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ERRA Tailor-made Training Course:
Principles of Tariff Regulation
Implemented for:
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ERRA
ENERGY REGULATORS REGIONAL ASSOCIATION

Principles of cost recovery: electricity tariff design

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ECA

Contents

A. Key principles of retail tariff design
B. Trading off cost-reflectiveness and other objectives
C. Calculating the marginal costs of supply
D. Case studies
E. Tariff design exercises

Tariff objectives

First-order requirements

- **Cost-recovery**: Prices recover total costs (after any subsidies)
- **Cost-reflectiveness**: Prices are equal to marginal costs

Important for tariff design

Second-order requirements

- **Transparency**: Prices are calculated using published methodologies
- **Simplicity**: Prices are calculated in an easily understandable way
- **Stability**: Prices are predictable, to allow planning by suppliers and consumers
- **Fairness**: Prices treat all consumers equitably and in a non-discriminatory way

These inevitably come into conflict with each other

Tariff level and structure

Electricity tariffs have two main aspects.

- **Tariff level** – The average tariff across all customers (often quoted in terms of USc/kWh)

- **Tariff structure** – How different customer categories are charged (eg, fixed monthly charge in $ plus volumetric charge in c/kWh).
- The tariff structure defines the relative charges between customer categories and whether some categories subsidise others.

The tariff level is scaled to ensure overall revenue requirements are met (called 'allowed revenues' by energy regulatory agencies)

For economic efficiency, tariff structures should reflect the marginal costs imposed on the system by each category of consumer.

Elements of tariff design

Tariff categories

How to group customers?

General tariff structure

How to charge customers?

Relative levels of tariffs

What should be the relative level of tariffs determined in the general tariff structure?

Why is cost-reflectiveness important?

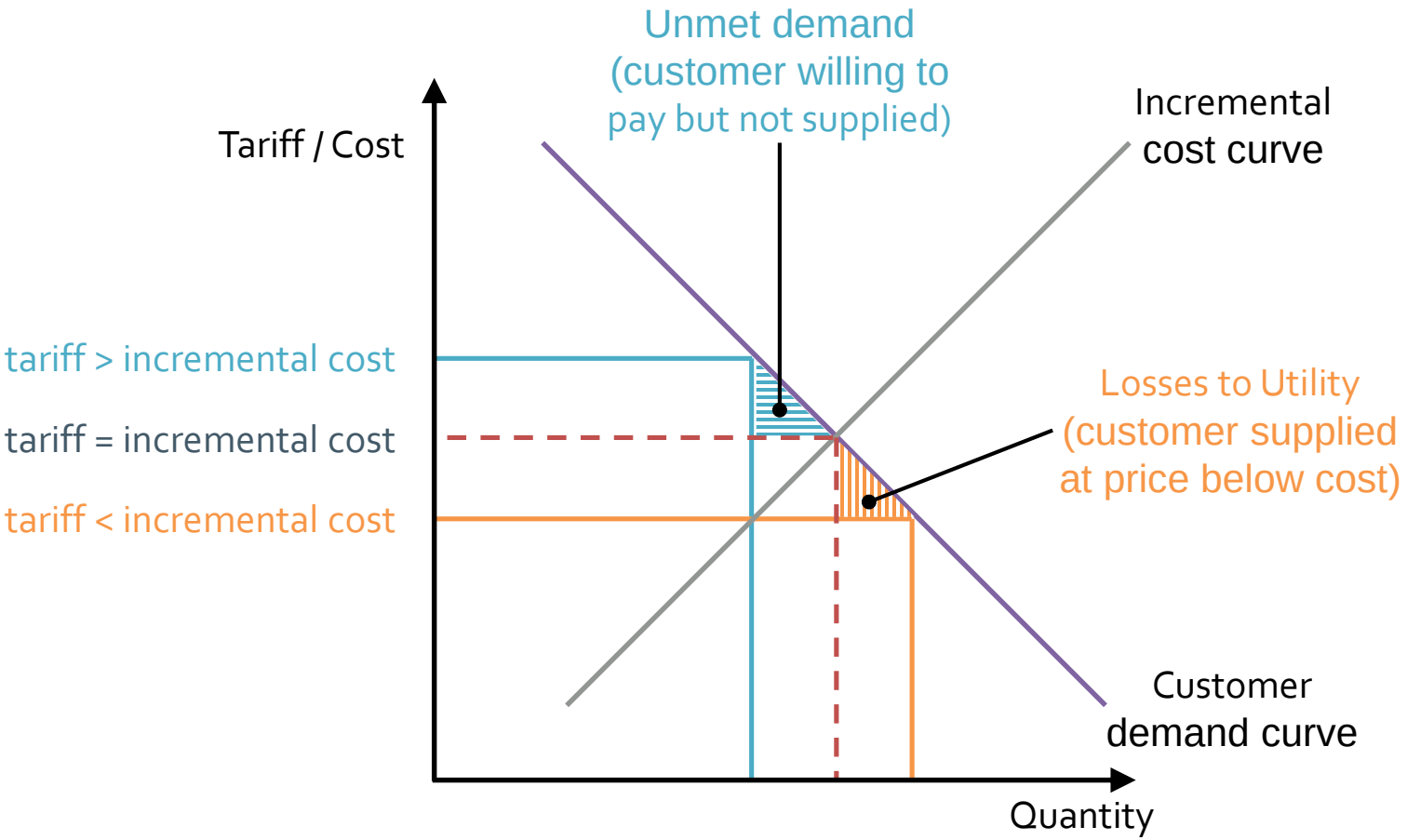
Price < Marginal Cost

- It costs the supplier more to provide one more unit than the customer pays for that additional unit
- As a result, the supplier is losing money for each additional sale

Price > Marginal Cost

- The customer has to pay more for an additional unit than it costs the supplier to provide that additional unit
- As a result, consumption is lower than the efficient level (customers who would be willing to pay the marginal cost are not supplied)

Cost reflectiveness visualised



Accepted economic approach to tariff design

Tariff provides a signal to the consumer to **use electricity efficiently**

- Economists treat existing electricity sector assets as sunk costs

Approach to designing electricity tariffs is **forward-looking** (to meet future demand):

- What are the capital and O&M costs for an efficiently run system going forward?
- What marginal costs are incurred at each voltage level and for each customer category?
- Need to consider long-term growth in electricity demand and system development

The 'cost of service' calculations should be **underpinned by an Electricity Masterplan**

- This is normally conducted using some power sector planning software such as WASP or PLEXOS

Grouping customers by tariff categories

Customers with similar load profiles

- Similar load characteristics
- Coincidence load factor, Load factor, Diversity factor, etc.

Customers with similar costs of electricity supply

- LV network usage?
- MV network usage?
- HV network usage?
- Other

Special categories

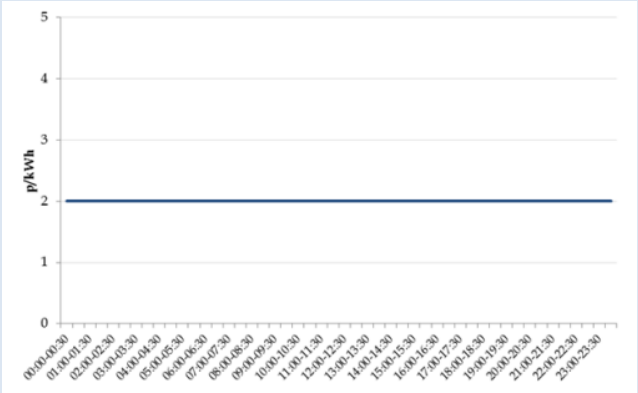
- Subsidised customers
- Interruptible supply, etc.

Tariff structure

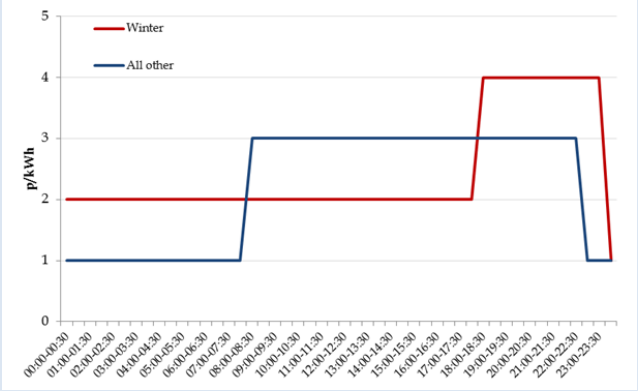
Choose general structure of tariffs

- Time-of-use (seasonal, time-of-day)
- Block tariffs
- Demand charges, kWh charges
- Fixed charges
- Reactive power charge
- Standing charge
- Minimum charge
- Combinations

Example of fixed volumetric charge



Example of time-of-day charge



Basic principles for tariff structures

Ideally, tariff structures should reflect the drivers of costs. In practice, tariffs will deviate from this ideal structure for many reasons including issues of acceptability, simplicity and cost of metering relative to the benefits achieved from more complex tariff structures.

