

Mark Jones
Executive External Strategy and Communications Fellow
June 2012

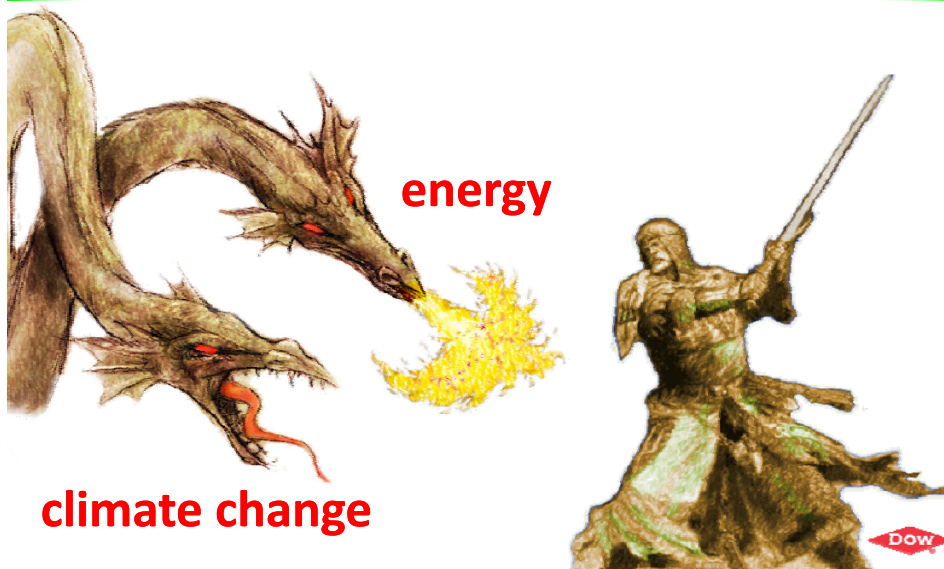


Biomaterials and Biofuels: *Path to Perdition or the Promised Land?*

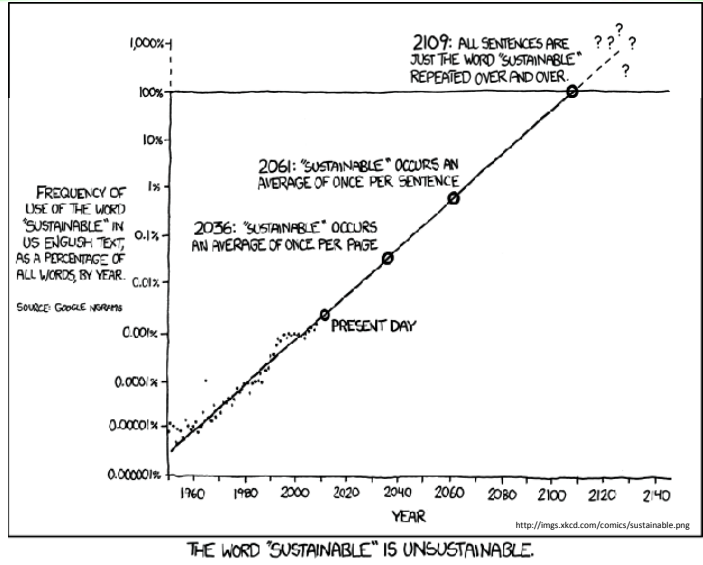
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Slaying the Dragon



Sustainability Hype?



