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Fueling the Commercialization of Cellulosic Ethanol

TIMBR Cellulosic Biofuels Conference
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Overview of Presentation

- Introduction to Verenium
  - Process technology overview
  - Commercial development focus
- Evaluating feedstocks: key criteria
- Geography of CEtOH production in the US
  - Near term
  - Long term
- Time cycle for CEtOH development and deployment as a complement / successor to today's petroleum fuels
- Massachusetts' opportunity for CEtOH industry leadership

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Verenium Today:
Two Commercially-Focused, Complementary Businesses

Significant Market Opportunities	Unmatched In-house "Know-How"	Intellectual Property	Infrastructure Development Skills

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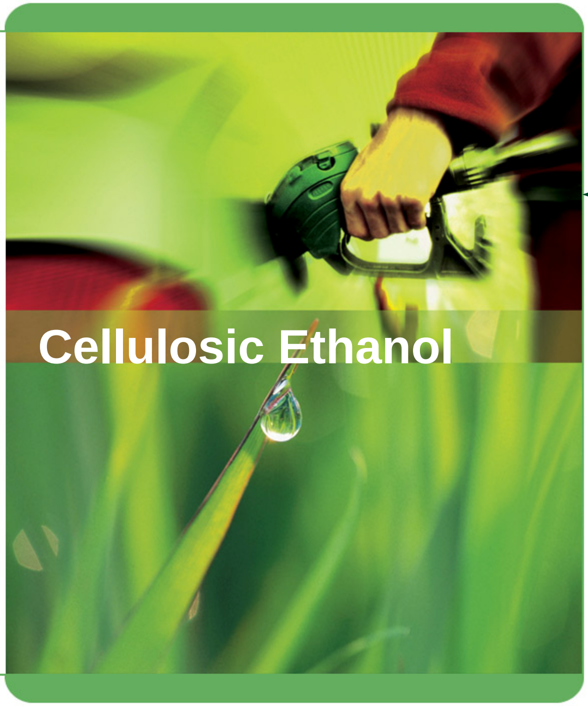
Next-Generation, Cellulosic Biofuels:
Supportive Factors in the External Environment

Traditional Drivers



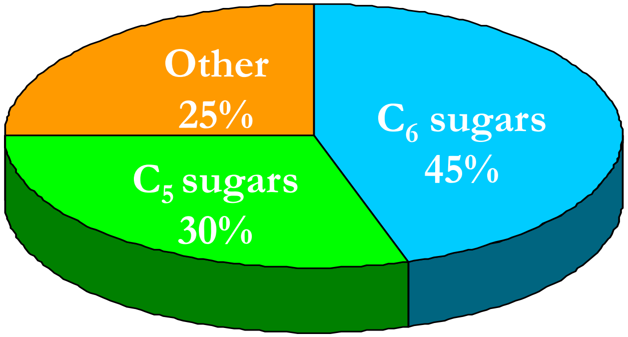
From renewable cellulosic biomass

Immediate Drivers

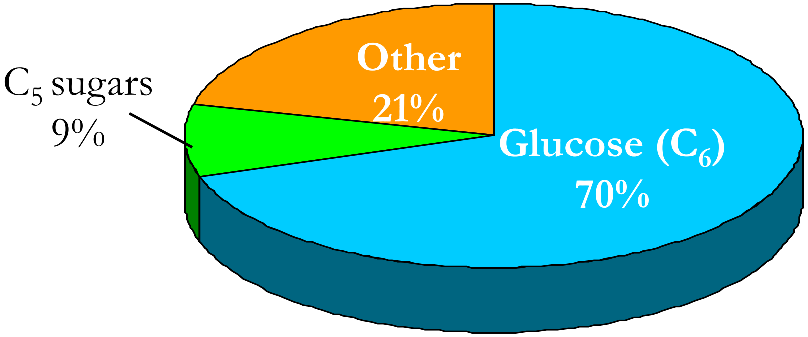
Verenium's C5 / C6 Process:
Full Use of Sugars from Non-Food Feedstocks

