THE GOOD, THE BAD, AND THE OTHER

Public Health and the Future of Distributed Generation

CALPIRG Charitable Trust
Coalition for Clean Air

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Prepared by

California Public Interest Research Group Charitable Trust
Coalition for Clean Air

With support from the California Clean Distributed Generation Campaign Group

American Lung Association of California
Center for Energy Efficiency and Renewable Technologies
Environmental Defense
Latino Issues Forum
Natural Resources Defense Council
Physicians for Social Responsibility
Planning and Conservation League
Sierra Club
James Lents, UC Riverside Center for Environmental Research and Technology

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Executive Summary

The debate over California's energy future has focused attention on a growing sector of the energy market. Homeowners and businesses are generating electrical energy near the place it is used as an alternative or supplement to the statewide power grid.

Known as distributed generation (DG), this family of technologies holds great promise for locally controlled power generation. But continued reliance on polluting technologies poses a threat to public health.

As elected officials wrestle with solutions to the short-term energy crisis and as all policy makers strive to promote energy efficiency, state agencies are working to assure that clean, reliable technologies are available to encourage greater energy generation flexibility.

The California Air Resources Board (ARB) and the 35 regional air districts are setting air pollution standards for distributed generation technologies. They are seeking to establish a single standard across all technologies and applications that reduce environmental emissions and protect public health.

The ARB should set strict standards that fully protect human health and the environment, and these standards should be phased in over time to allow manufacturers to prepare for change. New standards should encourage clean technologies such as solar and wind, allow developing technologies such as fuel cells and microturbines to gradually decrease emissions, and prohibit use of the most polluting technologies such as diesel.

The most prevalent forms of distributed generation are fueled by diesel. These generators have been installed outside many public buildings and advertised for home use as a solution to the "energy crisis."

Due to severe environmental and public health impacts from the growing use of diesel generators, emissions standards must be set at levels that limit diesel applications to emergency situations and only when generators are operated in conjunction with emission-control measures.

Distributed generation is at a crossroads. New standards should promote clean technologies, no longer allowing dirty technologies to proliferate and pollute the air. These standards need to establish uniform treatment of the various DG technologies and applications.

We have produced this report to point the way to a clear future direction for energy use. As we simultaneously work to promote the highest possible level of efficiency in our use of energy, we must also support sustainable, reliable, versatile technologies that can bring efficient energy generation right to the source of use while reducing harmful air pollution.

California must encourage existing and emerging technologies that work to reduce the threat to public health posed by diesel generators and other dirty forms of DG.

Policy Recommendations

To ensure that public health is protected and that new technologies to reduce pollution are encouraged, distributed generation policy should be based on the following principles:

- Distributed generation must be as clean as or cleaner than the cleanest central power plant technology.
- State rules and incentives must promote the cleanest energy industry for the future of California.
- Regulations should be as simple as possible so manufacturers can anticipate changes and comply with new technology requirements.

The ARB and regional air districts can

help move distributed generation in the right direction as they determine uniform emissions standards for these technologies.

To protect the health of Californians and the air quality of the state while helping to assure reliable local power generation, we recommend the following immediate ARB policy actions:

- Set stringent emissions and efficiency-based standards for all distributed generation units operated in California.
- Streamline the permitting process for clean units that meet or beat state or air district standards.
- Ensure adequate enforcement of standards and establish significant penalties for violation.

In addition, many other specific policies could advance clean DG while curbing the use of dirty DG. We recommend that state agencies:

Establish standards and rules for DG operation:

- Require that all DG units operated in California receive ARB certification or air district permit in order to be interconnected to the electric grid.
- Require that transmission grid operators draw on clean, efficient distributed generation power before similarly priced dirty installations.
- Require emission-control equipment for diesel generators used for emergency back-up power supply.
- Require that all new residential and commercial construction be "solar-ready" with the basic infrastructure to ease future installation of photovoltaic panels.

Provide funding for clean DG:

- Establish priority funding for clean distributed generation technology advancement.
- Continue and expand the availability of financial incentives, including financing assistance, buy-down programs, and grants, for the installation of clean distributed generation.
- Provide incentives for developers to include clean DG at new residential or commercial construction projects.
- Create a dedicated revenue stream to defray the costs of cleaning up polluting distributed generation by taxing the purchase of dirty diesel fuels.
- Extend the Carl Moyer Program, which provides incentives for the trade-in and upgrade of dirty diesel equipment, to include polluting distributed generation installations.

Clear hurdles to the implementation of clean DG:

- Streamline the permitting and utility interconnection process for clean distributed generation installations.
- Develop incentive tariffs and reduced stand-by and exit fees for clean distributed generation installations.
- Establish a renewable purchase obligation, such as a renewable portfolio standard or renewable purchase requirement for state and local governments, that allows aggregation of distributed resources or includes distributed generation.
- Inventory clean distributed generation sources operating in California.

The adoption of these recommendations will help to promote a vital distributed generation system that reduces the negative public health impacts associated with diesel and other dirty DG technologies.

What Is Distributed Generation?

For more than a century, the standard formula for generating and distributing electricity has been simple. Build a huge power plant near an available fuel source. Run power lines to population centers where industry and people need the electricity. Connect the individual home or business to the electrical grid and power up.

Using primarily fossil fuels, these facilities have grown in scale and quantity as our demand for electrical power has increased. Many of these giant power plants have been major polluters as they have worked to provide a cheap, reliable electricity source for consumers. Despite advances in technology, these large central power plants continue to dominate our energy system in size, environmental consequences, and convenience.

The dominance of this model and its easy connection to the grid have facilitated the proliferation of electrically powered devices to the point where most of us never think about how power is generated. We just plug our computer into the wall outlet and get to work.

In some cases, it has been advantageous to develop localized power generating capacity. Geographically isolated facilities and some large factories have been using local power generation for years, frequently deploying many of the technologies that cause environmental harm. But it was a rare occurrence that the average individual would need or want independent local power generation in their home or business.

Deregulation of the electric power production industry and the recent turmoil in energy markets has changed all that. With growing concerns about the reliability of traditional power sources due to increases in power plant downtime, more and more consumers are questioning the conventional model of central power plants. They are looking for more reliable energy sources, searching for greater control over power costs, and seeking alternatives to power sources that degrade the environment and undermine public health.

The combination of advancing technology and widespread concerns about large central power plants has made localized power generation an idea whose time has come. Instead of concentrating power sources at large plants, distributed generation systems locate power sources closer to the consumer — in an office building, a neighborhood, a factory, or a home.[1]

For many, small power generation units located near the point of use have been a safety measure to supply back-up power during blackouts. Others have suggested that, in light of escalating energy costs during peak demand periods, distributed generation can be used as a cheaper alternative power source, or even as a source of profit by selling the distributed power into the grid.

Distributed generation has the potential to reduce costs for power generation. For example, DG can dramatically reduce high transmission costs that can reach \$1.50 for every \$1.00 spent on electricity generation.[2]

In addition, society can benefit through enhanced reliability and decreased need for infrastructure. Estimates

Table 1: The Economic Benefits of Decentralized Power (¢/kWh)[3]

Benefit	Savings
Substation deferral	0.16-0.6
Transmission system losses	0.2-0.3
Transmission wheeling	0.28-0.71
Distribution benefits	0.067-0.17
Enhanced reliability	1.0
Total	**1.7-2.8**

of the monetary value of these benefits range nearly as high as 3 ¢/kWh. This is a substantial savings from current generating costs, which now typically range from approximately 4-9 ¢/kWh.

Growing interest in local control of electrical power generation is both an opportunity for and a threat to California residents. The central power plant system has developed some cleaner technologies, but older DG technologies are still predominant. We cannot allow the proliferation of localized power generation to undermine pollution standards.

Over the next few months, as public agencies consider regulations addressing distributed generation technologies, we have the opportunity to promote cost-effective renewable energy sources that are significantly less harmful to our health. But if the growing demand for distributed generation results in the proliferation of polluting technologies, we face the prospect of higher levels of localized emissions that place our respiratory health at significant risk.

What follows is an overview of the pollution and public health impacts of many of the technologies currently available to those interested in the deployment of distributed generation. As should be clear from the title of this report, we have grouped the various technologies into three categories based on their current environmental performance. New regulations should be performance-based so that emerging technologies have equal opportunity to meet emissions standards in the future.

