Redacted

Exemption 4

Redacted

Exemption 4

Redacted

Exemption 4

Redacted

Exemption 4

Redacted

Exemption 4

Applicant Name: **Membrane Technology and Research, Inc.** Award Number: **YEAR ONE**

Budget Information - Non Construction Programs

OMB Approval No. 0348-0044

Section A - Budget Summary

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. DE - FOA - 0000096	81.087			$148,854	Exemption 4	
2.						
3.						
4.						
5. Totals		$0	$0	$148,854		

Section B - Budget Categories

6. Object Class Categories	Grant Program, Function or Activity				Total (5)
	(1) 81.087	(2)	(3)	(4)	
a. Personnel	Exemption 4				
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies					
f. Contractual					
g. Construction					
h. Other					
i. Total Direct Charges (sum of 6a-6h)					
j. Indirect Charges					
k. **Totals** (sum of 6i-6j)					
7. Program Income	$0				$0

Authorized for Local Reproduction

Section C - Non-Federal Resources

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) **Totals**
8. DE - FOA - 0000096	$37,214	Exemption 4		
9.				
10.				
11.				
12. **Total** (sum of lines 8 - 11)	$37,214			

Section D - Forecasted Cash Needs

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th quarter
13. Federal	$148,854	$37,214	$37,213	$37,214	$37,213
14. Non-Federal	Exemption 4				
15. **Total** (sum of lines 13 and 14)					

Section E - Budget Estimates of Federal Funds Needed for Balance of the Project

(a) Grant Program	**Future Funding Periods (Years)** (b) First	(c) Second	(d) Third	(e) Fourth
16. DE - FOA - 0000096	$615,304	$114,382	$113,508	$0
17.				
18.				
19.				
20. **Total** (sum of lines 16-19)	$615,304	$114,382	$113,508	$0

Section F - Other Budget Information

21. Direct Charges

22. Indirect Charges
Provisional rate, Exempt% of direct labor (6a. Personnel), includes all allowable indirect costs.

23. Remarks

Authorized for Local Reproduction

Applicant Name: **Membrane Technology and Research, Inc.** Award Number: _____ **YEAR TWO**

Budget Information - Non Construction Programs

OMB Approval No. 0348-0044

Section A - Budget Summary

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. DE - FOA - 0000096	81.087			$615,304	Exemption 4	
2.						
3.						
4.						
5. Totals		$0	$0	$615,304		

Section B - Budget Categories

6. Object Class Categories	Grant Program, Function or Activity				Total (5)
	(1) 81.087	(2)	(3)	(4)	
a. Personnel	Exemption 4				
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies					
f. Contractual					
g. Construction					
h. Other					
i. Total Direct Charges (sum of 6a-6h)					
j. Indirect Charges					
k. **Totals** (sum of 6i-6j)					
7. Program Income	$0				$0

Section C - Non-Federal Resources

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) **Totals**
8. DE - FOA - 0000096	$153,826	Exemption 4		
9.				
10.				
11.				
12. **Total** (sum of lines 8 - 11)	$153,826			

Section D - Forecasted Cash Needs

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th quarter
13. Federal	$148,854	$37,214	$37,213	$37,214	$37,213
14. Non-Federal	Exemption 4				
15. **Total** (sum of lines 13 and 14)					

Section E - Budget Estimates of Federal Funds Needed for Balance of the Project

(a) Grant Program	**Future Funding Periods (Years)** (b) First	(c) Second	(d) Third	(e) Fourth
16. DE - FOA - 0000096	$615,304	$114,382	$113,508	$0
17.				
18.				
19.				
20. **Total** (sum of lines 16-19)	$615,304	$114,382	$113,508	$0

Section F - Other Budget Information

21. Direct Charges

22. Indirect Charges

Provisional rate, Exempt% of direct labor (6a. Personnel), includes all allowable indirect costs.

23. Remarks

Applicant Name: **Membrane Technology and Research, Inc.** Award Number: _____ **YEAR THREE**

Budget Information - Non Construction Programs

OMB Approval No. 0348-0044

Section A - Budget Summary

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. DE - FOA - 0000096	81.087			$114,382	Exemption 4	
2.						
3.						
4.						
5. Totals		$0	$0	$114,382		

Section B - Budget Categories

6. Object Class Categories	Grant Program, Function or Activity				Total (5)
	(1) 81.087	(2)	(3)	(4)	
a. Personnel	Exemption 4				
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies					
f. Contractual					
g. Construction					
h. Other					
i. Total Direct Charges (sum of 6a-6h)					
j. Indirect Charges					
k. **Totals** (sum of 6i-6j)					
7. Program Income	$0				$0

Section C - Non-Federal Resources

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) **Totals**
8. DE - FOA - 0000096	$28,596	Exemption 4		
9.				
10.				
11.				
12. **Total** (sum of lines 8 - 11)	$28,596			

Section D - Forecasted Cash Needs

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th quarter
13. Federal	$148,854	$37,214	$37,213	$37,214	$37,213
14. Non-Federal	Exemption 4				
15. **Total** (sum of lines 13 and 14)					

Section E - Budget Estimates of Federal Funds Needed for Balance of the Project

	Future Funding Periods (Years)			
(a) Grant Program	(b) First	(c) Second	(d) Third	(e) Fourth
16. DE - FOA - 0000096	$615,304	$114,382	$113,508	$0
17.				
18.				
19.				
20. **Total** (sum of lines 16-19)	$615,304	$114,382	$113,508	$0

Section F - Other Budget Information

21. Direct Charges

22. Indirect Charges

Provisional rate, Exempt% of direct labor (6a. Personnel), includes all allowable indirect costs.

23. Remarks

Applicant Name: **Membrane Technology and Research, Inc.** Award Number: _____ **YEAR FOUR**

Budget Information - Non Construction Programs

OMB Approval No. 0348-0044

Section A - Budget Summary

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. DE - FOA -0000096	81.087			$113,508	Exemption 4	
2.						
3.						
4.						
5. Totals		$0	$0	$113,508		

Section B - Budget Categories

6. Object Class Categories	Grant Program, Function or Activity				Total (5)
	(1) 81.087	(2)	(3)	(4)	
a. Personnel	Exemption 4				
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies					
f. Contractual					
g. Construction					
h. Other					
i. Total Direct Charges (sum of 6a-6h)					
j. Indirect Charges					
k. **Totals** (sum of 6i-6j)					
7. Program Income	$0				$0

Authorized for Local Reproduction

Section C - Non-Federal Resources

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) **Totals**
8. DE - FOA -0000096	$28,377	Exemption 4		
9.				
10.				
11.				
12. **Total** (sum of lines 8 - 11)	$28,377			

Section D - Forecasted Cash Needs

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th quarter
13. Federal	$148,854	$37,214	$37,213	$37,214	$37,213
14. Non-Federal	Exemption 4				
15. **Total** (sum of lines 13 and 14)					

Section E - Budget Estimates of Federal Funds Needed for Balance of the Project

	Future Funding Periods (Years)			
(a) Grant Program	(b) First	(c) Second	(d) Third	(e) Fourth
16. DE - FOA -0000096	$615,304	$114,382	$113,508	$0
17.				
18.				
19.				
20. **Total** (sum of lines 16-19)	$615,304	$114,382	$113,508	$0

Section F - Other Budget Information

21. Direct Charges

22. Indirect Charges

Provisional rate, Exempt% of direct labor (6a. Personnel), includes all allowable indirect costs.

23. Remarks

Applicant Name: **Membrane Technology and Research, Inc.** Award Number: **CUMULATIVE**

Budget Information - Non Construction Programs

OMB Approval No. 0348-0044

Section A - Budget Summary

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1. DE - FOA -0000096	81.087			$992,048	Exemption 4	
2.						
3.						
4.						
5. Totals		$0	$0	$992,048		

Section B - Budget Categories

6. Object Class Categories	Grant Program, Function or Activity				Total (5)
	(1) 81.087	(2)	(3)	(4)	
a. Personnel	Exemption 4				
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies					
f. Contractual					
g. Construction					
h. Other					
i. Total Direct Charges (sum of 6a-6h)					
j. Indirect Charges					
k. **Totals** (sum of 6i-6j)					
7. Program Income	$0				$0

Authorized for Local Reproduction

Section C - Non-Federal Resources

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) **Totals**
8. DE - FOA -0000096	$248,013	Exemption 4		
9.				
10.				
11.				
12. **Total** (sum of lines 8 - 11)	$248,013			

Section D - Forecasted Cash Needs

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th quarter
13. Federal	$148,854	$37,214	$37,213	$37,214	$37,213
14. Non-Federal	Exemption 4				
15. **Total** (sum of lines 13 and 14)					

Section E - Budget Estimates of Federal Funds Needed for Balance of the Project

	Future Funding Periods (Years)			
(a) Grant Program	(b) First	(c) Second	(d) Third	(e) Fourth
16. DE - FOA -0000096	$615,304	$114,382	$113,508	$0
17.				
18.				
19.				
20. **Total** (sum of lines 16-19)	$615,304	$114,382	$113,508	$0

Section F - Other Budget Information

21. Direct Charges

22. Indirect Charges

Provisional rate, Exempt% of direct labor (6a. Personnel), includes all allowable indirect costs.

23. Remarks

BUDGET JUSTIFICATION, PAGE 1 OF 3

LINE B.6.a. PERSONNEL.

YEAR ONE/PHASE I:	Estimated	Rate/hour	Estimated
Exemption 4			

YEAR TWO/PHASE II:	Estimated	Rate/hour	Estimated
Exemption 4			

YEAR THREE/PHASE III:	Estimated	Rate/hour	Estimated
Exemption 4			

BUDGET EXPLANATION, PAGE 2 OF 3

YEAR FOUR/PHASE III:	Estimated	Rate/hour	Estimated
Exemption 4			

[NOTES: HOURLY RATES USED ARE BASED ON ACTUAL CURRENT SALARIES FOR INDIVIDUALS (OR AVERAGES OF GROUPS OF INDIVIDUALS) ADJUSTED TO MEET EXPECTED PROJECT START DATE (OCTOBER 2009). SUBSEQUENT YEAR ESTIMATES ARE THE RESULT OF APPLYING AN ESCALATION FACTOR OF 4% TO FIRST-YEAR RATES. FRINGE BENEFITS ARE INCLUDED IN LABOR OVERHEAD, J.)]

LINE B.6.c. TRAVEL.

	Year 1/	Year 2/	Year 3/	Year 4/	Subtotal,
Exemption 4					

[NOTE: AIR FARES ARE BASED ON CURRENT QUOTES FOR UNRESTRICTED ECONOMY FARE FROM SAN FRANCISCO AIRPORT. GROUND TRANSPORTATION INCLUDES COMPACT RENTAL CAR AND TRANSPORTATION TO AND FROM AIRPORT. PER DIEM AMOUNTS ARE BASED ON CONUS RATES IN EFFECT 1 JANUARY 2009.]

LINE B.6.d. EQUIPMENT.

	Year 1/	Year 2/	Year 3/	Year 4/	Subtotal,
Exemption 4					

[NOTE: EQUIPMENT COSTS ARE ENGINEER'S ESTIMATES, BASED ON PREVIOUS EXPERIENCE AND/OR VENDOR QUOTES.]

BUDGET EXPLANATION, PAGE 3 OF 3

LINE B.6.e. SUPPLIES.

	Year 1/	Year 2/	Year 3/	Year 4/	Subtotal,
Exemption 4					

[NOTE: MATERIAL AND SUPPLIES COSTS ARE ENGINEER'S ESTIMATES, BASED ON PREVIOUS EXPERIENCE AND/OR VENDOR QUOTES.]

LINE B.6.h. OTHER:

	Year 1/	Year 2/	Year 3/	Year 4/	Subtotal,
Exemption 4					

LINE B.6.j. INDIRECT COSTS.

An indirect cost rate of Exemption 4% (as overhead applied to direct labor, net of fringe benefits) is requested for the duration of the project. This single rate includes all allowable indirect costs, including fringe benefits, G&A and B&P/IR&D. MTR's most recently DCAA-audited indirect cost rate (2005) was Exemption 4% (audited by Ms. Elizabeth Sanchez, Western Region, Peninsula Branch, 650-917-5005); claimed rates for subsequent years 2006 and 2007 are Exemption 4 %, respectively. A provisional billing rate agreement for Exemption 4% is currently in effect with DCAA (Reference: 4281/820.5/09-V-0031).

COST SHARE.

The proposed cost share of $Exemption 4 of the total cost of the subcontract, will come from internal funds, primarily to support labor and overhead costs.

PMC 121 1
(07/2008)

U.S. DEPARTMENT OF ENERGY
PROJECT MANAGEMENT CENTER

PRE-AWARD INFORMATION SHEET

Awardee Name:	Algenol Biofuels Inc.
Award Number:	
Awardee Business Officer:	Katie McFadden
Awardee Project Director:	Craig R. Smith, M.D.

Employer/Taxpayer Identification Number (EIN/TIN):	REDACTED EXEMPTION 6
Data Universal Numbering System (DUNS):	800399904

For assistance in obtaining a DUNS Number, call Dunn & Bradstreet at 1-800-333-0505.
The Applicant should be prepared to provide the following information to Dunn & Bradstreet:
(1) Company name
(2) Company address
(3) Company telephone number
(4) Line of business
(5) Chief executive officer/key manager
(6) Date the company was started
(7) Number of people employed by the company
(8) Company affiliation

A. TYPE OF BUSINESS - the Awardee is a:

- ☒ For-Profit Organization (Other than Small Business)
  - ☒ Corporation
  - ☐ Partnership
  - ☐ Sole Proprietorship
- ☐ Government
  - ☐ Local Government
  - ☐ State Government
  - ☐ Indian Tribal Government
- ☐ Individual
- ☐ Institution of Higher Education
- ☐ Other NonProfit Organization
- ☐ Small Business
- ☐ Other (specify):

If NonProfit, select one below:

☐ A university or other institution of higher education or an organization of the type described in Section 501(c)(3) of the Internal Revenue Code of 1954 (26 USC 501(c)) and exempt from taxation under Section 501(a) of the Internal Revenue Code (26 USC 501(a)); or

☐ An organization of the type described in Section 501(c)(4) of the Internal Revenue Code of 1954 (26 USC 501(c)) and exempt from taxation under Section 501(a) of the Internal Revenue Code (26 USC 501(a)); or

☐ An organization of the type described in Section 501(c)(6) of the Internal Revenue Code of 1954 (26 USC 501(c)) and exempt from taxation under Section 501(a) of the Internal Revenue Code (26 USC 501(a)); or

☐ A nonprofit scientific or educational organization qualified under a State nonprofit organization statute. (Please identify the statute.); or

☐ Other (specify type):

Is the Applicant a member of the Federal Demonstration Partnership (FDP)? ☐ Yes ☐ No
A listing of FDP members is available at http://www.thefdp.org/FDP_Members.html.

B. INTELLECTUAL PROPERTY

1. WAIVER OF DOE PATENT RIGHTS

This section applies only to large businesses and nonprofits other than 501(c)(3) organizations. All others should leave this subsection blank and proceed to the "Rights in Application Data" subsection that follows. Large businesses and nonprofits other than 501(c)(3) organizations have the right to request, in advance or within 30 days after execution of an award, in accordance with applicable statutes and DOE Patent Waiver Regulation (10 CFR 784), a waiver of all or any part of the rights of the United States in Subject Inventions. Accordingly, please check all that apply:

☐ I intend to request an advance waiver in accordance with 10 CFR 784.
☒ I intend to request an advance waiver on behalf of one or more subrecipients/subcontractors.
☐ I have at least one subrecipient/subcontractor that will request a waiver on its own behalf.
☐ I do not intend to request an advance waiver.

2. RIGHTS IN APPLICATION DATA

For an award based on an application/proposal, the Government will obtain unlimited rights in the technical data contained in the application/proposal, unless the Awardee marks those portions of the technical information which it asserts as "proprietary data" or specifies those portions of such technical data which are not directly related to or will not be utilized in the work to be funded under this award.

Accordingly, please indicate:

☐ No restrictions on Government rights in technical data contained in the application/proposal; or

☒ The application/proposal contains the following identified technical data that is proprietary, or is not directly related to, or will not be utilized in the work to be funded under this award.

Please list specific page numbers, table numbers, etc., and the dated version of the application/proposal to which you refer:

The data contained on pages 6-10 of the Project Narrative; pages 3-6 and 12-13 of Environmental Questionnaire; pages 1-10, 16-18 and 20 of the Business and Commercialization Plan; and pages 2-4 of the IP Statement and all information contained the files named Lifecycle Energy and Greenhouse Gas Emissions, SF424A, Budget, Subaward Budget Files, Process Flow Diagram, Project Management Plant and Project Executive Plan have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in

connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award.