Capacity charges ($/kW)	• Used to recover generation and network capacity costs. Should be based on demand (kW) at time of system peak, as this is the driver of investment needs.
Seasonal and Time-of-Day (STOD) energy charges ($/kWh)	• Used to recover the variable costs of additional electricity supply in each interval.
Fixed or standing charges ($/customer)	• Used to recover the costs of customer related activities such as metering, billing and collections which do not vary with customer demand or consumption.
Reactive power charges ($/kVArh)	• Used to provide incentives for customers to improve their power factor and, therefore, reduce the costs of supplying them.

Relative levels of tariffs

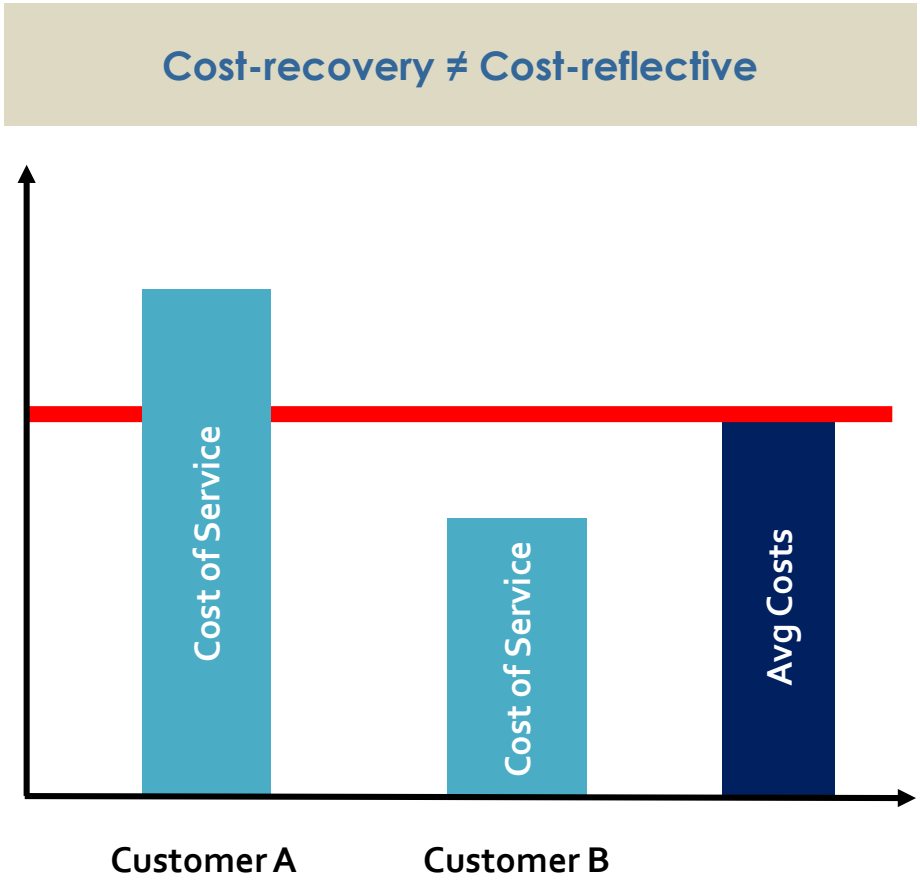
Determined by the marginal costs of supply of each customer

- Time of use is the key tariff design factor
  - Costs by time of use
  - Customer profiles (time pattern of demand)
  - Combine the two sets of information

Cost-recovery tariffs vs cost-reflective tariffs

Cost-recovery tariffs – The revenues fully recover efficient costs. Such revenues area referred to as 'required revenues' or 'allowed revenues'.

Cost-reflective tariffs – Tariffs that equal the cost of supplying electricity at different voltages, and at different times of the day and different seasons of the year.



Balancing cost-recovery and cost-reflectiveness

The cost-recovery problem

- Cost-reflective pricing requires that Price = Marginal Cost
- Cost-recovering pricing requires that Price = Average Cost
- However, Average Cost ≠ Marginal Cost
  - Fixed costs do not change with volumes
  - Average costs and marginal costs are only equal if there are no fixed costs

The 'standard' approach to resolving this problem

1. Calculate marginal costs
2. Determine cost-reflective prices (prices = marginal costs)
3. Adjust these prices to recover total costs (average price = average cost)

Options for recovering differences between average and marginal costs

Scale cost-reflective prices uniformly

- For example, multiply all cost-reflective prices by X%
- Results in fairer but more inefficient prices

Allocate cost differences (i.e. fixed costs) to peak periods only

- Assumes that fixed costs are driven by the need to provide capacity to meet peak demand
- May exaggerate existing signals built into cost-reflective prices

Mark-up prices in inverse proportion to price elasticity of demand

- Minimises changes in consumption relative to cost-reflective prices
- Tends to allocate fixed costs to households and small customers

