Biomass and Biorefinery Systems RD&D

Funding Profile by Subprogram

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Biomass and Biorefinery Systems RD&D		
Feedstocks	36,212	16,000
Conversion Technologies	82,115	117,000
Utilization of Platform Outputs R&D	97,898	0
Integrated Biorefineries	0	25,000
Analysis and Sustainability	0	10,000
Biopower	0	22,500
Cellulosic Biofuels Reverse Auction	0	150,000
Total, Biomass and Biorefinery Systems RD&D	216,225	340,500

Public Law Authorizations:
P.L. 93-577, "Federal Non-nuclear Energy Research and Development Act" (1974)
P.L. 94-163, "Energy Policy and Conservation Act" (EPCA) (1975)
P.L. 94-385, "Energy Conservation and Production Act" (ECPA) (1976)
P.L. 95-91, "Department of Energy Organization Act" (1977)
P.L. 95-618, "Energy Tax Act" (1978)
P.L. 95-619, "National Energy Conservation Policy Act" (NECPA) (1978)
P.L. 95-620, "Powerplants and Industrial Fuel Use Act" (1978)
P.L. 96-294, "Energy Security Act" (1980)
P.L. 100-12, "National Appliance Energy Conservation Act" (1987)
P.L. 100-615, "Federal Energy Management Improvement Act" (1988)
P.L. 101-218, "Renewable Energy and Energy Efficiency Technology Competitiveness Act" (1989)
P.L. 101-549, "Clean Air Act Amendments" (1990)
P.L. 101-575, "Solar, Wind, Waste, and Geothermal Power Production Incentives Act" (1990)
P.L. 102-486, "Energy Policy Act of 1992"
P.L. 106-224, "Biomass Research and Development Act" (2000)
P.L. 107-171, "Farm Security and Rural Investment Act" (2002)
P.L. 108-148, "Healthy Forest Restoration Act" (2003)
P.L. 109-58, "Energy Policy Act of 2005"
P.L. 110-140, "Energy Independence and Security Act of 2007"
P.L. 110-234, "The Food, Conservation, and Energy Act of 2008"

Mission

The Biomass Program develops and transforms domestic, renewable, and abundant biomass resources into cost-competitive, high performance biofuels, biopower, and bioproducts through targeted planning, research, development and demonstration (RD&D) leveraging public and private partnerships.

Benefits

An economically-viable, sustainable, domestic biomass industry that produces clean, secure, renewable biofuels, biopower, and bioproducts will: 1) enhance U.S. energy security by reducing dependence on oil; 2) provide environmental benefits including reduced GHG emissions through substitution; and 3) create domestic economic growth and opportunities across the Nation by developing the entire supply chain domestically. The RD&D work conducted by the Biomass Program improves process and cost efficiencies, while indentifying and validating technological pathways for sustainable growth in the emerging American biofuels industry and biopower sector.

In FY 2012, the Biomass Program, in collaboration with Office of Science, will begin an innovative biofabrication effort to standardize and scale up the fabrication of fundamental biological components, allowing for rapid prototyping and testing for new approaches to synthesizing biofuels. Establishing this capability domestically will help America capture world leadership in the emerging field of biomanufacturing.

The program's integrated biorefinery projects and cellulosic biofuels reverse auction are also expected to stimulate direct private sector employment and the growth of domestic biofuels industry. The program's RD&D work and support of private sector innovation is critical to achieving the EISA RFS targets for advanced and cellulosic biofuels. The RFS requires 36 billion gallons of renewable fuel per year by 2022, of which 21 billion gallons is to be advanced biofuels.

The Biomass Program utilizes a peer review-driven resource loaded multi-year planning process that is based on extensive analysis. Technology performance is examined through annual state of technology assessments and performance against project technical milestones and passage through decision-critical stage-gates. This process is outlined in greater detail in the program's web-published Multi Year Program Plan.[a]

The ongoing work associated with the American Recovery and Reinvestment Act has further informed the Biomass Program's FY 2012 budget decisions. Nineteen small-scale integrated biorefinery projects are funded, the program's intermediate blends testing is being completed, and two R&D consortia are accelerating the Program's algal and advanced biofuels R&D efforts. This acceleration of the program's mission was taken into consideration when developing the FY 2012 request.

The Biomass Program pursues its mission through a set of integrated activities that are designed to increase the use of domestic renewable resources. Improvements are expected to continue to provide concomitant economic, environmental and security benefits. While the most significant benefits are expected to be a reduction of oil use and CO_2 emissions, consumers will benefit as well.

Program will facilitate rapid private sector growth in renewable energy supplies through technologies that produce competitive sources of fuels and electricity with full price parity with alternative methods of producing fuels, electricity, and feedstocks. Priority work includes RD&D critical to improving technology for biomass handling and conversion to fuel, power, and products, validating performance,

[a] http://www1.eere.energy.gov/biomass/pdfs/mypp.pdf.

reducing investment risk, and promoting deployment and market adoption. Strategic and sustainability analysis, biomass resource assessment, outreach, and market transformation work is also performed.

The program will leverage its planning, analysis and deployment funds by collaborating with EERE's Strategic Programs in activities that maximize the effectiveness of both program and corporate activities for EERE and DOE. The Biomass Program's RD&D supports a national reduction in GHG emissions, lowering the amount of carbon introduced into the Earth's atmosphere through displacing petroleum-based liquid transportation fuels.[a] Biopower technologies, if applied in a regionally appropriate manner, also have the potential to reduce fossil carbon contributions to atmospheric GHGs.

The displacement of fossil fuels from sources with sustainably produced advanced domestic biofuels will enhance energy security. New markets will be created simultaneously to produce sustainable feedstocks, biofuels, and biopower. The increased production of biofuels and biopower has the potential to help reshape markets, and support sustainable generation of transportation technologies capable of reducing fossil carbon emissions and ensuring future prosperity and security in the global community.

Annual Performance Results and Targets

The Department is in the process of updating its strategic plan, and has been actively engaging stakeholders including Congress. The draft strategic plan is being released for public comment concurrent with this budget submission, with the expectation of official publication this spring. The draft plan and FY 2012 budget are consistent and aligned. Updated measures will be released at a later date and available at the following link http://www.mbe.doe.gov/budget/12budget/index.htm.

[a] Further research and analysis is underway to better assess potential GHG contributions related to changes in land-use associated with increased biofuels production.

Feedstocks

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Feedstocks		
Sustainable Production	6,646	973
Logistics	20,316	4,868
Algae & Advanced Feedstocks (formerly Algae)	9,250	9,737
SBIR/STTR	0	422
Total, Feedstocks	36,212	16,000

Benefits

An increased and reliable domestic supply of environmentally sustainable biomass feedstocks will be required for an expanded bioenergy industry. Feedstocks activities are critically important to increasing the availability and accessibility of domestic biomass resources and improving the infrastructure technologies needed to reliably supply cellulosic and alternative feedstocks to future large-scale biorefineries at reasonable costs. Investments in resource availability and feedstock logistics systems development are thus needed to ensure a stable feedstock supply and the economic viability of the domestic biofuels industry.