Possible versus Practical

HYPE

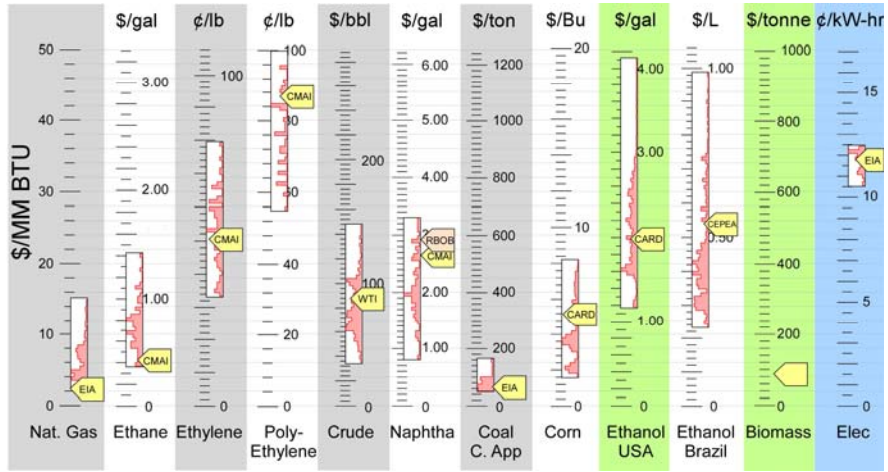
ENERGY DENSITY

LIMITATIONS OF BIOLOGY

PRACTICAL APPLICATION



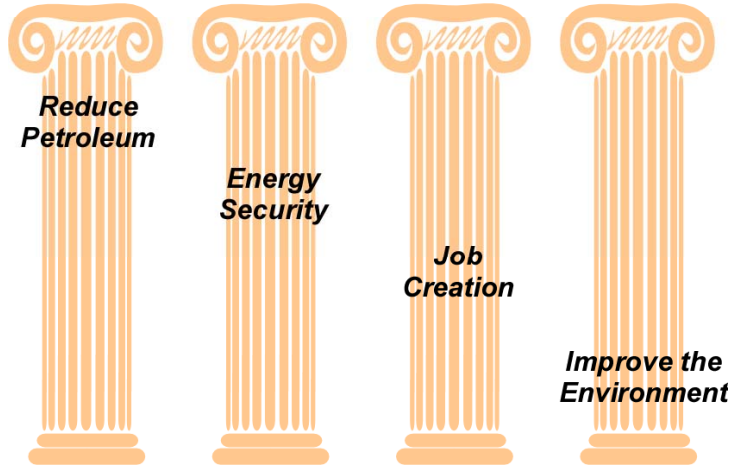
Energy Content



EIA is DOE Energy Information Agency, CMAI is an IHS affiliate, CARD is Iowa State Center for Agricultural and Rural Development, CEPEA is Centro de Estudos Avancado em Economia Aplicada – data for 3-5 years depending on source. 6 June 2012



Biomass Fuels Program



How CAPITALISM Works....

Companies have to make money



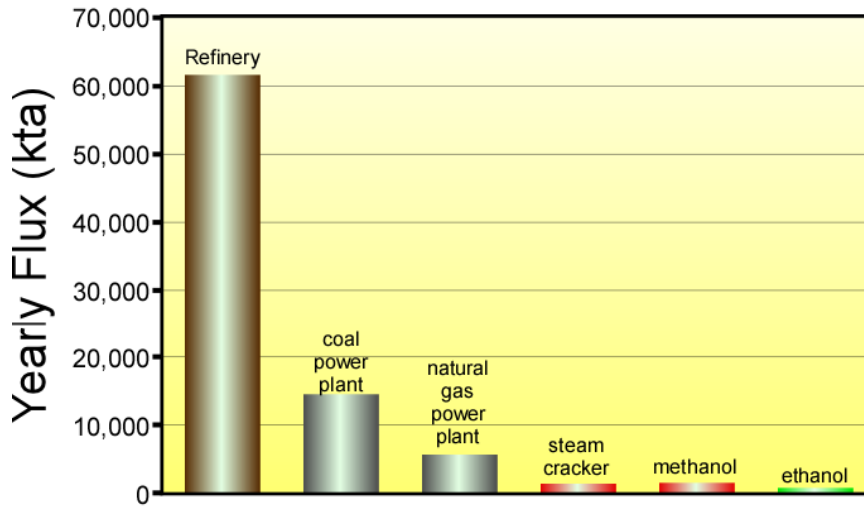
Money flows towards higher returns

Investors are risk adverse

Wrong investments drive companies to collapse



Largest Plants



feedstock limits scale



Bloom is Off the Cellulosic Rose



- How much *biomass is available?*
not enough to replace fossil fuels
- How much *will the biomass cost?*
it is not cheap!
- How much *will biofuels cost?* *more than fossil*
- How much *more are we willing to pay?* *no premium*
- How realistic *is chemical production from biomass?*
we already do, but chemical use doesn't address the big issues

NRC, "Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy", 4 October 2011.