All existing data on our process, procedures and know-how embody trade secrets, commercial and financial data that are confidential and privileged.

Paragraphs in this application's respective files that are preceded by an asterisk (*) contain proprietary information that Algenol Biofuels requests not be released to persons outside the Government, except for the purposes of review and evaluation.

3. IDENTIFICATION OF LIMITED RIGHTS DATA AND RESTRICTED COMPUTER SOFTWARE

Below, please identify any Limited Rights Data or Restricted Computer Software you plan to use to carry out your work under the award. Limited Rights Data means data (other than computer software) developed at private expense that embody trade secrets or are commercial or financial, and confidential or privileged. Restricted Computer Software means computer software developed at private expense and that is a trade secret, is commercial or financial, and confidential or privileged, or is published, copyrighted computer software, to include modifications of the computer software.

Please note that these data do not include data that you will produce under this award. Data that is first produced under this award is treated separately under the data rights clause of this award. This section covers only those data that you bring into this award that were privately funded.

If you plan to use Limited Rights Data or Restricted Computer Software under the award, please describe it in a few sentences or bullets, with sufficient detail that the DOE Project Officer can determine whether DOE will need to have any of it delivered, for example, to validate your results or the data produced under the award. You are not required to list issued patents or published patent applications. You do need to list unpublished patent applications (by title and brief description) and trade secret processes (by non-proprietary title with brief, non-proprietary description). If you have questions regarding the completion of this section, please contact the Contract Specialist handling your award.

Based on the above, please review the requirements in the technical scope of work for this award and indicate, to the best of your knowledge:

☐ No Limited Rights Data will be utilized in the performance of this award.

☒ Limited Rights Data as follows will be utilized in the performance of this award.

Use this block to provide additional information or provide an attachment:

All existing data on our process, procedures and know-how embody trade secrets, commercial and financial data that are confidential and privileged.

Based on the above, please review the requirements in the technical scope of work for this award and indicate, to the best of your knowledge:

☐ Awardee Restricted Computer Software will NOT be utilized in the performance of this award.

☒ Awardee Restricted Computer Software as follows will be utilized in the performance of this award.

Use this block to provide additional information or provide an attachment:
Attached please find the Process Flow Diagram that was included the application. The Supervisory Control and Data Acquisition system is described on pages 28-35. As well, the Vapor Compression Steam Stripper control system is described on pages 14-23. These systems are privileged and confidential restricted computer software.

C. PROJECT PERFORMANCE SITE and CONGRESSIONAL DISTRICT

List the address and congressional district for the primary site where the work will be performed:

Street Address:	2301 N Brazosport Blvd. APB 2436
City:	Freeport
State:	TX
Zip:	77541
Congressional District:	TX-14th

If a portion of the work will be performed at any other site(s), identify those site(s) below, and indicate what portion of the effort will be performed at this/these site(s):

Street Address:	16121 Lee Road
City:	Ft. Myers
State:	FL
Zip:	33912
Congressional District:	FL-14th

Briefly describe portion of effort for this Site:	Algenol is in the process of consolidating already established research and development activities at this location. Research and development activities detailed in our application will be located at this facility.

Street Address:	2805 B Road
City:	Loxahatchee
State:	Florida
Zip:	33470
Congressional District:	FL-16th

Briefly describe portion of effort for this Site:	The process development unit detailed in the application will be located at this site.

Street Address:	1700 Union AVE, Suite A
City:	Baltimore
State:	Maryland
Zip:	21211
Congressional District:	MD-3rd

Briefly describe portion of effort for this Site:	On-going research and development activities detailed in the application will continue to be conducted at this site.

D. INVOICING AND PAYMENTS

1. Has the Awardee received any prior DOE awards administered by the Golden Field Office (GO)?

   ☐ Yes

   If yes, please list the most recent award number: _____

   ☒ No

2. Is the Awardee currently enrolled with the U.S. Department of Treasury / ASAP system (Automated Standard Application for Payment System) under the DOE / Golden Field Office (GO) Agency Locator Code (ALC) and Region Code (#8900-0001-04)?

   ☐ Yes

   Enter Awardee Seven-digit ASAP ID Number: _____

   ☒ No

3. Please provide the following contact information for ASAP and/or Payments:

   IMPORTANT: If not currently enrolled in the ASAP system under GO's ALC and Region Code, the person identified below will be contacted by the U.S. Department of Treasury with further instruction on completing the ASAP enrollment process.

   ASAP / Payments Contact Person: Katie McFadden

   Phone No.: (239) 498-2000 Extension: _____ E-mail: Katie.mcfadden@algenolbiofuels.com

4. Indicate preferred payment method below: (NOTE: this section is reserved for universities, hospitals, other non-profit organizations and state and local governments that are authorized Advance Payment Procedures, unless a specific need is supported. All other entities desiring advance payment should discuss with the DOE Award Administrator.)

   ☐ Payment by Advance is preferred. (SF 272 reporting will be required.)
   ☒ Payment by Reimbursement is preferred. (SF 272 reporting will not be required.)

5. Indicate the name, phone number, and email address of the Designated Responsible Employee for complying with national policies prohibiting discrimination (see 10 CFR 1040.5 and the Certifications and Assurances found at http://management.energy.gov/documents/CERTSASSUR.doc).

Craig R. Smith, M.D.	(239) 498-2000
Name	Telephone Number
Chief Operating Officer	**Craig.smith@algenolbiofuels.com**
Title	Email Address

REPRESENTATION/CERTIFICATION

I represent by my signature below that all the information provided by this form is accurate.

Name: Craig R. Smith, M.D.

Title: Chief Operating Officer

Signature of Authorized Company Official: Craig R. Smith, MD.

Date: 1/4/10

PMC 410.1
(07/06)

U.S. DEPARTMENT OF ENERGY
PROJECT MANAGEMENT CENTER

FINANCIAL INFORMATION

PROVIDE ALL INFORMATION REQUESTED ON THIS FORM

Applicant: **Algenol Biofuels Inc.**

Project Title: **Pilot-Scale Integrated Biorefinery Operations for Producing Ethanol from Hybrid Algae**

Announcement/Award No: **DE-FOA-0000096 /**

1. Have you had prior Federal awards? ☐ Yes ☒ No

2. Have you had an outside audit or an A-133 audit? ☒ Yes ☐ No
If yes, please provide a copy of the A-133 or outside audit (electronic preferred).

INFORMATION FOR DETERMINING COGNIZANT AGENCY/OFFICE

3. Applicant's fiscal year end date is December 31st

4a. Identify Cognizant **Federal Agency** (agency providing the preponderance of Federal funding), and provide Agency name, a point of contact, phone number, and e-mail.

Agency: Department of Energy
Point of Contact: Christy Sterner
Phone: 303-275-4720
E-mail:Christy.sterner@go.doe.gov

4b. To assist our office in validating Cognizant **Federal Agency** (4a), please provide following information for the 5 highest dollar award value for current Federal contracts, grants or awards (do not include sub-awards). (State Agencies and Universities can skip 4b)

Contract/Award #	Awarding Agency	Awarding Office	Start Date	End Date	Total Value

5a. If applicant has current DOE awards, identify Cognizant **DOE Office** (office providing the preponderance of DOE funding), and provide DOE office name, a point of contact, phone number, and e-mail.

DOE Office:
Point of Contact (Contracting Officer):
Phone:
E-mail:

5b. To assist our office in validating Cognizant **DOE Office** (5a), please provide following information for the 5 highest dollar value awards for current DOE contracts, grants or awards (do not include sub-awards). (State agencies and Universities can skip 5b)

DOE Contract/Award #	DOE Awarding Office	Start Date	End Date	Total Value

FINANCIAL MANAGEMENT SYSTEM

To qualify for Financial Assistance, compliance with 10 CFR 600.121 - Higher Education, Hospitals, and Other Non-Profit Organizations, 10 CFR 600.220(b) - State and Local Governments or 10 CFR 600.311 - For-Profit Organizations is required. Please check applicable boxes below.

☐ The Financial Management System is in compliance with 10 CFR 600.121, 10 CFR 600.220(b), or 10 CFR 600.311.

☒ I do not know if my Financial Management System is in compliance with 10 CFR 600.121, 10 CFR 600.220(b), or 10 CFR 600.311. If this block is checked, complete the survey below.

Accounting System Survey

	Yes	No	NA
1. Is your Accounting System in accordance with Generally Accepted Accounting Principles applicable to the circumstances?	☒	☐	☐
2. Accounting System provides for:			
a. Segregation of direct costs from indirect costs.	☒	☐	☐
b. Identification and accumulation of direct costs by project.	☒	☐	☐
c. A logical and consistent method for the allocation of indirect costs to intermediate and final cost objectives. (Project is final cost objective)	☒	☐	☐
d. Accumulation of costs under general ledger control.	☒	☐	☐
e. A timekeeping system that identifies employees' labor by intermediate and final cost objectives.	☐	☐	☒
f. A labor distribution system that charges direct and indirect labor to appropriate cost objectives.	☒	☐	☐
g. Interim (at least monthly) determination of costs charged to a project through routine posting of books of account.	☒	☐	☐
h. Excluding costs charged to Government projects which are not allowable in terms of FAR 31, Contract Cost Principles and Procedures, or other provisions.	☒	☐	☐
i. Identification of costs by project line item and by units (as if each unit or line item were a separate project) if required by the proposed award.	☒	☐	☐
3. Is the Accounting System designed, and are the records maintained in such a manner that adequate, reliable data are developed for use in developing cost proposals?	☒	☐	☐
4. Is the Accounting System currently in full operation?	☒	☐	☐

Applicant Name___ Algenol Biofuels Inc. _____

Announcement Number_____ DE-FOA-000009____

Representation of Limited Rights Data and Restricted Computer Software

(a) Any data delivered under an award resulting from this announcement is subject to the Rights in Data – General or the Rights in Data – Programs Covered Under Special Data Statutes clause (See Intellectual Property Provisions at http://www.gc.energy.gov/financial_assistance_awards.htm). Under these clauses, the Recipient may withhold from delivery data that qualify as limited rights data or restricted computer software. As an aid in determining the Government's need to include Alternate I and/or Alternate II in these clauses, which allow for delivery of limited rights data and/or restricted computer software, the applicant must complete paragraph (b) below to either state that none of the data involved in the proposed work effort qualify as limited rights data or restricted computer software, or identify, to the extent feasible, which of the data qualifies as limited rights data or restricted computer software. Any identification of limited rights data or restricted computer software in this application is not determinative of the status of such data should an award be made.

(b) The applicant has reviewed the proposed work effort and the requirements for the delivery of data or software and states:

☐ None of the data proposed for fulfilling such requirements qualifies as limited rights data or restricted computer software.

☒ Data proposed for fulfilling such requirements qualify as limited rights data or restricted computer software and are identified as follows:

The data contained on pages 6-10 of the Project Narrative; pages 3-6 and 12-13 of Environmental Questionnaire; pages 1-10, 16-18 and 20 of the Business and Commercialization Plan; and pages 2-4 of the IP Statement and all information contained the files named Lifecycle Energy and Greenhouse Gas Emissions, SF424A, Budget, Subaward Budget Files, Process Flow Diagram, Project Management Plant and Project Executive Plan have been submitted in confidence and contain trade secrets or proprietary information, and such data shall be used or disclosed only for evaluation purposes, provided that if this applicant receives an award as a result of or in connection with the submission of this application, DOE shall have the right to use or disclose the data herein to the extent provided in the award.

All existing data on our process, procedures and know-how embody trade secrets, commercial and financial data that are confidential and privileged.

Paragraphs in the application's respective files that are preceded by an asterisk (*) contain proprietary information that Algenol Biofuels requests not be released to persons outside the Government, except for the purposes of review and evaluation.

Note: "limited rights data" and "restricted computer software" are defined in provision "Rights in Data – General."

STATEMENT OF PROJECT OBJECTIVES
Algenol Biofuels Inc.
Pilot-Scale Integrated Biorefinery for Producing Ethanol from Hybrid Algae

A. PROJECT OBJECTIVES

1. Demonstrate the commercial potential of DIRECT TO ETHANOL™ technology by building a pilot-scale DIRECT TO ETHANOL™ integrated biorefinery on The Dow Chemical Company's facility in Freeport, Texas.
2. Operate a pilot-scale DIRECT TO ETHANOL™ integrated biorefinery that uses approximately 2 tonnes per day of carbon dioxide from industrial emissions as the feedstock for making ethanol.
3. Implement an integrated biorefinery project that will immediately create or save more than 300 well-paying high-tech jobs in Texas, Maryland, and Florida.
4. Assess the economic and environmental impact of a new breakthrough energy technology that could eventually create billions of dollars of economic value and thousands of new well-paying jobs while consuming large quantities of carbon dioxide from industrial emissions, displacing petroleum, and moving the U.S. toward energy independence.
5. Assemble a consortium of private industry, federal laboratories, and academic institutions that will contribute to the development, construction, operation and optimization of Algenol's pilot-scale integrated biorefinery and can contribute to future improvements in DIRECT TO ETHANOL™ technology.

B. PROJECT SCOPE

The DOE Office of Energy Efficiency and Renewable Energy (EERE) has established performance goals. Among these goals are to: 1) dramatically reduce, or even end, dependence on imported oil; and 2) spur the creation of the domestic bio-industry. To that end, the Office of the Biomass Program is offering to fund integrated biorefinery projects under this FOA entitled "Demonstration of Integrated Biorefinery Operations." The FOA lists three main criteria for selection; 1) technical merit and rationale, 2) credible economics and competitive advantages that justify an award, and 3) knowledge and experience in project management.

Algenol and its collaborators, The Dow Chemical Company, National Renewable Energy Laboratory, Membrane Technology & Research Inc., and The Georgia Institute of Technology, have collectively prepared an application that is responsive to the selection criteria as detailed below.

Algenol's DIRECT TO ETHANOL™ technology is based on over-expressing in blue-green algae the genes for fermentation pathway enzymes found widely in nature. The resulting metabolically enhanced hybrid algae actively carry out photosynthesis and utilize carbon dioxide to make ethanol inside each algal cell. The ethanol diffuses through the cell wall into the culture medium and then evaporates, along with water, into the headspace of an enclosed, sealed bioreactor. The ethanol-water vapor is then condensed, collected as a liquid, and distilled into fuel grade ethanol. Algenol currently has hybrid algae that produce ethanol at a rate greater than 0.6 moles/m2 per week. The productivity of these algae is currently being evaluated in 20-liter laboratory bioreactors and in 100-liter outdoor bioreactors under "field" conditions. The proposed pilot-scale bio-refinery will consist of approximately 17 acres of plastic fully enclosed 4500-liter specialized bioreactors and supporting areas for testing, distillation, and storage. The project will be divided into three Phases. In Phase I we will complete optimization of the hybrid algae and bioreactors and obtain the necessary regulatory approvals and permitting for construction. In Phase II we will construct the pilot scale bio-refinery, establish minimum performance characteristics and test second-generation ethanol/water separation equipment. In Phase III we will demonstrate commercially viable operations, optimize operating conditions, improve efficiency and reduce costs.

C. TASKS TO BE PERFORMED

Phase I: Development, Planning and Preparation of Integrated Biorefinery
The primary deliverable for this WBS element is to complete the planning and preparation of all aspects of

the proposed Integrated Ethanol Biorefinery.

WBS Element A.1 Appoint Algenol/Dow Chemical Joint Project Team
Algenol and Dow will each assign employees to the Program Management Team (PMT). The PMT will be responsible for all final decisions related to the proposed Biorefinery project.

WBS Element A.2 Organism Development
This research and development component will involve the optimization of Algenol Biofuels 1st generation ethanogenic hybrid algae, as well as continued research on developing second-generation strains with improved ethanol production capabilities.

WBS Element A.3 Flexible Film Photobioreactor Development
Over the past three years, Algenol has conducted research and development on photobioreactor systems. The data generated during Phase I will be used to identify preliminary design specifications of the photobioreactor systems that will be used in the proposed pilot-scale biorefinery. The commercial scale photobioreactor research and development will be focused on the materials of construction and manufacturing of the photobioreactor, the materials, methods of construction and the mixing system for the photobioreactors.

WBS Element A.4 Process Engineering
Over the past three years, Algenol has conducted research and development on process engineering. The research and development to date has resulted in the design and construction of a commercial scale photobioreactor system and a process for operating these systems. Process engineering is broken down into two phases, Upstream Processes and Downstream Processes. Phase I will be used to define preliminary specifications for the various systems and develop Standard Operating Procedures (SOPs).

