Evaluating RE And CE Programs—EE's Emergent Siblings

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ABSTRACT

A "new wave" of programs are currently spreading across the nation: programs that promote the use of renewable and/or highly efficient and non-polluting technologies to generate electricity at the premises of energy end-users (i.e., utility customers). While primarily intended to reduce the need to purchase electricity supplied "through the meter" from the power grid, these generating units may at times supply power to the grid.

Several aspects of these programs are closely similar to "traditional" DSM programs (similar barriers of high first-cost, awareness and availability, limited supporting infrastructure of thoroughly trained dealers and contractors who have extensive experience with the technologies, and a reluctance to invest in equipment that is unproven and may not perform as the seller is claiming), and similar approaches for overcoming these barriers. Each of the various technologies featured in electricity-from-renewable-energy programs have unique operating characteristic and unique siting challenges, and hence have unique participation barriers. Participation rates are usually smaller than for traditional programs.

Program evaluations must be designed to include the presence of multiple competing technologies and multiple "gatekeepers" (e.g., multiple inspectors, each serving a particular interest) as well as the unique features of technologies.

RE and CE Technologies

Historically, an "energy program" has usually—although not exclusively—been regarded as an energy-conservation program (prior to the late 1980s), or an energy-efficiency program (subsequently) that operates more-or-less exclusively on the demand-side (i.e., the customer side of the electric or gas meter, the fuel-oil or propane tank, or the coal pile). A "new wave" of programs are currently spreading across the nation: programs that promote the use of renewable and/or highly efficient and non-polluting "clean-energy" technologies to generate electricity at the premises of energy end-users (i.e., utility customers).[1] These distributed-generation installations are generally not designed to supply all the power required by the premise during any given month, but rather to simply reduce the amount that is purchased from the local utility or another supplier and delivered via the power grid.

Twenty-five years ago there was a flurry of activity focused on a different type of energy program sponsored by the federal government—active and passive systems that captured solar energy and used it for space-heating and water-heating applications. Today, these programs are widely regarded as failures because they were implemented hurriedly in response to the perception of an "Energy Crisis," without first ensuring that adequate quality standards had been established to ensure system were designed and installed such that they would operate reliably and produce long-term savings. Virtually all

[1] The same technologies are also deployed in other programs, where the technologies are directly connected to and supply electricity to the power grid. These "supply-side" programs are not further addressed in this paper.

of the current wave of systems that generate electricity from renewable sources are based on designs that have been demonstrated to be able to operate reliably for extended periods.

Solar energy has much to recommend it as a contributor to every nation's portfolio of energy sources:

- It is available everywhere on earth and to every inhabitant[2]
- It is non-depletable and "renews itself" with the dawn of each new day
- It is nonpolluting.

Its main drawbacks derive from the facts that: 1) it has relatively low power density (Btu/hr/sq.-ft.) and hence large surface areas are needed to collect large amounts of energy, 2) its source is constantly moving across the sky, and hence the power density incident upon a fixed surface is constantly varying, it is unavailable after sunset, and 4) it can be largely blocked by clouds, so power density may fall to near zero for periods of hours or days.

Technologies for capturing solar energy and converting it to thermal energy (heat) have been refined over the past two decades. These technologies are becoming more widely used in several nations near the equator for domestic water heating. Of greater interest is the conversion of solar energy into electricity, which in most frequently done in direct-conversion "solar panels." (An alternative is to first convert concentrated solar energy to heat (thermal energy), use this to generate steam (or another vapor) in a boiler, and then converting the thermal energy in this fluid to electricity via a turbine and generator.

We read about the use of solar panels to power military and civilian satellites, the International Space Station, and unmanned vehicles that explore other planets in the solar system. Here on earth, we use them in "off-grid" applications in our hand-held calculators, and see them powering signs and emergency telephones in remote areas along interstate highways. A number of manufacturers are producing ever-growing quantities of flat-panel solar cell arrays and selling them in global markets.

Electricity has come to be the primary focus of energy-supply technologies because electricity is: 1) the most versatile and most easily controlled form of energy; 2) easily and efficiently converted to other forms of energy, especially light and shaft power;[3] 3) a conveniently transported form of energy suitable to power communications equipment, computers, and all other electronic devices.

