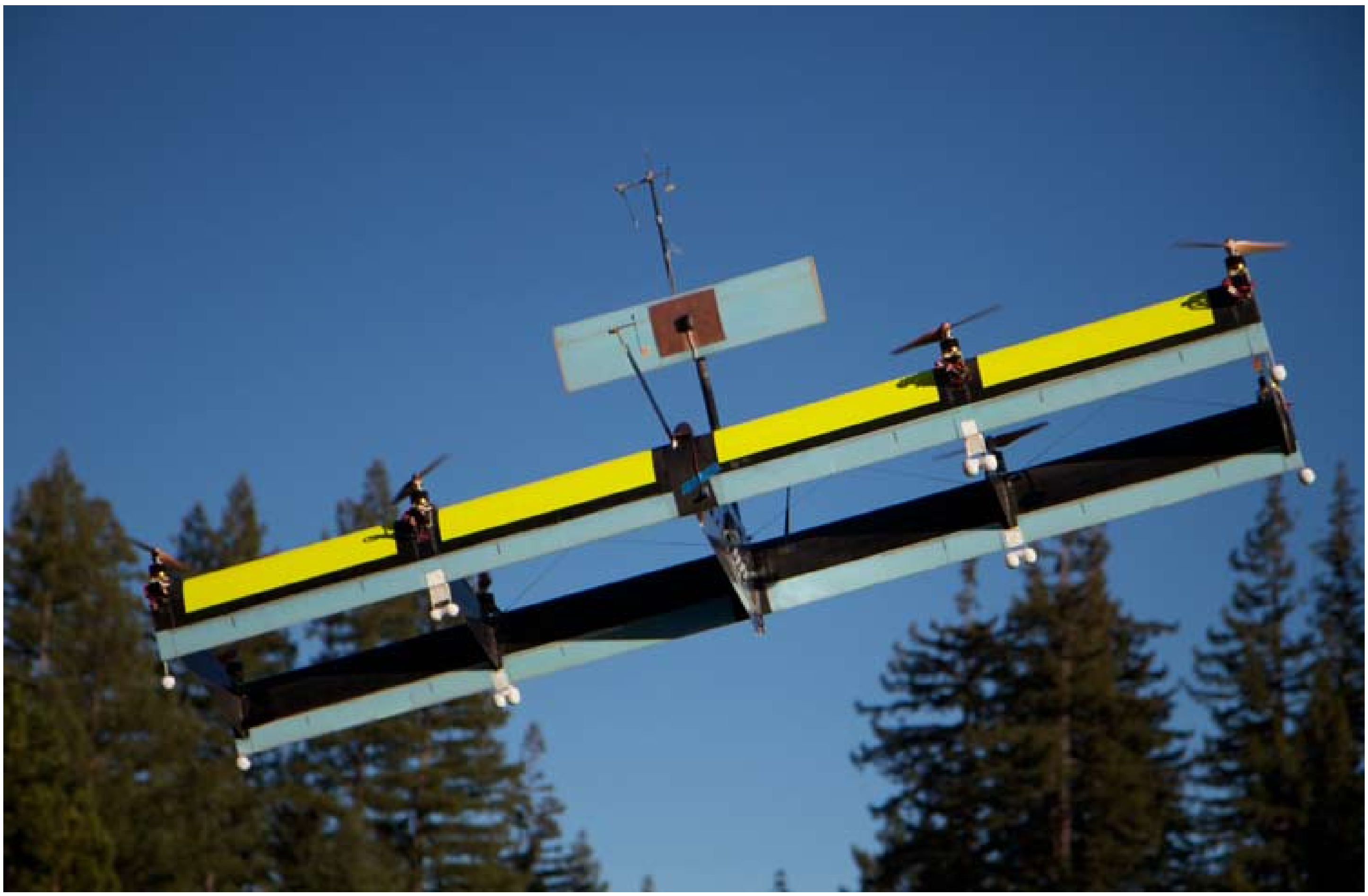
JOBY ENERGY | QUARTERLY

Q2 2010

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



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AIRBORNE WIND ENERGY COMPANIES DEPLOY WORLDIDE

University-sponsored research labs and private industry throughout the world are working toward a common goal -- to launch the airborne wind energy industry. Though each company's system design, operational height and market deployment goals vary, they all intend to take advantage of the phenomenal energy resource available in high altitude winds.

