Optimizing Behind-the-Meter (BTM) Rates and Incentives

Charging Ahead Webinar

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Agenda and Housekeeping

Agenda

- Economics 101
- US Rate Design Requirements and Guidelines
- Best Practice Tariff and Incentive Design
- Real-World Case Studies
- Recommendations

Housekeeping

This webinar is being recorded and distributed to all registrants along with this presentation

Add your questions to the chat. My colleague, Sara, is monitoring the queue of questions for the Q&A session

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US Rate Design Requirements and Guidelines

History

Governance

Processes

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History of US Utility Pricing Events

Year	Person	Event
1882	Thomas Edison	Electric light priced to match gas light and not based on the cost of generating electricity
1892	John Hopkinson	Suggested a **two-part** rate, with the first part based on usage and the second part based on **connected kW demand**
1894	Arthur Wright	Modified Hopkinson's proposal so that the second part would be based on **actual maximum demand**
1898	Williams S Barstow	Proposed time-of-use (ToU) pricing
1946	Ronald Cease	Proposed a **two-part** rate; first part recovering **fixed** costs, and the second part recovering fuel plus other costs that **vary** by amount of kWh sold
1951	Hendrik S Houthakker	Argued that a two-period ToU rate is better than a max demand rate because the latter ignores **coincident** system peak
1961	James C. Bonbright	Published "Principles of Public Utility Rates" which would become a canon in the decades to come
1971	William Vickrey	Proffered the concept of **real-time**-pricing (RTP) in *Responsive Pricing of Public Utility Services*
1976	CA Legislature	Added a baseline law to the Public Utilities Code in the *Warren-Miller Energy Lifeline Act*, creating a two-tiered **inclining rate** for energy efficiency
1978	US Congress	Passed the *Public Utility Regulatory Act*, which called on all states to assess the **cost-effectiveness** of TOU rates
2001	CA Legislature	Introduced AB 1X, creating the five-tier inclining block rate where the heights of the tiers bore no relationship to costs. By freezing the first two tiers, it ensured that the upper tiers would spiral out of control
2005	US Congress	Passed the Energy Policy Act of 2005, which requires all electric utilities to offer net metering upon request
2023	CPUC	Decision D.22-12-056, which replaced NEM 2.0 with NEM 3.0. NEM 3.0 aligns retail export compensation with the value that behind-the-meter energy generation systems provide to the grid, and encourage adoption of solar paired with storage
2024	CPUC	Approved AB 205, which adds a fixed charge of $24.15 to customers' monthly bills in exchange for lower volumetric rates to encourage transport and building electrification

Source: Brattle, California Constitution, CPUC

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Federal Legislation – Public Utility Regulatory Policies

CHAPTER 46, SUBCHAPTER II—STANDARDS FOR ELECTRIC UTILITIES

§2621. Consideration and determination respecting certain ratemaking standards

The following Federal standards are hereby established:

(1) Cost of service

Rates charged by any electric utility for providing electric service to each class of electric consumers shall be designed, to the maximum extent practicable, to reflect the costs of providing electric service to such class, as determined under section 2625(a) of this title.

(2) Declining block rates

The energy component of a rate, or the amount attributable to the energy component in a rate, charged by any electric utility for providing electric service during any period to any class of electric consumers may not decrease as kilowatt-hour consumption by such class increases during such period except to the extent that such utility demonstrates that the costs to such utility of providing electric service to such class, which costs are attributable to such energy component, decrease as such consumption increases during such period.

(3) Time-of-day rates

The rates charged by any electric utility for providing electric service to each class of electric consumers shall be on a time-of-day basis which reflects the costs of providing electric service to such class of electric consumers at different times of the day unless such rates are not cost-effective with respect to such class, as determined under section 2625(b) of this title.

(4) Seasonal rates

The rates charged by an electric utility for providing electric service to each class of electric consumers shall be on a seasonal basis which reflects the costs of providing service to such class of consumers at different seasons of the year to the extent that such costs vary seasonally for such utility.

(5) Interruptible rates

Each electric utility shall offer each industrial and commercial electric consumer an interruptible rate which reflects the cost of providing interruptible service to the class of which such consumer is a member…

(14) Time-based metering and communications

(A) Not later than 18 months after August 8, 2005, each electric utility shall offer each of its customer classes, and provide individual customers upon customer request, a time-based rate schedule under which the rate charged by the electric utility varies during different time periods and reflects the variance, if any, in the utility's costs of generating and purchasing electricity at the wholesale level. The time-based rate schedule shall enable the electric consumer to manage energy use and cost through advanced metering and communications technology.

Source: United States Code

(B) The types of time-based rate schedules that may be offered under the schedule referred to in subparagraph (A) include, among others—

(i) **time-of-use** pricing whereby electricity prices are set for a specific time period on an advance or forward basis, typically not changing more often than twice a year, based on the utility's cost of generating and/or purchasing such electricity at the wholesale level for the benefit of the consumer. Prices paid for energy consumed during these periods shall be pre-established and known to consumers in advance of such consumption, allowing them to vary their demand and usage in response to such prices and manage their energy costs by shifting usage to a lower cost period or reducing their consumption overall;

(ii) **critical peak** pricing whereby time-of-use prices are in effect except for certain peak days, when prices may reflect the costs of generating and/or purchasing electricity at the wholesale level and when consumers may receive additional discounts for reducing peak period energy consumption;

(iii) **real-time** pricing whereby electricity prices are set for a specific time period on an advanced or forward basis, reflecting the utility's cost of generating and/or purchasing electricity at the wholesale level, and may change as often as hourly; and

(iv) credits for consumers with large loads who enter into pre-established peak load reduction agreements that reduce a utility's planned capacity obligations.

(C) Each electric utility subject to subparagraph (A) shall provide each customer requesting a time-based rate with a time-based meter capable of enabling the utility and customer to offer and receive such rate, respectively.

…

(17) Rate design modifications to promote energy efficiency investments

(A) In general

The rates allowed to be charged by any electric utility shall—

(i) align utility incentives with the delivery of cost-effective energy efficiency; and

(ii) promote energy efficiency investments.

(B) Policy options

In complying with subparagraph (A), each State regulatory authority and each nonregulated utility shall consider—

(i) removing the throughput incentive and other regulatory and management disincentives to energy efficiency;

(ii) providing utility incentives for the successful management of energy efficiency programs;

(iii) including the impact on adoption of energy efficiency as 1 of the goals of retail rate design, recognizing that energy efficiency must be balanced with other objectives;

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California Legislation, CPUC Regulations

In California, article XII of the California Constitution established the California Public Utilities Commission (CPUC), which regulates electricity rates

- Section 3 establishes the right of the CPUC to regulate public utilities

The CPUC's rate regulation is set out in the Public Utilities Code (PUC)

- 451 All charges demanded or received by any public utility… shall be just and reasonable. Every unjust or unreasonable charge demanded or received for such product or commodity or service is unlawful…
- 454(a) Except as provided in Section 455, a public utility shall not change any rate or so alter any classification, contract, practice, or rule as to result in any new rate, except upon a showing before the commission and a finding by the commission that the new rate is justified…
- 454.1(a) Except as provided in subdivision (b), if a customer with a maximum peak electrical demand in excess of 20 kilowatts located or planning to locate within the service territory of an electrical corporation receives a bona fide offer for electric service from an irrigation district at rates less than the electrical corporation's tariffed rates, the electrical corporation may discount its noncommodity rates, but may not discount its noncommodity rates below its distribution marginal cost of serving that customer… The electrical corporation may recover any difference between its tariffed and discounted service from its remaining customers, allocated as determined by the commission.
- 747(a) For purposes of this section, "time-variant pricing" includes time-of-use rates, critical peak pricing, and real-time pricing, but does not include programs that provide customers with discounts from standard tariff rates as an incentive to reduce consumption at certain times, including peak time rebates.
- 747(b) The commission may authorize an electrical corporation to offer residential customers the option of receiving service pursuant to time-variant pricing and to participate in other demand response programs. The commission shall not establish a mandatory or default time-variant pricing tariff for any residential customer except as authorized in subdivision (c).
- 747(c) Beginning January 1, 2018, and subject to the commission making the findings required by subdivision (d), the commission may require or authorize an electrical corporation to employ default time-of-use rates for residential customers subject to all of the following:
  - (1) Residential customers receiving a medical baseline allowance…, customers…who cannot be disconnected… shall not be subject to default time-of-use rates without their affirmative consent.
  - (2) The commission shall ensure that any time-of-use rate schedule does not cause unreasonable hardship for senior citizens or economically vulnerable customers in hot climate zones.
  - (3) The commission shall strive for time-of-use rate schedules that utilize time periods that are appropriate for at least the following five years.