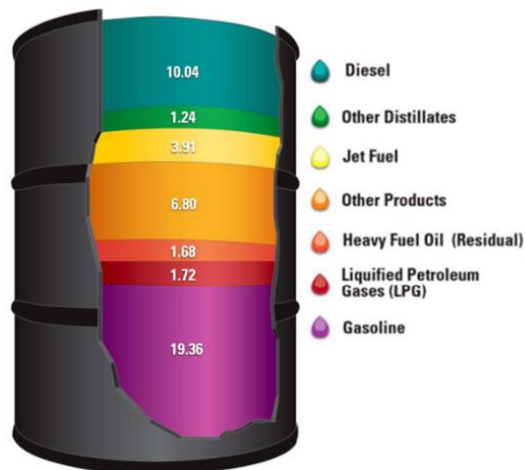
Changing Emphasis

Biomass 2011: Replace the Whole Barrel,
Supply the Whole Market
The New Horizons of Bioenergy

July 26–27, 2011



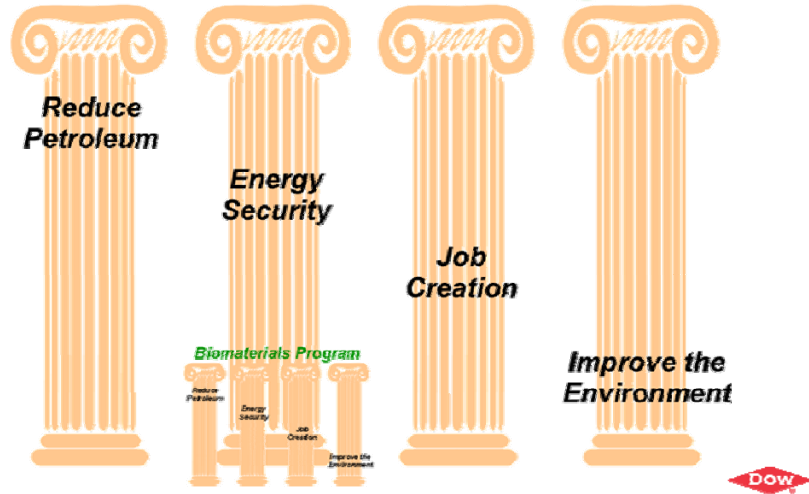
"sugar is the new crude"