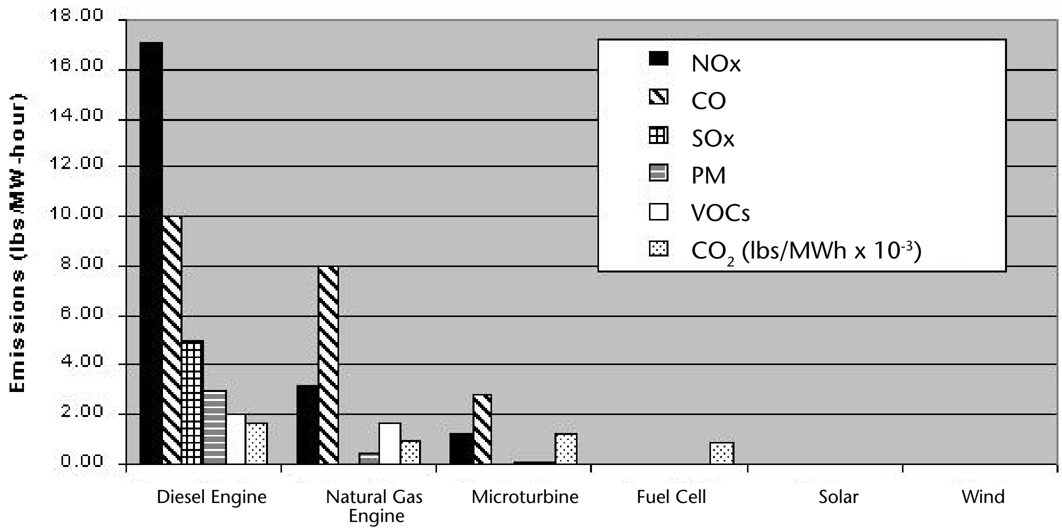
- **THE GOOD** – The cleanest distributed generation technologies, primarily using renewable fuel sources. These include solar, wind, and fuel cells. These forms of power generation have minimal negative public health impacts. In addition, high-efficiency combined heat and power systems can significantly reduce negative impacts.
- **THE BAD** – The dirtiest and best-known technologies, using fossil fuel sources. Diesel generation is the most available technology, but there are also gasoline and natural gas engines that are excessively polluting. These forms of power generation undermine public health and cause disease.
- **THE OTHER** – These emerging technologies have the potential to deliver cleaner power. Options such as alternative fuels and microturbines hold promise for the future. The health impacts of these forms of power generation vary.

On-site power generation in itself is no panacea for the problems plaguing the energy market. If the rush to distributed generation is a rush to the most available technology, then some of the problems — including increased pollution, inefficient energy production, costs tied to non-renewable fuels, and growing public health problems — will be perpetuated.

The technology is available to avoid those pitfalls and to promote efficient and increasingly cost-effective distributed generation that can benefit the environment, the reliability of the electricity system, and public health. Some of the potential advantages of clean distributed generation include:

- Power doesn't have to travel long distances over the grid, reducing energy loss and the need to build new power lines.
- Wind and solar technologies are fueled by renewable energy sources.
- Generation at point of use allows for the utilization of waste heat for other energy needs.
- Local generation can enhance the electricity system by reducing the burden on the grid.

Figure 1: The Difference is Clear
Polluting Emissions from Distributed Generation Technologies[4]



- Fewer large, central-station power plants will be needed as distributed generation increases.
- The potential for large-scale blackouts is reduced.
- Local control of energy sources allows increased responsiveness to local concerns.
- Power sources can be built to appropriate scale for local consumption.
- Greater local reliability for a continuous source of power.

The vast majority of distributed generation units currently operating in California are diesel generators. There are no reliable statewide statistics on the numbers of other types of DG units.[5]

Diesel generators release 131 times more smog-forming pollutants than the most efficient natural gas power plant technologies.[6] These pollutants have been shown to increase the risk of serious health problems ranging from headaches and nausea to asthma complications and lung cancer.[7]

The opportunity to end this threat to public health is at hand if we use policy incentives and the current development of standards for distributed generation to push newer technologies to the forefront.

THE GOOD: THE CLEANEST DISTRIBUTED GENERATION

California has been a testing ground for the cleanest power generating technologies for more than three decades. With abundant sun and wind resources, solar and wind technologies have been proven effective for local power generation in California. With free fuel, advanced technology, and incentives provided by the state, these technologies are becoming more cost-effective and cost competitive.[8]

Recently, the power industry has made substantial advances in fuel cell technologies and in using combined heat and power generation to increase energy efficiency. Public agencies, small and large businesses, and individual homeowners are taking advantage of these advancements to install localized and independent power generation capacity.

In the wake of last winter's energy crisis, the California Public Utilities Commission designed a $125 million per year "Self-Generation Incentive Program" to encourage individuals and businesses to install distributed generation units. Greater incentives will be provided for customers who purchase photovoltaics, wind turbines, and fuel cells using renewable fuel. No incentives will be provided for any diesel generation or for back-up power systems.

These clean technologies are not without their environmental impact, but they substantially reduce the toxic pollutants released into the air by older technologies.

Solar Photovoltaics

Solar energy is an ideal distributed generation technology for Californians. California's solar potential is excellent, and solar power generation peaks at the same time that California's energy demand peaks — in the heat of summer afternoons. Of the different technologies for harnessing the sun's energy, solar photovoltaic technology (PV) is the most suited for distributed electrical generation. For much of California, it is the best option for distributed generation.

Photovoltaic technology converts sunlight directly into electricity without using any moving parts. The basic building block is the photovoltaic cell, which is made of semiconductor materials. Cells can be connected together to form modules, and modules can be connected to form arrays. A few PV cells will power a hand-held calculator, while interconnected arrays can provide electricity for a remote village or serve as a power plant for a city. PV is a truly unique technology with many advantages. According to the U.S. Department of Energy, "it is easy to foresee PV's 21st century preeminence.[9]

Although PV panels only generate electricity when the sun is shining, connection with the grid makes it possible to depend on PV, both from the consumer and the state planning perspectives. On hot days, when electricity consumption is at its peak, PV panels feed electricity into the grid. In the evening when the sun is down, interconnected PV systems draw electricity from the grid. Recent improvements in "net metering" have made this much more practical for consumers.

Advantages of Photovoltaic Technologies

- Simplicity – With no moving parts (or very few, for some applications), operation and maintenance costs are minimal.
- Versatility – PV can connect to the existing infrastructure of the utility

grid and serve as an alternative power source during peak periods of power demand, or it can operate remotely (off the utility power-line grid). Many PV systems are easily transported. PV can also be scaled according to the amount of power needed.

- Reliability – First developed for U.S. man-made satellites in the 1950s — where low maintenance was an absolute necessity — and now with over 40 years of technical advancements improving performance, PV has very high online availability.[10]

- Peak Output – PV power output peaks when California's demand peaks.

- Quiet – PV systems make no noise.

- Sustainability – PV shares the two advantages common to all renewable energy sources: it has a low environmental impact (it is nonpolluting) and the fuel is free.

Solar PV has zero operating emissions, and there are negligible associated health hazards. Therefore, solar PV is exempt from all air quality permitting requirements.

PV at the Santa Rita Jail

The Santa Rita Jail in Alameda County, California, installed the nation's largest rooftop solar system in July 2001. The jail uses energy to house, cook and provide medical services for up to 4,000 inmates. During the winter, the jail uses as much as two megawatts of electricity—enough to power 2,000 homes. In the summer months, usage swells to three megawatts.[11]

The 642 kilowatt solar PV installation now provides 20% of the jail's power. The Powerlight Corporation, based in Berkeley, installed 5,700 PV tiles on the roofs of eight housing units at the jail. In addition to collecting sunlight, these innovative tiles provide added insulation to the buildings, further reducing energy consumption.

Photo by Powerlight Corporation

The County maximized the benefits of the solar installation by simultaneously implementing additional energy conservation measures. Reflective coatings now cover the rest of the jails' roofs, inefficient cooling equipment has been replaced, and an advanced computer system monitors energy consumption to limit demand during peak hours. Together these improvements and the solar installation reduce Santa Rita Jail's annual consumption from the public energy grid by 1.8 million kilowatt-hours. In addition, the project eliminates emissions of nine million pounds of carbon dioxide and 2,900 pounds of nitrogen oxides.

