The Evolving Role of the Power Sector Regulator

A CLEAN ENERGY REGULATORS INITIATIVE REPORT

Owen Zinaman and Mackay Miller
National Renewable Energy Laboratory

Morgan Bazilian
Joint Institute for Strategic Energy Analysis

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Accelerating the Transition to Clean Energy Technologies

Abstract

This paper seeks to briefly characterize the evolving role of the power sector regulator. Given current global dynamics, regulation of the power sector is undergoing dramatic changes. This transformation is being driven by various factors including technological advances and cost reductions in renewable energy, energy efficiency, and demand management; increasing air pollution and climate change concerns; and persistent pressure for ensuring sustainable economic development and increased access to energy services by the poor. These issues add to the already complex task of power sector regulation, of which the fundamental remit remains to objectively and transparently ensure least-cost service delivery at high quality. While no single regulatory task is trivial to undertake, it is the prioritization and harmonization of a multitude of objectives that exemplifies the essential challenge of power sector regulation. Evolving regulatory roles can be understood through the concept of existing objectives and an additional layer of emerging objectives. Following this categorization, we describe seven existing objectives of power sector regulators and nine emerging objectives, highlighting key challenges and outlining interdependencies. This essay serves as a preliminary installment in the Clean Energy Regulatory Initiative (CERI) series, and aims to lay the groundwork for subsequent reports and case studies that will explore these topics in more depth.

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1 Introduction

Across the globe, the power sector–and regulation of it–is undergoing profound change. Regulators are, as always, tasked with balancing a multitude of objectives in order to optimize for least-cost service delivery, ensuring high quality and reliability (Bazilian et al. 2013). Yet, as policy directives and technology continue to evolve, they increasingly face pressure to address environmental and social goals, namely via increased incorporation of clean energy technologies.[1,2] Furthermore, small producers, responsive consumers, and variable renewable resources continue to permeate many electric systems, creating a fundamental shift in how power systems operate, and therefore how the sector must be regulated. While these new technologies present new challenges for regulators, as will be detailed in this paper, they also present new opportunities to address social and environmental goals.

The key challenge of modern-day power sector regulation is reconciling the new regulatory objectives of this evolving landscape with the already difficult task of balancing existing objectives. This paper aims to catalogue the various objectives of power sector regulators, highlighting challenges, opportunities, and interdependencies. It is intended to serve as a preliminary installment in the Clean Energy Regulatory Initiative (CERI) series, and aims to lay the groundwork for future publications that will explore these topics in more depth.

[1] In this paper, we define *clean energy technologies* generally as those which encourage efficient and low-carbon power system operation.

[2] See, e.g., Abdullah et al. (2014); Acevedo and Molinas (2012); Arteconi, Hewitt, and Polonara (2013); Bellekom et al. (2012); Bernardon et al. (2014); Breukers et al. (2011); Camblong et al. (2009); Fadaeenejad et al. (2014); Koh et al. (2013); Mai et al. (2012); Warren (2014); Zeng et al. (2014); and Sioshansi (2012).

2 The Complex Objectives of Power Sector Regulators

Electricity regulation seeks to navigate many constraints in order to achieve policy and social objectives. The interdependencies among these constraints comprise the central challenge of regulation. Emergent policy goals, such as addressing climate change, add complexity to the already difficult task of power sector regulation. In many markets, utility business models will be challenged (Kind 2013; Lehr 2013) and associated principles and models of regulation will need to evolve as well. Evolving regulatory roles can be understood through the concept of existing objectives and an additional layer of emerging objectives (Figure 1). Following this taxonomy, we provide a brief, high-level overview of the existing and emerging objectives of power sector regulation.[3]

