Department of Energy Recovery Act Investment in Biomass Technologies

The American Recovery and Reinvestment Act of 2009 (Recovery Act) provided more than $36 billion to the Department of Energy (DOE) to accelerate work on existing projects, undertake new and transformative research, and deploy clean energy technologies across the nation. Of this funding, $1029 million is supporting innovative work to advance biomass research, development, demonstration, and deployment.

EERE – Biomass Program: $718 million[3]

Biomass Program awarded $718 million to projects that aim to accelerate advanced biofuels research, development, and demonstration; speed the deployment and commercialization of advanced biofuels and bioproducts; and further the U.S. bioindustry through market transformation and creating or saving a range of jobs (see *American Recovery and Reinvestment Act Biomass Program Investments* factsheet).

Office	Organization	Total*
Energy Efficiency and Renewable Energy (EERE)	*Biomass Program*	$718M
	Facilities and Infrastructure	$14M[1]
	Biomass Manufacturing Tax Credit (48C)	$29M
	Community Renewable Energy	$13M
	SBIR Biomass Projects	$1M
	SBIR/STTR and Program Direction[2]	$68M
Advanced Research Projects Agency - Energy (ARPA-E)	*ARPA-E Projects*	$39M
Office of Science	*Energy Frontier Research Centers (EFRCs)*	$59M
	Bioenergy Research Centers (BRCs)	$14M
	Joint Genome Institute	$13M
Fossil Energy	*Industrial Carbon Capture and Storage*	$61M
Total		**$1029M**

** Rounded to the nearest million*

[1] This amount was originally part of the Biomass Program appropriation of $800 million total.

[2] These funds, originally appropriated to the Biomass Program, were reallocated for use across DOE Energy Efficiency and Renewable Energy projects for SBIR/STTR and for staffing, management, and oversight activities.

[3] These funds include about $27.17 million for independent engineering, NEPA and project evaluation, project risk management, and administrative expenses.

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Recipient	Description	DOE Cost Share
Commercial-Scale Integrated Biorefineries		
Bluefire, LLC (Fulton, MS)	This project will construct a facility that produces ethanol fuel from woody biomass, mill residue, and sorted municipal solid waste. The facility will have the capacity to produce 19 million gallons of ethanol per year.	$81,134,686
Demonstration-Scale Integrated Biorefineries		
Enerkem Corporation (Pontotoc, MS)	This project will be sited at an existing landfill and use feedstocks such as woody biomass and biomass removed from municipal solid waste to produce ethanol and other green chemicals through gasification and catalytic processes.	$50,000,000
INEOS New Planet BioEnergy, LLC (Vero Beach, FL)	This project will produce ethanol and electricity from wood and vegetative residues and construction and demolition materials. The facility will combine biomass gasification and fermentation, and will have the capacity to produce 8 million gallons of ethanol and 2 megawatts of electricity per year by the end of 2011.	$50,000,000
Myriant (formerly Bioenergy, LLC; Lake Providence, LA)	This project will biologically produce succinic acid from sorghum. The process being developed displaces petroleum based feedstocks and uses less energy per ton of succinic acid produced than its petroleum counterpart.	$50,000,000
Sapphire Energy, Inc. (Columbus, NM)	This project will cultivate algae in ponds that will ultimately be converted into green fuels, such as jet fuel and diesel, using the Dynamic Fuels refining process.	$50,000,000
Pilot-Scale Integrated Biorefineries		
Algenol Biofuels Inc. (Freeport, TX)	This project aims to make ethanol directly from carbon dioxide and seawater using algae. The facility will have the capacity to produce 100,000 gallons of fuel-grade ethanol per year.	$25,000,000
American Process Inc. (Alpena, MI)	This project will produce fuel and potassium acetate, a compound with many industrial applications, using processed wood generated by Decorative Panels International, an existing hardboard manufacturing facility in Alpena. The pilot plant will have the capacity to produce up to 890,000 gallons of ethanol and 690,000 gallons of potassium acetate per year starting in 2011.	$17,944,902
Amyris Biotechnologies, Inc. (Emeryville, CA)	This project will produce a diesel substitute through the fermentation of sweet sorghum. The pilot plant will also have the capacity to co-produce lubricants, polymers, and other petro-chemical substitutes.	$25,000,000
Archer Daniels Midland (ADM; Decatur, IL)	This project will use acid to break down biomass that can be converted to liquid fuels or energy. The ADM facility will produce ethanol and ethyl acrylate, a compound used to make a variety of materials, and will also recover minerals and salts from the biomass that can then be returned to the soil.	$24,834,592

