Research Direction and Funding

Woody Biomass and Small Log Workshop

From Feedstock to Product

College of the Siskiyous

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Research Focus Areas

- Sustainability
  - Standards
  - Practices
- Technology
  - Improved environmental performance
  - Improved economics
- Organisms
  - Genetic modification
  - Robust microorganism communities
  - Integrated production and conversion approaches
    - High value uses
  - Improved production
- Catalysts
  - Chemical catalysis
  - Biocatalysis
- Synthetic biology
  - Controlled synthesis from solar energy
- Systems
  - Integration of solar and other energy technologies
  - Scheduling and timeliness
  - Life cycle design

State recommendations: California Roadmap for Sustainable Management and Development of Biomass (California Biomass Collaborative)

Goal 1 - Increase sustainable production and improve acquisition of biomass

Goal 2 - Increase production of biopower, heat, and cooling

Goal 3 - Increase production and improve environmental performance of renewable biofuels

Goal 4 - Increase production of bio-based products

Goal 5 - Improve knowledge and disseminate information

Priority Areas

1. Resource access and feedstock markets and supply
2. Market expansion, access, and technology deployment
3. Research, development, and demonstration
4. Education, training, and outreach
5. Policy, regulations, and statutes

Priority Areas

Resource access and feedstock markets and supply*:*

Feedstock suppliers need access to biomass resources and must be able to deliver feedstock into biomass markets in sustainable ways and at acceptable prices.

- Standards and best practices for sustainable feedstock supply and use
- Land use
- Environmental impacts

Priority Areas

Resource access and feedstock markets and supply (continued)

- Resource monitoring
- Dedicated biomass crops
- Biomass collection and transport
- Seasonality and storage
- Biomass commodity markets
- Biomass enterprise zones

Priority Areas

Market expansion, access, and technology deployment:

- Power plants, biorefineries, and other biomass converters require access to both biomass feedstock supplies and product markets.
- Market access in turn requires both the physical capacity to deliver product through power lines, pipelines, trucks, and other transport systems, and the ability to price products competitively.

Priority Areas

Market expansion, access, and technology deployment (continued)

- Funding and incentive mechanisms
  - Tax mechanisms, loans, contracts, and pricing structure
- Regulatory incentives
  - Emission Offsets
  - Renewable Energy, Environmental, and Carbon Credits
- Infrastructure improvements and access
  - Transmission Access
  - Biofuels Production Potential and Infrastructure
- Technology deployment

Priority Areas
RD&D

- Resource base, sustainability, and access
- Feedstock processing and logistics
- Bioscience and biotechnology
- Conversion technology and process engineering
- Systems analysis
- Knowledge base, information dissemination, information resources

Priority Areas

Education and Outreach

- Public education and outreach to decision makers
- Consumer information and education
- Environmental justice
- Industry training and professional education
- K-12 education
- Higher education
- Research extension and technical interaction

Priority Areas
Policy, regulations, and statutes

- State policies, regulations, and laws influence behavior, technology implementation, resource management, and markets.
- Policies need to be comprehensive, allow for effective innovation, and have a vision of the long-term potential of bio-based technologies.

Priority Areas
Policy, regulations, and statutes

- Accounting for externalities
- Renewable Fuels Standard
- Permitting process
- Performance-based standards
- Emission Offsets
- Interconnection standards and net metering

Priority Areas
Policy, regulations, and statutes

- Forest biomass harvesting
- Working landscapes and agricultural buffers
- Alternative fuel credits
- State procurement
- Enterprise zones
- Best management practices/sustainable practices
- Environmental Justice

Federal view on ethanol RD&D

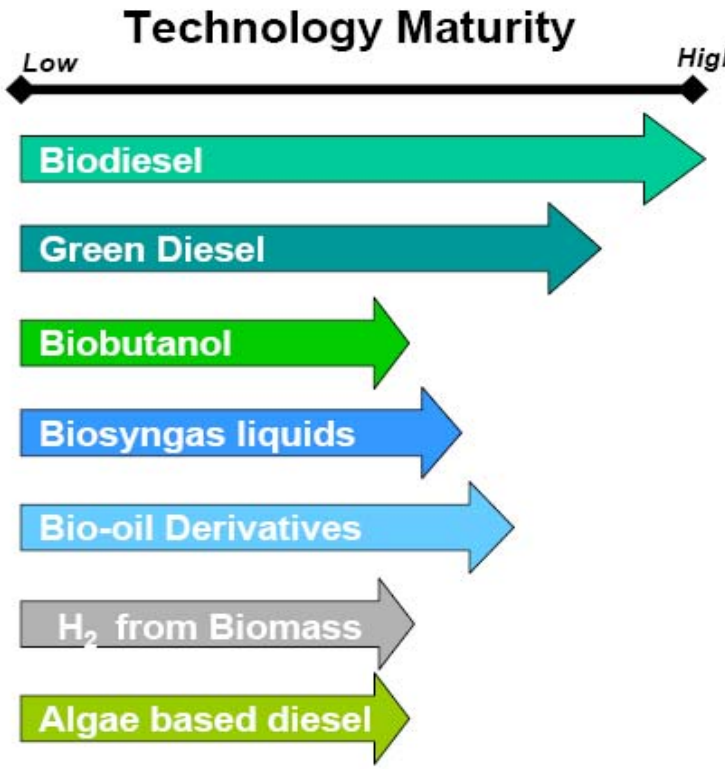
U.S. Department of Energy
Energy Efficiency and Renewable Energy

