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Policy and Regulation to Support Energy Efficiency as a Power Sector Resource in China

David Crossley and Wang Xuan

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The Regulatory Assistance Project (RAP)®
CITIC Building, Room 2504
No.19 Jianguomenwai Dajie
Beijing, 100004

Tel: 86 10-8526-2241
E-mail: china@raponline.org
raponline.org
linkedin.com/company/the-regulatory-assistance-project
twitter.com/regassistproj

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This policy paper was written by RAP Senior Advisor Dr David Crossley, who has more than 40 years' international experience in the energy sector, providing advice on sustainable energy policy and programs to governments, regulators, energy companies, industry associations, and NGOs. From 2009 to 2015, David managed the provision in China of technical assistance on demand-side management and energy efficiency to governments, regulators, and the electricity industry.

David Crossley was assisted in preparing this policy paper by RAP Consultant Wang Xuan, who provides project management and research support for RAP's China team, working closely with local government, RAP's partner organizations, and research institutes in China. Based in Shanghai, she focuses on demand response, renewable energy integration, air quality management, and distributed generation.

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Acronyms

CNY . . . . Chinese yuan or renminbi (currency unit)

CPUC . . . . . . California Public Utilities Commission

DSM . . . . Demand-side management

EEO. . . . . Energy efficiency obligation

EESoP . . . . . Energy Efficiency Standards of Performance (United Kingdom)

EM&V . . . . . . Evaluation, measurement, and verification

ESCO . . . . . . Energy services company

ESPI . . . . Energy Savings Performance Incentive

E.U. . . . . European Union

GBP . . . . British pound (currency unit)

GW . . . . Gigawatt

GWh . . . . Gigawatt-hour

IOU . . . . Investor-owned utility

kV . . . . Kilovolt

kWh . . . . Kilowatt-hour

LRAM . . . . . . Lost revenue adjustment mechanism

MW . . . . Megawatt

RDM . . . . Revenue decoupling mechanism (Massachusetts)

ROE. . . . . Return on equity

RRIM. . . . . . . Risk/return incentive mechanism (California)

TWh . . . . Terawatt-hour

U.S. . . . . United States

USD . . . . United States dollar (currency unit)

WMECO . . . . Western Massachusetts Electric Company

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Executive Summary

In several jurisdictions around the world, electricity utilities employ end-use energy efficiency as a resource in meeting their customers' needs for energy services. Energy efficiency is seen as a cost-effective alternative to investing in supply-side resources, such as building power plants and expanding the electricity grid. Using energy efficiency as a power system resource is particularly important in China, where air pollution from coal-fired power plants is a large and growing problem. Energy efficiency can do double duty: it can economically meet a portion of China's needs for energy services while also making an important contribution to achieving the goals of China's current Clean Air Action Plan. The concept of using energy savings to reduce emissions is very well understood in China, and the country has had much success with various policies to support energy efficiency. However, there are many ways in which international experience can be useful for integrating this concept in a more meaningful way into the detailed planning process for the power sector.

Internationally, methods for integrating energy efficiency into power system resource planning are readily available and are in active use in many jurisdictions. Some jurisdictions have established comprehensive policy, regulatory, and organizational systems that enable energy efficiency to be used as a power system resource. In China, however, such policy, regulatory, and organizational systems are still under development. This paper explores policy and regulation that could be put in place in China to support the use of energy efficiency as a resource.

In China, as in many other jurisdictions, the companies that own and operate the grid and distribution networks (hereafter referred to as grid companies) can play important roles in supporting energy efficiency as a power system resource. However, there are powerful barriers that discourage the grid companies from doing so. In particular:

- grid companies are concerned about the reduction of marginal revenue that results from encouraging customers to use electricity more efficiently;
- grid companies are unable to make profits from their investments in energy efficiency; and
- until recently, government policy in China did not require grid companies to implement energy efficiency programs until 2011.

Overcoming these barriers involves the implementation of policy and regulatory mechanisms that address these barriers. This paper includes detailed consideration of six mechanisms, classified into the following three categories:

- mechanisms for maintaining grid company financial performance;
- mechanisms to enable grid companies to make profits from energy efficiency investments; and a mechanism that requires grid companies to implement energy efficiency programs.

Two of the six specific mechanisms have already been implemented in China:

- establishing a grid company-owned energy services company (ESCO); and
- establishing an energy efficiency obligation (EEO) scheme.

The four mechanisms that have not been implemented are:

- establishing rate cases and public benefits charges;
- fully establishing revenue-based regulation ("decoupling") to address the net lost revenue problem;
- implementing energy efficiency performance incentives; and
- using energy efficiency to reduce grid infrastructure costs.

The Chinese government's current effort to implement "transmission and distribution price reform" provides an opening for implementation of some combination of these remaining mechanisms.

The six policy and regulatory mechanisms described in this paper are generally effective in addressing the barriers to grid companies in China using energy efficiency as a power system resource. However, implementing one, several, or even all of the mechanisms will not be sufficient to ensure that grid companies commence using energy efficiency as a resource. Before this can occur, both the grid companies and governments in China have to be convinced that energy efficiency is a cost-effective and practical alternative to investing in supply-side resources, such as building power plants and expanding the electricity grid.

In China, the central government has taken an important initial step in establishing an EEO on the two major grid companies. What is needed now is for government to strengthen policy and regulatory mechanisms to both expand the energy efficiency programs delivered by grid companies and to enable energy and capacity savings achieved by all energy efficiency programs implemented in China to be used as power system resources. This will reduce the number of new power stations and augmentations of grid infrastructure that must be built in the future.

In addition, careful attention to the details of implementing the government's further planned reforms of grid company regulation will be necessary to lead the grid companies to seriously consider using energy efficiency as a power sector resource. The government must follow through with eliminating the throughput incentive and, in addition, create financial incentives for grid companies to deliver cost-effective demand-side management (DSM) and end-use energy efficiency, building on the existing EEO.

1. Introduction

1.1 Energy Efficiency as a Resource

A previous paper by The Regulatory Assistance Project[1] showed that, in several jurisdictions around the world, electricity utilities employ end-use energy efficiency as a resource in meeting their customers' needs for energy services. Energy efficiency is seen as a cost-effective alternative to investing in supply-side resources, such as building power plants and expanding the electricity grid. A study by the International Energy Agency has shown that, when energy efficiency is used as an alternative to investing in supply-side resources, it provides multiple benefits to the power system, to electricity customers, and to society as a whole.[2]

Using energy efficiency as a power system resource is particularly important in China, where air pollution from coal-fired power plants is a large and growing problem. Energy efficiency can meet a portion of China's needs for energy services while also contributing to reducing air pollution. In this way, it can make an important contribution to achieving the objectives of China's current Clean Air Action Plan.

Internationally, methods for integrating energy efficiency into power system resource planning are readily available and are in active use in many jurisdictions. Some jurisdictions have established comprehensive policy, regulatory, and organizational systems that enable energy efficiency to be used as a power system resource. In China, however, such systems generally do not exist. This paper explores policy and regulation mechanisms that could be put in place in China to support the use of energy efficiency as a resource.

1.2 Overcoming Barriers to Using Energy Efficiency as a Resource

In China, as in many other jurisdictions, grid companies[3] are the key to using energy efficiency as a power system resource. However, there are many barriers preventing grid companies from doing this. In particular:

- grid companies are concerned about the reduction of marginal revenue that results from encouraging customers to use electricity more efficiently;
- grid companies are unable to make profits from their investments in energy efficiency; and
- until recently, government policy in China did not require grid companies to implement energy efficiency programs (although this changed in 2011).

Overcoming these barriers involves the implementation of policy and regulatory mechanisms that address these barriers. The remainder of this paper comprises detailed consideration of six mechanisms, classified into the following three categories:

- mechanisms for maintaining grid company financial performance;
- mechanisms to enable grid companies to make profits from energy efficiency investments; and
- a mechanism that requires grid companies to implement energy efficiency programs.

1 Crossley (2014b).

2 International Energy Agency (2014).

3 In China, grid companies are government-owned and carry out high-voltage transmission and low-voltage distribution of electricity and also sell electricity to retail customers. Electricity generation is carried out by other companies that sell electricity in bulk to the grid companies.

2. Maintaining Grid Company Financial Performance

When grid companies assist their customers in using electricity more efficiently, the grid companies sell less electricity. Other things being equal, grid company revenue is reduced. In China, the central government's State-Owned Assets Supervision and Administration Commission evaluates grid company performance primarily on the bases of the revenue they earn and the profits they make. Consequently, revenue reduction is a major barrier to grid company implementation of energy efficiency.

This barrier can be removed by changing the metrics for evaluating grid company performance, particularly by developing a metric that measures grid company performance in delivering energy efficiency. The multiple benefits that using energy efficiency as a power system resource will bring to China provide ample justification for changing the evaluation of grid company performance in this way.

However, given energy efficiency's depressing effect on revenues, a change in evaluation metrics should be accompanied by other policy and regulatory changes that will make it easier for grid companies to achieve good financial performance while implementing energy efficiency programs. There are three main types of these mechanisms:[4]

- **Direct Cost Recovery** refers to regulator-approved mechanisms for the recovery of costs related to the administration of energy efficiency programs by the utility, implementation costs such as marketing, and the actual cost of any rebates or incentives paid to customers for energy efficient appliances and equipment. Such costs are recovered by including them in retail prices (determined in **rate cases**) or through **system benefits charges** (separate fees included in customers' bills).
- **Fixed Cost Recovery** refers to mechanisms that assist the utility in recovering investment costs that do not vary (in the short run) with changes in sales (from whatever cause, including customer energy efficiency). Such costs are referred to as "fixed" (although they do vary in the long run). Typically, these costs (which also include the allowed return on investment) are recovered in energy prices, which regulators set, given an assumed level of energy sales. If energy sales fall below the assumed level, the utility may not recover all of its fixed costs. **Revenue "decoupling" and lost revenue adjustment mechanisms** allow for timely recovery of fixed costs when energy sales are reduced by customer energy efficiency.
- **Performance Incentives** are mechanisms that reward utilities for reaching certain energy efficiency program targets, and impose a penalty for performance below the agreed-upon targets. Performance incentives allow utilities to earn a return on their investment in electric efficiency, typically similar to the return on supply-side investments.

