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Economic and Technical Analysis of Distributed Utility Benefits for Hydrogen Refueling Stations

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EXECUTIVE SUMMARY

This report presents the potential economic benefits of operating hydrogen refueling stations to accomplish two objectives:

- Supply pressurized hydrogen for vehicles, and
- Supply distributed utility generation, transmission and distribution peaking energy and capacity to the utility

The study determined under what circumstances using a hydrogen-fueled generator as a distributed utility generation source, co-located with the hydrogen refueling station components (electrolyzer and storage), would result in cost savings to the station owner, and hence lower hydrogen production costs.

Study Approach and Scope

The systems studied include a refueling station (including such components as an electrolyzer, storage, hydrogen dispensers, and compressors) plus on-site hydrogen fueled electricity generation units (e.g., fuel cells or combustion engines). The operational strategy is to use off-peak electricity in the electrolyzer to fill hydrogen storage, and to dispatch the electricity generation about one hour per day to meet the utility's local and system peaks. The utility was assumed to be willing to pay for such service up to its avoided generation, fuel, transmission and distribution costs.

The station's cost of supplying hydrogen to the vehicles is the figure of merit for the study. If the distributed generation concept has economic merit to the refueling station, such a station could sell its hydrogen at lower prices, or the owner could have a faster payback on their investment. In either circumstance, hydrogen would be more likely to be used for transportation and utilities would gain some experience with hydrogen technologies connected to their grids.

The basic station design was derived from Dr. Joan Ogden's work at Princeton.

The hydrogen fueled generation technologies studied were:

- proton exchange membrane (PEM) fuel cell
- regenerative PEM fuel cell

- hybrid combination of a regenerative fuel cell plus additional electrolyzer capacity
- future regenerative fuel cell
- hydrogen burning engine

Key Results

- Across the board, the higher vehicle throughput designs (400 cars per day) were more cost effective.
- The low-cost future regenerative fuel cell can provide additional net value to a station owner of up to several dollars per delivered GJ (out of about 20 $/GJ) for both the 200 and 400 car per day designs.
- The PEM and hydrogen burning engine would have modest value in the double-duty application since the electrolyzer cannot be eliminated. These two technologies look interesting where utility avoided costs are very high and if all of the utility benefits are awarded to the station owner.
- As would be expected, the results are sensitive to electricity costs, capital cost assumptions, and details of the refueling station's design and operation.
- The willingness of the utility to reward a station owner for peaking relief and the local value of that peaking capacity will likely determine the first locations where this double-duty station would be installed.

The report Appendix includes a complete set of all 104 cases for future researchers to examine and manipulate.

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1.

INTRODUCTION AND BACKGROUND

Overview

Distributed Utility Associates and Longitude 122 West, Inc. analyzed the economic and technical feasibility of using a hydrogen filling-station as a distributed utility generation source. The objective was to determine the value of this double-duty concept as an early niche market for hydrogen production and storage technologies.

Scope

Hydrogen refueling stations will represent a major capital investment in the hydrogen transportation infrastructure of the future. As a way to offset some of those costs and hence expand hydrogen markets, it is possible that a second use (and hence an additional benefit) can be found for some of the on-site components if employed as part of a modern distributed electric utility. By dispatching a fuel cell on-peak with hydrogen created off-peak, appreciable benefits may be gained for the local utility. As those utility benefits are realized and shared with the owner of the hydrogen refueling station, the hydrogen transportation scenario becomes more economical. This project required selection of an operational hydrogen transportation/refueling scenario, station redesign to accommodate generation of power, determination of relevant economic figures of merit, and construction of an economic model with which to compare the system options.

Objective

The objective of this analysis was to determine if, for a re-optimized system configuration, this dual-use concept provides superior economic value over separate refueling and distributed utility systems. US market estimates were also created.

Approach

The hydrogen refueling/distributed utility station consists of either a regenerative fuel cell, or a fuel cell and electrolyzer, or a hydrogen-fueled engine, plus an inverter, a converter, a hydrogen storage system, transportation hydrogen refueling station components capable of handling an appropriate number of vehicles per hour, and a control system to coordinate operations.

The refueling station is connected to a utility source of electricity to power the electrolyzer to produce hydrogen. The refueling of cars results in a time-varying electrical demand for power to the dispensing systems and energy from the hydrogen storage system.

The combined hydrogen refueling/distributed utility system is designed to add value to the simple hydrogen refueling station by dispatching a hydrogen-fueled generator (fuel cell or engine) to meet critical local and system electrical needs of the local utility.

As a of figure of merit, this study determined the potential reduction in the costs of hydrogen delivered by the refueling station for the case of adding the distributed utility dispatch capability to a refueling station.

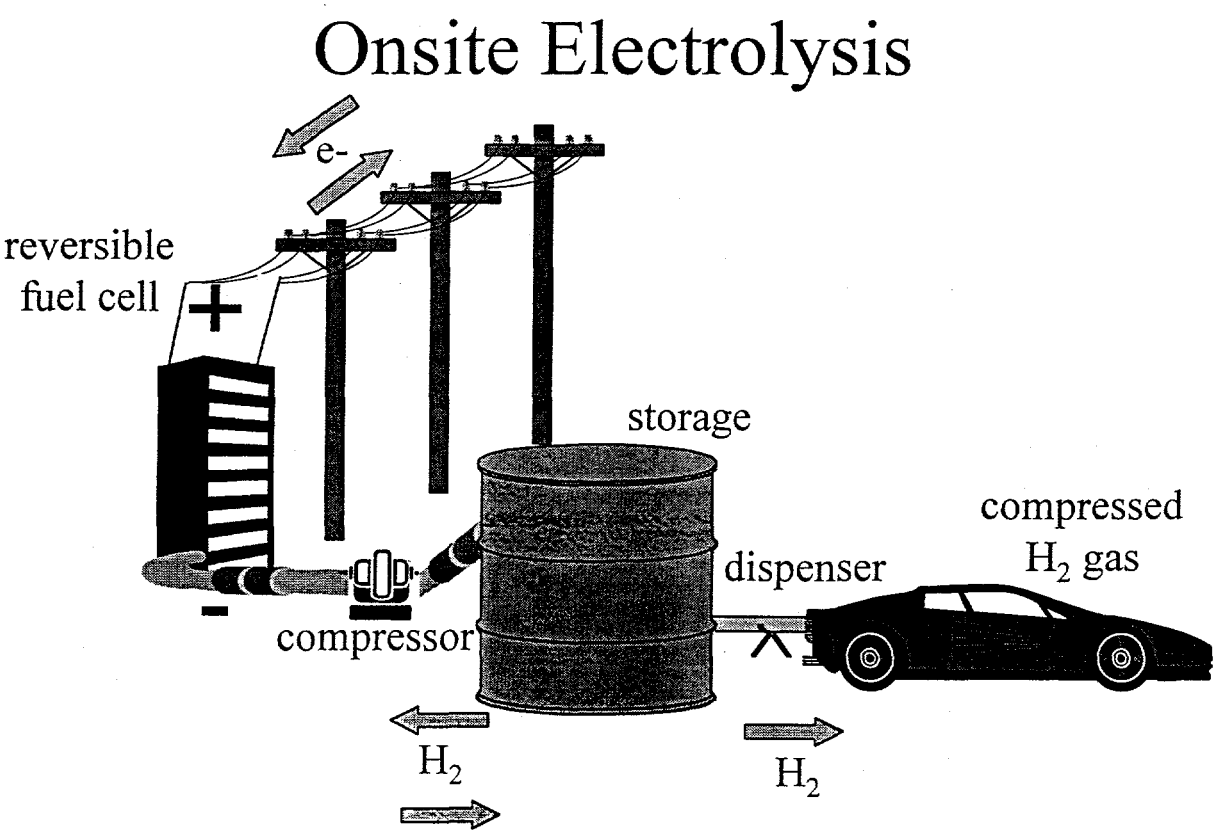
Using a stochastic approach to the range of avoided costs in U.S. utilities, an estimate was made for the range of hydrogen cost reductions possible across the U.S. and their likelihood of occurrence. Sensitivity to the on- and off-peak costs of electricity was also analyzed.

2.

DISTRIBUTED UTILITY/REFUELING STATION ASSUMPTIONS

Exhibit 1 shows the components of the distributed utility/refueling station system. In this figure, a regenerative (or reversible) fuel cell is shown as the generation system. Other generation types were also analyzed.

Exhibit 1. System Components



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2.1 Technology Assumptions

In this study, we begin with Princeton University's onsite-electrolysis base case [Ref. 1]. We attempted to make as few changes as possible to the Princeton University study because of the great care given to the effort. Within the boundaries of the Princeton University study, however, we selected cases that appeared to have the best potential for substantial distributed utility benefits. A few of the parameters had to be adjusted in order to allow reverse power flow, to better define the electrical and mechanical interfaces, and to calculate energy and maximum electrolysis load costs for the station owner.

Our system consists of:

- Storage in pressurized cylinders; the pressure varies throughout the day from a minimum of 2000 psi to a maximum of 5000 psi.
- An advanced electrolysis process.
- Refueling station components, including a boost compressor that delivers hydrogen at 5000 psi.

We assume that hydrogen production occurs 100% off-peak, during the 18 hours from 6 PM to 12 noon.

For the combined station to provide electricity for distributed utility functions, we added the following to the Princeton design:

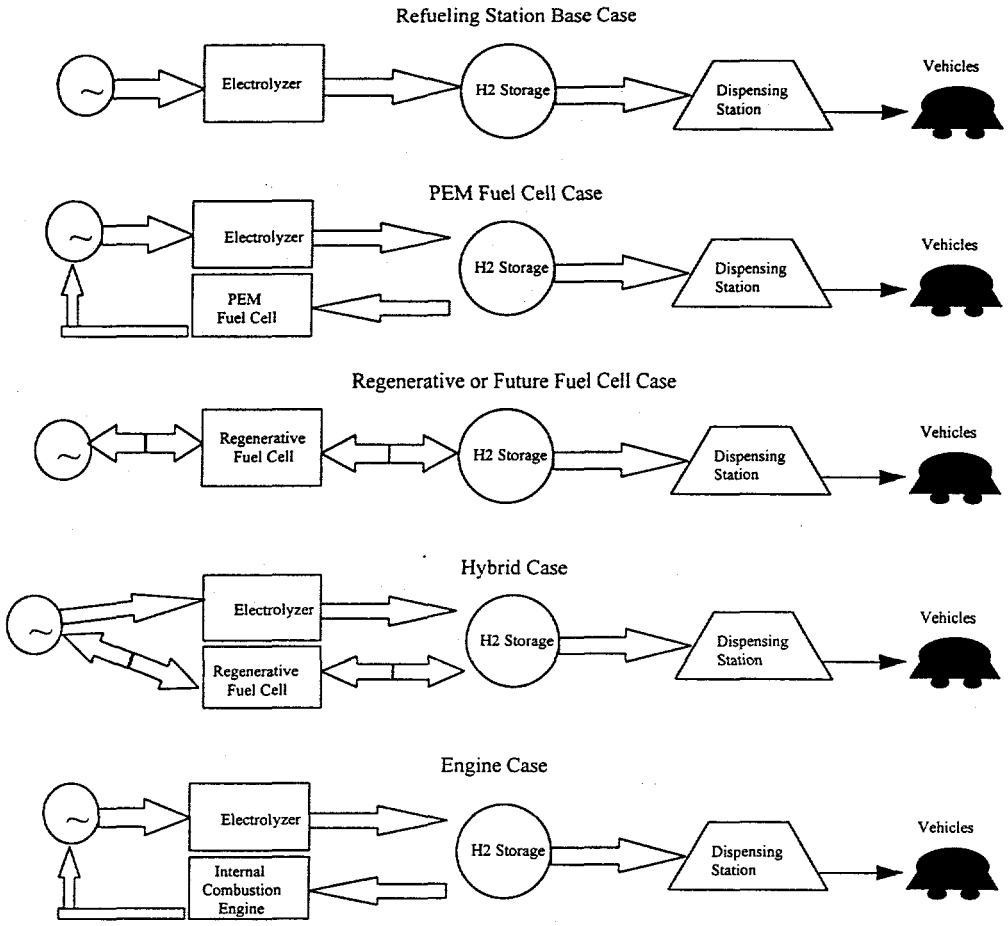
- additional electrolysis capability to create the H_2 needed for fuel cell operation; additional storage for this hydrogen, and
- generation capability, either as a separate fuel cell unit, or in the form of a regenerative fuel cell, or some combination of the two; or in the form of a hydrogen-fuel combustion engine. All of these options are examined.

A comparison of assumptions between the Princeton University analysis and this distributed utility analysis is shown in Exhibit 2. Layout flow charts for the cases considered in this study are shown in Exhibit 3.

Exhibit 2. Comparison of the Princeton University Parameters to this Study

Parameter	Princeton University Refueling Station Base Case	Distributed Utility/Refueling Station (this study)
Electrolyzer	Advanced	Advanced
Fuel cell	none	PEM or regenerative PEM
Storage	pressurized cylinders (containing 9,524 scf at max pressure 5000 psi)	same cylinders (max pressure 5000 psi), 40% extra Hydrogen capacity to keep pressure above 2000 psi minimum
Storage compressors	381 scf/min	381 scf/min
Boost compressor	1590 scf/min	1590 scf/min
# station dispensers	10	4
Dispensing rate (each dispenser)	400 scf/min	400 scf/min
Cars served per day	100-1000 (800 base case)	200 cars/day, 400 cars/day
H_2 fuel per car	1,250 scf	1,250 scf
Electrolyzer operation	12 hrs/day off-peak	18 hrs/day off-peak
Distributed utility dispatch	none	0.5 to 2 hrs/day
Generator (Fuel Cell or Engine) output	none	500 kW to 3000 kW

Exhibit 3. Component Layouts



2.2 Analysis Assumptions

1. The number of vehicles served per day is either 200 or 400. In the Princeton studies, the number of vehicle ranges from 100 to 1000 per day [Ref. 2]. The lower end of the Princeton University range was used to increase the potential benefits of the old dispatch. Above 400 cars/day, the utility would likely build a dedicated substation for the refueling station, making distributed utility and its value nearly irrelevant.

2. Refueling availability is undisturbed by the electrolysis or distributed utility function; i.e., the station is open 24 hours per day. We assumed station owners and clients would not adjust their lives or economics for the sake of distributed utility benefits increases, e.g. by stopping all refueling or boost compression during daily peak utility demand hours.

3. All hydrogen to meet the distributed utility function and refueling need is produced off-peak, during the 18 hours from 6 PM to 12 noon. This minimizes the cost of electricity use, minimizes electrolyzer sizes, and minimizes load factors.

4. Additional storage is the same type as the base case (pressurized cylinders) at the same $/scf.

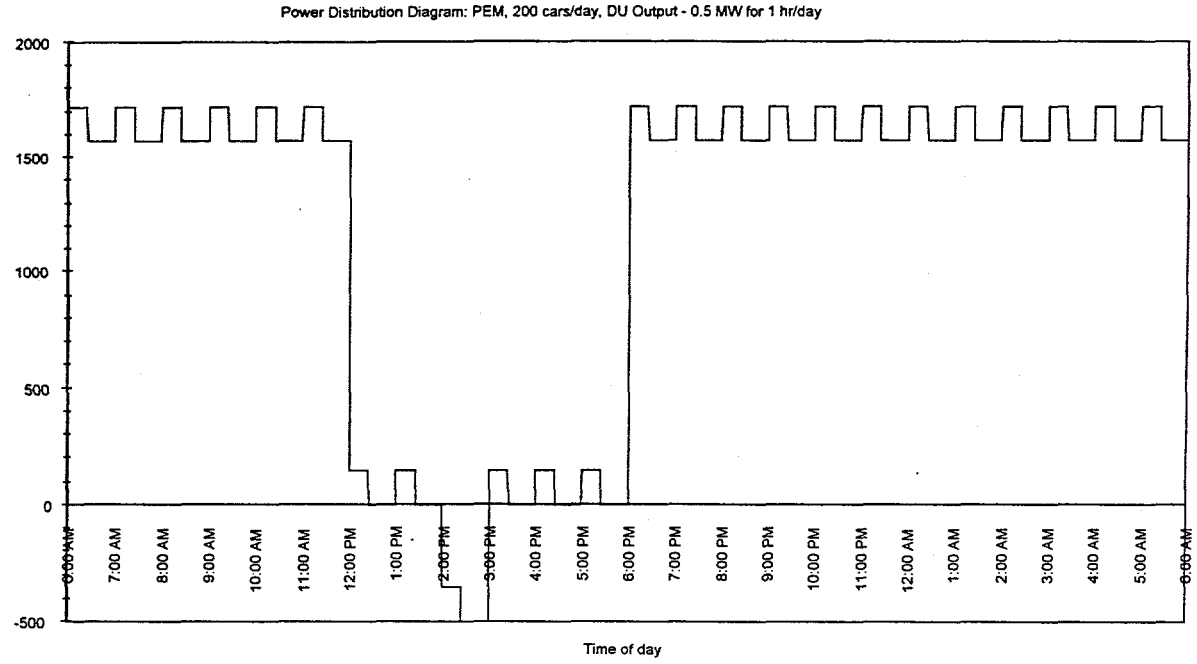
5. Electricity generation (i.e. fuel cell dispatch) always occurs at the time of optimum utility benefit. The major analytical work of this project involves optimizing the benefit versus cost of adding more hydrogen and generation components for distributed utility operation.

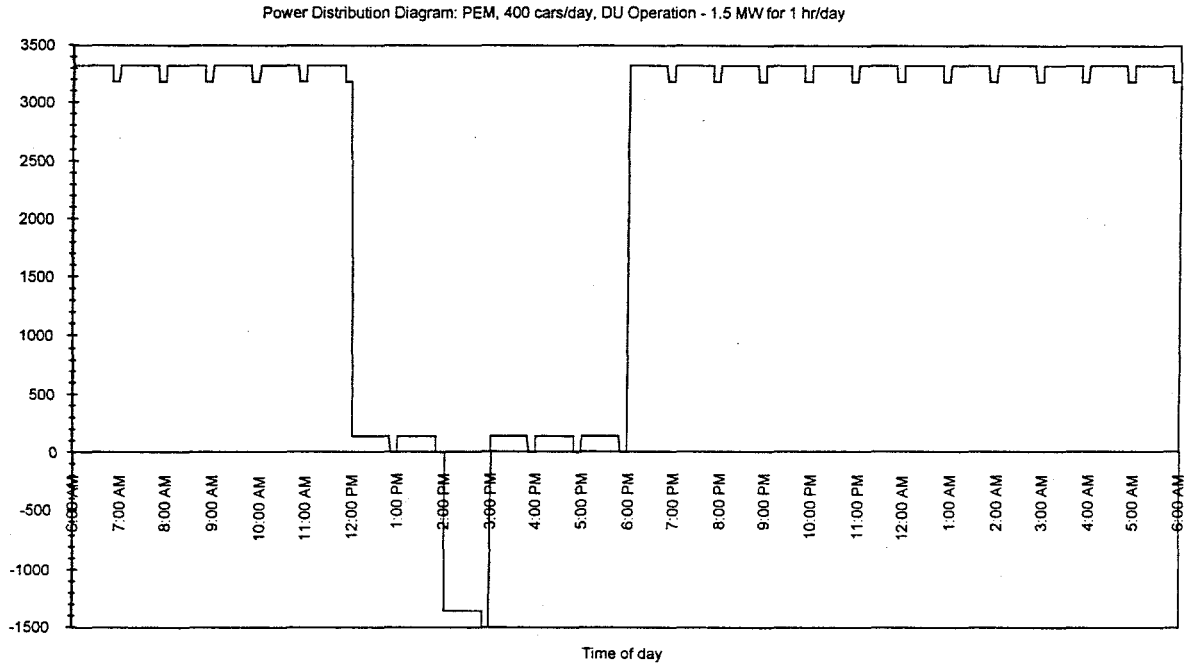
6. This study's base case has a distributed utility operating 1 hr/day and approximately sized at the same size as the electrolyzer, i.e. 1.4 MW for 200 cars, and 2.8 MW for 400 cars.

A representative daily schedule of power flows and stored hydrogen energy is shown in Exhibit 4 for two PEM cases. The figures show the profile for charging and discharging during peak and off-peak periods. In the power figures, positive values indicate primarily power to the electrolyzer and storage compressors. The small bumps indicate power to the boost compressor, i.e., one or more cars are filling. The negative power values indicate power from the distributed utility generator (in this case a PEM fuel cell) back to the grid. In the storage figures, the filling events are not individually illustrated, rather average charge (filling) and discharge (dispensing) rates are shown. The steeper discharge section (change in slope) occurs during operation of the DU unit.

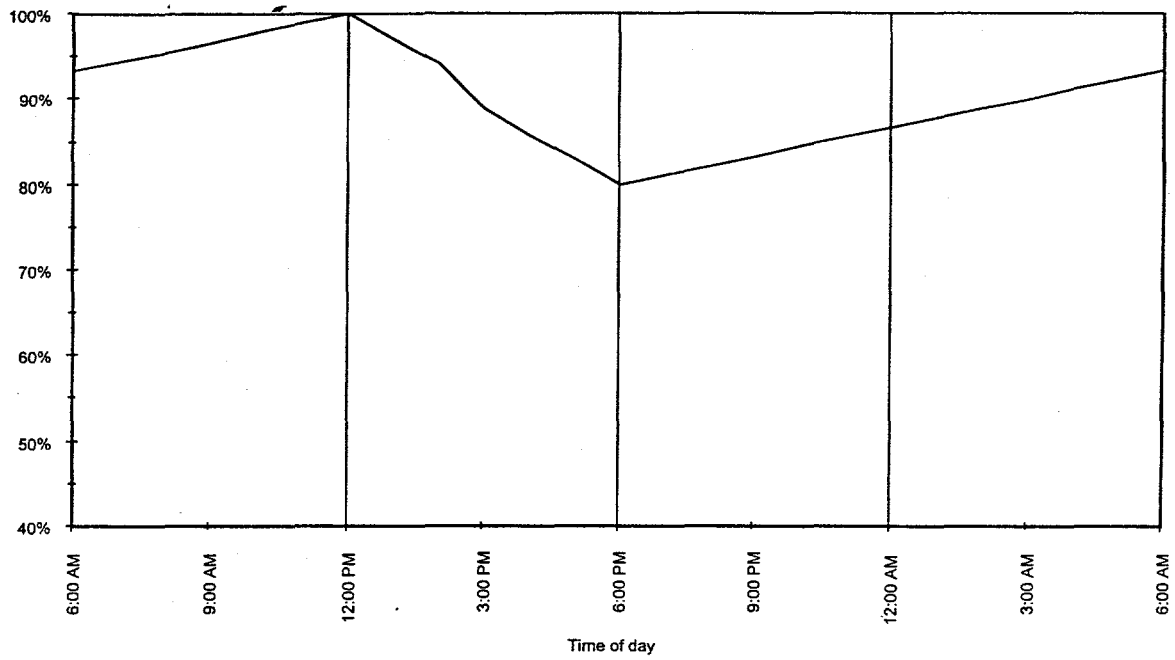
The cases shown in Exhibit 4 are representative, with a regularly spaced traffic of cars throughout the day. If all the cars arrived during the peak period when the electrolyzer does not operate, the stored hydrogen would decrease to 40% full. This is the minimum needed to maintain 2000 psi in the storage cylinders.