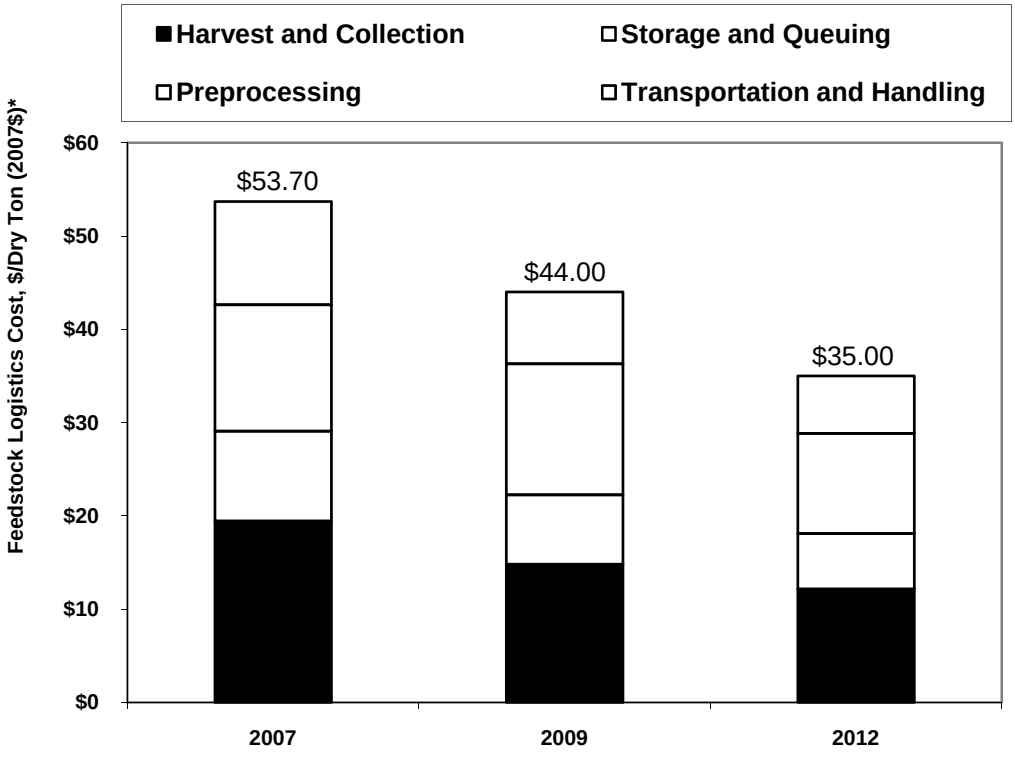
In order to identify a sustainable feedstock supply, resource assessment activities conducted in the Sustainable Feedstock Production area will continue to involve the evaluation of the amount of biomass feedstock resources potentially available in the U.S., where they will be located, at what cost, and under what environmental constraints. Results of these assessments will be incorporated into a GIS-based decision support tool incorporating best-available data from Federal agencies including DOE and USDA biorefinery project results and other assessments from public and private sources. This process will provide the best information to users, which will include Federal and State governments, biorefinery developers, growers, and researchers.

In the near term, the feedstock production goal is to establish criteria under which a sustainably produced, high quality feedstock supply can be available to support a growing biomass industry and meet biomass conversion quality specifications. This goal is necessary to spatially quantify the accessible resources and validate the percentage of resources that could be recovered cost effectively and sustainably.

Industry partnerships will continue to be used to improve feedstock logistics to enhance the economic viability of domestic biofuels. These collaborative efforts involve improvements in existing or the development of new feedstock handling and storage technologies, and proving their success through demonstration trials. The near-term cellulosic feedstock logistics goal is to reduce feedstock logistics costs, including harvesting, storage, preprocessing and transportation, to $0.39 per gallon of ethanol in 2012 (or approximately $35.00 per dry ton, in 2007$ and excluding payment to the grower). In order to reach this goal, the density of cellulosic biomass needs to be increased to 14 lbs per cubic foot. Providing a denser feedstock will have positive cost ramifications throughout the feedstock supply

chain. Indicators of progress toward this goal include cost-shared industrial partnerships for developing feedstock logistics systems.

Feedstock Logistics Cost Projections



*Excludes grower payment

Year	2007	2009	2012
Total, Feedstocks Logistics, $/Dry Ton	**$53.70**	**$44.00**	**$35.00**
Harvest and Collection	$19.45	$14.81	$12.15
Storage and Queuing	$9.64	$7.44	$5.95
Preprocessing	$13.54	$14.05	$10.74
Transportation and Handling	$11.07	$7.70	$6.16

In addition to terrestrial energy crops, algal feedstocks are being examined. Section 228 of EISA requires DOE to report the potential of microalgae as a feedstock for biofuels. This report concluded that microalgae are a potentially viable feedstock in the long-term, though algal biofuel technologies are still in relatively early stages of development. The Biomass Program released a final algae roadmap in June 2010 which documents technical challenges associated with producing algal biofuels and examines pathways to fuels from not only microalgae, but also cyanobacteria and macroalgae.

Feedstocks activities are an integral part of the Biomass Program's partnered strategic pathway of advancing biomass technologies from basic science to applied research and demonstration, utilizing a

market interdependent approach that incorporates linkages and feedback among each step in order to accelerate the benefits of technology development.

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Sustainable Production	**6,646**	**973**

Sustainable Production previously addressed biomass feedstock resource assessment, yield improvement, and sustainable feedstock systems development. Yield improvement and sustainable feedstock systems development were primarily addressed via the continuation of existing feedstock production trials with the Regional Biomass Feedstock Development. Those trial results will be published in FY 2012. It is anticipated that Federal level sustainable feedstock production efforts will be led by USDA starting in FY 2012. Resource assessment efforts will be limited to feedstock characterization from samples obtained during the feedstock trials. Results from these assessments will be incorporated into a GIS-based decision support tool developed at Oak Ridge National Laboratory that can incorporate best-available data from Federal agencies including DOE and USDA biorefinery project results and other assessments from public and private sources.

Logistics	**20,316**	**4,868**

Feedstock Logistics R&D addresses barriers associated with accessing and delivering the feedstock supply to an integrated biorefinery. This work involves the following unit operations: harvesting, collection, preprocessing, storage, queuing, handling, and transport. Feedstocks' efforts expanded from laboratory design work into industrial partnerships through competitively awarded projects initiated in late FY 2009. These projects will improve the operation and efficiency of feedstock collection and delivery systems and will be completed in FY 2012. In collaboration with the Integrated Biorefineries subprogram, a deployable process demonstration unit (PDU) housed at the Idaho National Laboratory (INL) was developed for feedstock logistics systems.

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Algae and Advanced Feedstocks	**9,250**	**9,737**

The feedstock production component of microalgae development will be integrated with algae efforts as algal biofuel challenges are addressed across the supply chain. The major components of this effort include: 1) resource assessments of the algae production inputs; 2) environmental assessments of the impacts of growing algae at scale; 3) identification and optimization of algae strains to improve feedstock production; 4) improvements of cultivation methods and operations; and 5) research of problems at the feedstock-fuel conversion interface, including harvesting and dewatering. Analytical and spatial modeling efforts will be directed to expand the current knowledge of algae production requirements. These include assessments on the availability of land, water and micronutrients on a national scale. Results of these modeling and analysis projects will be the inputs into a national GIS assessment tool, which can be used for visualization of scenarios of future biofuels development.

