KANSAS STATE UNIVERSITY

Figure 1 Agro-Industry Anaerobic Digester in UK

Figure 2 Dr. Parameswaran's Students Working with Anaerobic Treatment Pilot Plant

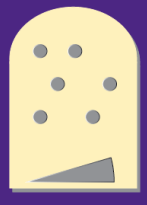
Figure 3 Kansas River

Engaging Students, Industry and Environmental Professionals to Assess the Potential to Generate Biogas and Other Resources from Kansas' Agro-Industrial Wastewater

Principal Investigator:
David A. Carter, CEM, CMVP
Director, Kansas Energy Program
Kansas State University Engineering Extension

Faculty Adviser:
Dr. Prathap Parameswaran
Assistant Professor, Department of Civil Engineering

Project Lead:
Robert Weil, PE
Masters of Science in Civil Engineering
Graduation December 2018



Kansas State University Engagement Goal:

Enrich scholarship, research, and creative activity; enhance curriculum, teaching, and learning; prepare educated, engaged citizens; strengthen democratic values and civic responsibility; address critical societal issues; and contribute to the public good.

Agro-industrial wastewater discharges present a problem and an opportunity

The societal issues to be addressed by this engagement project are: **1)** the high level of energy consumption, greenhouse gas emissions, and economic risk associated with current methods of treating agro-industrial wastewater (AIWW), **2)** the threat to the environment due to so-called "shock loads" from AIWW, and **3)** the threat to the economy if agro-industrial plants were to shut down or locate elsewhere due to inadequate AIWW treatment.

On the other hand, **the very characteristics of AIWW that tend to overload conventional wastewater treatment plants are the characteristics that make it ideal for a relatively new form of industrial pre-treatment: anaerobic digestion (AD)**. Agro-industrial wastewater tends to be high in organic matter (van Lier & Lettinga, 1999), which can be digested anaerobically to produce biogas and agricultural nutrients such as nitrogen and phosphorus. On average anaerobic treatment removes 59% of chemical oxygen demand in full scale plants (Cherchinaro, 2015). Using AD to produce biogas has been the subject of much research and development over the past 15 years and is widely used in other countries, but implementation of this beneficial technology is **lagging behind in the US** (McCarty, Bae & Kim, 2011). The approach in mind is to pre-treat the AIWW using AD and complete the final treatment at downstream municipal wastewater plants.

The project goal is to promote awareness of anaerobic digestion technology and to engage stakeholders on issues of concern

The project goal will **protect the environment** and **enhance the economy** by promoting awareness of an emerging technology: anaerobic pre-treatment of AIWW, which has the potential to generate biogas and other resources as well as lessen the treatment load on municipal wastewater treatment plants.

The project will also engage stakeholders, agro-industry environmental coordinators and wastewater treatment professionals, to identify issues of concern that represent barriers to implementation of this technology.

The project will build on past progress, lead to short-term positive impacts, and set the stage for long-term positive outcomes

The objectives of the project fit into an arc of progress toward a renewable energy future, in which the State of Kansas, and the KSU civil engineering department in particular, continue to serve as change agents (See Figure 4). This project, which is the subject of the project lead's graduate research, has the potential to advance the adaptation of this beneficial technology, through the following objectives:

1. By 7/15/18, a survey will be completed of a representative sample of wastewater treatment plants in Kansas to determine the **volume and strength of AIWW** received by those plants that would be suitable for AD. Wastewater professionals will also be surveyed regarding perceived barriers to AD pretreatment and current problems with treating AIWW. **The survey will be distributed by the Kansas Department of Health and Environment**.

2. By 7/30/18, an estimate will be completed of the **potential to generate biogas using AD pretreatment of AIWW**. The value of the biogas will be estimated at the market rate for natural gas as well as at the value available as a Renewable Identification Number (RIN) under the Renewable Fuel Standard. The estimate will be checked by the civil engineering faculty.

