

UNESCO Creative Cities of Crafts & Folk Art Annual Meeting

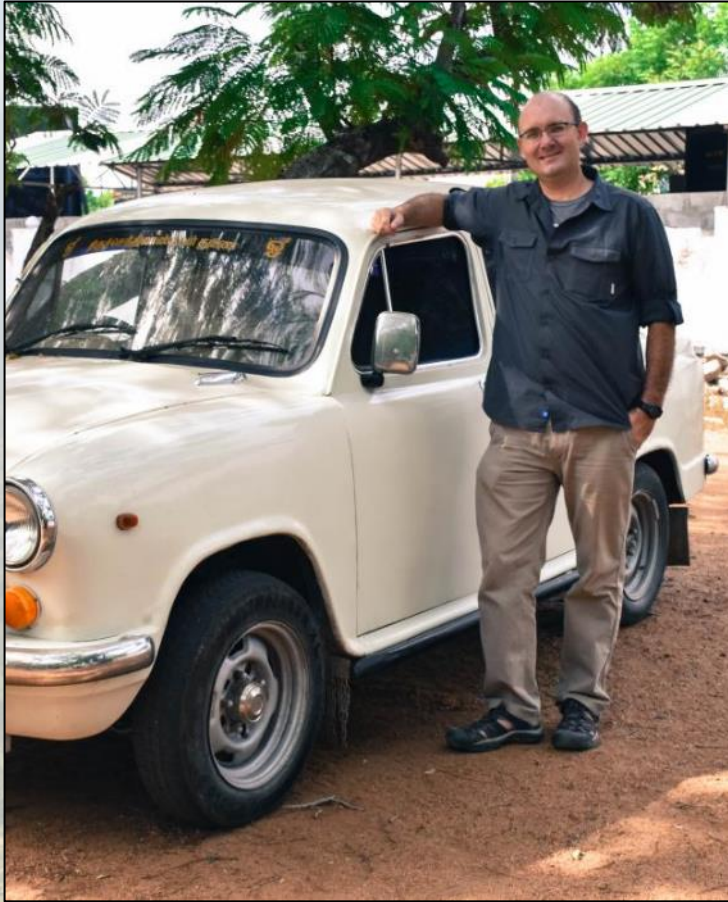
**Engineering Creative Solutions to  
Global Challenges:  
Converting Waste to Energy**

**Jeffrey R. Seay, PhD, PE**

**Department of Chemical and Materials Engineering  
University of Kentucky – Paducah Extended Campus**

**27 September 2017**

# Speaker Bio



## Jeffrey R. Seay, PhD, PE

Associate Professor of Chemical and Materials Engineering  
University of Kentucky, College of Engineering

- Dr. Jeffrey Seay is the Principal Investigator for the University of Kentucky Appropriate Technology and Sustainability (UKATS) Research Group.
- Dr. Seay joined the University of Kentucky in 2008 after a 12 year career in the chemical industry. His research interests include the application of appropriate technology to the production of biofuels in underdeveloped regions.
- Dr. Seay is a past Chair of the AIChE Sustainable Engineering Forum and is the inaugural recipient of the AIChE SEF Sustainability Education Award (2013) as well as the Outstanding Teaching Award in Chemical Engineering and Dean's Service Award at the University of Kentucky (2013).
- Dr. Seay has a BS from Auburn University (1996), an MS from the University of South Alabama (2005) and a PhD from Auburn University (2008), all in chemical engineering.



# University of Kentucky Paducah Campus

- The University of Kentucky maintains campuses in both Lexington and in Paducah.
- The Paducah Campus, founded in 1999, has Chemical and Mechanical Engineering programs, 10 faculty lines, 5 full-time staff and 200 students.





