The Four Es of DG Policy in California: Energy, Environment, Economics, and Education

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable and reliable energy services and products to the market place.

The PIER program, managed by the California Energy Commission (Energy Commission), annually awards up to $62 million to conduct the most promising, public interest energy organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy-Related Environmental Research
- Environmentally-Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Energy Systems Integration

What follows is the final report for the 4 E's of DG Policy in California: Energy, Environment, Economics, and Education, contract number 500-99-013 conducted by the University of California. The report is entitled The 4 E's of DG Policy in California: Energy, Environment, Economics, and Education. This project contributes to the Energy-Related Environmental Research program.

For more information on the PIER Program, please visit the Energy Commission Website http://www.energy.ca.gov/pier/reports.html or contact the Energy Commission at (916) 654 – 4628.

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Approach

The purpose of deregulating the electric utility system in California is to improve energy efficiency and lower electricity costs through market competition and greater consumer choice. This goal potentially supports the greater use of distributed sources of electrical power in the state and raises important questions:

- Exactly what kinds of distributed generation (DG) should energy and environmental policy favor?
- What level of government is best suited and/or most capable of governing DG?
- What is the range of regulations that would most easily facilitate the economic success of DG?
- And what information and educational measures are likely to ensure that California residents make wise decisions regarding their energy use?

Goals

This report responds to these questions by providing a comparative analysis of the electricity generation process with heat recovery, and a review of California's state and regional air quality laws, as a basis for recommending DG policy with the potential to be both economically viable and environmentally beneficial. The report also includes a discussion of environmental education in California, broadly understood, that illuminates the need to link the processes and discourses associated with energy generation and transmission, on the one hand, and air quality regulation, on the other, in the interest of environmental protection, public health, and social well-being.

More specifically, this report:

- Determines the forms of DG that are most likely to improve environmental quality—to reduce air pollution in California, in particular;
- Determines the government agencies that are best situated to govern the wide-scale introduction of DG into California;
- Recommends a set of regulatory actions designed to foster the growth of DG in a manner that is most likely to improve air quality, and generally improve the natural environment.
- Establishes a rationale for emphasizing the energy-environment nexus in environmental education.
- Assesses the level of polluting emissions associated with a range of technologies and fuel types. Given the results of this analysis, it evaluates the federal, state, and regional governance system responsible for regulating energy and environmental policy in California.
- Presents a policy recommendation based on these findings combined, the report that both compliments the state's existing regulatory structure and would facilitate the

commercialization of those DG technologies and fuel sources that are likely to be most beneficial to the environment and public health.

- Indicates the policy-relevance of educating the public about the ways in which energy generation and environmental quality are related.

Conclusions and Recommendations

The results reported here provide support for encouraging greater reliance on DG that meets or exceeds the low emissions and high levels of waste heat recovery associated with state-of-the-art combined cycle power plants. Such "clean" DG is destined to be found superior to traditional, centrally generated electricity (CG) once the greater reliability of the state's electric utility system and improved air quality theoretically associated with DG are realized in practice. More specifically, if ozone at the urban or regional level is the primary pollutant of interest, the direct oxidation fuel cell and the PEM fuel cell *with high rates of heat recovery* perform well against combined cycle CG. If particulates are of greatest concern in these cases, then the direct oxidation and PEM fuel cells are the only DG technologies that are even marginally competitive with combined cycle CG in terms of energy efficiency and pollution control. Alternative types of DG with at least 50 percent heat recovery are also worth considering in the case of global air pollution where CO_2 emissions are the primary concern. With the exception of the diesel internal combustion engine in that case, DG can compete well with combined cycle CG in terms of air pollution control.

In consideration of the high cost currently attached to super-efficient and ultra-low-emission DG technologies, such as direct oxidation fuel cells, this report advocates "forcing" the introduction of clean DG with high levels of heat recovery via manufacturer-based regulation. We argue that this method of regulation would encourage the production of DG units that are comparable to CG with respect to energy efficiency and emissions reduction at the point of manufacture. Like the manufacturer-based regulation of appliances and automobiles, which has facilitated significant and smooth technological improvements, this regulatory approach is likely to yield an economically tenable and socially acceptable transition from almost exclusive dependence on CG in California, to a reliance on some optimal mix of CG and DG. The manufacturer-based regulation developed in this report incorporates: 1) the establishment of stringent air quality emissions standards; 2) the certification of DG units; 3) in-use testing of certified DG units; 4) regulatory agency, manufacturer, and consumer "buy-in"; 5) the development of a mechanism for crediting DG using waste fuel and heat recovery; and 6) the regular evaluation of emission standards and other regulatory issues.

Granted, this is a tall order for the state's air quality regulators, DG manufacturers, and electricity consumers. This report, therefore, advocates the implementation of this policy recommendation in a context of close working relationships among energy and air quality regulators, DG manufacturers and facility managers, and an aware public. In particular, it supports voluntary standard setting along the lines of Underwriters Laboratory (UL) to ease the introduction of clean DG to the public. This report also strongly recommends expanding environmental education in California as a means of assisting electricity consumers in the state to make more socially conscious and environmentally responsible energy decisions.

Abstract

Deregulation of California's electric utility system is intended to improve energy efficiency and lower electricity costs through market competition and greater consumer choice. This process has provided an opportunity for increasing Californians' reliance on distributed sources of electrical power in the state, and raised important questions, including: Exactly what kinds of distributed generation (DG) should energy and environmental policy favor? What level of government is best suited and/or most capable of governing DG? What is the range of regulations that would most easily facilitate the economic success of DG? And what information and educational measures are likely to ensure that California residents make wise decisions regarding their energy use? This report responds to these questions by providing a comparative analysis of the electricity generation process with heat recovery, and a review of California's state and regional air quality laws, as a basis for recommending DG policy with the potential to be both economically viable and environmentally beneficial. The results of this analysis supports more widespread use of DG that meets or exceeds the low emissions and high levels of waste heat recovery associated with state-of-the-art combined cycle power plants. Such "clean" DG is destined to be found superior to traditional, centrally generated electricity (CG) once the greater reliability of the state's electric utility system and improved air quality theoretically associated with DG are realized in practice. This report, furthermore, advocates "forcing" the introduction of clean DG with high levels of heat recovery via manufacturer-based regulation. We argue that this method of regulation would encourage the production of DG units that are comparable to CG with respect to energy efficiency and emissions reduction at the point of manufacture. In conclusion, the report strongly recommends expanding environmental education in California as a means of assisting electricity consumers in the state to make more socially conscious and environmentally responsible energy decisions.

1.0 Introduction: The Energy –Environment Nexus

In contrast to much of its history, the U.S. electric utility system has been marked in the 1990s by increasing deregulation and the emergence of a free market for electricity (Hirsch, 1999). One important result of this regulatory change has been a growing potential for small, distributed sources of electrical power that may serve a single home, neighborhood, business, or business complex more efficiently and reliably than centrally located power plant, and at a lower cost (Vogel, 2000b). While the concept of DG has long proved appealing to those committed to energy conservation and renewable sources of electricity, reasons for the renewed interest in DG since the early 1990s are more economic than ethical (see Laurie and Tomashefsky 2002). Central generating companies, often referred to as wire companies, see the potential for reduced loading on transmission equipment, local voltage support, and economics (Bartos, 2000; Carlson, 2000). Government utility regulators and energy agencies see the potential for increased competition, and thus price reductions, improved system reliability, more efficient resource use, and the need to address growing electricity demands (Silverstein, 2000). The United States Environmental Protection Agency (EPA), the developers of the Kyoto Protocol, and public interest groups have pointed out the potential value of clean DG technologies for reducing air pollution and increasing energy efficiency (Grubb et al., 1999; MacCracken et al., 1999). Finally, DG equipment suppliers see the opportunity to increase market penetration and profits.

The possibility that its potential to provide reliable electrical power more efficiently and less expensively than conventional power plants[1] will increase the use of DG in California is problematic, though, because the most affordable and accessible DG technologies are extremely polluting. The state's air quality regulators—including the California Environmental Protection Agency (CalEPA), the California Air Resources Board (CARB), and the California Air Pollution Control Officers' Association (CAPCOA), which represents 35 air districts as a body—have concluded that, with the exception of wind- and solar- based DG and fuel cells, and in the absence of duly credited heat recovery, currently available DG technologies all emit higher amounts of air pollution per unit of electricity generated than emitted by modern combined cycle CG. Diesel-fired generators, in particular, emit nitrogen oxides (NO_x), as well as particulate matter (PM10) and fine particulate (PM2.5), which have been identified as toxic contaminants (CARB Resolution 98-35). In fact, on the basis of electrical energy produced, such generators are, on average, fifty times more polluting than large modern natural gas-fired power plants (Lents 2002). These technologies are designed and usually purchased for limited use during electrical outages at the facility level; yet even if used strictly in this capacity, diesel back up generators (BUGs) will significantly and negatively impact California's ability to meet

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[1] DG in the form of back up generators, or BUGs, currently requires a battery system, which allows the BUG to start and enables greater reliability of electrical energy supplies; the general expectation is that DG units that are as efficient and clean as centrally generated power sources will, in the future, provide electricity 24 hours, seven days a week (24/7), using the grid for back up.

the requirements of its State Implementation Plan (SIP) and thereby achieve federal air quality standards for NO_2, Ozone, PM10 and PM2.5.

The advent of the DG opportunity underscores the centrality of cost-effective energy conservation and environmental protection to public policy in California (California Energy Commission, 1995, Laurie and Tomashefsky 2001). Indeed, the primary goal of the current electric power restructuring in the state is to lower electricity costs through market competition and greater consumer choice (MacAvoy, 1992). The challenge of achieving this goal through a movement toward more efficient energy generation that is simultaneously less polluting poses important questions:

- Exactly what kinds of distributed generation (DG) should energy and environmental policy in California favor?
- Which government agencies are best suited and/or most capable of governing DG?
- What kind of regulatory policy would most easily facilitate the economic success of less polluting DG technologies?
- What information and educational measures are likely to ensure that California residents make wise decisions regarding their energy use?

These four questions clarify what we regard as significant interactions among the politics of energy generation, environmental protection, economics, and public education about the natural environment—the "four Es" of DG policy in California. State energy and environmental regulators, law-makers, environmental and economic analysts, educators, and the general public have been motivated by their concerns about these foundations for DG policy to assess the following issues:

- Effective interconnection of DG to the electricity grid.
- The ethics and safety of DG operating in residential and commercial applications.[2]
- The economics of DG as an alternative to CG.
- Environmental protection and air quality.
- Public attitudes about the environment and environmental education.

The research reported here focuses primarily on the environmental concerns illuminated by these issues with the intention to establish which DG technologies are capable of improving air quality. Our report also attends to economic matters in the context of outlining a model policy to encourage the cost-effective adoption of environmentally beneficial DG. Finally, it raises the

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[2] Ethical concerns refer chiefly to the implementation of "clean" DG as an antidote to environmental justice problems associated with the issue of siting polluting power plants in economically disadvantage urban areas. To the extent that the lowest-emitting DG technologies are adopted as primary sources of electricity in the state's poorer neighborhoods, the people living there will be subject to fewer health problems attributable to air pollution.

political importance of environmental education for heightening public awareness about the energy-environment nexus. More specifically, this report:

- Assesses the level of polluting emissions associated with a range of technologies and fuel types in order to determine the types of DG that are most likely to improve environmental quality—to reduce air pollution in California, in particular
- Evaluates the federal, state, and regional system of governance responsible for regulating energy and environmental policy in California as a means of determining the agencies best suited to govern the wide-scale introduction of DG into the state;
- Recommends policy designed to foster the growth of DG in a manner that is most likely to improve air quality, and generally improve the natural environment and ensure the public's health.
- Establishes the policy relevance of emphasizing the energy-environment nexus in environmental education.

2.0 Distributed Generation

DG may be defined in a number of ways (Vogel, 2000a; Weisberg, 2000). At one extreme, large central-station electrical generating units that traditionally fall under environmental regulatory and public utility regulatory constraints are not considered DG. These units require extensive permitting, must offset emissions, and must meet strict production and connection requirements. This, at a minimum, captures generating units in excess of 100 megawatts capacity. Generating units that are sized to support a single home or moderate sized business are clearly at the other extreme. These typically less than 1 megawatt units fit within virtually all definitions of DG and have only recently been included in current environmental regulatory structures. In the case of generating units greater than one megawatt and less than 100 megawatts, the designation as DG can vary from case to case. For the purposes of this report the exact cut-point for DG is not critical and no attempt will be made to define a specific value.

DG may also be distinguished by fuel type. Of course, DG has been developed in the form of renewable generation, such as photovoltaic conversion and wind energy conversion. These two forms of electrical generation may raise some environmental concerns in the broadest context such as visual blight, bird deaths (in the case of wind turbines), noise, or ultimate system disposal at the end of its life; however, they pose no direct air quality implications. Wind and solar energy should be subjected to a full cycle analysis and thus be fully evaluated in terms of environmental and energy penalties associated with the manufacture and disposal of this form of generation, but it is likely that they will pass easily. For our purposes here, they will be considered a net positive in all cases and will not be evaluated further. This report will thus evaluate DG derived from the combustion[3] of fuels as the main point of consideration because it has the potential to produce significant amounts of urban, regional, and global air pollution.

Of course, energy conservation may also fall under the rubric of DG, depending upon how this term is defined. To clarify this issue, the term distributed energy resources (DER) is often used in place of DG, and energy efficiency and energy conservation are viable forms of DER in the broader context. For the purposes of this report, there is no need to address this decision either. Energy conservation carries with it no presently identified negative air quality implications and generally enjoys wide public support.

3.0 Air Quality

For purposes of this report, air pollution is any material that is introduced into the air in such quantities that it creates a significant local, regional, or global health, welfare, or ecological impact. In the United States, air pollution has been traditionally divided into four categories. These are: 1) criteria pollutants[4], 2) toxic compounds[5], 3) ozone depleting compounds[6], and 3) global warming compounds.[7] DG can be a source of all such forms of air pollution except ozone depleting compounds. On a geographical basis, these types of air pollution are typically discussed in the following three settings: 1) urban air pollution, 2) regional air pollution, and 3) global air pollution. Any thorough consideration of DG must be taken in light of urban, regional, and global air pollution problems and the ability to provide adequate energy to support an economically developed world. At best, the goal for the application of DG should be to improve the environment. At worst, it should be developed in a way to avoid exacerbating environmental problems.

3.1. Urban Air Pollution

The highest levels of air pollution typically occur in the densely populated urban areas. This is also where the greatest health problems are incurred due to the proximity of people and acute air pollution. In spite of thirty years of efforts, most American mega-cities continue to violate

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[3] Combustion includes the ordinary combustion of fuel in a boiler, turbine, or internal combustion engine as well as the chemical "combustion," or direct oxidization, of fuel in a device such as a fuel cell..

[4] Criteria pollutants include carbon monoxide (CO), nitrogen oxides, sulfur oxides, ozone, volatile organic compounds (VOCs), and lead (though the elimination of lead from gasoline has minimized the generalized nature of lead pollution).

[5] Toxic pollutants involve a wide range of compounds that have acute toxic properties or can cause cancer. Common toxic pollutants are mercury, benzene, 1,3 Butadiene, chromium, formaldehyde, and many others. More recently diesel particulate matter has joined this list in California.

[6] The chlorofluorocarbons are the predominate members of this class. These compounds are now generally banned all over the world.

[7] The key anthropogenic compounds in this class are CO_2, methane, and NO_x.

one or more air quality standards. In response, the EPA promulgated tighter ambient air quality standards in 1997. While these standards are currently under judicial review, such tighter standards are likely to come into effect in the near future. This situation will demand even greater air pollution control efforts in U.S. cities to protect human health and welfare. It is into these urban settings that the highest concentrations of DG will likely develop.

3.2. Regional Air Pollution

The concern over regional air pollution began in the late 1970s with the development of programs to prevent significant deterioration (PSD)[8] of air quality in national parks and wilderness areas. This concern has grown as the impacts of acid rain and the reduced visibility in many regions throughout the United States has been recognized. More recently in the eastern United States, ozone has been recognized as a regionally transported pollutant. This problem is being addressed via a multi-state joint regulatory program. The long-range transport of acidic air pollution between the United States and Canada in the Northeast and between the United States and Mexico in the Southwest has long been noted, and is similarly the focus of binational air pollution abatement programs (Allison, 1999; Ingram, 1988). More recently, transboundary air pollution moving from Asia to the West Coast has also been identified (Smil, 1993).

