Abstract: Science and Engineering Fair of Houston

3256

Research and Development of a Novel Cost-Effective Thermoelectric Generator for Roadways

Wyatt Maddox

Conroe ISD /AST: Academy of Science and Technology

Category:

Energy and Transportation

Clean and renewable energy have been important areas of research in today's society, with the increased amount of fossil fuel usage leading to declining resources and growing amounts of pollution. Many viable technologies, such as wind or solar power, are highly intermittent and do not generate a consistent amount of electricity. Because of the unreliable nature of many of these technologies, it becomes important to not only improve current energy generation technologies but also create new ones. Among these new technologies are road thermoelectric generators (RTEGs). RTEGs are able to create electricity from the difference in heat between the heat from the roads surface and a cool source. However, this technology has not been implemented anywhere because in order to implement these designs, the entire road surface needs to be replaced, causing it to be incredibly expensive and not feasible. This project's goal was to make a cost-effective solution to road thermoelectric generators. This goal was approached by redesigning the RTEG so that instead of replacing the road, only several holes would be drilled into the road in which the device would be inserted into. To test this new device, a road was simulated using dirt and concrete and a prototype RTEG was made. During testing, the device produced incredibly low amounts of energy, meaning that in order to compete with existing technologies, an unreasonable amount of these devices would be needed. This makes this approach not feasible until the efficiency of this device can be approved.

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Abstract: Science and Engineering Fair of Houston

3257

Category: Energy and Transportation

EchoPhase: Analyzing Stability and Scalability Performance of Sound Energy Harvesting Device Using Electroacoustic Transducers

Victoria Velasquez Anderson

Conroe ISD /AST: Academy of Science and Technology

With the rise of renewable energy, industries continue to question the scalability and stability of energy harvesting systems to further their large-scale implementation. To support commercialization, the purpose of this project is to understand the limitations of the designed sound energy harvester in terms of distance to the sound source, time dependency, and parallel circuitry to induce voltage. The device utilizes magnetic induction driven by sound vibrations on mylar plastic with neodymium magnets, copper wire, and springs. The distance was tested from 0 to 100 cm, but results showed that after 5 cm, the device could not induce voltage. During time trials, the device ran at a constant 400 Hz, 100 dB tone for 5, 10, and 15 minutes. The data demonstrate a spike between 3 and 5 minutes and stabilize over time around 0.5 mV. To understand the device's scalability, the voltage and resistance of the device were analyzed with an increasing number of devices in parallel circuitry. The voltage produced resembles a sine wave, allowing for the prediction of induced voltage and evaluating the device's stability. From the measurements, the efficiency followed an exponential decline as distance and parallel circuitry increased. The calculated efficiency remained around 1%, which is consistent with past literature on electroacoustic transducers. The device heavily depends on proximity to the sound source and cannot be scaled modularly. However, it does show greater potential for stabilization over time and mathematical modeling that can be further studied along with a reevaluation of materials.

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Abstract: Science and Engineering Fair of Houston

3258

The Effect of Magnetic Levitation on Mechanical Friction and Energy Efficiency in High-Speed Rail Systems

Darshan Kirumakki, Roshan Kirumakki

Clear Creek ISD /Clear Springs High School

Category:

Energy and Transportation

When visiting Japan, last summer, we were able to experience one of Japan's famous bullet trains. This amazing experience left me with one question, "Why are there no levitating trains in the U.S.A?" In this project we looked to answer this question, and found out that bullet trains aren't compatible with existing railway infrastructure and are therefore too expensive to implement; In order to solve this problem we split up to design 2 prototypes, one being a new version of maglev train that is compatible with U.S railways, and the other being a traditional Chinese-style Maglev train through our research of two types of suspension methods, Electromagnetic Suspension and Electrodynamic Suspension. For our prototypes, we opted to create not one, but two types of Electromagnetic suspension train as it would be much easier to design in our model and implement in the real world After finishing our prototypes and final designs, we figured out that only the first prototype (the non-traditional one) was able to work and succeed in accomplishing our project objectives. We learned about energy-efficient high-speed rails like the ones we designed with renewable power, learning that, if implemented between major cities, magnetic levitation trains could forever change public and green transportation in America.

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Abstract: Science and Engineering Fair of Houston

3259

Category: Energy and Transportation

Year II: How Seamless camber and nose-radius morphing airfoils on blended-wing body aircraft directly affect fuel burn, economics, and pollution.