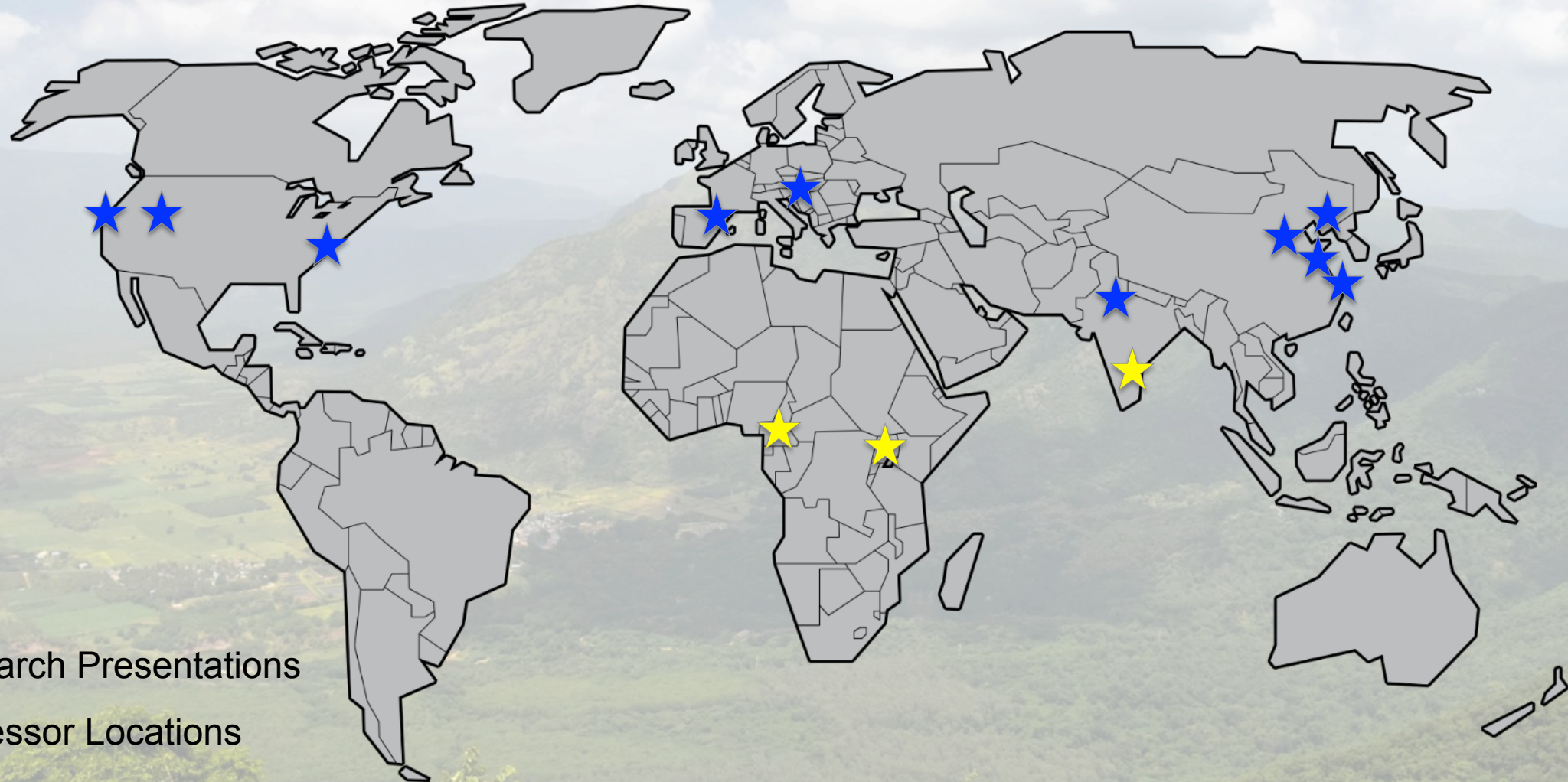
# UKATS Research Team

- **The University of Kentucky Appropriate Technology and Sustainability Research Team (UKATS)**
  - Focused appropriate technology applied to renewable fuels and green chemistry.
- **In 2012 and 2014, the UKATS group traveled to Bangang, Cameroon.**
  - Implemented a prototype design for an integrated biodiesel and biochar processor.
- **In 2015 the group travelled to Tamil Nadu, in Southern India.**
  - Implemented a project to convert plastic trash into fuel oil.
- **In 2016 and 2017, UKATS travelled to Kampala, Uganda**
  - Established a partnership in renewable energy research with Makerere University.
  - Implemented a project to convert plastic trash into fuel oil.





