Rate Design

CliffsNotes on the ‘art’ element of designing rates to reflect the cost of providing services to different customer types while promoting the efficient use of resources.

Disclaimer

This presentation was prepared by Christopher Mickelson exclusively for the benefit and internal use of the participants of the *2022 Michigan State Institute of Public Utilities Advanced Course*. No part of it may be circulated, quoted, or reproduced for distribution without prior written approval from Christopher Mickelson.

Agenda

DEFINITIONS

OVERVIEW

STRUCTURE TYPES

COMPETITIVE MARKETS

CHANGES AND CHALLENGES

MOCKUP

Definitions

- Energy: is measured as the force times the distance through which it acts.
  - Equates to work.
  - Measured in watt-hours (Wh).
  - Expressed in kilowatt-hours (kWh) or megawatt-hours (MWh).

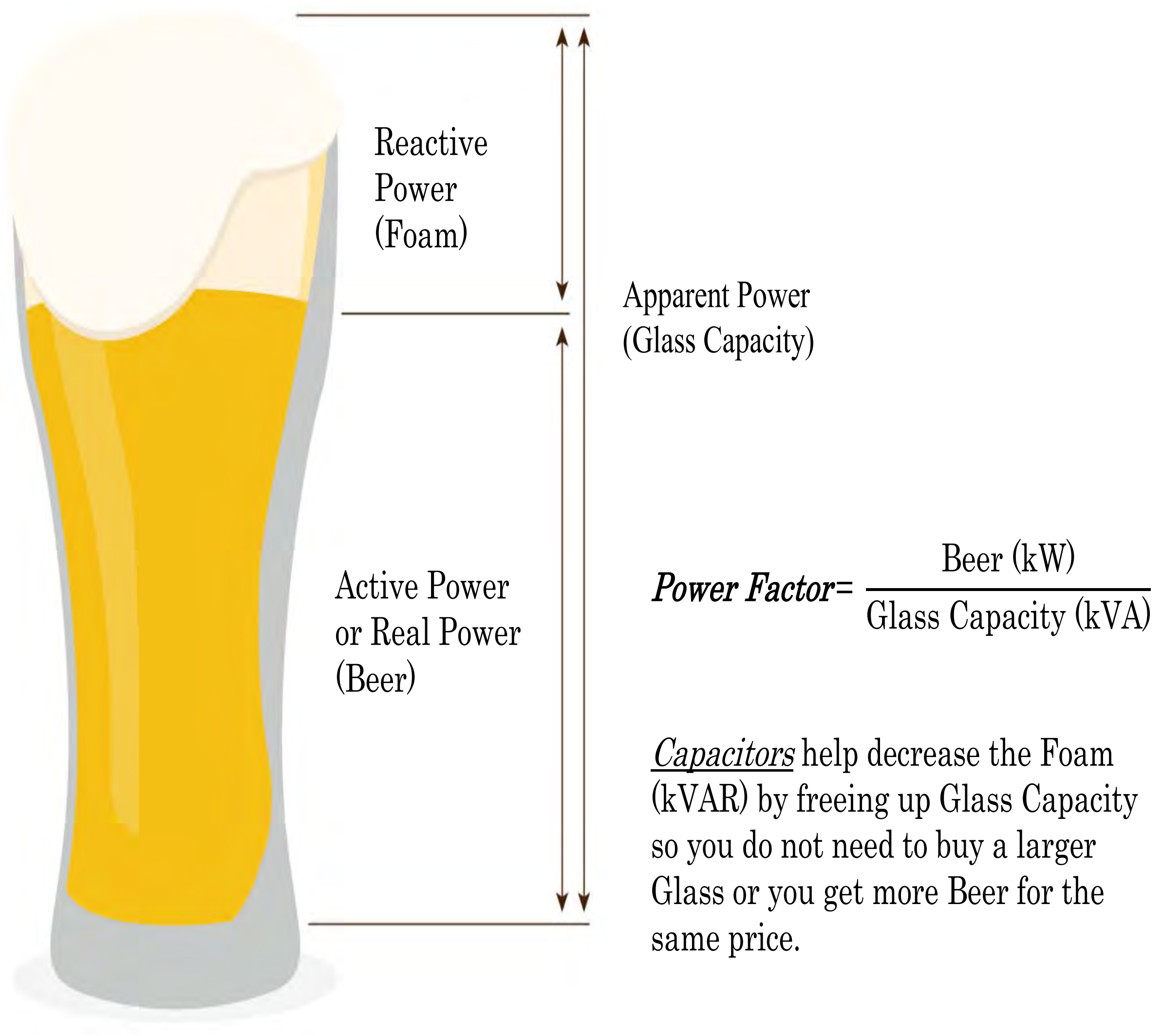
- Demand: the work done over a designated time interval.
  - Equates to power.
  - Measured in watts (W).
  - Expressed in kilowatts (kW) or megawatts (MW).

Definitions (Continued)

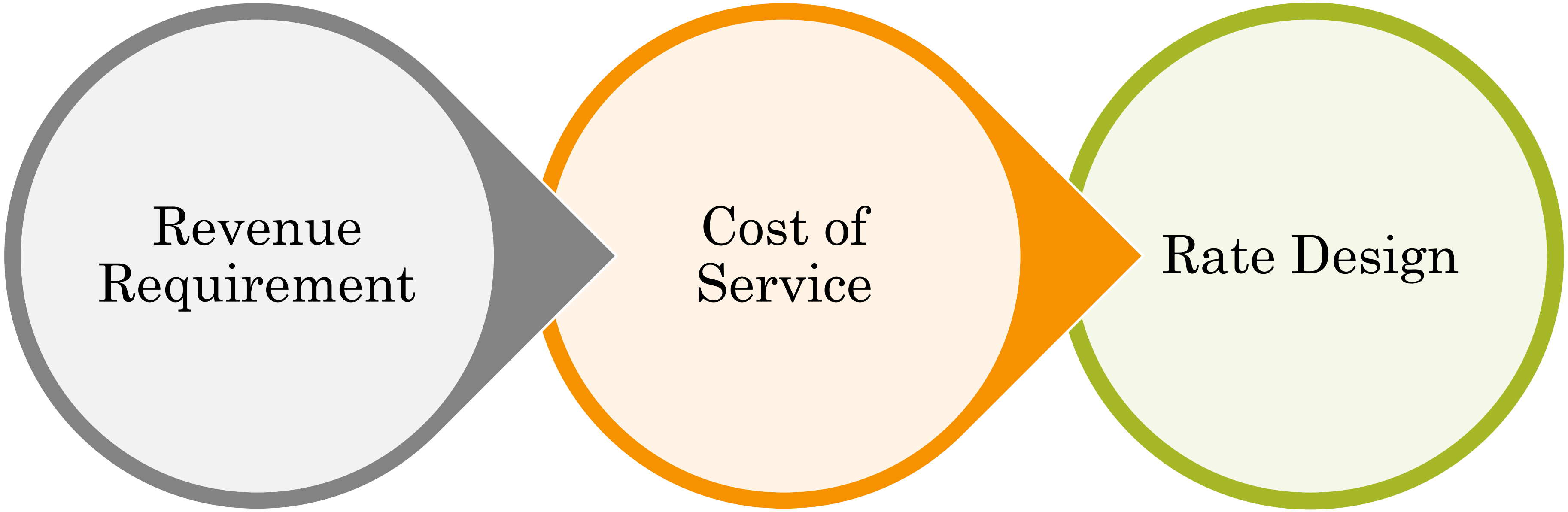
- Load Factor – measure of average use to maximum demand, or efficiency of electrical energy usage.
  - [kWh / (kW * Hours)] x 100 = LF%

- Power Factor – is used to express the relationship between "useless current" and "useful power" on a scale of 0 to 1.

Both help demonstrate different types of efficient and utilization use of electricity.



Traditional Ratemaking Overview



Privileged and Confidential

What is the Purpose

- Statue mandates a utility to establish 'just and reasonable' rates.
  - Protect the shareholder's interest by allowing the utility a reasonable *opportunity* to earn a fair rate of return on its investment.
  - Protect the ratepayer's interest by assuring safe, reliable, and reasonably priced services.
  - Rates serve as the means by which the utility collects revenues and covers its allowed cost of service, including that which is required under the fair-return standard.
  - Rates induce particular behaviors on the part of customers.
- Set rates that reflect costs and produces sufficient revenue requirement for each customer class.
  - If possible, set rates equal to cost to serve.
- Avoid unjust or undue discrimination within customer classes.
- Natural Monopoly: Law of supply and demand does not apply.

