Replace non-renewable generation with solar energy.

100% PVBB (PV with Battery Backup)

Ulrich Bonne
Kailua-Kona, HI

Take home message:

"Yes, we can -- displace remaining oil-generators with solar"

Can we overcome the technical, environmental, economic, social and policy hurdles towards a 100% solar, grid-tied **PVBB, in partnership with** Ratepayers, Installers, Manufacturers, State, County, PUC and Utilities in Hawaii?

Political will??

First: Let me ask some questions (next 3 slides)

Early PVBB adoption saves 20¢/kWh x 6000kWh = $1200/home/year

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Question: How does Hawaii retail ¢/kWh compare?

Country, State	Area sq.miles	Population --	El. Retail Rate ¢/kWh	
Tonga	289	104,940 (2012)	**47**	June 2011
Jamaica	**4,244**	2,712,000 (2012)	**44.7**	Dec 2013
Hawaii Is.	**4,028**	186,738 (2011)	**42**	April 2014
Hawaii	10,932	1,392,000 (2012)	37	Sept 2012
Germany	137,846	81,000,000 (2012)	**36.25**	May 2013
Philippines	115,831	100,000,000 (2012)	**36.1**	Dec 2013 **geo flash**
Puerto Rico	**3,515**	3,367,000 (2014)	**25.5**	Jun 2014 **65%oil**
Kodiak Is.(AK)	**3,588**	13,600 (2008)	**18**	Mar 2010 **
Fiji	7,054	874,742 (2012)	**12-14**	
S. Dakota	77,116	844,877 (2012)	**11**	2013
Iceland	39,769	318,000 (2010)	**9-10**	July 2011 **geo flash**

** Pillar Mountain Wind 12.0 ¢kWh x 0.92 US$/Can$ 16.9% | Generation cost:
Terror Lake Hydroelectric 6.8 ¢kWh 82.7% | 7.8 ¢kWh 4/2014
Diesel Generation 28.9 ¢kWh w/ 3.50 $/gal 0.4% |

HECO's net income 1Q-2014: 35.4 M$, up 45 % for 1Q-2013: 24.4 M$
due to lower operational and maintenance expenses and higher revenues.

How can some utilities pay for fuel AND deliver power for 10-15 ¢kWh?

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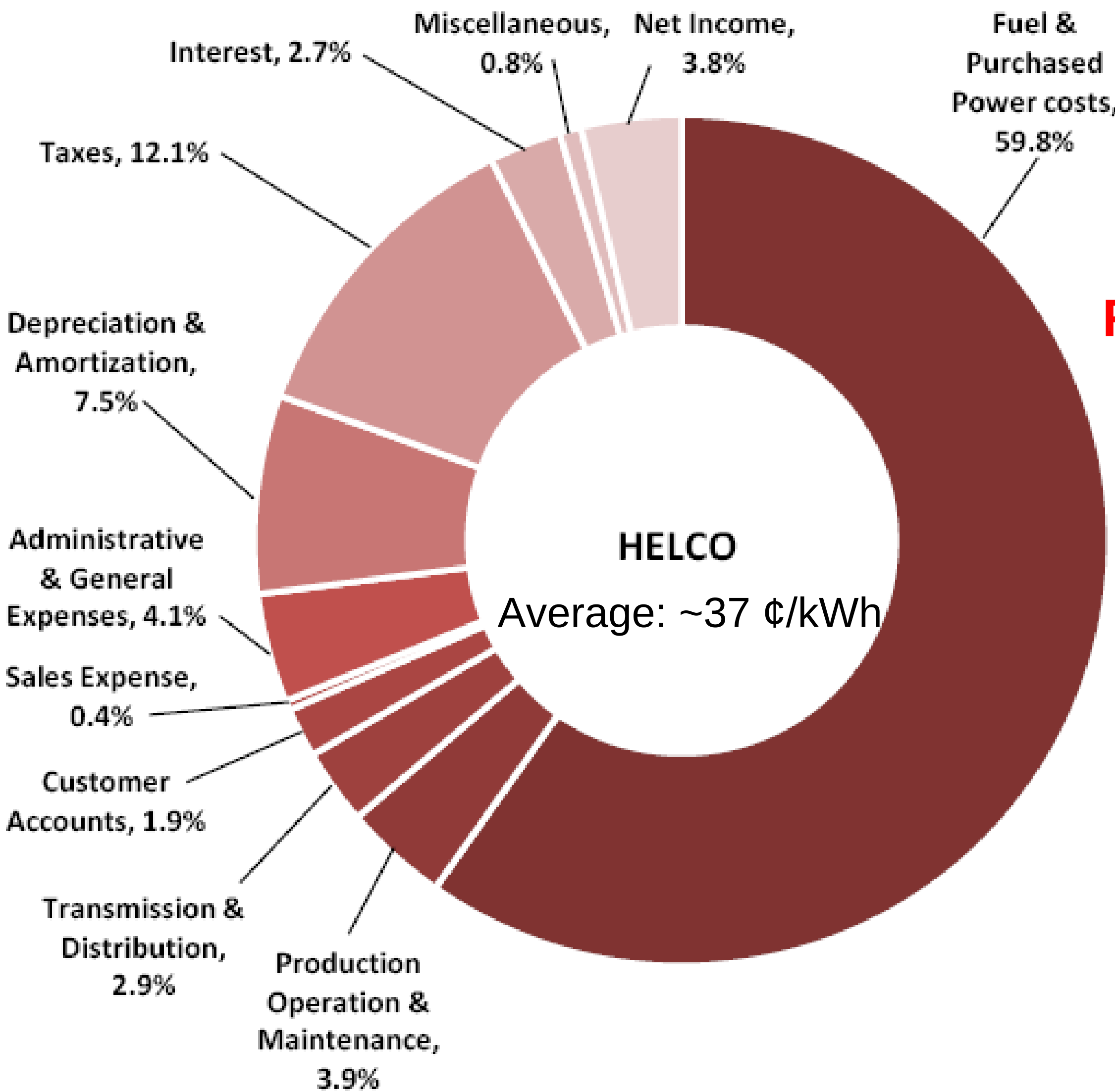
HELCO 2012 Revenue Breakdown



.598*37= 22.1 ¢/kWh

Residential: 42 ¢/kWh

Resid. Overhead: 20 ¢/kWh

Source: PUC Annual Report 2012-13, p. 56, Fig. 19, HELCO Revenue, 2012, by Expense Category http://puc.hawaii.gov/wp-content/uploads/2013/04/PUC-Annual-Report-Fiscal-Year-2012-13.pdf

Why is HELCO's overhead ~20 ¢/kWh, when US avg. < ~8 ¢/kWh

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Why Are Utility Overhead Costs so High in Hawaii?

HELCO:

Residential rate:	**42 ¢/kWh**
minus Fuel & PPA costs:	**– 22 ¢/kWh**
Overhead * :	**20 ¢/kWh**

***(Admin., T&D, Interest, Amortization, Customer Serv.,…)**

How come other utilities (USA average) can manage to keep their overhead costs to within 5 or 8 ¢/kWh, and HELCO can't?

CostCo diesel 7kW genset ~0.1 $/W. Utility gen.: >1 $/W. Why?

Demand for PV is high. Is 100% PVBB technically possible?

Is grid-tied "PVBB for All" technically possible and affordable?

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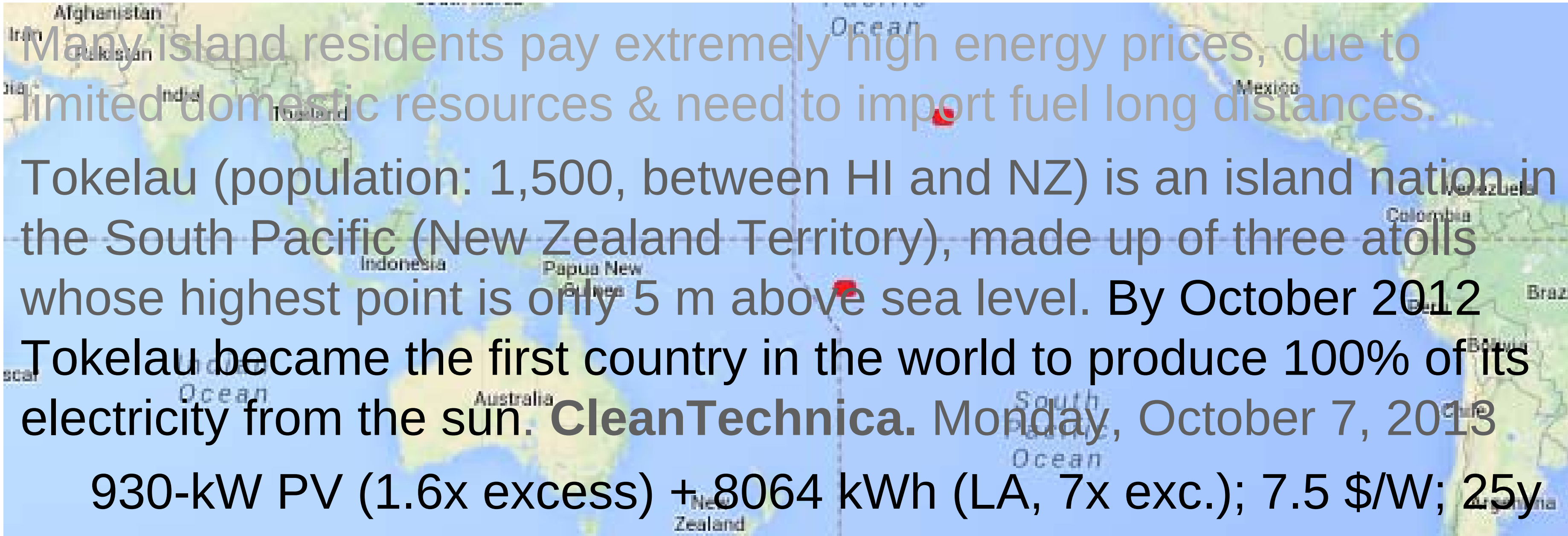
Tokelau Islands, a Country on 100% Solar Energy



Many island residents pay extremely high energy prices, due to limited domestic resources & need to import fuel long distances.