Aeroix - Berlin, Germany

The Aeroix Enerkite system is based on a project co-developed by Festo, a worldwide leader in pneumatic and electrical automation technology. Aeroix also provides technical textiles products.

CyberKite, an autonomously controlled kite wing of up to 24 square meters (258 square feet), is operable without any external energy feed-in. The kite uses resilient winches, which are supplemented with battery technology. In the "generator mode" the servo drives are being run periodically by the ropes, which are de-coiled by the traction relayed by the kite. The regained electrical energy is stored in the batteries and reduces the energy demand of the system.

Ampyx Power - Brennels, Netherlands

Ampyx Power spun-off from TU Delft and its Ladder Mill project 18 years ago. The Ampyx PowerPlane produces electricity at an operating altitudes between 300 and 500 meters. A system prototype has successfully generated 10 kilowatts of power.

Ampyx Power recently obtained second round financing from the Norwegian energy company, Statkraft, (Europe's biggest producer of renewable energy) and Byte, a Dutch IT company.

The PowerPlane system uses a glider plane to unwind a winch during flight to propel a generator on the ground. Ampyx is currently developing a 100 kW prototype. The Power Plane test rig has a wingspan of 5.5 meters and plans are to design larger systems with 35 meter wingspans capable of 1 MW power generation.

Ampyx received approval to test in Noordoostpolder, Netherlands and plans to demonstrate fully automated power production in late 2010 and produce a commercial 1MW PowerPlane in 2013.

Guangdong High-Altitude WindPower Technology - Guangdong Province, China

Dr. Zhang Jianjun began his research on high-altitude wind power generation in the United States and returned to China where he built China's first high-altitude wind energy research center and wind tunnel lab in Guangdong Province. The company plans to build a 1 MW high-altitude wind power generating system in Foshan City.

The technology consists of a kite/glider pulling cables and driving generators to produce electricity. When the kite ascends to the maximum height, the angle of the wings of the kite will be adjusted by the control system to make it descend with its own weight.

Joby Energy - Santa Cruz, CA USA

Joby Energy systems are comprised of two-wing airframes supporting an array of turbines. The turbines connect to motor-generators which produce thrust during takeoff and

Joby Energy Prototype Testing

generate power during crosswind flight. Orientation in flight is maintained by an advanced computer system that drives aerodynamic surfaces on the wings and differentially controls rotor speeds.

For launch, the turbines are supplied with power to enable vertical take-off. Upon reaching operating altitude, the system uses the power of the wind to fly cross-wind in a circular path. During occasional periods of low wind the turbines are powered to land the system safely.

The system uses a reinforced composite tether to transmit electricity and moor the system to the ground. The high redundancy of the array configuration can handle multiple points of failure and remain airborne.

The company is currently building and testing 10 - 30 kW system prototypes while simultaneously designing and building 100 and 300 kW systems. Plans are to fly initial commercial systems between 500 and 2,000 feet and to begin manufacturing of commercial systems in 2012.

Kitenergy - Torino, Italy

Kitenergy utilizes autonomously controlled tethered airfoils operating between 500 and 1000 meters. Electricity is generated at ground level by converting the traction acting on the tethers into mechanical and electrical power, using rotating mechanisms and electrical "yoyo" generators. The autonomous controls driving the airfoils pull the lines to direct the wing motion.

The Kite Steering Unit (KSU) is comprised of electric drives, the drums, the on-board sensors and hardware.

Kite Gen Research - Chieri, Italy

In the simplest configuration of the Kitenergy technology, the KSU is fixed on the ground. The KSU can autonomously perform a two-phase cycle, simply acting on the two lines that connect the airfoil to the fixed steering unit. The lines are connected to two alterno-motors by means of wrapping drums. In the traction phase, the airfoil is driven to fly fast in crosswind direction, with "figure eight" trajectories, and generates high traction forces that unroll the lines. The drums are put in rotation and the alterno-motors produce energy. When the maximal length of the lines is reached, the control enters into the recovery phase, where the wing is driven to a region where the lines can be pulled by the motors until the minimal length is reached, spending a small fraction of the energy generated in the traction phase and a new traction phase is undertaken. The energy balance between the traction and recovery phase is approx. 90% (i.e. only 10% of the energy generated during the traction phase is then spent during the recovery phase). The energy produced is stored in batteries and then directed to the electric grid.