Rafael Cantu, Muhammad Ur-Rehman

Conroe ISD /ASHP: Academy for Science and Health Prof

Seamless morphing camber systems have been proposed for decades as a path to improving aerodynamic efficiency compared to conventional slats and flaps. Hinged flaps, segmented morphing panels, and shape memory mechanisms have consistently faced issues from mechanical complexity, weight, flow-separation issues, and poor overall feasibility. These limitations have prevented seamless-camber wings from being viable for commercial aircraft. However, the potential of this technology could be amplified through the implementation on a Blended-Wing-Body aircraft. This project tests a seamless camber-morphing airfoil, designed for future blended wing body (BWB) aircraft, to compound the fuel-efficient effects of both technologies. The wing incorporates an internal carbon -fiber skeleton, eleven servos, TPU skin, and a friction-minimized mounting system. A complete open-circuit wind tunnel was designed and constructed. CFD simulations using k-omega SST turbulence modelling were performed to compare experimental and simulated behavior. Testing showed that the morphing configuration produced sufficient lift-to-drag ratios compared to fixed NACA 0012 and 4412 baselines. While CFD under-predicted efficiency, results confirmed that this technology reduces separation and drag. This nevertheless proves that this technology was possible to build and perform reliably. When scaled to commercial aircraft, these measured L/D improvements correspond to 30-38% reductions in fuel burn, consistent with published BWB studies. Per flight, this represents ~6,000 kg of fuel saved and ~20,000 kg of CO_2 avoided for an A320 flight from LA to NYC. Over a typical 1,095-flight annual schedule, equal to 6-7.6 million kg of fuel and 20-24 million kg of CO_2 avoided per aircraft per year.

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Abstract: Science and Engineering Fair of Houston

3260

Fermenergy: Analysis on the Effectiveness of Fermentation Byproducts, Organic Materials, and Harmful Waste Products as Sources of Exothermic and Endothermic Processes to Act as Heat Sources and Heatsinks in a Thermoelectric Generation System as an Electri

Ben Burket, Kaiden Patel, Bruno Reis

Conroe ISD /AST: Academy of Science and Technology

Category:

Energy and Transportation

Serious environmental issues arise concerning pollution and waste from fossil fuels, fermentation, and other industrial processes. Current renewable energy methods, while addressing environmental concerns, lack practicality due to cost and reliance on specific conditions. This study aims to eliminate these issues by analyzing how thermoelectric generation, the conversion of temperature differences to electricity, can be combined with fermentation byproducts and waste materials to create a viable alternative energy source. To do this, various endothermic/exothermic processes were tested based on their ability to generate electricity when paired with an array of thermoelectric generators (TEGs). The experiments identified urea dissolution as the most optimal heatsink, and ethanol/ethanol gel combustion as the most optimal heat sources. This experimentation also uncovered the advantages of few TEGs with concentrated heat over many TEGs with dispersed heat. Findings from this experimentation lead to the design of a real-world viable TEG system with an initial cost of $2.20 that is able to generate $0.03 per watt, challenging solar panel outputs. The heat sources and heatsinks researched in this project can also be combined with existing energy systems, such as heat from fossil fuels, as well as original concepts such as a fermentation-based TEG system in space that can generate energy, water, fuel, etc. Data from this project can be used to repurpose organic materials, environmental waste, and fermentation byproducts into various TEG systems to generate power anywhere in the world at a fraction of the cost of current systems, revolutionizing future energy generation worldwide.

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Abstract: Science and Engineering Fair of Houston

3261

Dimples for Power: Enhancing VAWT Blade Performance with Golf Ball Surface Geometry

Janiru Dissanayake

Clear Creek ISD /Clear Lake High School

Category:

Energy and Transportation

The objective of this project was to determine whether intergating dimple into the design of a wind turbine would improve the aerodynamic and noise performance of the turbine itself. In order to test for this, a fluid simulation and a physical experimental validation were used. First, the designs were created in Fusion 360 with varying designs (4.5 mm, 8 mm, 12 mm, smooth). Then each of these designs was tested for performance using ANSYS Fluent. Finally, each design was tested physically using a fan to stimulate the wind at different speeds. After the data was collected, it was found that the dimple did not improve or decrease aerodynamic performance significantly in both the simulation and physical testing. However, it was found that the 8 mm did reduce noise significantly. The 12 mm dimple actually ended up increasing noise significantly. This means that the medium design is effective in its use for reducing the noise output of vertical axis wind turbines.