Exhibit 4. Representative Daily Schedule of Power Flows and Hydrogen Storage

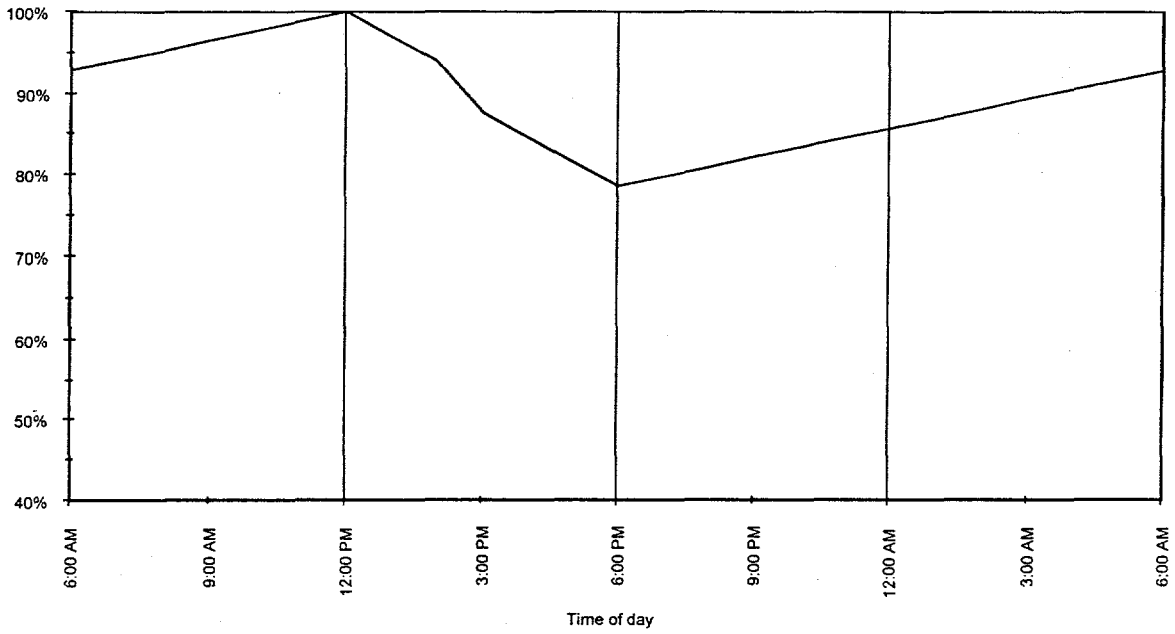




Hydrogen Storage Diagram: PEM, 200 cars/day, 0.5 MW DU from 2:00pm-3:00pm



Hydrogen Storage Diagram: PEM, 400 cars/day, 1.5 MW DU from 2:00pm-3:00pm



2.3 Hydrogen System Cost and Performance Analysis

The components of the system are:

- electrolyzer
- storage cylinders
- storage compressors
- fuel cell or combustion engine plus power conditioning components
- station components, including boost compressor, dispensers, and fixed infrastructure

The assumed capital cost, operating cost, lifetime and efficiency of these components are listed in the table in Exhibit 5. For those components which are the same as the Princeton study, the cost assumptions are identical [Ref. 2].

Two types of PEM fuel cells were included in the analysis: a simple hydrogen-fueled PEM, and a regenerative PEM. The regenerative PEM includes the electrolyzer function when operated in reverse. This makes it more expensive because the catalyst loading must be higher to operate in the higher temperature electrolysis mode [Ref. 3]. It is possible that future regenerative fuel cells may not need the additional catalyst [Ref. 4] and could cost the same as a simple PEM.

An internal combustion engine was also considered for this application. Diesel engine manufacturers have indicated that hydrogen combustion could be accomplished with little modification and at reasonable capital cost [Ref. 5, 6].

Other operating costs, in addition to O&M, are labor costs of $131, 400/yr and electricity costs at 2¢/ kWh off-peak and 7¢/kWh on-peak. These are identical to the Princeton study assumptions. An identical capital charge rate of 15% is also assumed. This is consistent with private (rather than utility) ownership of the station.

Exhibit 5. Technology Data

Component	Capital Cost	O&M Cost	Efficiency or Energy required	Lifetime
Advanced electrolyzer	300 $/kW H2 out	4% of cap cost/yr	η=0.8	20 yrs
Storage cylinders	1.1 $/scf	100 $/yr/cylinder		20 yrs
Storage compressor	2000 $/kW	$3000/yr/unit (2 units)	(.6225 kW/car × # cars/day × 18 hrs/day) +DU	10 yrs
PEM fuel cell	500 $/kW	4% of cap cost/yr	η=0.60	20 yrs
Regenerative fuel cell	1000 $/kW	4% of cap cost/yr	η=0.60 in gen mode	20 yrs
Future regenerative fuel cell	500 $/kW	4% of cap cost/yr	η=0.60 in gen mode	20 yrs
Internal combustion engine	350 $/kW	4$ of cap cost/ yr	η=0.40	20 yrs
Fixed components	$277,100 (= 4 dispensers + boost compressor)	4% of cap cost/yr	1.875 kWh/car × # cars/day	10 yrs

2.3.1 Energy and Power Requirements

The energy required per day and the peak power to the system depend on:

- the number of vehicles served per day
- the number of dispensers operating at the station (assumed to be four)
- the power level of the distributed resource (approximately same order of magnitude as electrolyzer, so as to not adversely affect distribution service rating)

The energy required per day and peak power are calculated as follows:

Energy required/ day	= 18 hrs ×	[1/.8 × $P_{electrolyzer}$ (kW) +	(.6225 kW/car × # cars/day)] + DU addition	+ 1.875 kWh/car × # cars/day
		electrolyzer	storage compressor	boost compressor
Peak Power required	=	$P_{electrolyzer}$ +	.6225 kW × # cars/day + DU addition	+ 36.4 kW/ dispenser × # dispensers

The results for a 1 hr/day distributed utility case are shown in Exhibit 6. The distributed utility rating of 1.4 MW equals the electrolyzer rating for the refueling function alone for 200 cars per day. The 2.8 MW rating corresponds to the 400 cars per day.

Exhibit 6. Example Energy and Power calculations for PEM w/ 1 hr. distributed utility @ 1.4 MW for 200 cars, 2.8 MW for 400 cars; 4 dispensers

	Electrolyzer	Storage Compressor	Boost Compressor
Energy			
200 cars	34.43 MWh	2.45 MWh	375 kWh
400 cars	68.85 MWh	4.90 MWh	750 kWh
Power			
200 cars	1.53 MW	136 kW	145.6 kW
400 cars	3.06 MW	272 kW	145.6 kW

Note: Electrolyzer rating ranges from 1.45 to 1.66 MW for 200 cars/day and from 2.93 to 3.32 MW for 400 cars/day depending on other scenario details such as hours and power rating of the distributed utility output.

2.3.2 Capital Cost Trade Study

To obtain a set of capital costs for the Benefit/Cost study, a range of distributed utility types, sizes and operating times were considered for two service levels. They were:

Service levels:	200 cars per day, 400 cars per day
Generation options:	PEM Fuel Cell plus separate electrolyzer (sized separately) Regenerative PEM (sized to meet electrolysis need) Hybrid (Regenerative PEM sized to meet DU load, plus separate electrolyzer sized to meet excess H_2 need) Future regenerative PEM fuel cell (lower cost, sized to meet electrolysis need) Hydrogen-fueled combustion engine plus separate electrolyzer (sized separately)
Distributed Utility Sizes:	Approx. equal to electrolyzer size Approx. half of electrolyzer size Somewhat larger than electrolyzer
Distributed Utility Operating Times:	1 hr, 0.5 hrs, 2 hrs

Note that the electrolysis rating for the combined refueling/generation station will always be somewhat larger than for the refueling station because the electrolyzer must generate enough hydrogen for both the generation and refueling functions.

The resulting system capital costs for the various parameterizations are shown in Exhibits 7 and 8 for the case of 200 cars per day, and in Exhibits 9 and 10 for the case of 400 cars per day. The least-cost approach, under most conditions and for the assumed costs, appears to be the future regenerative fuel cell. The lowest cost system does not necessarily yield the highest net benefits, however.

Exhibit 7. Capital Cost vs. Distributed Utility Power for 200 car, 1 hr Distributed Utility System

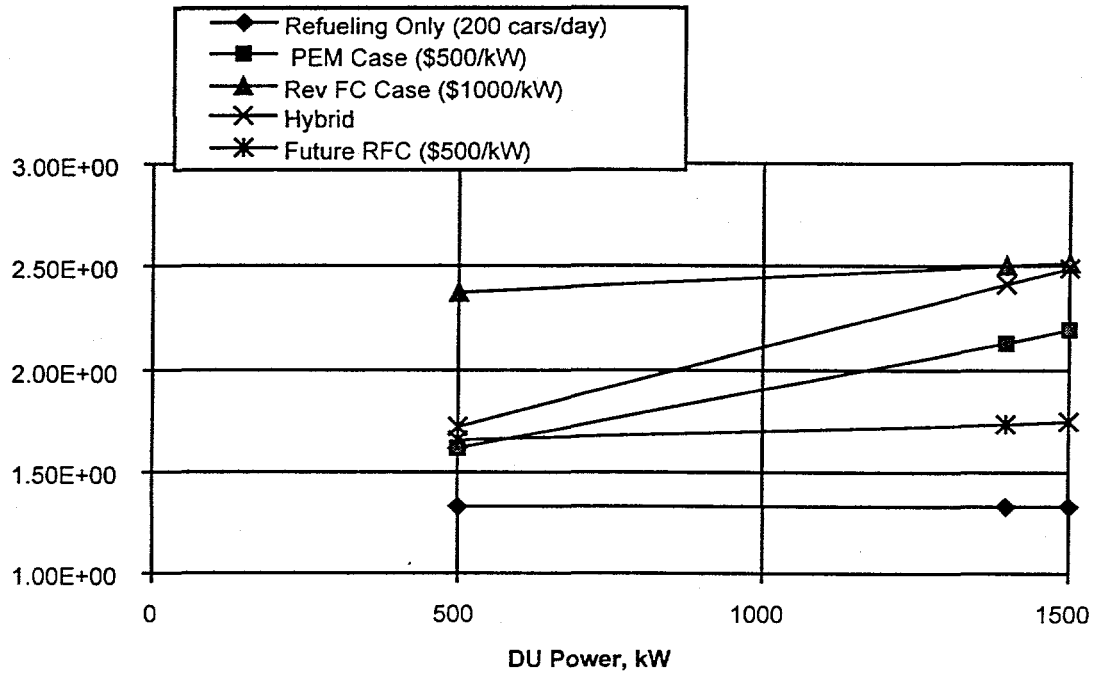


Exhibit 8. Capital Cost vs. Distributed Utility Operating Time for 200 cars, 1.4 MW Distributed Utility

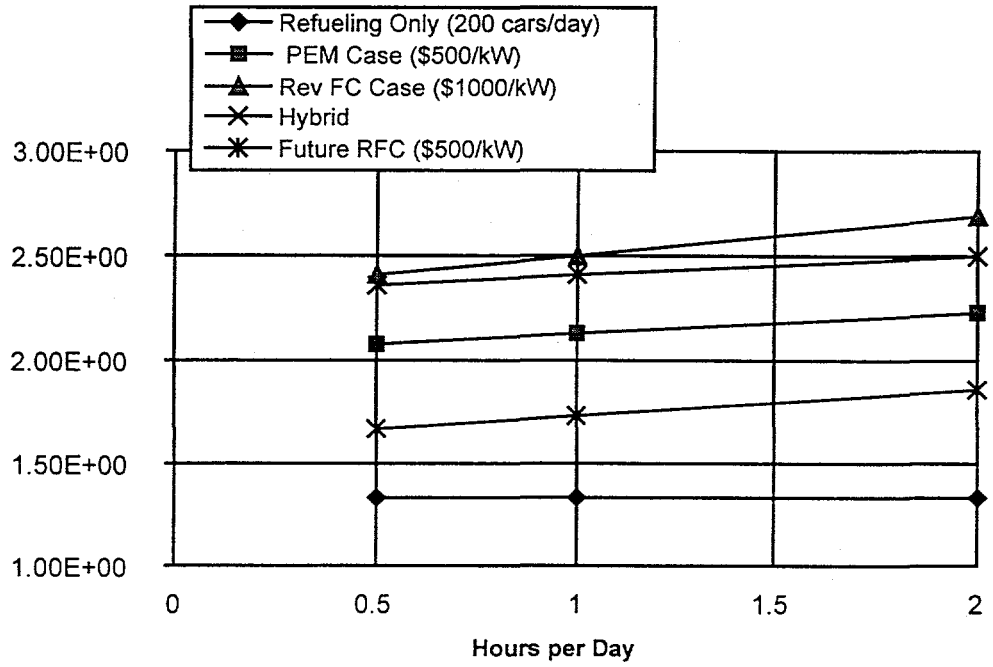


Exhibit 9. Capital Cost vs. Distributed Utility Power for 400 cars, 1 hr Distributed Utility System

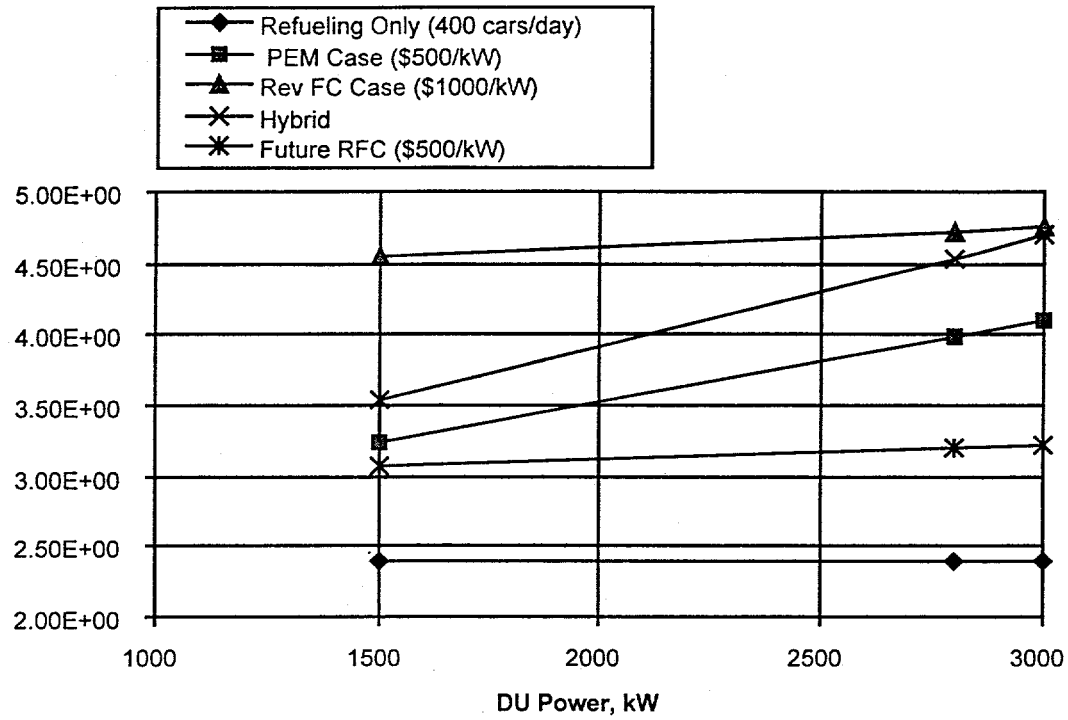
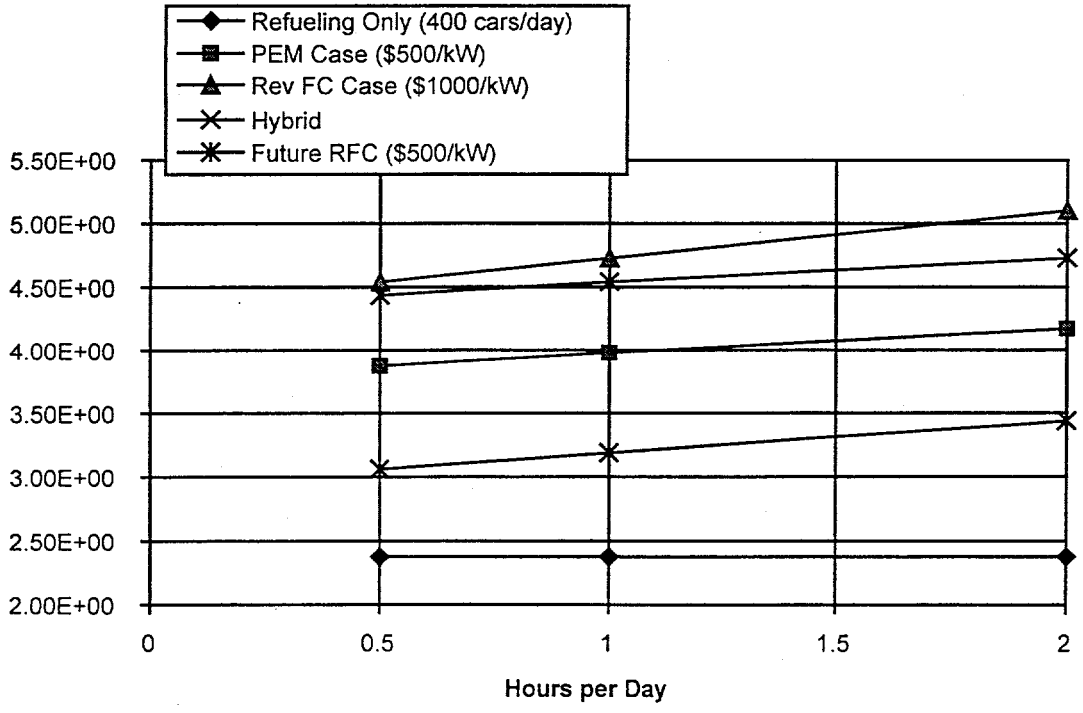
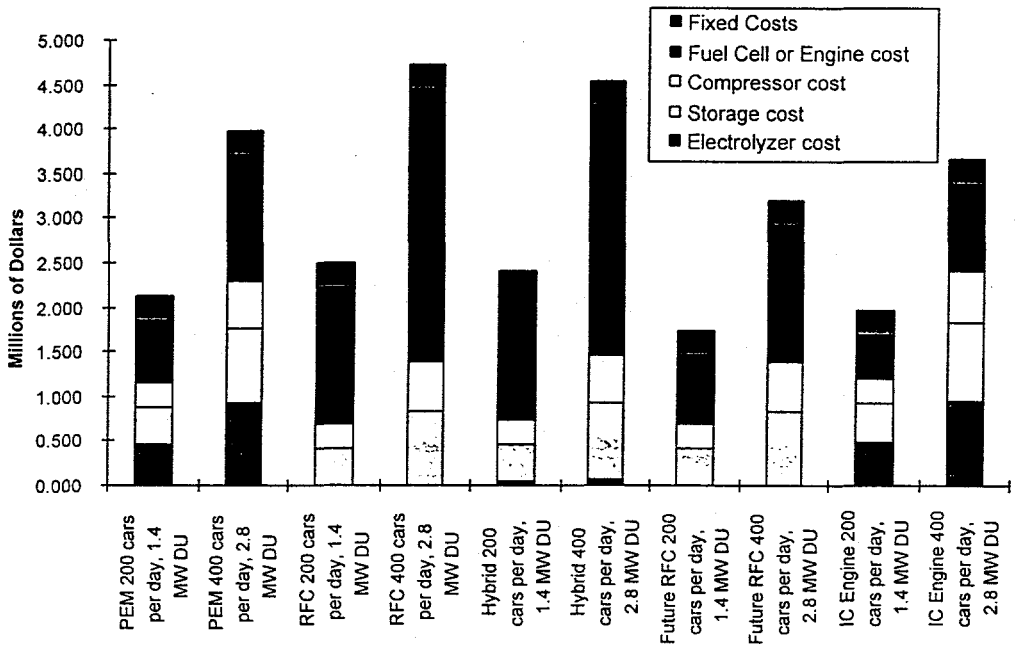


Exhibit 10. Capital Cost vs. Distributed Utility Operating Time for 400 cars, 2.8 MW Distributed Utility System



An interesting part of the system capital cost analysis is the breakdown into component costs. For the 200 cars and 400 cars 1 hr/day cases, Exhibit 11 shows the component costs for the different technologies. Not unexpectedly, the generator (fuel cell or engine) cost is the largest single component. The fixed costs are the same for both 200 and 400 car cases because a 4-dispenser station is assumed for both.

Exhibit 11. Capital Cost Components for all Technologies (Distributed Utility operates 1 hr per day)



3.

UTILITY SYSTEM BENEFITS

3.1 Economic Analysis Approach

The metric chosen for the economic optimization of the combined hydrogen refueling station/distributed utility plant is the delivered cost of hydrogen to the vehicles. If the distributed utility dispatch capability can more than pay for itself, the cost of delivered hydrogen should be reduced. The owner may choose to pass any savings along to the clients of the station, or may use them for higher profitability.

The station is considered to be owned by a private party, purchasing electricity from the local utility at prevailing rates. Most of the purchased electricity is used to power the electrolyzer (or equivalently the regenerative fuel cell), but additional power is needed for the storage compressor during electrolysis, for the boost compressor during fueling, and for other miscellaneous on-site loads.

In an effort to reduce his operating costs or increase the station's cash flow, the owner is considering dispatching an on-site fuel cell on demand for the utility. The owner is planning on receiving some or all of the benefits the utility gains by this dispatch. The fraction of the utility savings he receives is the subject of a negotiation with the local utility.

3.2 Operational Issues

Although each station's location and operation would be slightly different, we have assumed that the utility calls everyday in mid-afternoon to request dispatch of the fuel cell to meet system and transmission and distribution peaking needs. This is usually the peak of a utility's demand and costs and the most stressful time for the refueling station owner to dispatch the unit. We assume that the owner responds by dispatching the unit for the specified length of time as directed by the utility. An imperfect reliability is included in the economic analysis by decreasing the utility benefits by the presumed lack of availability of the fuel cell, 5%.

In addition, the full capacity of the distributed utility unit cannot be assured during the utility-requested dispatch time due to the need to continue serving calls and operating the boost compressor. Again the benefits of the generation, transmission and

distribution capacities are reduced by the peak boost compressor demand. An alternative operational approach could have been to close the station during the utility's peak demand period, but this was rejected as being detrimental to station business. Note that the station owner does not operate the electrolyzer at all during the peak rate period of noon to six PM, to avoid high demand or energy charges.

If the utility can depend on the fuel cell's capacity and energy the utility should be willing to entertain a financial contract with the station owner for these benefits. For both the 200 and 400 car per day service options, we have looked at three different sizes of distributed utility dispatch capability. These sizes and the number of cars served per day were chosen to make the distributed utility benefits as large as possible compared to their costs. The relatively low number of cars served kept the size of the electrical service under 10 MW, below the rating of a typical feeder. At the other size extreme, although the distributed utility benefits and costs are roughly linear with size, we assumed that the refueling station owner and the utility would not bother to negotiate contract for minute amounts of energy or capacity, thus the smallest sizes studied were half a megawatt.

We have also considered three durations of dispatch (one-half, one and two hours) which should cover most utility peak width situations. The half hour dispatch case is highly beneficial to a distributed utility owner since almost no fuel (in this case fairly expensive hydrogen) is needed to obtain the same capacity benefits as a longer dispatch period. The energy benefits are not very valuable for these low-capacity -factor distributed utility units. The one hour dispatch is probably the most important case since system and especially local peaks are not often very broad. Two hours every day is conservative. If weekend and off season dispatch could be avoided, it is possible that the economics could be improved marginally although the capital costs of the fuel cells, extra compressor and storage capacities remain sunk. The results of the modeling are independent of the actual time that the utility calls for load relief, but our assumption is that it comes at the most inopportune time in the mid-afternoon.

