Performance-Based Regulation to Improve Upstream Energy Efficiency

Traditional utility regulation provides inadequate incentives for electric utilities to invest in technologies that reduce network energy losses. This article examines how alternative regulatory designs influence such investments, and simulates the procurement and performance of distribution transformers under differing regulatory scenarios, to demonstrate the enormous potential benefits of a performance-based regulation scheme that targets network losses.

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I. Introduction

The specter of climate change requires dramatic reductions in the greenhouse gas emissions associated with energy services. To decarbonize the electricity grid, the power sector must receive contributions from all phases, from generation to end-use (**Figure 1**). The shift toward cleaner but intermittent generation sources will impose physical burdens on network infrastructure, such as those related to bidirectional power flow. Accordingly, utilities will need to complement this supply transformation with upgrades to transmission and distribution (T&D) networks to ease technical frictions associated with renewables integration. But T&D upgrades

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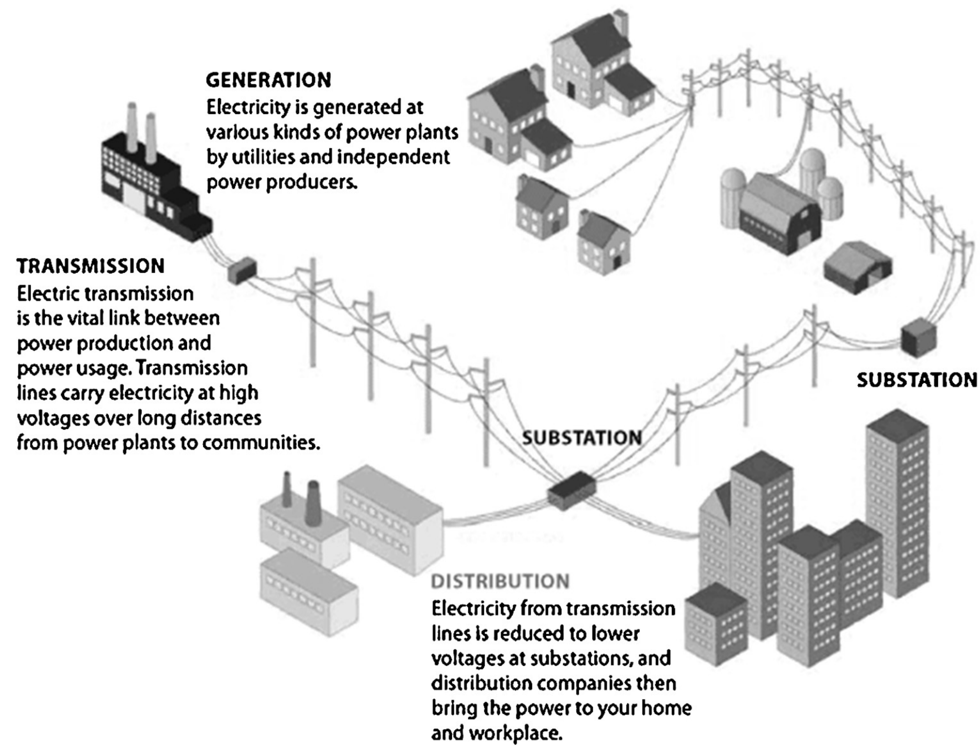

Figure 1: A Schematic Representation of Power Systems
Source: DOE.

can also improve the energy efficiency of power networks by utilizing advanced infrastructure equipment.

Utilities have been successfully employing energy efficiency to reduce carbon emissions since the 1970s, mostly through demand-side management (DSM) measures such as building weatherization and incentives for more energy-efficient appliances. DSM programs have become a favored tool for utility regulators to more cost-effectively ensure reliability and meet energy efficiency goals (LBNL, 1995). Yet while there is still room for improvement in end-use energy efficiency, *upstream* energy efficiency (i.e., that of energy infrastructure) has received less attention. By diminishing losses before electricity reaches the point of consumption, these technologies can reduce the amount of energy that is generated—and thus the amount of carbon that is emitted—in order to supply a unit of electricity to end-users.

Energy is inevitably lost in transit, either dissipated as heat owing to the electrical resistance of conductors (power lines) or lost through the magnetic fields of transformers during voltage changes. Within the U.S., loss rates vary widely; **Figure 2** shows that loss rates range from 2 percent in Maine to over 18 percent in Idaho (EIA, 2012). Utilities can improve upstream energy efficiency by deploying more efficient T&D equipment like high-temperature superconductors, which greatly reduce transmission losses, and transformers with amorphous steel cores, which can trim standby energy losses. These technologies are currently available at lower life-cycle cost than conventional equipment, particularly when greenhouse gas emissions are valued. However, it is not clear that prevailing regulatory structures provide utilities with proper incentives to weigh life-cycle costs against initial expenses. In this article, I argue that utility regulation can improve network energy

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