

ARPA-E Workshop Methane Emissions Prevention and Abatement

Happy Hour/Networking

October 20th, 2020

Reducing Emissions of Methane Every Day of the Year (REMEDY)



Prof. Yuri Roman

Chemical Engineering

yroman@mit.edu

Ideas, questions and feedback

- What are the weight limits for a device used in vehicles to handle methane slip?
- Energy consumption limits/requirements for plasma or hybrid thermo/electrocatalytic systems?

Relevant experience/ expertise:

- My group specializes in experimental heterogeneous catalysis, nanostructured materials, thermo- and electrochemistry.
- Developed catalysts (metal-exchanged zeolites, oxides, single-atom catalysts) for the selective oxidation of methane at mild conditions.
- Interested in learning more about sensors, device integration, and life cycle analyses of emissions.

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Dr. David Casper

Casper's Calf Ranch

Dairy Nutritionist & Lab
Director

David.casper10@jcwifi.com

Ideas, questions and feedback

- Uses of essential oils alone or in combinations to reduce methane emissions from ruminants, manure lagoons/pits, swamps, landfills, etc.
- Use of highly digestible forages for feeding to reduce methane emissions per unit of food produced.
- Small scale research laboratory for measuring in vitro fermentation of gas production and gas types when feeding by products and additives to reduce methane emissions.

Relevant experience/ expertise:

- Worked for USDA-ARS on energy metabolism and methane emissions by dairy & beef cattle.
- Research on essential oils reducing methane emissions
- Use of forages and forage quality to reduce methane emissions.
- Knowledgeable on livestock production, feeding systems and nutrient requirements.
- Prior VP Nutrition, Agri-King, Inc.

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CISTAR
NSF Engineering Research Center

Prof. Fabio Ribeiro

CISTAR Director

fabio@purdue.edu

Ideas, questions and feedback

- CISTAR has resources and programs to study and prevent emissions of methane
- We need to participate in an Innovation Ecosystem to define, quantify and find solutions for methane emissions

Relevant experience/ expertise:

- Heterogeneous catalysis, fundamentals and applications
- Part of a collaborative team funded by NSF with industrial participation to “responsibly realize the potential of shale resources” (www.cistar.us).
- We are looking for partners to develop technologies in light hydrocarbons

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Dr. Tarek Abichou
FAMU-FSU College of Engineering
Professor
abichou@eng.famu.fsu.edu

Relevant experience/ expertise:

- Professor of Civil and Environmental Engineering, at Florida State University
- Using Methane Bio-Oxidation Technology in Abating Landfill GHG Emissions
- Modeling Methane Emissions and Oxidation in Landfills
- Field Measurements of Methane Emissions
- Would like to extend our experience to mitigating emissions from coal mining, agricultural applications

Ideas, questions and feedback

- Continuous monitoring sensors or network of sensor
- Precision needed in the estimation of methane abatement for Carbon Credit purposes
- Closing open dumps in developing countries and using the GHG emission reduction as a way to fund such projects
- Any interest in optimizing of natural gas distribution systems
- Educational components of REMEDY?

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**Dr. Matteo
Cargnello**

Assistant Professor

mcargnello@stanford.edu



Relevant experience/ expertise:

- Expertise in catalysis and nanomaterials
- Experience in
 - catalyst development for methane oxidation
 - catalytic options to replace flaring
 - catalytic methane conversion
- Interested in topics related to reducing methane emissions

Ideas, questions and feedback

- How to develop economically viable solutions to methane emissions?
- Is methane capture the only potential option for feasible methane regulation?
- How is policy related to methane emissions going to evolve?
- Are there portable solutions for converting methane on-site, i.e. when a leak is found?

- Developing more active catalysts for methane oxidation is imperative; fundamental advances are required given that we have approached the limit.
- Teaming up of researchers involved in detecting methane leaks with those involved in conversion is essential.

