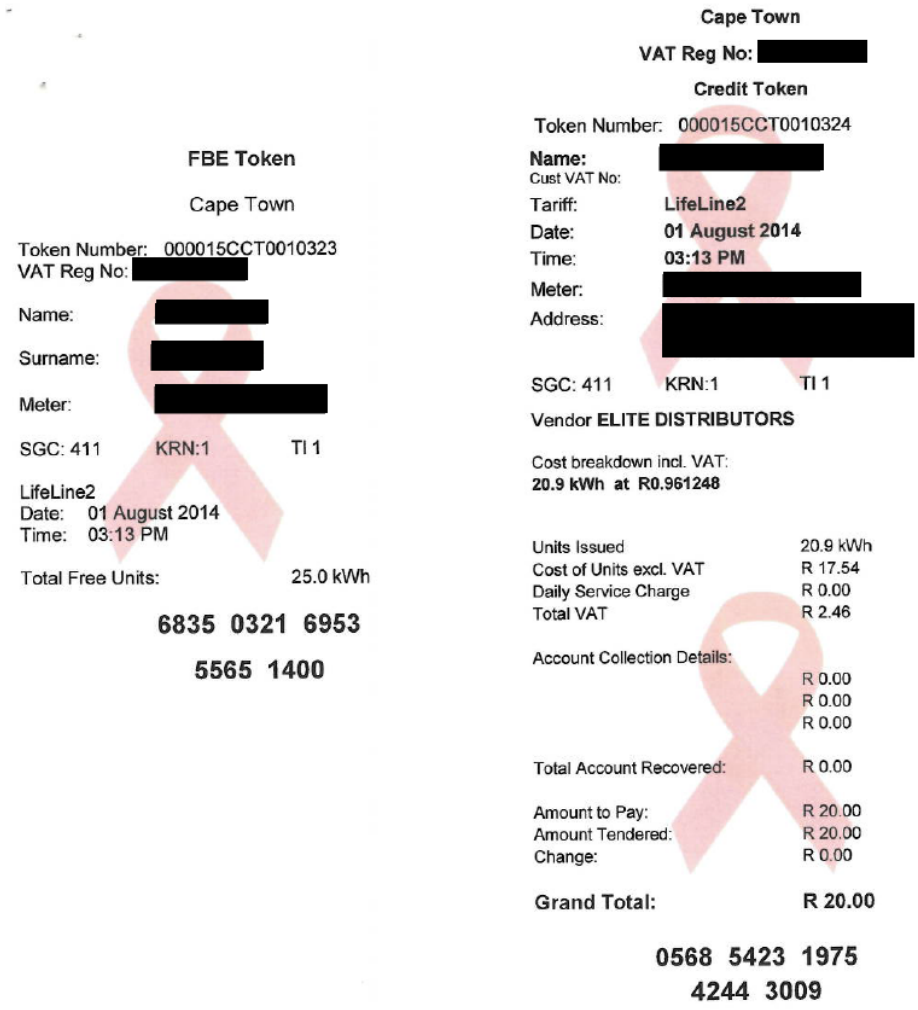
Appendix to *Charging ahead: Prepaid electricity metering in South Africa*



FBE Token

Cape Town

Token Number: 000015CCT0010323
VAT Reg No: [redacted]

Name: [redacted]

Surname: [redacted]

Meter: [redacted]

SGC: 411 KRN:1 TI 1

LifeLine2
Date: 01 August 2014
Time: 03:13 PM

Total Free Units: 25.0 kWh

6835 0321 6953

5565 1400

Cape Town

VAT Reg No: [redacted]

Credit Token

Token Number: 000015CCT0010324

Name: [redacted]
Cust VAT No:

Tariff: **LifeLine2**
Date: **01 August 2014**
Time: **03:13 PM**
Meter: [redacted]
Address: [redacted]

SGC: 411 KRN:1 TI 1

Vendor **ELITE DISTRIBUTORS**

Cost breakdown incl. VAT:
20.9 kWh at R0.961248

Units Issued	20.9 kWh
Cost of Units excl. VAT	R 17.54
Daily Service Charge	R 0.00
Total VAT	R 2.46
Account Collection Details:	
	R 0.00
	R 0.00
	R 0.00
Total Account Recovered:	R 0.00
Amount to Pay:	R 20.00
Amount Tendered:	R 20.00
Change:	R 0.00
Grand Total:	**R 20.00**

