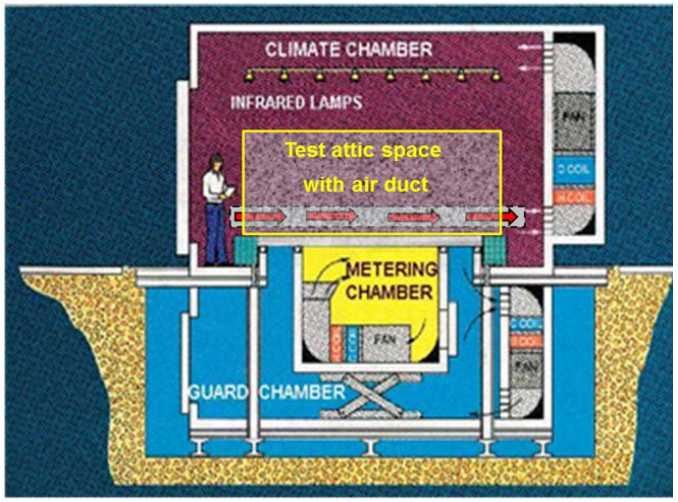
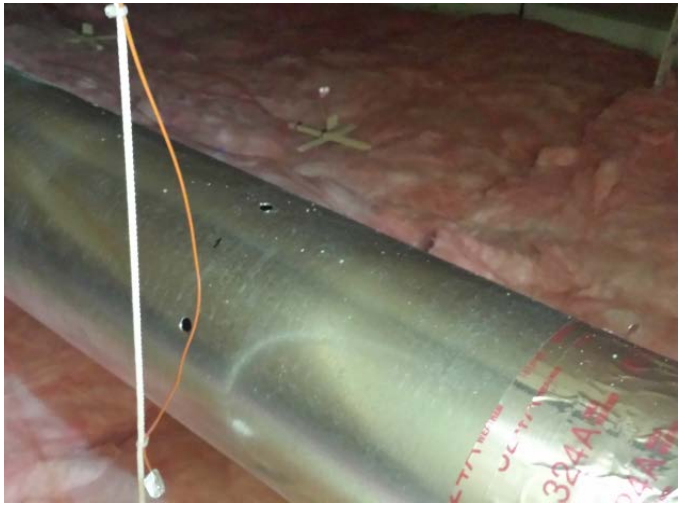
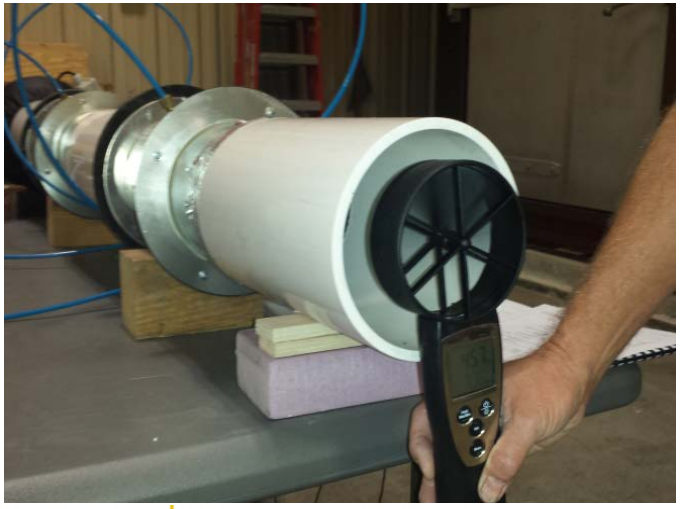
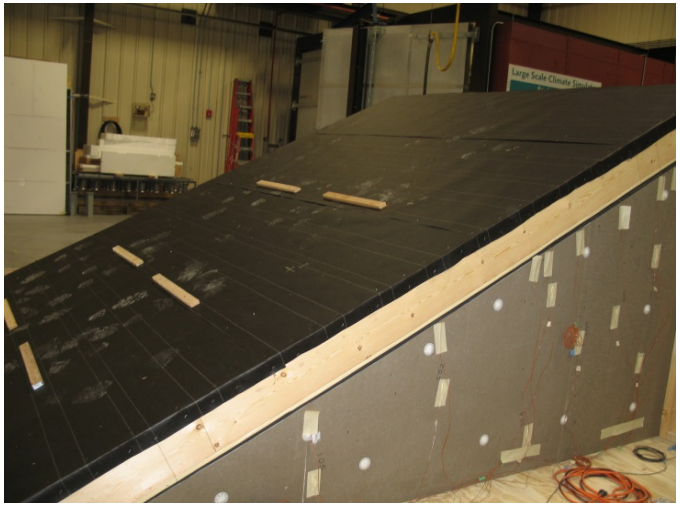
Development and Validation of an Attic Model