Utility Tariff

A tariff is a document, approved by a regulatory body, listing the terms and conditions under which utility services will be provided to customers.

Elements included in a tariff are:

- Rules and Regulations Statement of the general practices the utility follows in carrying out its business with its customers.
- Rate Schedules for each customer class that provides all of the individual rate component prices plus the provisions necessary for billing.
- Service Characteristics (*e.g.*, voltage, single or three phase) and metering methods.

CITY OF AUSTIN
ELECTRIC TARIFF

Lighting

Application:
Applies to any customer whose point of delivery is located within the limits of Austin Energy's service territory. For non-metered lighting accounts, the supply of electricity is determined by the number of hours of operation based on hours of darkness. The rate tables below reflect rates with effective dates of November 1, 2018.

Character of Service:
Service provided under these rate schedules are pursuant to City Code Chapter 15-9 (*Utility Service Regulations*) and the City of Austin Utility Criteria Manual, as both may be amended from time to time, and such other rules and regulations as may be prescribed by the City of Austin. Electric service of one standard character will be delivered to one point of service on the customer's premises and measured through one meter unless, at Austin Energy's sole discretion, additional metering is required.

Terms and Conditions:
Customers shall permit Austin Energy to install all equipment necessary for metering and permit reasonable access to all electric service facilities installed by Austin Energy for inspection, maintenance, repair, removal, or data recording purposes. All non-kilowatt-hour charges under this schedule remain unaffected by the application of any rider.

For information on other applicable rates (i.e., power supply adjustment, community benefit, and regulatory), please see corresponding schedules in this tariff (if applicable). For definition of charges listed below, see "Glossary of Terms" at the back of this tariff.

Discounts:
For any Independent School District, Military base as outlined in the Public Utility Regulatory Act §36.354, or State facilities, the monthly customer-, delivery-, demand-, and energy-charges billed pursuant to these rate schedules will be discounted by 20 percent; all other electric charges will be billed pursuant to these rate schedules and will not be discounted.

Rider Schedules:
Service under these rate schedules is eligible for application of the GreenChoice® Rider.

City of Austin - Owned Outdoor Lighting

This rate applies to electric service to non-metered outdoor lighting owned and operated by the City of Austin other than Service Area Lighting.

	Summer (June through September)	**Non-Summer** (October through May)
Fixture Charges ($/fixture/month)		
100 Watt or Less (Billable 35 kWh)	$7.03	$7.03
101 - 175 Watt (Billable 60 kWh)	$12.05	$12.05
176 - 250 Watt (Billable 90 kWh)	$18.07	$18.07
251 Watt or Greater (Billable 140 kWh)	$28.12	$28.12
Power Supply Adjustment Charge ($/kWh)		
Billed kWhs	$0.03007	$0.02936

The ‘Art’ Element

Bonbright’s Pricing Attributes (1961)

1. Simplicity and public acceptability.
2. Freedom from controversy.
3. Revenue sufficiency.
4. Revenue stability.
5. Stability of rates.
6. Fairness in apportionment of total costs.
7. Avoidance of undue rate discrimination.
8. Encouragement of efficiency.

Components of Rate Design

- Determined during a general rate case, sometimes referred to as base rates, and are set until the next general rate case.
- Customer Charge: also referred as fixed charge, is a recurring charge that appears on a utility bill each month independent of actual consumption.
  - Reflect the minimum equipment and service needed to access the grid.
    - The level of the customer charge can be a very contentious area within a general rate case, and rarely reflects the true fixed costs associated with serving a customer.
  - These costs do not vary with consumption:
    - Meters, reading, and billing.
    - Service drops and Transformers.
- Demand Charge: is designed to incentivize customers to use the grid as efficiently as possible.
  - Cost imposed on the system by the user's maximum load.
  - Typically, not applied to residential.
- Energy Charge: is a volumetric charge that covers (typically) incremental cost of each unit of service.

Each of the above could be segmented by season, time, or consumption.

Development of Rate Components

- In general, the units that are divided into a customer class cost are referred to as 'billing determinants':
  - Customer billing determinants are total number of customers in the class multiplied by 12.
  - Demand billing determinants are the total billed demand which is the sum of the individual customers' demands in the class (typically the individual customers' NCP demands) over all 12 months in the test year.
    - Average Monthly Billing Demand is the annual billing demand divided by 12 months.
  - Energy billing determinants are the total class energy consumption.
- We have a revenue requirement, or cost to service, for each customer class (or 'rate class').
  - Identify desired rate elements for each rate class and how much annual cost is to be recovered from that element.
  - Determine the ***adjusted*** annual billing determinants for each rate element.
- The manner in which charges are calculated must be consistent with the manner in which individual customers are metered; otherwise, the utility will over or under collect.

Rate Adjustments

- It is reasonable and administratively more convent to have some elements of the cost-of-service adjust on a periodic basis in a formulary manner where the mechanism reconciles to an actual expenditure.
- Common elements that adopt this treatment:
  - Fuel and Power Supply Expenses.
  - Expenditures for Energy Efficiency.
- How does a reconciling work?
  - Are any portion of the costs captured in base rates?
  - Impacts on pricing design.
- Reconciling and regulatory review
  - Does not mean the costs recovered in the adjustment clause are not reviewed.
  - Traditional standard of prudency is generally applied.
  - Trackers, riders, and adjustment mechanisms are special rate elements used to recover costs that vary greatly outside the control of the utility.

Increasing Customer Charge

- Advantages
  - Stabilizes company's revenue and cash-flow.
  - Better aligns the recovery of fixed cost to that of fixed revenues.
  - Some argue that cost-causation promotes higher customer charge.
- Disadvantages
  - Increases the bills for below-average energy consumption customers.
  - Positive correlation between kWh consumption and kW demand-related costs.
  - Disproportionately, affects low usage and low-income households.

Demand Charge Debate

- Arguments Against:
  - Engineering concept with no place in pricing theory.
  - Prices should be volumetric.
  - Dynamic pricing send the appropriate price signal.
- Arguments For:
  - Significant portion of operating cost structure is fixed.
  - Volumetric pricing does not send the appropriate price signal.
  - Transmission and distribution facilities are constructed to meet maximum load.

Ratchets

- Demand Ratchet (or Ratcheted Demand)
  - Full Ratchet: customer is billed based on the higher of the max. monthly demand in the current billing period or the highest demand from the previous 13 months.
  - Partial Ratchet: the higher of the current month's demand or 70% of the highest demand from the past 13 months.
- Demand ratchet will increase the billing determinant and, therefore, lower the demand charge for the rate class.
- Rationale: forces each customer within the rate class to pay their "fair share" of the capacity-related costs based on the customer's full demand for capacity.
  - As with most rate design changes, there will be winners and losers.
  - Example: Ski Resorts
- Used for Revenue Stability.

Ratchet Implementation Issues

- Calculation of billing determinants for calculating the demand charge requires a review of the measured demands of every customer in the rate class for a recent 12-month period and identification of the highest demand for each customer, because the billed demands were different from what the billed demands would have been had the ratchet been in place.
- Adequate customer notice and education.
  - When implementing a ratchet for the first time, the utility will bill based on previous 13 months of demand data.
  - That is, 13 months prior to the beginning of the rate effective period.
  - Can have significant bill impact on certain individual customers.
  - May want to phase-in the demand ratchet.

