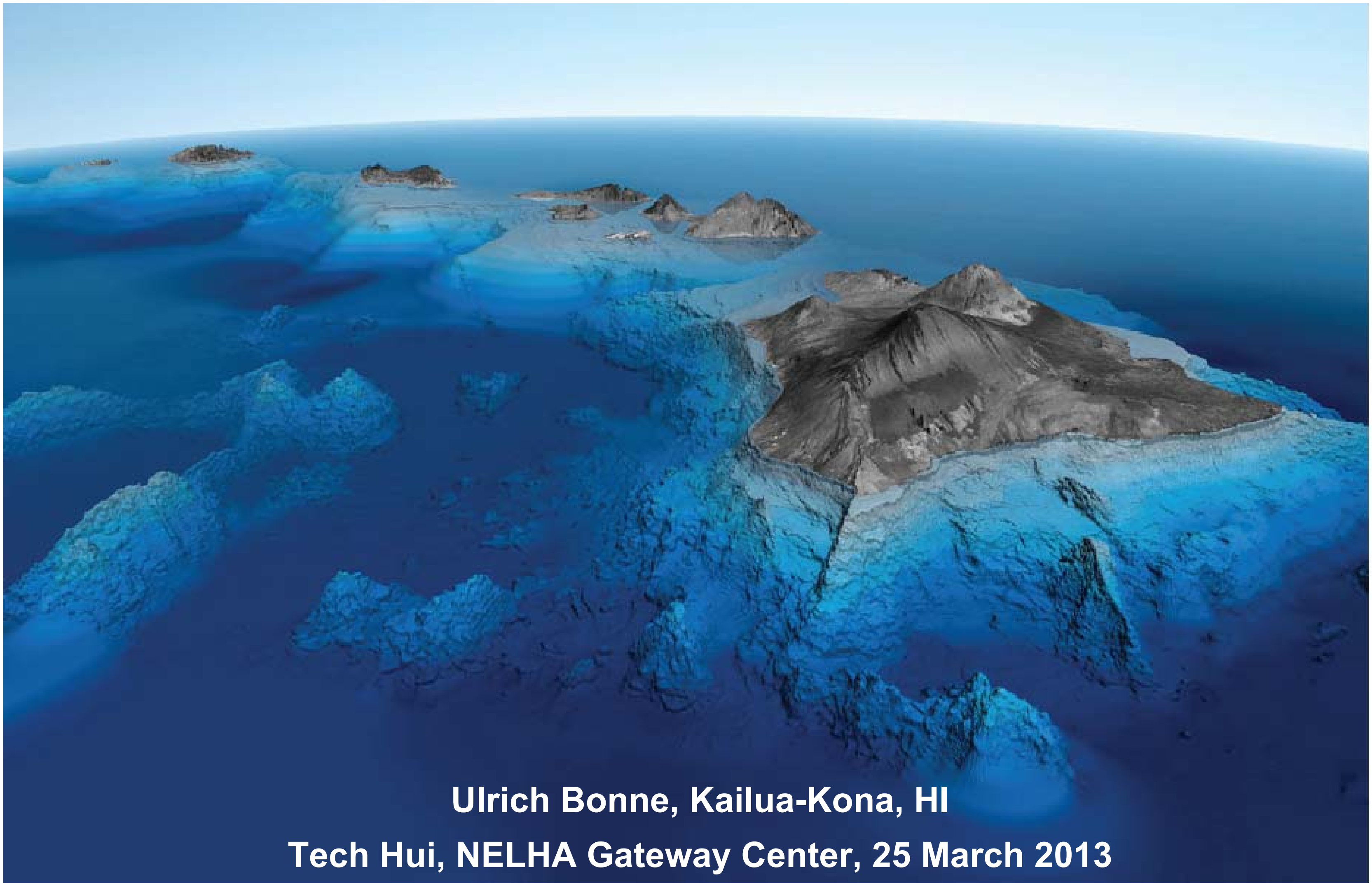
Energy Security via Distributed PVs with Battery Backup (PVBB)



PVBBs for Businesses

1.6 megawatts of solar generation on the roof of Google's offices

http://www.cpuc.ca.gov/environment/info/aspen/sunrise/rdeir_cmts/G0014%20CBH%20part6of7.pdf, **p. 98**

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Kona Civic Ctr. 250-kW PV + 250-kWh Li-ion Battery

http://www.bigislandvideonews.com/2011/08/02/konas-civic-center-launches-green-government-action-plan/

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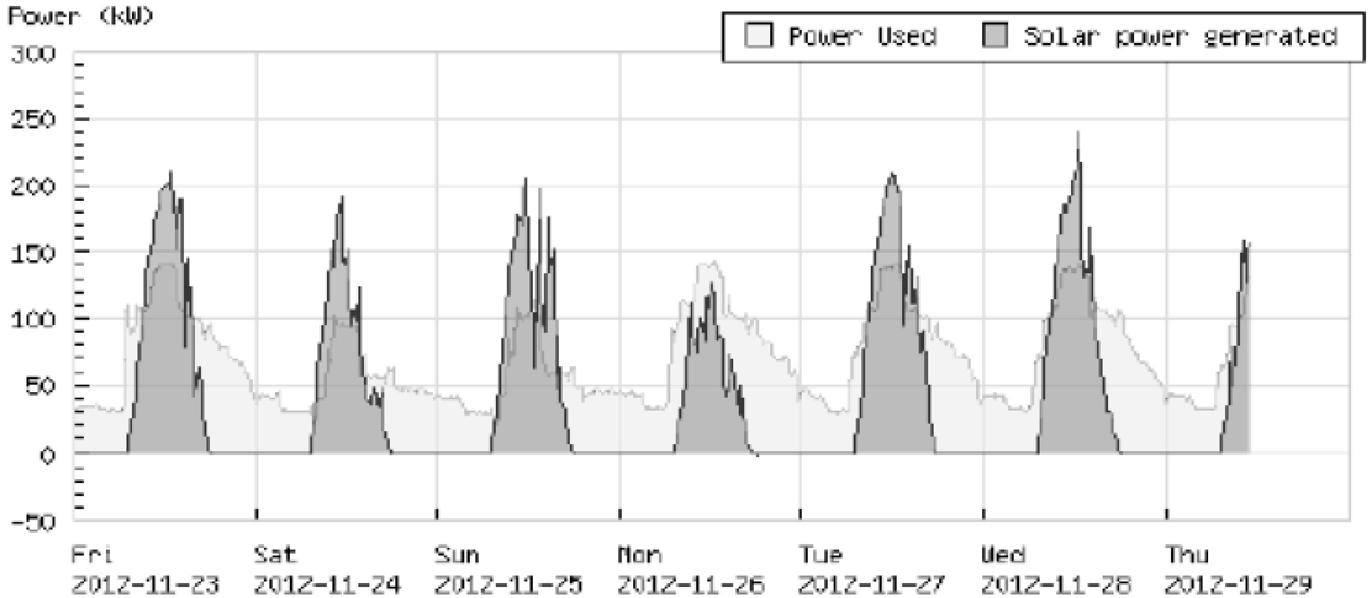
PVBBs for Businesses



Civic Center

My home

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PVBBs for Homes / Ground-Mounted

. This ground-mounted, on-grid, 2-kW PV in Honokaa, Hawaii County, features sixteen 12-V PV panels, and four 6-V deep-cycle batteries (10-kWh) for storage and night-time use. Batteries, charge controllers and inverters are located under the panels in a ventilated, weather-proof enclosure. The system provides uninterruptible power but requires no HELCO permit, as it can only draw from but not inject energy into the grid. With a two-way grid connection, the estimated electricity cost would be 16-19 ¢/kWh, incl. MMC, interest and some oversize. -- Prefabricated and installed in 2012 by Jonathan Cole (JonCole at gmail.com)[9].

http://alohafuels.pbworks.com/f/PB-12-HELCO-AKP-PUC-1.pdf

Portable, Off-Grid PVBBs

Plug & Play

0.54-kW PV
4 x 135 W
92-W 24/7

$6600
(Promotion.)

12.2 $/W

Incl: Inverter

Charge Ctr.

2.4-kWh bat.
$1199
(Promotion)

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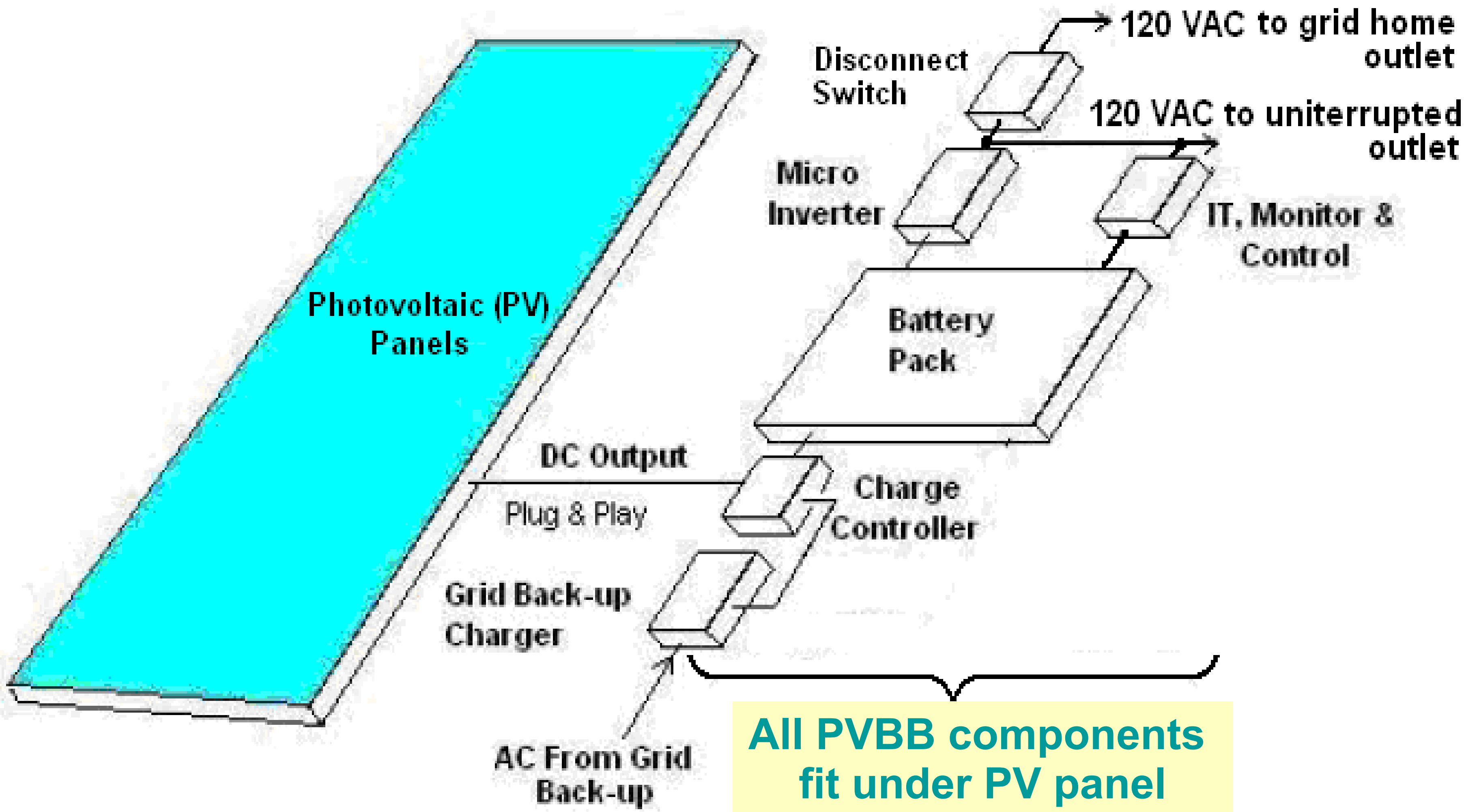
Future PVBBs: Integrated Solar PV Panel (iPVp)



All PVBB components fit under PV panel

Plug & play PVBB appliance

joncole@gmail.com, ulrichbonne@msn.com

PV-solar vs. Fossil Energy Cost Incentives

PVBB 6.69 $/W(pk,w/TC) = 669 /(0.001*0.17*8760*30)= **15 ¢/kWh**

Fossil at 2 $/W + F ⇒ **200 / (0.001*0.43*8760*30) = 1.8 ¢/kWh**

+ 300 ¢/GGE*/0.3/(110000*1054/3.6e6)= 31.0 ¢/kWh

33 ¢/kWh

PHEV at 15 ¢/kWh ⇒ 15 / 4 miles/kWh = 3.6 ¢/mile

33 ¢/kWh ⇒ 33 / 4 miles/kWh = 8.3 ¢/mile

GasIn. at 400 ¢/gal ⇒ 400 / 30 MPG = 13 ¢/mile

LNG* at 66 ¢/GGE ⇒ 66 / 30 MPG = 2.2 ¢/mile

LNG* at 8.6 ¢/kWh ⇒ 8.6 / 4 miles/kWh = 2.2 ¢/mile

***LNG at 6$/million Btu = 600/(1e6/0.11e6) = 66 ¢/GGE**

DEEP BLUE
2012

ELEKTRA-ONE
4-h, 500 km. 2011
440 lbs, $145,000

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PVBBs for Homes & Businesses

Why not deploy much cleaner, pono distrib. PV **generation?**

The Problem: for utilities (U), for rate payers (R)

- **U: Grid-stability or -overload, if PV-power(peak) exceeds 10-15% (50%?) of any nominal sub-grid power rating,**
- **U:** Loss **of kWh-sales. NEM-PV** w/o **batt**. is not **sustainable**
- **R: FIT-PVs w/o batteries are not sustainable for Rs**
- **R: As U e-sales drop**, $/kWh **rates increase for non-PV Rs**

The solution:

- **Prove that distributed PVBBs can reduce grid-load, -load variability, -losses, and -outages, even if they generate over 50% of total kWh (>300% of peak power)**
- **Allow utilities to invest in, maintain, or own distr. PVBBs**