2.1 Establishing Rate Cases and Public Benefits Charges

2.1.1 Description

Rate cases (i.e., the regulatory process by which retail prices are set) and public benefits charges can be used to enable utilities to recover the administration, implementation, and evaluation costs of DSM and energy efficiency programs, including the costs of any payments (rebates or incentives) to end-use customers. Because these program costs reduce utility revenues on a dollar-for-dollar basis, the timely recovery of these costs is a minimum requirement for the implementation of energy efficiency programs by utilities.[5]

A rate case, or a similar regulatory proceeding, is the formal mandated process that public utilities go through in order to set the rate or price at which they are allowed to charge consumers for their service. Rate cases serve as one of

4 Institute for Electric Innovation (2014).

5 American Council for an Energy-Efficient Economy (2016c).

the primary instruments of government regulation of such utilities. DSM and energy efficiency program costs can be included in these regulatory proceedings as one of a number of costs that are considered when public utility prices are set.

A public benefits charge is typically a small surcharge applied to the electricity bills of all customers to fund public benefits related to the provision of electricity. In many U.S. states and in some other jurisdictions around the world, a portion of the funds collected through a public benefits charge is used to fund DSM and energy efficiency program costs.

2.1.2 Implementation

Many jurisdictions around the world use different types of rate cases to determine the prices that can be charged by electricity utilities. The use of this mechanism to enable utilities to recover DSM and energy efficiency program costs was pioneered in the United States, which is still the world leader in this area. Other jurisdictions throughout the world also use rate cases in this way. For example, in Australia, the National Energy Regulator includes funds for utility DSM and energy efficiency programs in its five-yearly determinations of electricity prices and charges.

In the United States, about 10 states use a public benefits charge to collect funds to cover utility DSM and energy efficiency program costs. The mechanism is also used in several European jurisdictions, most notably in the United Kingdom, where a public benefits charge to fund energy efficiency implementation by electricity utilities was first levied in 1994 by the then-electricity regulator.[6]

2.1.3 Practice

In most jurisdictions, rate cases, or their equivalents, are typically carried out under the authority of a regulatory body in an administrative law format. In the United States, rate cases are carried out in a relatively formal, legalistic fashion, with lawyers representing the various parties to the proceeding: the utility, state agencies representing the public interest, and other affected stakeholders. In other countries, rate cases are generally less legalistic in this sense, but nonetheless conforming to the relevant rules of administrative procedure and evidence. The important point is that the process produces reliable information—evidence—on which a decision (the setting of prices) can be made.

A public benefits charge can come in many shapes or forms and under a variety of names, including system benefits charge, wires charge, access charge, universal service charge, or distribution charge. Whatever the form or name, two features are essential to making it work. It must be both competitively neutral and non-bypassable.[7]

To ensure that the public benefits charge is competitively neutral, it is typically levied as a surcharge for the use of the electricity distribution system, which is a monopoly service, whereas selling electricity to end-use customers may be contestable among several competitive retail suppliers. Non-bypassable means that the charge must be applied to all customers' electricity bills whether they receive service from a local utility or from a competitive electricity supplier.

A first step in deciding the optimum level of a public benefits charge to fund DSM and energy efficiency program costs is to calculate how much utilities currently spend to deliver these programs. Expenditure on utility DSM and energy efficiency programs in most U.S. states ranges from one to five percent of the average electricity bill. Although current spending is a good place to start, if it turns out that markets deliver DSM and energy efficiency services at reasonable levels without the involvement of utilities, or that these services are provided through other means (such as tax dollars), the benefits charge can be reduced accordingly.[8]

Public benefits charges may be levied in one of two ways:

- on a volumetric basis – generally a charge per kilowatt-hour (kWh), but occasionally on a kW basis; or
- on a fixed charge per customer basis.

Generally, levying a public benefits charge on a volumetric basis is more common, but some jurisdictions do impose a fixed charge per customer. Proponents of volumetric charges contend that energy efficiency and renewable resources predominantly deliver energy and capacity and hence should be charged on a volumetric basis, just like energy and capacity costs. Those favoring a fixed charge argue that fixed customer charges are not bypassable by those who lower their energy consumption.[9]

6 Crossley (2013a).

7 The Regulatory Assistance Project (1995).

8 The Regulatory Assistance Project (1995).

9 The Regulatory Assistance Project (1995).

When funds are collected via a public benefits charge, there are a number of organizations—ranging from the utility to a non-profit or governmental entity—that could appropriately be given the responsibility to manage the funds. Funds will be most successfully spent if there is as little conflict as possible between the purpose of the particular benefit being funded and the interest of the managing organization.

2.1.4 Market Impact

Generally, recovering DSM and energy efficiency program costs through rate cases and public benefits charges is done on the basis that the outcomes are competitively neutral. Although the program costs are essentially paid for by customers through increases in electricity prices, the financial impact is the same for all utilities involved. The market impact is therefore relatively minor.

2.1.5 Effectiveness

When DSM and energy efficiency program costs are included in rate cases and public benefits charges, funds are made available for utilities to implement DSM and energy efficiency programs, thereby overcoming the program costs barrier. However, program costs are only one of the financial impacts that lead to utilities not being prepared to implement DSM and energy efficiency. The rate case and public benefits charge mechanisms do not address the other major financial barrier—the loss of marginal revenue—that utilities face. Without other mechanisms to address the marginal revenue barrier, the effectiveness of rate cases and public benefits charges is limited.

2.1.6 Case Study: United Kingdom

The first public benefits charge implemented in the United Kingdom, and in Europe, commenced in 1994 when the then-electricity regulator for England and Wales commenced an initiative known as Energy Efficiency Standards of Performance (EESoP).[10] Under this initiative, the regulator required electricity suppliers (i.e., electricity retailers) with more than 15,000 customers to spend GBP 1.00 per residential customer on household energy savings measures. The regulator also set energy savings targets to be achieved by the suppliers. The program was extended to electricity suppliers in Scotland in 1995 and in Northern Ireland in 1997.

In 2000, the EESoP program was extended by the regulator to all electricity and gas suppliers in the United Kingdom with at least 50,000 customers. The suppliers were required to spend GBP 1.20 per customer on household energy savings measures.

The EESoP ran from 1994 until 2002 and became the dominant vehicle through which energy efficiency measures were delivered to residential customers in the United Kingdom. Suppliers met their energy savings targets by setting up in excess of 800 schemes to deliver energy efficiency measures.

EESoP had both social goals and environmental benefits. The majority of customers assisted under EESoP 1 (1994 to 1998) were disadvantaged.[11] In EESoP 2 (1998 to 2000) and EESoP 3 (2000 to 2002), energy suppliers were required to focus approximately two-thirds of their expenditure on this customer group. To reach disadvantaged households, suppliers integrated some of their schemes with social housing providers. In this way, energy suppliers could target a large number of low-income consumers and offer them the benefits of energy efficiency at little and no cost by leveraging funds from social housing providers. Energy suppliers also provided energy efficiency solutions to their own consumers who were in need. Some suppliers ran schemes that were targeted at their consumers who were in debt. Other suppliers ran schemes with their prepayment meter customers.

The EESoP program demonstrated that energy suppliers were capable of using the funds provided through a public benefits charge to meet, and in some cases exceed, the energy efficiency targets set. Over the eight years of the program, suppliers developed in-house expertise through managing and delivering energy efficiency schemes.[12]

2.1.7 Applicability in China

Electricity prices in China are not cost-reflective, but are set administratively, and there are no regulatory procedures similar to rate cases in China. Therefore, changes to current practices in China would be required to enable

10 Energy Saving Trust (2001).

11 Ofgem and Energy Saving Trust (2003).

12 Ofgem and Energy Saving Trust (2003).

the introduction of rate cases and public benefits charges as mechanisms to collect funds to cover DSM and energy efficiency program costs.

2.2 Establishing Revenue Decoupling and Lost Revenue Adjustment

2.2.1 Description

Revenue "decoupling" and lost revenue adjustment mechanisms (LRAMs) are regulatory mechanisms that break the link between the amount of electricity sold and the actual (allowed) revenue collected by a utility.[13] These mechanisms aim to reduce the "throughput effect," whereby utilities rely on supplying increasing volumes of electricity to maintain their revenue and therefore profits.[14] Consequently, they can ameliorate the reduction in utility marginal revenue that results from increased end-use energy efficiency. This enables decision-making by the utility to be refocused on making least-cost investments to deliver reliable energy services to customers, even when such investments reduce the volume of electricity sales.

There are a variety of different approaches to revenue decoupling, all of which share a common goal of ensuring the recovery of a defined amount of revenue, independent of changes in sales volume during the period under consideration.[15]

Decoupling mechanisms are usually implemented within a regulatory framework referred to as "revenue regulation" or "revenue cap regulation." Under revenue regulation, a portion of the total revenue of a utility is set each year by the regulator at a particular monetary value ("cap") calculated according to an established formula. The structure and levels of retail electricity prices are then set to ensure that the regulated portion of revenue remains within the cap determined by the regulator. Any over- or under-collection of revenue during one time period is corrected in determining the revenue cap for the following time period.

