FIELD ASSESSMENT OF DESIGN AND OPERATION OF MIDWESTERN AQUACULTURE BUILDINGS

Chairperson: Dr. Albert J. Heber

Extension Liaison(s): Robert Rode

Funding Request: $34,998

Duration: 1 year (July 1, 2016 to June 30, 2017)

Objectives:

1. Evaluate the approach and effectiveness of the environmental control currently being used in representative commercial aquaculture operations in the Midwest.
2. Determine most cost-effective methods to control condensation in aquaculture buildings.
3. Determine the most efficient and practical heating and ventilation systems for aquaculture buildings based on sound engineering principles.
4. Troubleshoot environmental problems observed in commercial aquaculture operations.

Proposed Budgets:

Institution	Principal Investigator(s)	Objective(s)	Year 1	Total
Purdue University	Albert J. Heber	1-4	$34,998	$34,998
		Totals		**$34,998**

Non-funded Collaborators:

Facility	Collaborator
Iowa State University	D. Allen Pattillo

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PROJECT SUMMARY

Many producers have converted an existing agricultural or livestock building into an indoor recirculating aquaculture system (RAS) to reduce the necessary capital, while some have constructed new structures. The extension agricultural engineering inputs to the structural aspects of the operations has been severely lacking. Indeed, existing written resources on environmental control of agricultural buildings available to most livestock producers (e.g. Midwest Plan Service) do not include the environmental control of aquaculture building due to the recent emergence of the industry. This gap needs to be filled because long term success of these operations include the useful life of the structure, efficiencies of energy usage and structural layout, and well-being of workers. Producers using indoor RAS systems are currently experiencing excessive surface condensation which degrades building materials, is unsightly, and creates an environment for mold and other microorganisms. Producers need guidance on efficient heating and ventilation so moisture, carbon dioxide, and other air contaminants are removed while minimizing energy costs. We propose to conduct comprehensive environmental and energy audits of five representative facilities during winter and summer, develop solutions to observed problems, and to disseminate findings and recommendations via publications and presentations to producers, consultants, extension personnel, and other stakeholders.

JUSTIFICATION

Many indoor aquaculture operations take place in converted structures or new buildings with inadequate engineering input. As a result, building and equipment integrity and reliability and worker safety and health are concerns at many of the facilities today. A critical unmet educational need exists to address problems of condensation, unhealthy indoor air quality, excessive energy costs, and deterioration of building materials and equipment. High humidity (>90%) coupled with high temperatures (>30EC) increase heat stress experienced by workers, enhances the growth of mold and other microorganisms, causes deterioration of insulation effectiveness, and causes slippery floors, and failures of electrical equipment, sensors, and instruments. These problems are caused by suboptimal methods of heating, inappropriate ventilation strategies, and subpar layouts of equipment. An increase of engineering inputs and education can ameliorate these problems.

While pond culture is not affected by these issues, indoor systems are increasing. Sustainability of the building is very important to business longevity and profit. They need to have significant life remaining after the last mortgage payment. Public tours of the facilities should be held without unsightly condensation on the walls, ceilings and floors.

The outcomes of this project will be applied directly to aquaculturists and their advisors (consultants, contractors, extension personnel, vendors, colleagues) who make engineering decisions regarding these confined environments.

The timeline and budget for the proposal were not conducive to identify project partners outside of Indiana. However, there is interdisciplinary collaboration between experts in aquaculture (R.A. Rode) and agricultural engineering (A. J. Heber), 2) interstate collaboration will be sought by the PI's for future proposals and this will be facilitated by attending aquaculture workshops and meetings as part of this study, and 3) it is expected that there will be at least ad hoc collaboration during this study as we visit sites in other states and notify our professional colleagues about our efforts. Therefore, we see collaboration developing with our academic colleagues and industry stakeholders from within and outside the region. We also anticipate future research that builds on what is learned during the study.

