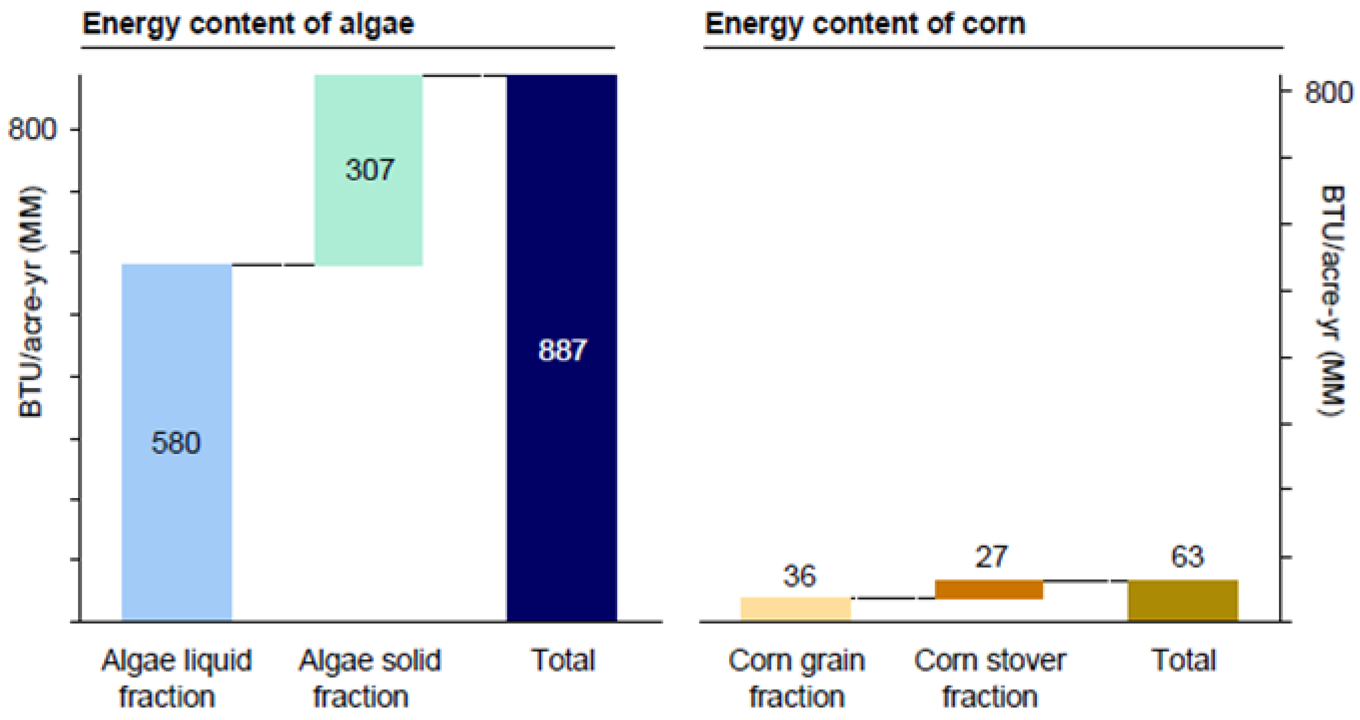
