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CPUC Self-Generation Incentive Program

Semi-Annual Renewable Fuel Use Report No. 11 for the Six-Month Period Ending December 31, 2007

Submitted to:

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1. Purpose of this Report

The purpose of this report is to provide the Energy Division of the California Public Utilities Commission (CPUC) with updated information on fuel use and installed costs of Self-Generation Incentive Program (SGIP) projects utilizing renewable fuel.[1]

The report identifies the compliance of renewable fuel use projects in the SGIP with specified renewable fuel use requirements. In particular, no more than 25 percent of the annual fuel consumption (determined on an energy input basis) of a renewable fuel use project can be derived from nonrenewable resources. These projects, which are *exempt* from waste heat recovery requirements, are referred to as Renewable Fuel Use Requirements (RFUR) projects in this report.

In addition, the report includes comparisons between costs of RFUR projects and other projects that are subject to heat recovery requirements. The reason for this comparison is a concern that RFUR projects could have lower project costs than other projects, which could result in fuel switching. The analysis of project costs includes examination of waste heat recovery and fuel treatment equipment costs.

This information is provided to the Energy Division to assist staff in making recommendations to the CPUC concerning modifications to the renewable project aspects of the SGIP. This report complies with Decision 02-09-051 (September 19, 2002) that requires SGIP Program Administrators to provide updated information on completed renewable fuel use projects on a six-month basis.[2] The six-month reporting period for this report extends

[1] The SGIP Handbook defines renewable fuels as wind, solar, and gas derived from biomass, landfills and dairies. Renewable fuel use in the context of this report effectively refers to biogas fuels obtained from landfills, waste water treatment facilities and dairy anaerobic digesters.

[2] Ordering Paragraph 7 of Decision 02-09-051 states:

"Program administrators for the self-generation program or their consultants shall conduct on-site inspections of projects that utilize renewable fuels to monitor compliance with the renewable fuel provisions once the projects are operational. They shall file fuel-use monitoring information every six months in the form of a report to the Commission, until further order by the Commission or Assigned Commissioner. The reports shall include a cost comparison between Level 3 and 3-R projects…."

Ordering Paragraph 9 of Decision 02-09-051 states:

"Program administrators shall file the first on-site monitoring report on fuel-use within six months of the effective date of this decision [September 19, 2002], and every six months thereafter until further notice by the Commission or Assigned Commissioner."

from June 1, 2007, to December 31, 2007, and includes analysis of all such projects installed since the SGIP's inception in 2001.

2. Summary of Operational RFUR Projects

Two new RFUR projects were completed during the six-month reporting period. As a result of these two new projects, there was a total of 31 RFUR projects operational in the SGIP as of December 31, 2007. A complete list of all SGIP projects utilizing renewable fuel is included as Appendix A. Principal observations about the recently completed RFUR projects include:

- The Pacific Gas & Electric (PG&E) and Southern California Edison (SCE) Program Administrators each had one new RFUR project completed during this six-month reporting period.
- Both of the new RFUR projects use digester gas exclusively (i.e., no nonrenewable fuel contribution) in internal combustion (IC) engines. One project is fueled by renewable fuel produced by digestion of manure generated at a small dairy; the other project is located at a municipal wastewater treatment plant.

The 31 operational RFUR projects represent nearly 11 MW of installed generating capacity. The prime mover technologies used by these projects are summarized in Table 1. Nearly 68 percent of the total rebated RFUR capacity uses IC engines. An emerging technology, fuel cells, accounts for a little less than 7 percent of RFUR project capacity. The average size of microturbine projects is 175 kW, whereas the average size of renewable-powered fuels cells is approximately 375 kW and the average size of renewable-fueled IC engines is approximately 570 kW.

Table 1: Summary of Prime Movers for RFUR Projects

Prime Mover	No. Projects	Total Rebated Capacity (kW)
FC	2	750
MT	16	2,800
IC Engine	13	7,448
Total	**31**	**10,998**

FC = fuel cell; MT = microturbine; IC Engine = internal combustion engine

While all RFUR projects could use as much as 25 percent nonrenewable fuel, most operate completely from renewable fuel resources. The fuel supplies for RFUR projects are summarized in Table 2. Nearly 76 percent of the total RFUR project capacity represents projects that operate solely from renewable resources.

