OAK RIDGE National Laboratory

DOE Bioenergy Technologies Office (BETO) 2019 Project Peer Review

3.1.3.2 Codes and Standards in IBRs

March 4-8, 2019

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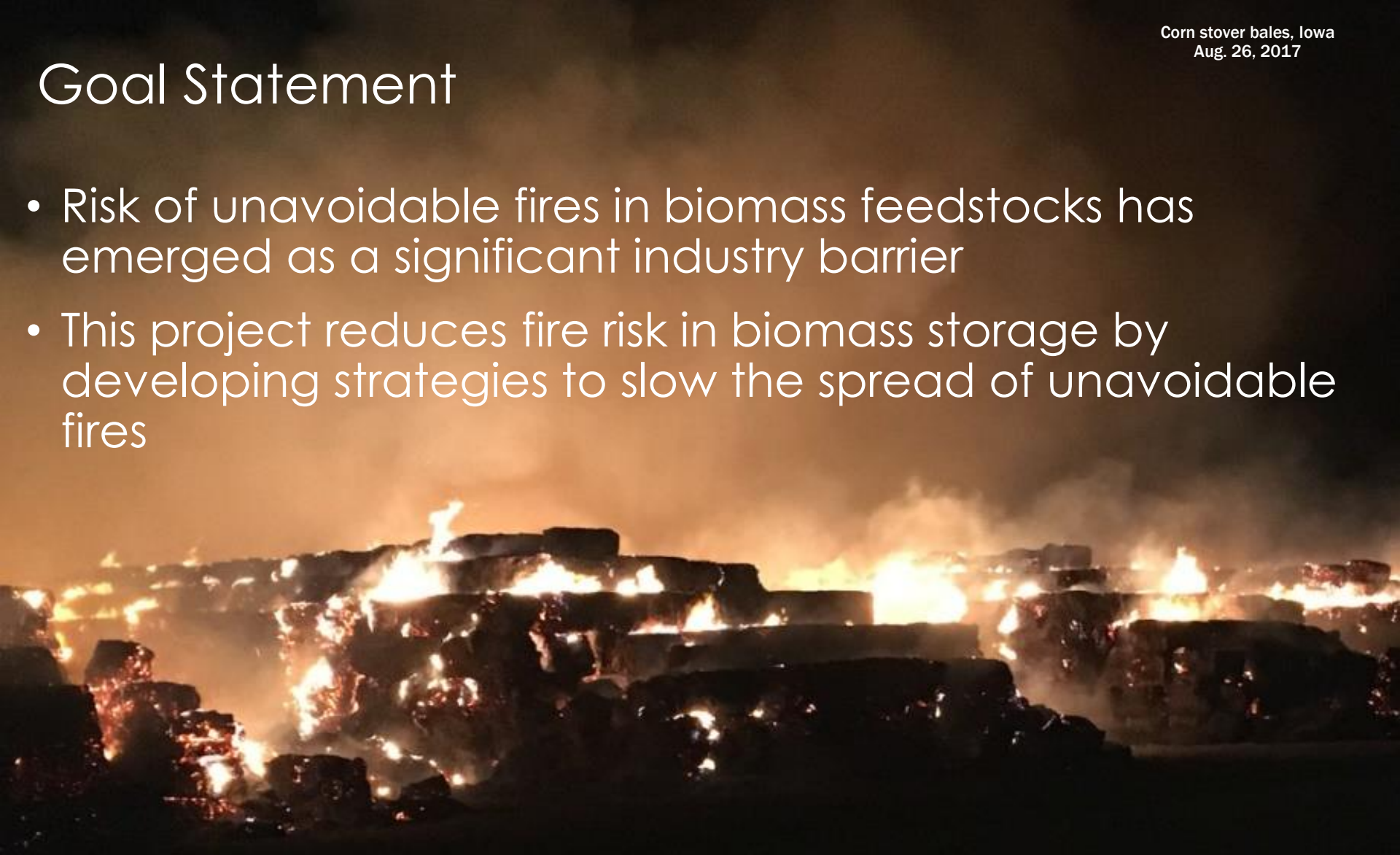
Oak Ridge National Laboratory

ORNL is managed by UT-Battelle, LLC
for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