RELATED CURRENT AND PREVIOUS WORK

Heber et al. (2011) conducted a $13M national scale assessment of the air emission rates from livestock buildings, which had several similarities to this proposed project, although much larger in scale. The goal of the National Air Emissions Monitoring Study (NAEMS) was to assess environmental problems of the industry and it was important to select representative farms. The planning involved a debate about whether 100s of farms should be sampled briefly or 20 farms sampled longer and more intensively. It was decided that only 20 farms should be selected based on farm information provided by a larger pool of producers, and to monitor for two years continuously (Heber et al. 2011). The approach was approved by the U.S. EPA who oversaw the project.

Miller (1985) developed an engineering simulation model for a catfish grow-out facility. An energy budget and seasonal heating, ventilation and air conditioning schedules were generated from insulation values, equipment usage, air and water temperatures, humidity levels, and weather data. The model allowed an evaluation of how building and production system designs affect energy requirements, water quality and production efficiency.

Hall and Saidu (2005) noted that controlling water temperature can be costly and inexpensive sources of heated water such as geothermal water, industrial cooling water or solar heated water can reduce costs. Fuller (2007) studied solar heating systems for heating water in recirculation aquaculture and developed a simulation model for systems that are enclosed by a greenhouse. Using the model, it was determined that solar energy can reduce heating costs and that covering the tanks at night reduces both condensation and conventional energy use. Li et al. (2009) also developed a thermal model for greenhouse aquaculture raceway systems. Model simulations were conducted to study the effects of the greenhouse on air and water temperatures and to calculate heat consumption and costs at four different climatic locations. Convection and radiation were shown to be a significant factors governing sensible and latent heat loss from the water surfaces.

Hoque et al. (2012) studied the complex tradeoffs between controlling humidity to a healthy target of 50 to 60%, and controlling air and water temperatures. They noted that a significant portion of the annual energy costs originates from water surface condensation and the lower the dew point temperature, the greater the evaporation rate. They stated that building integrated aquaculture must take humidity, airflow and condensation into consideration.

Singh and Marsh (1996) developed a thermal model to simulate RAS environment and energy use for heating, ventilation, water pumping, biofilter operation, and lighting over a production cycle and it was validated with experimental data. They recommended heat recovery from discharged wastewater to reduce energy cost.

A thermodynamic analysis of a recirculation aquaculture system (RAS) was conducted by Kucuk et al. (2010) for Black Sea trout in Turkey. They conducted experimental measurements of mass flow rates, inlet and outlet temperatures, etc. and determined the thermal efficiencies of various system components and the entire system. They concluded that improve operating conditions of various components will improve the overall energy efficiency of the RAS.

A life cycle analysis was performed to evaluate the environmental and energy performance of a RAS for fresh shrimp (Sun, 2009). They examined transportation, marketing, farm location, and biosolids handling. They determined that producing and distributing shrimp in the U.S. reduced pollutant emissions by 15 to 82% as compared with importing shrimp from Asia.

Rosati (1991) gave a paper at a workshop that provided an overview of the things to consider when remodeling farm structures to culture buildings. These factors included water supply, drainage, floor construction, lighting, doors, electrical service, heating, insulation, moisture control, and automatic monitoring and alarm systems. Worksheets for calculating building heat loss and heating fuel costs were provided.

No similar current projects were found from searches of the USDA Current Research Information System (CRIS), and the Research, Education, and Economics Information System (REEIS). Similar research and educational projects were also not found on the NOAA databases available at the state Sea Grant Program (www.seagrant.noaa.gov) and the NOAA Office of Aquaculture Funding Opportunities Page (www.nmfs.noaa.gov).

Preliminary Data

A visit was made on March 19, 2016 to a local shrimp production facility, which consisted of nursery, intermediate, and grower stages. All stages were under one roof and connected by doorways. Small exhaust fans in the intermediate and a new grower room exhausted stale air and created an underpressure to force fresh air into the rooms through ventilation inlets.