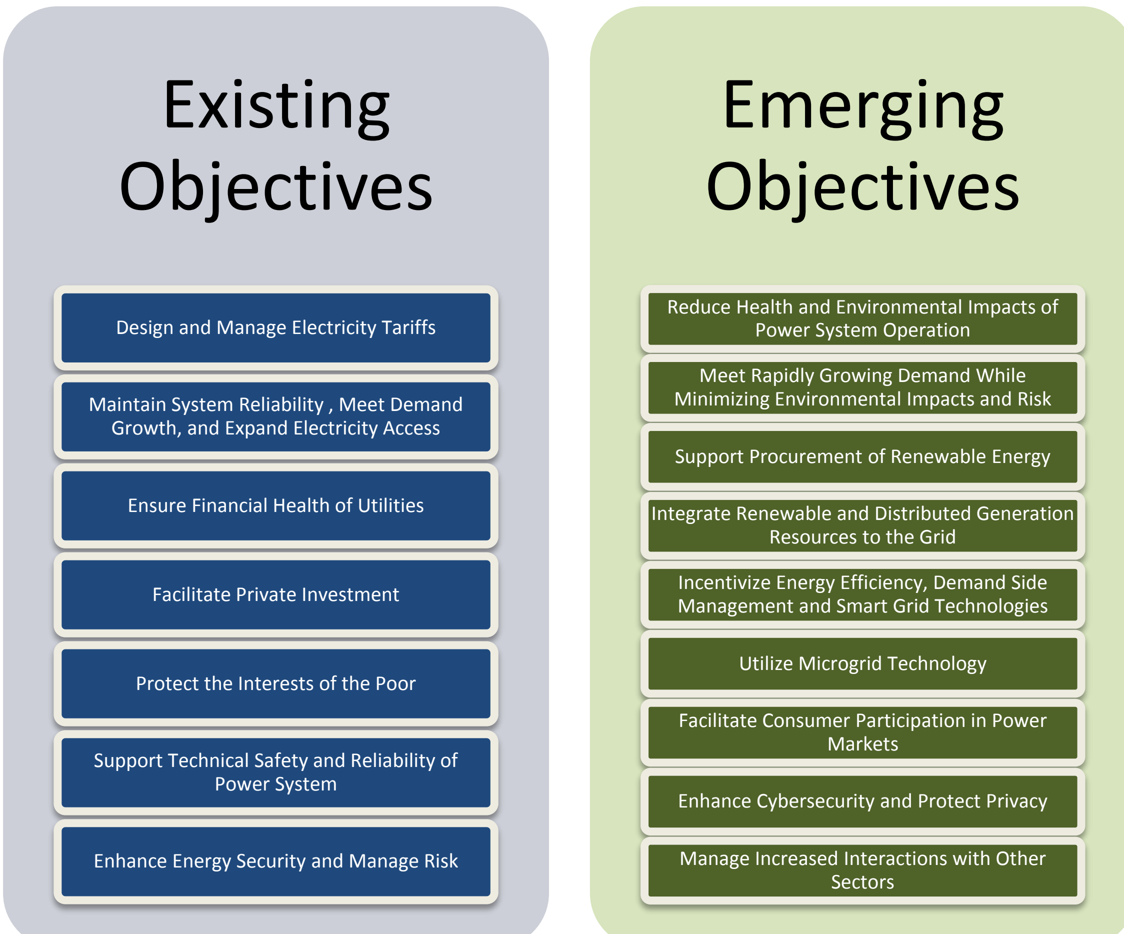

Figure 1. Schematic of existing and emerging regulatory priorities

[3] For more thorough and fundamental overviews of power sector regulation, see, e.g., Pérez-Arriaga (2013); Rothwell et al. (2003); and Stoft (2002).

2.1 Existing Objectives

- **Design and Manage Electricity Tariffs**

A core regulatory task is to design fair and equitable electricity tariffs for numerous customer classes and periodically review and redesign those tariffs considering a variety of objectives. Inherent to this process is the balancing of costs, benefits, and risk among ratepayers, utilities, and private investors, as well as aligning tariffs with public policy objectives. Tariffs must be designed at rates high enough to maintain the financial and operational health of the utility, attract private investment, meet growing demand, minimize outages, and address a variety of other capital-intensive objectives. Yet, consumer costs must be low enough to promote continued economic growth and productivity, protect the interests of low-income populations, and prevent ratepayers from providing windfall profits to utilities and private investors. Tariffs for one rate class may be subsidized by other rate classes or government budgets. Raising rates to reflect the true cost of delivered electricity may be necessary in many settings to ensure the financial health of the utility, but this option may be politically or economically unattractive.[4]

- **Maintain System Reliability, Meet Demand Growth, and Expand Electricity Access**