Alternative ways to recover cost differences

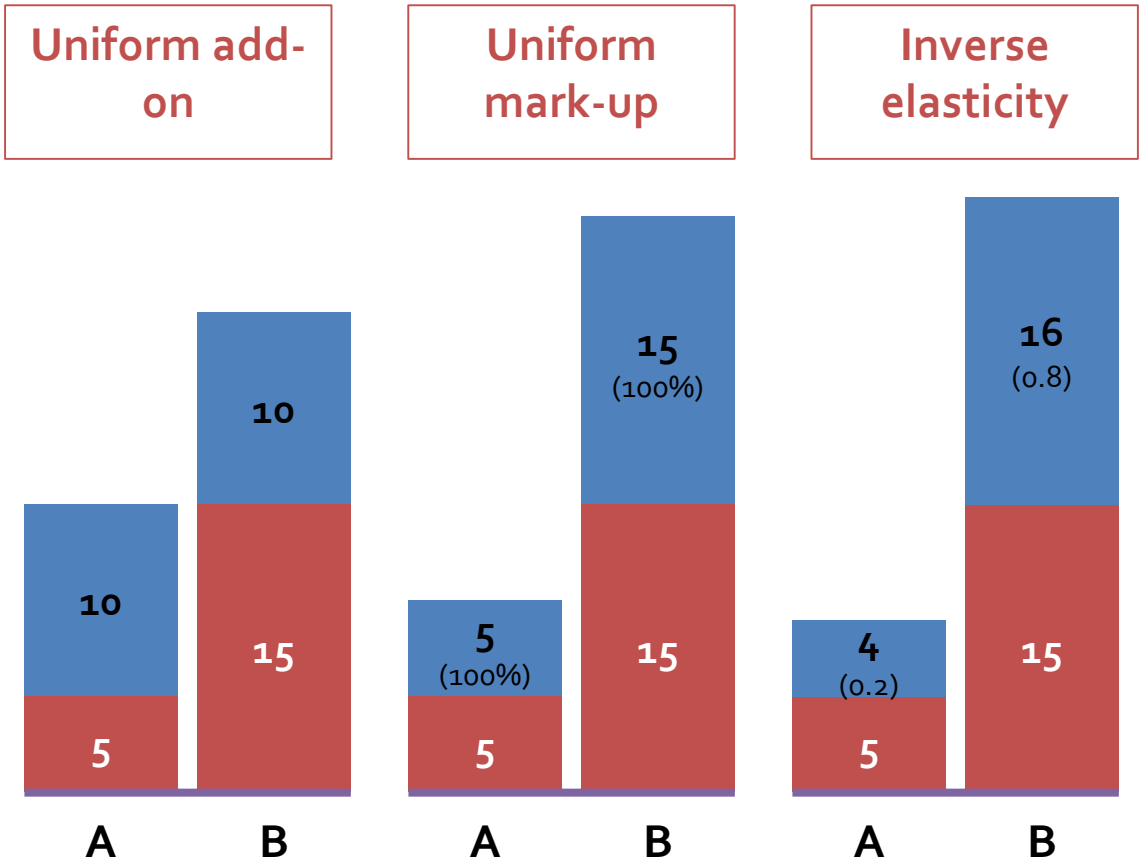
Customer A

- 50% of sales
- Marginal cost = 5
- Price elasticity = -0.8

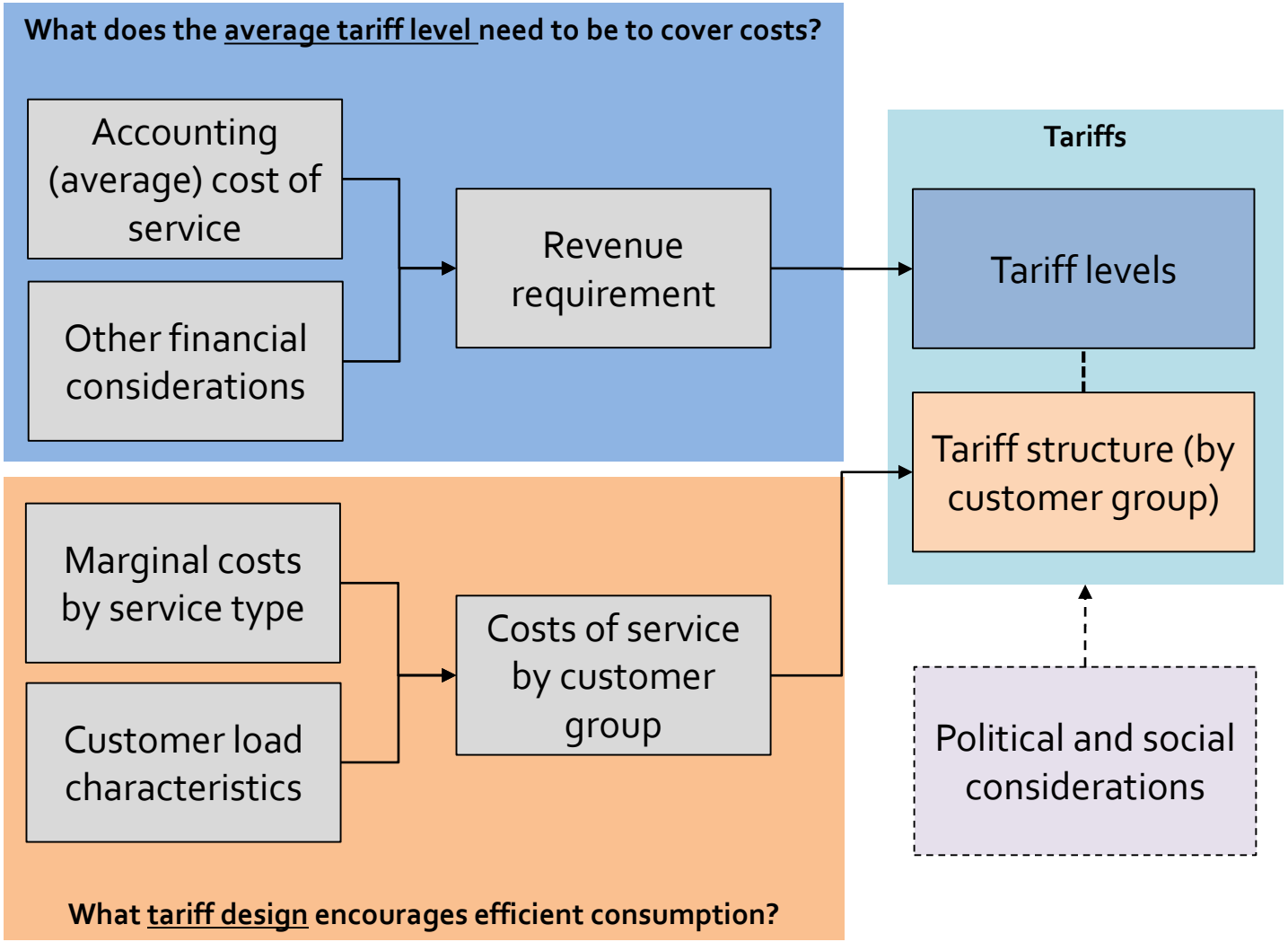
Customer B

- 50% of sales
- Marginal cost = 15
- Price elasticity = -0.2

Fixed costs to be recovered = 20



Setting tariff levels and design visualised



End result of tariff design

Tariff array with tariff categories, type of charges and relative level of charges which reflect the cost of supply

- Customers with similar load profiles and costs to serve are **grouped together**
- General tariff structure is set to **reflect drivers of costs** and issues of acceptability, simplicity and cost of metering
- Relative tariff levels are **based on long run marginal costs** of energy and capacity by customer class.

Tariff array

General tariff structure with relative levels reflecting the marginal costs of supply)

Tariff category		Fixed charge	Energy charge				Capacity charge	Demand charge
			Single rate	ToU				
				Peak	Shoulder	Off-peak		
		MK/ customer/ month	*MK/kWh*	*MK/kWh*	*MK/kWh*	*MK/kWh*	*MK/kVA/month*	*MK/kVA/month*
ET1	Domestic 1-Phase (Prepaid)	-	96.0	-	-	-	-	-
ET2	Domestic 1-Phase (Postpaid)	674	92.3	-	-	-	-	-
ET3	Domestic 3-Phase (Prepaid)	-	82.7	-	-	-	-	-
ET4	Domestic 3-Phase (Postpaid)	674	79.0	-	-	-	-	-
ET5	General 1-Phase (Prepaid)	-	63.3	-	-	-	-	-
ET6	General 1-Phase (Postpaid)	1,349	60.0	-	-	-	-	-
ET7	General 3-Phase (Prepaid)	-	63.3	-	-	-	-	-
ET8	General 3-Phase (Postpaid)	1,349	60.0	-	-	-	-	-
ET9	MD Industrial (400V)	2,697	-	37.2	20.1	10.7	10,263	21,140
ET10	MD Industrial (11kV, 33kV)	6,743	-	33.5	18.7	10.0	8,362	9,473
ET11	Public 3-Phase (Prepaid)	-	58.9	-	-	-	-	-

Tariff categories

Balancing cost-reflectiveness and affordability

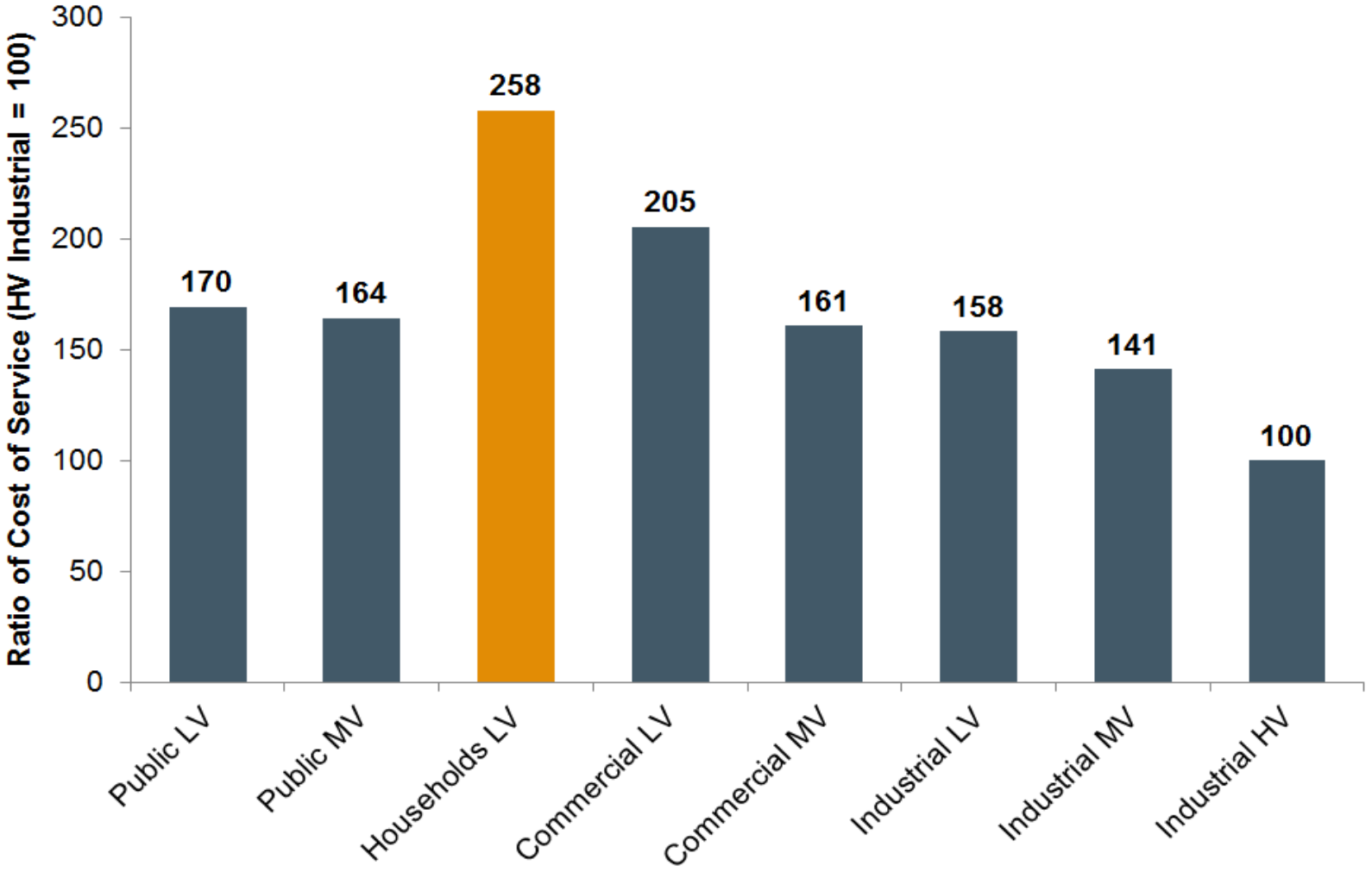
Households generally have the highest costs of supply

- Allocated fixed costs are spread over smaller volumes, resulting in higher unit costs
- Supply is generally at lower voltages, requiring more infrastructure and with higher transportation losses
- Demand is concentrated in peak hours, meaning higher marginal costs and potentially a higher allocation of fixed costs

Ensuring affordability may require compromising cost-reflectiveness

- Lowering tariffs to some or all households implies setting prices below the full costs of supply
- In turn, this means another customer must be paying more than the cost of supply or the utility must be receiving subsidies