Carbon dioxide and humidity were measured with a TelAire Model 7001 CO2 Sensor and a motorized psychrometer, respectively. Fan airflows were measured using an anemometer traverse method. The outside wet bulb and dry bulb temperatures were 8.6 and 12.8EC (47.5 and 55.0EF), respectively, at 1018.

The 9.8x17.1x2.6 m (32 ft x 56 x 8 ft) intermediate room contained seven 46-cm (18 in.) deep tanks (5 were covered at the time) held at 28.5EC (83.3EF). The total live animal mass was 88 kg (194 lb). The floor was insulated with 2.5 cm (1.0 in.) of rigid insulation board and heated using hydronic radiant heat. The ceiling was insulated R=7 EK-m^2/W (40 h-ft^2- EF/Btu). The walls consisted of plastic sheathing, batt insulation with R=3.35EK-m^2/W (19 h-ft^2-EF/Btu), 3-cm (1.2 in.) foam, a vapor barrier, and sheet metal.

The fan airflow rate was 1465 m^3/hr (862 cfm) which produced 3.4 air changes per hour, but incoming air was exhaust air at 24.9EC (76.8EF) and 88% RH) from the adjoining grower room. The exhaust air was 25.0EC (76.8EF) and 96% and water removal of 69 kg/day (152 lb/d) was calculated based on moisture balance. The inlet and exhaust CO_2 concentrations were 533 and 631 ppm, respectively.

The Grower 1 animals ranged from 3 to 18 g (46 to 278 gr) and the total live mass among 7 tanks was 396 kg (871 lb). Exhaust fans in other rooms created an underpressure that pulled fresh air in through exterior doors. The airflow rate was 1700 m^3/hr (1000 ft^3/min) or 1.56 air changes per hour. Based on the measurements of humidity and airflow, 69 kg/d (152 lb/d) of water was removed. The inlet CO_2 concentration was 325 ppm and the concentrations of air leaving the east and west doors were 481 and 533 ppm, respectively.

ANTICIPATED BENEFITS

The outputs of this project will consist of educational materials including extension fact sheets, power point presentations posted on web sites, a white paper on aquaculture environment, and a standard operating procedure for auditing an aquaculture building. Owners and operators of aquaculture operations will learn how to cost-effectively control condensation in their buildings, how to adequately and economically heat their facilities, and how to correct problems associated with poor air quality. They will also learn what factors to consider when renovating older facilities or building new facilities. As a result of this project, aquaculture buildings will last longer, workers will be healthier, and the industry will have an improved public image because people regularly tour their facilities.

OBJECTIVES

1. Evaluate approach and effectiveness of environmental control currently being used in representative commercial aquaculture operations in the Midwest.
2. Determine most cost-effective methods to control condensation in aquaculture buildings.
3. Determine most efficient and practical heating and ventilation systems for aquaculture buildings based on sound engineering principles.
4. Troubleshoot environmental problems observed in commercial aquaculture operations.

PROCEDURES

Site Selection

We intend to research environmental controls of existing aquaculture buildings. Factors of interest for aquaculture buildings include but are not limited to: insulation types and thicknesses, vapor barriers, HVAC characteristics, humidity control, saline corrosion, and air quality. Research results will be compared with first engineering principles to determine best management practices (BMP's) for buildings designed for aquaculture operations.

Prior to initiation of data collection, a survey of "indoor" aquaculture producers in the Midwest (including Ohio, Indiana, Michigan, Wisconsin, Illinois, Missouri, Iowa, Minnesota, North Dakota, South Dakota, Nebraska and Kansas) will gather information on existing operations. To obtain the names of the producers, we will start with the directories at aquaculture associations to obtain emails and phone numbers. For example, the list of Tilapia producers in Ohio is available at http://ohioaquaculture.org/tilapia.html. Aquaculture specialists in the NCRAC states will also be contacted for information on operations in their respective states. We will obtain names of producers by personal contact as well. We already received the names and addresses of six producers within 50 miles of an Iowa producer, who also has indicated willingness to participate in the study.

