PURPA and the Impact of Existing Avoided Cost Contracts on Hawaii's Electricity Sector

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Introduction

The United States has been trying to reduce its dependence on imported fossil fuel since the 1970s. Domestic fossil fuel supply initially peaked in 1970, and the oil crises of 1973 and 1979 accelerated domestic policy and investments to develop renewable sources of energy (Joskow, 1997). One such policy—passed in 1978 by the U.S. Congress—was the Public Utility Regulatory Policies Act (PURPA).

In this policy brief, we identify the existing PURPA-based contracts in Hawai'i and use a Hawaii-specific electric sector generation planning model, The Hawaii Electricity Model (HELM), to estimate the impact that PURPA contracts have on both total system cost and the mix of generation technologies. We study a variety of scenarios under the maintained assumption that the state will achieve the Hawai'i Renewable Portfolio Standard, which requires that 40% of electricity sales are generated using renewable sources by the year 2030.

PURPA and Avoided Cost

PURPA, a part of the National Act in Energy, incentivizes diversity in energy production by forcing electric utilities to buy power from qualifying energy producers. The rate paid to the energy producers is determined by the "avoided cost" of producing power otherwise. The policy is intended to make more sources of electricity available, including renewable sources, at rates that would otherwise be paid under the status quo. PURPA additionally supports the deregulation of utility monopolies by creating new incentives to develop independent production of renewable sources of electricity (Hirsh, 1999).

The core concept of PURPA is to have utilities purchase power from independent generators in the hope that competition provokes greater efficiency and lower rates. The Federal Energy Regulatory Commission (FERC) created a new class of power producers called Qualifying Facilities (QFs). To obtain a QF certification, a wholesale power generator must either be 1) a small power production facilities (80 MW or less) that produces electricity by employing biomass, waste, or renewable resources as the primary energy input, or 2) a cogeneration plant that meets a series of requirements regarding fuel use, fuel efficiency, and reliability (FERC, 2012).

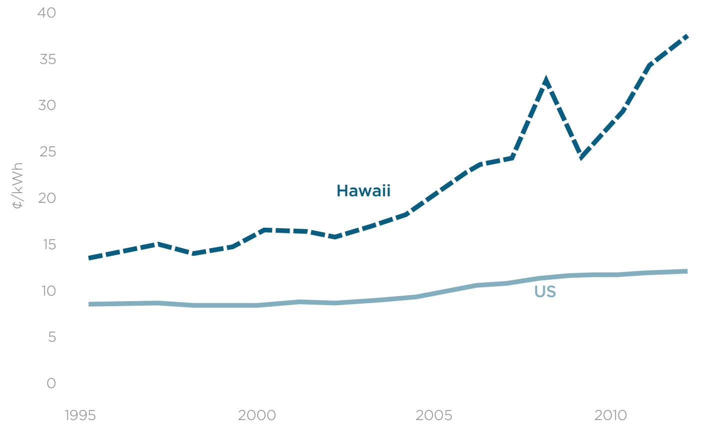
QFs sell their power to utilities at a rate determined by avoided cost—the cost that the utility would incur and subsequently pass on to ratepayers if it generated the same power itself.

PURPA mandates that implementation and enforcement of the policy be left to the individual states to achieve the goals set by the federal law. States have varying interpretations of the meaning of avoided cost and this creates differences in implementation and enforcement of the policy (Abel, 1998).

PURPA in Hawai'i

Since PURPA was first implemented in Hawai'i, oil-fired facilities have provide most of Hawai'i's electricity. Therefore, the cost of electricity from renewable energy has been tied to the fluctuating cost of imported oil. In contrast, on the U.S. mainland coal is the primary energy source, and coal is both lower in cost and more stable in price. In Hawai'i, implementation

Figure 1 - Average Hawaii and US Electricity Rates



of PURPA meant that many QFs, or more commonly, independent power producers (IPP) contracts were tied to the price of oil. As the price of oil increases, so does the price of renewably generated electricity; ultimately, negating potential benefits in cost savings from renewable energy to the ratepayers.

Hawai'i's High Electricity Cost

Because Hawai'i's primary fuel source is oil, Hawai'i residents pay rates that are three to four times more than the national average. Historically, rates were closer to double the national average, though the gap between Hawai'i's prices and the U.S. have widened within the last several years, as shown in Figure 1.

