

Project Team



Technical Advisory Board Members



★ Prime Recipient: University of Oklahoma

🧠 PI: Pejman Kazempour

🤝 Sub-Recipient: Kansas State University (Prof. Chuancheng Duan)

📍 Location: Norman, OK

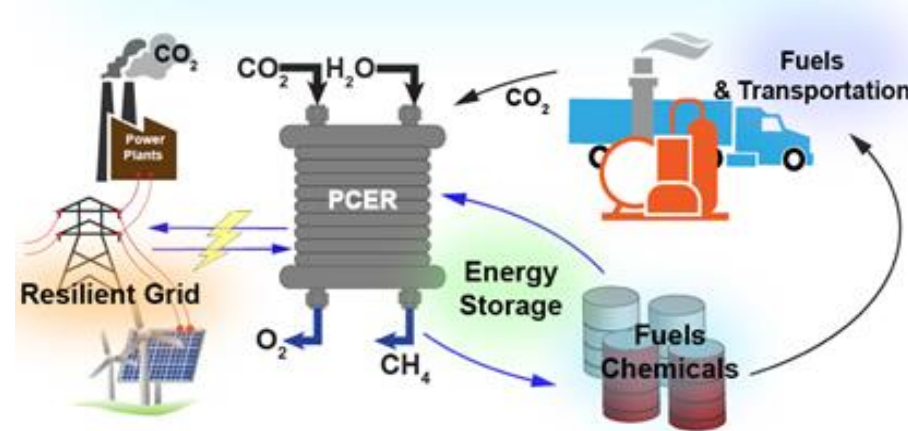
DOE: \$250,000 Non-DOE: \$62,504

Total: \$312,504

Project Title: Reversible Methane Electrochemical Reactors as Efficient Energy Storage for Fossil Power Generation

Award Number: DE-FE0032005

Program Objectives: The overall objective is to conduct a comprehensive Research & Development (R&D) program to demonstrate the suitability and future advancement and integration of reversible methane protonic ceramic electrochemical reactors (PCERs) as an efficient Energy Storage System (ESS) with fossil fuel power plants. Fundamental process and system models will be developed to conduct a preliminary conceptual study and investigate the power plant system integration requirements, performance requirements, and technical and non-technical gaps for eventual implementation at system level. Technology maturation requirements will also be investigated through identifying the critical technical elements and networking with industrial technology developers and end-users.



Technical Approach

- Using systems engineering to fully define the technology
- Conducting experimental tests to determine performance characteristic curves
- Establishing reduce-order models,
- Developing a comprehensive techno-economic model
- Networking with industrial technology developers and end-users

Technical Challenges

- The toxic contaminants in the exhaust gas from fossil industries might degrade the reversible methane electrochemical reactors
- High Faradaic efficiency is key to high energy efficiency in both electrolysis and fuel cell mode.
- Tight thermal, chemical, mechanical, and electrical couplings exists between the system components.

Program Deliverable

- Define the proposed energy storage system
- Develop experimental performance curves for Reversible methane protonic ceramic electrochemical reactors
- Develop Reduce order models for Reversible methane protonic ceramic electrochemical reactors
- Construct comprehensive Techno-economic and life cycle analyses

Anticipated Benefits of the Proposed Technology

- Possibility of directly using the captured CO2 for synthesizing CH4 and ensuing long-term energy storage.
- Exhibiting high H2S tolerance and coking tolerance
- Achieving High Faradaic efficiency (>98%). Reversible methane PCERs are completely reversible ($T\Delta S \approx 0$) and can approach a maximum round trip efficiency of 100%.