A final benefit of this project is its financial feasibility. By taking advantage of the California Energy Commission (CEC) Emerging Renewable Buy-Down Rebates Program, CEC AB970 funds, the CEC Energy Financing Program, and the California Public Utility Commission's "cost-cutting demand" program, Alameda County financed the entire project without tapping into its general fund.

Wind

Wind turbines are an excellent local power generation option for many Californians. A wind turbine consists of a rotor, an electrical generator, a speed control system, and a tower. When the wind blows and spins the propellers of the turbine, which are akin to airplane propeller blades, the kinetic energy of the wind is converted to mechanical power, which in turn drives the electrical generator and produces an electrical current.

Most Californians are familiar with these turbines when they are grouped together in a wind farm and operate like a conventional power plant, feeding electricity to the utility grid. But small turbines can be installed and operated individually to satisfy the electrical needs of a home or business, just as they were on farms during the earlier part of this century until they were replaced by rural electrification from the "New Deal" through the 1960s.

Individual turbines vary in size, ranging from about 30 feet high with propellers between 8 and 25 feet in length to 20 building stories high with propellers over 300 feet in length.[12]

Single home-sized wind turbines in the 10-50 kW range are becoming more popular in California. Since they don't need as much wind as the larger turbines, they can be effective in more areas. With the California Energy Commission's (CEC) rebate program of up to 50% on the purchase price of a home wind turbine system, the initial investment can be recovered in six to ten years, while the expected lifetime is at least 30 years.[13]

Advantages of Wind Technologies

- Simplicity – Operation and maintenance costs are minimal. Modern wind turbines require maintenance checks only once every six months.[14]
- Versatility – Wind turbines can

Home Wind in Tehachapi

Kevin Schiebel of Tehachapi, California, installed his Bergey 10 kW wind turbine in 1996 after becoming extremely frustrated with his utility company over billing issues. Schiebel, who works in the commercial wind energy business, installed the system himself; he purchased a used tower from a scrapped wind turbine, and designed and built a special mounting adapter for the Bergey turbine.

The turbine supplies clean power directly to the Schiebel home. Any excess production is "banked" by the local utility company for Schiebel to use in months when the wind and solar systems do not produce enough electricity. The turbine also works as an emergency back-up generator; Schiebelís house still has electricity during power outages. A final benefit of the wind turbine is that it will offset approximately 1.2 tons of air pollutants and 250 tons of greenhouse gases over its 30-year operating life.

Photo by Paul Gipe

connect to the existing infrastructure of the utility grid or can operate remotely (off the utility power line grid).

- Reliability – Wind power is the fastest growing energy source worldwide and its proven reliability has much to do with its success.[15] Small wind systems are designed to operate for at least 30 years.[16]
- Sustainability – Wind-generated power shares the two advantages common to all renewable energy sources: it has a low environmental impact (it is nonpolluting) and the fuel is free.
- Quiet – Modern wind turbines are much quieter than combustion turbines.

Wind technologies have many of the same advantages as solar photovoltaic technologies. Like solar PV, wind has zero operating emissions and there are negligible health hazards associated with it. Wind turbines are therefore exempt from all air quality permitting requirements.

Fuel Cells

Where solar photovoltaics or wind turbines are not feasible, fuel cell technologies are a good local power generation option, especially when operated in combined heat and power applications. (See below for more about combined heat and power.) Although they can use fossil fuels to create hydrogen, fuel cells emit far less pollutants than diesel and most other fossil fuel generators. Emissions from current cells are primarily CO_2 and water, and with further development they will be able to utilize renewable energy to produce their hydrogen fuel.

Through the chemical reaction of combining hydrogen and oxygen to make water, fuel cells convert chemical energy into electricity and heat without combustion. They operate similarly to batteries. Both batteries and fuel cells utilize an electrolyte separated by an anode and a cathode to generate a direct electrical current, and both can be combined into groups to increase power output.

Batteries store their fuel, then periodically run down and require recharging. Fuel cells, on the other hand, are fed a continuous supply of fuel. The varying types of fuel cells all rely on hydrogen as their fuel, but they can get it from a variety of sources.

Three different types of fuel cells — the Phosphoric Acid Fuel Cell (PAFC), the Molten Carbonate Fuel Cell (MOFC), and the Solid Oxide Fuel Cell (SOFC) — have been or are operating in 16 countries, and several more types are being developed and tested. Currently in the United States, only the PAFC is commercially available.[17]

Fuel cells are being developed both for use in vehicles and for stationary applications. These applications include backup power for hospitals, office buildings, schools, and utility power plants; primary power sources for remote villages and campgrounds; and power sources for temporary needs such as construction sites. As distributed electrical generation becomes more widespread, fuel cells could serve as primary power and thermal energy sources for virtually anything.

Most fuel cells are named for their electrolyte, and they each have different properties, capabilities, fuel requirements, and emissions. For example, the PAFC that is commercially available today is offered in the 200kW size, though it is technically able to operate in the range of 50 kW to 11 MW. The PAFCs in operation today use either natural gas or propane, but could also be fueled by methane, alcohols, landfill gas, or anaerobic digester gases.

California's South Coast Air Quality Management District (SCAQMD) conducted its own emissions test on the PAFC. The results prompted the SCAQMD to grant an exemption to PAFCs using natural gas from all air quality permitting requirements in the Los Angeles basin.

In the future, renewable energy sources may be widely used to generate the hydrogen needed to power fuel cells. Sunline Transit has a new hydrogen generation facility powered by wind and solar energy.[18]

Advantages of Fuel Cell Technologies

- Low emissions – Fuel cells emit fewer pollutants than any other fossil fueled DG technology.
- Quiet – Fuel cells are quiet.
- Versatility – Fuel cells are modular in design; so they can be stacked to increase power output.
- Simplicity – With few moving parts, fuel cells are low-maintenance.
- Flexibility – Fuel cells can use different fuel sources since they only need hydrogen and oxygen.
- Reliability – Fuel cells are online a greater percentage of the time than large power plants.

Fuel Cells in Operation

Fuel cells are becoming increasingly available. Ballard Technologies recently released a prototype fuel cell for residential use. Throughout California, businesses are just beginning to implement this type of distributed generation.

Southern California Gas installed eight 200 kW PAFC fuel cells manufactured by Onsi. As part of this demonstration project, the first fuel cell ever installed in the United States was placed in the South Coast Air Quality Management District (SCAQMD) building in Diamond Bar, California, in April 1992. This fuel cell has a lifetime of about 40,000 hours, after which the cell stack — the main electricity-producing element in the cell — requires repair. Southern California Gas repaired the SCAQMD fuel cell in 1998 and today it is operating at full capacity.

Photo by Charles Butler

The SCAQMD fuel cell operates as a combined heat and power system, reusing 700 Btu per hour emitted by the cell to heat the building and its water. 50-60% of the waste heat is reused in the summer months, and most of it is used in the winter. The fuel cell operating alone is 40% efficient. Operating as a combined heat and power system, the overall efficiency is more than 80%. The fuel cell provides 20-25% of the electricity needed to power the SCAQMD building.

Two other fuel cells installed as part of the Southern California Gas demonstration project remain in operation. One is located in the Hyatt Hotel in Irvine, California, and the other provides electricity for Kaiser Permanente Hospital in Riverside, California.[19]

Combined Heat and Power

Combined heat and power (CHP) is not a specific generating technology but rather an application of technologies to meet end-user needs for heating, as well as mechanical and electrical power needs.

Recent technology developments — particularly in turbines and microturbines — have made small-scale CHP systems more cost-effective and reliable. When properly designed, fossil fuel-based generators can dramatically increase their efficiency through modification into CHP systems.

In CHP systems, the heat that is normally released as waste heat is instead recovered and used to heat water, rooms and buildings and/or to drive motors for air conditioning or refrigeration. CHP systems can also use waste heat to provide steam to generate more electricity, like "cogeneration" at large power plants. Combined heat and power systems can be employed in many commercial and industrial facilities where there is a relatively constant thermal need.

Recovering and reusing waste heat in this manner can make generators more than 80% efficient, more than doubling the 33% average efficiency of conventional electricity generating systems.[20] CHP systems reach such high efficiency levels in two ways: they make use of the heat that would normally be wasted, and they save the extra fuel that would be necessary to operate heating systems — often replacing old, inefficient and dirty boilers.