To achieve full decoupling, the portion of total revenue subject to a cap must be set at 100 percent; a lower value will achieve only partial decoupling. Full decoupling insulates the revenue collected by a utility from any deviation of actual sales from expected sales. The cause of the deviation (e.g., increased investment in energy efficiency, weather variations, changes in economic activity) does not matter. Any and all deviations will result in an adjustment ("true-up") of actual collected revenue to conform to the allowed revenue set by the regulator.[16]

An LRAM provides a second means of recovering lost marginal revenue. This mechanism, unlike decoupling, does not attempt to completely sever the link between revenue and sales, but instead attempts to determine the portion of lost revenue that results only from a successful energy efficiency program.[17] This lost revenue is recovered by adjusting the prices charged by utilities, removing the utility disincentive to invest in efficiency.

2.2.2 Implementation

Revenue regulation and decoupling were first developed during the late 1980s and early 1990s and applied by regulators in several U.S. states to large vertically integrated, investor-owned monopoly utilities. Revenue regulation and decoupling have since been implemented in several other countries, including Northern Ireland and Australia, and many U.S. states now use revenue-cap regulatory regimes to make it easier for electricity utilities to deliver energy efficiency to their end-use customers.[18]

Decoupling can only be applied to electricity services that are subject to regulatory price controls. It cannot be applied to companies that are free to set their prices and thereby determine their own revenue, such as in jurisdictions where the retail electricity market is fully competitive.

13 Lazar, Weston, and Shirley (2011).

14 In theory, under traditional regulation, marginal revenue is equal to marginal costs, so increased sales do not lead to increased profits. However, given that much of a utility's costs are fixed in the short run, reality differs from theory. This means that practically all increases in sales lead to increased profits and vice versa. And these effects are made worse by the adoption of poorly designed deferred accounting practices and pass-through mechanisms.

15 Lazar et al (2011).

16 Lazar et al (2011).

17 American Council for an Energy-Efficient Economy (2016a).

18 Migden-Ostrander, Watson, Lamont, and Sedano (2014).

In jurisdictions where electricity utilities have been unbundled, decoupling can be applied to regulated monopoly utilities, particularly the utilities that own and/or operate electricity transmission and distribution grids. In Australia, revenue regulation is the standard form of regulation applied to all transmission utilities and to distribution utilities in some states. Consequently, the revenue of these utilities is independent of the volume of energy transported through their grids. This makes it easier for the utilities to use energy efficiency resources to reduce loads as an alternative to augmenting or expanding their grids.

2.2.3 Practice

When establishing decoupling for an electricity utility, the regulator begins with a rate case. It first determines the revenue requirement for the utility. The revenue requirement is the aggregate of all approved costs incurred by the utility, comprising: operating expenses; the cost of invested capital, including both interest on debt and a "fair" return to equity investors; and a depreciation allowance. The next step is to set the structure and levels of retail prices. The final step involves selecting the method, if any, whereby the allowed revenue or revenue cap (which is based on the revenue requirement calculated in the rate case) will be adjusted to reflect short-run cost drivers, such as productivity increases, inflation, or changes in numbers of customers.

Decoupling differs most from traditional regulation when setting retail prices (Figure 1). Whereas traditional regulation sets prices, then lets revenues float up or down with consumption, decoupling sets the allowed revenue, then lets prices float down or up with consumption. This price recalculation is done repeatedly, either with each billing cycle or on some other periodic basis (e.g., annually).[20] The focus here is on delivering the level of revenue needed to match the revenue requirement.

2.2.4 Market Impact

As mechanisms that apply only to electricity utilities that are subject to regulatory price controls, decoupling and LRAMs do not affect electricity markets directly. To the extent that they increase the use of energy efficiency resources by electricity utilities, decoupling and LRAMs may contribute to:

- establishing a market for energy efficiency resources where such a market does not already exist; and
- increasing the quantity of energy efficiency resources bid into competitive wholesale electricity markets where the market rules enable demand-side bidding.

2.2.5 Effectiveness

Decoupling and LRAMs diminish a bias against reducing electricity sales but they do not provide any incentive for electricity utilities to use energy efficiency measures to reduce load. Consequently, the effectiveness of these mechanisms in increasing the implementation of energy efficiency measures by electricity utilities has been questioned. However, decoupling and LRAMs are not intended to be major drivers for increased energy efficiency. Achieving this objective will require the implementation of other mechanisms in addition to decoupling and LRAMS.

Figure 1. Equations for Setting Electricity Prices With and Without Decoupling [19]

Traditional Ratemaking Equation

$$\text{Unit Price} = \frac{\text{Allowed Revenue Requirement}}{\text{Expected Units of Consumption}}$$

$$\text{Actual Revenue} = \text{Unit Price} \times \text{Actual Units of Consumption}$$

Ratemaking Equation with Current Period Decoupling

$$\text{Allowed Revenue} = \text{Last Rate Case Revenue Requirement}$$

$$\text{Unit Price} = \frac{\text{Allowed Revenue}}{\text{Actual Units of Consumption}}$$

19 National Renewable Energy Laboratory (2009).

20 Lazar et al (2011).

2.2.6 Case Study: Western Massachusetts Electric Company

The following case study briefly describes a decoupling mechanism applied to the electricity distributor Western Massachusetts Electric Company (WMECO) in the United States. The State of Massachusetts has adopted decoupling measures to make it easier for distribution companies to pursue an aggressive expansion of investment in energy efficiency and demand-side resources.

In July 2008, the Massachusetts Department of Public Utilities, in its Order in D.P.U. 07 50 A, directed each gas and electric utility to include a decoupling proposal in its next rate case.[21] In 2011, the Department issued an Order, subsequently updated in 2013,[22] in D.P.U. 10-70 (the WMECO rate case) that applied a mechanism for the annual reconciliation of WMECO's distribution revenue and adjustment of the company's distribution rates in accordance with a revenue decoupling mechanism (RDM).

As stated in WMECO's testimony to the rate case hearing,[23] the purpose of the RDM was to adjust base rates on an annual basis to account for the impact of changes in the company's actual base revenues relative to the Target Revenues (i.e., revenue caps) by rate class established in the company's rate case. The differences between Actual Revenues and Target Revenues were primarily the result of the company's energy demand-side resource initiatives and the energy efficiency efforts of its customers, as well as the continued economic decline in the company's service area, particularly among commercial and industrial customers.

For many years, WMECO has offered its customers support to implement energy efficiency measures to help them reduce electrical usage. These programs include the residential "MassSAVE" program that provides home energy audits and incentives to implement measures such as insulation and air sealing. They also include programs that cover the entire cost of implementing energy-saving measures for the company's low-income customers. WMECO offers programs for all businesses in its territory—from small commercial to large industrial—that help to fund both retrofit and new construction measures. Following approval of its Three Year Energy Efficiency Plan for 2010 through 2012, the company began to implement a significant increase in the size of its investment in energy efficiency from USD 12 million in 2009 to USD 35 million by 2012.

WMECO proposed a total revenue decoupling mechanism that annually reconciled the difference between the company's actual distribution revenues and Target Revenues for that year. The Company's proposed mechanism was designed to provide for annual filings that were straightforward to audit and review.

The Order implementing the RDM was generally based on WMECO's proposal. The Order required an annual adjustment to be made to Base Rates in a given Rate Year to reconcile Target Revenue with Actual Revenue received during the immediately preceding Rate Year. The Order specified that the annual RDM Adjustment should be calculated in accordance with the formula in Figure 2, and applied in the upcoming Rate Year.

The effect of this formula is that the annual RDM Adjustment Factor is calculated by dividing (1) the difference between Target Revenues and Actual Revenues for the most

Figure 2. Formula for Calculating the Annual Revenue Decoupling Mechanism Adjustment for Western Massachusetts Electric Company[24]

$$\mathbf{RDMAF_i = (TR_{i\text{-}1} - AR_{i\text{-}1} + PPA_i) / FkWh_i}$$

Where,

$RDMAF_i$ means the RDM Adjustment factor applicable during year i,

TR_{i-1} equals the total Target Revenue specified in the Order,

AR_{i-1} means the Actual Revenue reported during year i-1,

PPA_i means the reconciliation in the upcoming Rate Year of estimated actual revenue included in prior period calculations of RDMA, and the recovery of any deferred amounts, and

$FkWh_i$ = the forecast of total kWh sales applicable in the upcoming Rate Year, defined as the forecasted amount of electricity to be distributed to the Distribution Company's distribution customers.

21 Massachusetts Department of Public Utilities (2008).

22 Massachusetts Department of Public Utilities (2013).

23 Massachusetts Department of Public Utilities (2010).

24 Massachusetts Department of Public Utilities (2013).

recently completed annual period by (2) projected kWh deliveries for the next recovery period. This method of determining the RDM Adjustment Factor on a total revenue basis is consistent with the approach authorized by the Massachusetts Department of Public Utilities in previous rate cases for other electricity distributors.

WMECO calculates class Target Revenues for each rate (customer) class. The initial Target Revenues are equal to base revenues by class at the base rates that were provided in section 3 of the Order implementing the RDM. Actual Revenues, by class, are determined directly from the actual booked base distribution revenues on a calendar month basis accumulated for the 12- to 23-month period. The difference between Actual Revenues and Target Revenues for that year by class are summed and then divided by the projected total annual WMECO sales for the period over which the adjustment is to be recovered.

