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Enhancing efficiency and renewables with smart grid technologies and policies

Marilyn A. Brown *

Georgia Institute of Technology, United States

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ABSTRACT

Improving the energy efficiency of the built environment and expanding the use of distributed energy to power energy services are two low-carbon approaches that have received considerable attention over recent years. Both of these electricity resource options could be fostered by supportive smart grid technologies and policies, enabling a two-way flow of information and electricity between utilities and consumers and tapping into the full potential of energy efficiency and distributed renewables. This paper explores ways to use smart grid technologies and policies to help energy efficiency and distributed renewables meet future US energy needs. As documented in this review paper, recent progress and policy commitments suggest that the US grid can become an integral part of future clean energy solutions.

Expanding end-use energy efficiency has invoked great interest over the past several decades because the reduction of energy waste is often the fastest, cheapest and cleanest energy resource. Distributed renewables offer environmental advantages and garner substantial consumer enthusiasm because they offer electricity to off-grid markets and increased self-sufficiency to grid-connected consumers. Both of these electricity resource options could be fostered by supportive smart grid technologies and policies, enabling a two-way flow of information and electricity between utilities and consumers and tapping into the full potential of energy efficiency and distributed renewables. However, the pace of deployment of smart grids in the US has been hindered by regulatory, financial, and information barriers.

This paper explores ways to use smart grid technologies and policies to help energy efficiency and distributed renewables meet future US energy needs. It also compares the US drivers and obstacles with those in the EU. There have been tremendous breakthroughs in the performance of these technologies, particularly in distributed generation. At the same time, we have increasing threats to energy security, expanding demands of a digital society, and growing concerns over clean air and global climate change. Our current energy infrastructure is both an enabler and a hindrance to addressing each one of those challenges. As documented in this review paper, recent progress and policy commitments suggest that the US grid can become an integral part of future clean energy solutions.

1. The context

The *World Energy Outlook 2011* [1] concluded that "the door is closing to a 450 parts per million future" which is a level of CO_2 concentration that is consistent with restraining global climate temperature increases to 2 °C. Across the globe, countries have committed to power plants and industrial infrastructure, highway systems and other longstanding and

* Tel.: +1 4043850303.
E-mail address: marilyn.brown@pubpolicy.gatech.edu

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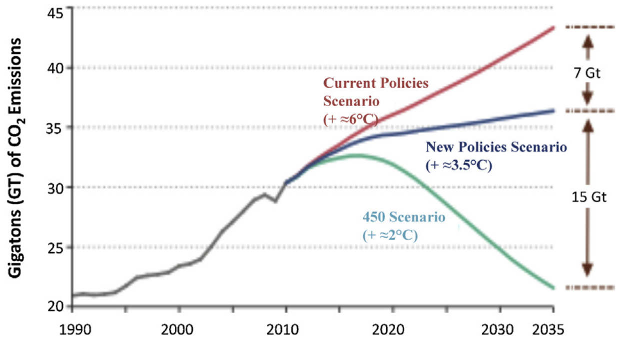

Fig. 1. World energy-related CO_2 emissions by scenario.
Source of data: [1].

enduring energy intensive CO_2 emitters. As a result, carbon-mitigation options are limited to the incremental investments that are made in the future. The vast majority of this incremental growth will be in developing countries.

Fig. 1 shows a range of growing versus declining CO_2 scenarios, with varying levels of long-term average temperature increases. They range from a 450 Scenario – a very aggressive policy future, to the New Policies Scenario, which is a less aggressive alternative, and then the Current Policies Scenario, which is the trajectory we are currently on.

- The 450 Scenario assumes strong policy action to limit climate change to less than 450 ppm of CO_2 concentration in the atmosphere. This scenario results in global CO_2 emissions peaking before 2020 and then declining to reach 21.6 Gt in 2035. This scenario would restrain long-term average temperature increases to approximately 2 °C.
- The New Policies Scenario takes account of both existing government policies and declared policy intentions (including cautious implementation of the Copenhagen Accord and Cancun Agreements), and would result in a level of emissions that is consistent with a long-term average temperature increase of more than 3.5 °C.
- The Current Policies Scenario assumes no change in government policies and measures beyond those that were enacted or adopted by mid-2011, and is consistent with a long-term temperature increase of 6 °C or more.

The International Energy Agency [1] estimates that 80% of the total CO_2 emitted in the 450 Scenario is already "locked-in" by existing capital stock (such as power plants, buildings, and factories), leaving little additional flexibility. As a result, the OECD (Organization for Economic Cooperation and Development) nations will be able to contribute to only 30% of these emission reduction goals. Because non-OECD countries are rapidly expanding in terms of both population and infrastructure, their contributions are seen as accounting for a majority (70%) of the reduction goals.

Similar to the "current policies scenario" in Fig. 1, modeling by the Pacific Northwest National Laboratory forecasts how global energy is likely to be produced over the next half century, beyond the 30 year trajectory of most IEA and EIA forecasts. Over this period, the US – much like the European Union – has a fairly flat trajectory of energy consumption. Where the US represented about 25% of total global energy consumption in 1990, in 2035, the US portion could decline to perhaps 13%, and by the year 2100 the US could represent less than 10% of global energy consumption. The statistics for the EU are quite comparable [2]. In contrast, rising living standards in China, India, the Middle East, and other emerging economies are driving fast-paced increases in their energy demand.

This growing worldwide demand for electricity and transport services compounds issues of energy security. The world is transitioning from a position of abundant fossil energy supplies to a largely resource-constrained supply future. World energy demand is expected to expand by 45% between now and 2035, and by more than 300% by the end of the century. Coal without carbon capture and sequestration (CCS) is projected to account for the largest share of this overall rise, with oil and natural gas consumption also expanding rapidly (Fig. 2).

This forecast has implications for the role the US might play in promoting global energy sustainability. It is not going to be how we consume energy necessarily that will be the driver of market conditions; our influence will be consequential only if we use our actions to signal how the rest of the world can leapfrog to a cleaner energy future. Energy efficiency and distributed renewables are particularly promising as clean energy alternatives, and their future success depends on enabling smart grid technologies and policies.

2. Economic potential for expanding energy efficiency

To date, most energy-efficiency programs and policies have been implemented in industrialized nations. Because today's emerging economies will dominate energy markets in the future, the applicability of this past experience to the context of the developing world needs to be explored. Thus, the challenge of expanding the current supply-side policy focus to include demand-side policies requires a nuanced approach. A portfolio of efficiency programs needs to be available reflecting the energy services being sought by consumers across a wide range of different countries with unique energy markets, resources,