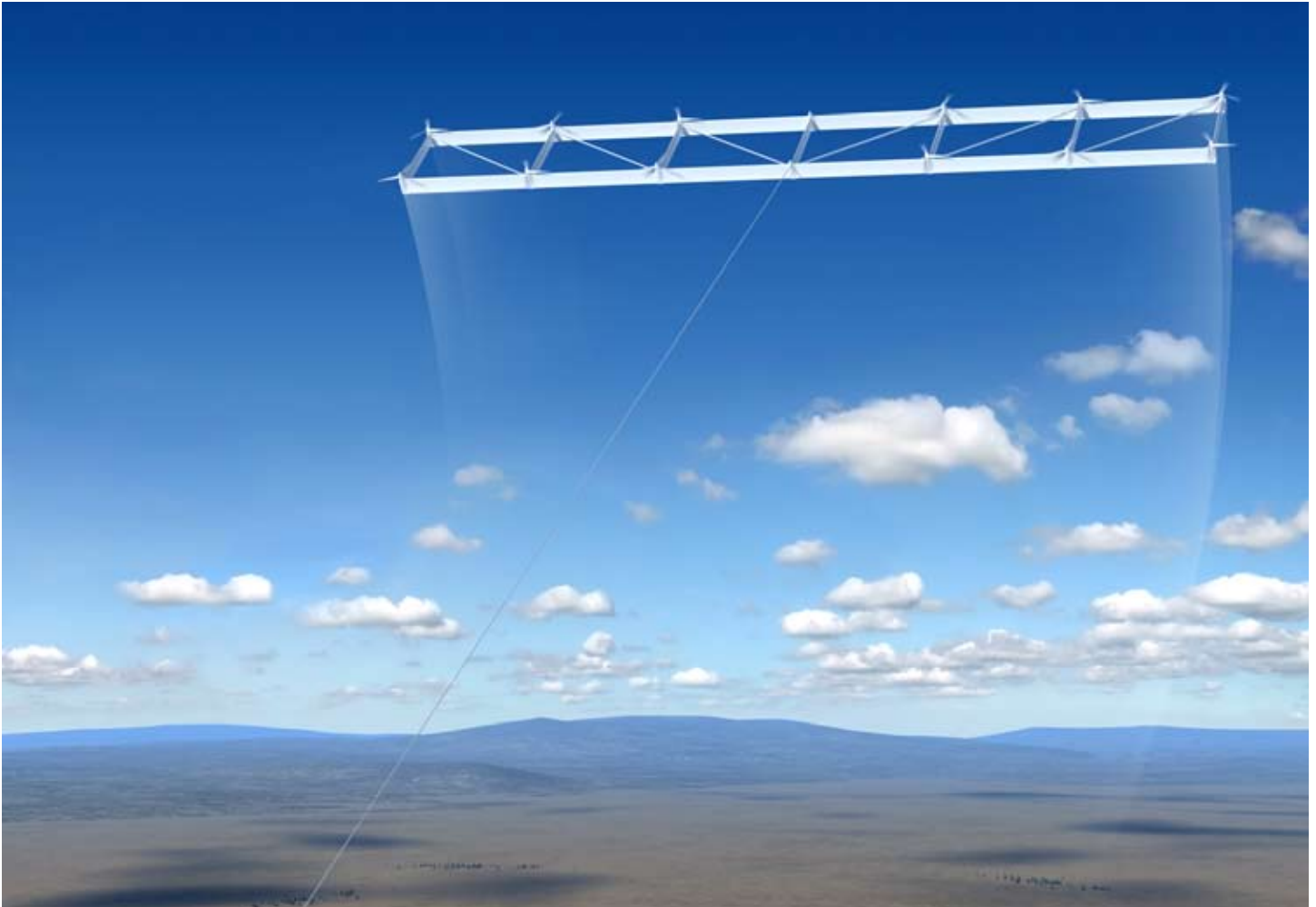


*Welcome to the Joby Energy inaugural newsletter. Check out our news, research developments, policy updates, upcoming events and let us introduce you to our crew. Stay connected with Joby E!*



## In This Issue:

NASA Collaboration: Countdown to Takeoff

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R & D Focus: The drive for a lightweight, super-efficient motor

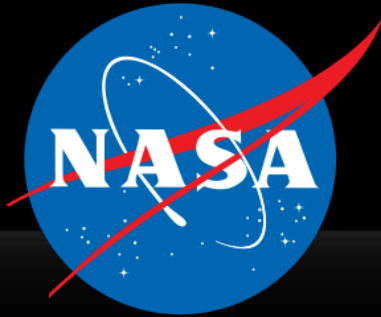
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Industry News, Policy Updates, and more...