A Producer Information Form (Table 1), similar to that used by Heber et al. (2011) will collect information on building and operational characteristics that will then be used to select representative operations for on-site environmental and energy audits. We expect to receive forms from at least 40 producers among these states and will follow up with phone visits with at least 50% of the respondents. This effort will help us to paint as complete of picture of the industry as possible. Using the following selection criteria, five sites that will be most beneficial to meeting the project objectives will be carefully selected from sites with 500 miles of Lafayatte, Indiana.

1. Species. At least two species (e.g. shrimp, tilapia, etc.) will be included in the study.
2. Severity of environmental issues such as condensation, temperature control, energy costs, and air quality.
3. Methods of heating, including alternative sources such as solar energy.
4. Room ventilation strategies and approach.
5. Insulation type and levels in floors, walls and ceiling.
6. Method of tank aeration.
7. Conduciveness to determining heat, moisture and carbon dioxide balances.
8. Completeness of site information such as insulation levels, energy costs, and production.
9. Distance from Lafayette, Indiana. The distance affects the travel budget.
10. Facility size.

Site Visits

Field surveys of the design and operational building parameters of the five selected aquaculture operations will be conducted both in the summer and winter because the environmental control challenges during hot and cold seasons are unique. Information collected will include production characteristics, building dimensions and materials, heating and ventilation methodology and insulation values of walls, ceilings and floors, dimensions and water holding capacities of various tanks and equipment as well as production levels, waste handling methodology, and years in operation. Measurements of air temperature, humidity, carbon dioxide concentration, and ventilation airflow rates will be conducted. A thorough inspection of surface temperatures and condensation in the building and room air circulation patterns will be assessed, along with an assessment of potential hidden condensation inside walls and attics. The presence of mold will be documented and addressed as well. An inspection of the electrical service entrance panel will be made to assess its vulnerability to moisture (Dr. Heber teaches a course in electricity). Basically, environmental audits (energy, HVAC, and air quality) will be conducted on each operation. It will require a full day at the site to gather information and complete the on-site measurements.

Surface temperatures will be measured with an infrared thermometer (Model 62 Max, Fluke Corporation, Everett, WA). Inlet and exhaust carbon dioxide will be measured with a handheld CO_2 monitor (TelAire Model 7001, Onset Computer Corporation, Bourne, MA). Relative humidity and temperature will be measured with a NIST-traceable humidity and temperature sensor (Model HMI41, Vaisala, Inc., St. Louis, MO). Fan airflow rates will be determined using a traverse of air velocities measured with a portable thermal anemometer (Model 425, Testo, Inc., Sparta, NJ).

Battery operated temperature recorders (HOBO Model MX1101 or equivalent, Onset Computer Corporation, Bourne, MA) will be placed at various locations in the buildings during each visit and sent to Purdue by the producers after two weeks of continuous recording. Discussions will be held with producers about their operations during each visit.

Data Analysis and Recommendations

Heat, moisture and carbon dioxide (CO_2) balances will be calculated based on survey results at each farm. Some preliminary measurements and calculations at a shrimp production operation near Fowler IN are included at the end of this proposal. Using the audit data and subsequent data analysis and mass balance calculations, a report discussing the existing designs including pitfalls, shortcomings, effectiveness, and cost will be generated. The report will show where good engineering practice were not followed, e.g. insufficient insulation, ventilation airflow rate, air and water heating, or improper placement of inlets, etc. The report will also discuss where facilities did follow good engineering practices and perhaps innovative designs and will also propose solutions to common problems and, how to retrofit existing facilities. The capital and operational costs will be determined for these solutions. Depending on results, the report may also recommend areas for future research to improve efficiencies of these operations as a whole.

