EXHIBIT A: **RESEARCH PROJECT**

This Research Project is issued pursuant to the Sponsored Projects Agreement ("Agreement") between ConocoPhillips Company ("Company"), Iowa State University ("University"), and Iowa State University Research Foundation ("ISURF"), dated March 5, 2007. The Agreement is hereby incorporated herein by reference and expressly made a part hereof. Accordingly, the terms and conditions of such Agreement shall be applicable to the research conducted under this Research Project. Capitalized terms used herein but not defined shall have the meanings ascribed to such terms in the Agreement.

1. Research Project Number: **2011-P-15**
2. Research Project Title: **Carbon Negative Fuels from Sequestered Charcoal**
3. Research Platform: **Pyrolysis** If other, please specify:
4. Program Principal Investigator: **Robert Brown**
5. Company Technical Representative: **Scott McQueen**
6. Research Principal Investigator(s): **Robert Brown**
7. Research Project Statement of Work: **See attached work plan**
8. Research Project Period: **January 1, 2011 – December 31, 2011**
9. Research Project Budget: **$99,754**
10. Research Project Payment Schedule: **Company shall remit payment net thirty (30) days from receipt of quarterly invoices, to be submitted by University as follows:**

| Year | January 1 | April 1 | July 1 | October 1 | Total |
|---|---|---|---|---|---|
| 2011 | $24,939 | $24,939 | $24,938 | $24,938 | $99,754 |

11. Equipment Needed:
12. Project Reporting Requirements: **Research Principal Investigator shall furnish quarterly progress/status reports and a final technical report. Quarterly reports should be submitted within 15 days of the end of each calendar quarter, and the final technical report should be submitted within 60 days of the end of the project period. Instructions for submission of reports will be sent by email within 15 days prior to the end of each quarter.**
13. Deliverables: **See attached SOW.**
14. Additional Terms and Conditions:

In addition to Company's rights in Article 10 of the Agreement, Company reserves the right to immediately terminate this Research Project, including all subsequent payment obligations of Company, should the Research Principal Investigator become unable to perform under this Research Project and provided the parties cannot agree on an appropriate substitute Research Principal Investigator.

Reasonable best efforts shall be made to use only funds from Company to carry out the Research Projects. Intended use of other funds for Research Projects, including federal funds, may only be used by mutual consent.

This Research Project will automatically terminate upon completion of the services to be provided hereunder or as otherwise set forth in the Agreement.

IN WITNESS WHEREOF, the parties have entered into this Research Project as of the date set forth below.

Iowa State University

Approved

Name: _____

Printed Name: Lisa L. Lorenzen

Title: Director, Industry Relations

Date: 11-19-10

ConocoPhillips Company

Name: _____

Printed Name: Scott McQueen

Title: Director, Biofuels

Date: 12-15-10

Agreed and Understood

By signing below, the Research Principal Investigator acknowledges that s/he has read and agreed to the terms of the Sponsored Project Agreement

Name: _____

Printed Name: Robert Brown

Title: Professor

Date: 12-02-10

116925 Brown (P-15)

Do not include any dollars shown on an earlier supplement budget. Do not use for budget revisions.

# IOWA STATE UNIVERSITY
## SUPPLEMENTAL BUDGET

400-25-43
Fund-acct Sect-Proj

Additional funds on EXISTING accounts should be directly deposited to the Treasurers Office. DO NOT ATTACH TO THIS FORM. However, a COPY of the cash report and check are required with this form.

For NEW account requests, complete the following: Check attached? ☐ Yes ☐ No
If yes, provide amount $

If funded from Admin Acct, list Admin Acct & PI signature

Admin Acct: 400-77-17

PI signature:

Sponsor: ConocoPhillips

Title of Project: Carbon Negative Fuels for Sequestered Charcoal (P15)

Period of Contract: From: 1/1/2012 To: 12/31/2012

Lead P.I.: Robert C. Brown
PI Address: 1040 BRL
PI ISU ID#: 649-89-9157
PI Phone #: 294-7934