How to Determine Load Factor

Formula: Load Factor = Energy ÷ (Hours * Demand)	
Energy	2,500,000
Demand	4,500
Hours	730
Load Factor Result	**76.1%**

How to Determine Demand

Formula: Demand = Energy ÷ Hours ÷ Load Factor	
Energy	2,500,000
Load Factor	76.1%
Hours	730
Demand Result	**4,500**

How to Determine Energy

Formula: Energy = Demand * Hours * Load Factor	
Demand	4,500
Load Factor	76.1%
Hours	730
Energy Result	**2,500,000**

How to Determine Class NCP

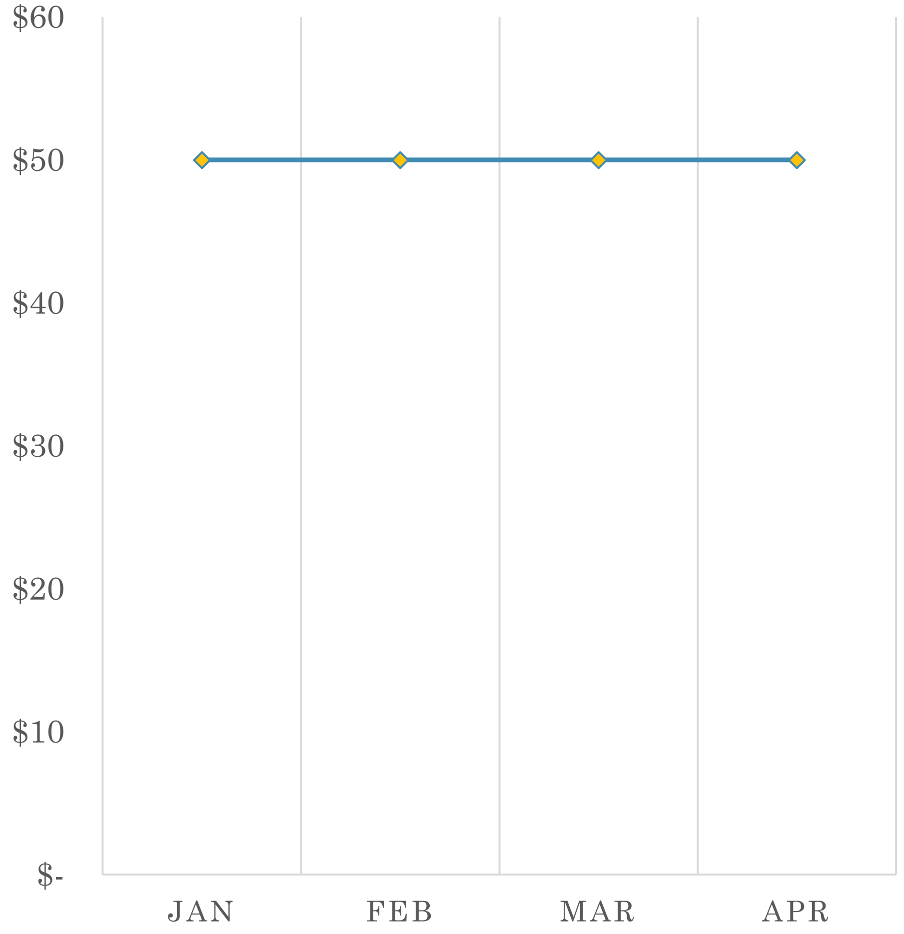
Customer	Peak for Month	Energy in Month	Load Factor
1	6.8	1,276	25.7%
2	4.6	869	25.9%
3	3.8	450	16.2%
Total	15.2	2,595	22.6%
Energy for Class			2,500,000
Hours in Month			730
NCP Demand for Class			**15,152**

Structure Types

- Fixed Charge
- Uniform Rate
- Fixture Charge
- Inclining Tiers
- Declining Tiers
- Slab Rates
- Seasonal Rates
- Lifeline Rates
- Hopkinson
- Straight-Fixed Variable (SFV)
- Dynamic Pricing
  - Real Time Pricing (RTP)
  - Time-Of-Use Rates (TOU)
  - Critical Peak Pricing (CPP)
  - Critical Peak Rebate (CPR)
- Distributed Energy
  - Net-Energy-Metering Rates (NEM)
  - Value-of-Solar (VOS)
- Subscription Plans
- Standby Rates
- Interruptible Rates
- Economic Development Rates (ED)
- AMP Based (Small Cell)

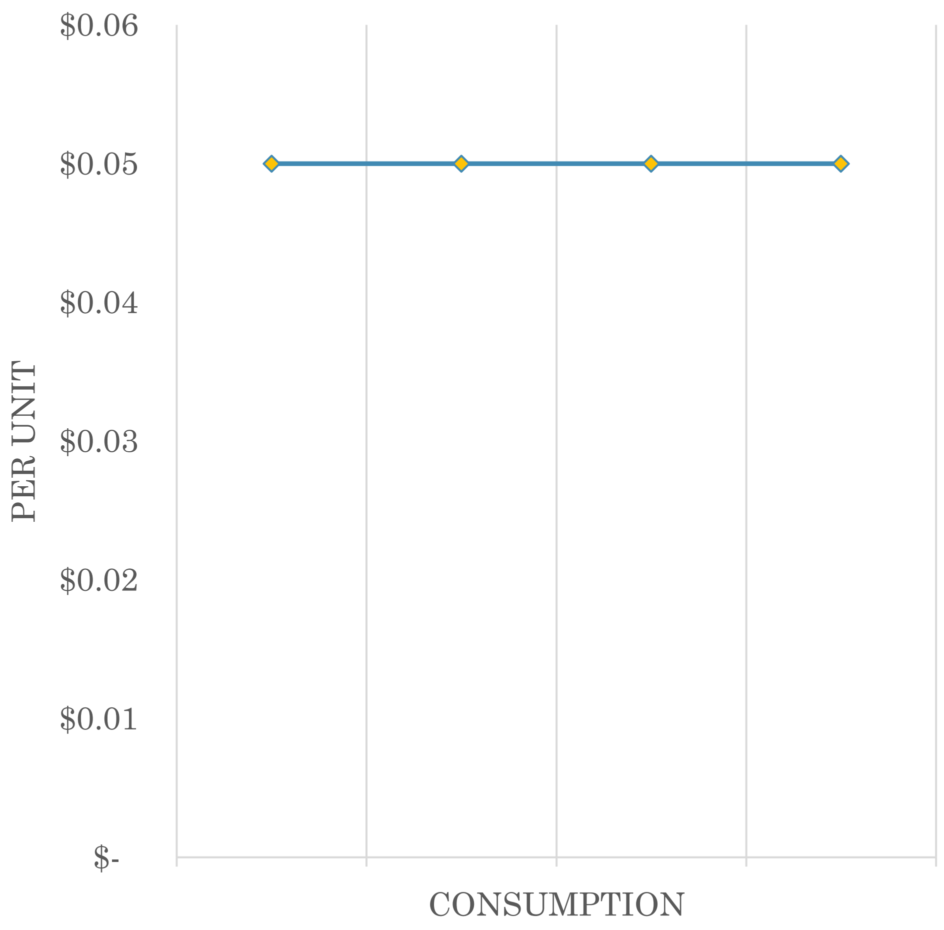
Fixed Charge

- Advantages
  - Easy to bill and understand.
  - No metering equipment required.
  - Provides a steady and reliable revenue stream for the utility.
- Disadvantages
  - Fails to capture demand or time-of-use differences.
  - Requires homogeneous customers.
  - No price signals sent.
  - Disproportionately affects customers who use the least amount of energy.
  - Disincentive for energy efficiency.