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Abstract: Science and Engineering Fair of Houston

3262

The Effects of Blade Angle on the Electrical Power Output of a Small Wind Turbine

Ojas Raiter

Houston ISD/Bellaire HS

Category:

Energy and Transportation

Wind energy is a significant source of renewable energy, one of the main design parameters that determine the efficiency of a wind turbine is the blade pitch angle. This project's object is the impact of blade pitch angle on the electrical power output of a small-scale wind turbine in controlled conditions. A miniature wind turbine was built with a permanent magnet alternator and three blades of the same size 3D-printed of PLA plastic. Each blade had the same SD7037 airfoil cross-section, so that blade geometry was kept constant during the tests. Interchangeable pitch-setting components were used to set blade pitch angle to fixed values of 0deg, 10deg and 20deg. The turbine was placed at a fixed distance from a controlled airflow source, and all other variables, including blade design, alternator, electrical load, and test duration, were held constant. For each pitch angle, the turbine was run for 30 seconds, and voltage and current were measured using a multimeter. The formula P = V x I was used to calculate electrical power. Each pitch angle was tested three times and the average power output was gathered and compared. The findings revealed that electrical power output was highly influenced by blade pitch angle. Power increased as pitch angle increased from 0deg to an intermediate value but decreased at higher pitch angles due to increased aerodynamic drag and reduced rotational speed. These results indicate that blade pitch optimization is a critical factor in the design of wind turbines and can give an idea of how to enhance the performance of small-scale wind energy systems.

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Abstract: Science and Engineering Fair of Houston

3263

How can wind possibly create energy?

Shiven Patel

Fort Bend ISD /Hightower High School

Category:

Energy and Transportation

The project that I picked shows the construction of a windmill to convert wind energy into solar energy. When I am doing the project, I will create a structure where there is a fan that blows onto a turbine which connects to a motor which causes a light bulb to light up showing electrical energy. This project will show me how wind can create light which could help us and our environment.

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Abstract: Science and Engineering Fair of Houston

3264

Maximizing Energy Through Carbon Fuel Cells on Mars

Leila Alboraihi

Harmony Public Schools - South District/Harmony School of Innovation Katy

Category:

Energy and Transportation

Sustainable energy generation is one of the main challenges of future Mars colonization missions. Traditional solar panels face limitations on Mars because of frequent dust storms and reduced sunlight intensity, while combustion engines cannot operate in Mars' oxygen-poor atmosphere. This project explores the possibility of generating electrical energy using a fuel cell operating in a simulated Martian atmosphere. A small-scale fuel cell system is designed and tested in a Martian habitat replication to better understand the details involved in building, operating, and maintaining a fuel cell on Mars. Electrical output is measured under controlled conditions. This research demonstrates the potential of using Martian resources for energy generation and supports future sustainable space exploration technologies.

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Abstract: Science and Engineering Fair of Houston

3265

Electromagnetic Accelerator

Category:

Energy and Transportation

Dru Patel, Zohair Ahmed, Affan Rafique

Harmony Public Schools - South District/Harmony School of Innovation Katy

Electromagnetic accelerators, such as railguns and coil guns, use magnetic fields to propel objects at high speeds without relying on chemical propellants. These systems offer a cleaner, more efficient alternative to traditional propulsion methods and have potential applications in defense, space exploration, and transportation. -Problem statement: ordinary projectile systems rely heavily on explosive to power them, which pose safety risks, environmental hazards, and other challenges. There is a growing need for safer more sustainable propulsion technologies that can obtain high speed acceleration without explosives. Electromagnetic accelerators present a promising solution. -Purpose: The primary goal of this project is to build a electromagnetic accelerator and discover the advantages with using a sustainable, environmental friendly projectile system rather than explosives. -Questions we are trying to solve: How does the strength of the electromagnetic field influence the acceleration of a projectile? What coil configurations produce the most efficient acceleration? Can electromagnetic propulsion systems be a solution for real-world problems? -Hypothesis: Increasing the electrical current supplied to the coil will result in greater acceleration of the projectile due to a stronger magnetic field. -Our experiment: After we have built the electromagnetic Accelerator we will test it by increasing the power input and then observing the differences it makes to the speed of the projectile. -Independent Variables: Electrical current supplied to the coil (e.g., 5 v, 10 v, 15 v) -Dependent Variables: Acceleration of the projectile (measured in m/s^2) -Controls and Constants: Projectile mass (e.g., 50 g metal slug) Coil material and wire gauge Power source type and voltage Launch rail length Environmental conditions (e.g., indoor lab setting) Coil configuration (e.g., number of turns, distance between coils)

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Abstract: Science and Engineering Fair of Houston

3266

True Timed Traffic Light System at Four-Way Intersections

Erica Mao

Conroe ISD /AST: Academy of Science and Technology

Category:

Energy and Transportation

Traffic congestion at four-way intersections led to excessive idling, increased fuel consumption, and higher carbon dioxide emissions, making efficient traffic signal control a critical urban challenge. This study compared five public traffic light systems, traditional coordinated timing, video imaging detection, pressure transducers, incident accident detection, and a replica of Google's Project Green Light, to determine which method most effectively reduced vehicle stop time at a four-way intersection. General public data on cost, emissions, and expected performance was first examined, after which each system was modeled using the SUMO traffic simulator in Visual Studio Code. A total of 5,000 vehicles were simulated across 50 trials, and the average wait time per vehicle was recorded for each system. The coordinate system, used as a baseline, produced an average wait time of 31 seconds, while the incident detection system achieved the best average wait time of 20 seconds, indicating superior responsiveness to real-time traffic change. In contrast, the video imaging detection resulted in the highest average wait time at 91 seconds, and pressure transducers and the Google Green Light replica showed moderate performance of 78 seconds and 60 seconds, respectively. Overall, the findings showed that faster reacting signal control methods reduced delays and idling more effectively, leading to lower fuel use and emissions at four-way intersections.

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Abstract: Science and Engineering Fair of Houston

3267

Enabled Power

Isaac Sinaga

Private/Strake Jesuit College Preparatory - HS

Category:

Energy and Transportation

This research project develops a mathematical framework using calculus and statistical tools to automatically characterize and quantify outage events from the US outage data to study the impact on medically at-risk populations in Texas. The mathematical and statistical results are used to recommend which counties to prioritize for programs that provide generators to homes. The results will also assist in developing a system to warn caregivers and medical providers of prolonged outages. The results show that there is a strong correlation between Texas counties with high medically at-risk populations and prolonged outages. The histogram shows that some counties have higher outage likelihood that can help regulators to prioritize allocation of home generators. The results also show that for the majority of counties with high medically at-risk populations, the power infrastructure's "breaking point", represented by the inflection points was consistently outages that impact 10,000 customers or more. This real time value of 10,000 outages, which is usually monitored online can serve as an early warning to caregivers, medical providers that prolonged outage is underway.

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Abstract: Science and Engineering Fair of Houston

3268

Self sustained harvest of wasted heat into thermo-power

Anthony Nwonye

Harmony Public Schools - South District/Harmony School of Innovation Katy

Category:

Energy and Transportation

This project explores whether the heat that computers normally waste can be turned into usable electrical energy for classrooms. Since CPUs and GPUs get hot during regular use, I tested if thermoelectric generators (TEGs) could capture some of that heat and convert it into electricity by attaching them to the outside of a computer's heat□producing areas. I measured the temperature differences created by normal operation and controlled cooling, then recorded how much power the TEGs produced under different conditions. By comparing setups and looking at how efficient the energy conversion actually was, the project evaluates whether computer heat could realistically help power classroom devices or if the output is too small to make a real impact.

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Abstract: Science and Engineering Fair of Houston

3269

LED Tower

Ryan Onyemechi, Anderson Rojas, Michelle Guevara Cruz

Harmony Public Schools - South District/Harmony Science Academy-Houston

Category:

Energy and Transportation

Bright, energy-efficient visual signals are needed for safety beacons at construction zones, school events, and emergency wayfinding, yet many low-cost LED towers either drain batteries quickly or are hard to see at distance and wide angles. This project investigates how LED color and drive current affect both visibility and power use so that a simple, battery-friendly LED tower can be reliably seen from far away.

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Abstract: Science and Engineering Fair of Houston

3270

Harnessing the Mechanical Energy of Water Droplets with a Triboelectric Nanogenerator

Lucas Liu, Aaron Chang

Klein ISD/Klein Cain - HS

Category:

Energy and Transportation

In recent years, numerous studies have explored the potential of harnessing mechanical energy from various aspects of everyday life to power a wide range of electronic devices using a triboelectric nanogenerator (TENG). In this project, a monolayer of graphene was mounted onto PMMA film, and controlled amounts of water were dropped onto the graphene through a custom-made device. After multiple trials, an average voltage of 107.8 mV was consistently measured by releasing a tap water droplet of approximately 0.35 mL from a height of 5.5 cm onto a graphene sheet measuring 3.75 cm x 1.25 cm. The measured voltage can be primarily attributed to the initial impact between the water and graphene, which results in contact electrification. Additionally, similar results could also be found with TENGs comprised of an FEP film layered onto aluminum tape and mounted to a PMMA substrate, which produced around 23.5 mV using the same setup and 1.44 V with direct human impact, providing significant promise in the usage of TENGs for harnessing various forms of mechanical energy. Overall, our findings demonstrate the practicality of TENGs in harvesting energy from everyday scenarios. Further alterations in substrate material and optimizations for specific applications could therefore greatly impact the relevance of a practical solution using TENGs for powering future electronic systems.