The approach: SELF-CONSUMPTION, **SC = ∑PV,local / ∑PV**

- **Maximize on-grid, distributed generation & SC via PVBB**
- Legislate fair PVBB-NEM/FIT terms, & allow **utility participation**

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Conclusions Preview

PVBBs can be a win-win for all stake-holders:

- **PVBB users: achieve half of today's 40-44 ¢/kWh rate, based on a 25-30-year levelized LCC; have uninterrupted power during occasional grid outages; maximize Rsc***
- **The Hawaii economy: boost in activity from saving 400 mill. gal oil imports. 250 (HI) & 2500 (US) jobs/ea.mill.pop. Raise ~7x total** 11/2012 **solar ind. jobs from 119 k to 750 k**
- **The environment: no new land** use **for new energy plants; no** LNG**, bio-mass, geo., util.-PVs, nuclear, or inter-is.cable. Exceed Hawaii's 40% renewable energy goal. All pono.**
- **State/County: replace tax revenue from oil-imports and electr. sales, w/revenue from increased economic activity**
- **The electric utilities: replace oil expenses w/ investment & maint. of PVBB systems where needed (new legal playing field).** Low-**loss grid income from managing "trickle charge"** and PV surplus as **needed. Distr. PVBB=hi. reliability**

***Maximize self-consumption ratio, Rsc = ∑PV,local / ∑PV**

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Distributed PVBB Agenda

1. **Problems:** **PV peaks.** Grid Xm**.-loss, -variability &** -un**rely.** **Financially-strapped households "left behind," w/o PVs**
1. **Tech. Solution:** **Despite variable insolation, BBs & PVs reduce grid-load, -load variability,* -losses & -outages**
2. **Econ. Solution:** **Utility to embrace new business model: less central (oil or PV) and more distributed renewable PVBBs, wind … generation**
3. **Implementation of PVBBs:** **Examples**
4. **Conclusions:** **Win-win for all PVBB stake-holders: Rate payers, HI economy, environ. tax revenue & utility**
6. **Actions:** **Brainstorm legislative petitions. Task force. Devise & update fair NEM and FIT contract terms**

***Maximize self-consumption ratio, Rsc = ∑PV,local / ∑PV**

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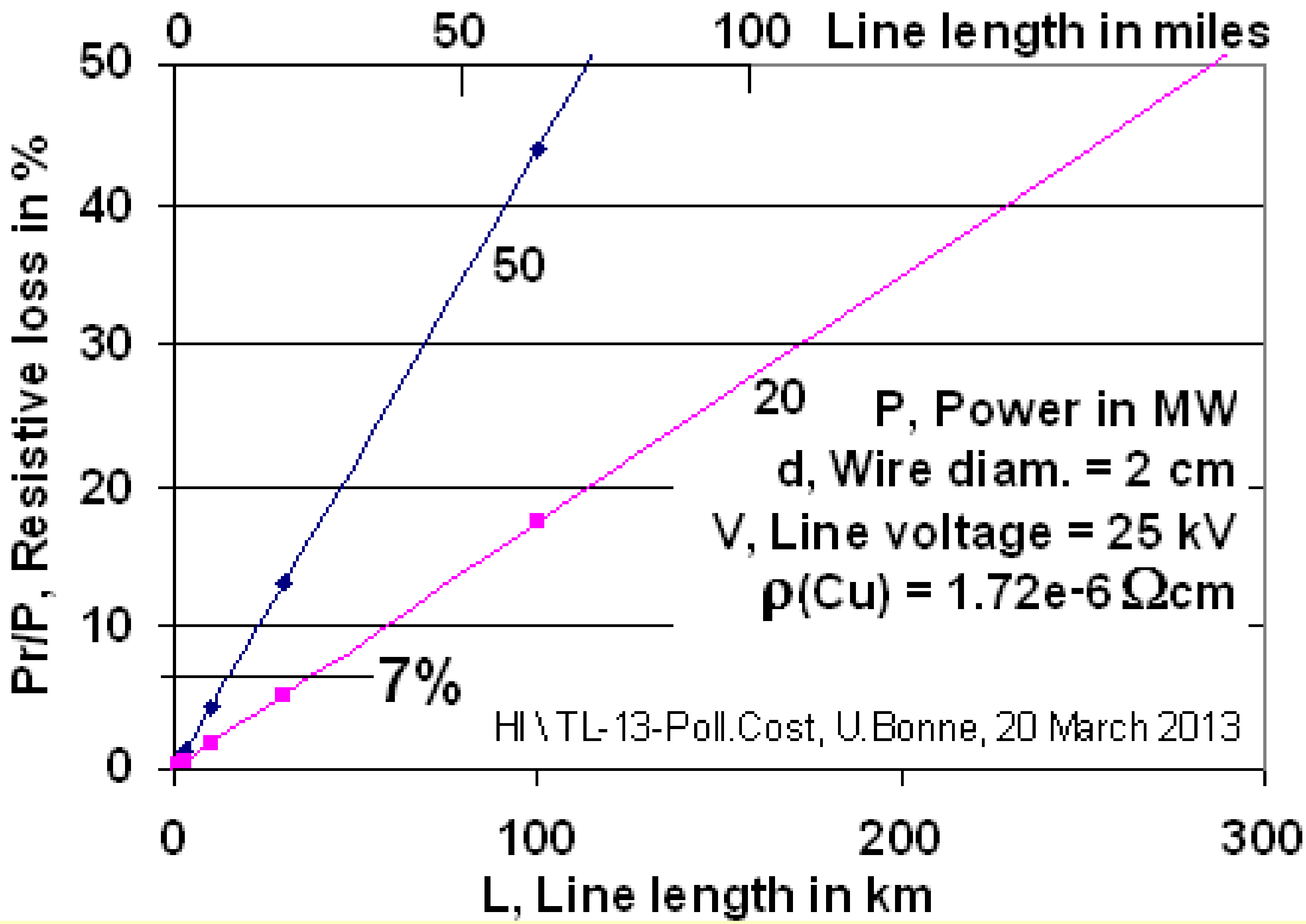
Problem: High Transm. Losses

Calculate ohmic (resistive) power grid loss, Pr, w/o & w/PVBBs:

$$Pr/P = It^2 / R / P = (P/V^2) / (\rho * L / A)$$



Local PVBB storage and generation reduce transmitted power & losses

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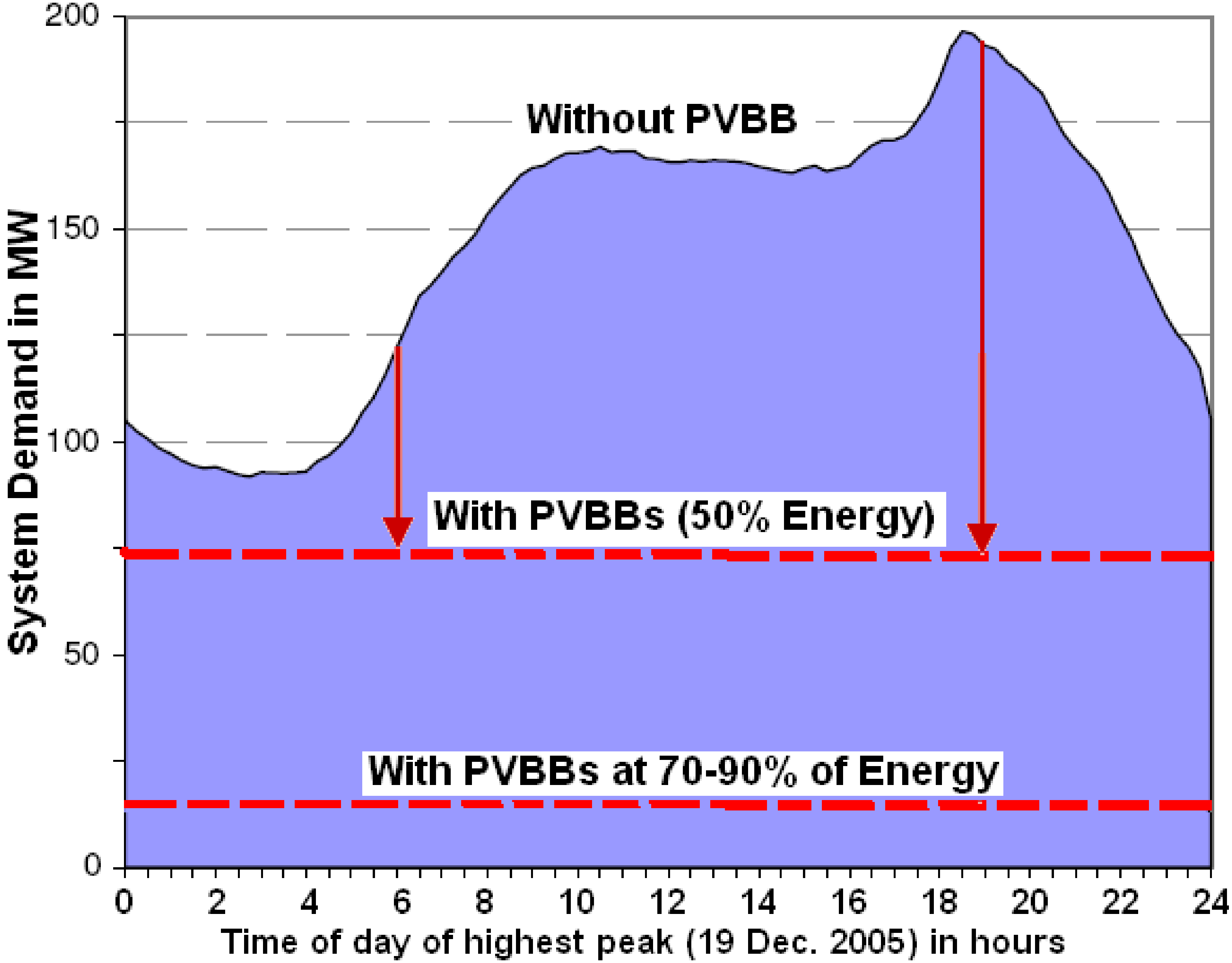
Problem: Uneven Load Demand



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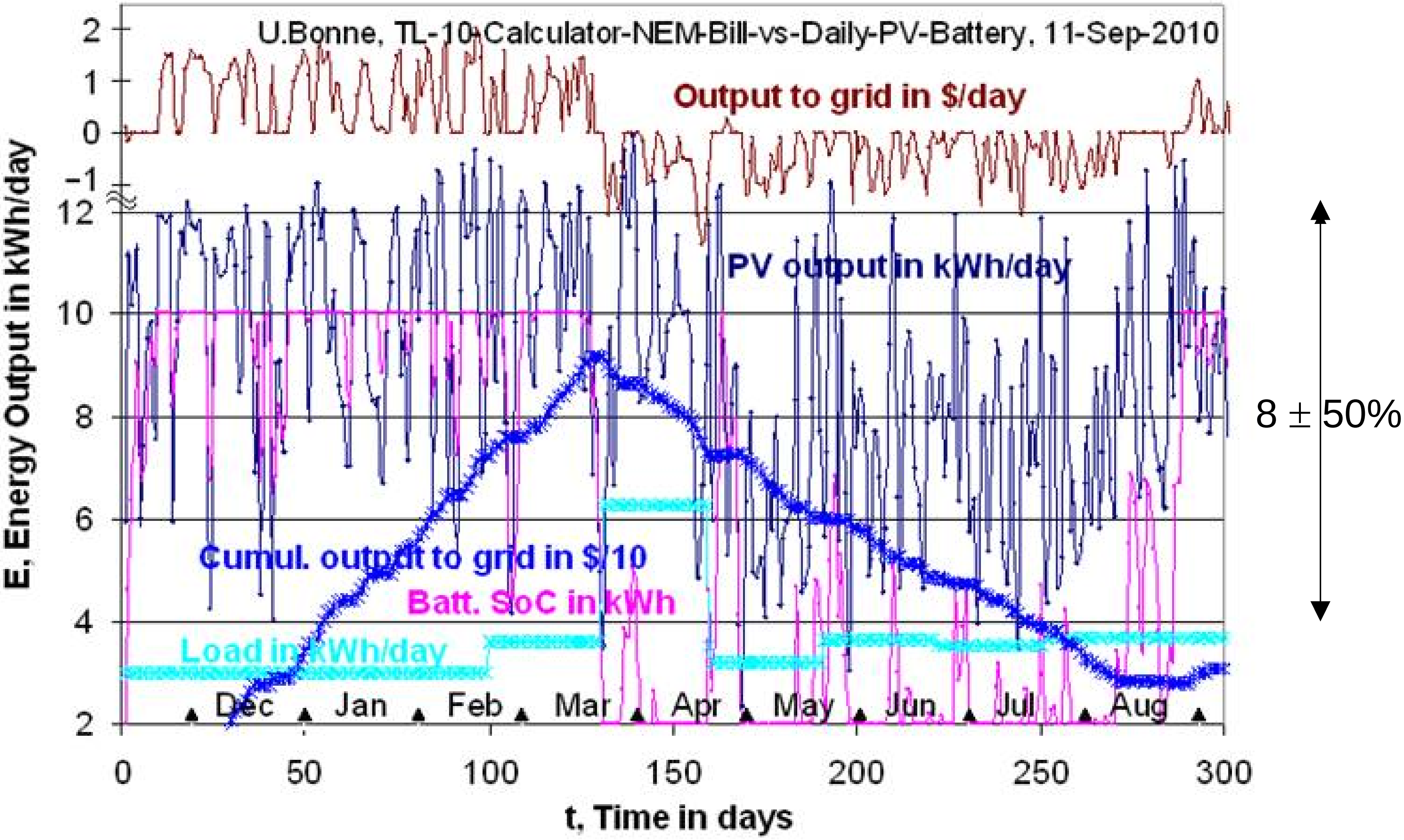
Problem: PV and Load Variability