2017 Building Technologies Office Peer Review









U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Andre Desjarlais, desjarlaisa@ornl.gov
Oak Ridge National Laboratory

Project Summary

Timeline:
Start date: FY15
Planned end date: FY17

Key Milestones:

1. Complete summer conditions cathedralized attic tests at ORNL and supply results; 3/17.
2. Project report showing the results of validation of the FATM's attic/roof deck ventilation algorithm against the experimental data; 12/17.

Budget:

Total Project $ to Date:

- DOE: $660K
- Cost Share: $0K

Total Project $:

- DOE: $660K
- Cost Share: $0K

Envelope Program Core Funding

Key Partners:

Fraunhofer CSE

Project Outcome:

Development of an attic simulation code that:

- Properly calculates energy efficiency through attics including convection phenomena and influences of duct systems within the attic (Fraunhofer CSE)
- Is validated with measurements (ORNL)
- Can be incorporated into EnergyPlus as a plug-in

Purpose and Objectives

Problem Statement: Attics use 1.3 quads of energy yearly. In whole building simulation tools, the attic is only represented by a simple R-value and many important physical phenomena are neglected. A detailed, validated module is needed to interface with our whole building tools.

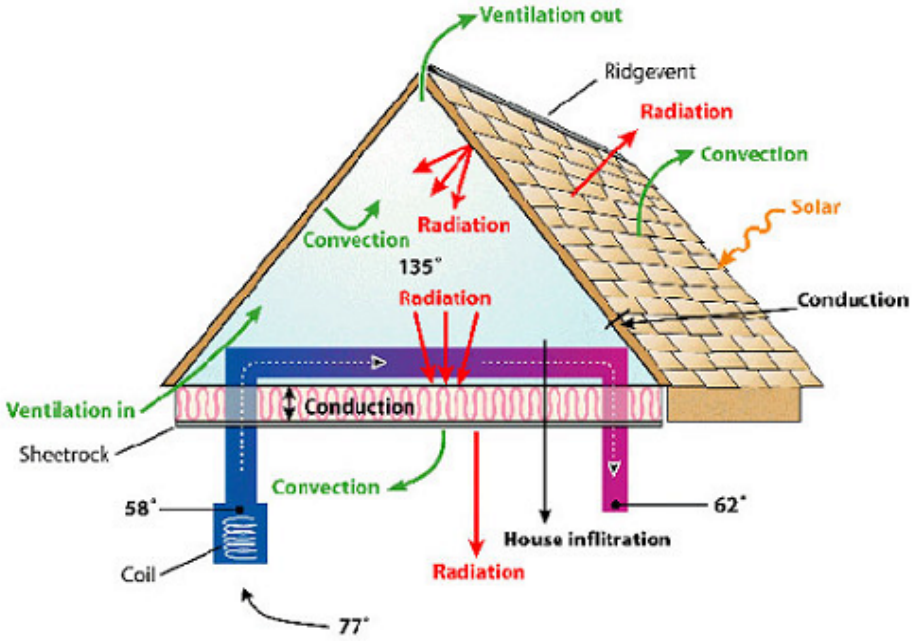
Target Market and Audience: IECC and other energy code developers need accurate estimates of attic performance for their prescriptive and performance paths. Will become an engine for the Roof Savings Calculator (R&D 100 Award winner).

