Grid stability with over 50% of distributed PV energy and on-site storage

Proposal Concept Paper in response to DE-FOA-0000838, Tier 1S

Applicant: The Kohala Center, P.O. Box 437462, Kamuela, Hawaii 96743
Attention: C. J. Davis, Grants Administrator, cdavis@kohalacenter.org, 808-443-2762
Total budget: $330k Total: Cost share: $70k, and DOE funding: $260k. Project duration: 12 months.
Date: March 5, 2013

Abstract

The Problem: Use of PVs in Hawaii is presently limited and/or blocked by utility concerns about grid-stability or -overload, if PV-power(peak) exceeds 10-15% of any nominal sub-grid power rating.

The Solution and Objective: Develop a quantitative approach to check that grid stability is maintained for grids with much higher (30-300%?) total PV-power(peak), through the use of distributed PVs with battery back-up (PVBB) to reduce PV peak grid injection power via on-site self-consumption.

The Approach: By introducing on-site storage for PV systems, grid loads are reduced substantially, if battery sizing and charging is done smartly, We will set up quantitative, time-dependent simulations of several individual on-grid PVBB grid-load variability models (using past real insolation data files), vs. conventional grid-load variability without distributed PVBBs to determine the grid-stability and economic benefits of PVBBs. This will enable us to quantify trade-offs between economics (battery cost and FIT rates) and grid stability.(time-dependent load variability). We envision that both smart battery management as well as some load management will be needed. In addition, we will:

(1) Develop a website tool to calculate and provide graphic displays of $/kWh and grid-load variability vs. PV & battery "size," capacity factor, PV & battery costs, local FIT & $/kWh rates and cost of capital;
(2) Vary FIT rates (with on-site minimum battery size) to meet a target low grid-load variability, and
(3) Propose and draft legislation that: (A) allows utilities to invest in, maintain PVBBs, as well as communicate and control operation of select energy-consuming appliances and/or energy storage systems like hydrogen producers; and (B) gives proper credit and incentives to invest in PVBBs as reflected by special FIT rates and attach mandatory storage requirements for new NEM contracts, both of which are equivalent to presently-levied utility demand charges.

The Uniqueness and Innovation: (1) Quantifying the relation between on-site storage of weather-dependent PV energy to grid-load variability or load-levelling; (2) Defining a profitable business role for utilities in a post PV-saturation era; and (3) Creating tools to define fair FIT rates for PVBB and PV (w/o storage) systems, which would be consistent with present utility-levied demand charges.

The Impact: With a high probability of success, this "Non Hardware" project would create a win-win for all energy stake-holders in Hawaii (and in many other locations) today:

- The **PVBB users**, who would experience a 25-year levelized LCC of less than half the present 40-44 ¢/kWh, besides benefiting from uninterrupted power during occasional grid outages;
- The **Hawaii economy**. It would experience a boost in activity due to reduced oil imports. Conservatively, the transition to such a decentralized system would create 250 & 2500 permanent, full jobs for local installers/sales & for the total PVBB industry, respectively, for each 1-million people, which would raise by ~7x the 11/2012 total solar industry 119,000 jobs, to 0.75 million US-wide.
- The **environment**, not requiring new land use for or exposure to new large energy plants (LNG, biomass, geothermal, central-PVs or nuclear), nor costly inter-island cable connections. At 50% average PVBB penetration, about 500 GWh from oil-fired generators would be replaced by clean PV on Hawaii Island, or over 400 million gal of state-wide imported oil per year would be avoided.
- Hawaii's **renewable energy goal** of 40 % would be met and exceeded.
- State/County net **tax revenue** would stay largely unchanged, replacing taxes on oil-imports and electricity sales with increased revenue from sales of local products and services.
- The **electric utilities**, which would be invited to participate and to invest and maintain PVBB systems for those homes or businesses who would welcome such help, while continuing to deliver energy (battery "trickle charge") or manage PVBB surplus as needed – provided the ordinances and laws of Hawaii are updated to allow such utility involvement.

Project Description

The Applicant Description – The Kohala Center is an independent 501(c)(3) environmental studies institute for education, research, conservation and economic development based on the island of Hawai'i with three core areas of work: energy self-reliance food self-reliance, and ecosystem health. Energy projects related to this proposal include energy sustainability plans and updates for the County of Hawai'i[1,2], participation in Hawaiian Electric Company's Integrated Resource Planning processes, and a study of University of Hawaii at Hilo's potential for campus energy efficiency and the development of a micro-grid. The Center currently employs 21 full time and 4 part-time staff members and manages a 2012-13 annual budget of $2,680,000.

For the proposed project, The Kohala Center has retained as PI Chris Williams, who just completed his MS thesis entitled **"Distributed PV & Storage Systems for demand Side Management: Algorithms to Analyze Domestic Benefit and Reduce Network Impact,"** as applied to German households and climates, and consultant U.Bonne, PhD, who also has focused his recent work on the technical and economic viability of PVBBs, focusing on conditions in Hawaii, since moving here in 2009.