3.3. Global Air Pollution and Sustainability

Atmospheric levels of carbon dioxide have risen throughout the 20th Century as a result of increased fossil fuel burning. Simultaneously, average temperatures worldwide appear to be rising. This trend has led to an intense debate about the impact of anthropogenic pollution on global climate. The debate has extended from discussions of carbon dioxide (CO_2) emissions to anthropogenic emissions of methane (CH_4), and nitrous oxide (N_2O). The causes of the CO_2 and N_2O emissions are overwhelmingly the combustion of fossil fuels. CH_4 can result from combustion processes, but also results from the decay of vegetation and waste and intestinal gases associated with human food production. Global warming gases are closely associated with human economic development and energy use and thus also relate closely to sustainability issues.

4.0 Estimating the Air Quality Implications of Distributed Generation

The following analysis responds to the aforementioned goals for the development of environmentally beneficial DG. We necessarily begin with the important question: To which power production technologies is DG compared when evaluating its air quality impacts? One might argue that the comparison should be to either no power production (and thus possibly

[8] The concept of PSD is to prevent the air quality in clean areas from getting worse. Following the 1970 Clean Air Act amendments and a suit by the Sierra Club, a program was codified into the 1977 Clean Air Act amendments that sets special requirements for the protection of National Parks and wilderness areas and lower levels of protection for other non-urban areas.

austerity or more energy conservation) or to solar or wind energy. Austerity is not a likely or reasonable choice in the United States, and energy conservation can cover some of the needed demand but has not proved to be an adequate method for supplying all future power demands. Solar power continues to be too expensive for general application and there are simply not enough good sites for wind energy to fill the demand for additional power generation cost-effectively.[9] Therefore, an alternative response to this question would be to compare contending DG technologies with the central power plants that are currently being approved for construction and operation. At this time, all of the proposals for new power plants under review in California and Texas as well as in the Midwest and on the East Coast concern combined-cycle gas-fired power plants.[10] From this perspective, the most reasonable choice of a CG technology for comparison would be the gas fired combined cycle power generation.[11] The electricity generation process associated with fuel burning is illustrated in Figure 1.

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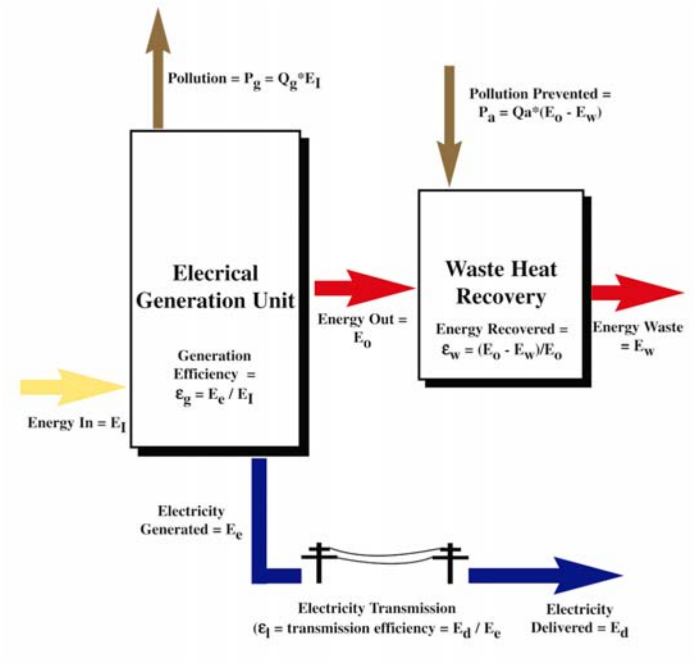
[9]See the "California Distributed Energy Resources (DER) Guide," available online at: http://my.ca.gov/state/portal/myca_homepage.jsp, which provides instructions for evaluating the cost of electricity from various DG technologies versus CG. At approximately .16 per kilowatt-hour, solar DG is quite expensive.

[10] Although coal-fired power plants are inexpensive to operate in areas such as the Midwest and East Coast, where coal is plentiful, they are increasingly costly to build. This is in part due to restrictions included in the CAA New Source Performance Standards (NSPS).

[11]Although it is increasingly apparent that, in the near-term, DG is less likely to compete directly with CG than it is to provide a source of reliable, high-quality, and possibly economically efficient electricity for highly specific applications, we are convinced that DG policy should foster the development of technologies that are at least as clean as the least polluting CG available. Notably, this is also the position taken by CARB in developing its DG certification program and guidance to California's air quality control districts.



Where,
Q_g = generator pollutant emissions per kwhr of input energy.
P_g = generator pollutant emissions.
Q_a = avoided pollutant emissions per kwhr of input energy in waste heat recovery.
P_a = avoided pollutant emissions from waste heat recovery.
ε_g = generator efficiency (electricity generated per energy used).
ε_w = waste heat recovered.
ε_l = electricity transmission efficiency (energy transmitted per energy generated).

Figure 1. The Electrical Generation Process with Waste Heat Recovery

Given that waste heat is seldom recovered in the case of CG, Figure 1 can be used to represent either CG or DG.[12] More specifically, the emissions from the process in Figure 1 can be written:

Equation 1

$$P_g = Q_g * E_I = Q_g * E_e / \varepsilon_g = Q_g * (E_d / \varepsilon_l) / \varepsilon_g = Q_g * E_d / (\varepsilon_g \varepsilon_l)$$

Equation 2

$$P_a = Q_a * (E_o - E_w) = Q_a * E_o * \varepsilon_w = Q_a * E_d * \varepsilon_w * (1 - \varepsilon_g) / (\varepsilon_g \varepsilon_l)$$

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[12] One might consider that combined cycle generation recovers heat. However, this heat is used to generate more electricity, which is included within the context of the electrical generation unit. For purposes of this analysis the "heat recovery" in the combined cycle unit is captured as higher generation efficiency.

Therefore, the net emissions from a generating system with heat recovery is:

Equation 3

$$P_N = P_g - P_a = [\, E_d / (\varepsilon_g\, \varepsilon_l)\,]^* [Q_g - Q_a * \varepsilon_w\, (1 - \varepsilon_g)\,]$$

Note that Equation 3 allows calculation of air pollution from a generating process with heat recovery based on the electricity to be supplied and the emission factors and efficiencies of the various processes.

The overall air quality impacts of a theoretical DG unit to the air quality impacts of a theoretical combined cycle CG unit are compared in Equation 4. That is:

R_{DC} = ratio of DG emissions to combined cycle CG emissions = P_{NDG} / P_{NCG}

Using Equation 3, setting $\varepsilon_l = 1$ for DG and $\varepsilon_w = 0$ for combined cycle CG, and introducing a new term f_C that corresponds to the fraction of combined cycle CG that is carried on in an urban area, we have:

Equation 4

$$R_{DC} = [\, (\varepsilon_{gC} * \varepsilon_{lC}) / \varepsilon_{gD}\,] * (Q_{gD} / Q_{gC}) * [\, 1 - (Q_{aD} / Q_{gD}) * \varepsilon_{wD} * (1 - \varepsilon_{gD})]^* (1 / f_C)$$

We assume $\mathbf{f_C}$ equals 1 for regional and global pollution concerns because the air pollution from combined cycle CG and DG are normally being introduced into the same air quality region for these two cases.

5.0 Analysis of DG Using Natural Gas or Diesel Fuel w/Heat Recovery

A likely application of DG is in the form of small turbines, internal combustion engines, or fuel cells in a small commercial or residential setting. In this case, any heat recovery will likely be in the form of hot water, space heating, and, more recently, space cooling; Equation 4 is used to analyze this situation. Emissions and efficiency information for some potential DG units are summarized in Table 1. The values presented were taken from a study for the California Air Resources Board (CARB) (this study is currently in draft form; see also Greene and Hammerschlag, 2000). The emission rates and efficiencies of many of the DG systems are continuing to change and the values in Table 1 will likely change over the next few years.[13] The final row in Table 1 indicates the water heating emissions that we assume are replaced by any waste heat used for this analysis. Clearly, future experience will provide improved information on likely heat recovery applications.

Table 1. Emission Factors and Efficiencies Used for DG Analysis

Generation Type	Efficiency	CO	VOC	NOx	SOx	PM2.5	CO2*
	Elec.Out / Energy In	lbs / kWhr gen	lbs / kWhr gen	lbs / kWhr gen	lbs / kWhr gen	lbs / kWhr gen	lbs / kWhr gen
Combined Cycle Gas	0.52	0.00017	0.00011	0.00013	0.00002	0.00002	0.62
Micro-Turbine	0.27	0.00285	0.00005	0.00140	0.00002	0.00009	1.25
ATS**	0.36	0.00260	0.00003	0.00109	0.00002	0.00007	0.95
Conventional Turbine	0.28	0.00151	0.00004	0.00124	0.00003	0.00009	1.20
Gas Powered ICE	0.35	0.00800	0.00170	0.00320	0.00001	0.00048	0.97
Diesel ICE	0.44	0.03000	0.00200	0.01700	0.00030	0.00300	1.70
PEM Fuel Cell	0.36	0.00000	0.00090	0.00002	0.00001	0.00000	0.95
Solid Oxide Fuel Cell	0.40	0.00000	0.00000	0.00000	0.00000	0.00000	0.85
Home/Commercial Water Heating	0.80	0.000119	0.00002	0.00044	0.00000	0.00002	0.34

*Emissions data for the other "greenhouse gases," N_2O and CH_4 were unavailable.

** Advanced Turbine System

5.1. Ozone and Particulate Indices

To simplify the analysis that follows, pollutants have been grouped into two categories. The first category addresses ozone precursors. The second category addresses particulate

[13] Indeed, our current intention is to include consideration of pollution-free carbonate fuel cell power plants in this analysis.

precursors. Urban and regional ozone is the result of the interactions of volatile organic compounds (VOC), NO_x, and carbon monoxide (CO). CO acts like VOC but is only 2.1 percent as effective as typical VOC in forming ozone (CARB, 1990). Urban and regional particulate matter, which contributes to visibility degradation and acid deposition, is the result of direct particulate matter emissions combined with NO_x, sulfuric oxides (SO_x), and VOC, which is converted to particulate matter in the atmosphere. To simplify comparisons, we created an ozone and particulate matter index. The ozone index adds VOC to NO_x plus 0.02 times the CO. The particulate index adds the PM2.5 emissions to 25 percent of VOC plus 50 percent SO_x plus 50 percent of NO_x to approximate the conversion rates.

5.2. Generation Location

An important consideration in carrying the analysis forward is the location of the various types of generation and the resulting impacts on urban airsheds. For example, by definition, all DG will be used within the local airshed,[14] while only a portion of central-station power generation typically occurs in the local airshed. Thus, from an urban airshed perspective, some central-station power generation will contribute no emissions to that airshed. In the regional and global pictures, DG and central-station power will of course be emitting equally into these much broader airsheds.

It is also important to consider that central-station power plants use much taller stacks than will typically be used for DG. These taller stacks disperse pollutants over a wider geographical range and reduce local impacts compared to DG. Thus, in the local urban situation, the impact of any polluting emissions from DG will be relatively greater than comparable emissions from CG. This argument, of course, does not apply to the regional or global analysis. The great difficulty for the urban analysis will be the development of an appropriate factor to account for the central-station to DG location and stack height differences. In an exact analysis specific modeling studies would be necessary; however, this is beyond the scope of this study.

For the purposes of this analysis, we assume that 70 percent of central-station generation that would be displaced by DG will occur in the related urban airshed due to likely power plant location and stack height issues. Because considerably more effort is needed to understand the direct urban impacts of CG relative to DG, this conservative assumption is closer to an educated guess than a scientifically derived estimate and arguments might be made in both directions.

5.3. Transmission Losses

One benefit of DG is its proximity to the point of use, whereas CG may be located at a considerable distance from the point of use. For this general analysis, we assume simply that power generation outside of an urban area results in a 15 percent transmission loss. We assume

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[14] The issue of what DG will displace also becomes important in this context as well. We assume that, subject to the considerations discussed above, the most likely power source to be offset by DG is natural gas powered combined cycle electric generation. The central-station power plants being proposed for development at the present time tend to be very near or in urban areas.

that electricity generation inside of an urban area results in no loss. Thus DG and central-station power in the urban airshed is assumed to have no loss.[15]

6.0 Results of Analysis

The initial results[16] of the analysis suggest that at the urban and regional levels, only the direct oxidation and PEM fuel cell technologies are competitive with combined cycle CG. When ozone is the primary pollutant of interest, the direct oxidation fuel cell and the PEM fuel cell with high rates of heat recovery are both competitive with combined cycle CG. If particulates are of greatest concern, direct oxidation and PEM fuel cells are the only DG technologies that are competitive with combined cycle CG. DG with at least 50 percent heat recovery fairs better at the global level where CO_2 emissions are the primary issue. With the exception of the diesel internal combustion engine in that case, DG can compete well with combined cycle CG in terms of air pollution control.

6.1. Modifying DG to Achieve Equivalency

Although fuel cell DG is at least as clean and efficient as combined cycle CG, the cost of installing, operating, and maintaining fuel cell generators and power plants continues to represent a significant barrier to the widespread adoption of this technology (this point is elaborated in Section XIV below). Therefore, for the purposes of this section's discussion, we assume that combined cycle CG is the preferred alternative from an environmental viewpoint, *until* the cleanest DG technologies—i.e., direct oxidation fuel cells, in addition to solar and wind power—become more cost effective, and further fuel efficiency, significant heat recovery, or further reductions in polluting emissions are achieved as appropriate for the alternative types of DG considered. Interestingly, Equation 4 suggests that the type of DG unit that would be competitive with combined cycle CG for urban, regional, and global emissions would have: 1) a generation efficiency of at least 30 percent; 2) a unit emission rate of less than 1.30 times combined cycle; and 3) waste heat recovery of at least 60 percent. The emission reductions such candidate DG technologies would need to achieve in order to meet these goals are approximated in Table 2.

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15 Making the assumption that 70 percent of displaced central-station power would be located within the urban airshed results in an assumption that displaced central-station power has an overall transmission efficiency of 96 percent. If a 10 percent loss were assumed, the transmission efficiency would shift to 97 percent; if a 20 percent loss was assumed, the transmission efficiency would shift to 94 percent. Arguably, these tiny efficiency differences are extremely small in light of the present broad analysis.

16 These results are reported in their entirety in Allison and Lents 2002.

Table 2 Approximate Emission Reductions and Efficiency Improvements (assuming 60 percent heat recovery) to Provide Equivalent Performance to Combined Cycle

DG Unit	Overall Emission Reduction Needed	Generation Efficiency Improvement Needed
Micro-Turbine	80%	10%
Advanced Turbine	74%	0%
Conventional Turbine	77%	6%
Gas Fueled Internal Combustion Engine	96%	0%
Diesel Fueled Internal Combustion Engine	99%	0%
PEM Fuel Cell	49%	0%
Direct Conversion Fuel Cell	0%	0%

6.2. Control Options for DG

Depending upon specific DG technology and the fuel used to provide energy, the control options available for DG include: engine adjustments, fuel reformulations, and add-on control equipment. While such adjustments potentially reduce emissions from the more readily available but relatively more polluting DG technologies, they may prove too expensive and/or difficult to adopt—especially in the case that the DG equipment in question is to be used exclusively or primarily for back-up power generation. Because, in time, DG manufacturers and users are likely to meet whatever such financial and technical challenges exist, we discuss each type of control options currently applicable to DG below.

- *Engine Adjustments***.** During engine operations, the two key variables that influence the formation of air pollution in fuel burning engines are the air/fuel ratio and temperature. If the relative amount of air provided to the combustion chamber compared to fuel, or the air/fuel ratio, is such that the combustion chamber contains exactly the correct amount of air for the amount of fuel introduced into the chamber then the air/fuel ratio is said to be stoichiometric. If the air is less than stoichiometric, then the mixture is said to be rich. If the air is greater than stoichiometric, the mixture is said to be lean. Figure 2 indicates that emissions from a gasoline-fueled reciprocating engine can vary as much as 20 times depending upon the on air/fuel ratio.