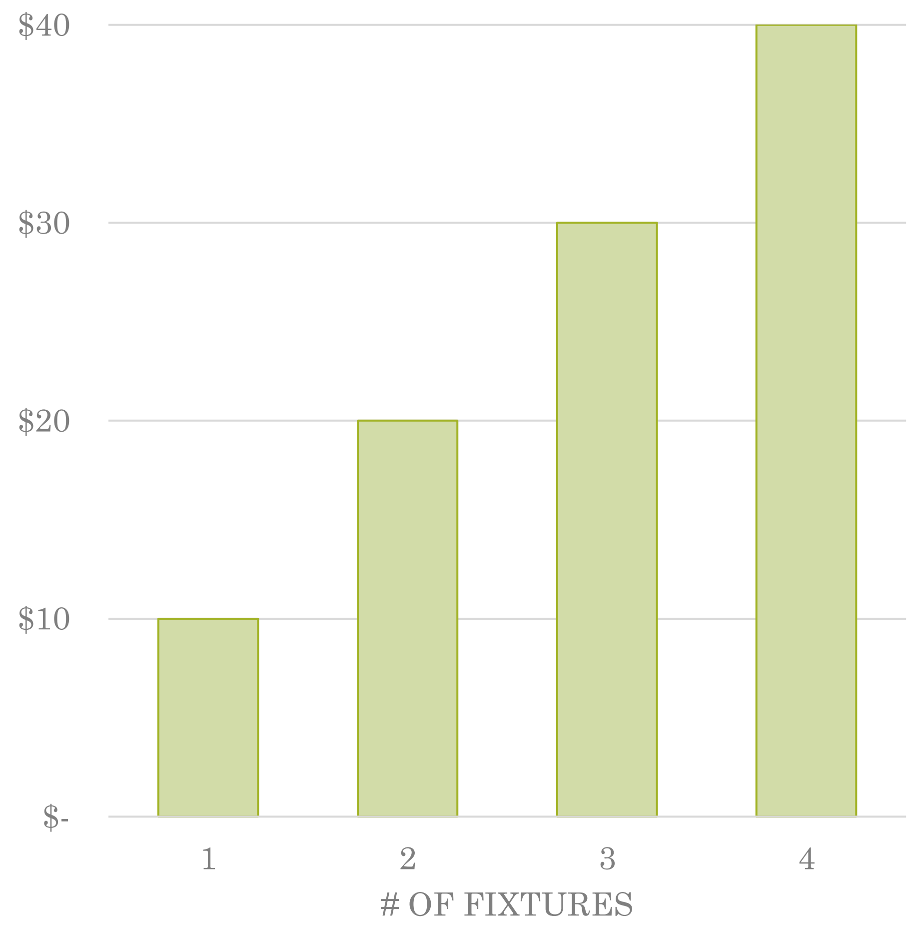
Uniform Rate

- Advantages
  - Easy to bill and understand.
  - Simple metering required.
- Disadvantages
  - Fails to capture demand or time-of-use differences.
  - Requires homogeneous customers.



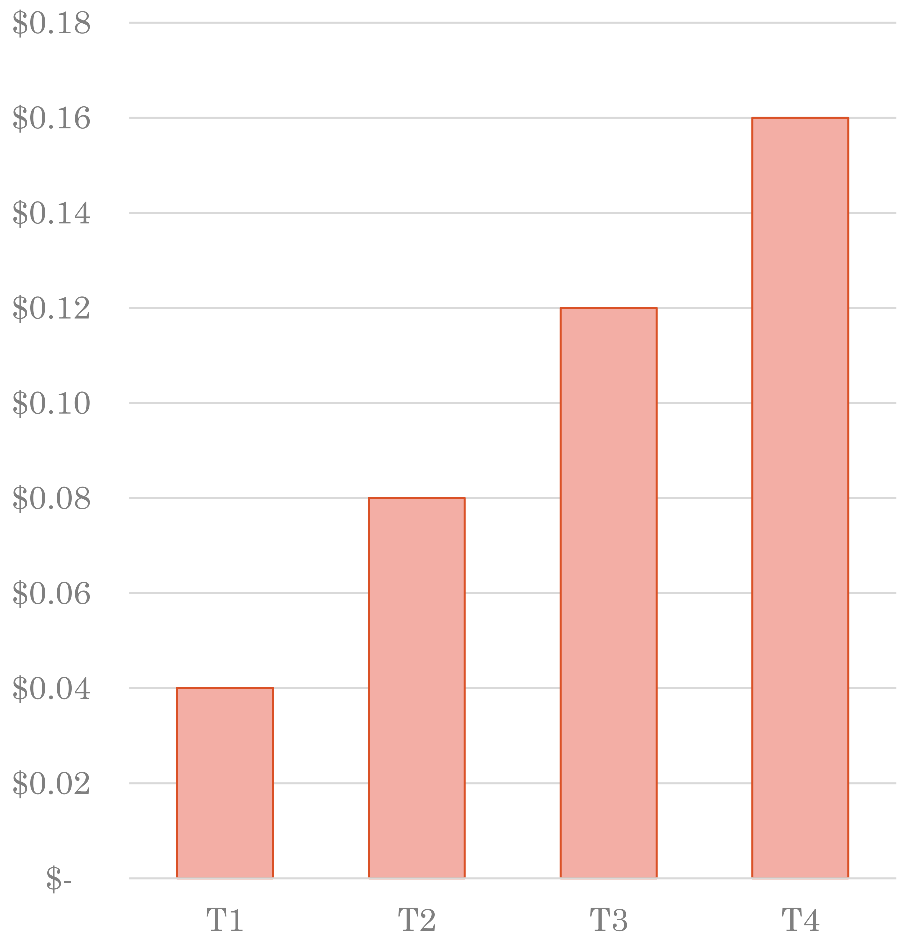
Fixture Charge

- Advantages
  - Easy to bill and understand.
  - Best when metering costs outweigh benefits.
  - May reflect the cost of service better than a flat fee or uniform rate.
- Disadvantages
  - Fails to capture demand and time-of-use differences.
  - Requires homogeneous customers.
  - Price signals are not sent.



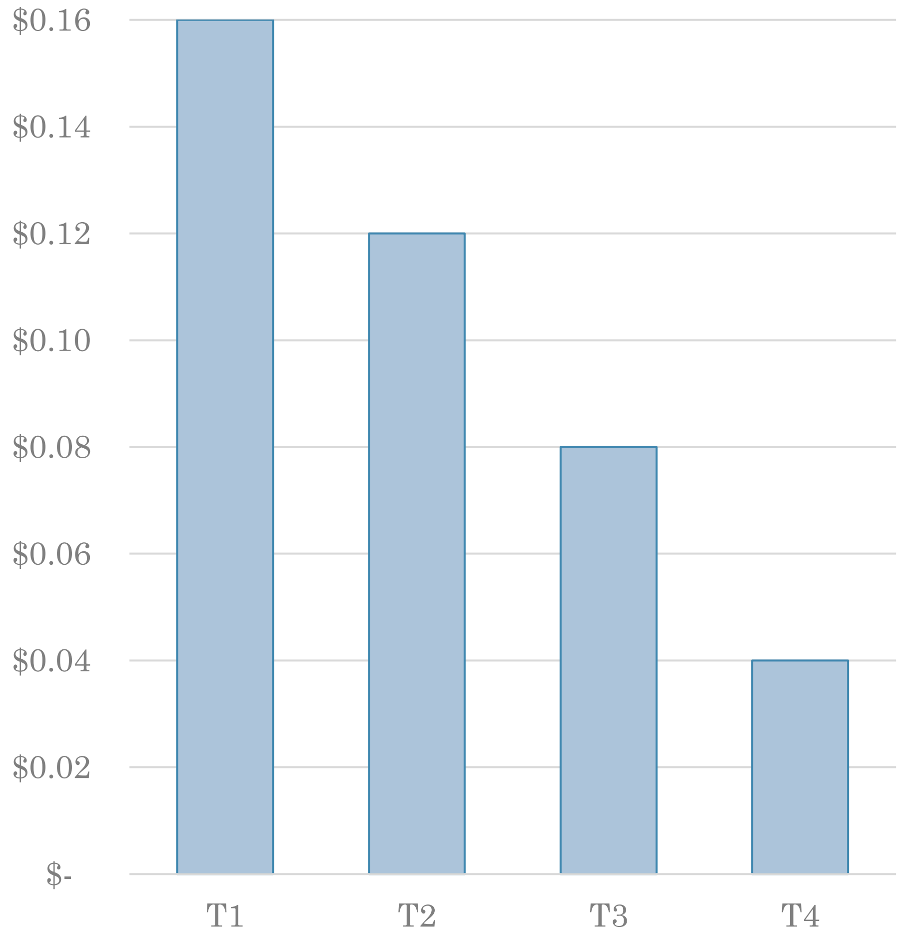
Inclining Tiers

- Advantages
  - Simple to bill and meter.
  - Fairly simple to understand.
  - Appropriate when average revenue requirement is less than the marginal cost.
  - Used for reducing average consumption, sometimes peak.
- Disadvantages
  - Fails to capture demand and time-of-use differences.
  - Requires homogeneous customers.
  - Shift costs to larger users.
  - Large-load customers consider this structure inequitable.