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Abstract: Science and Engineering Fair of Houston

3271

Comparative Testing and Analysis of Heat Transfer Fluids in a Lake Based Geothermal System to Cool Residential Buildings

Sanvi Yalamanchili

Conroe ISD /AST: Academy of Science and Technology

Category:

Energy and Transportation

The focus of this experiment is to test different ratios of propylene glycol, bio based glycerin and water as heat transfer fluids in a lake based geothermal system. These heat transfer fluids were tested in two different ratios with three different fluids. One fluid consisted of 30% propylene and 70% water. The second consisted of 15% propylene glycol, 15% bio based glycerin and 70% Water. The third consisted of 30% bio based glycerin and 70% Water. The hypothesis was that if 15% propylene glycol, 15% bio-based glycerin and 70% of water was used as a heat transfer liquid, then it would cool the model house more efficiently than its 30-70 counter parts because of common qualities of both antifreezes posses such as their thermal conductivity working more effectively together than apart. This hypothesis was tested by creating three residential buildings. The three heat transfer fluids would go individually from a model of a hypolimnion from a lake and into a model house. This method created nine trials. Each heat transfer fluid was given five hours to cool the respective building. The results indicated that 30% propylene glycol with 70% was the most efficient with 15% propylene glycol, 15% bio based glycerin and 70% second, with 30% bio based glycerin and 70% water coming last. The analysis of these results reveal that when polyalcohols are used as heat transfer fluids, the more viscosity the fluid has, the less efficient it will be no matter their thermal conductivity properties.

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Abstract: Science and Engineering Fair of Houston

3272

Algorithmic Optimization of Solar Electricity Distribution for Underserved Communities

Hammad Tariq

Clear Creek ISD /Clear Brook High School

Category:

Energy and Transportation

Solar Panels have long been used to provide electricity access to underserved communities and serve as a renewable energy source for environmental protection. Community Solar initiatives have been increasing in recent years as a way to handle large-scale solar panel systems at low costs for many. However, there has been a problem with fairness in these initiatives, as some lower-income households don't have their electricity demand met. To combat this, three algorithms, round-robin, threshold control, and proportional sharing, have all been suggested to be implemented in community solar initiatives to ensure their fair distribution. To compare the fairness of these algorithms, an Arduino Uno powered by a 6V Solar Panel was used to simulate the algorithms' effects on a 4-home grid with the same demand of 0.023 amps, modeled by 4 LEDs with 220-ohm resistors. The Proportional Sharing algorithm was found to have the most fair distribution in community solar initiatives, as it accounted for both time and current solar energy provided to each household, allowing it to meet household demands with adequate time. Conversely, the round-robin algorithm prioritized time rather than current & demand, and the threshold control algorithm prioritized current and demand rather than time. The Proportional Sharing algorithm's function of accounting for current, demand, and time equally makes it best suited to mitigate fair distribution problems in community solar. Machine learning approaches to creating fairness algorithms can be tested in the future to provide an even fairer distribution from additional possible factors being considered.

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Abstract: Science and Engineering Fair of Houston

3273

Design and Optimization of a Hybrid Piezoelectric–Electromagnetic Energy Harvesting System for Mechanical Energy Conversion

Rithvika Pradeesh

Conroe ISD /AST: Academy of Science and Technology

Category:

Energy and Transportation

This project's purpose is to explore a novel hybrid energy harvesting model that uses two kinds of sustainable harvesting that tap into unused energy in the world, piezoelectric (uses vibrations/motion) and electromagnetic (uses a changing magnetic field) systems. The aim of this project was to see if the hybrid energy harvester model could produce more consistent voltage in comparison to harvesters that use only one method (piezoelectric or electromagnetic). Three prototypes were designed and built, a piezoelectric model, using a flexible ruler to provide oscillating motion and piezo discs, an electromagnetic model, using copper wire wound into a coil and neodymium magnets, and a hybrid model, incorporating both methods and materials into a single system. Constant mechanical input was used across all three models, and the voltages were measured across multiple trials to determine consistency. The results revealed that the hybrid model that combined both piezoelectric and electromagnetic materials and methods did better in consistency and voltage in comparison to the other models. These findings help show that hybrid models could be a possible solution in the future for more sustainable energy. Capturing unharnessed energy using a hybrid model can help create more voltage and remain consistent, making a piezoelectric and electromagnetic hybrid energy harvester a viable solution to using unharnessed energy, like vibrations, footsteps, or waves, to potentially power devices in a sustainable and efficient way.

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Abstract: Science and Engineering Fair of Houston

3274

Is building your own battery worth it?