Goal Statement

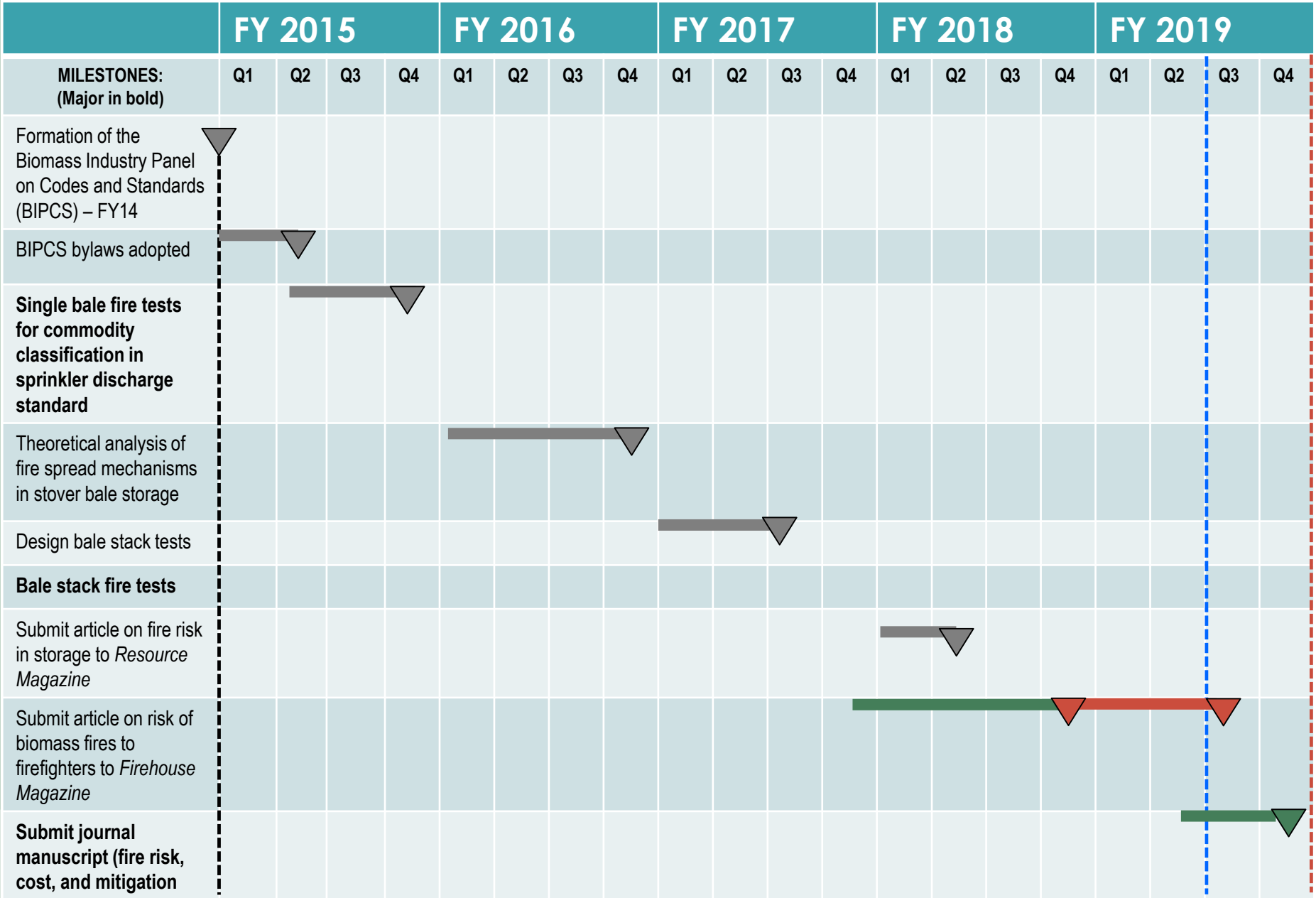
- Risk of unavoidable fires in biomass feedstocks has emerged as a significant industry barrier
- This project reduces fire risk in biomass storage by developing strategies to slow the spread of unavoidable fires



Corn stover bales, Iowa
Aug. 26, 2017

Unavoidable fires
"caused by lightning or arson"

Key Milestones



Project Budget Table

	Original Project Cost (Estimated)			Project Spending and Balance		Final Project Costs
Budget Periods	**DOE Funding**	**Project Team Cost Shared Funding**	**Contingency**	**Spending to Date**	**Remaining Balance**	**What funding is needed to complete the project.**
FY17						
Task 1: Observing fire growth and spread in corn stover bale stacks	$543K	N/A	N/A	$276K	$267K	N/A
Task 2: Standard for sustainability assessment**	$182K	N/A	N/A	$102K	$80K	N/A
FY18-19						
Task 1: Observing fire growth and spread in corn stover bale stacks	$100K	N/A	N/A	$30K	$70K	N/A
Task 2: Assess costs of fire risk mitigation strategies	$247K	N/A	N/A	$109K	$138K	N/A

***In FY18, Task 2 moved to separate project. Remaining funds redirected to fire task.*

Quad Chart

Timeline

- Project start date: FY15
- Original end date: FY18
  - Revised end date: FY19
- 90% complete