Impact of Project: The availability of a validated, new attic module for whole building tools would allow for the accurate and confident estimation of attic thermal performance, including the effects of complex geometries, temperature dependent material properties, radiant and switchable surfaces, traditional ventilation, and above-sheathing ventilation.

Complexity of Current Roof and Attic Designs





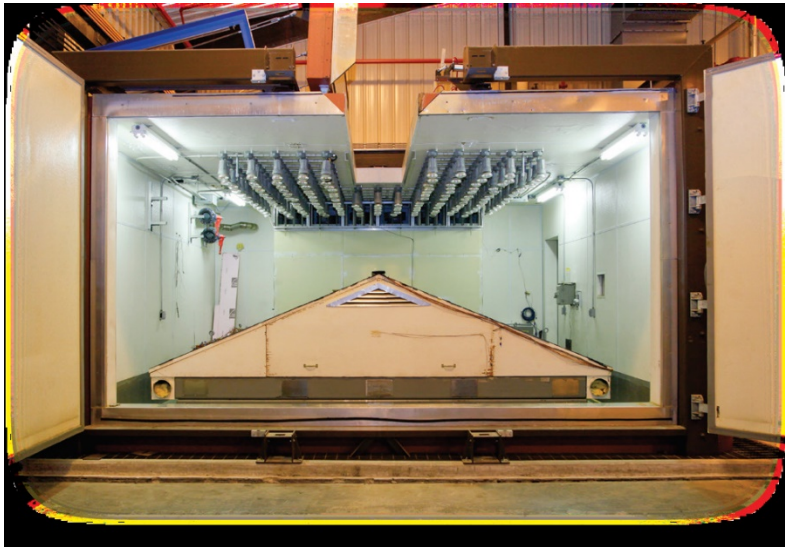



Experimental Approach

Approach: Create suitable attic test mockups for proposed measurements that will be evaluated in the Large Scale Climate Simulator (LSCS). The mockups will be instrumented to track the influence of parameters of interest.

Key Issues: Create an experimental plan that allows for the parameters of interest to change enough that the changes can be measured accurately.

Distinctive Characteristics: The LSCS is the only experimental facility that can perform these measurements. The combination of capabilities such as chamber size, solar simulation, additional volume and temperature controlled air sources make this chamber unique internationally.



Analytical Approach

Approach: Create an attic energy model that can accurately estimate heat gains and losses with attics containing air ducts and above sheathing ventilated cavities. The energy model will be used to estimate thermal performance of attics around the U.S.

Key Issues: Develop numerical correlations and algorithms that accurately predict the measurements provided by the experimental test matrix.

Distinctive Characteristics: The Fraunhofer Attic Thermal Model (FATM) is a recently developed, object oriented, flexible, numerical framework based on the methods and software developments of ASTM C1340. FATM is the only attic energy model that can analyze the use of phase change materials in attics and complicated attic geometries.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Progress and Accomplishments

Accomplishments:

Work to date includes:

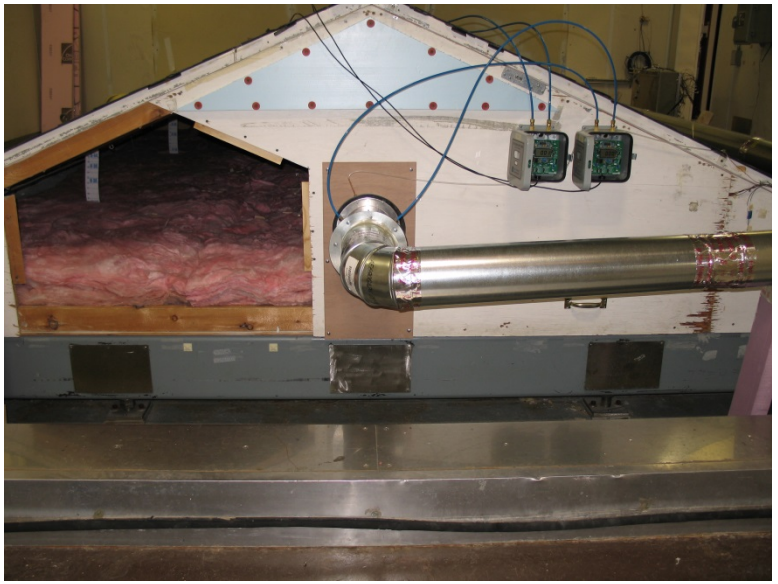
1. Modified LSCS to evaluate air duct/attic interactions and completed a series of eight experiments looking at the interaction between attics and attic air distribution systems.
2. Developed an air duct algorithm to estimate attic-air duct performance and validated the air duct algorithm with LSCS measured data.
3. Designed and constructed cathedralized ceiling assembly and completed five of eighteen cathedralized ceiling experiments.
4. Extended state-of-the-art above sheathing ventilation (ASV) algorithm and have preliminary validation comparisons for the ASV algorithm.