This tool will inform industrial stakeholders' decision-making processes and ultimately determine the feasibility of domestically producing four billion gallons of algal biofuels by 2022 in support of the advanced biofuels component of the EISA RFS. Research and modeling activities will also help determine likely environmental impacts associated with producing algal biofuels at that scale, under different production scenarios. In addition, research will begin characterizing basic properties of algae feedstocks to ensure compatibility and integration with the available cultivation strategies and downstream fuel conversion processes.

SBIR/STTR	**0**	**422**

SBIR/STTR funding transferred in FY 2010 was $697,000 for the SBIR and $84,000 for the STTR program. The FY 2012 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Feedstocks	**36,212**	**16,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Sustainable Production	
The decrease reflects the expectation that USDA will lead in the area of sustainable feedstock production through regional crop development centers, via its Agricultural Research Service, Forest Service, and National Institute of Food and Agriculture.	-5,673
Logistics	
The decrease reflects the completion of the industrial partner logistics projects and building of the PDU. Efforts will be focused on TRL 1-3 activities.	-15,488

	FY 2012 vs. FY 2010 Current Approp ($000)
Algae & Advanced Feedstocks	
The increase is comprised of new algae projects involving: feasibility, environmental, and resource assessments; exploration of conversion interface issues; and organism characterization.	+487
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities.	+422
Total Funding Change, Feedstocks	**-20,212**

Conversion Technologies

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Conversion Technologies		
Thermochemical	26,830	56,310
Biochemical	30,820	57,447
Algae	24,465	0
SBIR/STTR	0	3,243
Total, Conversion Technologies	82,115	117,000

Benefits

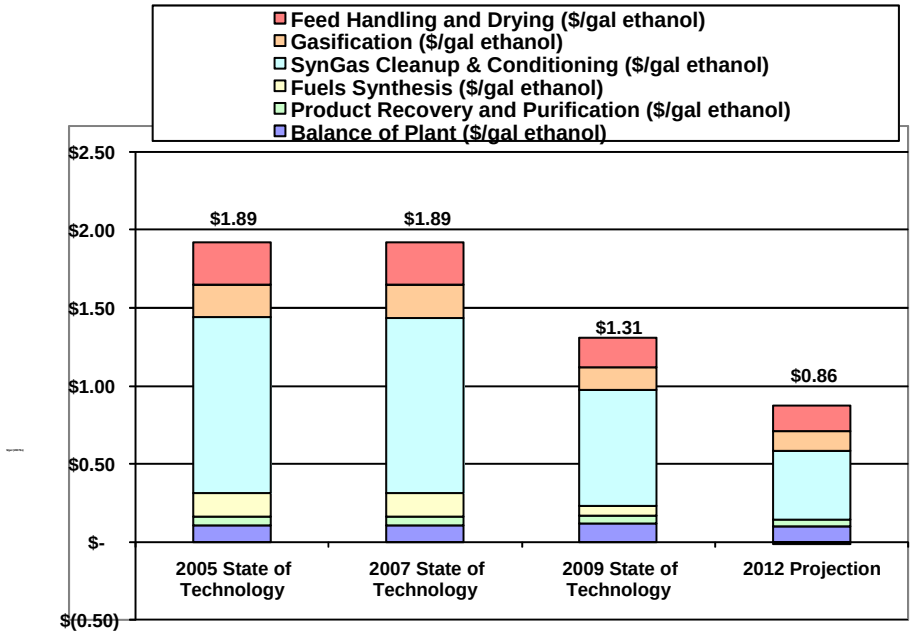
The Conversion Technologies subprogram supports the advancement of Thermochemical and Biochemical technologies for converting feedstocks and intermediates into quality, cost-competitive liquid transportation fuels, materials, and other chemicals. Thermochemical conversion R&D focuses on reducing the costs associated with producing liquid transportation biofuels from gasification and pyrolysis technologies, which includes R&D in feedstock interface, thermochemical processing, intermediate cleanup and conditioning, and upgrading for fuel synthesis. Biochemical conversion R&D will focus on process integration supported by further improvements to feedstock interface (pre-processing), pretreatment, enzymatic and chemical hydrolysis, and fermentation. These integrated steps are required to reduce production costs and therefore enable economically viable cellulosic biofuels production by biorefineries. Additionally, a new initiative will be launched to work with industry partners to design and construct complex, multi-component, biological systems to enhance the cost-effectiveness of advanced biochemical conversion technologies and facilitate the accelerated commercial deployment of these technologies helping America achieve leadership in the emerging field of bio-manufacturing.

This R&D work focuses on the development of technologies capable of converting biomass feedstocks into biofuels. The technical projections for the Conversion Technologies subprogram aligns progress with the achievement of modeled ethanol costs supporting the overall Biomass Program target of $1.76 per gallon of cellulosic ethanol in 2012 (in 2007$) in the near term and $2.76/gallon jet fuel, $2.84/gallon diesel and $2.85/gallon gasoline by 2017 (in 2007$) in the longer term. The Conversion Technologies annual performance targets for FY 2012 support the meeting of the overall 2012 programmatic cost target. The two sets of charts and tables below contain the Biomass Program's current conversion cost projections, which are used to make modeled ethanol selling price (MESP) projections. In the longer term (for years 2013-2015), the Thermochemical conversion performance measures are strategically shifting from cellulosic ethanol to "drop in" hydrocarbon fuels. Thermochemical conversion technologies have several other advantages, including their ability to convert a broad range of feedstocks as supplies shift seasonally or even on a day-to-day basis; full utilization of lignin and well as cellulosic material; efficient use of the complete energy content of the feedstock via co-generation of electricity; and, potential to produce a broad range of bio-products as well as biofuels, allowing adaptation to long-term shifts in transportation fuels markets.

Thermochemical Conversion of Woody Feedstocks to Ethanol ($/gal in 2007$s) via Gasification*

	2005 State of Technology[a]	2007 State of Technology	2009 State of Technology	2012 Projection
Processing Total * ($/gal ethanol)	$ 1.89	$ 1.89	$ 1.31	$ 0.86
Balance of Plant ($/gal ethanol)	$ 0.11	$ 0.11	$ 0.12	$ 0.10
Product Recovery and Purification ($/gal ethanol)	$ 0.06	$ 0.06	$ 0.05	$ 0.05
Fuels Synthesis ($/gal ethanol)	$ 0.15	$ 0.15	$ 0.07	$ (0.01)[b]
SynGas Cleanup & Conditioning ($/gal ethanol)	$ 1.13	$ 1.13	$ 0.74	$ 0.44
Gasification ($/gal ethanol)	$ 0.21	$ 0.21	$ 0.15	$ 0.13
Feed Handling and Drying ($/gal ethanol)	$ 0.27	$ 0.27	$ 0.19	$ 0.16

