Introduction to Exploratory Projects – Ongoing

In addition to deep research into high-risk, high-impact fundamental science and technology, GCEP also funds smaller exploratory efforts. These exploratory projects can be funded for up to one year, and have budget limits of up to $100,000 each. The goal of these projects is to quickly evaluate the feasibility of a novel concept. If such an investigation proves successful, the investigators may apply for regular GCEP funding.

Six exploratory projects are currently being funded.

Biondo Biondi and Sjoerd de Ridder are investigating whether passive seismic imaging by interferometry is a reliable and feasible low-cost alternative to active seismic monitoring. The researchers have been analyzing two high-quality passive data sets. These data sets were recorded by using semi-permanent installations that had been deployed with the goal of developing and monitoring oil reservoirs, not CCS projects. However, the lessons learned from the analysis of these data sets could be used to design, and possibly execute, a passive seismic acquisition targeted specifically to monitoring a CCS project. CCS projects are planned in both marine and land environments. The data sets reflect this reality: the first data set was recorded on the sea bottom in the Norwegian North Sea (Valhall), and the second data set was recorded on land in South California (Long Beach). The researchers plan to process and image these data using a work-flow similar to the one used for the Valhall data. If the results will be equally encouraging, passive-data monitoring of land-based CCS projects will become equally feasible as the one of marine-based projects.

Matthew Kanan and Thomas Veltman are studying materials that catalyze efficient electrochemical N_2 fixation which would open up the possibility of using an N_2/NH_3 cycle to store and utilize energy from diffuse renewable sources. In such a cycle, N_2 and H_2O would be electrolytically transformed to NH_3 and O_2 in an electrolyzer powered by a renewable electricity source. With existing technologies, NH_3 can be utilized in solid oxide fuel cells or combustion engines to generate electricity or work and regenerate N_2 and H_2O. In contrast to H_2, which has received the most attention for fuel-based renewable energy storage, NH_3 is easy to store in solid form by complexation with earth-abundant salts.

The availability of effective and reliable monitoring is recognized as a requirement for the acceptance of geologic sequestration of CO_2. Peter Kitanidis and Eric Darve are developing ultra fast computational methods for the real-time monitoring of CO_2 plumes and the evaluation of risks of leakage. The ultimate objective is the development of computational tools for data assimilation and uncertainty quantification based on sound fundamentals and numerical methods but adapted to specific problems.

Nick Melosh and James Harris are exploring photon enhanced thermionic emission (PETE) for solar energy conversion. PETE operates at elevated temperatures (600 to 900 ºC) under high solar concentration (100s to 1000s of suns) appropriate for concentrated solar power. The process operates by thermionically emitting photo-excited electrons from a light absorbing p-type semiconductor cathode into vacuum, where they are collected by a lower temperature, low work function anode. Due to the combination of photovoltaic and thermal energy collection processes, PETE has the potential to achieve power conversion efficiencies above 47%, higher than the fundamental limits for single-junction PV. Furthermore, PETE devices integrated with solar thermal converters could achieve efficiencies over 55%.

Jennifer Wilcox and Zhenan Bao are investigating the potential for carbon capture using amine-modified carbon nanotubes. The purpose of this research project is to develop a robust, inexpensive solid sorbent for CO_2 capture from large point sources. Multi-walled carbon nanotubes (MWNTs) have been chosen for functionalization using both primary and tertiary aminosilane compounds. The use of carbon nanotubes, which are essentially an activated carbon material that can be tuned to achieve desired properties, and aminosilane compounds creates a combination of materials that are well understood, and have been used widely in industry as individual components. Carbon nanotubes offer an advantage over other engineered materials, such as zeolites and metal-organic frameworks, which may preferably adsorb H_2O, making them difficult to work with in humid environments. The research objectives of this work include the: 1) development of a method for successful functionalization of MWNTs; 2) characterization and testing of sorbents for CO_2 capture and release under relevant conditions; and 3) use of knowledge gained from these experiments to better tune the sorbents for enhanced CO_2 capture.

Shanhui Fan and Sven Beiker are exploring the feasibility of safe wireless power transfer directly to vehicles cruising at highway speed. They aim to use magnetically coupled resonating coils located in the roadbed and in the vehicles as the power transfer mechanism. Using large-scale electromagnetic simulations the researchers are examining the influence of the body of a vehicle, modeled as a metallic ground plane, on the efficiency of the resonant power transfer scheme in order to establish a preliminary experimental set up for the wireless power transfer system.