

Biopolymers and Plastics: Expectations and Reality

Judith Giordan

Managing Director - ecosVC, Inc

CTO – Qteros, LLC

Co-Founder – Chemical Angel Network

May 2014

JOSEPH E. LEVINE
MIKE NICHOLS
LAWRENCE TURMAN



This
is
Benjamin.
He's
a little
worried
about
his
future.

THE GRADUATE

“I just want to say one word to you,” character Mr. McGuire said to young Dustin Hoffman’s character, Benjamin, in the 1967 film, [The Graduate](#). “Just one word. Plastics.”

The Challenge

Providing environmentally *sustainable* solutions for...



Confounding the picture...

- **Biodegradable Plastic Markets with high growths to 2015 over 6 Billion US Dollar and 12.5 bn 2025**

Bioplastics are biodegradable and can be made from a wide range of different plants.

According to [a piece in AgWeb](#), bioplastics can be made from two components: PHA (Polyhydroxyalkanoates) and PLA (polylactide) resins. The former, PHA, is flexible, biodegradable, and can be composted. The latter is a tough product that may only be broken down by municipal compost facilities.

But what does BIOpolymer or plastic *really* mean?

BioBASED

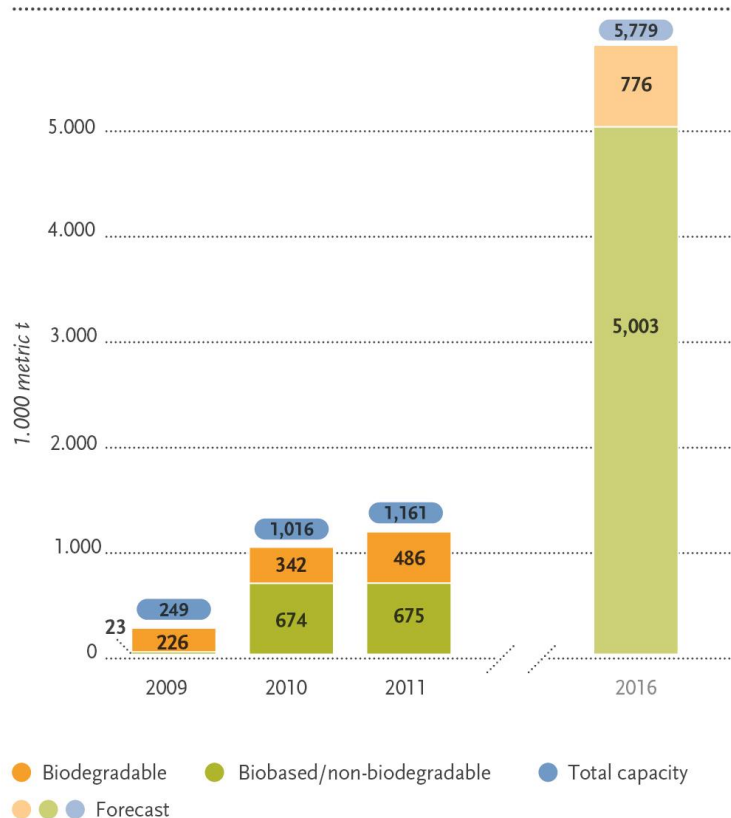
- Bio-based plastics are derived from naturally occurring plant and animal materials such as those found in sugar, starch, proteins, cellulose, lignin, bio-fats and oils.
- Do NOT have to be bio-degradable!

BioDEGRADABLE

- For a plastic to be termed “compostable” in Europe, 90 per cent of it must degrade in clearly defined conditions into fragments smaller than 2 mm within 12 weeks.
- Does NOT have to come from BioBASED feedstocks!

Biopolymers and Plastics: Expectations and Reality

Global production capacity of bioplastics



Source: European Bioplastics | Institute for Bioplastics and Biocomposites (October 2012)



Transforming
traditional
petroleum based
value streams for
polymers and
plastics to
“bioplastics” has
seen its fits and
starts.

Biopolymers and Plastics: Expectations and Reality

Transforming traditional petroleum based value streams for polymers and plastics to “bioplastics” has seen its fits and starts.

- **The BIOMASS solution - WHY Biomass NOW?**
- **BIOMASS the great (re)leveler?**
- **KEYS FOR SUCCESS - winning at BIOMASS to Polymers and Plastics**
- **KEY DECISIONS –who will need to make them.**

The *old* Solution

Staying with petrochemicals is *not sustainable*



...as a means to addressing major global issues

The *new* Solution

Going BIOMASS **GREEN**



...as a means to addressing major global issues

Unilever Seeks More Renewables

Industrial Biotech: Consumer products firm, U.K. university join for biobased chemicals development

By **Alex Scott**

Department: **Business** | Collection: **Green Chemistry**
Keywords: **biomaterial, renewable, U.K., collaboration**

[+]Enlarge



Unilever has begun a research project with English **Liverpool** to develop renewable chemicals from biomass and personal care products. The effort is the latest move for the consumer products company to increase the renewable materials used in its products without adding costs for the buying public.

5

Len Sauers, P&G's VP for Global Sustainability highlighted in the firm's most recent environmental report: Few consumers are willing to pay a premium for greener goods. Thus the processes they are developing will have to be cost-competitive from the outset...

And that's not all...



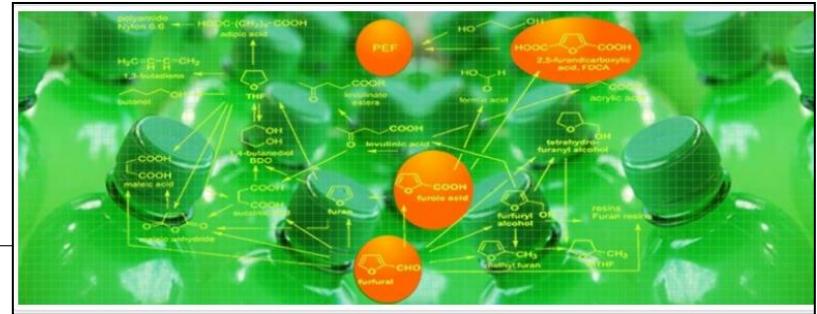
Coca-Cola Eyes
Growth In The
Sparkling Bottled
Water Market

 Trefis Team
Contributor

Coca-Cola And Competitors Go Green

In 2009, the largest CSD manufacturer in the world, Coca-Cola, introduced PlantBottle for its water brand Dasani. PlantBottle uses about 30% PET resin from sugarcane and is thus more eco-friendly than traditional plastic bottles. Sales of Dasani have increased by 20% since the launch of PlantBottle. The company also plans to introduce bottles made completely out of plant-based resin in the coming few years. This move could further boost sales of Dasani, which currently has a market share of ~10% in the still water category with retail sales of over \$900 million in FY2013.