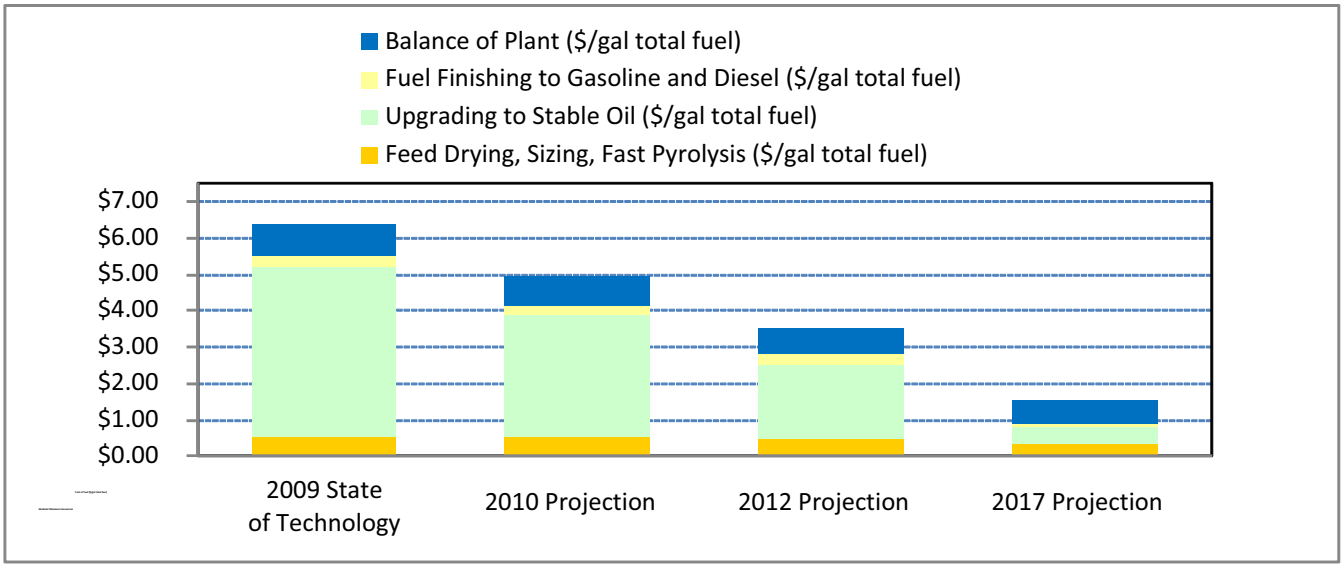
*These are solely the conversion costs additional feedstock costs are required to derive the modeled minimum ethanol selling price.



[a] Note: the numbers in the column below do not exactly add up to this value due to rounding in the computer software used. When the proper calculations were performed without rounding individual values, this number resulted; it is considered the most technically accurate.

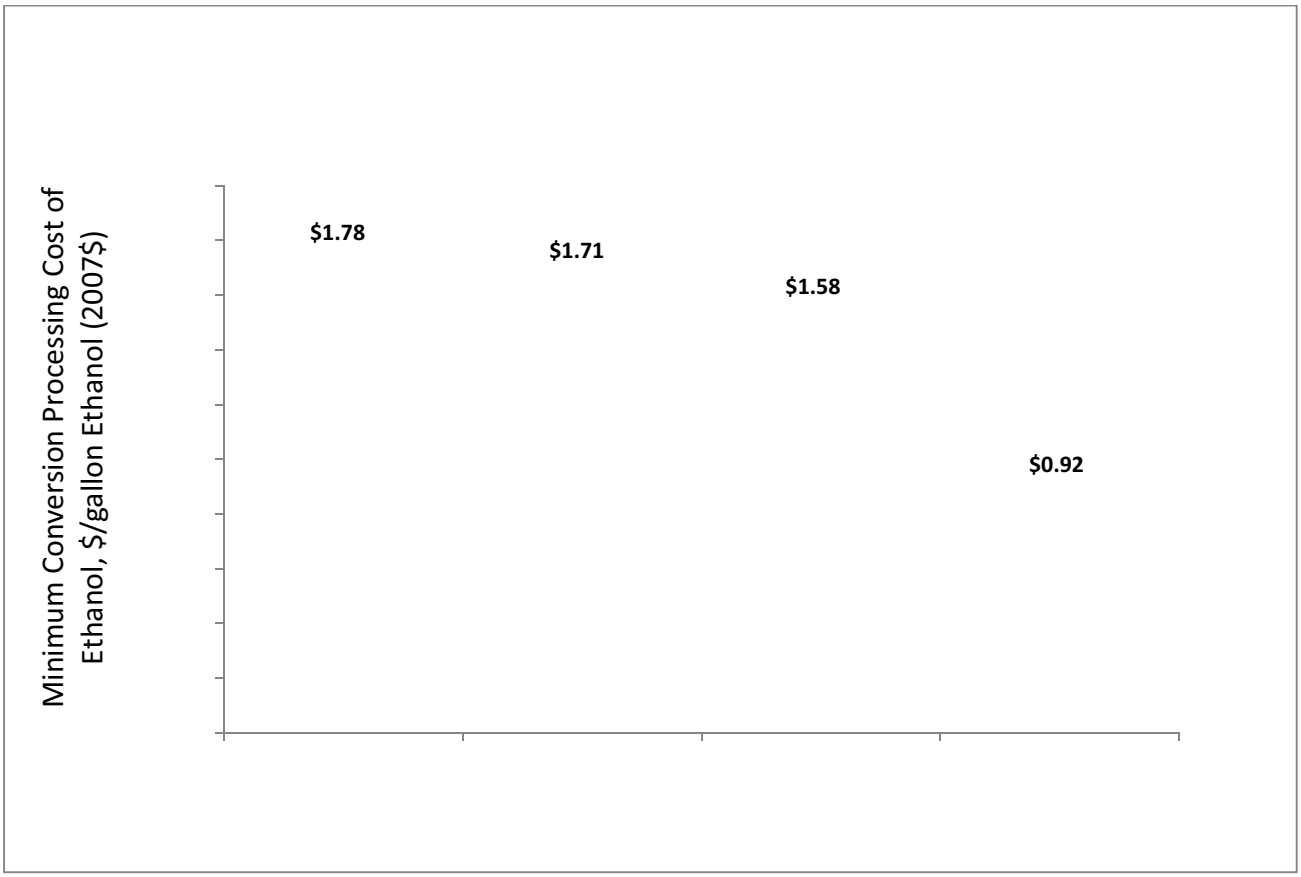
[b] A credit for a mixed alcohols co-product is factored into the calculation, thus in this particular instance, costs are reduced enough that the credit for the co-product is larger than the rest of the costs; thus a negative cost is shown.

Thermochemical Conversion of Woody Feedstocks to Renewable Gasoline and Diesel Blend Stocks ($/gallon gasoline in 2007$) via Pyrolysis



	2009 State of Technology	2010 Projection	2012 Projection	2017 Projection
Conversion Contribution ($/gal gasoline)	$6.30	$4.92	$3.51	$1.56
Conversion Contribution ($/gal diesel)	$6.37	$4.99	$3.57	$1.56
Conversion Contribution ($/gge total fuel)	$6.02	$4.71	$3.38	$1.48
Feed Drying, Sizing, Fast Pyrolysis ($/gal total fuel)	$0.54	$0.53	$0.52	$0.34
Upgrading to Stable Oil ($/gal total fuel)	$4.69	$3.34	$2.01	$0.46
Fuel Finishing to Gasoline and Diesel ($/gal total fuel)	$0.30	$0.29	$0.29	$0.12
Balance of Plant ($/gal total fuel)	$0.82	$0.81	$0.74	$0.64