WBS Element A.5 Architect Search and Site Selection, Construction Planning, Employee Recruiting and SOP Development
The primary purpose of this element is to interview and hire architectural firms, and continue to evaluate the site location, all designs, preliminary blueprints, systems specifications and deliver all of this information to an architectural firm for the preparation of construction blueprints. In parallel, we will identify and interview various general contractors for construction of the pilot plant and issue Request for Proposals to the top three candidate firms. We will also start the recruiting process for the Plant Manager and other critical personnel to operate the Pilot Plant.

WBS Element A.6 NEPA Review and Determination
As with any federally funded project, a satisfactory NEPA determination will be required in order to proceed to phase II of the project. Based on the favorable responses we have received from APHIS and the EPA, as well as Algenol's assessment, we remain optimistic that under DOE's own NEPA implementation regulations, Algenol's activities could be categorically excluded from additional NEPA environmental review. However, should the DOE determine that an environmental assessment of phase II activities be required, Algenol is prepared to meet those requirements. The ultimate deliverable in this element will be a finding of a categorical exclusion or, subsequent to an environmental assessment, a finding of no significant impact allowing the project to proceed as scheduled to Phase II.

WBS Element A.7 Regulatory Submissions and Approval
The primary purpose of this element is to prepare all regulatory submissions and approvals from all applicable regulatory agencies for the Biorefinery.

WBS Element A.8 Life Cycle Analysis (Phase I Update)
The purpose of this element is to update the life-cycle analysis of the projected Algenol commercial process in light of on-going research and development and evaluation of the carbon dioxide emission reduction in comparison to gasoline.

WBS Element A.9 Program Management of DOE Phase I Activities

The purpose of this element is to capture the activities of certain employees, the Principle Investigator, project management professionals and others, who are involved with overall management of the project as well as specific tasks. The goal of activities associated with this element is to provide effective and efficient communication, administration and general support to advance the project successfully.

WBS Element A.10 Phase I Gate Review

The Phase I gate criteria will be finalized as part of the startup of the project. Phase I Gate Criteria will be proposed by the PMT at the initiation of the project, approved by the Internal Gatekeeper Team (IGT), and communicated to DOE. At the end of Phase I, the IGT will review the project reports prepared by the PMT. After review, the IGT will submit, with appropriate documentation, a recommendation to the DOE regarding the pass or fail or extension of the Phase.

WBS Element A.11 Pre-award Lookback

The purpose of this element is to capture pre-award costs for budget period 1 that were incurred within the ninety (90) calendar day period immediately preceding the effective date of the award, the costs are allowable in accordance with the applicable Federal cost principles and direction from the DOE.

PHASE II – Build Pilot-Scale Integrated Biorefinery

After entering Phase II, Algenol and Dow will sign a construction contract with a general contractor and build the Pilot Plant according to the final construction blueprints prepared by the architect and approved by the local regulatory authorities. Key Pilot Plant personnel will be hired from the pool of applicants identified in Phase I. During the construction of the Pilot Plant, these personnel will be trained to run the facility at Algenol's PDU in Florida. In addition, Pilot Plant and PDU personnel will transfer and write Standard Operating Procedures (SOPs) for the Pilot Plant based on the SOPs developed and used at the PDU. Upon completion of the construction of the Pilot Plant, systems checks and shake down runs will be performed. After appropriate shake down runs have been performed, an independent engineer will evaluate and verify the process and issue a report. The independent engineer's report will be provided to the gate committee as the basis for moving into Phase III.

PHASE III - Ethanol Biorefinery Project – Optimize Pilot Plant Operations, Prepare and Submit Technical and Financial Reports to the DOE, Wind Down Operations and Decommission the Biorefinery.

After entering Phase III, Algenol will continue with the operations of the facility and focus on the reduction of operating, feedstock, energy and capital cost. Part of the cost reduction effort will be to evaluate the cost and operation of the MTR ethanol purification unit. During this time, technical and financial reports will be prepared and submitted to the DOE. Upon completion of negotiated plant operation duration, the operations of the Biorefinery will be wound down and decommissioned.

A. PMP Project Information

OBP WBS	5.11.1.2	Title	Pilot-Scale Integrated Biorefinery for Producing Ethanol from Hybrid Algae				
Contact Information	Name		Phone	Email	Program Element/Area	5-Integrated Biorefineries	CID or Laboratory Designation	EE0002867
HQ Technology Manager					Project Initiated (dd/mm/yy)	1-Feb-10	CPS Agreement #	WBS5.11.1.2
PMC Project Officer	Christy Sterner		CSS (303)275 4720	christy.sterner@go. doe.gov	Planned Project Completion Date (dd/mm/yyyy)	30-Sep-14	Program Value (B&R) Code	1004173
PMC Project Monitor	Christine English		ce 720-356-1324	christine.english@ go.doe.gov				
Company Contact or Lab Relationship Manager	Pat Ahlm		239-444-6313	pat.ahlm@algenolbiof uels.com	Last Gate or Project Review (dd/mm/yy)		Status	Proposed
cipal Investigator	Dr. Craig Smith		239-498-2000	Craig.smith@algenol biofuels.com	Next Anticipated Stage Gate or Project Review (mm/yy)	30-Sep-10	Overall Stage of Development	3 - Development
Co-Principal Investigator (if applicable)	Ed Legere		561-714-3816	ed.legere@algenolbio fuels.com	Performing Organization (Only Prime Recipient)	Algenol Biofuels, Inc.	Funding Partner(s) [Any partner or subcontractor who provides cost share]	The Dow Chemical Company; MembraneTecnology and Research, Inc.
Project Description (non-proprietary)	Algenol's DIRECT TO ETHANOL™ technology is based on over-expressing in blue-green algae the genes for fermentation pathway enzymes found widely in nature. The resulting metabolically enhanced hybrid algae actively carry out photosynthesis and utilize carbon dioxide to make ethanol inside each algal cell. The ethanol diffuses through the cell wall into the culture medium and then evaporates, along with water, into the headspace of an enclosed, sealed bioreactor. The ethanol-water vapor is then condensed, collected as a liquid, and distilled into fuel grade ethanol. Algenol currently has hybrid algae that produce ethanol at a rate greater than 0.6 moles/m2 per week. The productivity of these algae is currently being evaluated in 20-liter laboratory bioreactors and in 100-liter outdoor bioreactors under "field" conditions. The proposed pilot-scale bio-refinery will consist of approximately 17 acres of plastic fully enclosed 4500-liter specialized bioreactors and supporting areas for testing, distillation, and storage. The project will be divided into three Phases. In Phase I we will complete optimization of the hybrid algae and bioreactors and obtain the necessary regulatory approvals and permitting for construction. In Phase II we will construct the pilot scale bio-refinery, establish minimum performance characteristics and test second-generation ethanol/water separation equipment. In Phase III we will demonstrate commercially viable operations, optimize operating conditions, improve efficiency and reduce costs.							
Summary of Project Objectives & Tasks (at the A, B, C, etc.level from Section C of PMP, non-proprietary)	STATEMENT OF PROJECT OBJECTIVES Algenol Biofuels Inc. Pilot-Scale Integrated Biorefinery for Producing Ethanol from Hybrid Algae Exemption 4							
Annual Work Plan FY2010 (typically 1-4 paragraph lengths of text or about 1/2 to 3/4 page of text)	Exemption 4							

Summary of Work to date (typically 2-6 paragraphs or about 1-2 pages of text)	Exemption 4

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 FY10 (if applicable)	FY10 DOE Spend plan	DOE FY Estimated Spending Plan (if applicable)				Current Approved Spend Plan Total	Comments/Issues
					FY11	FY12	FY13	FY14		
Algenol Biofuels Inc.	34135			$13,866,729.00						
Subcontractors or Lab Partners										
The Dow Chemical Company				Exemption 4						
Membrane Technology and Research, Inc.										
Georgia Tech Research Corporation										
NREL										
Funding by task number at the major task level (A,B,C,D, etc.) as specified in section C below (columns E-H)		Total Funds to date		FY10 Total Spend plan (DOE & Cost Share)	Milestones have been updated in Appendix C. Please provide updated links. imated Spending Plan (if applicable, including Cost Share)				Current Approved Spend Plan Total	Comments/Issues
						FY12	FY13	Barriers have been updated in Appendix B.		
A.1				Exemption 4						
A.2										
A.2.3										
A.2.4										
A.3.1										
A.3.2										
A.3.3										
A.4.1										
A.4.2										
A.5.1										
A.5.2										
A.5.3										
A.6.1										
A.6.2										
A.6.3										
A.6.4										
A.6.5										
A.6.6										
A.7.1										
A.7.2										
A.7.3										
A.7.4										
A.8.1										

A.9				Exemption 4		
A.10.1						
A.10.2						
A.11						

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)	Relation-ship to Pathway Milestone(s)	Develop-ment stage of task or subtask	Barriers Addressed (Use Barrier numbers from Appendix B to show Barriers Addressed. Separate multiple entries with	Task or Milestone Completion Criteria (to include cost and performance metrics)	Task or Milestone decription (as needed)	Mark as proprietary or confidential
5.11.1.2	A	Exemption 4											
5.11.1.2	A.1												
.1.2	A.2												
5.11.1.2	A.2.1												
5.11.1.2	A.2.2												
5.11.1.2	A.2.3												
5.11.1.2	A.2.4												
5.11.1.2	A.2.4.DL.1												
5.11.1.2	A.3												
5.11.1.2	A.3.1												
.2	A.3.2												
5.11.1.2	A.3.3												
5.11.1.2	A.4												
5.11.1.2	A.4.1												
5.11.1.2	A.4.1.1												
5.11.1.2	A.4.1.2												
5.11.1.2	A.4.1.3												
5.11.1.2	A.4.1.4												

Exemption 4

5.11.1.2	A.4.1.5
5.11.1.2	A.4.1.6
5.11.1.2	A.4.1.7
5.11.1.2	A.4.2
5.11.1.2	A.4.2.1
5.11.1.2	A.4.2.1.1
5.11.1.2	A.4.2.1.2
..1.2	A.4.2.1.2.DL.1
5.11.1.2	A.4.2.1.3
5.11.1.2	A.4.2.1.4
5.11.1.2	A.4.2.1.5
5.11.1.2	A.5
5.11.1.2	A.5.1
5.11.1.2	A.5.2
5.11.1.2	A.5.3
5.11.1.2	A.6
.2	A.6.DL.1
5.11.1.2	A.6.GN.1
5.11.1.2	A.6.DL.2
5.11.1.2	A.6.GN.2
5.11.1.2	A.6.DL.3
5.11.1.2	A.6.GN.3
5.11.1.2	A.7
5.11.1.2	A.7.1
5.11.1.2	A.7.2

		Exemption 4
5.11.1.2	A.7.3	
5.11.1.2	A.7.4	
5.11.1.2	A.8	
5.11.1.2	A.8.DL.1	
5.11.1.2	A.9	
5.11.1.2	A.10	
.2	A.10.GN.1	
5.11.1.2	A.11	
5.11.1.2	B	
5.11.1.2	B.1	
5.11.1.2	B.1.1	
5.11.1.2	B.1.2	
5.11.1.2	B.2	
5.11.1.2	B.3	
5.11.1.2	B.4	
5.11.1.2	B.4.1	
5.11.1.2	B.4.2	
5.11.1.2	B.4.3	
5.11.1.2	B.5	
5.11.1.2	B.5.1	
.2	B.5.1.1	
5.11.1.2	B.5.1.2	
5.11.1.2	B.5.1.3	
5.11.1.2	B.5.1.4	
5.11.1.2	B.5.1.5	

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) ►►		

Program Barriers Addressed

Feedstock Integration

Ft-A. Resource Availability and Cost: The lack of credible data on price, location, quality and quantity of biomass creates uncertainty for investors and developers of emerging biorefinery technologies. In addition to a lack of information regarding national cellulosic biomass production, current estimates of feedstock resources are limited in scope, and do not consider how major technological advantages in production technologies will impact biomass availability. Due to the diversity and wide distribution of biomass feedstock resources, a regional approach is required to complete a more detailed assessment of the resources initially identified in the Billion Ton study. Feedstock supply is a significant cost component of bio-based fuels, products, and power.

Ft-B. Sustainable Production: Existing data on the environmental effects of feedstock production and residue collection are not adequate to support lifecycle analysis of biorefinery systems. The lack of information and decision support tools to predict effects of residue removal as a function of soil type, and the lack of a selective harvest technology that can evenly remove only desired portions of the residue make it difficult to assure that residue biomass will be collected in a sustainable manner. Until the residue issue is addressed, particularly with regard to corn stover, deployment of the Agricultural Residue pathway will be severely constrained. The production and use of perennial energy crops also raise a number of sustainability questions (such as water and fertilizer inputs, establishment and harvesting impacts on soil, etc.) that have not been comprehensively addressed.

Ft-C. Crop Genetics: Current crops and potential new crops require improvement to achieve the production potential estimates of the billion ton vision. There is inadequate information on plant biochemistry as well as insufficient genomic and metabolic data on many potential biomass crops. Genetic modification of energy crops for improved characteristics may create risks to native populations of related species, and any modification of commodity crops to improve residue characteristics may affect grain values.

Ft-D. Sustainable Harvest: Current crop harvesting machinery is unable to selectively harvest desired components of biomass and address the soil carbon and erosion sustainability constraints. Biomass variability places high demand and functional requirements on biomass harvesting equipment. Current systems cannot meet the capacity, efficiency, or delivered price requirements of large cellulosic biorefineries, nor can they effectively deal with the large biomass yields per acre of potential new biomass feedstock crops. In addition, feedstock specifications and standards against which to engineer harvest equipment, technologies, and methods, do not currently exist

Ft-G. Feedstock Quality and Monitoring: Physical, chemical, microbiological, and post-harvest physiological variations in feedstocks arising from differences in variety, geographical location, and harvest methods are not well understood. Passive, noninvasive analytical tools and sensors for rapid and/or real-time compositional and conversion efficiency measurements for cellulosic feedstocks are needed. In addition, processor standards and specifications for feedstocks are not currently available.

Ft-H. Storage Systems: Engineering analysis of unconventional storage methods, including centralized versus distributed systems, is needed to define storage requirements. Key elements requiring better understanding include in storage biomass losses, infrastructure for packaged (i.e., bale, silage wrap, etc.) and bulk stored biomass, storage bulk density, and post-harvest physiology of storage systems. These storage elements need to be understood as a function of feedstock source, biomass moisture, climate, storage time, and cost. Stored biomass that is or becomes wet is susceptible to spoilage, rotting, spontaneous combustion, and odor problems, therefore, the impact of these post-harvest physiological processes must be controlled to the benefit of biorefining processes.

Ft-J. Biomass Material Properties: Data on biomass quality and physical property characteristics for optimum conversion are limited. Information on functional moisture relations on quality and physical properties of biomass as affected by crop variability and climatic conditions during harvest and post-harvest operations is incomplete. Methods and instruments for measuring physical and biomechanical properties of biomass are lacking.

Ft-K. Biomass Physical State Alteration (i.e., grinding, densification, and blending): The initial sizing and grinding of biomass affects efficiencies and quality of all the downstream operations, yet little information exists on these operations with respect to the multiplicity of cellulosic biomass resources and biomass format requirements for biorefining. New technologies and equipment are required to process biomass between the field and conversion facilities. The harvest season for most crop-based cellulosic biomass is short, especially in northern climates, thus requiring preprocessing systems that facilitate stable biomass storage, densification, and blending for year-round feedstock delivery to the biorefinery.

Ft-L. Biomass Material Handling and Transportation: The capital and operating costs for the existing package-based (i.e., bales, modules, pellets, etc.) equipment and facilities are not cost effective. The low density and fibrous nature of cellulosic biomass make it difficult and costly to collect, handle and transport. Present methodologies for collecting, storage handling, transport, and in-biorefinery handling of the biomass are too costly and inefficient for handling million ton quantities of biomass in a manner compliant with the efficiency and permitting requirements of cellulosic biorefineries.

Ft-M. Overall Integration: Existing biomass collection, handling, and transport systems are not designed for the large-scale needs of integrated biorefineries. Feedstock logistics infrastructure has not been defined for various locations, climates, feedstocks, storage methods, etc. The lack of experience with integrating time-sensitive collection, storage, transportation and delivery operations to ensure year-round supply of large amounts of biorefinery feedstock is a barrier to widespread implementation of biorefinery technology. The lack of data on variability of biomass resources and how this variability affects shelf life and processing yields are further barriers. In addition, it may be possible to better integrate one or more aspect of the feedstock supply system either alone or in combination with biorefinery operations. The lack of a quantitative analysis that assesses the benefits and drawbacks of these potential integration options is a potential barrier to cost savings and biorefinery efficiency improvement.

