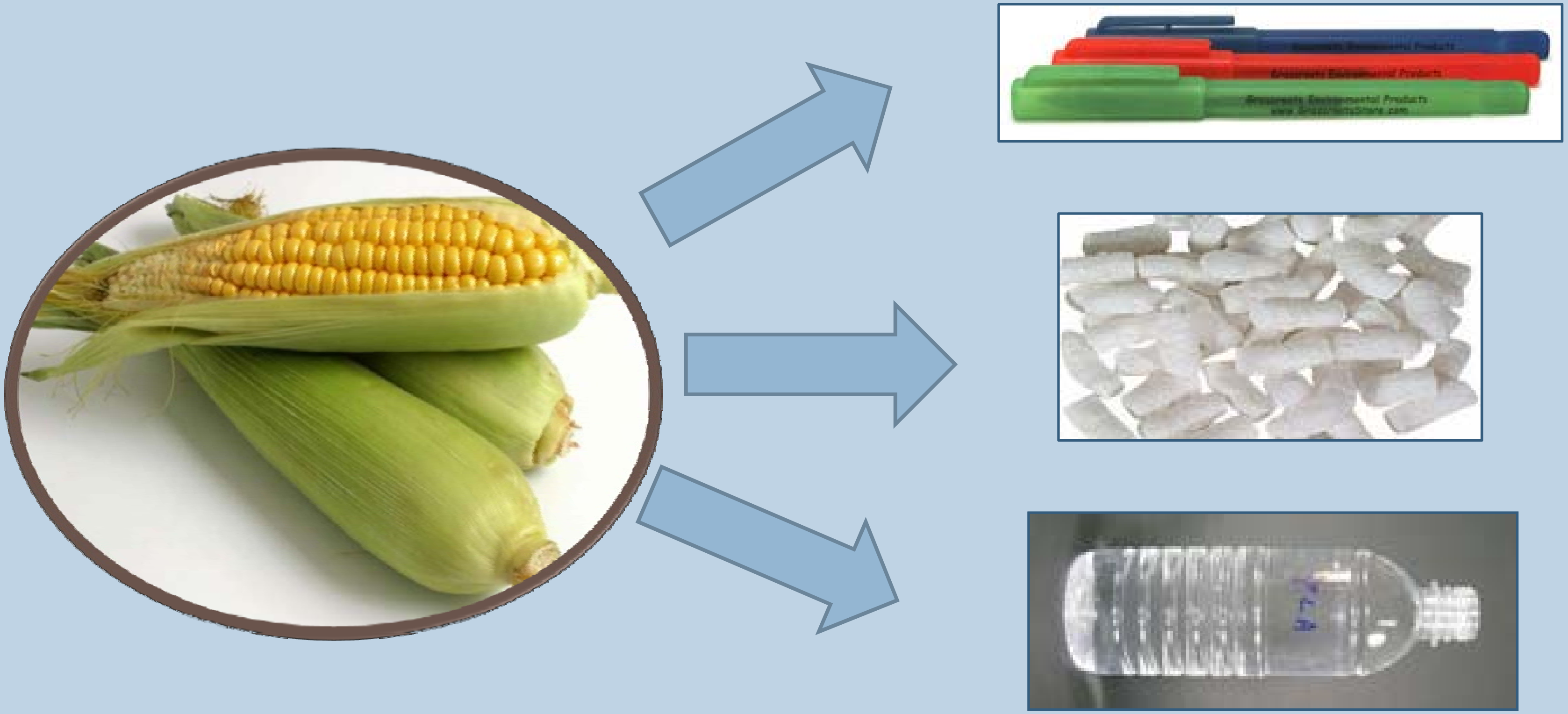

Biodegradable polymers as energy efficient replacement of polymers from fossil fuels