The high cost of energy prompted the 2009 Hawai'i Legislature to pass Act 50 amending §269-27.2(c), of the Hawai'i Revised Statutes (HRS). Act 50 attempts to de-link the cost for non-fossil fuel generated electricity from fossil fuel prices by allowing the electric utility to negotiate non-avoided cost contracts with IPP's. Contracts must be approved by the Public Utilities Commission (PUC). Given the high cost of oil-based generation, this policy creates the potential for promoting price stability and cost savings as a result of pursuing more generation from alternative sources of energy (PUC, 2009). As a consequence, purchase power agreements negotiated after 2009 are primarily fixed-price contracts (generally with inflation-adjustment clauses) (The Kohala Center, 2012).

Current Avoided Cost Contracts

Although the amended avoided cost policy - and its subsequent modifications - are now in

Table 1. Hawaii Island PPI's Under Avoided Cost Contract ($2007)

IPP's Under Avoided Cost Contract	Total Payment 2010 ($/MWh)	Total Payment 2011 ($/MWh)	Total Payment 2013 Test Year ($/MWh)	Average[a] (¢/kWh)
Puna Geothermal Venture	149	187	158	16.5
Tawhiri Power LLC	145	151	175	15.7
Hawi Renewable Development	133	171	148	15.1
Wailuku River Hydro	133	176	156	15.9

[a] Weighted average based on generation.
Source: HELCO, 2012a.

place, several existing contracts with IPPs do not expire until between 2021 and 2027 (The Kohala Center, 2012). Most of these are on Hawai'i Island. Specifically, we identified four IPP's that are under avoided cost contract on Hawai'i Island: Puna Geothermal Venture (25 MW), Tawhiri Power LLC (21 MW), Hawi Renewable Development (10.6 MW), and Wailuku River Hydro (9.8 MW). Table 1 shows the total payments that were made to these four IPPs in 2010 and 2011, the most recent years for which data are available.

A small portion of the Maui Electric Company contract with the Kaheawa wind project is at avoided cost. Because the avoided cost component of this contract is relatively small we focus on the avoided cost contracts only on Hawai'i Island.

Expected Impacts to Consumers

Whether these avoided cost contracts are good or bad for consumers depends on their cost relative to the actual cost of generating power from these sources. Because the avoided cost contracts are tied to the price oil, a relatively costly fuel, they are generally higher than what would be expected based on levelized cost.[1] For example, the levelized cost of renewable generation such as wind and geothermal plants typically range from $0.03 to $0.12 cents per kWh (NREL, 2013). As shown in Table 1, the public utility paid the IPPs roughly $0.16 cents per kWh. Moreover, the gap between the levelized cost of electricity generated from non-avoided cost renewable sources and oil-fired generation will widen in the future if the U.S. Energy Information Agency's (EIA) forecasts for oil prices is realized. The EIA's 2013 Annual Energy Outlook forecasts crude oil prices to rise by an average of 1.8% over the next 20 years leaving oil roughly 45% more expensive 20 years from now (EIA, 2013b). Therefore, electricity prices could be reduced if these avoided cost contracts were renegotiated at a rate closer to their actual cost rather than at the avoided cost of oil-fired generation.

The conundrum of course is that IPP's have little incentive to renegotiate existing contracts and would clearly prefer receiving higher rates for their electricity production. Nonetheless, many avoided cost contracts in Hawai'i have either expired and/or been renegotiated. The incentives for renegotiation are either because the IPP wants to expand operations or forego curtailment. Curtailment occurs when the utility does not purchase some of the power generated by IPP's. This is done for several reasons, the first is to maintain the stability of the power system. When demand for electricity is low, the utility makes the decision to not purchase intermittent power, such as wind, to keep the firm, baseload generation units on-line. In addition, depending on the IPP's contract, the utility can choose to prioritize taking some sources of generation over others depending on relative cost. This means that even if an IPP is providing a firm source of power, its generation could be curtailed if it is relatively costly. This depends on the terms of

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[1] *Levelized cost for a generating unit is the price at which its electricity must be sold for it to break even over its lifetime under an assumed utilization rate. For example, the estimation of levelized cost for wind energy would account for an assumption that the wind turbines are expected to have a useful economic life of approximately 30 years.*

the IPP's contract, however, and these terms are rarely made public.

Given that avoided cost prices are significantly higher than the levelized cost of the IPP's generation raises the question, "How would ratepayers benefit if the utility were to renegotiate these contracts?" This analysis looks at the implications for cost savings and the mix of electric generation if the four avoided cost contracts on Hawaii Island were to be renegotiated. To answer these questions, we use the HELM Model.

The Hawaii Electricity Model

HELM is a dynamic, partial equilibrium model of Hawaii's electric sector. Often referred to as "bottom-up" models, this type of model supports detailed analysis based on capital and operating costs, technological constraints, and environmental factors (Zhang and Folmer, 1998). It solves for the least-cost mix of generation subject to satisfying demand, regulatory requirements, and system constraints. It dispatches electricity against a load duration curve that has 84 different load blocks that represent variation in load throughout the day and year.