Biochemical Conversion

Bt-A. Biomass Fractionation: Fractionation can be used to increase the value of the individual components in biomass prior to their subsequent conversion to products. Currently, the interactions between chemical, biological, solvation (ability to go into solution), and mechanical processes to ultimately allow biomass to be more efficiently fractionated at high yield into high-purity components is insufficiently understood to implement commercially.

Bt-B. Biomass Variability: The characteristics of biomass can vary widely in terms of physical and chemical composition, size, shape, moisture content, and bulk density. These variations can make it difficult (or costly) to supply biorefineries with feedstocks of consistent, acceptable quality year-round, and also feedstock variability affects overall conversion rate and product yield of biomass conversion processes.

Bt-C. Biomass Recalcitrance: Lignocellulosic biomass feedstocks are naturally resistant to chemical and/or biological degradation. The fundamental role of biomass structure and composition and the critical physical and chemical properties that determine the susceptibility of cellulosic substrates to hydrolysis are not well understood. This lack of understanding of the root causes of the recalcitrance of biomass limits the ability to focus efforts to improve the cost-effectiveness and efficiency of pretreatment and other fractionation processes.

Bt-D. Pretreatment Chemistry: Thermochemical prehydrolysis of biomass, typically referred to as pretreatment, is required to break down the structure of biomass and increase its susceptibility to subsequent enzymatic hydrolysis by cellulase enzymes. The critical physical and chemical properties that determine the susceptibility of cellulosic substrates to hydrolysis and the role that lignin and other pretreatment products play in impeding access to cellulose are not well enough understood. Continued significant cost reductions in pretreatment technologies via improved sugar yields and quality require developing a better understanding of pretreatment process chemistries, including the kinetics of hemicellulose and cellulose hydrolysis.

Bt-E. Pretreatment Costs: Pretreatment reactors typically require expensive materials of construction to resist acid or alkali attack at elevated temperatures. In addition, the impact of reaction configuration and reactor design on thermochemical cellulose prehydrolysis is not well understood. Developing lower-cost pretreatments depends on the ability to process the biomass in reactors designed for maximum solid levels and fabricated out of cost-effective materials.

Bt-F. Cellulase Enzyme Production Cost: Cellulase enzymes remain a significant portion of the projected production cost of sugars from cellulosic biomass. Cost-effective enzyme production technologies are not currently available, although significant progress has been made through concerted efforts with industrial enzyme producers.

Bt-G. Cellulase Enzyme Loading: Reducing the cost of enzymatic hydrolysis depends on identifying more efficient enzyme preparations and enzyme hydrolysis regimes that permit more cost-effective and lower ratios of enzyme to substrate to be used.

Bt-H. Enzyme Biochemistry: Currently available enzymes do not exhibit the high thermostability and substantial resistance to sugar end-product inhibition. Developing enzymes that enable low-cost enzymatic hydrolysis technology requires more understanding of the fundamental mechanisms underlying the biochemistry of enzymatic cellulose hydrolysis, including the impact of biomass structure on enzymatic cellulose decrystallization. Additional efforts aimed at understanding the role of cellulases and their interaction not only with cellulose but also the process environment is needed to affect further reductions in cellulase cost.

Bt-I. Cleanup/Separation: Sugar solutions resulting from thermochemical pretreatment are impure, containing a mixture of sugars and a variety of non-sugar components. Potential impurities include acetic acid liberated upon hydrolysis of hemicellulose, lignin-derived phenolics solubilized during pretreatment, inorganic acids or alkalis or other compounds introduced during pretreatment, various salts, and hexose and pentose sugar degradation or transglycosylation products. The presence of some of the non-sugar components can be inhibitory to microbial fermentation or biocatalysis or can poison chemical catalysts. Low-cost purification technologies need to be developed that can remove impurities from hydrolysates and provide concentrated, clean sugar feedstocks to manufacture

Bt-J. Fuels Organism Development: Fermentation organisms used today have not been optimized for production of liquid fuels (ethanol, butanol and other alcohols) from the sugar mixture in the hydrolyzate broth produced during biomass pretreatment and enzymatic hydrolysis. For example, current organisms are not capable of utilizing the five-carbon sugar components, xylose and arabinose, in the biomass hydrolyzate as efficiently as glucose. In addition, impurities generated during pretreatment inhibit the organism, resulting in slow fermentations and incomplete utilization of sugars; this can lead to the need for costly purification. Improvements in fermentative organisms to perform in hydrolysate broths can significantly lower capital costs.

Bt-K. Biological Process Integration: Process integration remains a key technical barrier hindering development and deployment of biochemical conversion technologies. Biochemical conversion technologies currently present large scale-up risks because of lack of high-quality performance data on integrated processes carried out at the high solids conditions required for industrial operations. The effect of feed and process variations throughout the process must be understood to ensure robust, efficient biorefineries. Process integration work is essential for characterizing the complex interactions that exist between many of the processing steps, identifying unrecognized separation requirements, addressing bottlenecks and knowledge gaps, and generating the integrated performance data necessary to develop predictive mathematical models that can guide process optimization and

Bt-L. Biochemical/Thermochemical Processing Integration: Integration of the entire biorefinery is the final conversion barrier and overcoming it will require successful integration at the interfaces between the biochemical and thermochemical processes. For example, the lignin residue can be used as a feedstock for syngas or bio-oil production and for subsequent conversion to combined heat and power, fuels, or chemicals. Without planned and managed integration, the complete picture of biomass conversion to fuels and chemicals will not be clear enough to attract potential developers because the risks of commercialization will be too high for financiers. As conversion technologies mature, higher levels of integration will be feasible and second generation biorefineries are envisioned to be closely coupled biochemical / thermochemical facilities enabling the most efficient use of a wide range of feedstocks.

Thermochemical Conversion

Tt-A. Feeding Dry Biomass: In the near term, there are no significant barriers to feeding and handling dry wood or agricultural residues in atmospheric systems provided they are of a relatively uniform particle size. In the longer term, there is a need for improvements in the processing and feeding of dry biomass including densification and removal of problematic chemical contaminants (e.g. alkali species). Demonstrating reliable feeding of dry biomass into pressurized systems is also

Tt-B. Feeding or Drying Wet Biorefinery Streams: There is a need to understand the costs and trade-off of drying or feeding wet biorefinery residues such as wet lignin-rich fermentation residues. Innovative dryer designs capable of utilizing low-value process heat will be important to the integrated biorefinery.

Tt-C. Gasification of Wood, Biorefinery Residue Streams and Low Sugar Content Biomass: There is a need to understand the fuel chemistry and physical handling properties of other biomass feedstocks, minor byproducts and co-products, and biorefinery residual solids. This includes developing an understanding of gasification options and their chemistries for materials including wood, spent pulping liquors, agricultural residues that are high in minerals, high-lignin feedstocks and residues, and high-moisture organic residues.

Tt-E. Pyrolysis of Biomass: Development of new methods to control the pyrolytic pathways to bio-oil intermediates in order to increase product yield and recovery is needed. These product quality improvements are important to achieving the stability specifications of the resulting bio-oil and may also result in more favorable chemistry for processing in conventional petroleum refineries. New methods to clean and stabilize the bio-oil intermediate are also needed to ensure the product is compatible with refining technology. These advances include improved hydrotreating catalysts and techniques for processing the bio-oil.

Tt.-F. Syngas Cleanup and Conditioning: There is a near-term need for gas cleaning and conditioning technology that can cost-effectively remove contaminants such as tar, particulates, alkali, and sulfur. The interactions between the catalysts used for gas cleanup and conditioning, and the gasification conditions and feedstock are not well understood. These interactions require careful attention to trace contaminants.

Tt-G. Fuels Catalyst Development: The production of mixed alcohols from syngas has been known since the beginning of the last century; however, the commercial success of mixed alcohol synthesis has been limited by poor selectivity and low product yields. Improved catalysts with increased productivity and selectivity to higher alcohols are required to enable viable capital costs. The development of robust catalysts for the upgrading of pyrolysis oil for the production of liquid transportation fuels is critical to the economic viability of the process. The catalysts must afford high selectivity to the desired end product, be robust with respect to the pyrolysis oil impurities, and have high conversion rates and long lifetimes. Improvement to the robustness of hydrocracking catalysts for producing hydrocarbon biofuels via pyrolysis is also needed.

Tt-H. Validation of Syngas Quality: Syngas quality specifications for production of liquid fuel products like methanol/dimethyl ether (MeOH/DME), mixed alcohols and hydrocarbon liquids are reasonably well known. However, validation that syngas from biomass can meet the rigorous quality specification needed for the production of liquid fuels via catalytic synthesis is still needed.

Tt-I. Sensors and Controls: Effective process control will be needed to maintain plant performance and regulate emissions at target levels with varying load, fuel properties, and atmospheric conditions. Commercial control systems need to be developed for thermochemical processes and systems.

Integrated Biorefineries

Im-A. Political and Competitive Environment: The commercial use of biomass technologies is dependent on a variety of external factors which are beyond OBP's control. These exogenous variables include future energy prices, availability of conventional energy supplies, cost or success of competing technologies, labor and feedstock costs, and consumer preferences regarding energy sources.

Im-B. Lack of Feedstock Infrastructure: The uncertainty and concern for the reliability and affordability of feedstocks are a barrier to procuring capital funding for start-up biorefineries.

Im-C. Lack of Consideration of Externalities: The lack of a framework for the monetization and reward of external benefits, like energy security and environmental improvements, is a barrier to deploying biorefineries on a wide-scale basis.

Im-D. Biorefinery Plant Economics: The largest market hurdles are often associated with the scale-up and economics of pioneer plants, because the financial investment required will be high. Achieving design capacity as quickly as possible after start-up is critical to achieving economic viability. Reasonable estimates of plant performance will be key to attracting investors and future market

Im-E. Lack of Industry Standards and Regulations: The lack of a regulatory approach or cohesive strategy for the permitting of biorefineries has the potential to constrain biomass development and result in industry and financial institutions that are unwilling to accept the risks. The long lead time associated with developing and understanding new and revised regulations for new technology restricts commercialization. In the case of permitting, the lack of standard or consistent implementation of existing general regulations hampers development.

It-A. End-to-End Process Integration: Successful advances in biochemical processes and the biorefinery concept are co-dependent. This biorefinery concept encompasses a wide range of technical issues related to collecting, storing, transporting, and processing diverse feedstocks, as well as the complexity of integrating several innovative process steps, thus entailing considerable technical risk. The challenge of feed-to-product process integration is crucial, as it impacts both performance and profitability.

It-B. Commercial-Scale Demonstration Facilities: As with all new process technologies, demonstrating sustained integrated performance that meets technical, environmental and safety requirements at sufficiently large scale is an essential step toward commercialization. Demonstration facilities that are capable of testing and validating new technologies and integrated systems are critical to successful commercial deployment. Additionally, increased understanding of these combined systems will result in the optimization of process configurations. Integrating new bioenergy processes with existing biorefineries, while improving the efficiency of all biorefineries, are two critical areas of focus for the platform.

It-C. Risk of Pioneer Technology: The first biorefineries will incorporate a variety of new technologies. The number of new process steps implemented in a demonstration project has been shown to be a strong predictor of future performance shortfalls. Heat and mass balances, and their implications, are not likely to be well understood in regard to new technologies. In addition, the impact of unanticipated buildup of impurities in process streams that can result in abrasion and corrosion of plant equipment and deactivation of process catalysts is not well understood.

It-D. Sensors and Controls: Effective process control will be needed to maintain plant performance and emissions at target levels because of variability in processing conditions, load, feedstock and intermediate stream properties. Development of new sensors and analytical instruments is needed to optimize control systems for biochemical and thermochemical systems. There are several key technical barriers to consider, including the lack of real-time sensors for measuring feedstock moisture and composition, the need for better tools to analyze various process streams, and the lack of process control systems for reactor systems and subsystems.

It-E. Engineering Modeling Tools: The current level of understanding regarding fuels chemistry is insufficient for optimization, scale-up, and commercialization. In order to better understand how fuel chemistry affects commercial viability, rigorous engineering computational fluid dynamic models are needed. Engineering modeling tools are also needed to address heat integration issues.

Biofuels Distribution and End Use

Dm-A. Lack of Biofuels Distribution Infrastructure: The lack of infrastructure to transport, store and dispense biofuels puts biofuels at a disadvantage compared to conventional fuels that already have mature infrastructure. Today's biofuels distribution infrastructure, which includes about 1,000 E85 fueling stations, is concentrated in the Midwest, near the feedstocks (corn and soybeans) and ethanol and biodiesel production facilities. To contribute significantly to the 20 in 10 volumetric goal, expansion beyond this region of the country will be required.

Dm-B. Availability of Biofuels-Compatible Vehicles: About six million ethanol FFVs have been manufactured for the U.S. market, at a price competitive with conventional vehicles. However, at this time, only a limited number of vehicle model/fuel type combinations exist. In addition, most FFVs on the road today use less than 4 gallons of E85 per year due to the limited number of E85 pumps across the U.S.

Dm-C. Industry and Consumer Acceptance and Awareness: To be successful in the marketplace, biomass-derived products must perform at the same level or better than the existing fossil-energy-based products. Industry partners and consumers must believe in the quality, value and safety of biomass-derived products and their benefits.

Dt-A. Ethanol Pipeline Distribution Issues: Ethanol is a stronger solvent than the petroleum products moved via pipeline today. Consequently, ethanol will remove water, rust, gums and other contaminants from the existing petroleum pipeline distribution system. This downgrades the value of the delivered ethanol and adds back-end costs to restore the fuel to meet specifications. Construction of new dedicated ethanol pipelines are limited by the high cost of capital investment, insufficient ethanol supplies, materials compatibility issues, technologies that can measure quality in real time, and existing right-of-way agreements.

Dt-B. Limited Information Available for Developing Codes and Standards: National organizations that develop codes and standards recognize that additional date is required to integrate biofuels into the model codes for infrastructure construction. Thousands of local code jurisdictions in the U.S. adopt and modify these model codes for use in their jurisdictions. At this time, insufficient technical information hinders revision of various codes and standards in support of the quickly accelerating biofuels industry. Lack of codes as well as costly project permitting processes can stymie the introduction of new technologies, including infrastructure, into the marketplace.

Dt-C. Materials Compatibility Issues of Alcohol Fuels: Alcohol fuels and alcohol fuel blends require components throughout the infrastructure system (e.g., fuel storage, pipes and piping, and on-board vehicle systems) that are compatible with the higher electrical conductivity and solubility of the fuel. Higher cost materials, including stainless steel, lined fiberglass tanks, and mild steel with epoxy coatings, are often required to ensure compatibility and mitigate risk of decay or failure.

Dt-D. Increased Evaporative Hydrocarbon Emissions of Ethanol Blends: Adding ethanol to gasoline increases the fuel volatility, as measured by its Reid vapor pressure (RVP). The higher RVP results in higher evaporative hydrocarbon emissions from ethanol blends than from straight gasoline. Ethanol in gasoline also increases the permeability of plastic on-board fuel tanks, which in turn contributes to increased evaporative emissions.

Dt-E. Ethanol Blend Vehicle Fuel Economy: Since ethanol has a lower heating value than gasoline (83,000 Btu/gal for E85 vs. 113,500 Btu/gal for gasoline), E85 delivers a lower fuel economy when compared to gasoline on a gallon by gallon basis. Lower fuel economy can be counteracted by optimizing the engine design to take advantage of the higher octane rating of E85 (98 for E85 vs. 87 for gasoline).

Sustainability

St-A. Climate: Reduce greenhouse gas emissions associated with biofuel production, conversion and use, in comparison to fossil fuels.

St-B. Soil Health and Agronomics: Maintain or improve soil quality and land productivity.

St-C. Water Quality and Quantity: Increase water re-use efficiency and maintain or improve water quality.

St-D. Air Quality: Maintain or improve air quality by reducing the emissions of harmful pollutants such as SO2, NOx, and aromatic compounds.

St-E. Biological Diversity: Conserve biological diversity.

St-F. Land Use: Minimize negative land use change impacts domestically and globally.

St-G. Efficiency and Productivity: Enhance efficient use of nonrenewable resources and recovery of resources; maximize conversion efficiency and productivity.

St-H. Profitability: Lower production costs.

St-I. Rural Development: Enhance economic welfare and rural development through job creation and income growth.

St-J. Standards: Develop standards and corresponding metrics for ensuring sustainable biofuel production globally.

St-K. Energy Diversification and Security: Reduce dependence on foreign oil and increase energy supply diversity.

St-L. Net Energy Balance: Ensure positive net energy balance for all alternatives to fossil fuels.

