

**THE FOLLOWING CONTENT IS TO BE AVAILABLE ONLINE ONLY**

## **A Appendix – Proof of the Sufficient Condition for**

$$D^d > D^r$$

Maximizing  $W$  given the traditionally regulated utility's incentive compatibility constraint

results in the following first order conditions:

$$\frac{\partial W^r}{\partial p}(1-\beta) + \lambda^r \left( \frac{\partial R(p^r, 0)}{\partial p}(1-\beta) - \frac{\partial R(p^r, D^r)}{\partial p} \right) = 0 \quad (1)$$

$$\frac{\partial W^r}{\partial p}(1-\beta) + \lambda^r \left( 1 - \frac{\partial R(p^r, D^r)}{\partial p} \right) = 0 \quad (2)$$

Combined, these conditions form the marginal rate of substitution:

$$\frac{\frac{\partial W^r}{\partial p}}{\frac{\partial W^r}{\partial D}} = \frac{\left( \frac{\partial R(p^r, 0)}{\partial p} - \frac{\partial R(p^r, D^r)}{\partial p} \right) (1-\beta) + \beta \frac{\partial R(p^r, D^r)}{\partial p}}{1 - \frac{\partial R(p^r, D^r)}{\partial D}} \quad (3)$$

Under Decoupling, the first order conditions are:

$$\frac{\partial W^d}{\partial p} - \lambda^d \beta \frac{\partial R(p^d, D^d)}{\partial p} = 0 \quad (4)$$

$$\frac{\partial W^d}{\partial D} - \lambda^d \left( 1 - \frac{\partial R(p^d, D^d)}{\partial D} \right) = 0 \quad (5)$$

The corresponding marginal rate of substitution is:

$$\frac{\frac{\partial W^d}{\partial p}}{\frac{\partial W^d}{\partial D}} = \frac{\beta \frac{\partial R(p^d, D^d)}{\partial p}}{\left(1 - \frac{\partial R(p^d, D^d)}{\partial D}\right)} \quad (6)$$

**Lemma 1**  $W(p^d, D^d) > W(p^r, D^r)$

**Proof.** Assume (Error: Reference source not found) is binding when evaluated at  $p^r, D^r$ .

Because  $\partial R / \partial D < 0$ , a direct comparison of (**Error: Reference source not found**)

and (**Error: Reference source not found**) shows that (**Error: Reference source**

**not found**) is not binding when evaluated at  $p^r, D^r$ . The regulator could decrease  $p$ ,

increase  $D$ , or both without violating incentive compatibility. Doing so would increase the

regulator's utility, as  $\partial W / \partial p < 0$  and  $\partial W / \partial D > 0$ . Thus, equilibrium prices and DSM

levels give the regulator greater utility under a decoupling setting. ■

Note that lemma 1 implies that either  $p^d < p^r, D^d > D^r$  or both.

**Theorem** A sufficient condition for  $D^d > D^r$  is

$$\frac{\partial^2 R(p, D)}{\partial p \partial D} < 0 \quad (7)$$

**Proof.** As shown above, either  $p^d < p^r, D^d > D^r$ , or both. Disproving the possibility that

$p^d < p^r$  and  $D^d \leq D^r$  proves that  $D^d > D^r$  .

Suppose both inequalities hold. Combining **(3)** and **(6)** under condition (7) implies:

$$\frac{\frac{\partial W^r}{\partial p}}{\frac{\partial W^r}{\partial D}} > \frac{\frac{\partial W^d}{\partial p}}{\frac{\partial W^d}{\partial D}} \quad (8)$$

but this violates the law of diminishing marginal rate of substitution. Thus, if  $p^d < p^r$  , then

$D^d > D^r$  . ■

## **B Appendix - Variable Descriptions**

**Electricity Consumption:** The natural logarithm of monthly residential electricity consumption per customer by utility and year was estimated using monthly data on electricity consumption and number of residential utility customers (Form EIA-826). Consumption is measured in megawatt hours (MWh).

**Utility DSM:** Form EIA-861 includes annual spending on DSM programs by utility in thousands of nominal U.S. dollars. The data encompass all utility-reported spending on energy efficiency and load management programs, including all indirect and administrative costs. Because data is frequently missing in EIA Form EIA-861, I supplemented the data set with data from regulatory documents, utility annual reports, and other primary sources. To the extent that there were still gaps in the data in EIA Form EIA-861, I imputed missing observations to minimize selection bias. See Section Error: Reference source not found and the online Appendix for a full explanation of imputations. A logarithmic functional form is used in this analysis. The logarithmic function was performed on  $1+(\text{Utility DSM})$  to include utilities with \$0 DSM expenditure in the analysis. Unfortunately, DSM spending is not broken down by sector in Form EIA-861 until 2010, so the DSM data used in this analysis encompasses spending in all sectors. Preliminary analysis suggests that DSM spending has a strong correlation with residential consumption and little correlation with non-residential consumption.