# Global Reach



- ★ Research Presentations
- ★ Processor Locations



# Global Service Learning

- Engineers play a critical role – both positive and negative – in modern society.
- Our service learning course has 3 objectives:
  - Introduce the concept of sustainability.
  - Provide students with a broader perspective on how engineering can benefit society.
  - Introduce students to different culture.
- International experiences extend the engineering classroom.





# Engineering Creativity

- Engineering is not just nuts and bolts and calculus and chemistry!

## The Design Process

### Step 1

Identify  
the  
Problem

### Step 2

Imagine a  
Solution

### Step 3

Create a  
Design

### Step 4

Implement  
and  
Improve



# Identify the Problem: A World of Trash

- **Causes of trash accumulation in developing countries:**
  - Population growth and urbanization.
  - Increased availability of prepackaged goods.
  - Lack of trash collection infrastructure.
- **Trash accumulation leads to problems:**
  - Public health concerns.
  - Waterway and ocean pollution.
  - General aesthetics of a community.





# The Global Waste Plastic Challenge

- 3rd largest contributor of municipal solid waste (MSW).
- Accounts for 20-30% by volume and 10-12% by weight of MSW.
- 5.25 trillion pieces of plastic at sea, weighing over 270,000 tons.
- Unregulated dumping leads to leaching and soil impregnation along with contamination of underground waters.
- Open burning converts waste plastic into CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, dusts, dioxins and similar toxins.





# Plastic in the Ocean

**PLASTIC OCEAN**

**192 COUNTRIES** BORDERING THE ATLANTIC, PACIFIC, INDIAN OCEANS AND MEDITERRANEAN AND BLACK SEAS PRODUCED **2.5 BILLION METRIC TONS OF SOLID WASTE IN 2010**. AN ESTIMATED **8 MILLION METRIC TONS** OF PLASTIC ENTERED THE OCEAN THAT SAME YEAR.

**2.5 BILLION** METRIC TONS OF SOLID WASTE IS PRODUCED ALL AROUND THE WORLD

**2 BILLION PEOPLE** WITHIN 30 MILES OF THE COAST CREATE **100M** METRIC TONS OF COASTAL PLASTIC WASTE

AND WITHIN THAT **275M** METRIC TONS IS PLASTIC WASTE

AND EVERY YEAR, **8 MILLION** METRIC TONS OF PLASTIC GOES INTO THE OCEAN

**WHAT WE CAN DO**

- REDUCE PLASTIC IN WASTE STREAM
- IMPROVE SOLID WASTE MANAGEMENT
- INCREASE CAPTURE & REUSE

**HEALTHY OCEANS**

JAMBECK ET AL., SCIENCE 2015  
\*PLASTICS EUROPE, "PLASTICS—THE FACTS 2013" (2010 DATA)  
\*\*COZAR ET AL., 2014; ERIKSEN ET AL., 2014



# Imagine a Solution

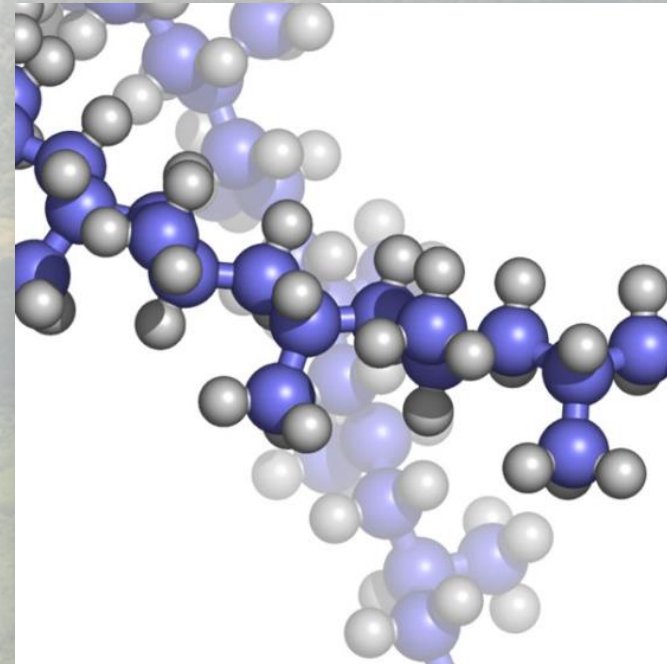
- **Decentralized Waste to Fuel**
- **When plastic does not have a value, it eventually travels to:**
  - Streets
  - Waterways
  - Open Dumps
- **The plastic must be given a value so that it isn't discarded.**
- **Supply chain constraints mean that local solutions are favored:**
  - Decentralized collection
  - Decentralized utilization