1. Wet Mill Improvements Pathway	
Milestone #	**Milestone Title**
M.1	***Complete systems level demonstration and validation of technologies to improve corn wet mill facilities using corn grain feedstock***
M.1.1	Demonstrate and validate economical residual starch conversion in a wet mill
M.1.1.1	Convert residual starch in fiber stream to EtOH
M.1.1.2	Evaluate new feed product
M.1.1.3	Validate integrated process at pilot scale
M.1.1.4	Validate new process in wet mill
M.1.2	Demonstrate and validate economical fiber conversion to C5 and/or mixed C5/C6 sugars in a wet mill (residual starch also expected to be converted during fiber processing)
M.1.2.1	Solubilize hemicellulose in fiber to C5 sugars
M.1.2.2	Hydrolyze cellulose to C6 Sugar
M.1.2.3	Validate integrated process at pilot scale
M.1.2.4	Evaluate new feed product
M.1.2.5	Validate new process in wet mill
M.1.3	Demonstrate and validate economical conversion of mixed sugars to ethanol in a wet mill
M.1.3.1	Convert released sugars to ethanol
M.1.3.2	Validate integrated process at pilot scale
M.1.3.3	Validate new process in wet mill
M.1.4	Demonstrate and validate economical new products from C5 or mixed C5/C6 sugars in a wet mill
M.1.4.1	Convert released C5 sugars to products
M.1.4.2	Convert C5 sugars to building block chemicals
M.1.4.3	Convert mixed sugars to products
M.1.4.4	Convert mixed sugars to building block chemicals
M.1.4.5	Convert building block chemicals to products
M.1.4.6	Demonstrate product separation and recovery specification
M.1.4.10	Validate integrated process at pilot scale
M.1.4.11	Validate new process in wet mill
M.1.5	Demonstrate and validate economical new products from C6 sugars in a wet mill
M.1.5.1	Convert C6 sugars to products
M.1.5.2	Convert C6 sugars to building block chemicals
M.1.5.3	Convert building block chemicals to products
M.1.5.4	Demonstrate product separation and recovery specification
M.1.5.5	Validate integrated process at pilot scale
M.1.5.6	Validate new process in wet mill
M.1.6	Demonstrate and validate economical new products from corn-derived oils in a wet mill
M.1.6.1	Convert corn derived oils to products
M.1.6.2	Demonstrate product separation and recovery specification
M.1.6.3	Validate integrated process at pilot scale
M.1.6.4	Validate new process in wet mill
2. Dry Mill Improvements Pathway	
Milestone #	**Milestone Title**
M.2	***Complete systems level demonstration and validation of technologies to improve corn dry mill facilities using corn (or other) grain feedstock***

M.2.1	Demonstrate and validate economical residual starch conversion in a dry mill
M.2.1.1	Conversion of residual starch to glucose
M.2.1.2	Evaluate new feed product
M.2.1.3	Conversion of converted glucose to ethanol
M.2.1.4	Validate integrated process in a dry mill
M.2.2	Demonstrate and validate economical fiber conversion in a dry mill (residual starch also expected to be converted during fiber processing)
M.2.2.1	Convert fiber to monomer sugars
M.2.2.2	Evaluate new feed product
M.2.2.3	Validate integrated process at pilot scale
M.2.2.4	Validate new process in dry mill
M.2.3	Demonstrate and validate economical conversion of mixed sugars to ethanol in a dry mill
M.2.3.2	Convert released sugars to ethanol
M.2.3.4	Validate integrated process at pilot scale
M.2.3.5	Validate new process in dry mill
MI.1	Demonstrate and validate economical corn fiber-to-ethanol in a dry mill.
M.2.4	Demonstrate and validate economical conversion of mixed sugars to products in a dry mill
M.2.4.1	Conversion targets from C6 sugars to building blocks
M.2.4.2	Conversion targets from building blocks to products
M.2.4.3	Demonstrate product separation and recovery specification
M.2.4.4	Validate integrated process at pilot scale
M.2.4.5	Validate new process in dry mill
M.2.5	Demonstrate and validate economical new products from C6 sugars in a dry mill
M.2.5.1	Conversion targets from C6 sugars to building blocks
M.2.5.2	Conversion targets from building blocks to products
M.2.5.3	Product separation specification
M.2.5.4	Validate integrated process at pilot scale
M.2.5.5	Validate new process in dry mill
M.2.6	Demonstrate and validate economical front end fractionation processes in a dry mill
M.2.6.1	Derive additional value added products from front end fractionation
M.2.6.2	Evaluate new feed coproducts
M.2.6.3	Validate integrated process at pilot scale
M.2.6.4	Validate new process in dry mill
M.2.7	Investigate alternate sources for dry mill heat and power
M.2.7.1	Thermochemical processing of fiber stream to heat, power
M.2.7.2	Thermochemical processing of residues (i.e. corn stover) to heat, power
M.2.7.3	Validate integrated process at pilot scale
M.2.7.4	Validate new process in dry mill
3. Oil Mill Improvements Pathway	
Milestone #	**Milestone Title**
M.3	***Complete systems level demonstration and validation of technologies to improve oil processing mill facilities***
M.3.1	Demonstrate and validate economical and sustainable new oil crop production for production of biodiesel and other renewable diesel alternatives
M.3.1.1	Demonstrate sustainable agronomic practices
M.3.1.2	Demonstrate oil crop harvesting

M.3.1.3	Demonstrate oil crop storage
M.3.1.4	Demonstrate oil crop transportation
M.3.1.5	Demonstrate quality and quantity of oil crop available
M.3.1.6	Validate integrated oil crop logistics at pilot scale
M.3.1.7	Validate integrated oil crop logistics at demonstration scale
M.3.2	Demonstrate and validate economical new products from glycerol in a natural oil processing facility
M.3.2.1	Convert glycerol to products
M.3.2.2	Recover new products
M.3.2.3	Validate integrated process at pilot scale
M.3.2.4	Validate integrated process in natural oil processing facility
M.3.3	Demonstrate and validate economical new fuels from oils in natural oil processing facility
M.3.3.1	Convert oil to fuels
M.3.3.2	Recover fuels
M.3.3.3	Validate integrated process at pilot scale
M.3.3.4	Validate integrated process in natural oil processing facility
M.3.4	Demonstrate and validate economical new products from oils in natural oil processing facility
M.3.4.1	Convert oil to products
M.3.4.2	Convert oils to building block chemicals
M.3.4.3	Convert building block chemicals to products
M.3.4.4	Recover new products
M.3.4.5	Validate integrated process at pilot scale
M.3.4.6	Validate integrated process in natural oil processing facility
M.3.5	Demonstrate and validate economical cleanup of waste fats and greases for fuel production
M.3.5.1	Validate cleanup performance
M.3.5.2	Validate integrated cleanup at pilot scale
M.3.5.3	Validate integrated process in natural oil processing facility
4. Agricultural Residue Processing Pathway	
Milestone #	**Milestone Title**
M.4	***Complete systems level demonstration and validation of all key technologies to utilize agricultural residue feedstocks in existing or new facilities***
JI.2007	Complete preliminary engineering design package, market analysis, and financial projedctionfor at least two industrial-scale projects consistent with EPAct 2005 requirements.
JI.2008	Approve a final engineering design package of at least one commercial scale biorefinery (up to 700 metric tons per day of feedstock) including findings from an independent engineering review.
JI.2009	Complete engineering design package, market analysis and finanical projections for at least one industrial-scale biorefinery (1-3 MGY).
JI.2009	Initiate construction of at least one commerical-scale biorefinery project (700 tons/day feedstock) including hard orders for all tangible equiopment, vendor packages and structural steel.
JI.2010	Complete commissioning and preliminary operation of at least one commercial-scale biorefinery project (700 tons/day feedstock processed)
JI.2011	Complete constuction, mechanical completion, and commissioning of a 10% industrial scale biorefinery (1-3 million gallons/year) in support of nth plant economics at $1.31 (2007$) per gallon of ethanol by 2012.
JI.2011	Validate economics, system performance, of at least one commercial-scale biorefinery project (700 tons/day feedstock processed) awarded in FY2007 in support of nth plant economics at $1.31 per gallon of ethanol by 2012. (2007$)
JI.2012	Using commercial scale biorefinery and 10% industrial-scale biorefinery performance, validate nth plant economics at the $1.31/gal ethanol (2007$).

MI.6	Demonstrate and validate integrated agricultural residues-to-ethanol process at demonstration or commercial scale (Biochemical route)
MI.19	Demonstrate and validate production of ethanol from mixed alcohols produced from agricultural residues-derived syngas at demonstration or commercial scale.
JF.2008	Conduct replicated field trials across regions to determine the impact of residue removal on grain yield, and energy crops to assuess resource supply cost and potential and to optimize biorefinery location
JF.2009	Implement a GIS-based regional feedstock atlas system linked to the lateste National Agricultural Statistic Service data, energy crop field test resultes and residue removal trial results
JF.2010	Complete a core R&D engineering design that can receive multiple feedstock resources and preprocess them into cellulosic feedstock for an average of $35 per ton delivered to biorefineries.
JF.2011	In conjunction with USDA, land grant universities, and private sector, incorporate yield and othe data from field trials. Complete and validate dry and woody feedstocks at $35 per ton in line with 2012 goal.
JF.2012	Feedstocks (wet, dry, and woody) in support of $1.07 per gallon cost target will be validated on a regional basis.
M.4.1	Demonstrate and validate integrated corn stover harvesting logistics
M.4.1.1	Demonstrate sustainable corn agronomic practices that account for corn stover harvesting
M.4.1.2	Demonstrate wet and dry corn stover harvesting
M.4.1.3	Demonstrate wet and dry corn stover storage
M.4.1.4	Demonstrate wet and dry corn stover transportation
M.4.1.5	Demonstrate wet and dry quality and quantity of corn stover available
M.4.1.6	Demonstrate corn stover preprocessing benefits
M.4.1.7	Validate integrated corn stover logistics in prototype equipment
M.4.1.8	Validate integrated corn stover logistics at demonstration scale
M.4.2	Demonstrate and validate integrated wheat straw harvesting logistics
M.4.2.1	Demonstrate sustainable wheat agronomic practices that account for wheat straw harvesting
M.4.2.2	Demonstrate wet and dry wheat straw harvesting
M.4.2.3	Demonstrate wet and dry wheat straw storage
M.4.2.4	Demonstrate wet and dry wheat straw transportation
M.4.2.5	Demonstrate wet and dry quality and quantity of wheat straw available
M.4.2.6	Demonstrate wheat straw preprocessing benefits
M.4.2.7	Validate integrated wheat straw logistics in prototype equipment
M.4.2.8	Validate integrated wheat straw logistics at demonstration scale
M.4.3	Demonsrate and validate integrated rice straw harvesting logistics
M.4.3.1	Demonstrate sustainable rice agronomic practices that account for rice straw harvesting
M.4.3.2	Demonstrate wet and dry rice straw harvesting
M.4.3.3	Demonstrate wet and dry rice straw storage
M.4.3.4	Demonstrate wet and dry rice straw transportation
M.4.3.5	Demonstrate wet and dry quality and quantity of rice straw available
M.4.3.6	Demonstrate rice straw preprocessing benefits
M.4.3.7	Validate integrated rice straw logistics in prototype equipment
M.4.3.8	Validate integrated rice straw logistics at demonstration scale
M.4.4	Feedstock FlexIbility and Availability via Blending Depot or Elevator
M.4.4.1	To be determined
M.4.5	Demonstrate and validate ag residue fractionation to produce mixed, dilute biomass sugars
M.4.5.1	Validate cellulase enzyme cost
M.4.5.2	Validate pretreatment technology cost

M.4.5.3	Demonstrate ability to economically satisfy internal heat and power demands
M.4.5.4	Validate capital cost
M.4.5.5	Validate integrated pretreatment and enzymatic hydrolysis at pilot scale
M.4.5.6	Validate integrated pretreatment and enzymatic hydrolysis at demonstration scale
M.4.5.7	Validate feed flexibility in integrated system
M.4.6	Demonstrate and validate ethanol from 5 biomass sugars
M.4.6.1	Validate fermentation of all 5 sugars to produce ethanol
M.4.6.2	Optimize ethanol separation
M.4.6.3	Optimize integrated production of ethanol from sugars at pilot scale
M.4.6.4	Optimize integrated production of ethanol from sugars at demonstration scale
JB.2007	Complete integrated tests of pretreatment and enzymatic hydrolysis in conjunction with existing fermentation organisms at bench scale on corn stover that validate the $0.125 per pound sugars on the pathway to achieving $0.064 per pound in 2012.
JB.2010	Achieve 85% xylan-to-xylose conversion with chemical and/or enzymatic hydrolysis that contribute, via increased ethanol yield, to the $1.31 per gallon (2007$) selling price.
JB.2011	Data from integrated runs of pretreatment and enzymatic hydrolysis at lab scale combined with a process design and cost estimate validates that an integrated biorefinery potentially could produce ethanol at a $1.31 per gallon (2007$) selling price
MB.14	Validate integrated corn stover-to-ethanol pilot operation
JB.2012	Data from integrated pilot operation combined with process design and cot estimate validates a $1.31 per gallon (2007$) selling price.
M.4.7	Demonstrate and validate chemical building blocks, chemicals or materials from 5 biomass sugars
M.4.7.1	Optimize chemical building blocks production
M.4.7.2	Optimize high value chemical production
M.4.7.3	Optimize product separation
M.4.7.4	Optimize integrated production of product(s) from sugars at pilot scale
M.4.7.5	Optimize integrated production of product(s)from sugars at demonstration scale
M.4.8	Demonstrate and validate high value chemical and material products from lignin intermediates
M.4.8.1	Demonstrate high value chemical/material production from lignin
M.4.8.2	Validate product separation
M.4.8.3	Validate integrated production of product(s)from lignin at pilot scale
M.4.8.4	Validate integrated production of product(s)from lignin at demonstration scale
M.4.9	Demonstrate and validate fuel products from lignin intermediates
M.4.9.1	Demonstrate direct fuel production from lignin
M.4.9.2	Validate fuel product separation
M.4.9.3	Validate integrated production of fuel(s)from lignin at pilot scale
M.4.9.4	Validate integrated production of fuels(s)from lignin at demonstration scale
M.4.10	Demonstrate and validate combined heat and power from lignin intermediates/residues
M.4.10.1	Demonstrate combined heat and power production from lignin
M.4.10.2	Validate integrated production of heat and power from lignin at pilot scale
M.4.10.3	Validate integrated production of heat and power from lignin at demonstration scale
M.4.11	Demonstrate and validate lignin gasification to produce syngas
M.4.11.1	Validate feeder system performance
M.4.11.2	Validate gasification performance
M.4.11.3	Validate gas cleanup performance
M.4.11.4	Validate capital costs
M.4.11.5	Validate integrated gasification and gas cleanup at pilot scale

M.4.11.6	Validate integrated gasification and gas cleanupat demonstration scale
M.4.12	Demonstrate and validate biomass gasification to produce syngas
M.4.12.1	Validate feeder systems to reliably feed solid biomass to high pressure (30 bar) systems
M.4.12.2	Validate gasification performance
M.4.12.3	Validate gas cleanup performance
M.4.12.4	Validate capital costs
M.4.12.5	Validate integrated gasification and gas cleanup at pilot scale
M.4.12.6	Validate integrated gasification and gas cleanupat demonstration scale
M.4.12.7	Validate feed flexibility in integrated system
JT.2007	Demonstrate conversion of 50% of non-methane (C2+ higher) hydrocarbons that result in a syngas cost of $7.15/MBtu in 2007.
JT.2009	Validate technology capable of economically converting biomass residues, pulping liquors or waste fats and greases to synthesis gas or bio-oils that are suitable for fuels and chemicals produciton. The target is a modeled cost of $5.81/Mbtu in 2009.
JT.2010	Validate and demonstrate technology for the cost-effective cleanup of biomass synthesis gas leading to a modeled syngas cost of $5.40/Mbtu in 2010.
M.4.13	Demonstrate and validate ethanol from mixed alcohols using lignin or biomass derived syngas
M.4.13.1	Demonstrate ethanol production from mixed alcohols
M.4.13.2	Validate ethanol separation
M.4.13.3	Validate integrated production of ethanol from syngas at pilot scale
M.4.13.4	Validate integrated production of ethanol from syngas at demonstration scale
MT.19	Validate integrated corn stover/wheat straw-to-ethanol (via gasification) pilot operation.
M.4.14	Demonstrate and validate hydrogen production from lignin or biomass derived syngas
M.4.14.1	Demonstrate optimized hydrogen production from syngas
M.4.14.2	Validate hydrogen separation/recovery
M.4.14.3	Validate integrated production of hydrogen from syngas at pilot scale
M.4.14.4	Validate integrated production of hydrogen from syngas at demonstration scale
M.4.15	Demonstrate and validate combined heat and power production from lignin or biomass derived syngas
M.4.15.1	Demonstrate combined heat and power production from syngas
M.4.15.2	Validate integrated production of heat and power from syngas at pilot scale
M.4.15.3	Validate integrated production of heat and power from syngas at demonstration scale
M.4.16	Demonstrate and validate non-ethanol fuels from lignin or biomass derived syngas
M.4.16.1	Demonstrate non-ethanol fuel production from lignin or biomass-derived syngas
M.4.16.2	Validate non-ethanol fuel separation
M.4.16.3	Validate integrated production of non-ethanol fuels from syngas at pilot scale
M.4.16.4	Validate integrated production of non-ethanol fuels from syngas at demonstration scale
M.4.17	Demonstrate and validate product(s) from lignin or biomass derived syngas
M.4.17.1	Demonstrate high value chemical/material production (C3-C5 alcohols) from syngas
M.4.17.2	Validate product(s) separation
M.4.17.3	Validate integrated production of product(s) from syngas at pilot scale
M.4.17.4	Validate integrated production of product(s) from syngas at demonstration scale
M.4.18	Demonstrate and validate non-ethanol fuels from 5 biomass sugars that are econonomically viable
M.4.18.1	Validate fermentation of all 5 sugars to produce non-ethanol fuels
M.4.18.2	Optimize non-ethanol fuel separation
M.4.18.3	Optimize integrated production of non-ethanol fuels from sugars at pilot scale
M.4.18.4	Optimize integrated production of non-ethanol fuel from sugars at demonstration scale