[1] J. Johnson, D. Leistra, J. Opton-Himmel, and M. Smith, **"Hawaii County Baseline Energy Analysis"** sponsored by The Kohala Center, 10 May (2006), http://www.co.hawaii.hi.us/rd/hawaii_county_baseline_energ.pdf

[2] Christopher P. Cooke and David C. Parsons (Yale Univ.), **"County of Hawai'i Energy Sustainability Program: Five Year Roadmap,"** The Kohala Center, 6 Dec. 2012, http://www.kohalacenter.org/pdf/energy/CoH_EnergySustainabilityProgram_Final.pdf

Definitions:

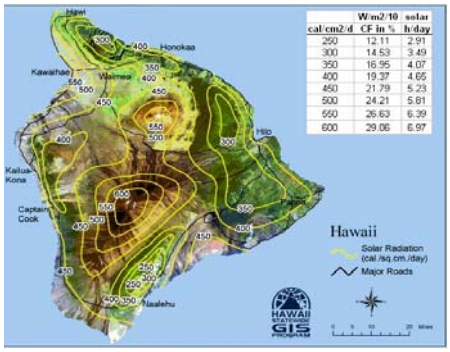
- Total electrical energy used for the household appliances $\sum_{el,total}$
- Locally produced PV energy after losses $\sum_{PV}$
- Part of the PV energy used locally, i.e. on-site of the PVBB $\sum_{PV,local}$
- **Self-Consumption** $\sum_{PV,local} / \sum_{PV}$
- **Autonomy** $\sum_{PV,local} / \sum_{el,total}$

How project supports goal of $1/W – PVBBs help continued 10-20 %/year growth & cost reductions, &

- Our simulations and web calcs. will provide useful tools for appropriate and effective development and sizing of distributed PVBB systems. Proper sizing of PVBBs is required for any particular user to ensure customer satisfaction while providing realistic expectations of the economic return. And
- Will aid to transparently derive fair FIT rates to ensure stable growth of PVBB systems in the region

Project's target level of performance by the end of the award in the form of deliverables

1) Number of buildings per land area analyzed: The subject grid (here Hawaii Island) as a whole will be analyzed first for its different regions of insolation and types of electricity users (in relation to their electricity demand profile), individual buildings/locations for each type of user in each region. The resultant average user load profiles for each type of day and season (summer, winter & transition) as well as the average seasonal irradiation profile for the different regions will be submitted.(Completion in 3 months);



Insolation levels for Hawaii Island

2) Characteristic grid power supply and demand profiles as well as self-consumption/autonomy potential of each type of user in each location would be established. Based upon the number of each type of user in each region, these individual results can be extrapolated to produce results for the entire grid. Based upon the set-up of the grid infrastructure, specific supply and demand of power at nodes

can be established, thereby permitting further grid stability analyses to be performed. This takes a series of simulations involving: a) a PVBB system alone; b) a PVBB system including smart charge control of battery storage to further aid in the balance of supply and demand of grid power while maintaining self-consumption; c) a PVBB system with smart charge control and load shifting of controllable cooling/heating appliances to increase self-consumption/autonomy; d) all of the above, while also utilizing the generation/storage of hydrogen to fulfill remaining grid compatibility requirements;

The simulations will be conducted within the Matlab environment. The associated code used to conduct simulations as well as a summary of the self-consumption/autonomy potential for each user-type in each region will also be submitted. (Completion in 6 months)

3) Surveys of the willingness of suitable candidates to have their heating/cooling appliances automatically controlled. This will yield a measure of the potential to which this aspect can be implemented for grid balancing. (Completion in 9 months)
4) Conduct and complete parametric analyses for the above scenario, in which grid-load variability and 25-year levelized life-cycle cost (LLCC) of electricity is determined vs. nominal battery use (derived from its kWh, PV-kW, capacity factor and daily load), FIT and regular rate, and cost of capital. (Completion in 9 months);
5) Draft legislation to enable a) utility investment and maintenance of distributed PVBBs, b) utility to manage operation of specific and consumer-volunteered appliances for load-leveling, and c) consideration of FIT or NEM terms, which give credit to investments in on-site storage, and preferably are independent of time-dependent grid rate escalations, such as NEM contracts. (Completion in 12 months)

Current state-of-the-art in the field and application including key shortcomings, limitations, costs and challenges and how the proposed project will overcome them.

A fully functional electric grid based solely upon renewable energies is not yet practical. There is, however, growing intent among many of the world's nations to increase the share of power that is derived from renewable sources. This is particularly true in Germany, where the feed-in tariff incentive scheme originated. Due to the scheme's success from its onset, Germany is now approaching the point (52 GWp of installations) at which power produced from PV systems can no longer be simply injected into the supporting grid infrastructure without creating problems. To begin preparing for this, Germany is now implementing a subsidy for storage measures that can be used to balance the power produced by PV over the course of a day. A recent study by one of the world's leading research firms in this subject, the Fraunhofer ISE, suggests that energy management systems could reduce peak solar power production by as much as 40% and allow up to 66% more solar to be integrated into the power grid.

PV-FIT(top) & system costs cut to 50 % in Germany in 5 yrs

The study conducted by the Fraunhofer ISE was just an estimate however, as PV systems currently are not typically coupled with storage due to the fact that the FIT rate in Germany was once considerably higher than the electricity grid price and is now about 9 Euro cents below. In Hawaii, the difference between grid price and FIT level is already more than twice this amount. The increase in self-consumption offered through on-site storage would already be cost effective at or close to such rates. This justifies the combination of storage with PV from the onset as suggested by the proposed project.