The Order implementing the RDM also required that, as part of its annual filing, WMECO must submit the following information for its residential, commercial, industrial, and street lighting customers: (1) monthly customer counts; (2) monthly kWh sales; (3) weather-normalized kWh sales; (4) lost base revenue from energy efficiency programs for the most recent calendar year available; and (5) forecasted sales for the next two years.

2.2.7 Application in China

Until recently, there has been no opportunity to apply revenue decoupling or LRAMs to grid companies in China. Although China is in transition to market-based power pricing, administratively set retail electricity prices still exist and no information is available about the factors considered in the price-setting process.

Commencing in early 2015, various policy changes occurred that could provide opportunities to introduce revenue decoupling for grid companies. In March 2015, the Chinese central government released a policy statement Deepening Reform of the Power Sector (《关于进一步深化电力体制改革的若干意见（中发〔2015〕9号）文》全文).[25] This policy statement includes a commitment to gradual national implementation of grid company regulation based on the principle of “Approved Costs + Reasonable Revenue.” This regulatory reform will make it easier for grid companies to implement cost-effective energy efficiency and DSM, and eventually move toward using energy efficiency as a power sector resource.

The *Deepening Reform* policy statement includes expanding several existing transmission and distribution pricing pilots to cover the entire country. These pricing pilots were first implemented in Shenzhen and Inner Mongolia in November 2014.[26] In May 2015, the central government announced that the regulatory principles implemented in the first pilots will be extended to Yunnan, Anhui, and Hubei provinces, and to Ningxia autonomous region.[27] In March 2016, the National Development and Reform Commission (NDRC) included another 12 provincial grids and North China regional grid to pilot transmission and distribution pricing reform[28]; a later document directs that the policy be adopted nationwide by requiring the remaining 14 provincial grids to start pilots in September, 2016, and in Tibet and the other regional grids in 2017.[29]

Depending on implementation details, the kind of pricing reform implemented in these pilots may open up greater opportunities for grid companies to support energy efficiency and DSM by breaking the link between electricity sales and grid company revenues. Specifically, the revenue of each grid company involved in the pricing pilots is set for three-year periods at a particular level determined by the government.[30,31] Although the primary objective of this pricing reform is to drive increased operational efficiency, in effect it introduces revenue decoupling and therefore makes it easier for grid companies to implement DSM and end-use energy efficiency. While the pricing pilots were not introduced specifically with the intention of encouraging grid companies to implement DSM and end-use energy efficiency, grid companies involved in the pilot projects should, in principle, be able to claim expenditure on implementing DSM and energy efficiency programs as “allowed costs” under the regulatory regime for the pricing pilots.[32,33]

25 Central Committee of the Communist Party and State Council of China (2015).

26 Crossley, Wang, and He (2014).

27 China National Development and Reform Commission (2015c).

28 China National Development and Reform Commission (2016a).

29 China National Development and Reform Commission (2016c).

30 China National Development and Reform Commission (2015a).

31 China National Development and Reform Commission (2015a).

32 Dupuy, Crossley, Kahrl, and Porter (2015).

33 At the time of writing, there is some anecdotal evidence that DSM expenses are being treated as allowed costs, as the DSM Rule, issued in 2010, calls for.

New rules for the transmission and distribution pricing pilot in the western part of Inner Mongolia provide further support for grid company DSM and energy efficiency because they call for the formulation of incentive mechanisms targeting various aspects of grid company service provision.[34] The rules specifically mention "strengthening DSM" as one of the aspects for which an incentive mechanism will be developed. Similar incentive mechanisms have been developed in Yunan province.[35] These rulings should effectively create a performance incentives regime for grid company DSM and energy efficiency that could be replicated throughout China.

2.3 Energy Efficiency Performance Incentives

2.3.1 Description

Revenue decoupling removes disincentives for electric utilities to deliver energy efficiency to their end-use customers, but it does not necessarily motivate the utility to invest more broadly in energy efficiency as a resource. This is where another type of financial performance mechanism comes in: specifically, performance incentives to support utility investment in end-use energy efficiency. Particularly in the United States, some state regulatory commissions have implemented mechanisms that provide financial rewards when the utility meets specified targets for promoting end-use energy efficiency.

The rationale for utility energy efficiency performance incentives is that utility investment in energy efficiency programs can be more cost-effective than supply-side solutions such as building more power stations and transmission and distribution infrastructure. However, under traditional regulation, investor-owned electric utilities earn returns on capital invested in generation, transmission, and distribution and there is no incentive for utilities to invest in cost-effective energy efficiency. There is a clear financial incentive for utilities to prefer investment in supply-side assets, because these investments contribute to enhanced shareholder value. Providing financial incentives to a utility if it performs well in delivering energy efficiency can change that business model by making energy efficiency profitable rather than merely a break-even activity.[36]

To justify the payment of performance incentives, programs must be cost-effective, after taking into account all costs of implementing the programs (including any performance incentive payments). In the United States, cost-effectiveness is a primary goal of utility energy efficiency programs. Although public demand for energy efficiency, customer service, and environmental goals can be important drivers, all programs must offer cost-effective energy and demand savings to meet the regulators' least-cost requirements. To ensure cost-effectiveness, independent program evaluators review utility energy efficiency programs under rigorous benefit/cost rules that examine the stream of energy savings benefits provided by the programs over the expected lifetimes of the energy efficiency measures, against the costs of installing the measures.[37]

2.3.2 Implementation

Payment of incentives for utility delivery of energy efficiency has been almost entirely restricted to certain states in the United States. About 25 states currently have, or are considering, some type of performance incentive.[38] In some of these states, incentive payments to utilities can be substantial. Penalties for failure to meet targets are also used by some states to strengthen the incentive.

2.3.3 Practice

The three major types of performance mechanisms that have been most prevalent in the United States include:[39]

- performance target incentives;
- shared savings incentives; and
- rate of return adders.

Performance target incentives provide payment (often set as a percentage of the total budget for energy efficiency programs) for achievement of specific metrics, usually including savings targets. Most U.S. states providing such incentives set performance ranges; incentives are not paid

34 China National Development and Reform Commission (2015b).

35 China National Development and Reform Commission (2015b).

36 National Action Plan for Energy Efficiency (2007).

37 Dupuy et al (2014).

38 American Council for an Energy-Efficient Economy (2016b).

39 National Action Plan for Energy Efficiency (2007).

unless a utility achieves some minimum fraction of proposed savings, and are often capped at some level after achievement of projected savings.

Shared savings incentive mechanisms provide utilities with an opportunity to share with customers the net benefits resulting from successful implementation of energy efficiency programs. These mechanisms also include specific performance targets that tie the percentage of net savings awarded to the percentage of goal achieved. Some, but not all, shared savings mechanisms include penalty provisions requiring utilities to pay customers when minimum performance targets are not achieved.

Rate of return adders provide an increase in the return on equity (ROE) applied to capitalized energy efficiency expenditures. This approach currently is used in only a few U.S. states, mainly because it requires energy efficiency program costs to be capitalized, which relatively few utilities prefer. In several cases, the adder is not tied to performance in delivering energy efficiency, it simply is applied to all capitalized energy efficiency costs as a way to broadly incentivize a utility for spending on energy efficiency programs.

2.3.4 Market Impact

Performance incentives increase the cost of electricity to end-use customers because the incentives are ultimately paid for by customers. When a regulator awards an incentive to a utility, the utility is allowed to increase its electricity prices to recover the amount of the awarded incentive. However, as noted previously, all utility energy efficiency programs that include the payment of incentives to the utility must be cost-effective.

2.3.5 Effectiveness

In the United States, performance incentives have been very effective in increasing the implementation of end-use energy efficiency in those states where incentives are in place. In some states, such as California, DSM and energy efficiency performance incentives have become a major source of revenue for utilities. Least effective, however, have been rate-of-return incentives, which reward investment, not performance.

2.3.6 Case Study: California

To enable utilities to take a large role in implementing energy efficiency programs, the California Public Utilities Commission (CPUC) provides a "shared savings" incentive mechanism for investor-owned electricity and gas utilities (IOUs) in California. The purpose is to give utilities a portion of the net energy value that the energy efficiency savings produce for customers. The version of shared savings adopted in 2007 was called the "risk/return incentive mechanism" (RRIM) and was designed to align ratepayer and shareholder interests by creating a significant reward or penalty for IOUs' success or failure in meeting the CPUC's targets for reducing customer demand for electricity and natural gas.[40]

The RRIM was calculated for each IOU based on how well it met the energy savings targets and the economic benefits generated from its energy efficiency portfolio. IOUs were eligible for the RRIM if they achieved 80 to 85 percent of CPUC energy savings targets and could earn larger incentives if they exceeded the targets. Penalties might be triggered if savings were less than 65 percent of the CPUC's energy savings targets. For the 2006 to 2008 program cycle, total potential incentives were capped at USD 450 million (less than one percent of total revenues) for the four IOUs combined. Two interim payments were provided, first after verifying actual energy efficiency measures installed and program costs, then after evaluation, measurement, and verification (EM&V) studies documented projected per-measure savings. Thirty percent of the total incentive was held back pending a final post-installation EM&V "true-up."[41]

In 2012, the RRIM was replaced by a different incentive mechanism, called Energy Savings Performance Incentives (ESPI), which pays out based on units of energy saved, instead of as a percent of goals. For energy savings achieved, utilities can earn a performance-based award of up to nine percent of energy efficiency program expenditures (minus codes and standards program expenditures). ESPI also added some small amount of bonuses for complying with CPUC procedures.[42]

40 California Public Utilities Commission (2007).

41 California Public Utilities Commission (2007).

42 California Public Utilities Commission (2014).

2.2.7 Application in China

There is no precedent in China for awarding financial incentives to utilities that implement end-use energy efficiency. Before such incentives could be introduced, there would have to be a general acceptance that energy efficiency can be a cost-effective alternative to investing in supply-side resources. Because electricity prices in China are not cost-reflective, recognizing the cost-effectiveness of using energy efficiency as a resource would require major changes to current practices in China.

