ares

the power of gravity

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Introduction to ARES

Advanced Rail Energy Storage (ARES), is a Santa Barbara, California based company, bridging the gap between small and grid scale energy storage technologies.

Since its founding in February 2010, ARES has developed and filed both domestic and international patents for an advanced method of utility-scale electrical storage. ARES facilities are designed to: guarantee grid security and reliability, support the increased use of renewable technologies, and to provide an energy storage solution that does not rely on water. ARES is the first viable grid-scale alternative to pumped hydro energy storage. ARES is less expensive, more efficient, and more widely deployable than pumped hydro storage technology and all other comparable storage technologies.

ARES Addressing the Energy Crisis of Today

The electric grid is the largest and arguably the most complex and important machine in the world. It's facing a crisis now due to a confluence of events including but not limited to: a per capita increase in energy demands, a worldwide increase in the deployment of intermittent renewable energy technologies (such as wind and solar), and the abandonment of legacy generation facilities that traditionally provided the heavy inertia which has kept the electric grid stable.

The Department of Energy indicates that over a hundred gigawatts (GW) of new storage capacity will be required in the United States by 2030 to meet national renewable energy integration goals. This demand represents a potential market of hundreds of billion of dollars.

Beyond the research and development phase, ARES is now ready to implement its technology and is actively engaged in project development. The ARES team is taking its breakthrough technology worldwide by partnering with government agencies to create a comprehensive strategy towards a secure energy future for all citizens. ARES has the ability to create a game changing system for energy storage.

ARES Supports the Expanding Renewable Energy Market

Although pumped hydro is the most widespread energy storage technology currently in use for utility applications, the potential for expansion of pumped hydro is severely limited by the high capital cost of these facilities together with the limited availability of suitable geographic locations with adequate water supplies. Permitting pumped hydro projects is

also difficult and prolonged.

Unlike pumped hydro technology limitations, there are many locations across the US and around the world where ARES technology can be deployed with minimal environmental implications.

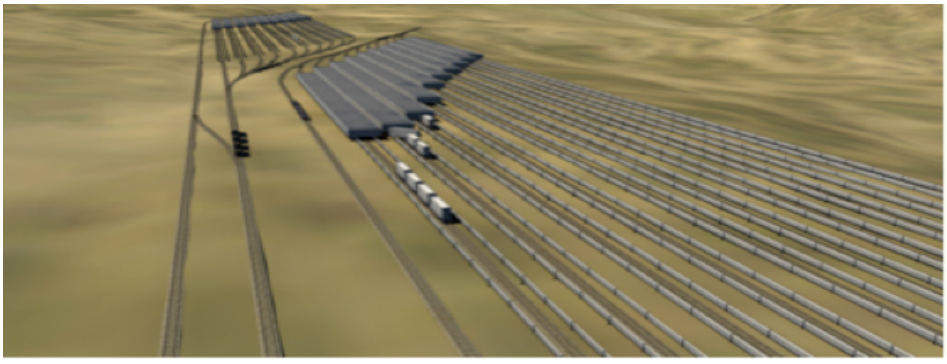
Utility-scale energy storage currently represents approximately 3 percent of world electric power generating capacity; however this capacity must increase dramatically to accommodate an increasing reliance on low-carbon energy generation technologies.

Solar and wind generation sources are fundamentally intermittent and cannot vary output in response to changes in demand. Peak generation may occur when the output cannot be economically used. The efficacy of these energy sources depends on storing energy when demand is low so it can be economically deployed when demand is high. Energy storage can also be used to increase the efficiency of traditional generation systems. ARES high capacity storage can be combined with renewable energy and traditional power plants to provide overall system flexibility that would not be possible with other forms of energy storage.

ARES systems and technology are ideally suited for arid regions where existing transmission capacity is attempting to keep up with the increasing deployment of large-scale wind and solar generation facilities. ARES facilities promote the growth of renewable energy by stabilizing its input into the grid.

Technology That “Drives” Efficiency - How an ARES System Works

ARES is a rail-based technology that stores energy by raising the elevation of mass against the force of gravity and recovering the stored energy as the mass is returned to its original location.