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Dr. David T. Montgomery

Montgomery_dave@cat.com

Relevant experience/ expertise:

- Manager, Natural Gas and Alternative Fuels @ Caterpillar
 - ½ the team is Ph.Ds
- Adjunct Professor of Mechanical Engineering @ Colorado State University teaching graduate level '*Industrial Natural Gas and Dual-Fuel Engines* class'
- Technology options for methane reduction in all applications
Caterpillar serves are of interest to me and my team

Ideas, questions and feedback

Excited to investigate in-cylinder, engine-level, aftertreatment, and customer-site level solutions to reduce methane emissions

Interested in considering partners for solutions

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Claire White

Associate Professor

Princeton University

whitece@princeton.edu

Relevant experience/ expertise:

- Materials science (chemistry, physics) of cement-based materials, inorganic silicate minerals, disordered and heterogeneous materials
- e.g., CO₂/acid resistant cements for use in wells/mines
 - Long-term performance
 - Potential degradation routes and mitigation
- Interested in potential synergies with other researchers

Ideas, questions and feedback

- Need for dynamic materials to adjust to changing conditions (stresses, strains, etc.)
 - Enhanced ductility?
- Important to understand rock/material interactions to avoid unintended leakage pathways
- Can methane be actively used to ensure its continual entrapment by a cementing (or other) material?
- ...

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Olya Irzak

CEO

Frost Methane

olya@frostmethane.com



Relevant experience/ expertise:

- Company expertise:
 - Low cost IoT Devices
 - Image processing
 - Natural methane vents such as permafrost
 - Coal mine drainage system / abandoned coal mines
 - Methane monitoring via 'proxies' visual / thermal / acoustic
- Looking for partners

Ideas, questions and feedback

- Questions: where in the ecosystem will having low cost detection result in mitigation? (landfills, O&G, natural sources, etc) Can any of that be done with proxies?
- Ideas: Smaller methane sources (<500 tonnes CH₄/ year) cannot economically participate in the carbon offset markets due to cost of the monitoring & flaring systems available today and some parts of the protocol needing in person inspection and tight accuracies. We've found a large number of such sources. Contact me if you're interested in solving this or have small methane sources you'd like to monetize.

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Baker Hughes 

**Melissa Allin, Myalee
Muller & Rob Krumm
Ph.D.**

Melissa.allin@bakerhughes
.com

Relevant experience/ expertise:

- Methane sensing
 - Aerial drones
 - Remote sensing
- Plug and abandonment
- Plume modeling / geosystems
- Catalysis
- Process optimization w/ real time data analytics
- Gas turbines / compression
- Intellectual Property Management
- Technology commercialization

Areas of Interest

- Methane emissions at abandoned O&G production sites
- Methane emissions from oil & condensate Tanks
- Methane emissions from flaring activities
- Methane emissions from natural gas compression
- Methane slip during turbine start-up
- Photocatalysis for methane oxidization
- Emission quantification
- Emissions sensing (via aerial drone and ground-based means)
- System-level monitoring and controls

**Baker Hughes is interested in
partnering on transformative
technologies**

Oxidation of Methane in Nonflammable Air Mixtures by Nonequilibrium Plasma



Dr. Xiaoshuang Chen

Dr. Elijah Thimsen

Postdoctoral associate

Assistant professor

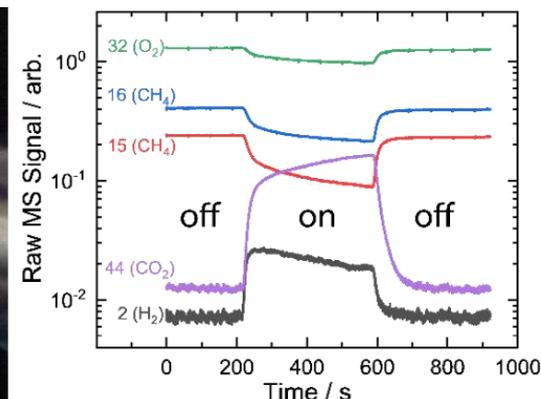
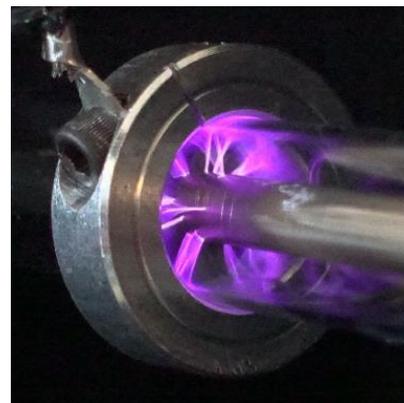
c.xiaoshuang@wustl.edu