Table 2: Summary of Fuel Supplies for RFUR Projects

Fuel Supply	No. Projects	Total Rebated Capacity (kW)
Renewable only	26	8,350
Renewable & nonrenewable	5	2,648
Total	**31**	**10,998**

Many of the renewable fuel use projects recover waste heat even though they are exempt from heat recovery requirements. Waste heat recovery incidence by renewable fuel type is summarized in Table 3. Verification inspection reports obtained from Program Administrators indicate that 22 of the 31 RFUR projects recover waste heat. All but 2 of the 20 digester gas systems include waste heat recovery. Waste heat recovered from digester gas systems is generally used to pre-heat waste water sludge prior to its being pumped to digester tanks. Less than half of the landfill gas systems include waste heat recovery. Those systems that do recover heat do not use it directly at the landfill site. Instead, the landfill gas is piped to an adjacent site that has both electric and thermal loads, and the gas is used in a prime mover at that site.

Table 3: Summary of Waste Heat Recovery Incidence and Type of Renewable Fuel for RFUR Projects

Renewable Fuel Type	No. of Sites	Sites With Heat Recovery	Sites Without Heat Recovery
Digester Gas	20	18	2
Landfill Gas	11	4	7
Total	**31**	**22**	**9**

3. Fuel Use at RFUR Projects

As shown in Table 2, 26 of the 31 RFUR projects obtain100 percent of their fuel from renewable resources. By definition, all 26 of those projects are in compliance with the SGIP's renewable fuel use requirements. Of the remaining five projects:

- **PG&E A-1313**. No metered data are yet available to assess the actual fuel mix during this reporting period. This microturbine project came online in March 2007. In PG&E's February 2007 installation verification inspection report, the participant identified that the system was using 87 percent digester gas and 13 percent natural gas.
- **SCE PY03-017.** This IC engine system was designed to use natural gas for back-up and piloting purposes. Metered electric generation, biogas consumption, and natural gas consumption data received from the SGIP participant indicate that

natural gas usage was much less than 25 percent of the total annual fuel input during the current reporting period.

- **SCE PY04-158 and SCE PY04-159.** These two systems are located at the same wastewater treatment facility and utilize renewable fuel produced by the same digester system. These two projects are grouped together here because they share a common fuel blending system. The fuel blending system controls the mix of renewable and nonrenewable fuel. No metered data are yet available to assess the actual fuel mix during this reporting period. In SCE's September 2006 installation verification inspection reports, the participant identified that the systems were using 80 percent digester gas and 20 percent natural gas. In the future, Itron will install natural gas metering to verify that the nonrenewable consumption remains below the requisite 25 percent of annual fuel use on an energy input basis.
- **SCE PY03-092.** This 500 kW fuel cell project uses natural gas for backup fuel supply and piloting purposes. The fuel cell system is composed of two molten carbonate fuel cells, each of which is rated for 250 kW of electrical output. Renewable fuel used by this system is produced as a by-product of a municipal wastewater treatment process. A natural gas metering system has been installed by Southern California Gas (SCG) to monitor natural gas usage. Itron received natural gas usage data from SCG and metered electric output data from the applicant. Metered electric generation and natural gas consumption data indicate that natural gas usage was substantially less than 25 percent of the total annual fuel input during the current reporting period.

Fuel use compliance for dual-fuel systems is summarized in Table 4. Overall, at least 28 (90 percent) of the RFUR projects comply with the SGIP's 25 percent nonrenewable cap. Itron is moving forward with installing fuel metering to enable definitive conclusions to be drawn about the remaining three projects.