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Recipient	Description	DOE Cost Share
ClearFuels Technology Inc. (Commerce City, CO)	This project will produce renewable diesel and jet fuel from woody biomass by integrating ClearFuels' and Rentech's conversion technologies. The facility will also evaluate the conversion of bagasse and biomass mixtures to fuels.	$23,000,000
Haldor Topsoe, Inc. (Des Plaines, IL)	This project intends to convert wood to green gasoline by fully integrating and optimizing a multi-step gasification process. The pilot plant will have the capacity to process 21 metric tons of feedstock per day.	$25,000,000
ICM, Inc. (St. Joseph, MO)	This project will modify an existing corn-ethanol facility to produce cellulosic ethanol from switchgrass and energy sorghum using biochemical conversion processes.	$25,000,000
Logos Technologies, Inc. (Visalia, CA)	This project will convert switchgrass and woody biomass into ethanol using a biochemical conversion processes.	$20,455,849
Renewable Energy Institute International (REII; Toledo, OH)	This project by REII will produce high-quality green diesel from agriculture and forest residues using advanced pyrolysis and steam reforming. The pilot plant will have the capacity to process 25 dry tons of feedstock per day.	$19,980,930
Solazyme, Inc. (Riverside, PA)	This project will validate the projected economics of a commercial scale biorefinery producing multiple advanced biofuels. This project will produce algae oil that can be converted to oil-based fuels.	$21,765,738
UOP LLC (Kapolei, HI)	This project will integrate existing technology from Ensyn and UOP to produce green gasoline, diesel, and jet fuel from agricultural residue, woody biomass, dedicated energy crops, and algae.	$25,000,000
ZeaChem Inc. (Boardman, OR)	This will use purpose-grown hybrid poplar trees to produce fuel-grade ethanol using hybrid technology. Additional feedstocks such as agricultural residues and energy crops will also be evaluated in the pilot plant.	$25,000,000
Biorefinery Research & Development		
Elevance Renewable Sciences (Newton, IA)	This project aims to complete preliminary engineering design for a future facility producing jet fuel, renewable diesel substitutes, and high-value chemicals from plant oils and poultry fat.	$2,500,000
Gas Technology Institute (Des Plaines, IL)	This project aims to complete preliminary engineering design for a novel process to produce green gasoline and diesel from woody biomass, agricultural residues, and algae.	$3,489,127
Research, Development, & Demonstration Projects		
National Advanced Biofuels Consortium (NABC; Golden, CO)	This consortium project intends to develop infrastructure-compatible, cellulosic-based hydrocarbon fuels resulting in a sustainable, cost-effective production process that maximizes the use of existing refining and distribution infrastructure.	$34,949,784