Specifically, ARES energy storage technology employs a fleet of electric traction drive shuttle-trains, operating on a closed low-friction automated steel rail network to transport a field of heavy masses between two storage yards at different elevations (see photo on previous page).

ARES facilities integrate significant recent advances in motor/generator traction drives and power control technologies with proven rail technology to produce a reliable and highly capable system that approaches an 80% charge / discharge efficiency.

The facility designs are highly scalable in power and energy ranging from small installations of 100MW with 200MWh of storage capacity up to large 2-3GW regional energy storage systems with 16-24GWh energy storage capacity. ARES technology does not require the use of water nor does it release noxious emissions.

Protecting Communities & Putting People Back to Work

A 1GW ARES energy storage facility can provide 8 GW hours of energy storage, enough energy to power one million homes for eight hours.

Constructing a 1GW ARES energy storage facility would provide 382 person years of construction work, this is in addition to the manufacturing labor required to build ARES system components and the facility's ongoing operation and maintenance staffing. The economic multiplier effect of an ARES facility is truly significant.

As entrepreneur and author Paul Hawken noted in Blessed Unrest, the word "immunity" comes from the Latin im munis, meaning, "ready to serve". Society's immunity and ability to experience a decent quality of life depends on energy. Energy access, energy reliability, energy storage - the developed world has taken these aspects of daily life for granted. As the system load demands increase, our national security and quality of life are in jeopardy. Our immunity to disasters, personal and communal, depends on energy security and grid reliability. ARES provides both energy security and grid reliability in service to communities, energy companies, and governments alike.

ARES Demonstration & Pilot Site

We are currently working with several state agencies in the U.S., along with industry leaders worldwide, to develop a demonstration site in the Southwest United States.

Expert Analysis

ARES technology has been thoroughly reviewed by one of California's largest utility companies, as well as experts in the fields of heavy haul rail engineering, locomotive design, electrical engineering, power transmission & distribution, environmental and regulatory affairs, and energy storage economics. The resulting analysis has confirmed the system viability and performance estimates. For more information on peer reviews and system analysis, please contact us.

ARES Management Team

James Kelly - Chief Executive Officer

James Kelly worked at Edison International for 38 years. Prior to his retirement he was the Senior Vice President of Transmission & Distribution for Southern California Edison (SCE), and was responsible for the operation and maintenance of an electrical grid comprised of about 12,000 miles of transmission and 100,000 miles of distribution lines spread across a 50,000-square-mile service area.

Mr. Kelly was also President of Edison ESI, a subsidiary company that operates one of the largest electrical and mechanical repair facilities in the U.S. Prior to that position, Mr. Kelly was the Vice President of Engineering & Technical Services, responsible for planning, engineering, and designing SCE's electrical grid, as well as research and development, safety and training.

Francesca Cava - Chief Operating Officer, Board Member for ARES

Prior to this position, she served as the Arctic Policy Project Manager for the Aspen Institute Dialogue and Commission on Arctic Climate Change. She also served as the ocean literacy project manager at the National Geographic Society and was a submersible pilot and project manager for the 5-year exploration of the ocean during the Sustainable Seas Expeditions.

She was appointed as a Coastal Commissioner on the California Coastal Commission for 4 years. Additionally, she completed a 21-year career in the National Oceanic and Atmospheric Administration [NOAA], where she served as the Director of the U.S. National Marine Sanctuary and National Estuarine Research Reserve Programs, overseeing over 200 employees.

William Peitzke - Founder and Director of Technology Development, Board Member for ARES

Bill has 29 years experience in the energy business. He founded Williams Resources Corporation, a California company providing a wide range of energy, strategic alliance and project conceptualization services in the deregulated California utility marketplace.

In the mid-1980's he pioneered private brokering of long-term natural gas contracts to large co-generation facilities in California as well as providing the enabling economic studies for many significant pipeline expansions and generation facility acquisitions. Before deregulation of the California gas and electricity marketplace, his investment banking practice successfully consummated the sale of numerous large oil and gas reserve packages including major utility natural gas reserve portfolios.

Matt Brown - Director of Engineering, Board Member for ARES

As President of Matt Brown Performance Design, provided advanced concept design and managed prototype construction, testing and analysis for clients including Clipper Windpower, Gyroton and Aquantis.