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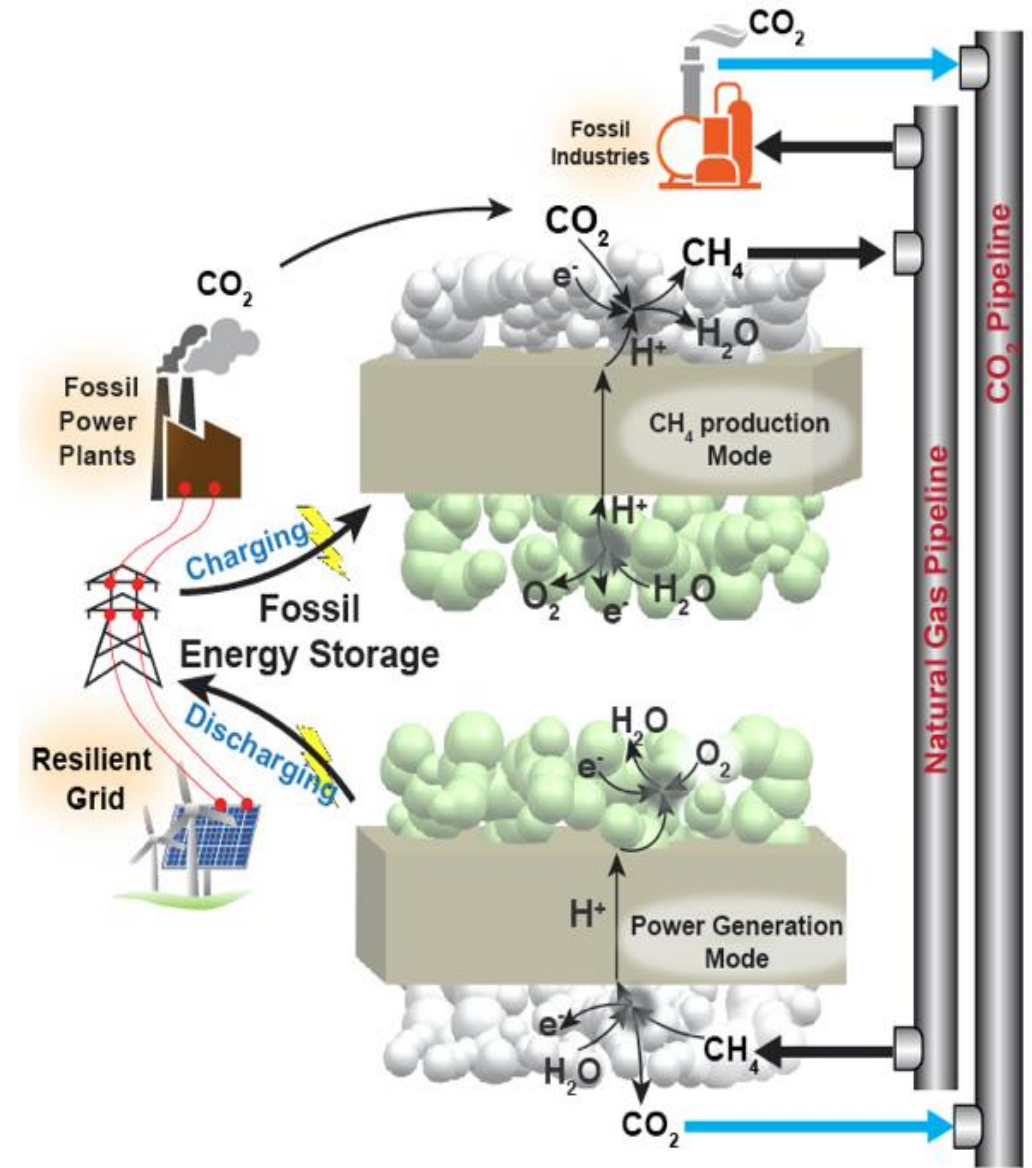
The use case / application of the proposed technology

- The proposed technology can manufacture CH_4 directly from CO_2 and H_2O , which are two primary components of the flue gas from existing and new fossil fuel assets.
- The sustainable CH_4 produced in PCERs can be blended into natural gas pipeline, used as the feedstock for fossil industries, stored in a tank for later power generation in PCERs.

Market considerations for the energy storage technology

The proposed system can be directly or indirectly integrated with the fossil fuel power plants and other fossil-fueled industries.

- ✓ Direct integration means that the flue gas enters the system without additional complex separation and purification processes to capture CO_2 , allowing significant cost reduction.
- ✓ Indirect integration of the proposed system with fossil fuel assets means that CO_2 gas is captured and separated through an intermediate system before entering the reversible PCER.



Reversible CH_4 protonic ceramic electrochemical cells.

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- 1) What is needed to be able to pilot **a demo plant by 2025?**
- 2) What does NETL need to consider in regard to a **low-carbon future?**

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Contact information

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The graphic features a central blue box with the text "Center for Sustainable Energy and Carbon Management". To the left, under "Sustainable and Alternative Energy Sources", is an image of an oil pumpjack and solar panels. Below that, under "Carbon Management", is an image of industrial smokestacks. To the right, under "Smart Production Through Digitization", is an image of an industrial facility. Below that, under "Energy Storage and Management", is an image of a battery storage facility. At the bottom left is a sustainability pyramid with "Social", "Environmental", and "Economic" pillars. At the bottom right is the Oklahoma State University logo. The central text reads: "For more information, please contact Dr. Pejman Kazempoor (pkazempoor@ou.edu). Developing solutions that are locally appropriate; socially beneficial; economically and technically feasible; and environmentally responsible."

The banner features a dark background with a world map. Text on the left reads: "Materials Research Laboratory for Sustainable Energy (MRLSE) at Kansas State University". Text on the right reads: "Chuancheng Duan, Google Scholar, Assistant Professor, Tim Taylor Department of Chemical Engineering at Kansas State University".

Please send me an email (cduan@ksu.edu) if you would like to join the group!

We have multiple PhD student and Postdoc open positions.

The banner is titled "Representative Publications" and includes the instruction "(click on figures below to see or download publications)". It displays five journal covers: Science, nature (with a butterfly effect image), nature energy, Energy & Environmental Science, and Applied Energy Reviews.