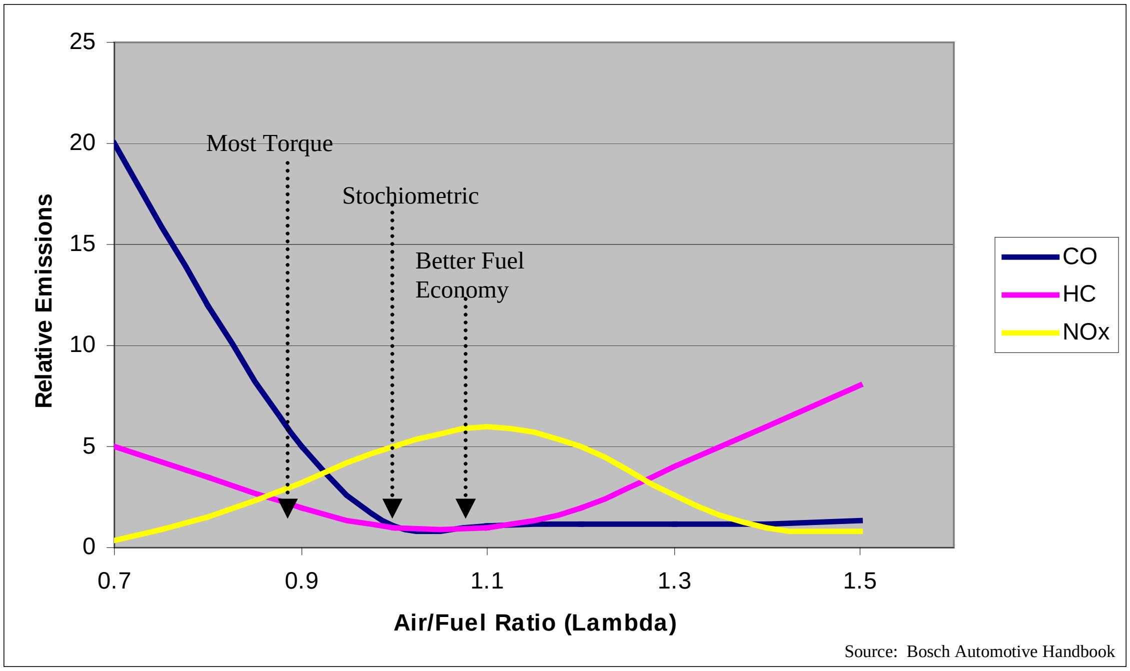

Figure 2. Comparison of Emissions versus Air/Fuel Ratio for Gasoline Engine

Temperatures reached during the combustion process are affected by the size of the combustion chamber, the air/fuel ratio, and the pressures reached in the chamber. The higher the temperature reached in the chamber, the greater the formation of NO_x. It follows that air pollution may be minimized by optimizing the air/fuel ratio and temperatures in the combustion chamber. As illustrated, in Figure 2, some pollutants increase while other pollutants decrease with changes in the air/fuel ratio and chamber temperatures. Even in the case of hydrogen, the use of air, which contains 80 percent nitrogen, can produce NO_x due to combustion chamber temperatures. Ideally, we seek a balance between air pollution formation for different pollutants and engine efficiency. Turbines tend to run very lean, and diesel and natural gas reciprocating engines tend to run lean. Thus, emissions from these types of engines tend to be lower with the exception of NO_x, which are a function of chamber temperature. Table 3 indicates some of the more important options to improve air/fuel management and combustion chamber temperature.

Table 3. Options to Modify Engine Operating Parameters to Control Emissions

Engine Type	Control Approach	Discussion
All	Air/Fuel Management	Considerable effort has been applied to diesel, gasoline, and natural gas fueled engines to improve air/fuel management. The dominant approach today is the use of fuel injection, microprocessors, and oxygen exhaust sensors to maintain appropriate air/fuel balance. Emissions reductions on the order of 10 to 50 percent can be achieved with improved air/fuel ratio management.
All	Exhaust Gas Recirculation	Exhaust gas is recirculated to the engine to reduce combustion chamber temperatures and thus nitrogen oxides. Emissions reductions of 10 to 30 percent can be achieved with exhaust gas recirculation.
Spark Compression and Ignition Engines	Combustion Timing	The time that combustion takes place impacts the temperatures reached, combustion efficiency, and so also air pollution formation rates. Improved timing can reduce emissions in the 10- to 30-percent range.
All	Combustion Chamber Design	Combustion chamber design can influence temperatures and the air/fuel mixtures in subsections of the combustion chamber.

- *Fuel Reformulations*. Gasoline, diesel fuel, and natural gas do not occur in nature in exact specifications. Thus, the specific combustion qualities of the raw materials can vary considerably. In addition, additives that do not naturally occur in fuels can be incorporated to further improve combustion qualities. Key specifications for fuels that impact combustion qualities and evaporation and thus associated emissions are shown in Table 4.

Table 4. Key Specifications for Distributed Generation Fuels to Control Emissions

Fuel Type	Control Approach	Discussion
Diesel, Gasoline	T10, T50, T90	Indicates the temperatures that different percentages (10, 50, or 90) of the fuel evaporates and provides some indication of the combustibility of the fuel. Emissions from different fuel mixture combinations can vary by up to ten percent.
Gasoline	Benzene content	Impacts the rate of emissions of the toxic compound benzene.
Gasoline	Vapor Pressure	Impacts the rate of evaporation of the fuel from the storage tank and from the engine.
All	Sulfur Content	Impacts the rate of emissions of sulfur compounds and also impacts the efficiency of some catalytic control equipment. For example, higher sulfur fuel can reduce catalyst efficiency by 0.2 to 0.4 percent, increasing emissions by 10 to 40 percent.
Diesel	Cetane Number	Indicates the combustibility of the diesel fuel.
Natural Gas	Methane Content	The amount of methane in the fuel compared to longer chain hydrocarbons can influence the toxic content and to a limited extent the combustibility of the gas.

Fuel reformulations can also improve fuel performance to a degree. Two reformulations have become particularly important for reducing emissions from liquid fossil fuels: denoted oxygenates and water. Popular oxygenates include methyl tertial butyl ether (MTBE) and ethanol—compounds that contain oxygen in their molecules; in the combustion process, they supply this oxygen to provide for leaner combustion. Water can be emulsified into diesel fuel resulting in lower particulate and slightly lower nitrogen oxide emissions. Table 5 summarizes the use of these important fuel additives and the environmental and public health impacts associated with them.

Table 5. Emissions Reducing Fuel Additives

Fuel Type	Control Approach	Discussion
Gasoline	MTBE Addition	Increases oxygen in the combustion process resulting in leaner combustion and reduced CO and VOC emissions. While MTBE can reduce emissions by 10 to 30 percent, ground water pollution concerns have resulted in the ban of MTBE use in gasoline in many locations.
Gasoline	Ethanol Addition	Increases oxygen in the combustion process resulting in leaner combustion and reduced CO and VOC emissions. Increases fuel vapor pressure requiring gasoline to be reformulated to accommodate ethanol. Similar to MTBE, the addition of ethanol can achieve emissions reductions of 10 to 30 percent.
Diesel	Emulsified Water	Modifies combustion characteristics to lower particulate emissions and slightly lower nitrogen oxide production. This addition can yield emissions reductions in the 10- to 60-percent range.
Diesel	Hydrogen, Propane Addition	Some limited studies concerning the addition of hydrogen and propane to diesel fuel indicate that particulate emissions may be reduced.

- *Add-On Control Equipment*. The use of add-on control equipment has become the prime approach for achieving large emission reductions from fuel combustion processes. Controls can be broken into the following five classifications: (1) afterburners, (2) oxidation catalysts, (3) three-way catalysts, (4) NO_x control, and (5) filters. Afterburners were one of the first types of controls to be applied to combustion engines and simply involve the addition of oxygen and sometimes heat into a hot portion of the exhaust stream to further oxidize engine emissions. This approach is generally ineffective on lean burning combustion processes. Oxidation catalysts act in a similar manner, except that a catalyst is used to promote oxidation of remaining combustible emissions at lower temperatures. Oxidation catalysts were the first type of catalyst to be applied to gasoline engines, and are currently being tested as a means to reduce particulate emissions from diesel-fueled engines. Three-way catalysts consist of two different catalysts, or an integrated catalyst, that provides oxidation capability plus the capability to destroy nitrogen oxides. While these catalysts are very effective, they can be extremely sensitive to the sulfur content of the exhaust stream. NO_x control can also involve additives to the exhaust stream, with or without an associated catalytic converter. Ammonia addition and urea addition are two common additives. Catalytic converters can be added to increase the process efficiency. Filters are used to remove particulate matter. Table 6 outlines add-on control equipment now available to reduce emissions from combustion processes.

Table 6. Add-On Control Approaches

Engine Type	Control Approach	Discussion
All	Oxidation Catalyst	Can reduce CO and VOC emissions by up to 99 percent in gasoline engines. Can reduce Particulate emissions from diesel engines in the 10- to 5-percent range.
Gasoline	Afterburner	Can reduce CO and VOC emissions by up to 40 percent in rich burning engines. Does not work well in very lean exhausts.
All	3-Way catalyst	Can reduce CO, VOC, and NO_x emissions by 99 percent in some situations. Three-way catalysts tend to be sensitive to the sulfur content of the exhaust.
All	Ammonia and Urea addition to exhaust stream with and without catalyst	Ammonia and Urea can be introduced to exhaust streams to reduce NO_x emissions. In cases with high exhaust temperatures this approach can yield emissions reductions of up to 50 percent. In cases of lower exhaust temperature, catalysts must be added. In this latter case the control approach is referred to as Selective Catalytic Reduction (SCR). It is associated with emissions reductions in the 70- to 90-percent range.
Diesel	Exhaust Filters	Catalytic and non-Catalytic exhaust filters are being used to reduce particulate emissions. In some cases, the filters are replaced at appropriate intervals. In other cases, the filters contain catalysts and are periodically purged to destroy collected particulates. These measures can achieve emissions reductions of 70 to 95 percent.
All	SCONOX	The SOCNOX process is a patented process that uses a carbonate absorption system and regeneration process to destroy NO_x. It has been found to be very effective at reducing NO_x emissions in natural gas-fueled engines on the order of 90 percent.

It follows from this discussion that, with the exception of fuel cells, add-on control technologies will be necessary for existing DG technologies to match the performance of combined cycle CG. Note that the requisite controls are already available for natural gas and gasoline ICEs, and similar controls are increasingly available for diesel-fueled ICEs; however, due to the very lean operating conditions of turbines, appropriate add-on control technologies will require further development. Despite the availability of add-on control technologies, their currently high cost renders them uneconomical DG modifications in most cases.

6.3. Impacts of DG Location

Although the analysis presented above recognizes the importance of where DG is located, it does not directly address the key policy issue that while a little "bad" DG, like a few "dirty" cars, may not result in a major air pollution problem, the wholesale replacement of CG with DG that is not at least as energy efficient and free of polluting emissions as CG could very well do so. In response to this concern, we estimated the VOC, NO_x, and particulate matter emissions that would be created in the hypothetical case that every household in Los Angeles opted to rely on natural gas ICEs for all of its electricity needs.[17] This crude analysis suggests that the emissions of CO, NO_x, and PM10 might not exceed ambient air quality standards; however, the associated production of secondary air pollutants, such as ozone and secondary particulates, could exacerbate local air pollution problems. Furthermore, toxics could be a problem. Formaldehyde, which is emitted when natural gas is used as a fuel source, could exceed not only current mean levels of formaldehyde in the atmosphere, but also thresholds above which it might be considered carcinogenic. This finding is sufficient to warrant additional research, and the most stringent regulation of DG meanwhile.

7.0 Distributed Generation Policy to Improve Air Quality

According to the analysis presented in the previous sections, DG policy must consider the impacts of all sources of air pollution emissions and the potential for air pollution problems to result from DG in certain circumstances. *The bottom line is that fossil fuel powered DG may or may not be environmentally beneficial relative to other alternatives for generating electricity, depending upon the specific application and the amount of heat recovery achieved*. An important issue to be resolved is how to encourage beneficial DG but discourage or prevent DG that does not represent an overall air pollution benefit.

This policy problem essentially complicates the quintessential public goods problem that California's air quality regulators have long faced: providing clean air to California residents (and others living downwind of the state). That is, the emissions associated with relatively smaller DG on a unit-by-unit basis are typically an insignificant source of pollution, even though the emissions from a large number of DG units running at once would yield serious environmental consequences (see Polakovic 2001). Thus "small" DG units have only recently been regulated by government agencies. In this sense, DG resembles the situation that many regions face with respect to home and small commercial heat systems, or even automobiles, where the units on an individual basis pose little environmental threat, but in large numbers can create significant air quality problems.

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[17] The source for our data on energy use is California Energy Commission 2002b; the sources for our population density data were areaConnect at www.areaconnect.com/population.htm?s-CA and Wikipedia, California at http://www.wikipedia.org/wiki/Los_Angeles.

The extent to which DG technologies installed in large numbers will precipitate increased air pollution depends on the kinds of technologies available to energy consumers, and the economic and ecological motivations they have to invest in them. Consequently, regulatory policy designed to improve the availability, affordability, and desirability of environmentally sound DG can be used to influence consumers' decisions to adopt these alternative sources of energy sources for some, or even all, of their electrical power. This policy characteristic suggests the use of a manufacturer-based form regulatory approach, such as the one advocated in this report. That is, the smaller DG units would be certified in the manner that appliances and cars are—that is, at the point of manufacture, rather than at the point of use. This approach supports both CARB's October 2002 Distributed Generation Certification Program, and the California Energy Commission's June 2002 Distributed Generation Strategic Plan. It also provides an impetus for California's legislators and regulators to "force" the development of the cleanest kinds of DG, behavior that could reduce the costs of these technologies for consumers.

This report's focus on developing regulatory policy to encourage the adoption of clean DG notwithstanding, the costs associated with installing, operating, and maintaining DG systems requires serious consideration. DG has long been attractive to the inhabitants of rural areas, environmentalists, technologically savvy businesses, political anarchists, and others committed to living "off the grid" and/or relying on renewable sources of electricity. Although the cost of DG is a consideration for such individuals and organizations, the moral or political virtues of DG often outweigh what can be, for the average energy consumer, prohibitively high costs of installing, maintaining, and using DG. These costs, though, are the primary issue for most potential DG users today.[18] Until recently, the prevailing view that clean, on-site energy is more expensive than dirtier kinds of DG, or any CG, was accurate in the absence of significant government subsidies (Niebauer and Funderburk 2002). In fact, the rising cost of CG electricity over the past two years is largely responsible for today's more widespread interest in DG as an economical alternative to conventional sources of electrical power. Yet there are still relatively few energy consumers who might benefit financially by installing DG technologies and using them, as opposed to relying on CG, most of the time.

The most straightforward way to determine the cost-effectiveness of a particular DG technology is to compare the estimated cost of electricity associated with that technology with the retail cost of electricity from the local electric utility. The cost of electricity is the sum of the cost of installing a DG system; the costs of operating and maintaining that system; and the fuel costs, expressed in dollars per kilowatt-hour.[19] While these costs may vary widely by the size and

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[18] Although environmentally conscious consumers have been regarded as among those most likely to adopt clean energy technologies, today's financially savvy and open to change "soccer moms" are rapidly becoming the target of efforts to solicit support for clean DG and renewable energy sources (Green Mountain Energy 2001; Rosoff et al. 2002).

[19] The "California DER Guide" recommends that electricity costs be calculated for specific manufacturer's DG system, at the location where that system will be installed and for the application(s) it will perform. Then, installation costs typically associated with a selected DG system will vary with the cost of financing it, including applicable incentives, as well as with its generating capacity; operating and maintenance

Footnote continued on the next page.

type of DG technology, where that technology is located, and how it is used, DG is generally more economical for "large" commercial and industrial electricity consumers than for "small" residential consumers. Moreover, the time it takes for any cost-of-energy savings to pay for the up-front costs associated with the installation of DG is typically much shorter for commercial and industrial consumers than it is for their residential counterparts. For example, while the energy savings associated with the photovoltaic system installed at Toyota Motor Corporation's new Torrance plant will cover the costs of that energy upgrade in approximately seven years, it could take twice that long for a solar or other distributed source of electricity to pay for itself once installed in the average California home.[20]

Reducing the cost of clean energy is one of the key ways in which regulatory policy has already induced consumers to opt for the most environmentally sound DG. Providing subsidies for those who choose clean DG and easing the permitting process for those DG technologies are obvious and important regulatory initiatives. Yet these measures remain insufficient to support the widespread use of DG as that option becomes necessary as a means to responding adequately to the state's energy demands, or simply more desirable to large numbers of California's residents. What is needed is policy to ensure the development and distribution of more affordable DG, and education to foster a new mindset—one that conceptualizes energy and the natural environment as a single concern.