elijah.thimsen@wustl.edu

Plasma chemistry, plasma process development, plasma catalysis

We are looking for a team of:

- Sensor development and device prototyping
- Plasma power supply developer
- Catalyst developer



Ideas, questions and feedback

- Plasma reactors can rapidly respond to input fluctuations.
- Current plasma processes can meet a net greenhouse gas reduction of **>85%**, based on 100 year warming potentials.
- Current experimentally demonstrated processes are close to, or even on the surplus side of, the breakeven point where **operating expenses (OPEX) are equal to gross revenue**.
- If the specific energy input of current processes was reduced by **one to two orders of magnitude**, then the process is expected to be economically profitable and meet the net greenhouse gas reduction target of **>90%**.

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Dr. Arash Dahi Taleghani

Associate Professor

Arash.Dahi@psu.edu

Relevant experience/ expertise:

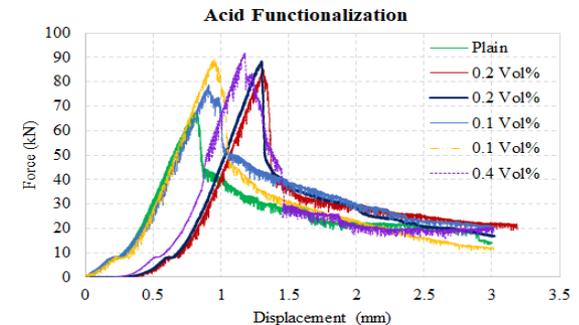
- PhD in Petroleum Engineering – more than 100 technical papers and 8 patents
- 15 years experience in industry and academia with areas of interest
 - Drilling and Completion
 - Geomechanics
- Looking for industrial partners to team up with.

Objectives

- Sealing cement microfractures
- Reducing cement permeability
- Increasing cement resiliency & fracture toughness

Ideas, questions and feedback

- How much mechanical improvement is needed to reduce emission? Does cement durability play a critical role?
- Using new cement additives rather than new cement formulations? Smart materials versus nanomaterial options?
- What would be an acceptable price range?



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Questor

Audrey Mascarenhas

President and CEO

amascarenhas@questortech.com

Relevant experience/ expertise:

- 38 years in energy
- 20 years working on methane abatement technology to eliminating flaring and venting
- First ISO certified clean combustion unit solving;
 - Routine flaring/venting
 - Non-routine
- Solution recognition from ND and CO regulator
- Looking for strategic partners and companies detecting methane.

Ideas, questions and feedback

- Does anyone have experience evaluating the efficiency of flares?
- Has emissions from maintenance activities (engines, pipelines, well unloading, soft starts...) been accounted for?
- Has anyone been involved in a full site emission audit including maintenance activities?
- We would be interested in partnering with companies with experience in detection.
- I would like input on the opportunity to take flared/vented gas and combust it cleanly and then use the heat to generate power and treat water

Improved Well Cementing for Reducing Methane Emissions



Prof. Sriramy D. Nair

Civil & Environmental Eng.