3.3 Economic Analysis without the Distributed Utility Units

The economic analysis is straightforward with the exception of the inclusion of the distributed utility benefits. All analysis is done on a single year evaluation taking into account the multiyear nature of capital investments. Thus all capital costs are amortized over a reasonable period of time and assigned a fixed charge rate; in this case for private investors we used the same 15% as the Princeton work upon which our engineering designs were based. All recurring costs such as electricity costs were already in annual terms, such as kWh per year of dollars per year for labor. Once all costs were annualized they were summed to the annual system costs.

Each day and each year of station operation the same number of cars are served, either 200 cars per day or 400 cars per day. Thus the number of gigajoules of hydrogen provided annually is fixed.

In the case with no distributed utility components, dividing the annual system cost by the annual hydrogen provided yields the base case cost hydrogen.

3.4 Economic Analysis with the Distributed Utility Units

Of course, the capital costs for cases with distributed utility components are higher than the base case due to the need for the fuel cell (in all cases except the future regenerative fuel cell) and for more hydrogen storage capacity in all cases. Additionally the need for more hydrogen for dispatch of the fuel cell means a larger compressor, more cushion hydrogen gas, and more electricity for the electrolyzer and storage compressor.

In the cases with distributed utility components included, the distributed utility benefits are subtracted from the annual system costs to yield a net annual cost including these benefits. Depending on the magnitude of the distributed utility benefits, they may or may not pay for the additional distributed utility dispatch hardware. This is the subject of this study.

Utility avoided costs consist of both central and distributed components, assuming utility type economics for their avoided costs. The central benefits included in this study are central capacity (the ability to avoid the purchase of additional peaking capacity) and energy (the ability to avoid fuel purchases). If a utility can dispatch a distributed generation plant it can benefit by this avoided or deferred investment in capacity. If the fuel is not paid for by the utility this is an added benefit. The magnitude of these benefits depends upon whether the utility currently needs more peaking capability and the type and cost of fuel, and the utility plant's heatrate on the margin. Central capacity benefits can be as low as zero or as high as 50 $/kW-yr; the units of $/kW-yr are used as a way to annualize the carrying cost of owning or contracting for peaking capacity; the same units are used for transmission and distribution avoided costs. The fuel used by the power plants on the margin can range up to five cents per kWh, but rarely would fall below three cents per kWh. This unit is converted to $/kW-yr by multiplying by the appropriate hours per year of distributed utility unit operation.

The distributed benefits included are the avoided transmission and distribution investments for wires and transformers by the local distribution company and the value of improved reliability to the local customers. Similar to the central capacity benefits, if local load can be served by local generation, wires investments can be reduced, saving

the utility money. Transmission and distribution avoided costs (benefits are rarely zero since wires capacity expansions are never done without need being proven first) can be as high as 20 $/kW-yr and 70 $/kW-yr, respectively. Improved customer reliability is not an immediate, direct bottom-line benefit to the utility, but is increasingly important to utilities as they strive for customer loyalty as deregulation unfolds. Reliability benefits can be as low as zero and can range up to many dollars per lost kWh. We have used 25 $/kW-yr.

If a distributed utility unit is perfectly dependable, all of these benefits (avoided costs) can theoretically be earned by the owner of the unit. The owner of the distributed utility unit of course must pay for the fuel used, the carrying costs of the capital and the O&M costs.

In order to evaluate a range of utility situations the generation, transmission and distribution, energy and reliability avoided costs were evaluated for bins each representing one fifth of the U.S. Thus the costs range from the lowest avoided costs in the U.S. up to the highest (best for distributed utility) 20% in the country. In this way the broad range of values in the U.S. could be examined without site-specific information.

The utility avoided costs are derived from many sources, such as EIA annual summaries of utility capital investments, FERC Form 1, GRI projections of future fuel costs, etc. All utility avoided costs are annualized assuming a typical amortization of 30 years for generation, transmission and distribution investments.

4.

COST OF HYDROGEN RESULTS

4.1 Overview

A wide range of technologies, sizes, dispatch durations and numbers of cars refueled per day were examined to determine the overall viability of using distributed utility dispatch at hydrogen refueling stations.

The majority of the analysis was done using nominal or median values for the distributed utility benefits which these hydrogen refueling station installations could earn; one sensitivity section examines a range of avoided costs and the impact of sharing the benefits between the utility and the station owner. Another sensitivity section considers the impact of changing on-peak and off-peak electricity costs from the original Princeton values.

The most important results are reviewed below, but the reader is urged to study the Appendix where the detailed results, assumptions, and worksheets are included. With these a skillful reader can examine many more sensitivities and possibilities than can be included herein.

4.2 Base Case Results

For the 200 car per day base case (refueling station only with no distributed resource), hydrogen could be delivered to the clients for 18.33 $/GJ. For the 400 car per day capability the costs dropped to 15.55 $/GJ. The capital cost of the larger capability station is only 79% more than the smaller version, and since the throughput is doubled the overall economics are approximately twenty percent superior. This substantial superiority of the higher capacity station is reflected in all of the results of the study, whether including distributed utility units or not. The improvement with number of cars served per day agrees with the Princeton Study.

These two base cases are used for comparison to the distributed utility economics to evaluate the relative value of adding dispatch capability.

4.3 Technologies Considered

Four relatively near-term fuel cell technologies (PEM, RFC, hybrid, and IC Engine) and one long-term future regenerative fuel cell option (future RFC) were compared to one another.

- The PEM design has separate electrolyzer and fuel cell components, the electrolyzer sized to meet the hydrogen supply needs and the fuel cell sized to provide the desired distributed utility output.

- The RFC design has a single electrolyzer/fuel cell unit, sized to meet the hydrogen supply needs; this makes the fuel cell capability oversized to provide the desired distributed utility output.

- The hybrid design has a small RFC sized to provide the desired distributed utility output and a small portion of the hydrogen supply needs, plus a separate electrolyzer component sized to meet the remainder of the hydrogen supply needs. This is a cost-efficient design since it uses the more expensive reversible component precisely for the distributed utility aspects only.

- The future RFC design has a single electrolyzer/fuel cell unit, sized to meet the hydrogen supply needs; this makes the fuel cell capability oversized to provide the desired distributed utility output.

- The engine system assumes mass produced diesel generator technology suitable for hydrogen combustion; the separate electrolyzer is sized to meet the hydrogen supply needs and the fuel cell sized to provide the desired distributed utility output.

4.4 Overview of Distributed Utility Results Using National Average Data

4.4.1 Technology Ranking

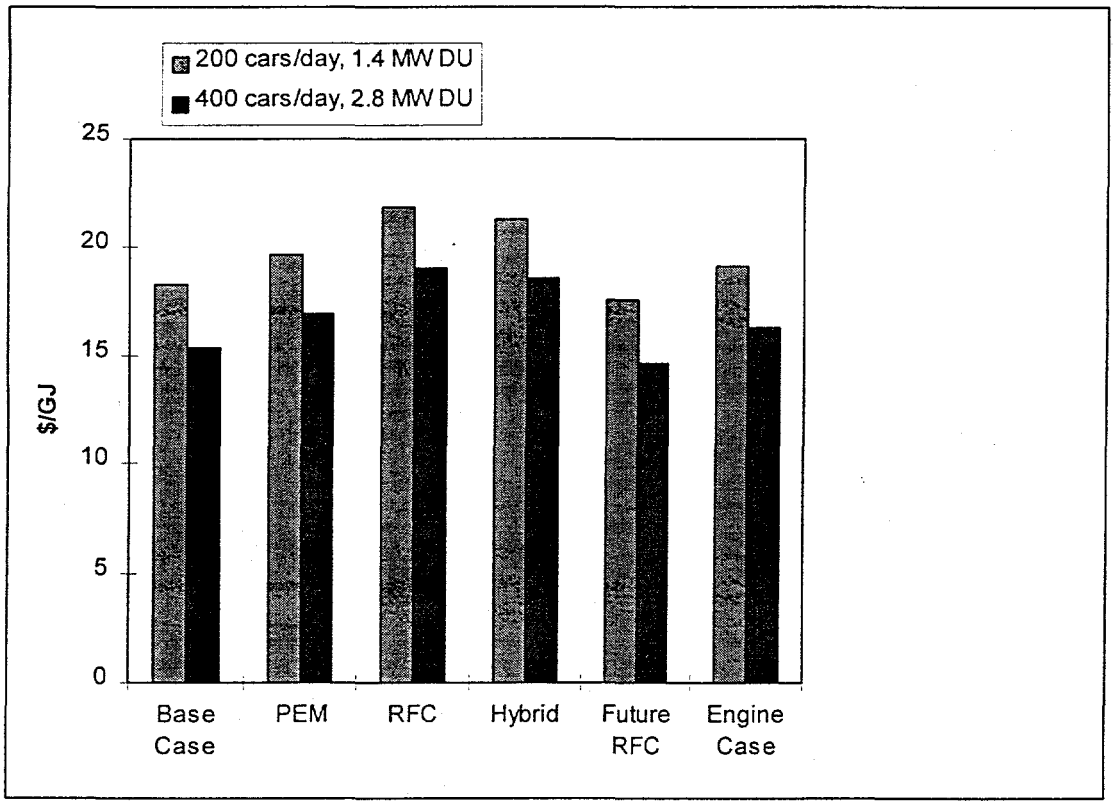
In a general sense the future RFC has the best (lowest) cost of hydrogen production followed by the engine, the PEM, the HYB and least desirable is the RFC. Using any of the near-term joint refueling/distributed utility designs to reduce the cost of hydrogen does not appear to be likely, but it is very close to making sense for the PEM.

The long-term future RFC design is ideal for distributed utility applications at refueling stations, handily beating the base case at both car handling sizes. The future RFC

design, should it ever be realized, is ideal for such a refueling station application since the hardware is used nearly continuously, whether electrolyzing off-peak or discharging for an hour or so per day.

The technology comparison is shown in Exhibit 12.

Exhibit 12. Cost of Hydrogen for 1 hr/day Distributed Utility Cases with Median Benefits



4.4.2 Sensitivity to Distributed Utility Power Level and Hours of Distributed Utility Operation

Across the board, the cost effectiveness of the distributed utility units is improved as the number of hours of operation is decreased. This is to be expected since the benefits are primarily proportional to the MW rating while much of the additional costs of the distributed utility system are proportional to the duration of dispatch. With these types of dependencies there is much to gain and little to lose by reducing the duration of the dispatch. In reality the one hour duration is probably as short as a utility distribution engineer is likely to accept to ensure thorough peak clipping. Thus while the sensitivity to duration is insightful, one hour is probably the realistic lower bound.

4.4.3 Sensitivity to the Dispatch Rating of the Distributed Utility Units

The rating of the distributed utility unit provides a much more interesting story. The PEM and HYB cases become less attractive as the distributed utility unit is dispatched at higher and higher power. Apparently as more power is demanded the additional capital costs for the fuel cell portions are not outweighed by the additional distributed utility benefits. Thus the economics are pushing the size toward zero fuel cell size.

However in the single component designs (RFC and future RFC) the fuel cell function is underutilized at low power, so that requesting that it operate at higher power levels reduces the net cost of hydrogen from the station. This is not an unlimited capability however since the electrolyzer side has capabilities at 1.6 MW and 3.2 MW for the 200 and 400 car per day designs respectively, only slightly higher than the dispatch rating maximum studied here. Thus the most reasonable size to consider for distributed utility applications of refueling stations for single component designs is the electrolyzer forward rating, approximately the same as the high end of the dispatch size selected herein.

The results in $/gigajoule for each technology over the range of DU operation and for median DU benefits are shown in Exhibits 13-22.

Exhibit 13. Cost of Hydrogen vs. Hours/day of Operation 200 cars/day, PEM [$/GJ]

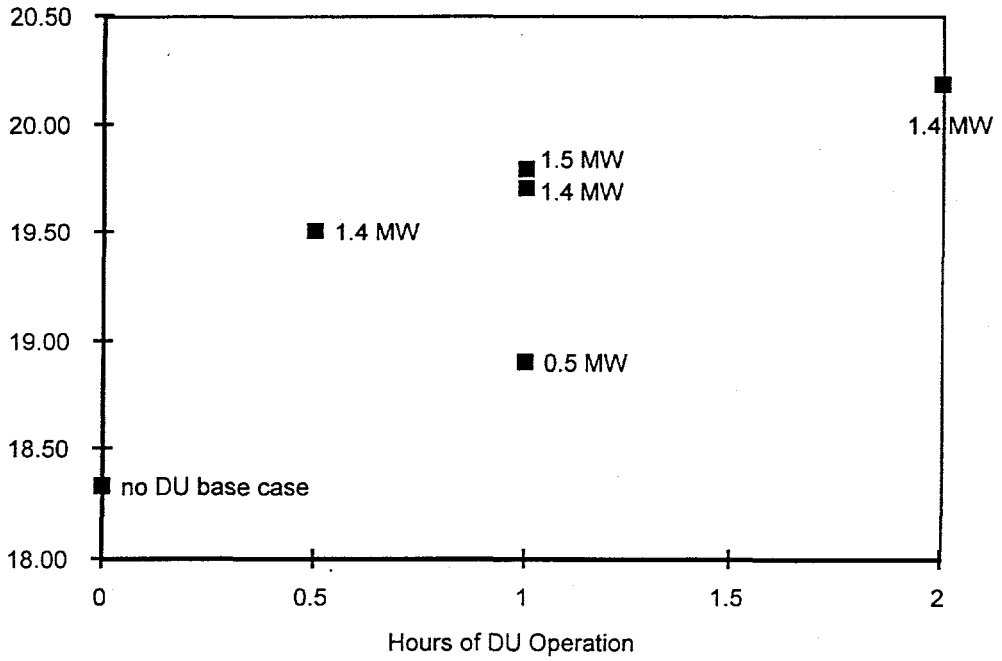


Exhibit 14. Cost of Hydrogen vs. Hours/day of Operation 400 cars/day, PEM [$/GJ]

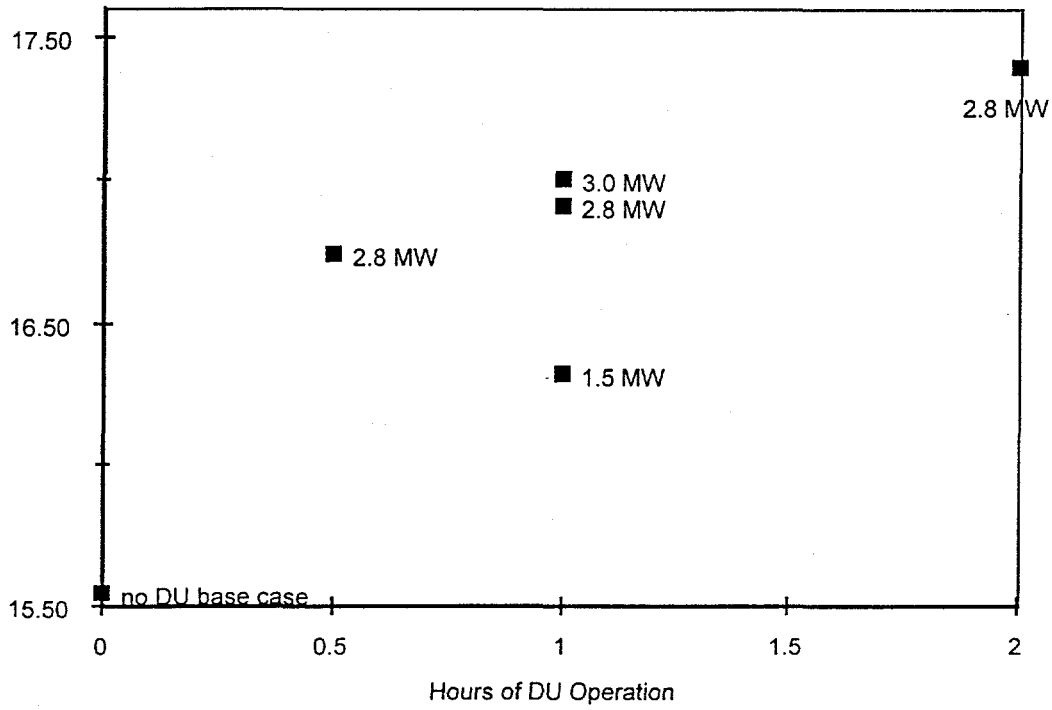


Exhibit 15. Cost of Hydrogen vs. Hours/day of Operation 200 cars/day, RFC [$/GJ]

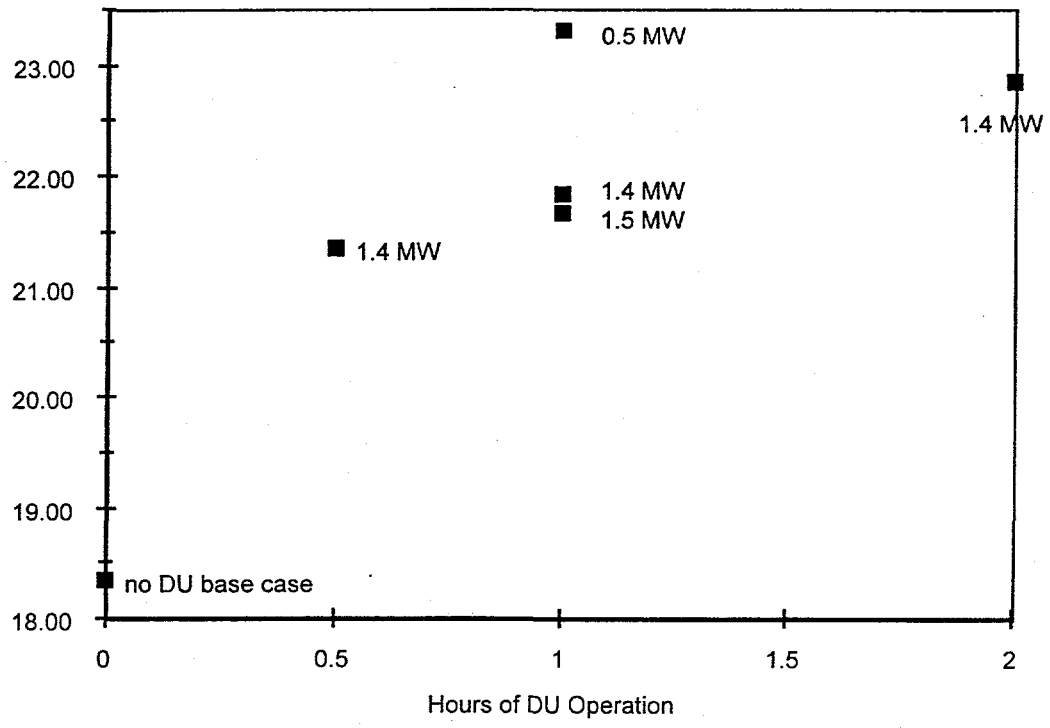


Exhibit 16. Cost of Hydrogen vs. Hours/day of Operation 400 cars/day, RFC [$/GJ]

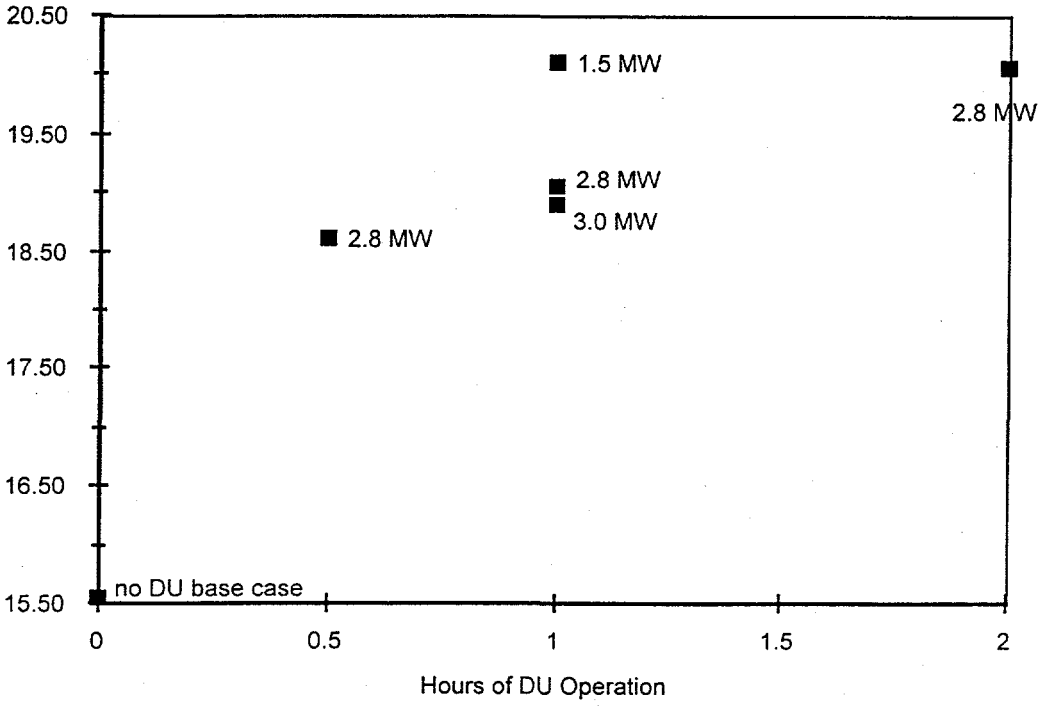


Exhibit 17. Cost of Hydrogen vs. Hours/day of Operation 200 cars/day, Hybrid [$/GJ]

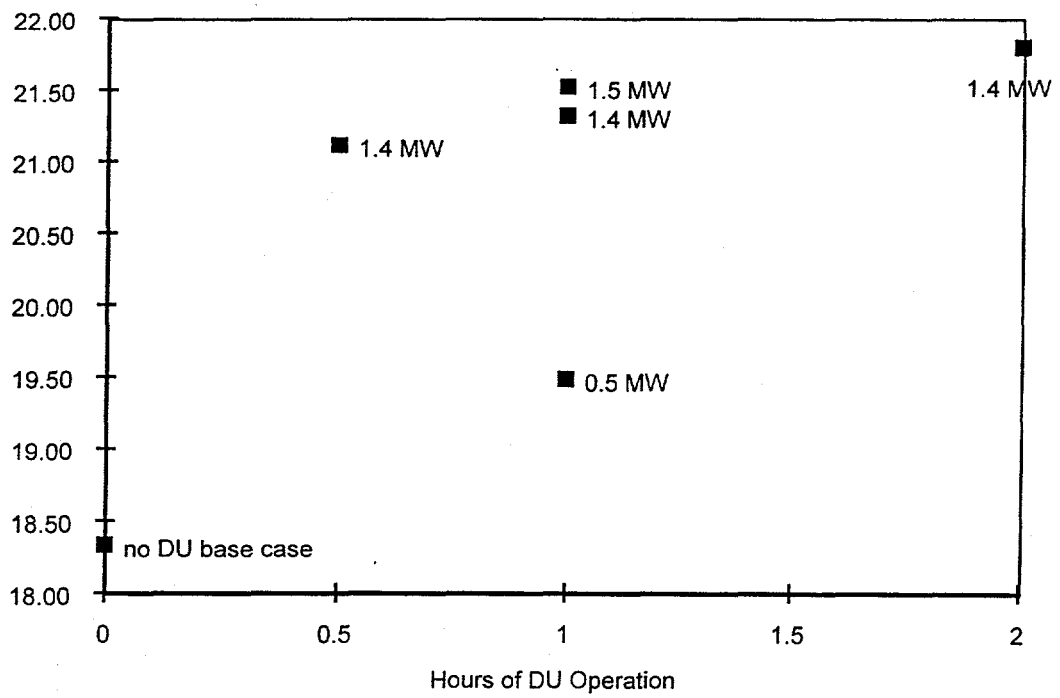


Exhibit 18. Cost of Hydrogen vs. Hours/day of Operation 400 cars/day, Hybrid [$/GJ]

