

VAISALA NEWS

Energy Issue 2014

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VAISALA NEWS

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Vaisala in Brief

Vaisala is a global leader in environmental and industrial measurement. Building on 75 years of experience, Vaisala contributes to a better quality of life by providing a comprehensive range of innovative observation and measurement products and services for chosen weather-related and industrial markets. Headquartered in Finland, Vaisala employs approximately 1,400 professionals worldwide and is listed on the NASDAQ OMX Helsinki stock exchange.

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Responsible, Customer-Based Innovation

At Vaisala, we seek to deliver quality products through expert staff and efficient, reliable processes. This is our cornerstone to creating customer value. However, this is not enough; we also need to make sure that our offering meets the customer needs of today, but also those of tomorrow. To achieve this we need to combine understanding our customers business and their operations with technological insight and expertise. Our reputation is built on being the best in what we do.

Vaisala has always believed in the power of innovation and investing into the future. An example launched last year is the next generation sounding system, which is spearheaded by the new and revolutionary Vaisala Radiosonde RS41. Our customers and third party partners have played a pivotal role in the research and development process. Putting the customer first is not only the best way to generate customer value, but also for fine-tuning our key products.

Looking at investments, in 2013 we made two acquisitions, one in remote sensing and data services for the wind energy industry, Second Wind Systems Inc.; and one in renewable energy assessment and forecasting services,

3TIER Inc. both in the United States. These acquisitions are part of a strategic objective to establish a presence in the weather dependent renewable energy technologies and services. Vaisala is to become a key player in forecasting, resource assessment, and operations in growing markets. The combination of technologies that Vaisala has brought under one roof with Second Wind and 3TIER, are not only unique, but it empowers energy utilities and other actors in the domain like never before to design, operate, and maintain a successful and profitable wind and solar energy business.

In 2014, we look forward to taking full advantage of the portfolio we have built for our Energy business and push for growth in this exciting new area. We also look to further strengthen our position as market leader with new products released, as well as increase momentum for our information system products, continuing on a successful path for growth.

For more information, check out Vaisala's Corporate Responsibility Report 2013 at: www.vaisala.com/sustainability/



A handwritten signature in blue ink that reads "Kjell Forsén". The signature is fluid and cursive, written in a professional style.

Kjell Forsén
President and CEO

VAISALA – YOUR WEATHER PARTNER IN RENEWABLE ENERGY

by Richard Pyle

WEATHER POWERS RENEWABLE ENERGY

In the energy industry, weather matters. It drives demand, affects transmission, and with renewable energy, provides the fuel for generation. If you have a stake in renewable energy, you know the importance of weather risk and the impact weather has on your daily work and profitability. Vaisala has nearly eight decades of experience measuring, recording, and interpreting weather to support smart, high-risk decision-making.

Minimizing weather risk in wind development and operations requires that you understand what is happening right now with reliable, high-quality observations. The value of observations improves with context:

- What is happening with nearby weather?
- What weather is typical for this time of year?
- How does this short-term perspective fit within the past 30 years?

Finally, and most importantly, you must translate this information into smart decisions with industry expertise. Vaisala's recent acquisition of Second Wind and 3TIER bring all of these components together for the renewable energy industry. Together we combine reliable observations and pragmatic science-based

approaches with a deep understanding of business.

VAISALA OFFERS WIND MEASUREMENT AND POWER PREDICTION

3TIER and Second Wind have combined industry experience of nearly 50 years. By teaming up with field-tested experts already deeply committed to the renewable energy sector, Vaisala now brings powerful solutions to clients around the world in ways no other company can. As a single business with strong leadership, vision, resources, and ethics, together we can fully commit ourselves to furthering the renewable energy industry – bringing stability and a forward-thinking perspective. We are able to support the industry today and tomorrow by continually investing, innovating, and improving our technologies based on client needs and the demands of a changing world and industry.

We provide wind observation equipment and energy assessment and forecasting services that offer much more than data. Our products and services capture, organize, enhance, and allow that data to serve as actionable, decision support. Our core strength is responsibly and

economically improving the ROI for alternative energy.