3. Enabling Grid Companies to Profit From Energy Efficiency

Under the current business model, a Chinese grid company generates revenue and profits by purchasing electricity in bulk from generation companies, then selling the electricity to end-use customers after it has transported the electricity to the end-user through grid infrastructure ("poles and wires") that the grid company owns. Under this model, higher volumes of electricity sales lead to increased profits. Conversely, if a grid company assists its customers to implement energy efficiency and use less electricity, the company profits fall.

Revenue regulation (decoupling) and performance incentives, discussed in the previous section, partially reverse this situation. In U.S. states where performance incentives are implemented, utilities can make a profit from the performance incentives paid when they meet targets for assisting their customers to be more energy efficient. This section discusses two other mechanisms that enable grid companies to make a profit from implementing end-use energy efficiency:

- using energy efficiency to reduce grid infrastructure costs; and
- establishing a grid company-owned energy services business.

3.1 Using Energy Efficiency to Reduce Grid Infrastructure Costs

3.1.1 Description

A major expense for grid companies is the costs involved in building transmission and distribution grid infrastructure ("poles and wires") to deliver electricity to end-users' premises. An alternative approach to building grid infrastructure is to assist customers to be more energy efficient, therefore reducing the amount of infrastructure that is required. Frequently, implementing energy efficiency measures to reduce customers' loads is cheaper than building poles and wires to deliver an equivalent quantity of energy.

3.1.2 Implementation

Implementing energy efficiency measures to lower customer loads and therefore reduce the requirement for grid infrastructure is now becoming increasingly common across a range of jurisdictions. Energy efficiency was first used in this way in the Pacific Northwest region of the United States, commencing in the 1980s. Today, several U.S. states, notably Connecticut and Vermont, have used energy efficiency to defer grid augmentations, and this has also been implemented in several Australian states, in some Canadian provinces, in the United Kingdom, and in France, India, and Poland.[43]

3.1.3 Practice

There are two ways in which energy efficiency can be used to reduce the requirement for grid infrastructure. First, widespread and long-term implementation of energy efficiency measures across a particular jurisdiction can lead to an overall reduction in the requirement for grid infrastructure in that jurisdiction. This has been achieved through more than 30 years of sustained energy efficiency implementation in several regions of the United States, notably in California and the Pacific Northwest.

Second, energy efficiency can be targeted to lower customer loads on particular grid elements, such as specific distribution or transmission lines, or substations. Typically, grid elements that are approaching their maximum loads are targeted, with the aim of deferring the need to augment or replace these elements. Deferring the construction of grid elements can significantly reduce costs for grid companies. In the United States, this practice is known as "geo-targeting" of energy efficiency.[44]

43 Crossley (2008).

44 Neme and Grevatt (2015).

3.1.4 Market Impact

Reducing the requirement for grid infrastructure is beneficial for grid companies and may increase grid company profits if the cost savings are large enough. However, in analyzing the overall financial impact on the grid company, cost savings from energy efficiency must be balanced against the loss of revenue from lower electricity sales, plus the cost of implementing the energy efficiency measures.

3.1.5 Effectiveness

There is now growing evidence from around the world that energy efficiency measures can be targeted to cost-effectively reduce the requirement for grid infrastructure.[45]

3.1.6 Case Study: France

In France, during the 1980s, planning commenced for the upgrading of transmission lines to supply increasing load growth in the French Riviera region. The initial plan comprised double 400 kilovolt (kV) lines on separate easements over 170 kilometers in length. Six route options for the upgraded line were proposed. There was strong opposition to this project, however, because the lines would pass through the classified scenic gorges of the Verdun Regional Park.[46]

In 2000, a decision was made on an alternative solution. This comprised:

- replacement of the existing 225-kV line by a single 400-kV line, 100 kilometers in length, on the same easement;
- removal of an existing 150-kV line that accompanied the 225-kV line; and
- implementation of an ambitious energy efficiency and renewable energy distributed generation program called the “Eco-Energy Plan” to slow down the growth in demand in the area served by the subject transmission lines.

Continuing public opposition to the project led to a court decision in May 2006, refusing planning permission for the upgrading of the transmission lines. Therefore, at that time, the energy efficiency and renewable energy program was the only way to secure supply to this region by keeping load growth within the capacity of the existing 250-kV line.

The Eco-Energy Plan comprised a very large energy efficiency and renewable energy project (including distributed generation). It was the largest project of its type in the European Union and possibly the world. It had three main objectives:

- to increase the efficiency of electricity usage and to create a critical mass of scientific and technological competence in relation to electricity DSM;
- to modify the electricity-using behavior of consumers and building owners and managers; and
- to contribute to the development of local renewable energy and to establish a solid basis for future energy choices.

Eight priority areas were identified for the Eco-Energy Plan:

- communication and information;
- new building construction;
- existing buildings;
- efficient lighting and domestic electrical appliances;
- large consumers and distributed generation;
- public housing;
- tourism; and
- demonstration projects by the Eco-Energy Plan institutional partners.

3.1.7 Application in China

In China, grid companies are subject to an EEO that requires them to achieve specified targets for reductions in electricity sales (gigawatt hours [GWh]) and peak demand (megawatts [MW]).[47] At present there is no requirement that energy efficiency measures implemented under the EEO be targeted to reduce the requirement for grid infrastructure. The obligation could be modified to add this requirement. The Chinese government should consider making this modification.

45 Crossley (2008).

46 Crossley (2008).

47 Crossley and Wang (2015).

3.2 Establishing a Grid Company-Owned ESCO

3.2.1 Description

With this mechanism, a grid company establishes a separate, grid company-owned, for-profit business focused on providing energy services to customers. Such a business is commonly called an energy services company (ESCO). The main purpose of establishing an ESCO is for the grid company to generate revenue and profits from providing energy services (predominantly energy efficiency) to customers.

Typically, grid company ESCOs commence by focusing on developing, installing, and financing comprehensive, performance-based projects centered around improving the energy efficiency of facilities owned or operated by customers. Over time, the definition of energy services may be broadened to include power marketing, energy brokering, equipment maintenance and/or warranties, power quality services, information technologies, and other activities that do not necessarily entail performance contracting, long-term agreements, or financing.[48]

3.2.2 Implementation

The United States has the most extensive experience with ESCOs established by, or closely affiliated with, electricity utilities. With the deregulation of the U.S. electricity industry in the 1990s, most large electricity utilities attempted to gain a competitive edge and make money in the unregulated energy services market by either creating their own ESCOs or, more commonly, by purchasing commercial ones. In just a few years, the number of utility-affiliated ESCOs in the United States increased from less than 30 to more than 300.[49] Utilities in other countries where similar electricity industry restructuring was being implemented also established ESCOs.

The experience with utility-owned ESCOs is decidedly mixed. Although utilities have the inherent advantage of strong pre-existing customer relationships, they are also challenged to effectively market energy efficiency as a product/service to customers who may be skeptical about why an energy supplier is offering to reduce the amount of energy they consume. In the early years of utility involvement in ESCO businesses, there was some conflict between what was seen as the utilities' traditional business of selling energy and the reductions in energy sales resulting from ESCO activities. Establishing an ESCO as a profit center and major contributor to utility revenue requires significant changes to the utility business model that many utilities found too difficult to implement. Furthermore, operating an ESCO is not simple. To become a successful and profitable business, an ESCO requires staff with a complex mix of skills plus a substantial level of equity capital, neither of which may be readily available within a utility.

In the United States, after the California "energy crisis" in the early 2000s, changes were made to the way utilities were regulated that made it much less attractive for utilities to own ESCOs. In response to this and the other difficulties, many utilities closed or disposed of their ESCOs.[50]

3.2.3 Practice

Most utilities establish an ESCO as a separate unregulated subsidiary. This business is therefore not subject to the regulation that controls many aspects of the main utility function of energy supply.

Utility ESCOs pursue two broad strategies. One is customer retention, in which the utility targets existing customers as a way to obtain long-term commitments. A second strategy is customer acquisition, wherein the utility targets new customers. In jurisdictions where customers can choose their energy retailers, these customers may eventually buy energy from the utility, in addition to energy services.

All utility ESCOs target customers in the utility's service territory and many also target customers outside this service territory. In the United States, nearly all utility ESCOs established in the 1990s targeted both commercial sector and industrial sector customers. Residential customers were targeted by only a few of the ESCOs. In these cases, it seemed that the ESCO was closely associated with an energy marketing business of the utility that was targeting residential customers along with commercial and industrial accounts.[51]

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48 Rosenstock and Barrett (1998).

49 Musser (2003).

50 Frank (2008).

51 Rosenstock and Barrett (1998).

3.2.4 Market Impact

In the 1990s, some utility-owned ESCOs in the United States made large profits and, for a while, it seemed as though the utility-owned businesses were in direct competition with unaffiliated independent ESCOs. There was even speculation that utility-owned ESCOs would eventually dominate the energy services industry in the United States.[52] However, regulatory changes in the early 2000s resulted in a major reduction in the numbers and influence of utility-owned ESCOs.

3.2.5 Effectiveness

In theory, establishing a utility-owned ESCO seems to be an effective way for utilities to generate revenue and profits from assisting their customers to be more energy-efficient. However, practical difficulties involved in an energy supplier marketing energy efficiency as a product/service to skeptical customers, coupled with difficulties in changing the utility business model, have resulted in this mechanism not reaching its potential.

