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Using CORE Model-Based Systems Engineering Software to Support Program Management in the U.S. Department of Energy Office of the Biomass Program

Preprint

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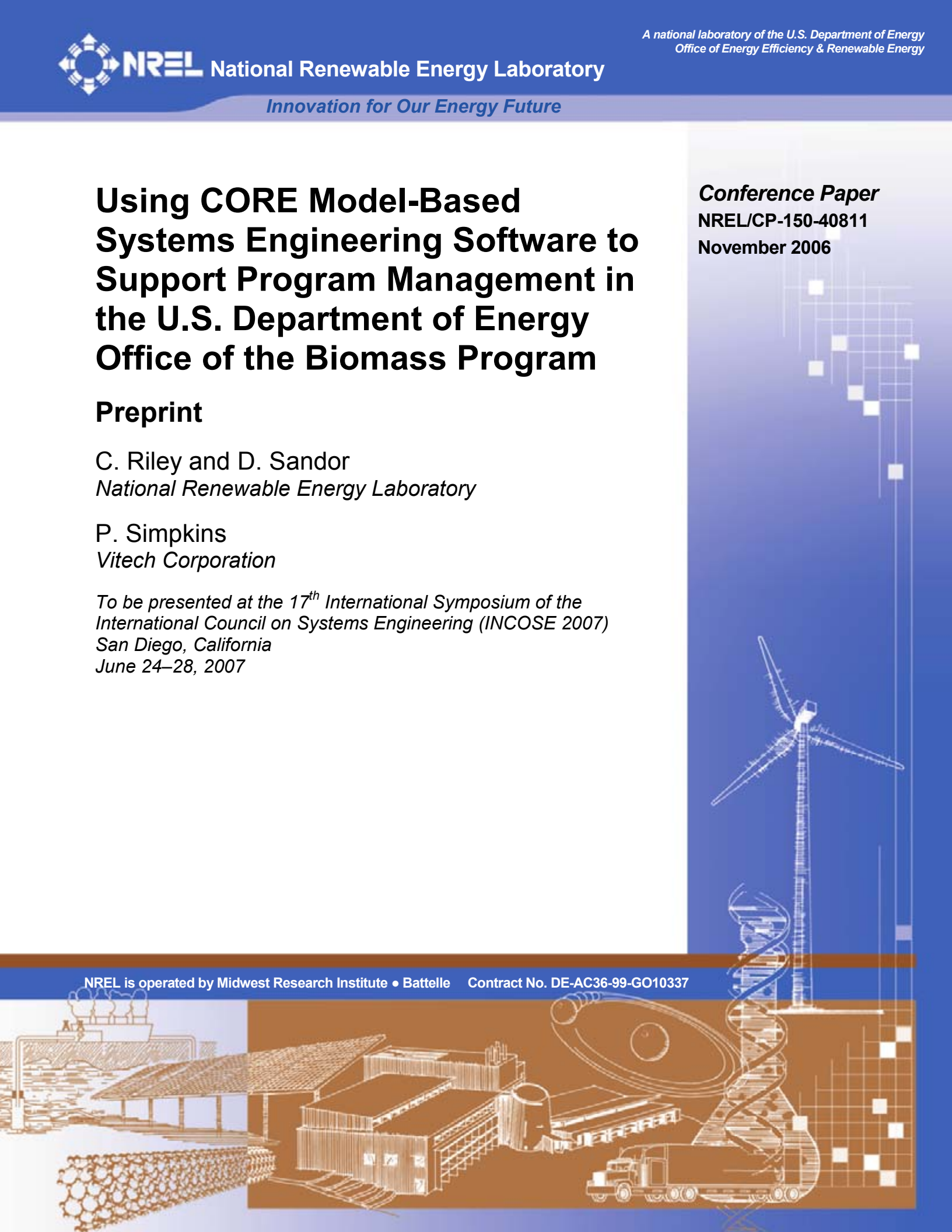

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Using CORE Model-Based Systems Engineering Software to Support Program Management in the U.S. Department of Energy Office of the Biomass Program

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Abstract. Biomass research has been a cornerstone of the U.S. Department of Energy's (DOE's) renewable energy development and deployment efforts during the last 25 years. Today, as the true cost of the nation's reliance on imported oil becomes increasingly clear, the DOE Biomass Program is poised to bring biomass-derived biofuels to the market as a sustainable, domestic alternative to petroleum-derived fuels. To ensure that the program is focused on the activities critical to achieving this goal, the program is implementing systems engineering processes, practices, and tools to guide informed decision-making as biomass-to-biofuel systems are advanced from concept to commercial adoption. The program is using CORE, a Model-Based Systems Engineering (MBSE) software tool, to organize, coordinate, and document the program goals, milestones, and project tasks in a central repository. CORE is facilitating management and communication of program status, through the automated generation of accurate and up-to-date custom reports, Gantt charts, and tables in Microsoft Word, Microsoft Project, and Microsoft Excel formats, which are widely available to all program participants.