# Process Chemistry

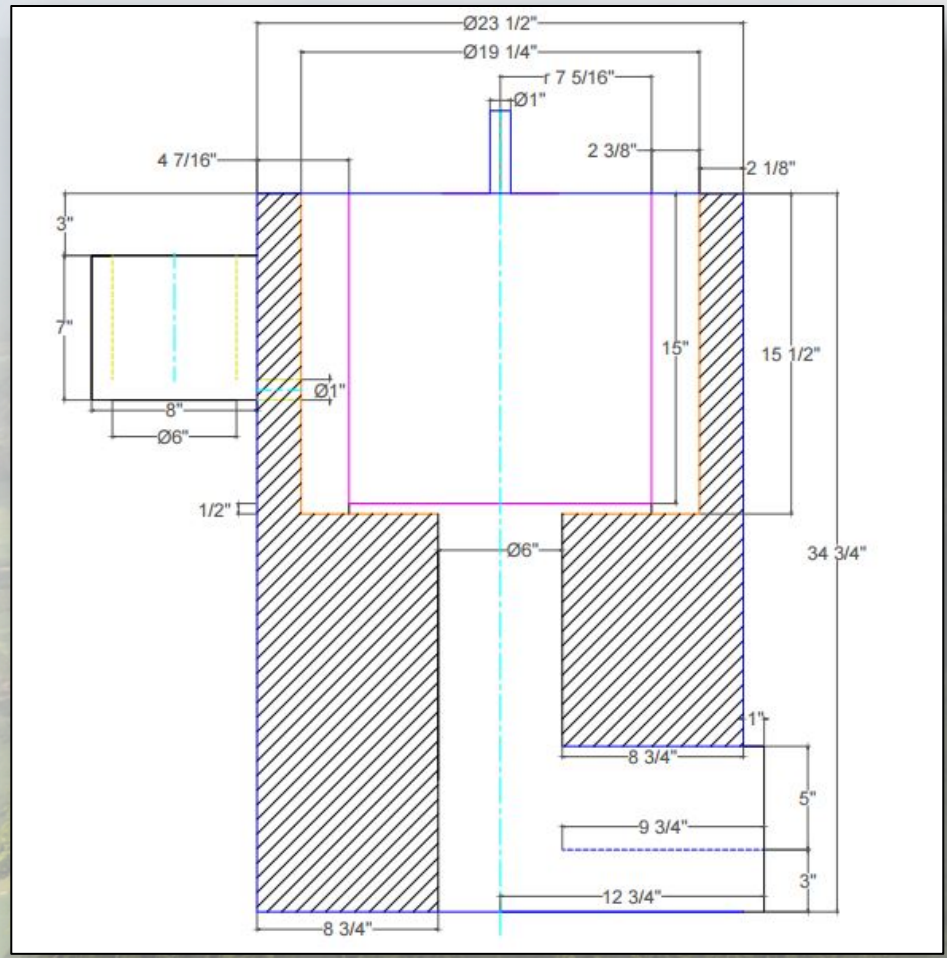
- **So, sometimes it IS calculus and chemistry!**
  - Plastic polymers are initially produced from petroleum.
  - These polymers can be broken down by heat into a fuel oil similar to diesel.
  - The fuel can be used directly without modification in a diesel engine.





# Create a Design

- And sometimes it's nuts and bolts!





# Implement and Continuously Improve

- **Field Trials in India and Uganda**

- Local farmers assisted with field trials.
- The fuel was successfully tested in diesel powered irrigation pumps and farm vehicles.





