Benefits Analysis
USDA Section 9008 Program

A Metrics Study

Requested by William F. Hagy III
USDA Rural Development

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Presented to the
Biomass R&D Technical Advisory Committee Meeting
Washington, DC
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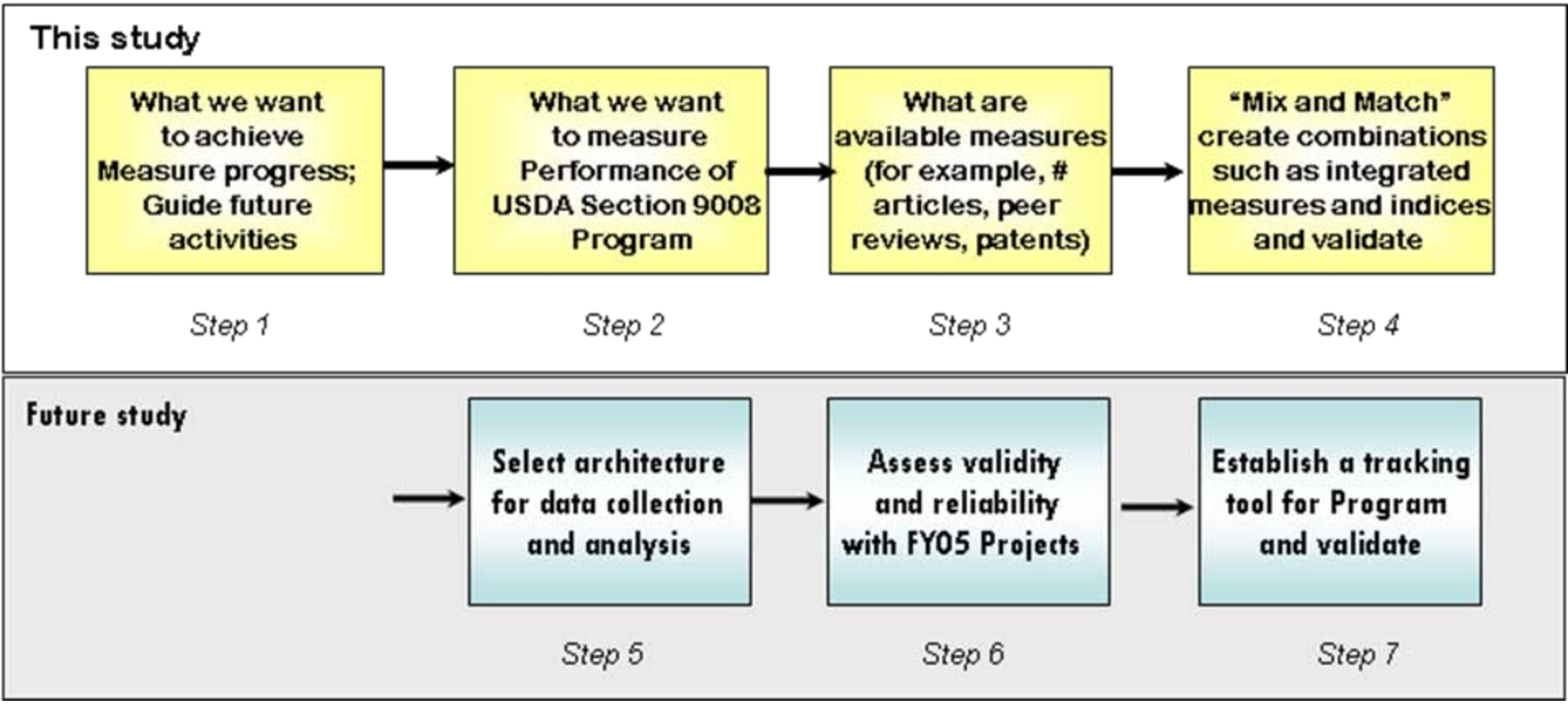
Outline

- Purpose
- Metrics
- Baseline Metrics for USDA Section 9008
- Tracking Measures to Assess Benefits

Study Purpose

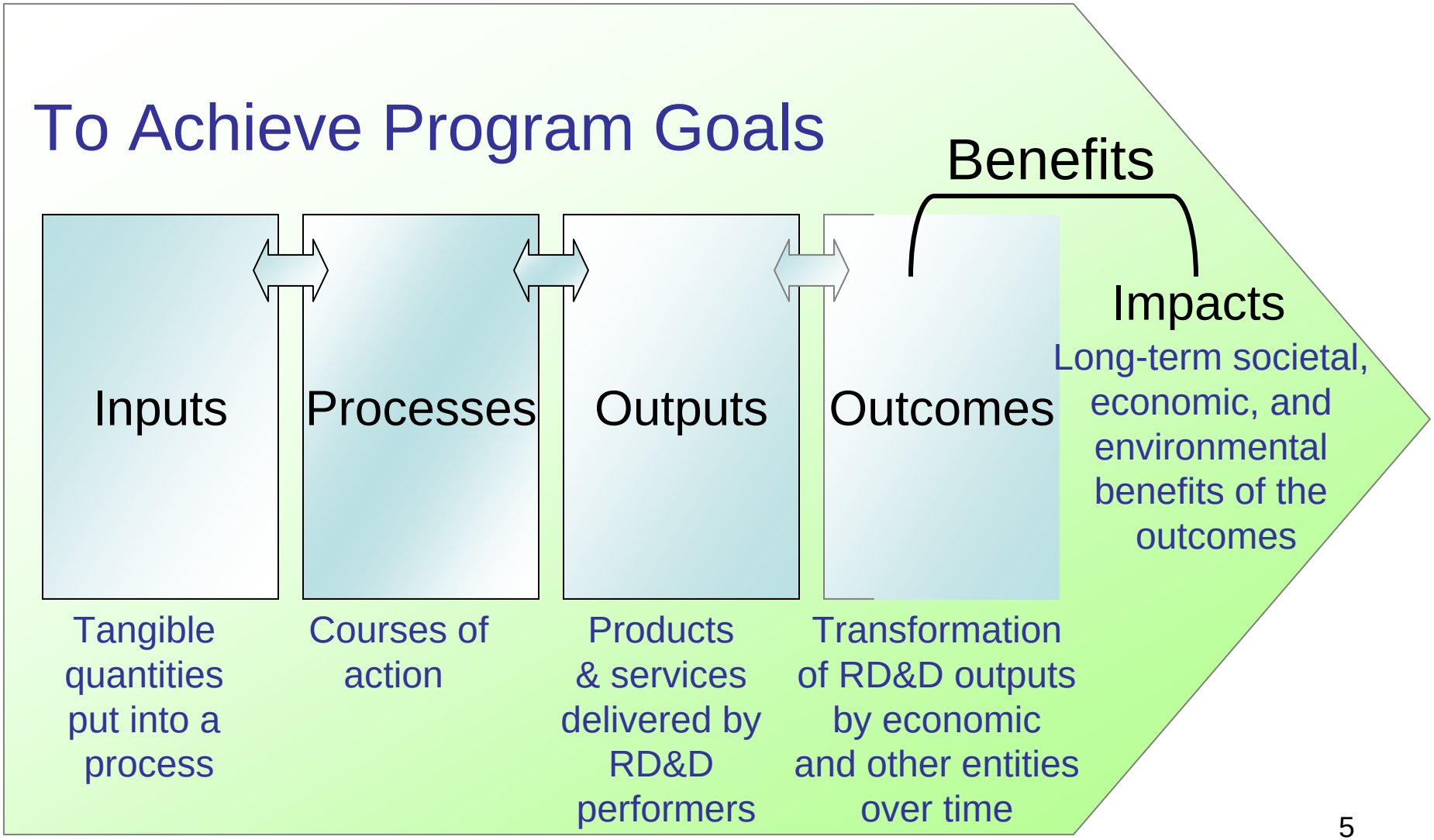
- To evaluate the USDA Section 9008 program and awards from fiscal years 2002 to 2005 solicitations.
  - Data collection from June 2006-May 2007
  - Perspective of 2002 and 2005 amendments of the Biomass R&D Act 2000
- To provide a general assessment of performance measures that could lend themselves to tracking of current and future benefits of the program