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## NASA Collaboration: Countdown to Takeoff

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**N**ASA Glenn is taking the lead in forging a NASA-wide agreement with Joby Energy with a goal of helping accelerate the development and deployment of airborne wind technology.

Robert J. “Joe” Shaw, Ph.D., Chief of the Business Development and Partnership Office, NASA Glenn Research Center based in Cleveland, Ohio is driving the partnership process. “We are exploring various cutting edge technologies. If our capabilities align with technology needs which can strengthen and add value to our nation’s energy secure future — then let’s make it happen,” Shaw said.

According to Shaw, NASA is interested in airborne wind systems because the technology complements its strategic missions and charter to advance science, space and aeronautics. Shaw says that wind energy is one area that NASA is very interested in exploring. “The fact that the wind generators are airborne adds a new twist for us.”

Shaw sees a particular urgency to unearthing and developing a technology which could be the ‘Apollo-like program in advanced energy’ that candidate Barack Obama called for in his campaign and that answers Energy Secretary Steven Chu’s call for a ‘golden moment in energy innovation’.

According to Shaw, a presentation by Archan Padmanabhan, Senior Engineer for Joby Energy at the



*Robert J. “Joe” Shaw, Ph.D.*

recent NASA Internal Workshop on Wind Power Capabilities, triggered NASA-wide interest and enthusiasm for a potential partnership. “His analysis of high altitude wind and the potential for airborne wind systems captured the attention of the audience and reinforced the potential of this emerging technology”.

Shaw said the technology and regulatory challenges inherent in further development and deployment of airborne wind systems align with a number of NASA areas of expertise. “I see how this technology could benefit from the core competencies of NASA sites throughout the country.” Shaw says that NASA’s capability in Unmanned Aircraft Systems, aeronautics, icing, airspace issues and other areas can hasten the

technologies development timeline.

Padmanabhan, one of Joby Energy’s founding engineers, is enthused about the potential NASA partnership. “A partnership with NASA would provide us with incredible research and development opportunities,” he said. “I see it as a win-win situation — we’ve made some important advancements in system optimization and developed some proprietary technological advances that could benefit NASA.”

Shaw said that he is advocating for a NASA Space Act Agreement. “That’s a formal agreement outlining areas of mutual interest between NASA and Joby Energy and paving the way for opportunities to find funding for mutual projects. It’s a legal document that establishes intellectual property rights and liability essential to a formal collaborative relationship.”

In addition to a Space Act Agreement with Joby Energy, Shaw said NASA would look forward to discussions with the Airborne Wind Energy Consortium to advance the industry and engage in a technology exchange.

“Ultimately we’re hoping NASA expertise to support the energy needs of this nation,” Shaw said. “If we make advances in areas that benefit NASA and industry we call that dual-use technology. That means technologies needed for NASA to achieve mission work in space, aerospace or science can be employed in other sectors”. ■

# R & D Focus:

the drive for a lightweight, super-efficient motor



10 kW Motor

Unique direct-drive motors power Joby Energy airborne wind systems. Electrical engineer Diederik Marius leads the motor design team and after two years of research and development, says the team has made significant progress in producing a highly optimized motor. “One of the main engineering challenges was to design a brushless permanent magnet motor to attain high torque at low speeds, but with high power density (kW/kg),” Marius said.

Marius said that reaching high efficiency at low speeds is accomplished through very careful magnetic design for the motor and an

optimal phase winding scheme. “In a way, our entire system works like a gearbox, since the propeller will see oncoming winds that are greater than actual wind speed because its circular flight pattern,” Marius said. “The success of our technology is highly dependent on system efficiencies — the motor needs to be lightweight and extremely efficient.” Marius said. “We’re working on improving efficiency of our motors to reach 95% efficiency or better — right now we are above 90% which is much more efficient than induction motors.”