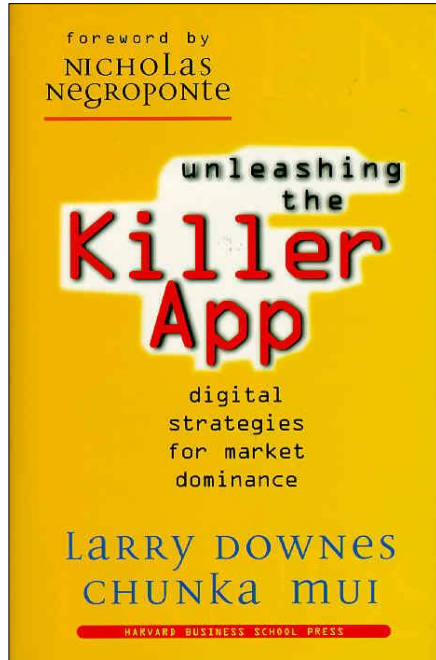
Coca-Cola might also look into the possibility of using PEF (polyethylene furanoate), a bio-based alternative to PET. However, the impact of PEF on the recycling stream is still to be known. As the company is a major user of recycled PET, it wouldn't want to harm its own recycled material. Coca-Cola is presently working on bottles from PEF with Avantium, a renewable chemicals firm based in Amsterdam. Coca-Cola also experimented with bottles made of ice that could melt away after consumption. The ice bottle is currently available only in Colombia and carries the company's flagship Coca-Cola CSD. However, these