Steps Used to Construct Metrics for Section 9008 Program



Geisler, E. 2002, "The metrics of technology evaluation: where we stand and where we should go from here," International Journal of Technology Management, Vol. 24, No.4 pp. 341-374

Section 9008 System of Measurements



Input and Process Metrics

Investments in a variety of categories

Organization, Strategic, and Managerial metrics indicate how well the activity is being performed

Legislative

2000 Biomass R&D Act

2002 Purposes — Entities, Areas

2005 Objectives — Purposes, Entities, Areas, Targets

Technical Advisory Committee

Vision 2006
Roadmap 2003
Oversight
Feedback

Biomass R&D Board

Interagency Coordination
Oversight/Approval
Strategic Plan Goals

Executive

USDA — Strategic Goals, Outcomes

DOE

OMB — GPRA and PART

USDA-DOE
Joint Solicitations Processes
FY02-FY05

- Topics
- Criteria
- Review
  - Internal
  - External
- Award Selection

41 USDA projects

- Award negotiation
- Project manager (distributed)
- Project Reviews
- **Metrics Analysis – This work**

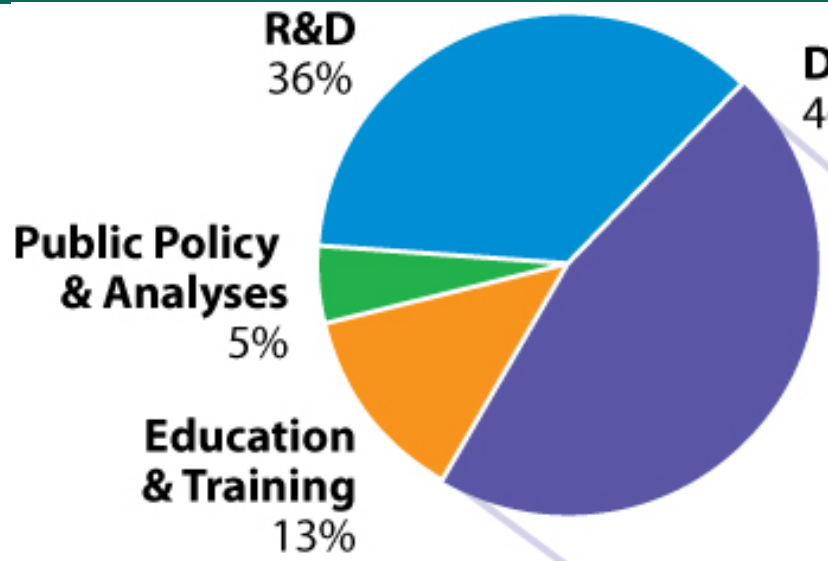
Peer review metrics indicate the degree to which the managed processes are reviewed to achieve the scientific and technical goals

USDA Section 9008 Selection of Projects

Solicitation FY, Manager # Pre- and Full Proposals Submitted	Awards Announced	#	Grants Started
2002 – DOE 190 pre-prop. 23 proposals	10/2002	2	1/2003
2003 – USDA 400 proposals	9/2003	15	9/2003 – 1/2004
2004 – DOE 400 pre-prop. 93 proposals	9/2004	13	12/2004-1/2005
2005 – USDA 670 proposals	10/2005	11	--

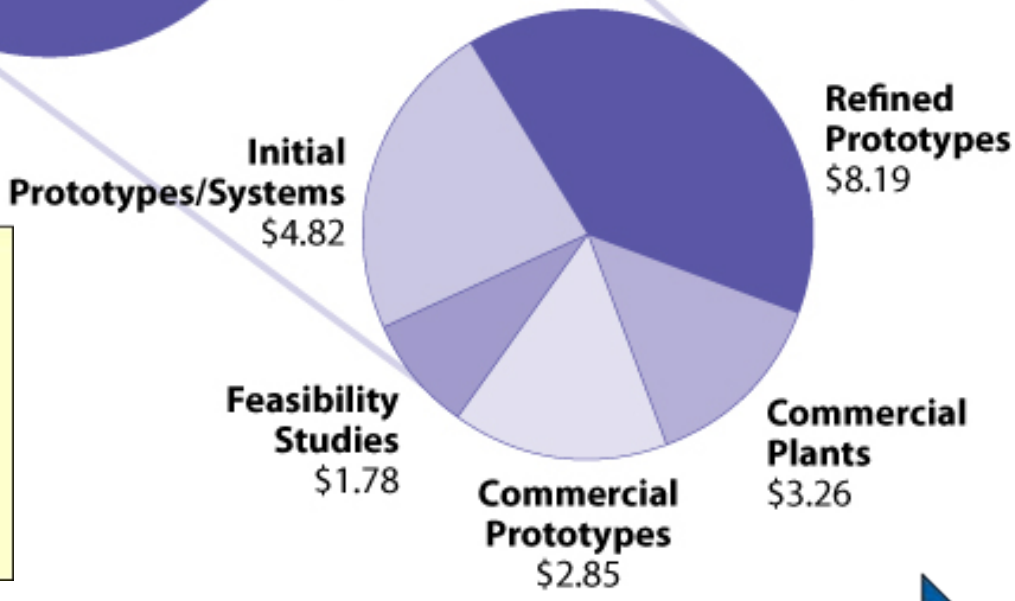
20 projects analyzed for outcomes
41 projects analyzed for overall processes