Conclusions from this research will be used to formulate recommendations for those interested in rehabilitating or constructing agricultural buildings to be used for aquaculture. The intent is for individuals to determine what the cost of building/rehabilitation might entail and be able to discuss options with their building contractor. Deliverables will include a white paper describing operations visited with their building success and failures and how engineering principles could help, a factsheet describing factors to consider when building/rehabilitating, and any invited presentations of results at the NCRAC bi-annual meeting and selected state association meetings. Arrangements are already being made to give an invited presentation in Iowa on September 9-11, 2016.

Outreach and Evaluation

Outreach for the project will have three distinct deliverables. From the interviews and surveys of individual farms, a <u>white paper</u> will be developed describing each operation, the positives and negatives of environmental controls associated with each building and where these could be improved using engineering principles. Based on these results an <u>extension fact sheet</u> will be developed outlining the various building factors that investors must consider when establishing an aquaculture operation in a new or existing building. Because the winter visits will be completed by January, the results of the site investigations will be presented at the World Aquaculture Society Meeting in San Antonia, Texas on February 19-22, 2017 where 2500 attendees are expected (Table 2).

Based on results of this study, authors plan to evaluate whether there is a need for more in-depth research associated with aquaculture buildings and to pursue topics that would lead to improvements in aquaculture operations. Some suggested possible topics would be alternative energy sources for heating water, standardization of ventilation for carbon dioxide and water vapor removal, heat exchangers to recover energy, etc. The success of the project will be assessed as shown in the logic model (Table 2). The information is expected to lead to significant cost savings to producers by increasing efficiencies and longevity of buildings, improving worker health environment, and saving energy.

Table 1. Site Information Form for Aquaculture Operations(E-mail to Albert Heber, Purdue University: heber@purdue.edu)

Contact person:			
Farm name			
Street address			
City, state, zip code			
Distance from campus, miles			
	Room 1	**Room 2**	**Room 3**
Year(s) of construction (e.g. 1999)			
Previous use (hogs, shop, school, etc.) or new			
Species (e.g., shrimp, tilapia, etc.)			
Inventory (#)			
Average weight, g			
Start weight, g			
Finish weight, g			
Phase of production			
Animal occupation time, # days			
Type of floor (concrete, etc.)			
Width, ft			
Length, ft			
Sidewall height, ft			
Number of tanks			
Tank depth, in.			
Tank diameter or length x width, ft.			
Tank spacing, ft			
Water source (well, pond, river, city)			
Method of heating water in tanks			
Method of heating air in room			
Alternative energy source type, if any.			
Size of electric service, Amps			
Backup generator? (Y/N)			
How much condensation on ceiling*?			
How much condensation on walls*?			
How much condensation on floor*?			
Ceiling insulation type			
Wall insulation type			
Floor insulation type			
Ceiling insulation thickness, in.			
Wall insulation thickness, in.			
Floor insulation thickness, in.			
Number of internal circulation fans			
Size of circulation fans, in.			
Number of exhaust fans			
Diameter of exhaust fans, in.			
Ventilation air inlet type			
Waste collection method			
Waste storage (e.g. lagoon)			
Is water usage measured?			

- 1 (none), 2 (sometimes, <50% of days), 3 (frequently, >50% of days), 4 (some condensation every day), 5 (severe condensation every day).

Table 2. Logic Model (Part 1).

Situation	Inputs	Activities	Outputs	Participation
Buildings experience severe condensation inside the rooms	Knowledge about building environmental control	On-site energy inspections and environmental audits	Infrastructure for communications and cooperation between stakeholders	Aquaculture producers
Aquaculture contributes to regional, state and local economies	Infrastructure for communication, collaboration, cooperation	Review pertinent literature and engineering handbooks	Greater understanding of building environment	Aquaculture owners
Buildings appear to have unacceptably high humidity	Experienced university faculty and staff	Present findings at NCRAC and state meetings and workshops	Extension fact sheet	Allied industries
Lack of knowledge about indoor CO2	Travel	Analyze on-site data	Taped presentations on web site	Engineering consultants
Indoor systems are increasing	Environmental measuring equipment	Calculate building moisture and heat balances	White paper on aquaculture environment	Extension faculty and staff
Lack of written guidance on how to heat and ventilate buildings	Existing commercial buildings	Write engineering guidance for new and remodeled facilities	Standard operating procedure for inspecting buildings	Media contacts

Table 3. Logic Model (Part 2). Outcomes.