In renewable energy assessment and forecasting, the strongest tools available are measurements and models. Both are essential for understanding weather behavior at the local and macro scale and, more importantly, for predicting power production. These tools complement each other and provide the most value when used together in an integrated system.

RENEWABLE ENERGY IS READY

Renewables sector is an industry with real answers to our global energy opportunities and challenges. As costs go down and efficiencies go up, renewable energy will have a strong place in our future. Of course, this isn't easy. Costs matter; the problems we face are complex; and making smart investment decisions is crucial. Our approach is to partner with you and offer guidance and decision support that best suits your needs. There is no one size fits all answer. Some technologies do not add value in all situations, for all clients, in all countries. Let us be more than your service provider as you navigate these key decisions.



The Energy Issue: Why Renewables?

by Pascal Storck

Energy is the lifeblood of modern civilization. Food, water, and shelter from the elements are the bare necessities for human survival, but it is energy that has allowed humanity to flourish. Energy lets 20 million people live in a single city and 7 billion of us inhabit the planet. Energy powers our industries, heats our homes, fuels our transportation, increases the yields of our agriculture, and delivers our entertainment. Since the dawn of the industrial revolution, we have had access to ever increasing quantities of energy in the form of fossil fuels.

These gifts to modern civilization come from ancient plants and animals that have converted tens of millions of years of sunshine into concentrated forms of energy that are easy to find, extract, store, transport, and readily convert into electricity. Fossil fuels are also abundant. Even today, humanity is finding ever more stored sunshine in the tar sands of Canada and trapped in the fractured bedrock of ancient sea beds that underlie some of the world's great plains. Current estimates suggest that humanity has approximately 100 years' worth of proven fossil fuel reserves, and speculative reserves, such as those that underlie the Arctic Ocean, are thought to be even more plentiful.

However, against this picture of abundance and prosperity, a new trend is emerging that is a direct consequence of our consumption of fossil fuels: global warming and climate change. By harvesting and burning fossil fuels, humanity is releasing the carbon that has been stored over tens of millions of years into the planet's atmosphere at an accelerating rate. At the dawn of the industrial revolution that amount of carbon dioxide in the

earth's atmosphere was under 300 parts per million (ppm), today the concentration of this potent greenhouse gas exceeds 400 ppm, an amount which the earth has not seen for over 3 million years, when camels lived in the high Arctic and the global sea level was 30 feet higher than it is today.

The direct and proven link between climate change and the burning of fossil fuels, has led an increasing number of politicians, strategists, and financiers - no matter their philosophical foundation - to declare anthropogenic climate change to be a threat to the continued prosperity of human civilization. And so we find ourselves with a grand challenge, the same energy source that has formed the lifeblood of our modern civilization is now a threat to its continued prosperity.

A solution to this grand challenge is to significantly reduce the amount of carbon in our civilization's lifeblood; energy. What if we could skip the carbon step, and convert the energy from the sun directly to electricity? That is exactly what renewable energy promises, especially solar, wind, and hydro energy. These energy sources directly convert the Earth's weather, created by sunshine, which drives the wind and the rain, into electricity.

Large scale adoption of the weather-driven renewable energies allows us to lessen our reliance on carbon based energy sources, but it makes electricity and energy production dependent on something else that seems relatively unpredictable and unreliable: the weather. While the fuel of renewable energy power plants may seem to come at random, it is also a cost-free fuel that with the right technologies can be understood and anticipated.

Renewable energy, especially wind energy, is the fastest growing form of electricity generation today. In the year 2013, the world installed approximately 35,000 MW of wind turbines to bring the global installed base of wind turbines to 318,000 MW. That is enough generation capacity to provide roughly 2.5% of the world's demand for electricity. The growth of this form of energy comes from concerns about climate change and energy security, but increasingly its growth is a matter of simple economics. New wind energy projects can be installed quickly to meet growing energy demand in many parts of the world and can provide electricity at a cost that is competitive with some traditional forms of electricity generation.