Biochemical Conversion to Ethanol



	2005 State of Technology	2007 State of Technology	2009 State of Technology	2012 Projection
Processing Total	$1.79	$1.72	$1.58	$0.92
Prehydrolysis / Treatment	$0.50	$0.51	$0.42	$0.26
Enzymes	$0.35	$0.35	$0.35	$0.12
Saccharification & Fermentation	$0.35	$0.34	$0.32	$0.12
Distillation & Solids Recovery	$0.21	$0.19	$0.18	$0.16
Balance of Plant	$0.37	$0.32	$0.31	$0.26

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Thermochemical	**26,830**	**56,310**

Thermal and catalytic conversion processes that can convert a variety of biomass materials to suitable intermediates (e.g., syngas and bio-oils) for subsequent conversion to fuels are under development. Thermochemical conversion R&D focuses on the reduction of costs associated with converting biomass to fuels, chemicals, and power, via gasification, pyrolysis, and catalytic hydrotreating and hydrocracking processing technologies. Intermediate products include clean synthesis gas, or syngas, (a mixture of primarily hydrogen and carbon monoxide), bio-oil (a liquid product from pyrolysis or liquefaction), and gases rich in methane or hydrogen. These intermediate products can be upgraded to fuels and chemicals such as ethanol, other alcohols, gasoline, diesel, jet fuel, ethers, synthetic natural gas, or may be used directly for heat and power generation. Core research addresses key technical barriers such as the need for the entire process to have higher yields and selectivity of the intermediates and end products. Due to subsequent catalytic conversion of syngas to fuels and products, there is a critical need for purification of the syngas and more robust production catalysts. A critical barrier for bio-oil is the need to stabilize bio-oil from unwanted side reactions and upgrading to a form that is more amenable to hydrotreating and hydrocracking catalysts (similar to those used in petroleum refineries).

FY 2012 activities include technology validation to economically convert biomass feedstocks, including forest residues and other woody resources to synthesis gas or bio-oils that are suitable for fuels and co-products. The target for gasification and subsequent ethanol production is a modeled minimum ethanol selling price (MESP) of $1.70/gallon of ethanol, resulting from achieving a conversion cost of $0.97/gallon (2007$, feedstock cost of $51.80/dry ton). The technology and data for achieving this modeling is a result of competitively selected National Laboratory, university, and industry projects. These projects involve developing syngas to liquid fuels technologies and pyrolysis oil to liquid fuel conversion technologies. A go/no go decision was made in FY 2010 to affirm that the current R&D program is on track to attain the programmatic FY 2012 target. Beginning in, and beyond FY 2012, the focus will shift ever more away from ethanol to drop-in hydrocarbon advanced biofuels with expanded application beyond light duty vehicles (e.g., heavy duty trucks, rail, and airplanes). A competitive solicitation was issued to support pyrolysis oil production R&D and subsequent upgrading to non-ethanol, infrastructure-compatible biofuels, including but not limited to new catalysts for upgrading of bio-oil.

FY 2012 activities also include the finalization of applied R&D in a small fully integrated system to convert biomass feedstocks such as woody feedstocks to synthesis gas and subsequent conversion to either ethanol or Fischer-Tropsch alkanes. The target for gasification and subsequent ethanol production is a modeled conversion cost of $0.86/gallon of ethanol (2007$) and current data shows clear progress to meeting this goal in FY 2012. This conversion cost will result in a modeled minimum ethanol selling price (MESP) of $1.57/gallon in 2012 (2007$, feedstock cost of $50.70/dry ton). The data for completing this target will be produced through National Laboratories, universities and industry-led projects.

Current projects will continue to develop bio-oil production technology and subsequent hydrotreating to renewable gasoline, diesel, and jet fuel in FY 2012. Projects selected in a competitive solicitation for

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

non ethanol infrastructure compatible biofuels research will continue. Together with another solicitation to be initiated in FY 2012, these projects seek to resolve the critical barriers with catalysts for the production of renewable gasoline, diesel, and jet fuel such as lifetimes, activity, and selectivity. These processes and catalysis are a critical component in the successful thermochemical conversion of biomass to biofuels.

The fast pyrolysis technology will focus on achieving the renewable gasoline and diesel technical targets in 2017 of a modeled conversion cost of $1.56/gallon of gasoline or diesel. This conversion cost will yield a modeled minimum gasoline or diesel selling price of $2.04/gallon (2007$, feedstock cost of $50.70/dry ton). Additional R&D efforts for producing renewable-gasoline, -diesel, and –jet fuel will include (but not be limited to): hydrothermal liquefaction, catalytic pyrolysis, hydropyrolysis, gasification of biomass to syngas and subsequent conversion to renewable-gasoline, -diesel and –jet fuel, $>C_4$ alcohols, and ethers.

The objective will also be supported by expanding three key research areas to gain a better understanding of the fundamental sciences involved. Gasification fundamentals will include understanding the mechanisms involved in tar reforming, syngas "cleaning", and fuel synthesis particularly for infrastructure compatible fuels. Pyrolysis fundamentals will support efforts to improve bio-oil quality (reduction of total acid number, oxygen content, and residual char fines content) and bio-oil upgrading to gasoline and diesel blends. Catalyst fundamentals include examining the chemical and physical mechanisms involved in syngas and bio-oil catalysis, as well as developing catalysts to improve stability, selectivity, and activity for fuel intermediate and fuel production.

A full understanding of the factors controlling thermochemical conversion is needed to be able to develop new or improved technologies that increase yield and quality, and reduce cost. As the feedstock interface is further developed, cost and energy efficiency solutions can be employed to attain the feedstock with defined specification to readily enable optimal yields in conversion operations. Work will be done in collaboration with competitively selected laboratory, university, and industrial partners. In addition, these funds may be used to support efforts such as peer reviews, data collection and dissemination, and technical, market, economic, and other analyses.

Biochemical **30,820** **57,447**

The mission of Biochemical conversion is to develop technologies for the conversion of agricultural residues, energy crops and other biomass to mixed, dilute sugars, and further conversion to liquid fuels. Research is focused on reducing the biochemical conversion cost of producing liquid fuels by targeting key technology barriers in the unit operations processes, such as pretreatment, enzyme production, hydrolysis, and fermentation. Additional support is provided to advance technologies needed for successful integrated biorefineries and in supporting realization of the program's overall FY 2012 cost target. To meet this target, the program has established a modeled conversion cost target of $0.92 per gallon of ethanol , which, with an estimated feedstock cost of $50.90 per dry ton, contributes to the projected achievement of a modeled MESP of $1.49 per gallon in FY 2012 (2007$).

In FY 2012, Biochemical conversion R&D will continue to focus on integration and optimization of the individual process steps. Additionally, efforts will continue toward reducing cellulosic biofuel costs by focusing on barriers related to feedstock interface, pretreatment, hydrolysis, and conversion processes.

(dollars in thousands)

FY 2010 Current Approp	FY 2012 Request

The continued development of these technologies will enable the conversion of a wider range of feedstocks and diversify the R&D portfolio to include the production of hydrocarbon cellulosic biofuels. Biochemical pathways for advanced hydrocarbon drop in fuel technologies will also continue to be explored as the program transitions its focus beyond its FY 2012 ethanol cost performance targets toward longer range targets.