- California legislation provides broad discretion to the California Public Utilities Commission to determine IOU rates
- The CPUC states their rate design criteria include:
  - Encouraging conservation, electrification and efficient use
  - Affordability for essential usage
  - Equity among customer classes
- The PUC Code (the Code) regulates elements of IOU rate design, requiring
  - Rates to be just and reasonable
  - Rates to be cost reflective
    - At the class and/or component level?
  - Time periods to be 'appropriate' for the following five years
    - Reflect significantly different forward looking cost structures?
- Keen to get people's views here

Source: California Constitution

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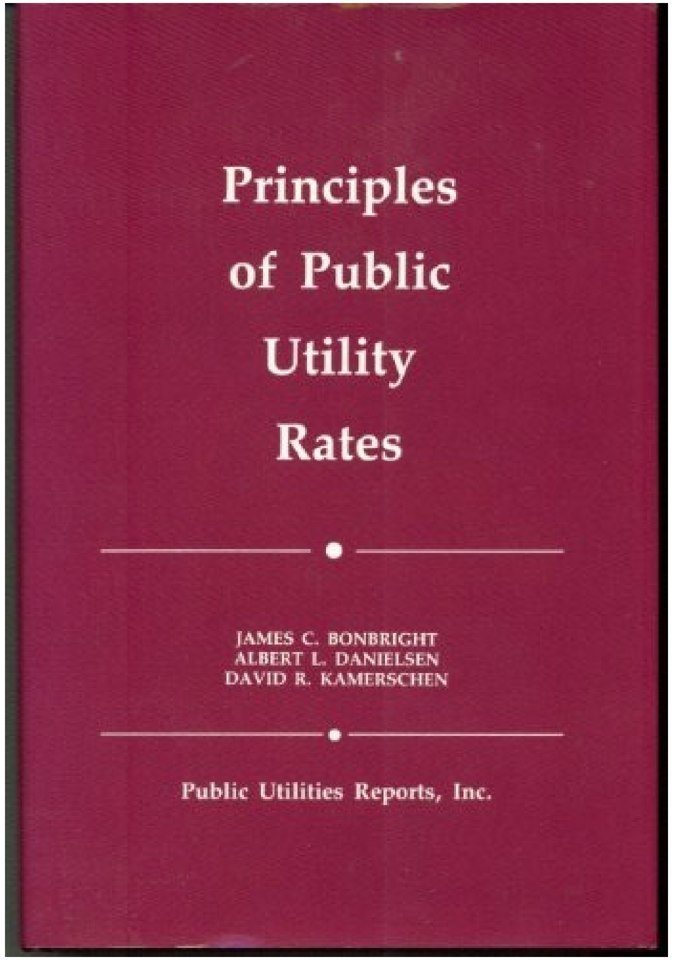
Bonbright and the Principles of Public Utility Rates

Principles of Public Utility Rates



Source: AbeBooks

- James C. Bonbright published *Principles of Public Utility Rates* in 1961, which became the standard for rate design in the US
- The principles covered revenue requirements, fair apportionment of costs among customers, and optimal efficiency
- Key attributes of sound rate structure include:
  - Be simple, understandable, acceptable, and feasible to implement
  - Yield total revenue requirements under the fair return standard
  - Be stable, with minimal unexpected changes that are seriously adverse to existing customers
  - Apportion the total cost of service fairly among different customers
    - Cost reflectivity, i.e. MR = MC, ensures cost causation recovery
  - Avoid unfair discrimination or cross-subsidization between customer groups
    - Cost reflectivity, i.e. MR = MC, avoids cross-subsidization
  - Discourage wasteful usage while promoting efficient and justified levels of consumption through appropriate price signals
    - Cost reflectivity, i.e. MR = MC, promotes efficiency consumption

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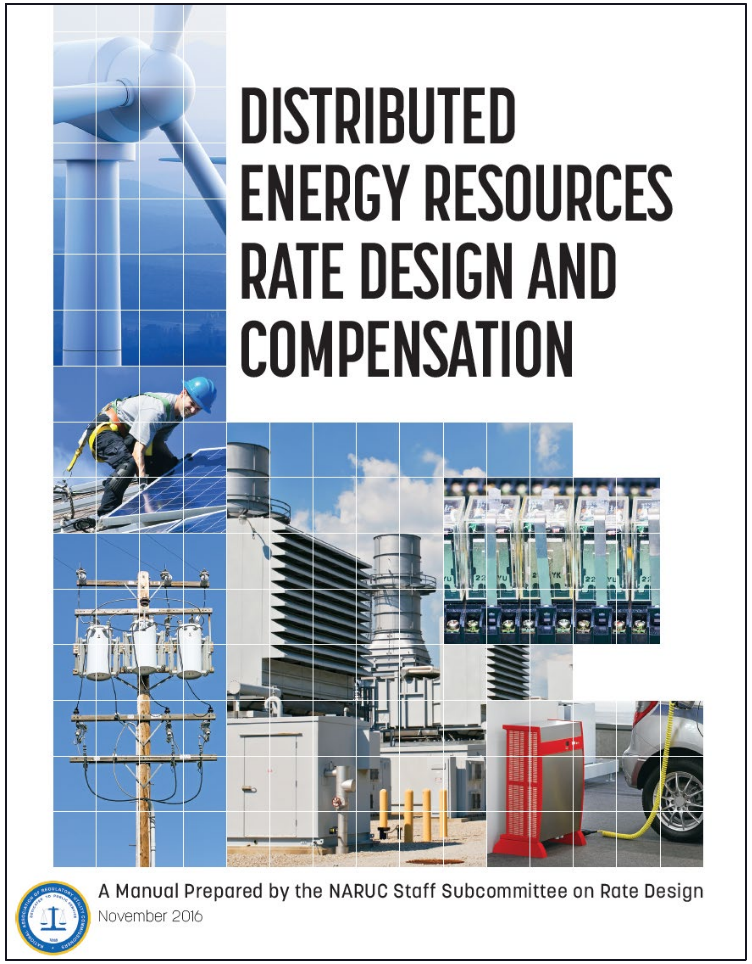
NARUC's Rate Design Manual for Distributed Energy Resources

NARUC's DER Rate Design Manual



Source: NARUC

- The National Association of Regulatory Utility Commissioners (NARUC) is a non-profit organization dedicated to representing the state public service commissions who regulate the utilities that provide essential services
- Their mission is to improve the quality and effectiveness of public utility regulation, which they do by:
  - Ensuring the maintenance of utility services
  - Ensure that services are provided at rates and conditions that are fair, reasonable, and non-discriminatory
- In their Distributed Energy Resources (DER) rates manual, NARUC's idea of best practice rate design for DER includes:
  - **Cost of Service** – rates should reflect the actual cost of service, including generation, transmission, and distribution
    - Voltage compensation, integration platforms, e.g. DERMS, etc.
  - **Equity** – Rates should be fair and avoid unfairly burdening different customer classes
  - **Efficiency** – Rates should encourage efficient energy usage
  - **Transparency** – Rates should be clear and understandable to customers
- In Australia, with over 50% penetration of rooftop PV, export charges are being levied to recover specific costs