Background

Over the next 20 years, energy consumption in the United States is projected to rise by 30 percent, while domestic energy production is only expected to grow by 25 percent. Petroleum imports already supply more than 55 percent of U.S. domestic needs, and they are expected to exceed 62 percent by 2030 as worldwide oil demand continues to rise and domestic oil production continues to decline. This increased reliance on imported sources of energy threatens our national security, economy, and future competitiveness.

Biomass is the only domestic, sustainable, and renewable primary energy resource that can provide liquid transportation fuels currently produced from fossil sources. Biomass resources include agricultural and forest residues such as corn stover (stalks and leaves that remain after the corn grain is harvested), wheat straw and forest thinnings. Also included are non-edible perennial crops such as switchgrass and poplar, which can be grown as energy crops. It is estimated that the United States has the potential to produce up to 1.3 billion tons of biomass annually—equivalent to 30 percent of current petroleum consumption—sustainably, and without impacting food, feed, and fiber uses (Billion Ton Study 2005).

In his 2006 State of the Union Address, President Bush highlighted the role of biomass in reducing the nation's future demand for oil and refined gasoline and diesel fuels. The President's near-term goal for biomass is "to foster the breakthrough technologies needed to make cellulosic ethanol cost-competitive with corn-based ethanol by 2012, enabling greater use of this alternative fuel to help reduce future U.S. oil consumption" (Advanced Energy Initiative 2006). To support this effort, dubbed the Biofuels Initiative, the President's 2007 Budget increases the research funding for the U.S. Department of Energy (DOE) Biomass Program by 65% to a total of $150 million.

DOE Biomass Program

The Biomass Program has overall responsibility for managing DOE research, development, and demonstration (RD&D) activities relating to the use of renewable biomass for fuels, chemicals, and power production. The program's overarching strategic goal is to develop "biorefinery-related technologies to the point that they are cost- and performance-competitive and are used by the nation's transportation, chemical and power industries to meet their market objectives" (Multi-Year Plan 2005).

Biomass research has been a cornerstone of DOE's renewable energy RD&D efforts over the last 25 years. Today, the unprecedented national visibility of cellulosic ethanol, in particular, and biofuels, in general, as viable alternatives to conventional transportation fuels puts the Biomass Program under greater pressure to produce measurable results than at any other time in its history. The monetary requirements for deployment will dwarf what has been spent on research, even over the last 25 years. The risks are high and the resources are limited. As the program moves forward with the deployment of full-scale biofuels systems, increasingly larger sums of government money will be spent on research and large-scale technology demonstrations. The Biomass Program has an obligation to make sure the money is spent properly on the right projects and that the projects are conducted in the best possible manner.

Role of Systems Engineering in the Biomass Program

The Biomass Systems Integration Office (SIO) was established to implement the systems engineering processes, practices, and tools that will enable the program to meet the challenges of aligning RD&D efforts with the program's strategic goals and directing funding to the efforts that offer the most promise. As the technical arm of the Biomass Program Management structure, SIO delivers independent and objective analyses, advice, and planning options that enable the program manager to make informed decisions as biomass systems are advanced from concept to commercial adoption. Specifically, SIO is tasked with (1) establishing, validating, and maintaining the integrated baseline as biomass technologies and systems are advanced from concept to commercial adoption, (2) providing consistent results of analyses to support programmatic decisions, and (3) verifying that technology and system designs meet program requirements.

Biomass Program Management Structure

The DOE Biomass Program is organized around a research and development (R&D)-based Work Breakdown Structure (WBS) and a resource-based Pathway Structure. This organization is designed to integrate the technology advancements from the R&D efforts into complete biorefinery systems.

Research-Based WBS: Programmatic Baseline

The Biomass Program WBS comprises five RD&D technology elements, as illustrated in Figure 1:

- **Feedstock R&D**. Development of new sustainable agricultural and feedstock infrastructure technologies and methods that will be required to supply lignocellusic feedstocks to future large-scale biorefineries.
- **Biochemical Conversion R&D**. Fundamental and applied research and technology development for producing low-cost sugars from lignocellulosic biomass.
- **Thermochemical Conversion R&D**. Fundamental and applied research and technology development for cost-effective, efficient thermochemical technologies for producing intermediate products (e.g., syngas, pyrolysis oil) from lignocellulosic biomass and biomass-derived biorefinery residues.
- **Products R&D**. Investigation, evaluation, and demonstration of cost-effective fuels—as well as co-product, chemical, material, and heat and power production from process residues and intermediates— to improve overall biorefinery plant economics.
- **Integrated Biorefineries Demonstration**. Pilot- and demonstration-scale evaluation of cost- and performance-competitive integrated biorefinery technologies through public–private partnerships.