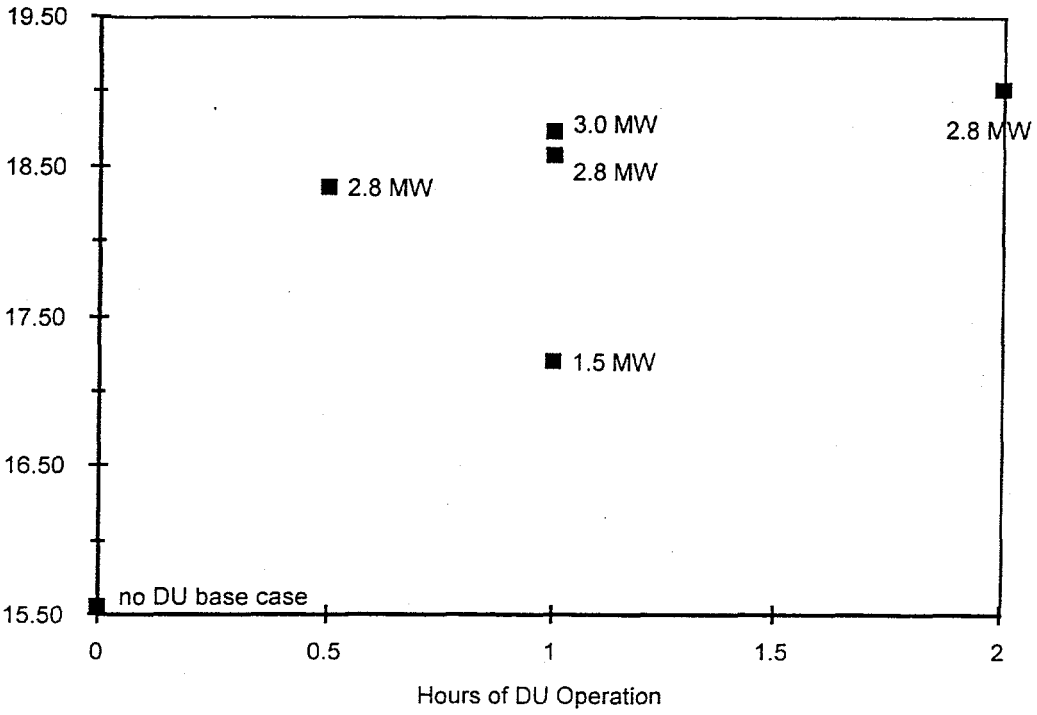


Exhibit 19. Cost of Hydrogen vs. Hours/day of Operation 200 cars/day, Future RFC

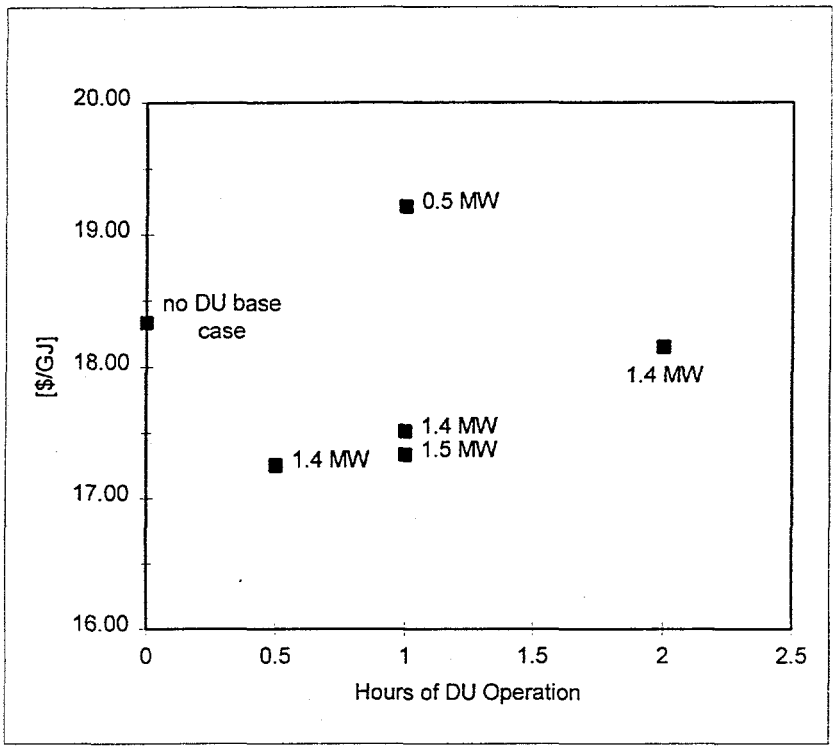


Exhibit 20. Cost of Hydrogen vs. Hours/day of Operation 400 cars/day, Future RFC

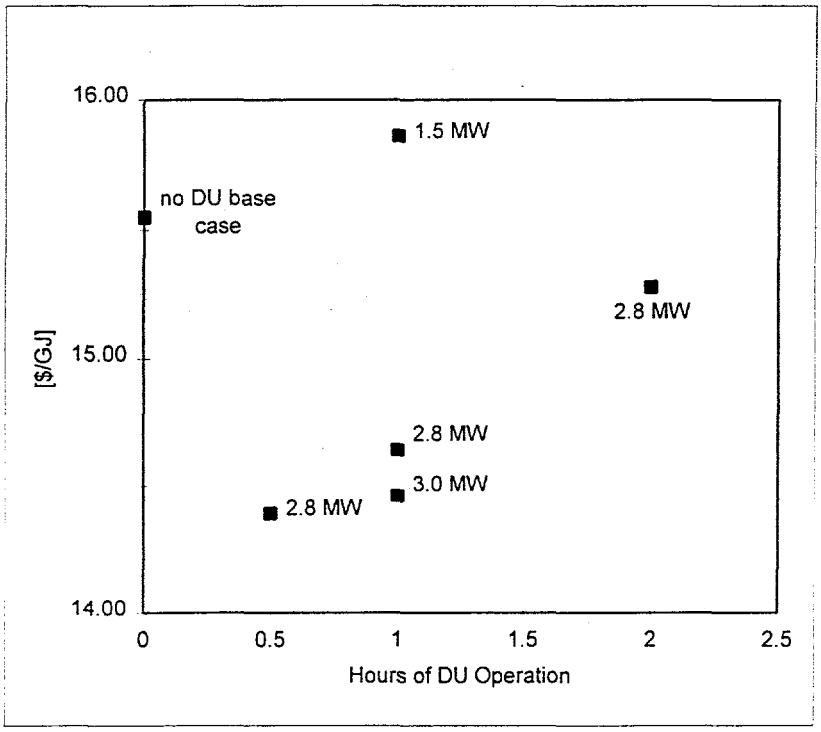


Exhibit 21. Cost of Hydrogen vs. Hours/day of Operation 200 cars/day, IC Engine [$/GJ]

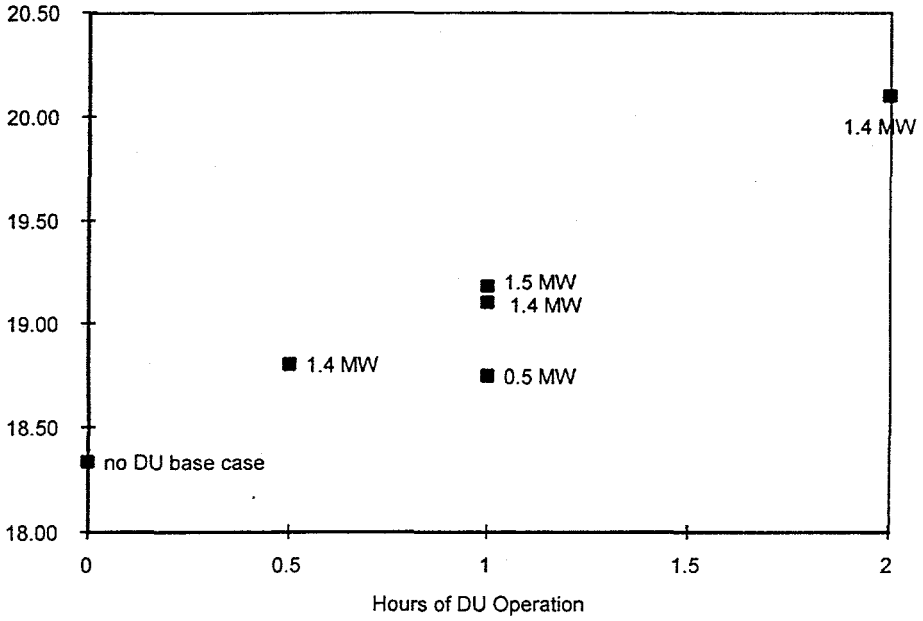
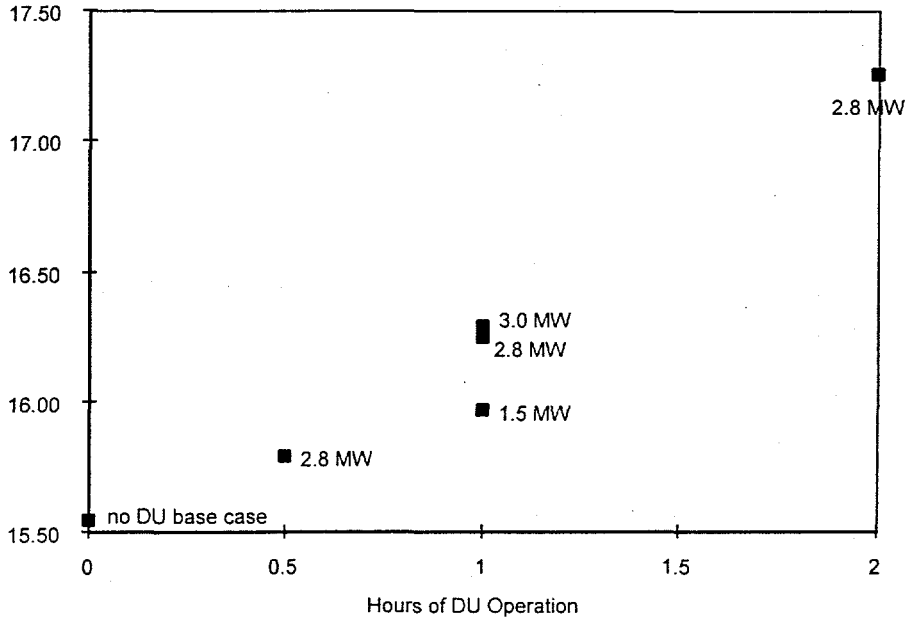


Exhibit 22. Cost of Hydrogen vs. Hours/day of Operation 400 cars/day, IC Engine [$/GJ]



4.5 Studying the Sensitivity to Utility Benefits Using a Distribution of Avoided Costs

The near-term applications potential for distributed utility operation of fuel cells in conjunction with refueling stations looked near enough to economic viability that a closer look seemed reasonable. Perhaps the use of a national average for the utility benefits of distributed utility dispatch was hiding the application of these units in some fraction of the upper end of utility avoided costs.

We selected the PEM case for further in-depth analysis. We added two features to the analysis to provide more insight into the potential for this application:

- a distribution of utility avoided costs into five bins, and
- a parameter to show the amount of savings which a utility and a distributed utility owner might negotiate

The results for the five bins are shown in Exhibit 23 for the 200 car/day case and in Exhibit 24 for the 400 car/day case.

Exhibit 23. Cost of Hydrogen vs. Range of Utility Benefits for 1 hr/day, PEM, 200 cars/day

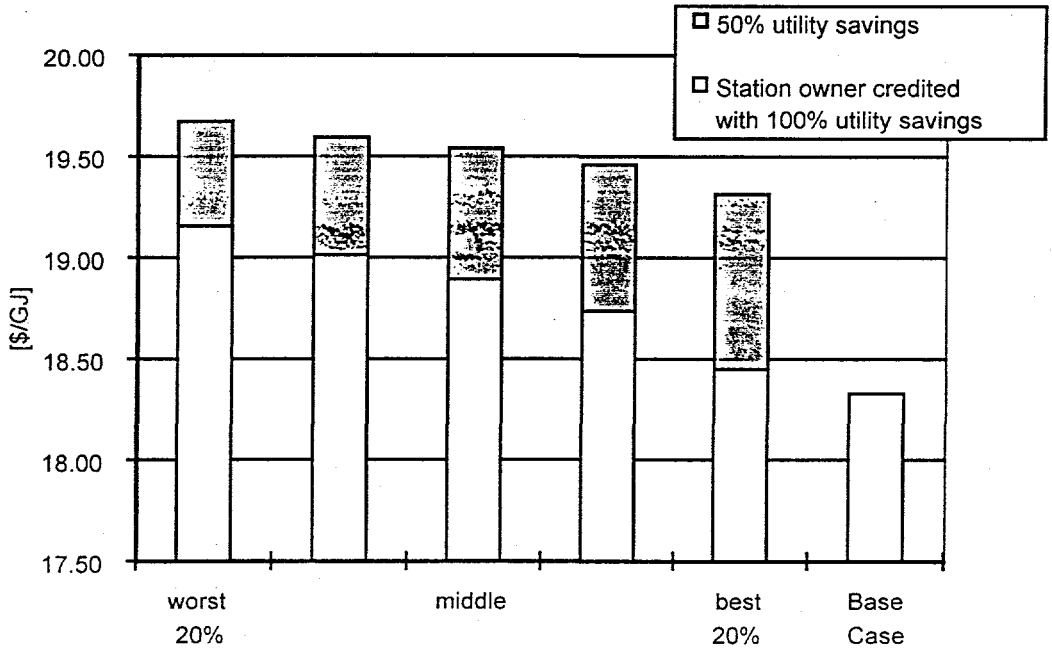
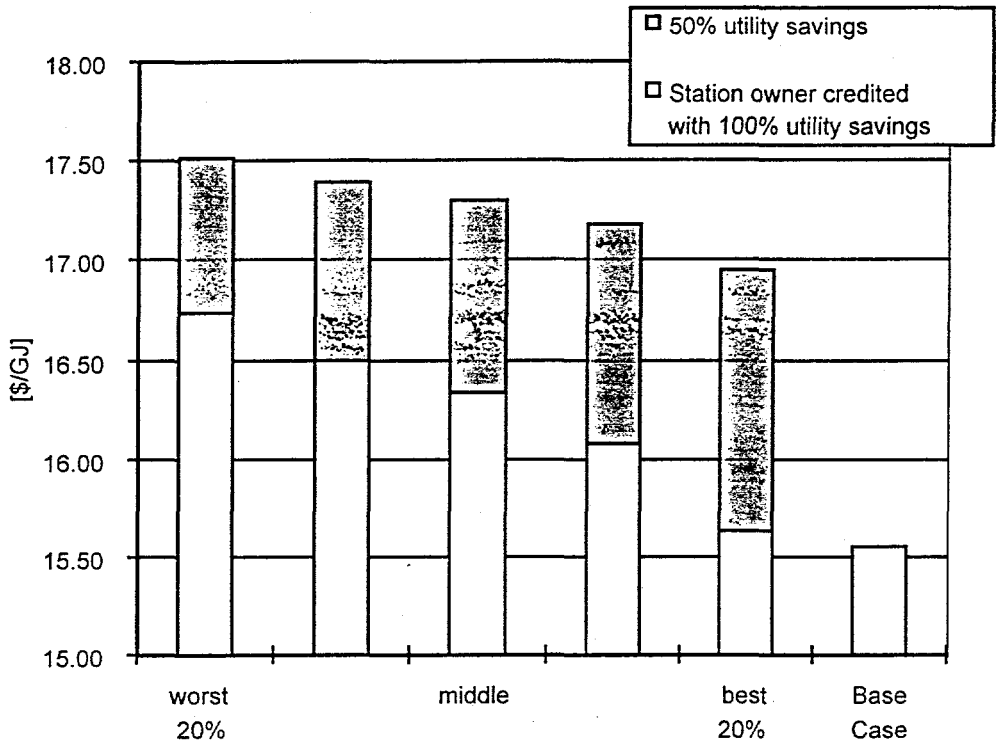


Exhibit 24. Cost of Hydrogen vs. Range of Utility Benefits for 1 hr/day, PEM, 400 cars/day



4.6 Studying the Sensitivity to Electricity Costs

The baseline electricity costs (2 cents per kWh off-peak and 7 cents per kWh on-peak), while consistent with the Princeton refueling station economics study, may not be representative of a large portion of the US. These original electricity costs are more representative of electricity production costs than the price a commercial customer would pay for electricity. Further, electricity costs have risen somewhat in the last few years in parts of the country and the relationship between peak and off-peak is not the same everywhere.

To study the sensitivity to this important variable in estimating the cost of electrolysis, we have used an alternative set of higher costs to purchase electricity:

- 4 cents per kWh off-peak, and
- 8 cents per kWh on-peak.

The results are shown in Exhibit 25. Even though the hydrogen production costs rise by roughly one-third with more expensive electricity, the technology ranking results are not impacted to first order by the use of higher electricity costs, since the base case

hydrogen costs also rise proportionately. Slight relative advantage will be found for the more efficient fuel cells compared to the less efficient hydrogen engine technology since the electricity to make the extra hydrogen for distributed utility dispatch has become more costly.

A more subtle issue is whether the electrolyzer should still operate eighteen hours per day if the off-peak costs average as high 4 cents per kWh.

Exhibit 25. Cost of Hydrogen for 1 hr/day Distributed Utility Cases with Median Benefits (Baseline Electricity Costs: 2¢/kWh off-peak, 7¢/kWh on-peak; Alternative Electricity Costs: 4¢/kWh off-peak, 8¢/kWh on-peak)

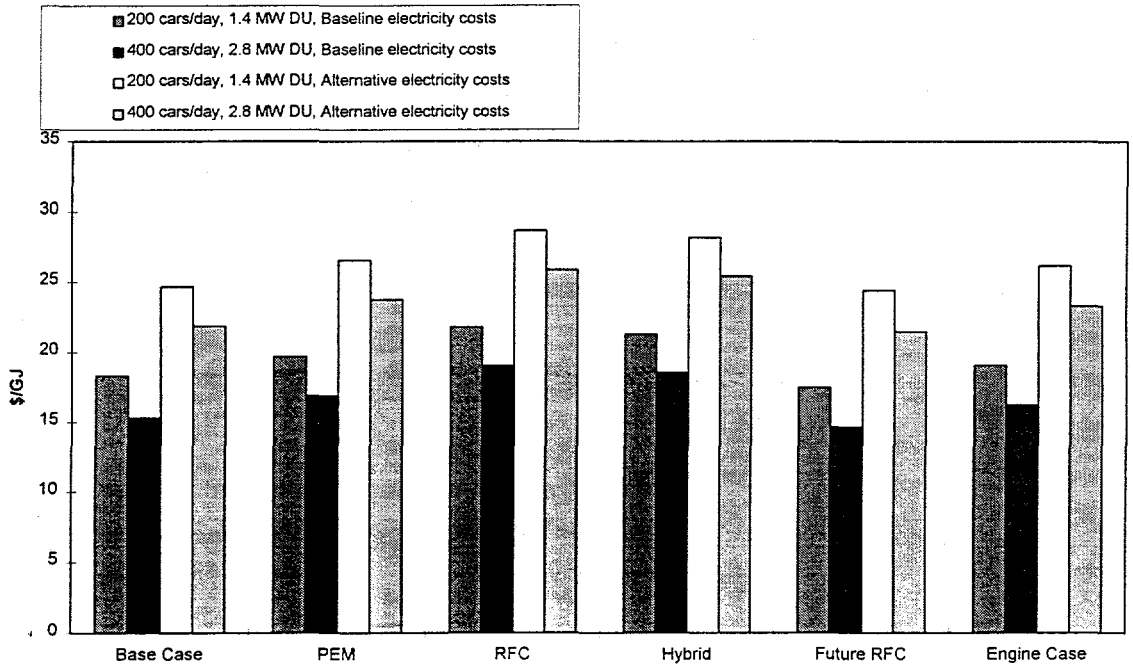
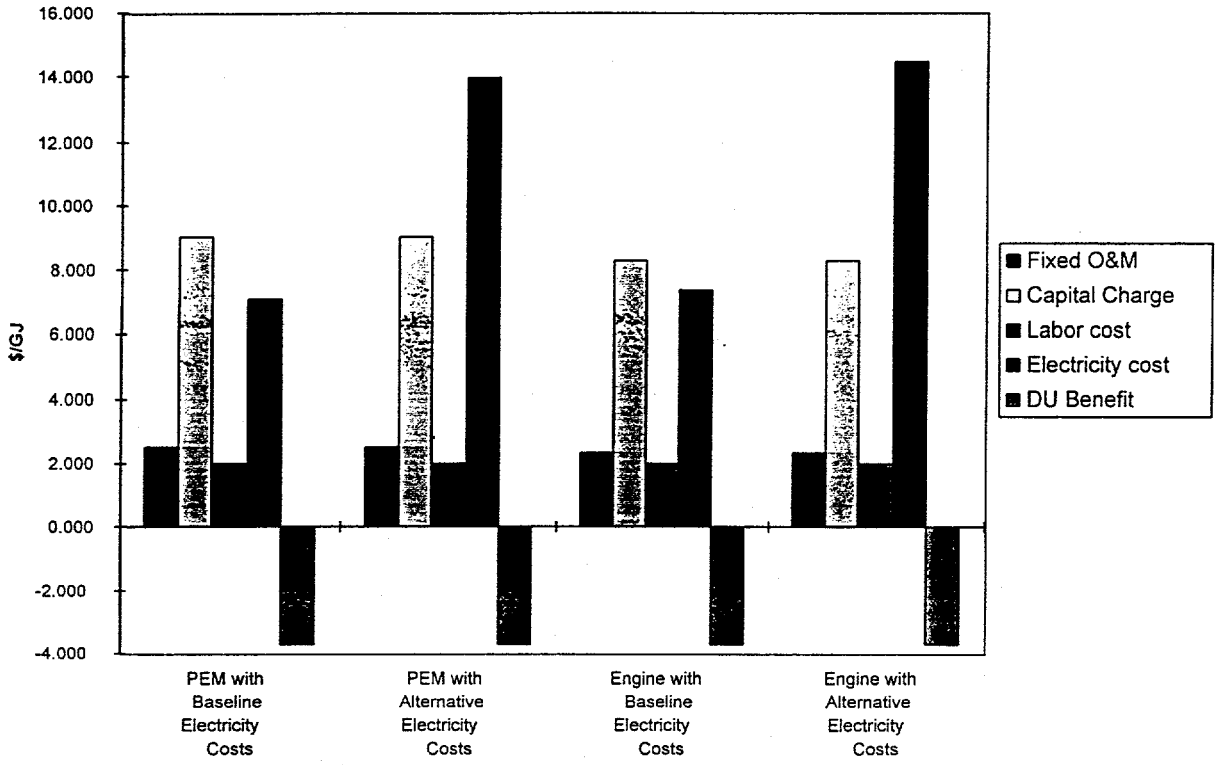


Exhibit 26 shows the components of delivered hydrogen cost ($/GJ) for several cases at both the baseline and alternative (higher) electricity costs. The figure indicates that electricity and capital are the major cost elements. The final cost of hydrogen is very sensitive to off-peak electricity costs. The size of the DU benefits is also shown for these cases. These values are negative since they subtract from the cost components in computing the final cost of hydrogen.

Exhibit 26. Components of Cost of Hydrogen for 1 hr/day Distributed Utility Cases with Median Benefits (Baseline Electricity Costs: 2¢/kWh off-peak, 7¢/kWh on-peak; Alternative Electricity Costs: 4¢/kWh off-peak, 8¢/kWh on-peak)



5.

DISCUSSION

As utilities become more comfortable negotiating such shared distributed utility savings arrangements with owners of distributed utility plants, the near-term PEM or hydrogen engine technical options should be re-evaluated for economic viability.