“We’ve come a long-way in the design process,” Marius said. “Technically speaking, the design was complicated

because the motors serve a dual role, first acting to power the system up and down and once the system reaches optimal operating altitude, its function shifts to power generation.”

While direct drive turbines are not new in the wind industry, Marius says that the design of our motor/generators is very specialized and unique. “They are optimized for reliability, safety, weight and longevity,” he said. “The motors are also quieter and have a longer life because with fewer parts, they are less prone to fail.”

The design team is currently building 5 kW motors for small airborne wind system prototypes while





*Diederik Marius*

simultaneously building 20-30 kW motors for future vehicles. These motors will be used to pilot and test 30 and 100 kW systems in the short-term. Larger motors are planned for multi-MW commercial systems.

Marius is now concentrating on what the design team sees as another big challenge — designing the prototype motor controller. “Our motor controller is fairly complex. It needs to handle high electric current and voltage, needs to be lightweight and efficient both in motoring and generating mode,” he said. “It also needs to be highly reliable and robust, keep optimal speeds and protect against overloads and faults.”

The multiple motors on our airborne wind energy system are each driven by a controller. “That greatly helps the safety our system,” Marius says. “This is one of the multiple redundancies of our system design — if one motor or controller fails, it will continue to fly or generate power because other motors/generators will take over its role.” Marius, a native of Belgium, received his M.S. in Engineering Physics from Ghent University and a M.S. in Electrical Engineering from Stanford University.

In addition to Marius, the prototype motor control team includes John Greene, Ganymede Stanek and Tom Smith. Piotr Esden-Tempski, an embedded systems engineer from Poland, is working on an additional motor control design. ■

## Federal Funding Needed for Airborne Wind Energy

Federal funding is needed to accelerate R&D of airborne wind energy and to capture the interest of significant venture capital. To date, about \$50 million in U.S. private investment capital from diverse funders such as Google and Boeing has launched the industry. Funding from the Advanced Research Projects Agency - Energy (ARPA-E) would validate the potential of this promising technology and spur venture capital investment.

ARPA-E is the Energy Department entity charged with ensuring U.S. leadership in development and deployment of advanced energy technologies. The new agency aims to maintain technological leadership by developing and deploying advanced energy technologies — “especially by accelerating transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty.”

Director Arun Majumbar, Ph.D., has put together a team of top-notch energy scientists and a responsive business infrastructure to enable a rapid response to emerging green energy technology. Now what the agency needs is enough funding to make investments in enough promising technologies to successfully meet its goals.

With China taking a commanding lead in public and private funding of clean energy innovation, the U.S. needs to dramatically increase funding to overcome a decades-long trend of [declining investment in energy research](#), both from the government and the private sector. The 2011 Department of Energy (DOE) budget request for ARPA-E is \$300 million. (In 2010, ARPA-E received \$400 million in ARRA funds.) Let’s hope that’s enough investment to move innovative energy technologies forward fast enough.

## Activities:

### ARPA-E

Joby Energy along with SkyWindPower and Makani Power exhibited at the ARPA-E Energy Innovation Summit March 1-2, 2010. The conference was an opportunity to showcase airborne wind system technology to an audience of federal agency representatives, funders, venture capitalists and the media. JoeBen Bevirt was featured in a CleanSkies television report while at the conference. Engineers Archan Padmanabhan and David Craig and Sher Quaday from the business development team also represented Joby Energy.

### USMC Conference

Joby Energy was selected to present its technology at the U.S. Marine Corp Expeditionary Power & Energy Symposium in New Orleans, LA on Jan. 25-27, 2010. Senior Engineer C.O. Lee Boyce, Ph.D., and Nancy Connelly, from our business development team, represented Joby Energy at the conference. The conference showcased emerging technologies which improve renewable energy sources, shelter systems, energy efficiencies and support equipment for Main Operating Bases, Forward Operating Bases, Combat Posts and Patrol Bases.