	Total Costs Pre FY17**	FY 17 Costs**	FY 18 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	$673K	$378K	$139K	FY19 costs $208K
Project Cost Share*	Informal cost share estimate - $150K *Estimate includes industry staff time, travel, and corn stover bales*			

*No new funding was received in FY18-19

** Task on development of a sustainability reference standard became a separate project “Scientific Methods for Biomass Reference Scenarios”

Barriers addressed

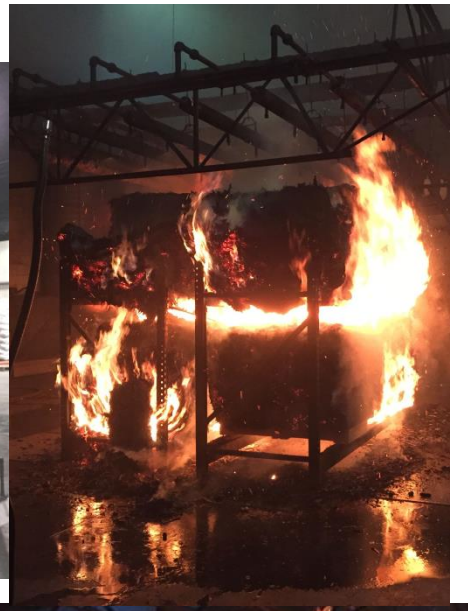
- Ft-F. Biomass Storage Systems
- Ot-C. Risk of Financing Large-Scale Biorefineries
- Aft-A. Biomass Availability and Cost

Partners

- Collaborations
  - DuPont
  - Antares
  - Genera Energy, LLC
  - POET
  - DuPont
  - Idaho National Laboratory
  - American Society of Agricultural & Biological Engineers
  - Iowa State University
  - City of Nevada
  - UL

Project Overview
Previous research

Stover rectangular bales



Stover round bales

Switchgrass rectangular bales

Observations

- Switchgrass burns much better than stover
- Lower density of round bales enabled fire more access to oxygen
- After netwrap was burned away, outer layers of round bales fell away exposing fresh material to fire

Proposal to add bales stover and switchgrass to sprinkler discharge standard is in development

Round stover bales	Class IV
Rectangular stover bales	Class III
Rectangular switchgrass bales	Product rank exceeds that of cartons unexpanded group A plastics

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Photos courtesy of Bob Davidson, Davidson Code Concepts

Project Overview
Recent fires in stover storage sites

- Ignition sources were arson (DuPont, confirmed) and lightning (KS, unconfirmed)
- Product value ~ $2.5 million (DuPont)
- DuPont responsible for fire, in contact with local authorities
- Fires smolder for weeks, sometimes months
- Concerns: PR, health impacts of smoke, fire spread to nearby properties

Kansas, February 2018
photo from: Stevenson County Emergency Management (Facebook)

Iowa, August 2017 (DuPont)

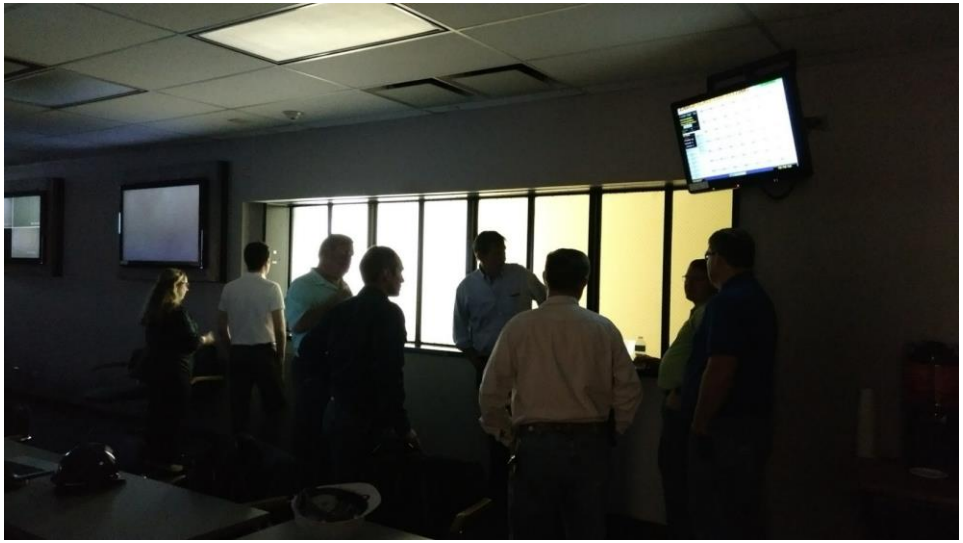
Management Approach

- Team
  - PI: Erin Webb
  - Firefighting expertise and biomass acquisition
    - Jeff Chambers (ORNL technical support staff member with 15+ years experience as a volunteer rural firefighter)
  - Fire testing
    - UL, subcontractor
  - Industry and academic collaborators
    - Advise on industry storage practices, fire experiments, presentations and other documents
    - Provide biomass for experimental testing
    - Conduct outdoor fire tests