Wind and solar energy may be the fastest growing forms of new electricity generation, but it is also increasingly understood that depending on the weather for one's energy presents its own challenges. An incomplete understanding of the weather - be it in the past or in the future - leads to uncertainty and risk in the development, financing, and operations of renewable energy projects. Depending on weather to power renewable projects impacts how we select project locations, obtain project financing, and schedule power for grid stability and economic optimization. A deep understanding and ability to predict the weather is therefore one of the primary keys for unlocking the potential of renewable energy and successfully integrating it with the rest of the world's energy generation and power systems.

Vaisala, your trusted partner in all things weather, and is now here to lead the way and help you, our clients and partners, make better decisions about renewable energy. We will do this by leveraging our long history of operational excellence and innovation in weather measurement instruments and systems with advanced modeling techniques and decision support tools that improve the economics and mitigate the risks of renewable energy.

World-Class Remote Sensing Technologies

Increasing the capability and accuracy of meteorological measurements is critical to keeping pace with advancements in turbine technology. Accurate weather observations and the ability to use them to make smarter, more informed decisions for wind development and operations are key to the success of the industry and are at the core of Vaisala's business.

Vaisala's vision is a world where observations improve daily life. The acquisition of Second Wind fits perfectly into this vision for the wind energy industry – an industry where accurate weather observations and decision support services improve the life, work, and financial success of our customers. The combined expertise of Vaisala and Second Wind bring an integrated suite of wind measurement solutions to customers around the globe.

Proven Technology, Industry-Leading Capabilities

With the integration of Second Wind, Vaisala is now able to provide the wind energy industry with the observational intelligence required to plan, finance, and operate highly efficient and profitable wind generation facilities. The product and service

offerings for the customer include: remote sensing systems; tower-based wind measurement systems and data loggers; and web-based wind data services.

Second Wind was founded in 1980 by Walter Sass and Kenneth Cohn. Sass and Cohn recognized that for wind energy to succeed, the industry needed more than wind turbines. Wind developers also needed software and hardware that would help them measure wind accurately at prospective sites, and monitor successful turbine performance at established wind farms.

The company has maintained a presence in wind resource assessment since introducing the first data logger designed specifically for wind prospecting in 1981. By 2007, Second Wind took another major step forward by launching the Triton® Sonic Wind Profiler, which uses advanced SoDAR technology to

provide more wind assessment data than can be acquired by conventional means. Today the Triton is the wind energy industry's market-leading remote sensing system.

Key Products

As part of Vaisala, the Second Wind team will continue to create, develop, and support ground-breaking innovation related to wind data. The key products include our well-known Triton® Sonic Wind Profiler as well as our Nomad® 2 Wind Data Logger, SkyServe® Wind Data Service, the C3 Anemometer, and the PV-1 Wind Vane.

The **Triton® Sonic Wind Profiler** is a SoDAR system that provides accurate wind measurement data for wind resource assessment and wind farm operations. The Triton accurately measures the wind speed and direction across the full rotor sweep of a wind turbine. The technology behind the Triton was specifically designed for the commercial wind energy industry. Triton provides hub height wind data, which allows wind developers to optimize project financing packages, or operators to gain valuable information about conditions on an operating wind farm.

The **Nomad 2® Data Logger** is a field proven and flexible option for met tower based measurement systems. The Nomad 2 allows customers to connect up to 12 anemometers and 8 analog devices to collect the data they need at their sites. With

simple installation and maintenance and flexible communications options, the Nomad 2 is used in more than 50 countries to measure wind on prospective and operating wind farms.

SkyServe[®] Wind Data Service provides remote wind data monitoring, allowing customers to understand what is happening at their sites and securely record wind data for reference at any time. SkyServe works with both met towers and remote sensing, and all data is viewable through the software dashboard.

The **C3[®] Anemometer** measures wind speeds using the popular three-cup design used and trusted in wind assessments for decades. It is manufactured to precise industry standards and is both durable and reliable.