Declining Tiers

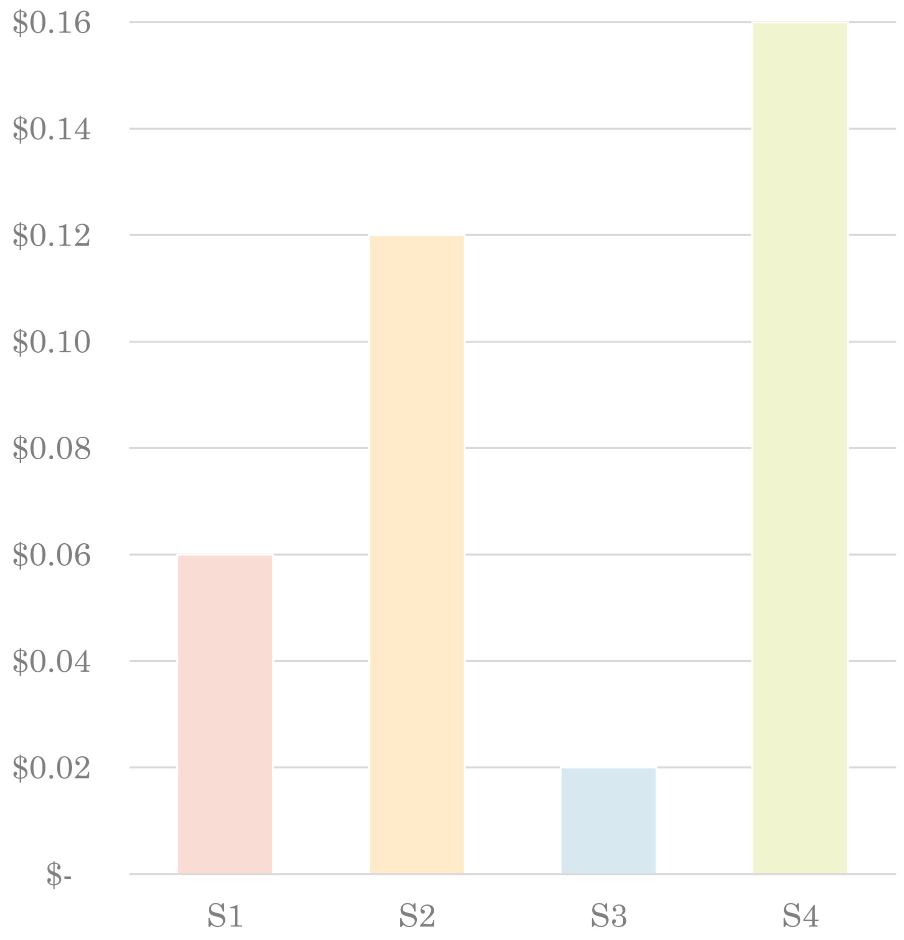
- Advantages
  - Simple for the utility to bill
  - Used for retaining large-load customers.
  - Simple for the utility to meter
  - Fairly simple for customers to understand
  - Appropriate when the average revenue requirement exceeds the marginal cost to supply customers, plus will probably decrease the system cost.
- Disadvantages
  - Fails to capture differences in demand
  - Fails to capture difference in time--of--use
  - Requires that customer classes be homogeneous
  - Can shift costs to smaller users.



Privileged and Confidential

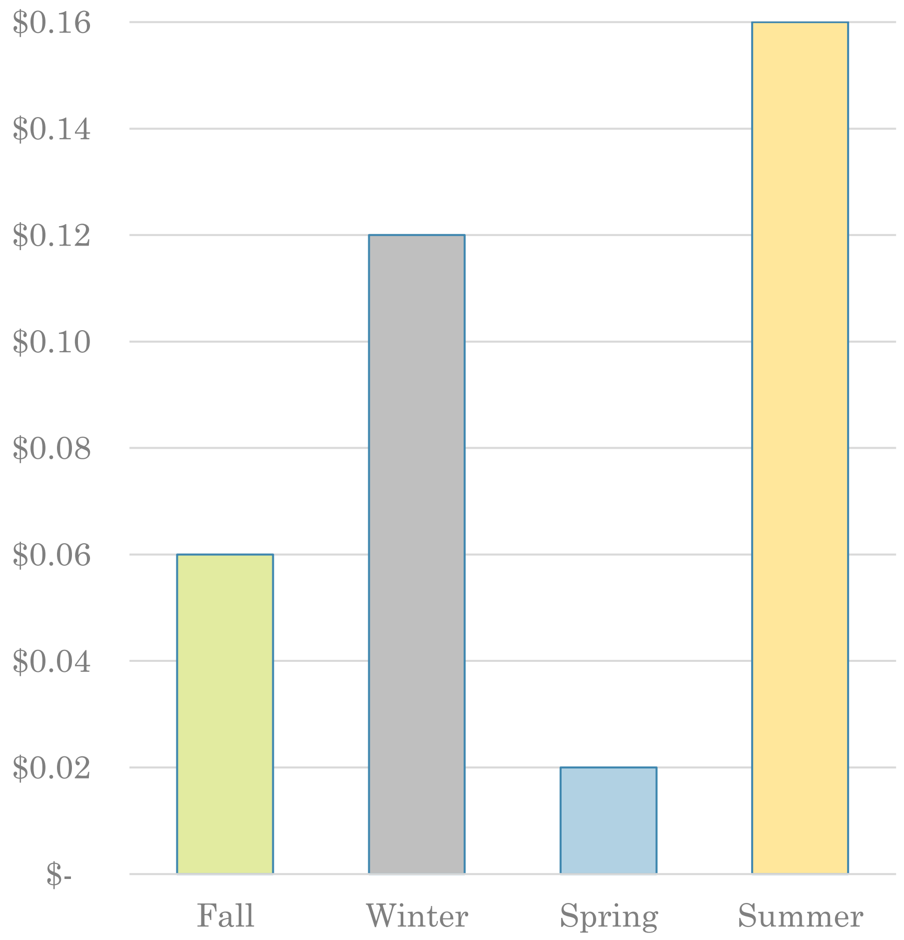
Slab Rates

- Advantages
  - Common in deregulated markets.
  - Sends range-based price incentives.
- Disadvantages
  - Fails to capture differences in demand.
  - Fails to capture difference in time--of-use.
  - Requires educated customers.
  - Bill volatility.



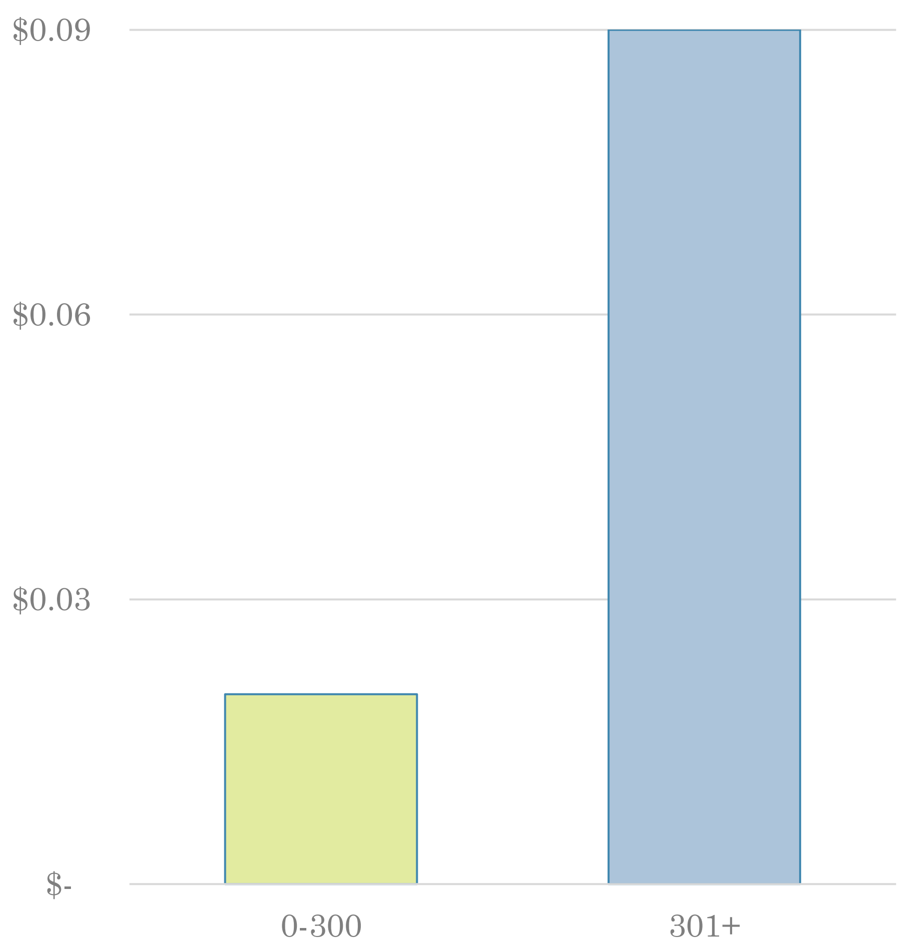
Seasonal Rates

- Advantages
  - Fairly simple to understand.
  - Sends a more accurate price signal.
- Disadvantages
  - Cross-subsidization between year-round vs partial-year customers.
  - Revenue instability.
- Seasonal Industries
  - Agricultural
  - Irrigation Systems