It is often difficult to convince power utilities and many citizens of the true costs associated with adopting a renewable energy incentive program. Utilizing current and projected future pricing models in conjunction with the self-consumption/autonomy potential of households to produce a system lifetime

cash flow analysis, the current economic validity of the system as well as its expected progression can be established. Applying this to a number of households in different regions of the grid allows for a direct cost comparison with a 100% fossil-based system. There is also serious debate in Germany as to what the FIT level should be, in order to enable sufficient yet sustainable profits for PV system investors. This provides a basis from which to propose legislation for NEM/FIT levels that will ensure stable growth without exploitation. Comparison of different simulation scenarios provides further basis from which to include separate incentives for aspects such as load shifting of appliances and smart battery charge control to balance grid supply and demand. Such measures enable further expansion of PVBB systems without adversely affecting the grid infrastructure; the extent to which this is possible and the resultant effect on grid price levels justifies incentive creation.

The accuracy of the simulations can also be an issue as the exact functionality for system components is often specific to the technology and/or the manufacturer. Reasonable assumptions are typically made but can result in the accumulation of error or in other cases it is not possible. Batteries in particular can vary greatly depending upon the technology and manufacturer. Having real entities partner to create such a PVBB device as suggested within this program, allows for simulations to be modeled based upon the realistic functioning of equipment. This ensures that simulations are as accurate as possible.

Also contributing to the accuracy of the simulations is the survey of the willingness of potential entities to participate in the program to allow their appliance needs to be controlled for grid balancing purposes. This is an aspect that can contribute significantly to grid balancing efforts, but it cannot be assumed that all would be willing to participate. Some may view such control as an invasion of privacy or decline for other reasons. An open and transparent description of the efforts along with a quick survey of potential subscribers could provide a proper assessment as to the true potential of such balancing efforts.

The key risks/issues and how they will be addressed -- It is difficult to determine at what exact point the inclusion of significant levels of PVBB systems will begin to start creating issues with grid stability, but an initial first engineering approximation would be when PVBB systems begin covering greater than 50% of the demand at any one time. As previously mentioned, this program is taking the approach that would generate data to enable and facilitate grid stability analyses in the future. Furthermore, the early adoption of storage through a "plug and play" “PV appliance” would allow for grid impact results to be monitored from the onset of such a program. In contrast to the present situation in Germany, where PVBB analyses are based solely upon estimates, this would allow for realistic predictions and grid stability analyses to be conducted. As the cumulative installed capacity increases, grid stability can be monitored and incentives altered or further measures added to ensure that it is maintained. This would prevent the program from over-stepping its limit but facilitate the eventual transition to a 100% renewable-powered grid infrastructure, while also making it more cost effective.

DOE Funding will -- help to overcome the US (1) utility and (2) legislative problems:
(1) Large deployment of on-grid, distributed PV systems, despite being environmentally benign and increasingly cost competitive, is being held back by the valid concern of electric utilities about **grid stability and loss of business.** (2) Utilities in most communities are presently excluded by law, to participate or invest in distributed PV systems. In addition, communities are becoming more outspoken against large power plants (fossil, solar, geothermal or wind) in their back yards. -- The proposed time-dependent simulations will prove and quantify the current grid capacity for increased penetration achieved via “smart” on-site PV battery back-up (PVBB) in relation to grid stability and loads without PVs. The simulation results will also prove the merits of (1) increasing penetration levels above the 50% threshold by maintaining (a utility business and) a viable grid to “trickle charge” the distributed batteries and to manage the surplus PV output as needed; and (2) encourage creation of (A) ordinances or legal base that allows utilities to invest and maintain such distributed PVBBs and thus mitigate their “loss of business” concerns; and (B) FIT or NEM terms and conditions that fairly incentivizes PVBBs.

The resulting high volume of PV installations will decrease their cost to consumers (the 1 $/W has already been met in Germany) and generate win-win outcomes for all stakeholders in Hawaii now, as listed via the bottom bullets in the Abstract, on p.1.

Qualifications and Resources

The Applicant Description – The Kohala Center (TKC) is an independent 501(c)(3) environmental studies institute for education, research, conservation and economic development based on the island of Hawai‘i with three core areas of work: energy self-reliance food self-reliance, and ecosystem health. These areas of work involve basic and applied research, policy research, conservation and restoration initiatives, public outreach and education – all carried out through local, regional, national, and international partnerships that include government agencies and prominent universities such as Yale and Cornell. For the proposed project, TKC has retained:

As PI, Chris Williams (resume on the next page), who just completed his MS entitled **“Distributed PV & Storage Systems for demand Side Management: Algorithms to Analyze Domestic Benefit and Reduce Network Impact,”** as applied to German households and climates. In related field test work (along with simulations) with his colleagues at the Center for Solar and Hydrogen Energy Research in Stuttgart, Germany, the goal was to maximize grid-connected self-consumption of the PV energy output[3]. That team also conducted on- and off-grid tests with the small grids in Corsica, Guadeloupe and Martinique islands, to prove efficient management of the battery charge[4]. And

Consultant Ulrich Bonne, PhD, who also has devoted his recent studies on the technical and economic viability of PVBB systems, but focused on conditions in Hawaii. Since moving here in 2009, he not only installed a 2-kW PV on his roof a month after moving here, but also continues to participate and testify in favor of PVBBs at public meetings with our local utility; the state PUC and with gov. officials.