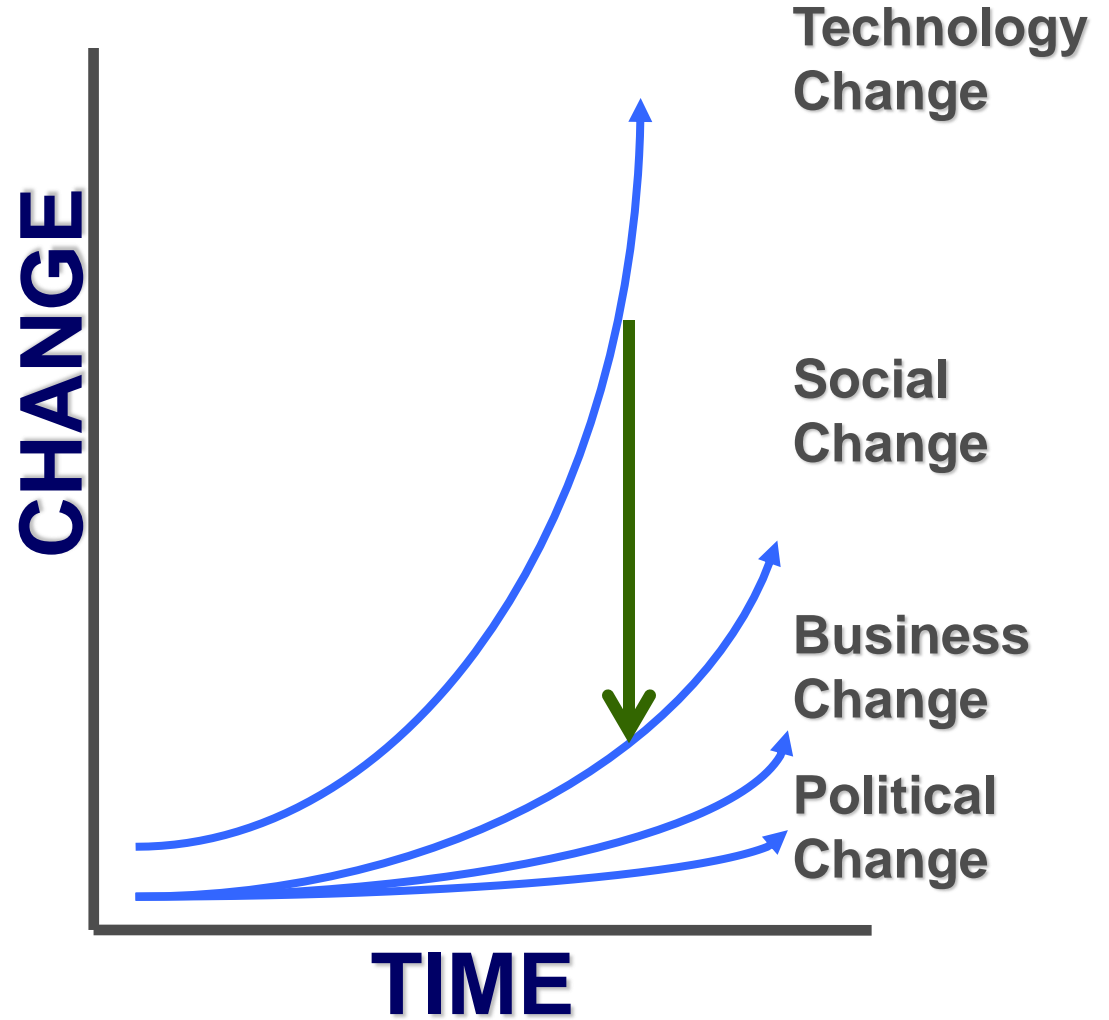
ES AND MORE

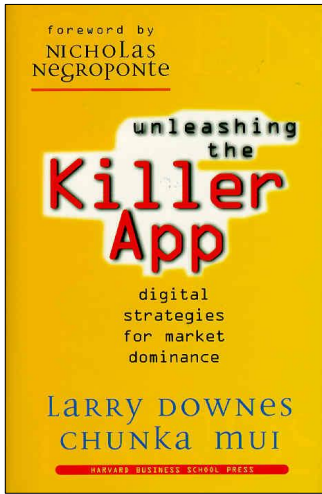
6

1998

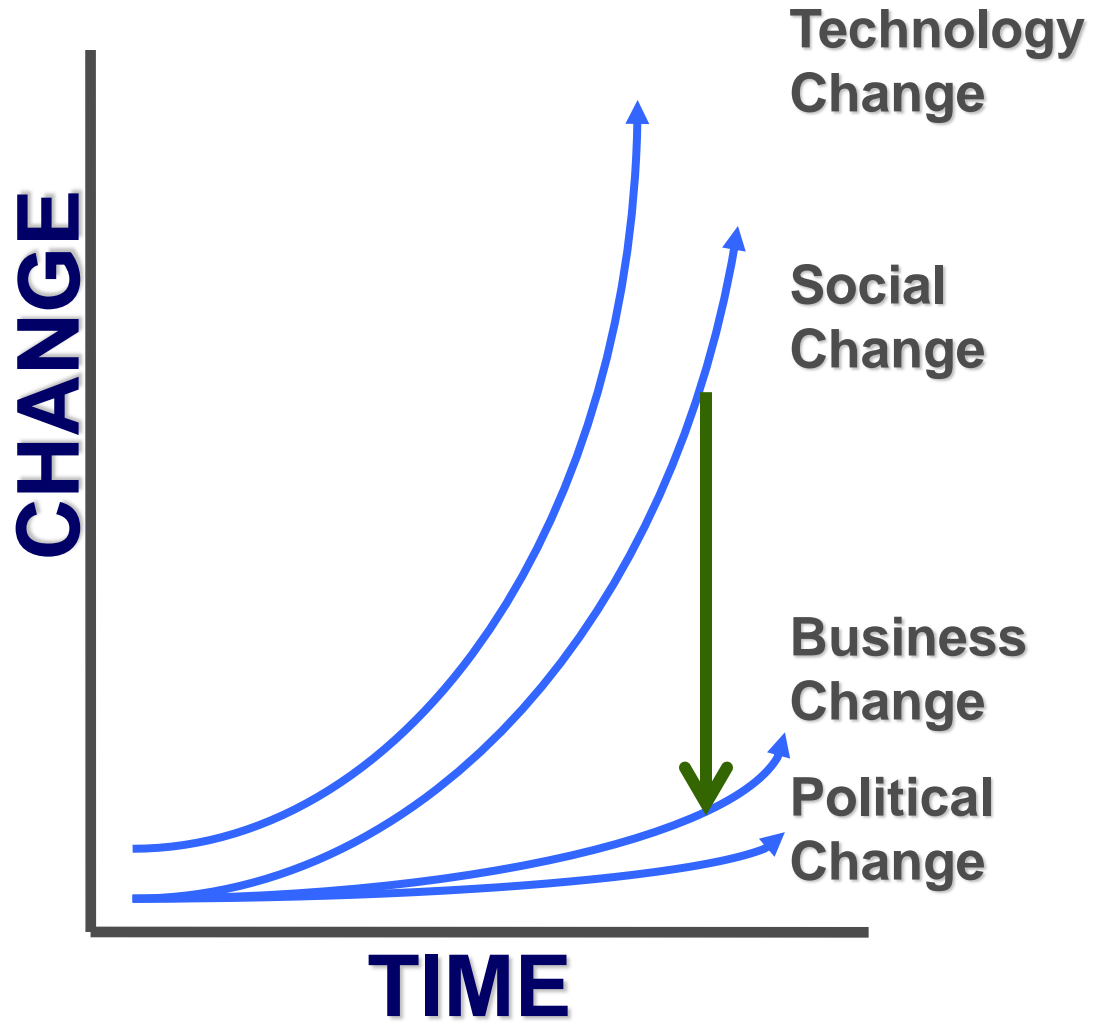


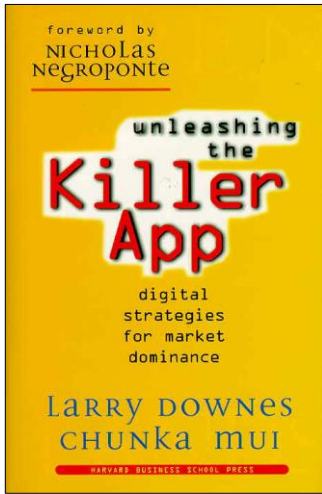
8



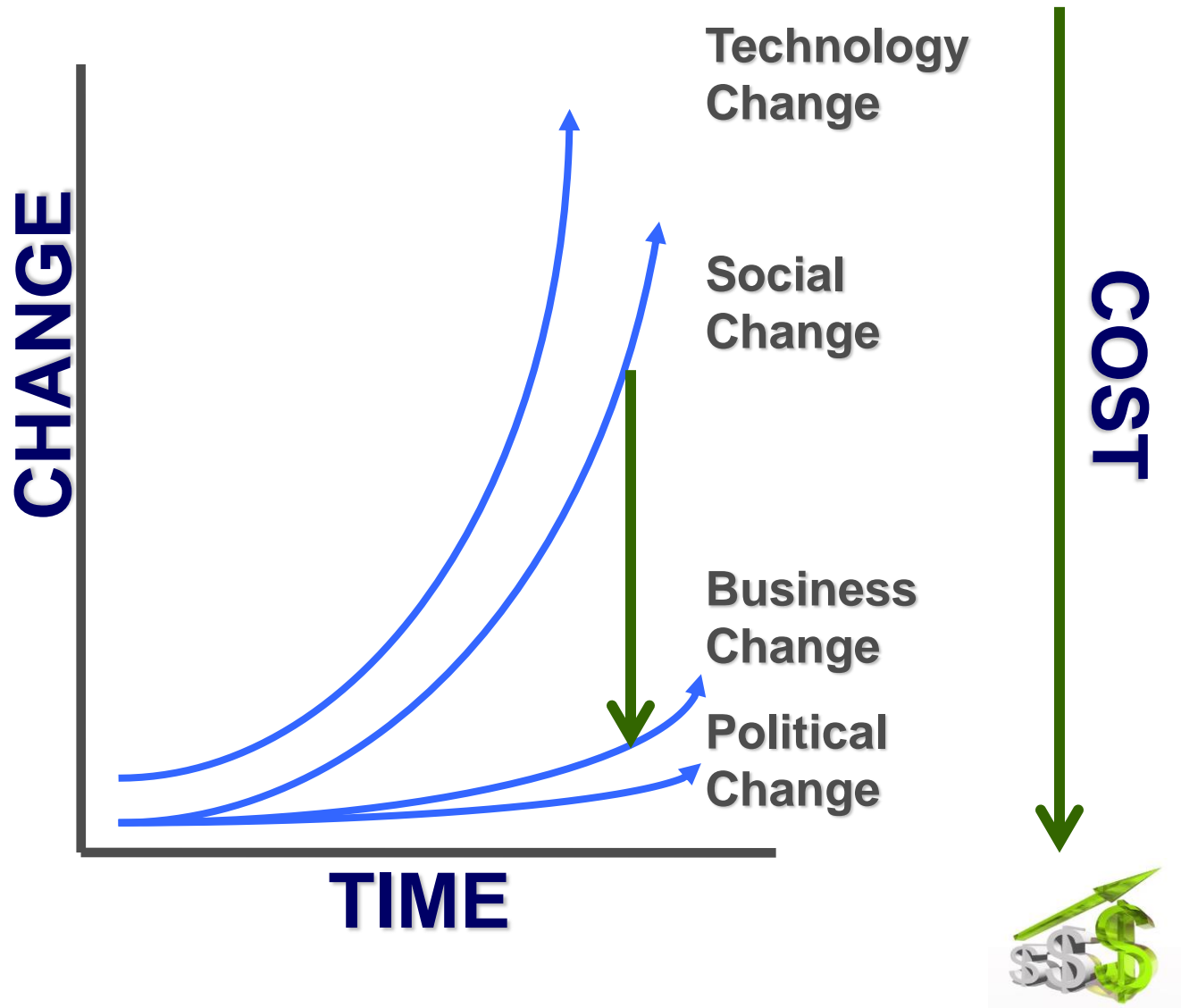


2014

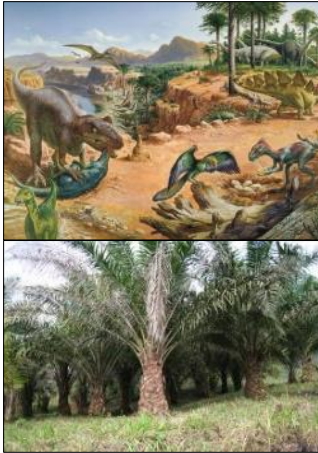




2014



The *Real* Solution



Feedstock

Conversion

Profitable
Product

Smart and Courageous Capital

...as a means to addressing *major* global issues

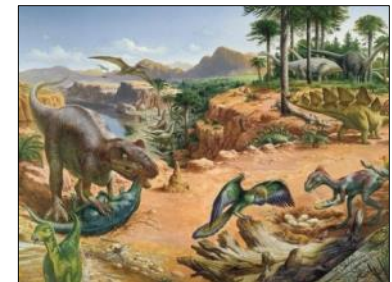
Crossing the Great Divide



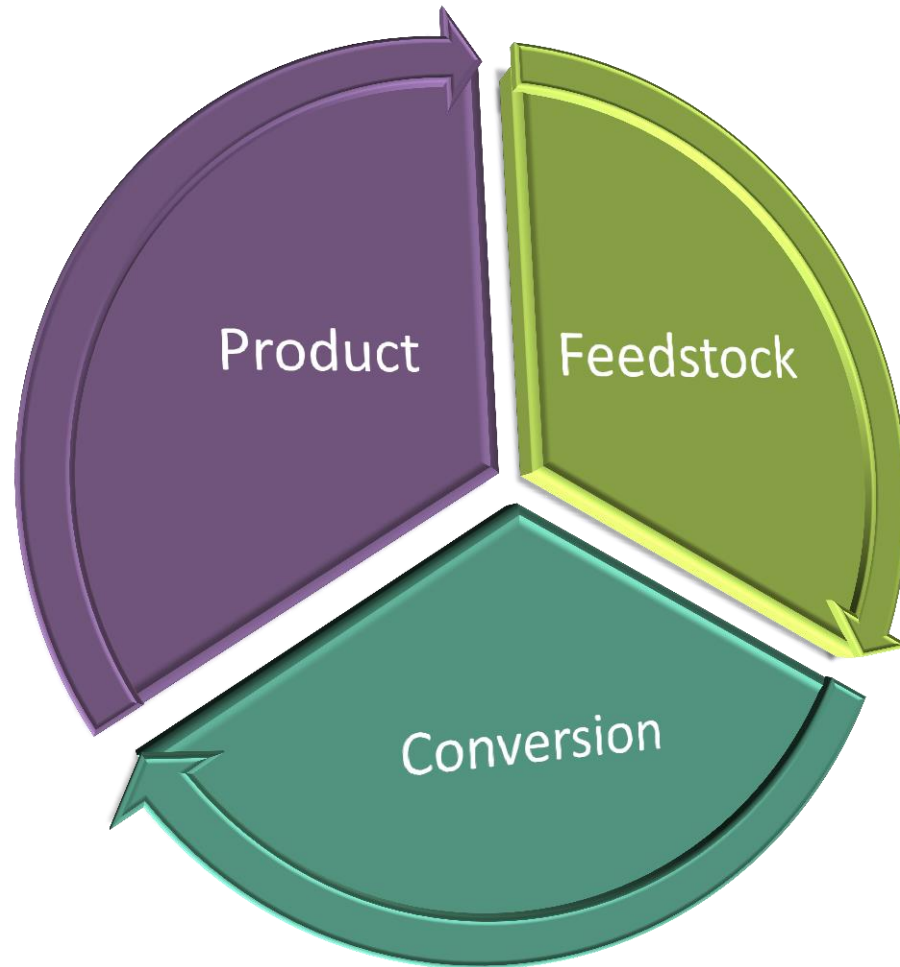
The Golden Rules of **CREATING VALUE** –

- The **chemical and fuel** industries have *always* been driven by *feedstock costs*
- The **technology** was there to *profitably and safely convert* to the desired products
- The **courageous capitalization** support was available

- *And woe to anyone who forgets...*