- Project management
  - Monthly conference calls with industry advisory committee
  - Quarterly updates to BETO technology managers
  - Presentation to BETO-wide staff meeting, Sept 2017

- Project Timeline

Management Approach
Industry Engagement



UL

OAK RIDGE National Laboratory

DUPONT

ABENGOA

POET

ASABE

Genera energy

ANTARES Group Incorporated

INL Idaho National Laboratory

Vista Consulting Group

Technical Approach
Evaluating fire growth in biomass bale stacks

Original experimental plan

Bale stack fire tests, June 2017

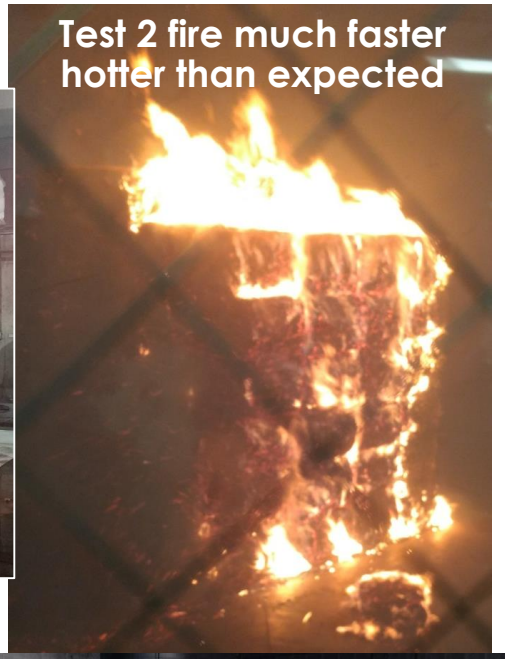
- Test 1 – Small, 12-bale stack in calorimeter
- Test 2 – Large, 76-bale stack
  - Low wind (17 mph)
  - Target stacks to observe impacts of embers
- Test 3 – Large, 76-bale stack
  - High wind
  - Target stacks to observe impacts of ember

Technical Approach
Evaluating fire growth in biomass bale stacks

Revised experimental plan

Bale stack fire tests, June 2017

- Test 1 – Small, 12-bale stack in calorimeter
- Test 2 – Large, 76-bale stack
  - Low wind (17 mph)
  - Target stacks to observe impacts of embers
  - *Fire more severe than anticipated, cancelled additional large stack test*
- ~~Test 3 – Large, 76-bale stack~~
  - ~~High wind~~
  - ~~Target stacks to observe impacts of ember~~
- Test 3 – Small, 12-bale stack in calorimeter *with fire breaks*



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Technical Approach
Evaluating fire growth in biomass bale stacks

In a 12-bale stack fire in a calorimeter at UL, we observed that fire spreads through the vertical channels between bales, not along the sides of the stack.

Technical Approach

Evaluating fire growth in biomass bale stacks

Control

With fire breaks

- Bale moisture measured with microwave system developed by ISU. Bales ≥ 20% rejected
- 12-bale stack
- 10 MW calorimeter
- Measurements:
  - heat release rate
  - smoke generation rate

IOWA STATE UNIVERSITY UL DUPONT

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Technical Accomplishments/Progress/Results
Adding fire breaks significantly slows fire growth