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Economics 101

Productive Efficiency

Allocative Efficiency

Ramsey Pricing

Price Elasticity

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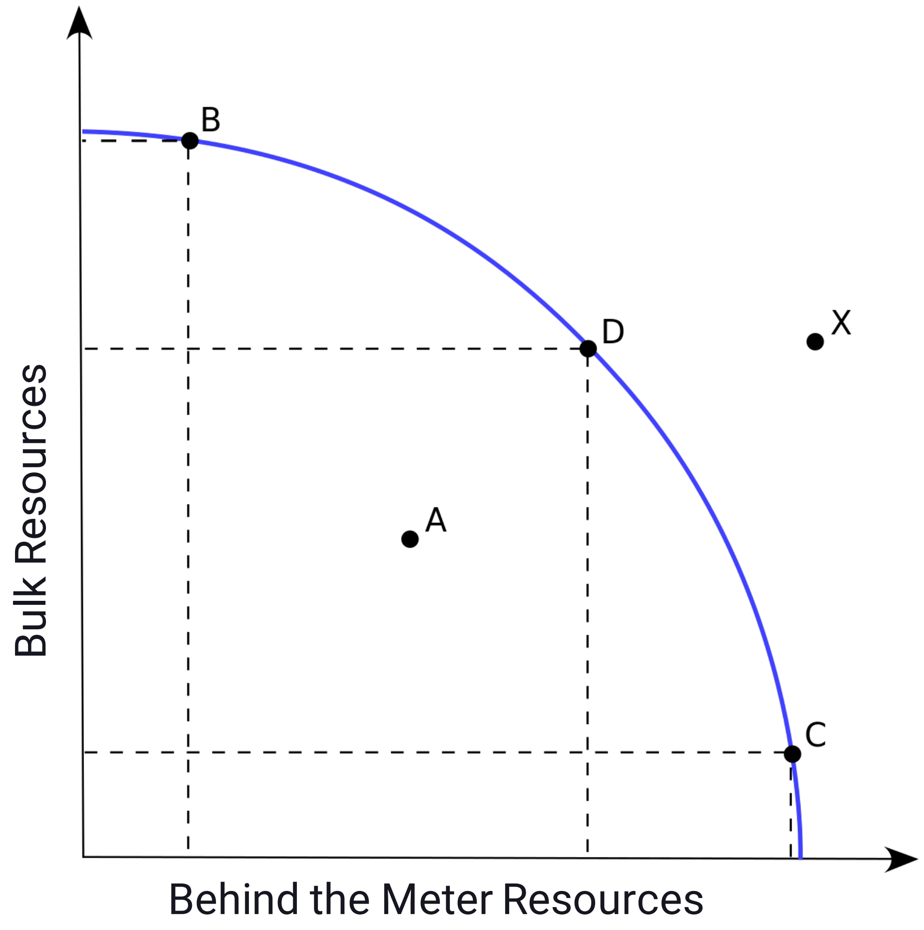
Economic Efficiency - Productive

Illustration of Productive Efficiency



Source: Wikipedia.org

- Productive efficiency is achieved when output reflects the lowest cost combination of input factors
  - B, D, and C are on the efficient frontier
  - X costs more, and is therefore less efficient
  - A costs less, but is not viable
- For the electricity system, factors of production include centralized and decentralized resources
- Productive efficiency requires allocative efficiency
- *Both allocative and productive efficiencies require an accurate understanding of costs*

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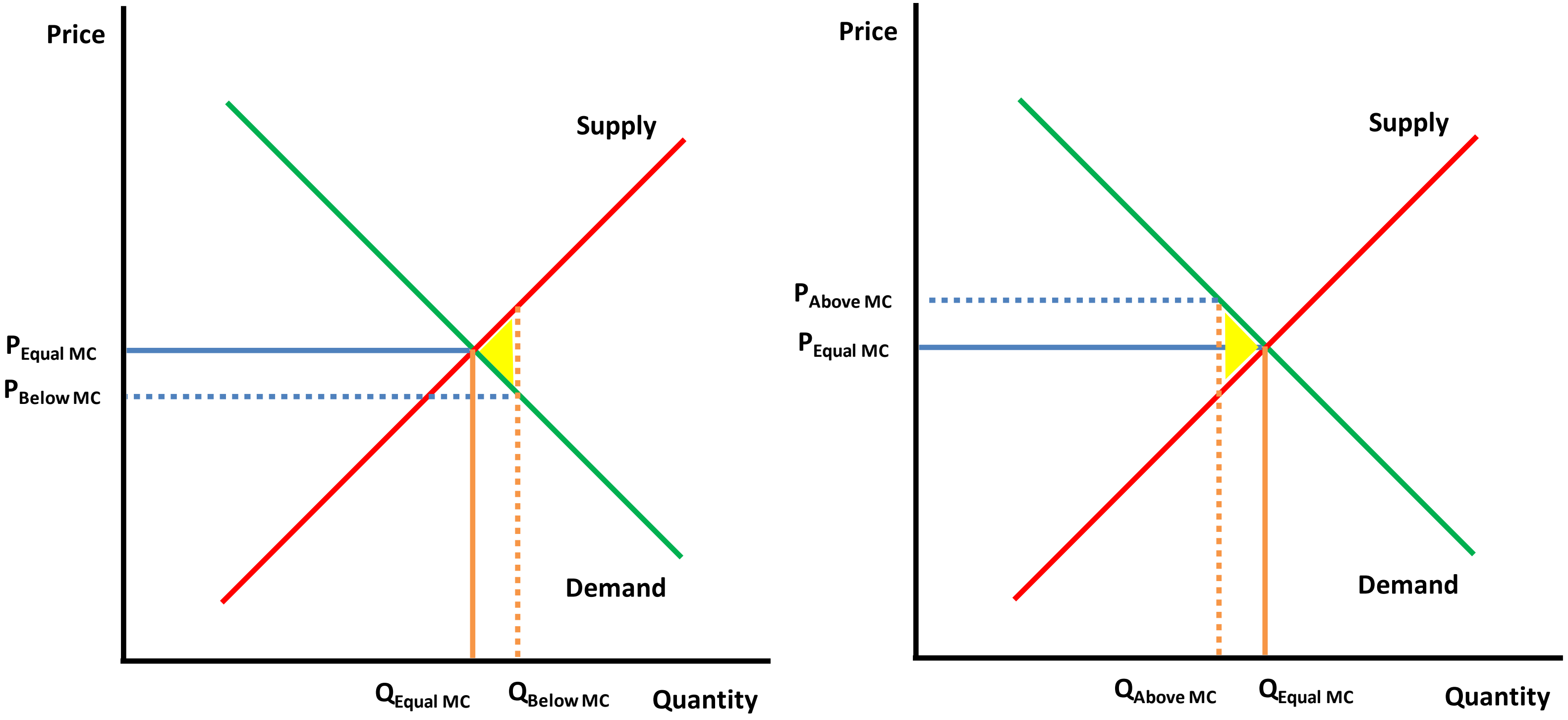
Economic Efficiency – Allocative

Why Marginal Revenue (Price) Should Equal Marginal Cost



- Allocative efficiency occurs when Marginal Revenue (MR) = Marginal Cost (MC)
- 'Marginal Revenue' is another way of saying 'Price'
- When Marginal Revenue is not equal to Marginal Cost , it leads to economic inefficiency
  - Over/under consumption
  - Over/under production
- Cross-subsidies are often involved
  - Especially in regulated sectors, where revenue recovery is assured