For example, the top 20% bin of utility avoided costs still represents an average of almost 200,000 MW of installed capacity in the US; at the upper end of that bin can be large markets and profitable locations which could be quite viable if the utility is motivated to share the distributed benefits.

Even small reductions in some of the technology costs or improvements in performance could swing the equation in favor of PEM or hydrogen engine distributed utility units at refueling stations.

A decision to slow down or eliminate refueling during the utility peak hour (to eliminate the parasitic load of the boost pump), would have made the PEM or hydrogen engine attractive.

Alternatively, allowing the pressure in the cushion gas to drop below 40% of maximum (which would only occur if all 200 or 400 vehicles/day were fueled during the peak period with no electrolyzer operating) might have been cost effective. The lost distributed utility benefits would need to be traded off with an occasional excessive power drain to get storage pressure back within operating range once the utility's daily peak hour is over.

Another major factor which could make these hydrogen engine or PEM distributed utility units compellingly cost-effective would be even small incentives or green power credits for their operation. A one cent per kWh credit for hydrogen derived output would make DU at a refueling station much more attractive economically. Likewise, a strategy in which the DU plants are not scheduled for dispatch on weekends and during the off-peak season could provide some savings in electrolysis costs.

The hydrogen fueled engine results deserve discussion for two reasons: 1) the engine could be the nearest term technology option, and 2) its cost and performance assumptions depend on different factors than the other electric generation technologies. All of the generation technology cost and performance estimates used in this study anticipate technical success and mass production levels (for utility or transportation applications). The hydrogen fueled engine costs may be the most sensitive to

transportation market mass-production levels. The fuel cells may reach mass production via utility applications at prices higher than the transportation market sector can likely support. However the simplicity of the hydrogen engine approach may be very attractive to the transportation industry. The hydrogen engine distributed utility generator might have looked even more promising if the station had been designed to service vehicles with hydride storage or if hydride storage had been used for the bulk on-site storage.

The future RFC seems to be ideally suited to the distributed utility application at refueling stations. This technology should studied carefully and the economics reexamined as it comes closer to the marketplace.

Utilities should be alerted to the potential for use of hydrogen refueling technologies as assets in their electric systems. As utilities become more familiar with hydrogen as a fuel and with the distributed utility concept in general this option will gain in importance.

The higher electricity cost sensitivity suggests that there might be a preferred operational strategy. A more detailed analysis might consider dispatch of the electrolyzer against real time of day rates, varying seasonally and daily; more detailed vehicle refueling patterns would need to be included also. The results of such a study might recommend using the electrolyzer only during super-off-peak times, perhaps less than twelve hours per day, when commercial rates can approach 2 cents per kWh. Of course, more electrolyzer capacity would be needed and its capacity factor would diminish, but this might be economically preferred. The analysis of all of these optimum electrolyzer dispatch options was beyond the scope of the study.

6.

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3. C. E. Thomas, *Integrated Analysis of Hydrogen Passenger Vehicle Transportation Pathways,* Activity report to the U.S. Department of Energy, Subcontract No. AXE-6-16685-01, November 6, 1997.

4. Private communication with Fred Mitlisky, Lawrence Livermore National Laboratory, February 1998.

5. Private communication with Jay Keller, Sandia National Laboratories, March 1998.

6. NREL Data Sheet: Engine Generator Sets, June 4, 1997.

7.

ACKNOWLEDGMENTS

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8.

APPENDICES: WORKSHEETS AND CHARTS

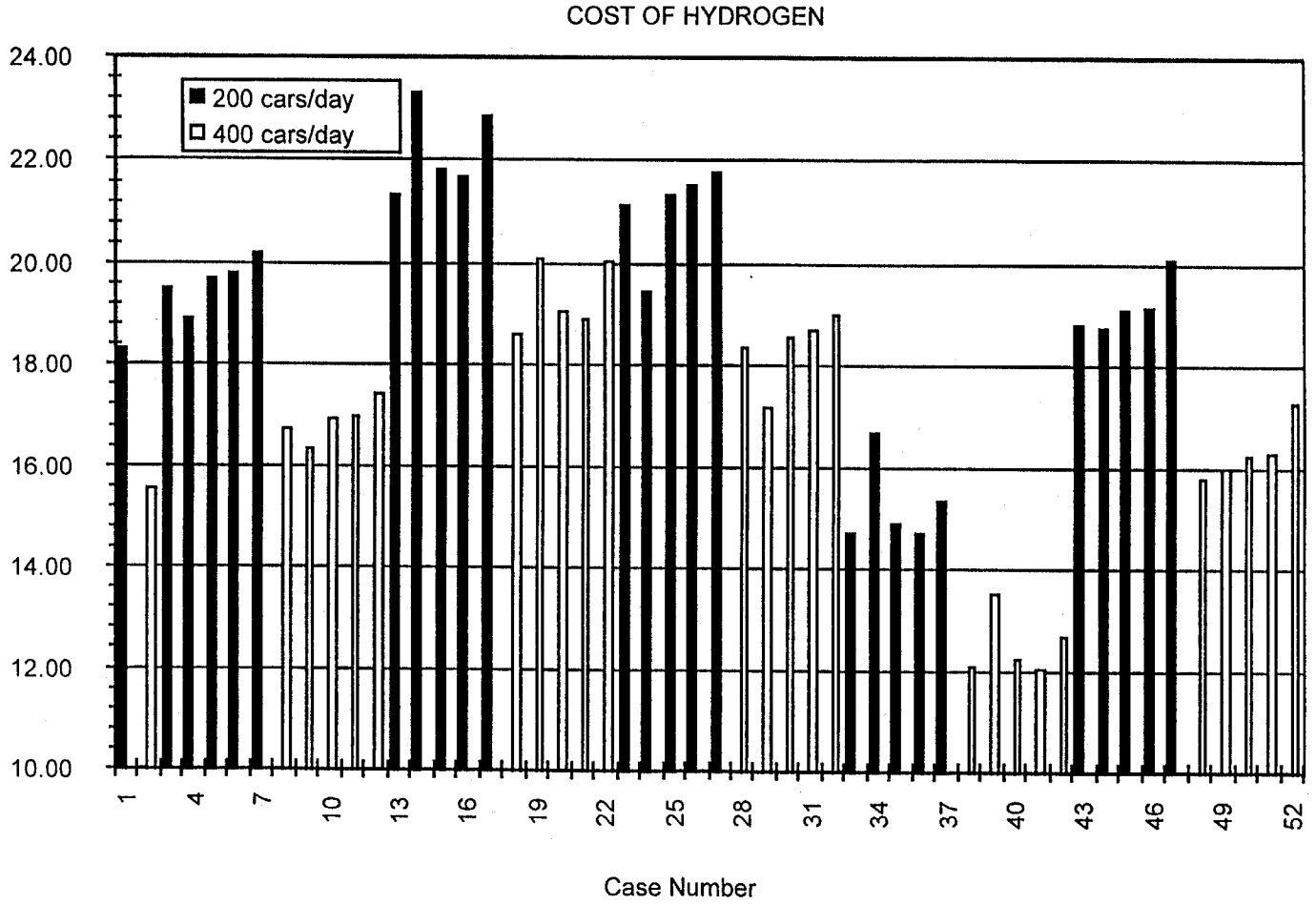
These appendices will include all case worksheets to allow the reader to understand the details of the calculations and perform extensive sensitivity studies.

Appendix A-1: Cases with Baseline Electricity Costs

Worksheet 1: Baseline Electricity Costs (2¢/kWh off-peak, 7¢/kWh on-peak)

Case No.	Sys. Tech.	Capacity [cars/day]	DU [hrs/day]	DU Output [MW]	TOTAL DU BEN. [$/yr]	COST OF H2 [$/GJ]	TOTAL CAPITAL COST [$]	SYS. ANNUAL COST [$/yr]
1	BC	200			0	18.33	1,331,000	605,581
2	BC	400			0	15.55	2,385,000	1,027,132
3	PEM	200	0.5	1.4	111,432	19.51	2,080,000	755,775
4	PEM	200	1.0	0.5	42,052	18.90	1,616,000	666,301
5	PEM	200	1.0	1.4	123,660	19.70	2,129,000	774,283
6	PEM	200	1.0	1.5	132,727	19.79	2,186,000	786,427
7	PEM	200	2.0	1.4	143,187	20.18	2,226,000	809,795
8	PEM	400	0.5	2.8	222,865	16.74	3,883,000	1,328,834
9	PEM	400	1.0	1.5	129,442	16.33	3,240,000	1,207,978
10	PEM	400	1.0	2.8	247,320	16.91	3,980,000	1,364,346
11	PEM	400	1.0	3.0	265,455	17.00	4,093,000	1,388,444
12	PEM	400	2.0	2.8	286,375	17.40	4,176,000	1,435,750
13	RFC	200	0.5	1.4	111,432	21.35	2,401,000	816,765
14	RFC	200	1.0	0.5	42,052	23.30	2,382,000	811,841
15	RFC	200	1.0	1.4	123,660	21.83	2,500,000	844,773
16	RFC	200	1.0	1.5	132,727	21.68	2,514,000	848,747
17	RFC	200	2.0	1.4	143,187	22.84	2,688,000	897,575
18	RFC	400	0.5	2.8	222,865	18.61	4,534,000	1,452,524
19	RFC	400	1.0	1.5	129,442	20.09	4,548,000	1,456,498
20	RFC	400	1.0	2.8	247,320	19.04	4,722,000	1,505,326
21	RFC	400	1.0	3.0	265,455	18.89	4,750,000	1,513,274
22	RFC	400	2.0	2.8	286,375	20.06	5,100,000	1,611,310
23	HYB	200	0.5	1.4	111,432	21.12	2,360,000	808,975
24	HYB	200	1.0	0.5	42,052	19.47	1,716,000	685,301
25	HYB	200	1.0	1.4	123,660	21.31	2,409,000	827,483
26	HYB	200	1.0	1.5	132,727	21.51	2,485,000	843,237
27	HYB	200	2.0	1.4	143,187	21.79	2,506,000	862,995
28	HYB	400	0.5	2.8	222,865	18.35	4,443,000	1,435,234
29	HYB	400	1.0	1.5	129,442	17.19	3,540,000	1,264,978
30	HYB	400	1.0	2.8	247,320	18.56	4,540,000	1,473,374
31	HYB	400	1.0	3.0	265,455	18.72	4,693,000	1,502,444
32	HYB	400	2.0	2.8	286,375	19.01	4,736,000	1,542,150
33	FRFC	200	0.5	1.4	111,432	14.72	1,673,000	597,568
34	FRFC	200	1.0	0.5	42,052	16.70	1,655,000	593,734
35	FRFC	200	1.0	1.4	123,660	14.89	1,735,000	615,446
36	FRFC	200	1.0	1.5	132,727	14.69	1,743,000	617,880
37	FRFC	200	2.0	1.4	143,187	15.33	1,858,000	649,748
38	FRFC	400	0.5	2.8	222,865	12.07	3,064,000	1,020,024
39	FRFC	400	1.0	1.5	129,442	13.53	3,078,000	1,023,298
40	FRFC	400	1.0	2.8	247,320	12.23	3,192,000	1,055,026
41	FRFC	400	1.0	3.0	265,455	12.03	3,210,000	1,060,174
42	FRFC	400	2.0	2.8	286,375	12.68	3,440,000	1,123,910
43	HICE	200	0.5	1.4	104,862	18.79	1,894,000	725,691
44	HICE	200	1.0	0.5	38,767	18.74	1,558,000	657,909
45	HICE	200	1.0	1.4	120,375	19.10	1,967,000	751,387
46	HICE	200	1.0	1.5	129,442	19.17	2,013,000	762,755
47	HICE	200	2.0	1.4	141,545	20.10	2,114,000	805,597
48	HICE	400	0.5	2.8	222,865	15.79	3,511,000	1,266,038
49	HICE	400	1.0	1.5	129,442	15.97	3,067,000	1,184,306
50	HICE	400	1.0	2.8	247,320	16.24	3,658,000	1,320,248
51	HICE	400	1.0	3.0	265,455	16.29	3,749,000	1,341,480
52	HICE	400	2.0	2.8	286,375	17.26	3,947,000	1,426,404

Exhibit A-1:
Cost of Hydrogen: 2 cents/kWhr off-peak, 7 cents/kWhr on-peak



CASE 1

System Technology:	**BC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**0 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0 [MW]**

CAPITAL COSTS [$]

Electrolyzer	420,000
Storage	385,000
Compressor	249,000
Fuel Cell	0
Fixed	277,000
TOTAL	1,331,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 199,650 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 53,240 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 56,940 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1400	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	25200	28533
				Total daily off-peak cost @ 2c/kW-hr:	$571

Total Daily Electricity Cost: 596 [$/day]
Total Annual Electricity Cost: 217,591 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 348,991 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 199,650 [$/yr]
Annual Fixed O&M Costs: 56,940 [$/yr]
Total Annual Variable Costs: 348,991 [$/yr]

ANNUAL TOTAL COSTS: 605,581 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	0 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	0 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	0 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	0 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	0 [$/yr]	(on-peak energy sales,$0.035/kW-hr)(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	0 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.33 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 2

System Technology: **BC** **Distibuted Utility:**
Station Capacity: **400 cars/day** **Time of Operation:** **0 [hrs/day]**
No. of Cylinders: **>74** **Output:** **0 [MW]**

CAPITAL COSTS [$]

Electrolyzer	840,000
Storage	770,000
Compressor	498,000
Fuel Cell	0
Fixed	277,000
TOTAL	2,385,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **357,750** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 95,400 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **102,800** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2800	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	50400	57,066
				Total daily off-peak cost @ 2c/kW-hr:	$1,141

Total Daily Electricity Cost: 1,192 [$/day]
Total Annual Electricity Cost: 435,182 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **566,582** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 357,750 [$/yr]
Annual Fixed O&M Costs: 102,800 [$/yr]
Total Annual Variable Costs: 566,582 [$/yr]

ANNUAL TOTAL COSTS: **1,027,132** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	0 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	0 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	0 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	0 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	0 [$/yr]	(on-peak energy sales,$0.035/kW-hr)(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	0 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	15.55 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 3

System Technology:	**PEM**	**Distibuted Utility:**		
Station Capacity:	**200 cars/day**		**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**	➢	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	439,000
Storage	403,000
Compressor	261,000
Fuel Cell	700,000
Fixed	277,000
TOTAL	2,080,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 312,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 83,200 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 86,900 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26280	29,613
				Total daily off-peak cost @ 2c/kW-hr:	$592

Total Daily Electricity Cost: 618 [$/day]
Total Annual Electricity Cost: 225,475 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 356,875 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 312,000 [$/yr]
Annual Fixed O&M Costs: 86,900 [$/yr]
Total Annual Variable Costs: 356,875 [$/yr]

ANNUAL TOTAL COSTS: 755,775 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.51 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 4

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	434,000
Storage	398,000
Compressor	257,000
Fuel Cell	250,000
Fixed	277,000
TOTAL	1,616,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 242,400 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 64,640 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 68,340 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26100	29,433
				Total daily off-peak cost @ 2c/kW-hr:	$589

Total Daily Electricity Cost: 614 [$/day]
Total Annual Electricity Cost: 224,161 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 355,561 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 242,400 [$/yr]
Annual Fixed O&M Costs: 68,340 [$/yr]
Total Annual Variable Costs: 355,561 [$/yr]

ANNUAL TOTAL COSTS: 666,301 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.90 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 5

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	459,000
Storage	421,000
Compressor	272,000
Fuel Cell	700,000
Fixed	277,000
TOTAL	2,129,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 319,350 [$/yr]

FIXED O&M

Fixed O&M percentage:	4% of Total Capital Costs		
Fixed Annual O&M Costs:	85,160	[$/yr]	
Additional Fixed O&M:	3,700	[$/yr]	($100/cyl.)(#cylinders)
Total Annual O&M Costs:	**88,860**	**[$/yr]**	

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27540	30,873
				Total daily off-peak cost @ 2c/kW-hr:	$617

Total Daily Electricity Cost: 643 [$/day]
Total Annual Electricity Cost: 234,673 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 366,073 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge:	319,350 [$/yr]
Annual Fixed O&M Costs:	88,860 [$/yr]
Total Annual Variable Costs:	366,073 [$/yr]
ANNUAL TOTAL COSTS:	**774,283 [$/yr]**

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.70 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 6

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	462,000
Storage	423,000
Compressor	274,000
Fuel Cell	750,000
Fixed	277,000
TOTAL	2,186,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 327,900 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 87,440 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 91,140 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27720	31,053
				Total daily off-peak cost @ 2c/kW-hr:	$621

Total Daily Electricity Cost: 647 [$/day]
Total Annual Electricity Cost: 235,987 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 367,387 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 327,900 [$/yr]
Annual Fixed O&M Costs: 91,140 [$/yr]
Total Annual Variable Costs: 367,387 [$/yr]

ANNUAL TOTAL COSTS: 786,427 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.79 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 7

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	498,000
Storage	456,000
Compressor	295,000
Fuel Cell	700,000
Fixed	277,000
TOTAL	2,226,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 333,900 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 89,040 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 92,740 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
		Total daily on-peak cost @ 7c/kW-hr:			$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	29880	33,213
		Total daily off-peak cost @ 2c/kW-hr:			$664

Total Daily Electricity Cost: 690 [$/day]
Total Annual Electricity Cost: 251,755 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 383,155 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 333,900 [$/yr]
Annual Fixed O&M Costs: 92,740 [$/yr]
Total Annual Variable Costs: 383,155 [$/yr]

ANNUAL TOTAL COSTS: 809,795 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	20.18 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 8

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	879,000
Storage	806,000
Compressor	521,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	3,883,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 582,450 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 155,320 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 162,720 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 2c/kW-hr:	$1,188

Total Daily Electricity Cost: 1,239 [$/day]
Total Annual Electricity Cost: 452,264 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 583,664 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 582,450 [$/yr]
Annual Fixed O&M Costs: 162,720 [$/yr]
Total Annual Variable Costs: 583,664 [$/yr]

ANNUAL TOTAL COSTS: 1,328,834 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	16.74 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 9

System Technology: **PEM** **Distibuted Utility:**
Station Capacity: **400 cars/day** **Time of Operation:** **1 [hrs/day]**
No. of Cylinders: **74** **Output:** **1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	882,000
Storage	808,000
Compressor	523,000
Fuel Cell	750,000
Fixed	277,000
TOTAL	3,240,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **486,000** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 129,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **137,000** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
				Total daily off-peak cost @ 2c/kW-hr:	$1,192

Total Daily Electricity Cost: 1,243 [$/day]
Total Annual Electricity Cost: 453,578 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **584,978** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 486,000 [$/yr]
Annual Fixed O&M Costs: 137,000 [$/yr]
Total Annual Variable Costs: 584,978 [$/yr]

ANNUAL TOTAL COSTS: **1,207,978** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	16.33 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 10

System Technology: PEM **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 74 **Output:** 2.8 [MW]

CAPITAL COSTS [$]

Electrolyzer	918,000
Storage	841,000
Compressor	544,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	3,980,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **597,000** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 159,200 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **166,600** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3060	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55080	61,746
				Total daily off-peak cost @ 2c/kW-hr:	$1,235

Total Daily Electricity Cost: 1,286 [$/day]
Total Annual Electricity Cost: 469,346 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **600,746** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 597,000 [$/yr]
Annual Fixed O&M Costs: 166,600 [$/yr]
Total Annual Variable Costs: 600,746 [$/yr]

ANNUAL TOTAL COSTS: **1,364,346** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	16.91 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 11

System Technology: **PEM** **Distibuted Utility:**
Station Capacity: **400 cars/day** **Time of Operation:** **1 [hrs/day]**
No. of Cylinders: **74** **Output:** **[MW]**

CAPITAL COSTS [$]

Electrolyzer	923,000
Storage	846,000
Compressor	547,000
Fuel Cell	1,500,000
Fixed	277,000
TOTAL	4,093,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **613,950** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 163,720 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **171,120** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 2c/kW-hr:	$1,242

Total Daily Electricity Cost: 1,293 [$/day]
Total Annual Electricity Cost: 471,974 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **603,374** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 613,950 [$/yr]
Annual Fixed O&M Costs: 171,120 [$/yr]
Total Annual Variable Costs: 603,374 [$/yr]

ANNUAL TOTAL COSTS: **1,388,444** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	17.00 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 12

System Technology: **PEM** **Distibuted Utility:**
Station Capacity: **400 cars/day** **Time of Operation:** **2 [hrs/day]**
No. of Cylinders: **74** **Output:** **2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	996,000
Storage	913,000
Compressor	590,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	4,176,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **626,400** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 167,040 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **174,440** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 2c/kW-hr:	$1,329

Total Daily Electricity Cost: 1,379 [$/day]
Total Annual Electricity Cost: 503,510 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **634,910** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 626,400 [$/yr]
Annual Fixed O&M Costs: 174,440 [$/yr]
Total Annual Variable Costs: 634,910 [$/yr]

ANNUAL TOTAL COSTS: **1,435,750** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	17.40 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 13

System Technology:	**RFC**	**Distibuted Utility:**		
Station Capacity:	**200 cars/day**		**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**	➢	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	403,000
Compressor	261,000
Fuel Cell	1,460,000
Fixed	277,000
TOTAL	2,401,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 360,150 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 96,040 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 99,740 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26280	29,613
				Total daily off-peak cost @ 2c/kW-hr:	$592

Total Daily Electricity Cost: 618 [$/day]
Total Annual Electricity Cost: 225,475 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 356,875 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 360,150 [$/yr]
Annual Fixed O&M Costs: 99,740 [$/yr]
Total Annual Variable Costs: 356,875 [$/yr]

ANNUAL TOTAL COSTS: 816,765 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.35 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 14

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	398,000
Compressor	257,000
Fuel Cell	1,450,000
Fixed	277,000
TOTAL	2,382,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 357,300 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 95,280 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 98,980 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26100	29,433
				Total daily off-peak cost @ 2c/kW-hr:	$589

Total Daily Electricity Cost: 614 [$/day]
Total Annual Electricity Cost: 224,161 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 355,561 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 357,300 [$/yr]
Annual Fixed O&M Costs: 98,980 [$/yr]
Total Annual Variable Costs: 355,561 [$/yr

ANNUAL TOTAL COSTS: 811,841 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.30 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold *annually* [GJ/yr]

CASE 15

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	421,000
Compressor	272,000
Fuel Cell	1,530,000
Fixed	277,000
TOTAL	2,500,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 375,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 100,000 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 103,700 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27540	30,873
				Total daily off-peak cost @ 2c/kW-hr:	$617

Total Daily Electricity Cost: 643 [$/day]
Total Annual Electricity Cost: 234,673 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 366,073 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 375,000 [$/yr]
Annual Fixed O&M Costs: 103,700 [$/yr]
Total Annual Variable Costs: 366,073 [$/yr]

ANNUAL TOTAL COSTS: 844,773 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.83 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 16

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	423,000
Compressor	274,000
Fuel Cell	1,540,000
Fixed	277,000
TOTAL	2,514,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 377,100 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 100,560 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 104,260 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27720	31,053
				Total daily off-peak cost @ 2c/kW-hr:	$621

Total Daily Electricity Cost: 647 [$/day]
Total Annual Electricity Cost: 235,987 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 367,387 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 377,100 [$/yr]
Annual Fixed O&M Costs: 104,260 [$/yr]
Total Annual Variable Costs: 367,387 [$/yr]

ANNUAL TOTAL COSTS: 848,747 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.68 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 17

System Technology: RFC **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 2 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	456,000
Compressor	295,000
Fuel Cell	1,660,000
Fixed	277,000
TOTAL	2,688,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **403,200 [$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 107,520 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **111,220 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	29880	33,213
				Total daily off-peak cost @ 2c/kW-hr:	$664