8.0 Regulating DG Emissions in California

At the federal level, the EPA is authorized under the Clean Air Act to set limits on how much of a criteria pollutant can be emitted, particularly for the larger sources. Yet permits to emit airborne pollutants are actually issued by Air Quality Management Districts (AQMDs), regional bodies that include all or parts of individual states. The permits themselves include information on which pollutants are being emitted, allowable emissions rates, and any efforts, such as air quality monitoring, that responsible individuals and corporations either already are taking or will be required to take. These documents are intended to ensure that air quality regulation at the state level meets federal air quality standards, though a number of states, including California, have established more stringent standards. The procedures for issuing permits within a given state contribute to its SIP or the collection of all those rules and regulations the state has developed to improve air quality within its borders. SIPs are subject to approval by the EPA. In the event that a SIP is deemed unacceptable or an AQMD repeatedly fails to attain

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costs likewise include fixed and variable expenses with using the system as intended; fuel costs refer to the costs of fuel required to generate electricity.

[20]See Vincent 2003. The "California DER Guide" indicates that it simply takes too long for the average residential customer to pay off his or her initial investment in clean DG and begin benefiting from the ultimately reduced costs of these technologies.

federal air quality standards, the EPA or other qualified administrative body can be empowered to enforce the Clean Air Act as necessary.

In California, CalEPA—specifically CARB—parallels the EPA's air pollution control efforts.[21] Like the EPA, it provides advice and guidance to California's AQMDs and Air Pollution Control Districts (APCDs) on power plant permitting and emissions regulations. There are, of course, clear differences between the federal approach to air quality regulation and California's. For example, while the state's air districts regulate small electricity generating units, authority to site larger units (greater than 50MW) has been vested in the Energy Commission. This division of labor conforms with the EPA's current position that state and regional agencies are best positioned to manage the process of developing and implementing DG policy (Bryson, 2000). This is not to say that it will not ultimately be necessary to establish minimum standards for DG at the federal level. In fact, because states, California included, have served as laboratories for the development of new air quality regulations before, it is possible that innovative regulation of DG at the state level now could lead to the desired national regulation in the future.

DG policy in California remains a work in progress. While some air districts have regulated all but the smallest DG units since the 1980s, it is only in the last decade that DG regulation has become routine at the local level in California (see Table 7). The initiative for statewide regulation is just three years old. California's state legislature formally charged CARB to develop emissions standards for DG with the passage of Senate Bill (SB) 1298 in September 2000. SB 1298 requires CARB to adopt uniform emission standards for DG that is exempt from air pollution control or air quality district permit requirements; it also directs CARB to establish a certification program for technologies subject to these standards. While the law stipulates that the standards initially—as of January 1, 2003—reflect the best performance achieved in practice by existing electrical generation technologies that are exempt from district permits, it demands that these standards be made equivalent to the level determined by CARB to be the best available control technology (BACT) for permitted CG as soon as possible. In addition to developing a DG certification program, SB 1298 mandates that CARB issue corollary guidance to the air districts on the permitting or certification of DG that *is* subject to district permits.

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[21]Pursuant to the preceding paragraph, CARB takes responsibility for air quality control in non-compliant air districts, as well as for California's smaller districts, which do not have the resources to regulate air quality themselves.

Table 7. Compilation of District Rules and Regulations for Back-up Generators (BUGS) & Other Distributed Generation (DG)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Amador County APCD *(All of Amador County)*	ICE: < 1,000 bhp	Rule 523.6	6-13-95	- Operate less than 1300 hours in a 12 month period - Use no more than 66,000 gallons of diesel fuel in a 12 month.	Maintain monthly log for operation and fuel use, to be submitted to the APCD at time of permit renewal
Antelope Valley APCD *(Northeast portion of Los Angeles County)*	ICE: > 50 bhp	Rule 1110.2	8-3-90 (9-7-90) (8-12-94) (12-9-94)	NO_X: 36 PPMV ROG[22]: 250 PPMV CO: 2000 PPMV	- Install continuous in-stack NO_X & CO monitoring system - Maintain engine operating log - Test at least once every 12 months
	Boilers: > 2 million Btu < 5 million Btu	Rule 1146.1	10-5-90 (7-10-92) (5-13-94)	NO_X: 30 PPMV [0.037 lb/MMBTU] CO: 400 PPMV	- Submit compliance plan to Executive Officer - Tune twice per year
	Gas turbines: ≥ 0.3 MW	Rule 1134	8-4-89 (12-7-95) (4-11-97) (8-8-97)	NO_X: 25 PPMV	- Maintain gas turbine operating log - Maintain monthly summary of emissions

[22] Reactive Organic Gases – A photochemically reactive gas composed of non-methane hydrocarbons that may contribute to the formation of smog.

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Bay Area AQMD *(Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, western portion of Solano, southern portion of Sonoma Counties)*	All technologies	Reg 2 (NSR)	7-17-91	BACT:	- Maintain records of fuel use and Higher Heating Value - Install non-resettable totalizing meter if applicable
	ICE: > 50 bhp	Reg 9-8	1-20-93 (8-1-01)	NO_X (@ 15% O_2): • RB[23] - 56 PPMV • LB[24] - 140 PPMV CO (@ 15% O_2): 400 PPMV	
	Boilers: > 1 million Btu < 10 million Btu	Reg 9-7	9-16-92 (9-25-93)	NO_X (@3% O_2): • Gaseous fuels- <30 PPMV • Non-Gaseous fuels - <40 PPMV • Comt. – Weighted average of gaseous and non-gaseous fuels CO (@3% O_2): 400 PPMV <u>W/low fuel use:</u> Maintain stack gas concentrations at ≤ 3% by volume on a dry basis, or comply with tune up procedure	

[23] The acronym RB stands for "rich burn," referring to relatively more polluting engines; such engines are routinely permitted when retrofitted with an air-fuel ratio controller and a 3-way catalyst.

[24] The acronym LB stands for "lean burn," to refer to the relatively less polluting, but more costly to control, engines currently available. Lean burn engines have been permitted in recent years through the use of selective catalytic reduction (such as ammonia injection).

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Bay Area AQMD *(Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, western portion of Solano, southern portion of Sonoma Counties)* (Continued)	Gas turbines: > 0.3 MW	Reg 9-9-300	5-03-93 (9-21-94)	Always < 42 PPMV normal, unless testing W/low usage NO_X (@15% O_2): • Gaseous fuels - <42 PPMV • Non-Gaseous fuels - <65 PPMV	Maintain a CEMS[25], alternative monitoring system, or daily gas turbine operating record
Butte County AQMD *(All Of Butte County)*	ICE > 50 bhp	Rule 430 (NSR)	1-12-93	BACT	Maintain records for maintenance and fuel use
		Interim Policy	3-22-01	Meet BACT requirements and install offsets if required	
	All Stationary Combustion Engines			BACT	

[25] Continuous Emissions Monitoring System.

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Colusa County APCD	Boilers: ≥ 5 million Btu	Rule 2-39	1-23-96	NO_X: • Gaseous fuels – 70 PPMV [0.084 lb/MMBTU] • Combined fuels – weighted average of gaseous & non-gaseous fuels • Liquid or solid fuels – 115 PPMV [0.15 lb/MMBTU] CO: 400 PPMV NH_3: 20 PPMV	- Testing and/or tuning at least once every 12 months - Install non-resettable totalizing volumetric or mass flow fuel meter if applicable - Maintain daily and quarterly reports

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
El Dorado County APCD *(All Of El Dorado County)*	ICE: > 50 bhp	Rule 233.3	10-18 -94	NO_X: • RB – 640 PPMV • LB – 740 PPMV • Diesel – 600 PPMV W/retrofit: • RB – 90 PPMV • LB – 150 PPMV • Diesel - 600 PPMV CO: 2000 PPMV	Maintain an inspection log for at least 2 yrs after the date of each entry
	Boilers: ≥ 5 million Btu	Rule 229[26]	(1-23-01)[27]	NO_X: • Gaseous fuels – 30 PPMV [0.036 lb/MMBTU] • Non-gaseous fuels – 40 PPMV [0.052 lb/MMBTU] • Combined fuels – weighted average of both limits	- Install non-resettable totalizing volumetric or mass flow rate meters if applicable. - Maintain weekly records

[26] Rule 232 covers biomass boilers and steam generators.

[27] Although we have double-checked the amendment date; as of this publication we were unable to specify the initial date for this rule.

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Glenn County APCD	Boilers: ≥ 5 million Btu	Article IV Section 100	12-1972 (4-81) (3-88) (1-91) (2-92) (3-93) (11-94) (5-96) (7-8) (5-99)	NO_2: • Gaseous fuels – 70 PPMV [0.084 lb/MMBTU] • Combined fuels – weighted average of both limits • Liquid or Solid fuels – 115 PPMV [0.15 lb/MMBTU] CO: 400 PPMV	- Install non-resettable totalizing volumetric of mass-flow meters if applicable - Maintain daily and monthly records
		Article III Section 51 (NSR)[28]			Select choice of additional permit conditions

[28] Article III Section 51 expands Article IV Section 100 to include New Source Review (NSR.)

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Kern County APCD *(Eastern portion of Kern County)*	ICE: > 50 bhp	Rules[29] 423, 427 (NSR)[30]	6-1-87 (10-13-94) (1-25-96) (7-2-98) (7-1-99)	NO_X: • RB – 50 PPMV • LB – 125 PPMV • Diesel – 600 PPMV CO: 2,000 PPMV	- Maintain monthly engine operation and service log - Test for compliance at least once a year
	Boilers: ≥ 5 million Btu	Rule 525.2	10-13-94 (4-6-95) (7-10-97)	NO_X: • Gaseous fuels – 70 PPMV [0.09 lb/MMBTU] • Liquid fuels – 115 PPMV [0.15 lb/MMBTU] CO: 400 PPMV	Install totalizing mass or volumetric flow rate meter if applicable
	Gas turbines: >10 MW	Rule 425	8-16-93	NO_X: BACT dependent on efficiency of specific equipment and control type	- Submit emissions control plan - Maintain daily operating log - Test for compliance annually

[29] Related Rule 422 covers municipal solid waste burning engines.
[30] Rule 427 expands Rule 423 to include NSR.

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Kern County APCD *(Eastern portion of Kern County)* (Continued)		Rule 425.2	10-13-94 (4-6-95) (7-10-97)	NO_X: • Gaseous fuels – 70 PPMV [0.091 lb/MMBTU] • Liquid fuels – 115 PPMV [0.15 lb/MMBTU] CO: 400 PPMV	- Install totalizing mass or volumetric flow rate meter - Monitor NO_X control system - Maintain operating and pollution control logs - Test annually
Mojave Desert AQMD *(Northern portion of San Bernardino County, eastern portion of Riverside County)*	ICE: > 100 bhp	Rule 1160	12-20-93 (10-26-94)	VOC – 106 PPMV NO_X: • RB – 50 PPMV or 90% reduction • LB – 140 PPMV or 80% reduction • Diesel – 700 PPMV or 30% reduction CO: 4500 PPMV	- Maintain quarterly log of operation and fuel use - Install, operate, and maintain emission controls according to approved plan
	Boilers: > 5 million Btu	Rule 1157	10-26-94 (5-19-97)	Comply with RACT and BACT standards	- Compliance testing every 12 months - Maintain records on operation, fuel usage, and other info. Submit records to AQMD once a year
	Gas turbines: > 0.3 MW	Rule 1159	2-22-95	Comply with NO_X RACT standards	- Emissions testing - Compliance plan

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
North Coast AQMD *(All Of Del Norte, Humboldt, Trinity Counties)*	ICE: > than 50 bhp	Interim Policy	5-18-01	PM[31]: 0.1 g/bhp-hr	Not Specified
Northern Sierra AQMD *(All Of Nevada, Plumas, Sierra Counties)*	ICE: > 1,000 bhp	Rule 526 Applies to standby engines only.	1-10-96	- 50% of major source thresholds for HAPs[32] - 5 tons/year of any one HAP - 12.5 tons/year of any comb. of HAPs 50% of any lesser threshold established by the EPA	Varies with permit

[31] Particlulate Matter

[32] HAPs – Hazardous Air Pollutants

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Placer County APCD	Boilers: > 5 million Btu	Rule 231[33]	8-3-90 (9-7-90) (8-12-94) (12-9-94)	NO_X: • Gaseous fuels – 30 PPMV [0.036 lb/MMBTU] • Non-gaseous fuels– 40 PPMV [0.052 lb/MMBTU] • Combined fuels – weighted average of both limits CO: 400 PPMV	- Install non-resettable volumetric or mass flow fuel meter if applicable - Maintain weekly records
	Gas turbines: ≥ 0.3 MW	Rule 250	10-17-94	NO_X: • Gas – 42 PPMV • Oil- 65 PPMV	- Install calibration equipment if applicable - Maintain daily gas turbine operating log
Sacramento Metro AQMD *(All Of Sacramento County)*	ICE: > 50 bhp	Rule 412	6-01-95	NO_X: • RB – 50 PPMV • LB – 125 PPMV • Compression-ignited – 700 PPMV Emission limits may vary for exempted engines according to engine rating and number of operating hour CO: 4000 PPMV	- Maintain records of operating hours, fuel usage, emissions testing, and maintenance. - Compliance plan.

[33] Related Rule 23 covers biomass boilers.

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Sacramento Metro AQMD *(All Of Sacramento County)* (Continued)	Gas turbines: ≥ 0.3 MW	Rule 413	4-06-95 (5-1-97)	NO_X (@15% O2): • Gaseous fuels – 42 PPMV • Non-gaseous fuels – 65 PPMV Emission limits may vary for exempted engines according to engine rating and number of operating hour	
San Diego County APCD *(All Of San Diego County)*	ICE: > 50 bhp	Rule 69.4	9-27-94 (11-15-00)	Comply with RACT and BACT emission limits	- Maintain operating log and monitor emissions control - Submit annual compliance report
	Boilers: > 5 million Btu	Rule 69.2	9-27-94	NO_X: • Gaseous fuels – 30 PPMV • Liquid fuels – 40 PPMV • Combined fuels – weighted average of both limits CO: 400 PPMV	- Install non-resettable volumetric or mass flow fuel meter if applicable - Maintain operating log - Submit to regular testing
	Gas turbines: ≥ 0.3 MW	Rule 69.3	9-27-94 (12-16-98)	NO_X: • Gaseous fuels – 42 PPMV • Liquid fuels – 65 PPMV	- Maintain operating log - Submit to regular testing

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
San Joaquin County APCD *(All of Fresno, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare, and western portion of Kern Counties)*	ICE: > 50 bhp	Rule 4701	10-20-94 (12-17-92) (10-20-94) (3-16-95) (12-19-96) (11-12-98)	NO_X: • RB – 640 PPMV [9.5 g/bhp-hr] • LB – 740 PPMV [10.1 g/bhp-hr] • Diesel – 700 PPMV [9.6 g/bhp-hr] CO: 2000 PPMV	- Maintain operating records - Test for compliance every 12 months
	Boilers:	Rule 4305[34]	12-16-93 (3-16-95) (12-19-96)	NO_X: • Gaseous fuels– 30 PPMV [0.036 lb/MMBTU] • Liquid fuels – 40 PPMV [0.052 lb/MMBTU]	- Maintain operating records - Test for compliance every 12 months
	Gas turbines: ≥ 0.3 MW	Rule 4703	8-18-94 (3-16-95) (2-15-96) (10-16-97)	NO_X: • Gas – 42 PPMV • Oil – 65 PPMV CO: 200 PPMV	- Install calibration equipment if applicable - Maintain dialing operating log - Test for compliance

[34] Related Rule 4352 covers municipal solid waste and biomass boilers.