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Recipient	Description	DOE Cost Share
National Alliance for Advanced Biofuels and Bioproducts (NAABB; St. Louis, MO)	This consortium project intends to develop and demonstrate the science and technology necessary to significantly increase production of algal biomass and lipids, efficiently harvest and extract algae and algal products, establish valuable co-products that scale with fuel production and model the lifecycle greenhouse gas emission reduction potential of the algal biofuels.	$49,095,783
USDA Forest Service (Aiken, SC) and *Oak Ridge National Laboratory* (ORNL; Oak Ridge, TN)	This sustainability project at the Forest Service's Savannah River site and at DOE's Oak Ridge National Lab is focusing on southeastern forest hydrology and water quality research.	$1,000,000
Great Lakes Bioenergy Research Center (GLBRC; Madison, WI) and *Pacific Northwest National Laboratory* (PNNL; Richland, WA)	GLBRC is working with PNNL, ORNL, and university partners in Michigan, Wisconsin, and Ohio on this sustainability project that focuses on soil carbon dynamics, water quality and direct greenhouse gas fluxes, and land-use change modeling.	$4,300,000
Lawrence Berkeley National Laboratory (LBNL; Berkeley, CA)	This LBNL project will lead to construction and management of a new advanced biofuels process development unit. This user facility will allow members of academia, national laboratories, industry, and other stakeholders to demonstrate new technologies for producing advanced biofuels at a small scale.	$17,700,000
Ethanol Infrastructure Projects		
National Renewable Energy Laboratory (NREL; Golden, CO) and *Oak Ridge National Laboratory* (ORNL; Oak Ridge, TN)	These NREL- and ORNL-led projects focus on testing the impacts of intermediate ethanol blends testing on distribution and dispensing infrastructure as well as vehicle engines.	$16,524,737
Bosch (Farmington Hills, MI), GM (Detroit, MI), and *Delphi* (Troy, MI)	Bosch, GM, and Delphi are engaging in flex fuel vehicle testing and engine optimization research in an effort to minimize the fuel economy penalty for engines running on E85	$2,500,000
AR, FL, GA, MI, MO, TX, VA, and WA	These projects will result in the installation of approximately 35 fuel dispensers that are capable of dispensing ethanol blends up to E85, and associated infrastructure, in multiple states.	$1,000,000

EERE – Facilities and Infrastructure: $13.4 million

Recovery Act funding of $13.4 million has been put toward expanding NREL's biomass-to-ethanol research capabilities at the current Alternative Fuels User Facility by allowing NREL to work simultaneously on multiple projects with multiple partners. *The Integrated Biorefinery Research Facility* will accelerate methods to produce cellulosic ethanol on a commercial scale that is cost-competitive with petroleum-based fuels.

EERE – Biomass Manufacturing Tax Credit (48C): $29.3 million

The Recovery Act authorized the Department of the Treasury to award $2.3 billion in tax credits for qualified investments in advanced energy projects to support new, expanded, or re-equipped domestic manufacturing facilities. The goal of this credit is to grow the domestic manufacturing industry for clean energy, thereby supporting the larger goals of ARRA to stimulate economic growth, create jobs, and reduce greenhouse gas emissions. Two biomass-related projects that applied were awarded credits.

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Recipient	Description	Funding
Novozymes Biotech, Inc. **(Blair, NE)**	Novozymes Biotech, Inc. will install equipment at a new manufacturing facility to produce biocatalysts (enzymes) used in manufacturing cellulosic ethanol from corn stover by the biochemical platform (biomass pretreatment, enzymatic hydrolysis, fermentation, distillation). These biocatalysts will aid the production of biofuels as a renewable energy source.	$28,401,000
RE-Gen LLC **(New York, NY)**	RE-Gen will build a factory to produce biomass gasification furnaces, with a capacity to produce 250 systems per year. The result will aid the domestic biofuels industry while promoting energy efficiency.	$903,480

EERE – Community Renewable Energy: $13 million

Up to $22 million of Recovery Act funding is supporting Community Renewable Energy efforts, including the planning and installation of utility-scale projects in up to four communities nationwide. The funded projects will demonstrate how multiple renewable energy technologies can be deployed at scale to supply clean energy to communities, helping them to rapidly plan and deploy utility-scale renewable energy systems that provide clean, reliable, and affordable energy supplies for their communities, while creating jobs and new economic development opportunities. Three biomass-related projects were awarded funds.

