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CLEAN DISTRIBUTED RESOURCES IN THE U.S. RESIDENTIAL MARKET

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***Abstract* --This paper evaluates how photovoltaics (PV) can be combined with energy efficiency and cogeneration fuel cells in a distributed system to satisfy the energy needs and greatly reduce carbon emissions in the residential sector in the United States. The demand for electricity in the residential sector can be satisfied locally if every household reduces its electricity consumption by one-third using end-use efficiency, replaces its space heater and water heater with a 2-kW cogeneration fuel cell, and installs a 2-kW PV system. There is a good match between monthly energy supply and energy demand because PV has high electricity production in the summer and a cogeneration fuel cell has high electricity production in the winter. The cost to the consumer of such an investment has the potential to be comparable to the cost of existing utility service.**

I. INTRODUCTION

The global climate change debate and electric utility restructuring are contributing to a renewed consumer interest in renewable energy. The global climate change debate is important because carbon emissions are a key greenhouse gas and about two-thirds of the U. S. carbon emissions come the combustion of fossil-based energy sources. Electric utility restructuring is important because consumers are thinking more about their energy needs and because they can choose their energy service provider.

The global climate change issue highlights the fact that renewable energy technologies have no carbon emissions and that they may be part of a solution to the global climate change debate [1,2]. Electric utility restructuring is giving energy service providers access to retail markets and some are using green power products to enter these markets [3].

The most common type of green power product currently sold in the market is electricity that is differentiated based on its environmental attributes.

Another green power product is to sell the renewable technologies that generate the electricity to consumers. This paper illustrates how such a product could satisfy residential energy consumption needs and, in the process, reduce carbon emissions. In particular, this paper illustrates how photovoltaics (PV) could be combined with energy efficiency and cogeneration in a distributed system to satisfy the energy needs of the residential sector in the United States [4]. The first part of the paper evaluates the technical feasibility and the second part assesses the economic feasibility from a customer's perspective.

II. TECHNICAL FEASIBILITY

This section evaluates the technical feasibility of using clean distributed resources to supply the energy needs of the 100 million households in the U.S. residential sector. The left side of Figure 1 presents the fuel that was consumed to produce electricity (10,500 kWh per household) and the natural gas (500 therms per household) used for heating in the U.S. residential sector in 1995. The figure, which is drawn to scale, represents 16.5 Quads of energy consumption, 30 percent of which was for heating using natural gas and 70 percent of which was for electricity [5]. The figure indicates that two-thirds of the fuel consumed was lost in waste heat.

Energy efficiency experts have long recognized the opportunity to use efficient end-use devices to eliminate waste. Another opportunity, however, is to integrate energy efficiency investments into a distributed electric system. A distributed system is one in which the electricity is generated at the location where it is consumed. An important benefit of a distributed system in this case is that it allows the consumer to capture waste heat, something that is impractical with central power plants because of the difficulty in transporting heat.

Suppose that each household in the U.S.: (1) reduces its electricity consumption by one-third using electrical end-use efficiency measures; (2) replaces its existing gas furnace and water heater with a 2-kW cogeneration fuel cell that has a 25 percent electrical/65 percent thermal efficiency; and (3) installs a 2-kW photovoltaic PV system on its roof. The right side of Figure 1 indicates that this would reduce the total fuel currently used by residential consumers by 70 percent. From a global climate change perspective, this would reduce carbon emissions from power generation in the residential sector: only the fuel cells consume fuel in the right side of Figure 1, and fuel cells have lower carbon emissions than combustion turbines.