Cornell University

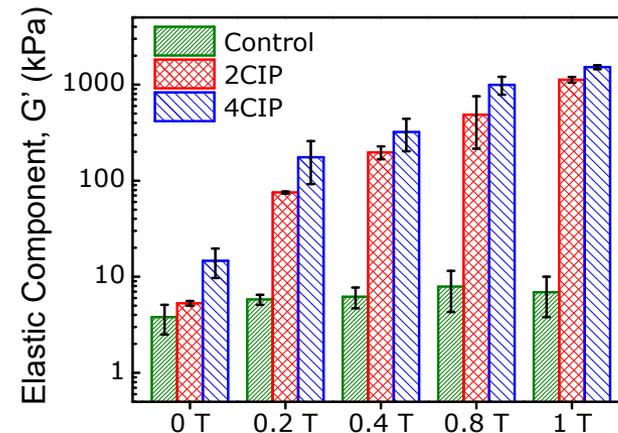
sn599@cornell.edu

Relevant experience/ expertise:

- Alternate Cementitious Materials for cementing of geothermal wells at Cornell University
- High energy X-ray experiments during in situ loading at CHESS
- Fiber optics for real-time detection of hydrocarbon leakage in cemented annuli
- Areas of Interest:
 - Mechanics and Materials
 - Reducing emissions in oil/gas/geothermal wells

Ideas, questions and feedback

- Role of alternate cementitious materials in improving zonal isolation
- Active rheology control during well cementing / plugging



Real-time stiffening behavior offered by magneto-rheological blended cements (MRBC) to prevent formation of permanent channels during hydration of cement slurry.

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Prof. Yiguang Ju
yju@Princeton.edu

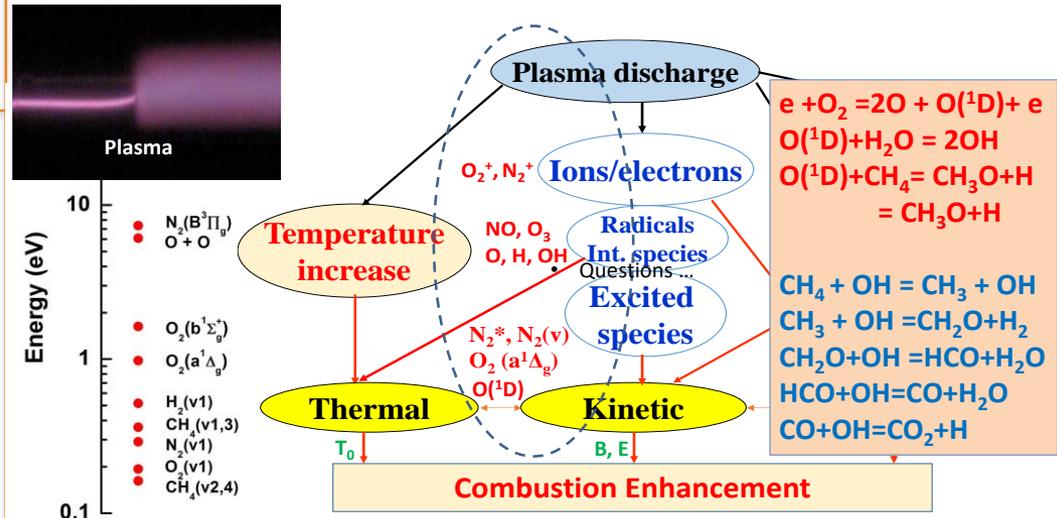
Relevant experience/ expertise:

- Robert Porter Patterson Professor in Mech. & Aerospace Engr. Research expertise in Combustion, Fuels, Plasma, and Low carbon energy conversion.
- **Areas of interest**
 - Low Temperature Combustion
 - Plasma Assisted Combustion
 - Energy materials
- **Looking for partners**

Ideas, questions and feedback

- Ideas: Plasma assisted methane oxidation

Major combustion enhancement pathways by plasma



Non-equilibrium plasma can enable low temperature oxidation of methane

- Challenges and feedback
 - Efficiency of active radical production and CH_2O oxidation
 - Energy efficiency and low methane concentration
 - Plasma instability control at atmospheric pressure

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Sandia National Laboratories

Dr. Ed Matteo

Geosciences Engineer

enmatte@sandia.gov

Relevant experience/ expertise:

- Durability of wellbore cement esp. chemical reactivity
- Subsurface seals - wellbore integrity and nuclear waste disposal
- Novel cementitious materials
- Field scale testing in underground research labs
- Modelling coupled processes, esp. chemo-mechanics
- Open to partners!!!