Tokelau (population: 1,500, between HI and NZ) is an island nation in the South Pacific (New Zealand Territory), made up of three atolls whose highest point is only 5 m above sea level. By October 2012 Tokelau became the first country in the world to produce 100% of its electricity from the sun. **CleanTechnica.** Monday, October 7, 2013

930-kW PV (1.6x excess) + 8064 kWh (LA, 7x exc.); 7.5 $/W; 25y

100% solar PVBB energy is achievable

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Replacing non-renewable generation with solar energy

Technical, economic & social feasibility for 100% PVBB based on:

1. Enough roof area suitable for solar energy
2. Reliability: Highest with many small generators
3. Insight: Daily PV output ~ +/- 50% of “design” average
4. Oversizing PV: ≥ 40% for grid-tied (≥ 80% for off-grid)
5. Storage: ≥ 1 night, or ~50% of total day’s avg. PV kWh
6. Economics: High up-front cost, but LCoE ~ 20 ¢/kWh
   Delaying costs ~$1200/year/home
7. Transition: Fairness to PV, non-PV and PVBB users and utilities
8. Political will

“100% PVBB” enabled by 8 key steps

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Preview: Conclusions and Recommendations

- Lets facilitate the popular demand for PV, due to its environmental, economic, and social benefits: long life; **no** maint. / power interruption / noise / emissions. We too can make “100% PVBB” work in Hawaii,” as in Tokelau and off-grid PVBBs

- Conversion to PVBB-electricity saves ~ $1200/year/avg.home, before Dec 2016

- Utility PVBB presently costs 2x more than private PVBB, **as will u-geo and u-LNG**

Proactive ratepayers can draft bills asking County/State/PUC for support (no subsidy) of PVBBs – for both private & utility-level PVBBs:

- Develop pre-approved PVBB configurations. Streamline permitting.
- Allow utilities to finance & partner with contractors to install roof-top PVBBs
- Develop a “fair” MMC, for PV, non-PV and PVBB users.
  Require greater transparency of utility overhead/administr. costs.
- **Encourage fair “Community Solar”: Any user can choose source & pay grid,** as with “Solar Gardens,” CCA or Community Solar SB2934, 2981,3110
- Compare our utility costs components w/others (Benchmarking)
- Incentivize utilities via “RE Integration Tax Credit” (as XcelEnergy)

PVBB 30-y LCoE < 20 ¢/kWh w/o cost of capital or subsidies

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1. Enough Roofs for 100% PVBBs

Do we have enough roof area for 100% PV generation? [1]

100% generation means 1200 GWh/year = 456 + 744

Need:

Homes: 38% = 456 GWh ~75,000 x 500 kWh/mo.

Businesses: 62% = 744 GWh

Road transp. / EVs: 650 GWh for EVs(100 Mgal/y @20% eff.)

Available, based on ground floor areas:

Homes[1]: 75.1 Mft^2 x 21.2 $kWh/ft^2/y$☺ = 1592 GWh/y

Accounting for ~40 % unsuitable roofs[1]

Enough for homes + all EVs + 44% oversize

Business.: ~23 Mft^2 x 21.2 $kWh/ft^2/y$☺ = 488 GWh/y

+ existing 30% renewables = 488+360=848

[1] U.Bonne, "http://friendsofnelha.org/can-hawaii-county-really-be-energy-self-sufficient/" 18 Oct. 2009, thanks to ground-floor area data from Hawaii County Real Property Tax Department

☺ 0.3 kWp/(39.1"x77.6"/144)*8760*0.17 = 21.2 $kWh/(year.ft^2)$.

Enough roofs for PVBBs: home + EV + 44% oversize. Business OK too.

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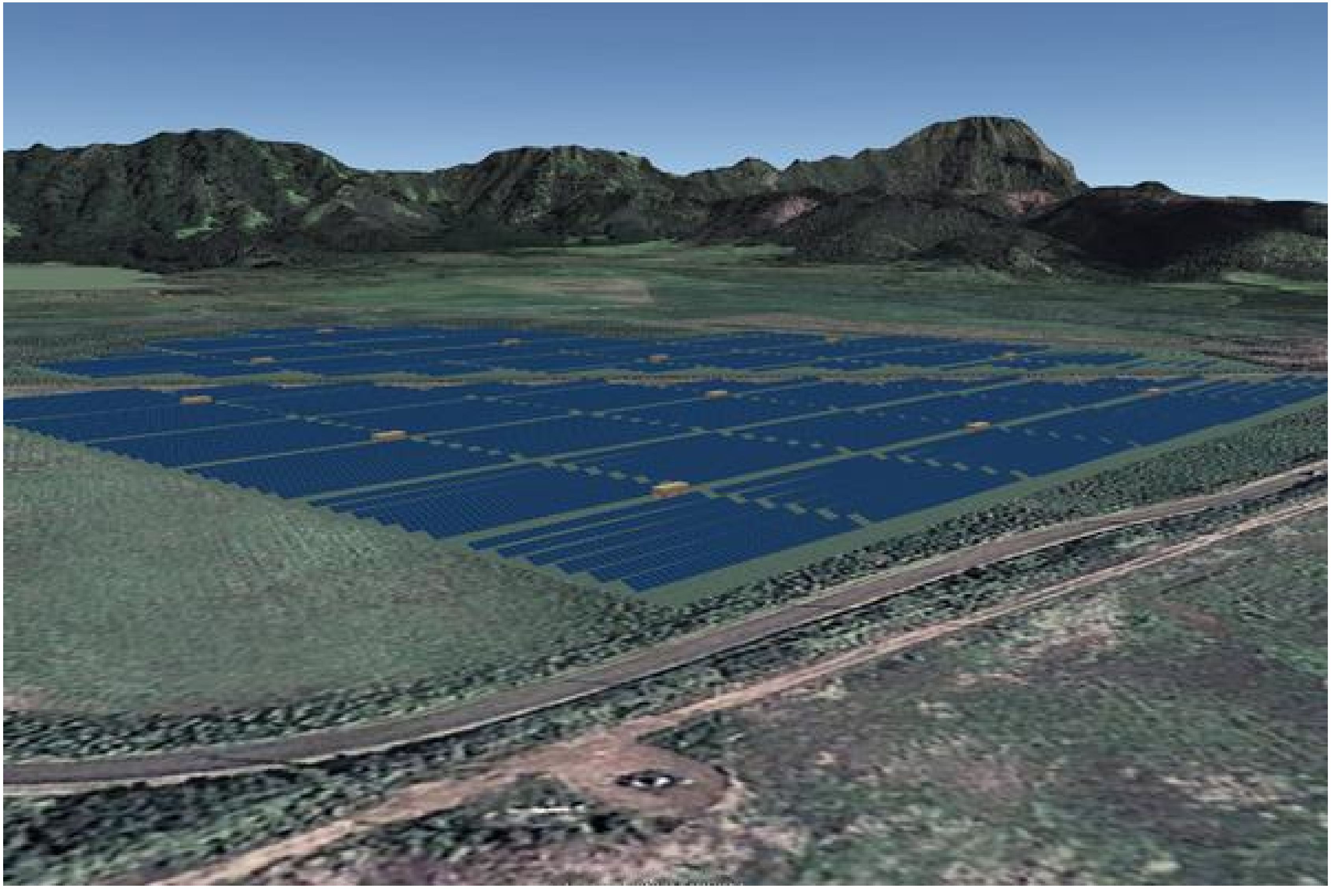
1. PUC OKs 12 MW (3.4 $/W) PV-Farm for KIUC on Kauai



Coop investment in clean, renewable energy. 67 acres. 24 MWh storage?

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2. Reliability of Electricity Supply

The probability of a single central generator outage supplying 1000 users is much higher than the simultaneous outage of 10 or 100 small PVBBs.