0568 5423 1975
4244 3009

Figure A.1: Prepaid electricity receipts - Lifeline customer

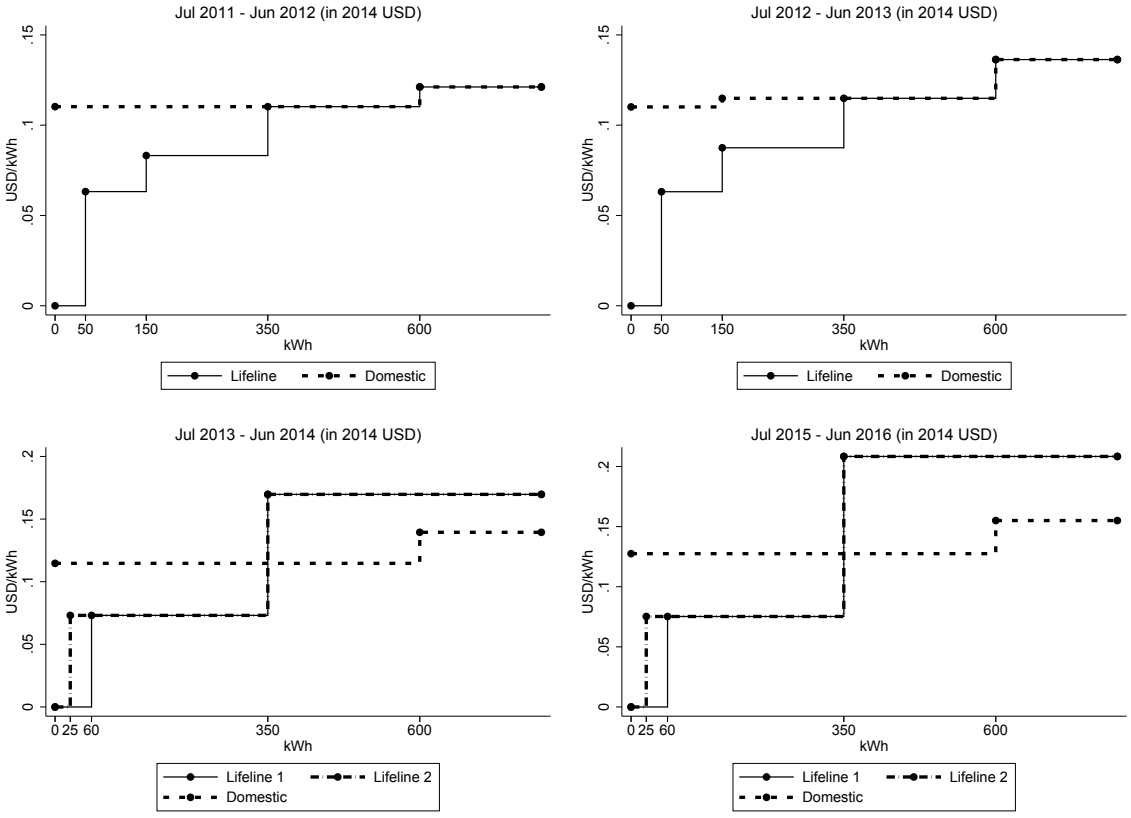
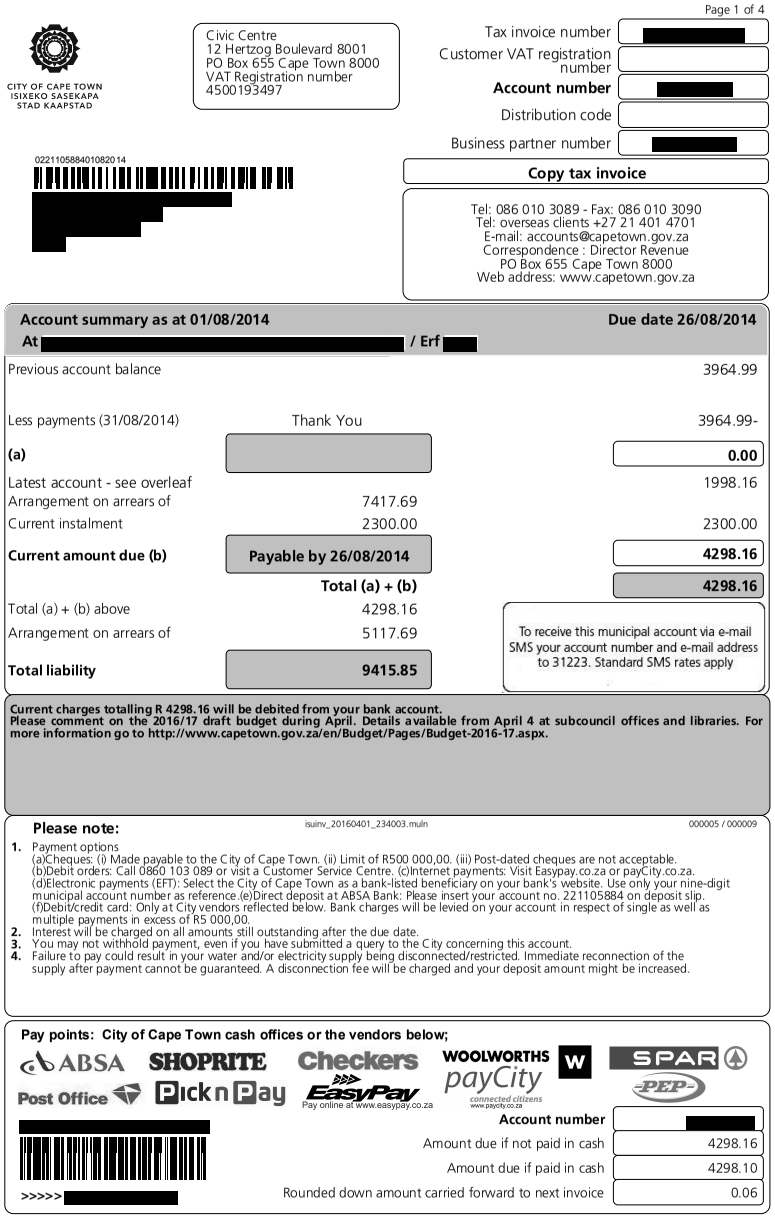


Figure A.2: Electricity tariffs



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CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Civic Centre
12 Hertzog Boulevard 8001
PO Box 655 Cape Town 8000
VAT Registration number
4500193497

Tax invoice number [redacted]
Customer VAT registration number
Account number [redacted]
Distribution code
Business partner number [redacted]