Problem: PV daily and seasonal output variability ± 50%

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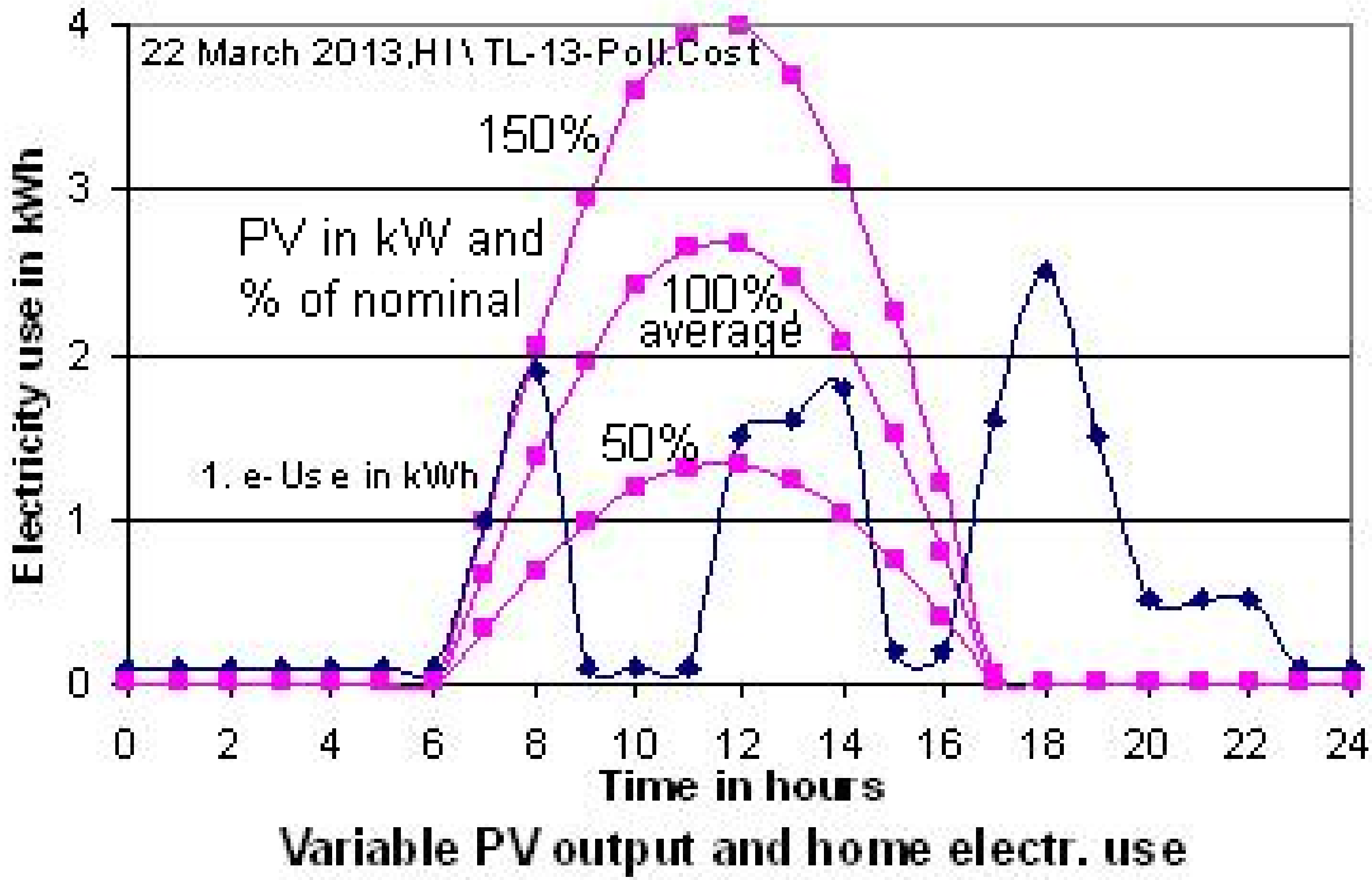
Problem: Load & PV Variability of One Home



1. Average daily use: 16.3 kWh, or 687 watts, w/o battery, showing (smoothed) output range of a 4-kW PV. 100% output equates to 16.3 kWh/d at a 17% capacity factor.

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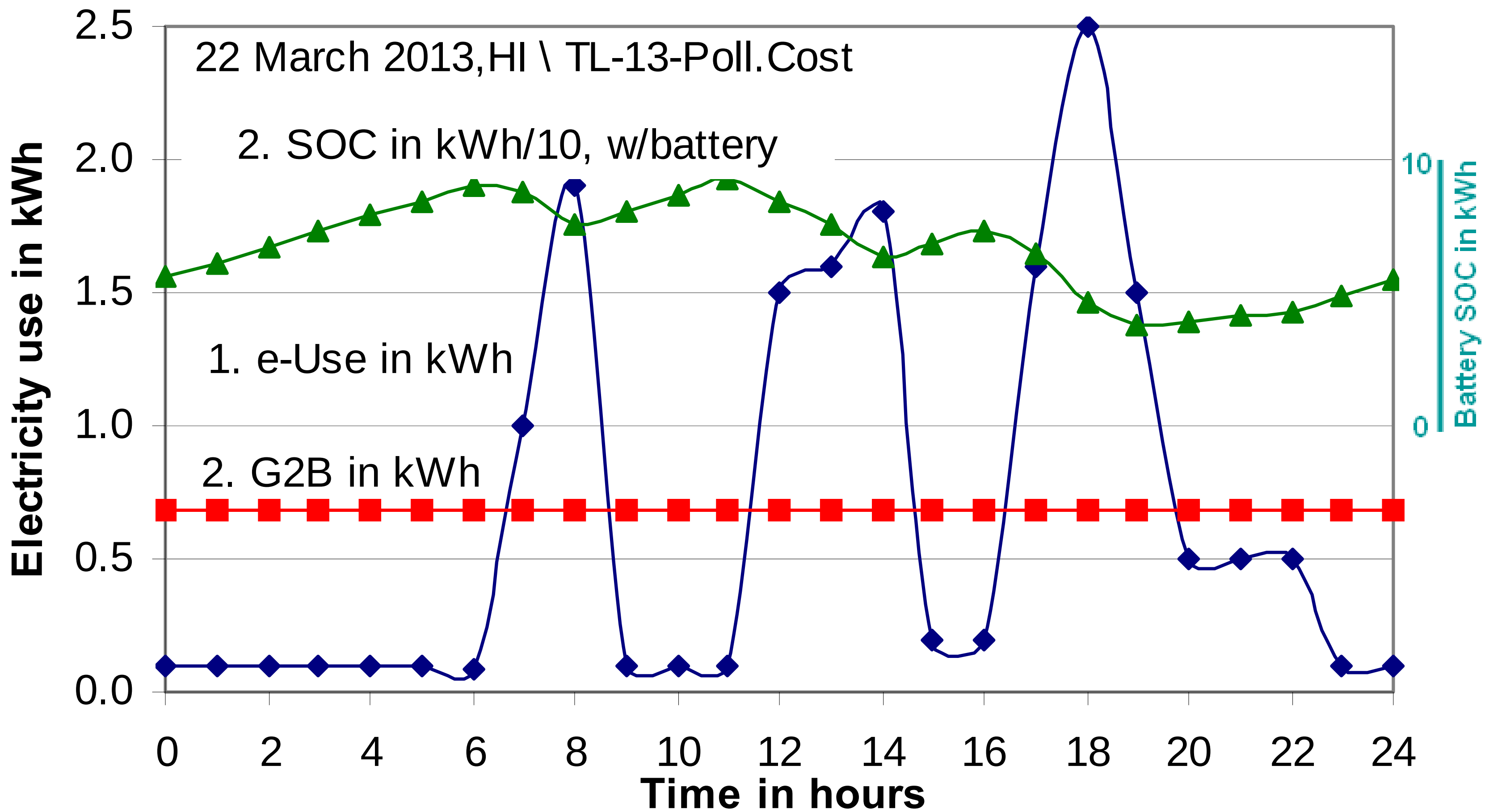
Solution #1: Add a 10 kWh Battery, no PV



Daily home electr. use, powered by grid

1. Avg. grid load: 16.3 kWh/day, or 687 watts, w/o battery.
2. Same home after addition of 10 kWh Li-ion battery.

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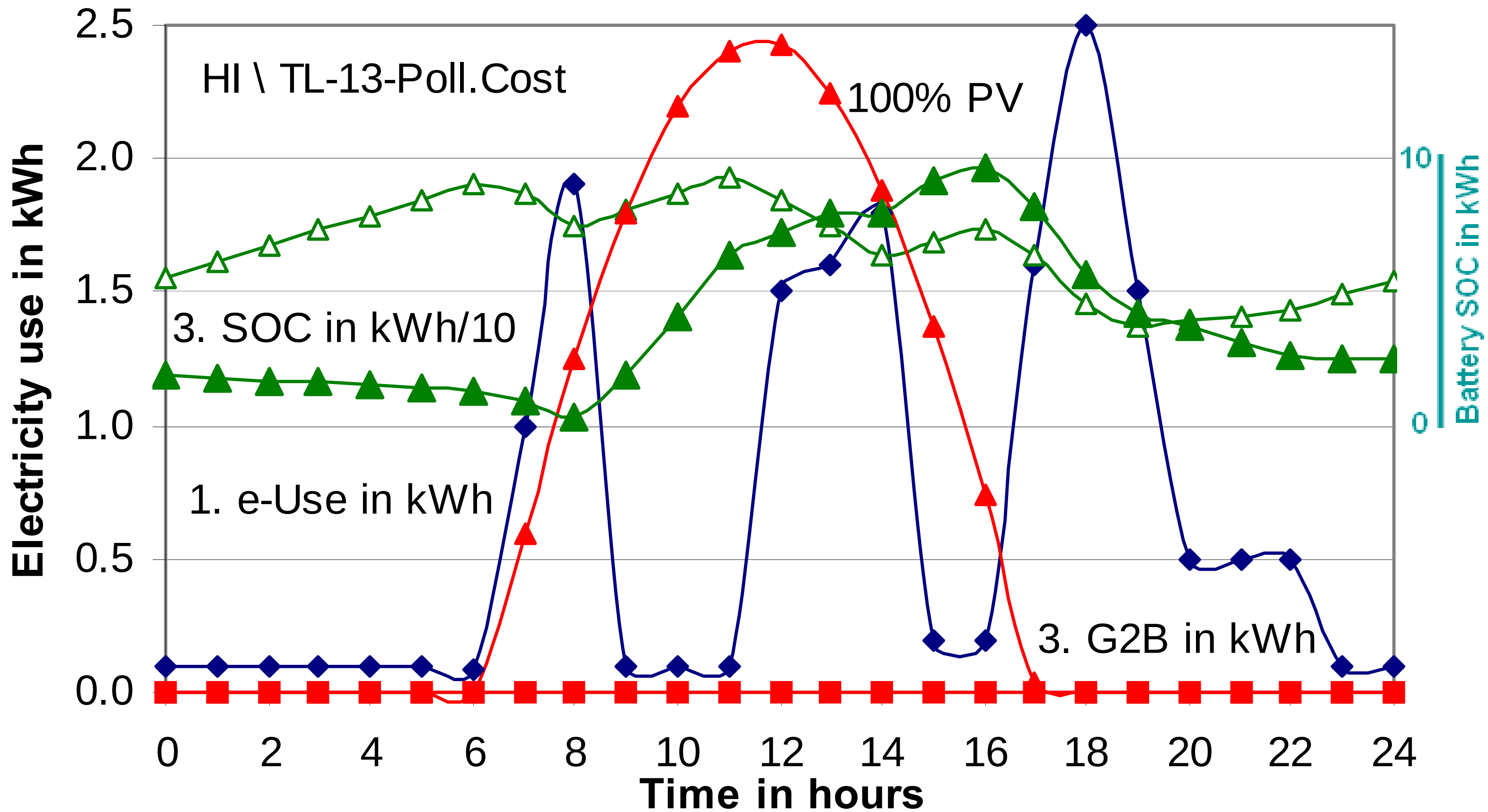
Solution #2: Add 4-kW PV + a Battery (PVBB)



Daily home electr. use, powered 100% by PV

3. Same home w/ 10-kWh Li-ion battery & 4-kW PV addition

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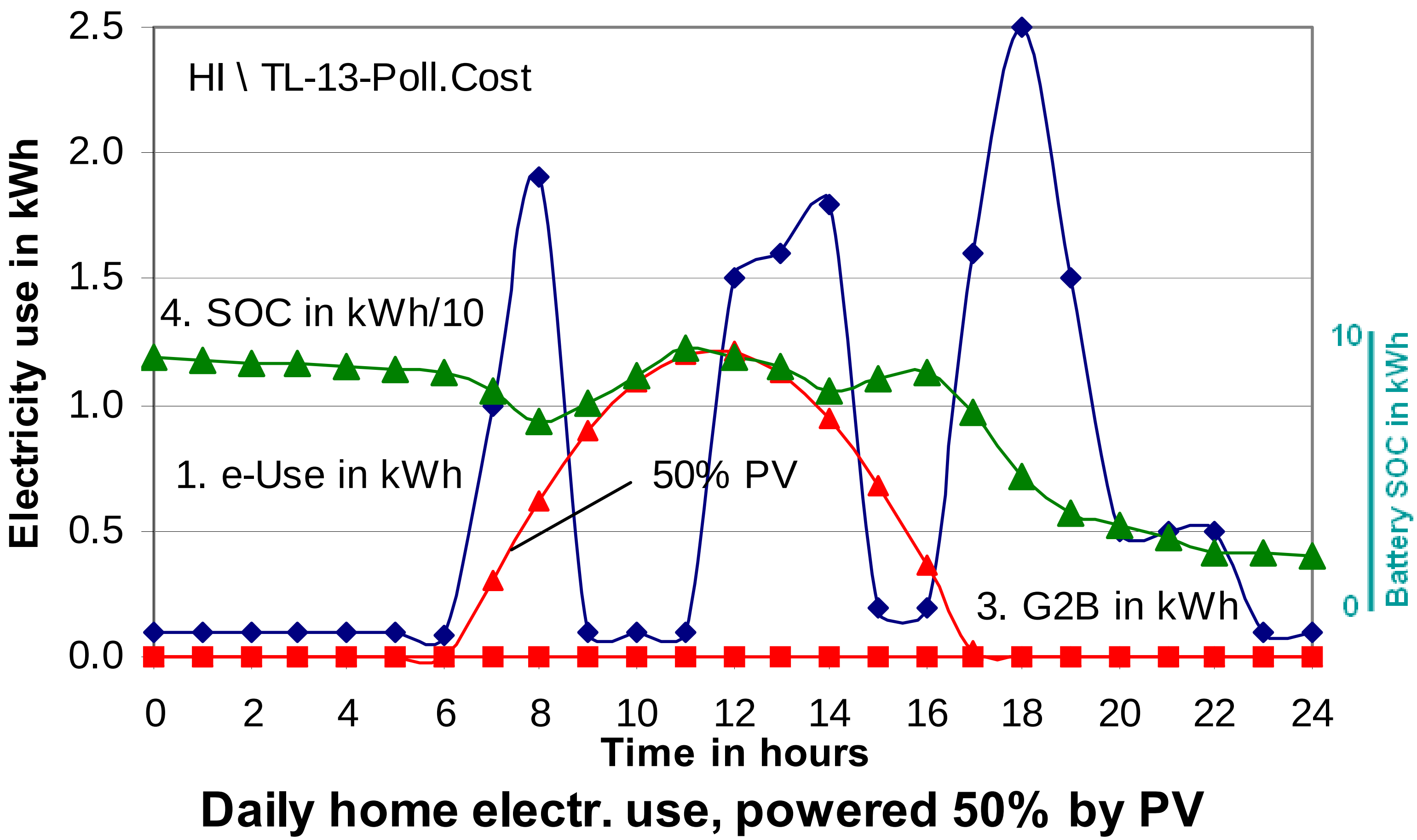
Solution #2: But What Happens on a Cloudy Day?