Example: relative costs of supply in Indonesia



Balancing cost-reflectiveness and transparency / simplicity / predictability

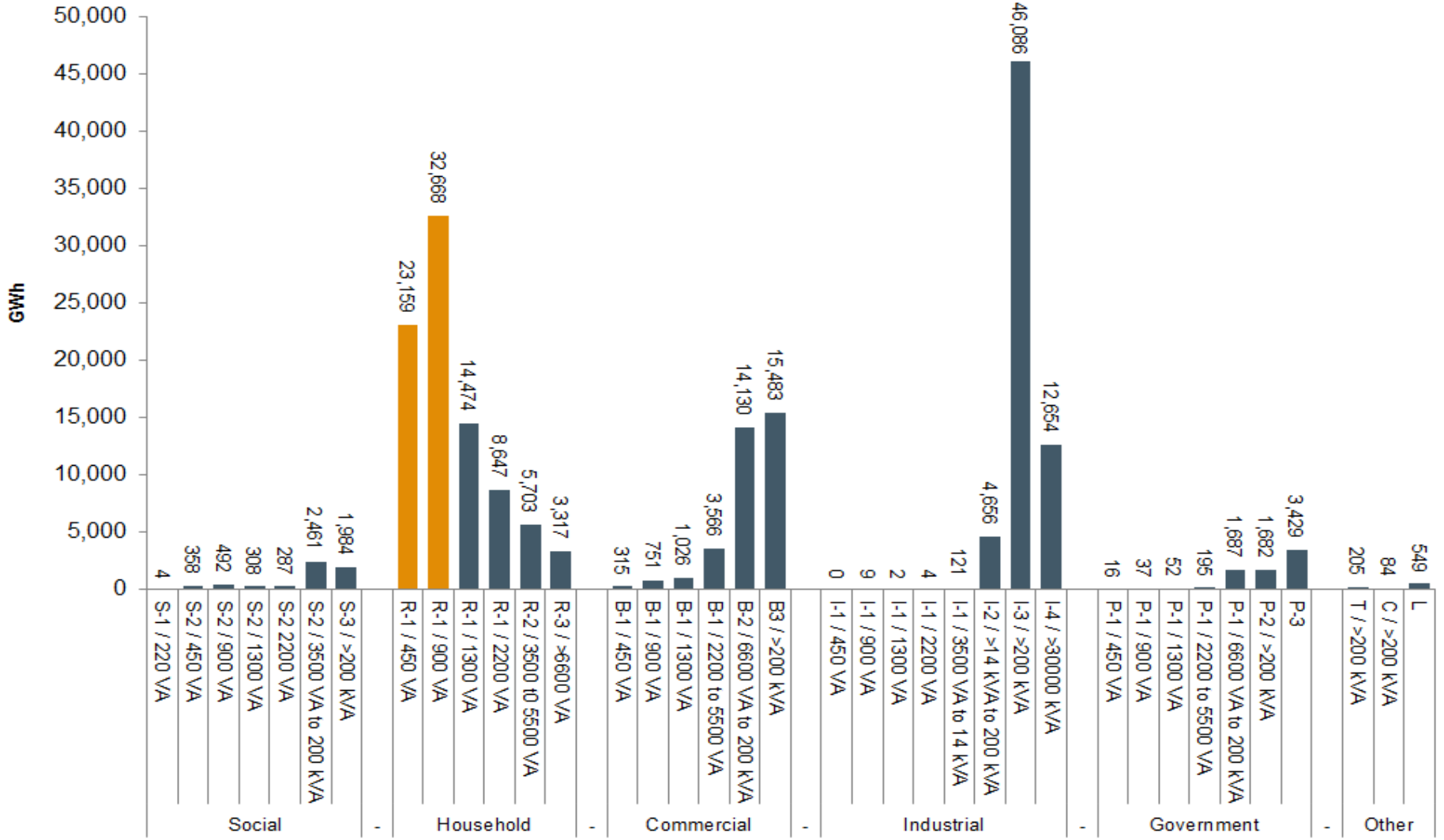
Cost-reflectiveness implies the use of very 'granular' tariffs

- Distinguish by customer type
- Distinguish by customer size
- Distinguish by customer locations
- Distinguish by time of use
- Distinguish by load factor
- Distinguish by size

This works against transparency, simplicity and predictability

- Very complex tariff structures are difficult for users to understand
- The makes acceptance harder and makes it more difficult for users to respond to pricing signals

As one example of complexity, Indonesia has 36 customer categories



As another example, PG&E (California) offers 12 different residential tariffs

Rate Schedule	Rate Design	Delivery Minimum Bill Amount (per meter per day)	Discount (per dwelling unit per day)	Minimum Average Rate Limiter (per kWh per month)	Energy Charge [1] ($/kWh)			California Climate Credit [2]	"Average" Total Rate [3] (per kWh)
			ES, ET, ESL & ETL Only	ES, ET, ESL & ETL Only	Tier 1 (Baseline) [4]	Tier 2 (101-200% of baseline)	Tier 3 (Over 200% of baseline)		
Residential Schedules: E-1, EM, ES, ESR, ET	Tiered Energy Charges	$0.32854	ES = $0.05075 ET = $0.18004	ES and ET $0.04892	$0.18205	$0.24081	$0.39984	($28.14)	$0.21775
Residential CARE Schedules: EL-1, EML, ESL, ESRL, ETL	CARE Tiered Energy Charges	$0.16427	ESL = $0.05075 ETL = $0.18004	ESL and ETL $0.04892	$0.11929	$0.14720	$0.21661	($28.14)	$0.12739

Rate Schedule	Rate Design	Delivery Minimum Bill Amount (per meter per day)	Total Meter Charge Rate [1] (per meter per day)		Season Summer: May-Oct Winter: Nov-Apr	Time-of-Use Period	Energy Charge [2] ($/kWh)			California Climate Credit [3]	"Average" Total Rate [4] (per kWh)
			E-7 Rate Only	Rate W Only			Tier 1 (Baseline)	Tier 2 (101-200% of baseline)	Tier 3 (Over 200% of baseline)		
Residential Time-of-Use Rate Schedule E-7 [5]	Time-of-Use Winter and Summer Peak and Off-Peak Energy Charges	$0.32854	$0.11532	$0.03843	Summer	Peak	$0.37797	$0.43736	$0.59638	($28.14)	$0.20447
						Off-Peak	$0.12982	$0.18920	$0.34823		
					Winter	Peak	$0.16347	$0.22285	$0.38188		
						Off-Peak	$0.13343	$0.19281	$0.35184		
Residential CARE Time-of-Use Rate Schedule EL-7 [5]	CARE Time-of-Use Winter and Summer Peak and Off-Peak Energy Charges	$0.16427	-	-	Summer	Peak	$0.30981	$0.34093	$0.49407	($28.14)	$0.13564
						Off-Peak	$0.09652	$0.12764	$0.18345		
					Winter	Peak	$0.12544	$0.15656	$0.22557		
						Off-Peak	$0.09963	$0.13075	$0.18798		
Residential Time-of-Use Rate Schedule E-6 and Rate Schedule EM-TOU [6]	Time-of-Use Winter and Summer Peak, Part-Peak, and Off-Peak Energy Charges	$0.32854	$0.25298	-	Summer	Peak	$0.34159	$0.40035	$0.55848	($28.14)	$0.21813
						Part-Peak	$0.22632	$0.28508	$0.44321		
						Off-Peak	$0.14954	$0.20831	$0.36643		
					Winter	Part-Peak	$0.17071	$0.22947	$0.38760		
						Off-Peak	$0.15388	$0.21264	$0.37077		
Residential CARE Time-of-Use Rate Schedule EL-6 and Rate Schedule EML-TOU [6]	CARE Time-of-Use Winter and Summer Peak, Part-Peak, and Off-Peak Energy Charges	$0.16427	$0.20238	-	Summer	Peak	$0.23609	$0.26508	$0.38670	($28.14)	$0.12750
						Part-Peak	$0.15159	$0.18058	$0.26364		
						Off-Peak	$0.09531	$0.12430	$0.18168		
					Winter	Part-Peak	$0.11083	$0.13980	$0.20428		
						Off-Peak	$0.09848	$0.12746	$0.18630		

More PG&E residential tariff options.....