His conservative estimate of the no. of permanent, full-time jobs to sustain a 50% on-grid generation by home PBVVs over a 25-year PVBB life cycle, for the Big Island is 60: Based on 75,000/2 households needing 1500 PVBBs/year at 10 person-days per installation, per our 200,000 citizens[8]. In addition, producing and shipping the 1500 PVBBs provides (1500*9 $/W-PVBB*4000 W *0.9 (production/total jobs)*(150 million US workers/ 15 T$ of GDP) = 485 jobs. Total jobs: 60 + 485 ≅ 500 jobs US-wide to sustain 50% Big Island PVBBs. If we proportion those jobs needed to sustain PVBBs for the Big Island population of 200,000, (1) To the 1.4 million of Hawaii State, the total jobs created would be 7*500 = 3500; and (2) To the 300 million US total, and assuming that the average US household also consumes 500 kWh/month, thus needing ~4 kW(peak) of PV, the total number of jobs is 0.75 million[8].

[3] J. Binder1, H.D. Mohring1, M. Danzer1, O. Schanz1, A.U. Schmiegel2, A. Linhart2, M. Landau3, J. von Appen3, F. Niedermeyer3, M. Braun3, D. Magnor4, D.-U. Sauer4, H. Schuh5, U. Thomas6, N. Martin7, J.-C. Marcel8, C. Jehoulet9, (1 Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW), Industriestraße 6, 70565 Stuttgart, Germany, Tel. +49 (0) 711 7870 209, jann.binder@zsw-bw.de, 2VoltWerk Electronics GmbH, Hamburg, 3Fraunhofer IWES, Kassel, Germany, 4ISEA RWTH Aachen, 5Saft Batterien GmbH, Nürnberg, 6E.ON Bayern AG, Munich, Germany, 7INES-CEA. Le-Bourget du-Lac Cedec, France, 8Tenesol, La Tour de Salvagny, France, 9Saft Batteries, Bordeaux, France), **“Sol-Ion PV storage system field test trial results, spread of operating conditions and performance evaluation based on field data,”** 27th European Photovoltaic Solar Energy Conference EUPVSEC 2012, Frankfurt, Germany, http://www.sol-ion-project.eu/export/sites/default/en/_data/publications/mediatheque-files/Conf_PVSEC2012_Sol_IonFieldTrial_Proc.pdf

[4] H.D. Mohring, J. Binder, M. Danzer, A.U. Schmiegel, M. Landau, J. von Appen, M. Braun, J.-C. Marcel, N. Martin, U. Thomas, W. Woyke, M. Garhamer, D. Magnor, D.-U. Sauer, C. Jehoulet, H. Schuh, “Experiences from the installation and operation of PV-storage systems: Field test of the Sol-ion Systems in South-Germany, Guadeloupe, Martinique and on research centers,” ZSW 2012 Report

In the following pages we provide

- **The resumes of** **Chris Williams, MS, Principal Investigator**
  Ulrich Bonne, PhD, Energy Consultant,
  Marc Bonne, LEED, Web Design and Development Consultant, and
  Betsy Cole, EdD, Deputy Director.
- **Letters of Support:** **Hawaii-State Representative Cindy Evans**

Resume

Christopher John Colin Williams, MS, Principal Investigator

Contact: Zentrum für Sonnenenergie- und Wasserstoff- Forschung (ZSW)
(Center for Solar and Hydrogen Energy Research)
Stuttgart, Germany
Phone: (49)-176-39016803,
e-mail: chrisjc.williams@gmail.com

Citizenship: Canada. GreenCard application is pending

Education

2013 **M.S., Renewable Energy Management**
Albert-Ludwigs-Universität Freiburg im Breisgau, Germany
Study focus: renewable energy technology, economics, policy, management skills
Electives: solar and wind energy

2006 **B.S., Chemical Engineering**
The University of Western Ontario, Canada
Dean's Honor List 2005 & 2006
Recipient of the 2001 Western Scholarship of Excellence based upon academic merit

Professional Experience

05/2012 – Present: Intern at Center for Solar and HydrogenEnergy Research, Stuttgart, Germany, Department: Modules Systems & Applications. Analysis of the self-consumption potential and economic sensitivity of unique household demand profiles supported with a photovoltaic energy system coupled to battery storage via MATLAB simulation models

04/2011 – 04/2012: Student Intern at the **Fraunhofer Institute for Solar Energy (ISE).** Department: Solar Cells – Development and Characterization. Process development of plasma-enhanced chemical vapor deposition of Si3N4 for passivation & anti-reflection properties

09/2011 – 11/2011: *Project Engineer Internship at* **SYNLIFT Systems GmbH.** • Analysis of wind resource data for projected wind turbine generator energy yields. Integration of variable wind and photovoltaic power supply with a desalination system. Economic evaluation of proposed projects. Project proposal & report preparation

02/2008 – 04/2009: *Process Engineer at* **Hatch,** Department: Non-Ferrous Hydrometallurgy. Preparation of reports explaining system design, meeting minutes. Analyzed and compared process design options based upon economics and feasibility. Researched and assessed equipment technologies available through various vendors. Performed heat/energy and mass balances around plant systems/locations. Process stream analysis using MS Excel and MetSim software

02/2007 – 01/2008: *Process Engineer at* **Xerox Supplies Development Centre.** Optimized batch polymerization process for toner production and managed and analyzed process data

Computer Skills

MS Office (proficient); MATLAB (proficient); AutoCAD (familiar); LabVIEW (familr.)

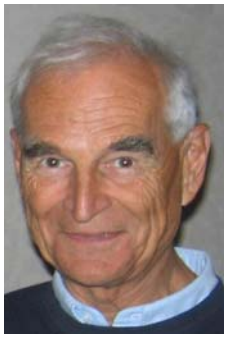
Publications

[5] J. Binder, C. Williams and T. Kelm. **"Increasing PV Self-Consumption, Domestic Energy Autonomy and Grid Compatibility of PV Systems Using Heat Pumps, Thermal & Battery Storage,"** 27th European PV Solar Energy Conf. & Exhibit.(PVSEC), Frankfurt, Germany, Sept.'12.