Funding Proportion by Stage of Development



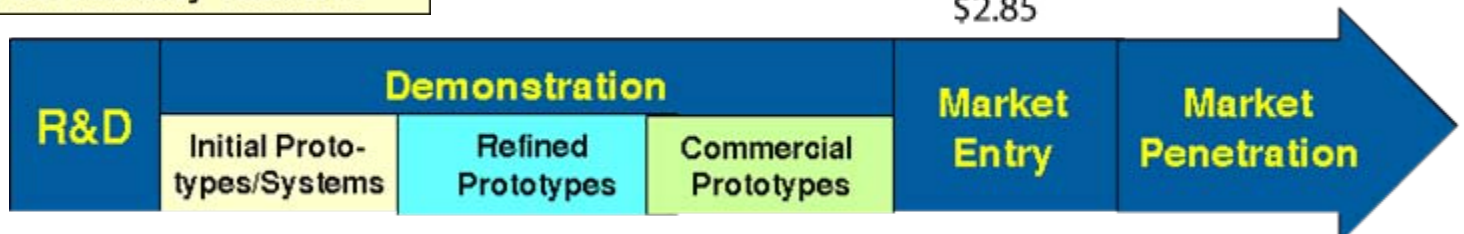
Total: $46 Mi

Demo Areas Funding in M $,
Total $20.9 M



2005 Act Amendments Future Targets	Current*
• 50% Demonstration	46%
• 35% Innovation	35-40%
• 15% Applied Fundamentals	17%

* Categories are not mutually exclusive



Qualitative and Quantitative Metrics

- Discovery and innovation are difficult to measure with quantitative metrics.
- The best approach is to use process and input metrics that ensure the promotion of discovery and innovation.
- As the science matures, more output metrics are appropriate and outcomes will emerge from these activities
- Hybrid qualitative and quantitative measures offer best strategic guidance

Technical Area Distribution

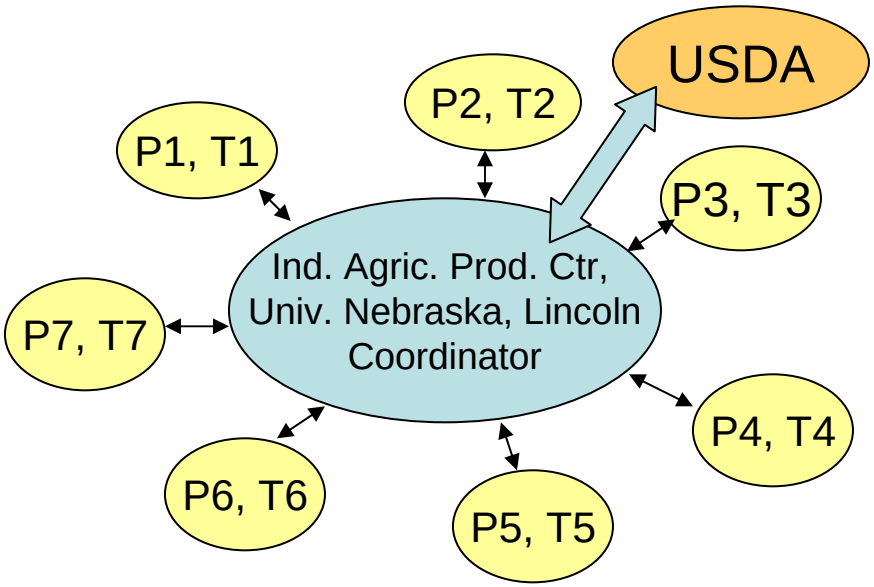
Areas	2005 Amended Act, %	Based on Solicitation Topics and Project Areas, %	Based on 2003 Biomass R&D TAC Roadmap Categories, %
Feedstock Corn, stover, DDG 37% Animal residues 22% Wood & residues 21% Switchgrass 13%	20	18-20	17 (R&D) 25 (with resource supply)
Conversion (Overcoming Recalcitrance)	45	45-50	45
Product Diversification	30	25-30	16 (5%-10% in conversion)
Strategic Guidance	5	4-6	

USDA Technical Area Distribution is consistent with the legislation

Project Peer Reviews

USDA – Site Review

CSREES designed review form;
Implementation by teams of researchers from the Multi-State Committee S-1007: The Science & Engineering for a Biobased Industry & Economy

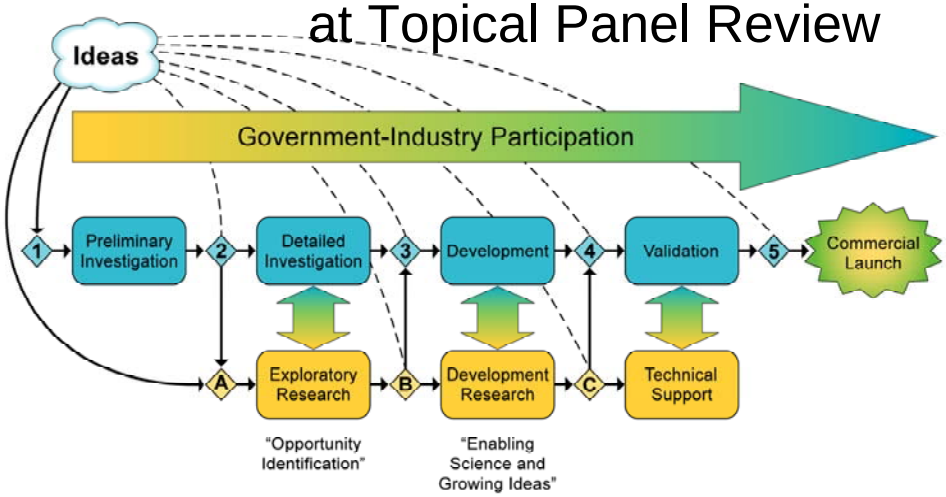


P = project PIs and participants
T = review team; 2 knowledgeable researchers, can sign non-disclosure agreements; prepare report after meeting (1-2 days). Significant feedback to PIs.

Coordinator assembles reports, summarizes review, provides USDA critique of status & future plans