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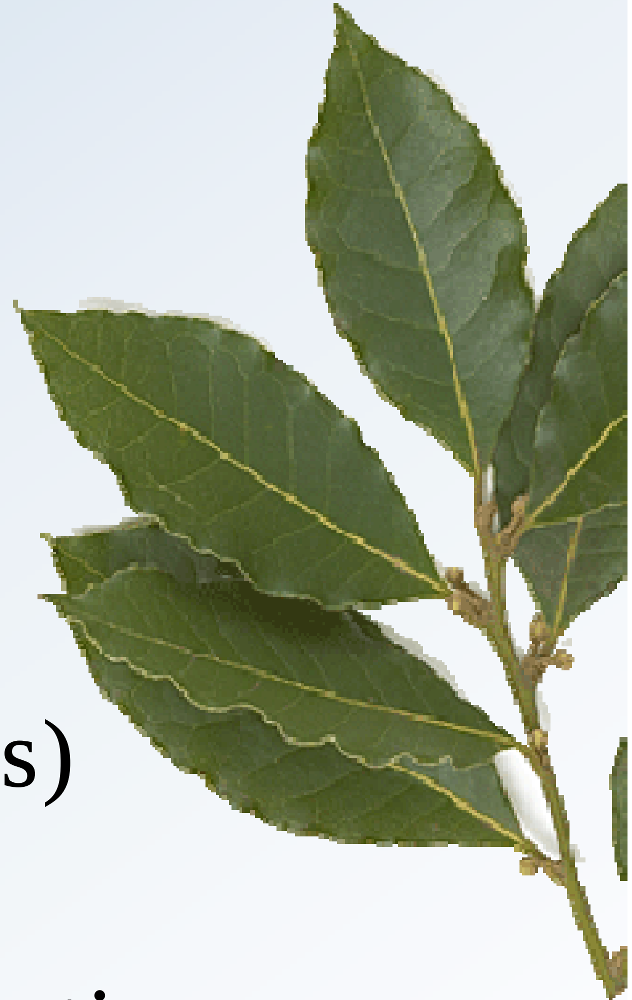
Outline

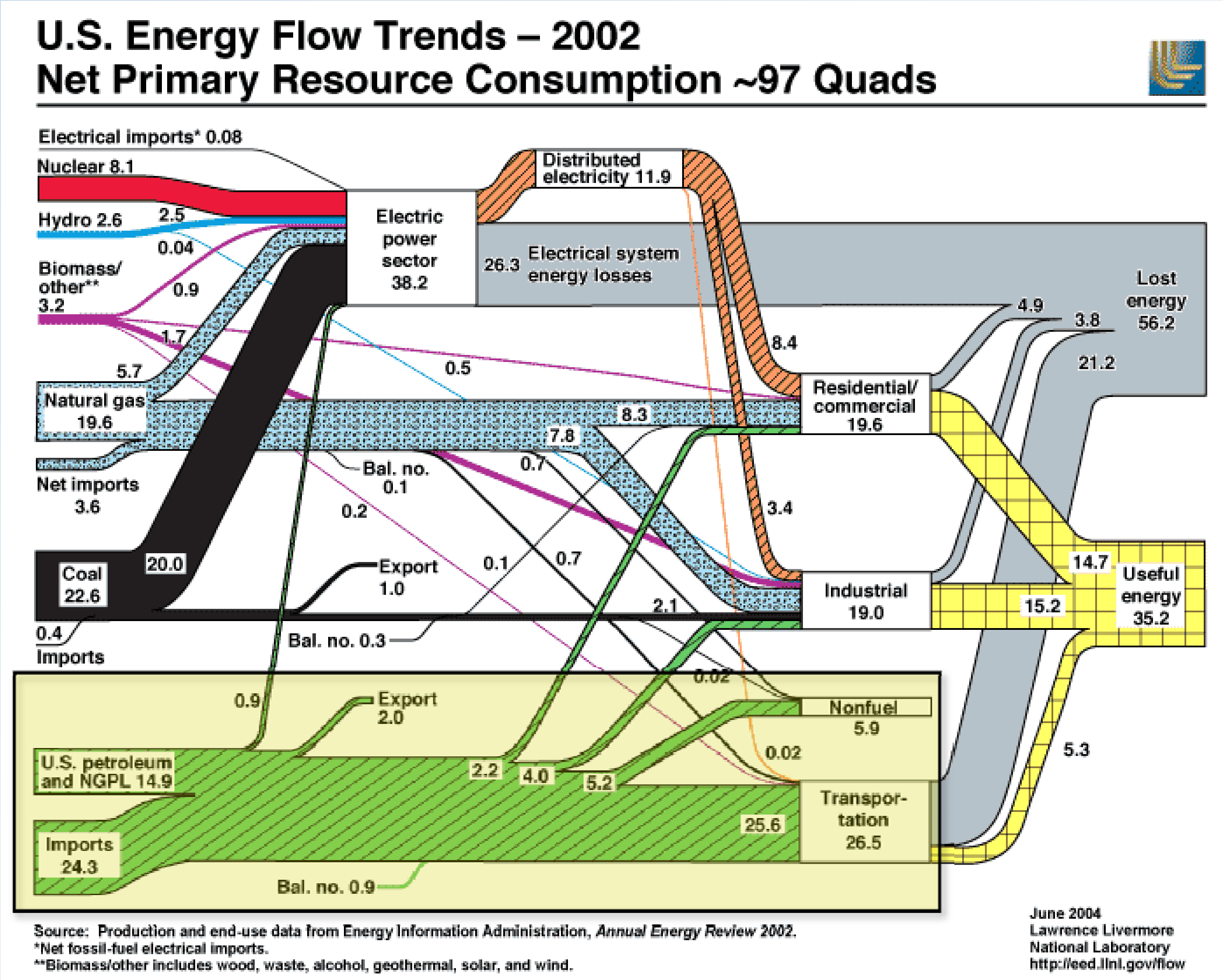
- Motivation
- Types of BPs
  - Starch based
  - Poly(lactides)
  - Poly(hydroxyalkanoates)
- Life Cycle Analyses
- Conclusions/Future Direction