4. Same home w/ PVBB but in cloudy weather: 50% PV output, before turning on grid trickle charger.

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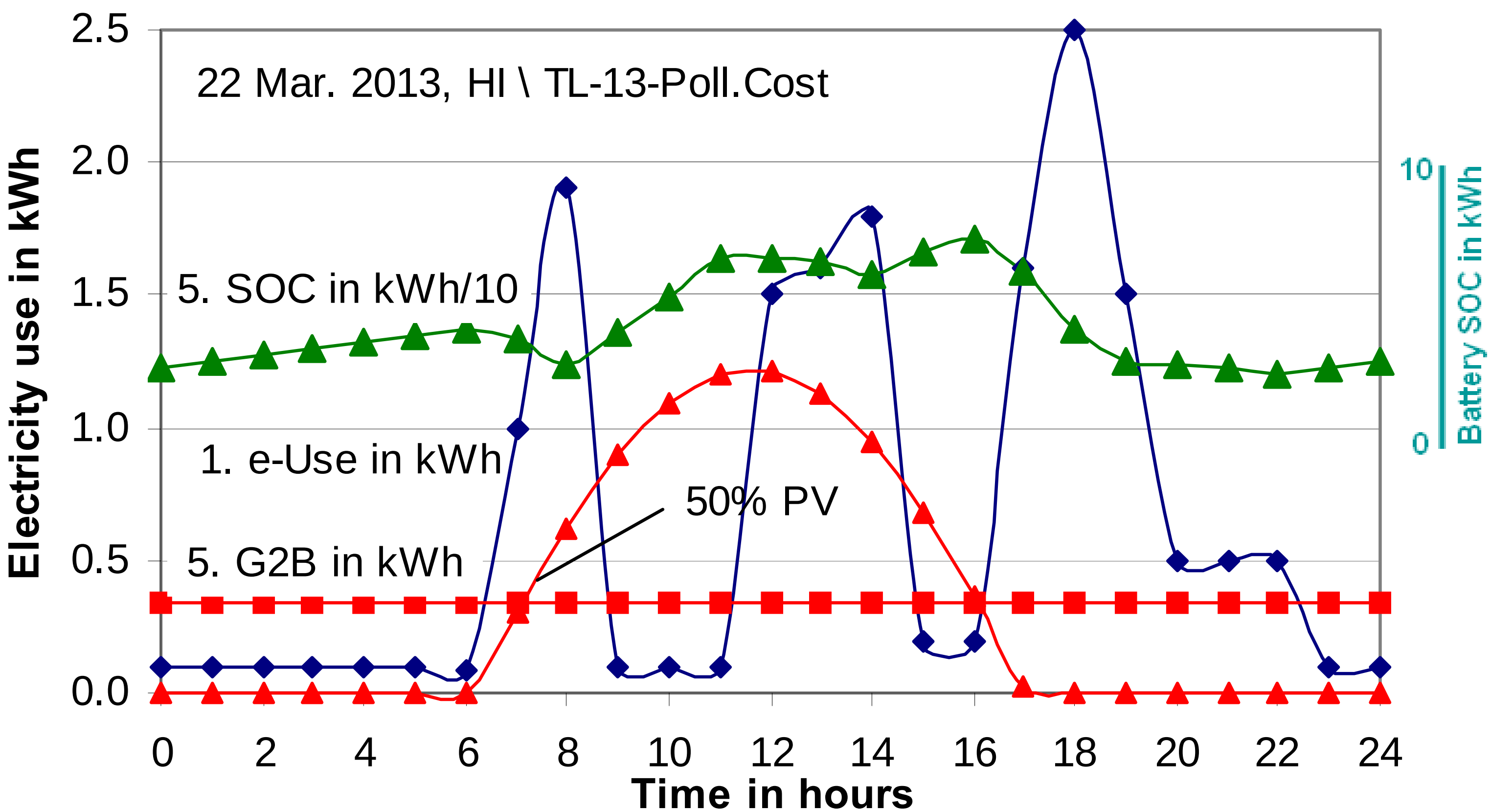
Solution #2: Trickle Charge on Cloudy Days



Daily home electr. use, powered 50% by PV

5. Same home w/ PVBB but in cloudy weather: 50% PV output, AFTER turning on 343-watt grid trickle charger.

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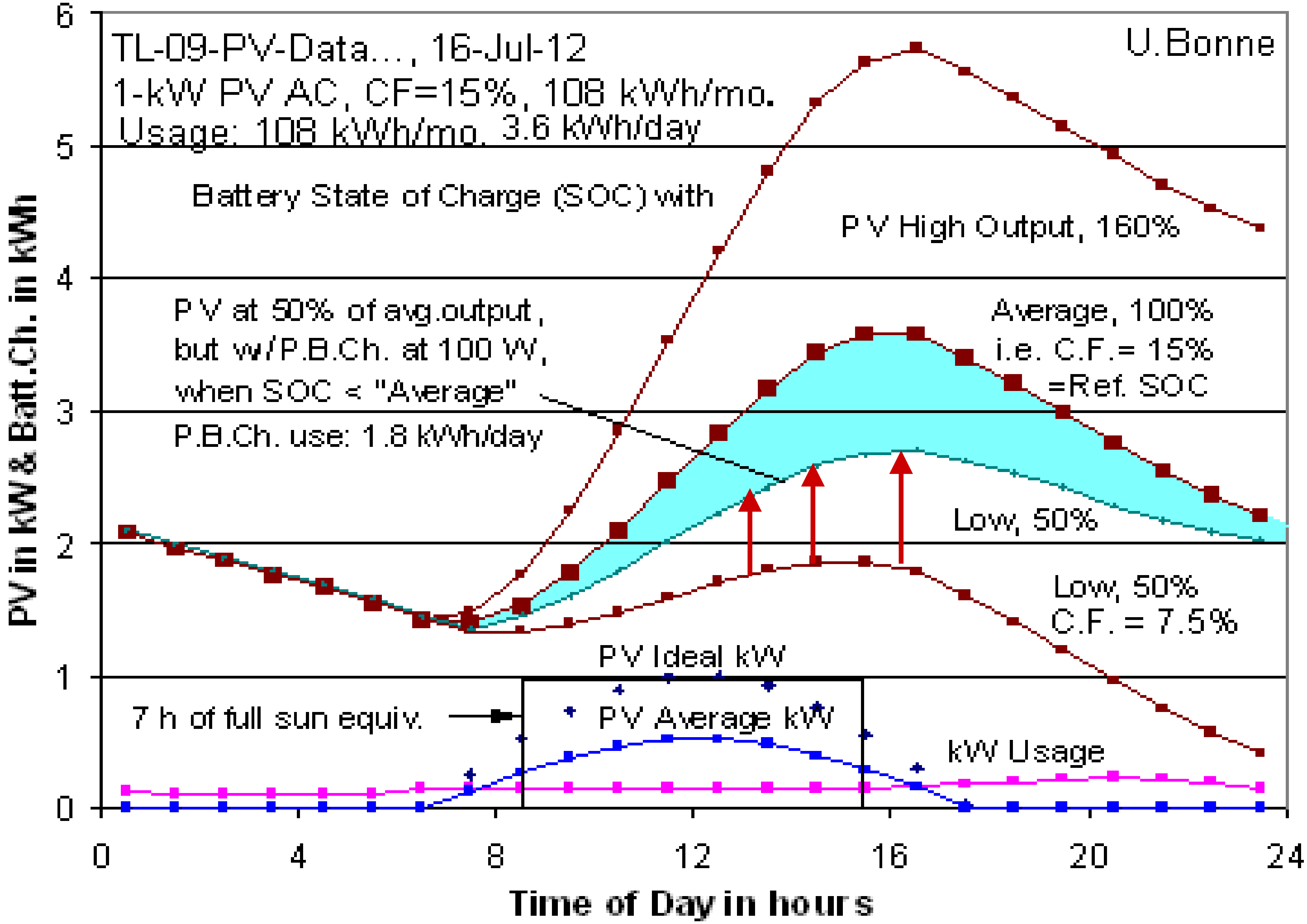
Implementation: Use of a Programmable Battery Charger



Load profile from LBL http://drrc.lbl.gov/system/files/58956.pdf

Solution #2: Excess Charge on Sunny Days.
Excess Generation of 8 kWh/day

Energy Management options **for peak 4-kW PV output days:**

- **Inject a steady 343 W into the grid:**
  - For use as trickle charge for neighbors under clouds
  - To reduce oil use for industrial customers

- **Pump or produce extra water for irrigation**

- **Produce hydrogen**

- **Other …**

To maximize economic PVBB benefit, it is important to maximize self consumption

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PVBB Implementation
NREL Insolation Data – PVWATTS vs. 2

http://rredc.nrel.gov/solar/calculators/PVWATTS/version2/pvwattsv2.cgi Bonne residence

Station Identification	
Cell ID:	0086299
State:	Hawaii
Latitude:	19.7 ° N
Longitude:	156.0 ° W
PV System Specifications	
DC Rating:	4.00 kW
DC to AC Derate Factor:	0.860
AC Rating:	3.44 kW
Array Type:	Fixed Tilt
Array Tilt:	19.7 °
Array Azimuth:	180.0 °
Energy Specifications	
Cost of Electricity:	44.0 ¢/kWh

Results

Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	5.31	524	230.56
2	5.68	505	222.20
3	5.87	582	256.08
4	5.86	563	247.72
5	5.58	549	241.56
6	5.62	534	234.96
7	5.64	550	242.00
8	5.99	586	257.84
9	6.11	572	251.68
10	5.76	557	245.08
11	5.37	508	223.52
12	5.17	508	223.52
Year	5.66	6537	2876.28

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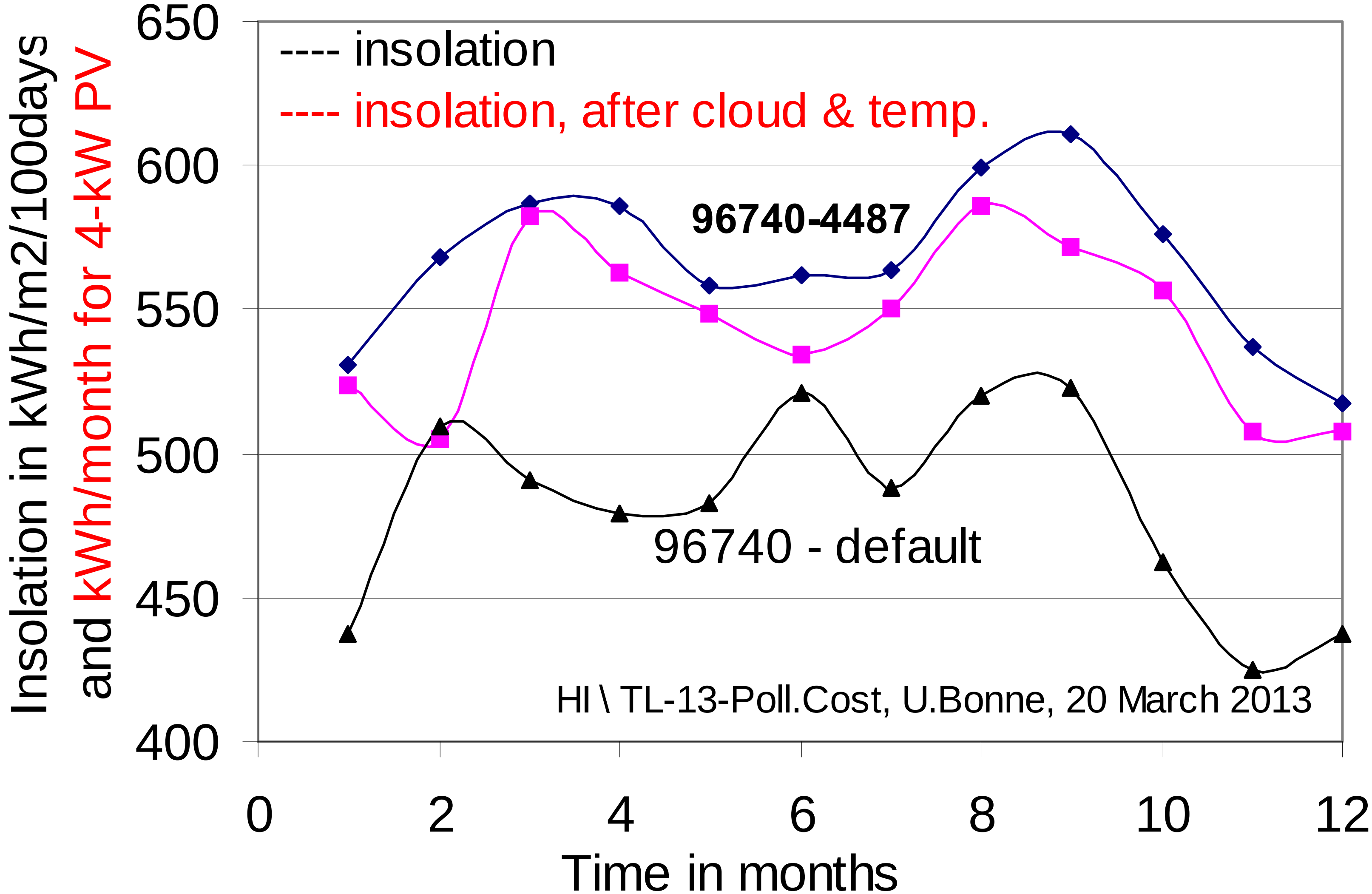
PVBB Implementation
NREL Insolation Data – PVWATTS vs. 2