Academia led

DOE – Stage Gate – Presentation at Topical Panel Review

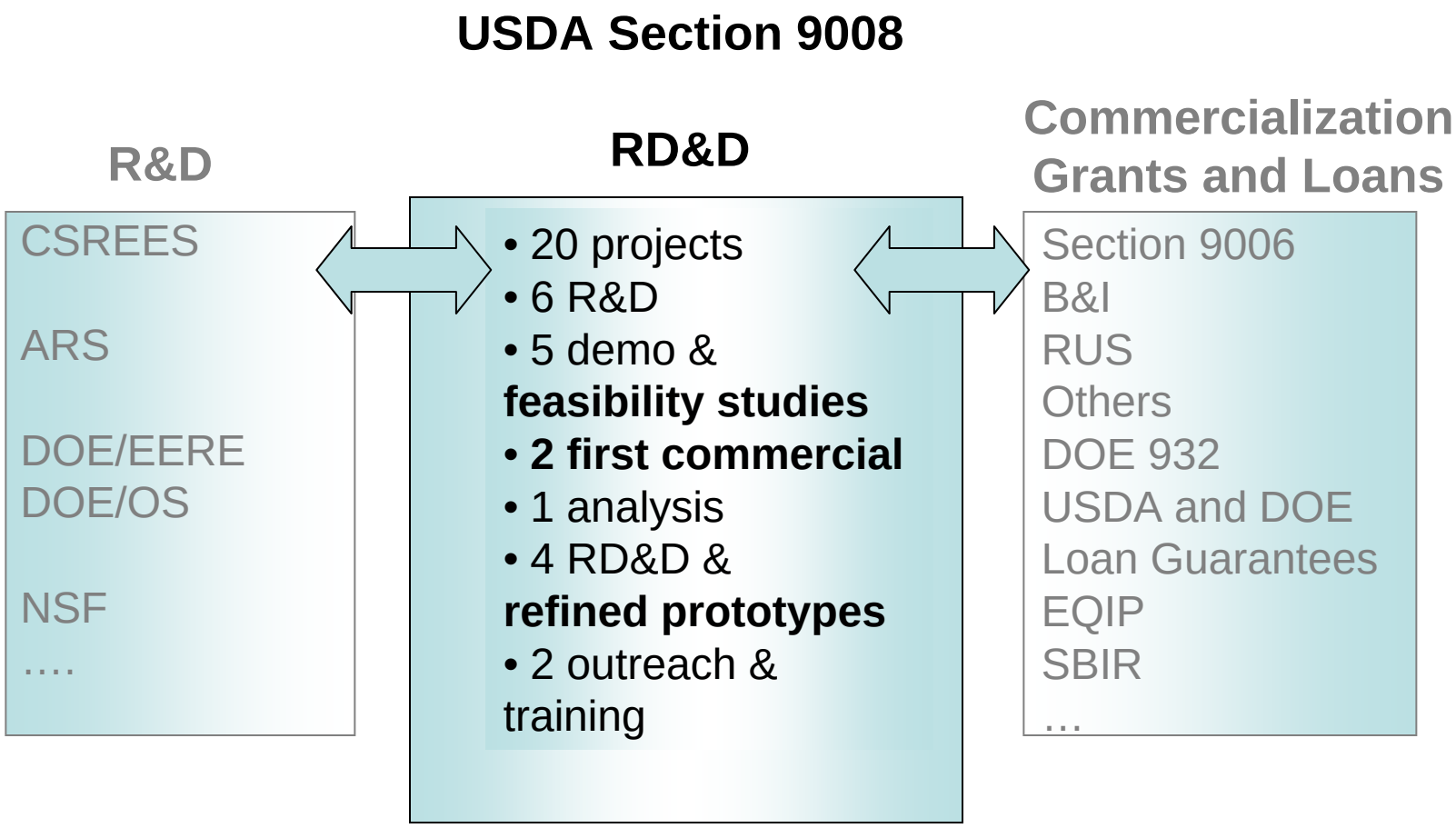


Integrated Feedstock Supply System for Corn Stover Biomass (#21)
Iowa State Univ.
Reviewers classified this as a Stage A research project. The involvement on industrial entities on the harvesting side was seen as positive, but overall the broad scope of the effort (plant breeding, harvesting, storage) was seen as a potential problem. The efforts should be coordinated with other storage projects and with conversion research to identify desirable properties in the harvested/stored stover. Further assessment of the project is premature due to it just getting underway.
Recommendation:
Project needs to coordinate with NREL to continue analysis of samples from ensilage at various treatment stages. In addition, providing data and coordination with IBSAL is crucial to success. Although breeding is seen as a long-term effort, project should continue to analyze different corn varieties for appropriate stover qualities, and should continue to include and interact with industrial partner(s). Finally, coordination with other projects is critical, even though some of the other projects are not performing necessarily parallel tasks.

Biomass Opportunity for Imperial, Nebraska Region: What's the Value? (#20)
Jim Hettenhaus
The reviewers felt the project was in Stage 3 or perhaps 4. Though the project is just getting underway, it was felt that it should provide good information on transportation and storage.
Recommendation: Assure coordination with other storage projects (INL, Cargill/MAT), and provide data to IBSAL for validation. Continue to interact with NREL regarding analysis of feedstock qualities with respect to the pile.

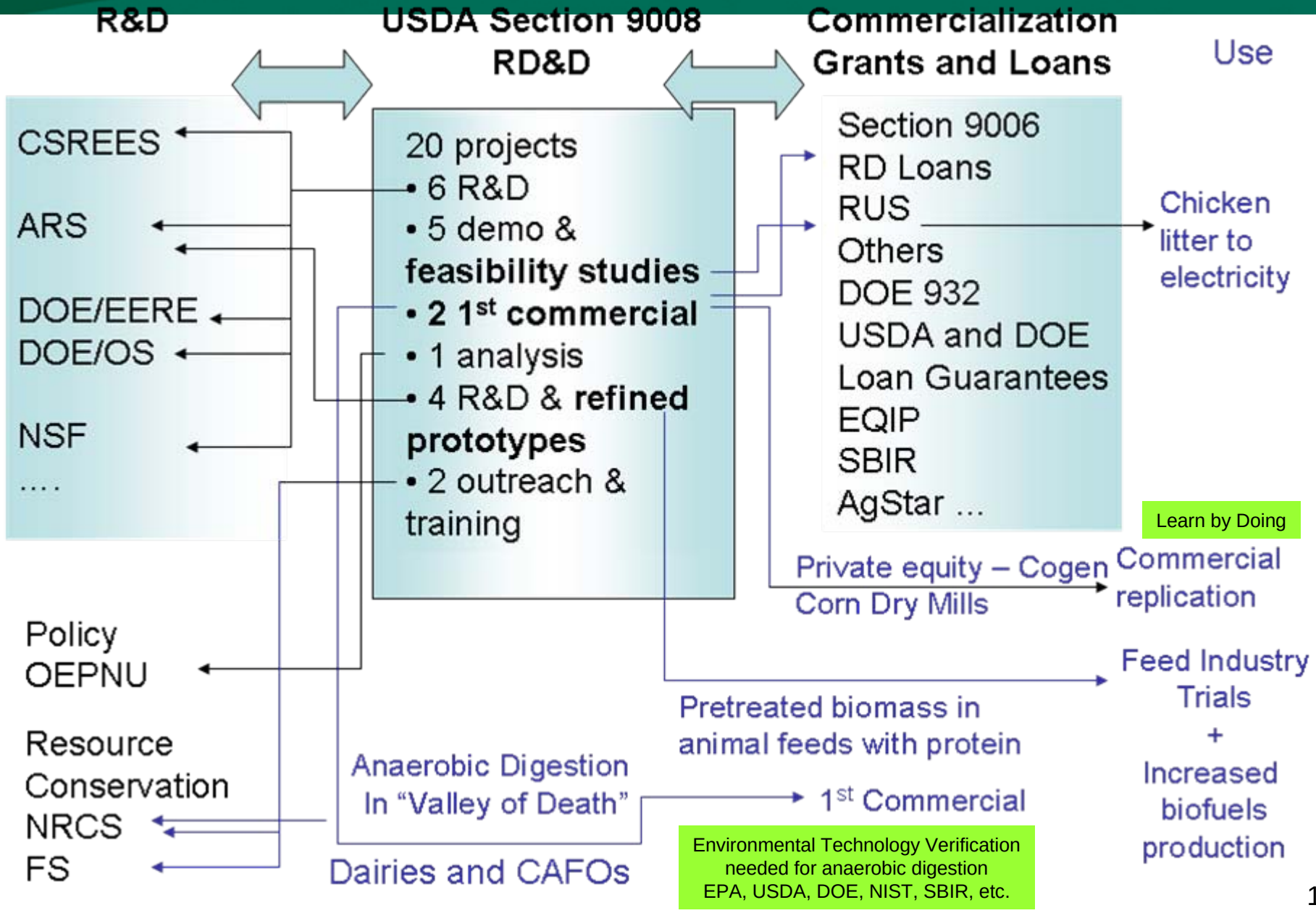
Industry led – Assess stage placement, program fit, quality, interactions with other program participants