- **Conventional (corn) ethanol is made from 6-carbon sugars in starch using yeast**
- **Biomass has 6-carbon sugars and many 5-carbon sugars in hemicellulose (which are not commercially fermentable by yeast)**
- **Verenium's unique, proprietary technology converts 5-carbon sugars directly into ethanol, in addition to 6-carbon sugars**

Typical Biomass Composition (Bagasse)



Corn Kernel Composition



Fermenting both C_5 and C_6 sugars drastically raises ethanol yields

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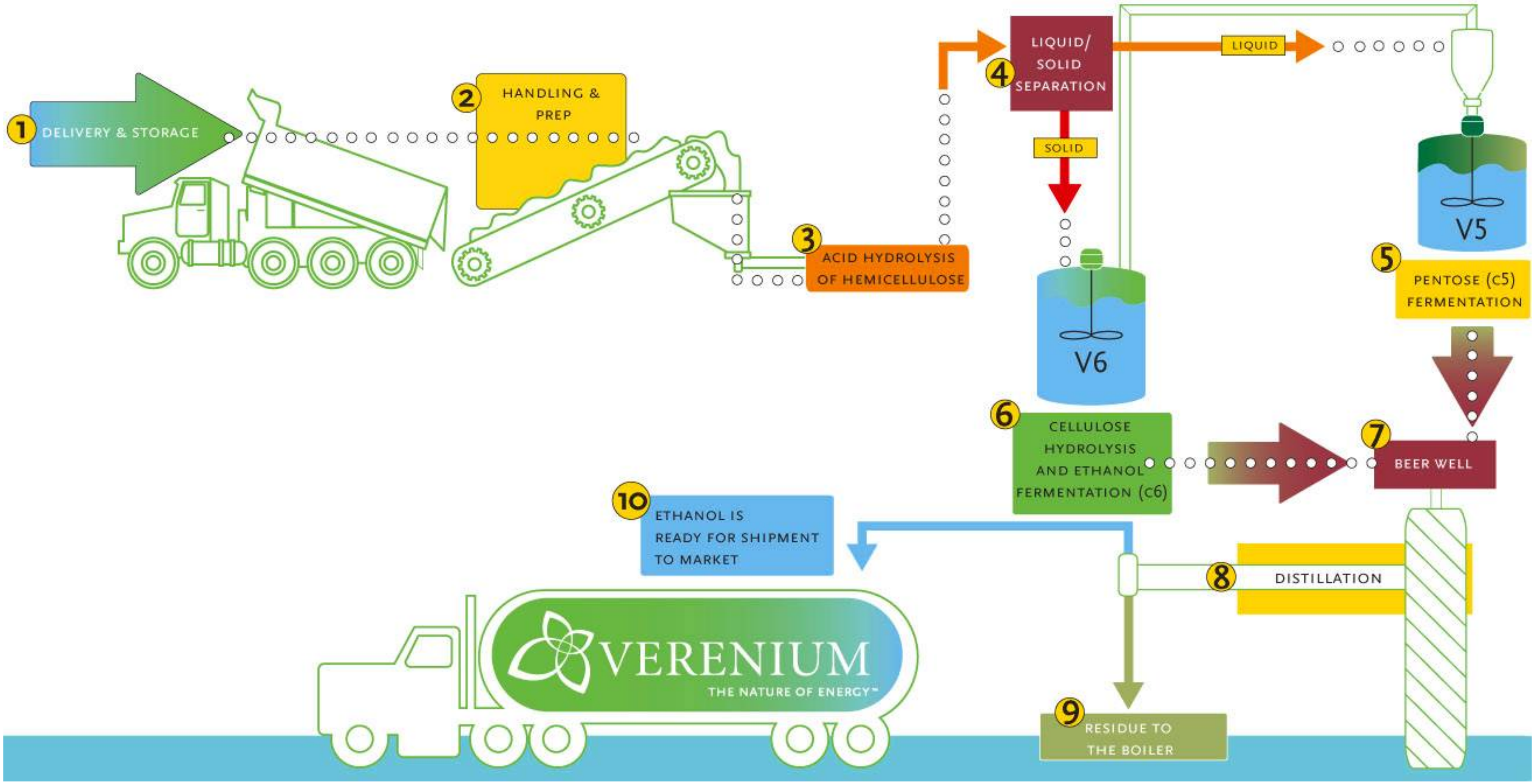
The Verenium CEtOH Production Process:

A High Level Overview



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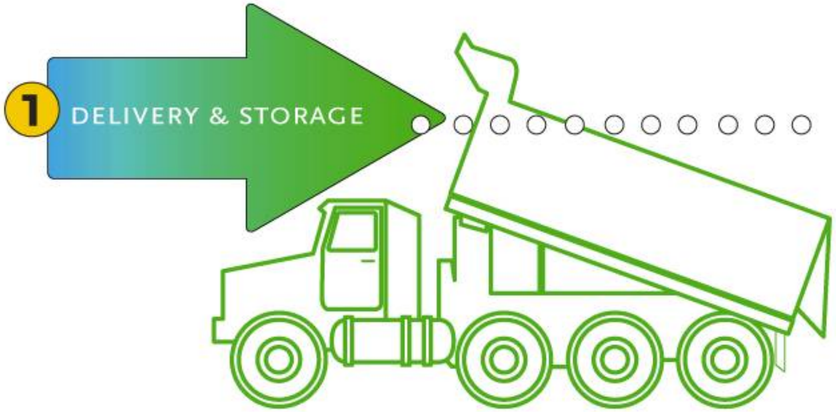
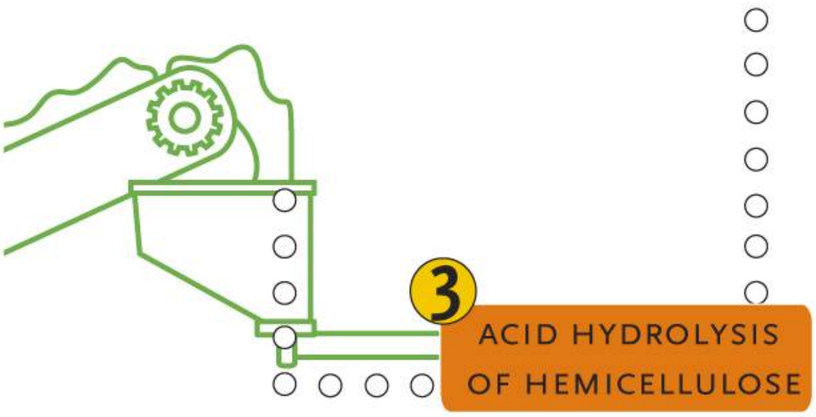
The Verenium Production Process:
Delivery and Storage



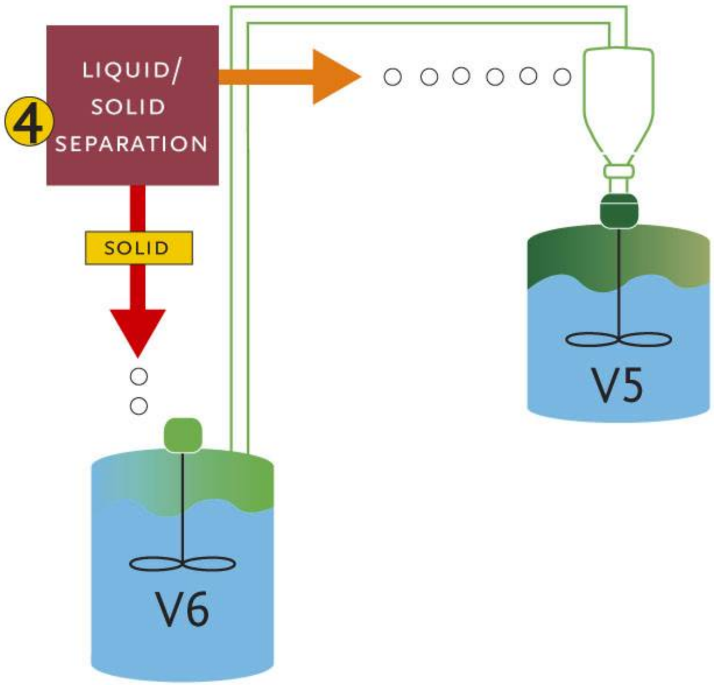
Once delivered to site, we have a well understood process for managing the bagasse pile