Sizing a PV system: Annual PV output to match annual load or 10-30% more?

http://www.nrel.gov/rredc/pvwatts/grid.html

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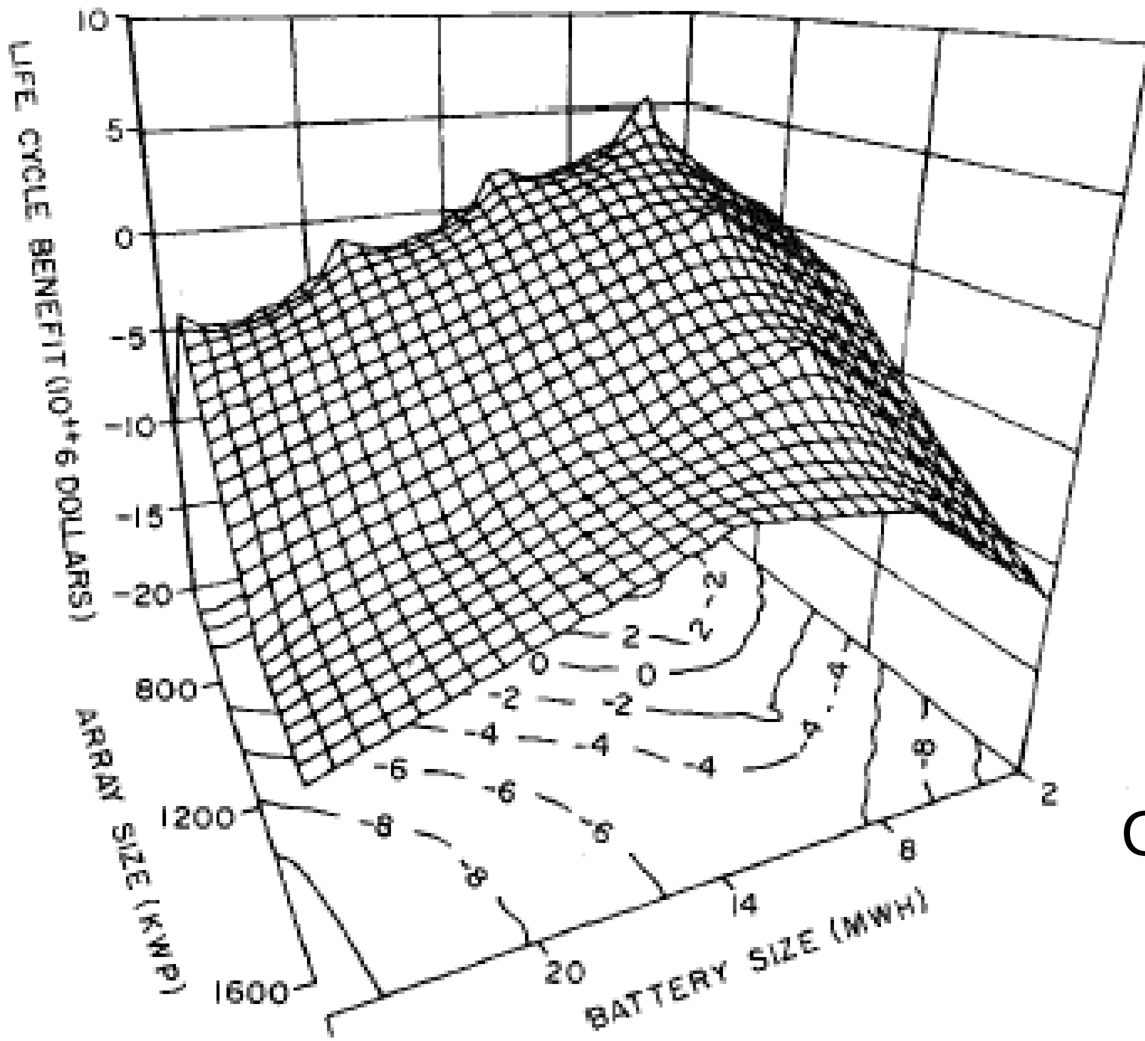
PVBB Implementation
David Menicucci, Sandia Nat.Lab., 1985



LA Battery

Optimal Size:

~6 kWh/kW

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PVBB Implementation
New Mexico Solar Energy Association (old)

Large house; 25 panels, = 5 kW PV
Daily energy need, E = 20 kWh (600 kWh/month)
Capacity factor, F = 16%
Battery (LA): 2 x E = 40 kWh (20 kWh for Li-ion)

Then the installed costs are:

Panels + Inverter: $26,666+5,000 =
= $31,666 (31.7/5=6.3 $/W is high)
Batteries (upfront) = $4000@ 100 $/kWh - acquisition
Batteries (life-cycle) = $16,000 5-8 ¢/kWh - Life Cy. Cost
Cost up front = $35,666.
Cost life-cycle = $47,666
Cost = 47,666/(5*0.16*8760*30) = 22.6 ¢/kWh w/o Tax Cr.

http://www.nmsea.org/Curriculum/7_12/Cost/calculate_solar_cost.htm

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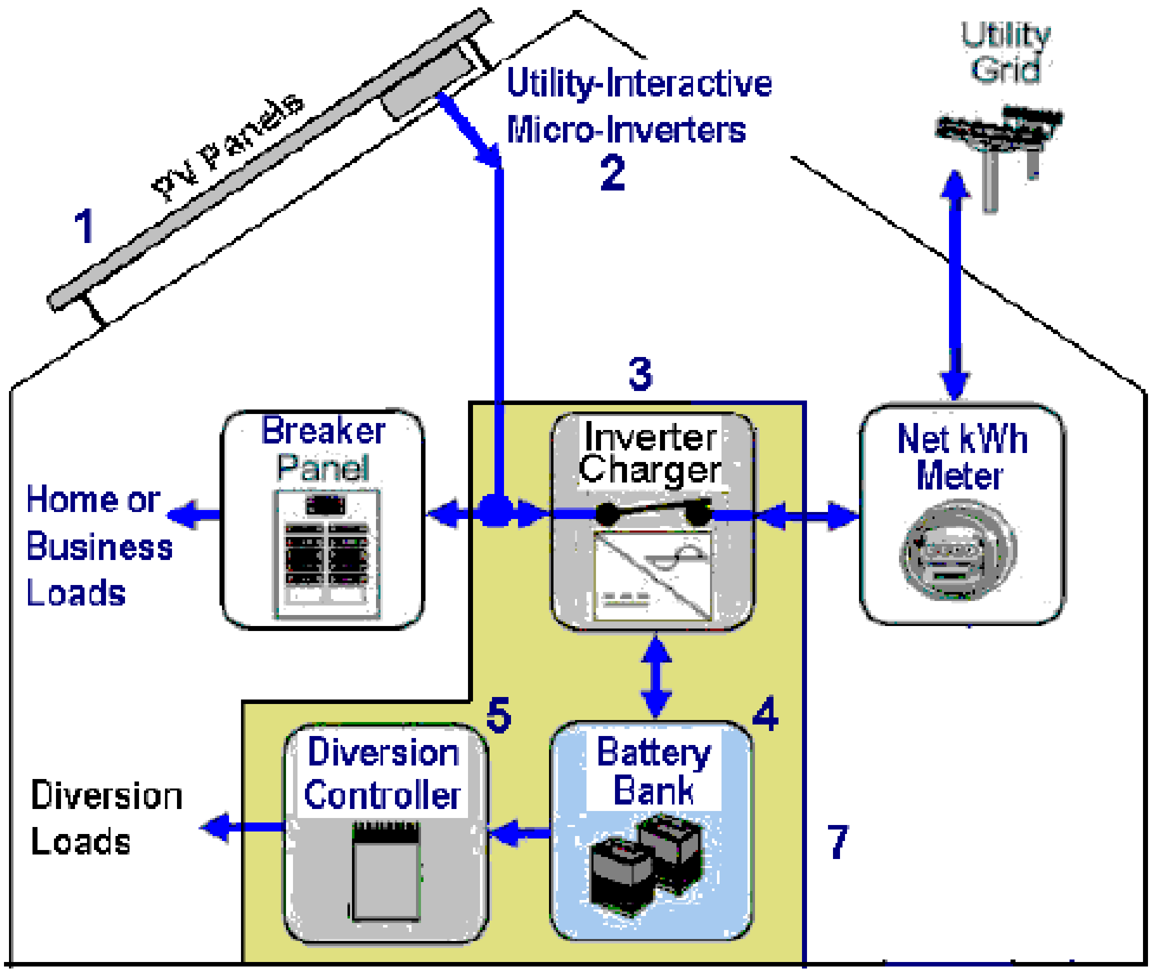
Implementation: AC-Coupled PVBB



Data adapted from WholesaleSolar Quote #57738, **6 Nov.2012**

	$/W AC-C
1. PV Panels	2.70
2. PV Inverter(s)	1.00
3. Inverter / Charger	2.00
4. Batteries	0.65
5. Diversion Control	0.20
6. Breakers & Miscell.	0.25
7. Cabinet	0.15
8. Shipping	0.50
9. Installation Labor	0.50
10. Profit (10%)	0.90
11. Permitting	0.10
12. Inspection	0.05
Total CapEx	9.00
13. Tax Credit, 44%	- 3.58
14. Interest, 4%/y,10y	1.26
Total Cost	6.69

30-year levelized electricity cost: 669/(0.17*8.76*30) = **15 ¢/kWh**

http://alohafuels.pbworks.com/f/PB-12-HELCO-AKP-PUC-1.pdf, adapted from

http://www.magnumenergy.com/Literature/Application%20Info/AN%200002%20AC%20Coupling%20(Rev%205-10).pdf

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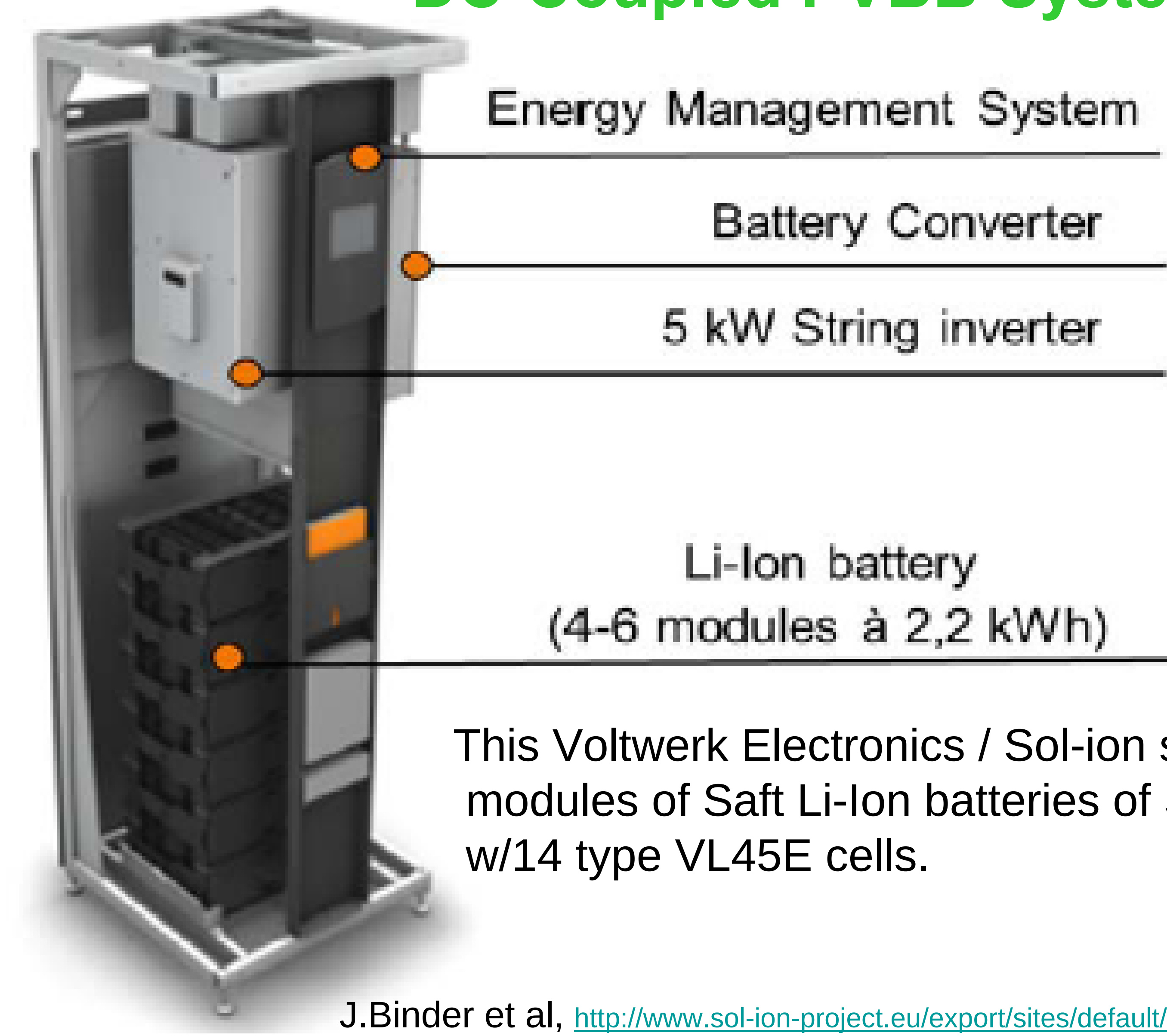
Implementation: Electronics & Battery for DC-Coupled PVBB System