Table 4: Fuel Use Compliance of RFUR Projects Utilizing Nonrenewable Fuel

PA Project ID No.	Program Administrator/ Funding Level	Technology/ Fuel Type	Capacity (kW)	Oper-ational Date[3]	Annual Natural Gas Energy Flow (MM Btu)[4]	Renewable Fuel Use (% of Total Energy Input)	Meets Program Renewable Fuel Use Requirements?
PY03-092	SCE/ Level 1	FC/ Digester gas	500	3/11/2005	12,522[5]	85.2%	Yes
PY03-017	SCE/ Level 3-R	IC Engine/ Digester gas	500	5/11/2005	5.1	99.3%	Yes
PY04-158	SCE Level 3-R	IC Engine/ Digester Gas	704[6]	11/15/2005	NA	NA	NA
PY04-159	SCE Level 3-R	IC Engine/ Digester Gas	704	11/15/2005	NA	NA	NA
1313	PG&E/ Level 3-R	MT Digester Gas	240	3/6/2007	NA	NA	NA

"NA" ≡ "Not Available". Metered data necessary to calculate estimates of natural gas energy use are not yet available. In the future, these projects will be monitored to determine if they meet the SGIP's renewable fuel use provisions.

4. Cost Comparison between RFUR and Other Projects

Beginning in September 2002, RFUR projects were eligible for a higher incentive level than nonrenewable projects. The size of this incentive premium was designed to account for numerous factors, including:

- RFUR projects face higher fuel pre-treatment costs
- RFUR projects might not face heat recovery equipment costs
- RFUR projects do not face fuel purchase expenses

[3] Since assignment of a project's operational date is subject to individual judgment, the incentive payment date as reported by the Program Administrators is used as a proxy for the operational date for reporting purposes.

[4] This field represents the natural gas consumption during the 12-month period ending 12/31/2007. The basis is the LHV of the fuel.

[5] The meter reading schedule of the natural gas utility is such that December 2007 natural gas usage data were not available in time to be included in this report. All values reported for this project are therefore based on metered electric and natural gas data for the period covering January 1, 2007, through November 30, 2007.

[6] In Renewable Fuel Use Reports #9 and #10 this project's size was reported as 296 kW. That was the capacity used in incentive calculations; the actual physical size of the system is 704 kW.

Concerns were expressed in CPUC Decision 02-09-051 that Level 3-R project costs could fall below Level 3 costs due to Level 3-R projects being exempt from waste heat recovery requirements. As a result, Level 3-R projects could potentially be receiving a greater-than-necessary incentive level, which could lead to fuel switching. To address this concern, the CPUC directed SGIP Program Administrators to monitor Level 3 and Level 3-R project costs.

It is possible to use historical SGIP project cost data to examine fuel treatment and heat recovery costs faced by SGIP participants. Eligible installed costs for all fuel cell, microturbine, and IC engine projects operational as of December 31, 2007 are summarized in Table 5. The summary distinguishes between fuel type[7] and heat recovery incidence to facilitate independent examination of the principal factors influencing costs of projects utilizing renewable fuel.

Table 5: Summary of Project Costs by Technology, Heat Recovery Provisions & Fuel Type

Tech	Includes Renewable Fuel?	Includes Heat Recovery?	No. Projects	Eligible Installed Costs ($/Watt)				
				Range	Median	Mean	Std. Dev.	Size-Weighted Average
FC	Yes	Yes	2	9.41 - 9.85	9.63	9.63	0.31	9.70
	Yes	No	0	-------	-------	-------	-------	-------
	Yes	Yes or No	2	9.41 - 9.85	9.63	9.63	0.31	9.70
	No	Yes	12	5.06 - 18.00	6.92	8.36	3.92	7.18
IC Engine	Yes	Yes	14	1.08 - 7.22	2.69	2.98	1.73	2.65
	Yes	No	1	1.71 - 1.71	1.71	1.71	-------	1.71
	Yes	Yes or No	15	1.08 - 7.22	2.64	2.90	1.70	2.63
	No	Yes	192	0.85 - 8.16	2.25	2.40	1.00	2.20
MT	Yes	Yes	13	2.26 - 11.30	3.99	5.13	2.69	4.55
	Yes	No	8	1.23 - 5.39	3.83	3.57	1.39	2.85
	Yes	Yes or No	21	1.23 - 11.30	3.90	4.53	2.37	3.87
	No	Yes	102	0.70 - 6.39	3.17	3.23	1.14	3.06

Besides the cost of waste heat recovery equipment, fuel clean up costs may account for much of the differential between renewable and nonrenewable project costs. The bases of heat recovery equipment and fuel clean up equipment cost comparisons are described below.

[7] To assess the difference in costs between those technologies using renewable fuel resources versus those using only nonrenewable fuels, we differentiate fuel type in Table 5 by identifying those using any amount of renewable fuel as a "Yes" classification.