Matt provided engineering, construction supervision and testing of an experimental, wave-piercing boat for Transonic Hull Company; and both designed and engineered racing yachts for Reichel-Pugh Yacht Design. As Vice President of Engineering for CBTF Co., co-invented, designed, engineered, tested and brought to market the patented Canting Ballast Twin Foil (CBTF) for sailboats; and designed and tested the M-Ship. As Associate Designer for Advanced Aeromechanisms Corp., provided engineering design, construction supervision and testing for both the 1992 and 1995 America's Cup Race entry Stars and Stripes.

James Kelly

Chief Executive Officer

James Kelly is the Chief Executive Officer at ARES. Before joining ARES, James worked at Edison International for 38 years, prior to his retirement he was the Senior Vice President of Transmission & Distribution for Southern California Edison, and was responsible for the operation and maintenance of an electrical grid comprised of about 12,000 miles of transmission and 100,000 miles of distribution lines spread across a 50,000-square-mile service area.

Mr. Kelly was also President of Edison ESI, a subsidiary company that operates one of the largest electrical and mechanical repair facilities in the U.S. Prior to that position, Mr. Kelly was the Vice President of Engineering & Technical Services, responsible for planning, engineering, and designing SCE's electrical grid, as well as research and development, safety and training.

Mr. Kelly, one of the early pioneers of the Smart Grid, led the deployment of synchronous phasor measurement, the Distribution Circuit of the Future, and many other advances in grid sensing, monitoring and control. Among many other awards and honors, Jim was selected as the IEEE's "Leader in Power" in 2009.

Jim earned a bachelor's degree from California State University, Long Beach, and a master's degree from California Polytechnic State University. He holds teaching credentials in several subjects, has taught at the university level, and serves on several Engineering Advisory Boards.

Jim is married to Leigh and has two grown daughters, Maren and Jan. He resides in Arcadia and Newport Beach, California.

Francesca Cava

Chief Operating Officer, Board Member

Francesca Cava currently serves as the Chief Operating Officer and Board Member for ARES. Prior to this position, she served as the Arctic Policy Project Manager for the Aspen Institute Dialogue and Commission on Arctic Climate Change. She also served as the ocean literacy project manager at the National Geographic Society and was a submersible pilot and project manager for the 5-year exploration of the ocean during the Sustainable Seas Expeditions.

She was appointed as a Coastal Commissioner on the California Coastal Commission for 4 years. And, completed a 21-year career in the National Oceanic and Atmospheric Administration [NOAA], where she served as the Director of the US National Marine Sanctuary and National Estuarine Research Reserve Programs, overseeing over 200 employees. While at NOAA, she served as Chief of Staff for the Under Secretary of Commerce for Oceans and Atmosphere. In that capacity, she led the US response for the environmental disasters after the Gulf War and oversaw a UN sponsored research expedition to study the impacts of the Kuwait oil spills and fires and the delegation to the Arab/Israeli environmental peace talks. She also led the agency review of the governments response to the Exxon Valdez oil spill. Ms. Cava was a commissioned officer in the US National Oceanic and Atmospheric Administration attaining the rank of Captain and also served aboard several NOAA research vessels.

She has B.S. degree in Mathematics from the University of Alaska and an M.P.A. degree from Harvard University.

William Peitzke

Founder and Director of Technology Development, Board Member

William (Bill) Peitzke is the Founder and Director of Technology Development and Board member for ARES. Bill has 29 years experience in the energy business. He founded Williams Resources Corporation, a California company providing a wide range of energy, strategic alliance and project conceptualization services in the deregulated California utility marketplace.

In the mid-1980's he pioneered private brokering of long-term natural gas contracts to large co-generation facilities in California as well as providing the enabling economic studies for many significant pipeline expansions and generation facility acquisitions. Before deregulation of the California gas and electricity marketplace, his investment banking practice successfully consummated the sale of numerous large oil and gas reserve packages including major utility natural gas reserve portfolios.

Mr. Peitzke is founder and principal of Cypress Resource Management, a Santa Barbara California firm specializing in renewable energy project development, green-field energy storage projects and energy infrastructure project development. Cypress also provides project conceptualization, economic valuation, strategic alliance and development capital in the wind energy and concentrating solar power field.