Yahya Abdelazim

Home School/Homeschool

Category:

Energy and Transportation

The purpose of this project was to determine whether discarded lithium-ion cells could be safely and practically reused as a battery pack. The idea originated after watching a YouTube video showing disposable e-cigarette batteries reused to build a powerwall capable of powering a house. This made me think about how many batteries are thrown away, even though they still have a very usable capacity. I hypothesized that recycled lithium-ion cells, when properly tested, sorted, and assembled, could provide useful energy output comparable to, if not better than, that of a commercial lithium iron phosphate battery. To test this, I collected used lithium-ion cells from modem backup batteries, tested them for voltage, capacity, and internal resistance, then assembled them into a battery pack. The pack was connected to an inverter and monitoring equipment, such as a DC wattmeter, to measure voltage, power output, and stability under load. Its performance was then compared with that of the prebuilt LiFePO4 battery under the same loads. Results showed that, while the reused lithium-ion battery experienced greater voltage sag due to its chemistry, it still powered the same loads and handled higher peak currents. This matters because when certain appliances are turned on, like a desktop computer, they take around 3x the current that they would idle at to start up. The LiFePO4 battery could not power a Desktop Computer because of this. The recycled battery was also cheaper, customizable, and repairable, since individual cells can be replaced, while the LiFePO4 battery required no assembly and had manufacturer support.

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Abstract: Science and Engineering Fair of Houston

3275

Power by Hand: A Hand-Cranked Generator

Camila Arguello

Pasadena ISD/Pasadena Memorial High School

Category:

Energy and Transportation

My project tackles power outages during natural disasters. Texas' power infrastructure is vulnerable, particularly in the Houston and Gulf Coast region. Gasoline generators release carbon monoxide and kill an average of 70 people in the US each year and injure thousands. My generator will not release carbon emmissions. My project is a hand-cranked generator. It will convert mechanical energy into electricity using electromagnetic induction.

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Abstract: Science and Engineering Fair of Houston

3276

Category:

Energy and Transportation

SignalMend: A Biodegradable, Microcapsule Integrated, Self-Healing Gel Polymer Electrolyte with Visual Repair Feedback for Sodium-ion Batteries

Siddharth Jain, Vuk Popovic

Conroe ISD /AST: Academy of Science and Technology

The growing demand for safe, sustainable, and scalable energy storage technologies has increased interest in alternatives to Lithium-ion batteries. Sodium-ion batteries present a promising option due to Sodium's low cost and compatibility with aqueous systems; however their commercialization is limited by carbonate type electrolyte instability, mechanical failure, and drying effects that reduce ionic conductivity and cycle life. This project introduces SignalMend, a biodegradable, self-healing gel polymer electrolyte with integrated visual repair feedback designed to address these limitations. The electrolyte consists of a dual cross-linked polyvinyl alcohol, cellulose, and sodium alginate polymer matrix plasticized with glycerol and doped with Sodium ions with Sodium Sulfate electrolytes. To enhance durability and damage tolerance, calcium-alginate microcapsules were used to crosslink within the gel, allowing localized self-healing and visible indication of damage. A Sodium-ion cell was created using symmetrical carbon electrodes and with asymmetric battery type electrodes to investigate multiple configurations. Mechanical damage was simulated through bending of the electrolytes. Mechanical damage, which disrupts the polymer network's continuity, was successfully recovered without no statistically significant difference in the capacity and voltage profile of the Sodium-ion cell, indicating autonomous performance recovery. This design is compatible with numerous other Sodium ion batteries and supercapacitors, with aqueous, carbonate, and metal oxide chemistries.

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Abstract: Science and Engineering Fair of Houston

3277

25 Seconds to Screen a Battery: Comparing Machine Learning Architectures for Rapid Battery State of Health Prediction

David Liu

Fort Bend ISD /Elkins High School

Category:

Energy and Transportation

By 2030, 120 GWh of reusable batteries, equivalent to 65% of global grid storage demand, will be discarded annually because current battery SOH (State of Health) assessment is costly and unscalable, requiring 20+ minutes per battery. Existing literature also lacks classification metrics and doesn't investigate generalizable prediction from minimal data. This project compares six standard machine learning architectures (Transformer, LSTM, TCN, MLP, DLinear, Linear) for rapid battery SOH prediction from just 25-100 second voltage windows. I applied cell-level splitting to ensure cross-cell generalization and match real-world conditions. Two prediction approaches were compared: State of Charge (SOC) aware and SOC-independent. Models were evaluated on accuracy, computational cost, and classification errors (false pass / false reject) at the 50% repurpose/recycle threshold. Results showed that deep learning is necessary, achieving 5-10x lower error than linear models. Under SOC-independent conditions, all DL models maintained <4.2% MAE across cells, with TCN achieving the best balance of safety in false pass and false reject (9%/19.6%) at the 50% threshold. When SOC position is known, accuracy improved threefold to ~1.11% MAE, with late-SOC reaching 0.56%. Both methods show cross-cell generalization, achieving 1.35%-4.07% MAE with only 25 seconds of data, demonstrating viability for rapid real-world assessment. To our knowledge, this is the first study to evaluate classification errors for SOH prediction, systematically compare architectures across accuracy, safety, and efficiency, and directly compare SOC-aware and SOC-independent methods. Results demonstrate 50x faster testing, challenge conventional assumptions that temporal modeling is essential (<1% MAE improvement), and show that cross-cell generalization is achievable with only 6 training cells without requiring SOC estimation, cell-specific calibration, or complex health indicators.

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Abstract: Science and Engineering Fair of Houston

3278

Category: Energy and Transportation

Evaluating the Effects of Irregular Humidities on the Performance of an Electroaerodynamic Thruster System for Optimizing Sustainable Aircraft Propulsion

Lemuel Idika

Houston ISD/Carnegie Vanguard HS

In recent years, there has been an increase in research on electroaerodynamic(EAD) propulsion. This is a propulsion technology that uses high-voltage electrodes to ionize the air and propel those ions to create an airflow, known as "ionic wind", without moving parts. This project aims to identify and evaluate the correlation between an EAD system's performance and the humidity of the environment in which it is operated. An EAD thruster was constructed by 3D printing it and electroplating the collector electrode to conduct electricity from a high voltage generator. The thruster was run at varying power levels(6-30W), and the resulting airflow was recorded using a digital anemometer. The thruster was then run at different humidity levels (20% - 90%), and again, the resulting airflow was recorded using a digital anemometer. The recorded wind velocities from each test were then put in different graphs and tables to analyze the performance of the EAD thruster with varying input power and different humidity levels. Airflow velocity was used as a proxy for thrust under constant geometry and operating conditions. As relative humidity increased from 20% to 99%, the ionic wind velocity produced by the EAD thruster decreased by approximately 20%, indicating a direct relationship between relative humidity and EAD performance. These results suggest that EAD propulsion remains functional across typical atmospheric conditions but experiences reduced efficiency in high humidity environments. These findings highlight the importance of environmental factors in the performance and scalability of EAD propulsion systems.

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Abstract: Science and Engineering Fair of Houston

3279

Optimization of Residential PV and Battery Storage System for Off-grid or Hybrid

Jason Wang

Katy ISD/Jordan - HS

Category:

Energy and Transportation

The adoption of residential solar photovoltaic (PV) systems has accelerated rapidly, with Texas emerging as a leading region due to its abundant solar resources. However, the high upfront cost of installing a solar PV array and battery energy storage system (BESS), typically $20,000 to $35,00, creates uncertainty for many homeowners evaluating the financial viability of such an investment. This project develops a decision-support software tool to help homeowners assess the economic feasibility of installing a hybrid or off-grid solar-plus-battery system. The model optimizes one of two financial objectives which are maximizing the Net Present Value (NPV) or minimizing the payback period. Using site-specific latitude and longitude, the tool retrieves solar irradiance and PV performance data from the National Renewable Energy Laboratory (NREL). The algorithm simulates hourly energy flows among the PV array, household load, battery storage, and the electric grid under adjustable system parameters such as battery charge/discharge efficiency and Depth of Discharge (DOD). Users may input cost variables including PV cost ($/kW), BESS cost ($/kWh), electricity purchase/sell-back rates, installation cost, grid-connection fees, and annual operating or depreciation costs. The model calculates annual cash flows and evaluates NPV or payback time for each PV–BESS configuration. A brute-force grid-search method identifies the optimal PV and battery sizes that satisfy the user's selected economic objective. By providing accurate estimates of PV generation, system performance, and financial return, this tool helps homeowners make informed decisions about adopting solar energy. Future development includes creating an AI-based mobile or web application with an intuitive interface, enabling users to adjust parameters easily and receive clear guidance on potential PV-plus-BESS investments.

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Abstract: Science and Engineering Fair of Houston

3280

Causal Machine Learning for Optimal Completion Control in Permian Basin Shale Oil Production.