Source: Wikipedia.org

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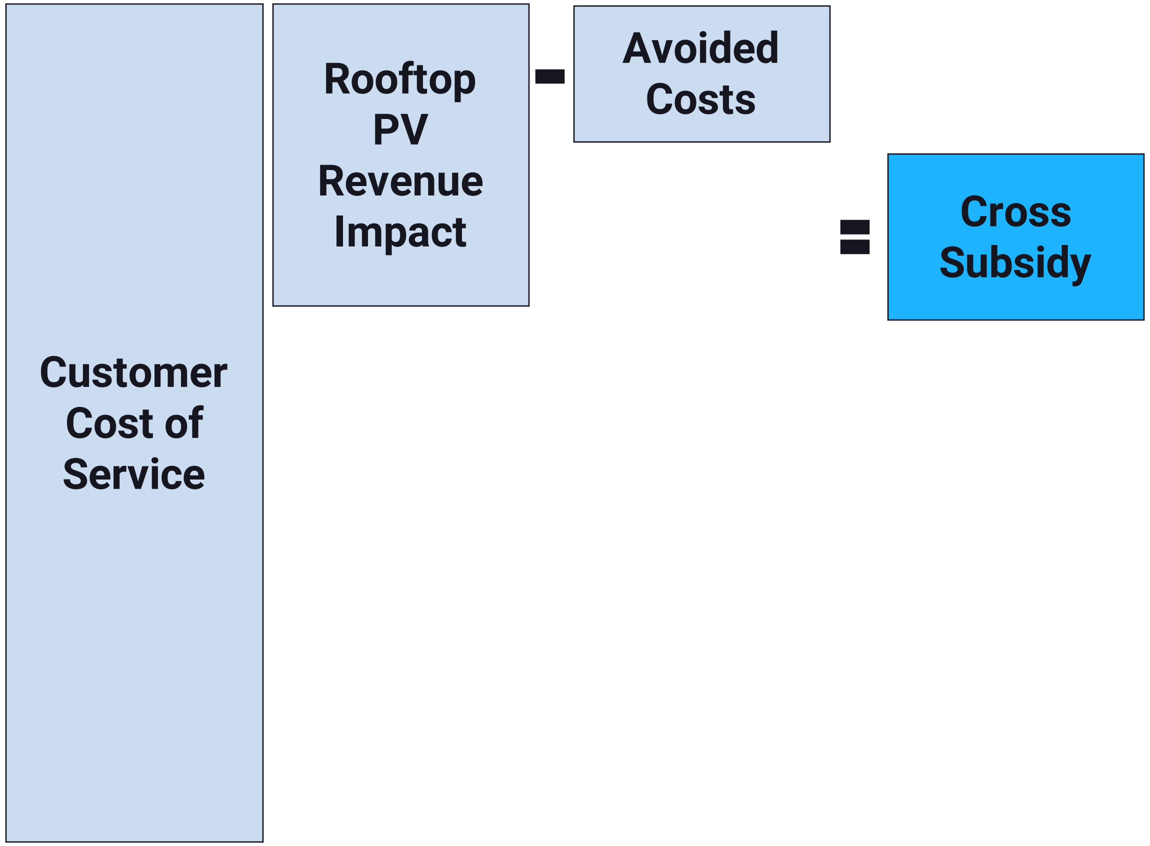
Allocative Efficiency – Worked Example

Illustration of Inefficient Solar PV Incentives



Source: Energeia

- Example to the left shows how inefficient rate designs lead to marginal revenues not equaling marginal costs
- In this case, solar PV is able to reduce bills (MR) more than they reduce the cost of serving the customer (MC)
- This leads to a cross-subsidy of solar PV, increasing inefficient adoption of solar PV
- The opposite can also be true, e.g. where EV charging is charged more than the marginal cost, leading to lower than efficient levels of demand for EV charging

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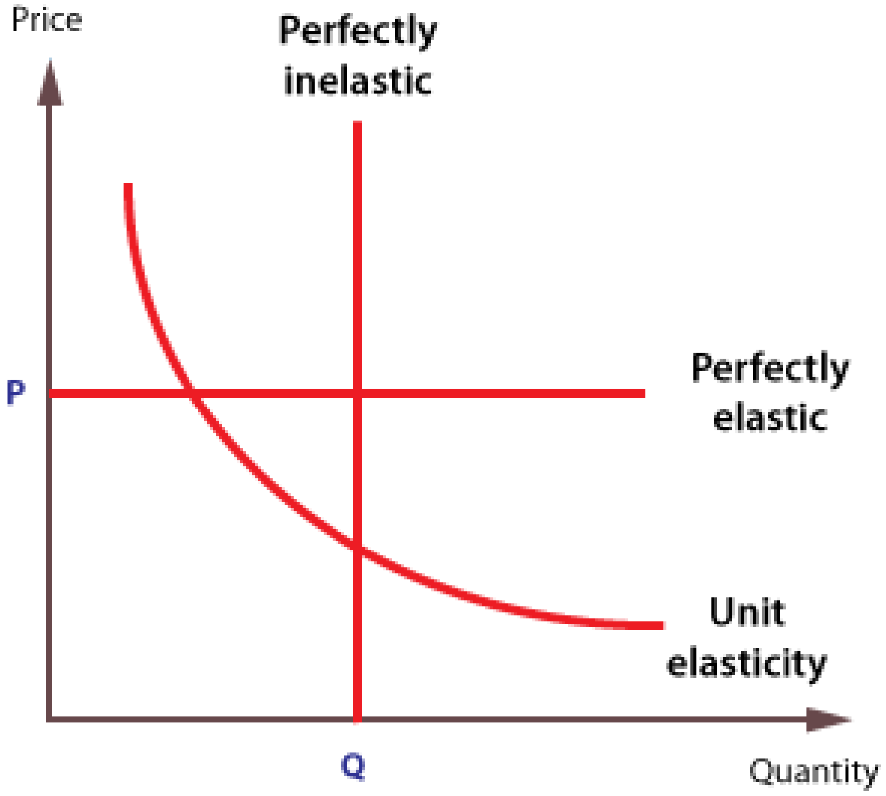
Price Elasticity of Demand

Examples of Customer Price Responses



Source: www.economicsonline.co.uk

- Price Elasticity of Demand, refers to the change in demand given a change in price
- In electricity, consumer price elasticity is traditionally viewed as almost perfectly elastic in the short-term
- Most electricity uses, e.g. lighting, motors, hot water, etc., are needed when turned on and difficult to substitute
- However, this is changing dramatically with more flexible loads, including EV charging, battery storage, and AI-based control
  - Inefficient prices will waste DER at best, and increase costs at worst
    - New peaks at the start of the off-peak
    - Investment in duplicative consumer and utility infrastructure
  - Efficient prices will support productive and allocative efficiency
- Price elasticity is an important concept in pricing theory, just ask Mr. Ramsey (we'll get to him next)

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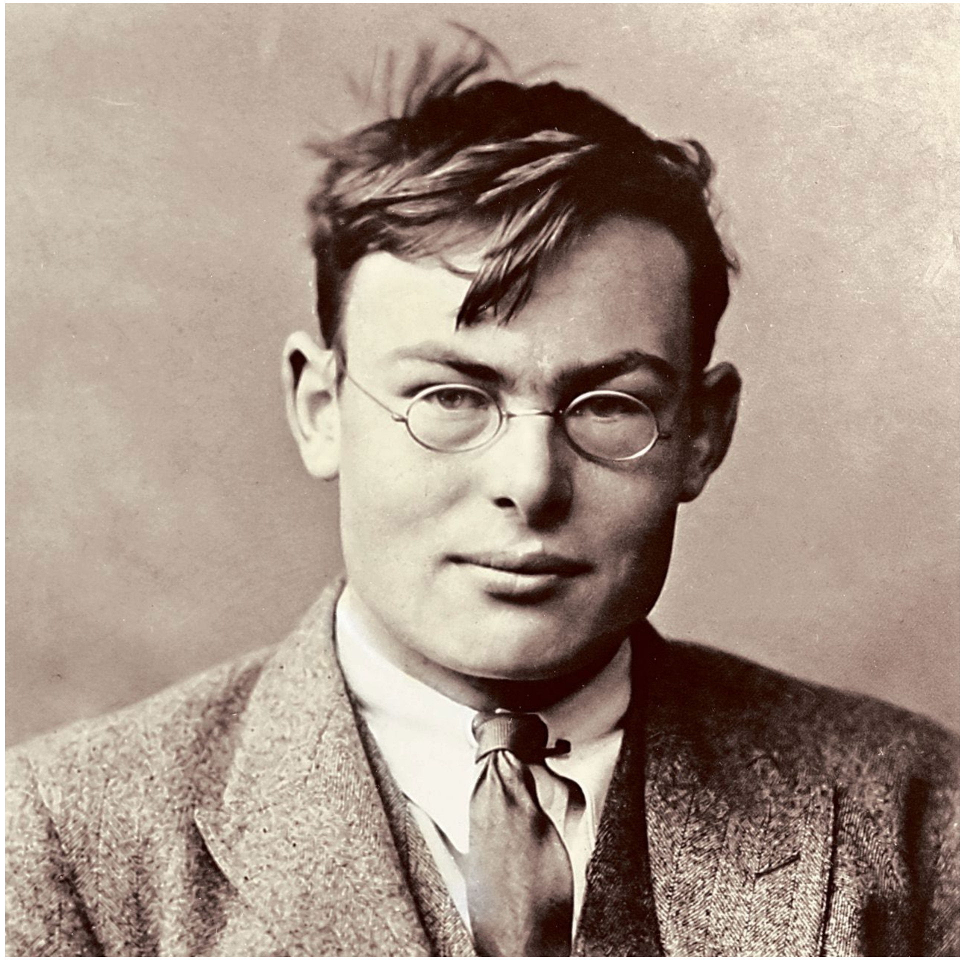
Ramsey Pricing

Frank Ramsey (1903-1930)



Source: wsj.com

- *Given emerging DER is able to significantly reduce consumption, and using battery storage, able to be highly flexible, how should residual costs be allocated?*
- Frank Ramsey proposed Ramsey Pricing in his 1927 article, "A Contribution to the Theory of Taxation"
- Ramsey Pricing maximizes social welfare by charging higher prices to groups with less elastic demand
- Ramsey Pricing segments the market by differentiating consumer groups and charging different prices based on perceived or assumed consumers' price elasticity
- Ramsey Pricing maximizes economic welfare subject to firms *achieving given profit targets*
- Its primary application in electricity rates and incentives lie in where residual costs are best recovered, i.e.
  - Those with less elastic demand, e.g. wealthy, those unable to invest in flexible technology, e.g. renters, apartment dwellers, etc.
  - Raises equity issues, but ignoring his advice likely to lead to greater defection – are fixed tariffs or exit fees the answer?