[6] C. Williams, J.O. Binder and T. Kelm. **"Demand Side Mgmt. through Heat Pumps, Thermal & Battery Storage to Increase Local Self-Consumption and Grid Compatibility of PV Systems"**, IEEE PES Innovative J.Smart Grid Techs.(ISGT) Europe Conf., Berlin, Germany, Oct. 2012.

[7] J. Binder, C. Williams and T. Kelm. **"Demand Side Mgmt. through Battery Storage to Increase Local Self-Consumption and Grid Compatibility of PV Systems"**, 5th International Conference on Integration of Ren. Energy & Distrib. Energy Resources (IRED), Berlin, Germany, Dec. 2012.

Resume



Ulrich Bonne, PhD, Consultant

Contact: P.O.Box 390831, Kailua-Kona, Hawaii 96739
Phone: 808-324-0108, e-mail: ulrichbonne$msn.com
Citizenship: USA

Education

1964 **Ph.D. (cum laude) Chemical Physics,** U. of Göttingen, Germany
1960 **M.S., Physics,** University of Göttingen, Germany
Study focus: Kinetics of flame inhibition and soot formation
1957 **B.S., Physics,** University of Freiburg im Breisgau, Germany
1955 Physical science courses at the University of Barcelona, Spain

Professional Experience

01/2007 – Present: Self-employed energy consultant and analyst. Co-founder of AlohaFuels div.of **H2 Technologies, Inc., Kailua-Kona, HI,** and S. & T. Adviser to **H2 Technologies, Inc.** Co-founder and CTO, **MinneFuel, LLC, Hopkins, MN.** Analyzed the technical performance, economic viability of, and policy implications for (1) Photo-voltaic panels with battery back-up (PVBB); (2) PV systems with hydrogen storage; (3) Renewable gasoline, ammonia and ethanol fuel production with renewable energy by extracting H2 from water and CO2 or N2 from air; and (4) Limits of single-well geothermal generators

04/1965 – 01/2007: Senior Research Fellow at the **Honeywell Labs in Plymouth, MN.** Performed, and lead R&D efforts in various Departments: Chemistry, Applied Physics, Advanced Development Lab., Materials and Processes, Sensor Systems and Microsensors. Most recently before retirement, his work focused on the thermo-physics of thermal micro-sensors and their use to microminiaturize gas chromatographic analyses (funded by DARPA and DOE); he devised and demonstrated new approaches to sensing oxygen, dew point, heating value; flame presence; thermal conductivity; specific heat, true volumetric, mass or energy flow, and pressure—all with Si-based microsensors. He conceived Si-based microactuators, which were then demonstrated to operate pneumatic controls; with available low-cost actuators he innovated approaches to sense viscosity and oxygen demand of gaseous fuels, measure the concentration of binary gas mixtures, and calibrate flow sensors on-line. He led and supported his Thermochemistry Group to develop a research prototype of a combustion efficiency monitor, introduced to the market in 1979, a "smart" optical coal flame sensor, and completed extensive efficiency sensitivity analyses for space heating systems. His development of an IR-absorption-based, smart natural gas leak detector was completed in 1988.
He proposed, won and led R&D projects for AGA/GRI, EPA, DOE, DARPA, NASA and EPRI, and served on DOE and DARPA advisory and on ASHRAE technical and research committees, organizing over 7 Seminar Sessions at ASHRAE national conferences. His work led to over 100 US Patents and 140 paper publications, and 8 Technical Awards

Relevant Publications

[8] U. Bonne (Kailua-Kona, HI), **"Clean Energy: Solar PV-with-battery storage for all?"** "Commentary" in West Hawaii Today (WHT), Kailua-Kona, HI, 27 Dec. 2012, pp.A6-A7, http://alohafuels.pbworks.com/f/PB-12-WHT-HELCO-IRP-3-950.pdf

[9] U. Bonne (Kailua-Kona, HI), **" … PV+battery approach for clean, secure, ~20 ¢/kWh Big Island energy future."** HELCO-PUC hearing in Kailua-Kona, HI, 30 Oct.'12, rev. 27 Nov.'12, http://alohafuels.pbworks.com/f/PB-12-HELCO-AKP-PUC-1.pdf

[10]U. Bonne and Guy Toyama (H2 Technologies, Inc),.**"Feasibility for production of renewable NH3 in Hawaii for food and energy security,"** 2011 Annual NH3 Conference, Portland, OR, Sep. 2011

[11]U. Bonne (Kailua-Kona, HI), **"Infuence of variable electricity supply on renewable fuel price."** http://minnefuels.pbworks.com/f/PB-11-Variable-ESource-vs-Fuel-Price.pdf, 29 July 2011

Resume

Marc G. Bonne, Owner, Design Nebula

Contact: 932 N 88th St, Seattle, WA 98103
Phone: 206-526-9311, email: marc@designnebula.com
Citizenship: USA

Education

2006 **LEED Accreditation,** US Green Building Council

1994 **Architecture Certificate,** Harvard University
Graduate School of Design, Cambridge, MA

1994 **B.A. Architectural Studies,** Tufts University, Medford, MA
Minor: Civil Engineering

Work Experience

01/2006 – Present: Self-employed web design and development consultant. Marc specializes in PHP and MySQL sever-side programming for database-driven websites, but brings combined artistic and technical aptitudes to design projects, facilitating collaboration among cross-functional work teams. He seamlessly integrates front-end UI with server-side processing, in particular, interactive design using AJAX/HTTPRequest dynamic loading. His coding background also includes responsive CSS, HTML, Javascript, and jQuery. Most unusual in the programming community is Marc's ability to communicate articulately with clients about the vision, direction, and progress of projects, aided by his knowledge of architecture, engineering, design, and green building.