Matt Brown

Director of Engineering, Board Member

Matt Brown currently serves as the Director of Engineering and Board member for ARES. As President of Matt Brown Performance Design, he provided advanced concept design and managed prototype construction, testing and analysis for clients including Clipper Windpower, Gyroton and Aquantis.

Matt provided engineering, construction supervision and testing of an experimental, wave-piercing boat for Transonic Hull Company; and both designed and engineered racing yachts for Reichel-Pugh Yacht Design. As Vice President of Engineering for Canting Ballast Twin Foil (CBTF) Company, he co-invented, designed, engineered, tested and brought to market the patented Canting Ballast Twin Foil for sailboats; and designed and tested the M-Ship. As Associate Designer for Advanced Aeromechanisms Corp., he provided engineering design, construction supervision and testing for both the 1992 and 1995 America's Cup Race entry Stars and Stripes.

At the Naval Research Laboratory, he designed, built, tested and flew a 25 ft. wingspan Variable Span Drone Aircraft.

Key Consultants and Advisors

David Scott, Principal, David Scott LLC.

David Scott spent the bulk of his 38-year career with the former General Motors Electro-Motive Division, the historically dominant builder of diesel electric locomotives for the world market, rising from a diesel engine design engineer to executive director. His responsibilities at EMD included product engineering, research and development, worldwide sales and marketing (locomotives and diesel engines), customer care and product service, program management and business development. He currently consults in a wide range of design engineering and strategic studies in the railway and locomotive markets.

Tom Scott, Principal, David Scott LLC.

Tom Scott is an independent consultant supporting major railroad, railroad suppliers and alternative energy projects. His design engineering expertise includes vehicle structural design, vehicle suspension design, vibration and noise control, development and validation testing and failure analysis. He previously spent 42 years with the former General Motors Electro-Motive Division, where he led engineering teams responsible for instrumentation

development and application, suspension design of the EMD radial steering truck (bogie), new design trucks for Europe and India, and structural design of the current EMD locomotives. He led a group that combined the highly analytical skills of finite element analysis and other highly specialized engineering analysis with the highly technical experimental based skills used for noise and vibration control.

Bill Moorhead, Principal, Trammco LLC.

Bill Moorhead has 51 years of experience in the railroad industry. His international and commercial work for railroads has involved track condition assessment, track alignment engineering and yard layout for branch line and new rail lines, capital improvement planning, tender and procurement specifications for rail line construction, and construction management of contractors working as the Owner's Representative. In turnouts and special trackwork, Mr. Moorhead has extensive knowledge in the design, specifications and installation of ballasted and concrete slab track including advanced special work designs. He is also a recognized expert in developing industry standard Recommended Practices for track and infrastructure, and guiding research activities through several oversight groups, including the Transportation Research Board of the National Academies and American Public Transportation Association, in the areas of track research.

Ziad Alaywan, CEO, ZGlobal, Inc.

Mr. Alaywan formed ZGlobal Inc. in early 2005 after working for almost a decade with the California Independent System Operator (CAISO), the control center responsible for ensuring a reliable power system for the state's 33 million residents. In 1996, prior to the formation of the CAISO, Ziad worked for the CAISO trustees and led the start-up effort of the new organization, focusing on the development and implementation of the bidding, scheduling, pricing and settlements systems. Previous to his work at the CAISO, Ziad was employed by Pacific Gas & Electric, the largest utility in California with over 23,000 MW of demand. Ziad held the posts of Plant Engineer, Senior Operations Engineer, Transmission Planner and Manager of Real-Time Grid Operation. Ziad has written over 50 publications on a variety of subjects from electricity market design to implementation and operation of the electric grid. He has given numerous testimonies at FERC, the California State legislation, the California State Senate and the CFTC.

Bill Erdman, CEO, BEW Engineering, Inc.