Crossing the Great Divide



The *Real* Solution

Align **feedstock** with **technology** for **product** in a *global market... where there is opportunity in delivering locally*

BIOMASS – Leveling the Playing Field



9

<http://www.globalccsinstitute.com/publications/potential-biomass-and-carbon-dioxide-capture-and-storage/online/102151>

BIOMASS – Leveling the Playing Field



10



12

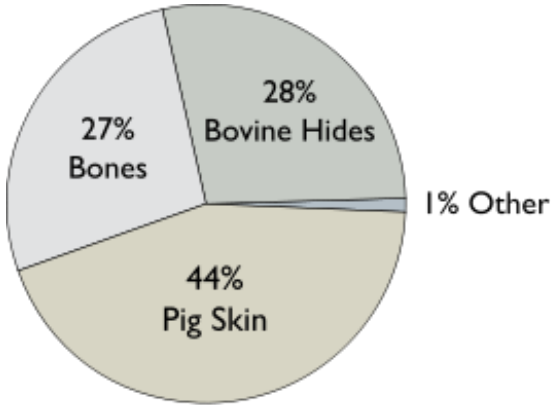


11

The Power, Promise and Problems of Biomass and Chemicals

- The BIOMASS solution – WHY Biomass NOW?
- BIOMASS the great (re)leveler?
- **KEYS FOR SUCCESS – winning at BIOMASS to CHEMICALS**
- KEY DECISIONS – who will need to make them.

BIOMASS is *not new*...

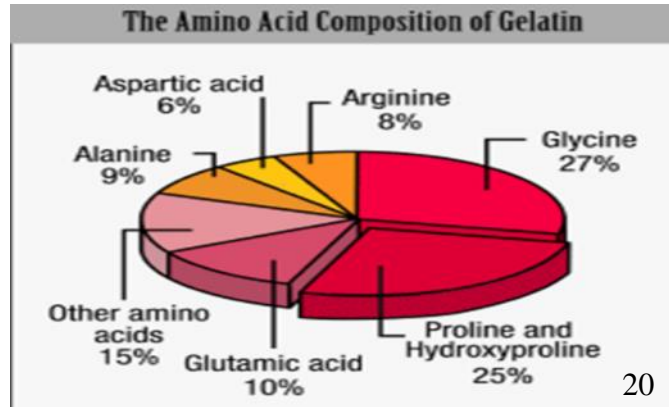


Materials Used in Gelatin Production

19



18



20



21

22



23



24



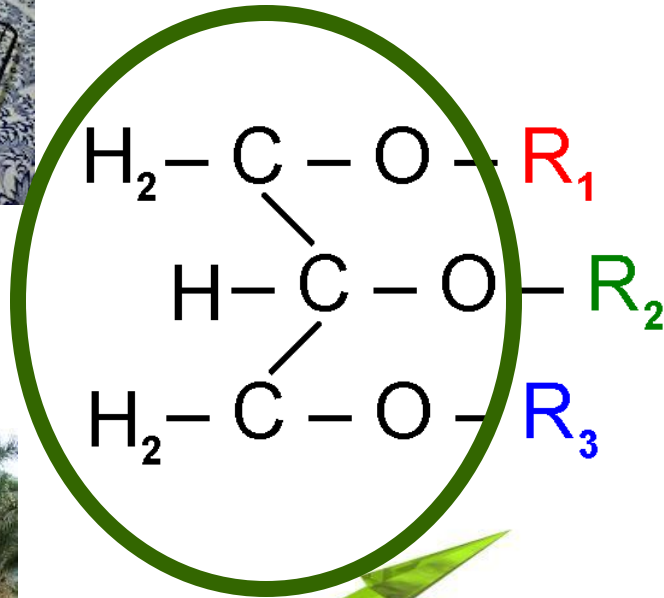
BIOMASS is *not new*...