Ideas, questions and feedback

- How to “sort” good wellbores from bad ones?
- How do we monitor subsurface seals?
- Prediction vs. observation (both are difficult in subsurface environments)
- Subsurface heterogeneity as a “bottleneck” to monitoring, modelling, and “understanding”
- Systems level approaches?
- Time horizon? Defining success?

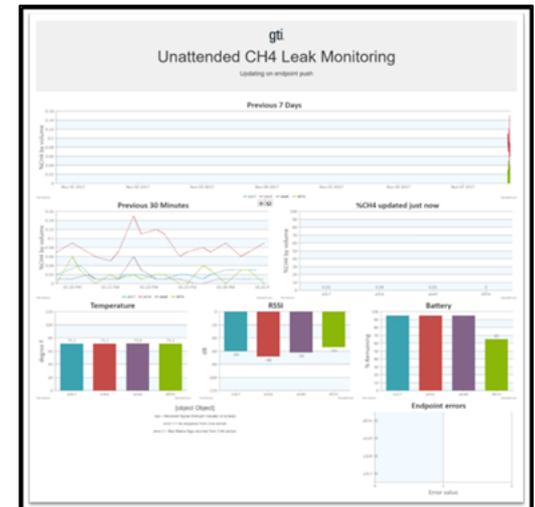
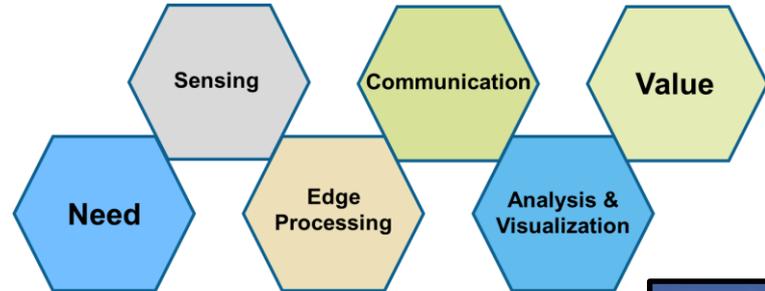
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gti[®]

Dr. Susan Stuver
R&D Manager
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Project Snapshots



GTI Experience: Continuous Sensing:

- Looking for partners
- Sensor/enclosure development
- Low power transmission and battery integrity
- Wireless and AMI solutions
- Machine learning algorithms on edge devices
- Code libraries and application processors
 - (high density to low density data)
- GIS/GNSS location-aware storage and display of data



CHANGING WHAT'S POSSIBLE

Project Astra: Field demonstration of quantification of methane emissions in an oil and gas production region

Contact: David Allen

<http://dept.ceer.utexas.edu/ceer/astra>
allen@che.utexas.edu

Astra sponsors: EDF, ExxonMobil, GTI, Microsoft, Pioneer Natural Resources and the University of Texas