HELM is calibrated to existing electricity units in the year 2007 for Hawaii's four counties. It solves for 2012, 2015 and in 5-year intervals until 2035. Future energy price forecasts are adopted from the U.S. Energy Information Administration's Annual Energy Outlook 2013, reference fuel price case. The electricity demand for Hawaii, Maui, and Oahu projections are adopted from HECO's IRP-4/s Stuck In The Middle case. Kauai's electricity demand is taken from its IRP-3 (HEI, 2013).

HELM is solved using GAMS (General Algebraic Modeling System) and a linear programming solver. For more information on this modeling platform, refer to Rosenthal (2008). For a complete technical description of HELM, see Coffman, Griffin and Bernstein (2012).

Unit Data

The database for HELM is constructed from several publicly available sources – including the utilities' Integrated Resources Plans (IRPs), which are mandated by the Public Utilities Commission (PUC), submitted "rate case" approvals to the PUC, and the U.S. EIA state energy database.

Several parameters are needed to fully define the existing and potential (new) units' costs and operating characteristics. Existing unit costs include fuel, fixed and variable operating costs. New units are also characterized by capital costs (CAP). A unit's fuel costs can be estimated to equal the product of its average heat rate (mmBtu/MWh) and fuel price ($mmBtu). Fuel costs exist for all fossil and biofuel-fired units.

All units have fixed operating and maintenance (FOM) and variable operating and maintenance (VOM) costs. A unit's annual FOM cost equals its annual capacity times its per kilowatt ($/kW) FOM cost. Within the utility data filings, FOM accounts for labor and other costs that are almost always fixed throughout a given year. A unit's annual VOM cost equals its per megawatt hour ($/MWh) VOM times its annual generation. VOM accounts for costs that are proportional to usage, such as materials like lubricants. Capital cost includes the construction and other building

Table 2. Cost and physical characteristics of existing and new units (2007$)

	Total potential capacity GW (sum)	FOM 2007$/ kW (avg)	VOM 2007$/ MWh (avg)	Capital Exp 2007$/kW (avg)	Capital Cost 2007$/kW (avg)	Heat Rate mmbtu/ MWh (avg)	Capacity Factor % (avg)	Availability % (avg)
Existing								
IC	0.18	66	14	-	-	9,769	-	34
ST	1.14	172	1	-	-	11,057	-	63
GT	0.31	45	16	-	-	17,501	-	11
CC	0.45	87	6	-	-	8,754	-	71
Coal	0.18	37	2	-	-	10,510	-	88
Biomass	0.01	170	5	-	-	10,011	-	80
MSW	0.09	263	18	-	-	15,932	-	60
Geo	0.04	162	19	-	-	-	-	90
Hydro	0.03	59	21	-	-	-	47	95
Wind	0.21	124	2	-	-	-	38	95
PV	0.02	42	22	-	-	-	22	95
Rooftop	0.24	-	-	1,384	-	-	18	95
New								
SC	No Limit	9	9	-	1,917	9,340	-	80
CC	No Limit	57	11	-	3,313	7,630	-	80
Gas	No Limit	58	7	-	3,110	7,660	-	80
Biomass	0.03	393	6	-	3,625	18,840	-	80
MSW	0.06	568	31	-	17,195	19,300	-	83
Geo	0.08	190	27	-	8,751	-	-	90
Wind	0.39	214	2	-	3,868	-	39	95
Windblatt	0.39	213	2	-	4,476	-	39	95
PV	0.28	37	3	-	3,248	-	27	95
PVbatt	0.07	43	3	-	3,626	-	27	95
Rooftop	0.86	-	-	1,384	3,959	-	22	95

Sources: Data aggregated based on a weighted average (by capacity), from each island's respective integrated resource plan, rate case filings, and the US Energy Information Administration. HELCO, 2006; HELCO, 2009; HELCO, 2012a; HELCO, 2012b; HECO, 2005; HECO, 2008; HECO, 2010; HEI, 2013; KIUC , 2008; KIUC, 2009; MECO, 2005; MECO; 2009; EIA, 2010-2012a; EIA, 2010-2012b.

[a] *This is the full cost before state and federal income tax credits (35% and 30%, respectively) are applied. Subsidies are accounted for within HELM.*

costs. We assume that operations and capital costs are constant through the model horizon, although a distinction is made between existing units and new units.