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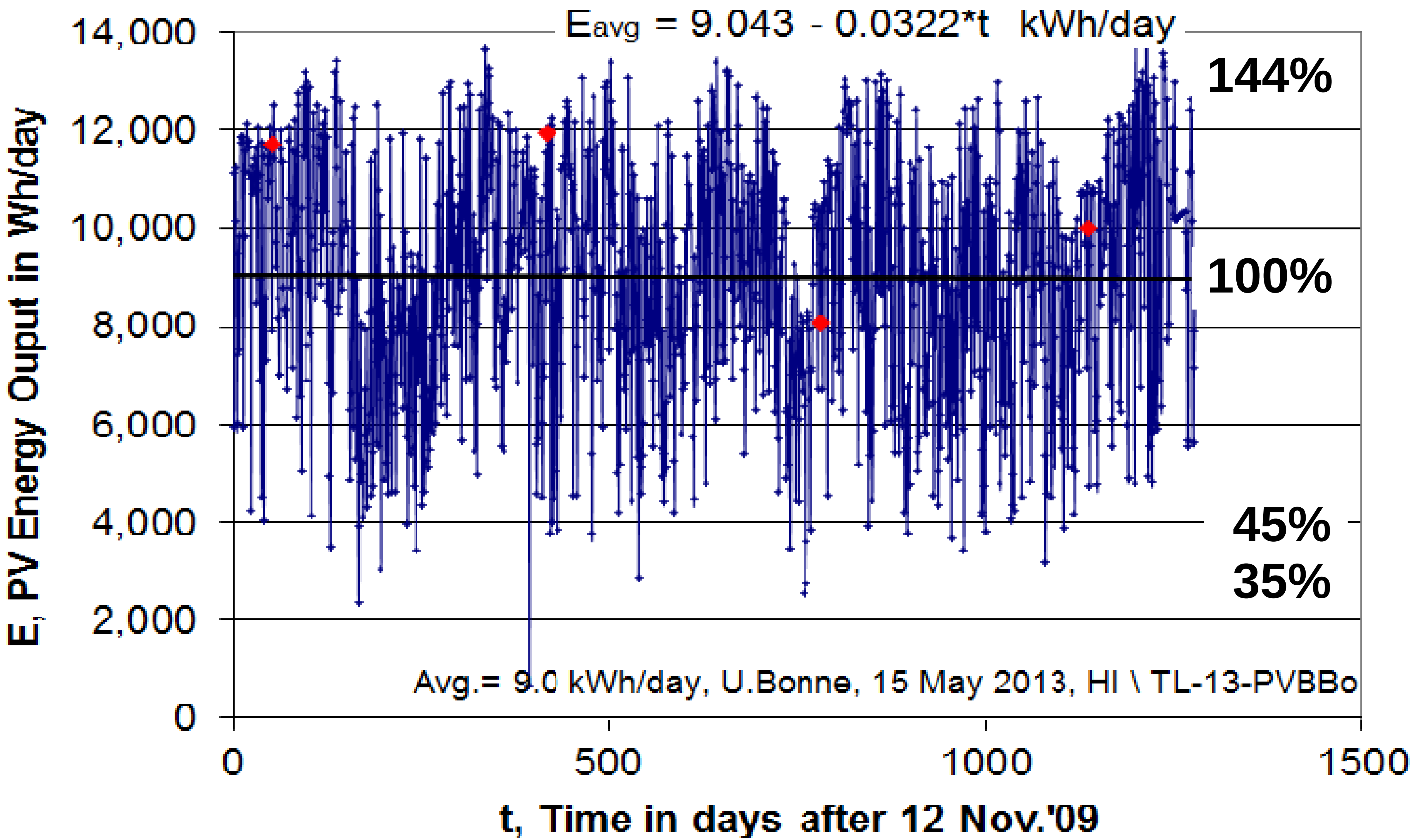
3. PV Daily Output Does Not Drop below 35%



Very cloudy day: 35*1.4% oversized PV + 26% grid + 25% DC = 100%
No seasonal-PV-output changes. Variability: +44% / -65% peak-to-peak

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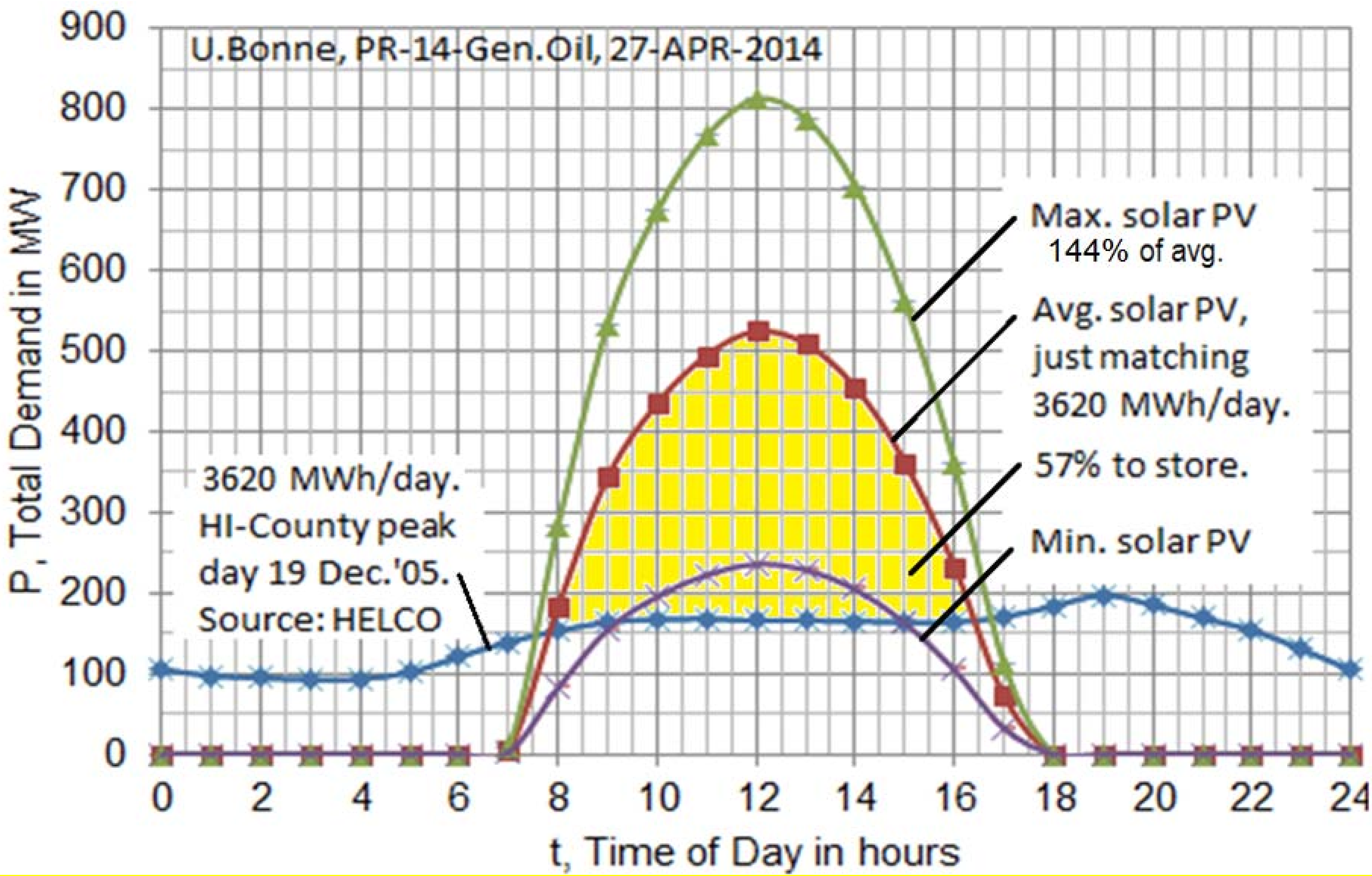
3. Solar PV Matching of Peak HELCO-Day in 2005



Meet demand on worst cloudy days: Oversize PV 50%+25%grid+25%DC

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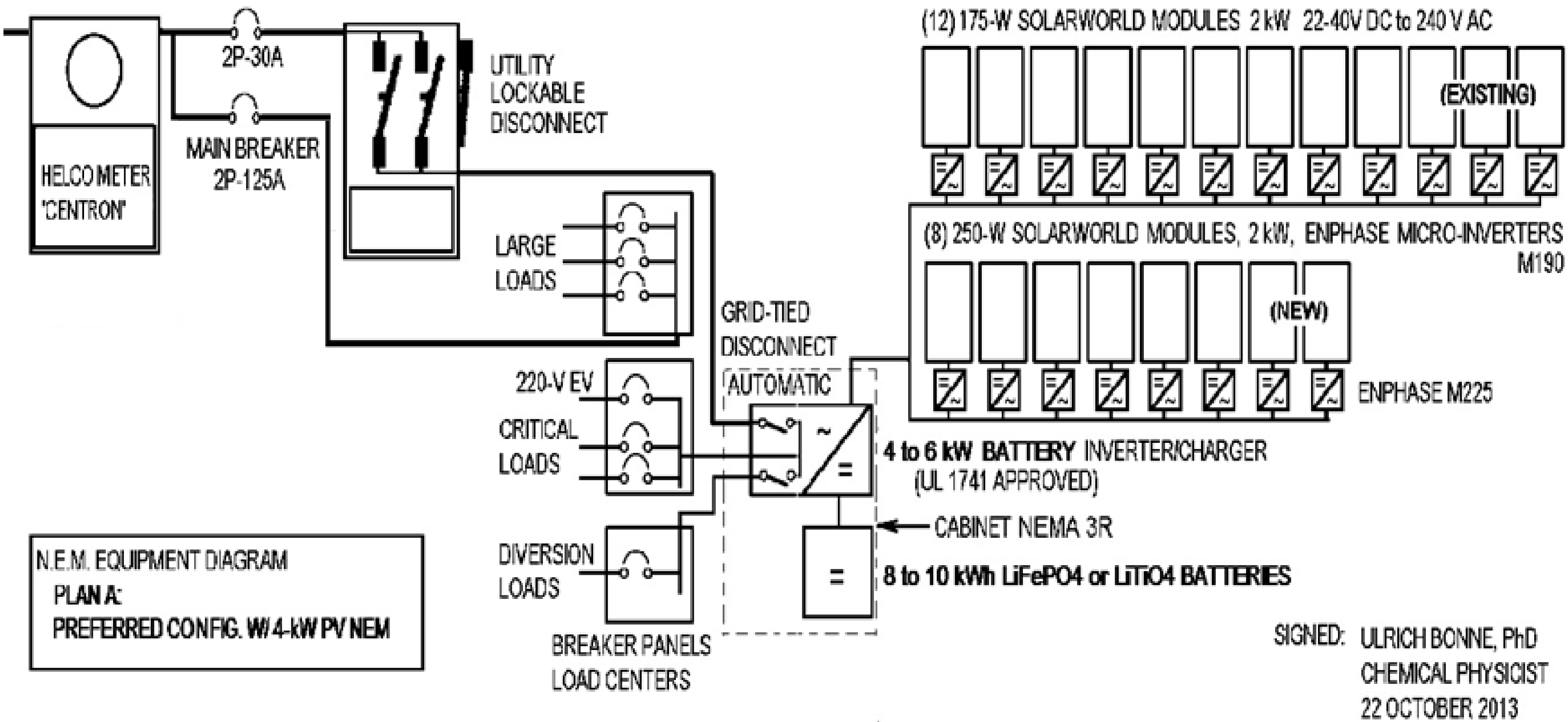
3. PVBB Example: 4-kW PV, AC-Coupled to Battery Inv./Ch.