Copy tax invoice

Tel: 086 010 3089 - Fax: 086 010 3090
Tel: overseas clients +27 21 401 4701
E-mail: accounts@capetown.gov.za
Correspondence : Director Revenue
PO Box 655 Cape Town 8000
Web address: www.capetown.gov.za

02211058840108201 4 [redacted]

Account summary as at 01/08/2014 — **Due date 26/08/2014**
At [redacted] **/ Erf** [redacted]

Previous account balance		3964.99
Less payments (31/08/2014)	Thank You	3964.99-
(a)		**0.00**
Latest account - see overleaf		1998.16
Arrangement on arrears of	7417.69	
Current instalment	2300.00	2300.00
Current amount due (b)	**Payable by 26/08/2014**	**4298.16**
	Total (a) + (b)	**4298.16**
Total (a) + (b) above	4298.16	
Arrangement on arrears of	5117.69	
Total liability	**9415.85**	

To receive this municipal account via e-mail SMS your account number and e-mail address to 31223. Standard SMS rates apply

Current charges totalling R 4298.16 will be debited from your bank account.
Please comment on the 2016/17 draft budget during April. Details available from April 4 at subcouncil offices and libraries. For more information go to http://www.capetown.gov.za/en/Budget/Pages/Budget-2016-17.aspx.

isuinv_20160401_234003.muln 000005 / 000009

Please note:

1. Payment options
(a)Cheques: (i) Made payable to the City of Cape Town. (ii) Limit of R500 000,00. (iii) Post-dated cheques are not acceptable.
(b)Debit orders: Call 0860 103 089 or visit a Customer Service Centre. (c)Internet payments: Visit Easypay.co.za or payCity.co.za.
(d)Electronic payments (EFT): Select the City of Cape Town as a bank-listed beneficiary on your bank's website. Use only your nine-digit municipal account number as reference.(e)Direct deposit at ABSA Bank: Please insert your account no. 221105884 on deposit slip.
(f)Debit/credit card: Only at City vendors reflected below. Bank charges will be levied on your account in respect of single as well as multiple payments in excess of R5 000,00.
2. Interest will be charged on all amounts still outstanding after the due date.
3. You may not withhold payment, even if you have submitted a query to the City concerning this account.
4. Failure to pay could result in your water and/or electricity supply being disconnected/restricted. Immediate reconnection of the supply after payment cannot be guaranteed. A disconnection fee will be charged and your deposit amount might be increased.

Pay points: City of Cape Town cash offices or the vendors below;

ABSA SHOPRITE Checkers WOOLWORTHS payCity W SPAR PEP Post Office Pick n Pay EasyPay Pay online at www.easypay.co.za

[redacted]

Account number	[redacted]
Amount due if not paid in cash	4298.16
Amount due if paid in cash	4298.10
Rounded down amount carried forward to next invoice	0.06

>>>>> [redacted]

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Account details as at 01/08/2014 **Account number** [redacted] >>>>> [redacted]

PROPERTY RATES (Period 02/07/2014 to 01/08/2014) 31 Days
At [redacted]

	# Total value	
	From 02/07/2014 : R 1700000.00 @ 0.0062540 ÷ 365 x 31	902.97
	# Statutory rebate credit	
	From 02/07/2014 : R 15000.00 @ 0.0062540 ÷ 365 x 31	7.97-
	# Additional rebate credit	
	From 02/07/2014 : R 185000.00 @ 0.0062540 ÷ 365 x 31	98.26-
		796.74

ELECTRICITY (Period 27/05/2014 to 24/07/2014 - 59 Days) (Actual reading)
At [redacted]
Meter no: [redacted] **/ Consumption 1185.000 kWh / Daily average 20.085 kWh**

*	Consumption charge: domestic	
	(1) 172.6030 kWh @ R 1.2500 (2) 230.1370 kWh @ R 1.2500	
	(3) 287.6710 kWh @ R 1.2500 (4) 12.5551 kWh @ R 1.5200	882.09
*	Consumption charge: domestic	
	From 01/07/2014 : (1) 118.3560 kWh @ R 1.3476 (2) 157.8080 kWh @ R 1.3476	
	(3) 197.2610 kWh @ R 1.3476 (4) 8.6089 kWh @ R 1.6387	652.10
	Reversal of estimated consumption (537.123 kWh)	671.40-
		862.79

WATER (Period 28/06/2014 to 24/07/2014 - 27 Days) (Actual reading)
At [redacted]
Meter no: [redacted] **/ Consumption 11.000 kl / Daily average 0.407 kl**

*	Consumption charge (domestic)	
	From 28/06/2014 : (1) 0.5920 kl free (2) 0.4440 kl @ R 7.6000	
	(3) 0.1862 kl @ R 11.6100	
	From 01/07/2014 : (1) 4.7340 kl free (2) 3.5510 kl @ R 8.7500	
	(3) 1.4928 kl @ R 12.5400	55.32
		55.32

REFUSE (Period 02/07/2014 to 01/08/2014) 31 Days
At [redacted]

*	Refuse charge (1 X 140L RECYL X 1 Removals)	0.00
*	Refuse charge (1 X 240lBIN X 1 Removals)	95.96
		95.96

SEWERAGE (Period 28/06/2014 to 24/07/2014 - 27 Days) (Actual reading)
At [redacted]