Prototype systems that were tested near Asti, Italy (where wind conditions are generally considered inadequate for convention wind turbines) produced 5kW average and 30kW peak, with a ground speed of 4.5 m/s.

Laddermill - Delft, Netherlands

The TU Delft University Laddermill project is developing the Kiteplane, a cross between a kite and a airplane. The systems will initially be deployed up to 1000 ft and plans are to eventually reach the jet stream. The Kiteplane will be comprised of a number of kites flying in a large loop and ascending and descending to create a rotation that is coupled to an on-ground generator that creates energy.

Makani Power - Alameda, CA USA

Google-funded Makani Power's most recent design utilizes an autonomously- controlled, rigid, single wing airframe with multiple on-board generators. A bi-directional tether powers the system to operating altitude and when generating power tranfers it via an aerodynamic tether to a power substation on the ground. The Makani system will fly at altitudes between 200 and 1,000 meters.

Makani Power boasts a relatively light-weight system that uses only a fraction of the materials a similarly-rated conventional turbine would use, resulting in energy that is cost-competitive with coal.

The company recently conducted a successful test of autonomous controls in continuous cross-wind flight -- simulating the desired flight pattern of its future systems.

Magenn Power - Mountain View, CA USA

The Magenn Power airborne wind energy system, MARS, is a helium-filled tethered wind turbine that rotates on a horizontal axis at altitudes from 600 to 1000 feet.

MARS rotation also generates the "Magnus effect" which provides additional lift, keeps the MARS stabilized, which means it will operate in a very controlled and restricted location.

Reaching winds at 1,000 feet above ground level allow MARS to be installed closer to the grid. MARS is mobile and can be rapidly deployed, deflated, and redeployed without the need for towers or heavy cranes. MARS is bird and bat friendly with low noise emissions. The system is capable of operating in a wide range of wind speeds - from 4 mph to greater than 50 mph.

NTS - Germany

NTS Energy & Transports won the recent European Union-hosted Knowledge Intensive Services Innovation Platform (KIS-IP) showcase of renewable energies and satellite downstream applications entrepreneurs.

According to the KIS-P contest website, the German company plans to present its unique and patented concept which will harness wind at high altitude and produce electricity for lesser costs than fossil fuels.

Sky Windpower - Oroville, CA USA

Sky WindPower intends to deploy a 1 MW Flying Electric Generator (FEG) in the jet stream. The FEGs utilize existing rotorcraft technology to capture and convert high altitude wind energy to electricity.

FEGs will operate at altitudes between 6,000 and 30,000 feet. A 12 kW prototype is undergoing testing and is expected to be flown in the fall of 2010. The goal is to produce power at altitude in the winter of 2010-2011.

As with most airborne wind systems, FEG systems may be economically feasible at lower wind sites where conventional wind turbines are impractical and could be located closer to existing transmission than new terrestrial wind farms. Sky WindPower predicts that FEGs will have capacity factors of up to 80% to deliver massive amount of clean power.

Swiss KitePower - Various research institutions in Switzerland

Swiss KitePower is an academic coalition of researchers at The University of Applied Sciences Northwestern Switzerland, FHNW, Swiss Federal Institute of Technology Zurich, EMPA and the Swiss Federal Laboratories for Materials Testing and Research, ETH. The coalition is sponsored by industry partner Alstom Switzerland AG -- the Swiss branch of a multinational power and transportation company.

Research and testing projects by research institution include:

FHNW:

- Force measurements on a 4-line power kite
- Airborne Kite Control Unit
- 10 kW ‘Pumping’ kite power plant

EMPA:

- Tensairity kite design, construction and testing
- Kite dynamics simulation
- Flying wing actuator design and testing

ETH:

- Kite control simulation
- Instrumented kite
- Automated kite control software

Windlift - North Carolina, USA

Currently Windlift is building a 12 kW mobile wind power system mounted on a 6 meter long trailer. The machine generates power by reeling a tether on and off of a winch drum. The airfoils are custom para-wings, similar to kiteboarding kites, but reinforced to handle net loads up to 5000 lbs.