If oversized by 50%, i.e. 6-kW PV, then plan for “Diversion Load”: Water pumping, heating, “making” (via dehumidifier), …

PVBB for “500-kWh/mo. home”: 4-kW PV + 8-10 kWh “active” storage

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3. Oversized PV May Need Diversion Load: Make Water

80°F, 60% RH

Diversion Load Example:

Dehumidifier by Santa Fe Thermastor XT105H:

530 W; 3.9 L/kWh; 50 L/day at $2190 + ~$200 S&H;

194 $/(1000 gal) with (free) electricity at 20 ¢/kWh; 165 lbs.

+50 $/(1000 gal) for CapEx, 87,000-h life(?); 1-5-y warranty.

(but maybe 1.46 $/1000 gal for a used, $50 dehumidifier)

Hawaii County Water Supply at **5.0 $/1000 gal** in 2014

at 4.5%/y rise, **7.8 $/1000 gal** in 2024

Water-making as insurance against prolonged grid outage

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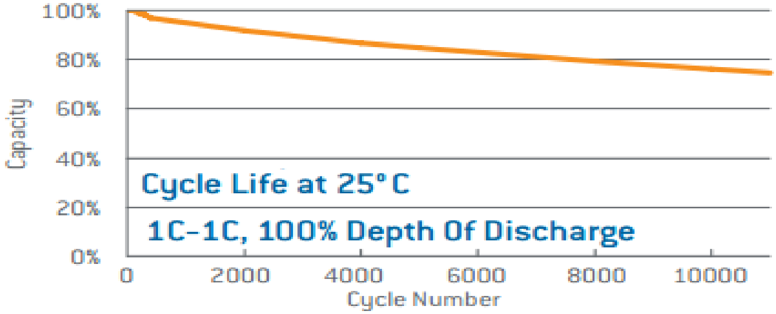
5. Distributed Storage: Grid-Level and On-Site



BeaconPower
SaftBatteries
Altairnano
OjaiEnergy
Corvus
Sony
AES Advancion
Aquion
Greensmith[9]
AES Americas
AxionPowerIntl
Tesla
Panasonic
PowerJapan+

- 1 MW, 2.8 MWh, Long Duration Li-Nanophosphate by A123, at IHI factory in Soma, Japan.
- The equipment is installed and commissioned in less than 6 weeks, worldwide, over 110 MW
- Cost of AES Li-batt.: LCoE = 250 to 500/(1*365*30) = 2.2 to 4.5 ¢/kWh
- 1 cycle/day, 100% DoD, 30 years, 11,000 cycles. AES Li-battery:1000 $/kW & 250 $/kWh

Battery storage is cost-effective and shovel-ready

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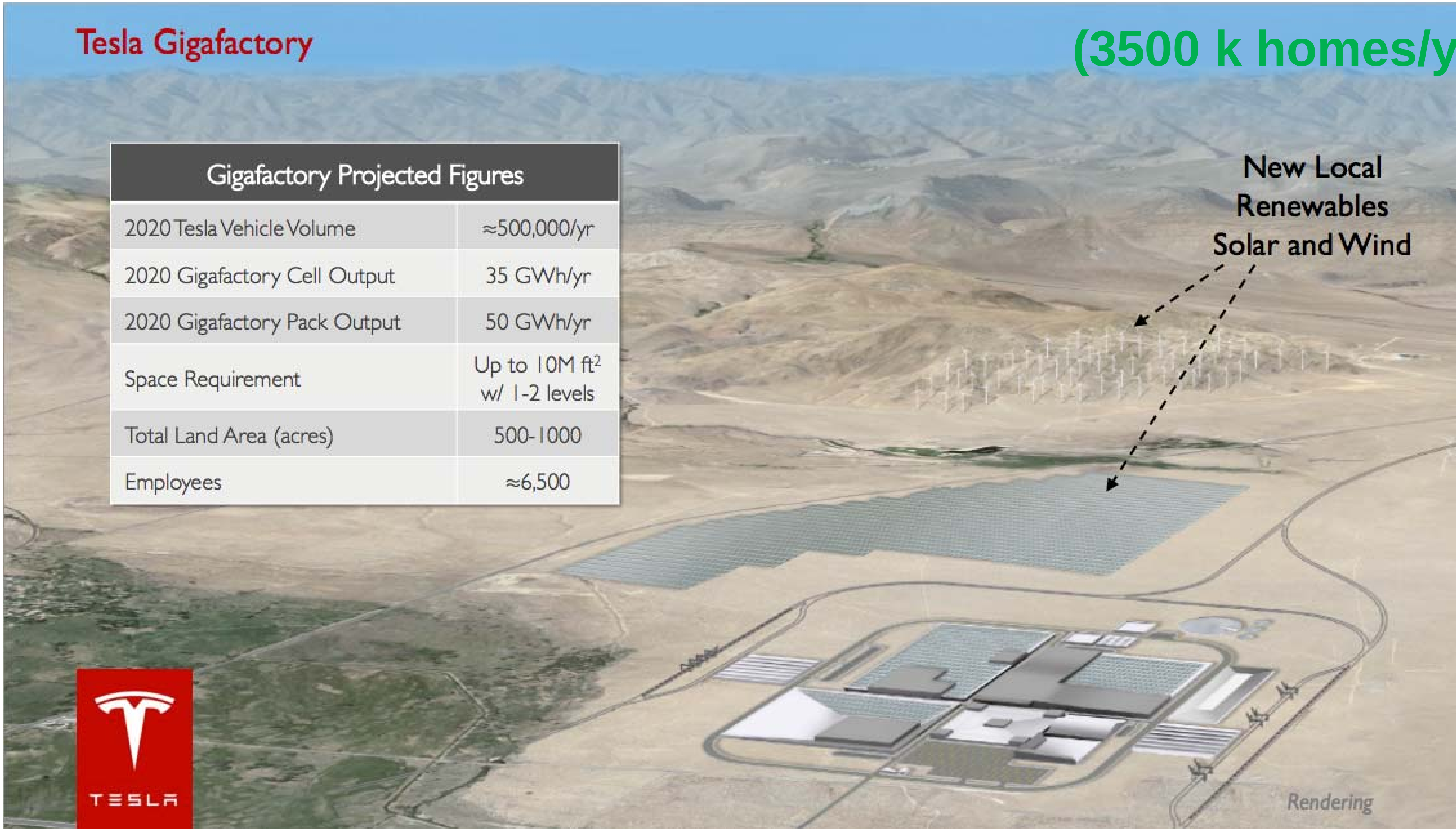
5.Tesla's Proposed 35 GWh/y Battery Factory (500 k EVs/y)



Gigafactory Projected Figures	
2020 Tesla Vehicle Volume	≈500,000/yr
2020 Gigafactory Cell Output	35 GWh/yr
2020 Gigafactory Pack Output	50 GWh/yr
Space Requirement	Up to 10M ft^2 w/ 1-2 levels
Total Land Area (acres)	500-1000
Employees	≈6,500

http://www.utilitydive.com/news/teslas-endgame-why-electric-vehicles-are-just-the-beginning/234321/