Academic Department: ME
Admin D/I/C/E: CSET
RRC Administering Unit: IPRT
Primary On- or Off- Campus Address of Project: Biorenewables Lab

| BUDGET | | |
|---|---|---|
| Salaries/Hourly | $ | 37,300 |
| Payroll Benefits | $ | 6,724 |
| Equipment >$5,000 | $ | |
| Travel-Domestic | $ | 2,000 |
| Travel-Foreign | $ | |
| Student Tuition | $ | 11,164 |
| *Supplies/Materials* | | |
| Ag & Vet Supplies | $ | |
| Lab & Research Supplies | $ | 7,500 |
| Other Supplies | $ | |
| *Subcontracts* | | |
| Subject to IDC | $ | |
| NOT subject to IDC | $ | |
| *Other Direct Costs* | | |
| Telecommunication Charges | $ | |
| Computer Usage | $ | |
| Printing/Copying | $ | |
| Honoraria/Services | $ | |
| POstage | $ | |
| Other | $ | |
| Program Income | $ | |
| TOTAL DIRECT COSTS | $ | 64,688 |
| INdirect Costs | $ | 25,692 |
| TOTAL ALL COSTS | $ | 90,380 |

**COMPLIANCES**

Will vertebrate animals be used in this project? ☐ Yes ☑ No
If yes, provide IACUC Log # _____

Are the following safety or health hazards involved?
- Recombinant DNA ☐ Yes ☑ No
- Human or Animal Pathogens ☐ Yes ☑ No
- Biological Toxins ☐ Yes ☑ No
- Radiological Materials ☐ Yes ☑ No

Will human subjects be used in this project? ☐ Yes ☑ No
If yes, provide assigned IRB number _____

**PRINCIPAL INVESTIGATOR CERTIFICATIONS**

* I agree to be bound by the terms and conditions of the outside grant or contract which supports this activity and, in consideration of the information and facilities made available to me by the University or the outside sponsor, to assign copyright and patent rights to the Iowa State University Research Foundation, Inc. in accordance with the terms and conditions stated in the Faculty Handbook.
* I certify that I have not been debarred, suspended, or declared ineligible to receive agency funds.

Conflict of Interest (COI): Real or perceived conflicts of interest may exist in a project when an investigator or a member of his or her family has: a management role in, financial interest in, or a paid consulting agreement with the sponsor or paid consulting agreements with other entities on topics related to the project. By signing this form, all investigators certify that they have read and understand ISU's Conflict of Interest Policy [http://www.provost.iastate.edu/faculty] and made all disclosures required by it. For further information call 4-8700.

Is there a potential for a Conflict of Interest? ☐ Yes ☑ No
If yes, are disclosure procedures being implemented? ☐ Yes ☐ No

* I certify to the best of my knowledge that the above statements are true.

Principal Investigator (sign) Date

12-1-11

**DEPARTMENT/INSTITUTE/COLLEGE/EXTENSION UNIT (D/I/C/E) and RRC(s) CERTIFICATION**

This has been reviewed and is judged to be consistent with the objectives and capabilities of the unit represented by the signatures below. The proposed effort is considered compatible with other University duties of the investigator(s) and consistent with University policies.

D/I/C/E Authorizing Signature: Beau Stadtler for Robert Brown — Date: 12-7-11

RRC (College/Vice President/Provost/President) Authorizing Signature: Cheryl Sansgaard — Date: 12/7/11

Office of Sponsored Programs Administration — Date: 12/19/2011

| | | | | | |
|---|---|---|---|---|---|
| SHADED AREAS FOR ACCOUNTING USE | Rate | Base | Code | IDC Budget | |
| | Rate | Base | Code | IDC Budget | |
| Resp Code | | Prime Contractor | | | |
| Contract # | | CFDA # | | | |
| Reimbursement Type: C F | | Account Type: Admin | | Sub of | |
| Bill | | | | | |

Revised 02/18/2008

## EXHIBIT A: RESEARCH PROJECT

This Research Project is issued pursuant to the Sponsored Projects Agreement ("Agreement") between ConocoPhillips Company ("Company"), Iowa State University ("University"), and Iowa State University Research Foundation ("ISURF"), dated March 5, 2007. The Agreement is hereby incorporated herein by reference and expressly made a part hereof. Accordingly, the terms and conditions of such Agreement shall be applicable to the research conducted under this Research Project. Capitalized terms used herein but not defined shall have the meanings ascribed to such terms in the Agreement.