The Verenium Production Process:
First-stage Hydrolysis of C5 Sugar Stream



- Dilute acid steam explosion hydrolyzes hemicellulose to 5 carbon sugars and produces a cellulose "cake"
- Utilize "off-the-shelf technology" from pulp and paper industry optimized for our process

The Verenium Production Process:
Liquid / Solid Separation



- Hydrolyzed bagasse (mixture of C5 sugar syrup and cellulose fiber) sent to liquid/solid separation system where C5 sugar syrup is washed and separated from cellulose fiber
- C5 syrup sent to C5 Fermentation process
- Washed cellulose (C6 cake) sent to C6 fermentation process

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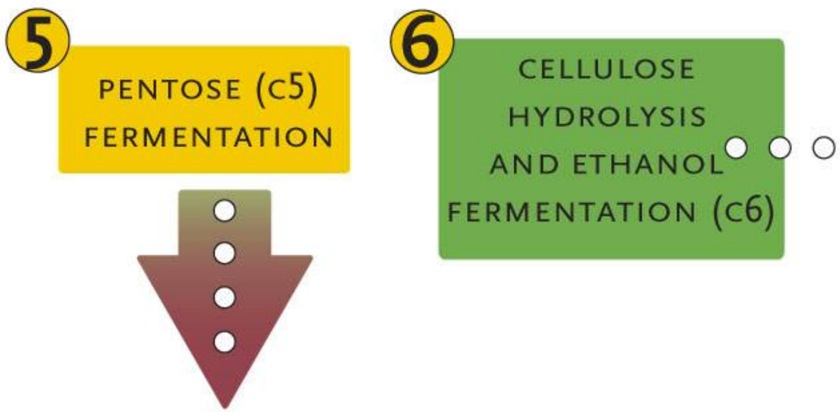
The Verenium Production Process:

Fermentation of Mixed Sugars



Two organisms for fermentation:

- V5 for C5 fermentation
- V6 for C6 fermentation
- Saccharification of cellulose by enzymes produced on-site

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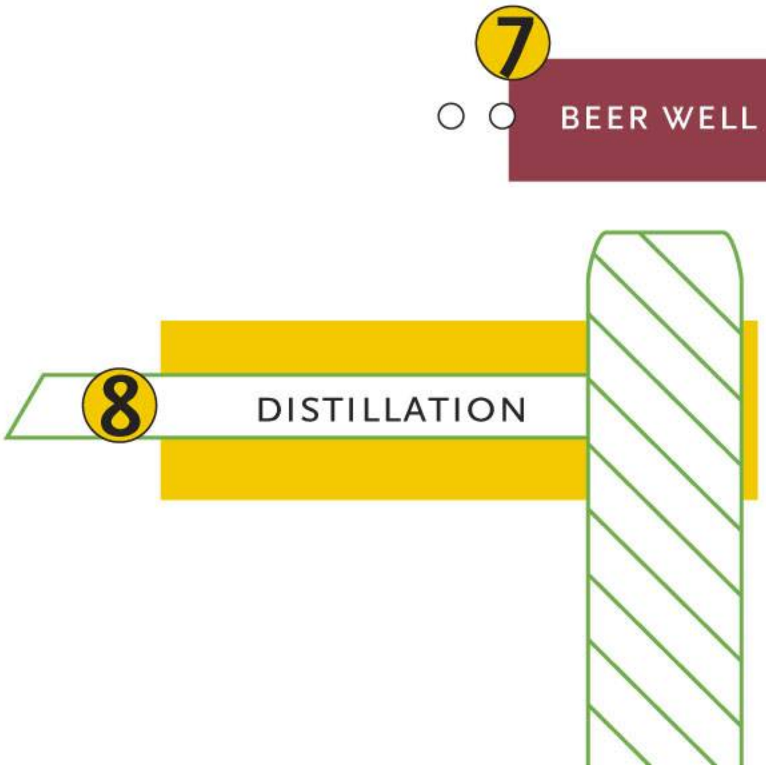
The Verenium Production Process: *Distillation and Stillage Processing*



C5 and C6 “beers” blended and stored in a “beer well,” then run through traditional three-stage distillation process (stripping, rectification, and dehydration) to produce fuel grade ethanol

