

Proposed Hawaii FIT Rates Discourages Installation of PV Systems below 3 kW

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Introduction -- Negotiations about FIT (Feed-in-Tariff) rates and how many intermittent clean energy generation sources to allow, without unduly compromising grid stability has been ongoing since October 2008, according to the growing volume of documents on the website for Docket 2008-0273[1]. The negotiations are between Hawaii State representatives, the PUC (Public Utility Commission), HECO and the public & businesses, as represented by intervenors.

Could small home PV systems benefit from installing more of PV power than needed by the household, on their unused roof space? Reasonable return of such investment in excess electricity generation capability may induce home owners to make such investment, and to sign up with a FIT agreement. After approval of the FIT regulations[2], home owners and small businesses may have such an option, besides staying with or entering into a NEM (Net Energy Metering) agreement, which does not pay for excess energy delivered to the grid. FIT regulations might thus in principle contribute to speeding up overall energy self-sufficiency via deployment of distributed clean energy generation (and storage as needed).

Summary – This study shows that emerging Hawaii legislation based on HECO-proposed FIT rates of 0.218 and 0.269 \$/kWh[1] (depending on applicable 35 and 24.5% State tax rebates, respectively) eliminates PV systems smaller than 3 kW from being economically viable, and is thus sadly and disappointingly discriminatory against average home PV systems, which rarely exceed 3 kW.

To insure that our calculation method[5] yields results consistent and comparable to those published by HECO[3], we verified that for small systems (7.04 \$/W, used by HECO, which we inferred to correspond to a 2.83 kW PV size), our cost of PV-generated electricity of 26 ¢/kWh[3] is close to HECO's 25 ¢/kWh.

Some key conclusions were:

- Payback time for a 20 kW PV system is 7.5 years, with generated electricity cost at 7.2 cents/kWh and compound ROI of 6.59%/year, which seems reasonable enough. But
- Payback time with a 2.83 kW PV is 29.9 years, with generated electricity cost of 26 ¢/kWh and a compounded, annualized Return on Investment (CAROI) of minus 0.781 %/year, even with an extended FIT contract of 25 years, while feeding all generated electricity into the grid.
- A 2 kW PV system, under a 20 year fixed FIT contract, but consuming 50% of the generated electricity in-house (thus in-part balancing the not-fixed present rate of ~40¢/kWh), would realize a CAROI of 1.1 %/year. Clearly, the FIT contracts with the HECO-chosen “midrange” rate of 21.8 ¢/kWh for a wide range of small (< 0.5 kW to 20 kW) is not “reasonable” economically, even with full tax incentives.
- Increasing the FIT rate for the latter 2 kW system to the regular rate (~40 ¢/kWh) would increase the CAROI to a more reasonable level of ~ 4 %/year (still with a stinging 15.2-year payback). Eliminating the MMC (Minimum Monthly Charge) of \$22.16 would increase that CAROI to ~6 %/year
- Small system economics could also be made “just and reasonable” by allowing annual FIT rate escalation, despite the (improbable) risk of negative escalation in some years

The efforts to accelerate the move towards energy self sufficiency, via the emerging FIT regulations would be even better served by having the PUC or HECO

1. Clarifying what PV ROI would be accepted as “**just and reasonable**” per PUC guidance and per HECO's letter[9].
2. Allowing a variable MMC (Minimum Monthly Charge), whereby smaller PV systems pay less than larger systems, which use larger and costlier equipment
3. Creating a technical framework with legal and financial incentives to facilitate and promote distributed generation (DG) and storage.

4. Clarifying FIT accounting: The monthly FIT accounting – will it be based on the monthly net energy the grid delivered or received, rather than on total energy delivered to and total energy received from the grid.

These results were based on the proposed 20-year fixed FIT of 21.8 ¢/kWh for PV systems < 20 kW DC, capacity factor of 16-17% as also used in HECO's analysis[3], HELCO Monthly Minimum Charge (MMC) = \$22.16 (assuming that such will still be charged with FIT systems[2]), and with full 30% Fed and 35% HI-State tax credits. The discussed output costs and rates below are in nominal dollars, rather than in "real dollars" corrected for inflation. The discussion below details how the study arrived at the above conclusions.