Barriers to Commercialization

- **R&D Success required:**
  - ✓ Reduce costs associated with biochemical conversion of feedstocks, specifically enzyme and fermentation costs
  - ✓ Reduce the cost associated with thermochemical conversion of feedstocks, specifically gasification, gas cleanup, and fuel synthesis
  - ✓ 2012 goal already accelerated from original 2020 goal
- **Land-use concerns to meet long term requirements**
  - ✓ Environmental, soil carbon, sustainability
- **Immature feedstock supply systems**
  - ✓ Costs range from $5/ton for waste wood to upwards of $50-65/ton for ag residues (depends on need to provide value to supplier)
- **Risks associated with first-of-a-kind plants and high capital investment for integrated biorefineries**
  - ✓ Capex $ can range from $4 to $9/gal ethanol (installed)
- **Lack of fuel distribution and vehicle infrastructures**
  - ✓ Estimated 20 to 40 billion dollar capital investment required

Source: US Department of Energy

Federal view on other biofuels



Issues	Prospects
Supply of oils	Small impact on market
Supply of bio-oils	Could out compete biodiesel handily
Immature technology	Better blending than ethanol in gasoline
Costs, catalysts	Omnivorous for feedstocks
Cleanliness for applications	Good feed to green diesel
Costs	Best as co-product?
Costs, technology	Good in certain regions

Development partners include government, academic, petrochemical, agricultural, and forestry sectors

Source: US Department of Energy

DOE Cellulosic Biorefinery Demonstration Project Awards, 2007-2010, $385M

Awarded to	Ethanol Capacity (MGY)	Technology	Feedstock (tpd=tons per day)	Location	Award ($ Milliion)
Abengoa	11.4 (cellulosic) 85 (starch) + power and syngas	Enzymatic hydrolysis + biomass gasification for process energy	700 tpd corn stover, wheat straw, switchgrass, others	Kansas	76
ALICO	13.9 + power, 8 tpd hydrogen, 50 tpd ammonia	Gasification followed by syngas fermentation (BRI)	770 tpd greenwaste and energycane	Florida	33
BlueFire Ethanol	19	Concentrated acid hydrolysis (Arkenol process)	700 tpd sorted greenwaste and wood waste from landfill	California	40
Broin (POET)	31 cellulosic 94 starch	engineered Zymomonas bacteria (Dupont)	842 tpd corn fiber, cobs, stalks	Iowa	80
Iogen Biorefinery Partners	18	Enzymatic hydrolysis (Iogen)	700 tpd wheat and rice straw, other ag. residues, switchgrass	Idaho	80
Range Fuels	40 + 9 methanol	Gasification followed by catalytic syngas upgrading	1,200 tpd wood residues and energy wood	Georgia	76

DOE Efficient Cellulosic Fermentation Solicitation Awards (2007)

- Cargill ($4.4 million)
- Celunol ($5.3 million)
- Dupont ($3.7 million)
- Mascoma ($4.9 million)
- Purdue University ($5.0 million)

JBEI—Joint Bioenergy Institute

- DOE funded bioenergy research center
  - $125 million each
  - Consortium of LBNL, LLNL, SNL (Livermore)
  - Partner institutions
    - UC Berkeley, UC Davis, Stanford

- Other DOE funded bioenergy research centers:
  - BioEnergy Science Center (Oak Ridge, GA Tech, NREL, UofGA, Dartmouth, UofTennesse)_
  - Great Lakes Bioenergy Research Center (UofWisconsin, Michgan State, PHNL, Lucigen Corp, UofFlorida, Oak Ridge, Illinois State, Iowa State)

California Energy Commission Biofuel Solicitation Awards (2007)

- Metcalf & Eddy/SFPUC ($995,791)
  - Brown grease
- Renewable Energy Institute International ($996,093)
  - Syngas with integrated energy production
- BlueFire Ethanol ($995,938)
  - Pilot support to USDOE project development

Funding

- California Energy Commission PIER program
  - Contracts and solicitations
    - http://www.energy.ca.gov/contracts/pier.html
  - EISG
    - http://www.energy.ca.gov/research/innovations/
- CalPERS/CalSTRS Environmental Investments
  - $700 million/$188 million
- Other State
- Federal
  - Grants.gov
  - SBIR/STTR
    - http://www.sba.gov/SBIR/indexwhatwedo.html
- Foundation
- Industry and venture capital
  - Global investments in clean energy technology of $17 billion by 2009