| | | | |
|---|---|---|---|
| 1 | Research Project Number: | **2012-P-15** | |
| 2 | Research Project Title: | **Carbon Negative Fuels for Sequestered Charcoal** | |
| 3 | Research Platform: | **Pyrolysis** | |
| 4 | Program Principal Investigator: | **Robert Brown** | |
| 5 | Company Technical Representative | **Scott McQueen** | |
| 6 | Research Principal Investigator(s): | **Robert Brown and David Laird** | |
| 7 | Research Project Statement of Work: | **See attached work plan** | |
| 8 | Research Project Period: | **1/1/2012 – 12/31/2012** | |
| 9 | Research Project Budget: | **$90,380** | |
| 10 | Research Project Payment Schedule: | **Company shall remit payment net thirty (30) days from receipt of quarterly invoices, to be submitted by University as follows:** | |
| | | **January 1:** | **$ 22,595** |
| | | **April 1:** | **$ 22,595** |
| | | **July 1:** | **$ 22,595** |
| | | **October 1:** | **$ 22,595** |
| | | **Total:** | **$ 90,380** |
| 11 | Equipment Needed: | | |
| 12 | Project Reporting Requirements: | **Research Principal Investigator shall furnish quarterly progress/status reports and a final technical report. Quarterly reports should be submitted within 15 days of the end of each calendar quarter, and the final technical report should be submitted within 60 days of the end of the project period. Instructions for submission of reports will be sent by email within 15 days prior to the end of each quarter.** | |
| 13 | Deliverables: | **See attached work plan** | |
| 14 | Additional Terms and Conditions: | | |

In addition to Company's rights in Article 10 of the Agreement, Company reserves the right to immediately terminate this Research Project, including all subsequent payment obligations of Company, should the Research Principal Investigator become unable to perform under this Research Project and provided the parties cannot agree on an appropriate substitute Research Principal Investigator.

Reasonable best efforts shall be made to use only funds from Company to carry out the Research Projects. Intended use of other funds for Research Projects, including federal funds, may only be used by mutual consent.

This Research Project will automatically terminate upon completion of the services to be provided hereunder or as otherwise set forth in the Agreement.

**IN WITNESS WHEREOF,** Sponsor and ISU have caused this Agreement to be executed by their duly authorized representatives as of Effective Date written above.

**Iowa State University**

**Agreed**

Name: Lynne Mumm
Printed Name: Lynne Mumm
Title: Industry Liaison, OSPA
Date: 12/19/2011

**ConocoPhillips Company**

Name:
Printed Name: Scott McQueen
Title: Director, Biofuels
Date: 11/16/11

**Read and Understood**
By signing below, the Research Principal Investigator acknowledges that s/he has read and agreed to the terms of the Sponsored Project Agreement.

Name: Robert Brown
Printed Name: Robert Brown
Title: PI
Date: 12-1-11

Name:
Printed Name: David Laird
Title: CO-PI
Date: 12-5-11

Project 2012-P-15

**ConocoPhillips Request for Proposals**
**Chemical Conversion of Biomass Grant Competition**

**Project Title:** Carbon Negative Fuels from Sequestered Charcoal

**PI**: Robert Brown, Center for Sustainable Environmental Technologies, 1140E BRL Building, 294-7934, rcbrown@iastate.edu

**Co-PI:** David Laird, Department of Agronomy

## EXECUTIVE SUMMARY

The goal of this project is to develop methods for estimating the stable fraction of carbon in fast pyrolysis biochars for sequestration and to determine whether these chars are safe to apply to soils. This information would allow marketing of fast pyrolysis biochar co-products for carbon credits and large scale field trials.

Our approach involves basic and state-of-art characterizations of biochar co-products generated by two kinds of fast pyrolyzers (fluidized bed and auger) operated with different feedstocks that have undergone various pretreatments (drying, dirt removal) and under different conditions for optimum bio-oil production. Dust and flammability hazards associated with the char handling will be investigated using particle size distribution analysis and Department of Transportation/United Nations Division 4.2 flammable solids classification procedures. Stability of the carbon in soil will be estimated using a sand incubation study tracking $CO_2$ emissions over time. Chemical analyses of char extracts and two bioassays (worm avoidance and seed germination) will be used to identify any negative soil environment effects of biochar application. In the final phase of the study, characterization methods will be adjusted to reflect any emerging standards and the current state of the biochar industry. By that time, it is expected that continuing development of biochar markets would allow for the assignment of a value to fast pyrolysis chars based on this characterization and safety information used in a technoeconomic analysis.

# STATEMENT OF WORK

PI: Robert C. Brown

## PROJECT DESCRIPTION

### Objectives

The goal of this project is to develop methods for estimating the stable fraction of carbon in fast pyrolysis biochars for sequestration and to determine whether these chars are safe to apply to soils. This information would allow marketing of fast pyrolysis biochar co-products for carbon credits and large scale field trials.