Discussion – The study comprised three main parts:

1. Arrive at a credible set of PV system installation costs vs. PV power or size
2. Calculate the cost of electricity generated with each of the PV system sizes, and
3. Cross-plot the obtained results, compare with HECO results and conduct an overall evaluation

The used **PV system installation cost** input data are shown in the yellow fields[4] of Table 1. The fitted power function between the data on installed PV cost and PV power is credibly good, with R^2 -values over 0.999. In addition, the 0.74 exponent is in line with general chemical engineering experience with scaling of installed process plant costs, with exponents ranging from 0.6 to 0.7. The derived PV costs vs. power functions (Q entered in kW) are:

- PV syst. cost, C, vs. syst. power, Q : $C = 9.1983 * Q^{0.7432}$, in k\$, $R^2 = 0.9997$
- PV syst. cost, C/Q, vs. syst. power, Q: $C/Q = 9.1822/Q^{0.2536}$, in \$/W, $R^2 = 0.9977$.

The **cost of PV-generated electricity** was obtained with the "Green Energy Cost and ROI Calculator" on the website of the "Friends of NELHA"[5]. Inputs to that Calculator, in part already mentioned above, were:

- Generator output variable, Q in kW (AC), although HECO lists kW (DC) to designate PV output[3]
- Capacity or use factor 17 %
- Generator product life 25 years, although the FIT is fixed for only 20 years
- Loan Interest 6 %/year
- Number of compounding periods 365 per year
- (FIT-) based electricity rate 0.218 \$/kWh if PV feeds 100% to grid
0.309 \$/kWh if PV feeds 50% to grid
- (FIT) electricity cost escalation 0 %/year if PV feeds 100% to grid
1.5 %/year if PV feeds 50% to grid
- Capital investment in \$ $C = 1000 * 9.1983 * Q^{0.7432}$
- Max. fed tax credit/refund 30%, no \$ limit
- Max. state tax credit/refund 35%, no \$ limit
- Crude oil cost 80 \$/barrel
- Util. min. mo. charge (MMC) 22.16 \$/month
- Utility MMC escalation 1 %/year

The obtained PV electricity cost, compound ROI and payback period are listed in Table 1.

To facilitate **evaluation** and understanding, the PV system cost, C/Q, and PV electricity cost were not only tabulated (Table 1) but also plotted in Fig.1 against Q, the PV power rating, after extending the range to 20kW via the above equation. A mathematical fit to the PV electricity cost resulted in the function:

PV system electricity cost, $E = 38.966/Q^{0.55527}$ in ¢/kWh, $R^2 = 0.9877$, for Q in kW, for both 0 and 3 %/year FIT escalation rates. In fact FIT escalation rates do not influence PV electricity cost because they do not influence the produced amount of electricity nor the annual debt repayment rate, which is determined by the first-year savings

By way of a validation check, we compared our results with those of the HECO spreadsheet model[3]. HECO selected 21.8 ¢/kWh for the Tier-1 FIT rate as the midpoint between 25.0 and 18.7 ¢/kWh for PV systems installed for 7.04 and 5.76 \$/W[6], both < 20 kW.:

- Our results are 26.0 and 13.7 ¢/kWh for PV systems in the same \$/W range, respectively. This is not as close as expected, but gets closer (13.7 to 16.2 ¢/kWh) if we reduce the system “life” from 25 years to the same term as the FIT agreement of 20 years, but
- The compound annualized or aggregate ROI values (or CAROI, comparable to the compounded yield of money in multi-year savings accounts) are only 1.38 and 4.3 %/year, respectively, even with a 3 %/year FIT escalation

Additional insights gained:

- For 0 %/year FIT escalation, the ROI values, for the same size PV systems as above, drop to -0.78 and 2.50 %/year, i.e. too low to entice even “green-minded” investors. Even a 20 kW PV system CAROI drops by 25%, as shown in Table 1.
- Numerically, payback time in years and electricity costs in cents/kWh are quite close, as the data in Table 1 show and as represented by the green curve in Fig.1
- Typical residential PV systems would generate, when oversized relative to their own needs, an excess amount of electricity by the end of each month. But it is not clear whether they will still have to pay HECO for any night-use of electricity at the normal residential rates of about 40 ¢/kWh each month. HECO only states that will do the metering “**either by use of multiple meters or a meter capable of separately recording the net inflow and outflow of electricity**”, but do not state how the accounting will be done.[7]
- Assuming that the FIT accounting is based on the **monthly net energy** rather than on **total energy** taken or delivered to the grid, then for PV systems oversized e.g. by 100 % relative to the own average monthly consumption of electricity, the effective electric tariff would be the mean between 0.218 and -0.400, or -0.309 ¢/kWh, and result in CAROI value increases from 1.38 to 4.40%/year for a 2.83 kW PV system and from 4.3 to 6.55 %/year for a 6.18 kW PV system, compared to feeding all generated energy into the grid.

As one can see on the web, other states and countries have opted for apparently higher FIT rates. However, they may not have the same climate, equipment costs or subsidies as we do in Hawaii. The 35% Hawaii State tax credit is worth about 22 ¢/kWh for small systems (2.83 kW, 7.04 \$/W) and 6 ¢/kWh for large systems (20 kW, 4.26 \$/W).

Oregon, without a State PV subsidy, passed a FIT of 65 ¢/kWh, well above the residential rate of 10 ¢/kWh, but for the above example of the 100% oversized PV system (plus less sun but lower equipment costs than in Hawaii) it may be equivalent to a rate of 26 ¢/kWh under Hawaii conditions, i.e. not too far from the proposed Hawaii FIT rate.

Conclusions – Despite the complexity of calculating an electricity cost generated by PV systems, our result agrees with HECO’s within 1 ¢/kWh for small systems (2.83 kW, 7.04 \$/W), but comes up with 5 ¢/kWh higher cost for larger systems (6.18 kW, 5.76 \$/W), which could simply be due to an adopted less steep relation between C/Q and power of PV systems than the one we derived from Takach’s data[4]. Size and C/Q both matter because the MMC is fixed and does not get proportioned to PV system size.

Contrary to appearances due to HELCO (on Hawaii’s Big Island) high ~40 ¢/kWh residential rate compared to other US regions, this analysis has shown that the proposed FIT rate of 21.8 ¢/kWh is reasonable for systems over 2.83 kW (installed for less than 7.04 \$/W), provided that some (half or more) of the generated energy is used to offset the regular rate of ~40 ¢/kWh, thereby also partly benefitting from the likely escalation of residential electric tariffs with time, even if the FIT rate stays fixed, as proposed.

To those concerned that PV deployment is premature because without government subsidy PVs may not yet be economically viable, it may be of interest to ponder the profitability of a 20 kW PV, \$85,240 system (still in Tier-1) with(a) and without(b) government subsidies, both based on:

20-year-fixed FIT contract, 17% capacity factor, 4% bank loan interest, and 50% of the kWh output used on-site:

- a. With full 30% Federal and 35% HI-State tax credits and a FIT rate of 21.8 ¢/kWh – the payback time is 4.77 years, CAROI is 8.19 and electricity cost is 8.2 ¢/kWh
- b. Without any tax credits and a FIT rate of 27.4 ¢/kWh – the payback time is 10.73 years, CAROI is 4.13 and electricity cost is 18.6 ¢/kWh

This study shows that achieving our goal of energy self sufficiency would be even better served by a FIT regulation that would:

1. Not use a “one size fits all” FIT rate approach for PV systems < 20 kW. Rationale: “One size fits all the PV systems under 20 kW” approach unduly penalizes small PV systems at the expense of larger ones within that range. The compounded, annualized ROI of a 2.83 kW (7.04 \$/W) is negative if 100% of the energy is fed to the grid. The CAROI increases to only 3.79 %/year if half the energy is used to offset some load at the residential rate of ~40 ¢/kWh. The CAROI is only 1.1% for a 2 kW (7.7 \$/W) PV system with a 20-year FIT contract, i.e. insufficient for business incentives or bank loans
2. Allow a variable MMC (Minimum Monthly Charge), whereby the MMC for smaller PV systems would be lower than for larger systems
3. Allow an annual FIT rate escalation, despite the (improbable) risk of negative escalation in some years
4. Clarify what PV ROI would be accepted as “**just and reasonable**” per PUC guidance and per HECO’s letter[9].
5. Create a technical framework with legal and financial incentives to facilitate and promote distributed generation (DG) and storage. Clearly the inclusion of battery-back-up storage would entail further costs to the home owner[10] and add to the bottom-line ¢/kWh of DG systems able to automatically and instantly switch to off-grid operation, thus experiencing fewer power outages, maybe with reduced or eliminated HELCO’s MMC (Minimum Monthly Charge) and so increasing the CAROI by 2 %/year units for a 2 kW system, while providing some distributed relief to HELCO about managing the growing need for energy storage.
6. Create a special FIT rate for PV or wind generators with some minimum battery back-up[10] or other means of electricity storage such as pumped air or water, hydrogen or ammonia [11,12]