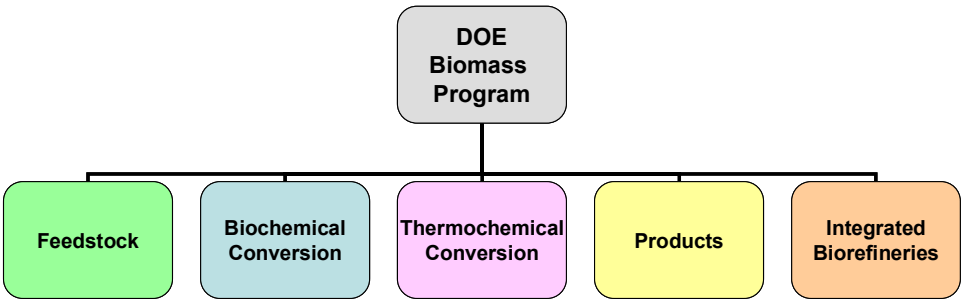


Figure 1. DOE Biomass Program high-level Work Breakdown Structure

Currently, the program uses this WBS to manage more than 150 projects conducted at universities, national laboratories, and in partnership with industry across the country. Detailed information on each of these projects—project tasks, milestones, stage of development, link to pathway, principal investigator, etc.—forms the basis of the Biomass Program's programmatic baseline.

Resource-Based Pathways: Technical Baseline

Because of the wide diversity of biomass feedstocks, conversion technologies, and potential products, these research elements can be combined in a multitude of biorefinery configurations. The Biomass Program has defined seven primary technology pathways to guide research efforts and identify key interfaces that will enable the establishment of commercially viable integrated biorefineries, as illustrated in Figure 2.

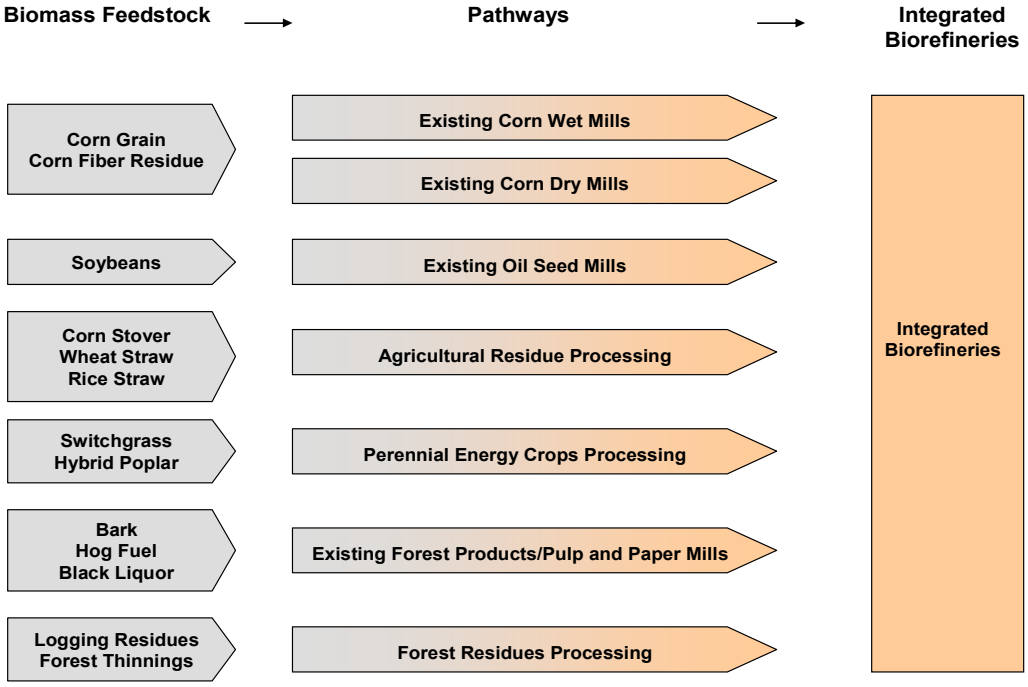


Figure 2. Resource-based conversion pathways

These technology pathways are linked to the U.S. biomass resource base, existing segments of today's bio-industry when possible, and future bio-industry market segments where envisioned. Each pathway represents a generic set of potential biorefinery configurations for a specific biomass resource base. Within each pathway there are multiple viable alternative routes to biofuels production.