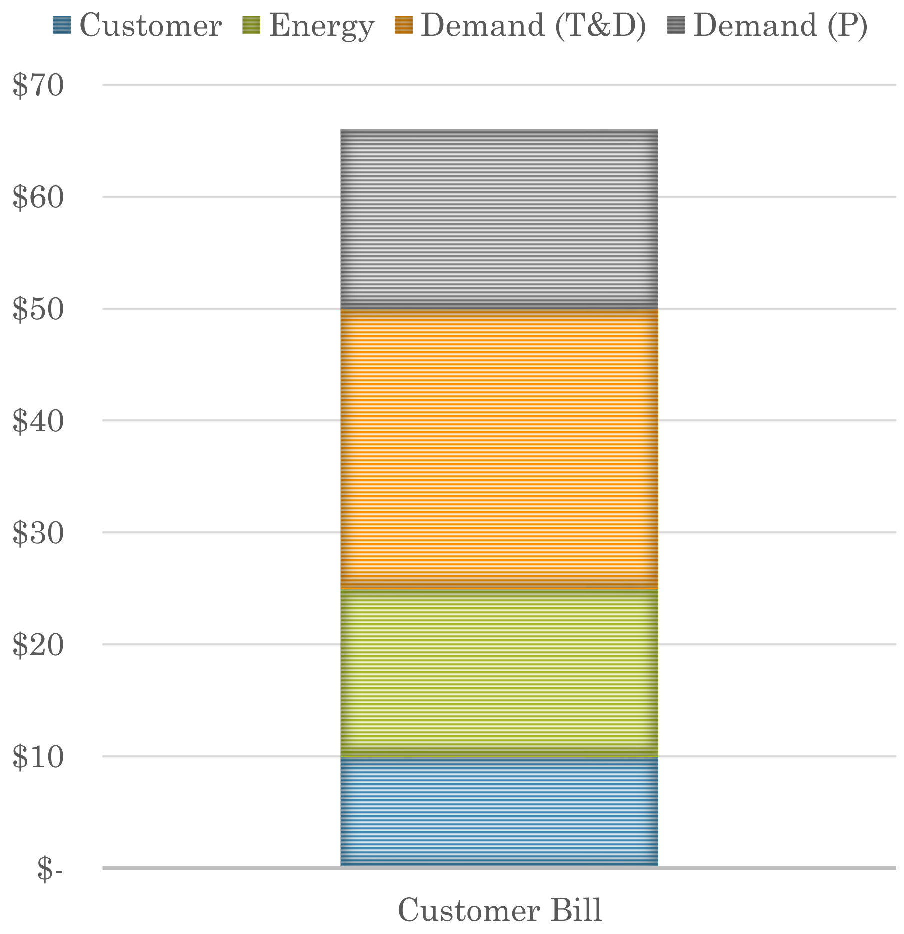
Lifeline Rates

- Advantages
  - Economic relief to disadvantage customers.
  - Greater flexibility for moving other customers to cost of service.
- Disadvantages
  - Determining who is economically disadvantaged.
  - Utility becomes a social service entity.



Hopkinson

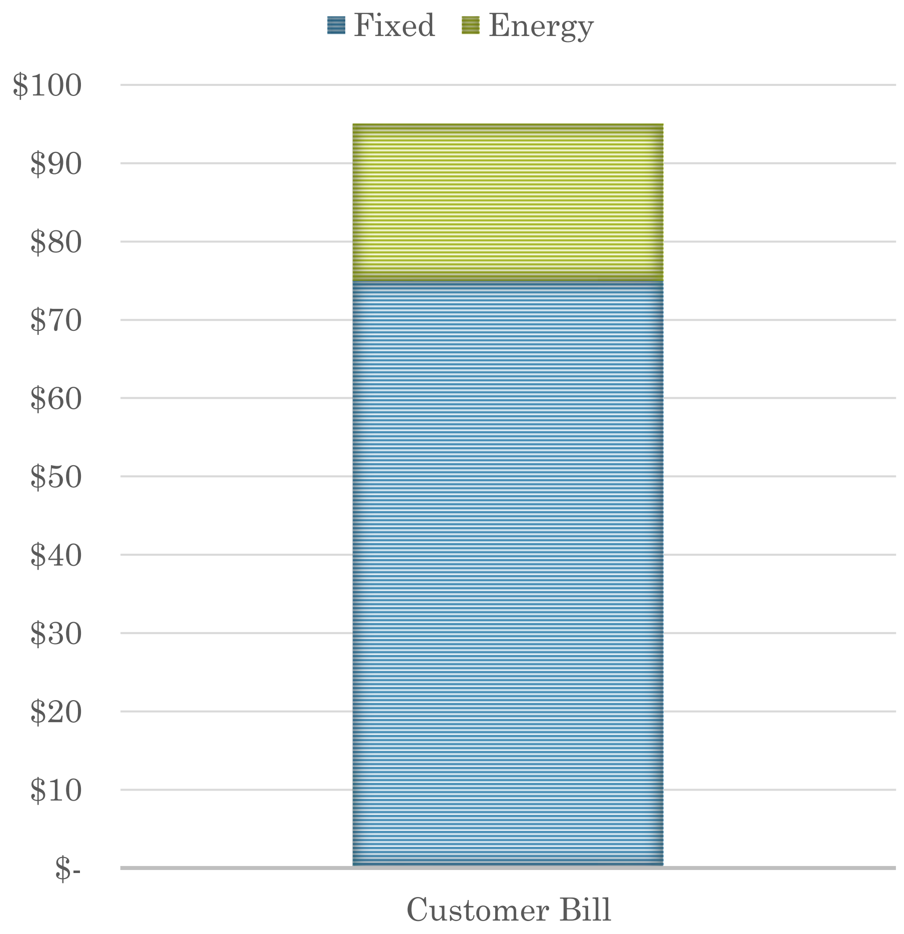
- Advantages
  - Most common method of pricing.
  - Understood by large C&I customers.
  - Clear price signal for energy and capacity.
  - Captures customer load factor differences.
  - More easily recover fixed costs
  - Reduces cross-customer subsidies for DG
- Disadvantages
  - More complex billing and implementation.
  - Demand portion is based on individual peak, not system peak.
  - Might result in cross-customer subsidies.
  - Disproportionately affects customers who cannot control or adjust.