*	Disposal charge	
	From 28/06/2014 : (1) 0.4140 kl free (2) 0.3110 kl @ R 7.2000	
	(3) 0.1306 kl @ R 13.5600	
	From 01/07/2014 : (1) 3.3140 kl free (2) 2.4850 kl @ R 8.2500	
	(3) 1.0454 kl @ R 14.6400	39.82
		39.82

Add 14% VAT on amounts marked with * above **147.53**
0% VAT on amounts marked with # above

Current account: Total due **1,998.16**

Meter details		Previous reading	New reading	Units used
ELECTRICITY	[redacted]	36191.000kWh(Actual)	37376.000kWh(Actual)	1185.000kWh
WATER	[redacted]	242.000kl(Actual)	253.000kl(Actual)	11.000kl

Figure A.3: Sample consolidated bill

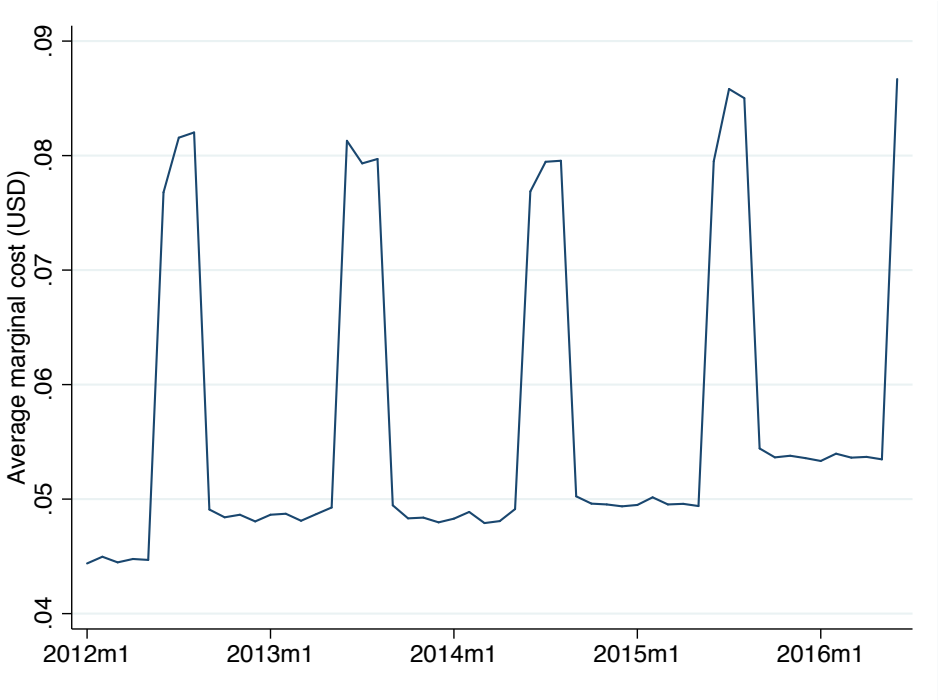

Figure A.4: City of Cape Town average marginal costs

Notes: Average marginal cost of electricity supply per month between 2012 and 2016, in USD2014.