Legislative actions

- Federal Farm bill
- Federal Energy bills
  - House—HR 3221
  - Senate—HR 6

UC Davis - Chevron
Joint Research Agreement

- $25 million over 5 years
  - Additional $5 million in-kind from Chevron
- Focus on transportation biofuels

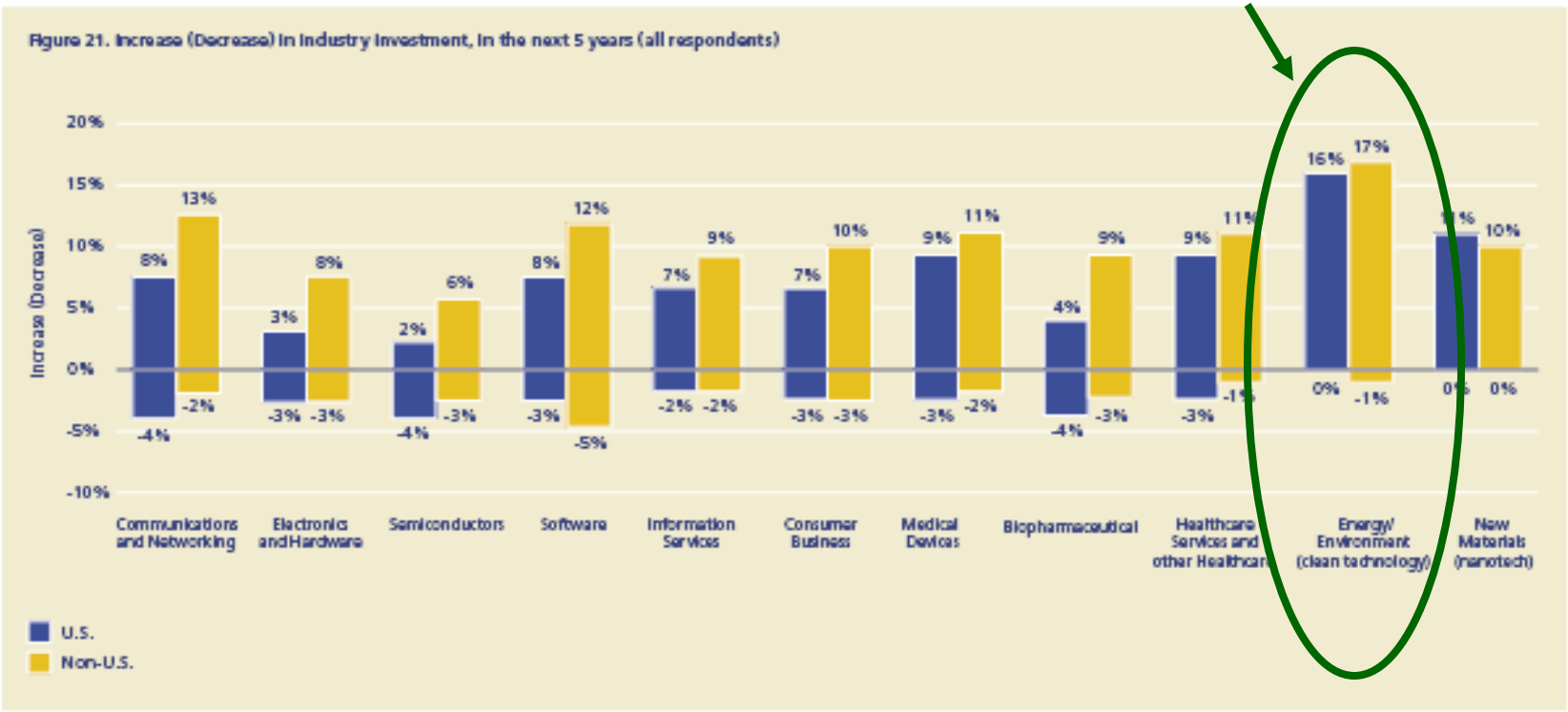
http://bioenergy.ucdavis.edu

Energy Biosciences Institute (BP-UC Berkeley)

- $500 million award from BP (announced 1 Februrary 2007)
  - University of California Berkeley
  - University of Illinois, Urbana-Champaign
  - Lawrence Berkeley National Laboratory
- Production of new and cleaner energy, initially focusing on renewable biofuels for road transport.
- Bioscience-based research in three other key areas
  - conversion of heavy hydrocarbons to clean fuels
  - improved recovery from existing oil and gas reservoirs
  - carbon sequestration

Increase in Industry Investment next 5 years

Cleantech: Energy and Environment



Source: Deloitte, Global trends in venture capital 2006 survey, available from http://www.nvca.org/presscenter.html