Increased fuel efficiency translates directly into reduced emissions of greenhouse gases and other pollutants. NOx, which forms smog and acid rain, and CO_2, the principal global warming pollutant, are significantly reduced. Combined heat and power systems also reduce SO_2 emissions, precursors to acid rain, and particulate matter, a cause of chronic lung disease.

Because it is still based on burning fossil fuels, CHP is not sustainable energy production on the level of wind and solar. But as long as fossil fuels are used to drive generators, CHP should be widely encouraged as a very good improvement over less efficient technologies.

Advantages of CHP Systems

- Efficiency – Increases efficiency of fuel use by capturing waste heat for heating, cooling and other on-site energy requirements.
- Flexibility – Can be designed to deliver multiple energy services.
- Reliability – Advanced technology and local control enhance service delivery.
- Improved Environmental Performance – Produces lower emissions than conventional separate systems.

Key Recommendations

Electricity generation has always had serious negative impacts on air quality. We now have the opportunity, however, to generate our power with minimal environmental consequences. State agencies must do all they can to encourage the widescale implementation of clean technologies, as they simultaneously encourage energy users to consume energy as frugally as practical. The many energy consumers who are making a transition to distributed generation should be using the best available technology. Recommended policy actions include the following:

- Establish a renewable purchase obligation, such as a renewable portfolio standard or a renewable purchase requirement for state and local governments, that allows aggregation of distributed resources or includes distributed generation.

CHP in San Diego

Determined to take control of their energy costs, Design Synthesis, a manufacturer of high-end windows and doors for custom homes, is working with Capstone California to design and install a distributed generation and cogeneration power system. The project, scheduled for construction immediately, will feature four Capstone microturbines, one MicoGen Heat Exchanger for heat recovery, and a modular hot water fired absorption chiller capable of providing heat, ventilation and air conditioning for their entire building.

Photo by Capstone

The microturbines will operate during business hours to shave over 75% off their peak power demand and lower their overall energy costs. Using natural gas, the Capstone microturbines can produce electricity at close to 7 ¢/kWh, compared to San Diego Gas and Electric's newly adjusted rates ranging between 15 ¢/kWh and 20 ¢/kWh. More importantly, Design Synthesis' exposure to expensive peak demand charges will be lessened by nearly 120 kW.

Close to 70% of the energy in the system — roughly 1.16 MMBtu — escapes out the top as waste heat. This waste heat is usable energy. By capturing that energy into a heat exchanger, which acts like a water radiator, between 30 and 60 gallons of water can be heated per minute, raising the water's temperature by 60 and 30 degrees Fahrenheit respectively. The "free" hot water is then piped through the absorption chiller, which uses hot water as its energy source. Depending on the thermostat control, the chiller will provide both cooling and heating for the nearly 12,000 square feet of conditioning space at Design Synthesis. The system will achieve fuel efficiencies between 70% and 90%, while emitting less than 0.49 lbs/MWh of NOx. This installation is the first of its kind in San Diego, serving as a model for energy efficient buildings and savings-minded business owners.

- Encourage Power Authority financing assistance for the installation of clean distributed generation.
- Continue and expand the availability of financial incentives, including buy-down programs and grants, for clean forms of distributed generation.
- Develop incentive tariffs and reduced stand-by and exit fees for clean distributed generation installations.
- Streamline the permitting and utility interconnection process for clean distributed generation installations.
- Establish priority funding for clean distributed generation technology advancement.
- Provide financing assistance for the installation of clean distributed generation.
- Provide incentives for developers to include clean DG at new residential or commercial construction projects.
- Establish requirements that all new residential and commercial construction be "solar-ready" with the basic infrastructure to ease future installation of photovoltaic panels.

The Bad: The Dirtiest Distributed Generation

The internal combustion engine (ICE), the traditional technology used in vehicles, is also the predominant technology for portable and stationary generators. Also called reciprocating engines, ICEs can use a variety of fuels, including diesel, gasoline, natural gas, and propane. Diesel is the most common fuel for ICEs used as distributed generation.

Diesel Generators

Although there are now many competitive technologies available for distributed generation, diesel generators have historically dominated the DG market. This form of distributed generation has also been the most cost-effective for consumers, largely because the public health and environmental costs of burning diesel fuel are not accounted for in the cost of generation.

Not only is the diesel generator the most commonly used form of distributed generation, it is also the most polluting form. Many people are familiar with the black plumes of smoke released by diesel trucks and buses. Diesel generators are not different. The harmful health effects of diesel exhaust have been studied and well documented for decades. Because many diesel generators are located in dense urban settings, this technology significantly increases the public's exposure to cancer-causing pollutants.

Quantifying the Problem

Providing power for everything from businesses to agricultural equipment to homes, diesel generators are widely used throughout California. Diesel generators are found in the basements of office buildings or powering lights used during freeway construction. ARB estimates that there are a total of 65,382 diesel generators in California. Approximately 26,285 of these diesel generators are believed to be used for DG purposes.

Diesel generators are used in a variety of ways. ARB defines three general categories of use:[22]

Emergency stand-by generators – Often referred to as "back-up generators" or BUGS, these are generators that operate on a temporary basis as back-up power supplies in the event of power outages.

Prime generators – Generators used on a regular basis to supplement energy from the power grid.

Portable generators – Generators that are moved from location to location to provide power (motor vehicles and engines used to propel equipment are not considered portable generators).

Table 2: Diesel Generators Used as DG in California[21]

Diesel Generators by Type of Use	Number in California	NOx (tons/year)	PM (tons/yr)
Emergency Stand-by Generators	11,344	2,758	138
Prime Generators	1,441	2,687	127
Portable Generators	13,500	6,125	395
TOTAL	**26,285**	**11,570**	**660**

The more hours a diesel engine operates, the more pollutants it releases into the air we breathe. For example, emergency back-up generators are generally used only 100-200 hours per year while prime engines operate anywhere from 100 to several thousand hours per year. Hence, although there are far more emergency generators in California, prime engines have the potential to be a larger source of diesel pollution in the state due to their longer hours of operation.

Currently, diesel generators are regulated differently depending on how they are used. The result has been confusing

Table 3: Description of Emissions

Name of Pollutant	Abbreviation	Source and Environmental Impacts	Health Impacts
Carbon Monoxide	CO	CO is produced by burning organic matter such as fossil fuels, wood and charcoal. Motor vehicles produce 67% of the man-made CO that is released into the atmosphere.	Fatigue, angina, reduced visual perception and dexterity, death in closed space.
Carbon Dioxide	CO_2	CO_2 is produced by burning organic matter such as fossil fuels, wood and charcoal. CO_2 is a greenhouse gas.	Major contributor to global warming, which has been linked to an increase in the spread of disease.
Nitrogen Oxides	NOx	Oxides of nitrogen are the chemicals responsible for giving smog its brown appearance. NOx contributes to the formation of ozone, production of particulate matter pollution, and acid rain.	Irritates lung tissue, causes bronchitis and pneumonia, has been linked to a decrease in lung function growth.
Particulate Matter	PM	Particulate matter consists of soot and dust particles that are smaller than the diameter of a human hair. Diesel generators account for 7% of the diesel particulate matter pollution in the state.	Penetrates deep into the lungs and is associated with numerous respiratory and cardiac problems and cancer.
Sulfur Oxides	SOx	Oxides of sulfur are produced by the burning of fossil fuels. Large emitters of SOx include motor vehicles, refineries and power plants. SOx contributes significantly to acid rain.	Reduces respiratory volume, increases breathing and nasal airway resistance.
Volatile Organic Compounds	VOC	VOCs are a class of reactive organic gases that contribute to the formation of ozone and smog. Motor vehicles, refineries and power plants are the primary source of VOCs.	Coughing, fatigue and nausea; contributes to the inflammation of lung tissue and reduced lung capacity.

and inconsistent standards for not only diesel generators but for all distributed generation. Such regulation needs to be improved by developing standards that are based on environmental and public health impacts.