Privileged and Confidential

Straight-Fixed Variable

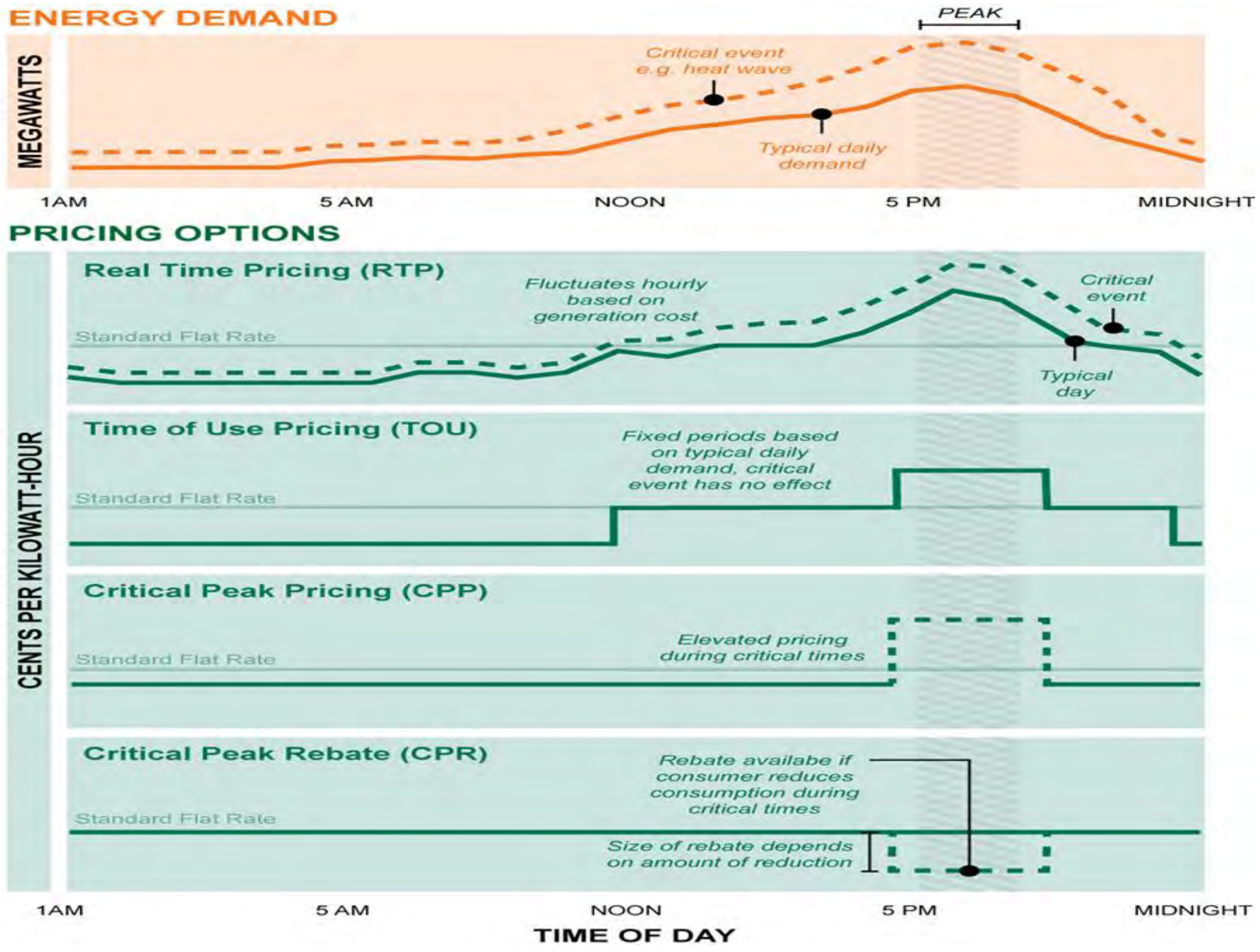
- Advantages
  - Simple form of decoupling design.
  - Recovers fixed costs.
  - Removes cross-customer subsidies for DG.
  - Simple billing and implementation.
- Disadvantages
  - Does not capture customer load factor differences.
  - Fails to capture demand or time-of-use differences.
  - Disproportionately affects customers who use the least amount of energy.
  - Disincentive for energy efficiency.



Dynamic / Time-Varying Pricing

- Advantages
  - Better price signals to the customer.
  - Better matching of revenues to costs.

- Disadvantages
  - Requires *costly* metering equipment.
  - Difficult to understand.
  - Difficult to manage without enabling technology.
  - Difficult to determine time periods and revenue allocation.
  - Traditional COS ignores added risk to customers.

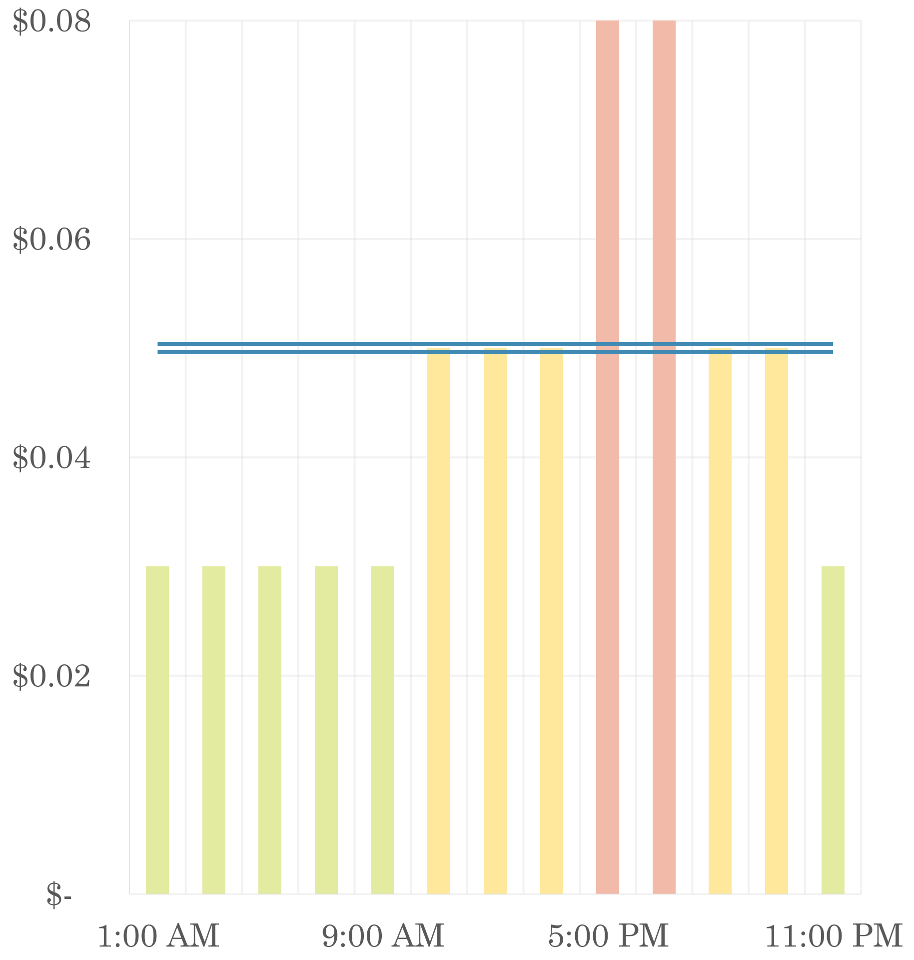


Privileged and Confidential

Time-of-Use

TIME OF USE RATE DESIGN COMPONENTS	NOTES
Customer Charge ($)	Includes all customer-related costs necessary to connect to grid
Off-Peak Period Rate ($/kWh)	Includes ✓ 100% of other expenses (G&A, non-generation O&M, etc) ✓ 60% of return on demand-based distribution assets ✓ 100% of return on baseload generation assets* ✓ 100% of baseload generation fuel and O&M
Intermediate Period Rate ($/kWh)	Off-peak rate, plus adder for ✓ 20% of return on demand-based distribution assets ✓ 100% of return on mid-merit generation assets* ✓ 100% of mid-merit generation fuel and O&M
Peak Period Rate ($/kWh)	Off-peak rate, plus adder for ✓ 20% of return on demand-based distribution assets ✓ 100% of return on peak generation assets* ✓ 100% of peak generation fuel and O&M

** Indicates costs for vertically integrated utilities. Illustrative purposes only.*



Privileged and Confidential

Net Energy Metering Rates

- Advantages
  - Easy to bill and understand.
  - Simple metering required.
  - Incentivizes distributed generation (DG).
- Disadvantages
  - Solar generation is credited at full retail rate.
  - Customers without solar may effectively subsidize customers with solar.

Description		Metering Grouping
Total Electricity Provided by Utility		Delivered
Total PV Generation that Flows back into the Grid	-	Received
Net Electricity Consumed by Customer	=	Net Load

Value of Solar Rates

- Advantages
  - Credit for solar generation reflects actual value of the generation to the system.
  - All electricity generated and consumed by customers with solar is accounted for.
  - Separate meters for DG customers allow for easy monitoring of bill and credits due.
- Disadvantages
  - May be a disincentive for customers to deploy DG.
  - Uses some subjective values (*e.g.*, estimated environmental value)
  - Requires additional metering for solar customers.
  - Complex to calculate.