04/2004 – 01/2006: *Marketing Director,* TDBC (non-profit arts organization). Marc created and implemented the organization's global marketing plan – media coordination (television, radio, print and internet), program guide publication, sponsorship negotiation, and community outreach – achieving $75k goal in ticket sales. He hired and supervised a 21-person volunteer work team of designers, writers, webmaster, database engineer, and press coordinators. He secured over $120k of in-kind sponsorship where the annual marketing budget was $14k, after having stepped in to help management recover from a disruptive reorganization.

01/2000 – 04/2004: *Graphic Designer,* Antioch University Seattle. Marc balanced ongoing, recurring, and last-minute projects for the entire university with a proficiency that allowed the marketing director to minimize oversight of the graphics department. He designed all printed materials, from postcards to catalogs to billboardsand received the 2003 Bronze Vision Award, League of American Communications Professionals, for his annual report design, as well as the 2005 Totem Award, Public Relations Society of America, for redesigning brochures that helped raise prospective student inquiries by 78 percent from the previous year.

Computer Skills

Photoshop, QuarkXpress, InDesign, Illustrator, Dreamweaver, HTML, CSS, PHP, MySQL, JavaScript, jQuery, AutoCAD, Filemaker

Current Projects

- Online ROI (Return on Investment) calculator for renewable energy installation projects, www.energyfuturehawaii.org/solarCalc.php
- Interactive, database-driven social-media website for wine enthusiasts, www.winefidence.com
- E-commerce website for wedding stationary, www.queergettingmarried.com

Resume

Betsy Cole, Ed.D, Deputy Director, The Kohala Center (TKC)
Contact : TKC, P. O. Box 437462 Kamuela, HI 96743
Phone: 808.887.6411 Fax: 808.886.6707
E-mail : cole@kohalacenter.org

EDUCATION

Ed.D, Harvard University, Graduate School of Education
Cross-cultural human development, education and economic development
B.S., University of Pennsylvania, Department of Sociology

PROFESSIONAL EXPERIENCE

2001 to present: Deputy Director. The Kohala Center, Founding member of the senior administration of an environmental studies institute based in Waimea on Hawaii Island, focusing on education, research, economic development and policy development in the fields of energy and food self-reliance and ecosystem health. Responsibilities include program development, project management, staff supervision, community outreach, grant writing and oversight, and project evaluation. Managed consulting teams to create Hawaii County Energy Sustainability Plans in 2007 and 2012 and a Hawaii County Agricultural Development Plan in 2010. Currently a member of the Hawaiian Electric Company Integrated Resource Planning Advisory Group and the Hawaii Energy Policy Forum.

2001 to : Assistance Team, Partnerships for Hawaii's Keiki, Member of a technical assistance team that advised a three-year, state-wide initiative to improve educational and health outcomes for Hawaii's youngest children

1997 to 2001: Executive Director, Five Mountains Hawaii. Responsible for the start-up of a community development organization founded to create a model of integrated community health that also provides a sustaining source of economic vitality for Hawaii Island through health-related private and public sector programs. Initial tasks included developing all organizational, program, and funding aspects of this 501(c)(3) corporation and gaining broad-based support for a comprehensive community health initiative.

1993-1997: Program Manager, Family Support Services of West Hawaii, Member of the senior management team of an innovative, community-based social support, education and advocacy organization. Created the agency's community outreach and advocacy capacity, designed and developed family literacy and youth development/entrepreneurship projects.

1982 to 1994: Lecturer, University of Hawaii at Hilo and West Hawaii. Part-time instructor of courses in human development, cross-cultural psychology, educational psychology.

Letter of Support

HOUSE OF REPRESENTATIVES

STATE OF HAWAII
STATE CAPITOL
415 SOUTH BERETANIA STREET
HONOLULU, HAWAII 96813

28 February 2013

Ms. Samantha Shiffman,
Office of Energy Efficiency and Renewable Energy (EERE)
U.S. Department of Energy (DOE)
Samantha.Shiffman@ee.Doe.Gov

Subject: DE-FOA-0000838 – Letter of Support to proposed project below
Title:"**Grid stability with over 50% of distributed PV generation & on-site storage**"

Aloha -

Dear Ms. Shiffman,

I am pleased to express my support for the subject proposal. The envisioned simulations, customized for Hawaii are urgently needed as we face energy-security decisions at both County and State levels. They would be very helpful for giving PV generation (with its technically proven, long service life, affordability in Hawaii and benign environmental status (no air/water pollution/health-care or ocean acidification issues) the attention and legislative support it deserves.