Recipient	Description	Funding
Combined Heat and Power (CHP) with a Biopowered Source		
City of Montpelier **(Montpelier, VT)**	This project will further Montpelier's energy goals by supporting installation of a 41 MMBtu CHP district energy system fueled with locally sourced renewable and sustainably harvested wood chips.	$8,000,000
Forest County Potawatomi Tribe **(Crandon, WI)**	This project of the Potawatomi Tribe proposes the implementation of an integrated renewable energy deployment plan to provide heating, cooling, and electricity for the Tribe's governmental buildings. The renewable energy installations will include a biomass CHP facility as well as a biogas digester and generator.	$2,500,000
Waste-to-Renewable-Energy (WTRE)		
University of California (UC) – Davis **(Reedley, CA)**	The proposed WTRE system, which intends to generate power from a renewable biogas-fed fuel cell, is one component of UC Davis' campus-oriented mixed housing and commercial development venture.	$2,500,000

SBIR/STTR: Seven projects at $100,000 each

SBIR and STTR are U.S. government programs in which federal agencies with large research and development budgets set aside a small fraction of their funding to be competitively awarded to small businesses. The recipients are encouraged to commercialize the technology and also retain the rights to any technology that they develop.

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Recipient	Description
Applied Colloids (Minneapolis, MN)	This project, a unique alcohol extraction process based on jojoba oil, will develop technology to improve biofuel production, such as ethanol. It will also help to reduce greenhouse gas emissions.
Media and Process Technology Inc. (Pittsburgh, PA)	This project, a no-phase-change process to displace distillation in biodiesel production, will deliver on-spec biodiesel, replace energy intensive distillation, save biodiesel producers hundreds of millions of dollars per year, and promote job growth in this green industry.
Piedmont Biofuels Industrial (Pittsboro, NC)	This project, involving the utilization of immobilized lipase system for waste water reduction in bioenergy, will develop an enzymatically catalyzed biodiesel process, the use of low quality and waste feedstocks, eliminate process waste water, and dramatically improve glycerin quality.
Seldon Technologies, Inc. (Windsor, VT)	This project—novel carbon nanotube containing media for water separation from B-100 biodiesel—will use its proprietary technology of carbon nanotube-containing media (nanomesh), also utilized in other Seldon filtration products, to develop a cost-effective solution to the problem of inseparability of water from biodiesel.
TDA Research, Inc. (Golden, CO)	This reactive distillation biodiesel project will develop a new process for making biodiesel that can use any oil or fat feedstock, including unrefined vegetable oils and waste greases.
Techfish, LLC (Charleston, SC)	This lignin recovery and purification project will increase production rates of papermaking operations and allow power companies to achieve renewable energy goals, both for low-capital and operating expense.
Phycal, LLC (Honolulu, HI)	This project—a novel method for dewatering using lateral displacement array—will demonstrate the feasibility of manufacturing arrays for a novel separation technology cost-effectively such that they can be used economically to remove algae and other particles from aqueous suspension.

ARPA-E –ARPA-E Biomass Energy Projects: $39.3 million[4]

Authorized, but without an initial budget, ARPA-E received $400 million funding in April 2009 through the Recovery Act. ARPA-E is modeled after the successful Defense Advanced Research Projects Agency (DARPA).[5] Specifically, ARPA-E aims to attract leading scientists and engineers, as well as students; bring innovation and creativity to energy research; sustain promising projects while phasing out those that have not proven successful; and bridge the gap between basic energy research and development/industrial innovation. The *ARPA-E Biomass Energy portfolio* includes 8 projects announced in October 2009.