Dr. Erdman is a founding principal of BEW Engineering and has a long history in utility-scale wind energy, energy storage, and photovoltaic systems. As president of BEW, he oversees all aspects of engineering and design and laboratory services. As Director and Vice President of Engineering at Kenetech Windpower from 1990 to 1997, he was responsible

for technology and intellectual property development for the first variable speed utility scale wind turbine in the US. In 1997, Bill founded Trace Technologies Corporation, a major supplier of utility scale, variable speed wind turbine converters and control systems, as well as a major converter supplier to the energy storage and photovoltaic industry. During his career, Bill has served as an expert witness in wind energy patent litigation venues ranging from Federal Superior Court to the US International Trade Commission. Bill completed his PhD in Electrical Engineering at the University of Missouri, Columbia. He is lead or co-inventor on over fifty US and international patents related to wind, energy storage, photovoltaic, and grid interconnection technology.

Jon Davidson, Vice President, Aspen Environmental Group

Mr. Davidson is an urban planning and environmental professional with more than 29 years of experience in providing environmental assessment, regulatory compliance, and habitat restoration services to public and private clients. He has a diverse background in land use planning, policy formulation, environmental review, technical writing, public presentation and project management. Most of this experience has been focused on infrastructure projects, including significant experience analyzing energy projects, including transmission lines, pipelines, and power generation projects. Mr. Davidson has significant experience working with federal land management agencies, including the US Forest Service and Bureau of Land Management, as well as state regulatory agencies, such as the California Public Utilities Commission, California Energy Commission and the California Department of Fish and Game.

FOR IMMEDIATE RELEASE

James A. Kelly Joins ARES as CEO

Santa Barbara, CA - June 26, 2012 - Advanced Rail Energy Storage (ARES), a California-based company bridging the gap between small and grid scale energy storage technologies, is pleased to announce that James (Jim) Kelly has joined their executive team. Coming from 38 years of service at Edison International (the parent company of Southern California Edison), Jim begins his tenure as CEO of ARES guiding the development and deployment of ARES system installations worldwide.

U.S. Secretary of Energy since 2009, Steven Chu, recently called upon the nation's energy sector to, "...better protect our economic and national security." Jim Kelly plans to put his considerable experience and expertise to use to meet this national imperative through the implementation of ARES' grid-scale energy storage technology in partnership with government agencies, energy companies, and communities alike.

ARES is designed to: guarantee grid security and reliability; support the increased use of renewable technologies, and to provide a grid-scale energy storage solution that does not rely on water. ARES is the first viable alternative to pumped hydro energy storage. ARES is less expensive, more efficient, and more widely deployable than pumped hydro storage technology and all other comparable storage technologies. Under Jim's leadership, ARES has the opportunity to change the face of energy storage.

Prior to his retirement from Edison, Mr. Kelly, as the Senior Vice President of Transmission & Distribution for Southern California Edison, was responsible for the operation and maintenance of an electrical grid comprised of about 12,000 miles of transmission and 100,000 miles of distribution lines spread across a 50,000-square-mile service area.

Mr. Kelly was also President of Edison ESI, a subsidiary company that operates one of the largest electrical and mechanical repair facilities in the U.S. Prior to that position, Mr. Kelly was the Vice President of Engineering & Technical Services, responsible for planning, engineering, and designing SCE's electrical grid, as well as research and development, safety and training.

Mr. Kelly, one of the early pioneers of the Smart Grid, led the deployment of synchronous phasor measurement, the Distribution Circuit of the Future, and many other advances in grid sensing, monitoring and control. Among many other awards and honors, Jim was selected as the IEEE's "Leader in Power" in 2009.

Kelly also previously served as the Vice President of Regulatory Compliance and Environmental Affairs and has in-depth experience with environmental regulation, permitting and licensing.

Jim earned a bachelor's degree from California State University, Long Beach, and a master's degree from California Polytechnic State University. He holds teaching credentials in several subjects, has taught at the university level, and serves on several Engineering Advisory Boards.

Jim is married to Leigh and has two grown daughters, Maren and Jan. He resides in Arcadia and Newport Beach, California.

For more information about Advanced Rail Energy Storage (ARES) contact:
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ARES Article in *Economist* Magazine

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http://www.economist.com/node/21548495

SUMMER in Texas last year was the hottest on record. Demand for power spiked as air conditioners hummed across the state. The Electric Reliability Council of Texas (ERCOT), the state grid operator, only narrowly avoided having to impose rolling blackouts. To do so, it had to buy all the electricity it could find on the spot market, in some cases paying an eye-watering 30 times the normal price.