The performance and cost targets specified for each of the seven resource-based pathways, along with the strategic goals and barriers identified in the program's *Multi-Year Program Plan* (*Multi-Year Plan* 2005), form the basis of the Biomass Program's technical baseline.

WBS-Pathway Matrix: Integrated Baseline

The pathway framework for biorefinery deployment provides the management structure and processes for integrating advanced technologies being developed by the R&D elements to achieve the program mission. The pathway matrix in Figure 3 illustrates how the research-based WBS elements map to the resource-based pathways.

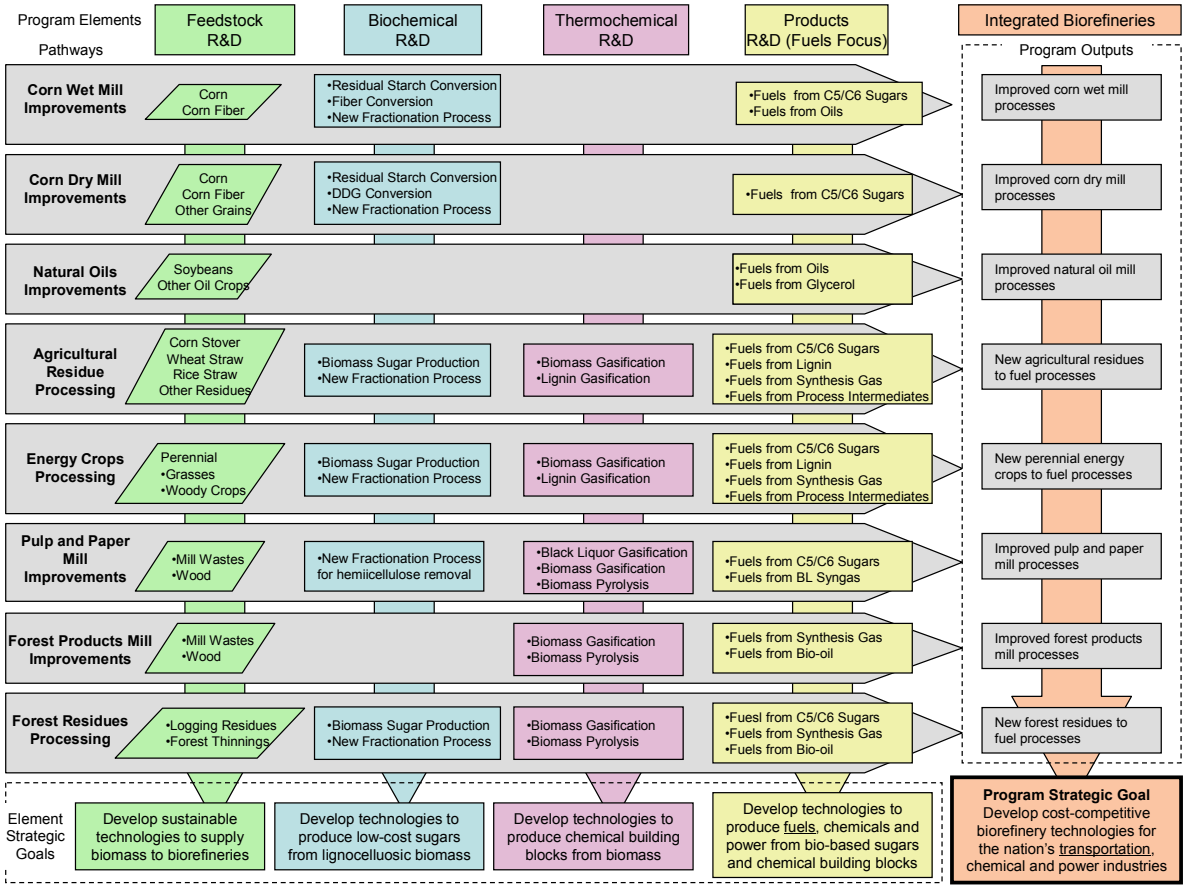


Figure 3. Biomass Program RD&D pathway matrix

This matrix links the WBS project information (scope of work, schedule, and cost) with the pathways (system configuration, performance, and characteristics) and forms the basis of the Biomass Program's integrated baseline.