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
San Luis Obispo County APCD *(All Of San Luis Obispo County)*	ICE: > 50 bhp	Rule 431	11-13-96	NO_X: • RB – 50 PPMV or 90% reduction • LB – 80 PPMV or 80% reduction • Diesel – 600 PPMV or 30% reduction	- Maintain monthly inspection log for 3 yrs after the date of each entry - Submit annual reports on fuel usage and operation
	Boilers: ≥ 5 million Btu	Rule 430	7-26-95	NO_X: • Gaseous fuels– 30 PPMV (dry @ 3% O_2) or [0.036 lb/MMBTU] • Non-gaseous fuels – 40 PPMV (dry@ 3% O_2) or [0.052 lb/MMBTU] • Combined fuels – weighted average of both limits CO: 400 PPMV (dry @ 3% O_2)	- Maintain monthly operating log - Monitor fuel usage - Submit compliance plan

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Santa Barbara County APCD *(All Of Santa Barbara County)*	ICE: ≥ 100 bhp	Rule 333	12-3-91 (12-10-91) (4-17-97)	@ 15% O_2 NO_X: • RB – 50 PPMV or 90% reduction • LB – 125 PPMV or 80% reduction • Diesel – 797 PPMV ROC[35]: • RB – 250 PPMV • LB – 750 PPMV CO: 4500 PPMV @ 3% O_2 NO_X: • RB - 152 PPMV or 90% reduction • LB - 380 PPMV or 80% reduction • Diesel – 2400 PPMV ROC: • RB – 178 PPMV • LB – 2275 PPMV CO: 13,653 PPMV	- Maintain a monthly operating log for a minimum of 2 yrs after the last entry - Submit compliance plan and source test plans to the APCO

35 ROC is the acronym for "Reactive Organic Compounds."

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Santa Barbara County APCD *(All Of Santa Barbara County)* (Continued)	Boilers: ≥ 5 million Btu	Rule 342	3-10-92 (4-17-97)	NO_X: • Gaseous fuels – 30 PPMV [0.036 lb/MMBTU] • Non-gaseous fuels– 40 PPMV [0.052 lb/MMBTU] • Combined fuels – weighted average of both limits	- Maintain a monthly record log - Test for compliance at least once every 24 months
Shasta County AQMD *(All Of Shasta County)*	ICE: > 50 bhp	Rule 3-28	4-01-97	NO_X (@ 15% O_2): ≤ 300 bhp • RB – 640 PPMV • LB – 740 PPMV • Diesel – 600 PPMV > 300 bhp • RB - 90 PPMV • LB -150 PPMV • Diesel – 600 PPMV CO: 4500 PPMV	- Maintain operating log and record of fuel use, maintenance and emissions testing - Emission tests annually
	Boilers: ≥ 5 million Btu	Rule 3-26	6-06-95 (12-5-95)	NO_X (@ 15% O2): • Gaseous fuels – 0.084 lbs/MMBTU (70 PPMV) • Liquid or solid fuels – 0.15 lbs/MMBTU (115PPMV) • Combined fuels – weighted measure	Install non-resettable totalizing volumetric or mass flow meter for record keeping

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
South Coast AQMD *(Los Angeles County except for Antelope Valley APCD, Orange County western portion of San Bernardino and western portion of Riverside Counties)*	ICE: > 50 bhp	Rule 1110	10-26-84 (10-4-85)	NO_X: • Standby – 6.9 gr/bhp or less • RB – not to exceed 90 PPMV and ultimate 80% reduction. • LB – not to exceed 150 PPMV and ultimate 70% reduction	- Install CEMS as required - Maintain record of operating times, fuel usage, and testing
	Boilers: ≥ 5 million Btu	Rule 1146	9-09-88 (1-6-89) (5-13-94) (6-16-00) (11-17-00)	NO_X: 30 PPMV [0.037 lb/MMBTU] CO: 400 PPMV	- Submit compliance plan to APCO - Install totalizing fuel meter if applicable
	Gas turbines: ≥ 0.3 MW	Rule 1134	8-04-89 (10-10-95) (6-12-01)	NO_X: 25 PPMV	- Maintain operating log - Submit monthly emissions summary to AQMD

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Tehama County APCD *(All Of Tehama County)*	ICE: > 50 bhp	Rule 4.34	6-3-97 (1-29-02)	≤300bhp NO_X: • RB – 640 PPMV • LB – 740 PPMV • Diesel & Liquid fired – 600 PPMV CO: 4500 PPMV >300bhp NO_X: • RB – 90 PPMV • LB – 150 PPMV • Diesel & Liquid fired – 600 PPMV CO: 4500 PPMV	Maintain records of operation, fuel usage, maintenance and emissions testing
	Boilers: ≥ 5 million Btu	Rule 4.31	3-14-95 (1-29-02)	NO_X: • Gaseous fuels – 70 PPMV [0.084 lb/MMBTU] • Liquid or Solid fuels– 115 PPMV [0.15 lb/MMBTU] • Combined fuels – weighted average of both limits CO: 400 PPMV	Maintain records of operation, fuel usage, maintenance and emissions testing

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Tehama County APCD *(All Of Tehama County)* (continued)	Gas turbines: ≥ 0.3 MW	Rule 4.37	4-21-98 (1-29-02)	NO_X: • Gas – 42 PPMV • Oil – 65 PPMV	- Install calibration equipment - Maintain records of operation, fuel usage, maintenance and emissions testing - Test for compliance annually
Ventura County APCD *(All Of Ventura County)*	ICE: > 50 bhp	Rule 74.9	7-21-81 (7-2-85) (9-5-89) (12-3-9) (12-21-93) (11-14-00)	NO_X: • RB – 25 PPMV or 96% reduction. • LB – 45 PPMV r 94% reduction. • Diesel – 80 PPMV or 90% reduction. ROC: • RB – 250 PPMV • LB – 750PPMV • Diesel – 750 PPMV CO: 4500 PPMV	Maintain inspection log for 2 yrs after date of each entry
	Boilers: > 5 million Btu	Rule 74.15	3-28-89 (12-3-91) (11-8-94)	NO_X: 30 PPMV CO: 400 PPMV	- Install totalizing fuel meter - Verify compliance every 12 months - Maintain records for 4 yrs

Table 7. (continued)

District	Unit Description	Rule Number	Adoption (Amend) Date(s)	Regulation	Implementation/ Compliance
Ventura County APCD *(All Of Ventura County)* (Continued)	Gas turbines: ≥ 0.3 MW	Rule 74.23	3-14-95 (10-10-95) (6-12-01)	NO_X: • Gaseous fuels – 42 PPMV • Liquid fuels – 65 PPMV	- Install calibration equipment - Install non-resettable totalizing hour meter - Maintain records
		Rule 26.2 (NSR)	10-22-91 (2-13-96) (1-13-98)	BACT for ROC, NO_X, PM10, and SO_x	
Yolo-Solano AQMD *(All Of Yolo And Eastern Portion Of Solano Counties)*	ICE: > 50 bhp	Rule 2-32	8-10-94	NO_X: • RB – 640 PPMV [9.5 g/bhp-hr] • LB – 740 PPMV [10.1 g/bhp-hr] CO: 2000 PPMV	Maintain operating and inspection log
	Boilers: ≥ 5 million Btu	Rule 2-27	10-27-93 (8-14-96)	NO_X: • Gaseous fuels – 30 PPMV [0.036 lb/MMBTU] • Non-gaseous fuels– 40 PPMV [0.052 lb/MMBTU] • Combined fuels– weighted average of both limits CO: 400 PPMV	Maintain weekly records
	Gas turbines: ≥ 0.3 MW	Rule 2-34	7-13-94	NO_X: • Gas – 42 PPMV • Oil – 65 PPMV	- Install calibration equipment - Maintain daily operating and fuel usage records

In response to SB1298, CARB has duly adopted a DG certification program and proposed guidance for the permitting of electrical generating technologies, including DG. The certification program includes emission standards for new DG units that take effect in 2003 and 2007 (older technologies, which may need to be modified in order to run legally, will continue to be regulated according to existing air district polices). These standards, which are reproduced in Table 8 and Table 9,[36] notably provide credit for the use of combined heat and power (CHP). This creates the nexus for both improving air quality and lowering the demand for limited fossil fuel supplies.

Table 8. January 1, 2003 DG Emission Standards (lb/MW-hr)

Pollutant	DG Unit w/o CHP	DG Unit integrated with CHP
NO_x	0.5	0.7
CO	6.0	6.0
VOC	1.0	1.0
PM	An emission limit corresponding to natural gas with fuel sulfur content of no more than 1 grain/100scf	An emission limit corresponding to natural gas with fuel sulfur content of no more than 1 grain/100scf

Table 9. January 1, 2007 DG Emission Standards (lb/MW-hr)

Pollutant	Emission Standard
NO_x	0.07
CO	0.10
VOC	0.02
PM	An emission limit corresponding to natural gas with fuel sulfur content of no more than 1 grain/100scf

Currently, DG and related technologies that are permitted for use only in emergencies (specifically, when electrical or natural gas service fails; for emergency pumping of water for fire protection; or for flood relief) are exempt from the certification program. Until the program

[36]The source for Table 8 and Table 9 is California Air Resources Board 2002.

is extended to cover these technologies, they will continue to be regulated pursuant to local air district rules as outlined in Table 7.

In summary, it is interesting to note that 22, or 63 percent, of California's local air districts have already adopted regulations covering DG defined as small, stationary sources of electrical power that are intended to run on a regular basis and serve nearby residential or commercial areas; most of these are conventional internal combustion engines.[37] Table 7 outlines these district rules. Because the districts that do have DG regulations in place developed them either prior to, or simultaneously with, CARB's DG initiative, it is not surprising that the existing DG regulatory regime at the district level is not yet consistent with the new, statewide DG certification program. While we expect this situation to change over time as air district regulation of DG becomes more stringent in accordance with CARB's program, it is problematic in the short term for at least the following three reasons:

- Unless it is new, the smallest DG, which would include the 10-15 kW generators residential and small business owners are purchasing as a means to ensure electricity supply and control electricity costs, remain under-regulated (see Dulley 2002).
- In many cases, the regulation of NOx and CO are emphasized, even though PM and other air pollutants have been identified as significant sources of respiratory disease in those regions of the state most vulnerable to air pollution (see, for instance, Moore and Bates 2001).
- The implementation process is inconsistent among the districts—ranging from non-existent, to record keeping, to periodic testing—and the extent to which it is monitored remains unclear.

Unlike the regulation of criteria pollutants, emissions associated with global climate change are rarely controlled at all by state or local agencies. In fact, California is thus far the only state that has ordered the reduction of emissions of GHG.[38] With this exception, climate change regulation, like energy efficiency, more generally, is currently and by default governed by the Department of Energy (DOE) as well as the EPA at the federal level, and by "energy commissions" at the state level. Consequently, GHG are practically unregulated. Thus an added bonus of policies intended to foster DG that is capable of increasing energy efficiency *and* improving air quality would be the indirect regulation of GHG.

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[37] These are: Amador Count APCD, Antelope Valley APCD, Bay Area AQMD, Butte County AQMD, Colusa County APCD, El Dorado County APCD, Glen County APCD, Kern County APCD, Mojave Desert AQMD, North Coast AQMD, Northern Sierra AQMD, Placer County APCD, Sacramento Metro AQMD, San Diego County APCD, San Luis Obispo County APCD, Santa Barbara County APCD, Shasta County AQMD, South Coast AQMD, Tehama County APCD, Ventura County APCD, and Yolo-Solano AQMD.

[38] AB 1493 directs the California Air Resources Board (CARB) to develop a plan for reducing the emissions of carbon dioxide and other gases that contribute to global warming from motor vehicles by January 2005, which will be put into effect for the 2009 model year. Signed into California state law in July 2002, AB 1493 has been heralded as the first U.S. law intended to reduce greenhouse gases.

9.0 DG and California's Electric Utility System

In contrast to air pollution control, which is clearly situated within a federal regulatory structure, energy policy is primarily within the state's jurisdiction. In light of California's distinction as the world's fifth largest consumer of energy, the state legislature created the Energy Resources Conservation and Development Commission--more commonly known as the California Energy Commission (Energy Commission). The Energy Commission's mandate and organized activities have increasingly included the incorporation of DG into California's electric utility system.

Since 1978, the federal government's Public Utility Regulatory Protection Act (PURPA) has supported the Energy Commission's commitment to identifying the appropriate role for small sources of electricity, such as DG, in California, and facilitating its technological and economic success by encouraging reliance on renewable sources of electricity and ownership of electric generating technologies and facilities by independent operators, and constraining public utilities to purchase power from them on long-term contracts (Williams 1997). By the 1990s, California's public utilities had also invested in DG research and development programs and initiated demonstration projects, including Pacific Gas & Electric's (PG &E's) use of solar photovoltaics to enhance grid stability. Their vision at that time reflected current technical and academic models for an electric utility system that includes both CG and mass-produced DG to reduce peak demand, strengthen voltage stability, help avoid line losses, and improve customer relations (California Energy Commission 2002a; see also Burch 2002; Samuelsen 2002; Schaffhauser 2002). However, the advent of electric power restructuring significantly reduced the involvement of utilities in the movement to increase the state's reliance on DG as a source of electrical power. Two legislative endeavors administered by the Energy Commission—the Renewables Program and the Public Interest Energy Research Program (PIER)—have ensured ongoing support for research on and testing of DG.

The Energy Commission was also instrumental in the creation of the California Alliance for Distributed Energy Resources (CADER), which encouraged the California Public Utilities Commission (CPUC), which is responsible for regulating privately owned electric companies, to begin rule-making on DG in 1998. Since then, the CPUC, in collaboration with the Energy Commission, has been responsible for resolving a number of regulatory issues related to DG, including: establishing standard interconnection rules, incentive programs for "self-generation," net metering programs, and policy for stand-by rates (California Energy Commission 2002a).

The foregoing research and development efforts and regulatory activity provide the backdrop for recent recommendations by the Energy Commission's Environmental and Energy Infrastructure and Licensing Committee concerning the development of policy for deploying DG in the state. The Energy Commission's Distributed Generation Strategic Plan is a product of this committee's work and is intended to establish the Commission's role in accommodating a greater role for DG in California, and to guide its coordination of DG-related activities in the state. The plan articulates the Energy Commission's vision of the future for DG, identifies the issues and opportunities related to making that vision a reality, and evaluates the role that government can play in this process (California Energy Commission 2002a, 6). According to this detailed and informative report, the development of DG regulatory policy is integral not only to the efficient, environmentally sound, and affordable integration of DG into California's electric utility system, but also to the state's intention to develop business opportunities and provide a wide variety of energy options for its residents.

The Energy Commission plan emphasizes the importance of activating regulation at the federal, state, and local levels of government (California Energy Commission 2002a, 21). While the application and regulation of DG in California is consistent with the Department of Energy's (DOE's) Distributed Energy Resource Strategic Plan, there remains a great deal of opportunity for regulatory innovation at lower levels of government. Most importantly, in our opinion, state agencies must sustain their commitment to stringent air quality standards for DG technologies; consider DG in the course of land use planning; and incorporate optimal uses for DG in building permit processes (see California Energy Commission 2002a, 18). We also recognize the significant role that local government can play by sponsoring demonstration projects and using the potential energy and cost savings associated with wise DG use to lure businesses and thereby improve the economic welfare of city and county residents (see California Energy Commission 2002a, 20).

The ENERGY COMMISSION plan also, notably, recognizes the gravity of raising consumer awareness about DG. It discusses the Energy Commission DG web page—http://www.energy.ca.gov/disgen/index.html—which is intended to provide the public with information about DG technologies, applications, and programs (California Energy Commission 2002a, 28). In addition, the plan indicates a need for consumer education, perhaps in the form of programs targeted at specific audiences, such as homebuilders, agencies, and select communities (California Energy Commission 2002a, 29; see also Nimmons and Associates, Inc. 2001). While we appreciate this insight, we indicate below that successful DG regulatory policy will also and ultimately require greater attention to environmental education as a more general means of informing residents about their relationship to the earth, and transforming the way they make decisions, such as purchasing a small engines, that could significantly impact the natural environment.