Rate Schedule	Rate Design	Delivery Minimum Bill Amount (per meter per day)	Total Meter Charge Rate [1] (per meter per day)		Season Summer: May-Oct Winter: Nov-Apr	Time-of-Use Period	Energy Charge ($/kWh) (No Tiers)			California Climate Credit [3]	"Average" Total Rate [4] (per kWh)
Residential Time-of-Use Service for Plug-In Electric Vehicle, Rate Schedule EV, Rate A	Time-of-Use Winter and Summer Peak, Part-Peak, and Off-Peak Energy Charges	$0.32854	-	-	Summer	Peak	$0.44385			($28.14)	n/a
						Part-Peak	$0.24148				
						Off-Peak	$0.11465				
					Winter	Peak	$0.31210				
						Part-Peak	$0.19034				
						Off-Peak	$0.11740				
Residential Time-of-Use Service for Plug-In Electric Vehicle, Rate Schedule EV, Rate B	Time-of-Use Winter and Summer Peak, Part-Peak, and Off-Peak Energy Charges	-	$0.04928	-	Summer	Peak	$0.43738			-	n/a
						Part-Peak	$0.23824				
						Off-Peak	$0.11418				
					Winter	Peak	$0.30521				
						Part-Peak	$0.18690				
						Off-Peak	$0.11691				

Rate Schedule	Rate Design	Delivery Minimum Bill Amount (per meter per day)	Total Meter Charge Rate [1] (per meter per day)	Season Summer: June-Sept Winter: Oct-May	Time-of-Use Period	Energy Charge [2] ($/kWh)			California Climate Credit [3]	"Average" Total Rate [4] (per kWh)
						Total Usage	Baseline Credit (Applied to Baseline Usage Only)			
NEW Residential Time-of-Day Rate Schedule E-TOU Option A (3-8 p.m.)	Time-of-Day Winter and Summer Peak and Off-Peak Energy Charges	$0.32854	-	Summer	Peak	$0.40315	($0.11705)		($28.14)	n/a
					Off-Peak	$0.32757	($0.11705)			
				Winter	Peak	$0.28518	($0.11705)			
					Off-Peak	$0.27088	($0.11705)			
NEW Residential Time-of-Day Rate Schedule E-TOU Option B (4-9 p.m.)	Time-of-Day Winter and Summer Peak and Off-Peak Energy Charges	$0.32854	-	Summer	Peak	$0.35632	-		($28.14)	n/a
					Off-Peak	$0.25326	-			
				Winter	Peak	$0.21886	-			
					Off-Peak	$0.20006	-			
NEW Residential CARE Time-of-Day Rate Schedule EL-TOU Option A (3-8 p.m.)	CARE Time-of-Day Winter and Summer Peak and Off-Peak Energy Charges	$0.16427	-	Summer	Peak	$0.23199	($0.04705)		($28.14)	n/a
					Off-Peak	$0.18437	($0.04705)			
				Winter	Peak	$0.15767	($0.04705)			
					Off-Peak	$0.14866	($0.04705)			
NEW Residential CARE Time-of-Day Rate Schedule EL-TOU Option B (4-9 p.m.)	CARE Time-of-Day Winter and Summer Peak and Off-Peak Energy Charges	$0.16427	-	Summer	Peak	$0.21711	-		($28.14)	n/a
					Off-Peak	$0.15218	-			
				Winter	Peak	$0.13051	-			
					Off-Peak	$0.11866	-			

And then there are the multiple block ('baseline') differences

Residential
ELECTRIC
Baseline Territories and Quantities
Effective August 1, 2014 - Present

Winter***
(Effective November 1, 2014)

TERRITORY	INDIVIDUALLY METERED (E-1,E-6,EL-1,EL-6, ES,ESL,ESR,ESRL,ET,ETL)		MASTER METERED (EM,EM-TOU,EML,EML-TOU)
ALL-ELEC. (Code H)	Daily[1/]		Daily[1/]
P	29.6		15.4
Q	**29.6***		**15.4***
R	29.8		15.4
S	27.1		15.3
T	14.9		9.8
V	26.6		14.5
W	20.6		12.9
X	16.7		14.0
Y	27.1		18.0
Z	18.7		12.5
BASIC ELEC. (Code B)	Daily[1/]		Daily[1/]
P	12.3		5.6
Q	**12.3***		5.6
R	11.0		5.3
S	11.2		5.1
T	8.5		4.8
V	10.6		5.2
W	10.1		5.5
X	10.9		6.2
Y	12.6		8.3
Z	9.0		5.9

Summer**
(Effective August 1, 2014)

TERRITORY	INDIVIDUALLY METERED (E-1,E-6,EL-1,EL-6, ES,ESL,ESR,ESRL,ET,ETL)		MASTER METERED (EM,EM-TOU,EML,EML-TOU)
ALL-ELEC. (Code H)	Daily[1/]		Daily[1/]
P	16.4		9.1
Q	8.3		5.4
R	18.8		9.2
S	16.4		9.1
T	8.3		5.4
V	13.6		8.0
W	20.8		10.3
X	9.3		7.5
Y	13.0		8.1
Z	7.7		4.8
BASIC ELEC. (Code B)	Daily[1/]		Daily[1/]
P	13.8		5.9
Q	7.0		3.9
R	15.6		6.6
S	13.8		5.9
T	7.0		3.9
V	8.7		4.3
W	16.8		7.4
X	10.1		5.4
Y	10.6		**9.0***
Z	6.2		5.3

The problem of 'lumpiness' in the electricity industry

- Electricity supply is 'lumpy' in nature
- You can't sensibly build power plants, transmission and distribution lines and substations in units of 1 kW
- Instead, large additions ('lumps') are made as demand approaches existing supply with the result being large swings in the margin of supply over demand
- From a regulatory perspective, this results in marginal and average costs diverging, making pricing decisions much harder

Why marginal costs?

Approach to designing electricity tariffs is forward-looking (to meet future demand)

Capacity charges ($/kW)	• Used to recover generation and network capacity costs. Should be based on demand (kW) at time of system peak, as this is the driver of investment needs.
Seasonal and Time-of-Day (STOD) energy charges ($/kWh)	• Used to recover the variable costs of additional electricity supply in each interval.

marginal cost

noun ECONOMICS

the cost added by producing one additional unit of a product or service.

Cost definitions

Average cost

- Total cost / Total volumes

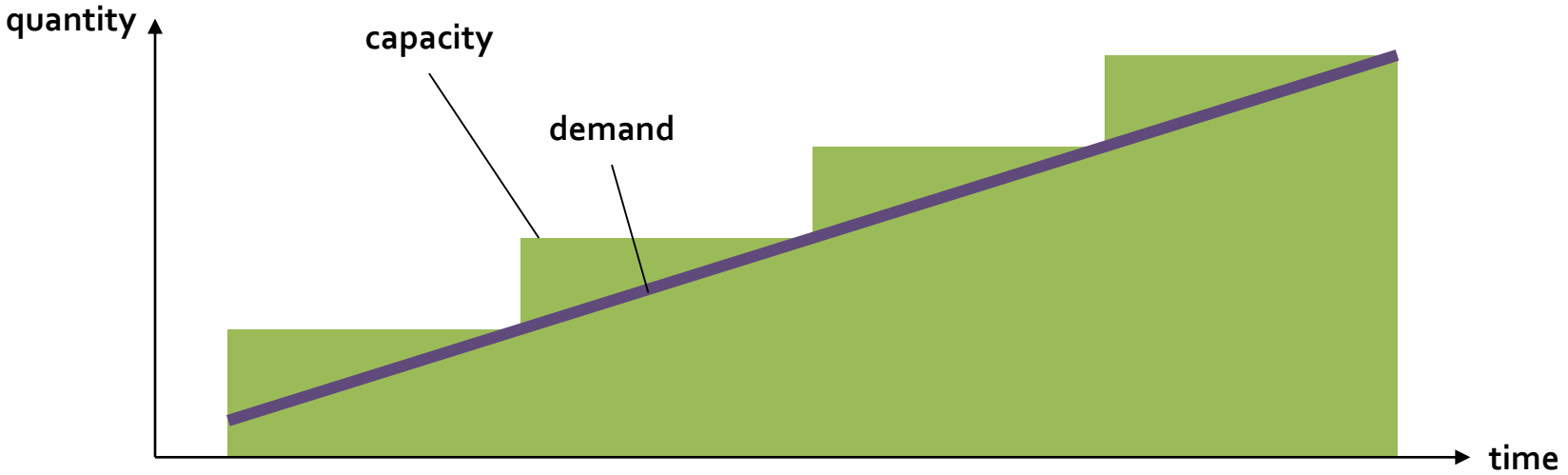
Short-run marginal cost (SRMC)