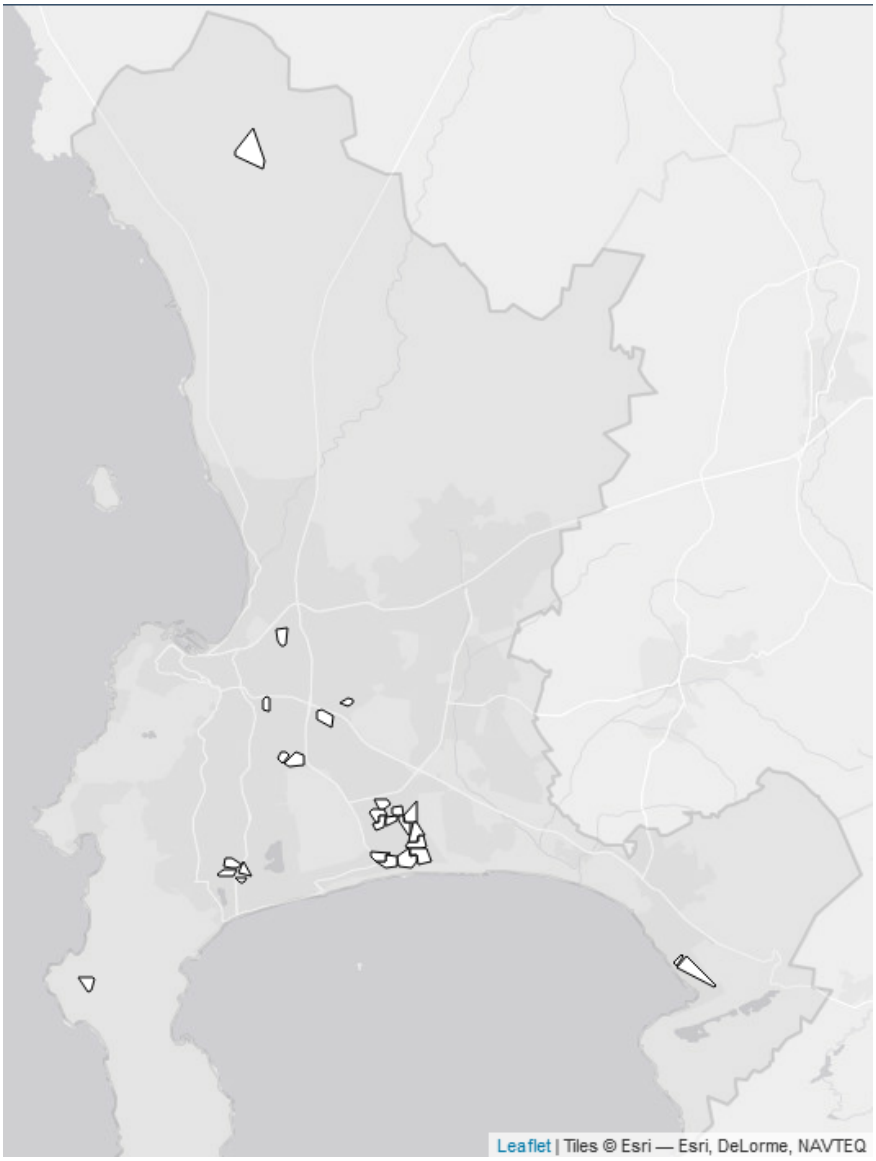

Figure A.5: Randomization groups

Notes: Map of Cape Town. The polygons correspond to the 27 randomization groups. The 13 groups that make up Mitchell's Plain are clustered in the lower center of the map. Each polygon contains between 150 and 200 customers.

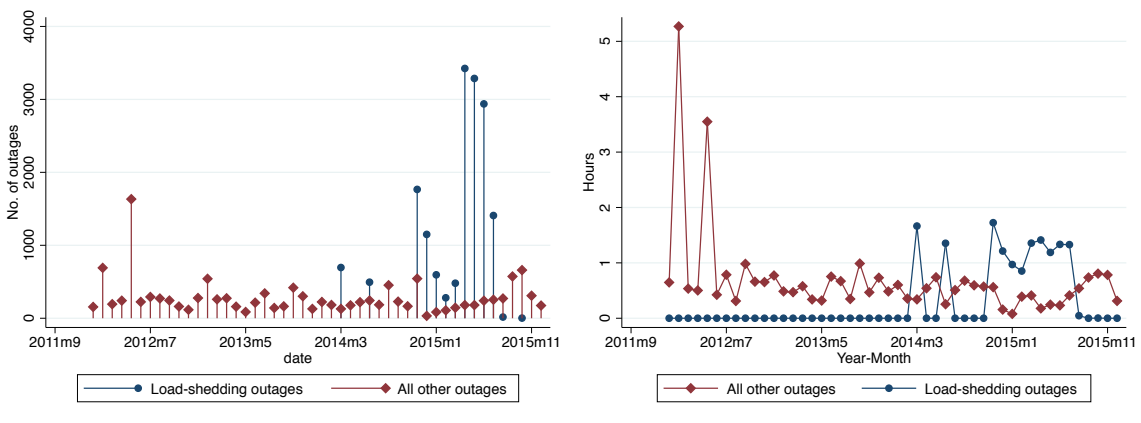

Figure A.6: Load-shedding events in Mitchell's Plain

Notes: Description of loadshedding events and other outages in Mitchells Plain. The left figure shows the total number of separate incidents per month and the right figure shows the total hours per month of each type of outage event.

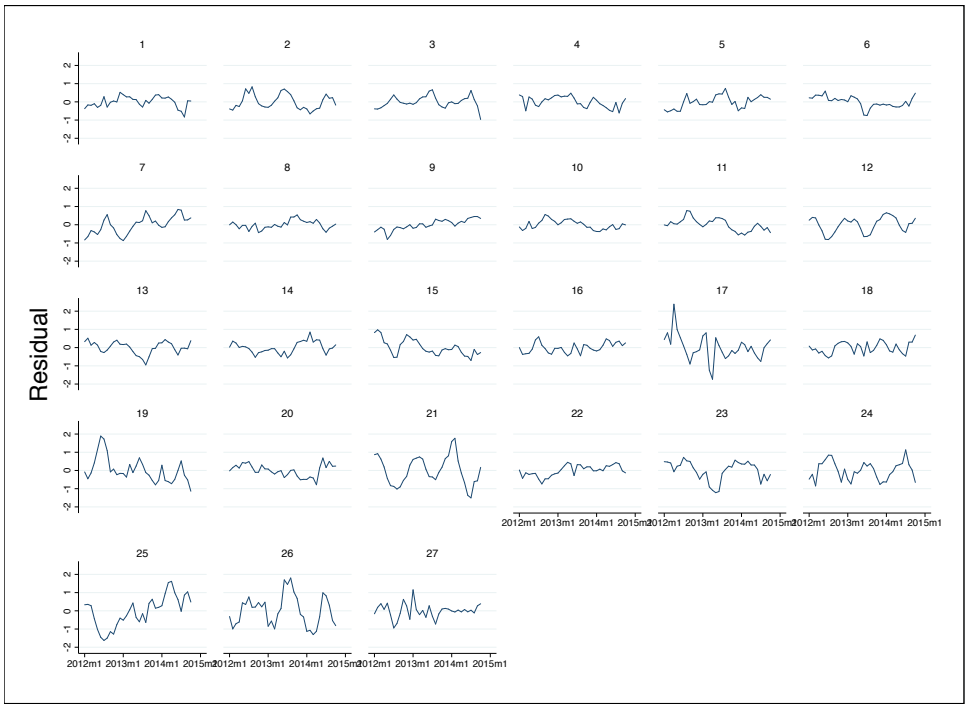

Figure A.7: Pre-program kWh residuals

Notes: Residuals from a regression of pre-program average daily kWh on customer and month-year fixed effects, by randomization group.