### Joby Energy Founder Speaks at PARC

JoeBen Bevirt spoke at the Palo Alto Research Center (PARC) in Palo Alto, CA on April 15, 2010. His presentation, Transforming Energy and Transportation: airborne wind turbines and personal electric aircraft, focused on big picture energy and transportation challenges. Audio and video of the [presentation are available online courtesy of PARC](#).

# Industry News:

## Airborne Wind Energy Consortium Offers Industry Leadership

JoeBen Bevirt, founder of Joby Energy, was named founding chair of the new [Airborne Wind Energy Consortium](#). Other inaugural members represent industry leaders [Makani Power](#), [Sky Windpower](#), and [Magenn](#). The organization unites the stakeholders of the international airborne wind energy industry into a single, focused and independent voice. Consortium membership will be comprised of industry firms, academic researchers, utilities, and regulators who have come together to promote the development and deployment of airborne wind energy systems. The organization will support and promote a number of initiatives, enabling members to be involved in key legislation concerning airborne wind energy technologies. To learn more about the Consortium or if you have an interest in joining, please visit [aweconsortium.org](http://aweconsortium.org) or contact [membership@AWEC2010.com](mailto:membership@AWEC2010.com).



Founder JoeBen Bevirt

## China Leads the World in Renewable Energy Investment

According to a [Pew Environmental report](#), China leads the U.S. and all other major countries in green energy investments over the past five years. The report noted that the \$34.6 billion in Chinese private investments during that time was nearly twice as much as its nearest competitor — the U.S.



## Scientific Evidence Spurs Airborne Wind Energy Industry Race to Top

A recent study by renown climate scientists validated the enormous power available in high altitude winds. Cristina Archer, Ph.D., of Chico State University and Ken Caldeira, Ph.D., of the Carnegie Institution of Washington published [a study in the journal Energies](#). The study confirmed that the strength and consistency of winds dramatically increase with altitude. This seminal study provides critical scientific data necessary to support the RD&D of airborne wind energy.

For decades, scientists and entrepreneurs have sought methods to extract energy from jet stream winds. Now the dreams of the early high-altitude wind energy pioneers are close to becoming reality as a new generation of entrepreneurs armed with scientific data and recent technological gains in power electronics, system controls and aeronautics takes up the challenge. [Academics and entrepreneurs](#) from

around the world are racing to claim technological leadership in this arena.

## Airborne Wind Energy Consortium Sponsors 2010 Airborne Wind Energy Conference with NASA

As its first event, the Airborne Wind Energy Consortium and co-sponsors NASA Ames, Glenn and Langley are co-sponsoring the [International Airborne Wind Energy 2010 Conference](#) at Stanford University September 28-29, 2010. The Conference will include presentations from leading international researchers, NASA, the Department of Energy, venture capital, federal regulatory agencies and will feature workshops focusing on industry interests including: technology R&D, regulatory and political challenges, and business development.



# Joby Energy People:

*Joby-E People offers an opportunity to meet some of our talented and growing team members.*

## Systems Control Experts Join the Joby Energy Team

Joby Energy commercial airborne wind turbines will be entirely autonomous and capable of long-term operation in a variety of weather conditions. This requires highly specialized system controls to handle multiple system components required to reliably produce renewable energy from high altitude winds. Joby Energy founder, JoeBen Bevirt has recently recruited two engineers to co-lead the system controls team.

Mechanical and Aerospace Engineer Frederic “Fred” Bourgault, Ph.D., and Mechanical Engineer Michael “Mike” Sherback, Ph.D., joined the Joby Energy system controls team in March 2010. Prior to arriving at Joby Energy, Fred was a senior scientist and Mike was a post-graduate fellow working with Professor Raffaello D’Andrea at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland.

Fred and Mike first learned about Joby Energy through an [article in Nature magazine](#). While still at ETH, they were investigating the feasibility of airborne wind power in their spare time. They met JoeBen after he delivered a company presentation and toured ETH facilities. After learning about the company’s technological progress, they were both interested in joining the growing company.