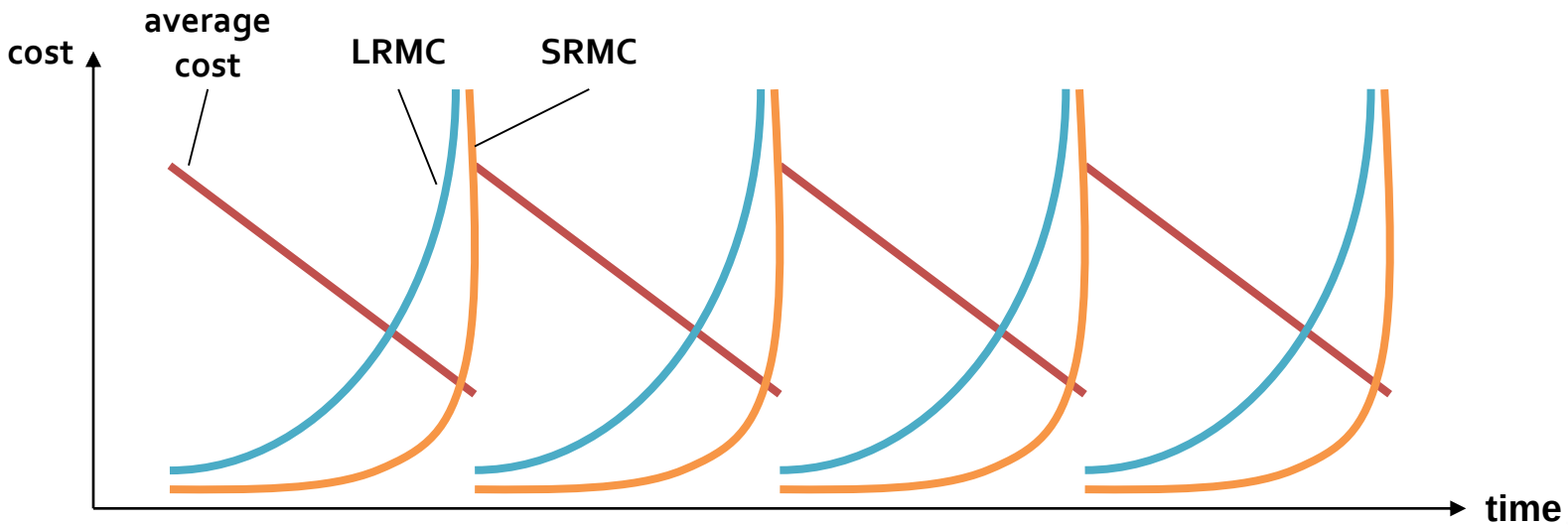
- The cost of supplying an additional unit in the next period
- For example, the cost of generating one more MWh in a power plant (= fuel + variable O&M)

Long-run marginal cost (LRMC)

- The cost of supplying an additional unit over a sustained period
- For example, the cost of building a new power plant to meet demand (= capital cost + fixed O&M + fuel + variable O&M)

The relationship between the different types of cost





Marginal cost of capacity and energy

Long-run marginal cost referred to as marginal cost of capacity

- Derived from the Electricity Masterplan study

Short-run marginal cost referred to as marginal cost of energy

- Calculated as the fuel and variable O&M cost of the plant operating at the margin

Marginal costs (and cost-reflective prices) differ over time and space

Time-varying marginal costs

- At off-peak times, there is a lot of spare capacity (marginal cost is low)
- At peak times, meeting any additional demand may require new capacity to be built (marginal cost is high)

Space-varying marginal costs

- Constraints on transportation of energy mean that surplus capacity in one region cannot be used to make up deficits in other regions (marginal cost is low in surplus and high in deficit regions)

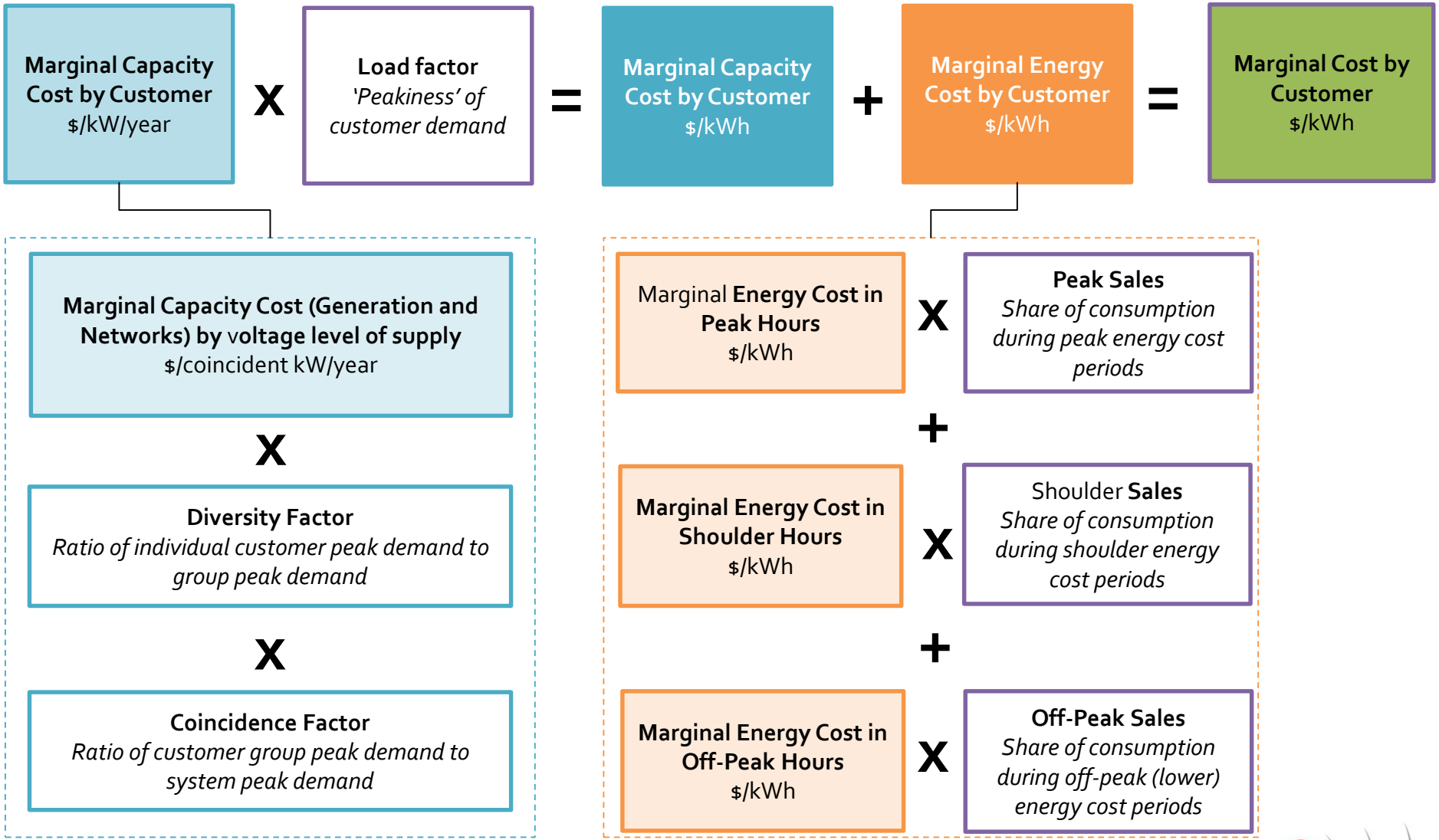
Important definitions

Load factor = average demand / peak demand
= total MWh for the year / (MWh x 8760)

Coincidence factor = demand at the time of system peak / peak demand of the customer (or group of customers)

Diversity factor = peak demand of the group / sum of the individual peak demand of the group members

Summary of marginal cost calculations



Indonesia case study: Tariff classes can be significantly simplified from 37 to 12

PLN currently uses 37 different tariff categories

- Eight main customer types, sub-divided by voltage level and connection size.
- Multiple tariff categories have similar load profiles and costs to serve
- Many categories have very small shares of total sales

We proposed to reduce these to 12 categories

- Government policy is now oriented towards targeting subsidies on identified low-income households and tariff classes can be simplified.
- Group together customers with similar load profiles and costs to serve
  - Based on a comparison of load profiles and costs, we propose 6 main categories (Residential, Public, Business, Industrial, Traction and Special) and
  - Separate classes by voltage level

Indonesia case study: Proposals for general tariff structure

LV customers

- Remove rising block tariffs
  - A rising-block tariff is a subsidy within a customer class. Policy is to target subsidies on low-income households (R-A class) using social criteria.
- Introduce an optional LV STOD tariff (if customer is willing to pay the additional metering costs)
- Retain minimum charges

HV and MV customers

- Apply TOU tariffs for HV and MV customers
- Retain reactive power charge penalty for MV and HV. Charges apply for power factors below 0.85.
- Retain capacity charges for MV and HV customers.
  - Capacity charge is set to recover 50% of capacity costs (the remainder being recovered in energy charges).
  - Where demand metering is not available, the charge is based on connected capacity (as now)

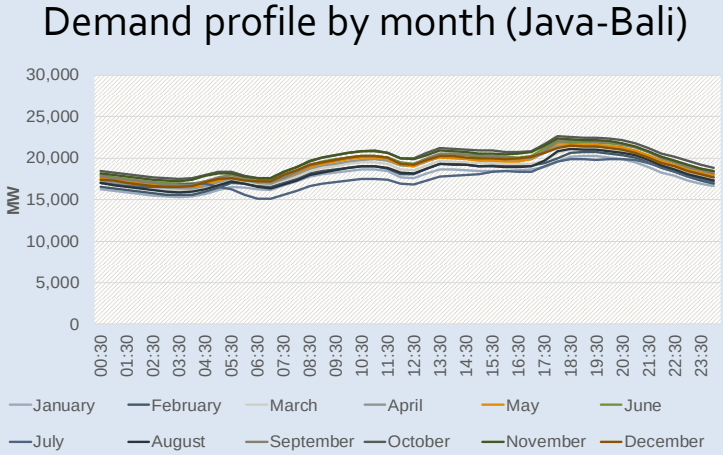
Customer category	Energy Charge		Minimum charge	Capacity charge	Reactive power charge
	Flat	TOU			
Residential					
R-A (LV)	•		•		
R-S (LV)	•		•		
R-L (LV)	•	*	•		
Business					
B-S (LV)	•	*	•		
B-M (MV)		•		•	•
Industrial					
I-S (LV)	•	*	•		
I-M (MV)		•		•	•
I-L (HV)		•		•	•
Public					
P-S (LV)	•	*	•		
Special					
T (MV)		•		•	•
L (LV, MV, HV)	•				
G (LV)*		•	•		