In addition to solar energy, technologies suitable for generating electricity from four other forms of renewable energy (RE)—wind,[4] hydropower, biomass,[5] and geothermal—have been the subjects of technological advancements over the past three decades. Two of these forms—wind and biomass—plus solar energy are most suitable for customer-sited generation. Wind and biomass share the disadvantage of non-uniform availability in the geographic sense, and less predictable availability in the temporal sense. They also have potential environmental liabilities,[6] but are generally regarded as forms of "clean

[2] At higher latitudes, its availability exhibits a strong seasonal dependency.

[3] Shaft power, in turn, can efficiently produce heating and cooling, drive machinery, generate electricity, and power vehicles.

[4] Wind energy and biomass are derived solely from solar energy, and hydropower derives from the combination of solar and gravitational energy.

[5] Biomass energy originally meant burning wood or crop residues to produce heat (and often to use the heat in a thermodynamic cycle to generate electricity). Over time, the term has been also applied to other organic wastes, including: 1) those produced by manufacturing industries, 2) mixed wastes ("trash") discarded by from homes and businesses, and 3) "biogas" generated when trash decomposes in a landfill, or when animal or human wastes are decomposed in a "digester." Because of the lack of a universal agreement of what biomass includes, specific energy programs often provide a program-specific definition.

[6] Wind energy is only practical in localities where strong winds are present a large number of hours in a year. Wind turbines are not benign because they kill or injure birds. Biomass materials have the potential for creating and/or releasing harmful byproducts when they are used as a fuel. Also, for some forms it is difficult to prove that supplies are being replenished as rapidly as they are being consumed, or that society would not be better served by recycling the material.

energy" because they cause less environmental damage than does the extraction, processing, transport, and use of depletable fuels (both fossil and nuclear).[7]

RE systems are often joined by fuel cells as eligible clean-energy (CE) technologies that are promoted via demand-side programs. In recent years, the promise of fuel cells as a practical means for generating electricity at very high efficiency is moving rapidly toward becoming a reality. A fuel cell is an electrochemical, direct-conversion device that operates like a battery that is continually recharged by the inflow of hydrogen and oxygen. The only byproducts are water and heat, both of which are potentially useful. One reactant—oxygen—is readily and freely available in the air. Hydrogen is only available as a chemical compound—the hydrogen atoms are linked to other atoms. The current means for obtaining hydrogen for fuel cells are either to break water molecules apart using electricity (possibly assisted by heat), or break hydrocarbon molecules apart. The first approach has the disadvantage of requiring more energy than will be later obtained in a fuel cell. However, in concept, the hydrogen could be produced from generating plants during off-peak periods when they would otherwise be shutdown, or could be produced at a remote location where the electricity is not needed (and the hydrogen then transported to the fuel cells). The U.S. DOE is funding studies of the possibility of constructing coal-fired or nuclear power plants expressly for the purpose of producing hydrogen. (Needless-to-say, these studies are highly controversial!) Innovative biological processes using algae or microbes such as cyanobacteria to convert solar energy and/or waste streams into hydrogen are also being researched.

Today and for the foreseeable future, the established technique is to reform hydrocarbons, such as natural gas, gasoline, methanol, ethanol, fuel oil, or propane. Biogas produced in landfills or waste-water treatment plants is another, somewhat specialized, source of hydrocarbons that can be converted to hydrogen. Although the biogas itself is a waste product and has zero cost, impurities are present with the gas and must be removed, which requires costly process equipment.

Irrespective of the feedstock used, three approaches can be taken: 1) produce hydrogen in large quantities and ship the hydrogen via pipeline or in storage tanks to the fuel cells[8], 2) package the reformer with the fuel cell, or 3) perform the reforming within the fuel cell itself (this is technically possible with only one of the fuel cell technologies now being commercialized)..