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Best Practice Rate and DER Incentive Design

Congestion

Long-Run-Marginal-Cost

Tariff Design

Incentive Design

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‘Appropriate’ Period Classification

Source: Energeia, ECA (2020)

- Peak Period = Times most likely to trigger additional investment (congested)
  - Asset weighted
  - Forward looking
  - Weather normalized
- Accurate period definition critical for MR = MC
  - Analysis shown suggests periods are wrong 95% of the time
- Longer peak periods are often used to ensure all assets are *covered* reducing efficiency

		Zone Sub is:	
		Peak	**Offpeak**
Pricing is:	**Peak**	Correct Peak	Overcharge
	Off Peak	Undercharge	Correct Offpeak

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Benchmarking Period Classifcation – Australia

Peak Period Methodology	NSW			QLD		ACT	VIC				SA	TAS	
	Ausgrid	Endeavour	Essential	Energex	Ergon	Evoenergy	AusNet	Jemena	Citpower / Powercor	United	SA Power	TasNetworks	Energeia
Coincident Peak Node	System	System	System and Asset	System and Asset	System	System	System	System	System and Asset	System	System	System	System and Asset
Years Considered	6	3	2	1	1?	1	1	1	8	1	5	?	5
Customer Classes Considered	✗	✗	✗	✓	✓	✓	✗	✗	✗	✗	✓	✗	✗
Definition of the Peak Period	Top 48 Annual Peak Demand Periods Summer/ Winter	Top 10% of Daily Peak Demand	Daily Peak Demand Summer/Winter	Residential – Average Daily Peak Demand Business - Top 1% of Monthly ZS Peak Demand	Average Daily Peak Demand Summer/Winter	Average Daily Peak Demand	Peak Demand timing of a Peak and Average Day	Daily Demand Peaks of 5 Highest Peak Summer Days	Daily Demand Peak of Example Summer/ Winter Day, Daily Peak ZS Demand Observations	Daily Peak Demand Summer/Winter	Daily Demand Peaks of Specific Peak Demand Events	?	Periods >=95% of annual peak hour
Definition of the Shoulder Period	?	Daily Demand Within Top 10-20% of Peak	?	?	?	?	?	?	?	?	?	?	Periods >=90% of peak
Weather Normalisation	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓
Forecast Demand	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓

Source: Energeia Research, DNSP Tariff Structure Statements

- Use of system peak timing means timing may be poorly aligned to actual period of greatest infrastructure (i.e. spatial asset) utilization
- Peak period definition varies greatly, with significant impacts on pricing levels
- Current methodologies are backward looking and not weather normalized
- Period of peak solar PV or storage utilization reflects similar diversity in approaches and outcomes as for load

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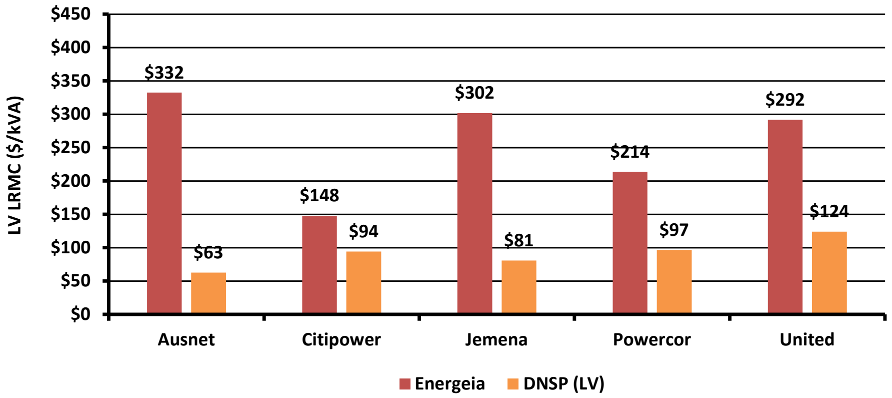
Long-Run-Marginal-Cost (LRMC)

LRMC with 100% Replacement Expenditure



Source: Energeia, Victorian DNSP

- LRMCs should reflect all future costs, discounted to present value
  - Long-run = Period over which all costs are variable
- LRMCs are likely 2-5 times too low, leading to substantial over consumption of the grid during the peak
  - LRMC often excludes replacement investments
- Additional uneconomic investment likely to make utilities uncompetitive with rooftop solar and storage

Asset Replace/Refurbish	Sub-Trans	Zone S/Stn	HV Feeder	Dist T/F	LV Feeder	Not Aug
Lines						
Planned						
Cable Replacement - Planned			15%		10%	75%
Conductor Replacement - Planned			15%		10%	75%
Line Ancillary Equipment - Planned (incl LFIs, fences, gates, signs etc)						100%
Line Regulation - Planned (incl regulators, capacitors)						100%
Overhead Line Components - Planned (incl insulators, crossarms, taps, pole earths)						100%
Poles - Planned						100%
Recloser Refurbishment - Planned						100%
Recloser Replacement - Planned						100%
Services Replacement - Planned					15%	85%
Strategic Line Maintenance Spares						100%
Switchgear - Ground Level - Planned						100%
Switchgear - Overhead - Planned						100%
Transformers - Planned				25%		75%
Poles - Planned plating						100%
Recloser Maintenance - Planned						100%
Pole Replacement Projects						100%
CBD ducts & manholes						100%
Cables - CBD 11kV PILC cable replacements						100%
Services - Aluminium neutral screen service line replacements						100%
Unplanned						
Cable Replacement - Unplanned			15%		10%	75%
Line Ancillary Equipment - Unplanned (incl LFIs, fences, gates, signs etc)						100%
Line Regulation - Unplanned (incl regulators, capacitors)						100%
Overhead Line Components - Unplanned (incl insulators, Xarms, pole earths)						100%
Poles - Unplanned						100%
Recloser Replacement - Unplanned						100%
Services Replacement - Unplanned					15%	85%
Switchgear - Ground Level - Unplanned						100%
Switchgear - Overhead - Unplanned						100%
Transformers - Unplanned				25%		75%
Other						100%
Substations						
Auxillary DC Supplies excl AC - Battery Banks & Chargers						100%
Capacitor Banks - CAPACITY UPGRADE?						100%
Circuit Breakers Planned Replacement		10%				90%
Circuit Breakers Planned Refurb		25%				75%
Mobile Substations		25%				75%
Protection Relays (Replace 33kV/66kV Fuses, incl Fault Thrower)						100%
Substation Insurance Spares & Asset Mgt						100%
Substation Infrastructure - Civil (incl buildings, structures)						100%
Substation Transformer Repl.		25%				75%
TF Refurb (18665 & 18977)						100%
Planned Transformer Refurbishment - also done under 18665						100%
Surge Arrester						100%
Carryover (subs)						100%
AC Panels + auxilary supply						100%
Protection Asset Replacement						100%
Unplanned CB Replacement		25%				75%
Standby Power Station						100%
Unplanned Substation Asset Repl - PROTECTION						100%
Other (sub cables)						100%
Northfield 66kV GIS Switchboard replacement (1/3rd)		25%				75%
MOD3C Substation Upgrades (trf to 18665)						100%
Substation Standards Templates and CU Developments						100%
Relay Replace on Failure						100%
Cable replacement & Cable Termination Support upgrade (tfr to other)						100%
GIS Assessment and Refurbishment						100%
Transformer planned replacement due to condition						100%