Summing Up Projects with Outputs as of May 2007



USDA Section 9008 projects investment in FY03-FY05 was $44 Mi.
5.4% of all USDA and 4% of USDA/DOE investments in the period.

Links with Other Programs



Biomass R&D for Fuels, Chemicals & Improved Cattle Feed

1. Dry Mill Improvement – fractionation of the germ, pericarp, and endosperm
2. Bioavailable cattle feed from corn processing by products and pretreated agriculture residues

Pellet extrusion

Pellets

Offset cracked, rolled and flaked corn feed with these products liberates corn for increased ethanol production. Potential increase is 40% of today's 4.4 billion gallons at full market penetration without increase of corn area.

Prime, Location: Archer Daniels Midland Co., Decatur & Champaign, IL; Decatur, IN
Participating Orgs: USDA ARS, EERC; Univ Illinois; ADM Animal Nutrition
Funding: $1.4 M ; Cost share: $600,000
PoP: Jan 04 to Dec 06 ***P.I.:*** *Charles Abbas; abbas@admworld.com*

Baseline Measures for Tracking

Measures	Measure Amount	Index Measure/ Million $	Comments
USDA Funding, Million $	$22.4		
Cost Share, Million $	$22.7	1:1	50 % cost share
# Proj. FY02 (2), FY03 (15), FY04 (4)	20	0.9	One FY03 project continued in FY04. Counted as 1
Cumulative # Publications	40	1.8	Easy to track but best associated with quality index
Cumulative # Patents (applied and issued)	20	0.9	Upper limit. Later separate applied and issued patents. Index is 0.04 for issued patent.
Cumulative # technologies under commercialization	2	0.08	One 1st commercial (Project # 14, FY03) and one commercial prototype (Project # 14 FY03)
Cumulative # Processes, products, systems under development	36	1.6	Difficult to track. Expert judgment on the overall portfolio.
Cumulative # Licenses	2	0.08	Easy to track
Cumulative # Companies involved ith IP generation	40	1.8	Requires detailed analysis of projects
Cumulative # Projects financed	2	0.08	Easy to track. USDA RUS Loan (Project # 3 FY03). Equity financing (Project # 14 FY03)
Cumulative # Feasibility studies	5	0.2	Decrease investment risk. Downselection tool
Cumulative # Outstanding training/ education courses/policy analysis	3	0.12	Not just numbers; counts only if quality is built into it.
Cumulative # of students to Post-docs	56	2.5	Human resource development dimension of training of professionals. Easy to track
Cumulative # of project investigators and lead collaborators	81	3.6	Human resource dimension of complexity of projects with multiple investigators at different organizations.

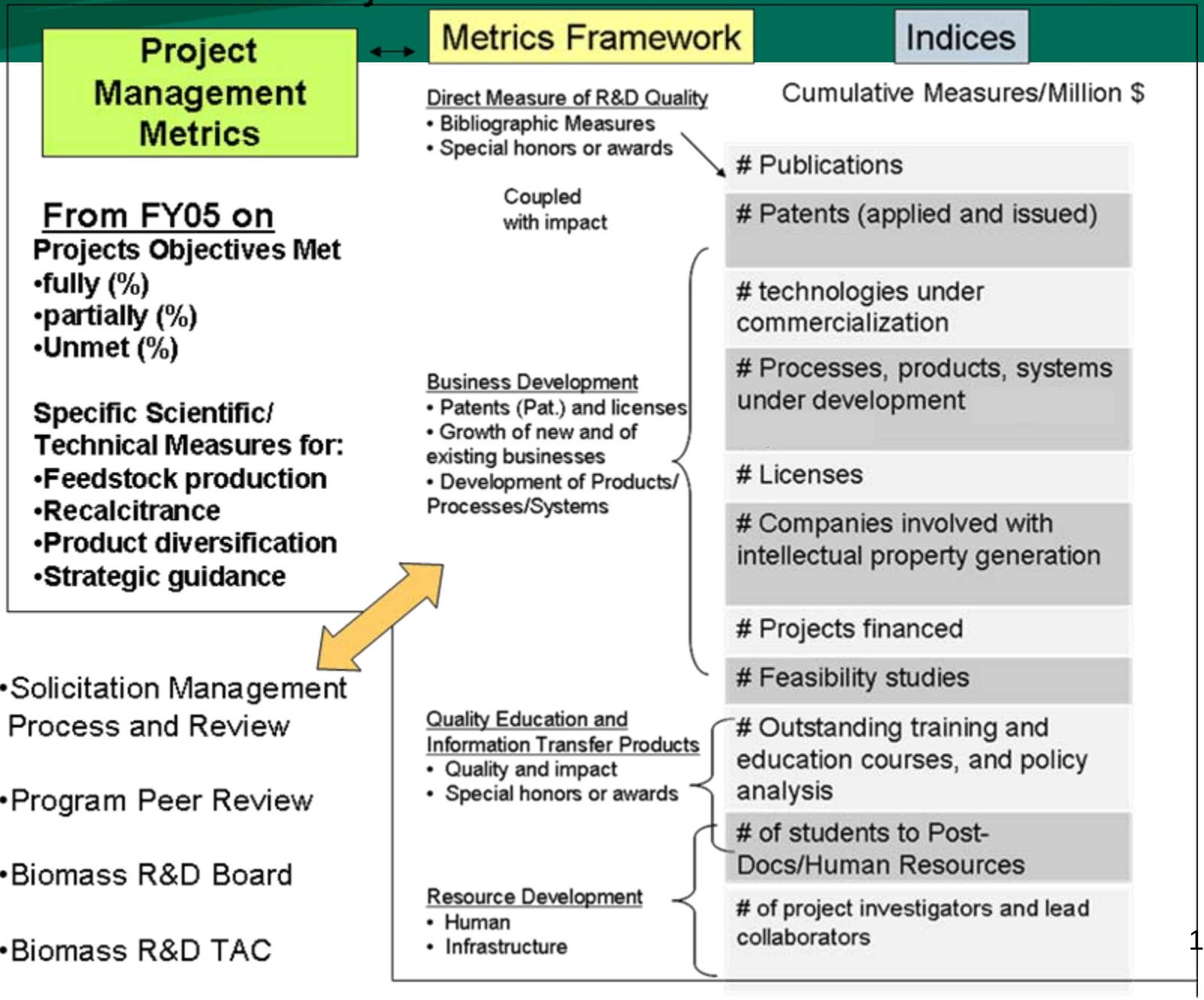
Comparison with DOC/NIST Advanced Technology Program (ATP)