CORE Database as a Tool for Managing the Biomass Program

The SIO uses CORE, a computer-assisted systems engineering support tool, to organize, coordinate, and document the integrated baseline development efforts. It captures the complete set of requirements, functions, strategies, technologies, inputs, and outputs in a central repository. The CORE software provides the Biomass Program Management with the necessary requirements for traceability to establish a defensible basis for budget estimates and technical decisions. In addition, this software allows program organization and efforts to be viewed from a variety of perspectives through automatic generation of standard reports, tables, and diagrams. In addition, custom scripts can be developed to import and export data and information through Microsoft Office products—Microsoft Excel, Microsoft Project, and Microsoft Word—which streamlines the production of program-specific periodic standardized reports and schedules.

CORE Biomass Model

A simplified representation of the CORE model developed for the Biomass Program is presented in Figure 4. This diagram highlights the traceability of the information back to its source document and shows the key relationships between the model components (or "elements"). This system establishes the framework to document and verify all aspects of the integrated baseline.

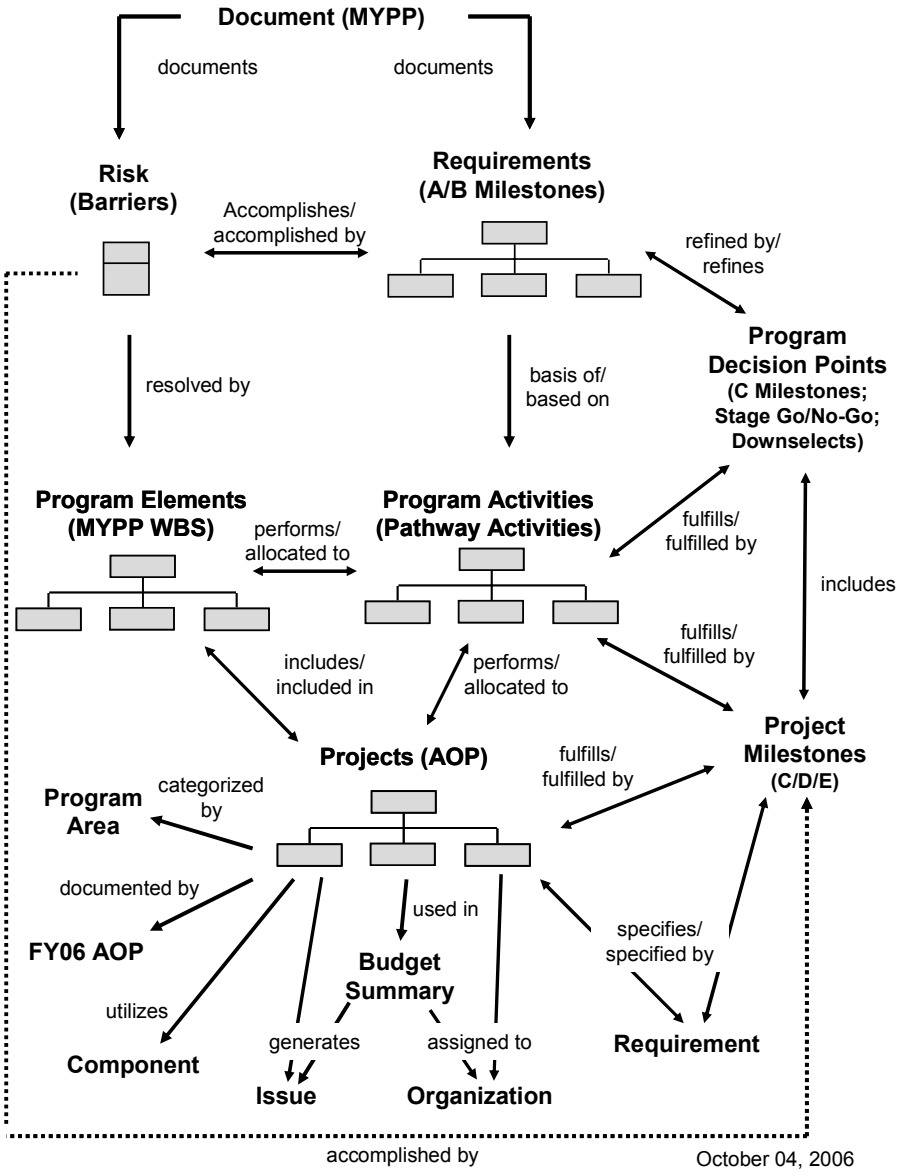
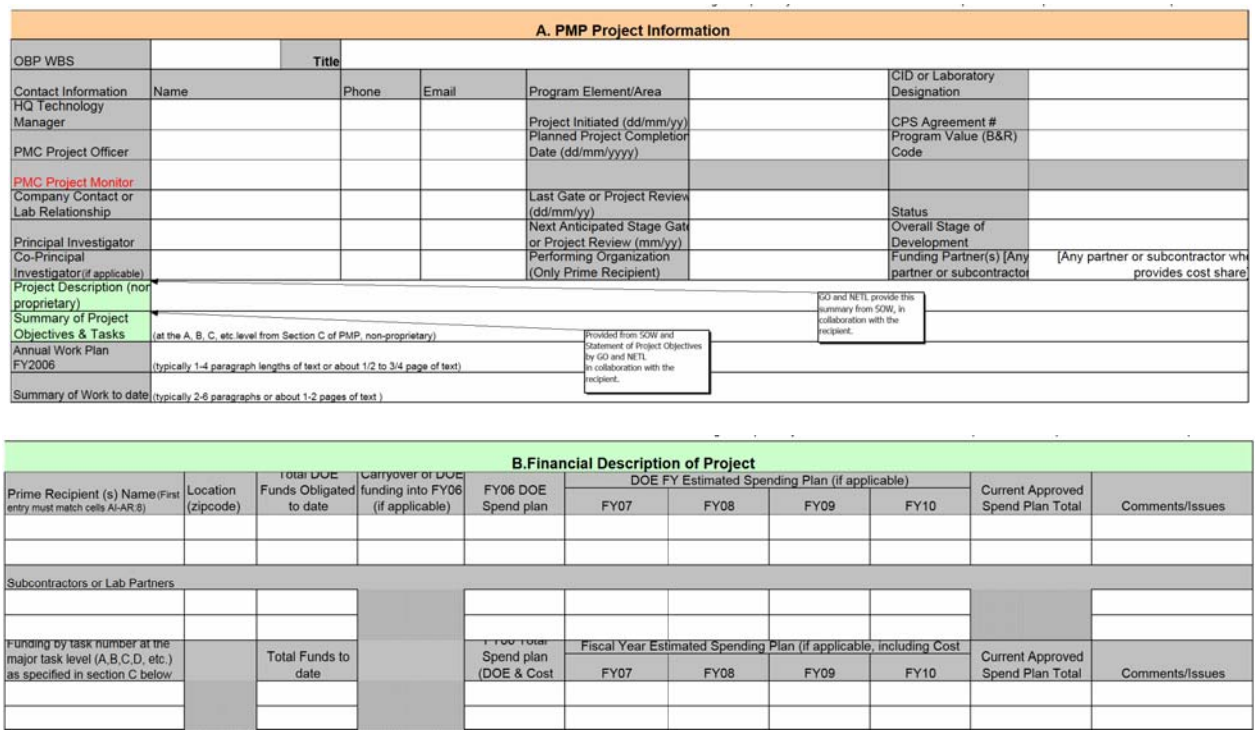