Recipient	Description	Funding
Agrivida (Cambridge, MA)	This project, focusing on conditionally activated enzymes expressed in cellulosic energy crops, aims to develop a new method for converting plant biomass into useful feedstock for the production of biofuels by developing cell wall-degrading enzymes that can be produced at high concentration within plants.	$4,565,800
Arizona State University (Tempe, AZ)	This project in sustainable cyanobacteria and designed for solar-powered highly efficient production will use cyanobacteria (specifically, synechocystis) to produce carbon-neutral, sustainable biofuels.	$5,205,706

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Recipient	Description	Funding
Ceres, Inc (Thousand Oaks, CA)	Using advanced plant breeding and biotechnology, Ceres Inc. is developing new varieties of high-yielding, low-input-energy crops (energy grasses, e.g., switchgrass, miscanthus, and sorghum) for use as feedstock for the production of biofuels.	$4,989,144
E.I. du Pont de Nemours and Company (Wilmington, DE)	DuPont is developing a commercially viable process for the production of an advanced biofuel, isobutanol, from seaweed.	$8,884,698
Iowa State University (Ames, IA)	Focused on a genetically tractable microalgal platform for advanced biofuel production, this project will modify an aquatic microorganism, Chlamydomonas, to generate feedstock for the production of biofuels.	$4,373,488
RTI International (Research Triangle Park, NC)	RTI International is developing a novel process for biocrude production using a single-step catalytic biomass pyrolysis process with high carbon conversion efficiency to produce stable bio-crude with low oxygen content.	$3,111,693
Univenture (Marysville, OH)	Univenture and Algaeventure Systems are collaborating to scale and commercialize algae harvesting technologies in new, inexpensive ways using low-energy surface chemistry properties in a mechanical-electrical device.	$5,992,697
University of Minnesota (Minneapolis, MN)	The University of Minnesota seeks to develop hydrocarbon biofuels from a renewable resource, namely the *Shewanella* bacteria.	$2,200,000

Office of Science – EFRCs: $58.5 million

In August 2009, the Office of Basic Energy Sciences in DOE's Office of Science established 46 EFRCs. These include universities, national laboratories, nonprofit organizations, and for-profit firms—singly or in partnerships—and were selected by scientific peer review and funded at $2–5 million per year over a 5-year initial award period. These integrated, multi-investigator EFRCs will conduct fundamental research focusing on one or more of several "grand challenges" recently identified in major strategic planning efforts by the scientific community.

Recipient	Description	Funding
The Pennsylvania State University (University Park, PA)	This EFRC, the PA Center for Lignocellulose Structure and Formation, aims to dramatically increase fundamental knowledge of the physical structure of biopolymers in plant cell walls to provide a basis for improved methods for converting biomass into fuels.	$21,000,000
Purdue University (West Lafayette, IN)	This EFRC, C3Bio, aims to use fundamental knowledge about the interactions between catalysts and plant cell walls to design improved processes for the conversion of biomass.	$20,000,000

[4] In April 2010, ARPA-E announced the conditional selection of more than $41M to pursue "electrofuels" research. The objective of the 13 announced projects is to engineer micro-organism pathways that can bypass photosynthesis to directly synthesize fuels using nonorganic substrates and application of electrical currents. While outside the scope of the other biomass technology development and deployment activities described in this sheet, these exciting research technology projects may one day yield transformational energy solutions. *Click here for more information.*

[5] DARPA is the agency responsible for technological innovations such as the Internet and the stealth technology found in the F117A and other modern fighter aircraft. *Click here for more information.*

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Recipient	Description	Funding
University of Delaware (Newark, DE)	This EFRC, the Newark DE Rational Design of Innovative Catalytic Technologies for Biomass Derivative Utilization, aims to design and characterize novel catalysts for the efficient conversion of the complex molecules comprising biomass into chemicals and fuels.	$17,500,000

Office of Science – Bioenergy Research Centers: $13.5 million

The Recovery Act funds provide infrastructure to the DOE BRCs to accelerate analysis of the plant feedstock genomes supplied by the Joint Genome Institute (JGI), leading to improved identification of traits that facilitate conversion to carbon-neutral biofuels. The equipment is enhancing the characterization of biomass variants, expanding fermentation facilities, increasing the data storage for additional high throughput experiments, enhancing imaging capabilities to improve deconstruction techniques, and better characterizing the synthesis of cell walls.