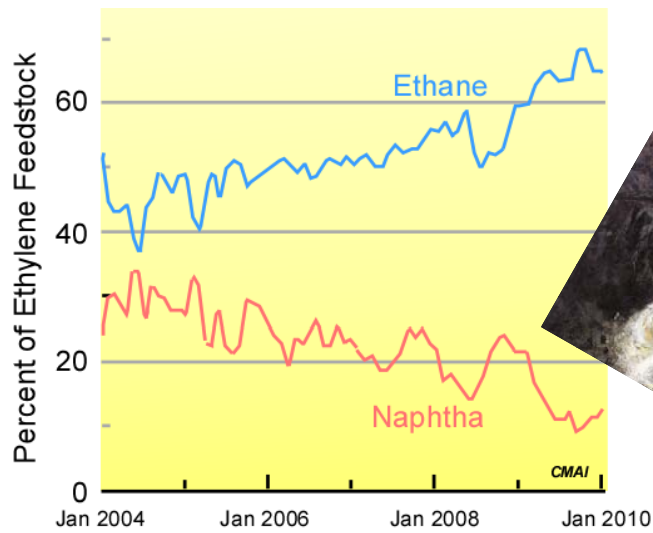
Biomaterials Instead of Biofuels

a much smaller target

Biomass Fuels Program



Shale Gas Revitalizes the Industry




Green Chemistry Principles









Twelve Principles of Green Chemistry


1. Prevention: It is better to prevent waste than to treat or clean up waste after it has been created.
2. Atom Economy: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product.
3. Less Hazardous Chemical Synthesis: Chemical products should be designed to be as innocuous as possible.
4. Safer Solvents and Auxiliaries: The use of auxiliary substances (for example, solvents, reagents, and catalysts) should be made unnecessary whenever possible and, when used, should be made innocuous.
5. Safer Reagents and Reaction Conditions: Chemical reactions should be run at ambient temperature and pressure.
6. Design for Energy Efficiency: Energy requirements should be recognized as a major factor in chemical design.
7. Use of Renewable Feedstocks: A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. Reduce Derivatives: Unnecessary derivatization (use of protecting groups, protection/deprotection, temporary modifications, etc.) should be avoided whenever possible, because such steps require additional reagents and can generate waste.
9. Catalysis: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. Design for Degradation: Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.
11. Real-time Monitoring and Control: Analytical methods for process control should be further developed to allow for real-time monitoring and control prior to the formation of undesired products.
12. Inherently Safer Chemistry for Accident Prevention: Analytical methods should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires.

Use of Renewable Feedstocks:
A raw material or feedstock should be renewable rather than depleting whenever technically and economically feasible.



Two Carbon Flavors

 Fuel	 Feed	 Fuel	 Feed
 Fuel	 Feed	 Fuel	 Feed



LCA of Polymers

Biopolymers rank in the middle of LCA rankings

POLYMER	Material	Green Design Rank	LCA Rank
Polylactic Acid – NatureWorks	Sugar/cornstarch	1	6
Polyhydroxyalkanoate-Stover	Cornstalks	2	4
Polyhydroxyalkanoate-General	Corn kernels	2	8
Polylactic Acid-General	Sugar/cornstarch	4	9
HD Polyethylene	Petroleum	5	2
PET	Petroleum	6	10
LD Polyethylene	Petroleum	7	3
Bio-PET	Petroleum /plants	8	12
Polypropylene	Fossil fuels	9	1
General Purpose Polystyrene	Petroleum	10	5
PVC	Chlorine/petroleum	11	7
Polycarbonate	Petroleum	12	11

Tabone, MD; Cregg, JJ; Beckman, EJ; Landis, AE. Environ. Sci. Technol. 2010, 44, 8264-9.



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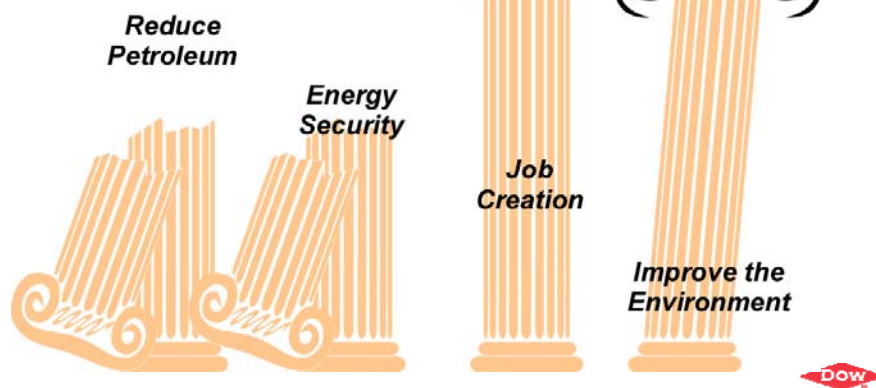
Tabone, MD; Cregg, JJ; Beckman, EJ; Landis, AE. Environ. Sci. Technol. 2010, 44, 8264-9.





Biomaterials Program

Much Smaller



Conclusions

- Too much hype for the possible and not enough focus on the practical
 - **Real** benefits must be created
 - **Incumbent fossil sources** set the standard for competition
 - It takes **decades** to deploy a new technology
 - **Scale** wins and biomass availability limits biofuels scale
- Requirements of **capitalism** must be addressed
 - Better **alternatives** get money
 - Low tolerance for **risk**, both market and technology
 - Society must be willing to pay **more**



For a successful technology, reality must take precedence over public relations, for Nature cannot be fooled.

- Richard Feynman