Costs represent only one part of a unit's data needs. The other involves its physical characteristics, such as heat rates for fuel-burning plants and utilization rates. Units are unavailable to operate all hours in a year because they must undergo routine or emergency maintenance. When possible, "availability" is computed from data on historical operations. For units which have no readily accessible information, we estimate availability based on similar units provided within the IRPs.

In addition "as available" units are subject to a capacity factor or utilization rate, which accounts for the fact that because of physical limitations of these units (e.g., the sun does not shine and the wind does not blow 24 hours a day), they cannot operate 100% of the time even if they underwent no maintenance. For wind units, capacity factors by county are adopted from a recent Hawaii-specific study on wind potential. This study shows that the wind patterns in Hawaii allow for an average capacity factor of 41% statewide (HNEI, 2011). In addition, new rooftop solar photovoltaic units are subject to a capacity factor of 22% (GE Consulting, 2012).

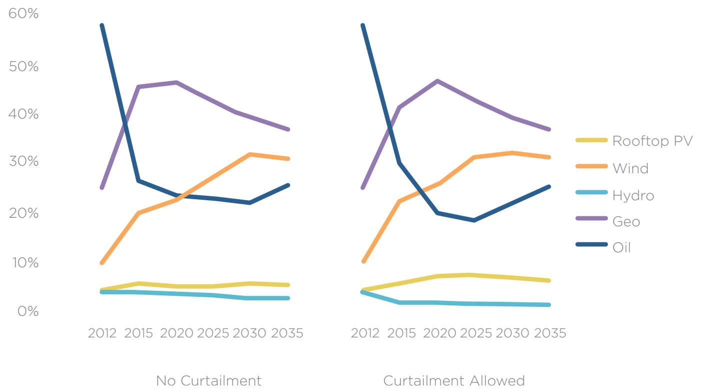
The initial capacity is provided as an input for all existing units. We assume that a unit can be retired from use—reducing its capacity to zero—if it ceases to be cost-effective. Oil-burning units can be modified to burn bio-oil or biodiesel depending on the type of oil-burning unit. For diesel burning units, we assume biodiesel and conventional diesel are perfect substitutes. For fuel oil units, we assume the maximum share of bio-oil (or crude palm oil) that can be burned is 75%. Table 1 provides an overview of the average costs and physical characteristics of existing (in 2005) and new units. HELM uses unit-specific figures.

Electricity units are presented by Internal Combustion (IC), Steam Turbine (ST), Gas Turbine (GT), Combined Cycle (CC), Simple Cycle (SC), Coal, Biomass, Municipal Solid Waste (MSW), Geothermal (Geo), Hydro, Wind, Wind with Battery Storage (Windbatt) Utility Scale Photovoltaic (PV), Utility Scale Photovoltaic with Battery Storage (PVbatt), and Rooftop Photovoltaic (Rooftop). We assume that ST, GT, CC, and SC and units are able to burn both conventional and bio-based oil.

Avoided Cost Contracts

Information on the structure of the avoided cost contracts is generally proprietary and thus quite limited. As a result, we have to make assumptions about the pricing structure of the four avoided cost contracts we study. We estimate the 2011 price charged to the Hawaii Electric Light Company (HELCO) for the four IPP's by dividing the total cost paid to the utility (reported in Table 1) by the unit's generation. Because the avoided cost contracts are indexed (either partially or in their entirety) to oil, we assume that the price of the avoided cost contracts change from their initial prices with the change in oil prices. We use the U.S. EIA 2013 Annual Energy Outlook's Brent reference crude oil price forecast (EIA, 2013b). We construct an

Figure 2 - Hawai'i Island generation by fuel type, allowing curtailment



oil price index normalized to one in 2011 with future values determined by the EIA's forecasted growth of oil prices. The cost of the contracts in a particular year is set equal to our 2011 estimate of the avoided cost price multiplied by the oil price index for that year.

While this approach captures the fact that avoided cost contracts are generally tied to the price of oil, without publicly available information on the structure of the contracts we can not be certain whether we are overstating or understating the cost of these contracts.

Scenarios

To assess the effects of the four avoided cost contracts on the overall cost of providing electricity, we consider two scenarios. The first scenario determines the least cost way to meet electricity demand. In this scenario, the utility is assumed to have full flexibility with the avoided cost contracts. Namely, the utility can curtail as much or as little power as it wants. In the second scenario, the utility must take all power produced by the four IPPs listed in Table 1.

To assess the implications of the current avoided cost contracts, we run HELM under these two scenarios. In these runs, we assume that the State's RPS is met.