26



25



27



28



29

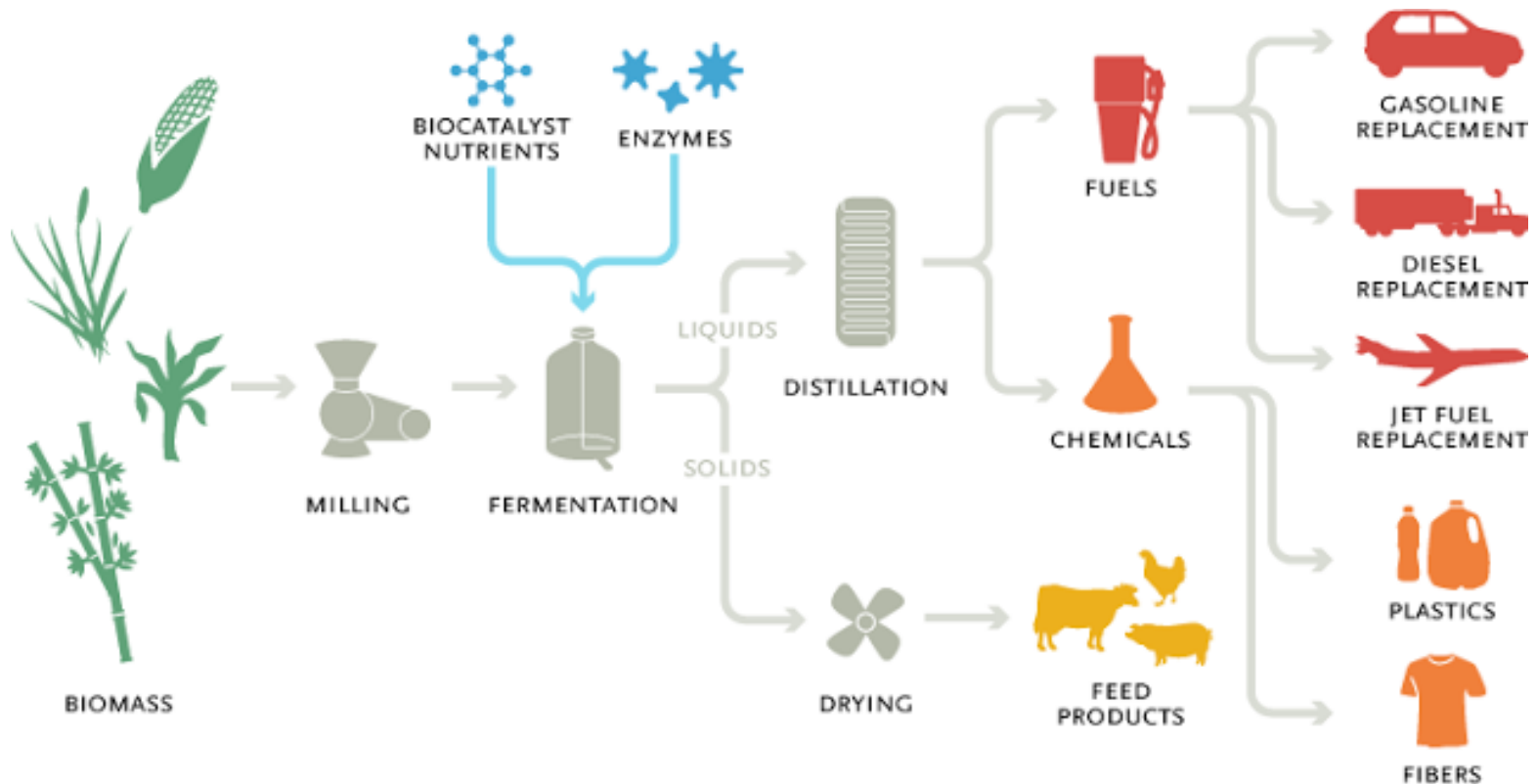


30

22



FOCUS must BE on aligned processes with outputs



31

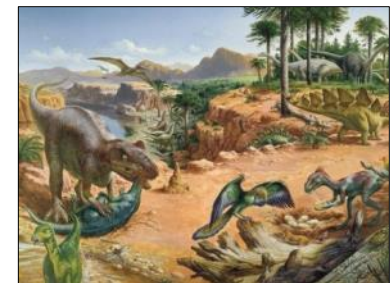
Crossing the Great Divide



The Golden Rules of **CREATING VALUE** –

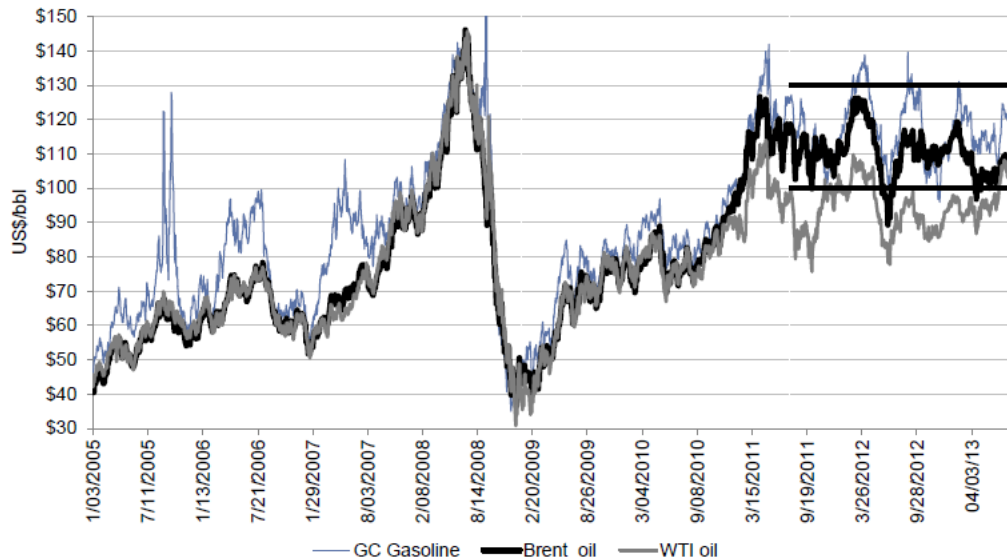
- The **chemical and fuel** industries have *always* been driven by *feedstock costs*
- The **technology** was there to *profitably and safely convert* to the desired products
- The **courageous capitalization** support was available

- *And woe to anyone who forgets...*



The Feedstock Wars

Oil prices have been volatile, but within a narrow range



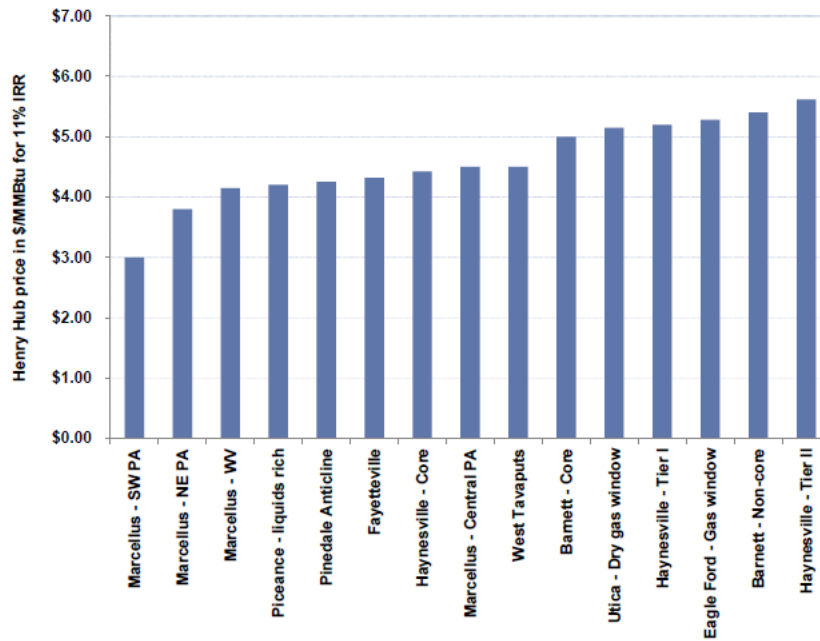
***\$100/bbl needed to fund non-OPEC capex and dividends;
\$130/bbl causes significant demand destruction and macro slowing***

Source: Goldman Sachs Global ECS Research, Goldman Sachs Global Investment Research.