Electricity disruptions and supply shortages can have significant economic costs to a jurisdiction as a whole (Balducci et al. 2002; Sanghvi 1982). During power shortages, utilities often rely on load shedding, industrial load response, or expensive emergency power. Coordinated planning efforts, large capital expenditures, and associated rate increases are often required to meet demand growth and maintain system reliability, particularly in the context of rapid economic growth. Many settings already experience deteriorating infrastructure, unmet demand, power quality issues, power scarcity, and large technical and non-technical losses; raising financing under these conditions may pose difficulties. Expanding access to unserved customers has historically required significant capital investment; however, those without electricity are often poor and living in sparsely populated regions. Without a sizable, financially equipped customer base to expand service to, such projects on a stand-alone basis may not be financially viable. The regulator is tasked with assigning costs across rate classes to pay for such projects, as well as coordinating with government and international development efforts to optimally execute electrification efforts.

- **Ensure Financial Health of Utilities**

Financially healthy utilities are able to invest in system improvement and to borrow capital from private institutions at lower interest rates, reducing debt service costs to ratepayers. Financial health also reduces uncertainty that a utility will be able to honor power purchase contracts from independent power producers. Regulators must establish a regulatory framework that ensures the financial health of utilities while incentivizing operational efficiency. Tariffs must be designed such that utilities are able to recover costs with a reasonable rate of return, maintain the technical health of the electricity system, retain and expand necessary staff, expand infrastructure to meet growing and unmet demand, and accomplish other objectives.

[4] For a recent overview of electricity tariff fundamentals, see Reneses, Rodríguez, and Pérez-Arriaga (2013).

- **Facilitate Private Investment**

Private investments help to take strain off of utility balance sheets or government budgets as capital expenditures and associated financing costs are avoided. To the extent that a power sector is open to private investment, and perhaps aims to increase such investment, the regulator must create a stable investment ecosystem. The regulator will help to facilitate power purchase or transmission use agreements, and provide private investors with certainty that those contracts will be honored. Avoiding erratic and non-transparent decision making helps to reduce investors' perceived regulatory risk and contributes to keeping the utilities' cost of capital low.

- **Protect the Interests of the Poor**

Regulators often have statutory mandates or experience political pressure to protect the interest of low-income customers. Tariff design is their key apparatus to do so as rates can be constructed to provide free or low-cost electricity to poor customers – though potentially at the cost of increased rates to other customer classes. Central or state governments may provide subsidies for these activities as well.

- **Support Technical Safety and Reliability of Power System**

Regulators must work with system operators, utilities, and standards bodies to develop and enforce standards for the safe interconnection to and operation of the power system. This task includes, but is not limited to: establishing technical requirements for transmission and distribution (T&D) expansion and power system components, rules for interconnection of utility-scale and distributed generation (DG) systems, and standards for maintenance practices and data collection systems.[5]

- **Enhance Energy Security and Manage Risk**

Regulators, often in coordination with other government actors, play a key role in facilitating an energy-secure power sector (Jamasb and Pollitt 2008). Regulators create frameworks to promote long-term security of supply for fuels used at generation facilities, minimize the frequency of fuel scarcity events, and insulate captive consumers from fuel price volatility and scarcity-related spikes. They must consider natural resource endowments and geospatial disparity in natural resource availability, geopolitical considerations and associated imported fuel delivery risks, and potential fuel price volatilities and hedging strategies. Facilitating utilization of a diverse portfolio of domestically produced energy sources is a key strategy to mitigating the risk of abrupt supply disruptions or fuel price spikes (Bahgat 2011; Lee et al. 2012). Utilities that are able to pass unexpected fuel price increases to consumers may lack incentive to consider fuel price risk; in this case, the regulator is required to assure risk-adjusted capacity expansion decisions are made (Binz et al. 2012; Awerbuch 2006).[6]

[5] For a more extensive review of this topic, see, e.g., Glover, Sarma, and Overbye (2011) and Dhillon (1983).
[6] For an overview of risk-aware regulation practices, see Binz et al. (2012). For an overview of energy security regulation strategies, see Barton (2004).