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Long-Run-Marginal-Cost Benchmarking – Australia

		VIC				NSW			QLD		ACT	SA	TAS	NT	
		AusNet	Jemena	CitiPower / Powercor	United	Ausgrid	Endeavour	Essential	Energex	Ergon	Evoenergy	SA Power	Tas Networks	Power and Water	Energeia
Demand incl. in LRMC	P10/P50/Raw	P50	Raw	Raw	-	P50	P50	Raw	Raw	Raw	Raw	P10	-		P10
	NCMD/CMD	NCMD	CMD	NCMD	-	-	NCMD	CMD	NCMD	CMD	CMD	CMD	-	CMD	NCMD
	NCMD Basis	ZS	-	ZS	-	-	ZS	-	-	-	-	-	-		ZS
% Expenditure incl. vs. AER FD	Repex	10%	0%	0%	-	1%	142%	10%	-	-	0%	9%	-	5%	50%
	Augex	0%	6%	174%	-	40%	27%	18%	-	-	89%	69%	-	97%	100%
	Connex	0%	21%	0%	-		43%		-	-	109%	0%	-	0%	0%
	Opex %	1.0%	4.3%	0.5%	-	2.0%	2.0%	-	1.5%-2.5%[1]	1.5%-2.5%[1]	2.0%	1.5%-2%	4.5%	2.3%	2.3%
Time	LRMC Start Year	FY20	FY19	CY16	CY11	FY19	FY19	FY18	FY19	FY19	CY18	FY16	FY20	FY20	FY20
	Actual Years in LRMC	FY20	CY19-20	CY16-20	CY11-20	FY19-20	FY19	FY17-19	FY19	FY19	CY18	FY16-20	FY17-19	-	-
	Forecast Years in LRMC	FY21-30	FY22-29	CY21-25	-	FY21-38	FY20-28	FY20-32	-	-	CY19-27	FY21-38	FY20-29	FY20-FY37	FY20-FY44
	Total Years in LRMC	11	11	10	10	20	10	15	-	-	10	23	10	18	25

Source: Energeia Research, DNSP Tariff Structure Statements

- Again, significant variation in how LRMC is calculated across Australian utilities
- Costs included vary from 0% to 100% across peak, replacement and customer driven expenditure
- Assumed operational expenditures vary from 1%-4.5%
- Total years varies from 10 to 25, but none reflect 'Period over which all costs are variable' reducing estimate accordingly
- Much of the focus to date has been on whether to use Average Incremental Cost or the Perturbation Method
- Cost stack for solar PV or battery storage depends on who it is serving, ***if not exporting, then it is just the LV circuit***

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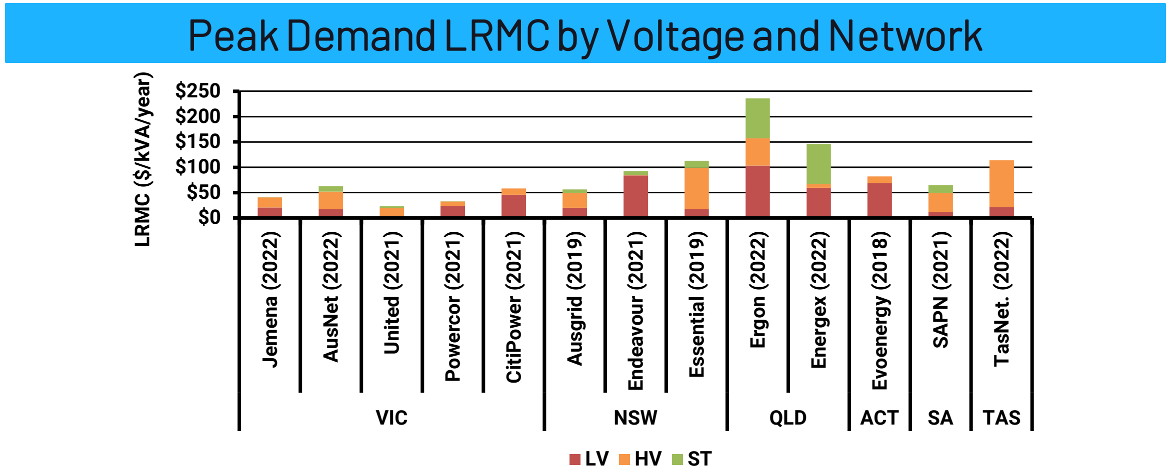
What is the Long-Run-Marginal-Cost of DER?



Source: Various DNSPs

- Analysis shows that low voltage (LV) costs represent a significant fraction of total LRMC
  - Classification of LV vs. HV main reason for discrepancies
- Prosumers drive additional costs
  - Voltage compensation costs
  - Load balancing costs
  - Integration costs, e.g. DERMS and other operational technology
- ‘Prosumers’ serving neighbors, i.e. without any back feeding, only using LV assets, and should not be subsidizing other consumers
  - Avoided costs could be paid to CER provider
  - Avoided transmission cost methodology could offer near-term pathway to realizing distributed benefits
- DER cost recovery applied to peak export periods in Australia

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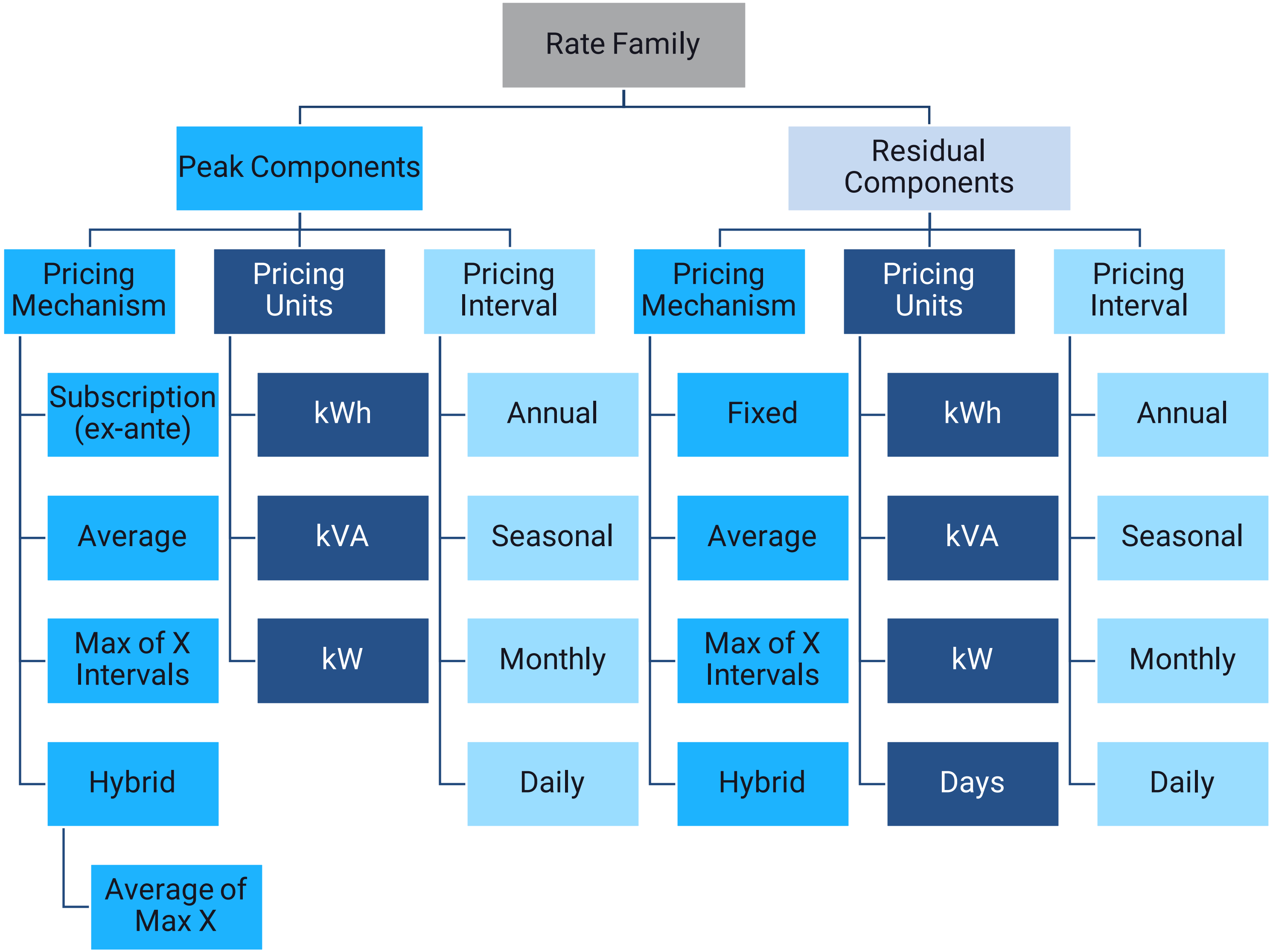
Rate Design Options