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Jennings Pilot Plant:
A Core Part of Verenium's Biofuels R&D Program

Modernized and Expanded During 2006

Overseas Licensing of Technology:
Extending Verenium's Reach Through Partnerships

Bioenergy Japan (Marubeni/TSK, 2007); 2nd in Thailand (2008)

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Jennings Demo Plant:
First Completed Demonstration-Scale Facility in USA

- Fully integrated, large-scale cellulosic ethanol facility
- Rated capacity: 1.4 million gallons-per-year
- Feedstock: initially bagasse/energy crops; wide range thereafter
- Currently in start-up and commissioning phase

First Commercial Plant Targeted to Break Ground in 2009

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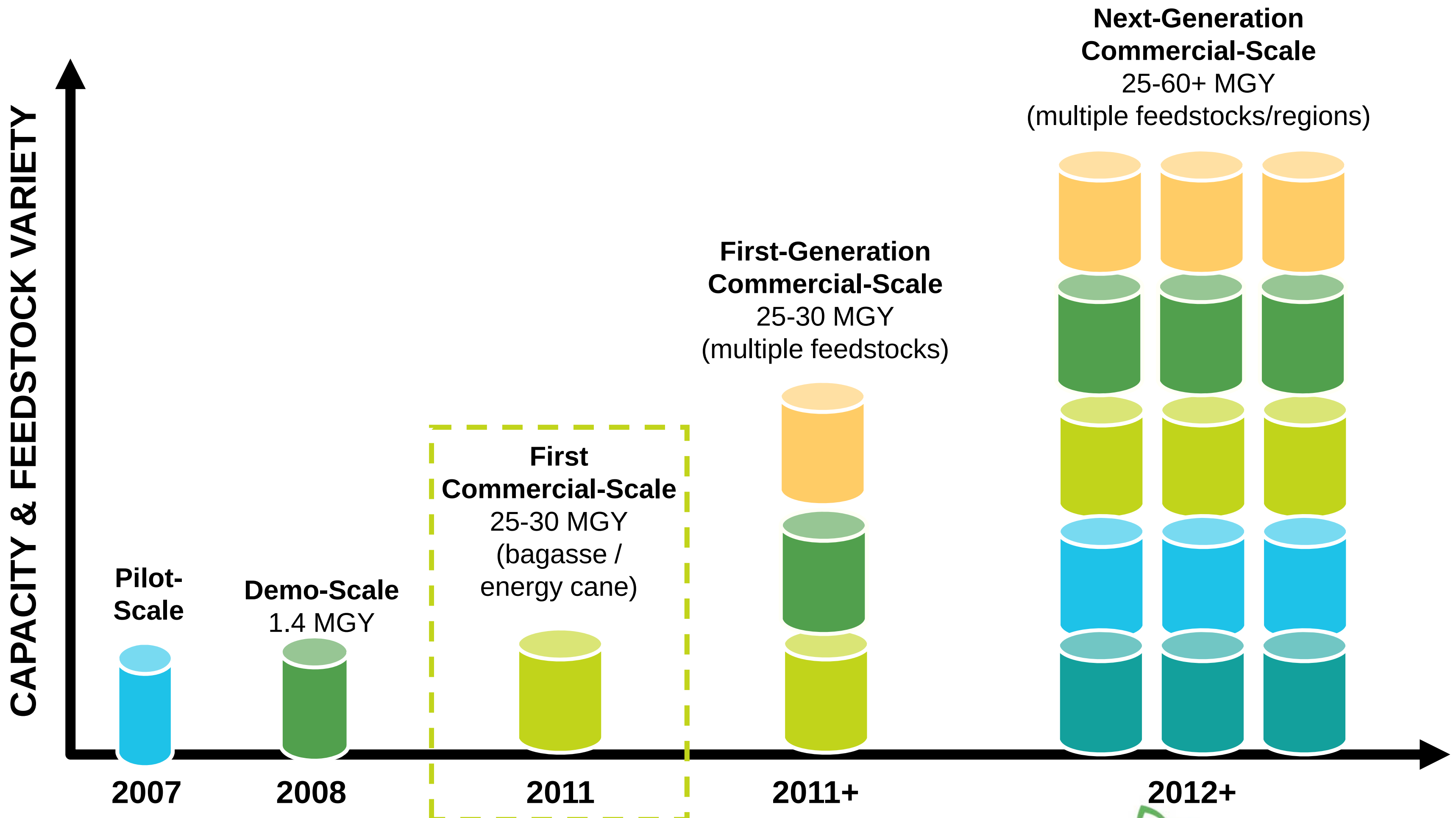
Verenium's Biofuels Growth Strategy:
Rapid Deployment of Facilities Following CP1