	ATP Development only 1990-present	RD&D - USDA Section 9008
Cumulative # Publications/Mi$	0.34 mid program 1.0 early 2000	1.8 includes earlier R&D phases
Cumulative # Patents/Mi$	0.42 mid program 0.67 early 2000	0.04 issued 0.9 applied
Cumulative # Techn. Under Development/Mi$	0.10 mid program 0.17 early 2000	0.08 0.24 estimated based on 36 tech under development and the ratio 9:1 from prototypes to successful commercialization*

NIST = National Institute for Standards & Technologies

*Stevens, G.A.; Burley, J. 1997. "3,000 Raw Ideas = 1 Commercial Success". Research Technology Management, Vol. 40(3) pp. 16-17

Quality Metrics for Section 90008



Metrics Summary

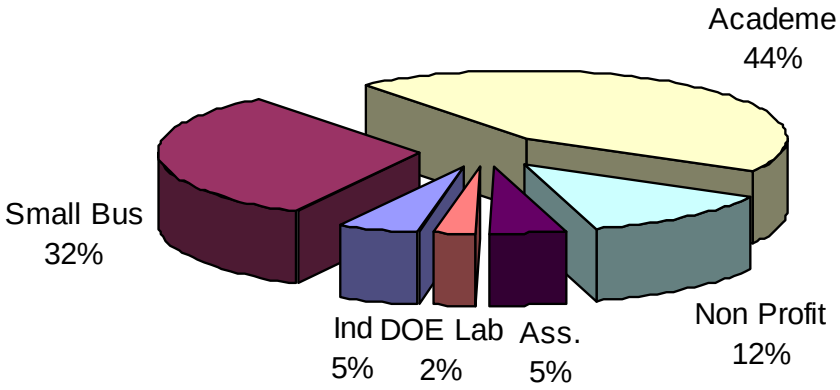
- Section 9008 is consistent with the legislation (2002 and 2005 ahead of schedule)
- Multi-level peer review consistent with legislation and best practices.
  - Feedback loops established
    - Input and feedback from TAC, Biomass R&D Board, USDA, DOE
    - Input to solicitations
    - Guidance to proposal reviewers in selecting projects with measurable goals based on lessons learned from 20 projects
    - PIs praise site reviews; issue of competitiveness with State Gate
- Projects producing scientific and technological outputs and outcomes, five years after the first two awards
- The road to assessing benefits of the program requires tracking of projects over time and periodic analyses of outcomes. Some quantitative measures are possible. The most meaningful require expert judgment of quality.
- Validation of measures and tracking mechanism needed.

Back Up Metrics Information

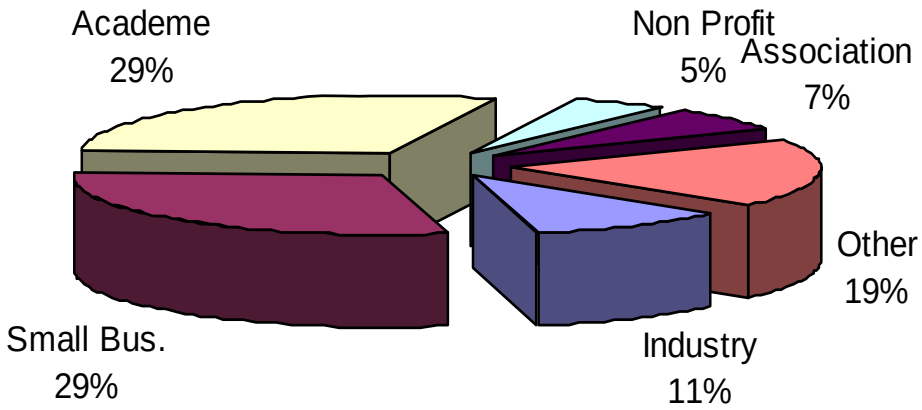
- Input and Process Metrics
- Output Metrics
- Outcomes and Impact Metrics

Input Metric

- Project partnerships include 150 participating organizations in 36 states, DC, and a few international
- Average 5 partnering organizations/project
- Projects with 60 participants common. Has + and - impacts
- All Act eligible entities participated



Award Recipients



All Participants

Other	%
USDA Lab	32
DOE Lab	32
State Org.	21
Indian Tribe	7
EPA	4
Public/Private	4

2002 Act's **Purpose** emphasized partnership formation, decreasing silos among RD&D contributors, and fostering multidisciplinary partnerships.

- Many effective networks of RD&D were created.
- Industry partners in most projects facilitated technology transfer.

Peer Review Metrics System

Level	Focus	Type	Mechanism
1	Solicitation Process (and Program)	a) Biomass R&D TAC b) Biomass R&D Board	a) External statutory FACA b) Interagency federal government (statutory)
2	Solicitation Proposals	a) Internal agency review for fit b) External peer review for quality	a) USDA b) Industry, academia, labs, and government experts
3	Individual Project	a) Peer Review (all) b) Stage Gate (select)	a) On site with two independent experts from academia b) External Panel Review

Section 9008 program management processes include multi-level reviews to achieve the scientific and technical goals of the program:

- Overall solicitation process
- Individual solicitations
- Individual projects
- Feedback loops built into all these processes through TAC and Board

Output Metrics Baseline of 20 Projects

Weight Average of 3 Years After Award

• Direct Measure of R&D Quality	Examples: **1** most downloaded; **1** most cited pub
• Bibliometric measures coupled with quality assessments	Production of peer reviewed and broadly accepted results and knowledge base increase. **40 publications**.
• Special honors or awards	None
• Resource Development	**81** faculty, industry, other led subprojects
• Human	**39** graduate students, **12** students, **5** postdocs
• Infrastructure	In academia, industry, research organizations
• Business Development foster creativity and innovation	Partnerships in all projects
• Patents (Pat.) and licenses	**1** Pat. Issues; **19** Pat. Filed; **2** licenses granted
• Growth of new and of existing businesses	**40** companies (75% small) can capitalize on IP
• Development of Products/ Processes/Systems	**10-12** processes; **17-25** products; **3** systems under investigation
•Quality Education and Information Transfer Products	Multilevel outreach
• Quality and impact	Biomass Encyclopedia Network Bioenergy tool; Policy development information; social/env. issues
• Special honors or awards	None