Specific research objectives include improved hydrolysis and fermentation methods, resulting in a reduction in process time and a two percent increase in conversion of xylan to xylose. While these activities will focus on the current portfolio of feedstocks, the results will inform future activities as additional feedstocks (e.g., energy crops, other agricultural residues, algal biomass) and fuels are considered.

To improve overall efficiency and reduce conversion cost, efforts on process integration will be continued. These efforts will result in a greater degree of process integration between the unit operations (pretreatment, saccharification and fermentation steps), which is needed to achieve programmatic cost targets.

A greater fundamental understanding of the factors and causes underlying the recalcitrance of biomass to biological and chemical degradation is needed to make processing more specific and less costly. Recalcitrance refers to the resistance of plant cell walls to break down. This work will continue in FY 2012. Barriers and technical challenges identified in the first of a kind integrated biorefineries under development will determine the necessary fundamental research needs. These efforts will provide the basic science groundwork to develop applied, and ultimately integrated, process solutions for biomass conversion. Specifically, this work will produce advanced conversion processes and techniques for future biorefinery concepts.

Additionally, beginning in FY 2012, Biochemical R&D will expand its activities in support of waste-to-energy conversion process technologies. This will initially include feasibility analyses on converting waste biomass feedstocks such as organic residuals and industrial sludges into bioenergy, and may lead to research in molecular biology to enhance in-depth understanding of the microbial population dynamics at an ecosystem level to manipulate and optimize energy production, develop enhanced effluent refining operations, and maximize co-product generation and value. Analysis activities will evaluate the feasibility of various conversion processes including anaerobic digestion, and may lead to a better understanding of the need to integrate waste-to-energy processes into the biorefinery scenario, to maximize use of biomass and water resources, and enhance revenue generation.

Work will be done in collaboration with competitively selected industrial partners. In addition, funds may be used to support efforts such as peer reviews; data collection and dissemination; and technical, market, economic, and other analyses.

Insights gained from stakeholder workshop will guide a new, $15 million effort to be established in FY 2012 in collaboration with the DOE Office of Science on the role of synthetic biology on biomanufacturing. Through a competitive peer reviewed process, partners will be selected that demonstrate the ability to reduce the time and costs of engineering biological systems and to improve their efficiency, predictability, reliability, and safety and assist in maximizing the potential of genetically engineered microorganisms for the synthesis of fuels, commodity and specialty chemicals,

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

and materials from a variety of sugar sources (e.g., cellulose, starch, and sucrose) or sunlight/CO2. Specifically, efforts will be initiated to design and construct complex, multi-component, biological systems through a required set of basic capabilities: computer-aided design software; a repository of well-characterized, standardized synthetic biology components, methods and tools for assembling those components into large systems. The direct application of these technologies will be to assist the biomass industry to produce biofuels and bioproducts and will be facilitated by either industry partners or industrial advisory boards.

Algae	**24,465**	**0**

FY 2010 appropriations directed $35 million to algae; $25 million was categorized under the Platform R&D subprogram with the remainder categorized under the Feedstock Infrastructure subprogram. Due to ongoing multi-year projects being completely funded with FY 2010 appropriations, no additional funding is requested for FY 2012.

SBIR/STTR	**0**	**3,243**

SBIR/STTR funding transferred in FY 2010 was $2,672,000 for the SBIR program and $321,380 to the STTR program. The FY 2011 and FY 2012 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Conversion Technologies	**82,115**	**117,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Thermochemical	
The increase in funding is essential to enabling the transition of Thermochemical R&D in two key areas: 1) developing catalysts that are critical in increasing the yield and quality, and decreasing the cost of thermochemically produced biofuels; and 2) expanding non-food crop derived infrastructure compatible biofuels, such as advanced hydrocarbons, and the routes and intermediates for producing these biofuels. Competitive solicitations will target industrial partners, National Laboratories, and universities for the latest technology and transformative research ideas in support of the EISA RFS targets for advanced biofuels and the drive towards cost effective infrastructure compatible biofuels. Solicitations will also allow for core technology development that complement the National Biofuels Consortia, as well as scale-up of integrated systems that provide near term options to accelerate deployment.	
Additional funding will expand the sustainable feedstock interface which is a critical enabler for delivery of feedstocks with required cost, quality, and volume. Customized pretreated feedstocks for specific technologies will be fully integrated into the conversion systems and deliver increased yields and quality of biofuels.	+29,480
Biochemical	
The increase in funding is due to the launch of a new innovative effort to standardize and scale up the fabrication of fundamental biological components, which will allow bioengineers to rapidly prototype and test new approaches to synthesizing biofuels. Establishing this capability domestically will help America capture world leadership in the emerging field of biomanufacturing. Funding also initiates R&D focused on biochemical waste to energy technologies and potential applications. Additionally, relevant work from the Products Budget line will continue under this subprogram.	+26,627
Algae	
The decrease is due to fully funding the multi-year algal research consortia in FY 2010. Additional algae R&D is now categorized in the Feedstocks subprogram.	-24,465
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities.	+3,243
Total Funding Change, Conversion Technologies	**+34,885**

Utilization of Platform Outputs R&D

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Utilization of Platform Outputs R&D		
Integration of Biorefinery Technologies	84,278	0
Products Development	13,620	0
Total, Utilization of Platform Outputs R&D	97,898	0

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Integration of Biorefinery Technologies	**84,278**	**0**

This work has been reclassified as the new Integrated Biorefineries subprogram.

Products Development	**13,620**	**0**

This activity is being discontinued. Relevant work will continue under the Biochemical key activity of the Conversion Technologies subprogram.

Total, Utilization of Platform Outputs R&D	**97,898**	**0**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Integration of Biorefinery Technologies	
This work has been reclassified as the new Integrated Biorefineries subprogram.	-84,278
Products Development	
This activity is being discontinued. Relevant work will continue under the Biochemical key activity of the Conversion Technologies subprogram.	-13,620
Total Funding Change, Utilization of Platform Outputs R&D	**-97,898**

Integrated Biorefineries

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Appropriation	FY 2012 Request
Integrated Biorefineries	0	24,860
SBIR/STTR	0	140
Total, Integrated Biorefineries	0	25,000

Benefits

An integrated biorefinery is a facility that converts biomass feedstock to advanced biofuels, biopower (e.g., process heat and steam, electricity), and/or bioproducts (e.g., chemicals). Integrated Biorefineries activities include public-private partnerships to design, construct, and operate fully integrated facilities at various scales using a variety of feedstock and conversion technology options. In FY 2007 and FY 2008, the program competitively selected small commercial scale (minimum 700 dry tonnes per day) and demonstration scale (minimum 70 dry tonnes per day) biorefinery projects. This funding supports the continuation of these projects. The operational data from these facilities is essential to benchmarking the state of technology in real industrial conditions, validating production costs at scale, and assessing the sustainability of biorefineries. Ultimately, these biorefinery projects will encourage private sector investments in future biorefineries.

Integrated Biorefineries' deployment efforts are directed at the Biomass Program's strategy to support meeting the EISA RFS advanced biofuels volumetric targets. Integrated biorefinery projects with the U.S. biofuels industry are aimed at overcoming key technical and economic barriers for producing advanced biofuels. These projects enable future scale up and replication of biorefineries by the private sector. As these biorefineries come online throughout the U.S., more petroleum will be displaced. An annual performance target monitors progress of these deployment activities in support of the EISA RFS volumetric advanced biofuels goal of 21 billion gallons by 2022. For FY 2012, this target is 15 million gallons of additional capacity.