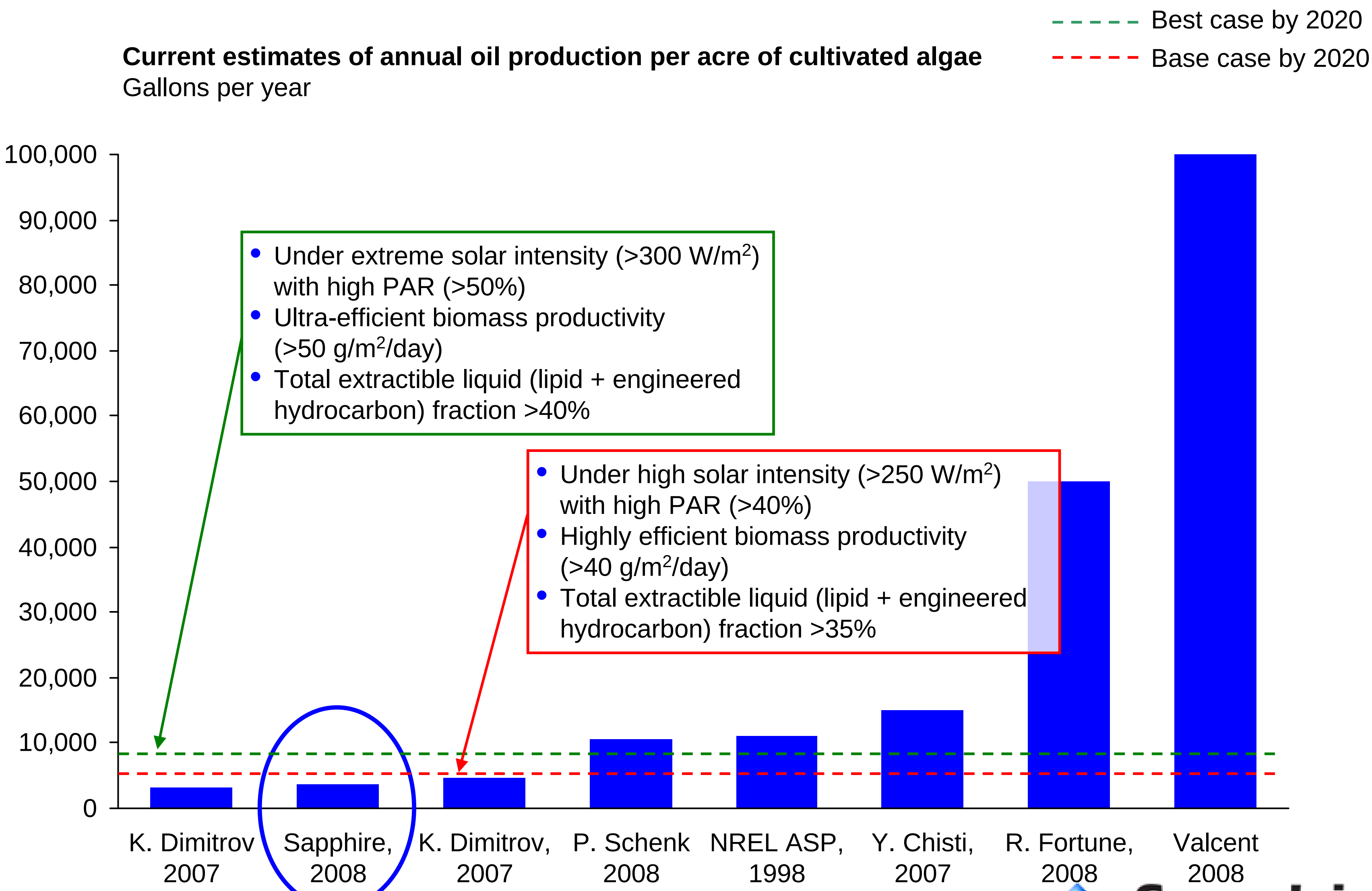