Figure 4. CORE biomass model elements and relationships

Importing Data into CORE

Working closely with DOE management, an Excel template was developed to collect project information directly from the principal investigator of each project. Excel was selected for this application because of its widespread availability and use. The template captures project objectives, tasks, milestones, budget, organizations involved, contract numbers, principal investigator, links to pathways and barriers, and DOE contacts, as illustrated in Figures 5 and 6.



A. PMP Project Information

OBP WBS		Title					
Contact Information	Name	Phone	Email	Program Element/Area		CID or Laboratory Designation	
HQ Technology Manager				Project Initiated (dd/mm/yy)		CPS Agreement #	
PMC Project Officer				Planned Project Completion Date (dd/mm/yyyy)		Program Value (B&R) Code	
PMC Project Monitor							
Company Contact or Lab Relationship				Last Gate or Project Review (dd/mm/yy)		Status	
Principal Investigator				Next Anticipated Stage Gate or Project Review (mm/yy)		Overall Stage of Development	
Co-Principal Investigator (if applicable)				Performing Organization (Only Prime Recipient)		Funding Partner(s) [Any partner or subcontractor	[Any partner or subcontractor who provides cost share]
Project Description (non-proprietary)							
Summary of Project Objectives & Tasks	(at the A, B, C, etc level from Section C of PMP, non-proprietary)						
Annual Work Plan FY2006	(typically 1-4 paragraph lengths of text or about 1/2 to 3/4 page of text)						
Summary of Work to date	(typically 2-6 paragraphs or about 1-2 pages of text)						