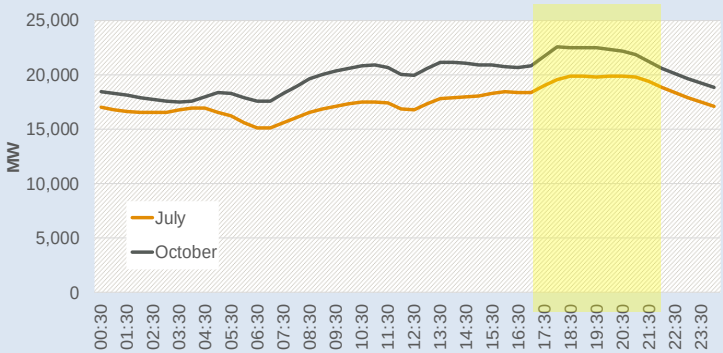
** Optional if customer is willing to pay extra costs for STOD meter*

Indonesia case study: No need for seasonal charges but TOD charges should apply

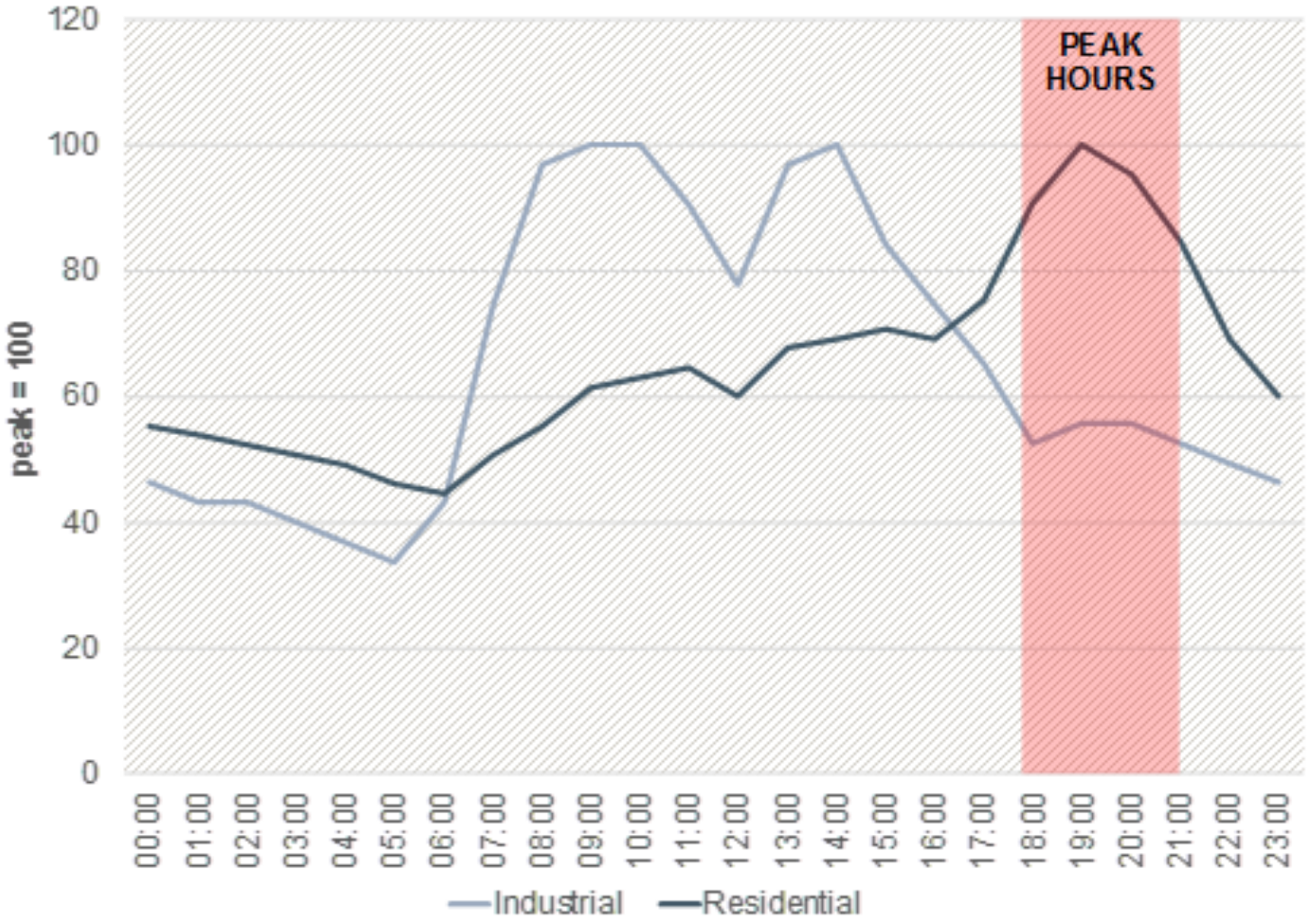
General tariff structure of Seasonal Time of Day Periods (STOD)

- TOD periods
  - Peak - 17:00 - 22:00 Weekdays
  - Off-peak - 22:00 - 17:00 Weekdays
  - Sundays and holidays
- HV and MV customers already have TOD metering
- Larger LV customers are given the option of paying the extra cost for a TOD meter