The **PV-1[®] Wind Vane** was developed by Second Wind in response to customers in the field who wanted more accurate direction measurements. It captures data in every direction with a simple construction, stable and smooth response to wind change, and perfect balance.

Remote Sensing Technologies

Vaisala has a reputation for innovative, reliable technology and excellent customer support across a diverse range of industries. Vaisala products, systems, and services - ranging from industrial environments to meteorological applications - are used in nearly every country around the world, including

the challenging climates of Antarctica and the Sahara. Vaisala sensors can even be found on NASA's Curiosity Rover on planet Mars.

Vaisala's objective is to provide accurate weather data and services, while helping improve the industry's understanding of weather information. We are committed to developing practical products and solutions that help energy professionals overcome obstacles, efficiently manage their daily workflows, and make better decisions. For the wind industry, this means offering customers the tools required to understand and use weather information effectively across the operational lifetime of a wind farm. Our goal is to take the industry to the next level of optimizing and integrating wind energy.



The Basic Principle of SoDAR Wind Measurement

SoDAR works by measuring the scattering of sound waves by atmospheric turbulence. SoDAR systems are used to measure wind speed at various heights above the ground, and the thermodynamic structure of the lower layer of the atmosphere. It produces a true wind profile, which is especially significant for wind farm developments and operational wind farms.

The Challenges of Renewable Energy and How We Help Solve Them



by Ed Mahlum

The wind whips over the hillside uncomfortably. Standing on the crest of a ridge, you look out at over 2,000 acres

of rolling farmland shortly after being assigned responsibility for managing the development of a \$200M 150 MW wind energy project at this location. Over a year ago a single met tower was installed at the site, and your company just informed you that the project must be ready for an investment decision in the second quarter of next year. This project is one of several in your company's portfolio, and you know from past experience that the company's appetite for investment risk requires that the uncertainty of your 10-year energy production estimate be less than 8.0%.

Your mind fills with questions and all the risks and unknowns come to the forefront. How much energy should I expect from the location? What types of turbine technologies are best suited to harvest the wind resource? And, perhaps most importantly, what next steps should I take to reduce the energy production uncer-

tainty in time to meet our investment criteria?

Helping answer these questions is part of Vaisala's 3TIER® services, which provide renewable energy assessment and forecasting information to the largest utilities, energy traders, financiers, and project developers around the world. For over a decade, our experts in weather, climate, and wind and solar risk have helped clients make profitable energy decisions. Our approach is unique in the renewable energy industry. We leverage weather science, expertise in weather modeling at both specific project locations and across large regions, and our many years of experience within the renewable energy sector to help clients understand and quantify the weather-driven risks of renewable energy production.

Typically a project will start out without any on-site observations, and our analysis serves to answer early-stage questions. For example, how windy is this site relative to others in a portfolio, and what is a reasonable estimate for average annual energy production? Once a company is ready to move forward with a project

location, measurement equipment is installed and local observations are collected. We assist the project developer in siting equipment and then incorporate the resulting data into our analysis to further reduce the uncertainty of the power production estimate. In addition to providing a comprehensive view of power production, our energy assessment services can also predict the level of uncertainty at the proposed time of investment. This allows clients to evaluate actions they can take now, such as installing additional measurement devices, to reduce uncertainty to acceptable levels within a specified time frame.

For example, a project with just one met tower collecting data for a single year might result in an energy production estimate with 11.5% uncertainty. An additional year and a half of data from the single met tower would likely drop uncertainty to just 11.3%, well above an 8.0% company investment threshold. In this case, an uncertainty model reveals that the lack of spatial coverage limits how much gain is possible from a single met tower. Our services enable you



to examine the uncertainty impact of adding more measurement devices to the program and to optimize each measurement location to find those that have the greatest impact on the final uncertainty number. Hundreds of scenarios are modeled, testing each configuration, and it is determined that two additional measurement devices placed in specific locations within the next two months will reduce uncertainty below the required investment threshold. This Energy Risk Framework allows developers to make justifiable, strategic investments to minimize risk while optimizing where capital is best spent.