Total Daily Electricity Cost: 690 [$/day]
Total Annual Electricity Cost: 251,755 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **383,155 [$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 403,200 [$/yr]
Annual Fixed O&M Costs: 111,220 [$/yr]
Total Annual Variable Costs: 383,155 [$/yr]

ANNUAL TOTAL COSTS: **897,575 [$/yr]**

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	22.84 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 18

System Technology: **RFC** **Distibuted Utility:**
Station Capacity: **400 cars/day** **Time of Operation:** **0.9 [hrs/day]**
No. of Cylinders: **74** **Output:** **2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	806,000
Compressor	521,000
Fuel Cell	2,930,000
Fixed	277,000
TOTAL	4,534,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **680,100 [$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 181,360 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **188,760 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 2c/kW-hr:	$1,188

Total Daily Electricity Cost: 1,239 [$/day]
Total Annual Electricity Cost: 452,264 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **583,664 [$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 680,100 [$/yr]
Annual Fixed O&M Costs: 188,760 [$/yr]
Total Annual Variable Costs: 583,664 [$/yr]

ANNUAL TOTAL COSTS: **1,452,524 [$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.61 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 19

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	808,000
Compressor	523,000
Fuel Cell	2,940,000
Fixed	277,000
TOTAL	4,548,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 682,200 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 181,920 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 189,320 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
		Total daily on-peak cost @ 7c/kW-hr:			$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
		Total daily off-peak cost @ 2c/kW-hr:			$1,192

Total Daily Electricity Cost: 1,243 [$/day]
Total Annual Electricity Cost: 453,578 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 584,978 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 682,200 [$/yr]
Annual Fixed O&M Costs: 189,320 [$/yr]
Total Annual Variable Costs: 584,978 [$/yr]

ANNUAL TOTAL COSTS: 1,456,498 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	20.09 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 20

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	841,000
Compressor	544,000
Fuel Cell	3,060,000
Fixed	277,000
TOTAL	4,722,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 708,300 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 188,880 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
***Total Annual O&M Costs:* 196,280 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3060	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55080	61,746
				Total daily off-peak cost @ 2c/kW-hr:	$1,235

Total Daily Electricity Cost: 1,286 [$/day]
Total Annual Electricity Cost: 469,346 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 600,746 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 708,300 [$/yr]
Annual Fixed O&M Costs: 196,280 [$/yr]
Total Annual Variable Costs: 600,746 [$/yr]

ANNUAL TOTAL COSTS: 1,505,326 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.04 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 21

System Technology: RFC **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 74 **Output:** 3 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	846,000
Compressor	547,000
Fuel Cell	3,080,000
Fixed	277,000
TOTAL	4,750,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **712,500 [$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 190,000 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **197,400 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 2c/kW-hr:	$1,242

Total Daily Electricity Cost: 1,293 [$/day]
Total Annual Electricity Cost: 471,974 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **603,374 [$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 712,500 [$/yr]
Annual Fixed O&M Costs: 197,400 [$/yr]
Total Annual Variable Costs: 603,374 [$/yr]

ANNUAL TOTAL COSTS: **1,513,274 [$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.89 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 22

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	913,000
Compressor	590,000
Fuel Cell	3,320,000
Fixed	277,000
TOTAL	5,100,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 765,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 204,000 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 211,400 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 2c/kW-hr:	$1,329

Total Daily Electricity Cost: 1,379 [$/day]
Total Annual Electricity Cost: 503,510 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 634,910 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 765,000 [$/yr]
Annual Fixed O&M Costs: 211,400 [$/yr]
Total Annual Variable Costs: 634,910 [$/yr]

ANNUAL TOTAL COSTS: 1,611,310 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	20.06 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 23

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	19,000
Storage	403,000
Compressor	261,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	2,360,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 354,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 94,400 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 98,100 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26280	29,613
				Total daily off-peak cost @ 2c/kW-hr:	$592

Total Daily Electricity Cost: 618 [$/day]
Total Annual Electricity Cost: 225,475 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 356,875 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 354,000 [$/yr]
Annual Fixed O&M Costs: 98,100 [$/yr]
Total Annual Variable Costs: 356,875 [$/yr]

ANNUAL TOTAL COSTS: 808,975 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.12 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 24

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	284,000
Storage	398,000
Compressor	257,000
Fuel Cell	500,000
Fixed	277,000
TOTAL	1,716,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 257,400 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 68,640 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 72,340 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26100	29,433
				Total daily off-peak cost @ 2c/kW-hr:	$589

Total Daily Electricity Cost: 614 [$/day]
Total Annual Electricity Cost: 224,161 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 355,561 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 257,400 [$/yr]
Annual Fixed O&M Costs: 72,340 [$/yr]
Total Annual Variable Costs: 355,561 [$/yr]

ANNUAL TOTAL COSTS: 685,301 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.47 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 25

System Technology: HYB **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	39,000
Storage	421,000
Compressor	272,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	2,409,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 361,350 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 96,360 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 100,060 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27540	30,873
				Total daily off-peak cost @ 2c/kW-hr:	$617

Total Daily Electricity Cost: 643 [$/day]
Total Annual Electricity Cost: 234,673 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 366,073 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 361,350 [$/yr]
Annual Fixed O&M Costs: 100,060 [$/yr]
Total Annual Variable Costs: 366,073 [$/yr]

ANNUAL TOTAL COSTS: 827,483 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.31 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 26

System Technology: **HYB** **Distibuted Utility:**
Station Capacity: **200 cars/day** **Time of Operation:** **1 [hrs/day]**
No. of Cylinders: **37** **Output:** **1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	11,000
Storage	423,000
Compressor	274,000
Fuel Cell	1,500,000
Fixed	277,000
TOTAL	2,485,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **372,750** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 99,400 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **103,100** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
	Total daily on-peak cost @ 7c/kW-hr:				$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27720	31,053
	Total daily off-peak cost @ 2c/kW-hr:				$621

Total Daily Electricity Cost: 647 [$/day]
Total Annual Electricity Cost: 235,987 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **367,387** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 372,750 [$/yr]
Annual Fixed O&M Costs: 103,100 [$/yr]
Total Annual Variable Costs: 367,387 [$/yr]

ANNUAL TOTAL COSTS: **843,237** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.51 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 27

System Technology: **HYB** **Distibuted Utility:**
Station Capacity: **200 cars/day** **Time of Operation:** **2 [hrs/day]**
No. of Cylinders: **37** **Output:** **1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	78,000
Storage	456,000
Compressor	295,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	2,506,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **375,900** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 100,240 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **103,940** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	29880	33,213
				Total daily off-peak cost @ 2c/kW-hr:	$664

Total Daily Electricity Cost: 690 [$/day]
Total Annual Electricity Cost: 251,755 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **383,155** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 375,900 [$/yr]
Annual Fixed O&M Costs: 103,940 [$/yr]
Total Annual Variable Costs: 383,155 [$/yr]

ANNUAL TOTAL COSTS: **862,995** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.79 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 28

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	39,000
Storage	806,000
Compressor	521,000
Fuel Cell	2,800,000
Fixed	277,000
TOTAL	4,443,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 666,450 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 177,720 [$/yr]
Additional Fixed O&M: 7,400 $/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 185,120 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 2c/kW-hr:	$1,188

Total Daily Electricity Cost: 1,239 [$/day]
Total Annual Electricity Cost: 452,264 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 583,664 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 666,450 [$/yr]
Annual Fixed O&M Costs: 185,120 [$/yr]
Total Annual Variable Costs: 583,664 [$/yr]

ANNUAL TOTAL COSTS: 1,435,234 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.35 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

System Technology: HYB **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 74 **Output:** 1.5 [MW]

CAPITAL COSTS [$]

Electrolyzer	432,000
Storage	808,000
Compressor	523,000
Fuel Cell	1,500,000
Fixed	277,000
TOTAL	3,540,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 531,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 141,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 149,000 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
				Total daily off-peak cost @ 2c/kW-hr:	$1,192

Total Daily Electricity Cost: 1,243 [$/day]
Total Annual Electricity Cost: 453,578 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 584,978 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 531,000 [$/yr]
Annual Fixed O&M Costs: 149,000 [$/yr]
Total Annual Variable Costs: 584,978 [$/yr]

ANNUAL TOTAL COSTS: 1,264,978 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	17.19 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 30

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	78,000
Storage	841,000
Compressor	544,000
Fuel Cell	2,800,000
Fixed	277,000
TOTAL	4,540,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 681,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 181,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 189,000 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 2c/kW-hr:	$1,242

Total Daily Electricity Cost: 1,293 [$/day]
Total Annual Electricity Cost: 471,974 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 603,374 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 681,000 [$/yr]
Annual Fixed O&M Costs: 189,000 [$/yr]
Total Annual Variable Costs: 603,374 [$/yr]

ANNUAL TOTAL COSTS: 1,473,374 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

ALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.56 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 31

System Technology: HYB **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 74 **Output:** > 3 [MW]

CAPITAL COSTS [$]

Electrolyzer	23,000
Storage	846,000
Compressor	547,000
Fuel Cell	3,000,000
Fixed	277,000
TOTAL	4,693,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 703,950 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 187,720 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 195,120 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
	Total daily on-peak cost @ 7c/kW-hr:				$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
	Total daily off-peak cost @ 2c/kW-hr:				$1,242

Total Daily Electricity Cost: 1,293 [$/day]
Total Annual Electricity Cost: 471,974 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 603,374 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 703,950 [$/yr]
Annual Fixed O&M Costs: 195,120 [$/yr]
Total Annual Variable Costs: 603,374 [$/yr]

ANNUAL TOTAL COSTS: 1,502,444 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.72 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 32

System Technology: **HYB** **Distibuted Utility:**
Station Capacity: **400 cars/day** **Time of Operation:** **2 [hrs/day]**
No. of Cylinders: **74** **Output:** **2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	156,000
Storage	913,000
Compressor	590,000
Fuel Cell	2,800,000
Fixed	277,000
TOTAL	4,736,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **710,400** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 189,440 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **196,840** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 2c/kW-hr:	$1,329

Total Daily Electricity Cost: 1,379 [$/day]
Total Annual Electricity Cost: 503,510 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **634,910** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 710,400 [$/yr]
Annual Fixed O&M Costs: 196,840 [$/yr]
Total Annual Variable Costs: 634,910 [$/yr]

ANNUAL TOTAL COSTS: **1,542,150** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 66065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.01 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 33

System Technology: **FRFC** **Distibuted Utility:**
Station Capacity: **200 cars/day** **Time of Operation:** **0.5 [hrs/day]**
No. of Cylinders: **37** **Output:** **1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	403,000
Compressor	261,000
Fuel Cell	732,000
Fixed	277,000
TOTAL	1,673,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **250,950** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 66,920 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **70,620** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	26280	29,993
				Total daily off-peak cost @ 2c/kW-hr:	$600

Total Daily Electricity Cost: 625 [$/day]
Total Annual Electricity Cost: 228,248 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **359,648** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 250,950 [$/yr]
Annual Fixed O&M Costs: 70,620 [$/yr]
Total Annual Variable Costs: 359,648 [$/yr

ANNUAL TOTAL COSTS: **681,218** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	17.25 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

System Technology: FRFC **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 37 **Output:** 0.5 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	398,000
Compressor	257,000
Fuel Cell	723,000
Fixed	277,000
TOTAL	1,655,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 248,250 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 66,200 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 69,900 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	26100	29,813
				Total daily off-peak cost @ 2c/kW-hr:	$596

Total Daily Electricity Cost: 622 [$/day]
Total Annual Electricity Cost: 226,934 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 358,334 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 248,250 [$/yr]
Annual Fixed O&M Costs: 69,900 [$/yr]
Total Annual Variable Costs: 358,334 [$/yr

ANNUAL TOTAL COSTS: 676,484 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.21 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 35

System Technology: FRFC **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	421,000
Compressor	272,000
Fuel Cell	765,000
Fixed	277,000
TOTAL	1,735,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 260,250 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 69,400 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 73,100 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	27540	31,253
				Total daily off-peak cost @ 2c/kW-hr:	$625

Total Daily Electricity Cost: 651 [$/day]
Total Annual Electricity Cost: 237,446 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 368,846 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 260,250 [$/yr]
Annual Fixed O&M Costs: 73,100 [$/yr]
Total Annual Variable Costs: 368,846 [$/yr

ANNUAL TOTAL COSTS: 702,196 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	17.51 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 36

System Technology: **FRFC** **Distibuted Utility:**
Station Capacity: **200 cars/day** **Time of Operation:** **1 [hrs/day]**
No. of Cylinders: **37** **Output:** **1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	423,000
Compressor	274,000
Fuel Cell	769,000
Fixed	277,000
TOTAL	1,743,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **261,450** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 69,720 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **73,420** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	27720	31,433
				Total daily off-peak cost @ 2c/kW-hr:	$629

Total Daily Electricity Cost: 654 [$/day]
Total Annual Electricity Cost: 238,760 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **370,160** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 261,450 [$/yr]
Annual Fixed O&M Costs: 73,420 [$/yr]
Total Annual Variable Costs: 370,160 [$/yr

ANNUAL TOTAL COSTS: **705,030** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	17.33 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 37

System Technology: FRFC **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 2 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	456,000
Compressor	295,000
Fuel Cell	830,000
Fixed	277,000
TOTAL	1,858,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 278,700 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 74,320 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 78,020 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	29880	33,593
				Total daily off-peak cost @ 2c/kW-hr:	$672

Total Daily Electricity Cost: 697 [$/day]
Total Annual Electricity Cost: 254,528 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 385,928 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 278,700 [$/yr]
Annual Fixed O&M Costs: 78,020 [$/yr]
Total Annual Variable Costs: 385,928 [$/yr

ANNUAL TOTAL COSTS: 742,648 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.15 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 38

System Technology: FRFC **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 0.5 [hrs/day]
No. of Cylinders: 74 **Output:** 2.8 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	806,000
Compressor	521,000
Fuel Cell	1,460,000
Fixed	277,000
TOTAL	3,064,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 459,600 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 122,560 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 129,960 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 2c/kW-hr:	$1,188

Total Daily Electricity Cost: 1,239 [$/day]
Total Annual Electricity Cost: 452,264 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 583,664 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 459,600 [$/yr]
Annual Fixed O&M Costs: 129,960 [$/yr]
Total Annual Variable Costs: 583,664 [$/yr

ANNUAL TOTAL COSTS: 1,173,224 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	14.39 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 39

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	808,000
Compressor	523,000
Fuel Cell	1,470,000
Fixed	277,000
TOTAL	3,078,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 461,700 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 123,120 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 130,520 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
				Total daily off-peak cost @ 2c/kW-hr:	$1,192

Total Daily Electricity Cost: 1,243 [$/day]
Total Annual Electricity Cost: 453,578 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 584,978 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 461,700 [$/yr]
Annual Fixed O&M Costs: 130,520 [$/yr]
Total Annual Variable Costs: 584,978 [$/yr

ANNUAL TOTAL COSTS: 1,177,198 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	15.86 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 40

System Technology: FRFC **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 74 **Output:** 2.8 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	841,000
Compressor	544,000
Fuel Cell	1,530,000
Fixed	277,000
TOTAL	3,192,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 478,800 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 127,680 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 135,080 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3060	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55080	61,746
				Total daily off-peak cost @ 2c/kW-hr:	$1,235

Total Daily Electricity Cost: 1,286 [$/day]
Total Annual Electricity Cost: 469,346 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 600,746 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 478,800 [$/yr]
Annual Fixed O&M Costs: 135,080 [$/yr]
Total Annual Variable Costs: 600,746 [$/yr

ANNUAL TOTAL COSTS: 1,214,626 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	14.64 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 41

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**3 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	846,000
Compressor	547,000
Fuel Cell	1,540,000
Fixed	277,000
TOTAL	3,210,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 481,500 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 128,400 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 135,800 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 2c/kW-hr:	$1,242

Total Daily Electricity Cost: 1,293 [$/day]
Total Annual Electricity Cost: 471,974 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 603,374 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 481,500 [$/yr]
Annual Fixed O&M Costs: 135,800 [$/yr]
Total Annual Variable Costs: 603,374 [$/yr

ANNUAL TOTAL COSTS: 1,220,674 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	14.46 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 42

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	913,000
Compressor	590,000
Fuel Cell	1,660,000
Fixed	277,000
TOTAL	3,440,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 516,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 137,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 145,000 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 2c/kW-hr:	$1,329

Total Daily Electricity Cost: 1,379 [$/day]
Total Annual Electricity Cost: 503,510 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 634,910 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 516,000 [$/yr]
Annual Fixed O&M Costs: 145,000 [$/yr]
Total Annual Variable Costs: 634,910 [$/yr

ANNUAL TOTAL COSTS: 1,295,910 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	15.28 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 43

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	449,000
Storage	412,000
Compressor	266,000
Fuel Cell	490,000
Fixed	277,000
TOTAL	1,894,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 284,100 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 75,760 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 79,460 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1500	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27000	30,333
				Total daily off-peak cost @ 2c/kW-hr:	$607

Total Daily Electricity Cost: 632 [$/day]
Total Annual Electricity Cost: 230,731 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 362,131 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 284,100 [$/yr]
Annual Fixed O&M Costs: 79,460 [$/yr]
Total Annual Variable Costs: 362,131 [$/yr

ANNUAL TOTAL COSTS: 725,691 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	104,862 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.79 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

System Technology: HICE **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 1.0 [hrs/day]
No. of Cylinders: 37 **Output:** 0.5 [MW]

CAPITAL COSTS [$]

Electrolyzer	441,000
Storage	404,000
Compressor	261,000
Fuel Cell	175,000
Fixed	277,000
TOTAL	1,558,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 233,700 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 62,320 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 66,020 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1470	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26460	29,793
				Total daily off-peak cost @ 2c/kW-hr:	$596

Total Daily Electricity Cost: 621 [$/day]
Total Annual Electricity Cost: 226,789 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 358,189 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 233,700 [$/yr]
Annual Fixed O&M Costs: 66,020 [$/yr]
Total Annual Variable Costs: 358,189 [$/yr

ANNUAL TOTAL COSTS: 657,909 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr)(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	38,767 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.74 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 45

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	478,000
Storage	438,000
Compressor	284,000
Fuel Cell	490,000
Fixed	277,000
TOTAL	1,967,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 295,050 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 78,680 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 82,380 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1590	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	28620	31,953
				Total daily off-peak cost @ 2c/kW-hr:	$639

Total Daily Electricity Cost: 665 [$/day]
Total Annual Electricity Cost: 242,557 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 373,957 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 295,050 [$/yr]
Annual Fixed O&M Costs: 82,380 [$/yr]
Total Annual Variable Costs: 373,957 [$/yr

ANNUAL TOTAL COSTS: 751,387 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	120,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.10 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 46

System Technology: **HICE** **Distibuted Utility:**
Station Capacity: **200 cars/day** **Time of Operation:** **1.0 [hrs/day]**
No. of Cylinders: **37** **Output:** **1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	483,000
Storage	442,000
Compressor	286,000
Fuel Cell	525,000
Fixed	277,000
TOTAL	2,013,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **301,950** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 80,520 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **84,220** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1610	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	28980	32,313
				Total daily off-peak cost @ 2c/kW-hr:	$646

Total Daily Electricity Cost: 672 [$/day]
Total Annual Electricity Cost: 245,185 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **376,585** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 301,950 [$/yr]
Annual Fixed O&M Costs: 84,220 [$/yr]
Total Annual Variable Costs: 376,585 [$/yr

ANNUAL TOTAL COSTS: **762,755** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.17 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 47

System Technology: HICE **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 2.0 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	537,000
Storage	492,000
Compressor	318,000
Fuel Cell	490,000
Fixed	277,000
TOTAL	2,114,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 317,100 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 84,560 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 88,260 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1790	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 7c/kW-hr:	$25
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	32220	35,553
				Total daily off-peak cost @ 2c/kW-hr:	$711

Total Daily Electricity Cost: 737 [$/day]
Total Annual Electricity Cost: 268,837 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 400,237 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 317,100 [$/yr]
Annual Fixed O&M Costs: 88,260 [$/yr]
Total Annual Variable Costs: 400,237 [$/yr

ANNUAL TOTAL COSTS: 805,597 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	141,545 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	20.10 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 48

System Technology: **HICE** **Distibuted Utility:**
Station Capacity: **400 cars/day** **Time of Operation:** **0.5 [hrs/day]**
No. of Cylinders: **74** **Output:** **2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	898,000
Storage	823,000
Compressor	533,000
Fuel Cell	980,000
Fixed	277,000
TOTAL	3,511,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **526,650** **[$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 140,440 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **147,840** **[$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2990	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	53820	60,486
				Total daily off-peak cost @ 2c/kW-hr:	$1,210

Total Daily Electricity Cost: 1,261 [$/day]
Total Annual Electricity Cost: 460,148 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **591,548** **[$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 526,650 [$/yr]
Annual Fixed O&M Costs: 147,840 [$/yr]
Total Annual Variable Costs: 591,548 [$/yr

ANNUAL TOTAL COSTS: **1,266,038** **[$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	15.79 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 49

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	903,000
Storage	827,000
Compressor	535,000
Fuel Cell	525,000
Fixed	277,000
TOTAL	3,067,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 460,050 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 122,680 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 130,080 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3010	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	54180	60,846
				Total daily off-peak cost @ 2c/kW-hr:	$1,217

Total Daily Electricity Cost: 1,268 [$/day]
Total Annual Electricity Cost: 462,776 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 594,176 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 460,050 [$/yr]
Annual Fixed O&M Costs: 130,080 [$/yr]
Total Annual Variable Costs: 594,176 [$/yr

ANNUAL TOTAL COSTS: 1,184,306 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	15.97 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 50

System Technology: HICE **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 1.0 [hrs/day]
No. of Cylinders: 74 **Output:** 2.8 [MW]

CAPITAL COSTS [$]

Electrolyzer	957,000
Storage	877,000
Compressor	567,000
Fuel Cell	980,000
Fixed	277,000
TOTAL	3,658,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 548,700 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 146,320 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 153,720 [$/yr]

VARIABLE COSTS

			Storage	Boost	Electrolyzer	
		Power [kW]	249	145.6	3190	
(400-->	On-peak:	hrs/day	0	5	0	Total usage
		kW-hrs/day	0	728	0	728
					Total daily on-peak cost @ 7c/kW-hr:	$51
	Off-peak:	hrs/day	18	15	18	Total usage
		kW-hrs/day	4482	2184	57420	64,086
					Total daily off-peak cost @ 2c/kW-hr:	$1,282

Total Daily Electricity Cost: 1,333 [$/day]
Total Annual Electricity Cost: 486,428 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 617,828 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 548,700 [$/yr]
Annual Fixed O&M Costs: 153,720 [$/yr]
Total Annual Variable Costs: 617,828 [$/yr

ANNUAL TOTAL COSTS: 1,320,248 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	*(Total benefits) - adjustment to acct. for boost operation*
COST OF HYDROGEN	16.24 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 51

System Technology: HICE **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 1.0 [hrs/day]
No. of Cylinders: 74 **Output:** 3.0 [MW]

CAPITAL COSTS [$]

Electrolyzer	965,000
Storage	885,000
Compressor	572,000
Fuel Cell	1,050,000
Fixed	277,000
TOTAL	3,749,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 562,350 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 149,960 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 157,360 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3220	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	57960	64,626
				Total daily off-peak cost @ 2c/kW-hr:	$1,293

Total Daily Electricity Cost: 1,343 [$/day]
Total Annual Electricity Cost: 490,370 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 621,770 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 562,350 [$/yr]
Annual Fixed O&M Costs: 157,360 [$/yr]
Total Annual Variable Costs: 621,770 [$/yr