The company has abandoned direct mechanical applications like pumping or compressing air for now, tying it’s winch system into a Azure Dynamics AC55 electrical motor/generator. The system’s optimal operations will be below 500 ft. in altitude to avoid any potential conflicts with air traffic. The company plans on completing a build of this system in early July 2010. ■

Summer Interns Join the Joby Energy Team

From left:

Greg Horn — Stanford Graduate School of Engineering
Jim Wilson — Stanford Graduate School of Business
Fergus Noble — University of Cambridge, UK
Joris Gillis — Belgium, Ph.D. Candidate, KU Leuven, Belgium
Laura Schumaker — MIT
Nathan Pallo — MIT
Kesavan Yogeswaran — MIT
Sam Weiss — MIT
Colin Beighley — UCSC Graduate
John Craig — Louisiana State University *(not pictured)*

R & D Focus:
optimizing high-performance turbine blades

Like many aspects of the Joby Energy airborne wind energy system, designing turbine blades is an exceptional engineering challenge. No one has designed a blade quite like this before.

That's because the blades serve multiple purposes -- delivering thrust to lift the system during take-off like a helicopter, then when at appropriate altitude, transitioning to hovering and then switching again to generate power like a windmill.

Neel Vora, a company founding engineer, who was instrumental in creating the initial global optmization model that most of the current designs are derived from, said that the blade requirements present an intriguing challenge.

"To meet the demands of very different operating points the blade needs to be precisely engineered," Vora said. "We also need to consider noise and structural considerations which impose additional constraints on the speed at which the blades rotate, which in turn affects blade size and the generator design."

The blade and turbine provide the physical mechanism for both capturing wind energy and propelling the vehicle. According to engineer Ian Horn, designing an optimal blade is one of the keys to gaining a competitive advantage over conventional wind.

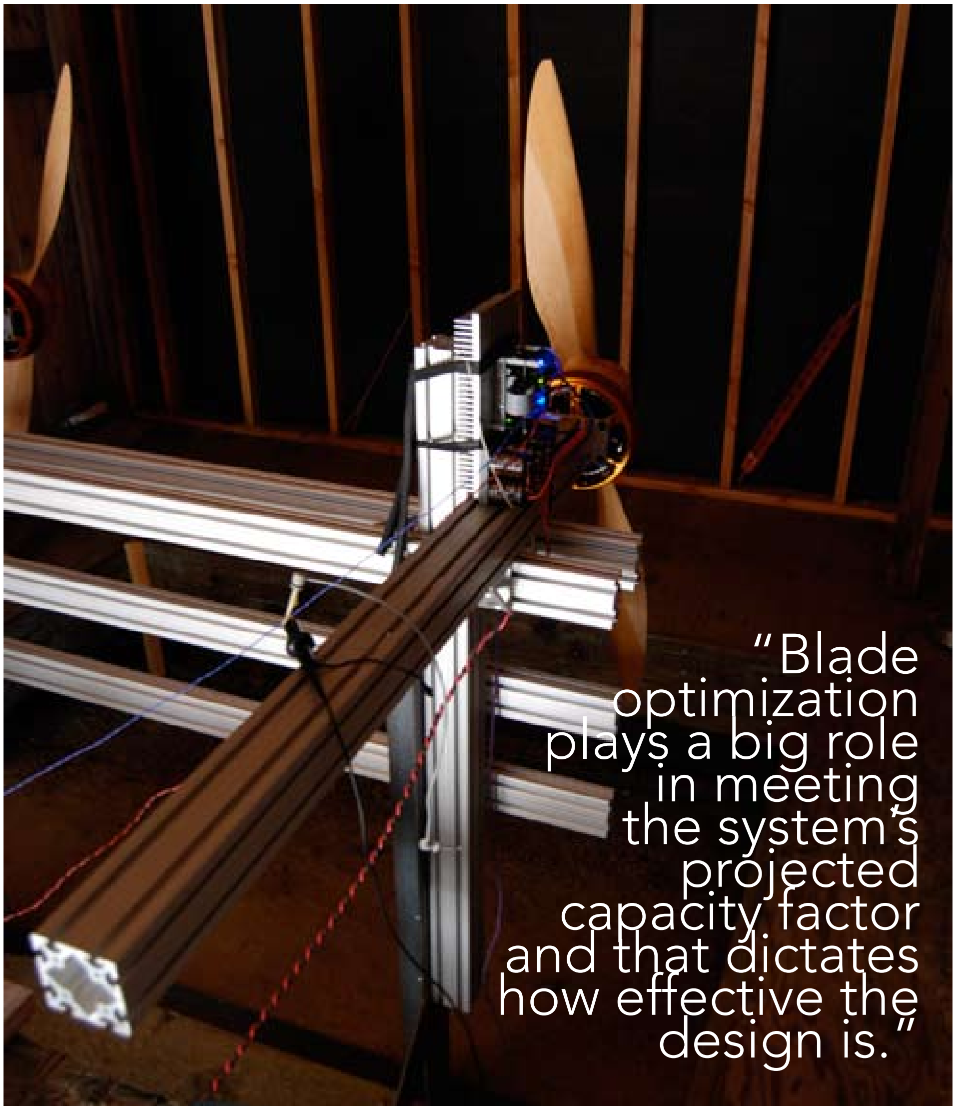
"Blade optimization plays a big role in meeting the system's projected capacity factor and that dictates how effective the design is."