- A ratetypically includes one or more peak components to signal MC and one or more residual components
- There are an infinite number of potential rate designs, the question is, which are efficient, i.e. MC = MR
  - Bill level
  - Cost driver level, e.g. peak demand

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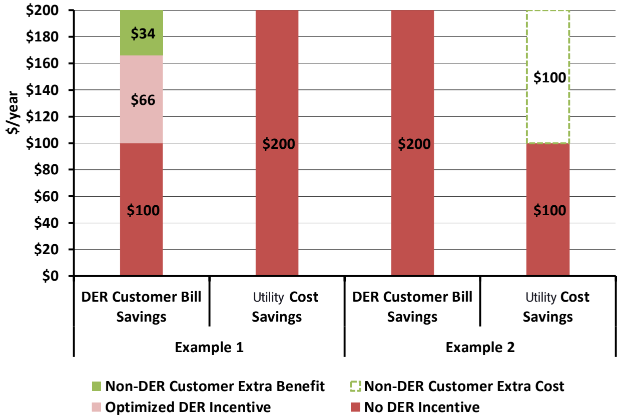
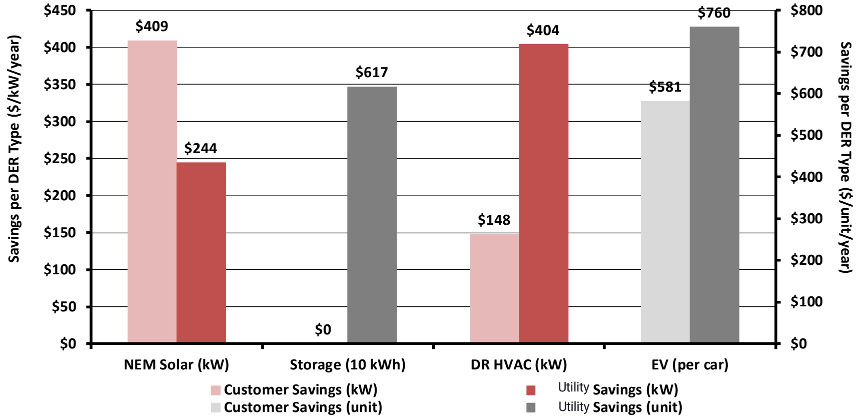
Complementary Use of Incentives for DER

Illustration of Incentives to Compensate for Rate Limitations



Source: Energeia

Illustration of MR vs. MC by Consumer Energy Resource



Source: Energeia

- Rates are highly politicized, and many customers are on an anytime, kWh-based rate with low price elasticity
- Moving them on to a cost-reflective rate may not be practical in the near term
- Offering incentives via rebates, etc., can achieve similar outcomes on a more targeted, easier-to-implement basis
- Example 1 shows how an optimized DER incentive can fill the gap, keeping some value for non-participants
- Example 2 is the solar PV situation and mandatory assignment to a more cost-reflective rate-only option
- The bottom left figure calculates marginal cost and marginal revenue by CER, showing the appropriate incentive level

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Best Practice Case Study

Rate Analysis

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Modeling of Tariff Design Impacts on Efficiency and Fairness

Description	Peak Mechanism							Residual Mechanism							
	Monthly Maximum Demand	Yearly Maximum Demand	Average Top Four Daily Maximum Demand	Average Monthly Demand	Monthly Maximum Demand with Threshold	Average Top Four Daily Maximum Demand with Threshold	Monthly Maximum Demand in Shoulder	Yearly Off Peak Maximum Demand	Monthly Off Peak Maximum Demand	Monthly Off Peak Maximum Demand with Threshold	Off Peak Energy	Off Peak Energy with Threshold	Anytime Energy	Anytime Energy with Threshold	Daily Fixed Charge
	MMD	YMD	ATF	AMD	MMD-Th	ATF-Th	SH	YOPD	OPD	OPD-Th	OPE	OPE-Th	ATE	ATE-Th	F
1 MMD/OPD/OPE/F	✓								✓		✓				✓
2 MMD/OPD/ATE/F	✓								✓				✓		✓
3 MMD/OPD/F	✓								✓						✓
4 MMD/OPE/F	✓										✓				✓
5 YMD/OPD/OPE/F		✓							✓		✓				✓
6 MMD/YOPD/F	✓							✓							✓
7 MMD/OPD-Th/F	✓									✓					✓
8 MMD/SH/OPD/OPE/F	✓						✓		✓		✓				✓
9 ATF/OPD/ATE/F			✓						✓				✓		✓
10 ATF/OPE/F			✓								✓				✓
11 ATF/YOPD/F			✓					✓							✓
12 AMD/OPD/ATE/F				✓					✓				✓		✓
13 AMD/OPE/F				✓							✓				✓
14 AMD/YOPD/F				✓				✓							✓
15 ATF-Th/OPD/ATE/F						✓			✓				✓		✓
16 MMD-Th/OPD-Th/ATE/F					✓					✓			✓		✓
17 MMD/OPD-Th/ATE	✓									✓			✓		
18 MMD/OPD-Th/ATE/F	✓									✓			✓		✓

- A wide range of rate designs are possible
- It is almost impossible to determine which achieves allocative efficiency and Ramsey pricing best in advance due to CER complexity
- Simulation best method: we use uSim to test

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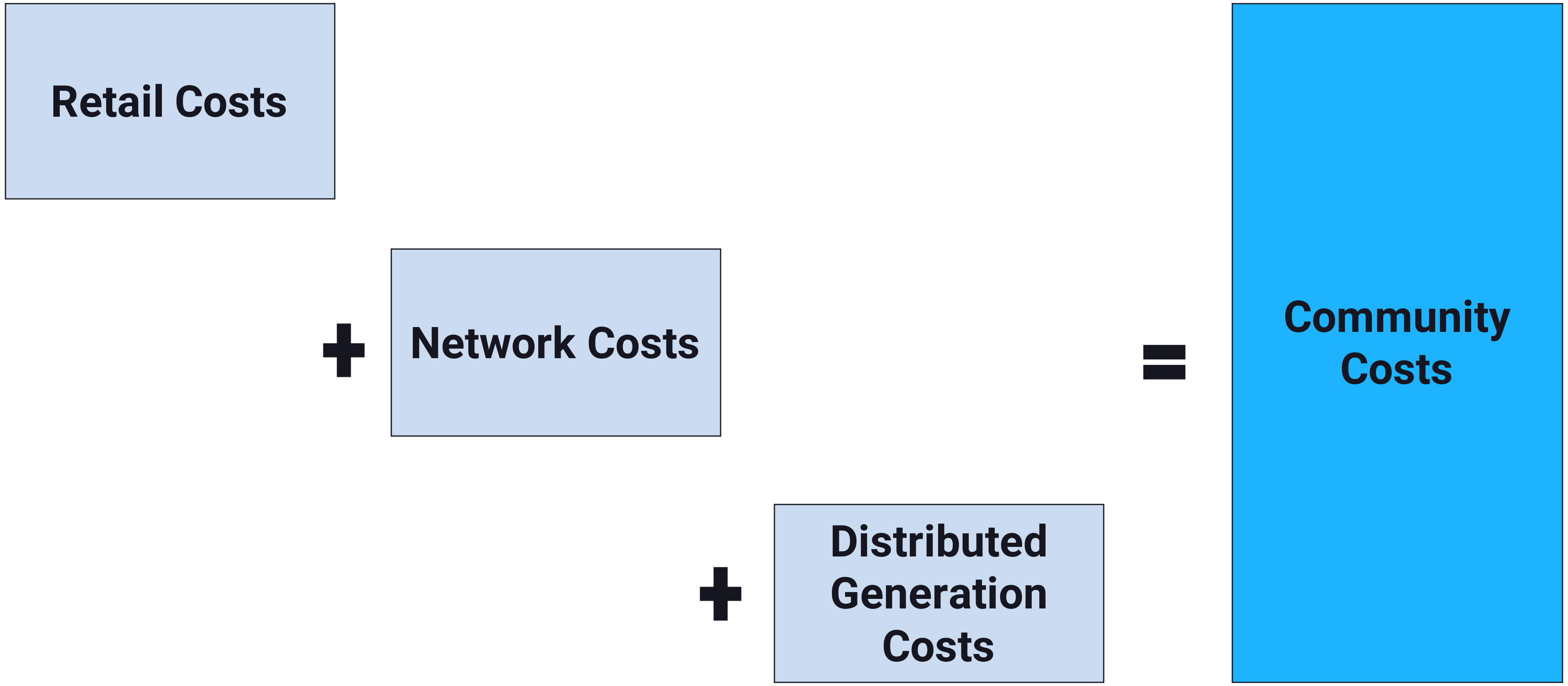
Allocative Efficiency – Worked Example