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Integrated Biorefineries	**0**	**24,860**

Over a half billion dollars in ARRA funding was invested in 19 biorefinery projects at the pilot, demonstration and commercial scale. These cost-shared partnerships are helping to bridge the "valley of death" between process development and commercial deployment of renewable biofuels technologies. The ARRA projects significantly enhance the biorefinery portfolio with a variety of feedstocks, conversion technologies and fuels produced. The table below shows how the 29 competitively selected integrated biorefinery projects in which the Program is invested are distributed by scale, feedstock type, and fuel type.

Pathway / Feedstock	Total	Agricultural Residues	Energy Crops	Forest Resources	Waste Processing	Algae Processing	Fuel Pathway	Ethanol / Other Alcohols	FT Liquids/ Renewable Hydrocarbon	Power	Products	Total
Total	29	7	4	13	1	4		17	11		1	29
Integrated Biorefinery Deployment	27	7	4	12	1	3		17	9		1	27
Pilot	12	3	3	5		2		6	6			12
Demonstration	11	2	1	5	1	1		7	3		1	11
Commercial	4	2		2				4				4
Continued Technology Development	2			1		1			2			2

In FY 2012, Integrated Biorefineries will continue cost-shared projects with industry partners selected through competitive solicitations in FY 2007 and FY 2008. The program may down select or delay at least four biorefinery projects based on comprehensive project review and peer review data. Funding levels will be determined on a project by project basis, as cost-share partners meet the necessary research, production and financial requirements to move from phase one awards (pre-construction engineering design, NEPA compliance and financial commitment) to phase two awards (facility construction). The comprehensive project reviews and peer reviews will also be considered in making the determinations about proceeding to construction.

SBIR/STTR	**0**	**140**

FY 2012 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Integrated Biorefineries	**0**	**25,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Integrated Biorefineries	
Up to four commercial- or demonstration-scale biorefinery projects may be down-selected or delayed based on the results of comprehensive project reviews and peer reviews. This will impact the Program's ability to support the volumetric goals for advanced biofuels in the EISA RFS. Further, cellulosic ethanol demonstration plants are being supported via the proposed Reverse Auction.	+24,860
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities	+140
Total Funding Change, Integrated Biorefineries	**+25,000**

Analysis and Sustainability

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Appropriation	FY 2012 Request
Analysis and Sustainability		
Systems Analysis	0	4,000
Crosscutting Sustainability	0	4,000
Systems Integration	0	2,000
Total, Analysis and Sustainability	0	10,000

Benefits

The Biomass Program's Analysis and Sustainability activities play a vital role in supporting decision-making, demonstrating progress towards established goals, directing research activities, and are instrumental in setting the entire biofuel value chain on an environmentally sustainable and economically viable course. Relationships with experts at the National Laboratories, institutions of higher learning, and numerous external stakeholders are leveraged to obtain the best qualitative information and quantitative data possible.

Through quantification, analysis activities give the program context and justification for decisions regarding the future direction and scope of the program's RD&D work. This information is critical to sound management of the program's RD&D portfolio and the establishment, adaptation, and fulfillment of its vision in a dynamic context of rapid technological progress and great economic and environmental uncertainty. This critical information enables the program to better inform policy makers and private sector stakeholders, shaping the growth of America's nascent cellulosic and advanced biofuels industries.

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Systems Analysis	**0**	**4,000**

Systems Analysis enhances each RD&D area individually and the program as a whole through the provision of critical quantitative measures of progress, future projections, and risk. Programmatic analysis activities are focused on clearly identifying synergies and addressing potential barriers, while progress is concurrently monitored and accomplishments validated in each of the program's technology areas. Programmatic analysis activities provide quantitative measurements and evaluations critical to strategic decisions at both the program and activity levels.

Specific focus areas include technical and economic feasibility analysis, integrated biorefinery analysis, and technology deployment analysis. Rigorous quantitative analysis is applied where possible, and the results are subsequently interpreted in the context of a greater body of work and peer

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request

discourse to provide vital insight for RD&D prioritization, technology performance needs, and reasonable performance expectations.

Crosscutting Sustainability **0** **4,000**

Crosscutting Sustainability analysis involves the documentation and understanding of critical relationships between the production of biofuels and bioenergy, and environmental sustainability. The activity focuses on the development and application of guidelines for measuring environmental benefits and barriers of a domestic biofuels industry, including impact prevention and mitigation strategies. Technical targets will be established and used to direct future sustainability activities. Appropriate indicators are being identified and selected based on their relevance. Research activities addressing land use, water, GHG emissions, soil quality and air quality will improve information and understanding of holistic sustainability from a systems and life cycle perspective.

A near term objective is to establish a transparent methodology for evaluating and comparing technologies, practices, and inputs in terms of environmental sustainability. Particular focus is given to a systematic evaluation of data related to climate, water, and land use for agricultural residue utilization and energy crop production for conversion to ethanol and advanced biofuels. Work is also underway to quantify the impact of consumptive water use and nutrient inputs on ground and surface water resources. Cross-cutting efforts are focused on continuously improving information and understanding sustainability principles from a systems and life cycle perspective, with particular attention being given to the nexus between feedstock production and conversion.

Systems Integration **0** **2,000**

Systems integration (SI) will provide independent, strategic, systems-level expertise and processes to enable data-driven decision-making, effective portfolio management and program integration for EERE Biomass Program and Project Managers.

Systems Integration provides tailored technical and programmatic support to the Biomass Program by employing systems engineering processes and practices to calibrate internal management processes for enhanced internal efficiency and overall performance. A decision-making support framework, data management tools, and analytical resources are provided to the program to inform and facilitate strategic planning, performance evaluation, and portfolio management.

Specific activities include: systems engineering and strategic planning process facilitation (change control, Multi Year Project Plan, analysis planning); creation of an integrated baseline (data reconciliation between databases); and performance verification (risk assessment of pilot and demonstration scale projects, independent project analysis).

With the decision-making and data management tools and support framework provided, the Biomass Program can better articulate its vision, identify and validate performance goals, measure progress toward these goals, plan for future work, prioritize its portfolio, conduct risk management, and plan for the successful fulfillment of its mission in support of national policies and priorities.

Total, Analysis and Sustainability **0** **10,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Systems Analysis	
The increase is due to the reclassification of crosscutting funds into a new activity in the revised budget structure. The level of funding is consistent with prior year activities.	+4,000
Crosscutting Sustainability	
The increase is due to the reclassification of crosscutting funds into a new activity in the revised budget structure. The level of funding is consistent with prior year activities.	+4,000
System Integration	
The increase is due to the reclassification of crosscutting funds into a new activity in the revised budget structure. The level of funding is consistent with prior year activities.	+2,000
Total Funding Change, Analysis and Sustainability	**+10,000**

Biopower

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Biopower	0	21,908
SBIR/STTR	0	592
Total, Biopower	0	22,500

Benefits

The biopower subprogram focuses on utilizing biomass for both large scale electricity generation and as a small scale heat source for cooking. The potential for electric biopower is highlighted in the Energy Information Administration's (EIA) 2010 Annual Energy Outlook where it is estimated that, excluding hydroelectricity, renewable energy consumption in the electric power sector is projected to grow from 1.2 quadrillion Btu in 2008 to 4.3 quadrillion Btu in 2035.[a] Biomass co-firing for utility power generation, referred to as biopower, has the potential to deliver a significant amount of renewable electricity in the U.S. over the next 30 years and contribute to GHG reductions and sustainable development. A biomass co-firing facility can use forest resources, agricultural residues, energy crops, and wastes, including municipal solid waste, to generate power. These types of biomass can require significant pre-treatment, such as pelletization or gasification. Various approaches for integrating these forms of biomass into utility power generation for up to 20 percent co-firing with minimal derating and improved efficiency will be assessed.