The blade design team coordinates with the various research and development teams.

"An optimized turbine blade needs to satisfy requirements from various subsystems. From the electrical perspective, the less power it draws in powered flight, the better. Also, we need to mitigate the risk of overheating of the motors in hover," Horn said. "From the controls perspective, there is a window of performance that the propeller must be able to provide so that the vehicle is controllable in flight."

Conventional vs. Airborne Turbines

Turbine blade optimization affects the system's ability to operate in conditions that render conventional wind turbines inoperable or not economically feasible.



"We can operate at lower wind sites than conventional turbines because we can adjust operations to sweep the most effective path," Horn said. "We can also fly in stronger winds than a conventional turbine."

According to Horn, airborne wind energy systems use about 1/20 the materials of a conventional turbine to deliver the same amount of energy -- leaving a smaller ecological and materials footprint.

"Airborne wind turbine blades can be much smaller and lighter and are subject to less loading so the entire blade can be designed to extract power," he said. "Also, smaller diameter blades results in higher rotational speeds, so we can use direct drive motors which eliminates the need for heavy gear systems prone to break down."

Engineering to a New Paradigm

The turbine engineering team is blazing new ground in blade research and development yet each design goes through a typical process to meet specified engineering requirements.

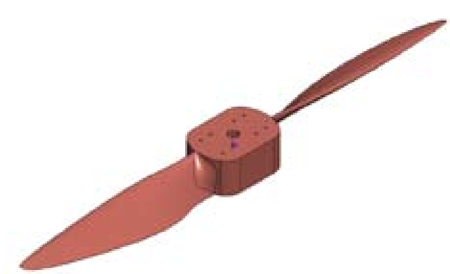
Vora said that the single blade shape must efficiently lift the system off the ground; effectively transition from hover to forward flight, and then provide power like a ground-based turbine blade does.

"We start with an existing set of requirements derived from our global optimization model, create an initial design using existing blade element codes. This allows rapid iterations and convergence to a desired design," Vora said. "This is then verified using more sophisticated fluids software that gives us a more realistic picture of the actual aerodynamic performance of the blade design and once the design is finalized, the blades are manufactured and tested to close the loop on the process."

Horn uses existing software to begin the design process and supplements that with his own optimization algorithm. Once Vora gets the initial design from Horn, he checks the design using more sophisticated modeling software, tweaks accordingly and hands over plans to Dave Craig, a mechanical engineer.

Craig then takes the blade designs and machines precision wood prototypes for testing. According to Craig, the most challenging aspect is making sure the shape of the blade prototype is accurate.

"This involves designing fixtures for machining the blades, programming the tool path for the CNC router, and running the machine to cut the wood."



Prop CAD Model

Then comes the testing.

"To close the loop, Dan Chebot builds testing apparatus and conducts blade testing," Craig said. "We get the results and then, we iterate as necessary."

According to Vora, blades for commercial systems will likely be built using high-strength carbon composite.

"The blades need to be strong enough to withstand cyclic bending and torsion loads across the entire operating regime and be able to last the life of the system," he said.

For Horn, the reward for his work comes with watching the system prototypes successfully launch, land and complete maneuvers during test flights. "Seeing everything come together is awesome."

The team completed the design and manufacturing of blades for 10kW and 30 kW prototype systems and is currently working on designing blades for 100 and 300kW systems.