M.4.19	Demonstrate and validate biomass pyrolysis to produce pyrolysis oil intermediate
M.4.19.1	Validate feeder systems to reliably feed solid biomass to pyrolysis reactor high pressure (30 bar) systems
M.4.19.2	Validate pyrolysis performance
M.4.19.3	Validate pyrolysis oil cleanup performance
M.4.19.4	Validate capital costs - ROI hurdle rate versus cost magnitude hurdle amount
M.4.19.5	Validate integrated pyrolysis and pyrolysis oil cleanup at pilot scale
M.4.19.6	Validate integrated pyrolysis and pyrolysis oil cleanup at demonstration scale
M.4.19.7	Validate feed flexibility in integrated system
M.4.20	Demonstrate and validate fuels from pyrolysis oil intermediate
M.4.20.1	Demonstrate fuel production from pyrolysis oil intermediate
M.4.20.2	Validate fuel separation
M.4.20.3	Validate integrated production of fuels from pyrolysis oil at pilot scale
M.4.20.4	Validate integrated production of fuels from pyrolysis oil at demonstration scale
M.4.21	Demonstrate and validate high value chemical and material products from pyrolysis oil intermediates
M.4.21.1	Demonstrate high value chemical/material production from pyrolysis oil
M.4.21.2	Validate product separation
M.4.21.3	Validate integrated production of product(s)from pyrolysis oil at pilot scale
M.4.21.4	Validate integrated production of product(s)from pyrolysis oil at demonstration scale
5. Perennial Crop Processing Pathway Milestones	
Milestone #	**Milestone Title**
M.5	***Complete systems level demonstration and validation of all key technologies to utilize perennial crops in existing or new facilities***
JF.2008	Conduct replicated field trials across regions to determine the impact of residue removal on grain yield, and energy crops to assuess resource supply cost and potential and to optimize biorefinery location
JF.2009	Implement a GIS-based regional feedstock atlas system linked to the latest National Agricultural Statistic Service data, energy crop field test resultes and residue removal trial results
JF.2010	Incorporate new varieties/clones developed at land grants, universities and private sector into regionally-based field trial sites. Update GIS system with new information obtained from trials and initiate new trials for post-2012 timeframe.
JF.2010	Complete a core R&D engineering design that can receive multiple feedstock resources and preprocess them into cellulosic feedstock for an average of $35 per ton delivered to biorefineries.
JF.2011	In conjunction with USDA, land grant universities, and private sector, incorporate yield and othe data from field trials. Complete and validate dry and woody feedstocks at $35 per ton in line with 2012 goal.
JF.2012	Feedstocks (wet, dry, and woody) in support of $1.07 per gallon cost target will be validated on a regional basis.
M.5.1	Demonstrate and validate integrated switchgrass production and harvesting logistics
M.5.1.1	Demonstrate sustainable switchgrass agronomic practices
M.5.1.2	Demonstrate wet and dry switchgrass harvesting
M.5.1.3	Demonstrate wet and dry switchgrass storage
M.5.1.4	Demonstrate wet and dry switchgrass transportation
M.5.1.5	Demonstrate quality and quantity of switchgrass available
M.5.1.6	Demonstrate switchgrass prepprocessing benefits
M.5.1.7	Validate integrated switchgrass logistics in prototype equipment
M.5.1.8	Validate integrated switchgrass logistics at demonstration scale
M.5.2	Demonstrate and validate integrated woody crop harvesting logistics
M.5.2.1	Demonstrate sustainable woody crop agronomic practices
M.5.2.2	Demonstrate woody crop harvesting

M.5.2.3	Demonstrate woody crop storage
M.5.2.4	Demonstrate woody crop transportation
M.5.2.5	Demonstrate quality and quantity of woody crops available
M.5.2.6	Demonstrate woody crop preprocessing benefits
M.5.2.7	Validate integrated woody crop logistics in prototype equipment
M.5.2.8	Validate integrated woody crop logistics at demonstration scale
M.5.3	Feedstock Flexlbility and Availability via Blending Depot or Elevator
M.5.3.1	To be determined
M.5.4	Demonstrate and validate switchgrass fractionation to produce mixed biomass sugars
M.5.4.1	Validate cellulase enzyme cost
M.5.4.2	Validate pretreatment technology cost
M.5.4.3	Demonstrate ability to economically satisfy internal heat and power demands
M.5.4.4	Validate capital cost
M.5.4.5	Validate integrated pretreatment and enzymatic hydrolysis at pilot scale
M.5.4.6	Validate integrated pretreatment and enzymatic hydrolysis at demonstration scale
M.5.4.7	Validate feed flexibility in integrated system
JB.2008	Achieve a modeled cost target of $0.11 per pound of sugars (equivalent to $2.09 per gallon of cellulosic ethanol) through the formulation of improved enzyme mixtures and pretreatments.
JB.2009	Demonstrate alternative pretreatment technologies integrated with enzymatic hydrolysis at lab scale that have the potential of contributing ot the $1.31 per gallon (2007$) ethanol selling price target in 2012.
M.5.5	Demonstrate and validate woody crop fractionation to produce mixed, dilute biomass sugars
M.5.5.1	Validate cellulase enzyme cost
M.5.5.2	Validate pretreatment technology cost
M.5.5.3	Demonstrate ability to economically satisfy internal heat and power demands
M.5.5.4	Valicate capital cost
M.5.5.5	Validate integrated pretreatment and enzymatic hydrolysis at pilot scale
M.5.5.6	Validate integrated pretreatment and enzymatic hydrolysis at demonstration scale
M.5.5.7	Validate feed flexibility in integrated system
MB.15	Validate integrated switchgrass-to-ethanol pilot operation
M.5.6	Demonstrate and validate ethanol from 5 biomass sugars
M.5.6.1	Validate ethanol production
M.5.6.2	Validate ethanol separation/recovery
M.5.6.3	Validate integrated production of product(s)from sugars at pilot scale
M.5.6.4	Validate integrated production of product(s)from sugars at demonstration scale
M.5.7	Demonstrate and validate products from 5 biomass sugars
M.5.7.1	Validate chemical building blocks production
M.5.7.2	Validate high value chemical production
M.5.7.3	Validate product separation
M.5.7.4	Validate integrated production of product(s)from sugars at pilot scale
M.5.7.5	Validate integrated production of product(s)from sugars at demonstration scale
M.5.8	Demonstrate and validate high value chemical and material products from lignin intermediates
M.5.8.1	Demonstrate high value chemical/material production from lignin
M.5.8.2	Validate product separation
M.5.8.3	Validate integrated production of product(s)from lignin at pilot scale

M.5.8.4	Validate integrated production of product(s)from lignin at demonstration scale
M.5.9	Demonstrate and validate fuel products from lignin intermediates
M.5.9.1	Demonstrate direct fuel production from lignin
M.5.9.2	Validate fuel product separation
M.5.9.3	Validate integrated production of fuel(s)from lignin at pilot scale
M.5.9.4	Validate integrated production of fuels(s)from lignin at demonstration scale
M.5.10	Demonstrate and validate combined heat and power from lignin intermediates/residues
M.5.10.1	Demonstrate combined heat and power production from lignin
M.5.10.2	Validate integrated production of heat and power from lignin at pilot scale
M.5.10.3	Validate integrated production of heat and power from lignin at demonstration scale
M.5.11	Demonstrate and validate lignin gasification to produce syngas
M.5.11.1	Validate feeder system performance
M.5.11.2	Validate gasification performance
M.5.11.3	Validate gas cleanup performance
M.5.11.4	Validate capital costs - ROI hurdle rate versus cost magnitude hurdle amount
M.5.11.5	Validate integrated gasification and gas cleanup at pilot scale
M.5.11.6	Validate integrated gasification and gas cleanup at demonstration scale
M.5.12	Demonstrate and validate biomass gasification to produce syngas
M.5.12.1	Validate feeder systems to reliably feed solid biomass to high pressure (30 bar) systems
M.5.12.2	Validate gasification performance
M.5.12.3	Validate gas cleanup performance
M.5.12.4	Validate capital costs
M.5.12.5	Validate integrated gasification and gas cleanup at pilot scale
M.5.12.6	Validate integrated gasification and gas cleanupat demonstration scale
M.5.12.7	Validate feed flexibility in integrated system
JT.2007	Demonstrate conversion of 50% of non-methane (C2+ higher) hydrocarbons that result in a syngas cost of $7.15/MBtu in 2007.
JT.2010	Validate and demonstrate technology for the cost-effective cleanup of biomass synthesis gas leading to a modeled syngas cost of $5.40/Mbtu in 2010.
M.5.13	Demonstrate and validate ethanol from mixed alcohols using lignin or biomass derived syngas
M.5.13.1	Demonstrate ethanol production from mixed alcohols
M.5.13.2	Validate ethanol separation
M.5.13.3	Validate integrated production of ethanol from syngas at pilot scale
M.5.13.4	Validate integrated production of ethanol from syngas at demonstration scale
MT.20	Validate integrated switchgrass/hybrid poplar-to-ethanol (via gasification) pilot operation.
M.5.14	Demonstrate and validate hydrogen production from lignin or biomass derived syngas
M.5.14.1	Demonstrate optimized hydrogen production from syngas
M.5.14.2	Validate hydrogen separation/recovery
M.5.14.3	Validate integrated production of hydrogen from syngas at pilot scale
M.5.14.4	Validate integrated production of hydrogen from syngas at demonstration scale
M.5.15	Demonstrate and validate combined heat and power production from lignin or biomass derived syngas
M.5.15.1	Demonstrate combined heat and power production from syngas
M.5.15.2	Validate integrated production of heat and power from syngas at pilot scale
M.5.15.3	Validate integrated production of heat and power from syngas at demonstration scale
M.5.16	Demonstrate and validate non-ethanol fuels from lignin or biomass derived syngas

M.5.16.1	Demonstrate non-ethanol fuel production from lignin or biomass-derived syngas
M.5.16.2	Validate non-ethanol fuel separation
M.5.16.3	Validate integrated production of non-ethanol fuels from syngas at pilot scale
M.5.16.4	Validate integrated production of non-ethanol fuels from syngas at demonstration scale
M.5.17	Demonstrate and validate product(s) from lignin or biomass derived syngas
M.5.17.1	Demonstrate high value chemical/material production (C3-C5 alcohols) from syngas
M.5.17.2	Validate product(s) separation
M.5.17.3	Validate integrated production of product(s) from syngas at pilot scale
M.5.17.4	Validate integrated production of product(s) from syngas at demonstration scale
M.5.18	Demonstrate and validate non-ethanol fuels from 5 biomass sugars that are econonomically viable
M.5.18.1	Validate fermentation of all 5 sugars to produce non-ethanol fuels
M.5.18.2	Optimize non-ethanol fuel separation
M.5.18.3	Optimize integrated production of non-ethanol fuels from sugars at pilot scale
M.5.18.4	Optimize integrated production of non-ethanol fuel from sugars at demonstration scale
M.5.19	Demonstrate and validate biomass pyrolysis to produce pyrolysis oil intermediate
M.5.19.1	Validate feeder systems to reliably feed solid biomass to pyrolysis reactor high pressure (30 bar) systems
M.5.19.2	Validate pyrolysis performance
M.5.19.3	Validate pyrolysis oil cleanup performance
M.5.19.4	Validate capital costs - ROI hurdle rate versus cost magnitude hurdle amount
M.5.19.5	Validate integrated pyrolysis and pyrolysis oil cleanup at pilot scale
M.5.19.6	Validate integrated pyrolysis and pyrolysis oil cleanup at demonstration scale
M.5.19.7	Validate feed flexibility in integrated system
M.5.20	Demonstrate and validate fuels from pyrolysis oil intermediate
M.5.20.1	Demonstrate fuel production from pyrolysis oil intermediate
M.5.20.2	Validate fuel separation
M.5.20.3	Validate integrated production of fuels from pyrolysis oil at pilot scale
M.5.20.4	Validate integrated production of fuels from pyrolysis oil at demonstration scale
M.5.21	Demonstrate and validate high value chemical and material products from pyrolysis oil intermediates
M.5.21.1	Demonstrate high value chemical/material production from pyrolysis oil
M.5.21.2	Validate product separation
M.5.21.3	Validate integrated production of product(s)from pyrolysis oil at pilot scale
M.5.21.4	Validate integrated production of product(s)from pyrolysis oil at demonstration scale
6. Forest Resources Processing	
Milestone #	**Milestone Title**
M.6	***Complete systems level demonstration and validation of technologies to improve pulp and paper mill facilities and/or produce additional products (fuels, chemicals and /or power) from wood feedstock in a pulp and paper mill environment***
JF.2010	Complete a core R&D engineering design that can receive multiple feedstock resources and preprocess them into cellulosic feedstock for an average of $35 per ton delivered to biorefineries.
JF.2011	In conjunction with USDA, land grant universities, and private sector, incorporate yield and othe data from field trials. Complete and validate dry and woody feedstocks at $35 per ton in line with 2012 goal.
JF.2012	Feedstocks (wet, dry, and woody) in support of $1.07 per gallon cost target will be validated on a regional basis.
M.6.1	Demonstrate and validate integrated logging residue and forest thinnings collection and logistics
M.6.1.1	Demonstrate sustainable logging practices
M.6.1.2	Demonstrate logging residue collection

M.6.1.3	Demonstrate forest thinnings collection
M.6.1.4	Demonstrate logging residue and forest thinnings transportation
M.6.1.5	Demonstrate quality and quantity of logging residue and forest thinnings available
M.6.1.6	Demonstrate logging residue and forest thinnings preprocessing benefits
M.6.1.7	Validate integrated logging residue and forest thinnings logistics in prototype equipment
M.6.1.8	Validate integrated logging residue and forest thinnings logistics at demonstration scale
M.6.2	Demonstrate and validate integrated fuel treatment biomass collection and logistics
M.6.2.1	Demonstrate fuel treatment biomass collection
M.6.2.2	Demonstrate fuel treatment biomass storage
M.6.2.3	Demonstrate fuel treatment biomass transportation
M.6.2.4	Demonstrate fuel treatment biomass quality and quantity of available
M.6.2.5	Demonstrate fuel treatment biomass preprocessing benefits
M.6.2.6	Validate integrated fuel treatment biomass logistics in prototype equipment
M.6.2.7	Validate integrated fuel treatment biomass logistics at demonstration scale
M.6.3	Demonstrate and validate forest resources fractionation to produce mixed, dilute biomass sugars
M.6.3.1	Validate cellulase enzyme cost
M.6.3.2	Validate pretreatment technology cost
M.6.3.3	Demonstrate ability to economically satisfy internal heat and power demands
M.6.3.4	Validate capital cost
M.6.3.5	Validate integrated pretreatment and enzymatic hydrolysis at pilot scale
M.6.3.6	Validate integrated pretreatment and enzymatic hydrolysis at demonstration scale
M.6.3.7	Validate feed flexibility in integrated system
M.6.4	Demonstrate and validate ethanol from 5 biomass sugars
M.6.4.1	Validate fermentation of all 5 sugars to produce ethanol
M.6.4.2	Optimize ethanol separation
M.6.4.3	Optimize integrated production of ethanol from sugars at pilot scale
M.6.4.4	Optimize integrated production of ethanol from sugars at demonstration scale
M.6.5	Demonstrate and validate non-ethanol fuels from 5 biomass sugars
M.6.5.1	Validate fermentation of all 5 sugars to produce non-ethanol fuels
M.6.5.2	Optimize fuel separation
M.6.5.3	Optimize integrated production of non-ethanol fuels from sugars at pilot scale
M.6.5.4	Optimize integrated production of non-ethanol fuels from sugars at demonstration scale
M.6.6	Demonstrate and validate chemical building blocks, chemicals or materials from 5 biomass sugars
M.6.6.1	Optimize chemical building blocks production
M.6.6.2	Optimize high value chemical production
M.6.6.3	Optimize product separation
M.6.6.4	Optimize integrated production of product(s) from sugars at pilot scale
M.6.6.5	Optimize integrated production of product(s) from sugars at demonstration scale
M.6.7	Demonstrate and validate fuel products from lignin intermediates
M.6.7.1	Demonstrate direct fuel production from lignin
M.6.7.2	Validate fuel product separation
M.6.7.3	Validate integrated production of fuel(s) from lignin at pilot scale
M.6.7.4	Validate integrated production of fuels(s) from lignin at demonstration scale
M.6.8	Demonstrate and validate high value chemical and material products from lignin intermediates