### Justification

Biofuels has the potential to be low-carbon or even zero-carbon fuels. However, even this may be insufficient to meet future targets for reducing atmospheric carbon dioxide. To meet this challenge will require carbon negative fuels, which not only incorporate atmospheric carbon dioxide into fuels but sequester some part of it from the atmosphere for long periods of time. The U.S. Department of Energy is investigating co-gasification of coal and biomass with subsequent carbon capture and sequestration (CCS) as a possible approach to carbon negative fuels. Even more exotic are the notions of "artificial trees" and "solar fuels" as ways to reduce greenhouse gas emissions. Possibly the simplest approach to carbon negative fuels is incorporation of the charcoal co-product of fast pyrolysis of biomass in agricultural lands. This so-called biochar appears to be stable in the soil for hundreds to thousands of years. In the case of highly weathered or leached soils, which occur naturally in many parts of the world, biochar can dramatically improve the fertility of the soil.

However, before biochar can be exploited for the production of carbon negative fuels, two things must be determined: (1) the fraction of biochar carbon that can be sequestered; and (2) the impact of biochar application on soil function.

There are currently no characterization or production standards in the nascent biochar industry. The International Biochar Initiative (IBI), which will likely serve as the primary certifying agency for biochars, has formed a working group of leading researchers and industry representatives to address this issue. This group has identified four critical qualities of good biochars[1]; these biochars:

1. Are not harmful to the soil environment
2. Exhibit a long carbon mean residence time
3. Have the potential to improve soil fertility
4. Come with information necessary for appropriate and safe handling

While a great deal of scientific research is still required to understand how a specific biochar will perform on a specific soil, we propose that biochar characterization methods described in the literature[2-4] can be used to demonstrate that biochar co-products from fast pyrolysis meet the first two criteria and are suitable for large-scale soil application trials to address the other two qualities.

Fast pyrolysis biochars are currently underrepresented in the biochar industry due to the lack of information available regarding their properties and soil effects. Once this information can be obtained, such biochars (and the fast pyrolysis energy platform) would have a competitive edge in carbon markets and with the many people interested in purchasing large amounts of biochar for

testing (carbon offset project administrators, farmers, academic and governmental research institutions, soil reclamation and waste management companies, etc.).

**Work Plan**

The first phase of this study involves selection of biochar co-products generated by two kinds of fast pyrolyzers (fluidized bed and auger) operated with different feedstocks that have undergone various pretreatments (drying, dirt removal) and under different conditions for optimum bio-oil production. These biochars would be characterized for basic composition and physical properties by methods such as proximate analysis (moisture, ash, fixed carbon) by thermogravimetric analyzer (TGA), CHNS elemental analysis, higher heating value by bomb calorimeter, BET surface area by gas sorption analysis, and particle density by pycnometer.

The second phase would consist of char handling safety tests. Particle size distribution (related to dust hazards) would be determined by sieve analysis. Risk of self-combustion (related to amounts of char that can be safely shipped and stored) would be tested using Department of Transportation/United Nations Division 4.2 flammable solids classification procedures.

The third phase would combine state-of-the-art biochar characterizations to measure the types of carbon in the biochars with a char-amended sand incubation test to measure readily degradable carbon. Advanced characterization methods would include diffuse reflectance Fourier transform infrared spectroscopy (DRIFT-IR), and quantitative solid-state $^{13}C$ nuclear magnetic resonance spectroscopy (NMR). The incubation studies would use carbon-free, coarse-textured sand amended with the biochar and a soil extract inoculation to estimate carbon degradation kinetics in soil-like conditions. The coarse texture of the sand would allow char particles to be isolated and reanalyzed for after-incubation properties.

The fourth phase would investigate soil environment safety tests and bioassays. Total microwave digestion would be used to measure concentrations of heavy metals in chars. Char water extracts would be subjected to pH, elemental analysis by inductively couple plasma spectroscopy (ICP), and seed germination studies to test for high levels of alkali, salts or organic compounds that would inhibit plant growth. Worm avoidance tests on char-amended soils would test for the presence of biological irritants.

The final phase would investigate the current state of the biochar industry and adjust characterization methods to reflect any emerging standards. By that time, it is expected that continuing development of biochar markets would allow for the assignment of a value to fast pyrolysis chars through technoeconomic analysis.

**References**

1. Major, J.; Wilson, K. *IBI Characterization Work Progress Report*; International Biochar Initiative: June 21, 2010; p 6.
2. Brewer, C. E.; Schmidt-Rohr, K.; Satrio, J. A.; Brown, R. C., Characterization of biochar from fast pyrolysis and gasification systems. *Environmental Progress & Sustainable Energy* **2009,** 28, (3), 386-396.
3. Baldock, J. A.; Smernik, R. J., Chemical composition and bioavailability of thermally altered Pinus resinosa (Red pine) wood. *Organic Geochemistry* **2002,** 33, (9), 1093-1109.