Short term	Medium Term	Long Term
Participants will learn how to control condensation in buildings (INDICATOR = # participants informed about how to control condensation)	Participants will use the extension publication and white paper to design or retrofit their facilities (MEASURE = # participants who self-report that the materials affected their decisions)	More energy efficient buildings
Participants will learn about most efficient ways to heat buildings (# participants informed about most efficient heating methods)	Participants will develop enhanced network with other producers, professionals, and Purdue Extension (MEASURE = # participants who self-report expanded network of contacts/resources)	Increased building longevity
Participants will learn about most effective ways to ventilate buildings (# participants informed about most effective ventilation methods)	Participants will adopt proven ventilation methods for their buildings (MEASURE = # participants who self-report that they adopted a recommended ventilation method for their building)	More profitable businesses
Participants will learn how to correct existing problems related to air quality and energy in buildings (# participants trained to solve problems)	Participants will adopt proven heating methods for their buildings (MEASURE = # participants who self-report that they adopted a recommended heating method for their building)	Revised engineering standards
Participants will learn about the new extension publications on buildings (# participants who downloaded publications)	Participants will adopt proven insulation methods for their buildings (MEASURE = # participants who self-report that they adopted a recommended insulation method for their building)	Healthier employees
Commercial producers will make changes based on the environmental audits (# participants that made changes to the buildings)	Participants will adopt proven alternative energy for their buildings (MEASURE = # participants who self-report that they adopted a recommended alternative energy source for their building)	Improved public image of the industry

FACILITIES

Facilities for this research will consist of existing aquaculture operations. The intent is to visit a wide spectrum of buildings; new construction, rehabilitation of existing agricultural structures, multiple aquaculture species and temperature regimes. At least five (5) facilities will be visited for this grant although more will be attempted depending on logistics of potential sites.

REFERENCES

Fuller, R. J. 2007. Solar heating systems for recirculation aquaculture. Aquacultural Engineering 36:250-260.

Heber, A. J., J. Q. Ni, E. L. Cortus, T. T. Lim, and B. W. Bogan. 2011. National study of livestock air quality in USA. International Symposium. on Health Environment and Animal Welfare, Chongqing, China, Oct. 19-22. p. 42-66. Beijing, China: Chinese Society of Agricultural Engineering.

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Li, S., D. H. Willits, C.L. Browdy, M.B. Timmons, and T.M. Losordo. 2009. Thermal modeling of greenhouse aquaculture raceway systems. 41:1-13.

Miller, G.E. 1985. An evaluation of a confinement catfish production facility incorporating recirculating culture systems with fish-barn: A simulation for aquaculture analysis. Ph.D. Dissertation, Purdue University, West Lafayette, IN.

Rosati, R. 1991. Remodeling Existing Farm Structures for Commercial Fish Culture. Proceedings of Second Annual Workshop On: Commercial Aquaculture Using Water Recirculating Systems, Publication CES 240, Purdue University, West Lafayette, IN, November 15-16.

Singh, S., and L. S. Marsh. 1995. Modelling thermal environment of a recirculating aquaculture facility. Aquaculture 139:11-18.

Sun, W. 2009. Life Cycle Assessment of Indoor Recirculating Shrimp Aquaculture System. M.S. Thesis, University of Michigan, Ann Arbor, MI.