RE and CE Programs

Because RE and CE programs have socially desirable attributes, they are promoted via "public benefits" programs by the federal government, state government agencies, and/or individual electric and gas utilities (investor-owned, municipal, and co-op). The focus of this paper is on programs that promote the installation of customer-sited distributed-generation systems using RE or CE technologies (i.e., systems installed by utility customers that reduce the amount of electricity they purchase). These are truly demand-side programs, but they may also at times supply small amounts of surplus power to the grid. Like energy-efficiency programs—they improve the natural environment (especially reducing CO_2 emissions), reduce the use of depletable resources, and reduce the need for new large power plants and new transmission lines.

Legislatures or utility regulatory agencies in fifteen states and the District of Columbia require that RE or CE programs be implemented and supported by a "public-benefit" (PB) surcharge applied to utility bills or by state tax revenues. Table 1 shows these states and the approximate funding levels.[9] Beyond this list, the U.S. Department of Energy (DOE), the Environmental Protection Agency (EPA),

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[7] The "residuals" from using these fuels (carbon dioxide, air pollutants, acid rain, mercury, and radioactivity in spent nuclear fuel) create the most significant environmental concerns.

[8] This approach is a common industrial practice today. Hydrogen is produced in large quantities for the steel industry and other end-users.

[9] Funding levels and program requirements are frequently modified, so table may not be accurate.

Table 1: States Having SBC-Funded Clean Energy Programs10

State	Fuel Types/Technologies Supported	Maximum System Size	Eligible Sectors	Estimated Average Annual Funding (Millions)
AZ	Renewable Energy & Cogeneration	100 kW	All	$18.0 through 2012
CA	Solar, Wind	1,000 kW	All	$135.0 through 2012
CT	Solar, Wind, Hydro, Fuel Cell, Biomass	No Limit	Residential	(Uncertain: owing to recent changes)
DE	Renewable Energy	25 kW	All	???
IL	Solar, Wind	40 kW		$5.0 through (est.) 2007
MA	Renewable & Cogeneration	60 kW	All	$40.0 through 2003, then reduced
MT	Solar, Wind, Hydro	50 kW	All	$2.0
MN	Renewable & Cogeneration	40 kW	All	$8.5
NJ	Photovoltaic, Wind, Biomass, and Fuel Cells with Biogas	1,000 kW	All	$17.0 through 2008
NM	Renewable & Cogeneration	10 kW	All	$4.0 through 2007
NY	Solar (Wind and Biomass to be added)	10 kW	Residential, Agriculture	$70.0 through 2006
PA	Renewable & Fuel Cells	10 kW	All	$9.4 through 2003
RI	Renewable & Fuel Cell	25 kW	All	$2.0 through 2007
WI	All	20 kW	Retail	$3.0
OH	Solar, Wind, Fuel Cells, Biomass, Hydro, Microturbines	No Limit	All	$7.5 through 2005
OR	Solar, Wind Fuel Cell, Hydro	25 kW	All	$9.5 through 2011

Department of Defense (DOD), and the Treasury Department, also promote the installation of RE and CE technologies. Also not shown in the list are various individual municipal, regional, and other utilities that have their own PB programs. Among the largest of these are programs offered by the Los Angeles Department of Water and Power, the Sacramento Municipal Utility District, and the Long Island Power Authority.

The largest statewide program is California's, but substantial funds also exist in Arizona, Massachusetts, New Jersey, and New York. Wind and solar photovoltaic (PV) generation are eligible for support from most of the funds. Landfill gas is eligible, especially in states that do not have a renewable portfolio standard (RPS) to support near-market technologies. Fuel cells (using either renewable or nonrenewable fuels) are eligible in many funds, especially in states with limited wind and solar resources and difficult project siting constraints, such as those in the Northeast. Biomass power production is eligible in most states, although only a few funds have thus far supported such projects.

Some programs have a market-transformation (MT) focus and others have a resource-acquisition (RA) focus. Both share a common set of barriers (see below). The most significant energy-policy

[10] Sources: Davies Associates 2002.

implication regarding RE and CE programs that have a long-term market transformation goal is the need to sustain the program for enough time and at a large enough level to accomplish the goal.