M.6.8.1	Demonstrate high value chemical/material production from lignin
M.6.8.2	Validate product separation
M.6.8.3	Validate integrated production of product(s) from lignin at pilot scale
M.6.8.4	Validate integrated production of product(s) from lignin at demonstration scale
M.6.9	Demonstrate and validate combined heat and power from lignin intermediates/residues
M 6.9.1	Demonstrate combined heat and power production from lignin
M 6.9.2	Validate integrated production of heat and power from lignin at pilot scale
M 6.9.3	Validate integrated production of heat and power from lignin at demonstration scale
M 6.10	Demonstrate and validate lignin gasification to produce syngas
M 6.10.1	Validate feeder system performance
M 6.10.2	Validate gasification performance
M 6.10.3	Validate gas cleanup performance
M 6.10.4	Validate capital cost
M 6.10.5	Validate integrated gasification and gas cleanup at pilot scale
M 6.10.6	Validate integrated gasification and gas cleanup at demonstration scale
M 6.11	Demonstrate and validate cost-effective biomass gasification of wood, forest residues and other process residues and synthesis gas cleanup in a forest resources mill environment
M 6.11.1	Develop cost effective gasification designs for syngas production at appropriate scale
M 6.11.2	Validate feeder system performance to reliably feed solids to high pressure (30 bar) systems)
M 6.11.3	Validate gasification performance
M 6.11.4	Validate cost-effective gas cleanup performance
M 6.11.5	Validate integrated biomass gasification and syngas cleanup process at pilot scale
M 6.11.6	Validate integrated biomass gasification and syngas cleanup process in a forest resources mill environment
	Validate feed flexibility in integrated system
JT.2007	Demonstrate conversion of 50% of non-methane (C2+ higher) hydrocarbons that result in a syngas cost of $7.15/MBtu in 2007.
JT.2009	Validate technology capable of economically converting biomass residues, pulping liquors or waste fats and greases to synthesis gas or bio-oils that are suitable for fuels and chemicals produciton. The target is a modeled cost of $5.81/Mbtu in 2009.
JT.2010	Validate and demonstrate technology for the cost-effective cleanup of biomass synthesis gas leading to a modeled syngas cost of $5.40/Mbtu in 2010.
M 6.12	Demonstrate and validate production of ethanol from syngas in a forest resources mill environment
M 6.12.1	Produce mixed alcohols from syngas
M 6.12.2	Recover ethanol fuel product
M 6.12.3	Validate integrated process at pilot scale
M 6.12.4	Validate new process in a forest resources mill environment
M 6.13	Demonstrate and validate production of non-ethanol fuels from syngas in a forest resources mill environment
M 6.13.1	Produce non-ethanol fuel from biomass syngas
M 6.13.2	Recover fuel product
M 6.13.3	Validate integrated process at pilot scale
M 6.13.4	Validate new process in a forest resources mill environment
M 6.14	Demonstrate and validate hydrogen production from lignin or biomass derived syngas forest resources mill environment
M 6.14.1	Demonstrate optimized hydrogen production from syngas
M 6.14.2	Validate hydrogen separation/recovery
M 6.14.3	Validate integrated production of hydrogen from syngas at pilot scale
M 6.14.4	Validate integrated production of hydrogen from syngas at demonstration scale

M 6.15	Demonstrate and validate product(s) from lignin or biomass derived syngas forest resources mill environment
M 6.15.1	Demonstrate high value chemical/material productionfrom syngas
M 6.15.2	Validate product(s) separation
M 6.15.3	Validate integrated production of product(s) from syngas at pilot scale
M 6.15.4	Validate integrated production of product(s) from syngas at demonstration scale
M 6.16	Demonstrate and validate syngas utilization for combined heat and power in a forest resources mill environment
M 6.16.1	Verify fuel gas quality to levels necessary for CHP or clean cold gas consuming equipment
M 6.16.2	Validate CHP from syngas and/or direct use of sygas in process equipment
M 6.16.3	Validate integrated process at pilot scale
M 6.16.4	Validate new process in a forest resources mill environment
M 6.17	Demonstrate and validate bio-oil production to a stable intermediate forest resources mill environment
M 6.17.1	Validate bio-oil production
M 6.17.2	Validate bio-oil inermediate recovery
M 6.17.3	Validate integrated process for producing bio-oil at pilot scale
M 6.17.4	Demonstrate and validate new process in a forest resources mill environment
M 6.17.5	Validate feed flexibility in integrated system
M 6.18.	Achieve cost-effective conversion bio-oil intermediate into product(s) in a forest resources mill environment
M 6.18.1	Validate production of products from bio-oil
M 6.18.2	Validate bio-oil product(s) recovery
M 6.18.3	Validate integrated process for producing bio-oil product at pilot scale
M 6.18.4	Validate integrated process in a forest resources mill environment
M 6.19.	Achieve cost-effective conversion bio-oil intermediate into product(s) in a forest resources mill environment
M 6.19.1	Validate production of products from bio-oil
M 6.19.2	Validate bio-oil product(s) recovery
M 6.19.3	Validate integrated process for producing bio-oil product at pilot scale
M 6.19.4	Validate integrated process in a forest resources mill environment
M 6.20	Demonstrate and validate cost-effective extraction of C5 and C6 sugars from hemicellulose upstream of the pulp digestor in a pulp mill without negatively impacting paper quality
M 6.20.1	Meet yield target for C5 and C6 sugars without negatively impacting paper quality
M 6.20.2	Meet sugar upgrading requirements
M 6.20.3	Meet targets for recovery of other intermediates
M 6.20.4	Validate integrated sugar extraction process at pilot scale
M 6.20.5	Validate sugar extraction process in pulp and paper mill
M 6.21	Demonstrate and validate reliable and economic gasification of spent pulping liquor, recycle liquor causticization, chemical recovery and gas cleanup in a pulp mill
M 6.21.1	Validate reliable and economic performance of gasification of spent pulping liquor
M 6.21.2	Validate cost effective causticization and return Na based pulping chemicals
M 6.21.3	Validate advantages of co-gasification of spent pulping liquors and other forms of biomass (woody, recycle paper streams, and bio-oil)
M 6.21.4	Validate process chemical recovery from spent pulping liquor syngas
M 6.21.5	Validategas cleanup technologies on spent pulping liquor syngas
M 6.21.6	Validate integrated black liquor gasification, causticization, chemical recovery and gas cleanup process at pilot scale
M 6.21.7	Validate integrated black liquor gasification, causticization, chemical recovery and gas cleanup process in pulp and paper mill
JB.2011	Demonstrate the conversion of synthesis gas or bio-oils, derived from biomass pulping liquors or waste fats and greases to chemicals or transportation fuels. The target modeled cost is $5.25/Mbtu in 2011.

7. Waste Processing Pathway	
Milestone #	**Milestone Title**
M.7	***Complete systems level demonstration and validation of technologies to process waste biomass streams to produce fuels, chemicals and /or power.***
M.7.1	Demonstrate and validate fractionation of carbohydrate rich waste streams to produce mixed, dilute biomass sugars
M.7.1.1	Validate cellulase enzyme cost
M.7.1.2	Validate pretreatment technology cost
M.7.1.3	Demonstrate ability to economically satisfy internal heat and power demands
M.7.1.4	Validate capital cost
M.7.1.5	Validate integrated pretreatment and enzymatic hydrolysis at pilot scale
M.7.1.6	Validate integrated pretreatment and enzymatic hydrolysis at demonstration scale
M.7.1.7	Validate feed flexibility in integrated system
M.7.2	Demonstrate and validate ethanol from 5 biomass sugars
M.7.2.1	Validate fermentation of all 5 sugars to produce ethanol
M.7.2.2	Optimize ethanol separation
M.7.2.3	Optimize integrated production of ethanol from sugars at pilot scale
M.7.2.4	Optimize integrated production of ethanol from sugars at demonstration scale
M.7.3	Demonstrate and validate non-ethanol fuels from 5 biomass sugars
M.7.3.1	Validate fermentation of all 5 sugars to produce non-ethanol fuels
M.7.3.2	Optimize non-ethanol fuel separation
M.7.3.3	Optimize integrated production of non-ethanol fuels from sugars at pilot scale
M.7.3.4	Optimize integrated production of non-ethanol fuel from sugars at demonstration scale
M.7.4	Demonstrate and validate chemical building blocks, chemicals or materials from 5 biomass sugars
M.7.4.1	Optimize chemical building blocks production
M.7.4.2	Optimize high value chemical production
M.7.4.3	Optimize product separation
M.7.4.4	Optimize integrated production of product(s)from sugars at pilot scale
M.7.4.5	Optimize integrated production of product(s)from sugars at demonstration scale
M.7.6	Demonstrate and validate high value chemical and material products from lignin intermediates
M.7.6.1	Demonstrate high value chemical/material production from lignin
M.7.6.2	Validate product separation
M.7.6.3	Validate integrated production of product(s)from lignin at pilot scale
M.7.6.4	Validate integrated production of product(s)from lignin at demonstration scale
M.7.5	Demonstrate and validate fuel products from lignin intermediates
M.7.5.1	Demonstrate direct fuel production from lignin
M.7.5.2	Validate fuel product separation
M.7.5.3	Validate integrated production of fuel(s)from lignin at pilot scale
M.7.5.4	Validate integrated production of fuels(s)from lignin at demonstration scale
M.7.7	Demonstrate and validate combined heat and power from lignin intermediates/residues
M.7.7.1	Demonstrate combined heat and power production from lignin
M.7.7.2	Validate integrated production of heat and power from lignin at pilot scale
M.7.7.3	Validate integrated production of heat and power from lignin at demonstration scale
M.7.8	Demonstrate and validate lignin gasification to produce syngas
M.7.8.1	Validate feeder system performance

M.7.8.2	Validate gasification performance
M.7.8.3	Validate gas cleanup performance
M.7.8.4	Validate capital costs
M.7.8.5	Validate integrated gasification and gas cleanup at pilot scale
M.7.8.6	Validate integrated gasification and gas cleanupat demonstration scale
M.7.9	Demonstrate and validate waste biomass gasification to produce syngas
M.7.9.1	Validate feeder systems to reliably feed solid biomass to high pressure (30 bar) systems
M.7.9.2	Validate gasification performance
M.7.9.3	Validate gas cleanup performance
M.7.9.4	Validate capital costs
M.7.9.5	Validate integrated gasification and gas cleanup at pilot scale
M.7.9.6	Validate integrated gasification and gas cleanupat demonstration scale
M.7.9.7	Validate feed flexibility in integrated system
JT.2009	Validate technology capable of economically converting biomass residues, pulping liquors or waste fats and greases to synthesis gas or bio-oils that are suitable for fuels and chemicals produciton. The target is a modeled cost of $5.81/Mbtu in 2009.
M.7.10	Demonstrate and validate ethanol from mixed alcohols using lignin or waste biomass derived syngas
M.7.10.1	Demonstrate ethanol production from mixed alcohols
M.7.10.2	Validate ethanol separation
M.7.10.3	Validate integrated production of ethanol from syngas at pilot scale
M.7.10.4	Validate integrated production of ethanol from syngas at demonstration scale
JB.2011	Demonstrate the conversion of synthesis gas or bio-oils, derived from biomass pulping liquors or waste fats and greases to chemicals or transportation fuels. The target modeled cost is $5.25/Mbtu in 2011.
M.7.11	Demonstrate and validate non-ethanol fuels from lignin or waste biomass derived syngas
M.7.11.1	Demonstrate non-ethanol fuel production from lignin or biomass-derived syngas
M.7.11.2	Validate non-ethanol fuel separation
M.7.11.3	Validate integrated production of non-ethanol fuels from syngas at pilot scale
M.7.11.4	Validate integrated production of non-ethanol fuels from syngas at demonstration scale
M.7.12	Demonstrate and validate hydrogen production from lignin or waste biomass derived syngas
M.7.12.1	Demonstrate optimized hydrogen production from syngas
M.7.12.2	Validate hydrogen separation/recovery
M.7.12.3	Validate integrated production of hydrogen from syngas at pilot scale
M.7.12.4	Validate integrated production of hydrogen from syngas at demonstration scale
M.7.13	Demonstrate and validate product(s) from lignin or waste biomass derived syngas
M.7.13.1	Demonstrate high value chemical/material production from syngas
M.7.13.2	Validate product(s) separation
M.7.13.3	Validate integrated production of product(s) from syngas at pilot scale
M.7.13.4	Validate integrated production of product(s) from syngas at demonstration scale
M.7.14	Demonstrate and validate combined heat and power production from lignin or waste biomass derived syngas
M.7.14.1	Demonstrate combined heat and power production from syngas
M.7.14.2	Validate integrated production of heat and power from syngas at pilot scale
M.7.14.3	Validate integrated production of heat and power from syngas at demonstration scale
M.7.15	Demonstrate and validate waste biomass pyrolysis to produce pyrolysis oil intermediate
M.7.15.1	Validate feeder systems to reliably feed solid biomass to pyrolysis reactor high pressure (30 bar) systems
M.7.15.2	Validate pyrolysis performance

M.7.15.3	Validate pyrolysis oil cleanup performance
M.7.15.4	Validate capital costs
M.7.15.5	Validate integrated pyrolysis and pyrolysis oil cleanup at pilot scale
M.7.15.6	Validate integrated pyrolysis and pyrolysis oil cleanup at demonstration scale
M.7.15.7	Validate feed flexibility in integrated system
M.7.16	Demonstrate and validate fuels from pyrolysis oil intermediate
M.7.16.1	Demonstrate fuel production from pyrolysis oil intermediate
M.7.16.2	Validate fuel separation
M.7.16.3	Validate integrated production of fuels from pyrolysis oil at pilot scale
M.7.16.4	Validate integrated production of fuels from pyrolysis oil at demonstration scale
M.7.17	Demonstrate and validate high value chemical and material products from pyrolysis oil intermediates
M.7.17.1	Demonstrate high value chemical/material production from pyrolysis oil
M.7.17.2	Validate product separation
M.7.17.3	Validate integrated production of product(s)from pyrolysis oil at pilot scale
M.7.17.4	Validate integrated production of product(s)from pyrolysis oil at demonstration scale

ALGENOL
BIOFUELS

REDACTED
EXEMPTION 4

Ft. Myers, FL 33912

Future Algenol Facility

REDACTED
EXEMPTION 4

Tenant's Initials REDACTED
EXEMPTION 6

REDACTED
EXEMPTION 4

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Tenant's Initials REDACTED EXEMPTION 6