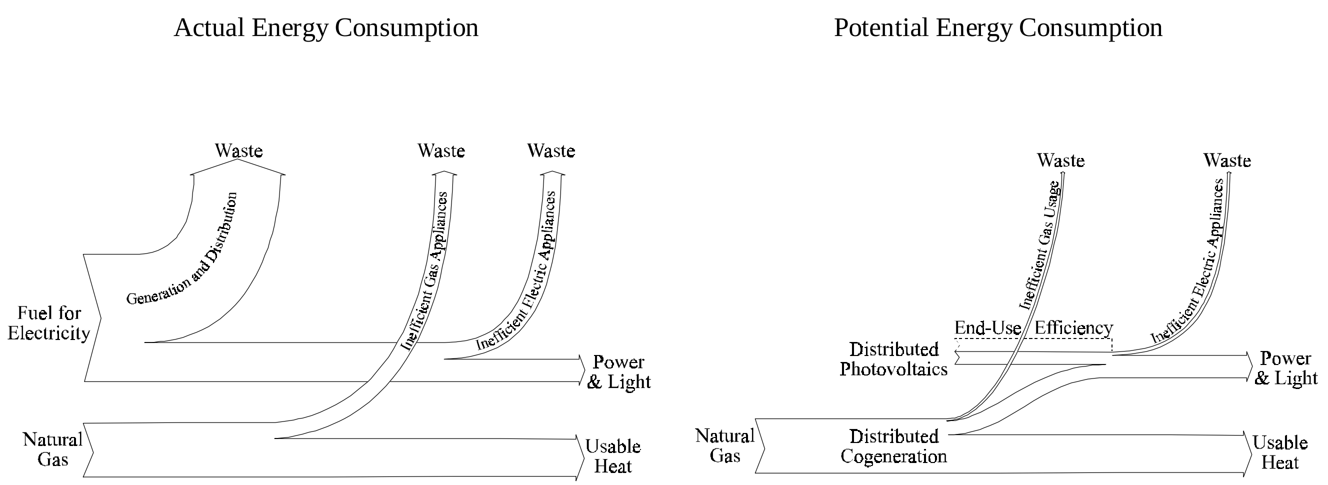

Figure 1. Actual consumption and potential energy consumption with distributed resources (U.S. residential sector in 1995).

Figure 2 presents the monthly match between electricity supply from this distributed system (the area plot) and measured electricity consumption (the solid line [6]). The bottom portion of the area plot is the savings from energy efficiency (it equals one-third of the solid line), the middle portion is the amount of electricity produced by cogeneration (it equals 25 percent of the natural gas used for space and water heating [6]), and the top portion is the amount of energy produced by the PV systems (the output distribution is based on data from [7]).

The figure suggests that there is a good match between consumption and production. This is due to the fact that electricity produced by distributed cogeneration occurs primarily during the winter when space heating requirements are the greatest while electricity produced by distributed PV occurs during the summer when there is the most sunlight and cooling needs. That is, the cogeneration and PV complement each other.

III. ECONOMIC FEASIBILITY

The preceding section indicates that a distributed energy system may be technically feasible; this section estimates the potential cost of the distributed system.

Suppose that each household invests in the technologies for the distributed system and that the existing utility manages the system imbalances and charges each customer $100 per year for this service. For illustration purposes, assume that the end-use efficiency improvements cost $2,000, a 2-kW cogeneration unit costs $3,000, and a 2-kW PV system costs $4,000. Since the cogeneration unit can replace the central furnace and the water heater, there is also a credit of about $2,000 for not having to purchase a new space heater and water heater. Thus, the capital cost for the distributed resources to the consumer is around $7,000. The annual payment for a $7,000 loan at an 8 percent interest rate and a 15-year term equals $800. Since the average residential household spent $300 on natural gas and $900 on electricity in 1995 [5], the consumer's cost for the distributed system is comparable to the consumer's current utility bill (see Table 1).

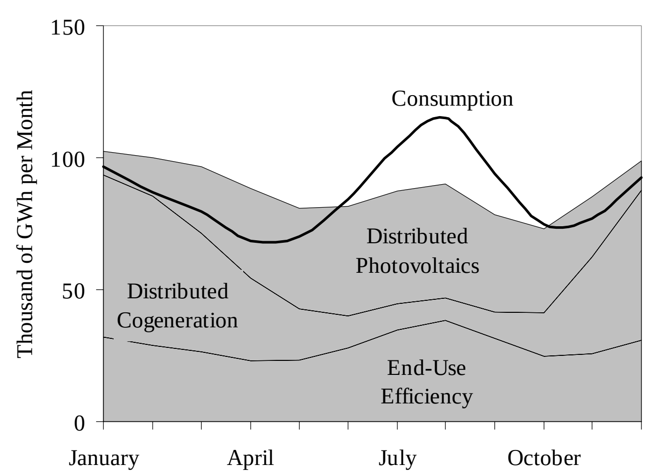

Figure 2. Measured electricity consumption and estimated production using distributed resources (U.S. residential sector in 1995).

Table 1. Annual gas and electric utility bill.

	Current Bill	New Bill
Electric Bill	$900/yr.	$100/yr.
Natural Gas Bill	$300/yr.	$300/yr.
Finance Charge for Capital Costs of: Efficiency: $2,000 Cogeneration: $3,000 PV System: $4,000 Furnace Credit: -$2,000 Total Capital: $7,000	$0/yr.	$800/yr.
Total Annual Bill	$1,200/yr.	$1,200/yr.

IV. Conclusions

This paper evaluated how PV could be combined with energy efficiency and cogeneration in a distributed application to satisfy the energy needs and greatly reduce carbon emissions in the residential sector in the United States. It showed that all of the electricity requirements for the residential sector could be satisfied locally if every household in the U.S reduced its electricity consumption by one-third using end-use efficiency, replaced its space heater and water heater with a 2-kW cogeneration unit, and installed a 2-kW PV system. There is a good match between energy supply and energy demand on a monthly basis because PV (high electricity production in the summer) and cogeneration (high electricity production in the winter) complement each other. It also showed that the cost of such a distributed system has the potential to be comparable to the cost of the existing service. Two important barriers to implementing such a system are that the capital cost of PV is too high (it is a factor of 3 too high without any subsidies) and that there do not appear to be any 2-kW residential cogeneration products available in the market.

V. References

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