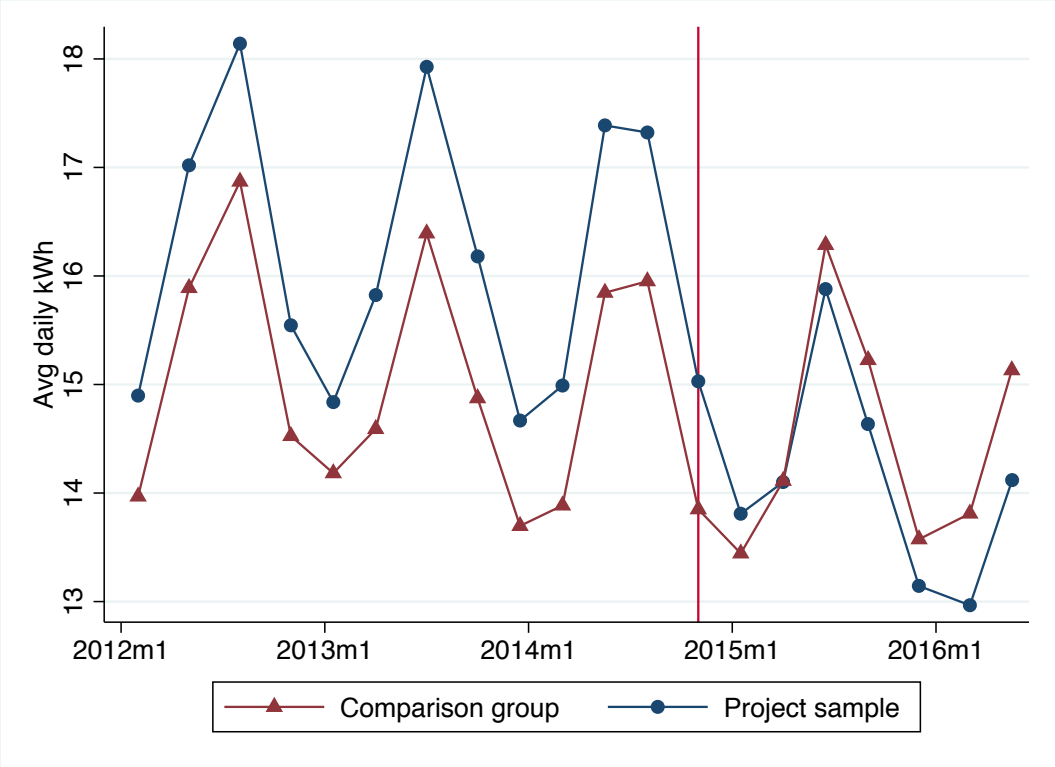

Figure A.8: Average daily kWh, project versus comparison customers

Notes: Monthly mean consumption for project and comparison customers. The comparison group is a sample of postpaid customers, matched on property value. The vertical line in late 2014 represents the start of the meter replacement program.

Table A.1: Balance

		Switch Date		
	Group	Assigned	Actual	Switched
Daily kWh	-0.058*	0.002	-0.002	0.514
	(0.032)	(0.005)	(0.003)	(0.315)
Lifeline tariff	0.007***	0.000	0.000	-0.041**
	(0.002)	(0.000)	(0.000)	(0.019)
Property value	-21.666	64.269***	16.454***	-3.9e+03***
	(55.855)	(8.242)	(4.537)	(540.824)

Notes: Correlations between program administrative variables and pre-program customer characteristics, at the customer level (N=4212). Column 3 is conditional on switching to a prepaid meter (N=3213).

Table A.2: Average daily kWh - Mitchells Plain only

	OLS		IV	
	(1)	(2)	(3)	(4)
		Panel A: Avg daily kWh		
Prepaid	-2.002***	-2.127***	-1.887***	-2.224***
	(0.126)	(0.198)	(0.117)	(0.383)
R^2	0.189	0.194	0.189	0.194
N	112,050	112,050	112,050	112,050
N customers	2,251	2,251	2,251	2,251
Fixed effects	month, year	month-year	month, year	month-year
		Panel B: Log avg daily kWh		
Prepaid	-0.117***	-0.132***	-0.106***	-0.159***
	(0.013)	(0.023)	(0.011)	(0.038)
R^2	0.108	0.112	0.108	0.111
N	111,725	111,725	111,725	111,725
N customers	2,251	2,251	2,251	2,251
Fixed effects	month, year	month-year	month, year	month-year

Notes: Consumption results for the Mitchells Plain sample only. Otherwise, details are as in Table 2.

Table A.3: Correlation between heterogeneity variables

	Lifeline	Low kWh	Low prop value	Usually late	Unpaid bills	Disconnected
Lifeline	1					
Low kWh	0.611***	1				
Low prop value	0.219***	0.222***	1			
Usually late	-0.114***	-0.141***	0.0203	1		
Unpaid bills	-0.00759	0.0201	0.0841***	0.307***	1	
Disconnected	-0.0709***	-0.0379*	-0.0401**	0.353***	0.299***	1

Notes: Pairwise correlations of variables used in the heterogeneity analysis, at the customer level. All characteristics are defined by the pre-project period as follows: Lifeline equals one for customers primarily on lifeline tariff, Low kWh equals one if the average daily kWh measure is below the median, Low prop value equals one for customers with a 2012 ZAR property value below 300,000, Outstanding debts equals one for customers with multiple unpaid bills at the end of the panel, Usually late equals one for customers who paid above the median share of their monthly bills past the due date. Disconnected equals one for customers that were ever disconnected on postpaid.