Motivation

- Plastics/polymer production exceeds 450 billion pounds per year!
  - That's **3 billion Kevins** of material by weight.
- The feedstock/fossil fuel energy used in the production of plastic is ~10% of total oil consumption
- Changing to a renewable feedstock could save 270 million tons of oil annually

Perspective



Solution?

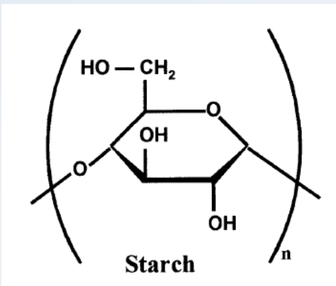
- Use renewable feedstock from nature
  - ⇨ Biodegradable polymers!

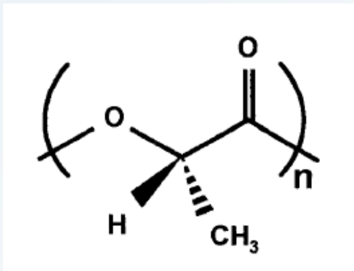
- Advantages
  - Eliminate fossil fuels as feedstocks
    - Saves millions of barrels of oil for use in other applications
  - More environmentally friendly?
    - Plastic accounts for 12% of solid municipal waste

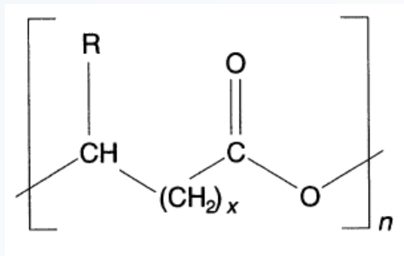
- Disadvantages
  - Not as well developed
  - Current output is 0.1% of petroleum based polymer

Types of BPs

Starch	Polyester	
	PLA	PHA
●Made from corn	●Made from corn	●Made from corn
●Chains are amylose and amylopectin	●Chains are lactic acid	●Chains are hydroxy alkanoates
●Naturally available- made by grinding components of corn	●Made by fermentation of glucose	●Made by fermentation of glucose or directly in bacterial or plant cells