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BP / Verenium Strategic Partnership:
A Transformational Alliance For CEtOH Industry

- Companies share a vision for the near-term commercial scale production of cellulosic ethanol
  - BP a leader energy, including biofuels – with 10% global market share
  - Verenium a technology development leader; proven science, existing production assets, including pilot and demonstration-scale facilities
- Landmark, 50/50 partnership to accelerate the development of low-cost, environmentally-sound cellulosic ethanol in the U.S.
- To date, largest (disclosed) single investment in a cellulosic biofuels company in the U.S.
  - BP's largest investment in the U.S. biofuels industry
  - Indicative of commitment to leverage leading technology to advance more sustainable fuels to the market

bp

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Feedstocks for CEtOH Production:
Key Criteria for Broad-Scale Commercialization

- Availability in high concentration
  - Industrial sites (e.g., pulp and paper mills)
  - Dedicated energy crops
- Yield/acre (= crop yield x process yield)
- Supplemental input requirements
- Transportation costs
  - Harvest and collection
  - Proximity to underserved markets
- Impact on the food chain
- Recalcitrance of biomass (woody vs. grassy crops)

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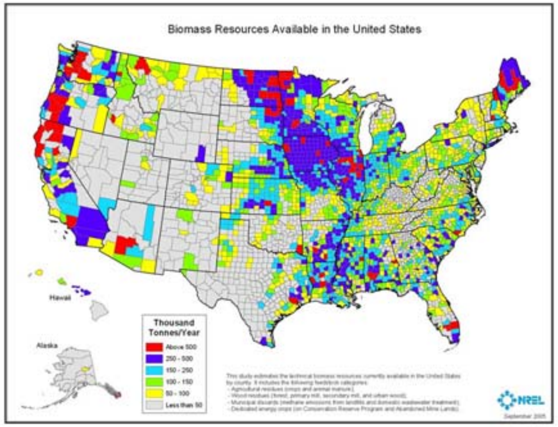
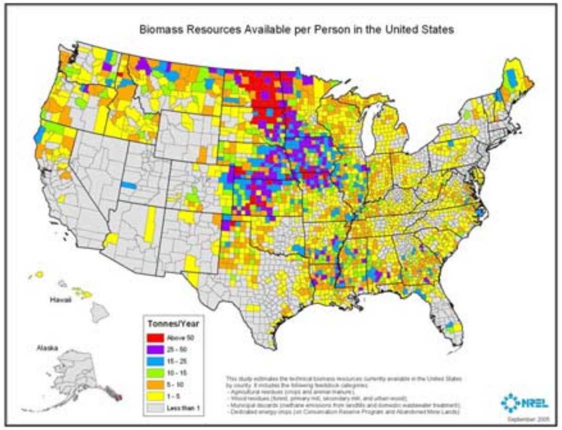
Feedstock Availability: Conventional View

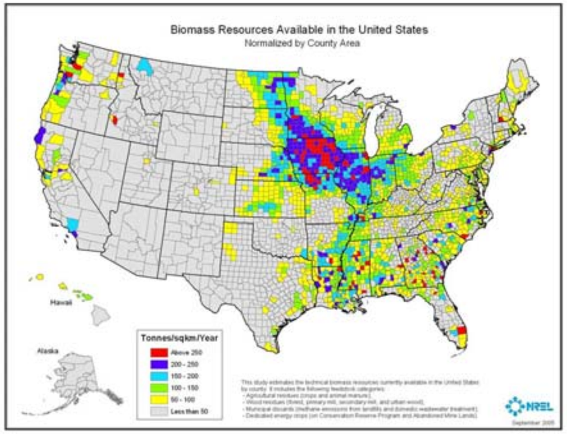
- Metrics in feedstock studies (e.g., Billion Ton Study) have tended to focus attention on grain belt sources of cellulose (stover, switchgrass)
- These metrics reflect <u>existing</u> land use patterns – and use criteria that measure aggregate supply (vs. local, economically accessible supply)



Biomass per county



Biomass per capita



Biomass per km^2

…What if… we focus on maximizing biomass production in our most naturally fertile regions?