4. Novak, J. M.; Busscher, W. J.; Watts, D. W.; Laird, D. A.; Ahmedna, M. A.; Niandou, M. A. S., Short-term CO2 mineralization after additions of biochar and switchgrass to a Typic Kandiudult. *Geoderma* **2010,** 154, (3-4), 281-288.

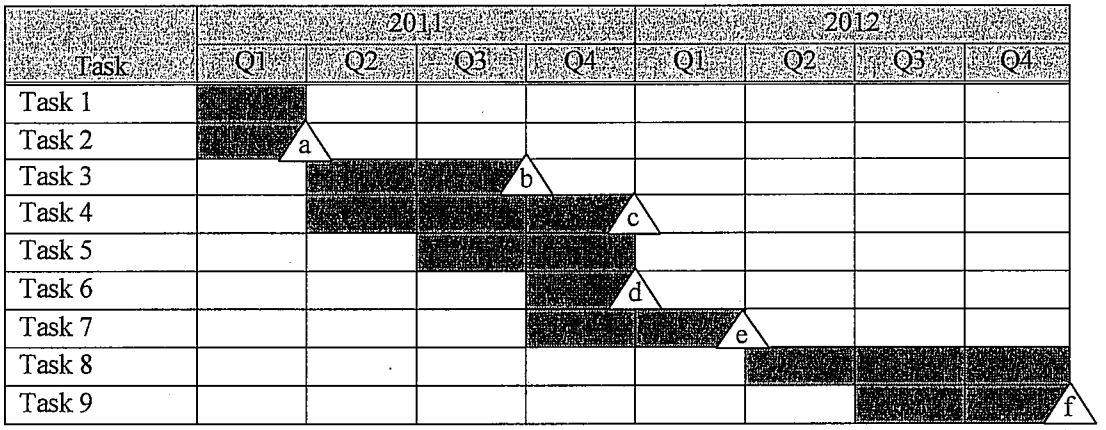
**Tasks**

1. Indentify fast pyrolysis biochars to be studied
2. Perform basic characterizations
3. Perform char handling safety tests
4. Conduct sand incubation studies
5. Perform advanced carbon sequestration characterizations (FTIR and NMR)
6. First round report
7. Refine characterization methods to align with developing industry standards
8. Perform soil environment safety tests and bioassays
9. Final report

**Milestones**

a. Completion of basic characterizations of selected biochars
b. Completion of safety tests and recommendations for further testing
c. Completion of incubation studies
d. Completion of advanced characterizations and first round report
e. Proposal of modifications to characterization methods based on state of the industry
f. Complete final report including recommendations of most promising biochars and overall pyrolysis conditions, and technoeconomic estimations of biochar value

**Schedule**



**Budget**

| Category | 2011 | 2012 | TOTAL |
|---|---|---|---|
| *Faculty Salaries* | $ - | $ - | $ - |
| *P&S Salaries* | $ 10,000 | $ 10,300 | $ 20,300 |
| *Postdoc Salaries* | | | $ - |
| *Grad Student Stipends* | $ 30,600 | $ 21,000 | $ 51,600 |
| *Undergraduate Wages* | $ 3,000 | $ 6,000 | $ 9,000 |
| Total Salaries & Wages | $ 43,600 | $ 37,300 | $ 80,900 |
| Fringe Benefits | $ 7,748 | $ 6,724 | $ 14,472 |
| Equipment | | | $ - |
| Travel | $ 2,000 | $ 2,000 | $ 4,000 |
| Student Tuition | $ 13,991 | $ 11,164 | $ 25,155 |
| Materials & Supplies | $ 4,600 | $ 7,500 | $ 12,100 |
| Other Direct Costs* | | | $ - |
| Total Direct Cost | $ 71,939 | $ 64,688 | $ 136,627 |
| Indirect Cost (@ 48%) | $ 27,815 | $ 25,692 | $ 53,507 |
| **Total Cost** | **$ 99,754** | **$ 90,380** | **$ 190,134** |

**Budget Justification**

- In the first year 1.5 graduate students will be supported (a senior graduate student due to graduate mid-2011 will train a junior graduate student in the several analytical methods required). In the second year, one PhD student will be responsible for characterization and testing activities. Undergraduate hourly helpers will support testing of samples.
- Partial support of a P&S staff will provide analytical support to the student.
- Travel monies will be used to support student attendance at professional meetings to present research results.
- Materials and supplies will be used to purchase gases, chemicals, containers for incubations and bioassays, and consumables for the various analyses.