Outputs Moving to Outcomes

- Early Outcomes from Direct RD&D Outputs result from the increased understanding of scientific and technical areas
  - Number of licenses granted while conducting RD&D – 2
  - Number of projects that obtained financing for commercial plants – 1 from USDA RUS and 1 from private equity
  - Number of advanced technology developments near commercialization – 1 bioavailable cattle feed

Intermediate Outcome Metrics from demos or advances from prior R&D by economic entitites

- Number of improved processes/products under commercialization
- Number of integrated biorefinery systems developed and tested moving to commercialization
- Number of new products developed
- Number of licenses granted post RD&D at various times
- Number of companies/cooperatives/ventures created
- Number of technology packages resulting from the RD&D in operation – 1 for advanced cogeneration of heat and power from biomass residues in a dry mill in Minnesota

Final Outcomes

- Number and amount of biobased products directly incorporated into manufactured products
- Number of companies and amount of biofuels and bioelectricity produced
- Existing biorefineries commercializing process improvements and products from the RD&D
- New commercial biorefineries

Impact Metrics

- Indices for economic/financial outputs per dollar of program investment (total or by technical area that generated the impacts)
  - Energy security index: Value of fossil fuels substituted with renewable fuels – a surrogate for imported fuels substitution
  - Economic development index: Value of biobased products generated also a surrogate for diversification in agriculture and forestry
  - Economic development index: Number of jobs created in rural America and industry from the application of the program outputs
  - Energy diversification index: Value of the biomass energy as thermal or combined heat and power, or power generated also a surrogate for rural development
- Environmental quality and sustainability indices:
  - A climate change mitigation index: tons of fossil carbon emissions (and other green house gases) mitigated per dollar of program investment
  - A sustainability index could be generated for biomass feedstock, water use, fertilizer use, soil carbon measurements and soil fertility, and land/water stewardship with appropriate development of life cycle based measures
  - A green engineering index could take into account energy efficiency, plant water closure level, and overall emissions from the biorefineries thus providing energy, water, and emissions indices for the plants incorporating RD&D outputs of the research

long-term societal, economic, and environmental benefits of the outcomes of the Program

Sebesta's Cogeneration Assessment and Implementation

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Committed to the future of rural communities.

Outcomes:

1. Public business plan
2. Cogen plant in operation
3. 1 MW Green Power - new product
4. NG independence
5. 20 jobs added in infrastructure with a 10-yr wood residue contract
6. 3 additional business plan projects for 6 dry mill cogen plants

Central Minnesota Ethanol Cooperative (CMEC)
Little Falls, MN

Prime, Location: Sebesta, Blomberg & Associates, Roseville, MN
Participating Orgs: CMEC, Primenergy, PCL, Dahlen
Funding: $2 M USDA, $2 M MN/Xcel, $11 M debt financing CMEC
POP: Sept 03–Aug 06

P.I.: *Cecil Massie; cmassie@sebesta.com*

Corn Dry Mill Improvement Pathway

Milling

Liquefaction /Cooking

Saccharification

Conventional Ethanol Fermentation

Ethanol Recovery

Ethanol

M 2.3 Mixed Sugars to Ethanol
- Ethanol Recovery
- C5/C6 Sugar Ethanol Fermentation

M 2.6 New Fractionation
- Fractionation
- Recover Oil and Fiber Coproducts

New Oil and Fiber Coproducts

M 2.5 New Products from C6 Sugars
- C6 Sugar Conversion to Chemical Intermediates
- C6 Sugar or Intermediate Conversion to Products
- Recover New Coproducts

Coproducts from C6 Sugars

M 2.1 Residual Starch Conversion
- Residual Starch Conversion to C6 Sugars
- Recover New Feed Product

Recover DDGS Product

M 2.2 Fiber Conversion
- DDG Fiber Conversion to C5/6 Sugars
- Recover New Feed Product

M 2.5 New Products from C5/C6 Sugars
- C5/C6 Sugar Conversion to Chemical Intermediates
- C5/C6 Sugar or Intermediate Conversion to Products
- Recover New Coproducts

Coproducts from C5/C6 Sugars

Feed Products

Natural Gas

Steam and Power Production

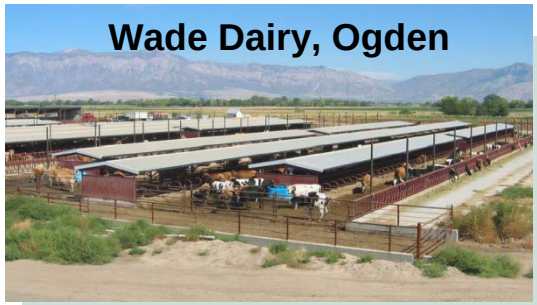
M 2.7 Alternate Sources for Heat and Power
- Biomass Resources
- Steam and Power Production

Heat and Power for Dry Mill

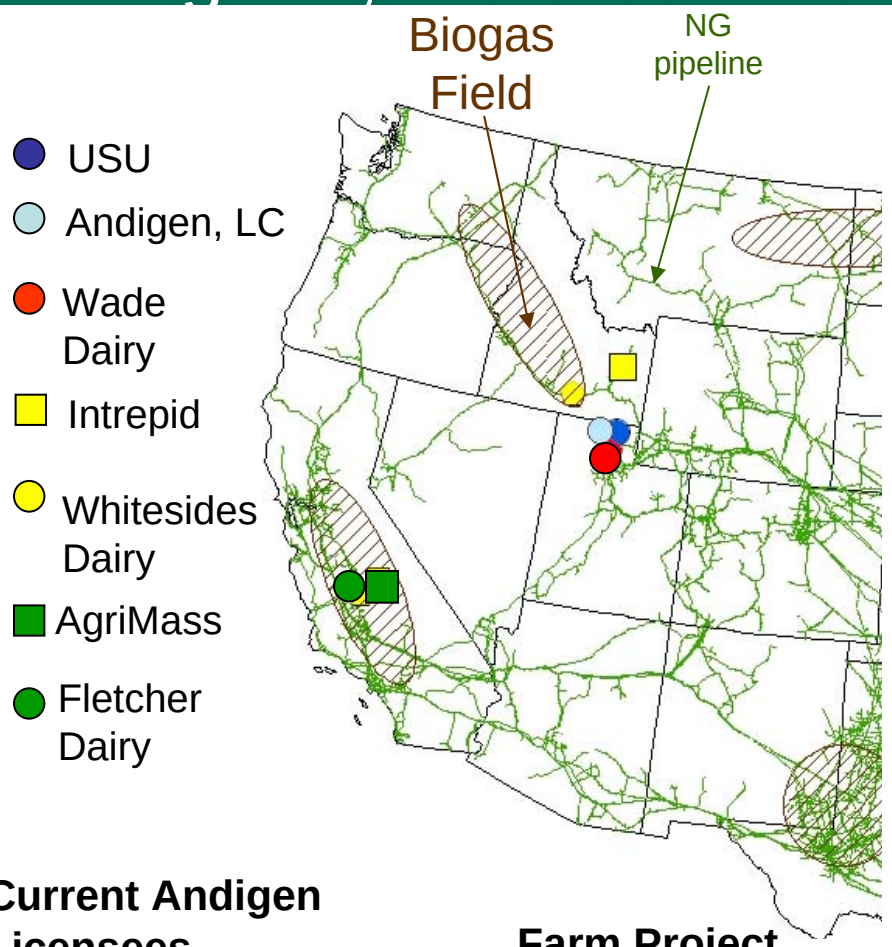
Sebesta's Project at CMEC produced 1st example