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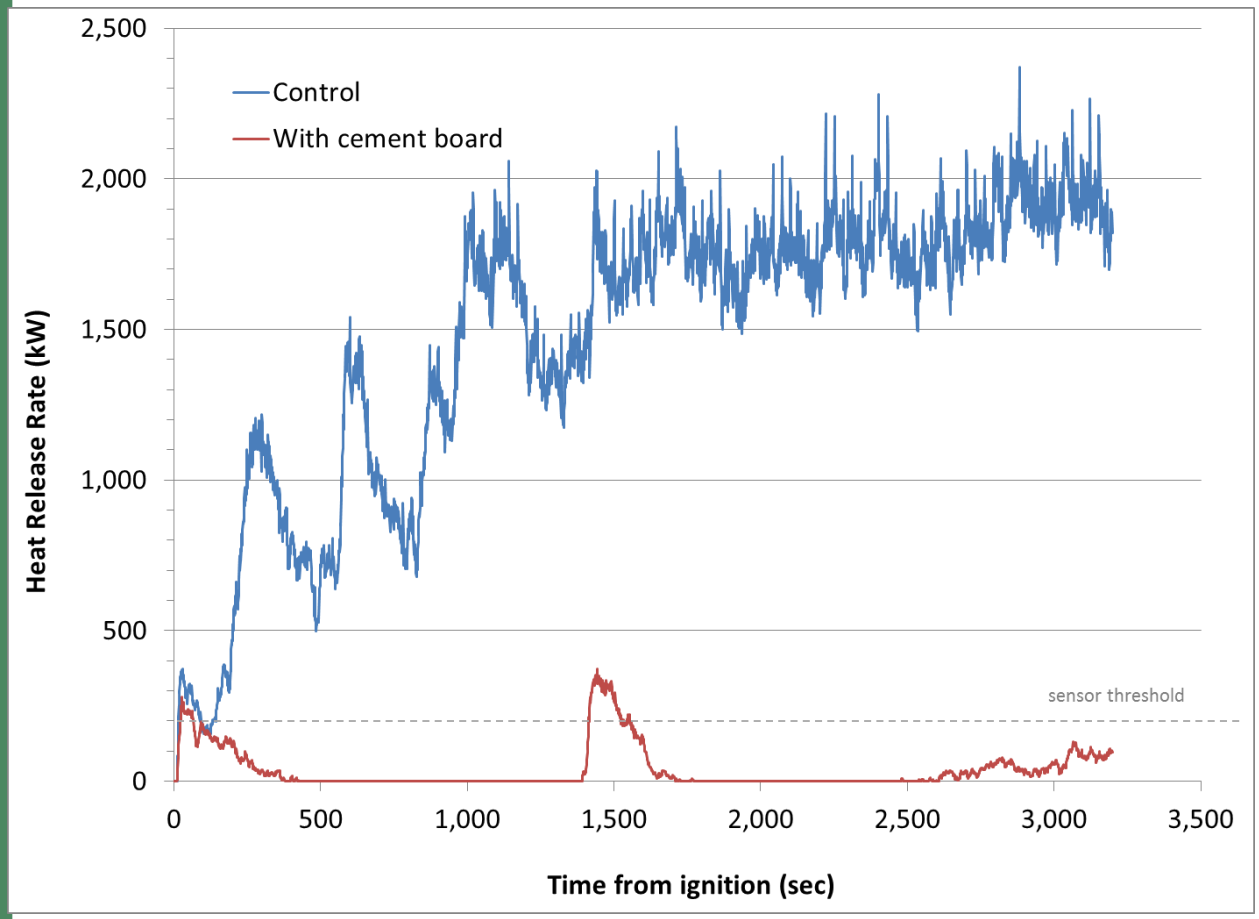
Adding fire breaks significantly slows fire growth

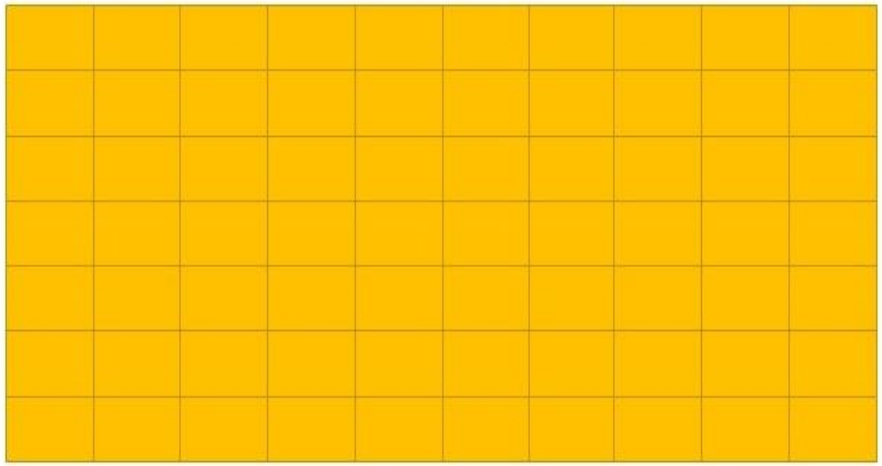


Technical Accomplishments/Progress/Results
Staggered stack design also successful in outdoor tests