Collective Monitoring

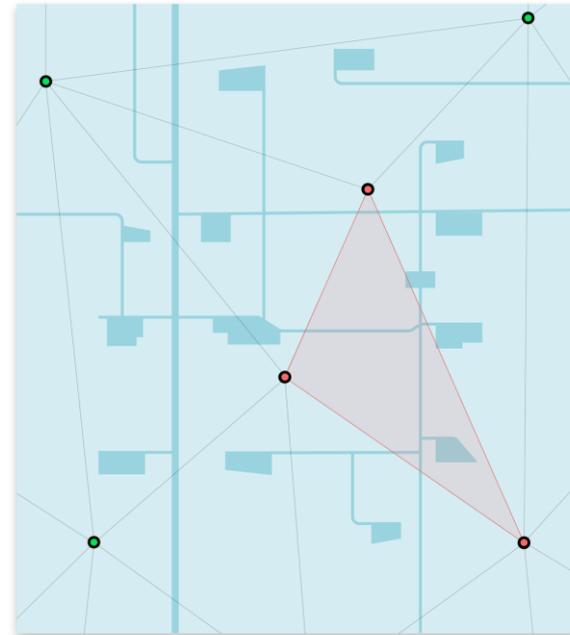
Near-Continuous Monitoring

Distributed Network of Sensors

Shared Cost Model

Inclusive Innovation

A shared constellation of sensors for low-cost, high-frequency methane emissions detection.



Project Astra includes a sensor field qualification (underway); the development of a virtual network design tool (being launched) and a pilot demonstration in a 100 mi² test region in the Permian Basin (late 2021)

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SAN DIEGO STATE
UNIVERSITY

Marina G. Kalyuzhnaya, PhD

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<http://sci.sdsu.edu/kalyuzhlab/>



Relevant experience/ expertise:

25 years of experience in physiology, genetics and engineering of methane biocatalysis.

Over 100 peer-reviewed scientific publications and numerous patents on methane bioconversions.

Research areas includes:

- 1) Technologies for production of chemicals, biomaterials, enzymes, and biofuels from methane and CO₂;
- 2) Methane Capturing via Enhanced Biofiltration;
- 3) Sustainability of Arid Ecosystems and Agriculture.

We are looking for biotechnology partners who can advance the technology to commercial scale



CHANGING WHAT'S POSSIBLE

LEAFs: Living Emission Abolish Filters (LEAFs)

Immobilized cells: 3D-printed matrix, scalable

Methane reduction: 80%

Input: 500 - 50000 ppm

Stability: > 6 months without maintenance

(no pumping, no media, no heat, no sludge removal)

Feasibility study and LCA are completed.

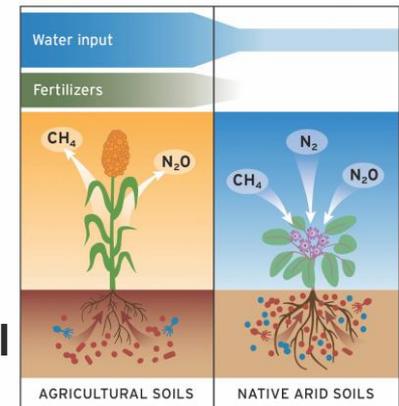
eSAV: Engineered Sustainable Arid Vegetation

microbial supplement from
desert plant rhizosphere

maximizes GHG capturing by
vegetation

improves plant growth under
water scarcity

**reinforcing the natural potential
of arid land microbiomes for
agriculture and bioenergy crop
production has the potential to
cut 25% of annual US CH₄
emissions.**



**Arid soils are main
natural sink of
methane in US
(87% of total natural
consumption)**

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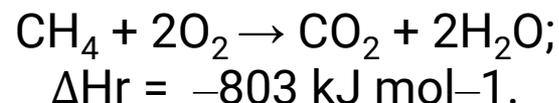
Dr. Maria L. Carreon

Assistant Professor

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Ideas, questions and feedback

CH₄ oxidation to CO₂ :



Relevant experience/ expertise:

- Rational design of materials at different scales
- Non-thermal plasma
 - CVD, PE-CVD, RF plasmas, DBD, LIBs, Platform chemicals from CO₂, separations
 - Plasma catalysis
 - Ammonia
- Looking for partners to team up with in: techno economical analysis, simulations

- 1. Can this reaction be effectively catalyzed via plasma-catalysis?*
- 2. What are suitable catalysts for methane oxidation via plasma catalysis?*
- 3. What is the economic feasibility of this process from the energy consumption perspective?*
- 4. Is the process amenable for scale-up?*