Battery costs to drop by 50-75% (to 200-300 $/kWh) **by 2020, as per E. Musk**

Nissan Leaf batteries 2010: 750 $/kWh

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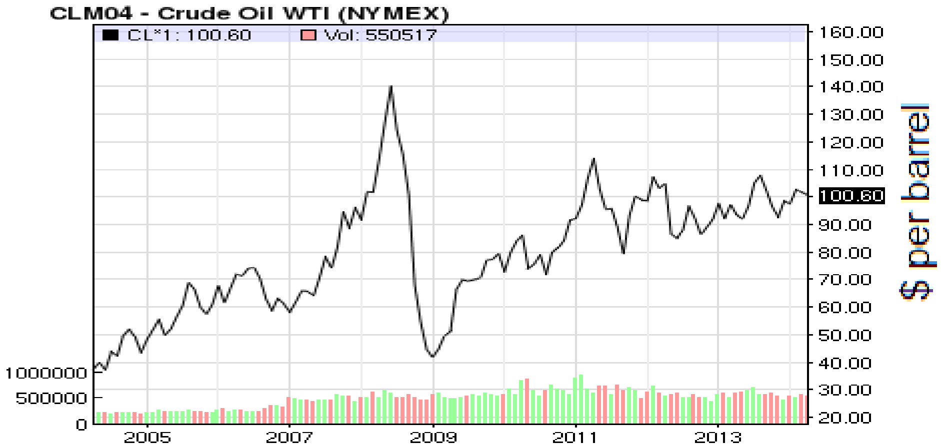
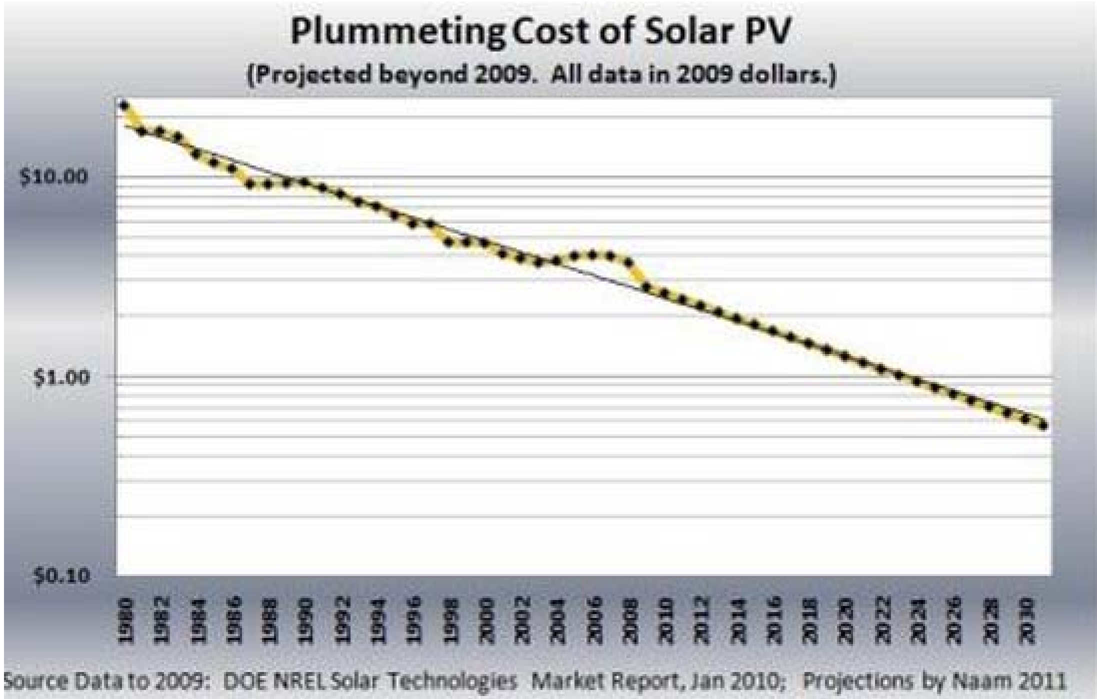
6. Cost Trends for Solar- and Oil-Sourced Electricity



Factor of 2.5x rise in 10 years
or 1.096x rise per year
http://www.nasdaq.com/markets/crude-oil.
Oil-electricity 1.045x rise per year

Panels drop by factor of 1.08 per year
Source: NREL Solar T. data until 2009.
Extrapolations by Naam 2011

Installed PVs drop by 1.04x per year



Utility retail $/kWh trends in %/y: Oil – 4.5 up; PVBB – 4 down

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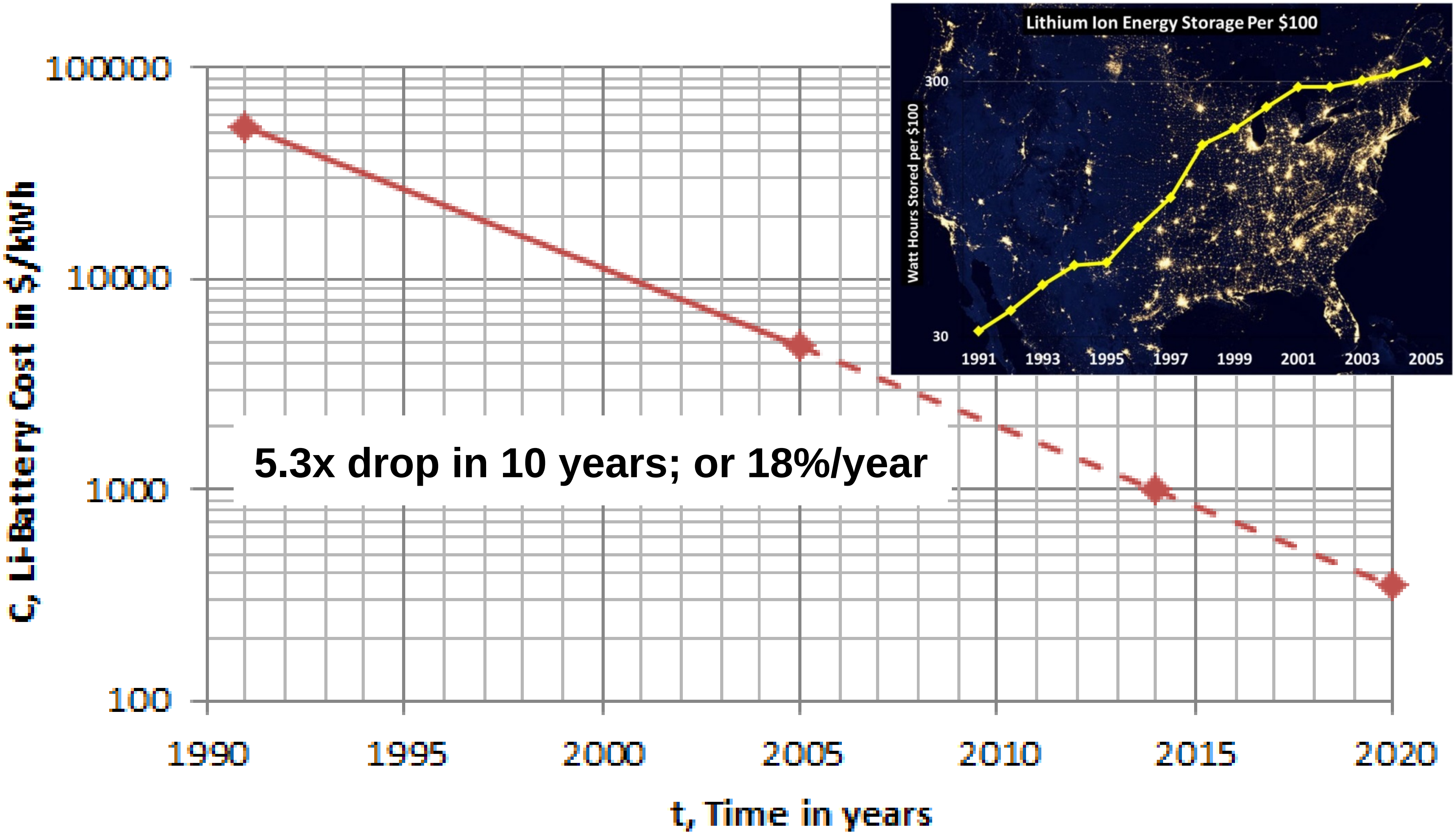
6. Li-Battery Cost Trend



LifeCycleCost (LCC) of Li batteries is lower than lead-acid batteries now.

http://rameznaam.com/2013/09/25/energy-storage-gets-exponentially-cheaper-too/

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6. Cost of PV Oversizing, Battery, T&D

PV e-Cost: 500 kWh/mo. needs 4-kW PV @ 5 $/W w/o cost of cap. or TaxCs;
battery + power electr. cost: 1500 $/kWh; MMC = 20.5 $/mo.