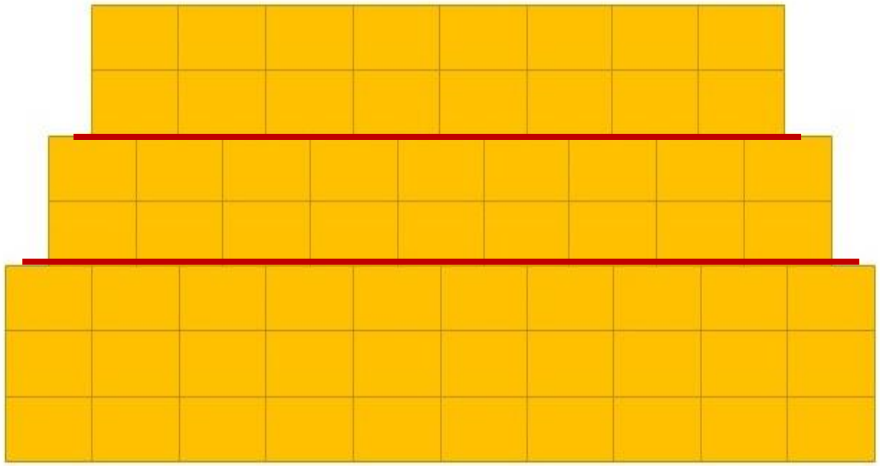
Worked with DuPont and Iowa State to develop stack design to make use of existing equipment

In outdoor test burns, 3-bale tall channel showed significantly slower fire growth than 5-bale tall channel

Technical Accomplishments/Progress/Results
New corn stover stack design at DuPont