The demonstration of biomass co-firing technologies at pilot scale will lead to the construction of up to 10 MW of new generation capacity by 2015 and additional 20 MW by 2016,[b] building a bridge from a fossil carbon-based energy economy to one based on renewable energy systems. Successful pilot demonstration will accelerate industry adoption of higher percentage biomass co-firing at utilities and create green jobs in the renewable power sector while developing the biomass supply chain. Synergies are expected to result from the collaborative implementation of this initiative with industry and partnerships between EERE and the Office of Fossil Energy (FE) and the Office of Electricity Delivery and Energy Reliability (OE). The small scale cookstove is still used by nearly half the world's population, with biomass as the main cooking fuel. More efficient, and cleaner, use of biomass fuel in cookstoves will lead to reduced GHG emissions, less deforestation, and lower household expenses. Collaboration between Federal agencies, researchers, universities, industry, non-profits, and international representatives from areas currently using cookstoves will build upon and highly leverage efforts of both non-governmental organizations (NGOs) and government agencies involved in providing assistance to developing countries.

[a] Annual Energy Outlook 2010, http://www.eia.doe.gov/oiaf/aeo/

[b] The biopower strategy can be implemented with distributed or centrally located co-firing or repowering concepts.

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Biopower	**0**	**21,908**

Biopower R&D on pretreatment and conversion of biomass to enable compatibility with utility power for up to 20 percent co-firing with minimal derating and improved efficiency will be demonstrated at pilot scale. Analysis including biopower-specific feedstock resource assessments and evaluating competition for biomass, availability of water, labor and transportation systems will be performed.

The Biomass Program sought information from technology vendors, utility and independent power producers, and other stakeholders, on their willingness to collaborate on three primary biopower topic areas and participate in a FOA. These topic areas include:

- Pre-treatment R&D: Develop technologies to densify biomass to increase energy and bulk density such as pelletization and torrefaction to meet feedstock specifications to enable up to 20 percent co-firing in utility systems with minimal derating and improved efficiency;
- Conversion R&D: Develop advanced conversion technologies with the objective of demonstrating higher overall biopower conversion efficiency (net power out divided by raw feedstock purchased) at up to 20 percent biomass co-firing in utility systems including pyrolysis and gasification to oil, biochar and syngas; and
- High Percentage Co-firing: Demonstrate up to 20 percent co-firing with pretreated or converted biomass at 10 MW pilot scale, while minimizing the capacity derating, improving efficiency, and lowering biomass power generation costs.

Options will be evaluated to determine the most efficient, cost-effective way to sustainably generate 30 MW of electrical power from biomass by 2016 while achieving the greatest reductions in greenhouse gases. An industry cost share of between 20 and 50 percent will be required on all biopower projects.

For cookstove RD&D, a technology roadmap will be developed by engaging both national and international stakeholders from other Federal agencies, universities, industry and NGOs, specifically targeting stakeholders from regions where cookstoves are widely used. The roadmap will determine the required areas for RD&D and the criteria for success at the project stage gates.

The cookstove RD&D will focus on increasing combustion efficiency and heat transfer while using control systems to reduce the carbon monoxide and particulate emissions. A wide range of biomass fuels will be considered, along with low cost materials of construction and sensors and controls. This RD&D will be conducted through a competitive solicitation with integrated project teams consisting of National Laboratories, universities, industry vendors, non-profits, and collaborators from other Federal agencies and developing countries, culminating in field demonstration and validation tests. Criteria for success are expected to include increases in efficiency and targets for emission reduction.

SBIR/STTR	**0**	**592**

FY 2012 amounts shown are estimated requirements for the continuation of the SBIR and STTR program.

Total, Biopower	**0**	**22,500**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Biopower	
This increase supports the establishment of a new subprogram for an entirely new DOE initiative that takes advantage of the improvements in thermal efficiency of power generation systems. These activities will address challenges from optimizing fuel type, feedstock logistics, regional supply issues, sustainability, including resources such as water, labor and grid limitations.	
This effort is a critical first step toward the implementation of large utility scale production of renewable electric power from biomass. In subsequent years, appropriate technologies can then be deployed at commercial scale to prove economic viability and establish a sustainable supply chain. These pioneering efforts are intended to create new economic opportunities, including jobs, across the supply chain and make a significant contribution to domestic renewable energy generation, further diversifying the U.S. renewable portfolio for enhanced energy and economic security.	+21,908
SBIR/STTR	
Changes in the SBIR/STTR funding are a direct result of changes in the funding of program activities.	+592
Total Funding Change, Biopower	**+22,500**

Cellulosic Biofuels Reverse Auction

Funding Schedule by Activity

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Cellulosic Biofuels Reverse Auction	0	150,000
Total, Cellulosic Biofuels Reverse Auction	0	150,000

Benefits

The Energy Policy Act of 2005 (EPAct 05) Section 942, Pub. L. No. 109-58 (August 8, 2005), states that the Secretary of Energy, in consultation with the Secretary of Agriculture, the Secretary of Defense, and the Administrator of the Environmental Protection Agency, shall establish an incentive program for the production of cellulosic biofuels. A reverse auction will help defray the cost of cellulosic biofuel production and serve as an important incentive and financial benefit to show the investment community they have a cash flow to reduce risk. Incentives such as the reverse auction are critical to the financing of "first-of-a-kind" or "pioneer" plants. In 2008, the Biomass Program published a rule making to establish the framework for implementing this reverse auction.

It is impossible to know in advance the incentive levels on a per-gallon basis as these levels will be the result of a competitive bidding process.

Detailed Justification

(dollars in thousands)

	FY 2010 Current Approp	FY 2012 Request
Cellulosic Biofuels Reverse Auction	**0**	**150,000**

In July 2010, the Program issued a Notice of Program Intent to request documents for pre-certification as required by our rule making. The Biomass Program is now proposing to hold an expanded Cellulosic Biofuels Reverse Auction., open to both cellulosic ethanol and other advanced biofuels, as defined in EISA 2007.

DOE detailed analysis demonstrated that the Department needs to create a strong market signal for cellulosic ethanol and other advanced biofuels to solidify investment towards commercialization and meet the RFS targets. A reverse auction would solicit bids from potential producers of cellulosic biofuels, and those producers submitting the lowest bids would be awarded the production incentives.

Total, Cellulosic Biofuels Reverse Auction	**0**	**150,000**

Explanation of Funding Changes

	FY 2012 vs. FY 2010 Current Approp ($000)
Cellulosic Biofuels Reverse Auction	
The increase is due to the initiation of a new Cellulosic Biofuels Reverse Auction subprogram.	+150,000
Total Funding Change, Cellulosic Biofuels Reverse Auction	**+150,000**