C(res.PV) = (5000$/kW) / (1*30*8760*0.17) = 11.2 ¢/kWh +4¢ MMC

C(res.PVBBGT) = (5000+3000) / (1*30*8760*0.17) = 17.9 ¢/kWh +4¢ MMC

>>C(res.PV+50%) = (2500) / (1*30*8760*0.17) = 5.6 ¢/kWh Off-Grid

Total PVBB = 23.5 ¢/kWh +4¢ MMC

GT = Grid-Tied; OG = Off-Grid; assumes NEM contract

>>C(res.battery) = (0 +3000) / (1*30*8760*0.17) = **6.7 ¢/kWh**

Leaf battery costs 18000$/24kWh = 750 $/kWh (2010, Wikipedia)

Transm. & Distribution Cost: 2.9% of HELCO's revenue of 42 ¢/kWh:

C(T&D)= 0.029*42 = 1.22 ¢/kWh or 6.09 $/mo. (0.2$/W ~ 0.45 ¢)

Good citizenship assumes that one's PVBB does not encroach on others

30-year LCoE residential, 50% oversized, PVBB-GridTied, 22-27 ¢/kWh.
30-year LCoE utility, 42 ¢/kWh now, w/4.5%/y esc.: 85 ¢/kWh

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6. US Average Levelized 2019 El. Costs in (2012 $)/MWh

Plant type	Capacity factor	Levelized capital cost	Fixed O&M	Variable O&M (including fuel)	Transmission investment	Total LCOE
	%	$/MWh				
Dispatchable Technologies						
Conventional Coal	85	60.0	4.2	30.3	1.2	95.6
Integrated Coal-Gasification Combined Cycle (IGCC)	85	76.1	6.9	31.7	1.2	115.9
IGCC with CCS	85	97.8	9.8	38.6	1.2	147.4
Natural Gas-fired						
Conventional Combined Cycle	87	14.3	1.7	49.1	1.2	66.3
Advanced Nuclear	90	71.4	11.8	11.8	1.1	96.1
Geothermal	92	34.2	12.2	0.0	1.4	47.9
Biomass	83	47.4	14.5	39.5	1.2	102.6
Non-Dispatchable Technologies						
Wind	35	64.1	13.0	0.0	3.2	80.3
Wind-Offshore	37	175.4	22.8	0.0	5.8	204.1
Solar PV2	25	114.5	11.4	0.0	4.1	130.0
Solar Thermal	20	195.0	42.1	0.0	6.0	243.1
Hydro3	53	72.0	4.1	6.4	2.0	84.5

PV and PVBB 30-y LCoE ≤ 23 ¢/kWh w/o CapEx or TaxCredits

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6. Source Options: Private or Utility PVBB, Geoth., LNG,Oil

PV 1.5x oversiz., 4 +2 $/Wp; & Oil-gen. 2.3x overs., 1.4 $/W; M 1 & 2%/y; 30-y		
30-year Levelized Cost of Electricity (LCoE)	**2014**	**2024**
Private cost of PV-el. (4%/year drop) in ¢/kWh:	15	12
Private cost of PVBB-el. (4%/year drop) in ¢/kWh:	22	17
Private cost of off-grid PVBB-el. (4%/year drop) in ¢/kWh:	23	15.5
Utility cost of PVBB (4%/year drop) in ¢/kWh:	42	39
Private cost of geo-el. (2%/year rise) in ¢/kWh:	11	14
Utility cost of geotherm. (2%/year rise) in ¢/kWh:	38	46
Utility cost comb.LNG (12 $/MBtu,4%/y rise) in ¢/kWh:	35	52
Utility cost FC LNG (12 $/MBtu,4%/y rise) in ¢/kWh:	40	59
Utility cost of oil-el. (4.5%/year rise) in ¢/kWh:	42	65
U.Bonne, PR-14-Gen.Oil, 13-JUN-2014		

Conversion delay penalty: 0.2 $/kWh x 6000Wh = 1200 $/y/home

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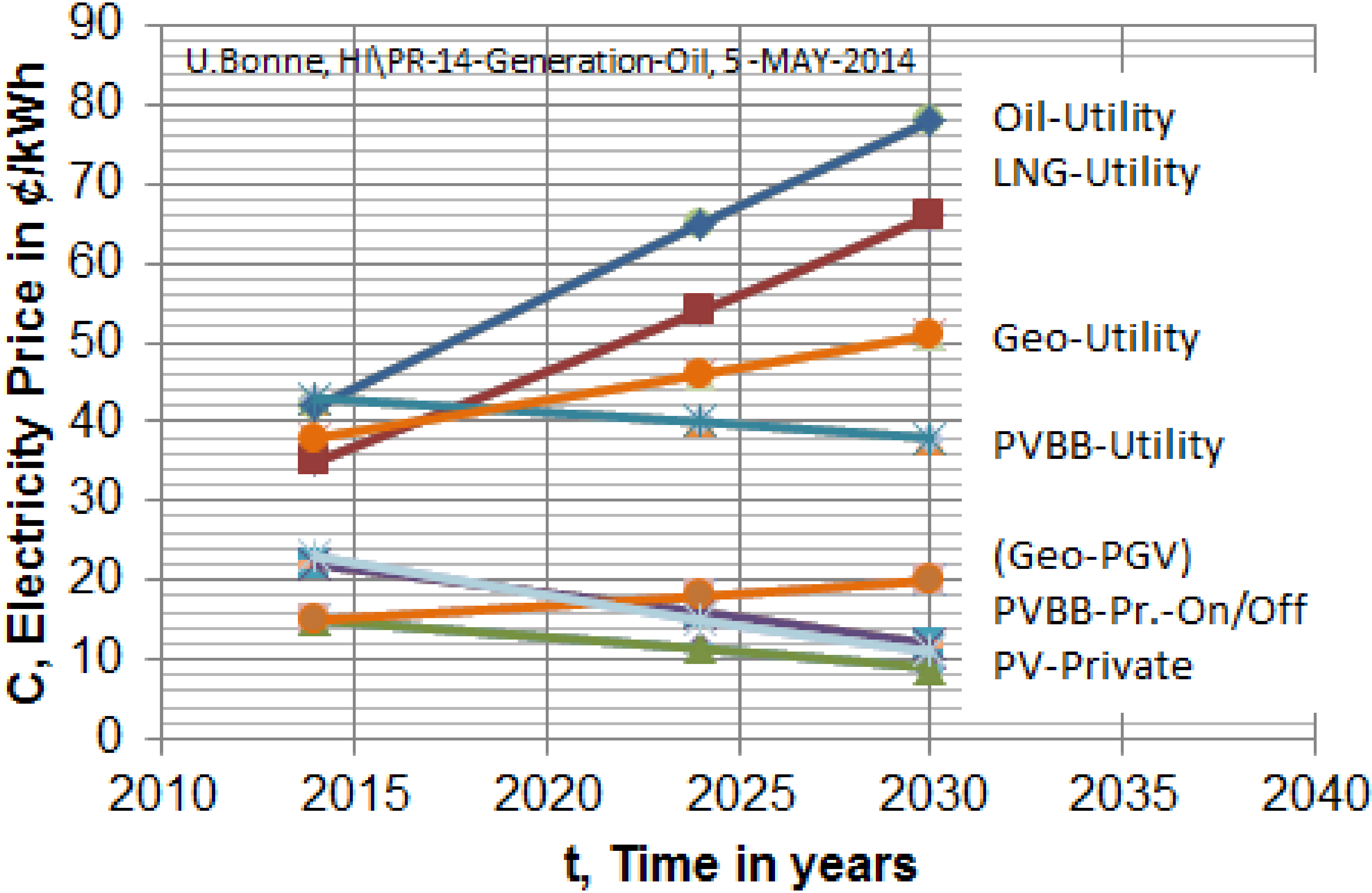
6. Trends of Retail Price of Grid vs. Private Electricity



Lowest ¢/kWh via Private PVBBs, on- or off-grid.
"…50 million US users x $20k PVs = 1T$ opportunity" David Crane, NRG

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6. Economics of 100% PVBB vs. 100% Oil Generation

PV 50% oversiz., 4 +2 $/Wp; & Oil-gen. 232% overs., 1.4 $/W; M 1 & 2%/y; 30-y					
	Power	CapEx	O&M	2014 LCC	2024 LCC
	MWp	B$	B$	B$	B$
PV in peak, overs. Watts	1220	4.9	~0	4.9	3.3
PVBB in peak, overs. W	1220 *	7.3	0.7	8.1	5.4
Oil gen. in avg. watts	331	0.5	11.0	11.4	28.3
$-Export Difference				3.4	22.9

*** 525 MWp x 1.55 x 1.5**

Minimize $-exports by switching from oil to PVBBs in the next 10 years

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7. Fairness during Transition & Social Acceptance of PV.

State Goal: Replace oil by 40% RE + 30% higher efficiency

Acceptance: Nobody is “left behind” lacking location or affluence

1. GEMS (Green Market Securitization program). 100 M$!?
2. Community solar (SB2934), almost passed in April ’14
3. Efficiency programs and subsidies do not penalize others
4. Solar water heaters widely deployed (but better use PV now)
5. Solar PV adds value to a community and does not penalize non-PV users, if a utility is managed w/kuleana
6. “Good PV citizenship” requires some on-site storage. Utility-scale PV farms w/o **storage** maybe neither smart nor fair

We need more political will to pass Community Solar and start GEMS
We need to insist on storage to match utility-scale PV

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8. Political Will: Bills that May Pass or "Failed" in 2014

California PUC 5 May 2014 Proposed Decision to "exempt NEM storage devices from fees"

Sent to Hawaii Governor
SB2196 CD1- Re-establishes the barrel tax, for energy systems development (special fund)
SB2199 SD1- Mandates 240-V EV charger for all building permits beginning 1/1/2015
SB2658 HD2- Limits solar energy facilities to occupy more than 10% of a parcel, or 20 acres
HB1943 CD1- Asks PUC to issue grid modernization guidelines for more RE & fair tariffs

Died in conference committee
SB2934 HD1- Requires the PUC to establish community-based RE tariffs
SB2198 HD1- Establishes the Renewable Fuels Task Force to perform a feasibility study
HB2060 SD2- Establishes a renewable fuels production income tax credit. Admin. by DBEDT
HB2618 HD2 SD2- Establishes tax credit for each grid-tied storage property after 12/31/2014

Never made it to conference
SB2040- PUC to establish preferential rates for electricity for agricultural activities.
SB2044- Makes it illegal to prevent installation of a solar PV for aesthetic reasons
SB2183- Exempts EVs from parking fees state or county parking stalls.
SB2180- Mandates new residential & comm. buildings to use cool roof materials by 1/1/2015
SB2656 SD2- Requires the PUC to initiate a proceeding by 7/1/2014, to modernize HI grids
SB2161- Allows "wheeling;" i.e. direct access by retail customers to the competitive e-market.
SB2238- Prohibits utilities from charging PV interconnection study costs to consumers
SB2239- Permits county to trim vegetation that blocks solar radiation from solar energy devices
HB1999 HD3- A new Legislative Utility Review Task Force to review investor-owned utilities
SB2932- Establish energy storage portfolio stds. that will enable more renewable energy

Passed minor policies for PV, but lacked political will to pass major p.