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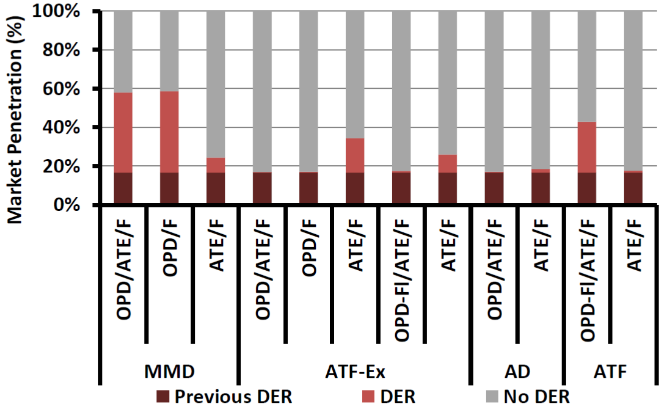
Impacts of Rate Design on DER Adoption and Configuration

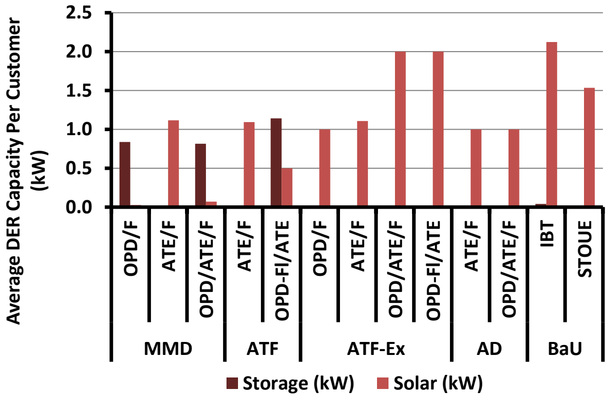
10-year Solar PV and Storage Penetration Rates



Source: Energeia modeling

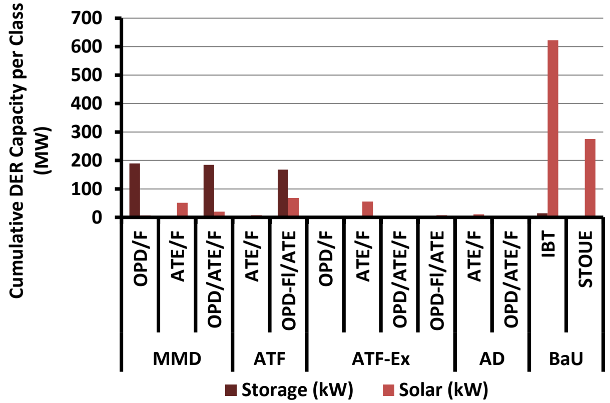
- Different, cost-reflective rate designs resulted in different solar PV and storage adoption patterns
- Inclining block and seasonal Time-of-Use energy rates showed the greatest levels of solar PV adoption
- This analysis reflects the cost structure and DER prices at the time (~10 years ago), and looks very different today

Average Solar PV and Storage System per Customer



Source: Energeia modeling

Cumulative Solar PV and Storage System Capacity



Source: Energeia modeling

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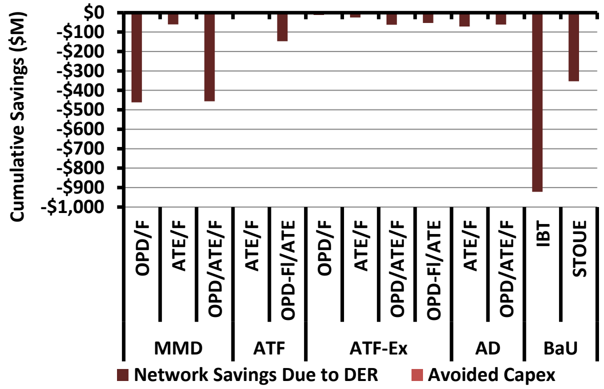
Impacts of Tariff Design on Cross-Subsidies, Costs and Prices

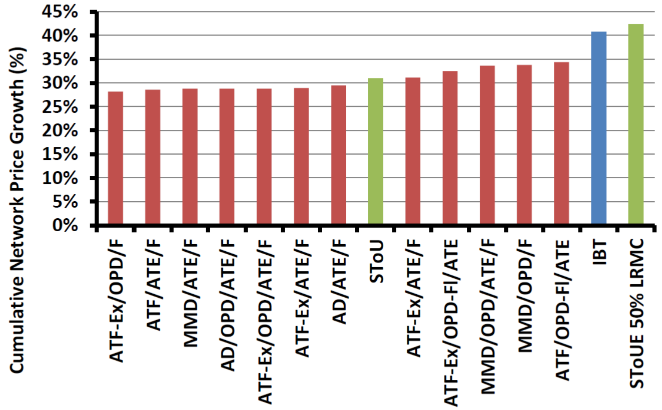
Consumer Network Bill Savings vs. Avoided Network Costs (Capex)



Source: Energeia modeling

- Different, cost-reflective rate designs resulted in different levels of efficiency
- Getting prices closer to costs saved over $1b for a utility with ~600k customers and minimised cross-subsidies

10-Year Cumulative Network Price Growth by Tariff Design



Source: Energeia modeling

Community Cost and Cross Subsidy Impacts by Tariff Design

Tariff	Comm Cost (Millions $PV)	Cross Subsidy (Millions $PV)
ATF-Ex/OPD-FI/ATE	$0	$4
AD/OPD/ATE/F	$19	$0
ATF-Ex/OPD/ATE/F	$25	$2
AD/ATE/F	$29	$3
ATF-Ex/OPD/F	$34	$1
ATF/ATE/F	$47	$0
MMD/ATE/F	$94	$4
ATF-Ex/ATE/F	$108	$39
ATF-Ex/ATE/F	$108	$39
MMD/OPD/ATE/F	$306	$78
ATF/OPD-FI/ATE	$336	$6
MMD/OPD/F	$397	$91
SToU	$621	$20
BaU	$1,108	$101

Source: Energeia modeling

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Key Takeaways and Recommendations

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Key Takeaways and Recommendations

- Key Takeaways
  - Rates and incentives are a primary driver of DER adoption and operation
  - Virtually all rates and incentives do not reflect key economic principles, resulting in inefficient adoption and operation
  - Key reforms needed include unbundling, locational, accurate LRMC and period calculation, and fair and efficient residual cost allocation
  - Efficient rate and incentives will deliver 2-3 times more DER, in the right places, at the right times, in the right mix
  - Reform will not increase costs for the disadvantaged or undermine efficient network investment or operation
- Key Recommendations
  - A rule change is probably needed to unbundle rates, ensure an optional rate is made available and is designed correctly
  - Real-time pricing is nice to have, but 90% of benefits will come from unbundling and improved cost and period accuracy

$$E = mc^2$$

2nd Law of Thermodynamics:

1. Heat flows spontaneously from a hot body to a cool one.
2. One cannot convert heat completely into useful work.
3. Every isolated system becomes disordered in time.

$$MR = MC$$

It's not just a nifty idea, it's the law…

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Thank You!

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