Heat Recovery Equipment Costs

All of the projects using renewable fuel include fuel-conditioning equipment. Approximately half of the renewable fuel projects include heat recovery even though most of them were not required to. Any difference observed between the average costs of these two groups could be due to the difference in provisions for heat recovery. This relationship is expressed symbolically in Equation 1. For example, the heat recovery difference for microturbines ($1.56) is calculated as $5.13 minus $3.57.

$$\Delta Heat\,\mathrm{Re}\,cov\,ery = \begin{pmatrix} RFUR \\ w/\,HR \end{pmatrix} - \begin{pmatrix} RFUR \\ w/\,o\,HR \end{pmatrix}$$ **Equation 1**

Fuel Treatment Equipment Costs

All of the nonrenewable fuel projects include heat recovery equipment. Many of the renewable fuel projects include heat recovery even though most of them were not required to. Any difference observed between the costs of these two groups could be due to the difference in provisions for fuel treatment (which is usually but not always limited to gas clean up such as removal of hydrogen sulfide). For example, the fuel treatment difference for internal combustion engines ($0.58) is calculated as $2.98 minus $2.40.

$$\Delta Fuel\,Treatment = \begin{pmatrix} RFUR \\ w/\,HR \end{pmatrix} - \begin{pmatrix} NG \\ w/\,HR \end{pmatrix}$$ **Equation 2**

Weighted Average RFUR Equipment Costs

All of the nonrenewable fuel projects include heat recovery equipment. Many of the renewable fuel projects include heat recovery even though many were not required to employ heat recovery. By looking at the observed difference in costs of these two groups, it is possible to see the average overall influence of different SGIP requirements. For example, the RFUR difference for internal combustion engines ($0.50) is calculated as $2.90 minus $2.40.

$$\Delta RFUR = \begin{pmatrix} RFUR \\ w/\,or\;w/\,o\;\;HR \end{pmatrix} - \begin{pmatrix} NG \\ w/\,HR \end{pmatrix}$$ **Equation 3**

Uncertainty Analysis

Project cost data are available for all completed projects. The sampling error included in 'difference of means' results calculated for projects completed in the past is zero because project cost data are available for all of these projects. However, the key question faced by the CPUC and other program designers is:

How accurately do the cost differences calculated for projects completed in the past represent the cost differences that are likely to be faced by program participants in the future?

This question is more difficult to answer. The answer depends on many factors, including:

1. The number of projects completed in the past.
2. The variability exhibited by cost data for the projects completed in the past.
3. The possible changes in system costs through time yielded by experience, economies of scale or technology innovation.

Cost comparison discussions for microturbines, internal combustion engines, and fuel cells are presented below. Difference of means results are augmented with 90 percent confidence intervals about these means.

Microturbine Project Cost Comparisons

Cost comparison results for microturbines are summarized in Table 6. These data show, for instance, that the average incremental cost associated with presence of heat recovery was $1.56 per Watt for SGIP participants with completed projects. When this value is used to estimate the incremental cost of heat recovery not just for completed projects but also projects that will be completed in the future it is necessary to summarize the uncertainty of the estimate.[8]

Table 6: Microturbine Project Cost Comparison Summary

Physical Difference	Difference of Means ($/Watt)	90% Confidence Interval ($/Watt)
Heat Recovery	1.56	-0.23 to 3.35
Fuel Treatment	1.90	1.22 to 2.58
RFUR	1.30	0.74 to 1.86

[8] Uncertainty is assessed by calculating confidence intervals around the point estimates. Standard statistical tests are used to describe the likelihood that the two samples underlying the two means used to calculate each incremental difference came from the same population. When n_1 & $n_2 \geq 30$ then a z-Test is used to determine confidence intervals. When n_1 or $n_2 < 30$ then a t-Test is used.

The 90 percent confidence intervals presented in Table 6 summarize uncertainty in estimates of the incremental costs associated with several key physical differences for the population comprising projects already completed as well as those that will be completed in the future. For heat recovery the lower bound of the confidence interval is negative. This counterintuitive result implies that systems without heat recovery might be more expensive. The statistical analysis of available cost data does not rule out the possibility that systems without heat recovery cost more than those with heat recovery. The possibility of this unlikely result, along with the very large confidence interval, are likely simply due to the small quantity of, and considerable variability exhibited by cost data available for SGIP projects completed in the past. This is a representative example of the general rule that caution must be exercised when interpreting summary statistics when sample sizes are small.