Some still unanswered questions, for which we would welcome feedback or answers to, are:

1. FIT Escalation: Although the FIT agreements are to be for 20 years, will the FIT rates be reset annually, e.g. with an escalation rate of 1 or 3 %/year, which would improve the ROI by over 25% for 20 kW systems and over 100% for small PV systems?
2. FIT Accounting: If at the end of each month, one hypothetical home-owner were to generate 100 kWh during the day, but also consistently consume 100 kWh each night (thus owing no money to the utility under a NEM agreement) -- would he owe nothing to the utility under the evolving FIT agreement or $100 \times (0.400 - 0.218) = \18.2 each month, if the normal residential tariff were 0.40 \$/kWh and the FIT rate were 0.218 \$/kWh?
3. FIT for Different Islands: Will the FIT rates be the same for all islands, despite the fact that residential “bottom line” rates are different from island to island?

According to R.Saito, after the PUC enacts the new FIT regulations, there will be a “grace period” of about a month to allow existing NEM agreement customers to switch to a FIT agreement. Therefore it behooves all present and future residential PV owners to stay informed. One deadline to submit comments on the FIT tariffs just expired August 18, 2010[7].

References

- [1] Hawaii PUC*, Document Management System, <http://dms.puc.hawaii.gov/dms/> enter "2008-0273" in Docket Quick Link search box; then click on "Documents" in the middle toolbar; when the new screen opens after some waiting, with a list of over 400 documents. Scroll

- down to the date and title of the desired document. *Hawaii Public Utilities Commission, 465 South King Street, Room 103, Honolulu, HI 96813, (808) 586-2020, Hawaii.PUC@hawaii.gov, <http://www.hawaii.gov/budget/puc>
- [2] Riley Saito, Intervenor to PUC, The Solar Alliance, Riley.Saito@sunpowercorp.com, 73-1294 Awakea Street, Kailua-Kona, Hawaii 96740, private communication, 24 July 2010
- [3] HECO "Cost of Generation Calculator," Hawaii, 2010, PV Tier 1 Project - RESIDENTIAL (sole proprietorship business)
- [4] T.Takach, Kailua-Kona, HI, takach@infowest.com, 808-345-0607
- [5] U.Bonne, "Green Energy ROI and Electricity Cost Calculator," on the "Friends of NELHA" website <http://www.energyfuturehawaii.org> . Direct access to instructions via <http://www.energyfuturehawaii.org/learn-more/7-renewable-energy-a-energy-efficiency/199-green-energy-roi-and-electricity-cost-calculator.html> and to the calculator via <http://www.energyfuturehawaii.org/solarCalc.php>
- [6] PUC Document July 29, 2010 by D.Endo-Omoto, "HECO Companies' filing of its revised tariffs and contracts for FIT Tier 1 & 2, and the IO's Status Report". And ditto filing dated 7 Jan. 2010, p.7
- [7] PUC Document 18 Aug 2010 by Blue Planet. ...the parties may submit comments on the Status Report and proposed redline revisions to the HECO Companies' proposed revisions to the Tiers 1 and 2 Schedule FIT and Standard Agreement by August 18, 2010.
- [8] Reference [6], p.7: "Metering" ...Electric energy delivered to the Seller by the Company will be metered separately from the electric energy delivered by the Seller to the Company, either by use of multiple meters or a meter capable of **separately recording the net inflow and outflow of electricity**.
- [9] PUC Document[1] (Letter) of 7 Jan. 2010 by D.Endo-Omoto of HECO, on p.5: "FIT rates will be based on the project cost and reasonable profit of a typical project..."
- [10] U. Bonne, "Cost of Battery-Stored Electricity," Kailua-Kona, HI, August 2010, in preparation. This study digs into the cost of installing, maintaining and replacing batteries for small home systems, vs. type of operation and battery.
- [11] Chester P. Lowrey, Jason C. Ganley, and Guy Toyama, "Air-Source Ammonia Plant (ASAP)," proposal submitted to HTDV, 12 July 2010
- [12] 7th Annual NH3 Fuel Conference, Crowne Plaza, Romulus, MI, Sept. 26-28, 2010