Table A.4: Robustness checks (average daily kWh)

	Base	Group IV	Mailing IV	DD Postpaid	DD Prepaid
	(1)	(2)	(3)	(4)	(5)
			Panel A: OLS		
Prepaid	-2.173***	–	–	-2.271***	-1.856***
	(0.137)			(0.117)	(0.087)
			Panel B: IV		
Prepaid	-1.889***	-1.746***	-1.781***	-2.325***	-1.718***
	(0.199)	(0.430)	(0.273)	(0.172)	(0.100)
N obs	207,930	207,929	207,929	271,137	2,004,004
N customers	4,246	4,245	4,245	5,452	38,248
Month-year FE	x	x	x	x	x

Notes: Robustness to alternative specifications. The base result (column 1) corresponds to columns 2 and 4 of Panel A in Table 2. Column 2 uses the group order as the instrument (equal to zero prior to the start of the program in November 2014). Column 3 uses the date of the mailing informing customers of the program as the instrument. Column 4 adds a comparison group of postpaid customers, not in the program (i.e. never switched), sampled based on property value. Column 5 adds a comparison group of prepaid customers in the project areas. See text for further details.

Table A.5: Robustness checks (average daily kWh)

	Base	Switchers only	No debt recovery	Trimmed	Smoothed	Balanced	Balanced
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Panel A: OLS			
Prepaid	-2.173***	-2.241***	-2.192***	-2.184***	-2.324***	-2.135***	-2.066***
	(0.137)	(0.165)	(0.139)	(0.112)	(0.132)	(0.140)	(0.149)
				Panel B: IV			
Prepaid	-1.889***	-2.143***	-1.905***	-2.158***	-1.987***	-1.724***	-2.025***
	(0.199)	(0.183)	(0.204)	(0.172)	(0.194)	(0.209)	(0.211)
N obs	207,930	160,083	204,828	203,738	207,052	209,075	170,678
N customers	4,246	3,252	4,245	4,234	4,246	4,246	3,213
Month-year FE	x	x	x	x	x	x	x

Notes: Robustness to sample and variable construction. The base result (column 1) corresponds to columns 2 and 4 of Panel A in Table 2. Column 2 only includes customers who switched meter types. Column 3 drops observations in which the prepaid meter is used to recover debts. Column 4 trims the top 1 percent of the outcome variable. Column 5 allows for a longer window over which bills or prepaid transactions are averaged. Column 6 balances the panel for all customers, replacing missing outcomes with zeros. Column 7 balances the panel by excluding customers with more than four missing months of data.

Table A.6: Robustness checks (average daily kWh)

	Base	Load-shedding	Tariff error	Placebo test
	(1)	(2)	(3)	(4)
		Panel A: OLS		
Prepaid	-2.173***	-2.200***	-2.490***	-0.153
	(0.137)	(0.138)	(0.147)	(0.121)
		Panel B: IV		
Prepaid	-1.889***	-1.886***	-1.626***	0.213
	(0.199)	(0.199)	(0.220)	(0.193)
N obs	207,929	185,761	162,706	153,748
N customers	4,245	4,243	3,316	4,213
Month-year FE	x	x	x	x

Notes: Robustness to program implementation issues. The base result (column 1) corresponds to columns 2 and 4 of Panel A in Table 2. Column 2 controls for the average daily hours of regular and load-shedding outages in the month and is restricted to the Mitchell's Plain sample of customers. Column 3 drops customers with tariff mistakes. Column 4 implements a placebo check that moves the assigned switch date and actual switch date ahead by one year.

Table A.7: Heterogeneity in returns to prepaid metering

	Average returns Postpaid	Relative returns Pre / Post
Domestic	22	1.11
		(0.01)
Lifeline	2	1.41
		(0.37)
Above median kWh	27	1.05
		(0.02)
Below median kWh	4	1.61
		(0.10)
High prop value	23	1.03
		(0.02)
Low prop value	13	1.18
		(0.03)
Usually on time	17	0.93
		(0.01)
Usually late	16	1.29
		(0.04)
No debts	20	0.90
		(0.01)
Outstanding debts	6	3.59
		(0.47)
Never disconnected	18	0.98
		(0.01)
Outstanding debts	11	1.93
		(0.14)

Notes: Returns to prepaid metering relative to postpaid metering, by customer characteristic. See Figure 6 for further detail.

Appendix: Data and variables description

This appendix details the data sources and how they are combined, and a detailed description of the variables used in the analysis.

A.0.1 Data sources and dataset construction

Billing records The City of Cape Town maintains billing records for any property served or taxed by the municipality. As discussed in the main text, most households receive a consolidated bill for all taxes and services every 25-35 days, with billing dates that vary across customers. We create a billing panel that sequences bills by meter reading date. The resulting panel contains both overlapping billing periods and gaps between billing periods. Overlapping billing periods are most commonly due to estimated meter readings (10.3 percent of bills in the raw data).[26] Once an actual reading is collected, the estimated readings are reversed and the customer is billed for the difference between the estimated and actual readings during the estimated months. Actual readings are used to replace estimated readings in the data, by assigning the actual consumption estimated billing periods assuming equal consumption on each estimated day. Gaps between bills are less common (2.1 percent of bills in the raw data). Gaps and bills with zero recorded consumption are dealt with similarly in the cleaning process. We allow for two alternative assumptions: (1) average over gaps of up to 30 days (including gaps associated with zero consumption bills), working backward from the date of the next non-missing (non-zero) bill, or (2) average over gaps of up to 365 days using the same process. (1) is our main outcome measure, and (2) is used in a robustness check. All gaps longer than 365 days are dropped (N=102).

