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Distributed power generation in the United States

Alexander Thornton, Carlos Rodríguez Monroy*

Department of Business Administration, School of Industrial Engineering, Universidad Politécnica de Madrid, José Gutiérrez Abascal, 2 28006 Madrid, Spain

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ABSTRACT

With electricity consumption increasing within the United States, new paradigms of delivering electricity are required in order to meet demand. One promising option is the increased use of distributed power generation. Already a growing percentage of electricity generation, distributed generation locates the power plant physically close to the consumer, avoiding transmission and distribution losses as well as providing the possibility of combined heat and power. Despite the efficiency gains possible, regulators and utilities have been reluctant to implement distributed generation, creating numerous technical, regulatory, and business barriers. Certain governments, most notable California, are making concerted efforts to overcome these barriers in order to ensure distributed generation plays a part as the country meets demand while shifting to cleaner sources of energy.

Contents

* Corresponding author. Tel.: +34 913364265; fax: +34 913363005.
E-mail address: crmonroy@etsii.upm.es (C.R. Monroy).

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1. Introduction

1.1. Traditional electrical grid

In the late 1800s as the newly industrialized United States was beginning to generate electric power in order to accomplish significant work, power plants were located geographically near to the demand as electricity was transmitted over high-loss direct current (DC) power lines. However, as transmission techniques evolved to rely upon safer and lower-loss alternating current (AC), power plants began to move further away from the point of demand. With this evolution developed the modern electric grid with massive central power plants. These power plants typically generate thousands of megawatts of power, transmitting electricity at around 100 kV over country-wide distribution networks, which helps reduce losses accumulated in transmitting electricity over long distances. Upon reaching the consumer, the voltage is stepped down through the distribution network to safer levels.

1.2. The state of the electrical grid

For most of the electrical grid's history, it has been in the hands of vertically integrated, investor-owned utilities that operated as monopolies within a region. These utilities owned the generators, transmission lines, and distribution networks, but were strictly regulated by the local and federal governments (Federal Energy Regulatory Commission, or FERC). Traditionally, the local governments had to approve the rates set by utility companies to ensure that they were covering investment costs and making a fair profit without overcharging the customers.

Beginning in the second half of the twentieth century, the structure of the grid began to change into wholesale markets, where utilities started choosing the generation source based on current prices. A variety of sources were controlled by computers to balance supply and demand perfectly. Then, in the 1970s, the Public Utilities Regulatory Policies Act (PURPA) was passed, allowing utilities to buy power from independent power producers. This created a wholesale market for electricity, where price was fluctuating hourly from constant negotiations between the utilities and independent producers.

At the turn of the century, the wholesale markets opened up even more. FERC proposed the forming of independent transmission organizations throughout the US, essentially dividing the power industry into generation, transmission, and distribution. Generators would bid hourly to sell power to regional markets. This discrete time size opened the prospect for allowing hourly pricing of electricity, directly affecting the consumer. In this way, the price of consumer electricity could be higher during times of peak usage and lower during the levels of low usage, called dynamic pricing [1]. Dynamic pricing is most commonly available to industrial consumers; however, it is becoming increasingly available to residential consumers.

As the electric grid becomes more market-driven, it also becomes more physically interconnected at the same time. While divided into numerous regulatory regions, all systems are connected, creating what is often described as the largest machine in the world. By interconnecting systems in California with those in New York, power could theoretically be generated on one side of the country and consumed thousands of miles away. Within the market-driven model, this helps to ensure competition.

Despite the market advantages of an ever expanding grid using centralized power plants, there are numerous drawbacks. Of the many, some include the lack of incentive for utilities to support energy efficiency, as the profit of utilities is most commonly tied to the amount of power that is sold. In addition, as seen in the power outage of 2003 in the northeast US, an interconnected grid can propagate problems causing cascading failures. The blackout was a result of poor management of power coming in from hundreds of different sources over thousands of miles of transmission lines. The liberalization of markets and the drawbacks of central power plans create opportunities for implementation of distributed generation (DG) within the United States.

1.3. Distributed generation

There are differing perspectives on the definition of DG. For the purpose of this paper, "distributed generation is an electric power source connected directly to the distribution network or on the consumer side of the meter [2]." Connection to the distribution network is a key component of the definition, as power generation units not connected to the distribution network is known as "dispersed generation," according to the US Energy Information Administration (EIA)[3].

According to the EIA, in 2007, there were 7103 commercial and industrial DG units installed with a total electric capacity of 12.7 GW-electric [4]. There are no statistics available on the residential sector; however, it can be assumed that it is currently a negligible, albeit growing, part of the DG picture. DG capacity represented 1.27% of the 995 GW-electric capacity in 2007 [5], an increase from 0.5% in 2000 [1].

The technology and applications of distributed generation, as well as its benefits and drawbacks of the economic, environmental and technical aspects will be discussed in this paper. Lastly, the barriers to further implementation as well as suggestions for improvement and further research will conclude.

2. Technology

2.1. Internal combustion engine

With 4614 MW installed capacity as of 2007 [4], the DG technology with the largest installed capacity is the internal combustion engine. Internal combustion engines achieved this position through low cost and a relatively high operating efficiency of up to 43%, and the ability to use various inputs. Gas-powered engines usually take natural gas, but can also use biogas or landfill gas. Diesel engines naturally take diesel fuel, but with the rise of environmental awareness, they are more commonly taking biodiesel [6].