Table 1. PV system cost, electricity cost, ROI and payback time vs. size and for

Input data									
PV Power kW	PV Cost \$	Fitted Cost, k\$	C/Q \$/W	PV Electricity Cost	CAROI		Payback Time, t years* **	HECO Letter 7 Jan.'10	
				Cost	%/year*	%/year**		\$/W	¢/kWh
0.47	5.25	5.25	11.17						
2.30	17.25	17.08	7.43	41.9	-1.17	-3.55	58.38		
2.83		19.93	7.04	26.0	1.38	-0.78	29.88	7.04	25.0
4.70	29.05	29.05	6.18	16.4	3.58	1.69	16.55		
6.18	35.61	35.61	5.76	13.7	4.30	2.50	13.63	5.76	18.7
7.50	41.12	41.12	5.48	12.2	4.73	2.98	12.15		
7.55	41.32	41.32	5.47	12.2	4.75	2.99	12.10		
20.00	85.00	85.24	4.26	7.6	6.43	4.79	7.80		
100.00		281.91	2.82	4.1	8.55	6.97	4.55		
500.00		932.36	1.86	2.5	10.42	8.85	2.85		

$$C = a \cdot Q^b; a = 9.1983$$

$$t = a \cdot Q^{(b-1)}; b = 0.7432$$

* For 3%/year FIT escalation rate
 ** For 0%/year FIT escalation rate

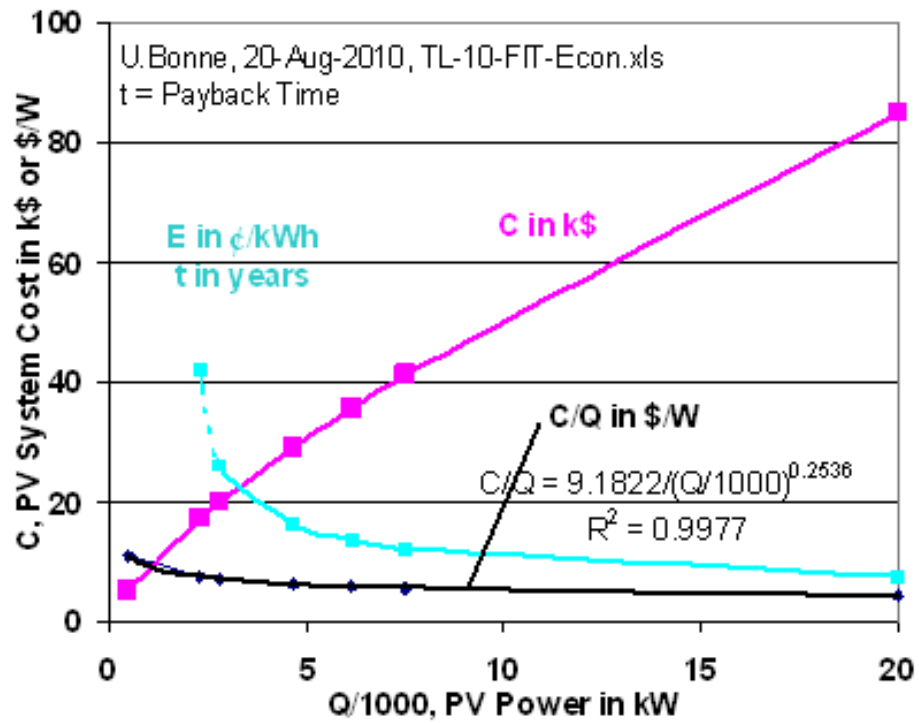


Fig. 1. Economy of Scale for Small PV Systems, with cost data by T.Takach[4]