FLC 2020 Impact Award, A Catalyst to Produce Ethanol and Reduce Reliance on Fossil Fuels

**Technology**
- Addressing carbon emissions and limiting the impact of carbon dioxide (CO₂) on Earth's atmosphere and environment are among the most urgent challenges of modern society.
- Of the many proposed CO₂ mitigation strategies, recycling is a compelling option. To make CO₂ recycling viable, scalable option, a process that can use surplus electricity to produce useful products from CO₂ is needed. Researchers at Oak Ridge National Laboratory (ORNL) have developed an electrochemical process that combines CO₂ with water and electricity to produce ethanol. The process can be operated as a distributed load that can supplement intermittent renewable energy sources, such as wind and solar. It is also a useful alternative to batteries for long-term or portable storage of renewable electricity.
- "This is the kind of technology industry must pursue if we're going to reduce our use of fossil fuels." - Dr. Adam Rondinone

**Key advantages of ORNL's technology include:**
- **Simplicity:** Converts CO₂ to ethanol in a single-pot reaction at room temperature and pressure.
- **Broad applicability:** Benefits any operation that produces a CO₂ byproduct.
- **Efficient:** Boasts total energy efficiency of ~22% with a ~1.8x electrical cost for synthesizing 1 gallon of ethanol.
- **Cost-competitive:** Competes with the costs of converting corn into ethanol, even before attempting to scale up the process, which may lead to further cost-saving efficiencies.
- **Streamlined:** Uses no rare earth elements, which are expensive and difficult to acquire.
- **Robust:** Offers a solution to many sites that off-gas CO₂ at high purity (e.g., geothermal applications) yet fail to convert the CO₂ into a useful product.

**Partner**
- The invention was matured at laboratory and pilot-scale plant through ORNL's unique Technology Innovation Program, leading to worldwide media and licensing interest. ORNL selected innovative startup ReactWell as the exclusive licensee, given its demonstrated qualifications and expertise. The company has contributed additional in-kind funding and is a cost-share partner on a Department of Energy Technology Commercialization Fund grant awarded to ORNL for this effort.
- ReactWell's commercialization plans start with introducing this waste-to-wealth technology to niche markets and eventually scaling up to the ethanol fuel industry within the next decade. If successful, this transfer effort will be highly impactful, helping to improve energy conversion methods for cleaner, more efficient oil and gas, chemical, and bioenergy production. This effort has the potential to introduce to industries worldwide a simple and cost-effective way to recycle CO₂ that would otherwise be released into the atmosphere and to reduce society's reliance on fossil fuels.

**Outcomes**
- **Introducing Energy-Efficient Technologies to the Marketplace:** ORNL's fundamental scientific research for this effort has resulted in innovation that advances the Department of Energy's goal of addressing the nation's need for more energy-efficient technologies and increasing US energy security overall.
- **Providing Public Benefit and Environmental Impact:** ORNL's technology offers a simple electrochemical approach to producing ethanol, the value of this approach is also simple: the surplus CO₂ used in the process, which would otherwise be emitted into the atmosphere, becomes a feedstock through which useful products can be produced—specifically, ethanol for fuel, solvents, and beverages/spirits.
- **Creating New and Renewable Sources of Energy:** ORNL's catalyst lowers ethanol production costs and is carbon-neutral, enabling operation by variable renewable electricity sources, such as wind. In fact, one of the use cases for this technology is as a modulator, able to turn feed to wind farms and solar energy sites for intermittent operation during times when supplantation is needed. Specifically, the process would allow renewable energy plants to take advantage of extra electricity available by making and storing ethanol for later use. This would then help to balance a grid with intermittent renewable resources.
- **Keeping Surplus Carbon Dioxide Out of the Environment:** ORNL's technology enables reducing emissions per unit of fuel. The process is completely carbon-neutral, channeling surplus CO₂ into a fuel source rather than releasing it into the atmosphere. Depending on the application and the reactor used, the process could also be carbon-negative, if no additional processes result in CO₂ emissions during production.
- **Adding Value to Current Ethanol Industry Infrastructure:** Although ORNL's catalyst does not require corn fermentation, that does not mean that the catalyst would supplant corn. In fact, currently operating fuel ethanol companies see this technology as adding value to existing fermenter operations. The average fuel ethanol fermentation plant annually produces 100 million gallons of ethanol but produces even more CO₂ in the process. If CO₂ could be captured and converted back to ethanol, then the ethanol could be purified and distributed through existing infrastructure.
- **Improving the US Economy and Energy Security:** This technology transfer success is expected to boost the economic competitiveness of the United States by providing additional ethanol fuel without additional farming. In addition to potentially lowering fossil fuel input requirements, the effort may also boost economic competitiveness by creating jobs and improving overall efficiencies in various markets. These markets include existing ethanol manufacturing sites, where new modular add-on units can be used to collect, feed CO₂ for ethanol production and biofuel or CO₂ generators with the ability to sell liquid ethanol in both compressed CO₂.