Michael “Mike” Sherback

“I love the idea of airborne wind turbines to address both the energy crisis and the carbon emission from burning fossil fuels problems,” Fred said. “If we hadn’t joined Joby Energy, Mike and I were seriously considering starting our own venture in this area or joining forces with other friends and colleagues.”

The two engineers are taking on a critical technological challenge. “When taken individually, the sub-systems of airborne wind systems such as power generation, structure, aerodynamics, estimation and control constitute very achievable engineering challenges,” Fred said.

“The challenge is to quickly converge on simple and robust sub-systems, and to integrate them. We can then refine this to produce airborne wind turbines that will fly and generate electricity autonomously and reliably. With sufficient scale and design optimization, we expect that they can be cost competitive with, for example, coal, when externalities are considered.”

The Company’s leadership, vision and product and its potential to be an industry trailblazer were what attracted both men to Joby Energy.



Frédéric “Fred” Bourgault

“Joby Energy is a well-funded and professional company with a charismatic and technically savvy founder and a talented and bright team,” Fred said. “The Company has a serious chance of succeeding.”

Bevirt said his vision of launching the first successful airborne wind energy system will become reality only by recruiting and retaining the very best team.

“Fred and Mike are top-notch engineers with the systems control know-how that will be instrumental to the success of the technology,” Bevirt said. “I expect their knowledge and skills will drive our technological leadership in the development and deployment of our product.”

Fred and Mike join C.O. Lee Boyce, Ph.D., Henry Hallam, Mathew Peddie and Allen Ibara on the systems control team.

## Introducing Michael “Mike” Sherback

As a post-doctoral research assistant at ETH, Mike wrote simulation, control, and estimation code for unmanned aerial vehicles. His solid robotics and controls research





*Mike Sherback snowboarding*

experience along with a desire to contribute to a technology with the potential of having a positive impact on society sold him on the Company. “I was drawn to Joby Energy because of the system control challenges and because I see the huge potential benefit for humanity,” he said.

Mike, received his Ph.D., M. Sc., and B.S. in Mechanical Engineering from Cornell University with a research focus on dynamics and controls. His work at Joby Energy will focus on deploying control systems for airborne wind turbines to compensate for inevitable modeling errors.

“We need to stay ahead of the ball. Computational modeling will have some real-life problems when a dynamic system is flown. Our job is to gather data to minimize these problems in advance, and to design control systems that can cope with what error is left over.”

Mike is convinced the technology can work. “The back-of-the-envelope calculations look great,” he said. According to Mike, the control of unmanned aeronautical vehicles is a reasonably mature field. “There may be some unknowns surrounding the tether and regulatory issues, but they aren’t too intimidating.”

Mike is married to Grace Li, a postdoctoral research assistant studying fibronectin for biomedical engineering at ETH Zurich. When not at work, Mike enjoys hiking, snowboarding and hockey. He is looking forward to having his wife join him in Santa Cruz in September.

## Introducing Frédéric “Fred” Bourgault

Fred’s main task, as part of the systems control group at Joby Energy, is to contribute to the design and implementation of algorithms that make the vehicle fly and generate power autonomously. This involves control and estimation theory, systems theory, some artificial intelligence and optimization.

“The challenge from the controls perspective is to assure that the airborne wind energy system is efficient and ultra-reliable” said Fred. “It must be robust in adverse weather conditions and to multiple subsystem failures.”

According to Fred, the engineering challenges ahead are ambitious but achievable. Some of the technology’s main hurdles may be non-technical, for example, changing public perception and gaining acceptance from large utility companies for this novel technology, and obtaining the legal framework and regulations to enable seamless large scale operations.

Fred was most recently Senior Scientist, Lecturer and Fellow at ETH Zurich, Mechanical & Process Engineering. His work at the Institute for Dynamic Systems and Control included performing design, analysis and developing control algorithms for the [Distributed Flight Array](#). The project featured small autonomous vehicles, each equipped with a single propeller, motored wheels and sensors, that are able to drive and join together into an array while on the ground, and then take off to fly as a single entity.