You made it. You met the internal investment criteria, received financing, managed successful construction, and now the project is operational and grid-connected. Your next challenge is the highly variable nature of wind energy output driven by the ever-changing local weather conditions. A state-of-the-art energy forecast is required to maximize plant profit. Greatly simplified, wind farm profit is maximized by scheduling the most amount of power at the highest

price while minimizing the costs associated with grid integration. Your exact use of the wind energy forecast will depend on the energy market rules, grid integration requirements, your position in the market, and your threshold for risk.

Our services deliver reliable and accurate wind and solar energy forecasts at multiple time horizons and scales – ranging from next hour to next week at single projects or across regional energy markets. These renewable energy forecasts improve energy trading, scheduling, and the overall utilization of renewable energy. In addition, we can perform forensic studies to isolate resource variability from other issues that may be causing over or underperformance as well as provide ongoing performance reconciliation services for wind and solar project portfolios.

Our energy forecasts enable you to use the risk threshold that best meets your requirements when scheduling and marketing wind plant energy. For example, if your wind farm is merchant (meaning that the power generated by the plant is sold directly into the energy market

without a long-term power purchase agreement) your plant profitability is extremely sensitive to the accuracy of the energy forecast. If you believe that energy prices will be higher tomorrow than today's day-ahead price, to avoid having to buy power at higher costs you need to minimize the chance of tomorrow's actual plant production being less than the amount you schedule. Depending on your risk profile, you may even want to opportunistically hold back some power to sell at the forecasted higher prices. Our services can provide this forecast, using accurate, sharp prediction intervals configured for your risk appetite and market position.

Back on the hillside, that uncomfortable wind is now generating enough clean, carbon-free power for 48,000 homes. Thanks in part to Vaisala's 3TIER® services, you managed to minimize the cost of capital during project development, and optimize your on-going wind plant revenue with an energy forecast tailored to your risk tolerance. Promoting profitable renewable energy projects is the driving force behind all of our assessment and forecasting services.

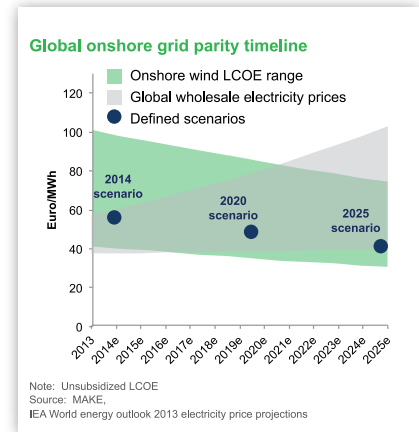
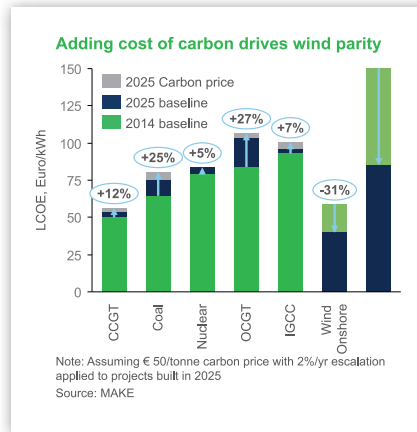
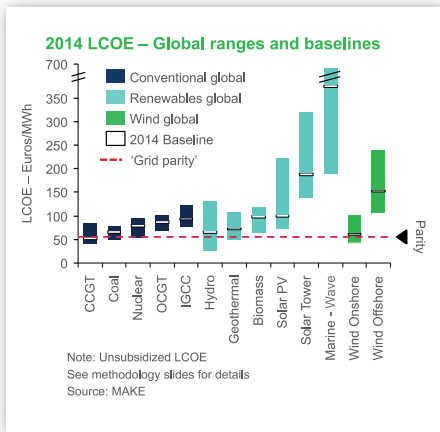
The Future is Bright for Renewable Energy

Guest Article by Daniel Shreve, MAKE Consulting

Wind already beats fossil fuel power generation in many locations, even without incentives. The road ahead is clear; the costs of renewable energy has nowhere to go but down, whereas the cost of fossil fueled generation will only rise as critical natural resources diminish. The renewable energy industry must maintain its momentum though, and that will require innovation throughout the entire value chain.