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Conclusions and Recommendations

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  as with "Solar Gardens," CCA or Community Solar SB2934, 2981, 3110
- Compare our utility costs components w/others (Benchmarking)
- Incentivize utilities via "RE Integration Tax Credit" (as XcelEnergy)
- Propose legislation that gives priority to RE generation, as in Germany

PVBB 30-y LCoE < 20 ¢/kWh w/o cost of capital or subsidies

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Comments and Questions?

Website: http://alohafuels.pbworks.com

Technical Reports

Presentation: http://AlohaFuels.pbworks.com/f/VG-14-100_PVBB.pdf

E-mail: ulrichbonne@msn.com

Thank you

Good News:

2 May 2014: HECO press release: “HECO is seeking proposals for one or more large-scale energy storage systems able to store 60 to 200 MW for up to 30 minutes.” (=30 to 100 MWh; 4-12 khomes)

10 May 2014: “To offset grid instability, MECO, ONR and UH-HNEI have proposed installing an AltairnanoTechnologies 2-MW lithium ion titanate battery.”

2002: CPUC passed Assembly Bill 117 (CCA) enabling “Community Solar.”

But in May 2014: Hawaii legislators did not pass “Community Solar”

Abbreviations

CCA	Community Choice Aggregation program (CA Assembly Bill 117), energy source choice
DBEDT	Department of Business, Economic Development and Tourism
EV	Electric Vehicle; FCV = Fuel Cell Vehicle
FIT	Feed-In Tariff contract: user buys el. at retail and sells at wholesale price
GWh	Gigawatthour = 1000 MWh = 1,000,000 kWh
HECO	Hawaiian Electric Company
HELCO	Hawaiian Electric Light Company
kWh	kilowatthour, a unit of energy; kW = kilowatt, a unit of power
LCC	Life-Cycle Cost
LCoE	Levelized Cost of Electricity; typically levelized over 20 to 30 years
LNG	Liquified Natural Gas
MBtu	MegaBtu or millionBtu; Btu = British Thermal Unit (other texts use M for mille)
MMC	Minimum Monthly Charge. 20.50 $/month in Hawaii County 2014
NELHA	Natural Energy Lab of Hawaii Authority
NEM	Net Energy Metering contract: user gets credit for surplus PV energy
NREL	National Renewable Energy Lab
PGV	Puna Geothermal Venture
PUC	Public Utility Commission
PV	Photo-Voltaic
PVBB	PV with Battery Backup
RE	Renewable Energy, such as solar PV, geothermal, wind
SB2934	Senate Bill 2934
T	Tera or Trillion
TC	Tax Credit
T&D	Transmission and Distribution
VOS	Value of Solar PV or PVBB system in ¢/kWh, which quantifies its worth to society

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Central and Distributed Generation: VOS

Value of Solar (VOS), as developed by www.cleanpower.com, is to find the $/kWh point at which all PV- and non-PV-users are indifferent, whether this value ($/kWh) is billed or not. **The method of calculating VOS** may be the same for any utility, but its value may differ, as a result of the specifics of each utility. A first cut at determining VOS for Hawaii is posted at http://alohafuels.pbworks.com/f/PB-14-VOS-Hawaii.pdf.

Table 2. VOS Estimate for Hawaii: Gross value, load match, loss savings and distributed PV value.*

		Gross Value ×	Load Match Factor x	(1+Loss Savings Factor) =					Distributed	Distributed
				LMF-PV	LMF-PVBB	LSF			PV Value	PVBB Value
25-Year Levelized Value	%	$/kWh	based on	%	%	%			$/kWh	$/kWh
Avoided F-Oil & PPA Cost	59.8	0.2512	3$/gal, 33%	100	100	8	LSF-Energy		0.2713	0.2713
Avoided Taxes	12.1	0.0508		100	100	0	LSF-Energy		0.0508	0.0508
Avoided Gen.Prod., O&M & 2.7% Int	6.6	0.0277		100	100	8	LSF-Energy		0.0299	0.0299
Avoided Depreciation & Amort.	7.5	0.0315	0.0457	90	90	9	LSF-Energy		0.0309	0.0309
Avoided Admin. & General Exp.	4.1	0.0172		50	50	9	LSF-Energy		0.0094	0.0094
Avoided Cust.Accts & Misc.&Sales	3.1	0.0130	33$/kWyear[4]	10	10	9	LSF-ELCC		0.0014	0.0014
Avoided T&D cost	2.9	0.0122	200$/kW[4]	0	100	8	LSF-PLR		0.0000	0.0132
Avoided Environmental Cost		0.0580		40	100	8	LSF-Energy		0.0251	0.0626
Added Voltage Contrl./Storage Cost		0.1096	1000$/kWh	-60	0	0	Added O&M		-0.0658	0.0000
Added Solar Integr. Cost (incl.storage)		0.0114	2500$/kW**	-100	-10	0	Added Cap.		-0.0114	-0.0011
Avoided Profit	3.9	0.0164	20.5$/mo.	100	100	0	Income		0.0164	0.0164
	100.0	0.4780	0.42		Total Value of Solar (VOS):				0.3580	0.4847

PLR = Peak Load Reduction; ELCC = Effective Load Carrying Capability

* Table format adapted and expanded from ref.[4] "VOS calculation ...", Fig.3, p.42, but with HELCO's breakdown of costs (PUC Report)

[4] Benjamin L. Norris et al (Clean Power Research, Kirkland, WA), "Minnesota Value of Solar: Methodology," 31 Jan 2014

** Letters from HELCO, Sept 2013: Requirements in subgrid regions with high PV penetration U.Bonne, 6-APR-2014, HI\PR-14-Generation...

VOS for Hawaii: 0.36 $/kWh for PVs and 0.49 $/kWh for PVBBs

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Cost of Electricity Benchmarks

PV e-Cost: 500 kWh/mo. needs 4-kW PV @ 5 $/W w/o cost of cap. or TaxCr:

C(res.PV) = (5000$/kW) / (1*30*8760*0.17) = 11.2 ¢/kWh +4¢ MMC

C(res.PVBBGT) = (5000+3000) / (1*30*8760*0.17) = 17.9 ¢/kWh +4¢ MMC

C(res.PVBBOG) = (7500+3000) / (1*30*8760*0.17) = 23.5 ¢/kWh +0¢ MMC

GT = Grid-Tied; OG = Off-Grid

C(util.PVBBGT) = (6000+2000) / (1*30*8760*0.17) = 18+20 ¢/kWh

Battery e-Cost: 8 kWh, 8-12k$ installed w/pwr.electr., w/o cap.cost or TaxCr:

C(util) = 8000 / (30y*12*500) = 4.44 ¢/kWh or 33 $/mo.

C(res) = 12000 / (30y*12*500) = 6.67 ¢/kWh or 33 $/mo.

Oil e-Cost: 90$/bl; 42gal/bl;1.4 $/W; O&M: 2%/y; 30 y; w/o cap.cost or TaxCs:

C(util) = 90/42*100/(115000*1053/3600000)/0.3 = 21.2 ¢/kWh Fuel cost

+140*(1+1.02*30)/(0.001*8760*30*0.43) = 2.0 ¢/kWh Amort+M

Transm. & Distribution Cost: 2.9% of HELCO's revenue of 42 ¢/kWh:

C(T&D)= 0.029*42 = 1.22 ¢/kWh or 6.09 $/mo. (0.2$/W ~ 0.45 ¢)

30-year LCoE residential PVBB 18 ¢/kWh

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LNG, H2 & Solar Thermal and EVs

LNG e-Cost: 14 $/Mbtu; 1.4 $/W; O&M: 2%/y; 30 y; w/o cap.cost or TaxCs:
2014
C(util) = 1200¢/(1e6Btu*1053/3.6e6)/0.3+ 20 = **34 ¢/kWh** fuel+admin. cost
2024
C(util) = 14*1.07^10 + 20*1.02^10 = **51 ¢/kWh** fuel+admin. cost

Hydrogen e-Cost: Electrolysis+FC round trip eff: 65% eff x FC 65% >> 42.2%
Catalyst life: Short due to H_2S & SO_2 poisoning
FCV ¢/mile: 20 ¢/kWh / 0.422 / (3 mi/kWh) = 16 ¢/mile
ICV ¢/mile: 400 ¢/gal / (30 mi./gal) = 13 ¢/mile
EV ¢/mile: 20 ¢/kWh / (3.3 mi./kWh) = 6 ¢/mile
C(util) ¢/kWh:11 ¢/kWh / 0.422 + 20 = 46 ¢/kWh-H2

Solar water heating: 5-10 k$ / (2500 kWh/y x 20 y) = 10-20 ¢/kWh, 44 gal/d
Better: One technology for all appl.: PV; no plumbing/leaks on roof