Claire Zhou

Fort Bend ISD /Dulles High School

Category:

Energy and Transportation

This project aims to identify and quantify the causal effects of key completion design parameters, such as proppant per stage, stage spacing, and lateral length, on shale oil production in the Permian Basin. The research seeks to optimize completion strategies by leveraging causal inference to identify true causal relationships and enhance operational efficiency and productivity. The project analyzes data from 1,532 horizontal production wells with completion parameters and 12-month production records, along with 355 vertical wells providing geological measurements (gamma ray, resistivity, porosity) from the Permian Basin's Beta zone. The project applies a causal Bayesian additive regression trees model to rigorously assess the heterogeneous causal effect of completion parameters on shale oil production, accounting for continuous treatments and spatial geological confounders. The causal analysis results reveal that proppant per stage has the strongest positive causal effect on production, with optimal results occurring at 1.5 standard deviations above baseline before plateauing. Stage spacing shows diminishing returns beyond moderate widths, while tighter spacing maintains a relatively stable level. Completed lateral length exhibits a non-linear causal relationship with production, peaking at intermediate lengths (~2 standard deviations above mean) before declining, suggesting diminishing returns from excessive extension. Stage intensity demonstrates a negligible impact on production outcomes. Spatial causal analysis highlights significant heterogeneity in treatment effects, particularly for lateral length, where production responses vary across geological settings. The findings provide valuable insights for completion optimization and can potentially advance shale oil development by replacing empirical practices with data-driven, causal relationships between completion designs and production outcomes.

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Abstract: Science and Engineering Fair of Houston

3281

Category:

Energy and Transportation

Taming the Plasma Curtain: Metamaterial-Guided Dielectric-Barrier-Discharge Plasma Actuators for Advanced Boundary-Layer Flow Control and Efficiency over Complex 3D Aerodynamic Surfaces

Aarav Asundi, Tristan Li, Arjun Paripelli

Conroe ISD /AST: Academy of Science and Technology

Dielectric-barrier-discharge (DBD) plasma actuators are an emerging flow-control technology capable of manipulating near-wall airflow without moving parts. However, conventional DBD actuators often suffer from limited discharge uniformity over complex surfaces and high onset voltages, reducing efficiency and scalability for practical aerodynamic applications. This study investigates the influence of exposed-electrode metamaterial patterning on near-surface electric-field behavior in DBD plasma actuators. Eight distinct electrode geometries were tested against a conventional DBD actuator across four airfoils using multiphysics simulations and bench testing in a constructed test section.Electrostatic simulations in COMSOL conducted comparative analyses of edge-localized field diffusion, spatial decay, and gradient behavior near the exposed-electrode–dielectric interface. Patterned geometries produced measurable differences in near-edge field structure within the first 0.1-0.5 mm above the dielectric surface. High edge-density patterns (interdigitated, serpentine, and Hilbert-fractal) significantly increased the field diffusion length λE, accompanied by a 55-70% increase in high-field area fraction fHF. In contrast, corner-dominated patterns such as chevron and split-ring resonator geometries produced higher edge percentile field magnitudes (kV/mm) but exhibited steeper decay and reduced diffusion lengths. Bench-top experiments validated COMSOL results by demonstrating reduced discharge onset voltages and more spatially extended, uniform plasma emission near the exposed-electrode edge compared to an unpatterned control. Corner-dominated patterns produced brighter but more localized discharge regions, indicating stronger local intensification with reduced lateral spread. These findings highlight the potential of integrating metamaterial patterning with DBD actuators as a scalable, cost-effective solution to issues with conventional DBD actuators.

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Abstract: Science and Engineering Fair of Houston

3282

Bio-Inspired Hydropower

Muhammad Farrukh

Clear Creek ISD /Clear Lake High School

Category:

Energy and Transportation

Hydropower is one of the most reliable renewable energy sources, and improving turbine efficiency can significantly increase energy output without requiring additional water resources. In nature, aquatic organisms such as whales, dolphins, and fish have evolved highly efficient fin and flipper geometries that move through water with minimal drag and maximum force transfer. This project investigates whether adapting these biological shapes into hydroelectric turbine blades can increase electrical power output compared to a traditional straight-blade design. Five turbine designs were created using computer-aided design software: a straight control blade, a whale-fin tubercle blade, a dolphin curved-fin blade, a mackerel crescent-tail blade, and a nautilus spiral blade. All blades were 3D-printed with identical dimensions and tested under the same water flow rate using a controlled hydropower test rig. Voltage and current were measured for ten trials per design, and power output was calculated using P=V×I. Results showed that all four biologically inspired designs outperformed the straight control blade. The whale tubercle blade produced the highest average power output at 0.353 W, representing a 57.6% improvement. These findings support the hypothesis that bio-inspired curvature enhances hydrodynamic performance. Biomimetic turbine blade geometries may provide a promising pathway for improving the efficiency of small-scale and large-scale hydroelectric systems.

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