3.2.6 Case Study: China

Since 2011, grid companies in China have been required to achieve specified targets for reductions in electricity sales (GWh) and peak demand (MW). Chinese government support for ESCOs and financial incentives for energy performance contracting have encouraged the grid companies to establish ESCOs as their main mechanism for acquiring energy and demand savings to meet these targets.[53]

State Grid Corporation of China has created ESCOs in all 27 provinces within its service territory as subsidiaries of State Grid-owned provincial grid companies. The main roles of the State Grid ESCOs are implementing energy efficiency projects, delivering specialized energy and consultancy services, and helping to organize workshops and seminars to better engage end-users in energy efficiency programs. State Grid's provincial companies have also constructed energy efficiency service platforms in which experts and energy users can get together to study energy efficiency policies and technologies and conduct energy audits.[54] In 2015, State Grid ESCOs signed 635 energy savings service contracts with a total investment of 2.5 billion RMB.[55]

In contrast, China Southern Grid Company has established one fully owned ESCO to implement energy efficiency projects. The Southern Grid ESCO exploits energy efficiency potential in industry and building sectors, green lighting, high-efficient electrical devices, and residential appliances. Southern Grid also plans to emphasize energy services by changing from pure peak load management to end-use energy efficiency, and from concentrating on electricity consumption management to providing comprehensive energy services.[56]

3.2.7 Application in China

Early experience with grid company-owned ESCOs in China showed that the ESCOs were not competitive and progress was slow for the following reasons:[57]

- insufficient capital — the initial registered capital for each grid company ESCO was about 30 to 40 million Chinese yuan (CNY) (USD 4.8 to 6.4 million), which is quite low compared with the scale of the energy and demand savings that are required to be achieved;
- lack of projects — the grid company ESCOs lacked marketing know-how;
- internal processes — State Grid required headquarters' approval for projects above CNY 10 million (USD 1.6 million) and the time taken for approval was lengthy; and
- staffing — the process to hire ESCO staff was complicated.

52 Frank (2008).

53 Crossley (2013b).

54 Crossley (2013b).

55 2015 State Grid CSR report (2016a).

56 Crossley (2013b).

57 Crossley (2013b).

Grid companies can improve their implementation of the ESCO business model by:[58]

- providing education and training to facility owners on the concept and operation of energy performance contracting;
- making sufficient funds available to grid company ESCOs to enable the ESCOs to provide off-balance sheet funding for energy efficiency projects at facility owners' sites;
- providing detailed training for grid company ESCO staff in the full range of skills required, including technical, business, and financial skills;
- establishing partnering arrangements with technical experts who have specialized technical skills and expertise that existing grid company ESCO staff do not have; and
- marketing grid company ESCO services to owners of facilities in areas of the market that match the technical capability and capacity of the ESCO and its partners.

58 Crossley (2013b).

4. Requiring Grid Companies to Implement Energy Efficiency

In addition to mechanisms that assist grid companies to implement energy efficiency by maintaining grid company financial performance and enabling grid companies to make a profit from energy efficiency, governments can ensure that grid companies implement energy efficiency by requiring them to do so. Many governments around the world are establishing EEO schemes to ensure that grid companies implement end-use energy efficiency.

4.1 Establishing an Energy Efficiency Obligation Scheme

4.1.1 Description

An EEO is a regulatory mechanism that requires obligated parties to meet quantitative energy savings targets by delivering or procuring eligible energy savings produced by implementing approved end-use energy efficiency measures. The requirement to meet quantitative energy savings targets distinguishes EEOs from other similar mechanisms, such as a general requirement to acquire all cost-effective energy efficiency with no target specified.[59]

Governments in many jurisdictions around the world have endeavored to improve end-use energy efficiency, and in some cases also achieve other objectives, by designing and implementing schemes that place EEOs on particular parties. These EEO schemes share three key features:

- a quantitative target for energy efficiency improvement;
- obligated parties that must meet the target; and
- a system that: defines the energy savings activities that can be implemented to meet the target; measures, verifies, and reports the energy savings achieved through these activities; and confirms that the activities actually took place.

Typically, obligations in EEO schemes are placed on providers of networked energy (e.g., electricity and natural gas distributors or standalone retail suppliers). Obligations can also be placed on providers of other energy forms (e.g., liquid propane gas, heating oil, transport fuels, district heating), and even on end-users of energy. In some jurisdictions, energy savings to meet the obligation are delivered by a third-party "energy efficiency utility."

4.1.2 Implementation

EEO schemes have been implemented in more than 50 jurisdictions across the world. In the European Union, the Energy Efficiency Directive requires that Member States establish EEO schemes or alternative measures that would deliver a growing level of energy savings from measures delivered to end-use energy customers. In early 2017, 16 E.U. Member States have adopted or plan to adopt EEO schemes. In the United States, similar obligations are called energy efficiency resource standards and have been adopted in 26 states, even in the absence of a federal mandate. In Australia, similar EEO policies have been adopted in three states plus the Australian Capital Territory.[60] Other jurisdictions that have implemented EEO schemes include Brazil, China, Korea, South Africa, Switzerland, Uruguay, and the province of Ontario in Canada.

4.1.3 Practice

Types of EEO Schemes

There are three broad types of EEO schemes:[61]

- schemes that have been established relatively independently, often with their own enabling legislation, and with energy savings targets specific to each scheme (e.g., schemes in Australia and Europe);
- schemes that are integral components of resource planning and acquisition by obligated energy utilities (e.g., schemes in North America); and

59 Crossley et al (2012).

60 Nadel, Cowart, Crossley, and Rosenow (In preparation).

61 Crossley et al (2012).

- schemes that have been established principally by governments as integral components of government policies (e.g., schemes in China and Korea).

Each of the three types of schemes is the product of quite different ways of thinking about how to use an obligation mechanism to deliver energy efficiency.

Policy Objectives

Determining and stating the policy objectives is the most important stage in designing an EEO scheme. These objectives define what the obligation is intended to achieve and significantly affect all the other parameters of the scheme. Policy objectives for an EEO scheme may include:[62]

- acquiring cost-effective energy efficiency as a resource;
- assisting disadvantaged households;
- developing an energy services industry; and
- improving environmental outcomes.

The chosen policy objectives must be clearly stated because they will strongly influence how the EEO scheme is developed and implemented.

Energy Savings Target

Setting the energy savings target is the second most important stage in designing an EEO scheme; the target defines the path to achieving long-term energy savings goals. There are six decisions to be made when setting the energy savings target.[63]

First, the level of the target should be set in the light of the overall policy objectives for the EEO scheme; the aim is to strike a balance between making progress and judging what is practically possible based on an assessment of energy efficiency potential.

Second, the target may be set in terms of primary energy or final energy; although final energy is familiar to end-users and energy providers, targets set in primary energy may be preferable for EEO schemes that cover a range of fuels.

Third, the units used for denominating the target should be chosen to demonstrate progress in achieving the main policy objective (e.g., reducing greenhouse gas emissions).

Fourth, the timeframe over which the target will be in place is typically set over the medium- to long-term (e.g., 10 to 20 years); setting a relatively long timeframe provides assurance to the obligated parties that the costs involved in setting up systems and procedures to meet the target will be justified.

Fifth, the time period over which eligible energy savings will be calculated may be set as first-year savings or as savings over a set period related to the lifetime of the particular energy efficiency measure; selecting first-year savings favors low-cost, short-lifetime measures over more costly measures that save more energy over a longer time period and that may be more cost-effective in the long run.

The sixth decision is whether to set sub-targets and portfolio requirements that address particular policy objectives, such as stimulating an energy services industry, assisting disadvantaged households, or reducing peak energy demand in addition to reducing energy consumption; if sub-targets are set, suitable metrics to measure progress in achieving the relevant policy objectives must be developed.

Administration and Governance

Administration and governance of EEO schemes vary enormously, but similar types of schemes tend to have comparable arrangements.[64] Schemes established under their own enabling legislation typically establish dedicated organizations (which may include private sector entities) to run the scheme, with oversight provided by government agencies or regulators. Schemes that are integrated into energy utility operations are usually run by the utility with strong oversight by energy industry regulators; in some jurisdictions dedicated organizations are established to deliver energy savings. Schemes established as integral components of government policies may be run by utilities in which they are the obligated parties, or by government agencies; oversight is provided by government agencies.

4.1.4 Market Impact

The purpose of EEO schemes is to expand or create a market for end-use energy efficiency. By requiring energy suppliers to meet energy savings targets by implementing end-use energy efficiency measures, EEO schemes ensure that a specified quantity of energy savings will be delivered.

62 Crossley (2014a).

63 Crossley (2014a).

64 Crossley (2014b).

Some EEO schemes allow trading of energy savings among obligated parties and some schemes also authorize third parties to implement energy efficiency measures and then sell the resulting energy savings to obligated parties. Both of these enhancements to basic EEO schemes function to substantially increase the number of players in the energy efficiency market and may also stimulate the development of an energy services industry.