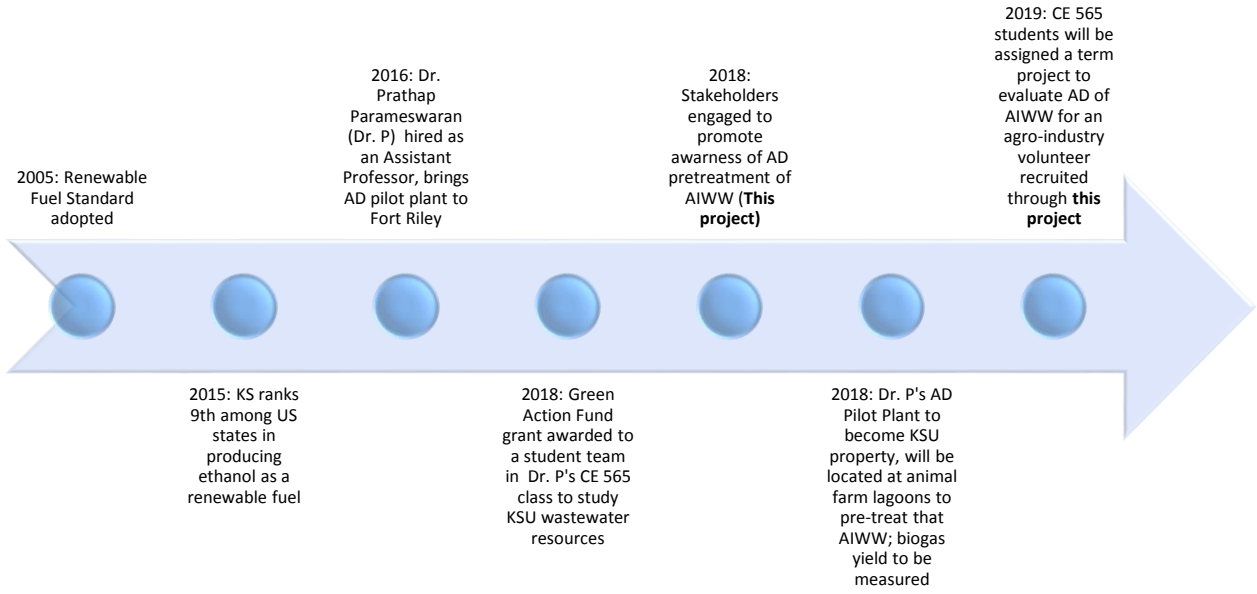


Figure 4 This project fits into an arc of progress toward a renewable energy future, in which KSU is serving as a change agent

3. By 7/30/18, an estimate will be completed of the **greenhouse gas reduction effects** of using AD to pre-treat AIWW using the EPA Waste Reduction Management (WARM) model, version 14.
4. By 8/15/18, stakeholder engagement will be enhanced through **updating Dr. Parameswaran's research website, with an emphasis on his team's AD research at KSU**. Availability and visibility of the website will be enhanced by implementing the recommendations of the Center for Advancement of Digital Scholarship, including links to ORCID iDs of the scholars on the team.
5. By 8/31/18, stakeholder engagement will be accomplished at the **Joint Annual Water and Wastewater Conference** in Topeka. The potential to reduce loading on wastewater treatment plants and generate biogas will be featured. The engagement will include a survey of awareness and attitudes regarding AD.
6. By 9/30/18, a **term project** will be developed for future use in CE 565 to prepare a conceptual design for **treatment of AIWW**, to include AD.
7. By 10/31/18, stakeholder engagement will be accomplished through a **workshop with food processing industries in Kansas, under the auspices of the Kansas Energy Program**, funded by the Kansas Corporation Commission and managed by KSU's Engineering Extension. Industries will be offered the change to volunteer for case studies on AD pre-treatment of AIWW as part of civil engineering student projects and/or Pollution Prevention Institute interns.
8. By 11/30/18, a report will be completed regarding the potential to generate biogas and protect the environment using AD pre-treatment of AIWW. The report will include a prototype design and an **economic analysis of potential to generate biogas using AD pretreatment at the KSU Manhattan campus and other AIWW sites**. The report will be submitted for publication to Bioresource Technology, an Elsevier publication with a 2016 impact factor of 5.651.

9. By 11/30/18, stakeholder engagement will be accomplished by **presenting the report at the Governor's Water Conference.**
10. By 12/31/18, stakeholder engagement will be enhanced by submitting the **Green Action Fund report to the New Prairie Press** for publication.
11. By 12/31/18, the report will be presented to National Renewable Energy Laboratory (NREL) in order to **update their estimate of biogas potential available in the State of Kansas**. This presentation could be combined with a field trip and educational tour for interested students.
12. By 12/31/18, **presentations will be offered to** the Riley County Food and Farm Council, the Union of Concerned Scientists Food & Environment Program, and the Global Food Initiative.

Metrics will be used to measure the project's impact

a. Biogas potential from AD of AIWW, in MMBTU of renewable natural gas and in gallons of gasoline equivalent per year
b. Chemical oxygen demand (COD) removal potential from AD of AIWW, in kg per day of load removed from municipal wastewater treatment plants
c. Greenhouse gas removal potential from AD of AIWW, in metric tons CO2 equivalents per year, using EPA WARM model, v. 14
d. Change to NREL's estimated biogas generation potential for the State of Kansas
e. Number of participants in stakeholder engagement activities
f. Change in awareness of AD, as measured by PollEverywhere surveys before and after stakeholder engagement activities

The team will bring a breadth and depth of strengths to the effort

The principle investigator, David Carter, brings a deep knowledge of Kansas energy policy and practices, an extensive network in agro-industry, and a passion for engaging and promoting student success. The faculty adviser, Dr. Prathap Parameswaran, or Dr. P (H=21), has published 47 peer-reviewed articles in such high impact journals as Bioresource Technology. In his two years at Kansas State University, he has already completed a very innovative pilot project that combines AD with another promising technology which uses fine-pored ultrafiltration membranes to purify water. The project lead, Robert Weil, PE, will provide a depth of project management and civil engineering experience, along with a strong desire to make a tangible difference in the profession and in his community.

The core team will be supplemented by specialists in the areas of sociology, statistics and communications, based on collaborative partnerships already in place. Dr. Matthew Sanderson is a sociologist who has done pioneering work on the human element behind water use and policy. Xianzhe Xue of the statistical consulting lab, is currently involved in the project and has guided the development of the statistical frame for the survey to estimate biogas potential. Amber Kelly, BS in Agriculture with a minor in chemistry, Graduation May 2020, is currently lending her expertise in communications and journalism to the Green Action Fund project for sustainable resource recovery from KSU wastewater.

The grant funds will be used to maximum effect

A budget of $10,000 is requested, based on the research work provided by the students involved in the project, as well as direct costs for in-state travel and web services. The engineering extension and faculty support will be provided from existing funding sources, representing a match of 107% to the grant funds.