10.0 Integrating Energy, Environment, and Economics

Issues surrounding DG users' interconnecting with the grid are largely outside of this report. Yet current debate over the costs related to interconnection provide a way into thinking about how energy and air quality regulations are related and can be used to foster the adoption of environmentally benign, or even beneficial, DG in California. Specifically, SB1038, signed into law on September 12, 2002 as part of an omnibus renewable-energy legislative package adds a section to the Public Utilities Code that permits the CPUC to consider energy efficiency and emissions performance when establishing rates and fees for DG.[39] This change was intended to

[39]Public Utilities Code Section 353.2(b).

encourage early compliance with the emissions standards established for DG in California by CARB. Now technologies that meet "ultra clean" emissions standards and other low-emissions DG can rightfully expect lower fees than their competitors (Niebauer and Funderburk 2002). At issue, therefore, are: the differential fees charged to energy consumers, such as DG owners and operators, who purchase all, some, or none of their electricity from the grid; the possibility that those consumers who rely on clean sources of electricity may be exempted from such fees; and the rules that will govern any fee exemptions.

10.1. The CPUC[40]

The CPUC's responsibilities include regulating privately owned telecommunications, electric, natural gas, water, railroad, rail transit, and passenger transportation companies. The CPUC is also liable for guaranteeing safe, reliable utility service at reasonable rates for California's utility customers, protecting these customers from fraud, and supporting the state's economy. It fulfills these responsibilities by establishing service standards and safety rules; authorizing utility rate changes; monitoring the safety of utility and transportation operations; and overseeing markets. In addition, it prosecutes unlawful utility marketing and billing activities; governs business relationships between utilities and their affiliates; and resolves complaints by customers against utilities. The CPUC also plays a role in implementing state and federal energy efficiency and environmental agendas—including California's energy efficiency programs and the California Environmental Quality Act (CEQA).[41]

With respect to the state's electricity market, the CPUC currently serves 10.2 million Californians by regulating 33,347 miles of transmission lines and 162,768 miles of distribution lines with a total economic value of $17.8 billion.[42] While most of these electricity customers rely exclusively on CG, 161 megawatts of DG were deployed by the start of 2001, and more than 230 megawatts of DG are now under consideration for interconnection by Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Edison (SCE) (Tomashevsky 2002). The upshot of this transformation of the market is that increasing numbers of utility customers have alternative sources of electrical power, which portends a significant revenue loss for California's utilities. Therein lies the problem. The CPUC is legally authorized to recoup some portion of the financial losses—or "stranded costs"—associated with

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[40] The CPUC was initially established as the Railroad Commission by Constitutional Amendment in 1911. A year later, the California Legislature passed the Public Utilities Act, which expanded the regulatory authority of the Railroad Commission to include natural gas, electric, telephone, water, railroad, and marine transportation companies. It was renamed the CPUC in 1946.

[41] CEQA is designed to develop and maintain a high-quality environment by requiring California's public agencies to: 1) identify any significant environmental impacts of their actions; and, where feasible, either 2) avoid those impacts entirely; or 3) mitigate them. In the event that significant effects are likely, agencies are required to provide an Environmental Impact Report (EIR). The EIR provides State and local agencies and the general public with detailed information on the potentially significant environmental impacts which a proposed project is likely to have; lists ways in which those effects may be minimized; and indicates alternatives to the project.

[42] www.cpuc.ca.gov/static/industry/electric/index.htm

AB 1890's restructuring of the state's electricity market.[43] The onset of the recent energy crisis and associated, emergency purchases of expensive electricity are the bases for the CPUC's ongoing efforts to recover these and other exceptional costs.

10.2. The CPUC and the California Energy Crisis

As a result of record high demand for electricity relative to supply, in May 2000, the wholesale price of electricity increased radically in comparison to previous years, to levels far higher than the cost of producing electricity. Seven months later, the Federal Energy Regulatory Commission (FERC) eliminated wholesale price caps, which had previously restricted the prices competitive generators, brokers, and marketers were able to charge utilities for electricity. Consequently, prices increased even further. Then, because AB 1890 restricts their authority to raise customer rates to cover their rising costs of purchasing electricity, both PG&E and SCE accumulated excessively high debts during this period while they struggled to pay for enough electricity to meet their customers' needs.[44]

In response to the utilities' financial difficulties and faced with the possibility of rolling blackouts, Governor Davis declared a State of Emergency in January 2001, and thereby ordered the California Department of Water Resources (DWR) to purchase power for the utilities to guarantee reliable electricity service for the states' residents and businesses.[45] Less than a month later, he, furthermore, authorized the DWR to enter into long-term contracts to ensure the state's electricity supply and directed the PUC to suspend customers' ability to purchase electricity from Electric Service Providers (ESPs), which competed with the utilities.[46] In

[43] AB 1890, passed into law on September 23, 1996, provides legislative guidance pursuant to restructuring California's electric utility system. Stranded costs refer to the difference between the present value of the amount not being charged to a customer who no longer relies on electricity generated by a utility and the costs avoided by not generating that electricity, plus the ongoing charges for any (transmission and distribution) services provided for the customer.

[44]Note that SDG&E escaped this fate because it had, by July 1999, already met the requirements for the rate freeze imposed by AB 1890; however, just over a year later, the legislature moved to cap the electricity costs passed on SDG&E customers at 6.5 cents per kilowatt hour through 2002, at least.

[45] Davis's Proclamation, dated January 17, 2001, specifically orders the DWR to: enter into contracts and arrangements for the purchase and sale of electric owner with public and private entities and individuals as may be necessary to assist in mitigating the effects of this emergency. The Department is herby directed to enter into these contracts as expeditiously as possible and is hereby authorized to do so notwithstanding the provisions of the Government Code and Public Contract Code applicable to state contracts.

[46]Davis signed SB 7 X into law two days after proclaiming a state of emergency, thereby permitting the DWR to purchase electricity as short-term measure. On February 1, 2001, he signed AB 1 X into law; this legislation provides long-term authorization for the DWP to buy and sell electricity on behalf of PG&E, SDG&E, and SCE. It also requires the CPUC to establish rates sufficient to repay the DWR for its purchases, and limits any rate increases for residential customers that may be necessary to do so. As per decision D01-09-060, Most electricity customers have been unable to purchase power from ESPs since September 2001.

conjunction with these measures, Davis also ordered that air and water quality regulations for power plants be waived under certain conditions, and spent millions of dollars to support energy efficiency and conservation programs.[47] Despite such efforts to generate more electricity within California—albeit with some known cost to air quality—and decrease customers' demand for the power available, the DWP still found it necessary to borrow more than $10 billion from the state's General Fund and independent investors, and issue $10 billion of Bonds, to purchase enough electricity to supply utility customers with electricity.[48]

AB 1 X, the legislation which authorized the DWR to purchase electricity on behalf of PG&E, SDG&E, and SCE also stipulates that these utilities and their customers are beholden to repay the funds allocated for these purchases. The CPUC duly increased electricity rates in 2001; however, the revenue generated from these increases has so far been insufficient to cover the DWR's electricity expenditures.[49] As such, the question remains: Who will ultimately pay? Electricity users or the utilities? (Niebauer and Funderburk 2002). Despite opposition from informed observers, analysts, and even some Commissioners, the CPUC has moved to increase electricity rates and impose additional "cost responsibility" surcharges[50] as necessary to compensate the DWR for its costs of "procuring and delivering power, and paying bond principal and interest."[51] The CPUC has approached the problem of establishing such rates by distinguishing between customers who subscribe to "bundled," service, or purchase their electricity from a public utility, and those who do not under the proceedings related to "direct access/departing load" (DA/DL). While customers who purchase bundled service from a utility pay an electricity charge to cover that utility's power supply costs, "direct access" customers purchase electricity from an ESP, and pay their utility for distribution and transmission services, plus a fee for exiting bundled service.[52] DG customers, or those who generate their power on-site, either in parallel with the electricity utility or alone, pay a "departing load" surcharge, or "exit fee," to the utility.[53]

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[47] Executive Orders (Eos) D-22-01, D-24-01, D-25-01, D-26-01, D-28-01, and D-40-01, signed between February 8 and June 11 2001 pertain to waivers for air and water quality regulations; Eos D-15-01, D-16-01, D-18-01, D-19-01, D-30-01, D-33-01, D-34-01, D-36-01, and D-39-01, signed between August 2, 2000 and June 8, 2001 are relevant to energy efficiency and conservation in the interest of assuaging the energy crisis.

[48]Decision 02-02-051, February 21, 2002. A portion of the revenue raised from issuing bonds was intended to repay the State's General Fund.

[49] Indeed, PG&E was even forced to file Chapter 11 Bankruptcy in April 2001.

[50] Define cost responsibility surcharges.

[51] See Decision D 02-02-051.

[52] See Decision D 01-09-060.

[53] "Departing load" includes the portion of a utility customer's electric load for which that customer: 1) discontinues or reduces its purchase of bundled service from the utility; 2) purchases or consumes electricity supplied and delivered by DG, and 3) is physically located within the utility's service territory when the ultimate decision on this matter by the Energy Commission becomes effective (Peevey and Kennedy 2003). Note that Peevey and Kennedy (2003) uses the terms "customer generation" instead of DG to refer to cogeneration, renewable technologies, or any other type of generation that (a) is dedicated

Footnote continued on the next page.

Although a specific surcharge for departing load customers has not yet been established, direct access customers currently face exit fees up to 2.7 cents per kilowatt-hour.[54] Thus, a key concern for existing and potential DG users, manufacturers of clean DG technologies, environmentalists, and others committed to supporting only the cleanest new sources of DG, in particular, is that the exit fees ultimately charged to departing load customers could push the cost of power from DG higher than it is for direct access. Critics of the CPUC's decision charge that by covering utilities' stranded costs, raising revenue for the DWP, and compensating for other financial errors associated with electric restructuring such exit fees are "discriminatory, unreasonable," (*Restructuring Today*) and likely to render customers' choice of alternative sources of electrical power uneconomical (Niebauer and Funderburk 2002). Certainly, compelling *all* DG customers to pay exit fees conflicts with long-term commitments by the CPUC and other state agencies to encourage the adoption of clean DG. The CPUC has consequently adopted a short-term exemption for small DG technologies that meet "ultra clean" emissions standards, and other low emissions DG.[55] This move arguably compensates DG customers for their contributions to improved air quality and public health, which would range between 0.1 and 0.2 cents per kilowatt-hour for solar- or wind-generated electricity.[56]

The Energy Commission notably has provided support for the exemption of clean DG from exit fees on the basis of both public policy, which has, historically, created and supported incentives for DG that does not harm the environment, and enhances grid capacity during periods of peak demand, and precedent (Tomashevsky 2002). For example, AB 970 establishes programs designed to "reduce or remove constraints on the state's existing electricity transmission or distribution system," and permits exemptions for stranded costs associated with AB 1890.[57] Such statutes essentially recognize that it can be expensive to adopt clean sources of electricity,

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wholly or in part to serve a specific customer's load; and (b) relies on non-utility or dedicated utility distribution wires rather than the utility grid, to serve the customer, the customer's affiliates and/or tenants, and/or not more than two other persons or corporations (2-3) located either on-site or adjacent to the property where the generator itself is located.

[54] Decision D 01-09-060 set exit fees for direct access customers at up to two cents per kilowatt-hour; according to *Restructuring Today*, the CPUC later voted to impose a 2.7-cent per kilowatt-hour exit fee for large users, effective from February 1, 2001.

[55]Niebauer and Funderburk 2002, Peevey and Kennedy 2003. The exemption adopted April 3, 2003 is summarized in the CPUC's DA/DL proceedings R 02-01-011.

[56]This result presumes that reducing VOC, nitrogen oxide, and particulate emissions to ambient air quality standards would likewise reduce public health costs attributable to air pollution by $5 - $10 billion in the South Coast air basin alone (Hall 1989). Because even the cleanest alternatives to solar and wind DG have some emissions, the financial contributions of such technologies would be marginally less.

[57]In addition to a number of programs administered by state agencies to promote renewable energy, Tomashevsky (2002) also references: AB 1890, which generally reflects California's commitment to "developing diverse, environmentally sensitive electricity resources; SB 1345 creates a program to further the adoption of the cleanest DG, while simultaneously improving the reliability of electrical service; and the Public Utilities Code, which allows exemptions from surcharges for co-generation customers in support of the Energy Commission's position.

including DG, and the state is committed to providing the financial incentives necessary to do so. That said, the Energy Commission recommendation is that only those DG units that are both environmentally responsible and available to provide grid support should be considered for exemption. Environmental and other disgruntled organizations, including the Center for Energy Efficiency and Renewable Technologies (CEERT),[58] have joined the Energy Commission in supporting these conditions on exit fee exemptions. This position is, furthermore, consistent with the recent CPUC decision, PG&E, and other parties who have registered support for exit fee exemptions for clean and/or efficient DG insofar as the benefits associated with encouraging the use of such technologies outweighs the additional costs that other electricity consumers would consequently have to pay (Peevey and Kennedy 2003).

This increasingly popular approach, though, begs the question of what we mean by "clean" DG. According to the CPUC and the Energy Commission, CARB's emissions standards for DG certification in 2003 are most appropriate for identifying DG that is eligible for exemption. Even though this standard is less stringent than the Best Available Control Technology (BACT) for CG, the argument is that DG exempted for assisting the grid during peak demand periods should be compared to the lower efficiency, more polluting power plants that operate only at peak demand periods (Tomashevsky 2002). Exemption-eligible DG must also qualify for a Energy Commission or CPUC incentive program.

This route for establishing eligibility for reduced or exempted exit fees is problematic because any restriction on the ability of the cleanest and most efficient DG to compete economically could compromise the state's clean air goals. More specifically, unless at least several hundred megawatts of DG that meets CARB's emissions standards for DG certification in 2007 are installed by that agency's scheduled technology review in 2005, DG emissions standards could be weakened (CARB 2002). According to the South Coast AQMD (Wallerstein 2002), this potential for regressive air quality regulation demands a more stringent standard for qualifying DG technologies for exit fee exemptions—a position supported by Bill Funderburk, General Counsel and Vice President of Risk Management, Emergent Energy Group, Inc., and other developers and financers of renewable energy and DG. These individuals and organizations

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[58]CEERT has worked with the California Air Resources Board (CARB) and overseeing a diverse coalition of environmental and public health groups working to help define emissions standards for distributed generation. The members of this coalition, the California Clean Distributed Generation Campaign Group, include the American Lung Association of California, Physicians for Social Responsibility, Natural Resources Defense Council, Sierra Club, Environmental Defense, Planning and Conservation League, and Latino Issues Forum.

suggest an alternative standard that would reflect the Public Utility Code's current definition of "ultra clean" electric generation technologies.[59] Ultra clean technologies that meet or exceed the CARB requirements for DG certification in 2007 include solar, wind, fuel cell, and certain combustion technologies with catalysts (Niebauer and Funderburk 2002). The intuition behind this basis for determining exit fees for departing load customers is that the 2007 emissions standards would be technology forcing. This is precisely the policy approach we advocate in the following section.

11.0 The Manufacturer-Based Regulatory Approach

Given the necessity established in the preceding sections to match federal and regional air quality standards with the state's intent to foster an electric utility system that includes efficient, environmentally sound, and affordable DG, we argue that a manufacturer-based regulatory approach like that used to improve the energy efficiency of appliances and automobiles would be highly desirable. If this approach could be modified to require, or at least strongly encourage, heat recovery, it is likely to be at least as successful as it has been for architectural paints and many appliances as well as for automobiles (Lents et al., 2000). Given the success of the automobile program, in particular, the manufacturer-based regulatory approach we advocate would consist of the following six elements:

Set meaningful air pollution emission standards to provide protection from inappropriate air quality degradation at the urban, regional, and global levels.

In the past, automobile and architectural paint standards have had to be technology forcing to provide the needed benefits. This may also be true for DG. Typically, in the case of technology-forcing regulations, a certain amount of time is allowed to reach the defined standards.