Financial Incentives

In general, four types of financial incentives may be provided to participants in RE and CE programs. Some programs provide substantial rebates or financial grants to those who purchase eligible systems. (Programs with relatively low annual funding levels provide support to only a small number of participants.) These rebates may be as high as 50-60 percent of the total installed cost. Some programs operate like traditional DSM programs and pay an incentive based on pre-established criteria (which may vary with technology and/or rated capacity of the system). Other programs require applicants to submit a request for a grant, with only a limited number being awarded. An approach that is becoming more common on a state and local level is to offer tax incentives for purchasers of renewable energy technology. These incentives take several forms (e.g., sales tax exemptions, property tax exemptions, personal and corporate tax deductions). The fourth type of incentive is low-interest (subsidized) loans.

Table 2. Financial Incentives for Renewable Energy Technology in Selected States[11]

STATE	Solar				Wind	Biomass	Geothermal		Hydro	Fuel Cells
	Photovoltaic	Solar Thermal (Low Grade), Water Heating, etc)	Solar Thermal (High Grade), Power Generation,	Passive Solar Design	Wind	Biomass	Geothermal Electricity Generation	Geothermal Heat-Pump (Thermal Output)	Hydro Waterway, Micro, Tidal, etc	Fuel Cells
AZ	T,R	T	T	T	T	T				
CA	T,L,G	T,L,G	T,G,L,R	T,G	T,G,L,R	T,G,L	G,L	L	G	G,L,R
CT	T,G,L	L,T		L,T	L,T	L		L	T	T
IL	T,G,R	T,G,R	G	G	T,G	G	T,G	T,G	G	G
NY	T,L,R	T,L	L		T,L	L,T		L		G,T
MN	T,R				TL					
OR	T,G,L:	T,L	T,L	T,L	T,G,L	T,L,G	T,G,L	T,L,R	T,G,L	T,R
RI	T,R	T	T		R					
WI	G,L,R	G,L,R	T	G,T	T,L	G,R		G,R	G,R	

Incentive types: G = Grant, L = Loan, R = Rebate, T = Tax

Net Metering

Because wind and solar systems generate when their energy resource is available and not as a function of electrical load, there are times when generation will exceed load. At these times, it is

[11] Source: DSIRE 2003.

desirable for the system to sell power to the power grid. The local utility sets regulations governing the technical aspects of the electrical interface. (Satisfying these requirements may result in delays and unanticipated costs, but eventually approval must be granted if electricity is generated in an RE system or a CE system that obtains recognition as a cogeneration facility.) The real issue is how much the owner gets paid for each kWh of electricity supplied. The ideal situation is "net metering," where surplus electricity (i.e., generated electricity that exceeds the premise's instantaneous load) is allowed to flow to the grid in the reverse direction through the revenue meter. This flow decreases the consumption total that has been recorded on the meter. In effect, this means that the selling price is exactly equal to the retail (purchase) price. (The cost of installing separate meter and interface equipment is also eliminated.)

A number of states with RE and CE programs have decreed that net metering will be permitted for specific technologies (such as only generation using solar or wind generation) and capacity ratings (e.g., up to 10 kW or 25 kW or 100 kW). The regulations may also require the rated capacity of the installed system be no larger than the annual peak demand of the host premise, or that the expected annual kWh generation be no larger than 120% (or some other number) of the kWh purchased during the 12 months prior to system installation.

If net metering is not authorized, then the price paid for surplus electricity must be negotiated between the system owner and some purchaser (with the local utility being one possibility). The growing interest in "Green Power" generated from renewable energy and in Green Tag programs that pay a premium above the wholesale price of electricity has improved the market for surplus electricity. In fact, some system owners are enjoying the benefits of both net metering and additional payments for selling Green Tags.