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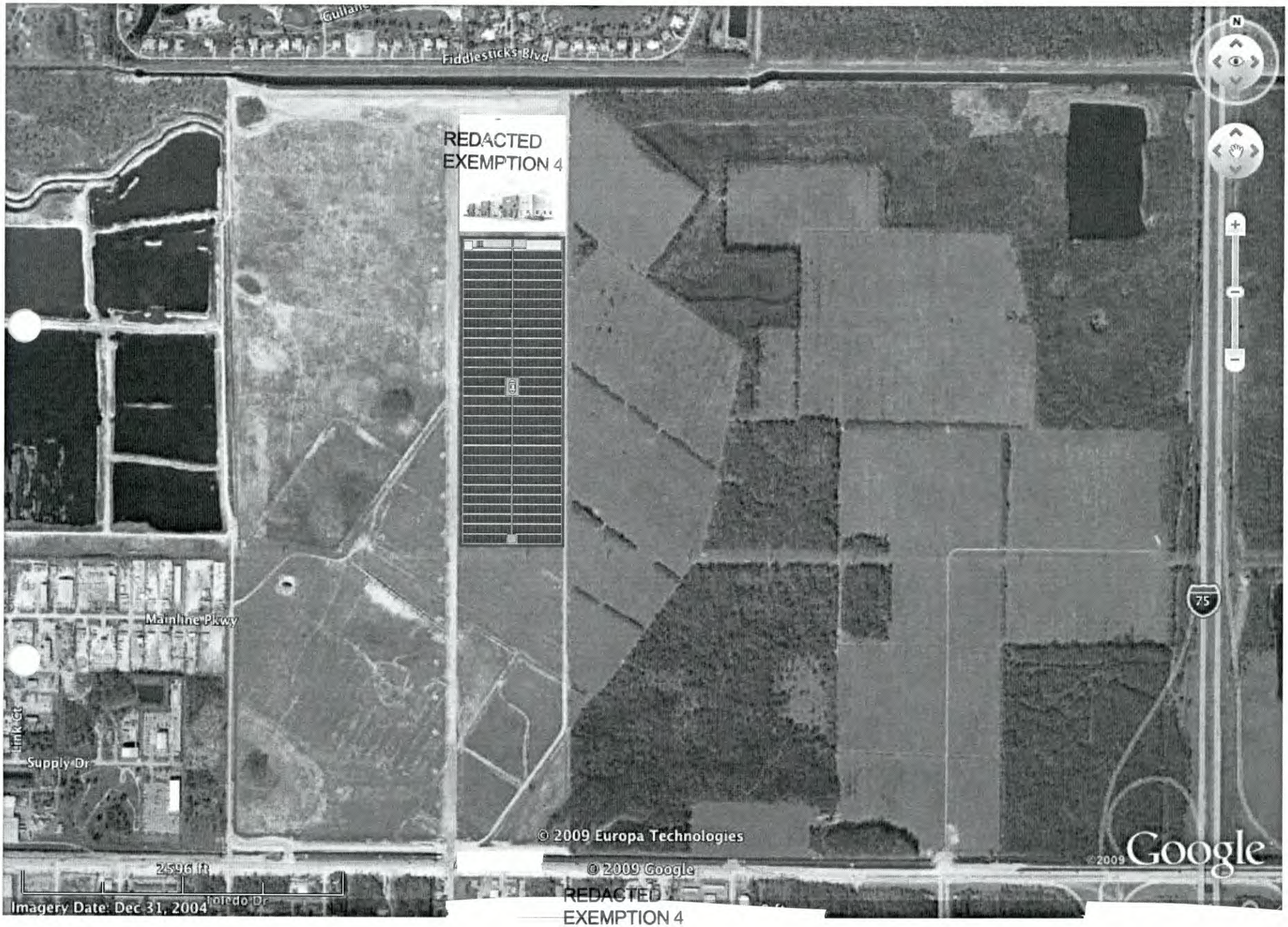
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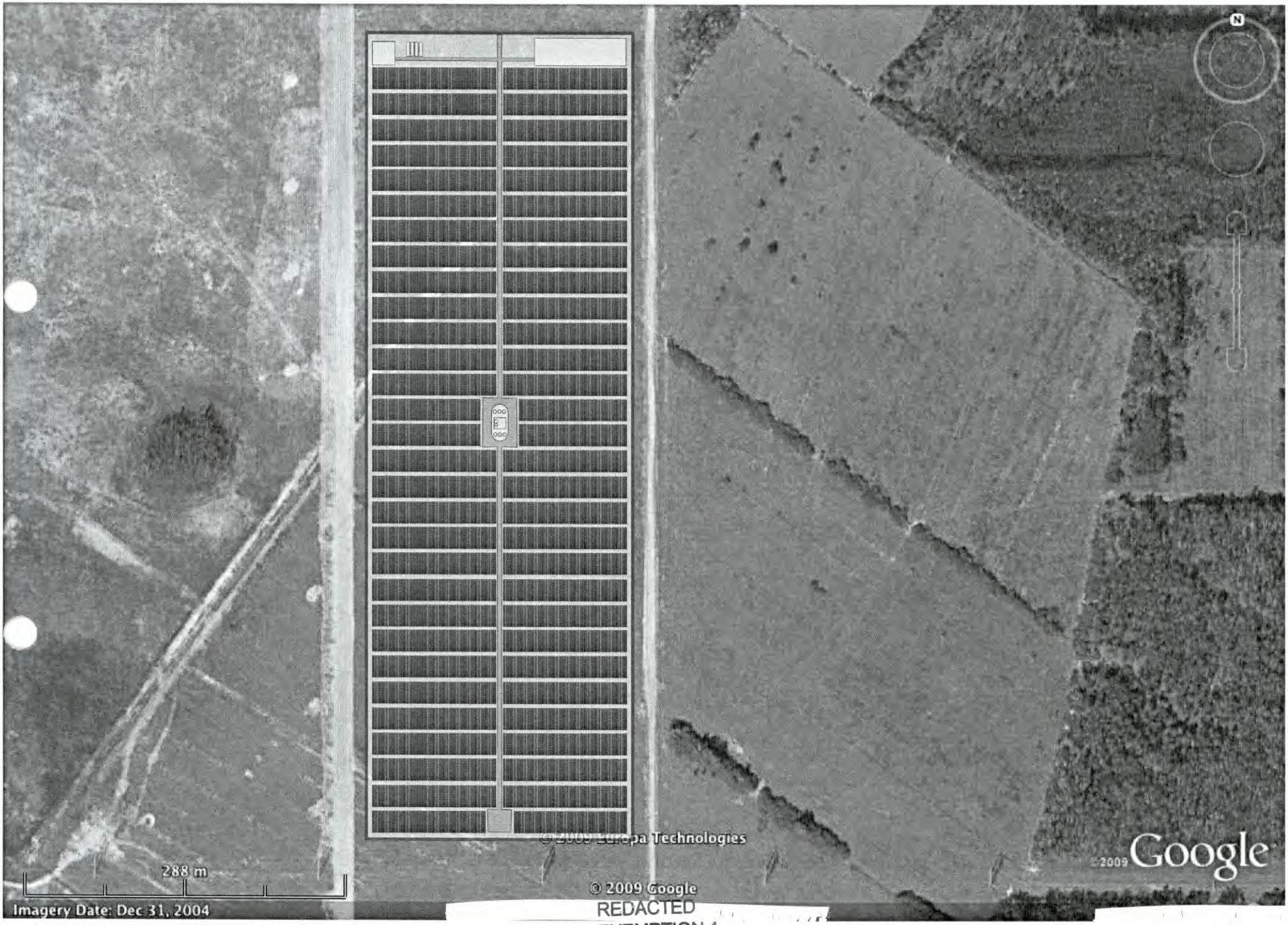

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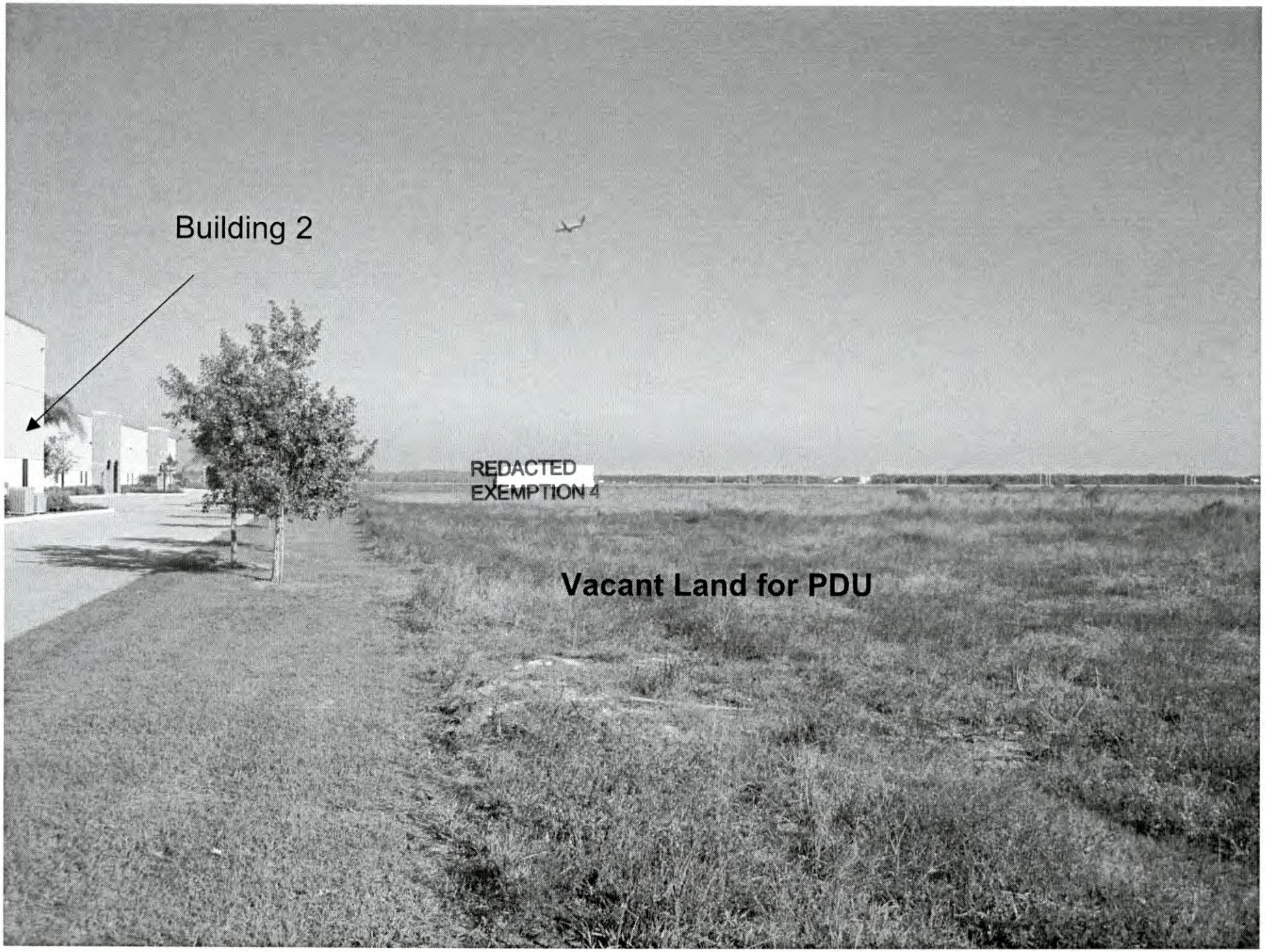
EXEMPTION 4

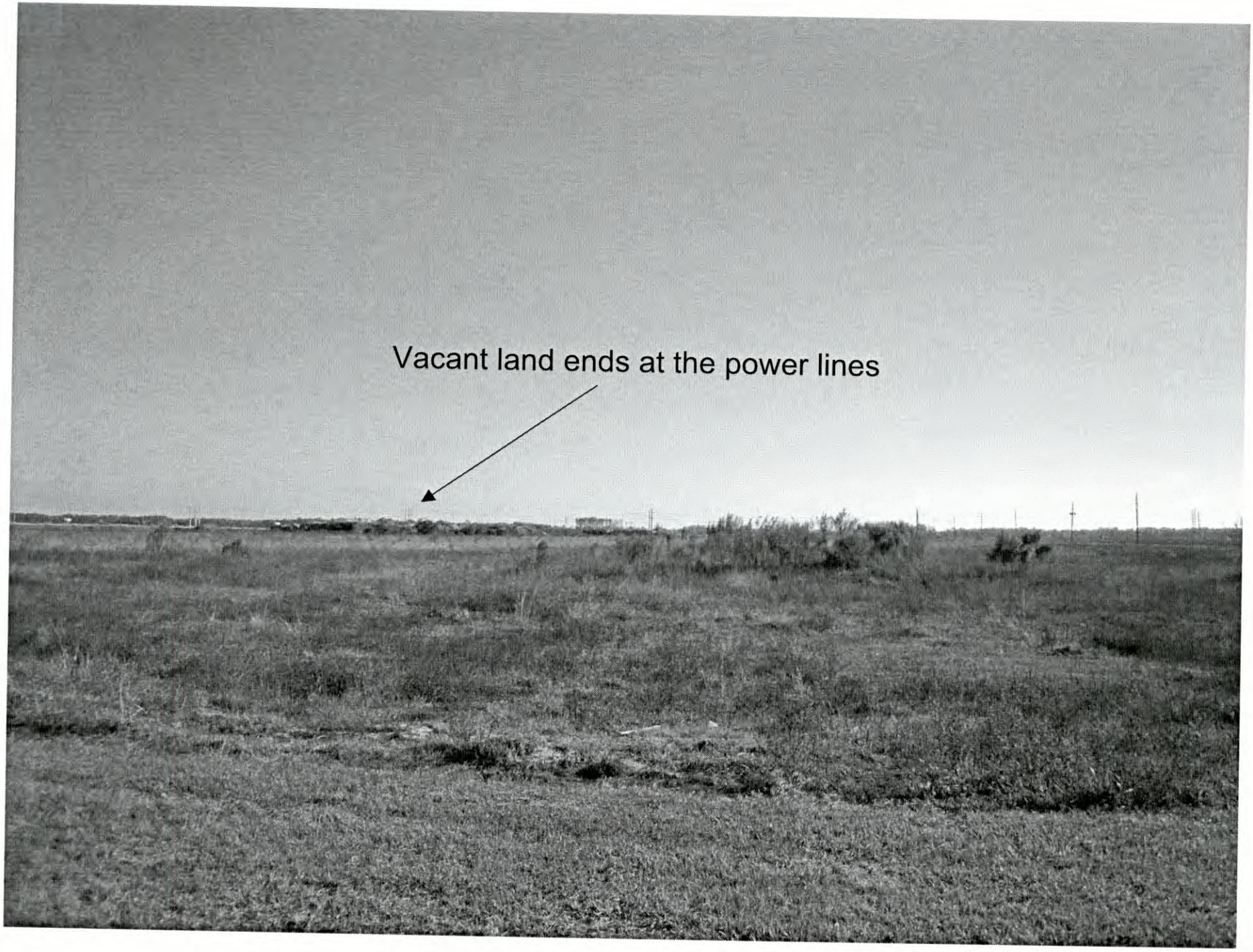
Front of Building 1

Future Lab and Office Area in Building 1

Future Lab and Office Area Building 2

Building 2 (Left) and Building 1 (Right)


Building 2
REDACTED
EXEMPTION 4
Vacant Land for PDU


Vacant land ends at the power lines

Attachment A: Resource Loaded Project Plan

ID	WBS	Task Name	Duration	Start	Finish	2009 Qtr 1	Qtr 2	Qtr 3	Qtr
1	**A**	Exemption 4							
2	A.1								
3	**A.2**								
4	**A.2.1**								
5	**A.2.1.1**								
6	A.2.1.1.1								
7	A.2.1.1.2								
8	A.2.1.1.3								
9	A.2.1.1.4								
10	**A.2.1.2**								
11	A.2.1.2.1								
12	A.2.1.2.2								
13	A.2.1.2.3								
14	A.2.1.2.4								
15	A.2.1.2.5								
16	**A.2.2**								
17	A.2.2.1								
18	A.2.2.2								
19	A.2.2.3								
20	A.2.2.4								
21	**A.2.3**								
22	A.2.3.1								
23	A.2.3.2								
24	A.2.3.3								
25	A.2.3.4								
26	A.2.3.5								
27	A.2.3.6								
28	**A.2.4**								
29	A.2.4.1								
30	**A.2.4.2**								
31	A.2.4.2.1								
32	A.2.4.2.2								
33	A.2.4.2.3								
34	A.2.4.2.4								
35	**A.3**								

Attachment A: Resource Loaded Project Plan

ID	WBS	Task Name	Duration	Start	Finish	2009 Qtr 1	Qtr 2	Qtr 3	Qtr
36	**A.3.1**	Exemption 4							
37	A.3.1.1								
38	A.3.1.2								
39	A.3.1.3								
40	A.3.1.4								
41	A.3.1.5								
42	A.3.1.6								
43	A.3.1.7								
44	A.3.1.8								
45	A.3.1.9								
46	A.3.1.10								
47	**A.3.1.11**								
48	A.3.1.11.1								
49	A.3.1.11.2								
50	**A.3.2**								
51	A.3.2.1								
52	A.3.2.2								
53	A.3.2.3								
54	**A.3.3**								
55	A.3.3.1								
56	A.3.3.2								
57	A.3.3.3								
58	**A.4**								
59	**A.4.1**								
60	**A.4.1.1**								
61	A.4.1.1.1								
62	A.4.1.1.2								
63	A.4.1.1.3								
64	**A.4.1.2**								
65	A.4.1.2.1								
66	A.4.1.2.2								
67	A.4.1.2.3								
68	**A.4.1.3**								
69	A.4.1.3.1								
70	A.4.1.3.2								