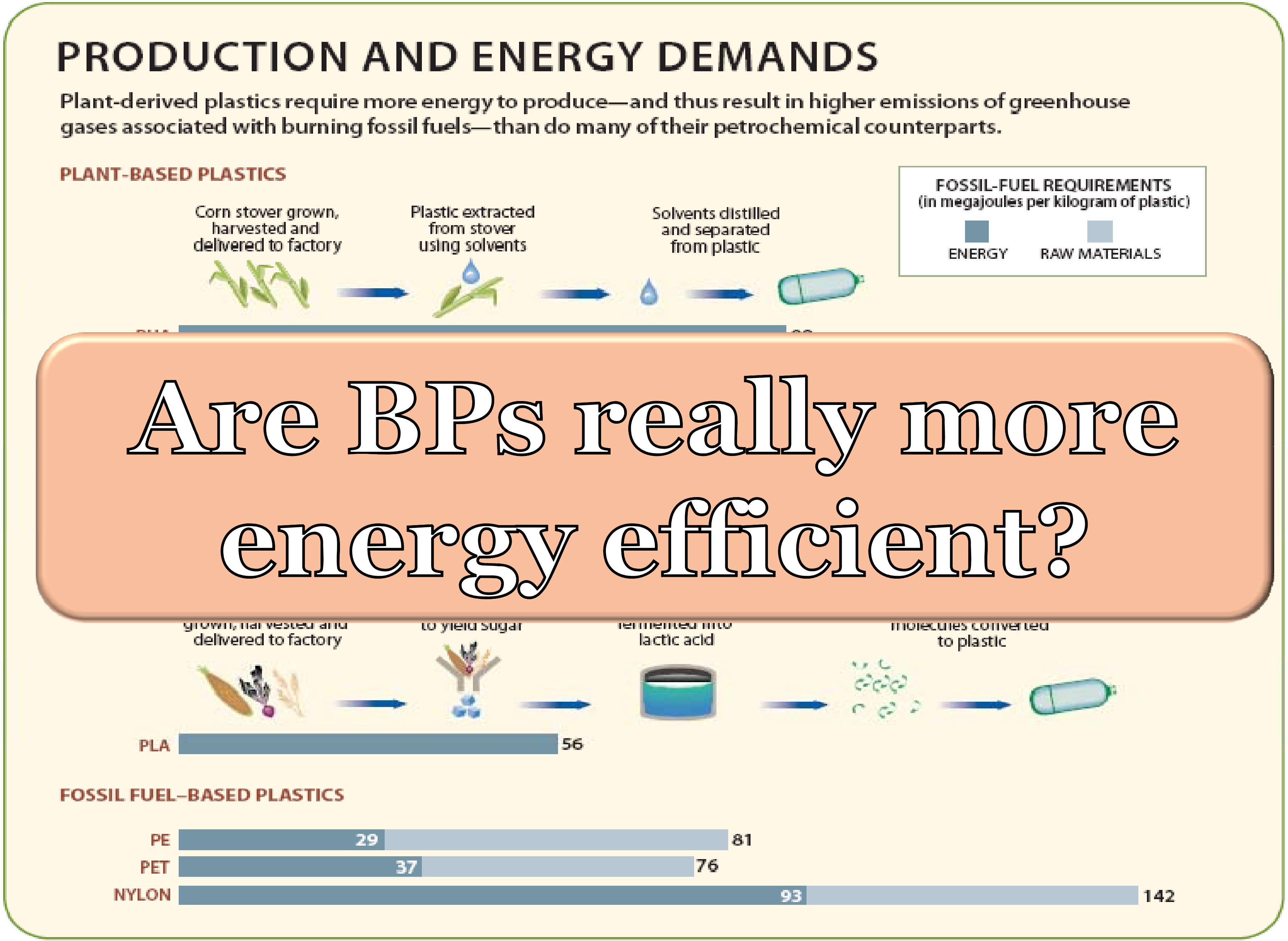






Life Cycle Analysis

Are BPs really more energy efficient?