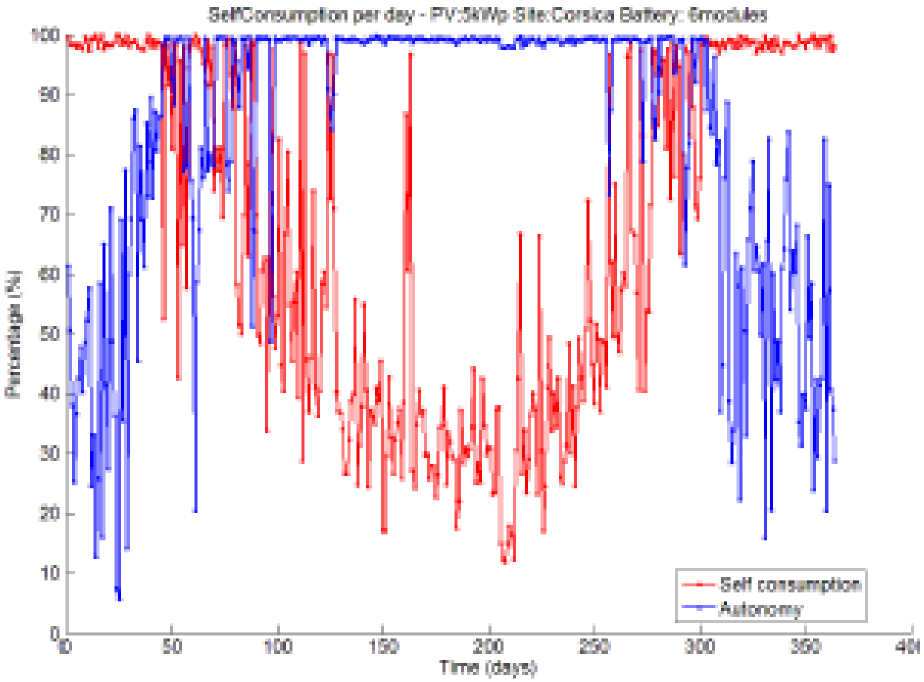


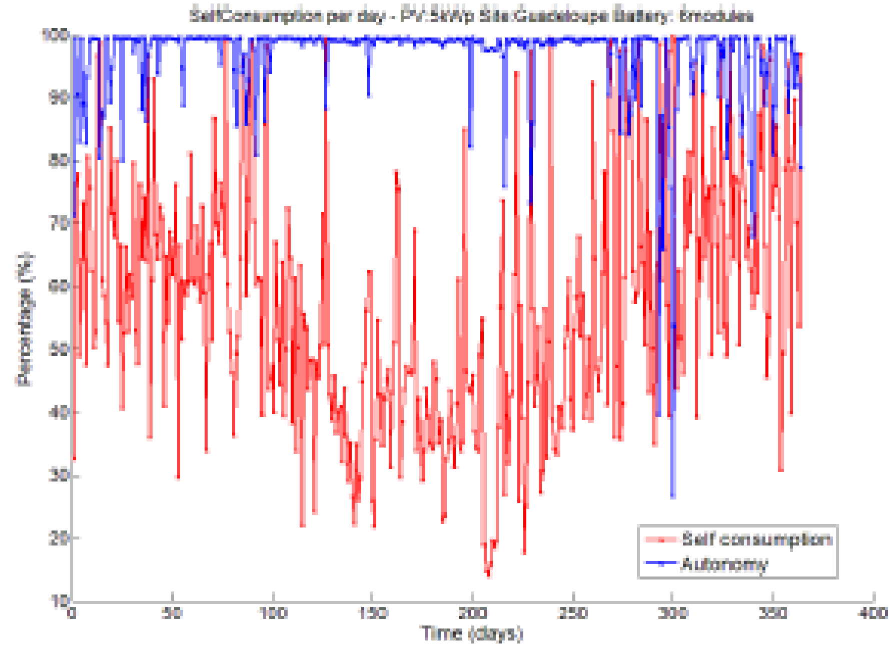
This Voltwerk Electronics / Sol-ion system can hold 4-6 modules of Saft Li-Ion batteries of SAFT, of 2.2 kWh/ea., w/14 type VL45E cells.

J.Binder et al, http://www.sol-ion-project.eu/export/sites/default/en/_data/publications/mediatheque-files/Conf_PVSEC2012_Sol_IonFieldTrial_Proc.pdf

Implementation: PVBB Island Field Test Simulations

Corsica | Guadeloupe





Daily Self-Consumption and Autonomy

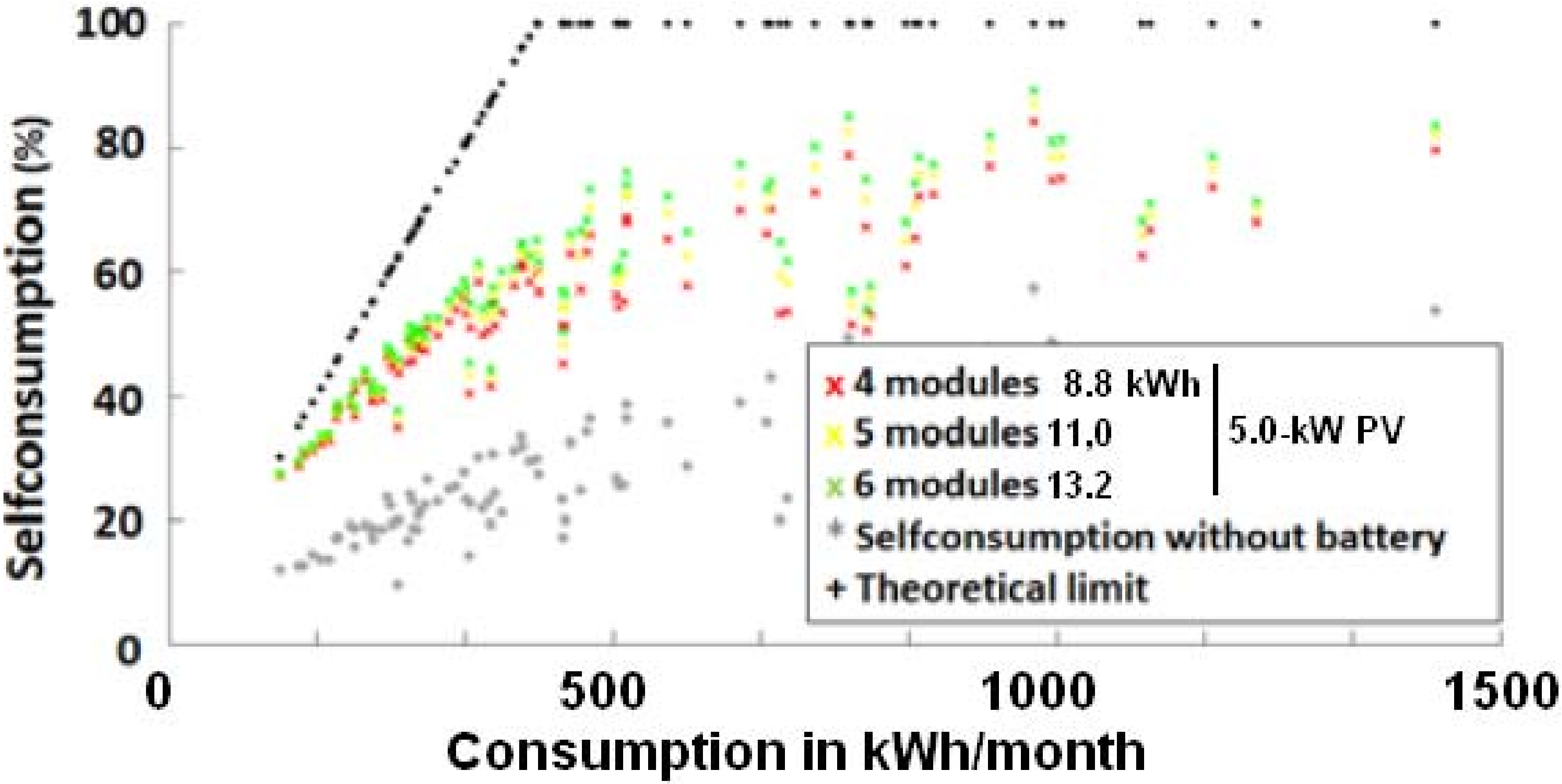
5-kW PV and 6 (2.2 kWh Li*) Saft/Sol-Ion battery modules

Message: Importance of sizing the PV and battery to maximize self-consumption

Center for Solar and Hydrogen Energy Research, Stuttgart, Germany

*14 cells type VL45E

Implementation: Simulated PVBB Field Tests



Simulated self-consumption vs. battery size, synthetic radiation profile for Kassel, Germany, and measured E-use from 89 households*.

* J.Binder et al, http://www.sol-ion-project.eu/export/sites/default/en/_data/publications/mediatheque-files/Conf_PVSEC2012_Sol_IonFieldTrial_Proc.pdf

Self consumption doubles by adding batteries to PVs

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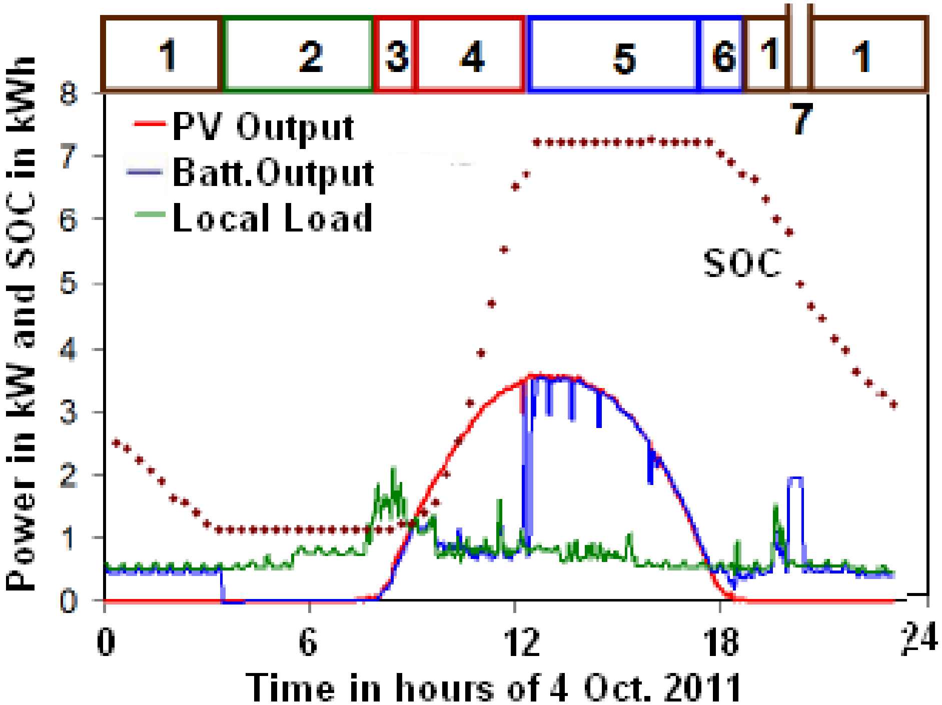
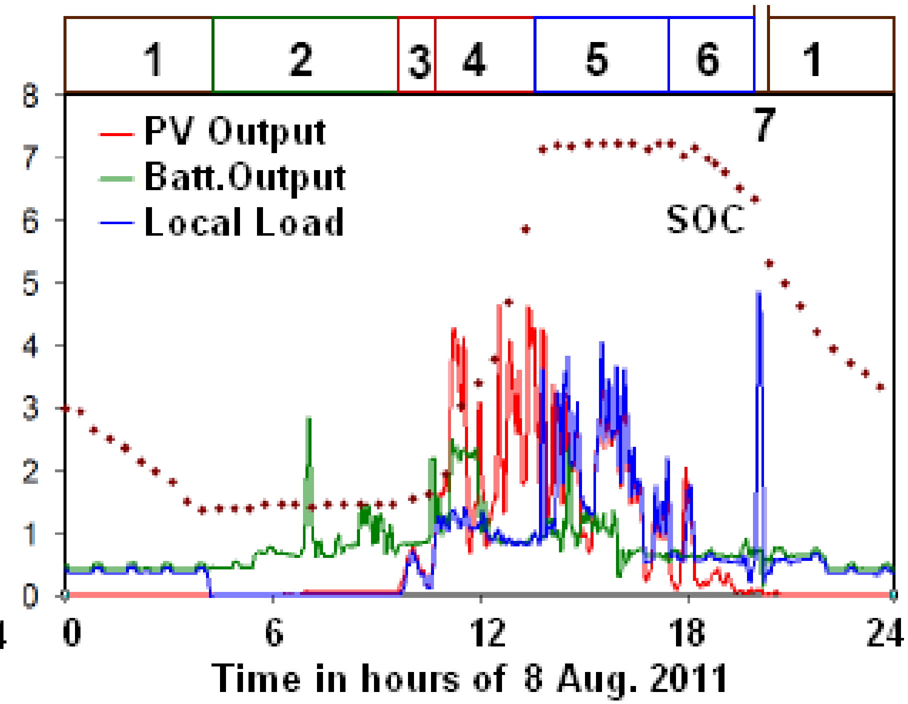
Implementation: Simulated PVBB Field Tests



Sunny Day



Cloudy Day

1 = Electr.(to load) from battery; 2 = E from grid; 3 = E from PV & grid; 4 = E from PV to charge batt.; 5 = E from PV & to grid; 6 = E from PV & B; 7 = E from battery & to grid.