EV Cost: Nissan-Leaf: 27 k$ / 24 kWh = 1125 $/kWh; 27 k$ / 80 kW=0.34 $/W
Battery pack:18 k$ / 24 kWh = 750 $/kWh (2010, Wikipedia)

Use PVBB instead of LNG, H2 or solar water heating

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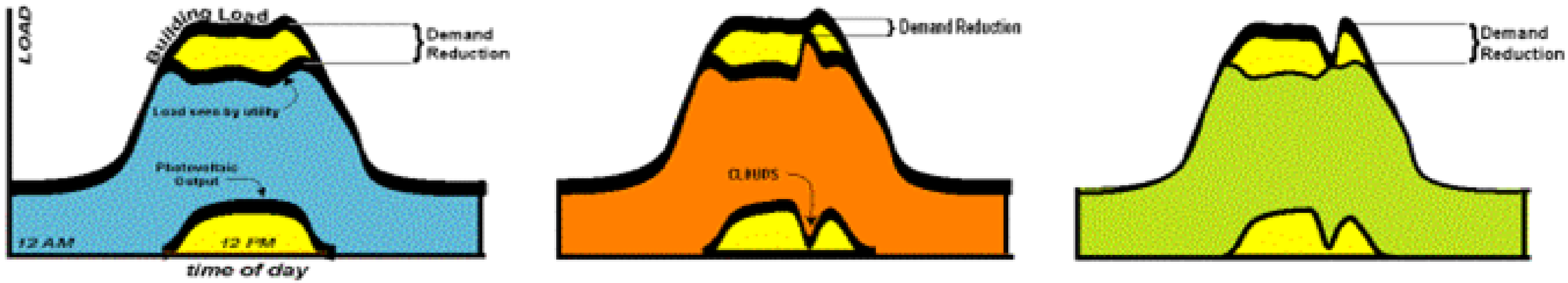
Load Control Action w/o Battery Backup



Because of the high correlation between commercial load demand and solar availability, PV provides power when needed, thus displaces peak energy and **reduces demand**

The PV-Load correlation is normally high, but localized demand reduction, therefore value, may be compromised by transient clouds

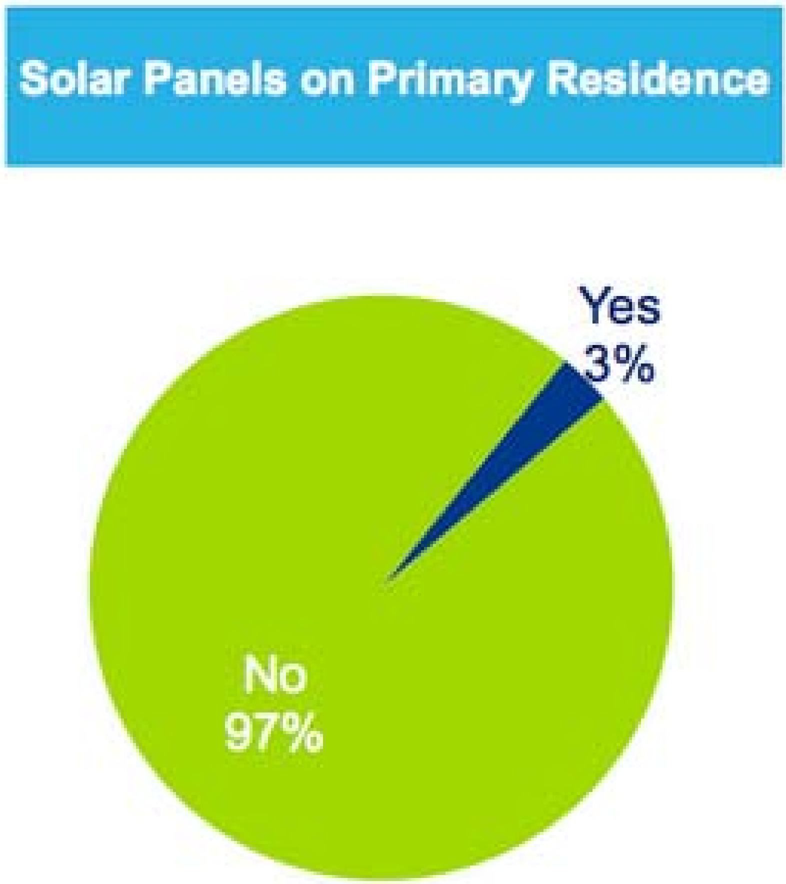
The **SLC** reduces the load when needed by acting on end-use settings or scheduling. Because of the high natural PV-load correlation, the **end-use inconvenience is minimal*** compared to the demand reduction enhancement.

Fig. 1: Description of load control action

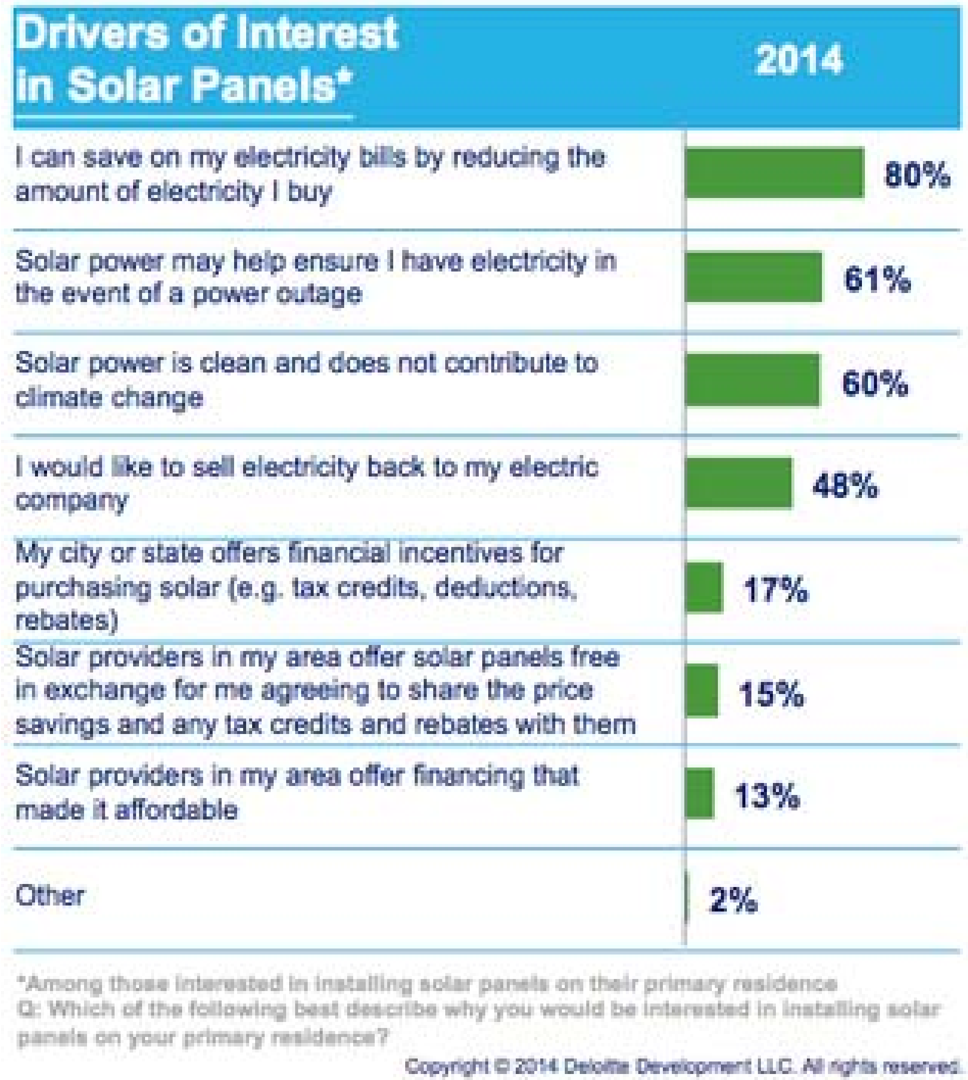
END-USE MAXIMIZATION OF PV'S PEAK SHAVING CAPABILITY, by Richard Perez & Jim Schlemmer, perez@asrc.cestm.albany.edu et al http://www.asrc.cestm.albany.edu/perez/publications/Utility%20Peak%20Shaving%20and%20Capacity%20Credit/Papers%20on%20PV%20Load%20Matching%20and%20Economic%20Evaluation/Solar%20load%20controler-00.doc.

Transient clouds drop PV output, but DC or storage can mitigate

Motivation to Install Solar PVs



Survey by Deloitte



1. Savings, 2. Uninterrupted power, 3. Clean RE

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Questions for Our Elected Officials

- Rather than sequentially evaluating many individual renewable energy plans by utilities (IRP), PUC, State House, State Senate, State Energy/DBEDT, when will we generate ONE JOINT plan with all stakeholders?
- What are the prime stumbling blocks, which delay deploying renewable energy to achieve affordable energy security:
  -- Political will – High up-front cost – Profit motives?
  -- Adherence to a central rather than DG business model?
  -- No one asked HECO to submit a plan leading to 20 ¢/kWh?
- How can utilities be incentivized to speed up PVBB grid-ties?
- Why were some of our legislators not able to agree on: (1) Indexing Minimum Wage to inflation and (2) Stopping to micro-manage any tip credit?   Have they not heard about our mushrooming income inequality?

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