Emissions

Diesel generators are a significant source of air pollution in the state of California and nationwide.[23]

Together the 26,000 diesel generators in California emit 11,600 tons per year of smog-forming NOx and 660 tons per year of cancer-causing particulate matter (PM).[24] Diesel generators account for 7% of the diesel particulate matter pollution in the state.[25]

As diesel fuel burns, over forty identified toxic air contaminants are released into the air we breathe. 70% of all toxic air pollution in California is believed to come from diesel particulate matter, including pollution from cars and trucks.[26]

The other primary pollutant is oxides of nitrogen, which can cause lung function deterioration and other serious human health effects. Additional pollutants include carbon monoxide, carbon dioxide, sulfur oxides, and volatile organic compounds.

Health Impacts

The extended use of diesel generators can result in serious human health implications, especially since most non-agricultural diesel generators are located in densely populated urban areas. According to the ARB, about 80% of the total emergency stand-by engines and 70% of the non-agricultural prime engines are located in four California air basins: San Francisco, San Diego, San Joaquin Valley and South Coast.[27]

In other words, where large numbers of people are, so too are these under-regulated, high-emitting engines that spew smog-forming chemicals, fine particles, and known cancer-causing agents.

Cancer Risk

ARB has estimated that a person's lifetime cancer risk increases by 50% if he or she lives near a single one-megawatt diesel generator that runs for as little as 250 hours annually.[28]

This should be of great concern to individuals who live in Los Angeles, Orange, and parts of San Bernardino and Riverside counties as their local air district, the South Coast Air Quality Management District, has recently increased the allowable number of operating hours for emergency stand-by diesel generators from 200 to 500 hours per year.[29]

In recent years, an increasing number of health organizations, including the United States Environmental Protection Agency and the California Environmental Protection Agency, have recognized the cancer-causing effects of diesel exhaust exposure.[30] Over forty individual chemical compounds in diesel exhaust have been identified as toxic air contaminants, known to cause either cancer or reproductive harm.[31] Air district officials now estimate that based on a lifetime risk of seventy years exposure, diesel exhaust may be responsible for over 125,000

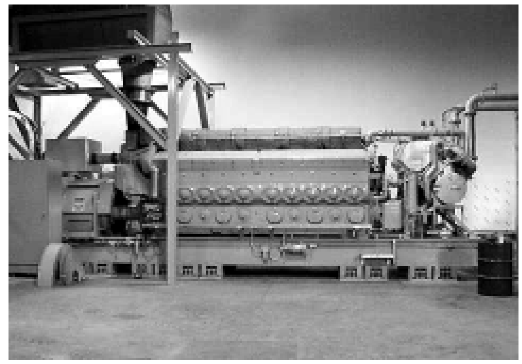
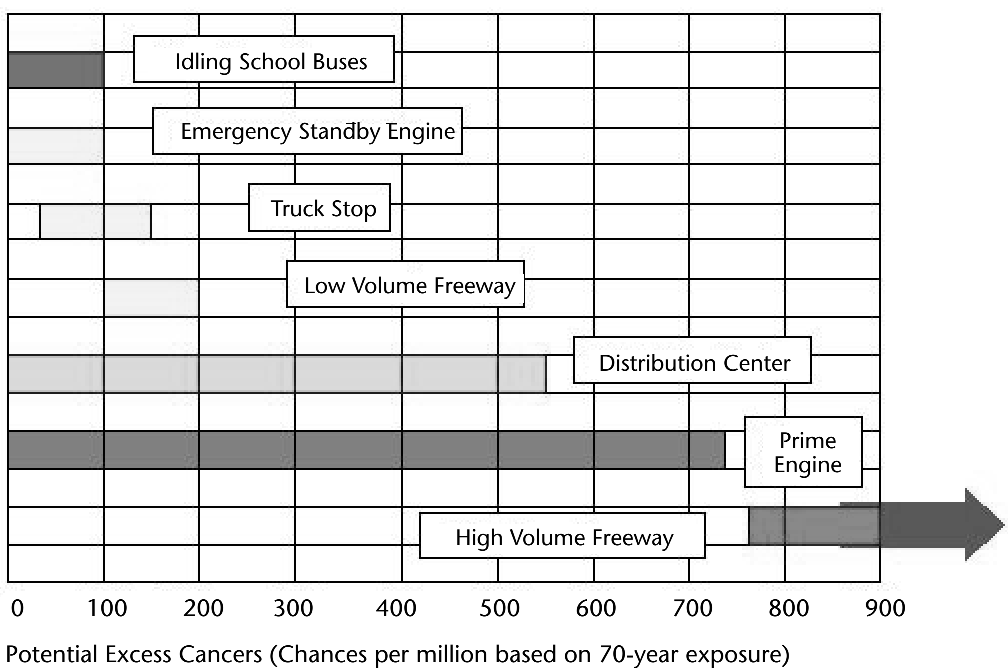


Photo by High Frequency Active Auroral Research

Figure 2: Potential Cancer Risk Range of Activities Using Diesel Fueled Engines



cancer cases each year nationwide.[32] In California alone, diesel exhaust emissions account for more than 70% of the total cancer risk from air pollution.

The cancer risk from diesel generators is also illustrated in the ARB Diesel Risk Reduction Plan. This document shows that the cancer risk from an emergency stand-by engine is equivalent to that of an idling school bus.[33] The cancer risk from prime engines (including non-agricultural engines and agricultural engines) is more than that of a low-volume freeway and that of a facility that has constant diesel truck traffic. Both current diesel BUGs and prime engines substantially surpass the acceptable risk level of one in a million cancer cases established by the U.S. EPA.

Non-Cancer Health Risks

Diesel exhaust is also known to cause numerous non-cancer respiratory problems. Diesel is a major source of particulate matter (PM), or soot, which can lodge deep in the lungs and result in the exacerbation of asthma, respiratory infections, increased susceptibility to allergens, chronic obstructive lung disease, pneumonia, and heart disease. A recent study found that even short-term exposure to PM may increase the chance of heart attacks in at-risk populations.[34]

Diesel exhaust also contains oxides of nitrogen, or NOx, a significant contributor to smog formation. NOx in the presence of sunlight and volatile organic compounds forms smog, making the decision to bring online thousands of diesel generators on hot summer days to meet the state's electricity demands a grim prospect. Recently, the USC Keck School of Medicine found in a long-term study that both NOx and PM can permanently reduce the lung function of a child living in Southern California by as much as 10%. Diesel exhaust was believed to be a significant contributor.[35]

Other Fossil Fuel Internal Combustion Engines

Natural Gas Engines

Internal combustion engines fueled by natural gas are cleaner than diesel generators, but still have high emissions of dangerous air pollutants. Natural gas generators have large reductions in NOx and SOx compared with diesel generators, medium reductions in PM and CO_2, and minimal reductions in CO and VOCs.

Natural gas engines are offered with two tuning settings (standard or stoichiometric, and low emissions or lean burning), but the choice is a trade-off of lowering emissions of one pollutant while increasing those of another. The low emission tuning will reduce NOx emissions in the standard tuning, but at the same time it increases CO emissions. All other emissions are similar between the two tunings.[37] Natural gas generators still contribute significantly to the same environmental and health impacts described in Table 3.

Engines Using Other Fossil Fuels

ICEs can also use gasoline and propane as fuel. Though not as common as diesel and natural gas generators, gasoline and

Table 4: Emissions Comparison of Diesel and Natural Gas Engines (lbs/MWh)[36]

Generator Type	Efficiency	CO	VOC	NOx	SOx	PM	CO_2
Diesel ICE	44%	10.0	2.0	17.0	5.0	3.0	1,700
Natural Gas ICE	35%	8.0	1.7	3.2	0.01	0.5	970

propane generators are commercially available.

Emissions levels from gasoline-fueled ICEs fall between those of natural gas and diesel-fueled generators. Gasoline generators are the cheapest generators on the market, but have a reputation of high maintenance requirements as compared to generators using any of the other fossil fuels.