PVBB energy management aimed at maximizing self consumption. Simulations using synthetic radiation profile for Kassel, Germany, and measured load profiles from 89 households.*

* J.Binder et al, http://www.sol-ion-project.eu/export/sites/default/en/_data/publications/mediatheque-files/Conf_PVSEC2012_Sol_IonFieldTrial_Proc.pdf

Win-Win Utility: Fewer System-Wide Failures w/Distr. PVBBs

Assume:

Nc = 10 Number of a few large, central generators
Nd = 10,010 Number of many small, distributed generators
kc ≅ kd = k = 0.5 Fraction of N failures ⇒ grid-wide outage
Pc ≅ Pd = P = 10^{-5} Probability of any one generator failure
Pcf = Probability of grid-wide failure due to Nc
Pdf = Probability of grid-wide failure due to Nd,

Calculate Pcf and Pdf (sum of geometrical series):

$$Pdf = Pd^{kdNd} + Pd^{kdNd+1} + Pd^{kdNd+2} + \ldots + Pd^{n} + \ldots + Pd^{Nd}$$

$$Pdf \cong Pd^{kdNd} \text{ and similarly: } Pcf \cong Pc^{kcNc}$$

Result: $Pdf / Pcf \cong P^{k(Nd-Nc)} = 10^{-5*0.5*10{,}000} = 1/10^{25{,}000}$

A more accurate calculation using **factorials** $\cong 1/10^{22{,}000}$

Conclusion: Under above premise, **the risk of a grid outage is many orders smaller for <u>many small distributed generators</u>, even if Pc~Pd/100**

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Win-Win: State Tax Revenue ~ Approx. Same with PVBBs

Table 2. 30-Year levelized energy costs and HI-State tax income: PV (9 $/W(p)) vs. oil.						
Parameters: PV+B, MW(cw) =	47		MGGE/y=	41	GWh/y =	403
Taxes on sales or GTE, % =	4		Taxes on income or profit, % =			9
	--------47-MW fossil-fuel utility----- =			------292 MW(p) distributed PVBB------		
	$/W(cw)	M$/30 years	M$/y	$/W(p)	M$/30 years	M$/y
Equipment Imports	4.00	186.9	6.229	7.45	2,175.4	72.513
Fuel Imports	105.05	4,907.9	163.596	0	0	0
Federal Subsid. (30%)	0	0	0	-2.70	-788.4	-26.280
Local Labor	2.00	93.4	3.115	0.65	189.8	6.327
OpEx or Battery Repl.	9.00	420.5	14.016	0.65	189.8	6.327
Hawaii Gov.Tax Revenue	11.33	529.4	17.647	2.02	590.0	19.667
State Subsidy, $5k cap	0	0	0	-1.25	-365.0	-12.168
Local Labor	0.18	8.4	0.280	0.06	17.1	0.569
Business Profit	0.05	2.5	0.084	0.04	10.5	0.350
Interest	0.02	1.0	0.034	0.04	12.3	0.409
Import	4.36	203.8	6.793	0.30	87.0	2.901
Electricity Sales or MMC	6.13	286.4	9.545	0.07	21.0	0.701
New Business (redirected oil import money to buy local)				2.74	799.5	26.651
Hawaii Net Imports	109.05	5,094.77	169.83	4.75	1,387.0	46.233
Household elec. cost in $	24,516.34	98,065	3,269	6.69	27,048	902
Levelized rate in ¢/kWh			59.2			16.3
		U.Bonne, 26-Nov-2012, HI \ TL-12-PV-BarGraph				
Assumptions to compare 4-kW(p)x73,000 home-PVs (=47 MW(cw)) vs. 47-MW fossil utility						
1. Average consumption of of 73,000 households is 460 kWh/month or 4-kW(p) PV						
2. Fossil generation plant OpEx = 5% CapEx/y, in addition to payments for imported fuel						
3. Fossil generator needs to be 2x oversize; but none for PV (w/NEM contract); CF = 0.16						
4. Utility fuel in $/gal and elec.rate in $/kWh, escalating at 2%/y,				3	0.44	, respectively
5. Fewer oil imports causes more taxable econ.actvity.W/30% "leakge," muliplier[13]=						3.32
6. The Hawaii-State 35% subsidy, capped at $5k, or 13.89% subsidy of $36k for an avg. 4-kW PV+B						

PVBB Energy Security

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Conclusions

PVBBs can be a win-win for all stake-holders:

- **PVBB users:** **achieve half of today's 40-44 ¢/kWh rate, based on a 25-30-year levelized LCC. Plus uninterrupted power during occasional grid outages. Maximize Rsc***
- **The Hawaii economy:** **boost in activity from saving 400 mill. gal oil imports. 250 (HI) & 2500 (US) jobs/ea.mill.pop. Raise ~7x the 11/2012 solar ind. jobs from 119 k to 750k**
- **The environment:** **no new land** use **for new energy plants; no** LNG, **bio-mass, geo., util.-PVs, nuclear, or inter-is.cable. Exceed Hawaii's 40% renewable energy goal. All pono.**
- **State/County:** **replace tax revenue from oil-imports and electr. sales w/revenue from increased economic activity**
- **The electric utilities:** **replace oil expenses w/ investment & maint. of PVBB systems where needed (new legal playing field).** Low-**loss grid income from managing "trickle charge" and PV surplus as needed. Distr.PV=hi. reliability**

***Maximize self-consumption ratio, Rsc = ∑PV,local / ∑PV**

Action: Distributed PVBB for Energy Security

Petition HI gov. / PUC to:

1. **Promote NEM contracts for PVBBs, w/≥ 2.5h(pk) storage Approve higher FIT rates for PVBBs than for PVs**
2. HELCO **to invest in d-PVBBs. No willing home left behind!**
3. **Encourage new bldg./electr. code to include PVBBs**

Rationale – distributed PVBBs provide:

- **Renewable, low-$/kWh & -maint., env.benign, <u>secure e-source</u>**
- **<u>Battery Backup</u> needed to meet the 5-9 pm peak demand period, cut transm. losses & cut imported oil**
- **<u>2nd-ary</u>** <u>Backup</u> **by grid = low maint. vs. on-site generator sets**
- **<u>Increased efficiency, reliability & uninterrupted energy</u>**
- **Reduce <u>3x transmission redundancy</u> (under sea & on land)**

Investment: 5 kW PVBB * 73,000 * 8-9 $/W = $3.1billion b.TC

200,000 / 2.75 ~73,000 homes, avg. suitable roof **area 50 m2 or 540 ft2, enough for 25 PV panels of 200 W = 5 kW(p) 500 kWh/month, 4.3 kW for 100% average utilization + 60-90 kWh/mo. or 2-3-kW PV per EV**

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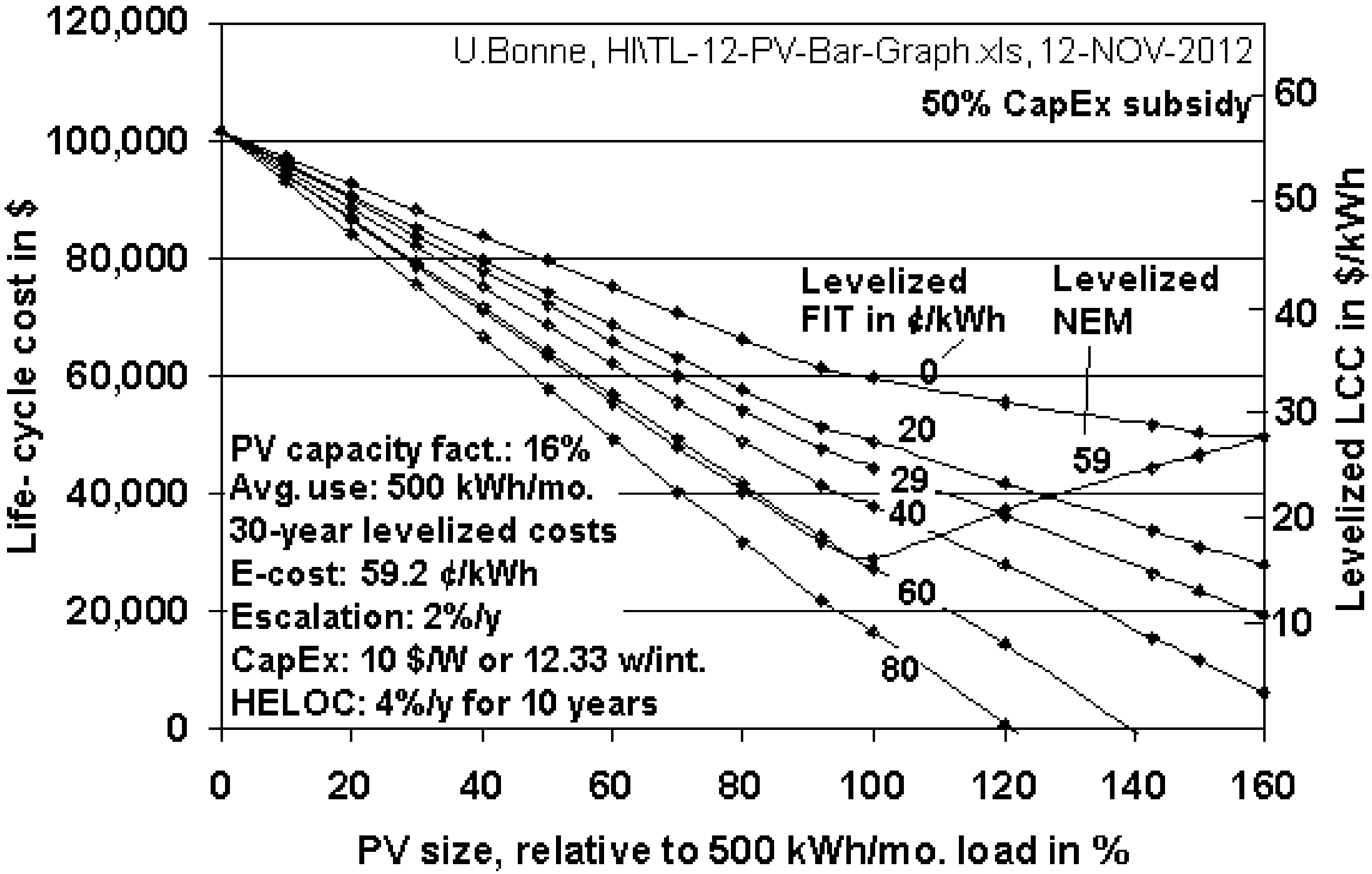
Action: How to achieve energy security



Levelized FIT rate would escalate from 21.8 to 29 ¢/kWh.
NEM contracts do not depend on annual FIT rate "updates"

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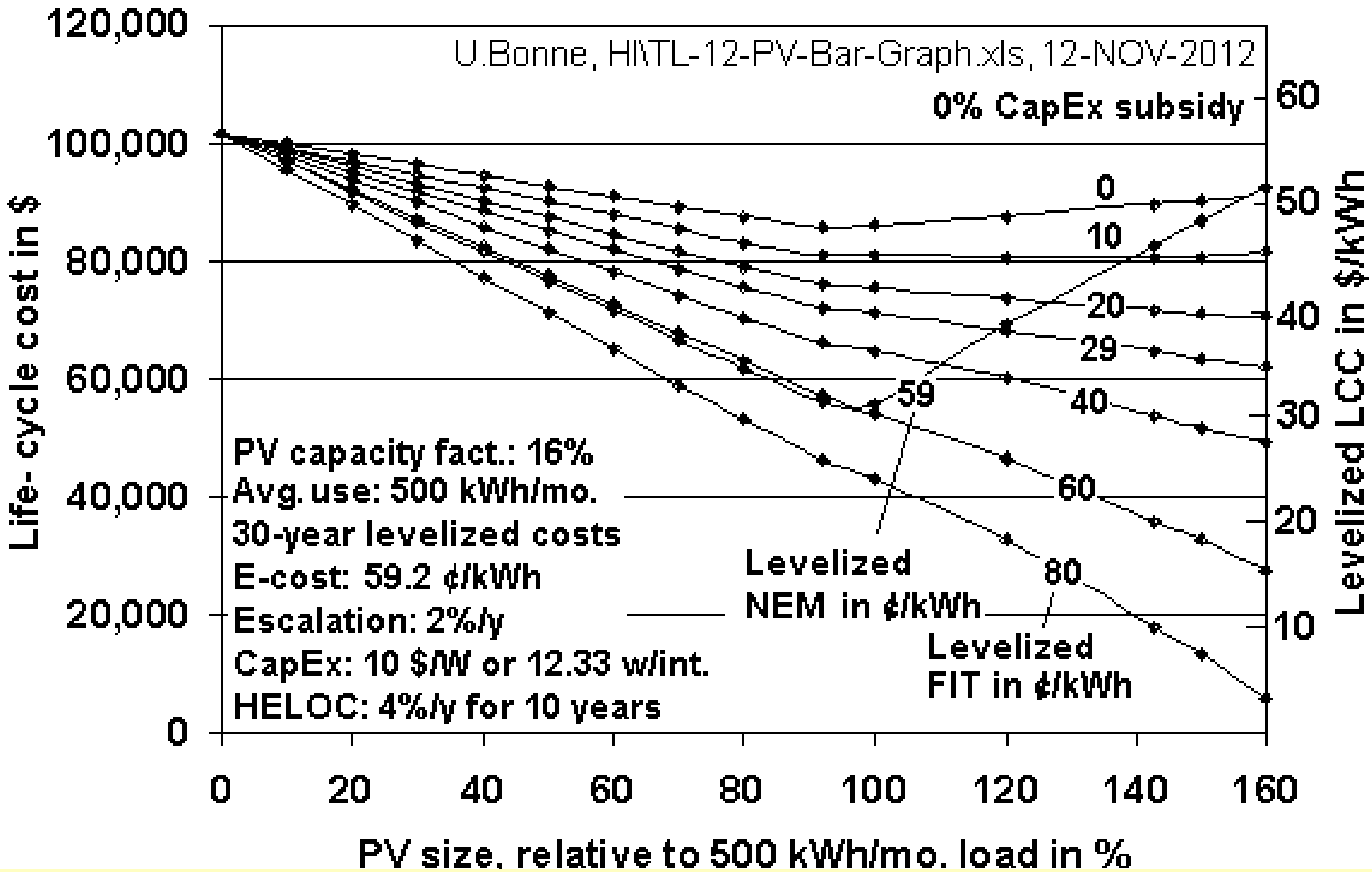
Action: How to achieve energy security



Levelized FIT rate would escalate from 21.8 to 29 ¢/kWh. NEM contracts do not depend on annual FIT rate “updates”

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Action: What is the next step to energy security?

