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. Yuriy Roman
Chemical Engineering
yroman@mit.edu

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.

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?
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Dr. David Casper
Casper’s Calf Ranch
Dairy Nutritionist & Lab Director
David.casper10@jcwifi.com

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.

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.
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Prof. Fabio Ribeiro
CISTAR Director
fabio@purdue.edu

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

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
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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  
ymcargnello@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., CO$_2$/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
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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

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

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

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

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Oxidation of Methane in Nonflammable Air Mixtures by Nonequilibrium Plasma

Dr. Xiaoshuang Chen  
Postdoctoral associate  
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Dr. Elijah Thimsen  
Assistant professor  
elijah.thimsen@wustl.edu

We are looking for a team of:

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

Plasma chemistry, plasma process development, plasma catalysis

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
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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?

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.
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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. Sriramya 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
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Relevant experience/ expertise:

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 CH₂O oxidation
  • Energy efficiency and low methane concentration
  • Plasma instability control at atmospheric pressure
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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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Dr. Susan Stuver
R&D Manager
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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

Project Snapshots
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

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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Marina G. Kalyuzhnaya, PhD
Phone: (619) 594-1839
E-mail: mkalyuzhnaya@sdsu.edu
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.

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
Maria.Carreongarciduenas@sdsmt.edu

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

Ideas, questions and feedback

CH₄ oxidation to CO₂:

\[
\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O};
\Delta H_r = -803 \text{ kJ mol}^{-1}.
\]

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?