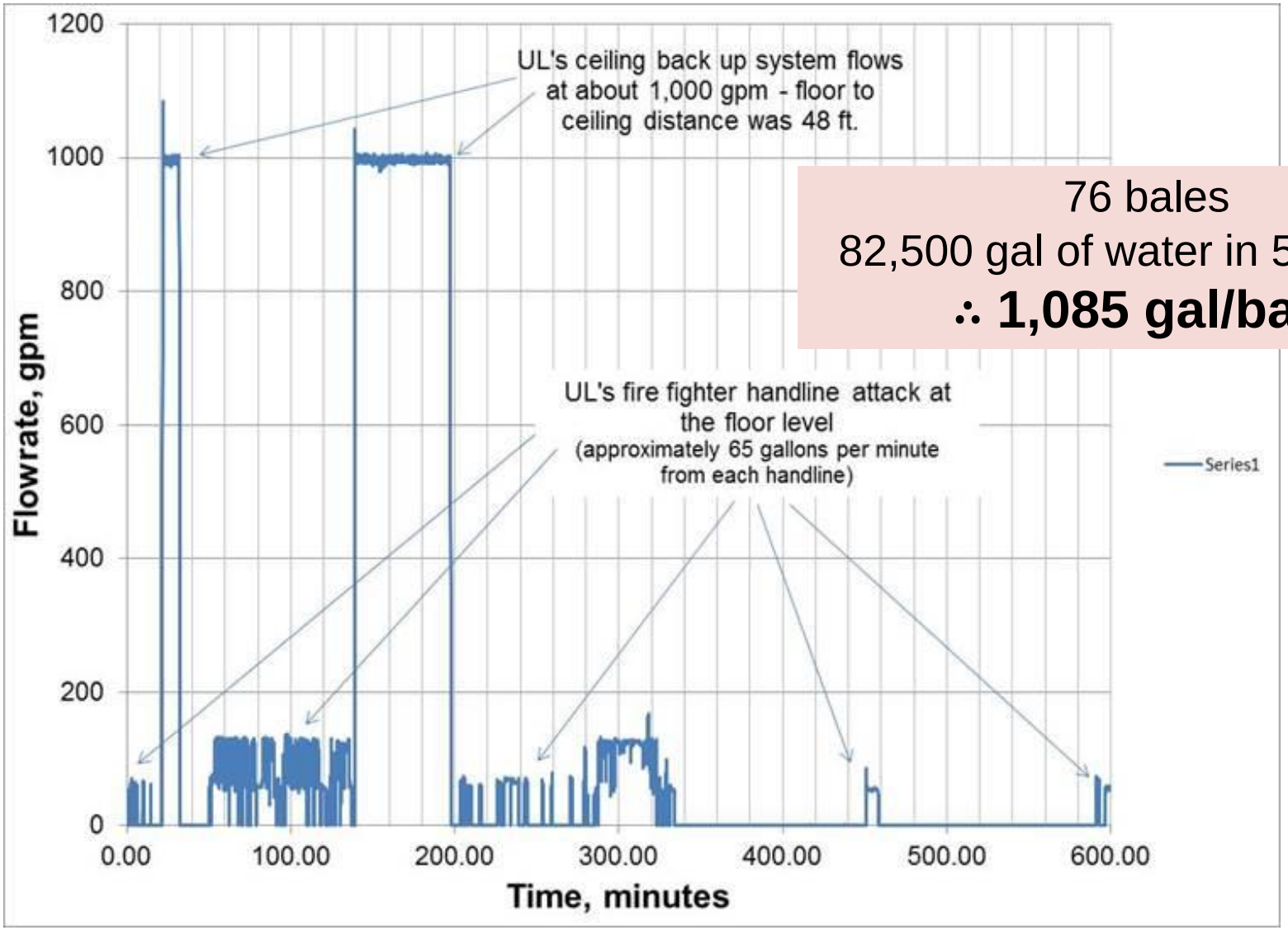
Conventional Stack Design



Improved Stack Design

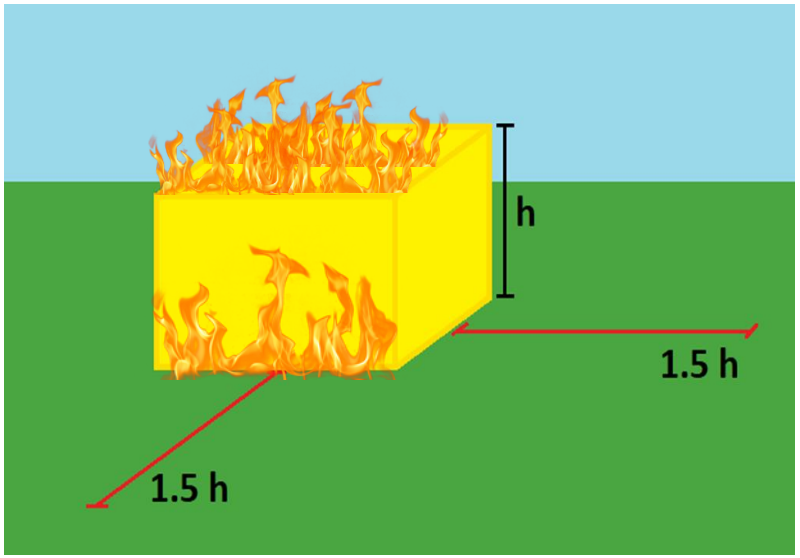
Vertical channels blocked at rows 4 and 6 by staggering bale placement

Technical Accomplishments/Progress/Results
Extinguishing a biomass fire requires A LOT of water



76 bales
82,500 gal of water in 5½ hours
∴ 1,085 gal/bale

Technical Accomplishments/Progress/Results
Establishing collapse zones to improve firefighter safety



- Distance of collapse zone perimeter should equal 1.5 times the height of the bale
- Flaming bales prone to fall off in sections weighing 120-200 pounds
- Collapse zones should be strictly enforced

Relevance

Engage industry in proactively addressing fire risks while not overburdening industry

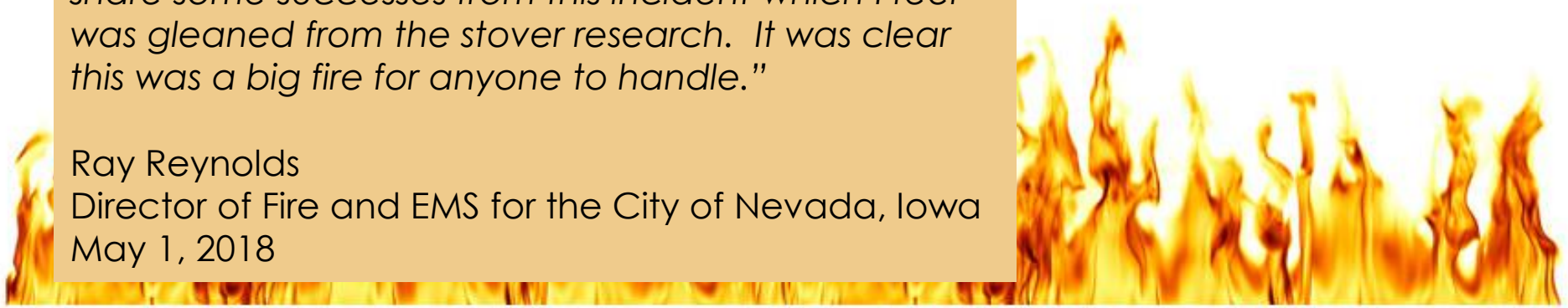
Risks of fires (real and perceived) for commercial-scale biomass-handling facilities has emerged as a barrier to the developing bioenergy industry

Hypothesis-driven fire tests to design safer biomass storage stacks.