The HI Energy Dept. deputy manager suggests that:

- **Xx House members sign a resolution asking for a Task Force (incl. gov. & energy officials)**
- **to gage how PVBBs can raise energy security**
- **to report findings by Oct.13**
- **to recommend policy steps to lawmakers**
- **Legislation to be drafted from those recommendations**
- **Those bills to be considered in the 2014 session**

Above is a process described in 3/15/13 WHT on how to achieve clean drinking water, free of Atrazine

Can the same process serve to achieve clean PV energy?

Investment: 5 kW PV * 73,000 * 8-9 $/W = $3.1 billion

200,000 / 2.75 ~73,000 homes, avg. suitable roof **area 50 m2 or 540 ft2, enough for 25 PV panels of 200 W = 5 kW.**

At 500 kWh/mo., **4.3** kW for 100% **average self-consumption**

6.1 kW for 70% **average self-consumption**

At 250 kWh/mo.,**3.0** kW for 100% **average self-consumption**

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Action: Distr. PVBB Utility Business Model

Mar. 25, 2013

SolarCity's Energy Sales Are Like Diamonds In The Sky

http://seekingalpha.com/article/1298881-solarcity-s-energy-sales-are-like-diamonds-in-the-sky?source=iphoneappmail

“The solar energy is sold back to the customers who've allowed SolarCity to install the equipment directly on the residential or commercial location.

Q4 showed a YOY nearly doubling of energy sales to over $14 million. Gross profit margin was an astonishing 66% with gross profit of $9.3 million”

Could a utility do this, but with our PUC limiting the profit?

Thank You
Questions?

Suggestions for further reading:

- Joe Schwartz, "AC Coupling in Utility-Interactive and Stand-Alone (PVBB) Applications,"
- https://solarprofessional.com/article/?file=SP5_5_pg74_Schwartz
- U.Bonne,"Clean Energy: Solar PV-with-battery storage for all?,"
- http://alohafuels.pbworks.com/f/PB-12-WHT-HELCO-IRP-3-950.pdf
- More: http://alohafuels.pbworks.com/f/PB-12-HELCO-AKP-PUC-1.pdf
- U.Bonne, "PV / PVBB ROI calculator," http://www.energyfuturehawaii.org/solarCalc.php
- C.Williams and U.Bonne, "Grid stability with over 50% of distributed PV energy and on-site storage," Concept Paper to DOE's SunShot Initiative FOA (Funding Opportuniy Application), 5 March 2013
- http://alohafuels.pbworks.com/f/PR-13-DOE-CPaper.pdf
- 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, Fr., 9Saft Batteries, Bordeaux, Fr.), "Sol-Ion PV storage system field test trial results, spread of operating conditions and performance evaluation based on field data," 27th Europ.PV Solar Energy Conf. EUPVSEC 2012, Frankfurt, Germany, http://www.sol-ion-project.eu/export/sites/default/en/_data/publications/mediatheque-files/Conf_PVSEC2012_Sol_IonFieldTrial_Proc.pdf

Implementation: FIT or NEM PVBB?

Table 1. Difference between NEM and FIT contracts*		
Question	**NEM**	**FIT**
• Payment for excess PV energy?	No, but accumulates & trades credits	Monthly payments for energy fed to grid
	Loses unused credits at end of 12 months,	Monthly billings for energy used from grid
• Is there a monthly fee?	No. But MMC, when no grid energy is used	$25/month, for any energy sold to grid
• Are the payments taxable?	NEM credits are not taxable	IRS views FIT payments are taxable income
• In insurance for PV needed?	Not for systems under 10 kW	Yes. General liability policy of 500k$ for
	* http://www.heco.com	bodily injury & prop/damage for PVs ≤ 20kW

http://www.heco.com/portal/site/heco/menuitem.508576f78baa14340b4c0610c510b1ca/?vgnextoid=2ef1894ba55bb210VgnVCM1000005c011bacRCRD&vgnextfmt=default&cpsextcurrchannel=1

Win-Win for Big Island Utility – PVBB On-Grid v.1.1

Sales to 73,000 homes @ 0.41 $/kWh, using 39% & 0% oil-based product

	BEFORE	AFTER 100% PV
	270*0.39=105 MW	~ 1 MW
Annual oil-kWh sales	*438 GWh / $ 180M	4.38 GWh / $ 2M
Annual excess PV-kWh sales	$ 0 M	54 GWh / $ 22M
PV-kWh freebees	$ 0 M	134 GWh / $(55)M***
Annual MM Charges <2.5% homes	<$ 0.5M	$20/mo./home $ 18M
Annual fuel costs	42 Mgal / $-125M	0.4 Mgal / $- 1M
Annual O&M generation expen. 3%	$- 10M	$- 5M
Annual O&M distrib. expenses 3%**	$- 27M	$- 27M
Annual Profit of 10%	$- 18M	$- 9M
Balance	0	0

Installed PV cost: 6.1 kW*73,000*4 $/W = $1800M; or 3kW ÷ $900M

* = 500 kWh/mo.*12 mo./y*73000 homes/1000000*0.41 $/kWh

** O&M Expenses are assumed to be 3% of CAPEX/year

*** free electricity, worth $55M if sold at 0.41 $/kWh, or worth
134*4 = 536 million EV miles or 45,000 EVs @ 12,000 miles/year, at
a fuel charger cost of $3000/30y/12000 = 0.83 ¢/mile
134*0.7/33.7*60mi,/GGE = 167 million FCV miles or 14,000 FCVs
at a fuel cost of 3-4 $/GGE-H2 or 5 - 7 ¢/mile. CV at ~ 15 ¢/mile

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Win-Win for Big Island Utility – PVBB On-Grid v.1.2

Sales to 73,000 homes @ 0.41 $/kWh, using 39% & 0% oil-based product

	BEFORE	AFTER 100% PV
	270*0.39=105 MW	~ 1 MW
Annual oil-kWh sales	*438 GWh / $ 180M	4.38 GWh / $ 2M
Annual excess PV-kWh sales	$ 0 M	76 GWh / $ 31M
PV-kWh freebees	$ 0 M	112 GWh / $(46)M***
Annual MM Charges <2.5% homes	<$ 0.5M	$20/mo./home $ 18M
Annual fuel costs	42 Mgal / $-125M	0.4 Mgal / $- 1M
Annual O&M generation expen. 3%	$- 10M	$- 5M
Annual O&M distrib. expenses 3%**	$- 27M	$- 27M
Annual Profit 10%	$- 18M	$- 18M
Balance	0	0

Installed PV cost: 6.1 kW*73,000*4 $/W = $1800M; or 3kW ÷ $900M

* = 500 kWh/mo.*12 mo./y*73000 homes/1000000*0.41 $/kWh

** O&M Expenses are assumed to be 3% of CAPEX/year

*** free electricity, worth $46M if sold at 0.41 $/kWh, or worth
112*4 = 448 million EV miles or 37,000 EVs @ 12,000 miles/year,
at only the fuel charger cost of $3000/30y/12000 = 0.83 ¢/mile
112*0.7/33.7*60mi,/GGE = 140 million FCV miles or 12,000 FCVs
at a fuel cost of 3-4 $/GGE-H2 or 5 - 7 ¢/mile. CV at ~ 15 ¢/mile

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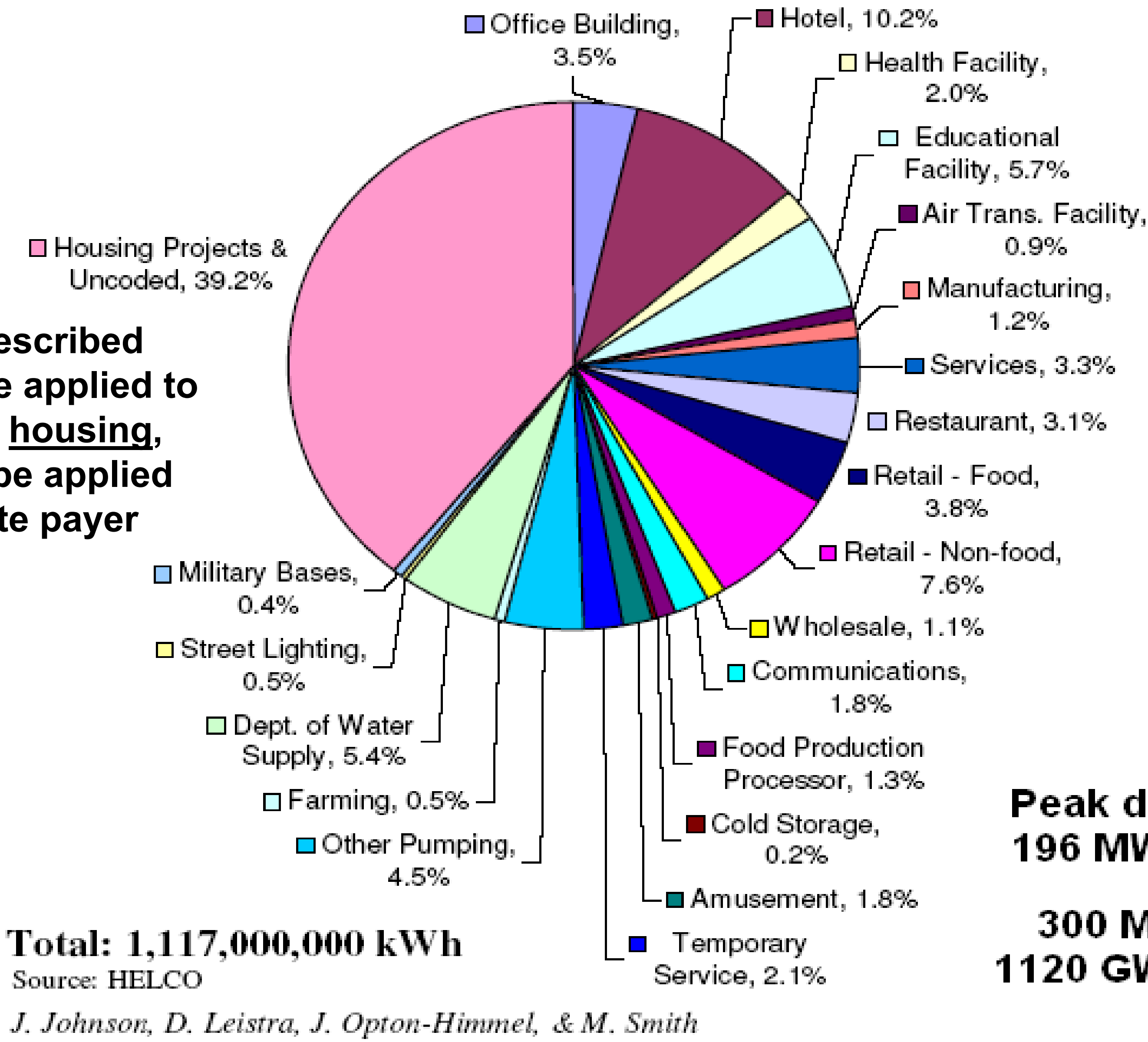
Big Island kWh Sales in 2005 (HELCO Data)



The PVs described below were applied to residential housing, but could be applied to other rate payer segments

Peak demand: 196 MW Dec.05

300 MW, 43%
1120 GWh/year

$/kWh Comparisons: Homes on- & off-grid vs. utilities

All entries normalized to 1 kW(peak)		Home PV	Home PV+B	Home PV+B	Utility PV	Fossil Fuel
CAPEX per 1 kW(peak) PV		On-Grid	Off-Grid	On-Grid	On-Grid	Utility
--		$/kW(peak)	$/kW(peak)	$/kW(peak)	$/kW(peak)	$/kW(peak)
PVs and inverters		3,000	2,500	2,500	1,500	1,500
Batteries, enough for 5-hour storage		0	1,000	1,000	2,500	0
Charge controller & information technoogy		0	340	340	0	0
Back-up generator, 2 kW/kW-PV		0	200	0	200	0
Installation of system (100% of hardware)		3,000	4,040	3,840	4,200	1,500
Transmission & distribution, at 1 M$/mile		0	0	0	3,333	3,333
Environmental impact anal., permits & reports		0	0	0	33	100
Real utilization of generated kWh by home or grid, %		70	70	70	70	43
OPEX for 30 yrs. per 1 kW PV; Capacity Factor, %		16	16	16	16	90
Minimum Monthly Charge		2,400	0	2,400	0	0
Land lease at 6000 $/y/acre		0	0	0	360	18
Op.& maintenan., taxes, salaries, insurance		0	0	0	3,520	7,220
Transmission loss (~10% for utilities)		0	0	0	1,383	4,872
Fuel for generator energy, back-up		0	720	0	360	58,906
Total life cycle cost in $/kW(peak)		**8,400**	**8,800**	**10,080**	**17,390**	**77,449**
A. Levelized electr.cost w/o subsidies in $/kWh		0.200	0.209	0.240	0.455	0.360
B. Levelized electr.cost after subsidies in $/kWh		0.129	0.124	0.157	0.363	0.360
C. Real level.electr.cost after subsidies in $/kWh		0.185	0.177	0.225	0.498	0.415
				FSyn\TL-11-MP-H2-Techs, 9 Oct.'12		

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