Barriers to Program Participation

The principal barriers for customer-sited RE and CE systems include:

- Lack of awareness. Potential purchasers often are not aware of the availability and salient features (including their societal benefits) of RE and CE systems.
- Very high initial cost. The installed cost of solar and fuel cell systems is in the $7 to 9 per Watt range; the installed cost of wind and biomass systems is in the $3 to 4 Watt range. Even with generous rebates and net metering, the payback period often exceeds eight years.
- Permitting requirements. Wind turbine-generators must be mounted on a tall tower (which typically requires a zoning variance). Biomass systems may have odor issues, issues associated with delivering and storing biomass materials, and issues associated with combustion products. Fuel cell systems may entail special requirements because of the use of hydrogen. In all cases, local authorities are likely to be unfamiliar with the technology and reluctant to approve its use.
- Electrical interface approval. Although the program sponsor may be the local electric utility, the same utility's distribution-system engineers are responsible for ensuring that power can flow into the utility grid only when the grid is operating normally. Under outage conditions, the electrical interface equipment provided with the RE system must be able to reliably isolate the generator from the grid. Each utility has regulations in this regard, and the distribution-system engineers apply them rigorously and conscientiously. This may introduce uncertainty to the schedule and project schedule.
- Concerns about damage to property. The possibility that extremely high winds may cause wind or solar equipment to be dislodged and be damaged, and also cause damage to

either the participant's own property or a neighboring property, is likely to be a concern. Insurance coverage can mitigate this concern, but at additional cost.

- Concern that property taxes may increase. The assessed value of the property may increase, and time-consuming arguments with the assessor may result.
- Technology-specific site requirements. A large unshaded area is needed for solar systems, and a location with frequent strong winds is needed for wind systems. Biomass systems require the biomass material to be readily available, to minimize transportation costs.
- Aesthetic considerations. Potential purchasers (especially homeowners) may worry about, "What will the neighbors think? Will they object and file complaints?"
- Uncertain reliability. The potential purchaser is likely to have concerns about the possibility of high repair and maintenance costs.
- Relatively few prior installations. The scarcity of installations means there may be none nearby that can be seen, and no other program participants who can be asked to verify that actual performance is as good as the performance described by those who solicit equipment sales and program participation.
- Relatively few nearby dealers and contractors. There is likely to be concerns about how well trained dealers and contractors are, and how long they will be in business (should problems develop a few years hence).
- "Hassle factors." The expectation that a great deal of time and effort will be needed to get quotes, verify that the system being proposed and the installer are both of high quality and that the prices quoted are "the best deal available," obtain needed permits, and pass inspections by up to three separate parties: the local code official, the local electric utility's engineer who must approve the "as-built" electrical interface equipment, and a representative of the program administrator.
- Changing regulations. There may be concern that the state regulations that established net metering and provided other on-going financial benefits will end.

Implications for Program Evaluation

Impact Evaluations

Because site-specific features have a strong influence of actual generation for solar and wind systems, a representative sample of these systems should be metered to determine, in each month (or at a minimum in each season): actual generation, reductions in purchased electricity and bill savings, and output at the time of the utility's peak seasonal or monthly demand. In the case of biomass and fuel cell systems, more limited metering is acceptable, but input fuel-supply should also be metered and efficiency calculated. In the case of all technology types, there should be sufficient metering and monitoring such that forced-outage rates and maintenance requirements can be accurately determined, with special attention given to the system designs and sizes that are most frequently installed.

Process and Market Evaluations

The program's process should be assessed relative to the program theory. Progress toward meeting program goals should be assessed. The focus should be on ascertaining whether program administrators are demonstrating measurable results and momentum towards the long-term development of a viable market for the technology(ies) being promoted. The relative importance of each participation barrier should be assessed, and a determination made concerning whether both the program's design and actual program implementation are effectively addressing and reducing these barriers. Also, the role, adequacy, and cost-effectiveness of incentives offered should be assessed. A key factor that is of particular importance for RE and CE programs is whether the program participants would recommend participation to their neighbors and peers. Market indicators that may be used to measure program and market progress include:

- Increase in public awareness and consumer knowledge of both the availability and characteristics of RE and CE technologies
- The number and capacity of systems installed as a function of time
- The number of manufacturers active in the market
- The number of trained dealers, installers, and service contractors available to participate in the market
- Number of code officials that are familiar and with the RE and CE technologies being promoted
- Decreases in participants' pre-incentive installed cost per Watt of generating capacity, as a function of capacity (i.e., the extent to which the cost curve has shifted downward).

References

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