IC Engine Project Cost Comparisons

Cost comparison results for IC engines are summarized in Table 7. Results for the incremental difference due to heat recovery are not presented because all but one of the renewable IC engine projects completed to date have included heat recovery even though it was not required by the SGIP. The differences between means are small in comparison to the variability exhibited by past costs of renewable fuel projects. This variability combined with relatively small numbers of renewable fuel projects results in very large confidence intervals.

Table 7: IC Engine Project Cost Comparison Summary

Physical Difference	Difference of Means ($/Watt)	90% Confidence Interval ($/Watt)
Fuel Treatment	0.58	0.09 to 1.07
RFUR	0.50	0.03 to 0.97

Fuel Cell Project Cost Comparisons

Due to the sensitivity of fuel cells to contaminants in the gas stream, gas clean-up costs for fuel cells powered by renewable fuels, which contain sulfur, halide, and other contaminants, should be higher than gas clean-up costs for fuel cells operating with cleaner fuels such as natural gas. Cost comparison results for fuel cells are summarized in Table 8. Results for the incremental difference due to heat recovery are not presented because all renewable fuel cell projects completed to date have included heat recovery even though they were not required to by the SGIP. The 90 percent confidence interval for fuel cells is not very large, which is not surprising given the emerging status of this technology and the small number of facilities.

Table 8: Fuel Cell Project Cost Comparison Summary

Physical Difference	Difference of Means ($/Watt)	90% Confidence Interval ($/Watt)
Fuel Treatment	1.27	-3.84 to 6.38
RFUR	1.27	-3.84 to 6.38

Cost Comparison Summary

Comparison of the installed costs between renewable and nonrenewable-fueled generation systems operational as of December 31, 2007 reveals that average nonrenewable generator costs have been lower than average renewable-fueled generator costs. However, these averages pertain to past program participants. The fundamental question motivating examination of RFUR project costs is stated explicitly below:

Do SGIP project cost data for past participants suggest that project costs are changing in ways that could necessitate modification of incentive levels received by future SGIP participants?

Confidence intervals calculated for populations comprising both past *and* future SGIP participants are very large. This suggests that data for past projects should not be used as the sole basis for SGIP program design elements affecting future participants. Engineering estimates, budget cost data, and rules-of-thumb likely continue to be more suitable for this purpose at this time.

Appendix A

List of All SGIP Projects Utilizing Renewable Fuel

All SGIP projects supplied with renewable fuel are listed in Table 9. Renewable Fuel Use Requirements (RFUR) projects subject to renewable fuel use requirements and exempt from heat recovery requirements are identified in the column titled "RFUR Project?". Only a small portion of these projects is also equipped with a nonrenewable fuel supply. These projects are identified in the column titled "Any Nonrenewable Fuel Supply?".

Table 9: SGIP Projects Utilizing Renewable Fuel

PA Project ID No.	Program Administrator/ Funding Level	Technology/ Fuel Type	Capacity (kW)	Operational Date[9]	RFUR Project?	Any Nonrenewable Fuel Supply?
0007-01	SDREO/ Level 3	MT/ Digester Biogas	88	8/30/2002	No	No
PY02-055	SCE/ Level 3-R	MT/ Landfill gas	420	4/18/2003	Yes	No
PY01-031	SCE/ Level 3	IC Engine/ Landfill gas	970	9/29/2003	No	No
110	PG&E/ Level 3	IC Engine/ Digester gas & Nat. Gas	900	10/23/2003	No	Yes
PY02-074	SCE/ Level 3-R	MT/ Landfill gas	300	2/12/2004	Yes	No
0026-01	SDREO/ Level 3	MT/ Digester gas	120	4/23/2004	No	No
514	PG&E/ Level 3-R	MT/ Digester gas	90	5/19/2004	Yes	No
0023-01	SDREO/ Level 3	MT/ Digester gas	360	9/3/2004	No	No
379	PG&E/ Level 3-R	MT/ Landfill gas	280	1/14/2005	Yes	No
PY03-092	SCE/ Level 1	FC/ Digester gas	500	3/11/2005	Yes	Yes

[9] Since assignment of a project's operational date is subject to individual judgment, the incentive payment date as reported by the Program Administrators is used as a proxy for the operational date for reporting purposes.