Market Impact: New attic model will allow code bodies to more accurately assess steep-slope roof performance. Basis for hygrothermal attic model?

Awards/Recognition: None.

Lessons Learned: None.

Experimental Mock Up for Attic/Air Duct Experiments

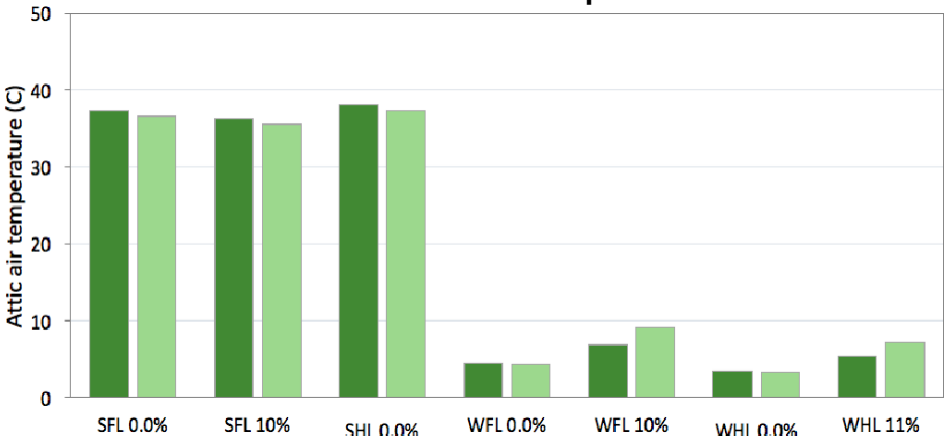


Progress and Accomplishments

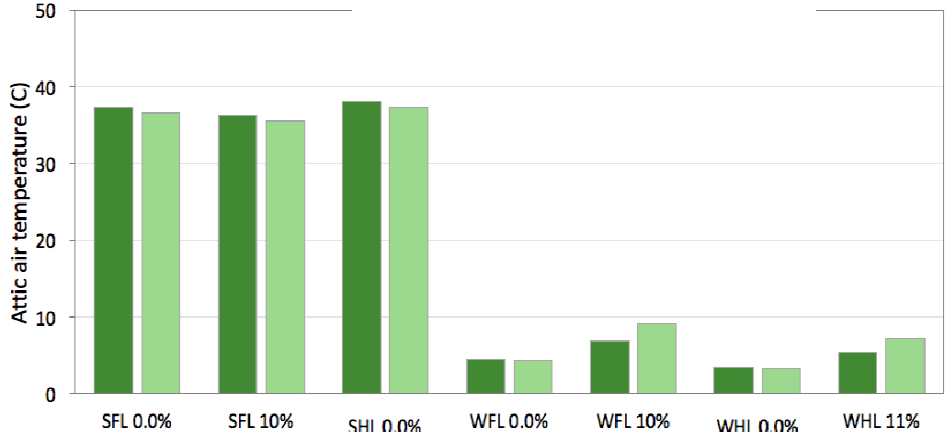
Validation Efforts with LSCS data

1. Air Duct Experiments
   - Summer / winter conditions
   - Fully exposed / half buried
   - No air leakage, air leakage