Results

The scenarios show that there is a substantial difference in both the profile of electricity generation on Hawai'i Island and electricity generation costs as a result of allowing or not allowing curtailment of the existing avoided cost IPP's. Specifically, we find that forcing the utility to accept all power generated by these relatively costly contracts increases the cost of generation by 6%. This means that electricity rates similarly increase by 6%; for example, increasing rates from $0.43 to $0.46 cents per kWh. Since this 6% reduction in electricity rates is based on replacing

Table 3. Change in Electricity Generation by Fuel Type in GWH
("Curtailment" minus "No Curtailment")

	2012	2015	2020	2025	2030	2035
Oil	0.0	47.3	-48.3	-70.3	-1.4	-1.6
Geo	0.0	-52.9	3.4	3.4	6.2	4.1
Hydro	0.0	-26.7	-26.7	-26.7	-26.7	-26.7
Wind	0.0	32.4	42.3	58.3	3.9	6.3
Rooftop PV	0.0	0.0	29.4	35.4	18.0	18.0

the avoided cost contract plants with entirely new ones, the savings is likely to be even greater (i.e. no capital costs) if they are renegotiated.

Figure 2 shows the optimal mix of electricity generation by fuel type, under the scenarios that curtailment is allowed (i.e. a price optimizing scenario) and that it is prohibited. Table 3 shows the difference in electricity generation between the "curtailment" and "no curtailment" scenarios, in GWH, by fuel type.

One of the most notable findings is in regards to geothermal-based generation. Under the "no curtailment" scenario, we find that the existing geothermal unit is run at full capacity (by assumption) and that an additional 47 MW of geothermal are built. Under the "curtailment" scenario, however, we find that the existing geothermal unit is so relatively expensive because of the avoided cost contract that the model chooses to curtail (effectively "retire" within the model framework) 25 MW of existing geothermal. Building new geothermal that is not under avoided cost pricing, however, is a cost effective technology and so a total of 73 MW of geothermal are additionally built. Thus although there is more geothermal under the "no curtailment" scenario in the year 2015 (by 53 MW), there is in the long-term more geothermal (and less costly geothermal) when the utility is allowed to curtail geothermal in the near-term. This finding is made even considering the capital expenditure for new geothermal units. This relatively extreme outcome is supported by the fact that geothermal provides a baseload electricity resource, and thus is overall a very cost-effective technology. This means that the difference between the estimated levelized cost of geothermal and the estimated payments made through avoided cost pricing is great enough to merit substantial curtailment of the existing resource while building out large amounts of new geothermal resource.

Similarly, we find that it is cost-effective to retire existing wind units that are under avoided cost contracts and replace them with new wind units based on actual costs. If existing wind units are allowed to be curtailed, we find there to be a total of 160 MW of new wind built; whereas under the no "curtailment" scenario, 121 MW of new wind is built.

We find that the hydro unit under avoided cost pricing is relatively expensive and should be (from a cost perspective), curtailed up to 27 GWH per year to optimally meet electricity demand on Hawaii Island.

Conclusions

In this analysis, we use the Hawaii Electricity Model to estimate the cost impacts and electricity generation profile on Hawaii Island of four existing avoided cost contracts. Because the structure of these contracts is not publicly available, we run two "extreme" scenarios – the first where the utility is allowed to minimize electricity generation costs freely (i.e. cannot curtail the generation of electricity from the avoided cost-based IPPs) and the second where the utility is forced to take all generation from the four avoided cost IPPs.

We find that the existing avoided cost contracts are so costly that it can make economic sense to curtail generation from these units and invest in new generation units of the same resource. This includes considerations for payment for new capital. This finding is most prominent for geothermal because the technology is relatively inexpensive and provides a firm, baseload resource for Hawaiʻi Island. We find that the existing four avoided cost contracts raise electricity costs by an estimated 6% in comparison to an optimizing scenario. This would be even greater if contracts are renegotiated rather than building new infrastructure.

The implications of this research are quite intuitive: contracting matters. Although PURPA was well-intended as a policy mechanism to increase the penetration of renewable energy within the U.S., the unintended consequence was that it limited the consumer's ability to realize lower cost prices from renewable energy sources. This is particularly relevant in Hawaii, where the cost of generating electricity is relatively high because of dependence on oil. This suggests that the structure of contracts, even long-term fixed-price contracts must be crafted carefully and, ultimately, aim to achieve marginal cost pricing for electricity generation by technology and resource. This is a fruitful area of future research, and will require an understanding of the bidding system for renewable energy projects, as well as issues of risk and market power.

It should also be noted that our results depend heavily on the path of future oil prices. More broadly, it can also vary by the interpretation of what constitutes "avoided cost." As lower cost energy technologies become available, this reinterpretation of avoided cost may help to lower the payments to existing contracts.

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