Energy content of algae
800
BTU/acre-yr (MM)
580
307
887
Algae liquid fraction
Algae solid fraction
Total
Energy content of corn
800
BTU/acre-yr (MM)
36
27
63
Corn grain fraction
Corn stover fraction
Total

There is no shortage of estimates for how much oil an acre algae can yield per year…



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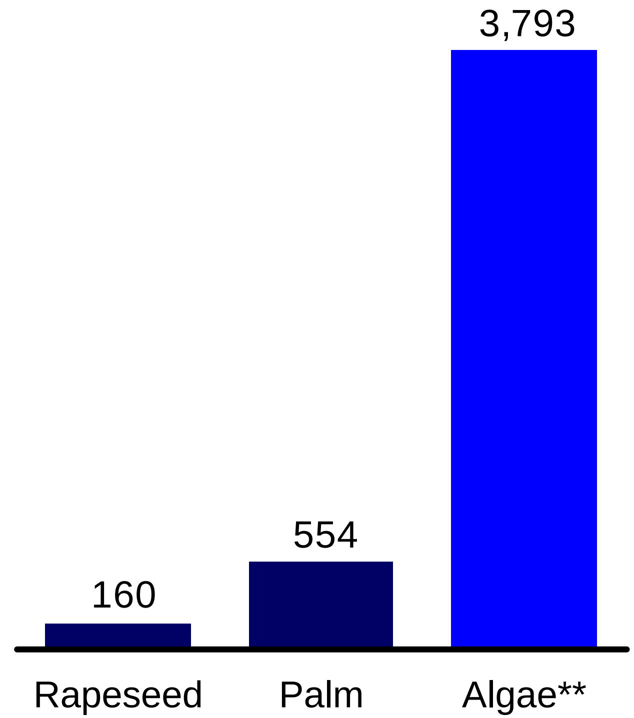
…but even with the most conservative estimates, extraordinary yields are likely

A highly efficient conversion of solar energy…

Solar irradiation	100%
Photosynthetic active radiation (PAR)	40%
Entering the water body	75%
Max efficiency of photosynthesis	25%
Theoretically maximum PE	**8% of total irradiation**
Target PE for conversion of sunlight to hydrocarbon*	**1.9 – 3.8% of total irradiation**

…Leads to high yields of oil

Oil yield
Gal per acre per year



* Assuming 25-50% of theoretical maximum PE is achievable
** Yield at 30 g/m^2/day (Medium irradiation); 30% oil content

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The implications of (even conservative) oil yields are dramatic

	Current trajectory	Base case, 2020	Best case, 2020	
	3,800	**5,000**	**8,000**	***Gallons oil per acre per year***
Entire USAF jet fuel consumption (200,000 bpd)	800,000 acres 35x35 miles	600,000 acres 31x31 miles	400,000 acres 25x25 miles	
5% of US consumption (1,000,000 bpd)	4 MM acres 80x80 miles	3 MM acres 70x70 miles	2 MM acres 55x55 miles	
10% of US consumption (2,000,000 bpd)	8 MM acres 112x112 miles	6 MM acres 97x97 miles	4 MM acres 80x80 miles	
25% of US consumption (5,000,000 bpd)	20 MM acres 180x180 miles	15 MM acres 150x150 miles	10 MM acres 125x125 miles	***Total US oil production**, including off-shore and arctic is 5 million bpd*
50% of US consumption (10,000,000 bpd)	40 MM acres 250x250 miles	30 MM acres 215x215 miles	20 MM acres 175x175 miles	
4% of US consumption by volume* (800,000 bpd equivalent)		23 MM acres** 190x190 miles		***Productivity of corn for ethanol** – 25% of corn growing land was used to make ethanol to displace 4% of US fuel*

* 3% Based on energy content. Numbers based on 2007 production figures from USDA, Greencarcongress