About the Engineers

Neel Vora received a Masters degree in Mechanical Engineering and Aeronautics and Astronautics, from Stanford University and a Bachelors Aerospace Engineering from the University of Southampton, 2001. Prior to joining Joby Energy, Vora was Lead Mechanical Engineer for the NASA-funded Satellite Test of the Equivalence Principle and was an Aerospace Engineer for Gravity Probe B, also a NASA-funded mission at Stanford University.

Ian Horn studied Physics at the University of California, Santa Cruz and worked at the Institute for Particle Physics on Application Specific Integrated Circuit design and layout, including optimization for low noise performance. Horn was a on a team which designed a MEMS (micro electro-mechanical systems) deformable mirror (DM) for adaptive optics in long range telescopes and designed the control system for the deformable mirror. Horn recently completed a project of the mathematical method of state-space attractor reconstruction of chaotic systems with both analytic and numerical methods.

David Craig received his Bachelor of Science in Mechanical Engineering from Louisiana State University in 2005 and went on to study Mechanical Engineering at at MIT culminating in a Master of Science in 2008. ■

From Left: *Dave Craig, Neel Vora, Ian Horn and Dan Chebot Joby Energy prop optimization team.*

Airborne Wind Energy Consortium Sponsors 2010 Airborne Wind Energy Conference

As its first event, the Airborne Wind Energy Consortium is 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.

Industry News:

Netherlands Airborne Wind Energy Company Secures Statkraft Funding

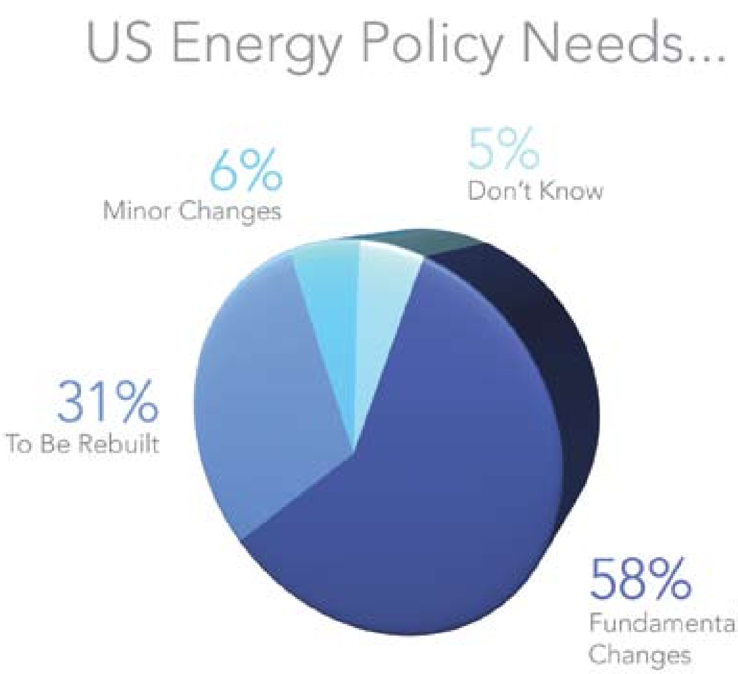
Ampyx Power located in Brennels, Netherlands recently obtained second round financing from the Norwegian energy company, Statkraft, (Europe's biggest producer of renewable energy) and Byte, a Dutch IT company.

"We are very proud and happy to have found two great partners who believe in Ampyx Power," Bas Lansdorp, Ampyx Power co-founder said. "The Statkraft investment in particular is very encouraging and sends a clear market signal concerning the future potential of the PowerPlane system."

Overwhelming Majority of Public Supports Major U.S. Energy Policy Changes

Nearly 90 percent of Americans think that U.S. energy policy requires fundamental changes or an entire revision while only six percent think only minor adjustments are needed.

The CBS/New York Times poll also found that nearly all Americans think that the U.S. is overly dependent on other countries for its oil supply and almost 60 percent express that the U.S. is likely to develop an alternative to oil as a major source of energy within the next 25 years.



Nevada Test Site to Serve as Solar Proving Grounds

The Las Vegas Sun reports that the Nevada Test Site, a chief U.S. nuclear proving ground, will serve a new role as proving ground for new solar technologies. The federally-owned site located 65 miles northwest of Las Vegas is now tasked with making the nation the global leader in solar power.