Propane generators emit very similar amounts of pollutants as the natural gas generators.[38]

Improving ICEs for Emergency Use

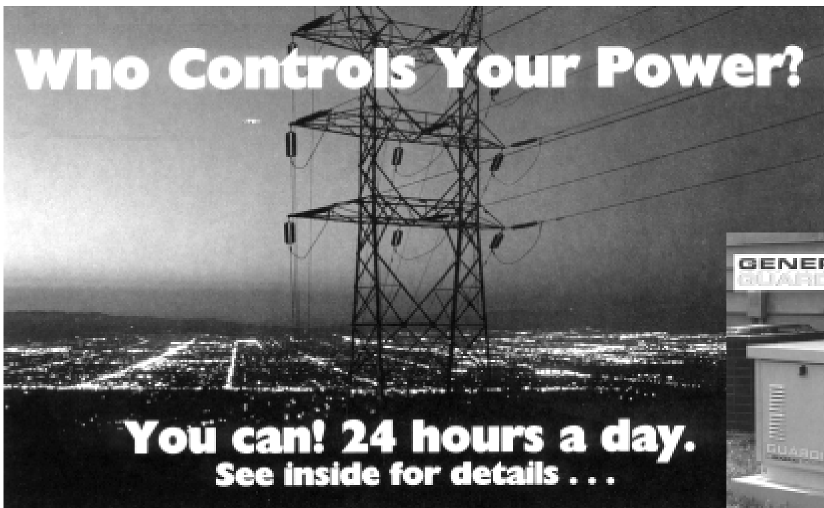
Due to the severe public health and environmental hazards associated with ICE generators, their use should be limited to emergency back-up generation and then only when operated in conjunction with emission-control measures. The pollution-reducing measures that can reduce the harmful impact of diesel generators on nearby communities include fuel advancements, control technologies, improved efficiency, and stringent operations and emissions standards.

- Fuel Advancements — The state of California is currently considering a requirement for low-sulfur diesel for various heavy-duty vehicle applications such as refuse and tanker trucks. The ARB adopted and the U.S. EPA is considering the adoption of regulations requiring petroleum producers to distribute low-sulfur diesel (15 ppm sulfur content) nationally by 2006.[39] Because most advanced diesel pollution control devices are sulfur-sensitive, such steps to require low-sulfur diesel are essential to achieve further emissions reductions for diesel engines.
- After-Treatment Technology / Emission Control — The ARB is currently testing many products to determine their overall effectiveness in reducing ICE emissions levels.[40] Particulate traps physically capture particulate matter in a filter and can reduce PM emissions by 83%.[41] Selective catalytic reduction (SCR) uses ammonia as a catalyst to capture NOx. SCR systems have been shown to reduce NOx by 65% to 99%.[42] Nitrogen Oxide Adsorbers have the potential to reduce NOx by 90%. This technology involves both a chemical catalyst and burning the filter clean. Even with these improvements, however, diesel and other fossil fuel generators are still dirtier than the good distributed generation technologies discussed earlier.
- Increased Efficiency — The efficiency of ICE generators can also be improved by ensuring proper installation and sizing. Improper installation can account for a 25% loss in efficiency. Another way to improve efficiency is to capture and reuse the generator's heat that is released as waste. The waste heat produced by the generator can be recovered to provide energy for further electricity production or space and water heating. This process can reduce emissions by 35 to 50%.
- Hours of Use — Reducing the operating hours of ICE generators will also reduce the amount of pollution that is released into the air we breathe.

Key Recommendations

The California state government has an obligation to protect the state's air quality. Since the move to local power generation has partly involved an increased reliance on the most polluting forms of electricity generation, state agencies should take steps to discourage the use of dirty DG. This would include the following measures:

- Require that all DG units operated in California receive ARB certification or air district permit in order to be interconnected to the electric grid.
- Create a dedicated revenue stream to defray the costs of cleaning up polluting distributed generation by taxing the purchase of dirty diesel fuels.
- Extend the Carl Moyer Program, which provides incentives for the trade-in and upgrade of dirty diesel equipment, to include polluting distributed generation installations.
- Require that transmission grid operators draw on clean, efficient distributed generation power before similarly priced dirty installations.



Manufacturers and distributors of diesel generators used the "energy crisis" to encourage consumers to purchase polluting home power systems.

The OTHER: Emerging Distributed Generation Technologies

New technologies for generating local power are emerging in the marketplace. Although they are not as clean as the renewable energy sources, most of these alternatives are distinct improvements over current diesel generators. Some will meet the proposed emissions standards in the short term, although improvements will be needed to meet the anticipated stricter standards in the future. By establishing stringent standards regardless of technology, state officials will push manufacturers to limit harmful emissions.

Some of these distributed generation options can be used in combined heat and power applications. They are not as simple to operate and maintain as sustainable options such as wind and solar, but they are often versatile and reliable. Most available technologies utilize carbon-based fuels. While they pollute less than diesel engines, they still emit harmful gases.

Alternative Fuel Reciprocating Engines

The reciprocating engine, or internal combustion engine, is the traditional engine used in vehicles and diesel generators, as noted above in the "Dirtiest Distributed Generation" section. This system draws air into a cylinder, compresses the air to heat it, then injects fuel, which ignites when mixed with the hot air. The resulting explosion moves the piston. It is an open system, meaning that it does not reuse the air it draws in; instead it releases it into the atmosphere as exhaust heat and gases.

Stationary reciprocating engines, like the diesel generator, are typically 5 MW or less, with the 1-3.5 MW range being the largest growing segment recently.[43]

When fueled by traditional fossil fuels, these engines are the most polluting of the distributed generation options. When operated with alternative fuels, however, their emissions can be reduced. See Appendix A for information on alternative fuels.

Turbines

A "gas turbine" differs from the reciprocating engine because it uses a continuous combustion process rather than intermittent combustion. Like a reciprocating engine, the basic gas turbine is an open system, but it can be modified to reuse its exhaust heat.

Gas turbines have traditionally been manufactured to generate several hundred megawatts for use as central power plants. Now some manufacturers are scaling down their units to less than 30 MW.[44] Most new turbines are fueled by natural gas.

Microturbines

Introduced over the last few years, the microturbine is a relatively new technology with a rapidly growing market. Based on the same technology as a jet engine, although much reduced in size and improved with advanced components and software, microturbines can provide power in the 25 kW to 500 kW range. The initially available commercial units generate power ranging from 28 kW to 75 kW. These smaller units are about the size of a refrigerator.

Microturbines have the potential to operate on a variety of fuels. Manufacturers, with some support from federal and state agencies, are working to improve microturbine performance, including generation efficiency. Models built to date have lower efficiency, and thus higher CO_2 emissions, than traditional engines.

In addition to their small physical size and flexibility regarding fuel sources, microturbines have only one moving part and, therefore, low maintenance costs. They are highly suitable for combined heat and power applications.

Microturbines' advanced fuel combustion technology results in low NOx emissions, without any emission-control technology, in comparison with gas-fired central station plants. Early tests indicate that this emissions performance will be maintained over extended operating periods. Capstone Turbine Corporation, located in California, claims that current units operate at 0.50 lbs/MWh, and projects that performance improvements will decrease NOx emissions output to 0.14 lbs/MWh by 2005 and 0.05 lbs/MWh by 2008, numbers which will meet recommended emissions standards.

Stirling Engines

Stirling engines are powered by the expansion of a gas that results when the gas is heated and by the compression of a gas that results when the gas is cooled. In this closed cycle system, a fixed amount of gas is externally heated, usually by combustion, and as it expands and contracts, it moves the pistons.

Theoretically, these engines can use any heat source. Currently, systems are being developed that use biomass, woodchips and solar heat. Stirling engines are physically smaller than conventional engines and relatively quieter. Engines ranging from 500 watts to 10 kW are either available now or under development.

Emissions associated with Stirling engines vary according to the heat source used. The Stirling engine itself has no emissions. So, when it is developed to use solar heat as the heat source, the entire system will be emission-free; when fossil fuels are burned to provide the heat source, there are emissions. Since the combustion takes place externally, it can be monitored to burn fuels completely and to limit the temperature, reducing emissions somewhat.

Potential Advantages of Emerging Technologies

Technical advancements, including improvements in fuel combustion and emissions reduction equipment, have the potential to significantly reduce the environmental impacts of these distributed generation technologies. Federal, state and manufacturer-funded research and development programs are pursuing such improvements. Clear emissions standards will provide clear signals regarding technology performance targets, and a strong incentives policy can establish attractive market advantages for the cleanest distributed generation technologies.

Key Recommendations

These technologies already show the promise of being safer for public health than the dirtiest distributed generation. To make sure that they move toward the cleanest distributed generation technologies, we must ensure that pollution standards are applied across the board to all developing technologies, and complement those standards with policies that provide economic and other incentives to the cleanest DG systems. State agencies should take the following actions:

- Establish priority funding for clean distributed generation technology advancement.
- Streamline the permitting process for clean units that meet or beat state or air district standards.