Prepaid vending records The prepaid vending system records each transaction and the meter with which it is associated. The meters themselves do not communicate with the grid, and as a result, we do not observe prepaid meter consumption directly. To construct monthly outcome measures comparable to those obtained through the billing records, we assume that electricity is consumed at a constant rate between purchases and that customers maintain a steady minimum balance (which may be zero) over time, i.e. there is no accumulation of prepaid credit on the meter.

[26] Estimates are taken when a customer's meter cannot be read, which usually occurs because it cannot physically be accessed. Consumption is instead estimated based on past consumption patterns observed for that customer. At most, three consecutive estimated readings are permitted by the system before an actual reading is obtained and used to "reverse" the estimated readings.

Customers purchase electricity frequently: the median frequency is every 3.3 days. Out of over 50,000 customer-month observations on prepaid metering, only 270 months are associated with no prepaid purchases, corresponding to 147 unique accounts. Consequently, any more sophisticated latent demand model would only affect the assumed within-month variation in demand, which we cannot observe on either the prepaid or postpaid system. We impose analogous averaging assumptions to what is described above for the billing panel to address gaps between prepaid purchases of over a month. We allow for two alternative assumptions: (1) average over gaps of up to 30 days, working forward from the last observed purchase (i.e. assume entire transaction is consumed within 30 days), or (2) average over gaps of up to 365 days using the same process. Gaps of longer than 365 days are dropped. (1) is our main outcome measure, and (2) is used in robustness checks.

Project data The contractor maintained records of attempted and completed meter installations, which we use to match postpaid and prepaid meters. Contractor records also include the date of meter installation, the meter serial number and the date that households received maildrops informing them of the project.

Sample construction and randomization used lists of targeted accounts provided by the Department of Electricity. We include all accounts that were on the lists in our analysis, with the following exceptions. First, non-domestic customers are dropped. Second, customers with 3-phase electricity meters were dropped. The contractor did not replace this type of meter. Finally, 13 meters in the randomization file that did not receive any bills between January 2012 and November 2014 and were not in the contractor installation logs were dropped from the sample.

A.0.2 Variables

- Average daily kWh: We construct an average daily kWh variable at the customer-month level. As described above, our main variable averages over up to 30 days prior to the most recent meter reading or since the most recent prepaid purchase in the case of months with no data. As a robustness check, we allow for a longer averaging window, of up to one year. We also use the total kWh consumed in the month in our benefit-cost analysis. We construct a binary indicator for above median kWh based on the customer's average consumption prior to November 2014.

- Amount owed: We apply the customer's tariff to the constructed consumption measure,

calculating the kWh on each tariff block and the marginal price. This results in an amount owed associated with the calendar month of consumption.

- Days to pay: We construct a variable that describes the number of days between when a customer consumes electricity and when he or she pays for that electricity. For prepaid observations, this is calculated as half of the average number of days between transactions, consistent with the assumption of a constant rate of consumption between transactions. For postpaid observations, we take the amount owed on the first bill in the panel and use that as the starting balance that must be cleared. A bill is cleared when cumulative payments catch up with the cumulative amount owed. For customers that receive a consolidated bill, accounting is similar, though debts must also be cleared before a payment is allocated toward electricity.[27] The days to pay is transformed into a months to pay variable for the benefit cost analysis. We also use this variable to construct late payment measures, which equal one if the bill was paid off after its due date. A customer is categorized as usually late if over 58 percent (the median share) of bills before November 2014 are paid late.

- Average marginal cost: We obtain records of the average marginal cost paid each month by the City of Cape Town to Eskom. This is calculated based on the time of consumption for all residential and commercial customers in the City.

- Non-payment: For bills that are not cleared by the end of the panel, we construct a payment probability variable based on observed payment probabilities associated with debts of different ages in a longer panel for the same sample. This payment probability is set to zero for debts older than 3 years, as per South Africa's Municipal Systems Act (i.e. debts older than 3 years are written off). For payments that we do not observe, we set the revenue measure in our benefit cost analysis equal to the amount owed times the payment probability. We use the customer's average time to pay to replace unobserved days to pay. We construct a measure of outstanding debts that equals one if the customer has multiple unpaid bills at the end of the panel.

- Disconnections: Customers are charged for disconnections and reconnections associated with enforcing payment. We record the cost of a disconnection in the month that it

[27] The City of Cape Town assigns payments against the consolidated bill to debt first, followed by electricity, then other services. We therefore assume that the electricity amount owed is cleared once cumulative payments catch up with the cumulative amount owed from past bills plus the current owed for electricity only.

shows up on the customer's bill. The disconnection costs to the City are factored into the benefit cost analysis. We construct an indicator for whether the customer received any disconnections on their postpaid meter.

- Property value: We use the City of Cape Town's 2012 general valuation of properties, which is the basis for property taxes, along with a geographic identifier to match property values to electricity meters. Our binary measure of low property value uses a threshold of 300,000 ZAR, which is the cutoff for several social programs in the City. We assume low values for flats and for a small number of parcels with missing data.

- Administrative cost records: Other details included in the benefit cost analysis were obtained from the City of Cape Town through personal communication with the Electricity Department. These include the rate of technical and non-technical losses, and the cost of preparing bills and reading meters.