Approaches developed in this project will reduce risk to people and assets and improve insurability of biomass facilities

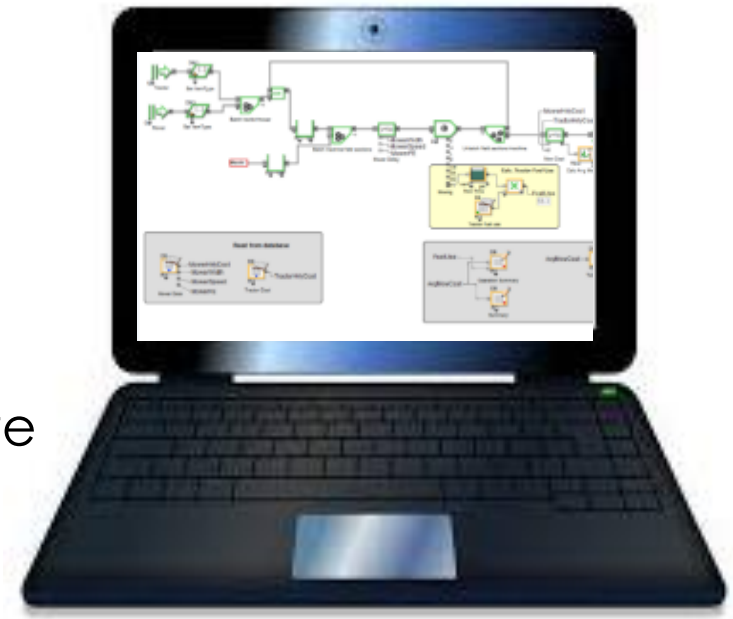
"Last night several departments were involved in a large fire of wood timber planks. In fact several thousand planks were involved with 60 foot flames. It was reminiscent of a large stover fire. I wanted to share some successes from this incident which I feel was gleaned from the stover research. It was clear this was a big fire for anyone to handle."

Ray Reynolds
Director of Fire and EMS for the City of Nevada, Iowa
May 1, 2018



Future Work

- Referred journal article documenting results of UL fire tests to compare heat release, smoke release, and water application data for
- Article for Firehouse Magazine
- Supply chain simulation to determine costs of fire events and mitigation practices
  - Empirical model of fire ignition and rate of growth based on lightening data, visual observations, etc.
  - Supply chain simulation to determine costs of fires and mitigation strategies (cross-stacking, expanded spacing)



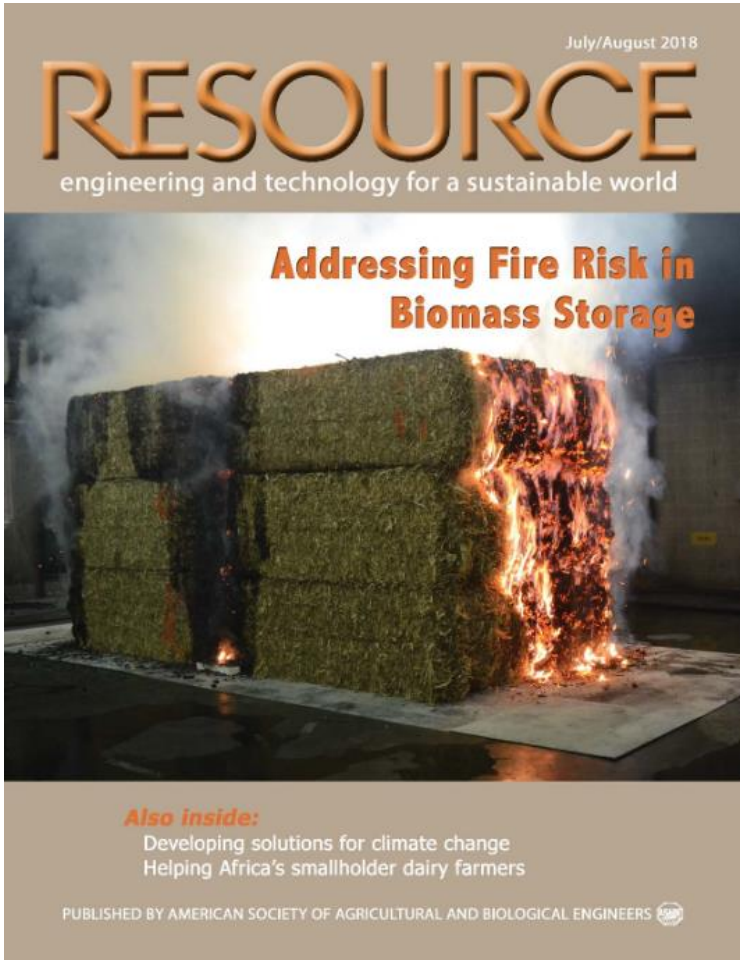
Summary

Goal: Reduces fire risk in biomass storage by developing strategies to slow the spread of unavoidable fires

Approach: Controlled fire tests to observe fire growth for different stacking designs

Accomplishments: Developed new biomass bale stack design to significantly slow fire growth. New design was implemented by DuPont.

Relevance: Fire risk in commercial-scale biomass storage facilities is a barrier to the developing bioenergy industry. Approaches developed in this project will reduce risk to people and assets and improve insurability.



ASABE *Resource* Magazine
July/August 2018