Table 9: SGIP Projects Utilizing Renewable Fuel (Continued)

PA Project ID No.	Program Administrator/ Funding Level	Technology/ Fuel Type	Capacity (kW)	Operational Date[10]	RFUR Project?	Any Nonrenewable Fuel Supply?
640	PG&E/ Level 3-R	MT/ Landfill gas	70	4/14/2005	Yes	No
641	PG&E/ Level 3-R	MT/ Landfill gas	70	4/14/2005	Yes	No
PY03-045	SCE/ Level 1	FC/ Digester gas	250	4/19/2005	Yes	No
PY03-008	SCE/ Level 3-R	MT/ Landfill gas	70	5/11/2005	Yes	No
PY03-017	SCE/ Level 3-R	IC Engine/ Digester gas	500	5/11/2005	Yes	Yes
842A	PG&E/ Level 3-R	MT/ Digester gas	60	5/27/2005	Yes	No
747	PG&E Level 3-R	MT/ Digester gas	60	7/18/2005	Yes	No
PY03-038	SCE Level 3-R	MT/ Digester gas	250	7/12/2005	Yes	No
483	PG&E/ Level 3-R	IC Engines/ Digester gas	300	1/13/2006	Yes	No
313	PG&E/ Level 3-R	MT/ Digester gas	300	3/16/2006	Yes	No
1297	PG&E/ Level 3-R	MT/ Digester Gas	280	4/7/2006	Yes	No
856	PG&E/ Level 3-R	MT/ Landfill gas	210	5/5/2006	Yes	No
658	PG&E/ Level 3-R	IC Engines/ Digester gas	160	5/22/2006	Yes	No
833	PG&E/ Level 3-N	MT/ Digester gas	70	9/1/2005	No	Yes
1222	PG&E Level 3-R	IC Engines/ Landfill gas	970	3/24/2006	Yes	No
1308	PG&E Level 3-R	IC Engines/ Digester gas	400	11/17/2006	Yes	No
1316	PG&E Level 3-R	IC Engines/ Landfill gas	970	10/2/2006	Yes	No
1505	PG&E Level 2	IC Engines/ Landfill gas	970	11/24/2006	Yes	No

[10] Since assignment of a project's operational date is subject to individual judgment, the incentive payment date as reported by the Program Administrators is used as a proxy for the operational date for reporting purposes.

Table 9: SGIP Projects Utilizing Renewable Fuel (Continued)

Project ID No.	Program Administrator/ Funding Level	Technology/ Fuel Type	Capacity (kW)	Operational Date	RFUR Project?	Any Nonrenewable Fuel Supply?
PY04-158	SCE Level 3-R	IC Engines/ Digester Gas	704[11]	11/15/2005	Yes	Yes
PY04-159	SCE Level 3-R	IC Engines/ Digester Gas	704	11/15/2005	Yes	Yes
PY05-093	SCE Level 3-R	IC Engines/ Landfill Gas	1030	09/1/2006	Yes	No
298	PG&E Level 3-R	MT/ Digester Gas	30	08/04/2004	Yes	No
1313	PG&E Level 3-R	MT/ Digester Gas	240	07/17/2006	Yes	Yes
1528	PG&E Level 2	MT/ Digester Gas	70	03/16/2007	Yes	No
1559	PG&E Level 2	IC Engines/ Digester Gas	160	11/16/2006	Yes	No
1298	PG&E Level 3N	MT/ Digester Gas	250	01/19/2007	No	Yes
PY06-094	SCE Level 2	IC Engines/ Digester Gas	500	05/27/2007	Yes	No
1577	PG&E Level 2	IC Engines/ Digester Gas	80	10/01/2007	Yes	No

[11] In Renewable Fuel Use Reports #9 and #10 this project's size was reported as 296 kW. That was the capacity used in incentive calculations; the actual physical size of the system is 704 kW.