On paper at least, ERCOT ought to have had plenty of power. In 2010 it reported 84,400 megawatts (MW) of total generation capacity, well over last summer's peak demand of 68,294MW. In theory, this is enough to produce some 740 billion kilowatt hours (kWh) of electricity a year—more than double the 319 billion kWh that ERCOT's customers actually demanded during 2010. In electricity generation, however, aggregates and averages carry little weight. One problem is that wind energy accounted for 9,500MW of ERCOT's total capacity, and the wind does not blow all the time. It tends to be strongest at night, when demand is low. Moreover, power firms are required by regulators to maintain a safety margin over total estimated demand—of 13.75%, in ERCOT's case—in order to ensure reliable supply.

If only it were easier for ERCOT and other utilities to store excess energy, such as that produced by wind turbines at night, for later use at peak times. Such "time shifting" would compensate for the intermittent nature of wind and solar power, making them more attractive and easier to integrate into the grid. Energy storage also allows "peak shaving". By tapping stored energy rather than firing up standby generators, utilities can save money by avoiding expensive spot-market purchases.

Surely the answer is to use giant batteries? Although batteries can deliver power for short periods, and can smooth out the bumps as different sources of power are switched on and off, they cannot provide "grid scale" performance, storing and discharging energy at high rates (hundreds of megawatts) and in really large quantities (thousands of megawatt hours). So other technologies are needed—and growing demand, driven chiefly by wider use of intermittent renewable-energy sources, is sparking plenty of new ideas.

It's got potential

The most widely used form of bulk-energy storage is currently pumped-storage hydropower (PSH), which uses the simple combination of water and gravity to capture off-peak power and release it at times of high demand. Pumped-hydro facilities typically take advantage of natural topography, and are built around two reservoirs at different heights. Off-peak electricity is used to pump water from the lower to the higher reservoir, turning electrical energy into gravitational potential energy. When power is needed, water is released back down to the lower reservoir, spinning a turbine and generating electricity along the way. PSH accounts for

more than 99% of bulk storage capacity worldwide: around 127,000MW, according to the Electric Power Research Institute (EPRI), the research arm of America's power utilities.

Yet despite its dominance, traditional PSH has limited capacity for expansion. The kind of sites needed for such systems are few and far between. As a result, several firms are devising new forms of PSH.

One ambitious idea (pictured above) is the Green Power Island concept devised by Gottlieb Paludan, a Danish architecture firm, together with researchers at the Technical University of Denmark. This involves building artificial islands with wind turbines and a deep central reservoir. When the wind blows, the energy is used to pump water out of the reservoir into the sea. When power is needed, seawater is allowed to flow back into the reservoir, driving turbines to produce electricity.

Gravity Power, a start-up based in California, has devised a system that relies on two water-filled shafts, one wider than the other, which are connected at both ends. Water is pumped down through the smaller shaft to raise a piston in the larger shaft. When demand peaks, the piston is allowed to sink back down the main shaft, forcing water through a generator to create electricity. The system's relatively compact nature means it can be installed close to areas of high demand, and extra modules can be added when more capacity is needed, says Tom Mason, the firm's boss.

Another company looking to harness the potential of gravity is Advanced Rail Energy Storage (ARES), based in Santa Monica, California. Its system uses modified railway cars on a specially built track. Off-peak electricity is used to pull the cars to the top of a hill. When energy is needed, the cars are released, and as they run back down the track their motion drives a generator. Like PSH, the ARES system requires specific topography. But William Peitzke, the firm's boss, says ARES delivers more power for the same height differential. He also says it is more efficient, with a round-trip efficiency—the ratio of energy out to energy in—of more than 85%, compared with 70-75% for PSH. A demonstration system is being built in California, and should become operational in 2013.