34

The Feedstock Wars

Natural gas to recover from lows, but low extraction costs put a ceiling on price



Shale gas production is still attractive below \$5.00/MMBtu

Henry Hub price required to generate 11% IRR. Assumes \$112/bbl Brent and NGL price of 40% of oil realization; does not include acreage acquisition cost.

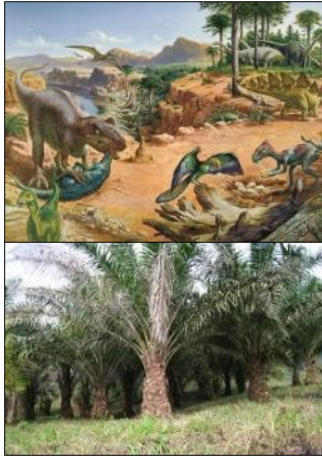
Source: EIA, state data, IHS, Goldman Sachs Global Investment Research.

3

CALYSTA Energy™

35

The *Real* Solution



Feedstock

Conversion

Profitable
Product

Smart and Courageous Capital

...as a means to addressing *major* global issues

The Power, Promise and Problems of Biomass and Chemicals

- The BIOMASS solution – WHY Biomass NOW?
- BIOMASS the great (re)leveler?
- **KEYS FOR SUCCESS – winning at BIOMASS to CHEMICALS**
 - It's NOT just FEEDSTOCK
 - It's BUSINESS STRATEGY
- KEY DECISIONS – who will need to make them.

MANY companies...and more

Bio-based polymers		Average biomass content of polymer	Producing Companies until 2020	Locations
Cellulose Acetate	CA	50%	9	15
Polyamide	PA	rising to 60%*	14	17
Polybutylene Adipate Terephthalat	PBAT	rising to 50%*	3	3
Polybutylene Succinate	PBS	rising to 80%*	11	12
Polyethylene	PE	100%	3**	2
Polyethylene Terephthalat	PET	30% to 35%***	4	4
Polyhydroxy Alkanoate	PHAs	100%	14	16
Polylactic Acid	PLA	100%	27	32
Poylpropylene	PP	100%	1	1
Polyvinyl Chloride	PVC	43%	2	2
Polyurethane	PUR	30%	10	10
Starch Blends ****		40%	19	21
Total companies covered with detailed information in this report			114	135
Additional companies included in the "Bio-based Polymer Producer Database"			133	228
Total companies and locations recorded in the market study			247	363

* Currently still mostly fossil-based with existing drop-in solutions and a steady upward trend of the average bio-based share up to given percentage in 2020

** Including Joint Venture of two companies sharing one location, counting as two

*** Upcoming capacities of bio-pTA (purified Terephthalic Acid) are calculated to in-crease the average bio-based share, not the total bio-PET capacity

**** Starch in plastic compound



http://www.bio-based.eu/market_study/media/files/13-06-21MSBiopolymersExcerpt.pdf

Financing - Follow The \$\$\$

Industry						
	2011 Total	2011%	2012 Total	2012%	2013 Total	2013%
Biotechnology	\$4,826,041,400	16.28	4,160,199,700	15.35	3,156,038,100	15.21
Computers and Peripherals	\$566,634,500	1.91	453,407,000	1.67	419,021,700	2.02
Consumer Products and Services	\$1,432,440,300	4.83	1,336,325,100	4.93	927,699,400	4.47
Electronics/Instrumentation	\$407,088,200	1.37	253,969,100	0.94	217,126,600	1.05
Industrial/Energy	\$3,637,272,800	12.27	2,861,101,100	10.55	940,576,800	4.53
IT Services	\$2,323,244,300	7.84	1,888,768,500	6.97	1,366,590,100	6.59
Media and Entertainment	\$2,278,607,600	7.69	2,039,814,800	7.53	1,655,030,500	7.98
Medical Devices and Equipment	\$2,882,478,600	9.72	2,474,218,600	9.13	1,609,314,500	7.76
Networking and Equipment	\$386,434,400	1.30	330,798,100	1.22	633,194,800	3.05
Semiconductors	\$1,309,863,900	4.42	923,655,000	3.41	375,893,200	1.81
Software	\$7,761,398,000	26.18	8,581,882,700	31.66	8,163,477,300	39.35
Telecommunications	\$612,326,800	2.07	706,310,300	2.61	435,957,900	2.10
Grand Total	\$29,645,324,000		27,106,747,200		20,745,836,500	

http://www.nvca.org/index.php?option=com_docman&task=cat_view&gid=57&Itemid=317

Financing - Follow The \$\$\$

Industry	2011 Total	2011%	2012 Total	2012%	2013 Total	2013%
	Biotechnology	\$4,826,041,400	16.28	4,160,199,700	15.35	3,156,038,100
Computers and Peripherals	\$566,634,500	1.91	453,407,000	1.67	419,021,700	2.02
Consumer Products and Services	\$1,432,440,300	4.83	1,336,325,100	4.93	927,699,400	4.47
Electronics/Instrumentation	\$407,088,200	1.37	253,969,100	0.94	217,126,600	1.05
Industrial/Energy	\$3,637,272,800	12.27	2,861,101,100	10.55	940,576,800	4.53
IT Services	\$2,323,244,300	7.84	1,888,768,500	6.97	1,366,590,100	6.59
Media and Entertainment	\$2,278,607,600	7.69	2,039,814,800	7.53	1,655,030,500	7.98
Medical Devices and Equipment	\$2,882,478,600	9.72	2,474,218,600	9.13	1,609,314,500	7.76
Networking and Equipment	\$386,434,400	1.30	330,798,100	1.22	633,194,800	3.05
Semiconductors	\$1,309,863,900	4.42	923,655,000	3.41	375,893,200	1.81
Software	\$7,761,398,000	26.18	8,581,882,700	31.66	8,163,477,300	39.35
Telecommunications	\$612,326,800	2.07	706,310,300	2.61	435,957,900	2.10
Grand Total	\$29,645,324,000		27,106,747,200		20,745,836,500	

Financing - Follow The \$\$\$



Industry	2011 Total	2011%	2012 Total	2012%	2013 Total	2013%
	Biotechnology	\$4,826,041,400	16.28	4,160,199,700	15.35	3,156,038,100
Computers and Peripherals	\$566,634,500	1.91	453,407,000	1.67	419,021,700	2.02
Consumer Products and Services	\$1,432,440,300	4.83	1,336,325,100	4.93	927,699,400	4.47
Electronics/Instrumentation	\$407,088,200	1.37	253,969,100	0.94	217,126,600	1.05
Industrial/Energy	\$3,637,272,800	12.27	2,861,101,100	10.55	940,576,800	4.53
IT Services	\$2,323,244,300	7.84	1,888,768,500	6.97	1,366,590,100	6.59
Media and Entertainment	\$2,278,607,600	7.69	2,039,814,800	7.53	1,655,030,500	7.98
Medical Devices and Equipment	\$2,882,478,600	9.72	2,474,218,600	9.13	1,609,314,500	7.76
Networking and Equipment	\$386,434,400	1.30	330,798,100	1.22	633,194,800	3.05
Semiconductors	\$1,309,863,900	4.42	923,655,000	3.41	375,893,200	1.81
Software	\$7,761,398,000	26.18	8,581,882,700	31.66	8,163,477,300	39.35
Telecommunications	\$612,326,800	2.07	706,310,300	2.61	435,957,900	2.10
Grand Total	\$29,645,324,000		27,106,747,200		20,745,836,500	