As discussed above and incorporated into CARB's certification program, existing air quality emissions standards applicable to DG will demand that DG become at least as efficient and clean as gas-fired combined-cycle CG. Thus, to insure minimal air quality degradation, DG units should perform in a manner comparable to that means of electricity production. (The exceptions would be those cases that use waste gas that is not otherwise used productively, or that has significant heat recovery that replaces otherwise heavily polluting processes.) Unfortunately, the proposed manufacturer-based regulatory approach has no ability to foresee the fuel source or waste heat recovery realized by a DG unit as it is being manufactured. One way to address this problem is to set DG standards to be equivalent to or surpassing the energy

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[59]According to Public Utility Code, Section 353.2 (a), ultra clean DG would include those distributed electricity generating technologies that begin operation between January 1, 2003 and December 31, 2005 and produce either zero emissions or emissions that are equal or less than the CARB requirements for DG certification in 2007, except that combustion technologies must operate in a high efficiency, combined heat and power application.

efficiencies and pollution reductions achieved by combined cycle CG, but allow the local permitting agency the ability to credit emission offsets from waste fuel and heat recovery such that non-complying DG can be used in these special cases.

Due to the high cost associated with those DG technologies that are best able to compete with combined cycle CG in terms of energy efficiency and pollution control, there are three basic options available for regulating DG in accordance with the policy position advocated here. Perhaps the most obvious tack would be to provide the financing, such as funding from the CPUC's Self Generation Incentive Program, necessary for clean DG to compete with less efficient and/or more polluting DG as well as CG in the energy market place. A second possibility would be to establish stricter standards, comparable to those applicable to combined cycle CG, that would prevent a given DG technology from entering the market until it is able to meet them. The problem with this approach is that DG manufacturers and potential electricity providers may not be willing to invest in cleaner, yet not salable, DG. The final approach considered here would entail establishing future standards that are appropriately strict, but allowing some less efficient and more polluting DG to be marketed in the short term, so long as environmental quality and public health are not significantly impaired. With the exception of diesel and gasoline ICEs, the types of DG that are available now, for instance, are unlikely to be problematic until and unless sales increase markedly. Given this caveat, an important advantage of this approach would be a profit stream that, combined with increasingly stringent standards for certification, could serve as a basis for DG manufacturers and electrical power providers to invest increasingly in environmentally beneficial DG.[60] The kilowatt-hours of DG generation that could be implemented with existing permissible emission rates, while keeping the emissions per day per square mile of particulate and ozone at 0.1%[61] of the current South Coast Air Basin emissions density, are indicated in Table 10[62]

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[60]The catch is that in the absence of attention to taking less efficient and "dirtier" DG units out of operation, DG owners can continue to generate bargain-basement electricity that subjects society to air pollution and often also ill health.

[61] 0.1 percent was selected as a level of air pollution impact that might be considered insignificant in the case of the introduction of an important technology that could, in the long run offer overall environmental improvement. In reality, many non-attainment areas must put considerable effort into adopting a rule or rules to gain a 0.1-percent reduction in overall emissions. Thus, it could easily be argued that the suggested increment is too large.

[62] The 1997 South Coast Air Quality Management Plan annualized daily emissions of CO, VOC, NO_x, SO_x, and PM2.5 were used for this analysis. These emissions are presented in the plan on a daily basis over the whole Basin. To determine the average emissions density in the Basin, the plan emissions were divided by South Coast Basin size (6800 square miles) to produce average emissions per square mile per day in the South Coast Air Basin. Because the South Coast Air Basin has some of the nation's worse air quality, the emissions density for this region was thought to represent a level that should be avoided. DG units were compared to this value with the intent of keeping DG emissions from increasing emission densities by more than 0.1 percent of the South Coast emission density.

Table 10. Estimation of Kilowatt Hours per Day That Could be Produced in the South Coast Air Basin and Keep Emission Increases Less Than 0.1 percent of Year 2000 Basin Emissions

DG Unit	Electrical Generation Limit for Particulate Index (kilowatt hours/day/square mile)	Electrical Generation Limit for Ozone Index (kilowatt hours/day/square mile)
Micro-Turbine	308	363
ATS	395	467
Conventional Turbine	340	418
Gas Powered ICE	37	108
Diesel ICE	21	28
PEM Fuel Cell	1053	598
Direct Fuel Cell	Unlimited	Unlimited

As can be seen in Table 10, 300-400 kilowatt hours per day per square mile can be generated using existing DG emission rates without increasing emissions in the South Coast Air Basin by more than 0.1 percent in the case of micro-turbines, advanced turbines, and conventional turbines. Internal combustion engines using gas or diesel would have to be severely limited under this approach, while a PEM fuel cell could go as high as 600 kilowatt hours per square mile per day. If 0.1percent is considered too high, then the values in Table 10 can be proportionally reduced to reflect a lower level. If a decreasing emissions limit over time is preferred, it should be recognized that significant technological advances have been realized in two- to five-year increments (Lents et al., 2000).

An important question related to Table 10 is: How many DG units might be accommodated under such a limitation? The answer will, of course, depend upon the average size of the DG units that are installed and the hours that they are operated each day. Some DG will be used to supply general power, some for peak shaving to reduce costs, and some to increase power reliability. A range in the number of DG units delivering 20 kilowatts while operating that might be accommodated in Los Angeles (the South Coast Air Basin), and meet the limits outlined in Table 10, are suggested by Table 11. As can be seen in Table 11, the number of units that could be put into place in this scenario is quite limited if they are to be used 24 hours per day. If they are used only for peak shaving or during times of stress on the electrical system, more units might be accommodated without exceeding the 0.1 percent guideline.

Table 11. Estimation of Number of DG Units That Could be Accommodated in Los Angeles and Keep Emissions Increases to De Minimum Levels

DG Unit	Used 24 Hours per Day	Used 3 Hours per Day
Micro-Turbine	4363	34907
ATS	5596	44767
Conventional Turbine	4817	38533
Gas Powered ICE	524	4193
Diesel ICE	298	2380
PEM Fuel Cell	8472	67773
Direct Fuel Cell	Unlimited	Unlimited

Develop an effective certification system to assure that the manufacturing process produces DG units that comply with emission standards at the point of sale and have a high probability of continuing to meet standards in use.

While this proposed requirement has been problematic in the automobile industry, where cars have historically been found to pollute in use at two or three times the certification levels, water heaters and paints remained closer to certification standards in actual use. We anticipate that this more promising generalization will prove true as well for DG certification. Recent discussions with air quality regulators in Southern California indicate that DG manufacturers and distributors typically have effective working relationships with air district representatives, and serve as valuable sources of information about emissions standards and the permitting process for DG consumers. In light of these regulatory relationships and knowledge base, it is likely that DG technologies will increasingly satisfy CARB's requirements for certification, or comply with air district permitting rules, as appropriate.

Of course, certification requires the establishment of a testing protocol for DG units that includes a way to test unit degradation over time. A process that has worked in the past involves bringing together a representative advisory group of manufacturers, potential regulators, and a research group. The research group assumes responsibility for developing the testing procedure under the direction of the advisory group. While it is not obvious that this approach was adopted by CARB, it was used to design emissions standards for restaurants in the South Coast Basin, and worked well to establish an accepted testing protocol in a case where testing repeatability was a problem, and there was substantial disagreement among parties on how testing should be conducted. As such, it represents a model that could be adopted should CARB's certification program, or something like it, be implemented universally with respect to DG.

A second issue, once a testing protocol is developed, is the determination of how the protocol should be applied. In the automobile industry, prototype vehicles are certified including a deterioration analysis over 50,000 to 100,000 miles. Once the prototype testing is completed the vehicle is approved for production. In addition, a small number of vehicles are pulled from the assembly line to test the manufacturing process; however, in-use testing as described in the next step may eliminate the need for assembly line testing.

Mandate statistically valid in-use testing as part of an appropriate regulatory scheme. Not every DG unit needs to be tested, but enough testing needs to be included to find systematic failures or significant deterioration of emissions reduction approaches.

In reference again to the automobile industry, both the EPA and CARB (in California) test hundreds of randomly selected in-use vehicles for emission problems. This process has allowed the identification of early failure of control components, emissions "cycle" cheating,[63] and user-control system modifications—issues that are relevant to DG.

An adaptation of this approach to in-use testing for DG would be to test 10 to 20 units per type of DG after a year of operation. The variability in emissions from this group would provide some basic information on the number of tests that should be conducted to get statistically valid results. CARB and the air districts would be the obvious agencies to carry out the routine in-use testing program. The cost of such a program could be covered by some type of fee on the sales of DG units or could be absorbed into the normal regulatory budget.

Establish adequate buy-in to the manufacturer-based approach by regulatory agencies to avoid duplicative certification programs at the state and local levels.

The extant and effective division of regulatory labor among CARB, the air districts, and the Energy Commission suggests that the problem of multiple, over-lapping certification, or permitting, programs will be minimized insofar as DG regulation within California continues to recognize the combined importance of the public's economic, health and safety, environmental, and other—often local—interests. (Considering California leads the nation's efforts to regulate DG, it is likely that relevant federal regulation will prove consistent with the state's certification and permitting programs.)

In the short-term, and potentially indefinitely, develop a credit system to encourage and support environmentally beneficial DG.

CARB and most air districts have already developed some means of tracking and transferring air pollution control credits for new construction. Although these programs are typically designed for major sources of air pollution, there is no reason why they could not be modified to include small sources, such as DG. Two characteristics of the cleaner DG technologies, in particular, would be well-suited for such a credit program: 1) waste gas or heat recovery, and

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[63] "Cycle" cheating refers to designing vehicle systems that operate such that they pass the requisite certification emission tests, but operate in a different higher polluting mode in use to provide the user with more power or better fuel mileage.

2) clean fuels. Thus, one element of a DG pollution control credit system would involve the establishment of a standard credit for the use of waste gas or for heat recovery. This standard credit would necessarily be conservative to insure that any excess DG emissions are truly offset.[64] The second element would establish a specific credit for individual applications where the offset fuel or heat would have been higher-polluting than the standard credit.

Revisit emission limits and efficiency levels on a regular basis to ensure that only the best available technologies are certified or permitted for operation.

Technologies can advance rapidly, leaving existing standards outmoded, and resulting in higher emissions of pollutants. In fact, significant progress is already being made in reducing DG emissions, increasing its efficiency, and reducing costs. As with any regulatory system, it is critical that CARB and the state's air districts continue to revisit emission limits set for DG regularly to account for technological progress and therefore also improved generation efficiency, reduced emissions, and lowered costs.

12.0 Organizing Voluntary Standard-Setting Among Manufacturers

While the manufacturer-based regulatory approach detailed above is designed to support extant efforts by CARB, California's air districts, and the Energy Commission to foster the manufacture and use of environmentally beneficial DG, voluntary standard setting represents one viable alternative to this kind of government regulation. The advantage of this approach is that it is likely to be less complex than government regulation, and relatively free of the attendant governmental bureaucracy. Yet the establishment of a voluntary standard setting program would still require some government process to develop a heat recovery credit mechanism

The voluntary standard setting approach we suggest mirrors the UL process established over 100 years ago in the electric appliance industry. UL is an independent, non-profit organization that completes as many as 94,396 evaluations a year. To be credible, either a group like UL or an independent testing group would have to be created or constitute itself as unbiased source of DG certification.[65] This group would, ideally, adopt the standards and testing procedures currently advocated by CARB and the air districts, and generally work to gain the confidence of California's air quality regulatory community. According to Harry Jones at UL, this process has notable already begun.[66]

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[64] That is, the credit will be established to cover cases in which the waste fuel replaced, or the energy displaced, in heat recovery is realistically set to reflect the heat-recovery capacities of cleaner types of DG. This will ensure that the credits are in fact real for the majority of all applications.

[65] A good place to visit to get a sense of the viability and complexity of such a process can be found by visiting the UL web site at www.ul.com/welcome.html.

[66] Electronic discussion with the authors, 27 November 2002.

13.0 Deepening Regulatory Policy Networks

Policy networks have proven essential to the development of DG regulation in California to date. As previously discussed, for example, collaboration between the Energy Commission and the CPUC has yielded standard interconnection rules for DG, incentive and net-metering programs, and stand-by rate policy; the Rule 21 Interconnection Working Group, which also includes representatives from Pacific Gas & Electric, San Diego Gas & Electric, and Southern California Edison, continues to meet regularly and is considered a model policy network pertinent to DG. Ongoing interaction among CARB, the state's air districts, and the Energy Commission at DG workshops and committee meetings has likewise facilitated more informed and holistic air quality and energy policy. In addition, coordination between California's larger air districts and DG manufacturers and distributors has eased the process of permitting increasingly cleaner DG units. We applaud this progress and urge the agencies and other regulatory entities involved in existing DG regulatory policy networks to deepen their activities by reaching "down to" local governments and the state's smaller air districts.

While the DOE, the EPA, and other federal agencies, as well as state and many large, local agencies, are well aware of the potential implications of DG, this is not always the case at the local level of government, nor among the many small air districts. Yet it is these agencies that will be among the first to address DG in the form of building permits, fuel use inspections, and air pollution control activities. Thus, there is a need to create a mechanism to provide these agencies with information and a mechanism for communicating about DG and its role in maintaining and improving air quality. This process may best be accomplished through deepening existing associations that represent and/or connect key energy and environmental regulatory processes. Indeed, this position is consistent with recent studies, which suggest regulatory networks whose membership is both broad and deep are essential to successful local and community-based environmental protection (John 1999; Schneider et al. 2002).

Because establishing and enforcing emissions standards for DG is the backbone of the manufacturer-based regulator policy advocated here, we also suggest that DG should become, or remain, a discussion topic at regular meetings of, at least, the following organizations associated with air quality in California:

- STAPPA) and the Association of Local Air Pollution Control Organizations (ALAPCO) are national organizations that operate under the same management. Their membership includes all STAPPA/ALAPCO**:** The State and Territorial Air Pollution Program Administrators (state air pollution control programs along with some interaction with U.S. territories and all major local air pollution control programs. They hold semiannual meetings, conduct conferences, and publish a newsletter. (http://ww.4cleanair.org/)
- CAPCOA**:** The California Air Pollution Control Officers Association is made up of all local air pollution control programs in the state of California. This association holds semiannual meetings, produces a newsletter, and has monthly sub-group meetings. (http://www.capcoa.org/)
- WESTAR**:** The Western States Air Resources Council includes the air pollution control programs for Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.

The purpose of the organization is to address western air quality issues. WESTAR holds meetings and distributes information similar to other multi-state organizations. (http://www.westar.org/)

There are other air pollution control groups, but those listed provide multiple access to almost all air pollution control agencies in the United States. STAPPA/ALAPCO is one of the better of these to focus on because it includes both state and local air pollution control agencies nationwide.