A Canadian, Fred completed postdoctoral research studies at Cornell University’s Sibley School of Mechanical and Aerospace Engineering. He received his Ph.D. from the University of Sydney, a M.S. in Aeronautics and Astronautics from MIT, and a B.Eng. in Mechanical and Aeronautical Engineering from Ecole Polytechnique de Montreal. He is also alumni of the International University. He also studied at Ecole Nationale Supérieure de l’Aéronautique et de l’Espace (Sup’aero) in Toulouse, France.

When off the clock, Fred actively pursues a wide variety of interests including traveling, learning languages and absorbing local culture (including food and wine). He is also a sports and fitness buff who enjoys mountaineering, skiing, cycling and running. An avid flyer, Fred competes



*Fred Bourgault paragliding*

in local and international paragliding competitions. While in Santa Cruz, he plans on adding kite surfing to his sports regimen. ■

# Policy Updates:

## Federal Policy Priorities

Joby Energy has identified several federal policy priorities. Recognition by U.S. Department of Energy (DOE) would offer the industry a level playing ground compete for federal funding. Federal support would rapidly advance industry R&D and propel the U.S. into technology leadership. There are also Federal Aviation Administration challenges that require Congressional action and a need for targeted appropriations for NASA and National Renewable Energy Laboratory to tackle industry research priorities.

We specifically support:

### Amendments to the Department of Energy Budget Appropriations Request of 2011:

Establishes an Airborne Wind Technology Research and Development Program and requests \$18 million for competitive funding. The Program will position the U.S. as the technological leader in airborne wind energy. Funding will be directed to efforts which focus on the technology's technical, regulatory, and environmental risks. Additionally, investment will facilitate advances in allied technical fields, create domestic jobs, promote local economic development and provide an abundant source of low-cost renewable energy at a cost competitive with coal.

### Amendments to HR 3165, the Wind Energy Research and Development Act of 2009:

Promotes research of high-altitude wind resources and development of

airborne wind technology. Proposed amendments to the bill, currently in the Senate Committee on Energy and Natural Resources.

### Amendments to P.L. 110-140 – the Energy Act of 2007:

Adds airborne wind energy as an area of research interest.

### A Push for ARPA-E to Issue a Funding Opportunity Announcement (FOA):

Provides a competitive grant opportunity to advance research and development of airborne wind energy.

### Legislation to Authorize Federal Aviation Administration (FAA) Commercial Airspace:

Congressional action will be needed to establish Interim Operational Approval procedures to approve commercially-operated airspace for pilot testing and deployment of airborne wind energy systems.

### Appropriations for a NASA Research Program:

Funds researchers at several centers who have expressed interest in working with airborne wind energy technology developers. The industry can benefit immensely from NASAs expertise in allied fields of science and technology. This funding will enable NASA scientists to perform exploratory, as well as collaborative research towards rapid development and deployment of this game-changing technology.

### Support America Competes Act: Research Program:

In addition, we also strongly urge

Congress to reauthorize the America Creating Opportunities to Meaningfully Promote Excellence In Technology, Education and Science (America COMPETES) for an additional five years.

Congress is well on its way to reauthorizing the bi-partisan America COMPETES Act. First authorized in 2007, America COMPETES is designed to stimulate and support US technical leadership. It has three main goals: (1) to increase research investment, (2) to strength educational opportunities and (3) to develop an infrastructure. The House Science Committee and Senate Energy Committee are leading the bill reauthorization effort.

The America COMPETES Act would combine three authorization bills including the Advanced Research Projects Agency - Energy (ARPA-E). ([HR 4906](#)). Given the current fiscal environment, there will likely be opposition to the bill's cost in both the House and Senate.

Please voice your support for increased ARPA-E funding by contacting your Congressional Delegation. Contact lists: [House](#) or [Senate](#)

### Draft Message:

Dear Senator or Representative \_\_\_\_\_,

*I am writing to urge your support of the reauthorization of the America COMPETES Act. This legislation provides increased funding to assure U.S. technology leadership in renewable energy. I especially encourage you to support an increase in funding levels for the Advanced Research Projects Agency — ARPA-E beginning in 2011. This program provides funding for emerging technologies with the potential to revolutionize the renewable energy industry. This investment will assure our technological leadership and U.S. energy security future.*

*Thank you for your support.*