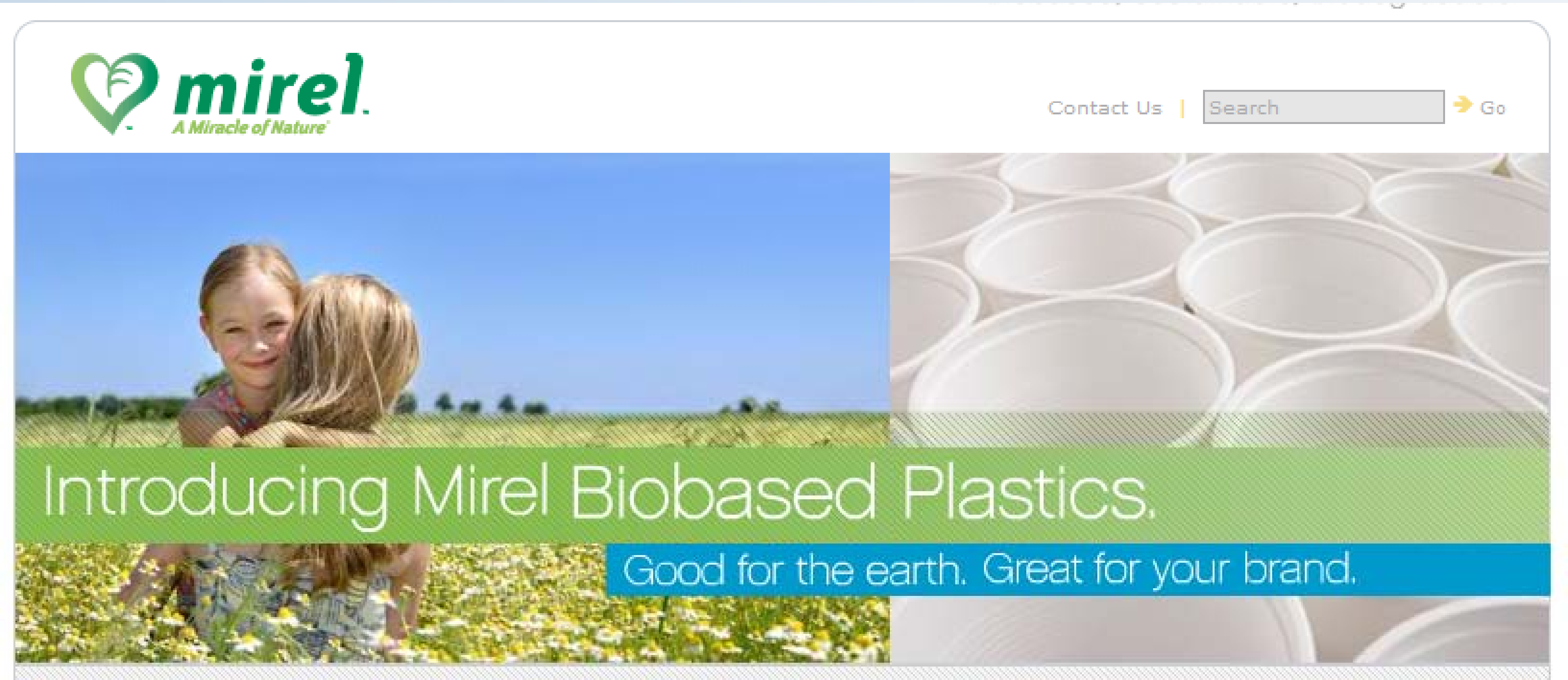


Life Cycle Analysis

	Source	CO_2 (kg/kg)	Fossil Energy (MJ/kg)
PHA/PHB	PHA: Gerngross (1999)[11]	2.4	50.4
	PHA: Kurdikar (2001)[5]	2.0	--
	PHA: Akiyama (2003)[4]	0.26-0.45	50-59
	PHB: Nonato (2001)[12]	--	113.7
	PHB: Harding (2007)[13]	2.6	44.7
PLA	Bohlman (2001)[14]	-.0005	56.7
	Vink (2003)[8]	1.8	54
	Vink (2007)[15]	0.27	27.2
Starch	Mater-Bi:	1.28	53.4

New technology and optimization is making BPs more energy efficient

Mirel by Metabolix



- Claim to reduce fossil fuel use by **95%** and **200%** reduction in CO_2 emission
- Employs bacterial fermentation for PHA production