4.1.5 Effectiveness

In the large majority of jurisdictions, EEO schemes have resulted in the delivery of substantial verified energy savings from implementing end-use energy efficiency measures. Only the EEO scheme in Poland has failed to achieve significant savings and this was because the scheme was badly designed.[65]

4.1.6 Case Study: China

In November 2010, the Chinese central government issued a national guidance document on Electricity Demand-Side Management Regulations (发改运行[2010] 2643号).[66] This document for the first time placed an EEO on the two government-owned grid companies, State Grid Corporation of China and China Southern Grid Company. The obligation requires the grid companies to achieve energy savings of at least 0.3 percent in sales volumes and 0.3 percent in maximum load compared with the previous year. The EEO also establishes a sub-target that requires the installation of load monitoring equipment on 70 percent of the peak load, and load control equipment on 10 percent of the peak load, in any locality. This sub-target provides an opportunity for the implementation of demand response programs in China. The Electricity Demand-Side Management Regulation is revised in September, 2017 by the National Development and Reform Commission to keep up with new development of power sector in China.[67]

The EEO placed on the grid companies covers electricity. In addition, energy savings from other fuel types may be converted to the equivalent electricity savings using standard coefficients published by the National Statistics Bureau and can then be counted toward the energy savings target. The energy savings and demand reduction targets set by the obligation can be met with end-use energy savings from all economic sectors and from any facility. In addition, reduction of losses in transmission and distribution networks can also be used to meet part of the targets. There is no targeting of energy efficiency activities to particular sectors, nor are certain sectors excluded, as occurs in some EEO schemes in other jurisdictions.[68]

In practice, there are five types of activities that grid companies can undertake to produce eligible energy savings that contribute to meeting their energy savings targets, subject to constraints specified in a Compliance Evaluation Scheme originally published by NDRC in 2011 as a trial version,[69] and updated in 2014:[70]

- directly implement energy efficiency projects in the grid company's own premises and in their end-use customers' premises;
- establish an ESCO affiliated with the grid company to implement energy efficiency projects;
- purchase energy savings by means of business transactions/trading[71] (not to exceed 40 percent of total eligible energy savings);
- promote energy efficiency to the grid company's end-use customers; and
- directly carry out grid system upgrades and operational management improvements that save energy and reduce losses in transmission and distribution networks.

As a further constraint, grid companies can claim 100-percent energy savings value only for those energy savings that are audited by a third party or recorded by online monitoring equipment; otherwise only 80 percent of the value can be claimed.

65 Nadel et al (In preparation).

66 China National Development and Reform Commission (2010).

67 China National Development and Reform Commission (2017).

68 Crossley and Wang (2015).

69 China National Development and Reform Commission (2011).

70 China National Development and Reform Commission (2014).

71 A grid company may purchase energy savings from customers (or ESCOs) if the grid company does not itself implement energy efficiency projects.

The initiative to place an EEO on grid companies was a departure from the existing paradigm of Chinese government involvement in energy efficiency that had commenced in the 1980s. Previous government interventions were part of a "wide net" industrial policy aimed at technology upgrading, driven by government agencies. In contrast, the EEO is more focused and is implemented by the grid companies.[72]

The EEO guidance document stated that DSM should be prioritized to meet electricity demand in the tight supply situation and power shortages that have occurred in most of China's central and southern provinces (although these shortages may occur less frequently in the future). DSM was considered to be a mechanism that would help to deal with power shortages as well as long-term sustainability issues, such as:[73]

- achieving end-use energy efficiency at lowest cost;
- reducing greenhouse gas emissions;
- improving environmental quality;
- integrating demand-side resources into energy, social, and economic planning; and
- enhancing grid security and reliability.

4.1.7 Application in China

China's grid company EEO is relatively new and the grid companies have experienced some difficulties in changing their business models to achieve the EEO energy savings and load reduction targets. Both grid companies have chosen to establish subsidiary ESCOs to carry out energy efficiency projects. This use of ESCOs as the main delivery mechanism locates the acquisition of energy efficiency resources in a separate, subsidiary business unit outside the grid company core business rather than incorporating energy efficiency into the grid company business model.[74] This raises questions about the commitment of the grid companies to achieving the EEO targets and suggests that the EEO mechanism may not continue over the long term without further policy action by the government. In addition, the levels of the two EEO targets are very low compared with targets for utility delivery of energy efficiency in other jurisdictions. In 2015, the total energy savings (on a first-year savings basis) were 14.27 terawatt-hours (TWh), and the total load reduction was 3.273 GW.[75] These savings are large in comparison to total annual energy savings in most other countries, but given China's size they are not particularly ambitious. Although it is too soon to enable a robust assessment of the effectiveness of the grid company EEO in China, performance to date has not been outstanding.

72 Crossley and Wang (2015).

73 Crossley and Wang (2015).

74 Crossley (2013b).

75 China National Development and Reform Commission (2016c).

5. Conclusions: Using Energy Efficiency as a Resource in China

This paper includes detailed consideration of six policy and regulatory mechanisms that address one or more barriers to grid companies in China using energy efficiency as a power system resource. Although the mechanisms are generally effective in addressing the barriers, implementing one, several, or even all of the mechanisms will not be sufficient to ensure that grid companies commence using energy efficiency as a resource. Before this can occur, both the grid companies and governments in China have to be convinced that energy efficiency is a cost-effective and practical alternative to investing in supply-side resources, such as building power plants and expanding the electricity grid.

In China, the central government has taken an important initial step in establishing an EEO on the two major grid companies. What is needed now is for the government to strengthen policy and regulatory mechanisms to both expand the energy efficiency programs delivered by grid companies and to enable energy and capacity savings achieved by all energy efficiency programs implemented in China to be used as power system resources. This will reduce the number of new power stations and augmentations of grid infrastructure that must be built in the future.

In addition, careful attention to the details of implementing the government's further planned reforms of grid company regulation will be necessary to lead the grid companies to seriously consider using energy efficiency as a power sector resource. The government must follow through with eliminating the throughput incentive and, in addition, create financial incentives for grid companies to deliver cost-effective DSM and end-use energy efficiency, building on the existing EEO.

References

American Council for an Energy-Efficient Economy. (2016a). *Incentivizing Utility-Led Efficiency Programs: Lost Margin Recovery.* Retrieved 31 May 2016 from http://aceee.org/sector/state-policy/toolkit/utility-programs/lost-margin-recovery.

American Council for an Energy-Efficient Economy. (2016b). *Incentivizing Utility-Led Efficiency Programs: Performance Incentives.* Retrieved 31 May 2016 from http://aceee.org/sector/state-policy/toolkit/utility-programs/performance-incentives.

American Council for an Energy-Efficient Economy. (2016c). *Incentivizing Utility-Led Efficiency Programs: Program Cost Recovery.* Retrieved 31 May 2016 from http://aceee.org/incentivizing-utility-led-efficiency-programs-program-cost-recovery-0.

California Public Utilities Commission. (2007). Interim Opinion on Phase 1 Issues: Shareholder Risk/Reward Incentive Mechanism for Energy Efficiency Programs. Decision 07-09-043. San Francisco: CPUC. Retrieved from http://www.cpuc.ca.gov/NR/rdonlyres/33471B66-CCCB-4999-B727-CB02CBAB8734/0/D0709043.pdf.

California Public Utilities Commission. (2014). Shareholder Incentive Mechanism. Retrieved 7 December 2014 from http://docs.cpuc.ca.gov/published/final_decision/73172.htm.

Central Committee of the Communist Party and State Council of China. (2015). *Deepening Reform of the Power Sector.*《关于进一步深化电力体制改革的若干意见（中发〔2015〕9号）文》全文. Beijing: Central Committee and State Council. Retrieved from http://www.ne21.com/news/show-64828.html.

China National Development and Reform Commission. (2010). Guidance on Electricity Demand-Side Management Regulations No. 2643. 关于印发《电力需求侧管理办法》的通知 (发改运行 [2010] 2643). Beijing: NDRC. Retrieved from http://www.ndrc.gov.cn/fzgggz/jjyx/dzxqcgl/201011/t20101116_381342.html.

China National Development and Reform Commission. (2011). DSM Regulation Compliance Evaluation Scheme (Draft) No. 2407. 发改委关于印发《电网企业实施电力需求侧管理目标考核方案》的通知 （发改运行 [2011] 2407 ）. Beijing: NDRC. Retrieved from http://www.sdpc.gov.cn/zcfb/zcfbtz/2011tz/t20111208_449720.htm.

China National Development and Reform Commission. (2014). *Grid Company DSM Compliance Evaluation Working Manual* (2014, Draft) 电网企业实施电力需求侧管理目标责任考核工作手册（2014，试行）. Beijing: NDRC.

China National Development and Reform Commission. (2015a). Notice on Issuing T&D Pricing Cost Regulation Rule (Trial). (NDRC Pricing Department No. 1347). 国家发展改革委 国家能源局关于印发《输配电定价成本监审办法（试行）》的通知 (发改价格 [2015]1347) Retrieved from http://www.sdpc.gov.cn/zcfb/zcfbtz/201506/t20150619_696580.html.

China National Development and Reform Commission. (2015b). Official Approval of T&D Pricing Reform Plan of Western Inner Mongolia Grid. (NDRC Pricing Department No. 1344). 国家发展改革委关于内蒙古西部电网输配电价改革试点方案的批复 (发改价格〔2015〕1344号). Retrieved from http://www.sdpc.gov.cn/fzgggz/jggl/zcfg/201506/t20150615_696095.html.

China National Development and Reform Commission. (2015b). Notice on Accelerating T&D Pricing Reform. (NDRC Pricing Department No. 742). 国家发展改革委关于加快输配电价改革的通知(发改价格〔2015〕742号). Retrieved from http://jgs.ndrc.gov.cn/zcfg/201504/t20150416_688233.html.

China National Development and Reform Commission. (2015d). Notice on Approving Yunan Grid T&D Pricing Reform Plan. (NDRC Pricing Department No. 2260).国家发展改革委关于云南电网输配电价改革试点方案的批复(发改价格〔2015〕2260号). Retrieved from http://www.sdpc.gov.cn/fzgggz/jggl/zcfg/201510/t20151013_754492.html.