As the lead scientists of this potential project have pointed out, high level deployment of distributed PV with on-site battery back-up (PVBB) is not only grid-sustainable, as Chris Williams showed via time-dependent & self-consumption simulations customized for Germany, but can be a win-win for all stake-holders in Hawaii now:

- The **rate payers**, who would pay 25-year levelized life cycle cost near 20 c/kWh
- The **Hawaii economy**, which would experience a boost in activity due to reduced oil imports
- The **environment**, not requiring exposure to new large energy plants (LNG, bio-mass, geothermal or nuclear) , nor costly inter-island cable connections
- Hawaii's **renewable energy goals**
- State/County **tax revenue** to stay about level, replacing taxes on oil-imports and electricity sales with increased revenue from sales of local products and services, whether w/ or w/o tax incentives for PVBBs, and
- The **electric utilities**, which would be invited to participate, and to invest and maintain PVBB systems for those homes or businesses who would welcome such help, while continuing to deliver energy (battery "trickle charge") or manage PVBB surplus as needed – provided the ordinances and laws of Hawaii are updated to allow such utility involvement

This project would be administered by The Kohala Center, which has established a stellar reputation in this County of Hawaii community for its effort and focus on coordinating funded R&D on energy and food security and well as to sponsor educational and local agriculture projects.

Sincerely,

Cindy Evans

Cindy Evans
Hawaii State Capitol
State Representative, House District 7

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Business Plan/ Commercialization Strategy

- **Statement of intent to manufacture resulting products or processes in the United States. –** The expected results of this "Non-Hardw." project, will lead to increased sales of US-made PBVVs, are :
  (1) Knowledge gained that will bring about the above-listed PVBB benefits for all stakeholders,
  (2) Software tools to optimally size on-site backup batteries for energy from distributed PVs, and
  (3) Policy concepts to serve as basis for legislative proposals to unlock above PVBB benefits
  We intend to publicize these results and reach out (via papers and presentations) to the local community, its leaders (including PUC and utility leaders) and to the leaders at the state and federal level. In addition, the results, calculators and tools will be made available on a special website.
- **Impact on PVBB on cost in 2015 and 2020:** As detailed in ref.[8], removing the present blocks to PVBB deployment would sustain 7x more jobs for new and replacement of PVBBs jobs US-wide than the 119,000 reported 11/2012, thereby also decreasing prices even faster than the listed 10-20%/year in the US & Germany
- **The phases of development required to achieve commercial deployment, --** To date, we have advised the community via commentary in the local paper, via presentations to the Mayor's Energy Advisory Commission, and to PUC and utility hearings in addition to written testimony, about the benefits of PVBBs – all based on average load and insolation data. With the time-dependent results from this project, the quantitative definition of grid peak loads, grid stability and grid-load variability will be more realistic, and the PVBB benefits more compelling. At that point, we will have the tools needed to overcome present blocks against large-scale deployment of PVBBs. Such blocks are (1) Utility concerns about grid stability, and loss of business concerns; (2) Inadequate FIT and NEM incentives and (3) Legal blocks preventing utilities to invest in, maintain and/or perform energy management functions in homes or businesses with PVBBs.
- **The approach anticipated for scaling/launching the proposed project and the scalability/cost issues related to this approach, --** We anticipate that during the 12 months Period of Performance we will complete drafting and submitting legislative or policy proposals to the utilities, PUC and government officials – but that PUC and government deliberations, hearings and bill preparations and voting will occur thereafter. Our interested involvement will then be pro-bono or the subject of a Tier 2S continuation proposal, to extend our insights gained with small island grids to the larger mainland grids, and where EPRI is studiyng central (rather than distributed) PVBB issues (see Brian Seal et al., "**Standard language protocols for PV and storage grid integration. Developing a common method for communicating with inverter-based systems**," EPRI White Paper 1020906, May 2010, http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001020906)
- **US jobs created –** 500 permanent jobs for 50% PVBBs for HI County, or 0.7 million for US-wide[8].
- **Phase of development and why will it result in commercialization --** Removal of the PVBB deployment block would complete this phase of the project and boost PVBB competitiveness because (1) A deployment boost of PVs with storage, i.e. PVBBs, will lower their installation costs down from the present 9 $/W (incl. 15 hours of available battery storage) equivalent to a 30-year-levelized LCC of 9000/(30*8760*1*0.17) = 20.1 ¢/kWh, before subsidies, in Hawaii, where consumers already pay 40-44 ¢/kWh, and (2) Viable utility businesses have to be allowed to invest in distributed PVBBs, as addressed in this project. They are more competitive than central PVBBs because the former lack land acquisition costs, transmission losses, costly field assembly, and NIMBY effects.
- **What is planned after DOE project end, regarding funding & licensing for commercialization --** Successful completion of this project may not require further DOE or private funding in order to create the policy framework described above, which will remove present blocks and enable large-scale, distributed PVBB deployment in the islands of Hawaii, as well as on the US Mainland. The needed hardware is commercially available today – but its installed cost would certainly drop, as we slide down the "learning curve" fuelled by the boost in PVBB installations[8]. -- The software developed during this project will be offered for sale or licensing, for use by others. The software tools to calculate (1) optimal battery sizing relative to a given nominal PV output and (2) fair FIT or NEM terms for sets of local conditions will be made available of a special TKC website

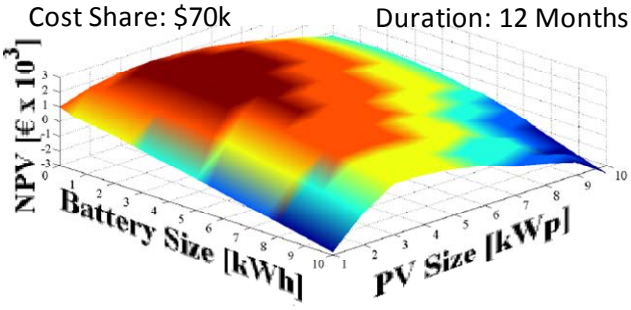
Control Number

"Grid stability with over 50% of distributed PV generation & on-site storage" by Chris J.C. Williams (PI), The Kohala Center