According to Interior Secretary Ken Salazar, the site will be available for testing four-six test projects which will likely focus on improving heat storage capacities, reducing water consumption and improving efficiency.

Editorial note: *The airborne wind energy industry is currently seeking similar test sites and hopes to secure a testing facility within the next two years.*

62% of European Union New Electricity Generation Supplied by Renewables

Renewable energy sources grew to 62 per cent (17GW) of new installed electricity generation capacity in 27 member states of the European Union in 2009 up from 57 per cent in 2008, according to Renewable Energy Snapshots, a European Commission report.

Wind energy accounts for the largest share of new capacity representing 38 per cent of the total compared to 21 per cent for photovoltaics (PV), 2.1 per cent for biomass, 1.4 per cent for hydro and 0.4 per cent for concentrated solar power.

AECOM Technology Corp. Wins Bid to Write Hawaii Undersea Inter Island Environmental Impact Statement

Los Angeles-based AECOM Technology Corp., was recently awarded a $2.9 million contract to prepare the environmental impact statement for building an undersea transmission cable. According to Hawaii Lt. Gov. James "Duke" Aiona Jr., the cables would transmit 400 megawatts of renewable electricity from the Interisland Wind Initiative farms in Molokai and Lanai to Oahu.

Ted Peck, administrator of the Hawaii State Energy Office said that the cable and the wind projects will reduce Hawaii's dependence on the volatile global petroleum market and lead to increased energy security.

Read more: *EIS awarded to AECOM for Hawaii interisland wind power project - Pacific Business News (Honolulu)*

Joby Energy People:

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

Joby Energy Composites

The Joby Energy composites team takes engineer-designed and cut “plug” (the base of the airframe) and builds the airframe with layers of materials the engineering team has selected for a specific prototype.

The team determines and orders the composite materials needed, then prepares and cuts the materials (divinycell, fiberglass cloth, carbon fiber). The process involves preparing resin used to bind the composite materials and a lay-up process of wetting a cloth and skillful placement of materials into the appropriate mold. After the composite process is completed the component is cured to maximize strength.

Introducing Kelly Carter

Kelly Carter brings 27 years of industry experience to Joby Energy. He joined the company in the summer of 2009. As a licensed private pilot and four-time Giant Scale Air Racing AT-6 Pro Class world champion, Carter combines his knowledge of aviation with his expertise in building composite airframes to provide expertise and leadership to the composites team.

The company’s mantra of rapid design and iteration keeps the composites team incredibly busy.

Kelly Carter

“The demands of changing priorities every day is challenging,” Carter said. “The challenges to this work are mainly around dealing with the unique stresses of an unusual aircraft. That’s just part of working in R&D -- things change every day.”

Carter oversees the conversion of foam parts to flight-worthy composite prototypes. Since his arrival, the composites team has built multiple prototypes while managing repairs and alterations.

According to Carter, the team is currently working on a 30 kW prototype while continuing to build smaller prototypes for continued testing. Short-term plans are to begin building 100 and 300 kW systems.

Since arriving at Joby Energy, Carter has established a fully operational composites shop capable of producing prototypes with wing components of up to 18 ft.

Prior to joining the company, Carter worked for Near Space Corporation as lead fabricator and back-up pilot for composite UAV airframes. He also worked on airframes for Lockheed Martin, NASA Dryden and NASA Ames, Aerospace Corporation, Raven Industries and Advanced Ceramic

Akria Tiltman

Research (BAE Systems).

Carter, a native of San Jose, CA, has an AA degree from San Jose City College, completed Cessna Pilot training at Gunnell Aviation and received a Airframe and Powerplant Technician certificate from Northrup University Aviation Technical School.

Introducing Akria Tiltman

When Carter joined the company, he recommended and successfully recruited long-time colleague Akria Tiltman, a composite technician with seven years of experience in mold making, composites and manufacturing.

Akria brings an amazing skill set to the organization. She keeps us well organized and on-track,” Carter said.

Tiltman, whose business background lends itself to dealing with multiple vendors and the demands of working under deadline pressure, prides herself in her ability to organize, troubleshoot and meet deadlines.