China National Development and Reform Commission. (2016a). Notice on Expanding T&D Pricing Pilot. (NDRC Pricing Department No. 498). 国家发展改革委关于扩大输配电价改革试点范围有关事项的通知(发改价格〔2016〕498号). Retrieved from http://www.ndrc.gov.cn/zcfb/zcfbtz/201603/t20160314_792666.html.

China National Development and Reform Commission. (2016c). Notice on Promoting T&D Pricing Reform. (NDRC Pricing Department No. 2018). 国家发展改革委关于全面推进输配电价改革试点有关事项的通知(发改价格〔2016〕2018号). Retrieved from http://www.ndrc.gov.cn/zcfb/zcfbtz/201611/t20161110_826066.html.

China National Development and Reform Commission. (2016c). *2015 Grid Companies DSM Compliance Evaluation Results.* (2016 No. 16 Notice). 2015年度电网企业实施电力需求侧管理目标责任完成情况 (2016年第16号公告). Retrieved from http://yxj.ndrc.gov.cn/dlxqgl/201608/t20160818_816103.html.

China National Development and Reform Commission. (2016d). Notice on Issuing Provincial Grid T&D Pricing Rule (Trial). (NDRC Pricing Department No. 2711). 国家发展改革委关于印发《省级电网输配电价定价方法（试行）》的通知(发改价格〔2016〕2711号). Retrieved from http://www.ndrc.gov.cn/zcfb/zcfbtz/201701/t20170104_834311.html.

Crossley, D. (2008). *Worldwide Survey of Network-Driven Demand-Side Management Projects. International Energy Agency Demand-Side Management Programme, Task XV Research Report No 1. Second Edition.* Hornsby Heights, NSW, Australia: Energy Futures Australia Pty Ltd. Retrieved from http://www.efa.com.au/Library/David/Published%20Reports/2008/IEADSMTaskXVResearchReport1_Secondedition.pdf.

Crossley, D. (2013a). *Effective Mechanisms to Increase the Use of Demand-Side Resources. Global Power Best Practice Series #3.* Montpelier, Vermont: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-crossley-effectivepoliciesfordsresources-final-24-jan-2013.pdf.

Crossley, D. (2013b). *ESCOs as a Delivery Mechanism for Grid Company DSM in China: Lessons From International Experience.* Beijing, China: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-crossley-escodeliveryofgridcompanydsminchina-stategridescowkshp-2013-may-16-encn.pdf.

Crossley, D. (2014a). *Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes.* Paper presented at the DSM University/Leonardo Energy Webinar. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rai-crossley-iea-dsm-university-best-practices-in-designing-and-implementing-eeo-schemes-2014-jun-25.pdf.

Crossley, D. (2014b). *Energy Efficiency As A Resource for the Power Sector in China.* Beijing, China: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-crossley-eeasaresourcechina-final-2014-aug-19.pdf.

Crossley, D., Gerhard, J., Kadoch, C., Lees, E., Pike-Biegunska, E., Sommer, A., & Watson, E. (2012). *Best Practices in Designing and Implementing Energy Efficiency Obligation Schemes.* Montpelier, VT: International Energy Agency Demand-Side Management Programme and The Regulatory Assistance Project. Task XXII Research Report. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-ieadsm-bestpracticesindesigningandimplementingenergyefficiencyobligationschemes-2012-may.pdf.

Crossley, D., & Wang, X. (2015). *Case Study: China's Grid Company Energy Efficiency Obligation.* Beijing, China: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-crossley-casestudychinagridcompanyeeo-2015-aug.pdf.

Crossley, D., Wang, X., & He, H. (2014). *China Opens the Door for New Utility Business Model and More Energy Efficiency.* Retrieved from http://www.raponline.org/featured-work/china-opens-the-door-for-new-utility-business-model-and-more-energy.

Dupuy, M., Allen, R., Crossley, D., Kahrl, F., Porter, K., Weston, F., & James, C. (2014). *Low-Carbon Power Sector Regulation: International Experience From Brazil, Europe, and the United States.* Beijing, China: The Regulatory Assistance Project and the World Bank. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-dupuy-lowcarbonpowersectorregulation-worldbank-2014-dec-01.pdf.

Dupuy, M., Crossley, D., Kahrl, F., & Porter, K. (2015). *Low-Carbon Power Sector Regulation: Options for China.* Beijing, China: The Regulatory Assistance Project and The World Bank Group. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-worldbank-lowcarbonpoweroptionsforchina.pdf.

Energy Saving Trust. (2001). *Energy Efficiency Commitment Report 2000–2001.* London: EST.

Frank, A. (2008). ESCOs and Utilities: Shaping the Future of the Energy Efficiency Business. *Greenbiz* (13 April 2008). Retrieved from https://www.greenbiz.com/news/2008/04/13/escos-and-utilities-shaping-future-energy-efficiency-business.

Institute for Electric Innovation. (2014). *State Electric Efficiency Regulatory Frameworks.* Washington, D.C.: IEI. Retrieved from http://www.edisonfoundation.net/iei/Documents/IEI_stateEEpolicyupdate_1214.pdf.

International Energy Agency. (2014). *Capturing the Multiple Benefits of Energy Efficiency.* Paris: IEA. Retrieved from http://www.iea.org/w/bookshop/475-Capturing_the_Multiple_Benefits_of_Energy_Efficiency.

Lazar, J., Weston, F., & Shirley, W. (2011). *Revenue Regulation and Decoupling: A Guide to Theory and Practice.* Montpelier, VT: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/wp-content/uploads/2016/05/rap-revenueregulation anddecoupling-2011-04.pdf.

Massachusetts Department of Public Utilities. (2008). Investigation by the Department of Public Utilities on Its Own Motion Into Rate Structures That Will Promote Efficient Deployment of Demand Resources. D.P.U. 07-50-A. Retrieved from http://web.mit.edu/cron/project/urban-sustainability/Old%20files%20from%20summer%202009/Ingrid/Urban%20Sustainability%20 Initiative.Data/2008-07-16-MA-DPU-07-50-A-decoupling.pdf.

Massachusetts Department of Public Utilities. (2010). Testimony of Ronald J. Amen on Behalf of Western Massachusetts Electric Company in D.P.U.10-70. Retrieved from http://nuwnotes1.nu.com/apps/wmeco/webcontent.nsf/AR/2010Rate_Vol3_Amen/$File/Volume%203%20-%20Testimony%20of%20Ronald%20J.%20Amen.pdf.

Massachusetts Department of Public Utilities. (2013). Western Massachusetts Electric Company. Revenue Decoupling Mechanism. M.D.P.U. No. 1050E. Retrieved from http://nuwnotes1.nu.com/apps/wmeco/webcontent.nsf/AR/RevenueDecouplingMechanism/$File/Revenue%20Decoupling%20Mechanism.pdf.

Migden-Ostrander, J., Watson, E., Lamont, D., & Sedano, R. (2014). *Decoupling Case Studies: Revenue Regulation Implementation in Six States.* Montpelier, VT: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/document/download/id/7209.

Musser, P. (2003). Utility-Affiliated ESCOs: Is the Honeymoon Over? *Transmission and Distribution World* (1 January 2003). Retrieved from http://tdworld.com/business/power_utilityaffiliated_escos_honeymoon/index.html.

Nadel, S., Cowart, R., Crossley, D., & Rosenow, J. (In preparation). *Energy Saving Obligations Across Three Continents: Contrasting Approaches and Results.* Paper presented at the ECEEE 2017 Summer Study on Energy Efficiency, Presqu'île de Giens, Hyères, France.

National Action Plan for Energy Efficiency. (2007). *Aligning Utility Incentives With Investment in Energy Efficiency.* Washington, D.C.: U.S. Environmental Protection Agency. Retrieved from http://www.epa.gov/cleanenergy/documents/suca/incentives.pdf.

National Renewable Energy Laboratory. (2009). *Decoupling Policies: Options to Encourage Energy Efficiency Policies for Utilities.* Golden, CA: NREL. Retrieved from http://www.nrel.gov/docs/fy10osti/46606.pdf.

Neme, C., & Grevatt, J. (2015). *Energy Efficiency as a T&D Resource.* Lexington, MA: Northeast Energy Efficiency Partnerships, Inc. Retrieved from http://www.neep.org/sites/default/files/products/EMV-Forum-Geo-Targeting_Final_2015-01-20.pdf.

Ofgem & Energy Saving Trust. (2003). *A Review of the Energy Efficiency Standards of Performance 1994¬–2003: A Joint Report by Ofgem and the Energy Saving Trust.* London: Ofgem and the Energy Saving Trust. Retrieved from https://www.ofgem.gov.uk/ofgem-publications/58653/4211-eesopreportjuly03.pdf.

Rosenstock, S.J., & Barrett, L.B. (1998). *Utility Affiliated ESCOs and the Market for Energy Services in the United States.* Paper presented at the ACEEE 1998 Summer Study on Energy Efficiency in Buildings, Pacific Grove, CA. Retrieved from: http://aceee.org/files/proceedings/1998/data/papers/0618.PDF.

State Grid Corporation of China. (2016a). *2015 Corporate Social Responsibility Report.* Retrieved from http://www.sgcc.com.cn/csr/images/reports/2016/02/22/C0F6696460C59686CFA54B9C11EFCB06.pdf.

The Regulatory Assistance Project. (1995). *IssuesLetter: System Benefits Charge.* Montpelier, VT: The Regulatory Assistance Project. Retrieved from http://www.raponline.org/knowledge-center/issuesletter-systems-benefit-charge/.

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Beijing, 100004

北京市朝阳区建国门外大街19号
国际大厦2504
100004

+86 10-8526-2241
china@raponline.org
raponline.org