- Require that all DG units operated in California receive ARB certification or air district permit in order to be interconnected to the electric grid.
- Ensure adequate enforcement of emissions standards and establish significant penalties for violation.

Policy Recommendations

Distributed generation is here to stay and is likely to expand rapidly in the coming years. This is both an opportunity and a risk for public health in California. Clean DG options have the potential to greatly reduce dangerous emissions from electricity production, but the most common DG technology — the diesel generator — is even more polluting than the leading technologies of large central power plants. To ensure that public health is protected and that new technologies to reduce pollution are encouraged, distributed generation policy should be based on the following principles:

- Distributed generation must be as clean as or cleaner than the cleanest central power plant technology.
- State rules and incentives must promote the cleanest energy industry for the future of California.
- Regulations should be as simple as possible so manufacturers can anticipate changes and comply with new technology requirements.

The ARB and regional air districts can help move distributed generation in the right direction as they determine uniform emissions standards for these technologies. To protect the health of Californians and the air quality of the state while helping to assure reliable local power generation, we recommend the following immediate ARB policy actions:

- Set stringent emissions and efficiency-based standards for all distributed generation units operated in California.
- Streamline the permitting process for clean units that meet or beat state or air district standards.
- Ensure adequate enforcement of standards and establish significant penalties for violation.

Other state agencies also have roles to play in ensuring that the move to local power generation leads to air quality benefits rather than a digression to polluting technologies. The ARB can encourage other agencies to adopt these measures, and the state legislature should provide funding. Together, state agencies should:

Establish standards and rules for DG operation:

- Require that all DG units operated in California receive ARB certification or air district permit in order to be interconnected to the electric grid.
- Require that transmission grid operators draw on clean, efficient distributed generation power before similarly priced dirty installations. Air pollution emissions should be considered in decisions regarding which generators are used in times of excess power capacity.
- Require emission-control equipment for diesel generators used for emergency back-up power supply. Back-up generators will continue to be a major pollution problem if they are left out of the regulatory picture.
- Require that all new residential and commercial construction be "solar-ready" with the basic infrastructure to ease future installation of photovoltaic panels.

Provide funding for clean DG:

- Establish priority funding for clean distributed generation technology advancement. State research and development programs can target the most promising clean DG technology options. Public money for the development of these technologies would be a good investment for the long-term health of the state economy.

- Continue and expand the availability of financial incentives, including financing assistance, buy-down programs, and grants, for the installation of clean distributed generation. As long as consumers are expected to shoulder the burden of the investment costs of new technology, the government should provide financial assistance.
- Provide incentives for developers to include clean DG at new residential or commercial construction projects. Since builders donít pay the ongoing energy costs of the units they build, they are reluctant to include energy-saving measures that will increase the initial sale price of their buildings.
- Create a dedicated revenue stream to defray the costs of cleaning up polluting distributed generation by taxing the purchase of dirty diesel fuels. The generators that create most of the air pollution from electricity generation should be the first to pay for pollution reduction upgrades.
- Extend the Carl Moyer Program, which provides incentives for the trade-in and upgrade of dirty diesel equipment, to include polluting distributed generation installations. This recommendation builds on the success of this existing program to encompass more of the dirty DG population.

Clear hurdles to the implementation of clean DG:

- Streamline the permitting and utility interconnection process for clean distributed generation installations. DG is currently at a disadvantage compared with traditional power generation due to an unnecessarily complicated interconnection process. Eliminating this disadvantage for clean DG would promote its expansion.
- Develop incentive tariffs and reduced stand-by and exit fees for clean distributed generation installations. This would address financial disincentives in utility relationships with distributed generation operators.
- Establish a renewable purchase obligation, such as a renewable portfolio standard or renewable purchase requirement for state and local governments, that allows aggregation of distributed resources or includes distributed generation. This policy would encourage installation of renewable DG, the cleanest of the DG options.
- Inventory clean distributed generation sources operating in California. In order to track the success of programs to promote clean DG, accurate information on installed capacity must be available.

The adoption of these recommendations will help to promote a vital distributed generation system that reduces the negative public health impacts associated with diesel and other dirty DG technologies.

Appendix A: Alternative Fuels

Several non-traditional fuels have been developed that can replace pure fossil fuels in some combustion engines, microturbines, Stirling engines, and fuel cells. While some of these fuels may hold promise for reducing emissions from electricity generation, most of them involve levels of health risk similar to those of traditional fuels.

Biodiesel is a fuel that is made from vegetable oils or animal fats. The "bio" part of the fuel mixture can be used alone, but is usually mixed with conventional petroleum diesel fuel at a ratio of 20-30% "bio" to 70-80% diesel.[45] The fuel operates in a conventional combustion engine like a diesel generator. Compared to regular diesel, biodiesel has reduced emissions of CO and SOx but has increased NOx and soluble CO_2 emissions and unknown toxic impact.

Propane, also called Liquefied Petroleum Gas (LPG), is formed as a by-product of processing natural gas and refining crude oil. Propane usage emits no aromatic compounds, benzene or particulates. Engines that are optimized for propane have lower CO_2 emissions than diesel generators. Propane can be used as a substitute for diesel fuel in internal combustion engines.

Ethanol is made from the fermentation of sugars or starches in grains, agricultural feedstocks and agro-forestry products. Ethanol is mixed with gasoline in different percentages to be used as a fuel.

Methanol is predominantly made from steam reforming of natural gas. It can also be made from feedstocks of coal or biomass, but currently these are not as economical. Methanol is a building block for the gasoline additive MTBE, which is used in gasoline as an oxygenate like ethanol. Methanol has also been demonstrated as a viable fuel for both diesel and combustion turbines.

Biomass describes many types of "waste to energy" electricity generation technologies. Some are unacceptably harmful to the environment while others provide a net benefit to the environment. The use of biomass in fuel cells, micro-turbines and Stirling engines is still being researched.

P Series Fuels are blends of methyltetrahydrofuran (MTHF), ethanol and hydrocarbons. Currently MTHF is produced from biomass or petroleum feedstocks.

Appendix B: Glossary

Back-up Generators (BUGs)
Emergency power generators used to avoid potential power interruptions caused by malfunctioning power plants, natural disasters, or demand overloads on the electric grid.[46]

British Thermal Unit (Btu)
The standard measure of heat energy, equal to the amount of energy needed to raise the temperature of one pound of water by one degree Fahrenheit at sea level. It takes about 2,000 Btus to make a pot of coffee.

California Air Resources Board (ARB)
The regulatory agency that ensures Californiaís compliance with the Clean Air Act.

Carbon Monoxide (CO)
An air pollutant produced by burning organic matter such as oil, natural gas, fuel, wood and charcoal. Motor vehicles produce 67% of the man-made CO that is released into the atmosphere.

Carbon Dioxide (CO_2)
A greenhouse gas, produced by burning organic matter such as oil, natural gas, fuel, wood and charcoal.

Combined Heat and Power (CHP)
A power generation system that uses waste heat to heat water, rooms and buildings; provide air conditioning or refrigeration; or provide steam to generate more electricity.

Distributed Generation (DG)
Energy production that occurs near the place where it is used.

Emergency Stand-by Generators
Often referred to as "back-up generators" or BUGS, these generators operate on a temporary basis as back-up power supplies in the event of power outages.

Fuel Cell
An energy production technology that creates electricity and heat through the chemical reaction of combining hydrogen and oxygen to make water.

Kilowatt-hour (kWh)
The most commonly used unit of measure telling the amount of electricity consumed, equal to the energy transferred in an hour by one kilowatt of power. In 1999, a typical California household consumed 534 kWh in an average month.

Megawatt (MW)
One thousand kilowatts (1,000 kW) or one million watts. One megawatt is enough energy to power 1,000 average California homes.

Megawatt-hour (MWh)
One thousand kilowatt-hours, or an amount of electricity that would supply the monthly power needs of a typical home having an electric hot water system.

Microturbine
A new distributed generation technology based on the same technology as a jet engine although much reduced in size and improved with advanced components and software.

Net Metering
A system for metering electricity consumption that subtracts the amount of power fed back into the grid by a DG unit from the amount that is drawn from the grid.