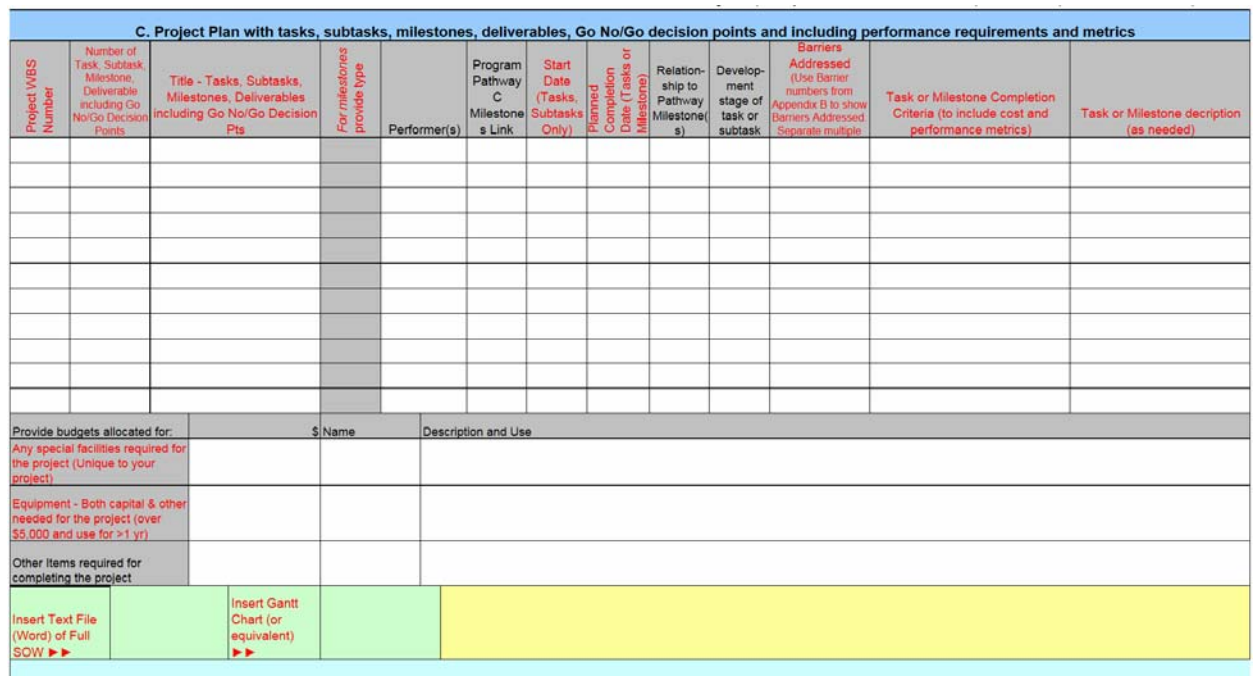
GO and NETL provide this summary from SOW, in collaboration with the recipient.

Provided from SOW and Statement of Project Objectives by GO and NETL in collaboration with the recipient.

B.Financial Description of Project

Prime Recipient (s) Name (First entry must match cells AI-AR,8)	Location (zipcode)	Total DOE Funds Obligated to date	Carryover of DOE funding into FY06 (if applicable)	FY06 DOE Spend plan	DOE FY Estimated Spending Plan (if applicable) FY07	FY08	FY09	FY10	Current Approved Spend Plan Total	Comments/Issues
Subcontractors or Lab Partners										
Funding by task number at the major task level (A,B,C,D, etc.) as specified in section C below		Total Funds to date		FY06 Total Spend plan (DOE & Cost	Fiscal Year Estimated Spending Plan (if applicable, including Cost FY07	FY08	FY09	FY10	Current Approved Spend Plan Total	Comments/Issues

Figure 5. Project Information Template, Sections A and B



C. Project Plan with tasks, subtasks, milestones, deliverables, Go No/Go decision points and including performance requirements and metrics

Project WBS Number	Number of Task, Subtask, Milestone, Deliverable including Go No/Go Decision Points	Title - Tasks, Subtasks, Milestones, Deliverables including Go No/Go Decision Pts	For milestones provide type	Performer(s)	Program Pathway C Milestones Link	Start Date (Tasks, Subtasks Only)	Planned Completion Date (Tasks or Milestone)	Relationship to Pathway Milestone(s)	Development stage of task or subtask	Barriers Addressed (Use Barrier numbers from Appendix B to show Barriers Addressed. Separate multiple	Task or Milestone Completion Criteria (to include cost and performance metrics)	Task or Milestone decription (as needed)

Provide budgets allocated for:	$	Name	Description and Use
Any special facilities required for the project (Unique to your project)			
Equipment - Both capital & other needed for the project (over $5,000 and use for >1 yr)			
Other Items required for completing the project			

Insert Text File (Word) of Full SOW ►►		Insert Gantt Chart (or equivalent) ►►		

Figure 6. Project Information Template, Section C

Custom scripts were developed to import the project information from the Excel files into the predefined database of CORE. Importing data into CORE is implemented by the CORE comma-separated variable (CSV) interlink and provides traceability of the requirements within CORE.