# Potential for Impact – Kiteezi Landfill, Kampala

- **Estimated 1,300-1,500 metric tons of municipal solid waste are dumped on a daily basis.**
- **7.8% of which is plastic, including 3.8% soft plastics – suitable for slow pyrolysis.**
- **Plastics such as PET bottles and PP construction tarps are currently recycled by waste pickers.**
- **But, HDPE and LDPE grocery bags have no value.**
  - Allowed to accumulate on the landfill.
- **If Rocket Stoves and UKATS Retorts are implemented to convert them to fuel 1,235 jobs per day could be created!**





# All work and no play...





# Benefits to Paducah

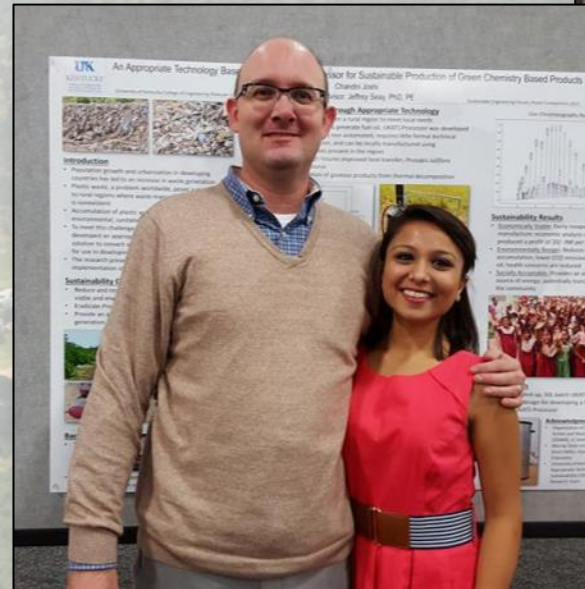
- **More than ever corporations are globally active.**
- **Study abroad students:**
  - Have a passport
  - Know how to acquire a visa
  - Have been through customs
  - Can navigate unfamiliar cultures
  - Are experienced travelers
- **Our program give Paducah a local source of internationally experienced graduates.**
- **A better workforce means better chances at bringing international companies to Paducah!**





# UKATS Achievements

- 8 Peer Reviewed Publications
- 29 Conference Presentations
- 23 National and International Undergraduate Research Awards since 2009
- Countries Visited:
  - Cameroon
  - China
  - Gabon
  - Hungary
  - India
  - Uganda





# Acknowledgments

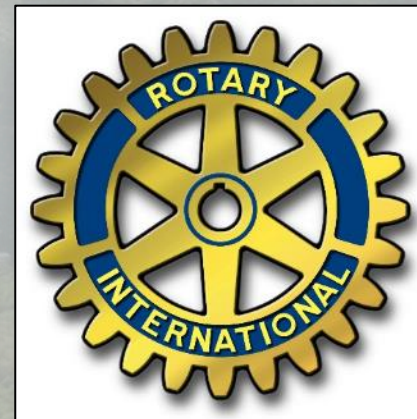
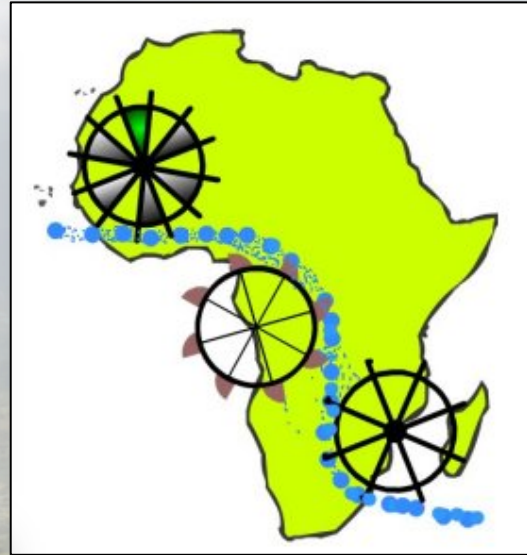
- **UKATS current and former student team members:**

- Elizabeth Behrens
- Shelby Browning
- Devan Buckhalter
- Emily Burkhart
- Bradley Butler
- Maxwell Croft
- William Croft
- Shelby Doucet
- John Higgins
- Keaton Johnson
- Chandni Joshi
- Austin McCallon
- Schubert Moffatt
- Kyle Lewis
- Riley Percy
- Mitchell Peeler
- Isiah Scott
- Christopher Sterrie
- Colton Tockstein
- Zachary Watson
- Christina Willett
- Sarah Willett





# Partnerships





**UK**

UNIVERSITY OF  
**KENTUCKY**

College of Engineering  
Appropriate Technology and  
Sustainability Research Team

**Thank you!**