Recipient	Description	Funding
BioEnergy Science Center (BESC), managed by Oak Ridge National Laboratory (ORNL)	The Recovery Act funds have provided for the purchase of equipment to increase the rate of the characterization of plant biomass, the expansion of fermentation capabilities, and the ability to better gather and analyze "omics" information on candidate microbes for conversion and fermentation.	$5,362,000
Great Lakes Bioenergy Research Center (GLBRC), managed by the University of Wisconsin	The Recovery Act funds have provided for the establishment of a plant cell wall fingerprinting nuclear magnetic resonance (NMR) core facility, a laboratory information system, and an intra-center communication and visualization infrastructure.	$4,099,000
Joint BioEnergy Institute (JBEI), managed by the Lawrence Berkeley National Laboratory (LBNL)	The Recovery Act funds have provided for the purchase of greenhouses, plant growth chambers, and plant cell wall imaging equipment.	$4,039,000

Office of Science – Joint Genome Institute: $13.1 million

The Recovery Act funds provide additional infrastructure to the DOE Joint Genome Institute (JGI), a DOE scientific user facility located in Walnut Creek, CA and managed by the Lawrence Berkeley National Laboratory (LBNL), to accelerate genome sequencing, analysis, and characterization of plant feedstocks such as Miscanthus and switchgrass. This new equipment, improved capacity for annotation, and sequencing will provide metagenomic analyses of complex biological systems found in specific niche environments as well as provide the scientific community with annotated genomes that will improve the capability to characterize and enhance plant feedstocks.

Recipient	Description	Funding
Joint Genome Institute (JGI), managed by the Lawrence Berkeley National Laboratory (LBNL)	The Recovery Act funds have provided for the needed capacity to process genome-scale sequencing and analysis of plant feedstock genomes as reference genomes for future biofuel feedstocks. The funds have purchased new computing infrastructure, a third-generation sequencing machine, and preliminary sequencing of important plant reference genomes.	$13,122,000

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Fossil Energy – Industrial Carbon Capture and Storage: $61.2 million

In October 2009, DOE announced the selection of 12 projects intended to capture CO_2 from industrial sources for storage or beneficial use. The five Phase I projects below, which are all algae-focused, are cost-shared collaborations between the government and industry to increase investment in clean industrial technologies and sequestration projects. In July 2010, FE announced that two of these projects were selected for *Phase II awards*. Phase II awards total an additional $454.7M.

Recipient	Description	Funding
Phycal, LLC (Highland Heights, OH)	The project objective is to capture CO_2 and recycle it in an algal oil production process in an open-raceway pond using partially processed wastewater.	Phase I: $3,000,000 Phase II: $48,487,018
Gas Technology Institute (GTI; Des Plaines, IL)	GTI and partners propose to capture power plant flue gas CO_2 using macroalgae (seaweeds) cultivated in nonsubmerged greenhouses. The macroalgae will be harvested and processed via anaerobic digestion into methane for fuel to the power plant.	Phase I: $933,378
Sunrise Ridge Algae Inc. (Houston, TX)	This project will involve the cultivation of algae using CO_2 from cement plant waste stack gas. The harvested algae will be converted into liquid fuel and carbonaceous char using catalyzed thermochemical conversion technology.	Phase I: $511,327
Touchstone Research Laboratory (Triadelphia, WV)	Touchstone and partners will use a novel phase-change material to enclose raceway ponds where they will cultivate algae using CO_2 from combustor flue gas. The algal lipids will be recovered to produce biofuel, and the algae biomass will be used in an anaerobic digestion process to produce electricity and recover nutrients.	Phase I: $517,818 Phase II: $6,239,542
UOP LLC – FE (Des Plaines, IL)	UOP and partners will capture exhaust stack CO_2 from the Hopewell, Virginia, caprolactam (used to make nylon) plant. The CO2 will be used to grow microalgae for eventual processing to biofuel and fertilizer.	Phase I: $1,552,449

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