The second-biggest form of bulk-energy storage, though it is dwarfed by PSH, is compressed-air energy storage (CAES). This involves compressing air and storing it in large repositories, such as underground salt caverns. During peak hours the air is released to drive a turbine. There are only two commercial CAES plants in operation: one in Huntorf, Germany, and the other in McIntosh, Alabama. The big drawback of CAES is its inefficiency. According to RWE, a German utility, the Huntorf plant is only 42% efficient, and the one in Alabama is only slightly better. The problem is that air heats up when pressurised and cools down when expanded. In

existing CAES systems energy is lost as heat during compression, and the air must then be reheated before expansion. The energy to do this usually comes from natural gas, reducing efficiency and increasing greenhouse-gas emissions.

As with hydro storage, efforts are under way to adapt the basic concept of CAES to make it more efficient and easier to install. RWE is working with GE, an industrial conglomerate, and others to commercialise a compressed-air system that captures the heat produced during compression, stores it, and then reapplies it during the expansion process, eliminating the need for additional sources of heat. Having proven the theoretical feasibility of this concept, the partners must now overcome the technical hurdles, which include developing pumps to compress air to 70 times atmospheric pressure, and ceramic materials to store heat at up to 600°C. The aim is to start building a 90MW demonstration plant in Strasfurt, Germany, in 2013, says Peter Moser, the head of RWE's research arm.

Several smaller outfits are also developing more efficient forms of CAES. SustainX, a company spun out of Dartmouth University's engineering school and supported by America's Department of Energy (DOE) and GE, among others, has developed what it calls "isothermal CAES", which removes heat from the compressed air by injecting water vapour. The water absorbs the heat and is then stored and reapplied to the air during the expansion process. And rather than relying on salt caverns, SustainX uses standard steel pipes to store the compressed air, allowing its systems to be installed wherever they are needed. The firm has built a 40 kilowatt demonstration plant and is partnering with AES, a utility, to build a 1-2MW system. General Compression, a Massachusetts-based company also backed by the DOE, has developed an isothermal CAES system focused on providing support to wind farms. With the backing of ConocoPhillips, an energy giant, it is building a 2MW demonstration plant in Texas.

Another way to store energy is in the form of heat. That is the approach taken by Isentropic, a company based in Cambridge, England, with a system it calls pumped heat electricity storage (PHES), which uses argon gas to transfer heat between two vast tanks filled with gravel. Incoming energy drives a heat pump, compressing and heating the argon and creating a temperature differential between the two tanks, with one at 500°C and the other at -160°C. During periods of high demand, the heat pump runs in reverse as a heat engine, expanding and cooling the argon and generating electricity. Isentropic says its system has an efficiency of 72-80%, depending on size.

BrightSource Energy, an energy company based in Oakland, California, has signed a deal with Southern California Edison, a utility, to implement a system that stores energy in molten salt. BrightSource generates electricity using an approach called concentrated solar power, in which computer-controlled mirrors, known as heliostats, focus the sun's

heat to boil water and turn a steam turbine. But this approach works only while the sun is shining. The storage system, called SolarPLUS, uses a heat exchanger to transfer some of the heat captured by the heliostats to the molten salt. It is then run back through the heat exchanger to drive the steam turbine when needed. This allows BrightSource's plants to deliver energy even after dark, and gives utilities and grid operators more flexibility than solar power usually provides. BrightSource is planning to equip three of its plants with SolarPLUS.

Changing the rules

The potential market is huge: according to Pike Research, a market-research firm, $122 billion will be invested in energy-storage projects between 2011 and 2021. It predicts that the bulk of this spending will go towards new forms of CAES. Green-minded governments and regulators are taking a closer interest in the technology. California has passed a law requiring utilities to consider storage in their plans. Germany's environment ministry last year proposed a project to assess technology developments and funding needs for energy storage. And the British government's "low-carbon networks" fund is being used to build some demonstration projects.

Yet large-scale deployment of bulk storage systems will require regulatory as well as technical progress. Storage systems do not fit neatly into regulatory frameworks that distinguish between power providers and grid operators, since they can be used by both. Their ability to take power off the grid, store it, and then release it later creates "potential problems for current tariff, billing and metering approaches," notes the EPRI in a recent report. Nor is it clear whether power companies will be allowed to pass on the cost of storage facilities to their customers. But given the technology's potential to make power grids cleaner and more reliable, it seems likely that changes to the rules are in store.

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From the print edition of Technology Quarterly