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Dedicated Grass Crops in the Gulf Coast:
Maximizing the Potential for CEtOH Production

- High-fiber “Energy Cane” (close to original cultivars) is bred for biomass growth
- Compositionally the most similar to sugar cane bagasse
- Among the highest yielding ethanol yielding agricultural feedstocks

Feedstock	Technology	Ethanol Yield Gallons / Acre
Energy Cane – SE U.S.	Cellulosic	1,830
Switchgrass – U.S.	Cellulosic	732
Sugar - Brazil	Sugar Fermentation	653
Sugar – U.S.	Sugar Fermentation	493
Corn – U.S.	Grain – Dry Mill	402

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Five-Year Commercial Development Plan:
Near-Term Focus on Gulf Coast Region

- Ultimately national / global play; Gulf region is first leg
- Initial focus: position 6 projects for close between 2009 and 2011

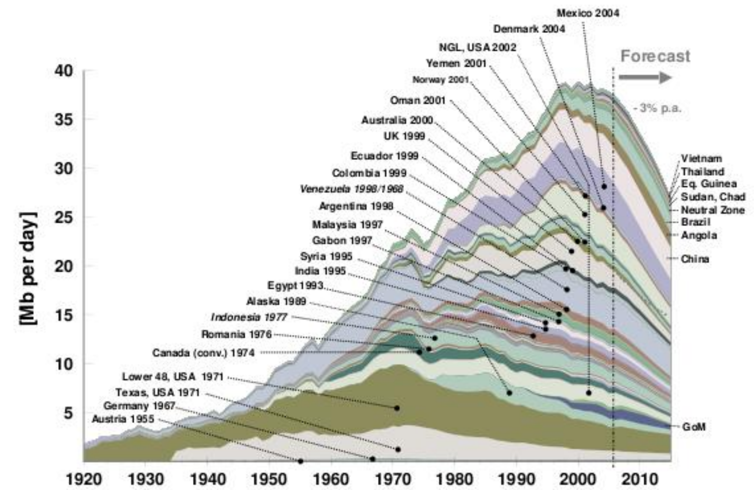
- Projects in Development:
  - Grasses/energy cane/bagasse
  - Local agricultural partners
  - Good logistical interfaces
  - Some co-located

- Three energy crop plantations
  - ~100 acres / plantation
  - Energy cane and sorghum
  - Energy cane expandable in two years to 17k acres
  - Validation platform for growers

Closing Thoughts: "Peak Oil" and the Impact of Near-Term Volatility in Oil Markets

- Oil prices are in retreat from $145
- But global <u>discoveries</u> (not reserve development or production) have declined since the 1960s
- Unconventional oil resources (offshore, Arctic, tar sands, CTL) will be costly and carbon-intensive
- Whether the global peak occurs now, in 5 or 20 years is almost immaterial – we have no time to lose in developing low-carbon, liquid fuel alternatives!

Figure 5: Oil producing countries past peak



Ludwig-Bölkow-Systemtechnik GmbH, 2007
Source: IHS 2006; PEMEX, petrobras ; NPD, DTI, ENS(Dk), NEB, RRC, US-EIA, January 2007
Forecast: LBST estimate, 25 January 2007

As of 2007, production in 43 countries (out of 55 that have ever produced petroleum) was in decline

The Biofuels Industry in Massachusetts

- Several factors (e.g., climate, size, cost of land, type of industry) will limit the opportunity for biofuels production within our borders
- But Massachusetts has an unparalleled opportunity to be a biofuels technology leader through biotech/university collaboration
- Public policy leadership (e.g., biofuels law) can foster a receptive market – and set a strong example for other states
- Technologies originating here can be deployed on a global scale
- Who will be the Apple Computer of the biofuels industry?

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Thank You?
Questions?

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