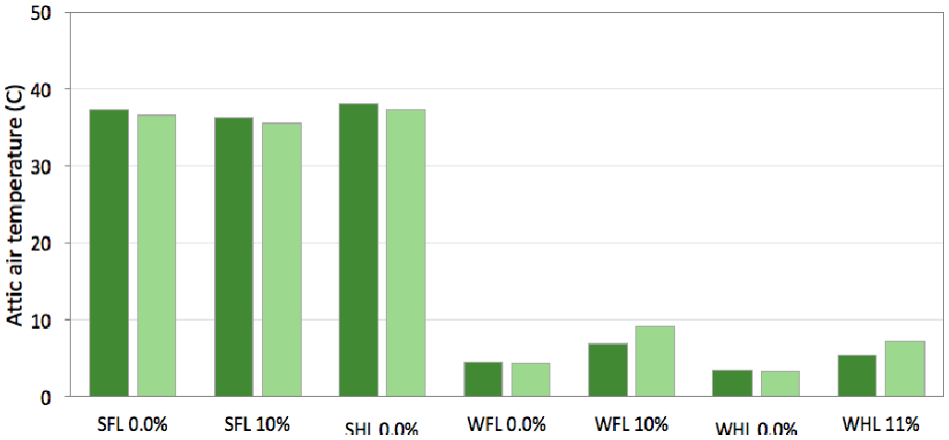
Duct Outlet Temperature



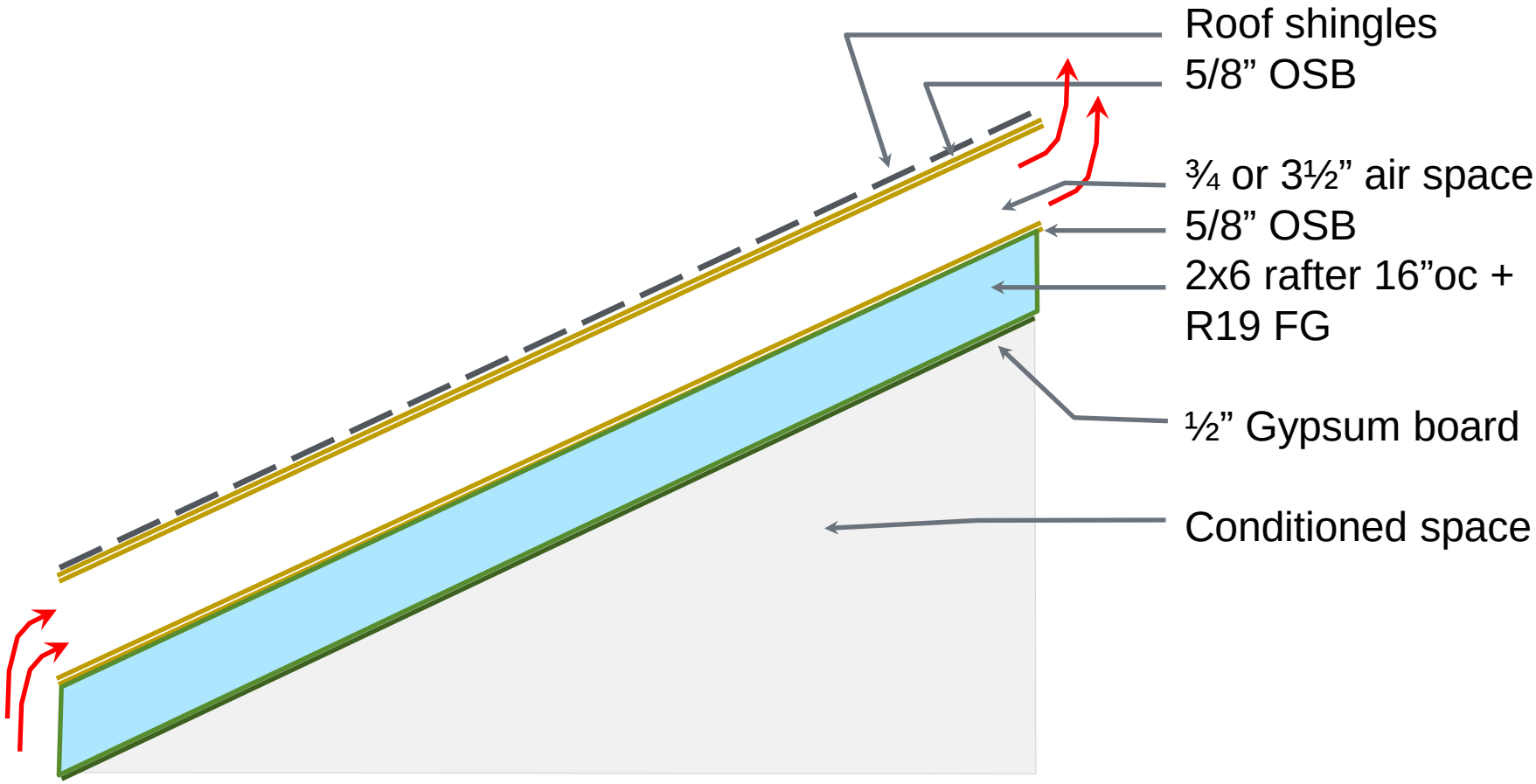
Ceiling Heat Flux



Attic Air Temperature

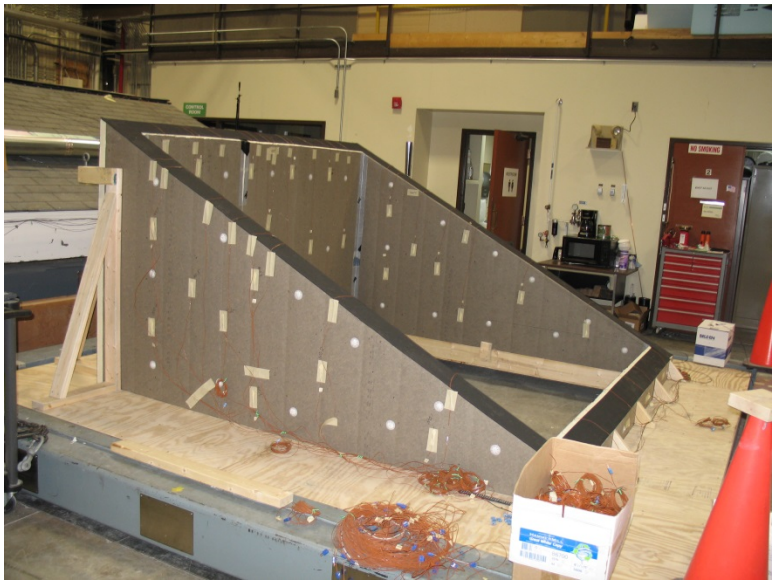


Experimental Progress and Accomplishments



- Evaluate roof at two slopes – 3/12, 5/12
- Evaluate under ASHRAE summer and winter conditions

Experimental Progress and Accomplishments



Project Integration and Collaboration

Project Integration: Project staff are voting members of the appropriate ASHRAE Technical and Standards Committees (TC 4.4 on Building Materials and Building Envelope Performance, TC 4.7 on Energy Calculations, and the Envelope Subcommittee of 90.1) and have shared information about this project with their membership.

Partners, Subcontractors, and Collaborators:
ORNL: Design attic experimental mockups and perform experiments.
Fraunhofer CSE: Develop model algorithms and validate algorithms using ORNL data.

Communications: ASHRAE Summer and Winter meetings, ASTM C16.30 Subcommittee on ASTM C1363 Thermal Testing, ASTM C1340 Task Group, Central European Symposium on Building Physics, RIMA International Conference, EnergyPlus development team.

Next Steps and Future Plans

Next Steps and Future Plans: During the balance of FY 2017, we will:

1. Complete cathedralized ceiling experiments
2. Develop algorithms to cover variations in cathedralized constructions that were evaluated
3. Validate algorithms
4. Supply DOE with executable form of the attic module

REFERENCE SLIDES

Project Budget

Project Budget: $220K per year for FY15-17

Variances: None

Cost to Date: $500K

Additional Funding: None

Budget History					
FY 2015– FY 2016 (past)		FY 2017 (current)		FY 2018 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$440K	$0K	$220K	$0K	$0K	$0K

Project Plan and Schedule