Wind energy has long been recognized as a mainstream form of power generation, accounting for over 185 GW of grid connected capacity over the past five years. The competitiveness of wind has been driven by the frantic pace of product evolution among the world's largest turbine OEMs. The market entry of power generation giants such as GE and Siemens in the early 2000s ushered in an era of innovation and intense industry rivalry, resulting in technology advancements that no one thought feasible in so short a time. Tiny kW class turbines in California flying 47-meter rotors on 50-meter steel lattice towers have evolved into 8MW behemoths featuring 164-meter rotors soon to be operating in the North



Sea. Onshore development has maintained pace, with massive concrete/ steel hybrid towers standing over 140 meters tall in Northern Europe, towering over forested canopies. All of this in just over ten years.

The next phase of product evolution will be every bit as exciting; however, a change in focus is in order for manufacturers and asset owners alike. Turbine technology is certain to evolve further, but the development, operation and optimization of the latest generation of wind assets must be addressed as well. Wind sites are all different. Different terrain, different wind resources, different turbulence will be the norm. In order to achieve maximum performance, asset owners need to select the right turbine for each site, and that means proper profiling of site wind conditions. Meteorological masts have long been the standard, but when blade tip heights reach over 150 meters, asset owners are left with mathematical extrapolations to determine wind conditions on the upper sweep of the turbine rotor. This is a notoriously dangerous extrapolation and so the industry is finally moving towards acceptance of remote wind sensing technology such as SoDAR and LiDAR to help measure the upper reaches of large turbines. These devices can profile wind conditions up to 200 meters in many cases, offering a wealth of data on wind shear that can be used for turbine siting and even turbine control optimization increasing the profitability of the project.

And, profits matter, regardless of how green a technology may be it must be financially sound to attract investment. Energy is big business, and access to actionable market intelligence is critical to making sound business decisions. This is especially true for power marketing groups and independent power producers worldwide. As the penetration of intermittent power increases, wind and solar forecasts become more important, and not just for wind plant owners, but for the fossil fired generators marketing their power into a market against those renewable assets. Regional transmission operators need assistance as well, balancing intermittent renewable energy with consistent power generation sources to ensure the safe operation of the grid. Technology providers are working vigorously to introduce energy storage products into the market to assist the balancing effort, but the scale and cost of these storage solutions are not financially viable. Turnkey wind and solar power models harnessing detailed observation data and robust analytical tools are the most cost effective means to achieve harmony on the grid.

Finally, it is every bit as critical to maintain the availability of wind assets while controlling operational expenditures. As noted before, turbine blade technology has come a very long way, going so far as to employ exotic carbon fiber structures to ensure blade stiffness at a reasonable component weight. This approach has proliferated

as of late with some unintended consequences, namely a substantial increase in blade damage due to lightning strikes. Lightning protection systems are employed on all turbines, generally consisting of copper electrodes embedded in the skin of the blade tip and conductors that channel the current to ground protecting the turbine's electrical systems. Unfortunately, turbine blades still experience a good deal of damage in these incidents, costing owners thousands in repairs and associated downtime for repair and/or replacement. The technologies exist to detect and understand how lightning interacts with wind turbines but new solutions are needed that are light on expensive hardware and heavy on intelligent information and clever controls. Blade maintenance is one of the hottest topics in wind services and low cost solutions addressing major maintenance issues are top of mind.

In summary, the future is bright for renewable energy. Technology advances will continue to drive down the LCOE of wind, putting on pace to reach grid parity globally in the 2020 timeframe. These gains will be driven by turbine OEMs increasing the scale of their turbines to increase energy capture while providers of mission critical services will ensure that power is properly integrated into the grid. A harmonious integration of intermittent resources will continue to draw investment and at the same time ensure a greener future for all.

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