ANNUAL TOTAL COSTS: 1,341,480 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	16.29 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

CASE 52

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2.0 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	1,070,000
Storage	984,000
Compressor	636,000
Fuel Cell	980,000
Fixed	277,000
TOTAL	3,947,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 592,050 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 157,880 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 165,280 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3580	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 7c/kW-hr:	$51
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	64440	71,106
				Total daily off-peak cost @ 2c/kW-hr:	$1,422

Total Daily Electricity Cost: 1,473 [$/day]
Total Annual Electricity Cost: 537,674 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 669,074 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 592,050 [$/yr]
Annual Fixed O&M Costs: 165,280 [$/yr]
Total Annual Variable Costs: 669,074 [$/yr

ANNUAL TOTAL COSTS: 1,426,404 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	17.26 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

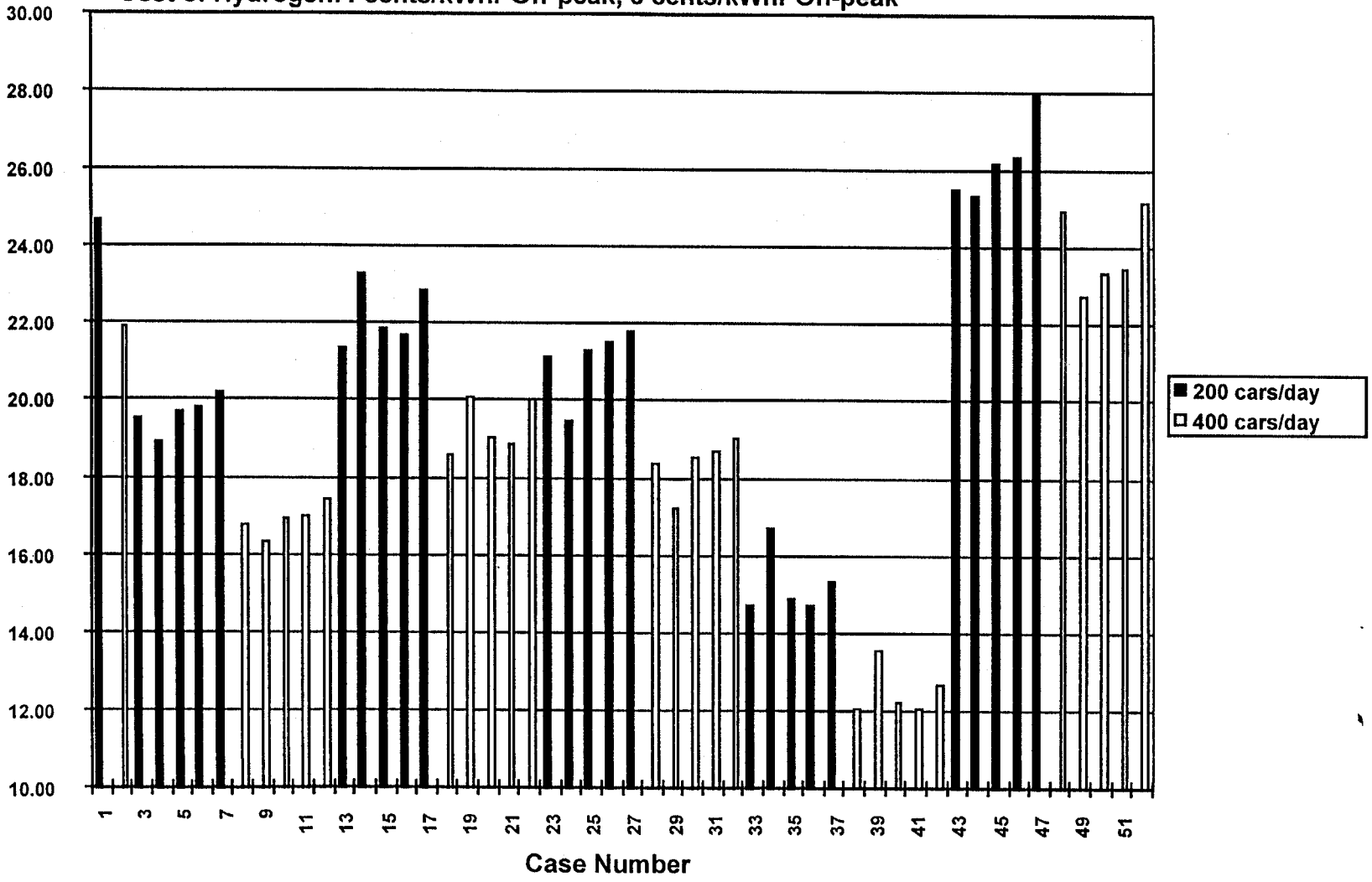
Appendix A-2: Cases with Alternative Electricity Costs

Worksheet 2: Alternative Electricity Costs (4¢/kWh off-peak, 8¢/kWh on-peak)

Case No.	Sys. Tech.	Capacity [cars/day]	DU [hrs/day]	DU Output [MW]	TOTAL DU BEN. [$/yr]	COST OF H2 [$/GJ]	TOTAL CAPITAL COST [$]	SYS. ANNUAL COST [$/yr]
1	BC	200			0	24.68	1,331,000	815,201
2	BC	400			0	21.89	2,385,000	1,446,371
3	PEM	200	0.5	1.4	111,432	26.09	2,080,000	973,279
4	PEM	200	1.0	0.5	42,052	25.44	1,616,000	882,491
5	PEM	200	1.0	1.4	123,660	26.56	2,129,000	1,000,985
6	PEM	200	1.0	1.5	132,727	26.69	2,186,000	1,014,443
7	PEM	200	2.0	1.4	143,187	27.56	2,226,000	1,053,579
8	PEM	400	0.5	2.8	222,865	23.35	3,883,000	1,765,155
9	PEM	400	1.0	1.5	129,442	22.95	3,240,000	1,645,613
10	PEM	400	1.0	2.8	247,320	23.77	3,980,000	1,817,749
11	PEM	400	1.0	3.0	265,455	23.90	4,093,000	1,844,475
12	PEM	400	2.0	2.8	286,375	24.78	4,176,000	1,923,317
13	RFC	200	0.5	1.4	111,432	27.94	2,401,000	1,034,269
14	RFC	200	1.0	0.5	42,052	29.85	2,382,000	1,028,031
15	RFC	200	1.0	1.4	123,660	28.69	2,500,000	1,071,475
16	RFC	200	1.0	1.5	132,727	28.58	2,514,000	1,076,763
17	RFC	200	2.0	1.4	143,187	30.22	2,688,000	1,141,359
18	RFC	400	0.5	2.8	222,865	25.22	4,534,000	1,888,845
19	RFC	400	1.0	1.5	129,442	26.71	4,548,000	1,894,133
20	RFC	400	1.0	2.8	247,320	25.90	4,722,000	1,958,729
21	RFC	400	1.0	3.0	265,455	25.79	4,750,000	1,969,305
22	RFC	400	2.0	2.8	286,375	27.44	5,100,000	2,098,877
23	HYB	200	0.5	1.4	111,432	27.70	2,360,000	1,026,479
24	HYB	200	1.0	0.5	42,052	26.02	1,716,000	901,491
25	HYB	200	1.0	1.4	123,660	28.17	2,409,000	1,054,185
26	HYB	200	1.0	1.5	132,727	28.41	2,485,000	1,071,253
27	HYB	200	2.0	1.4	143,187	29.17	2,506,000	1,106,779
28	HYB	400	0.5	2.8	222,865	24.96	4,443,000	1,871,555
29	HYB	400	1.0	1.5	129,442	23.81	3,540,000	1,702,613
30	HYB	400	1.0	2.8	247,320	25.46	4,540,000	1,929,405
31	HYB	400	1.0	3.0	265,455	25.63	4,693,000	1,958,475
32	HYB	400	2.0	2.8	286,375	26.39	4,736,000	2,029,717
33	FRFC	200	0.5	1.4	111,432	21.39	1,673,000	817,844
34	FRFC	200	1.0	0.5	42,052	23.33	1,655,000	812,696
35	FRFC	200	1.0	1.4	123,660	21.83	1,735,000	844,920
36	FRFC	200	1.0	1.5	132,727	21.67	1,743,000	848,668
37	FRFC	200	2.0	1.4	143,187	22.80	1,858,000	896,304
38	FRFC	400	0.5	2.8	222,865	18.67	3,064,000	1,456,345
39	FRFC	400	1.0	1.5	129,442	20.15	3,078,000	1,460,933
40	FRFC	400	1.0	2.8	247,320	19.09	3,192,000	1,508,429
41	FRFC	400	1.0	3.0	265,455	18.93	3,210,000	1,516,205
42	FRFC	400	2.0	2.8	286,375	20.06	3,440,000	1,611,477
43	HICE	200	0.5	1.4	104,862	25.54	1,894,000	948,451
44	HICE	200	1.0	0.5	38,767	25.37	1,558,000	876,727
45	HICE	200	1.0	1.4	120,375	26.20	1,967,000	985,973
46	HICE	200	1.0	1.5	129,442	26.35	2,013,000	999,969
47	HICE	200	2.0	1.4	141,545	28.00	2,114,000	1,066,463
48	HICE	400	0.5	2.8	222,865	24.98	3,511,000	1,873,179
49	HICE	400	1.0	1.5	129,442	22.73	3,067,000	1,631,139
50	HICE	400	1.0	2.8	247,320	23.36	3,658,000	1,790,733
51	HICE	400	1.0	3.0	265,455	23.47	3,749,000	1,815,907
52	HICE	400	2.0	2.8	286,375	25.15	3,947,000	1,948,135

Exhibit A-2:

Cost of Hydrogen:4 cents/kWhr Off-peak, 8 cents/kWhr On-peak



Case 1

System Technology:	**BC**	**Distibuted Utility:**		
Station Capacity:	**200 cars/day**	**Time of Operation:**	**>**	**0 [hrs/day]**
No. of Cylinders:	**37**	**Output:**		**0 [MW]**

CAPITAL COSTS [$]

Electrolyzer	420,000
Storage	385,000
Compressor	249,000
Fuel Cell	0
Fixed	277,000
TOTAL	1,331,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 199,650 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 53,240 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs:* *56,940* *[$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1400	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	25200	28533
				Total daily off-peak cost @ 4c/kW-hr:	$1,141

Total Daily Electricity Cost: 1,170 [$/day]
Total Annual Electricity Cost: 427,211 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 558,611 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 199,650 [$/yr]
Annual Fixed O&M Costs: 56,940 [$/yr]
Total Annual Variable Costs: 558,611 [$/yr]

ANNUAL TOTAL COSTS: 815,201 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	0 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	0 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	0 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	0 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	0 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	0 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	24.68 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 2

System Technology:	**BC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**0 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**0 [MW]**

CAPITAL COSTS [$]

Electrolyzer	840,000
Storage	770,000
Compressor	498,000
Fuel Cell	0
Fixed	277,000
TOTAL	2,385,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 357,750 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 95,400 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs:* *102,800* *[$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2800	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	50400	57,066
				Total daily off-peak cost @ 4c/kW-hr:	$2,283

Total Daily Electricity Cost: 2,341 [$/day]
Total Annual Electricity Cost: 854,421 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 985,821 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 357,750 [$/yr]
Annual Fixed O&M Costs: 102,800 [$/yr]
Total Annual Variable Costs: 985,821 [$/yr]

ANNUAL TOTAL COSTS: 1,446,371 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	0 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	0 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	0 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	0 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	0 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	0 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.89 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 3

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	439,000
Storage	403,000
Compressor	261,000
Fuel Cell	700,000
Fixed	277,000
TOTAL	2,080,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 312,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 83,200 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 86,900 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26280	29,613
				Total daily off-peak cost @ 4c/kW-hr:	$1,185

Total Daily Electricity Cost: 1,214 [$/day]
Total Annual Electricity Cost: 442,979 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 574,379 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 312,000 [$/yr]
Annual Fixed O&M Costs: 86,900 [$/yr]
Total Annual Variable Costs: 574,379 [$/yr]

ANNUAL TOTAL COSTS: 973,279 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.09 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 4

System Technology:	**PEM**	**Distibuted Utility:**		
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1**	**[hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5**	**[MW]**

CAPITAL COSTS [$]

Electrolyzer	434,000
Storage	398,000
Compressor	257,000
Fuel Cell	250,000
Fixed	277,000
TOTAL	1,616,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 242,400 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 64,640 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 68,340 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26100	29,433
				Total daily off-peak cost @ 4c/kW-hr:	$1,177

Total Daily Electricity Cost: 1,206 [$/day]
Total Annual Electricity Cost: 440,351 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 571,751 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 242,400 [$/yr]
Annual Fixed O&M Costs: 68,340 [$/yr]
Total Annual Variable Costs: 571,751 [$/yr]

ANNUAL TOTAL COSTS: 882,491 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.44 [$/GJ]	Annual Total Costs [$/yr] - *DU Benefits* / Total H2 sold annually [GJ/yr]

Case 5

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	459,000
Storage	421,000
Compressor	272,000
Fuel Cell	700,000
Fixed	277,000
TOTAL	2,129,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 319,350 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 85,160 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 88,860 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27540	30,873
				Total daily off-peak cost @ 4c/kW-hr:	$1,235

Total Daily Electricity Cost: 1,264 [$/day]
Total Annual Electricity Cost: 461,375 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 592,775 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 319,350 [$/yr]
Annual Fixed O&M Costs: 88,860 [$/yr]
Total Annual Variable Costs: 592,775 [$/yr]

ANNUAL TOTAL COSTS: 1,000,985 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr)(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.56 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 6

System Technology: PEM → **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 37 **Output:** 1.5 [MW]

CAPITAL COSTS [$]

Electrolyzer	462,000
Storage	423,000
Compressor	274,000
Fuel Cell	750,000
Fixed	277,000
TOTAL	2,186,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 327,900 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 87,440 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 91,140 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27720	31,053
				Total daily off-peak cost @ 4c/kW-hr:	$1,242

Total Daily Electricity Cost: 1,271 [$/day]
Total Annual Electricity Cost: 464,003 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 595,403 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 327,900 [$/yr]
Annual Fixed O&M Costs: 91,140 [$/yr]
Total Annual Variable Costs: 595,403 [$/yr]

ANNUAL TOTAL COSTS: 1,014,443 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.69 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 7

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	498,000
Storage	456,000
Compressor	295,000
Fuel Cell	700,000
Fixed	277,000
TOTAL	2,226,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 333,900 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 89,040 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 92,740 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	29880	33,213
				Total daily off-peak cost @ 4c/kW-hr:	$1,329

Total Daily Electricity Cost: 1,358 [$/day]
Total Annual Electricity Cost: 495,539 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 626,939 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 333,900 [$/yr]
Annual Fixed O&M Costs: 92,740 [$/yr]
Total Annual Variable Costs: 626,939 [$/yr]

ANNUAL TOTAL COSTS: 1,053,579 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	27.56 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 8

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	879,000
Storage	806,000
Compressor	521,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	3,883,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 582,450 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 155,320 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 162,720 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 4c/kW-hr:	$2,376

Total Daily Electricity Cost: 2,434 [$/day]
Total Annual Electricity Cost: 888,585 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,019,985 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 582,450 [$/yr]
Annual Fixed O&M Costs: 162,720 [$/yr]
Total Annual Variable Costs: 1,019,985 [$/yr]

ANNUAL TOTAL COSTS: 1,765,155 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.35 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 9

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	882,000
Storage	808,000
Compressor	523,000
Fuel Cell	750,000
Fixed	277,000
TOTAL	3,240,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **486,000 [$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 129,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **137,000 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
				Total daily off-peak cost @ 4c/kW-hr:	$2,383

Total Daily Electricity Cost: 2,442 [$/day]
Total Annual Electricity Cost: 891,213 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **1,022,613 [$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 486,000 [$/yr]
Annual Fixed O&M Costs: 137,000 [$/yr]
Total Annual Variable Costs: 1,022,613 [$/yr]

ANNUAL TOTAL COSTS: **1,645,613 [$/yr]**

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	22.95 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 10

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	918,000
Storage	841,000
Compressor	544,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	3,980,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 597,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 159,200 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 166,600 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3060	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55080	61,746
				Total daily off-peak cost @ 4c/kW-hr:	$2,470

Total Daily Electricity Cost: 2,528 [$/day]
Total Annual Electricity Cost: 922,749 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,054,149 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 597,000 [$/yr]
Annual Fixed O&M Costs: 166,600 [$/yr]
Total Annual Variable Costs: 1,054,149 [$/yr]

ANNUAL TOTAL COSTS: 1,817,749 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.77 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 11

System Technology:	**PEM**	**Distibuted Utility:**	➢
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**3 [MW]**

CAPITAL COSTS [$]

Electrolyzer	923,000
Storage	846,000
Compressor	547,000
Fuel Cell	1,500,000
Fixed	277,000
TOTAL	4,093,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 613,950 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 163,720 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 171,120 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 4c/kW-hr:	$2,484

Total Daily Electricity Cost: 2,542 [$/day]
Total Annual Electricity Cost: 928,005 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 613,950 [$/yr]
Annual Fixed O&M Costs: 171,120 [$/yr]
Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL TOTAL COSTS: 1,844,475 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.90 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 12

System Technology:	**PEM**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	996,000
Storage	913,000
Compressor	590,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	4,176,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 626,400 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 167,040 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 174,440 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 4c/kW-hr:	$2,657

Total Daily Electricity Cost: 2,715 [$/day]
Total Annual Electricity Cost: 991,077 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,122,477 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 626,400 [$/yr]
Annual Fixed O&M Costs: 174,440 [$/yr]
Total Annual Variable Costs: 1,122,477 [$/yr]

ANNUAL TOTAL COSTS: 1,923,317 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	24.78 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 13

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	403,000
Compressor	261,000
Fuel Cell	1,460,000
Fixed	277,000
TOTAL	2,401,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 360,150 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 96,040 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 99,740 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26280	29,613
				Total daily off-peak cost @ 4c/kW-hr:	$1,185

Total Daily Electricity Cost: 1,214 [$/day]
Total Annual Electricity Cost: 442,979 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 574,379 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 360,150 [$/yr]
Annual Fixed O&M Costs: 99,740 [$/yr]
Total Annual Variable Costs: 574,379 [$/yr]

ANNUAL TOTAL COSTS: 1,034,269 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	27.94 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 14

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	398,000
Compressor	257,000
Fuel Cell	1,450,000
Fixed	277,000
TOTAL	2,382,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 357,300 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 95,280 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 98,980 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26100	29,433
				Total daily off-peak cost @ 4c/kW-hr:	$1,177

Total Daily Electricity Cost: 1,206 [$/day]
Total Annual Electricity Cost: 440,351 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 571,751 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 357,300 [$/yr]
Annual Fixed O&M Costs: 98,980 [$/yr]
Total Annual Variable Costs: 571,751 [$/yr

ANNUAL TOTAL COSTS: 1,028,031 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	29.85 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 15

System Technology: RFC **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	0
Storage	421,000
Compressor	272,000
Fuel Cell	1,530,000
Fixed	277,000
TOTAL	2,500,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 375,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 100,000 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 103,700 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27540	30,873
				Total daily off-peak cost @ 4c/kW-hr:	$1,235

Total Daily Electricity Cost: 1,264 [$/day]
Total Annual Electricity Cost: 461,375 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 592,775 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 375,000 [$/yr]
Annual Fixed O&M Costs: 103,700 [$/yr]
Total Annual Variable Costs: 592,775 [$/yr]

ANNUAL TOTAL COSTS: 1,071,475 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	28.69 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 16

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	423,000
Compressor	274,000
Fuel Cell	1,540,000
Fixed	277,000
TOTAL	2,514,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 377,100 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 100,560 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 104,260 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27720	31,053
				Total daily off-peak cost @ 4c/kW-hr:	$1,242

Total Daily Electricity Cost: 1,271 [$/day]
Total Annual Electricity Cost: 464,003 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 595,403 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 377,100 [$/yr]
Annual Fixed O&M Costs: 104,260 [$/yr]
Total Annual Variable Costs: 595,403 [$/yr]

ANNUAL TOTAL COSTS: 1,076,763 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	28.58 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 17

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	456,000
Compressor	295,000
Fuel Cell	1,660,000
Fixed	277,000
TOTAL	2,688,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 403,200 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 107,520 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 111,220 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	29880	33,213
				Total daily off-peak cost @ 4c/kW-hr:	$1,329

Total Daily Electricity Cost: 1,358 [$/day]
Total Annual Electricity Cost: 495,539 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 626,939 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 403,200 [$/yr]
Annual Fixed O&M Costs: 111,220 [$/yr]
Total Annual Variable Costs: 626,939 [$/yr]

ANNUAL TOTAL COSTS: 1,141,359 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	30.22 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 18

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	806,000
Compressor	521,000
Fuel Cell	2,930,000
Fixed	277,000
TOTAL	4,534,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 680,100 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 181,360 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 188,760 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 4c/kW-hr:	$2,376

Total Daily Electricity Cost: 2,434 [$/day]
Total Annual Electricity Cost: 888,585 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,019,985 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 680,100 [$/yr]
Annual Fixed O&M Costs: 188,760 [$/yr]
Total Annual Variable Costs: 1,019,985 [$/yr]

ANNUAL TOTAL COSTS: 1,888,845 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.22 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 19

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	808,000
Compressor	523,000
Fuel Cell	2,940,000
Fixed	277,000
TOTAL	4,548,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 682,200 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 181,920 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 189,320 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
				Total daily off-peak cost @ 4c/kW-hr:	$2,383

Total Daily Electricity Cost: 2,442 [$/day]
Total Annual Electricity Cost: 891,213 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,022,613 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 682,200 [$/yr]
Annual Fixed O&M Costs: 189,320 [$/yr]
Total Annual Variable Costs: 1,022,613 [$/yr]

ANNUAL TOTAL COSTS: 1,894,133 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.71 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 20

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	841,000
Compressor	544,000
Fuel Cell	3,060,000
Fixed	277,000
TOTAL	4,722,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 708,300 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 188,880 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 196,280 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3060	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55080	61,746
				Total daily off-peak cost @ 4c/kW-hr:	$2,470

Total Daily Electricity Cost: 2,528 [$/day]
Total Annual Electricity Cost: 922,749 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,054,149 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 708,300 [$/yr]
Annual Fixed O&M Costs: 196,280 [$/yr]
Total Annual Variable Costs: 1,054,149 [$/yr]

ANNUAL TOTAL COSTS: 1,958,729 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.90 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 21

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**3 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	846,000
Compressor	547,000
Fuel Cell	3,080,000
Fixed	277,000
TOTAL	4,750,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 712,500 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 190,000 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 197,400 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 4c/kW-hr:	$2,484

Total Daily Electricity Cost: 2,542 [$/day]
Total Annual Electricity Cost: 928,005 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 712,500 [$/yr]
Annual Fixed O&M Costs: 197,400 [$/yr]
Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL TOTAL COSTS: 1,969,305 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.79 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 22

System Technology:	**RFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	913,000
Compressor	590,000
Fuel Cell	3,320,000
Fixed	277,000
TOTAL	5,100,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 765,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 204,000 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 211,400 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 4c/kW-hr:	$2,657

Total Daily Electricity Cost: 2,715 [$/day]
Total Annual Electricity Cost: 991,077 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,122,477 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 765,000 [$/yr]
Annual Fixed O&M Costs: 211,400 [$/yr]
Total Annual Variable Costs: 1,122,477 [$/yr]

ANNUAL TOTAL COSTS: 2,098,877 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	27.44 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 23

System Technology:	**HYB**	**Distibuted Utility:**	➢
Station Capacity:	**200 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	19,000
Storage	403,000
Compressor	261,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	2,360,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 354,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 94,400 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 98,100 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26280	29,613
				Total daily off-peak cost @ 4c/kW-hr:	$1,185