“The composites world is very systematic and here I can use both my business and composite-building experiences,” she said. “This demanding and fast-paced R&D environment means I can apply my expertise in vendor relations, materials sourcing and building airframes to help the Company succeed."

Tiltman takes great pride and care in her work. "With each one, it's like you created something," she said. "The airframes end up being like my babies."

Another aspect of Tiltman's job is co-training and mentoring technicians. She said that the best way to transfer knowledge is by using a hands-on, collaborative approach.

"I find it incredibly inspiring to see how the technicians are presented with a job and how they are able to use their own brain to come up with a plan and present their ideas to Kelly and me, and together we figure out the best way to do get the job done."

Prior to joining Joby Energy in fall 2009, Tiltman served as both office manager and composite builder at RnR Products. RnR is an aircraft and UAV design composites firm that built aircraft for NASA, Boeing and other top names in the aerospace industry.

Alex Nemeth, Ben Bancroft, Jessie Chebot round out the composites team roster. ■

Jessie Chebot Working in the Composites Shop

Policy Updates:

Federal Policy Priorities

Joby Energy is co-leading efforts to advance several federal policy priorities to enhance the rapid development of airborne wind energy systems.

Specifically we are working to:

- establish high altitude wind as an area of research interest within the U.S. Department of Energy (DOE)
- encourage ARPA-E to publish a relevant funding announcement
- secure funding for NASA and NREL to investigate industry research priorities
- develop Federal Aviation Administration relationships to ensure progress in technology R&D

The recent announcement that Statkraft, Europe's largest renewable energy company, has invested in the Netherland-based company Ampyx, is a positive sign for the industry in general. That should at minimum, signal that airborne wind energy is a promising technology worthy of federal R&D support.

S. 1462: American Clean Energy Leadership Act amended to include high altitude wind system as area of research interest:

The American Clean Energy Leadership Act (ACELA), sponsored by Senator Bingaman, was passed out of the Senate Energy and Natural Resources Committee on June 17, 2009 on a bipartisan vote of 15 to 8, and as amended by unanimous consent on May 6, 2010. It was passed as an energy bill with provisions related to increased energy production, energy efficiency,renewable energy standards, technology research and development, energy market stabilization, and transmission network improvements, among others.

According to Dave Berrick, energy staffer for Senator Ron Wyden D-OR, S. 1462 stands a reasonable chance to pass the Senate and House, and could be signed into law this year by President Obama. "At a minimum, passing the bill out of Committee sends a clear message to the DOE that airborne wind energy is a technology that should be pursed as a promising advanced energy technology," Berrick said.

S. 3635: Energy and Water Bill contains first appropriation recommendation for ARPA-E:

The full Senate Appropriations Committee approved the FY 2011 Energy and Water Development Appropriations on July 20th. The bill includes a report that recommends specific program appropriations. As of this writing, the counterpart House subcommittee has approved its FY 2011 funding bill although its report will not be released until the measure is considered by the full House Appropriations Committee. Senate Report 111-228, is available here.

The good news is that the Advanced Research Projects -- Energy, ARPA-E. which was originally funded by the economic stimulus act funding received an appropriations recommendation. The bad news -- funding will likely be half of its 2010 level.

Below are the Senate and House appropriations subcommittee recommendations:

- FY 2010 appropriation: none
- Economic stimulus act funding: $400 million
- FY 2011 Administration request: $300 million
- House subcommittee recommendation: $220 million
- Senate subcommittee recommendation: $200.0 million

Draft Senate committee report language continues to tout ARPA-E as the agency responsible for funding innovative, high-risk energy technologies.

H.R. 5116: America COMPETES Reauthorization Act of 2010:

In May the U.S. House of Representatives passed the America COMPETES Reauthorization Act. The bill authorizes $85.6 billion over five years for research and education programs at key federal agencies with the intention of boosting technology competitiveness. The bill was referred to the Senate referred it to the Committee on Commerce, Science, and Transportation on June 29.

Between 1985 and 2004, federal research and development funding dropped from 1.25 percent of the U.S. GDP to .08 percent. The bill funds ARPA-E for $300 million in FY 2011 increasing each year to $1 billion in FY 2015.

Support the American COMPETES Reauthorization Act of 2010 without any cuts in R&D funding. Contact your senator today to support this critical bill. Visit www.senate.gov, and type in your zip code to be automatically directed to your senator.