Total Project Cost: $330k
Cost Share: $70k

DOE Funding: $260k
Duration: 12 Months

Month	Major Deliverables Summary
3	**3-5 years of insolation & use data for 5 PVs in varied Hawaii climates**
6	**Time-dependent PVBB simulation**
9	**Parametric analysis of LCC $/kWh**
12	**Drafted leg. bills for win-win PVBB use**



Positive net present value of a home-PVBB system in Germany vs. PV and battery sizes, for expected 2015 costs, but today's FIT rates.

Project Summary

- **Problem:** Utilities' concern: PVs affect grid stability and lead to loss of business
- **Objective:** Prove that PVBBs can mitigate that concern despite >50% PVBB on-grid generation
- **Approach:** PVBB performance simulations over several seasons to prove lower grid-load variability with PVBBs than w/o, optimal battery sizing, & fair FIT rates for minimum battery size
- **Expected Results:** The simulations verified that PVBBs can cause less grid-load variability than grids w/o PVBBs. This removes the rationale for limiting prudent PV deployment

Impact

By **quantifying PVBB benefits our project will:**

- Remove utility concerns, to limit PV generation to ~15% (w/o added central storage), if PVs were to use the grid as sole backup
- Decreases installed PV cost to below 1 $/W (=DOE goal), due to increased volume of PV deployment as already proven in Germany
- Drop 30-y-levelized LCC rates for PVBB users/ owners to below half of today's 40-44 ¢/kWh
- Decrease HI-State's oil imports by 400 Mgal/y
- Boost Hawaii's economic activity, and thereby
- Maintain Hawaii tax revenue & utility business.

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Deliverables Table

Deliverables Table			
The Kohala Center /PI: Chris Williams – chrisjc.williams@gmail.com , 808-443-2762			
Deliverable	**Date** **Month** **%total DOE funding**	**Deliverable Title** **Deliverable Description: Specific, Measurable, Quantitative** ***Metrics to best reflect the functionality of the proposed product***	**Verification Process & Additional Notes** **What, Who***, Where**
D0	**Date (MM/DD/YY)** **3** **≥30%**	**Baseline Performance** Technical 1. 3-5 years of electrical power demand data for5 different user-types developed using a synthetic load profile generator 2. 3-5 years of insolation data for 3-5 locations in varied Hawaii climates 3. Prepare survey questionnaire for analysis of load shifting potential Business 1. Letter of intent to participate from system component manufacturers (PV, battery, inverter) 2. Letters of agreement from the 5 user-types to use their electricity consumption statistics	Technical 1. Average demand profile for summer, transition, and winter seasons and each day type (weekday, Saturday/holiday, Sunday/holiday) for each user-type sent to DOE 2. Average insolation profile for all 4 seasons in each location sent to DOE 3. Sample survey delivered to DOE via email Business 1. Letters of intent delivered to DOE by email 2. Letters of agreement delivered to DOE by email
D1	**MM/DD/YY**	**Simulations Complete** Technical 1. Functional model of the PVBB system (incl. hydrogen generation) as well as control strategies 2. Time-dependent PVBB	Technical 1. Matlab code describing system model submitted to DOE via email 2. Summary of self-consumption/ autonomy and grid injection balancing

	6 **20%**	simulations for each user-type within each location for each scenario under study	potential for each user-type within each climate region and each scenario submitted via email
D2	**MM/DD/YY** **9** **20%**	**Economical Analysis** Technical 1. Parametric analysis of LCC $/kWh for each type of household in each climate region 2. Preliminary on-line calculator (v. 1.0) to produce LCC ($/kWh) and grid load variability as a function of household type, PV size, battery capacity, FIT rate and electricity price Business 1. Survey results from xxx households 2. Coming soon page added	Technical 1. 3-D LCC sensitivity analysis plots for each household in each climate region with supporting input data sent to DOE via email 2. Calculator version 1.0 presented and demonstrated to utility, county officials and installers Business 1. Documentation delivered to DOE by email 2. DOE can access page
D3	**MM/DD/YY** **12** **≥30%**	**Application of Results** Technical 1. Drafted legislation to put forth proper incentives toward the effective implementation and use of PVBB systems benefitting both utility and rate payer 2. Functional on-line calculator version 2.x completed	Technical 1. A copy of the drafted legislation will be delivered to DOE via email 2. DOE can access calculator and perform inquiry as a typical user would

*** Contacts to whom presentations and demonstrations will be made, as part of the verification process:

- Mike Penev , Michael.Penev@nrel.gov, : (303) 275-3880 or Marc Melaina NREL, Colorado
- R&D Director at First Solar Co. in Sunnyvale, CA
- Vincent_Paul Ponthieux, CTO, paul@blueplanetresearch.us, The BluePlane Research, Hawaii Is.
- HELCO (Hawaii Electr. & Light Co), Hilo, HI, Laura Rogers (Engineer), Jay Ignacio (President), Warren Lee (former president), Tony J.Prietto (Comm. Acct.Mgr), Kamuela, HI
- State and County government officials concerned about energy and food security for Hawaii
- Local PV installers: Cano Electric, RevoluSun, Sunetric, Poncho's Solar, etc