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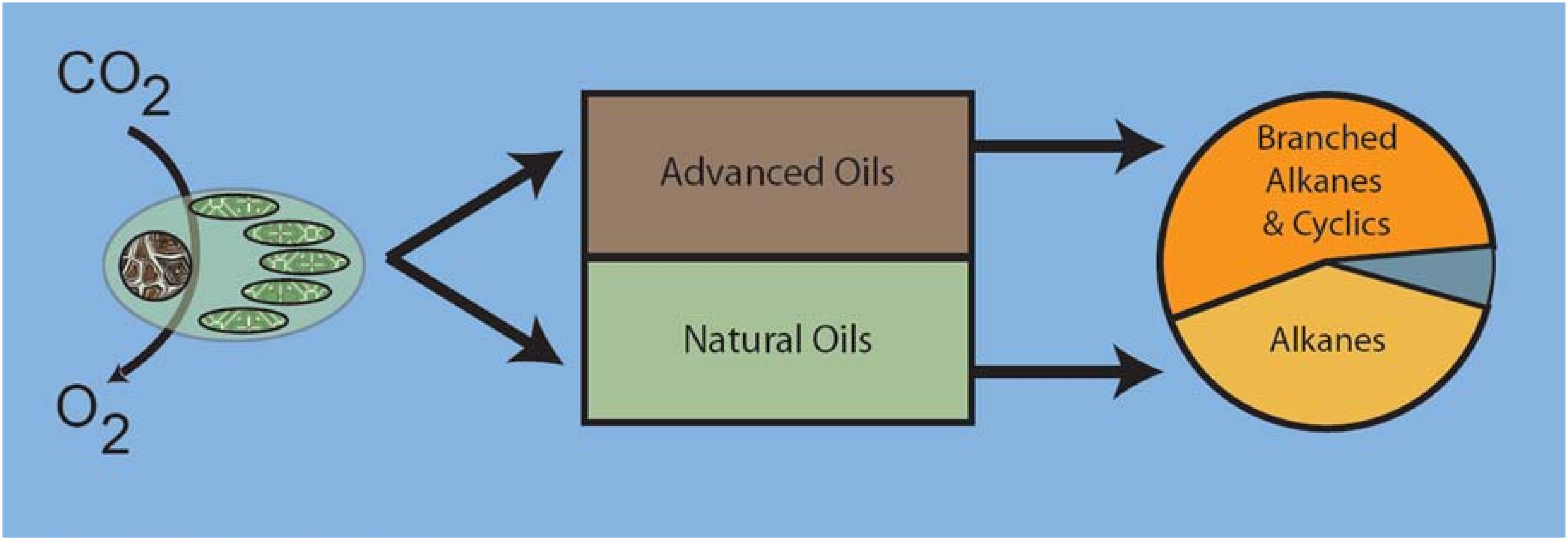
Carbon Neutral, Renewable transportation fuel of the future

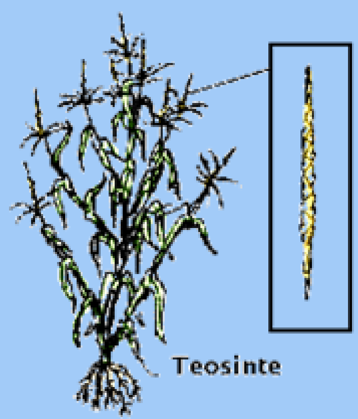
Sunlight + CO2 = Fuels



Sapphire Production Platform **Green Crude** **Aviation Fuel Diesel & Gasoline**

Biology and Engineering = CO_2 Neutral, Renewable Fuels

- Nothing in modern agriculture would be where it is today without thousands of years of directed evolution and, ultimately, genetic engineering



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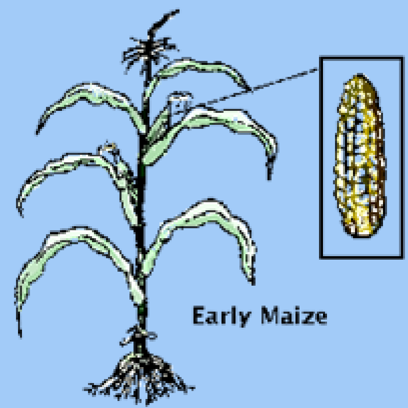

~1,000 years ago

Today

- With energy crops like algae we gain the benefits of science and engineering
- Without the luxury of thousands of years to direct the evolution of algae, the only solution for commercial scale is genetic engineering

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Rapid Developments

Algae Jet Fuel made in partnership with

UOP
A Honeywell Company

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Sapphire Energy Overview and Accomplishments

- Leaders in development of green crude from algae
- HQ San Diego, Development facilities Las Cruces New Mexico
- Team is best in class in biotechnology, algal production, civil engineering, biorefining, biofuels, and business development
- First algal feedstock refined to green gasoline, green diesel, and green jet fuel
- First commercial aircraft flight using algal fuel -- January 7, 2009, Continental Airlines
- Largest cultivation of enhanced algal strains
- Dominant IP portfolio, with over 200 patents in algal fuel space
- Raised over $100 million from top tier investors
- 90+ employees

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