Financing - Follow The \$\$\$



ANGEL
RESOURCE
INSTITUTE

2013 Halo Report

Average Angel Investments and Valuations Start to Climb

Halo Report Reveals Angel Group Investment Trends for Full Year 2013

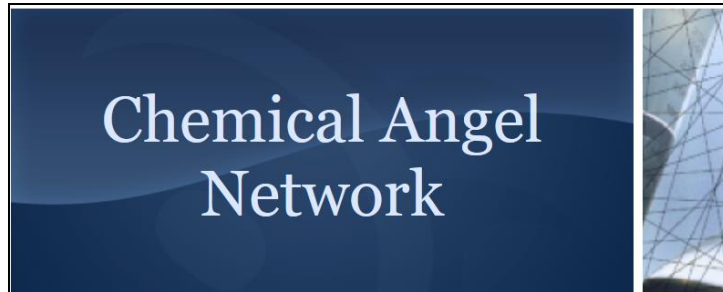
Top Sectors Claim Nearly 80% of Angel Group Dollars Mobile, Healthcare, and Internet Up 10% from 2012



Chart references annual share of angel group dollars across U.S.

www.angelresource.org/en/Research/Halo-Report/Halo-Report.aspx

Financing - Follow The \$\$\$



Financing - Follow The \$\$\$

USDA United States Department of Agriculture
National Institute of Food and Agriculture

research education extension

Home About Us Grants Forms Newsroom Help Contact Us

You are here: Home / Grants / Grant Search / Small Business Innovation Research: Biofuels and Biobased Products

Grants

Small Business Innovation Research: Biofuels and Biobased Products

This is one of 10 topic areas in the USDA SBIR program. The objective of this topic area is to promote the use of biofuels and non-food biobased products by developing new or improved technologies that will lead to increased production of industrial products from agricultural materials. This research will lead to new opportunities to diversify agriculture and enhance agricultures role as a reliable supplier of raw materials to industry. This topic area supports the NIFA Sustainable Bioenergy Societal Challenge Area and the Climate Change Societal Challenge Area.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Funding Opportunity Exchange

National Science Foundation
Directorate for Engineering (ENG)

QUICK LINKS

SEARCH

ENG HOME ENG FUNDING ENG AWARDS ENG DISCOVERIES ENG NEWS ABOUT ENG

Industrial Innovation and Partnerships (IIP)

Biological and Chemical Technologies (BC)

SBIR Proposal Due Date: June 11th
STTR Proposal Due Date: June 13th

Financing - Follow The \$\$\$

NONE WILL GET US TO The *new* Solution



...as a means to addressing major global issues

The Power, Promise and Problems of Biomass and Chemicals

- The BIOMASS solution – WHY Biomass NOW?
- BIOMASS the great (re)leveler?
- KEYS FOR SUCCESS – winning at BIOMASS to CHEMICALS
- **KEY DECISIONS – who will need to make them.**

Key Decisions

- Corporations...
 - Will you step up to the plate? And If so, then WHEN and HOW?



Key Decisions

- Ventures
 - Do you REALLY know the rules of the road for successful commercialization...

“Everything BUT the Squeal”



- REAL SOLUTIONS require more than “invention”



Key Decisions

- Investors
 - Do you have the skills, stamina and connections to make dreams a reality...or are you sticking with APPS!



ANGEL CAPITAL ASSOCIATION

Key Decisions

- The Public
 - Change is NOT free. Are you willing to help pay for the cost of what you say you want...

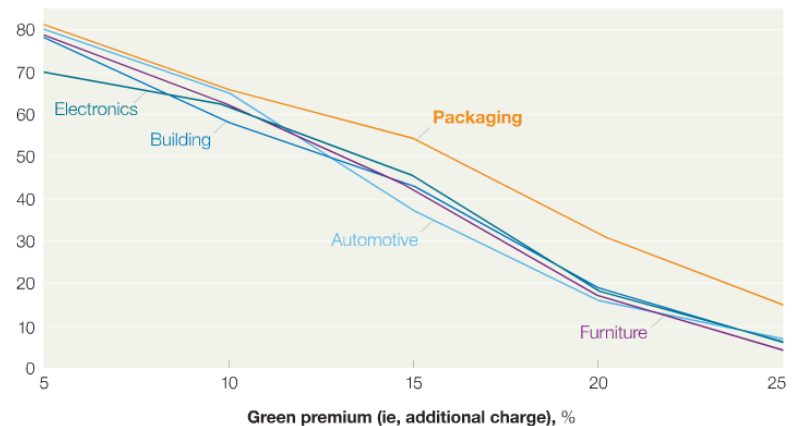
Wednesday, June 05, 2013



U.S. Consumers Increase 'Green' Purchases; But Are They Willing to Pay More?

PHILADELPHIA – (June 5, 2013) – U.S. consumers continue to go green, as 78 percent say they buy green products and services, a steady increase over 69 percent last year, according to the 5th Annual Tork Sustainability Study. The study was conducted by Harris Interactive on behalf of SCA, makers of the Tork® brand of away-from-home paper products and one of the world's most sustainable and ethical companies.

Share of consumers picking green, %



http://www.mckinsey.com/insights/manufacturing/how_much_will_consumers_pay_to_go_green

Key Decisions

- Governments
 - Globally can you make decisions and provide long term incentives that corporations and investors can trust and *stick with them*?



Member Login
Forgot your password

About RFA ▾

Public Policy ▾

The Industry ▾

Resource Center ▾

Study: Statutory 2014 RFS Levels Can be Met Through Increased E85 & E15 Consumption, Carryover RINs

January 24, 2014



(January 24, 2014) WASHINGTON — A new study by Informa Economics entitled “Analysis of the Potential Use of Biofuels toward the Renewable Fuel Standard in 2014” shows the originally intended Renewable Fuel Standard (RFS) 2014 blending requirements can be reached through expanded consumption of E85 and E15, as well as judicious use of carryover RIN credits. The study clearly demonstrates why the Environmental Protection Agency’s proposal to reduce RFS blending requirements is unnecessary and imprudent.

<http://www.ethanolrfa.org/news/entry/informa-statutory-2014-rfs-levels-can-be-met-through-e85-e15-rins/>

Key Decisions

- ALL of us here – ALL of us who wear many hats ...
 - WHAT will you commit to doing to make...