PROJECT LEADERS

State	Name/Institution	Area of Specialization
Indiana	Dr. Albert J. Heber	Agriculture and Biological Engineering
Indiana	Mr. Robert A. Rode	Fish Culture

OMB Approved 0524-0039
Expires 03/31/2004

ORGANIZATION AND ADDRESS Purdue University, 1555 S. Grant St., W. Lafayette, IN 47907	USDA AWARD NO. Year 1 : Objectives 1, 2, 3			
PROJECT DIRECTOR(S) Dr. Albert Heber Dr. Robert Rode	Duration Proposed Months: 12 **Funds Requested by Proposer**	Duration Proposed Months: ____ **Funds Approved by CSREES** (If different)	Non-Federal Proposed Cost-Sharing/ Matching Funds (If required)	Non-federal Cost-Sharing/ Matching Funds Approved by CSREES (If Different)

	CSREES FUNDED WORK MONTHS: Calendar	Academic	Summer	Funds Requested by Proposer	Funds Approved by CSREES	Non-Federal Proposed	Non-Federal Approved
A. Salaries and Wages 1. No. of Senior Personnel							
a. _1_ (Co)-PD(s)	0	0	0.92	17,912			
b. ___ Senior Associates							
2. No. of Other Personnel (Non-Faculty) a. _1_ Research Associates-Postdoctorates . . .	2			3,519			
b. ___ Other Professionals							
c. ___ Paraprofessionals							
d. ___ Graduate Students							
e. ___ Prebaccalaureate Students 2							
f. ___ Secretarial-Clerical							
g. ___ Technical, Shop and Other							
Total Salaries and Wages				21,431			
B. Fringe Benefits (If charged as Direct Costs)				5,343			
C. Total Salaries, Wages, and Fringe Benefits (A plus B)				26,774			
D. Nonexpendable Equipment (Attach supporting data. List items and dollar amounts for each item.)							
E. Materials and Supplies				1,100			
F. Travel				5,625			
G. Publication Costs/Page Charges				1,500			
H. Computer (ADPE) Costs							
I. Student Assistance/Support (Scholarships/fellowships, stipends/tuition, cost of education, etc. Attach list of items and dollar amounts for each item.)							
J. All Other Direct Costs (In budget narrative, list items and dollar amounts and provide supporting data for each item.)							
K. Total Direct Costs (C through I)				34,999			
L. F&A/Indirect Costs. (If applicable, specify rate(s) and base(s) for on/off campus activity. Where both are involved, identify itemized costs in on/off campus bases.)							
M. Total Direct and F&A/Indirect Costs (J plus K)				34,999			
N. Other							
O. Total Amount of This Request				34,999			

P. Carryover -- (If Applicable) . . . . **Federal Funds: $** **Non-Federal funds: $** **Total $**

Q. Cost Sharing/Matching (Breakdown of total amounts shown in line O)	Leave Blank	
Cash (both Applicant and Third Party)		
Non-Cash Contributions (both Applicant and Third Party)		

NAME AND TITLE (Type or print)	**SIGNATURE** (required for revised budget only)	**DATE**
Project Director Dr. A. Heber		
Authorized Organizational Representative		
Signature (for optional use)		

BUDGET EXPLANATION

OBJECTIVES: 1-4

A. Principal Investigator Dr. Albert Heber, supported at 8.8% level of effort, will direct the project, personally visit and conduct all site visits, analyze the data with some limited graduate student help, calculate heat, moisture and carbon balances, develop engineering solutions with economic considerations, present results, and write the white paper, extension publication, and final report. At least a week of full time effort will be required to analyze and interpret the data from each site visit.

   Coinvestigator Robert Rode will coordinate communications with producers, review the reports and white paper, and assist in writing the extension publication. Mr. Rode requests no external support on this project.

   The graduate student (Ms. Xiaoyu Feng) will be supported with two months at 50% effort to assist Dr. Heber in the on-site environmental audits and analyzing of data. Ms. Feng is in her third year of her Ph.D. graduate study and has taken a course in Environmental Design of Agricultural Structures taught by Dr. Heber.