**Third-party DSM:** Data on utility payments to third-party DSM providers come from

regulatory documents, annual utility and third-party DSM provider summary reports, and other primary documents. Spending is in thousands of nominal U.S. dollars. A logarithmic functional form is used in this analysis. The logarithmic function was performed on  $1+(Utility\ DSM)$  to include utilities with \$0 DSM expenditure in the analysis.

**Decoupling:** The dummy decoupling variable is based on information from regulatory dockets, the ACEEE State Energy Efficiency Database, and publications by the National Resource Defense Council (NRDC), Edison Electric Institute (EEI), Innovation Electricity Efficiency (IEE), and Center for Climate and Energy Solutions (C2ES). In the monthly data set, this variable takes the value of one if the specified utility had any type of decoupling mechanism in place in the given month and year. In the annual data set, this variable assumes the value of one if the utility was decoupled for at least half of the months in that year.

**Number of Customers:** Monthly data on number of residential customers per utility are from Form EIA-826. The natural logarithm of number of customers is used in this analysis.

**Electricity Price:** Monthly average utility residential retail electricity prices were estimated using data on monthly residential sales (in Megawatt-hours) and monthly residential revenue (\$ thousands) by utility from Form EIA-826. Prices are in units of dollars per kilowatt hour (\$/kWh). For use in one robustness check, non-residential prices were calculated in the same manner using non-residential sales and revenue from Form

EIA-826.

**Natural Gas Price:** Monthly retail residential natural gas prices by state are from the EIA Natural Gas Prices Residential Price Data Series. Natural gas prices are in dollars per cubic feet.

**GDP:** Data on annual nominal GDP per capita by state are from the Bureau of Economic Analysis for the years 2001-2010. GDP is measured in thousands of nominal U.S. dollars. The natural logarithm of GDP was used in the analysis. Each annual value was used for all monthly observations in a given state and year.

**Quarterly Personal Income:** State quarterly personal income data in millions of nominal U.S. dollars are from the Bureau of Economic Analysis. This analysis employs the natural logarithm of personal income.

**Pop:** The natural logarithm of annual population was computed using annual state GDP and annual per-capita state GDP from the Bureau of Economic Analysis. Each annual value was used for all monthly observations in a given state and year.

**EERS:** A dummy variable for whether or not the state had an Energy Efficiency Resource Standard in place during the given month and year was generated based on data from ACEEE. Primary dockets were consulted when necessary.

**Environmental Sensitivity:** Annual environmental sensitivity ratings were calculated for each state and year based on scores from the League of Conservation Voters National Environmental Scorecards. The ratings equal the average League of Conservation Voters mean scores of the state politicians in the house and in the senate. The ratings are on a scale of 0 to 100 and are based on how the politicians vote on key environmental legislation.

**CDD and HDD:** Population-weighted monthly heating and cooling degree days by state were compiled from the National Weather Service Climate Prediction Center archived degree days statistics. Experiments with various climate indicators and functional forms of CDD and HDD suggest that the respective linear models best capture the relation between climate and per-capita energy consumption.

**% Generation from Oil/Coal/Gas:** Data on percentage of electricity generation by fuel and state come from EIA's database. This analysis employs 2005 data on percentage generation from oil, coal, and natural gas.

**US Oil/Gas/Coal Prices:** U.S. oil refiner prices, natural gas city gate prices, and U.S. coal prices were retrieved from the EIA's database. These series reflect the input prices faced by producers of electricity. Oil prices are in dollars per barrel, natural gas prices are in dollars per thousand cubic feet, and coal prices are in dollars per short ton. Oil and natural gas prices vary by month, but U.S. coal prices are annual.

**Time Dummies:** One hundred nineteen dummy variables were created for each month (2001- 2010), with January 2001 the excluded base month. Together, these variables capture all nationwide time and seasonal discrepancies.

**Utility Dummies:** Each utility in the U.S. has a unique identification number in Forms EIA-826 and EIA-861. These were used to create utility dummies. For multi-state utilities in this analysis, each utility-state combination was assigned a unique identifier.