Exporting Files from CORE

To supplement the standard scripts within CORE that export data to interactive html files and standard data tables, custom scripts were written to provide data in Word, Excel, and Project file formats as specified by the DOE Biomass Program.

The scripts for the custom Word output extract selected project data from the CORE database and output to the formats defined by DOE. The script is flexible and allows selection of one project or a group of projects to meet a variety of DOE requests for information.

The scripts for exporting to Excel and Project pull selected data into CSV files that can be imported into the final application to output the desired reports and forms. The Excel export script exports the information from CORE into the same pre-formatted Excel worksheet used to collect project information from the principal investigators. The Project export script transfers the scheduling information (dates) that reside in CORE into the Project program for presentation in Gantt or PERT chart formats.

These custom scripts serve to automate the generation of a number of ongoing reports required by the Biomass Program. Pre-formatted custom status reports, schedules, and Word files can be generated to accurately and efficiently meet program management needs.

Future Plans for CORE Biomass Model

The CORE biomass model is a work in progress. The first efforts to import project data have been successfully completed. For the next steps, the Biomass Program plans to import analysis results, project status reports, external reviews, and risk assessments into the CORE database.

Summary

The DOE Biomass Program is taking on the challenge of advancing biomass technologies and systems from concept to commercial adoption. Systems engineering approaches and tools, such as the CORE MBSE software, are facilitating management and communication of program activities, milestones, and strategic goals among all program participants. The CORE model aides program management by:

- Establishing and maintaining links among program goals, projects, platforms, and pathways
- Automatically generating schedules and status reports
- Allowing access to up-to-date program information in useful, easy-to-understand standard formats
- Allowing import from and export to tools that are widely available to all program participants (Microsoft Word, Excel, and Project)

With the proper tools in place, the Biomass Program Management Team can make informed decisions regarding prioritization and utilization of limited resources to achieve the program's goals.

References

Advanced Energy Initiative. National Economic Council, The White House, February 2006 (http://www.whitehouse.gov/stateoftheunion/2006/energy/).

Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. U.S. Department of Energy and U.S. Department of Agriculture, April 2005 (http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf).

Multi-Year Program Plan: 2007-2012. Office of the Biomass Program, Energy Efficiency and Renewable Energy, U.S. Department of Energy, August 31, 2005 (http://www1.eere.energy.gov/biomass/pdfs/mypp.pdf).

Biography

Cynthia Riley, PE

Ms. Riley has experience in the energy and environmental industries and expertise in the analysis and evaluation of emerging alternative energy technologies. She has over 28 years of experience, including alternative energy research with Exxon, process design engineering with Fluor and Raytheon, and research engineering and management at NREL. During her 16 years at NREL, she has worked on DOE Energy Efficiency and Renewable Energy programs, including Biofuels and Biomass, Clean Cities, and Energy Policy Act implementation. She is currently the Biomass Program lead systems integrator within the recently established Systems Integration Office, which is charged with implementing systems engineering within the DOE Office of Biomass Program. She holds a BS in Chemical Engineering from the University of New Hampshire and is a Registered PE (Colorado).

Debra Sandor, ***PMP***

Ms. Sandor has over nine years of process engineering experience in both manufacturing and R&D organizations. She has a range of hands-on and theoretical experience, including scaling up pilot-scale operations to full-scale production processes, process evaluation and validation, modeling of conceptual processes, and program and personnel management. She is the lead systems engineer for the newly established Systems Integration Office. Her current responsibilities include developing and maintaining the program's integrated baseline. She holds a BS in Chemical Engineering from the University of Florida.

Philip Simpkins, ***CSEP***

Mr. Simpkins has over 15 years of collective experience in the areas of nuclear/chemical process operations, systems engineering, and nuclear safety analysis. During his 13+ years at the Department of Energy's Savannah River Site, Mr. Simpkins had a demonstrated track record in applying project management tools to support a mission-essential design. He has developed an extensive knowledge in the systems engineering approach using functions and requirements analysis, risk management, interface management, and analytical software. Mr. Simpkins is an INCOSE Certified System Engineering Professional (CSEP). He holds an M.S. in Engineering Management and a B.S. in Electrical Engineering from the University of Missouri-Rolla.

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14. ABSTRACT *(Maximum 200 Words)*

This paper describes how a model-based systems engineering software, CORE, is helping the U. S. Department of Energy's Office of Biomass Program assist with bringing biomass-derived biofuels to the market. This software tool provides information to guide informed decision-making as biomass-to-biofuels systems are advanced from concept to commercial adoption. It facilitates management and communication of program status by automatically generating custom reports, Gantt charts, and tables using the widely available programs of Microsoft Word, Project and Excel.

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