The *new* Solution

Going BIOMASS GREEN



...as a means to addressing major global issues

Thank you



Judith Giordan

Managing Director - ecosVC, Inc

CTO – Qteros, LLC

Co-Founder – Chemical Angel Network

Image sources

1. http://2.bp.blogspot.com/_g_E2gZAoeT0/T8cvNuyNh3I/AAAAAAAAAhg/UKzI8K6WY4M/s1600/saurolophus_pinacosaurus_psittacosaurus_by_zdenek_burian_1971.jpg
2. http://upload.wikimedia.org/wikipedia/commons/d/d2/TASNEE_001.jpg
3. http://upload.wikimedia.org/wikipedia/commons/5/54/Elaeis_guineensis_MS_3467.jpg
4. http://chenected.aiche.org/wp-content/uploads/2013/12/2013-12-23_13-30-14-enerkem-edmonton-.jpg
5. <http://cen.acs.org/articles/91/i36/Unilever-Seeks-Renewables.html>
6. <http://www.forbes.com/sites/greatspeculations/2014/01/30/beverage-companies-go-green-in-hope-to-sell-more-water/>
7. http://www.dalinyebo.com/media/k2/items/cache/3cee03f16e025a4c4456f628550bf95f_XL.jpg
8. <http://www.businessweek.com/chapter/images/downes.jpg>
9. <http://cdn.globalccsinstitute.com/sites/default/files/publications/102121/advanced/fig-021.jpg>
10. <http://www.anaphylaxis.org.uk/userfiles/images/allergens/Wheat.jpg>
11. <http://ethanolproducer.com/uploads/posts/magazine/2011/09/resize/13158434516345-300x300-noup.jpg>
12. <http://2.imimg.com/data2/XB/QS/MY-5053031/buy-import-rice-from-chennai-india-500x500.jpg>
13. <http://books.openedition.org/irdeditions/1069?lang=it>
14. <http://static.guim.co.uk/sys-images/Guardian/Pix/pixies/2012/4/17/1334658324771/Food-waste-008.jpg>
15. http://www.energy.ca.gov/biomass/images/biomass_graphic.jpg

Disclaimer: We do not endorse nor advocate for any of the companies, products or constructs in any of the images selected. They are shown as examples only.

Image sources

16. <http://www.eia.gov/todayinenergy/images/2013.07.25/worldenergy.png>
17. <http://clilenergies.wikispaces.com/file/view/renewable-sources-energy.gif/419174398/638x349/renewable-sources-energy.gif>
18. http://www.gelatin-gmia.com/images/GMIA_Gelatin_Manual_2012.pdf
19. http://upload.wikimedia.org/wikipedia/commons/thumb/b/b4/Materials_Used_in_Gelatin_Production.svg/294px-Materials_Used_in_Gelatin_Production.svg.png
20. http://www.cfs.purdue.edu/FN/fn453/pdf_full/gelatin_2.pdf
21. <http://www.fitgelatins.com/gummi1.jpg>
22. <http://2.bp.blogspot.com/-jJyJs08q-Xg/Ts6553bO1bI/AAAAAAAAHYE/vcKeg0NVoto/s400/mold2.jpg>
23. http://www.gmap-gelatin.com/advantages_photographic.html
24. http://www.nitta-gelatin.co.jp/products/gelatin/images/gelatin_p_02.jpg
25. http://myblessedlife.net/wp-content/uploads/2012/05/coconut_oil.jpg
26. <http://media-cache-ec0.pinimg.com/236x/69/b8/62/69b862f8d4065f7a2642854b435f2dc6.jpg>
27. <http://www.greendiary.com/wp-content/uploads/2012/09/114441961.jpg>
28. http://www.fraunhofer.de/en/press/research-news/2012/june/naturally-adhesive/_jcr_content/pressrelease/textblockwithpics/image1.img.jpg/rn06_fo4_m_Naturally%20adhesive.1337878679009.jpg
29. http://i00.i.aliimg.com/photo/v0/137242362/Fragrances_for_Detergents.jpg
30. <http://blogs.mcgill.ca/oss/files/2013/05/cosmetic-150x150.jpg>

Disclaimer: We do not endorse nor advocate for any of the companies, products or constructs in any of the images selected. They are shown as examples only.

Image sources

31. http://1.bp.blogspot.com/_4ify7vDXrDs/TFI3INbkWJI/AAAAAAAAAGWU/2byetLokUVQ/s640/Gevo_biomass_cor_nucopia.png
32. http://www.eia.gov/biofuels/workshop/pdf/paul_kamp.pdf
33. <https://www1.eere.energy.gov/bioenergy/pdfs/35523.pdf>
34. http://www.greenpowerconferences.com/EF/Events/BN1310US/docs/2/Bio-basedChemicals_and_Materials/Alan_Shaw.pdf
35. http://www.greenpowerconferences.com/EF/Events/BN1310US/docs/2/Bio-basedChemicals_and_Materials/Alan_Shaw.pdf
36. http://www.atkearney.ru/documents/10192/1641099/FG-Unleashing-Pharma_1.png/06499f1c-ef55-4a23-a4eb-3ec353b25879?t=1373465507947
37. http://www.atkearney.ru/documents/10192/1641099/FG-Unleashing-Pharma_2.png/9d66b916-bbca-487e-bced-6f80a77b53cf?t=1373465507533
38. <http://garvandwane.com/images/microbes.jpg>
39. http://bioinfo.med.utoronto.ca/~lamoran/name_this_molecule_1.gif
40. <http://mcdonald.ucdavis.edu/uploads/1/8/5/3/1853874/1167012.jpg>

Disclaimer: We do not endorse nor advocate for any of the companies, products or constructs in any of the images selected. They are shown as examples only.

Some References

- ATKearney, “Unleashing Pharma from the R&D Value Chain”
 - http://www.atkearney.ru/health/ideas-insights/article/-/asset_publisher/LCcgOeS4t85g/content/unleashing-pharma-from-the-r-d-value-chain/10192
- IEA Greenhouse Gas R&D Programme (IEAGHG), “Potential for biomass and carbon dioxide capture and storage. 4. Technical Potential”
 - <http://www.globalccsinstitute.com/publications/potential-biomass-and-carbon-dioxide-capture-and-storage/online/102151>
- Inbicon, “Inbicon Biomass Refinery Cellulosic Ethanol Technology Platforms. Growth and Sustainability through Biomass Refining, CHP”
 - http://www.eia.gov/biofuels/workshop/pdf/paul_kamp.pdf
- Melody M. Bomgardner, “Seeking Biomass Feedstocks That Can Compete”
 - <https://cen.acs.org/articles/91/i32/Seeking-Biomass-Feedstocks-Compete.html>
- Parratt & Associates, “Scoping Biorefineries: Temperate Biomass Value Chains”
 - <http://www.innovation.gov.au/industry/biotechnology/IndustrialBiotechnology/Documents/ScopingBiorefineriesTemperateBiomassValueChains.pdf>
- U.S. Department of Energy, “Top Value Add Chemicals from Biomass. Volume I – Results of Screening for Potential Candidates from Sugars and Synthesis Gas”
 - <https://www1.eere.energy.gov/bioenergy/pdfs/35523.pdf>
- Plastice Conference, 2013, Warsaw, Poland
 - http://www.plastice.org/fileadmin/files/conference_brochure_01.pdf
- Current progress on bio-based polymers and their future trends; Ramesh P Babu^{12*}, Kevin O'Connor³ and Ramakrishna Seeram⁴⁵⁶
 - <http://www.progressbiomaterials.com/content/2/1/8>
- **Links in the body of the presentation**

Disclaimer: We do not endorse nor advocate for any of the companies, products or constructs in any of the references selected. They are provided as examples only.