## C Appendix – Decoupled Electric Utilities

Table 5: Utilities with Proposed or Implemented Full Decoupling Mechanisms

Utility	State	Case/Docket
Los Angeles Department of Water and Power	CA	N/A
Pacific Gas & Electric Co	CA	Decision 11-05-018
San Diego Gas & Electric Co	CA	Decision 08-07-046
Sierra Pacific Power Co / Liberty Utilities	CA	N/A
Southern California Edison Co	CA	Decision 12-11-051
Southern California Water Co / Bear Valley Electric	CA	Advice Letter 240-E; Decision No.09-10-028; Decision No. 10-03-016
United Illuminating Co	CT	Docket No. 08-07-04
Delmarva Power & Light	DE	Docket No. 04-414; Docket No. 09-276T
Hawaiian Electric Company	HI	Docket No. 2008-0274
Hawaiian Electric Light Company	HI	Docket No. 2008-0274
Maui Electric	HI	Docket No. 2008-0274
Idaho Power Company	ID	Case No. IPC-E-11-19
Potomac Electric Power Company (PEPCO)	MD	Case No. 9092
Delmarva Power & Light	MD	Case No. 9093
Baltimore Gas & Electric	MD	Letter Order No. 108069; Letter Order No. 108061
Southern Maryland Electric Cooperative (SMECO)	MD	N/A
Fitchburg Gas & Electric	MA	DPU 11-01
Western Massachusetts Electric	MA	DPU 10-70
Consumers Energy	MI	Case No. U-15645
Detroit Edison	MI	Case No. U-15768
Upper Peninsula Power	MI	Case No. U-15988
Central Hudson Gas & Electric	NY	Case No. 08-E-088
Niagara Mohawk Power Corp. (National Grid)	NY	Case No. 10-E-0050
New York State Electric & Gas	NY	Case No. 09-E-0715
Orange & Rockland Utilities	NY	Case No. 07-E-0949
Rochester Gas & Electric	NY	Case No. 09-E-0717
Consolidated Edison	NY	Case No. 07-E-0523
AEP Ohio (Ohio Power Company & Columbus Southern Power Company)	OH	Docket No. 11-0351-EL-AIR; Docket No. 11-0352-EL-AIR
Duke Energy Ohio	OH	Docket No. 11-3549-EL-SSO; Case 11-5905-EL-RDR
Portland General Electric	OR	Order No. 10-478
Puget Sound Energy	WA	Docket No. UE-121697
Wisconsin Public Service Co	WI	Docket No. 6690-UR-121

Table 6: Utilities with Proposed or Implemented Partial  
Decoupling Mechanisms

Utility	State	Case/Docket
Arizona Public Service	AZ	Docket No. E-01345A-11-0224, Decision No. 73183
Entergy Arkansas	AR	Docket No. 07-085-TF
Oklahoma Gas & Electric	AR	Docket No. 07-075-TF
Duke Energy Indiana	IN	Cause No. 43374
Indiana-Michigan Power	IN	Cause No. 43827
Northern Indiana Public Service	IN	Cause No. 43618
Southern Indiana Gas & Electric	IN	Cause No. 43938; Cause No. 43405
Kansas Gas & Electric	KS	Docket No. 10-WSEE-775-TAR
Westar Energy	KS	Docket No. 10-WSEE-775-TAR
Duke Energy Kentucky	KY	Case No. 95-321; Case No. 2004-00389
Louisville Gas & Electric Nov	KY	Case No. 93-150
Kentucky Power	KY	Case No. 95-427
Kentucky Utilities	KY	Case No. 2000-0459
Entergy New Orleans	LA	Resolution No. R-09-136
NSTAR Electric	MA	D.P.U. 90-335; D.P.U. 10-06
Massachusetts Electric	MA	D.P.U. 09-39
Unitil (Fitchburg Gas and Electric Light Company)	MA	D.P.U. 12-01A
National Grid (Massachusetts Electric Company and Nantucket Electric Company)	MA	D.P.U. 12-01A
Western Massachusetts Electric Company	MA	D.P.U. 12-01A
Northwestern Energy	MT	Docket No. D2004.6.90
Duke Energy Carolinas	NC	Docket No. E-7, Sub 831
Progress Energy Carolinas (Carolina Power & Light)	NC	Docket No. E-2, Sub 931
Virginia Electric Power	NC	Docket No. E-22, Sub 464
First Energy Ohio (Cleveland Electric Illuminating, Toledo Edison, Ohio Edison)	OH	Docket No. 08-935-EL-SSO
Dayton Power & Light	OH	Docket No. 08-1094-EL-SSO
Empire District Electric	OK	Cause No. 200900146
Oklahoma Gas & Electric	OK	Cause No. 200800059
Public Service of Oklahoma	OK	Cause No. PUD 200900196
Narragansett	RI	Docket No. 4206
Progress Energy Carolinas	SC	Docket No. 2008-251-E
Duke Energy Carolinas	SC	Docket No. 2009-226-E
South Carolina Gas & Electric	SC	Docket No. 2009-261-E
Central Vermont Public Service Corporation	VT	Docket No. 7336
Green Mountain Power	VT	Docket No. 7175
Montana-Dakota Utilities	WY	Docket No. 20003-108-EA-10
Cheyenne Light, Fuel, and Power	WY	Docket No. 20004-65-ET-06