With respect to building permits and safety inspections, related issues are handled by a variety of agencies. Councils of Government (COG), often denoted Metropolitan Planning Organizations (MPO), are set up for each metropolitan area to bring coordinated planning between city and county governmental entities. The interests of the COGs include air quality planning, zoning, and public safety. Additionally, there are several other city/county organizations that might provide a valuable interface concerning DG issues. The following city/county associations, in particular, provide portals into the issue of building, zoning, and safety permits associated with city governments:

- ICMA**:** The International City/County Management Association addresses many issues associated with city/county management. This association has interests in city/county safety issues and links with fire departments and other city safety agencies. (http://www.icma.org/)
- NARC**:** The National Association of Regional Councils provides an interface at the national level to COGs and MPOs. NARC is associated with the Association of Metropolitan Planning Organizations (AMPO). These groups include air quality as one of their major interest and thus may be a good starting point for an interface into local zoning and safety issues handled by city and county governments. (http://www.narc.org/)
- PRIMA**:** The Public Risk Management Association addresses local safety issues which includes city/county organizations as members. (http://www.primacentral.org/)
- IAFC**:** The International Association of Fire Chiefs may provide a useful interface to city and county fire departments, which do much of the safety inspections for cites and counties. (http://www.iafc.org/)

14.0 Environmental Education

According to the Clean Energy Group (CEG), a non-profit organization dedicated to the greater use of clean energy technologies, support for “green power” in the United States is sufficient to elicit the willingness 50-95 percent of Americans to pay more for electricity generated from renewable sources (Rosoff et al. 2002, National Renewable Energy Laboratory 2001). Yet market penetration of renewable and other clean energy technologies, including DG, in the United States hovers at less than one percent (National Renewable Energy Laboratory 2001). Likewise in California, despite residents’ natural preference for clean, efficient, and economical electrical power, in addition to the development of an effective regulatory structure to govern the introduction of environmentally sound DG into the state, a fully functioning electric utility system that smoothly integrates clean DG with the predominant sources of CG is still an unrealized goal. Of course, the emergence of such a system requires the broad availability of clean, efficient, and affordable DG as an alternative to CG. Prevailing research indicates that price remains the "single most important factor in selecting a utility provider" (Rosoff et al. 2002), and clean energy commands a premium price. Regardless of price, optimal integration of clean DG into California's electric utility system also demands the predominance of consumers who are aware of the relationship between energy and environmental issues and capable of making informed decisions regarding the sources of their electrical power. It follows that the success of any DG policy designed to improve the efficiency of the state's electric utility system and protect its air quality and other natural resources depends on the context in which it is implemented (see Carpenter, Esterling, and Lazer 2002). The obvious method for creating a desirable consumer context for implementing the kind of DG policy suggested in this report is to prioritize environmental education.[67]

Environmental education is most often regarded as a means of providing issue-specific *information* to enable individuals to make knowledgeable decisions, and assist them in becoming more *aware* about how their individual actions impact local, state, national, and even global energy and air quality problems. Yet this is not enough, according to a 1996 report by the National Environmental Education Advisory Council, with assistance by the North American Association for Environmental Education (NAAEE). The report's review of a variety of studies and other evidence suggests that in order for individuals and groups to make ecologically wise choices and become environmentally responsible, they must also learn to investigate and *evaluate* alternative courses of action on the basis of their environmental impact, and develop *skills* necessary for engaging in individual and collective efforts to protect the natural environment (National Environmental Education Advisory Council 1996; see also Bransford et al. 2000, Brewer 2001). Hence our position that education about energy use and air pollution control must be situated in the context of environmental education intended to provide California's residents with the knowledge, skills, and ethic necessary for them to live sustainably.

[67] This assertion is premised both on our research pursuant to this report and related work and on the efforts of others, including the CEG and educational initiatives by the CalEPA, CARB, the Energy Commission and comparable agencies in other states, such as Colorado, Illinois, Maine, Massachusetts, Michigan, Minnesota, Oregon, Rhode Island, Texas, and Wisconsin (Gecils and Schumacher 2003; Rosoff et al. 2002).

14.1. Types

Current research indicates that there are two types of environmental education:

- Formal, which includes both K-12 and post-secondary programs, the latter of which often stress teacher training or relating environmental science to the environmental policy process (National Environmental Education Advisory Council 1996).
- Nonformal, which includes the print and electronic media as well as programs sponsored by government agencies and non-profit organizations.

Currently, environmental education in both instances favors "infusion." This method folds education about the natural environment into existing lessons on relevant topics, including history, geography, and science. One of the best examples of this mode of environmental education exists at the Chapman Ranch School in Mt. Baldy, California, which provides both teacher training and day-long programs that immerse students in nature and seasonally-specific interdisciplinary projects. For example, one spring lesson on water transport, use, and conservation challenges students to construct a mining camp out of giant-sized "Lincoln Logs," design a system for transporting water there from a nearby pond, and develop a plan for water storage and reclamation.[68] The "block" approach, which features the separate, environmental courses found on many high school and college campuses, provides an alternative to infusion intended to foster in-depth knowledge of selected environmental issue areas. According to the National Environmental Education Advisory Council (NEEAC), these alternative approaches to environmental education are best understood as complementary, and decisions regarding which to adopt should be made on a case-by-case basis (National Environmental Education Advisory Council 1996).

14.2. Sources

Although California's Department of Education's endorsement of environmental education in the state's public schools places it at the forefront nationwide with respect to policy in this area, to date there is no consensus on curriculum, and environmental education occurs almost exclusively on an ad-hoc, supplementary basis. Elementary school children, for instance, may do a unit on energy conservation or plant a garden, if there is time and sufficient teacher interest. The state's current reliance on standardized testing to hold teachers accountable for instructing students in math and language arts compounds this problem by constraining educators to "teach to the test" rather than create authentic opportunities for learning about the natural environment. Consequently, most environmental education in California takes place outside of the classroom. There are three sources of this public environmental education:

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[68] Author’s interview with Pat Chapman, owner and director of the Chapman Ranch School, 3 March 2002.

- *State government, state and local agencies, including the Energy Commission and CARB*. These agencies have, in some instances, partnered to create networks in the interest of co-sponsoring educational programs on selected topics to identified groups. The California Environmental Education Interagency Network (CEEIN), for instance, includes the California Department of Education, CalEPA, the Department of Food and Agriculture, and the California Resources Agency. It is credited with sponsoring an annual Envirothon, in which high school students test their competence in five environmental issue areas: soils, aquatics, wildlife, forestry, and a current issue of importance (California Department of Education 1995).
- *Non-profit organizations, such as the Sierra Club and Greenpeace*. Many of these groups operate on multiple levels in the community to provide opportunities for environmental education in the course of outdoor excursions, campaigns to generate activism around specific issues—i.e., wilderness preservation or wildlife protection—and outreach via participation in local and regional cultural events and other activities.
- *Private entities, for example, "green businesses."* Increasingly, businesses are jumping on the green bandwagon. While some, such as Silk soy products and the Calvert Group (Fromartz 2002), represent genuine efforts to provide consumers with products that support environmental sustainability, others have adopted green practices, such as reducing packaging or becoming sources of information and activism, as a means to increase sales. The Chevron Corporation's "People Do" campaign and Procter and Gamble's efforts to market refills represent prominent examples of this phenomenon.

14.3. Historical and Institutional Context

The significance of environmental education for sustainable economic and social development is not new; nor is it confined to California, or even the United States as a whole. Indeed, at the height of the 1970s' environmental activism, the United Nations Educational, Scientific and Cultural Organization (UNESCO) held the first international conference on environmental education in Tbilisi, USSR. That conference yielded the Tbilisi Declaration, which defines environmental education as a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (United Nations Education, Scientific, and Cultural Organization 1978). This definition emphasizes critical thinking, problem-solving, and effective decision-making skills, and focuses on teaching individuals to weigh various sides of an environmental issue to make informed and responsible decisions. The key components associated with this understanding of environmental education are:

- Awareness and sensitivity to the environment and environmental challenges.
- Knowledge and understanding of the environment and environmental challenges.
- Attitudes of concern for the environment and motivation to improve or maintain environmental quality.
- Skills to identify and help resolve environmental challenges.
- Participation in activities that lead to the resolution of environmental challenges.

Because it does not advocate a particular viewpoint or course of action, it is this definition of environmental education that has been adopted by national governments, policy-makers, and educators in the United States and throughout the world.

Most notably, environmental education is implicated throughout Agenda 21, a product of the 1992 United Nations Conference on Environment and Development in Rio de Janeiro, Brazil as a "blueprint" for achieving sustainability in the twenty-first century.[69] Chapter 36 of that document, which includes public awareness and training as well as formal education in its definition of environmental education, emphasizes that:

> Both formal and non-formal education are indispensable to changing people's attitudes so that they have the capacity to assess and address their sustainable development concerns. It is also critical for achieving environmental and ethical awareness, values and attitudes, skills, and behavior consistent with sustainable development and for effective public participation in decision-making.

This progressive understanding of environmental education informs Agenda 21's educational objectives, which include: international and national support for increasing access to primary education and increasing adult literacy; improving scientific education and training; integrating ecological considerations into politics and economics; strengthening people's awareness of the relationship between environment and development, and their commitment to sustainable development values; and training decision-makers.

Despite generally inadequate funding, progress toward achieving these objectives and associated activities has been made by a wide variety of nations throughout the world. The United States is among those nations that have made significant efforts to institute environmental education programs consistent with the Tblisi Declaration and Agenda 21. It most recently renewed the nation's commitment to environmental education by passing the Environmental Education Act in 1990. The Act signaled the federal government's recognition that solutions to the complex ecological challenges confronting us now will require a well-educated and trained public with the knowledge and skills necessary to make informed decisions and the motivation to take responsible action. The EPA was assigned responsibility for implementing the Act and an Environmental Education Office was established within the EPA to oversee a bundle of initiatives, including:

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[69] Agenda 21. Available online at: http://www.un.org/esa/sustdev/agenda21text.htm. Chapter 36 of that document, entitled "Promoting Education, Public Awareness, and Training" is premised on the principles outlined in the "The Declaration and Recommendations of the Tbilisi Intergovernmental Conference on Environmental Education" (UNESCO 1978).

- A training program for educational professionals.
- An environmental education grants program.
- An internship and fellowship program for both students and teachers.
- An environmental education awards program.
- A federal task force and advisory council.

The many activities ongoing as a result of these programs reinforce the efforts of federal, state, and local environmental agencies and organizations, public and private educational institutions, businesses and other corporate actors, and individuals to heighten Americans' environmental awareness and activism. With respect to energy conservation and air pollution control, educational outreach on behalf of the federal and state agencies discussed in this report includes: participation at educational fairs, teacher training, curriculum development, investment in "energy smart" schools, internship programs, and interactive websites geared to children and young adults, in addition to consumer education, more narrowly defined. Information regarding much of this activity is, of course, available by contacting the agencies directly; however, for those with access to computer, modem, and telephone line, it is more readily accessible online at the following locations:

- EPA Environmental Education Office - www.epa.gov/enviroed/eedefined.html.
- CARB Know Zone for Kids, Students, and Teachers - http://www.arb.gov/kst/arb012/index.html
- DOE Energy Efficiency and Renewable Energy Network - www.eren.doe.gov/education/
- Energy Commission Energy Quest - www.energyquest.ca.gov/index.html.

14.4. Commercializing Clean DG

The three-tiered—i.e., international, national, and state—organization of environmental education discussed here provides a backdrop for a wide range of specific educational efforts directed specifically at prospective renewable energy consumers and clean DG users. Among the most innovative and potentially most effective such public education strategies currently afoot involves the CEG's Clean Energy Funds Network (CEFN), which facilitates the CEG's activities as a "strategic broker" in the negotiation of clean energy investment opportunities for state governments. The CEFN is now coordinating the collective public clean energy funds of 14 states to create a clean energy ad campaign designed to elicit widespread recognition of renewable energy as a brand name capable of changing individual and social behavior (Rosoff et al. 2002). Notably, this much-anticipated public education ad campaign is intended to broaden the target audience for clean energy to include commercial as well as residential consumers. The logic shared by its creators is that the adoption of renewable or otherwise clean energy technologies, including DG, by a commercial or other large consumer is easily equivalent to up to 1,000 residential consumers.[70] Of particular importance to the success of this strategy is the identification and cultivation of corporate and industry leaders capable of seeing the prospective long-term cost savings and market advantages associated with adopting a new, more efficient, and cleaner source of electric energy.

This emphasis on commercial energy consumers promises to support and expand the efforts of trade associations and other industry-specific efforts to capitalize on the deregulation of electric utilities combined with the availability of increasingly more efficient and cleaner sources of DG technologies, as well as the financial incentives for adopting them. The metal casting industry is a case in point. One of the world's oldest crafts, metal casting has existed for over 6,000 years and contributed to the manufacturer of myriad products during that time—from swords and spearheads in ancient eras to automobiles, golf clubs, and irrigation pumps today. Foundries remain traditional, small businesses, with very large demands for electricity. Collectively, the 175 foundries in California generate a demand for 175-700 megawatts of electricity each day, or approximately two percent of the state's total daily demand.[71] The cost of electricity can account for up to 20 percent of production costs for each one of these businesses, which contributes to metal casters' extreme sensitivity to any volatility in electricity prices. Additionally, because foundries use electricity to melt steel, the casting process is sensitive to power fluctuations; "forty tons of molten steel cannot be placed on 'simmer' during interruptions [in electrical supply]" (Simonelli 2003a).

According to James Simonelli, Managing Director of the California Cast Metals Association (CCMA), DG emerged in spring 2000 as a solution to the rapid price increases and blackouts foundries faced as a consequence of the energy crisis. Recognizing that DG might be used to provide reliable electricity at stable costs, the CCMA researched the possibilities available—including the natural gas- and diesel-fueled engines and fuel cell technologies analyzed for this report—in terms of energy efficiency, size, production capacity, electricity costs, and regulatory burdens. Its conclusion was that while natural gas-fired engines represented a promising option, fuel cells would provide advantages in every area, except cost (Simonelli 2003a). The CCMA's response to this finding was to seek affordable fuel cell DG and introduce these select technologies to its members. Simonelli's position is that in order for individual foundries to "buy into the change," they will need "accurate and positive information" [72] about fuel cells. Therefore, in early 2001, the CCMA organized a meeting of fuel cell manufacturers and metal casters with the intention to educate its members on the commercial potential of onsite fuel cell generators.

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[70] Rosoff et al. 2002 reiterates points made by Christian Lagier, Regional Manager for Northern Power Systems, in an interview with the author, 5 February 2002.

[71] Simonelli 2003b. According to CAISO, aggregate daily demand for electricity in California is currently 32,000 megawatts; 175 of the approximately 300 metal casters in the state are foundries, each of which demands up to four megawatts of electricity per day.

[72] Interview with the author, 25 June 2003.

The CCMA has since become one of California's most active business organizations in support of fuel cell DG. In recognition of its interest and activities, the state's South Coast AQMD awarded the CCMA a $701,000 grant to install up to four 250 kilowatt units in the Los Angeles Basin. While this grant certainly represents progress, it is important to note that each one of the proposed units will cost approximately $1.5 million to install, less than half of which may be covered by the PUC's self-generation incentive fund. Then, if and only if a foundry uses its generator around the clock, seven days a week, for ten years, and uses all of its electrical output, will it realize the currently best possible fuel cell price of .13 per kilowatt-hour with the current exit fee exemption in place. Meeting this condition is difficult for foundries, which, like many comparable small businesses, operate under the 24/7 thresh-hold and are rarely credited for the excess electricity their generators produce. As such, electricity rates may approach .17 cents per kilowatt-hour for fuel cell DG, even at "massive" sites where installation costs are lowest (Simonelli 2003a).

For the most part, the information and education provided by the CCMA, as well as the CEG and state agencies, including CARB and the Energy Commission, is directed primarily at adult electricity consumers, and it has apparently been wildly successful in some instances. California's recent energy crisis is a pertinent example (see Marcóczy and Randazzo 2002). The catch is that the effects of education—regarding California's energy crisis, that might mean information about the energy situation and the likely behavior of energy consumers—are often temporary if not premised on a corresponding environmental ethic and sense of efficacy. Because the cultivation of any ethical commitment to protect the natural environment and corresponding skill-building is time-intensive, it is reasonable to suggest that the successful integration of DG into the California electric utility system will depend on educating school children and other young people, as well as informing today's energy consumers.

15.0 Conclusion

This report makes it patently clear that DG does have the potential to provide security to the U.S. electrical generation system, along with the economic competition that will assure the lowest-cost electricity. Additionally, we expect that DG will play a role in reducing local, regional, and even global air pollution, though this outcome is far from assured within the existing regulatory framework. Large-scale generating systems face stringent permitting requirements that are resulting in the implementation of gas-powered combined cycle generation with significant pollution control technologies in nearly every case. DG will, therefore, most likely be compared as a potential source of electricity to combined cycle CG rather than to existing coal-fired power generation. Yet some of the most cost effective DG at this time consists of diesel and gas powered internal combustion engines, and these units are highly polluting. As established here, only the lowest emitting DG with significant waste heat recovery is even marginally competitive with combined cycle central power production when air pollution issues are considered. Thus, we advocate technology-forcing in the specific form of manufacturer-based regulation, to require DG emissions to be reduced over time[73] to ensure improved air quality. We, furthermore, recognize that the integration of DG into the state's electric utility system is likely to require profound changes in how Californians conceive of electricity generation, heating and cooling systems, and their relationships to the natural environment. As such, we suggest that the proposed manufacturer-based policy be implemented in a context of close working relationships among energy and air quality regulators, DG manufacturers, facility managers, and an aware public. This final contextual requirement will be hard to ensure without prioritizing environmental education understood to include knowledge- and skill-building.

[73]The single current application of DG that should be encouraged immediately is the flaring of waste fuel, which could be put to use in a DG generation unit. In this case, even with microturbines and advanced turbines now available, air pollution can be further reduced.

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