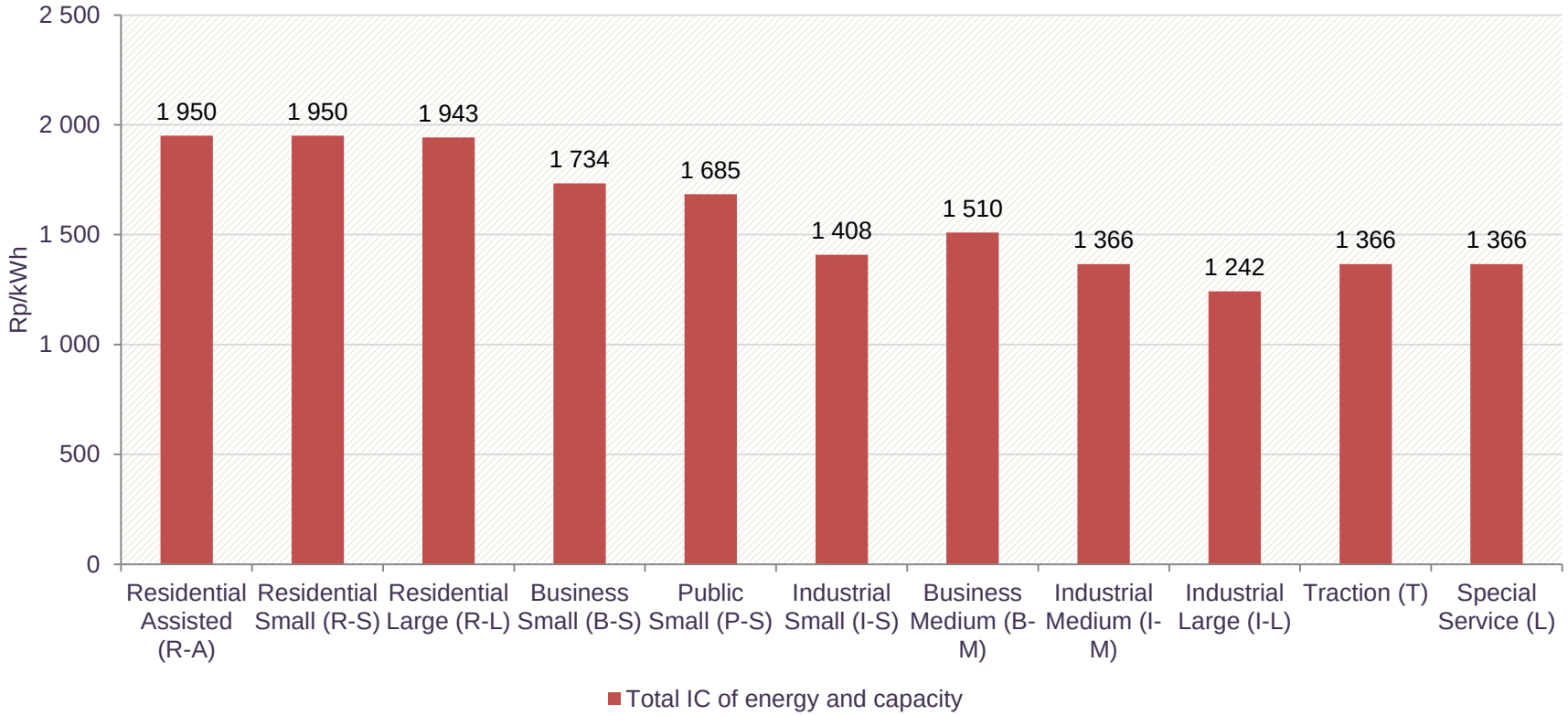


Customers with more 'peaky' demand have a higher incremental costs



Indonesia case study: Estimated Incremental costs by customer class

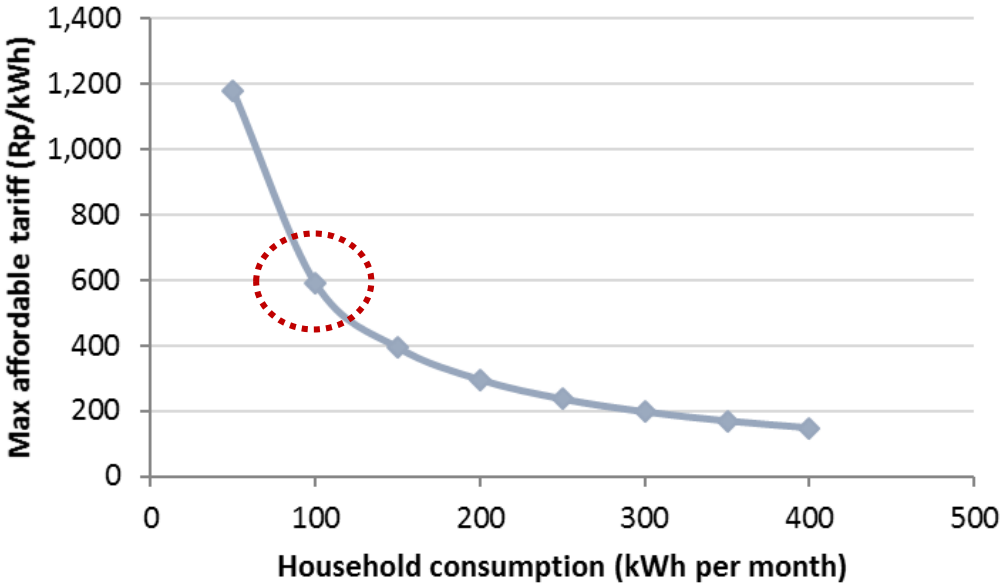
- System Incremental costs of energy and capacity by customer class after overlying tariff classes load profiles and system costs.
- Capacity costs are expressed in an equivalent energy charge.



Indonesia case study: Affordable tariffs for low-income residential ~600 Rp/kW

Low-income customers are defined as the tenth decile (ie, the poorest 10% of households)

Affordability limits are calculated assuming electricity bills should be no more than 5% of household expenditures



Indonesia case study: 2017 tariffs by customer class

2017 SOE Revenue Requirements; 50% of capacity costs allocated to TOU energy charges for STOD tariffs.

Tariff class	Minimum charge	Energy charge					Capacity charge	Reactive Power charge
		Single-rate	Time-of-Use (c)					
			Weekday		Non-Weekday			
	(a)	(b)	Peak	Other hours	Peak	Other hours		(d)
	Rp/month	*Rp/kWh*	*Rp/kWh*	*Rp/kWh*	*Rp/kWh*	*Rp/kWh*	*Rp/kVA/month*	*Rp/kVAr*
Residential Assisted (R-A)	10,800	600	-	-	-	-	-	-
Residential Small (R-S)	66,768	1,855	-	-	-	-	-	-
Residential Large (R-L)	96,096	1,848	-	-	-	-	-	-
Business Small (B-S)	85,733	1,649	-	-	-	-	-	-
Public Small (P-S)	83,314	1,602	-	-	-	-	-	-
Industrial Small (I-S)	69,635	1,339	-	-	-	-	-	-
Business Medium (B-M)	-	-	2,309	826	972	677	45,802	1,161
Industrial Medium (I-M)	-	-	2,322	810	972	677	52,152	1,161
Industrial Large (I-L)	-	-	2,041	785	948	665	46,546	1,039
Traction (T)	-	-	2,322	810	972	677	17,695	865
Special Service (L)	-	1,299	-	-	-	-	-	-
General LV STOD (G)	-	-	2,711	921	1,111	751	42,178	-

a Calculated as *40 hours * energy charge (Rp/kWh) * connected capacity (kVA)*, rounded to the nearest one thousand. To be paid by customers whose monthly electricity bill, calculated using metered consumption, falls below this level.
b Applicable to customers with credit or post-paid meters. Customers with pre-payment meters will pay the *applicable energy charge (Rp/kWh) * 1.10*.
c Peak hours are from 17:00 to 22:00.
d Applied where power factor is below 0.85.

Exercise overview

- Calculate the marginal costs of network investment
- Calculate cost-reflective tariffs based on given assumptions
- Adjust cost-reflective tariffs to meet revenue requirements

Exercise (a)

Calculate the network marginal costs from the investment plan

Inputs											
Year		1	2	3	4	5	6	7	8	9	10
Investment costs	$m	10	15	8	20	10	15	5	6	12	10
Peak demand on network	MW	1,000	1,020	1,050	1,070	1,105	1,120	1,140	1,165	1,185	1,205
Discount rate	%	10%									
Life of assets	years	40									
O&M costs as % of capital costs	%	4%									
Network average incremental costs											
NPV of investment costs	$m										
Change in peak demand on network	MW										
NPV of change in peak demand	$m										
NPV of incremental investment cost	$/kW										
Annualised incremental investment cos	$/kW/yr										
O&M costs	$/kW/yr										
Total average incremental costs	$/kW/yr										

Exercise (b)

Calculate cost-reflective tariffs, including both a capacity and energy charge (ignoring network voltages & losses and assuming that there is only one tariff category)

Inputs		
Marginal cost of energy generation	$/kWh	0.200
Marginal cost of generation capacity	$/kW/yr	150
Marginal cost of network capacity	$/kW/yr	83
Cost-reflective tariff		
Capacity charge	$/kW/month	
Energy charge	$/kWh	

Exercise (c)

Calculate the same equivalent tariffs if there is no capacity charge (i.e. all costs are recovered through the energy charge)

Inputs		
Marginal cost of energy generation	$/kWh	0.200
Marginal cost of generation capacity	$/kW/yr	150
Marginal cost of network capacity	$/kW/yr	83
Load factor	%	60%
Cost-reflective tariff		
Capacity charge	$/kW/month	
Energy charge	$/kWh	
Capacity charge per kWh equivalent	$/kWh	
Combined per kWh equivalent	$/kWh	

Exercise (d)

Calculate cost-reflective tariffs for two different customer categories

Inputs			
Marginal cost of energy generation	$/kWh	0.200	
Marginal cost of generation capacity	$/kW/yr	150	
Marginal cost of network capacity	$/kW/yr	83	
		Residenti	**Commercial**
Load factor	%	60%	80%
Coincidence factor	%	95%	60%
Diversity factor	%	90%	90%
Cost-reflective tariff			
		Residenti	**Commercial**
Capacity charge	$/kW/month		
Energy charge	$/kWh		
Combined per kWh equivalent	$/kWh		

Exercise (e)

Adjust cost-reflective tariffs to meet the revenue requirement

Revenue requirement	$m	5.0	
		Residential	**Commercial**
Total consumption	MWh/yr	18,000	7,000

Cost-recovery adjustment			
Forecast revenue at cost-reflective tai	$m		
Adjustment for cost-recovery	%		
Cost-reflective tariffs after adjustment			
		Residential	**Commercial**
Capacity charge	$/kW/month		
Energy charge	$/kWh		
Combined per kWh equivalent	$/kWh		
Forecast revenue	$m		

Exercise (f)

Calculate cost-reflective tariffs for different voltage supplies, by including network losses

Calculate the marginal costs of:

- Energy supplied
- Generation capacity
- Network capacity

Calculate the:

- Capacity charge
- Energy charge
- Combined per kWh equivalent

Marginal cost of energy generation	$/kWh	0.200		
Marginal cost of generation capacity	$/kW/yr	150		
Marginal cost of MV network capacity	$/kW/yr	53		
Marginal cost of LV network capacity	$/kW/yr	30		
		Resident	**Commerc**	**Commerc**
Load factor	%	60%	80%	85%
Coincidence factor	%	95%	60%	50%
Diversity factor	%	90%	90%	90%
		MV	**LV**	
Network losses at system peak	%	3%	8%	
Network losses on average	%	2%	6%	

Exercise (g)

Calculate cost-reflective tariffs by season

Calculate the marginal costs of:

- Energy supplied
- Generation capacity
- Network capacity

Calculate the:

- Capacity charge
- Energy charge
- Combined per kWh equivalent

		Season 1	Season 2
Marginal cost of energy generation	$/kWh	0.250	0.150
Marginal cost of generation capacity	$/kW/yr	150	
Share of capacity costs attributable t	%	80%	20%
Months in season	months	6	6
Marginal cost of MV network capacity	$/kW/yr	53	
Marginal cost of LV network capacity	$/kW/yr	30	

		Resident	Commerc	Commerc
Load factor	%	60%	80%	85%
Coincidence factor	%	95%	60%	50%
Diversity factor	%	90%	90%	90%

		MV	LV
Network losses at system peak	%	3%	8%
Network losses on average	%	2%	6%

If the marginal cost also varies by time of day, how should this be incorporated into the tariffs?

THANK YOU
FOR YOUR ATTENTION!

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