2.2 Emerging Objectives

Against this backdrop of existing objectives, regulators also face emerging objectives, driven by technological change, evolving social priorities, and global events. Some of these objectives are new while others represent evolutions of existing objectives. These objectives include:

- **Reduce Health and Environmental Impacts of Power System Operation**

  Depending on its composition, electricity generation infrastructure has significant impacts on local and regional air quality, public health [31,32], water resources [33,34], and global carbon emission levels [35]. Mandates to reduce environmental impacts may clash with objectives to contain costs, meet growing demand, and maintain system reliability. In order to meet environmental requirements, utilities may be required to invest in high-cost-mitigating technologies such as emissions controls systems or cooling technologies that lower water impacts; in some cases, utilities may opt to shut down power plants in lieu of retrofits, increasing stress on power reserve margins [36]. Regulators are tasked with overseeing and approving these decisions and balancing environmental objectives with others in planning and capacity procurement decisions.

- **Meet Rapidly Growing Demand While Minimizing Environmental Impacts and Risk**

  Globally, the size of the middle class is expected to increase by 1.4 billion between 2009 and 2020 (Pezzini 2012). Reconciling the resulting demand for electricity with environmental objectives and the goal of low prices is a signature challenge for many regulators. Energy efficiency (EE) plays a key role in striking this balance. In contrast, pursuing purely supply-side strategies of fast, low-cost generation investments may lock utilities into using fuels and facilities that are subject to significant market price volatility (Bazilian et al. 2013; Kalkuhl, Edenhofer, and Lessman 2012). Such investments also introduce the risk that assets will be stranded as the sector moves towards decarbonization. Regulators are tasked with making prudent, risk-adjusted decisions for capacity expansion in concert with EE to meet growing demand.

- **Support Procurement of Renewable Energy**

  There has been an intensified interest in accelerating renewable energy (RE) deployment in many settings. Regulators are tasked with designing RE incentives and regulating their integration into T&D systems. Incentives such as feed-in-tariffs (Couture et al. 2010), adders (Tongsopit and Greacen 2013), or auctioned long-term contracts (Maurer and Barroso 2011) aim to achieve desired levels of renewable development while appropriately limiting the costs to consumers. While conventional technology costs change relatively slowly, a key challenge of RE regulation is setting tariffs in the context of declining RE technology costs.

- **Integrate Renewable and Distributed Generation Resources to the Grid**

  Regulators are tasked with setting rules that ensure reliable and safe operation and that appropriately allocate renewable integration costs across various stakeholders. Low-cost distributed generation resources, especially solar photovoltaic systems, are becoming widely available in many jurisdictions (REN21 2013). As these systems permeate low-voltage distribution systems, new forms of regulation are needed to accommodate them (Scheepers and Jansen 2007; Ropenus and Skytte 2005). Regulators must create interconnection protocols which address distribution and transmission infrastructure limitations, voltage regulation, and other power quality issues. They are also involved in facilitating financial arrangements between generators and utilities, including setting network tariffs, infrastructure connection charges, and system utilization charges. DG systems may clash with traditional utility business models and financial arrangements must attempt to balance the costs and benefits of DG across various stakeholders (Cossent, Gómez, and Frías 2009). As DG penetration levels increase, more active planning, management, and oversight of distribution networks will be required of regulators (Lopes et al. 2007).[7]

- **Incentivize Energy Efficiency, Demand Side Management, and Smart Grid Technologies**

EE, demand side management (DSM), and smart grid programs present low-cost opportunities to meet growing and unmet demand, reduce strain on reserve margins, and benefit individual customers. Smart grid systems can ease integration of distributed generation (Eurelectric 2013), and advanced metering systems are key to enabling time-of-use tariffs or dynamic pricing to help manage demand and impact consumer behavior (Marques, Bento, and Costa 2014; Agrell, Bogetoft, and Mikkers 2013). However, these systems may clash with legacy utility business and regulatory models, which rely on increased sales volumes to increase revenues. Regulators are tasked with assigning costs, benefits, and risks of EE and DSM programs appropriately across various stakeholders, and may oversee jurisdictions where there is limited availability or awareness of EE products. They also must establish clear and robust protocols for measuring and verifying savings from EE and DSM programs.