Section 9008 USDA Project Numbers 1, 10, 11, 13 support pathway

R&D of Anaerobic System on a Large Dairy Farm in Ogden, UT



Designed, built & in operation



Prime: Utah State University, Logan, UT
Participating Orgs: Andigen, LC
Funding: $761,385 USDA; $400,000 UT
POP: Sept 2003–July 2006
P.I.: *Conly Hansen; chansen@cc.usu.edu*

Current Andigen Licensees

Intrepid Resources and Tech Inc., Idaho Falls, ID

AgriMass Enviro-Energy Inc., Visalia, CA (Central CA)

Farm Project

Whitesides Dairy, Rupert, ID

Fletcher Dairy, Tulare, CA

Biopolymers and Other Value-Added Products from Distillers' Dried Grain

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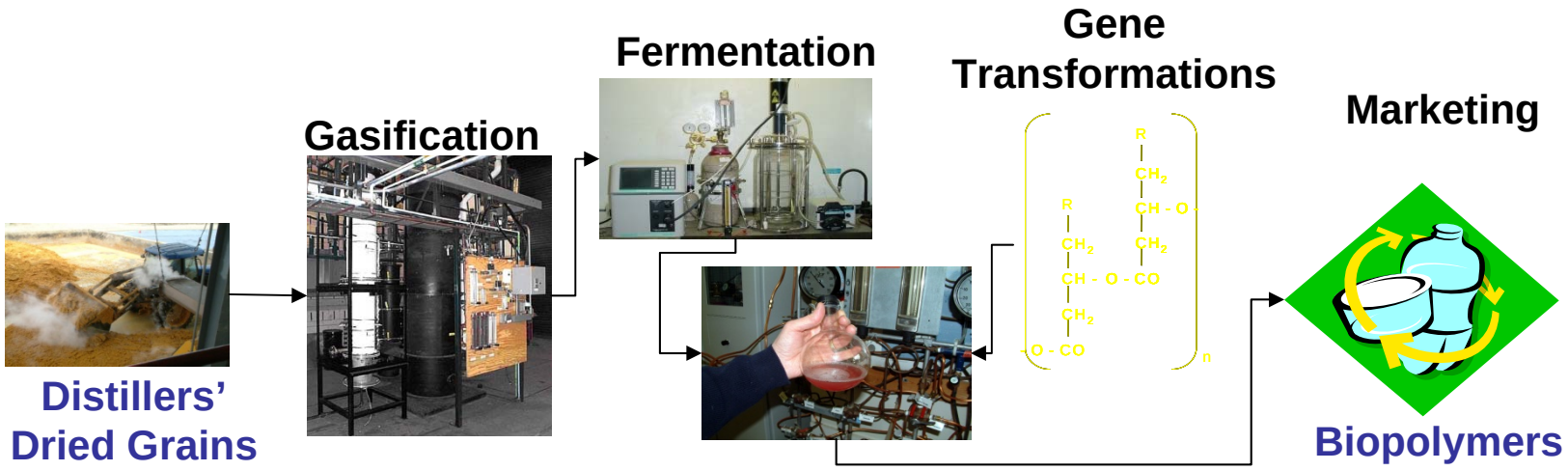
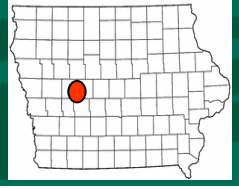
1. Corn dry milling process changes to extract lipid and protein/zein;
2. Gasification of extracted DDGS and syn gas conditioning; Char to soil amendment
3. Syn gas to biopolymers
   - Fermentation syn gas with *Rhodospyrillum rubrum* for polyhydroxyalkanoates
   - Cloned *R. rubrum* to produce multiple products from syn gas; 4 patent applications
4. Technoeconomic evaluation.

Team: 5 faculty ISU; 10 SDSU; 1 MGP; Multidisciplinary, science, eng., economics, food, marketing, other



Prime, Location: Iowa State University, Ames, IA
Participating Orgs: South Dakota State University; Midwest Grain Processors Coop.
Funding: $1,000,000
PoP: Oct 03 to Dec 06



New Technologies for the Production of Methyl Esters

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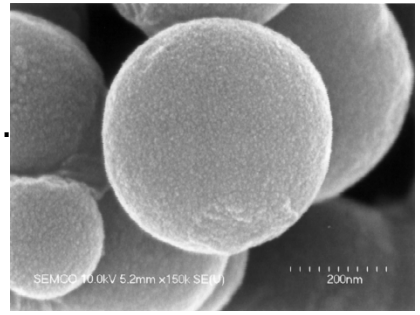
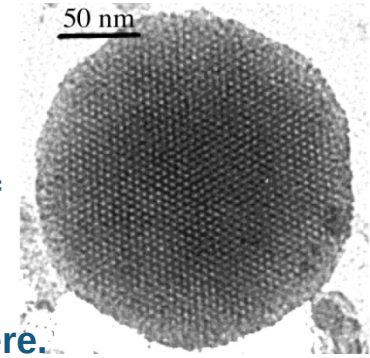
- Base-type catalysts synthesized, mounted on mesoporous solid supports and evaluated for efficiency and recyclability in catalyzing the transesterification of oils with methanol. Acid-type mesoporous solid catalysts synthesized for esterification of various oils and fatty acid feedstocks with methanol.
- Field testing new, recyclable heterogeneous acid and base catalysts for converting various oils and fatty acid oils to methyl esters,
- Fine tuning performance characteristics of the new heterogeneous catalysts,
- Conducting cost analyses using selected heterogeneous catalysts with various oils and fatty acid feedstocks.
- Identified best catalyst; performance held in 7-mo bench scale tests.
  US Patent filed. PCT in filing process.
  Partnerships discussions.
- 8 graduate students trained.



SEM image of the mesoporous silica microsphere.



TEM image of cross-section showing hexagonal lattice units of porous framework.

Prime, Location: West Central Cooperative, Ralston, IA
Participating Orgs: Iowa State University
Funding: **$**1,826,648; cost share
POP: Oct. 03–Dec. 06

P.I.: *Scott Vernimont; scottw@westcentral.net*
P.I.: *Victor Shang-Yi Lin; vsylin@iastate.edu*