B. Fringe benefits are 28.1% and 8.8% for faculty and grad students.

E. Materials and Supplies: Funds are budgeted to purchase: 1) TelAire CO_2 Sensor (Model 7001) for $550 and 2) Testo 425-KIT Thermal Anemometer for $550. To cover publication costs of the extension publication, $1,500 is allocated.

F. Travel funds will support the costs to make a total of 10 trips to farms and to present on-site assessment results at the Aquaculture 2017 in San Antonio, TX in February, 2017.

   The average one-way distance to the farms is estimated at 210 miles at $0.54/miles. It is assumed that two of the five farms will require one night's lodging for two people at $75/night and per diem costs of $54/day. The mileage, per diem and lodging costs will therefore be $2268, $600 and $864, respectively, for a total of $3732.

   The airfare to Aquaculture 2017 will cost $450. Lodging for three nights is estimated to be $525. Conference registration is estimated at $500. Personal car mileage to the airport will total $78, airport parking will be $48, and total taxicab expense is estimated at $100. The total travel cost for attending Aquaculture 2017 is therefore $1893.

BUDGET SUMMARY FOR EACH YEAR FOR EACH PARTICIPATING INSTITUTIONS

Expense Category	NCRAC Funds (all objectives)	
	Purdue	Project total
Salaries, Wages	21431	21431
Fringe Benefits	5343	5343
Total Salaries, Wages, and Fringe Benefits	26774	26774
Nonexpendable Equipment	1100	1100
Materials and Supplies	1500	1500
Travel	5625	5625
All Other Direct Costs	0	0
Total	34999	34999

SCHEDULE FOR COMPLETION OF OBJECTIVES

1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Survey producers	Write white paper	Write white paper	Publish white paper
Select farms	Publish extension pub 1	Write journal article	Publish extension pub 2
Conduct summer visits	Write audit SOP	Conduct winter visits	Finalize audit SOP
Analyze data	Analyze data	Analyze data/mass balances	Write final report
Review literature/standards	Calculate mass balances	Present at Aquaculture 2017	Submit journal article
Iowa invited talk	Invited presentations	Invited presentations	Invited presentations

PARTICIPATING INSTITUTIONS AND PRINCIPAL INVESTIGATORS

Purdue University
Dr. Albert J. Heber
Mr. Robert A. Rode

VITA

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Aquaculture Research Laboratory, Purdue University | Fax: (765) 496-1115
225 S. University St., West Lafayette, IN 47907 | Email: heber@purdue.edu

EDUCATION

B.S. South Dakota State University, Brookings, SD, 1978, Agricultural Engineering
M.S. South Dakota State University, Brookings, SD, 1979, Agricultural Engineering
Ph.D. University of Nebraska, Lincoln, NE, 1984, Bioengineering

POSITIONS

2002-present Professor, Agricultural and Biological Engineering, Purdue University, West Lafayette, IN
1993-2002 Associate Professor, Agricultural Engineering, Purdue University, West Lafayette, IN
1989-1993 Associate Professor, Agricultural Engineering., Kansas State University, Manhattan, KS
1984-1989 Assistant Professor, Agricultural Engineering, Kansas State University, Manhattan, KS

SCIENTIFIC AND PROFESSIONAL SOCIETIES

American Society of Agricultural and Biological Engineers, 1980-present

SELECTED PUBLICATIONS (CAREER TOTAL NUMBER OF JOURNAL ARTICLES = 106)

Wang, K., Q. F., Li, L. Wang-Li, E. L. Cortus, B. W. Bogan, I. Kilic, W. X. Liang, C. H. Xiao, L. L. Chai, J. Q. Ni, and A. J. Heber. 2016. National air emissions monitoring study - Southeast layer site: Part V: Hydrogen sulfide and volatile organic compounds. Transactions of ASABE 59:681-693.

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