Nitrogen Oxides (NO_X)
The chemicals responsible for giving

smog its brown appearance. NOx contributes to the formation of ozone, production of particulate matter pollution and acid rain.

Particulate Matter (PM)
An air pollutant made up of soot and dust particles that are smaller than the diameter of a human hair.

Peak Load or Peak Demand
The electric load that corresponds to a maximum level of electric demand in a specified time period. Peak periods during the day usually occur in the morning hours from 6 to 9 a.m. and during the afternoons from 4 to about 8 or 9 p.m. The afternoon peak demand periods are usually higher, and they are highest during summer months when air-conditioning use is the highest.

Photovoltaic (PV) Panel
Also known as a solar panel, PVs convert sunlight directly into electricity using semiconductor technology.

Phosphoric Acid Fuel Cell (PAFC)
This is the type of fuel cell currently available for commercial sale in the United States.

Prime Generators
Generators used on a regular basis to supplement energy from the power grid.

Portable Generators
Generators that are moved from location to location to provide power (motor vehicles and engines used to propel equipment are not considered portable generators).

Sulfur Oxides (SOx)
An air pollutant produced by the burning of fossil fuels. Large emitters of SOx include motor vehicles, refineries and power plants. SOx contributes significantly to acid rain.

Volatile Organic Compounds (VOCs)
A class of reactive organic gases that contribute to the formation of ozone and smog. Motor vehicles, refineries and power plants are the primary source of VOCs.

Wind Turbine
An energy generation technology in which the kinetic energy of the wind is converted to mechanical power, which in turn drives the electrical generator and produces an electrical current.

NOTES

1 Distributed generation should not be confused with the "peaker plants" that are much in the news recently. Although both are small electricity generating plants, peakers are utility-run generators that are used only during peak demand times. They are typically 50-100 MW. DG units are normally not operated by utilities, and are typically in the 2 kW to 75 kW range.

2 David Morris, *Seeing the Light: Regaining Control of Our Electricity System* (Minneapolis: Institute for Local Self-Reliance, 2001), 54.

3 Ibid.

4 Distributed Utility Associates, prepared for the California Air Resources Board, *Air Pollution Emissions Impacts Associated with Economic Market Potential of Distributed Generation in California*, June 2000. These are 2002 projections. CO2 emissions are divided by 1000 to fit into the same graph as the other emissions. CO2 emissions are a very significant air pollution problem due to their global warming effect.

5 Documented PV capacity: 871 solar power systems producing 3.1 MW of electricity are registered with the CEC rebate program (Sandy Miller, California Energy Commission, personal communication, 31 August 2001); a leading industry analyst estimates there is a total of 15 MW of dispersed PV capacity in California (Paul Maycock, PV Energy Systems, personal communication, 6 June 2001); 7 MW of PV is installed in the Sacramento Municipal Utility District system (Donald Osborn, "Putting the Sun to Work in Sacramento," *Solar Today*, May/June 2001). Documented wind capacity: California now has 1,600 MW of wind capacity, though very little of this is from small DG units (American Wind Energy Association, *Wind Project Database*, 6 November 2000); 53 wind power systems producing 157 kilowatts of electricity are registered with the CEC rebate program (Sandy Miller). Documented fuel cell capacity: Three fuel cells of 200 kW each are operating in the Southern California Gas Company service region (Charles Butler, Southern California Gas Fuel Cell Team Leader, personal communication, 27 August 2001); there is one fuel cell of 400 kW registered with the CEC rebate program (Sandy Miller).

6 Distributed Utility Associates, *Air Pollution Emissions Impacts Associated with Economic Market Potential of Distributed Generation in California*, June 2000.

7 Many studies have established the links between these pollutants and their health effects, including D.W. Dockery et al, "An Association between Air Pollution and Mortality in Six U.S. Cities," *New England Journal of Medicine*, 1993. For a good overview of the health effects of power plant pollution, see Clean Air Task Force, *Death, Disease & Dirty Power*, October 2000.

8 California Public Interest Research Group, *Affordable, Reliable Renewables: The Pathway to California's Sustainable Energy Future*, July 2001; and California Public Interest Research Group, *Predictably Unpredictable: Volatility in Future Energy Supply and Price from California's Over-Dependence on Natural Gas*, September 2001, available at www.calpirg.org.

9 U.S. Department of Energy (DOE), Office of Utility Technologies, *Renewable Energy Technology Characterizations*, December 1997.

10 PV has an average availability factor of 96%: Sacramento Municipal Utility District, *Sustained Orderly Development of PV*, downloaded from www.ttcorp.com/upvg/4.5doc/4.5mwsmd.htm, 4 June 2001.

11 Alan Zibel, "Home Grown Power," *Oakland Tribune*, 22 April 2001.

12 U.S. DOE, *Quick Facts about Wind Energy*, downloaded from www.eren.doe.gov/wind/web.html, 15 July 2001.

13 American Wind Energy Association, *California Energy Crisis Spurs Sales of Home Wind Energy Systems* (press release), 13 February 2001

14 Danish Wind Turbine Manufacturer's Association, *Windpower FAQs*, downloaded from www.windpower.dk/faqs.html, 25 May 2001.

15 Lester Brown et al, *State of the World 2001* (NY: W.W. Norton, 2001), 94.

16 American Wind Energy Association, *California Electricity Crisis Spurs Sales of Home Wind Energy Systems* (press release), 13 February 2001. Wind turbines have an average availability factor of 98%: U.S. DOE, Office of Utility Technologies, *Renewable Energy Technology Characterizations*, December 1997.

17 Pacific Northwest National Laboratory, *Federal Technology Alerts: Natural Gas Fuel Cells*, November 1995.

18 Sunline, *Clean Fuels*, downloaded from www.sunline.org/clean_fuels/clean_fuels/cf_frameset.html, 31 August 2001.

19 Pacific Northwest National Laboratory, *Federal Technology Alerts: Natural Gas Fuel Cells*, November 1995; Charles Butler, Southern California Gas Fuel Cell Team Leader, personal communication, 27 August 2001.

20 U.S. Combined Heat and Power Association, *Combined Heat and Power: Distributed Generation Applications that Save Power, Reduce Costs, and Improve Energy Security*, downloaded from www.nemw.org/uschpa/papers.htm, 17 August 2001.

21 ARB, *Diesel Risk Reduction Plan, Appendix II*, October 2000. ARB, *Public Meeting to Consider Approval of California's Emissions Inventory for Off-Road Large Compression-Ignited (CI) Engines (25HP)*, January 2000. Figures for prime generators are approximate.

22 Ibid.

23 State numbers are in the previous section. An estimated 371,000 tons of NOx and 16.7 million tons of CO2 are emitted from diesel generators nationwide: Virinder Singh, Renewable Energy Policy Project, *Blending Wind and Solar into the Diesel Generator Market*, Winter 2001.

24 California Air Resources Board (ARB), *ARB Diesel Risk Reduction Plan, Appendix II*, October 2000

25 Calculated from ARB, *California's Plan to Reduce Diesel Particulate Matter Emissions* (fact sheet), October 2000 and ARB, *Diesel Risk Reduction Plan*, October 2000. The fact sheet explains that together all diesel engines in California emit over 28,000 tons of PM per year.

26 South Coast Air Quality Management District, *Multiple Air Toxics Exposure Study in the South Coast Air Basin (MATES-II)*, March 2000; ARB, *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles* (draft), 13 July 2000.

27 ARB, "Stationary and Portable Diesel-Fueled Engines," *Diesel Risk Reduction Plan*, October 2000.

28 ARB, *Attachment to Letter on Emergency Generators: Air Pollution Emissions from Electricity Generation*, 21 February 2001. Based on 70-year exposure.

29 South Coast Air Quality Management District, *Rule 118 Executive Order #01-01*, 26 January 2001. Ordinance applies to police and fire departments, hospitals, K-12 schools, public water facilities, public transit, prisons, 911 or emergency services, sewage treatment facilities, landfill facilities and necessary military. The generators may only be used during an imminent or actual blackout.

30 Cal EPA, *Chemicals Known to the State to Cause Cancer or Reproductive Toxicity*, revised 1 May 1997.

31 State of California listing under the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65); ARB, *Listing of Toxic Air Contaminants.*

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46 Thanks to the CEC (www.energy.ca.gov/glossary) for many of these definitions.