NatureWorks PLA

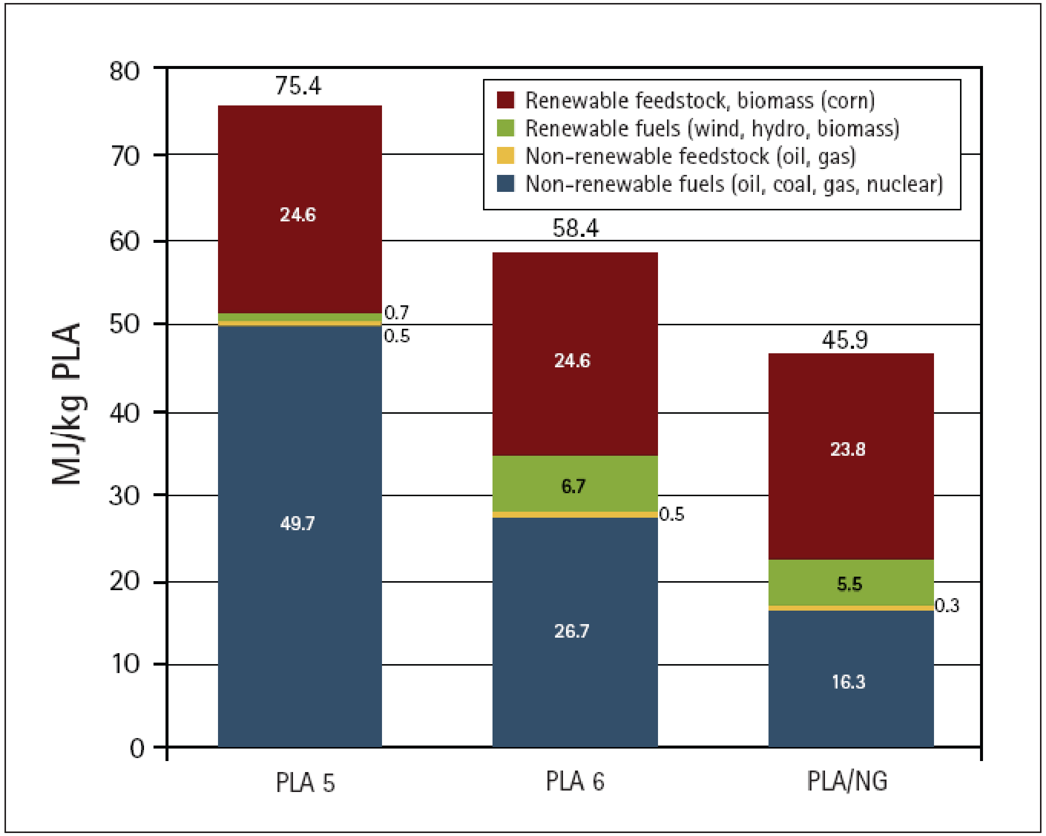


Figure 6. Cradle-to-polymer-factory-gate gross energy use for the various PLA production systems

- Fossil fuel use reduc
  reduction in CO2 er
- Employs bacterial fe

How much land is necessary?

- NatureWorks reports 1.65 m^2 land requirement for producing 1 kg of PLA
- Total cropland in US: 1.8 trillion m^2
- Could meet entire polymers production worldwide with **18% of current cropland**
- Could meet North American consumption with **4.8%**

Issues

Very complex topic- many points to consider

- Effect on food cost/production
- Recycling compatibility with current polymers
- CO_2 emission from biodegradation
- Landfill space requirements for polymers
- Concern with GMO's
- Mechanical properties of BPs
- Production capability in coming years
- Cost of technology

Future Directions

- Using non-edible portions of plant to grow polymer at same time as another crop
- Cellulose-based fermentation
- Specialty facilities for biodegradation of polymer/recovery of fuel produced
- Cost-competitiveness with oil as prices increase

Conclusions

- Polymeric materials are used in a substantial amount of consumer goods, and have properties not available in other materials
- With depletion of oil reserves, plastics production will become more expensive and difficult
- A lot of controversy behind BPs but a lot of potential demonstrated within the past 2-3 years
- Sequestration versus landfilling

Promising Technology!

Questions?