- **Utilize Microgrid Technology**

In developed settings, microgrids present opportunities to increase resiliency against outages and cyber-attacks, provide ancillary services, and accelerate the deployment of distributed energy resources (Mercurio 2013; Yuen and Oudalov 2007; Chowdhury, Crossley, and Chowdhury 2009). In developing settings, many utilities face chronic challenges expanding electricity access; bottom-up network expansion using microgrids with "backwards compatibility" to central grid infrastructure presents a novel opportunity for expanding electricity access (Zeng et al. 2014; Raman et al. 2012; Xu and Chowdhury 2013; Deshmukh, Carvallo, and Gambhir 2013; Greacen, Engel, and Quetchenbach 2013; Tenenbaum, Greacen, and Siyambalapitiya 2014). With these new opportunities come new regulatory challenges, including establishing new interconnection and operation standards, creating streamlined permitting processes, facilitating sustainable business models, and spreading costs and risks appropriately.[8]

[7] For an overview of distributed generation impacts, interactions, challenges and benefits, see Pepermans et al. (2005) and Ackermann and Knyazkin (2002).

[8] For an overview of regulatory principals for off-grid electrification, see Reiche, Tenenbaum, and Mästle (2006). For an overview of emerging business models for electricity access, see Peterschmidt et al. (2013) and Bardouille (2012).

- **Facilitate Consumer Participation in Power Markets**

In many jurisdictions, due to new technologies and business models, consumers are now able to directly participate in power markets. This is one of the most rapidly changing aspects of the power sector in many jurisdictions, and the benefits of participation are significant for individual consumers as well as the power system as a whole (Gelazanskas and Gamage 2014; Zehir and Bagriyanik 2012). A more active and participatory demand side brings new challenges for regulators in managing risk, revenues, reliability, and quality of supply. In order to facilitate increased demand-side participation, new tariff structures, dynamic market pricing schemes, demand aggregation guidelines, and market-bidding rules are likely required (Arteconi, Hewitt, and Polonara 2013; Warren 2014; Finn and Fitzpatrick 2014; Brennan 2010).

- **Enhance Cybersecurity and Protect Privacy**

As more complex information and communication technology (ICT) systems are being deployed in modern grids, new cybersecurity challenges and privacy concerns are arising as well (Cárdenas and Safavi-Naini 2012). Regulators, in conjunction with other government actors, are increasingly being asked to incorporate cybersecurity considerations into their reliability planning (Pearson 2011; Kumar, Pandey, and Punia 2014). Furthermore, as ICT systems generate more consumer data, regulators may be asked to issue regulations which preserve the privacy of consumers (Malashenko et al. 2013).

- **Manage Increased Interactions with Other Sectors**

Interactions with other sectors of the economy are widening the traditional scope of power regulation. These include growing interaction with water and food systems, transport infrastructure (for example electric vehicles), and relationships between RE and natural gas markets (Lee et al. 2012; Bazilian et al. 2011; Richardson 2013; Cochran et al. 2014). These energy system integration or “nexus” issues are gaining traction in international and country-level policy dialogues and will likely be increasingly incorporated into power sector decision making.

3 Conclusion

Here, we have considered some of the complexities of the evolving role of power sector regulation. As emerging objectives become more prominent, the task of power sector regulation grows even more complex. In this context, a thoughtful examination of the current landscape and more importantly, a path forward, will be critical to the rapid global development of low-carbon electricity systems. The state of clean energy regulation is nascent in most jurisdictions, and will require experimentation and collaboration. There is no one-size-fits-all solution to navigating this constellation of objectives, yet common principles may nevertheless apply across many jurisdictions. *Ex-post* evaluation of specific interventions will remain critical. Many aspects of regulation will evolve by trial and error; it is vital that this evolution occurs in a transparent, open, and non-erratic manner—under clear regulatory principles—in order to reduce perceptions of risk, maximize learning opportunities and facilitate a healthy environment for clean energy investment.

The exploration of these regulatory principles is the chief goal of the Clean Energy Regulatory Initiative (CERI), an actively growing platform for regulatory knowledge exchange established in 2013. CERI will explore these principles through a range of products, including in-depth looks at particular regulatory issues and targeted case studies. Achieving global energy access while deploying low-carbon electricity systems worldwide will require decisive and robust action from well-informed, well-supported power sector regulators; to that end, CERI attempts to provide a path forward on clean energy regulatory issues.

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