Total Daily Electricity Cost: 1,214 [$/day]
Total Annual Electricity Cost: 442,979 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 574,379 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 354,000 [$/yr]
Annual Fixed O&M Costs: 98,100 [$/yr]
Total Annual Variable Costs: 574,379 [$/yr]

ANNUAL TOTAL COSTS: 1,026,479 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	27.70 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 24

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	284,000
Storage	398,000
Compressor	257,000
Fuel Cell	500,000
Fixed	277,000
TOTAL	1,716,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 257,400 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 68,640 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 72,340 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26100	29,433
				Total daily off-peak cost @ 4c/kW-hr:	$1,177

Total Daily Electricity Cost: 1,206 [$/day]
Total Annual Electricity Cost: 440,351 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 571,751 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 257,400 [$/yr]
Annual Fixed O&M Costs: 72,340 [$/yr]
Total Annual Variable Costs: 571,751 [$/yr]

ANNUAL TOTAL COSTS: 901,491 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.02 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 25

System Technology: HYB ➢ **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 1 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	39,000
Storage	421,000
Compressor	272,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	2,409,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 361,350 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 96,360 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 100,060 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27540	30,873
				Total daily off-peak cost @ 4c/kW-hr:	$1,235

Total Daily Electricity Cost: 1,264 [$/day]
Total Annual Electricity Cost: 461,375 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 592,775 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 361,350 [$/yr]
Annual Fixed O&M Costs: 100,060 [$/yr]
Total Annual Variable Costs: 592,775 [$/yr]

ANNUAL TOTAL COSTS: 1,054,185 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	28.17 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 26

System Technology: **HYB** **Distibuted Utility:**
Station Capacity: **200 cars/day** **Time of Operation:** **1 [hrs/day]**
No. of Cylinders: **37** **Output:** **1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	11,000
Storage	423,000
Compressor	274,000
Fuel Cell	1,500,000
Fixed	277,000
TOTAL	2,485,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: **372,750 [$/yr]**

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 99,400 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **103,100 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27720	31,053
				Total daily off-peak cost @ 4c/kW-hr:	$1,242

Total Daily Electricity Cost: 1,271 [$/day]
Total Annual Electricity Cost: 464,003 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: **595,403 [$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 372,750 [$/yr]
Annual Fixed O&M Costs: 103,100 [$/yr]
Total Annual Variable Costs: 595,403 [$/yr]

ANNUAL TOTAL COSTS: **1,071,253 [$/yr]**

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	28.41 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 27

System Technology: HYB **Distibuted Utility:**
Station Capacity: 200 cars/day **Time of Operation:** 2 [hrs/day]
No. of Cylinders: 37 **Output:** 1.4 [MW]

CAPITAL COSTS [$]

Electrolyzer	78,000
Storage	456,000
Compressor	295,000
Fuel Cell	1,400,000
Fixed	277,000
TOTAL	2,506,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 375,900 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 100,240 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 103,940 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	29880	33,213
				Total daily off-peak cost @ 4c/kW-hr:	$1,329

Total Daily Electricity Cost: 1,358 [$/day]
Total Annual Electricity Cost: 495,539 [$/yr]

Labor: 131,400 [$/yr]

***Total Annual Variable Costs:* 626,939 [$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 375,900 [$/yr]
Annual Fixed O&M Costs: 103,940 [$/yr]
Total Annual Variable Costs: 626,939 [$/yr]

ANNUAL TOTAL COSTS: 1,106,779 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	29.17 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 28

System Technology: HYB **Distibuted Utility:**
Station Capacity: 400 cars/day **Time of Operation:** 0.5 [hrs/day]
No. of Cylinders: 74 **Output:** 2.8 [MW]

CAPITAL COSTS [$]

Electrolyzer	39,000
Storage	806,000
Compressor	521,000
Fuel Cell	2,800,000
Fixed	277,000
TOTAL	4,443,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 666,450 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 177,720 [$/yr]
Additional Fixed O&M: 7,400 $/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 185,120 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 4c/kW-hr:	$2,376

Total Daily Electricity Cost: 2,434 [$/day]
Total Annual Electricity Cost: 888,585 [$/yr]

Labor: 131,400 [$/yr]

***Total Annual Variable Costs:* 1,019,985 [$/yr]**

ANNUAL COST SUMMARY

Annual Capital Charge: 666,450 [$/yr]
Annual Fixed O&M Costs: 185,120 [$/yr]
Total Annual Variable Costs: 1,019,985 [$/yr]

ANNUAL TOTAL COSTS: 1,871,555 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	24.96 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 29

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	432,000
Storage	808,000
Compressor	523,000
Fuel Cell	1,500,000
Fixed	277,000
TOTAL	3,540,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 531,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 141,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 149,000 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
				Total daily off-peak cost @ 4c/kW-hr:	$2,383

Total Daily Electricity Cost: 2,442 [$/day]
Total Annual Electricity Cost: 891,213 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,022,613 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 531,000 [$/yr]
Annual Fixed O&M Costs: 149,000 [$/yr]
Total Annual Variable Costs: 1,022,613 [$/yr]

ANNUAL TOTAL COSTS: 1,702,613 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.81 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 30

System Technology:	**HYB**	**Distibuted Utility:**		
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1**	**[hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8**	**[MW]**

CAPITAL COSTS [$]

Electrolyzer	78,000
Storage	841,000
Compressor	544,000
Fuel Cell	2,800,000
Fixed	277,000
TOTAL	4,540,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 681,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 181,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 189,000 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 4c/kW-hr:	$2,484

Total Daily Electricity Cost: 2,542 [$/day]
Total Annual Electricity Cost: 928,005 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 681,000 [$/yr]
Annual Fixed O&M Costs: 189,000 [$/yr]
Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL TOTAL COSTS: 1,929,405 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.46 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 31

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**3 [MW]**

CAPITAL COSTS [$]

Electrolyzer	23,000
Storage	846,000
Compressor	547,000
Fuel Cell	3,000,000
Fixed	277,000
TOTAL	4,693,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 703,950 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 187,720 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 195,120 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 4c/kW-hr:	$2,484

Total Daily Electricity Cost: 2,542 [$/day]
Total Annual Electricity Cost: 928,005 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 703,950 [$/yr]
Annual Fixed O&M Costs: 195,120 [$/yr]
Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL TOTAL COSTS: 1,958,475 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.63 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 32

System Technology:	**HYB**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	156,000
Storage	913,000
Compressor	590,000
Fuel Cell	2,800,000
Fixed	277,000
TOTAL	4,736,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 710,400 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 189,440 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 196,840 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 4c/kW-hr:	$2,657

Total Daily Electricity Cost: 2,715 [$/day]
Total Annual Electricity Cost: 991,077 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,122,477 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 710,400 [$/yr]
Annual Fixed O&M Costs: 196,840 [$/yr]
Total Annual Variable Costs: 1,122,477 [$/yr]

ANNUAL TOTAL COSTS: 2,029,717 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.39 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 33

System Technology:	**FRFC**	**Distibuted Utility:**		
Station Capacity:	**200 cars/day**	**Time of Operation:**	➢	**0.5 [hrs/day]**
No. of Cylinders:	**37**	**Output:**		**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	403,000
Compressor	261,000
Fuel Cell	732,000
Fixed	277,000
TOTAL	1,673,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 167,300 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 66,920 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 70,620 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1460	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	26280	29,993
				Total daily off-peak cost @ 4c/kW-hr:	$1,200

Total Daily Electricity Cost: 1,229 [$/day]
Total Annual Electricity Cost: 448,524 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 579,924 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 167,300 [$/yr]
Annual Fixed O&M Costs: 70,620 [$/yr]
Total Annual Variable Costs: 579,924 [$/yr

ANNUAL TOTAL COSTS: 817,844 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	111,432 [$/yr]	(Total benefits) - *adjustment to acct. for boost operation*
COST OF HYDROGEN	21.39 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 34

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	398,000
Compressor	257,000
Fuel Cell	723,000
Fixed	277,000
TOTAL	1,655,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 165,500 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 66,200 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: **69,900 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1450	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	26100	29,813
				Total daily off-peak cost @ 4c/kW-hr:	$1,193

Total Daily Electricity Cost: 1,222 [$/day]
Total Annual Electricity Cost: 445,896 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 577,296 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 165,500 [$/yr]
Annual Fixed O&M Costs: 69,900 [$/yr]
Total Annual Variable Costs: 577,296 [$/yr

ANNUAL TOTAL COSTS: 812,696 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	42,052 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.33 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 35

System Technology:	**FRFC**	**Distibuted Utility:**		
Station Capacity:	**200 cars/day**	➢	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**		**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	421,000
Compressor	272,000
Fuel Cell	765,000
Fixed	277,000
TOTAL	1,735,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 173,500 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 69,400 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 73,100 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1530	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	27540	31,253
				Total daily off-peak cost @ 4c/kW-hr:	$1,250

Total Daily Electricity Cost: 1,279 [$/day]
Total Annual Electricity Cost: 466,920 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 598,320 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 173,500 [$/yr]
Annual Fixed O&M Costs: 73,100 [$/yr]
Total Annual Variable Costs: 598,320 [$/yr

ANNUAL TOTAL COSTS: 844,920 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	123,660 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.83 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 36

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	423,000
Compressor	274,000
Fuel Cell	769,000
Fixed	277,000
TOTAL	1,743,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 174,300 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 69,720 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 73,420 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1540	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	27720	31,433
				Total daily off-peak cost @ 4c/kW-hr:	$1,257

Total Daily Electricity Cost: 1,286 [$/day]
Total Annual Electricity Cost: 469,548 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 600,948 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 174,300 [$/yr]
Annual Fixed O&M Costs: 73,420 [$/yr]
Total Annual Variable Costs: 600,948 [$/yr

ANNUAL TOTAL COSTS: 848,668 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	132,727 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	21.67 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 37

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	456,000
Compressor	295,000
Fuel Cell	830,000
Fixed	277,000
TOTAL	1,858,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 185,800 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 74,320 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 78,020 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	145.6	145.6	1660	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2620.8	1092	29880	33,593
				Total daily off-peak cost @ 4c/kW-hr:	$1,344

Total Daily Electricity Cost: 1,373 [$/day]
Total Annual Electricity Cost: 501,084 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 632,484 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 185,800 [$/yr]
Annual Fixed O&M Costs: 78,020 [$/yr]
Total Annual Variable Costs: 632,484 [$/yr

ANNUAL TOTAL COSTS: 896,304 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33,033 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr)]
TOTAL DU BENEFITS	143,187 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	22.80 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 38

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	806,000
Compressor	521,000
Fuel Cell	1,460,000
Fixed	277,000
TOTAL	3,064,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 306,400 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 122,560 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 129,960 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2930	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52740	59,406
				Total daily off-peak cost @ 4c/kW-hr:	$2,376

Total Daily Electricity Cost: 2,434 [$/day]
Total Annual Electricity Cost: 888,585 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,019,985 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 306,400 [$/yr]
Annual Fixed O&M Costs: 129,960 [$/yr]
Total Annual Variable Costs: 1,019,985 [$/yr

ANNUAL TOTAL COSTS: 1,456,345 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.67 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 39

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	808,000
Compressor	523,000
Fuel Cell	1,470,000
Fixed	277,000
TOTAL	3,078,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 307,800 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 123,120 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 130,520 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	2940	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	52920	59,586
				Total daily off-peak cost @ 4c/kW-hr:	$2,383

Total Daily Electricity Cost: 2,442 [$/day]
Total Annual Electricity Cost: 891,213 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,022,613 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 307,800 [$/yr]
Annual Fixed O&M Costs: 130,520 [$/yr]
Total Annual Variable Costs: 1,022,613 [$/yr

ANNUAL TOTAL COSTS: 1,460,933 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	20.15 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 40

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	841,000
Compressor	544,000
Fuel Cell	1,530,000
Fixed	277,000
TOTAL	3,192,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 319,200 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 127,680 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
***Total Annual O&M Costs:* 135,080 [$/yr]**

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3060	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55080	61,746
				Total daily off-peak cost @ 4c/kW-hr:	$2,470

Total Daily Electricity Cost: 2,528 [$/day]
Total Annual Electricity Cost: 922,749 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,054,149 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 319,200 [$/yr]
Annual Fixed O&M Costs: 135,080 [$/yr]
Total Annual Variable Costs: 1,054,149 [$/yr

ANNUAL TOTAL COSTS: 1,508,429 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	19.09 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 41

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**3 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	846,000
Compressor	547,000
Fuel Cell	1,540,000
Fixed	277,000
TOTAL	3,210,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 321,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 128,400 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs:* *135,800* *[$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3080	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	55440	62,106
				Total daily off-peak cost @ 4c/kW-hr:	$2,484

Total Daily Electricity Cost: 2,542 [$/day]
Total Annual Electricity Cost: 928,005 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,059,405 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 321,000 [$/yr]
Annual Fixed O&M Costs: 135,800 [$/yr]
Total Annual Variable Costs: 1,059,405 [$/yr

ANNUAL TOTAL COSTS: 1,516,205 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	18.93 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 42

System Technology:	**FRFC**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	0
Storage	913,000
Compressor	590,000
Fuel Cell	1,660,000
Fixed	277,000
TOTAL	3,440,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 344,000 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 137,600 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 145,000 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3320	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	59760	66,426
				Total daily off-peak cost @ 4c/kW-hr:	$2,657

Total Daily Electricity Cost: 2,715 [$/day]
Total Annual Electricity Cost: 991,077 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,122,477 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 344,000 [$/yr]
Annual Fixed O&M Costs: 145,000 [$/yr]
Total Annual Variable Costs: 1,122,477 [$/yr

ANNUAL TOTAL COSTS: 1,611,477 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	20.06 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 43

System Technology:	**HICE**	**Distibuted Utility:**		
Station Capacity:	**200 cars/day**		**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**37**		**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	449,000
Storage	412,000
Compressor	266,000
Fuel Cell	490,000
Fixed	277,000
TOTAL	1,894,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 284,100 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 75,760 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 79,460 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1500	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	27000	30,333
				Total daily off-peak cost @ 4c/kW-hr:	$1,213

Total Daily Electricity Cost: 1,242 [$/day]
Total Annual Electricity Cost: 453,491 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 584,891 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 284,100 [$/yr]
Annual Fixed O&M Costs: 79,460 [$/yr]
Total Annual Variable Costs: 584,891 [$/yr

ANNUAL TOTAL COSTS: 948,451 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	8,943 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	104,862 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.54 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 44

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**0.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	441,000
Storage	404,000
Compressor	261,000
Fuel Cell	175,000
Fixed	277,000
TOTAL	1,558,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 233,700 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 62,320 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 66,020 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1470	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	26460	29,793
				Total daily off-peak cost @ 4c/kW-hr:	$1,192

Total Daily Electricity Cost: 1,221 [$/day]
Total Annual Electricity Cost: 445,607 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 577,007 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 233,700 [$/yr]
Annual Fixed O&M Costs: 66,020 [$/yr]
Total Annual Variable Costs: 577,007 [$/yr

ANNUAL TOTAL COSTS: 876,727 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	14,250 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	3,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	9,025 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	11,875 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	6,388 [$/yr]	(on-peak energy sales,$0.035/kW-hr)(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	38,767 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.37 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 45

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	478,000
Storage	438,000
Compressor	284,000
Fuel Cell	490,000
Fixed	277,000
TOTAL	1,967,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 295,050 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 78,680 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 82,380 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1590	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	28620	31,953
				Total daily off-peak cost @ 4c/kW-hr:	$1,278

Total Daily Electricity Cost: 1,307 [$/day]
Total Annual Electricity Cost: 477,143 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 608,543 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 295,050 [$/yr]
Annual Fixed O&M Costs: 82,380 [$/yr]
Total Annual Variable Costs: 608,543 [$/yr

ANNUAL TOTAL COSTS: 985,973 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	120,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.20 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 46

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	483,000
Storage	442,000
Compressor	286,000
Fuel Cell	525,000
Fixed	277,000
TOTAL	2,013,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 301,950 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 80,520 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 84,220 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	161.0	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	28980	32,313
				Total daily off-peak cost @ 4c/kW-hr:	$1,293

Total Daily Electricity Cost: 1,322 [$/day]
Total Annual Electricity Cost: 482,399 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 613,799 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 301,950 [$/yr]
Annual Fixed O&M Costs: 84,220 [$/yr]
Total Annual Variable Costs: 613,799 [$/yr

ANNUAL TOTAL COSTS: 999,969 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	26.35 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 47

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**200 cars/day**	**Time of Operation:**	**2.0 [hrs/day]**
No. of Cylinders:	**37**	**Output:**	**1.4 [MW]**

CAPITAL COSTS [$]

Electrolyzer	537,000
Storage	492,000
Compressor	318,000
Fuel Cell	490,000
Fixed	277,000
TOTAL	2,114,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 317,100 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 84,560 [$/yr]
Additional Fixed O&M: 3,700 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 88,260 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	124.5	145.6	1790	
On-peak:	hrs/day	0	2.5	0	Total usage
	kW-hrs/day	0	364	0	364
				Total daily on-peak cost @ 8c/kW-hr:	$29
Off-peak:	hrs/day	18	7.5	18	Total usage
	kW-hrs/day	2241	1092	32220	35,553
				Total daily off-peak cost @ 4c/kW-hr:	$1,422

Total Daily Electricity Cost: 1,451 [$/day]
Total Annual Electricity Cost: 529,703 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 661,103 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 317,100 [$/yr]
Annual Fixed O&M Costs: 88,260 [$/yr]
Total Annual Variable Costs: 661,103 [$/yr

ANNUAL TOTAL COSTS: 1,066,463 [$/yr]

TOTAL H2 SOLD ANNUALLY: 33032.50 [GJ/yr]

CALCULATE:

G benefit	39,900 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	10,640 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	25,270 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	33,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr)(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	141,545 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	28.00 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 48

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**0.5 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	898,000
Storage	823,000
Compressor	533,000
Fuel Cell	980,000
Fixed	277,000
TOTAL	3,511,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 526,650 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 140,440 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 147,840 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3610	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	64980	71,646
				Total daily off-peak cost @ 4c/kW-hr:	$2,866

Total Daily Electricity Cost: 2,924 [$/day]
Total Annual Electricity Cost: 1,067,289 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,198,689 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 526,650 [$/yr]
Annual Fixed O&M Costs: 147,840 [$/yr]
Total Annual Variable Costs: 1,198,689 [$/yr

ANNUAL TOTAL COSTS: 1,873,179 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	17,885 [$/yr]	(on-peak energy sales,$0.035/kW-hr)(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	222,865 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	24.98 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 49

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**1.5 [MW]**

CAPITAL COSTS [$]

Electrolyzer	903,000
Storage	827,000
Compressor	535,000
Fuel Cell	525,000
Fixed	277,000
TOTAL	3,067,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 460,050 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 122,680 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 130,080 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3010	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	54180	60,846
				Total daily off-peak cost @ 4c/kW-hr:	$2,434

Total Daily Electricity Cost: 2,492 [$/day]
Total Annual Electricity Cost: 909,609 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,041,009 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 460,050 [$/yr]
Annual Fixed O&M Costs: 130,080 [$/yr]
Total Annual Variable Costs: 1,041,009 [$/yr

ANNUAL TOTAL COSTS: 1,631,139 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	42,750 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	11,400 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	27,075 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	35,625 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	19,163 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	129,442 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	22.73 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 50

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	957,000
Storage	877,000
Compressor	567,000
Fuel Cell	980,000
Fixed	277,000
TOTAL	3,658,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 548,700 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 146,320 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 153,720 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3190	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	57420	64,086
				Total daily off-peak cost @ 4c/kW-hr:	$2,563

Total Daily Electricity Cost: 2,622 [$/day]
Total Annual Electricity Cost: 956,913 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,088,313 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 548,700 [$/yr]
Annual Fixed O&M Costs: 153,720 [$/yr]
Total Annual Variable Costs: 1,088,313 [$/yr

ANNUAL TOTAL COSTS: 1,790,733 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	35,770 [$/yr]	(on-peak energy sales,$0.035/kW-hr)
		(DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	247,320 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.36 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 51

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**1.0 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**3.0 [MW]**

CAPITAL COSTS [$]

Electrolyzer	965,000
Storage	885,000
Compressor	572,000
Fuel Cell	1,050,000
Fixed	277,000
TOTAL	3,749,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 562,350 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 149,960 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 157,360 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3220	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	57960	64,626
				Total daily off-peak cost @ 4c/kW-hr:	$2,585

Total Daily Electricity Cost: 2,643 [$/day]
Total Annual Electricity Cost: 964,797 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,096,197 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 562,350 [$/yr]
Annual Fixed O&M Costs: 157,360 [$/yr]
Total Annual Variable Costs: 1,096,197 [$/yr

ANNUAL TOTAL COSTS: 1,815,907 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	85,500 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	22,800 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	54,150 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	71,250 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	38,325 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	265,455 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	23.47 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]

Case 52

System Technology:	**HICE**	**Distibuted Utility:**	
Station Capacity:	**400 cars/day**	**Time of Operation:**	**2.0 [hrs/day]**
No. of Cylinders:	**74**	**Output:**	**2.8 [MW]**

CAPITAL COSTS [$]

Electrolyzer	1,070,000
Storage	984,000
Compressor	636,000
Fuel Cell	980,000
Fixed	277,000
TOTAL	3,947,000

Fixed Charge Rate: 15% of Total Captial Costs
Total Annual Capital Charge: 592,050 [$/yr]

FIXED O&M

Fixed O&M percentage: 4% of Total Capital Costs
Fixed Annual O&M Costs: 157,880 [$/yr]
Additional Fixed O&M: 7,400 [$/yr] ($100/cyl.)(#cylinders)
Total Annual O&M Costs: 165,280 [$/yr]

VARIABLE COSTS

		Storage	Boost	Electrolyzer	
	Power [kW]	249	145.6	3580	
On-peak:	hrs/day	0	5	0	Total usage
	kW-hrs/day	0	728	0	728
				Total daily on-peak cost @ 8c/kW-hr:	$58
Off-peak:	hrs/day	18	15	18	Total usage
	kW-hrs/day	4482	2184	64440	71,106
				Total daily off-peak cost @ 4c/kW-hr:	$2,844

Total Daily Electricity Cost: 2,902 [$/day]
Total Annual Electricity Cost: 1,059,405 [$/yr]

Labor: 131,400 [$/yr]

Total Annual Variable Costs: 1,190,805 [$/yr]

ANNUAL COST SUMMARY

Annual Capital Charge: 592,050 [$/yr]
Annual Fixed O&M Costs: 165,280 [$/yr]
Total Annual Variable Costs: 1,190,805 [$/yr

ANNUAL TOTAL COSTS: 1,948,135 [$/yr]

TOTAL H2 SOLD ANNUALLY: 66,065 [GJ/yr]

CALCULATE:

G benefit	79,800 [$/yr]	($30/kW-yr)(FC rel.)(FC size[kW])
T benefit	21,280 [$/yr]	($8/kW-yr)(FC rel.)(FC size[kW])
D benefit	50,540 [$/yr]	($19/kW-yr)(FC rel.)(FC size[kW])
R benefit	66,500 [$/yr]	($25/kW-yr)(FC rel.)(FC size[kW])
E benefit	71,540 [$/yr]	(on-peak energy sales,$0.035/kW-hr) (DU operation time[hrs/day])(FC size[kW])(365 days/yr])
TOTAL DU BENEFITS	286,375 [$/yr]	(Total benefits) - adjustment to acct. for boost operation
COST OF HYDROGEN	25.15 [$/GJ]	Annual Total Costs [$/yr] - DU Benefits / Total H2 sold annually [GJ/yr]