Description		Metering Grouping
Total Electricity Provided by Utility		Delivered
Total PV Generation that Flows back into the Grid	-	Received
Net Electricity Consumed by Customer	=	Net Load
Total PV Generation	+	PV Generation
Total Electricity Consumed by Customer	=	Whole Premise Consumption

VOS Calculation Illustration

Component	Definition	Formula
Energy Value	Estimated avoided cost of energy to meet electric loads as well as transmission and distribution losses, based on the solar production profile. This is inferred from forward projections of ERCOT wholesale price based on future NG prices.	(∑(Implied Heat Rate * Gas Price * PV Production * Risk Free Discount Factor)) * (1+ Loss Factor) ∑ (PV Production * Risk Free Discount actor)
Plant O&M Value	Estimated avoided cost associated with natural gas plant operations and maintenance by meeting peak load through customer-sited renewable resources.	(∑ (O & M Cost * (1+Inflation) ^ year * PV Capacity * Risk Free Discount Factor)) * (1+ Loss Factor) ∑ (PV Production * Risk Free Discount Factor)
Generation Capacity Value	Estimated avoided cost of capital by meeting peak load through customer-sited renewable resources, inferred from ERCOT market price data.	(∑ (Annual Capital Carrying Cost * PV Capacity * Risk Free Discount Factor)) * Load Match * (1+ Loss Factor) ∑ (PV Production * Risk Free Discount Factor)
Transmission and Distribution Value	Estimated savings in transmission costs resulting from the reduction in the peak load by locally-sited renewable resources, and savings or costs related capital investments to distribution grid.	(∑ (Transmission Cost * PV Capacity * Risk Free Discount Factor)) * Load Match * (1+ Loss Factor) ∑ (PV Production * Risk Free Discount Factor) - Where Transmission Cost is Austin Energy's contribution to ERCOT Transmission Cost of Service (TCOS). - N.B.: Distribution value is currently not calculated but will need further review as solar penetration increases.
Environmental Value	Estimated avoided emissions cost to comply with local policy objectives.	Set at $0.015 per kWh based on estimated avoided emissions at Austin Energy emission rate and priced at the societal cost of carbon.

Electrification of Transportation

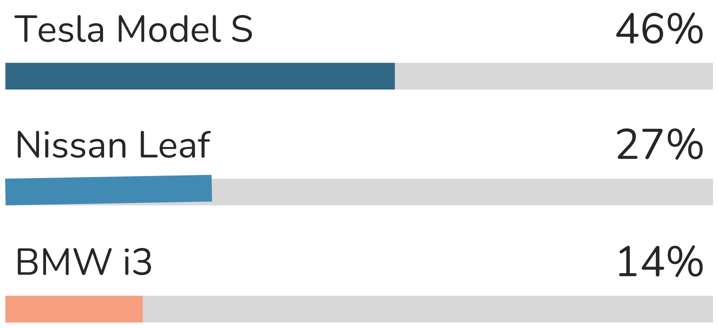
9

4.2 kW

9 p.m.

452 kWh

- A residential subscription pricing model that allows unlimited electric vehicle charging at home and around Austin, as part of public charging network. Austin Energy's EV360.

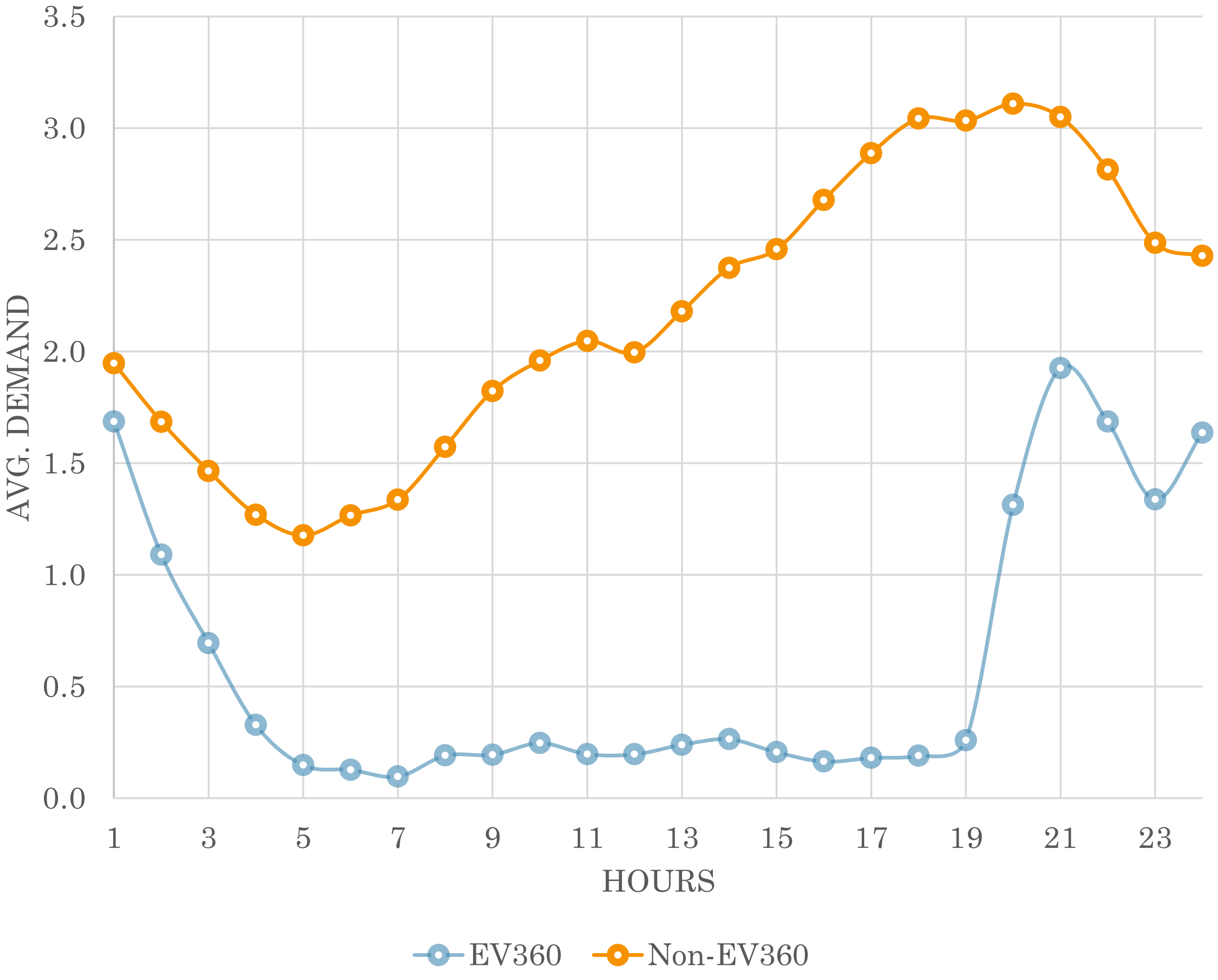


Charging Times

reduced peak load

- Austin Energy is observing a ~90% load reduction between 1 – 7 p.m. compared to EVs not signed up on the program.

- Potential value to Austin Energy customers and reduced impact on infrastructure provide a roadmap to leverage this opportunity.



Privileged and Confidential

Lessons Learned

Planning

- How Are You Going to Use the Data
- Bring Everyone at the Beginning
- All Components Need to Communicate
- Evaluating Requirements
- Uniformity
- Lots of Training

Processes

- New Business Procedures
- Feedback Loops
- Quantitative and Qualitative Benefits
- Data Volume Extremes
- New Skillsets
  - Data Scientists (human/machine)
  - Modelers
  - Visual Designer/Developer
  - Data Steward/Plumber

Results

- Optimize Assets and Reliability
- Revenue Protection
- Theft Detection
- Data-driven Decisions
- Enhanced Pilot Assessments
- Focus on High-Value Activities
- Leveraging Load Research
- Remote Access to Data

Rate Considerations

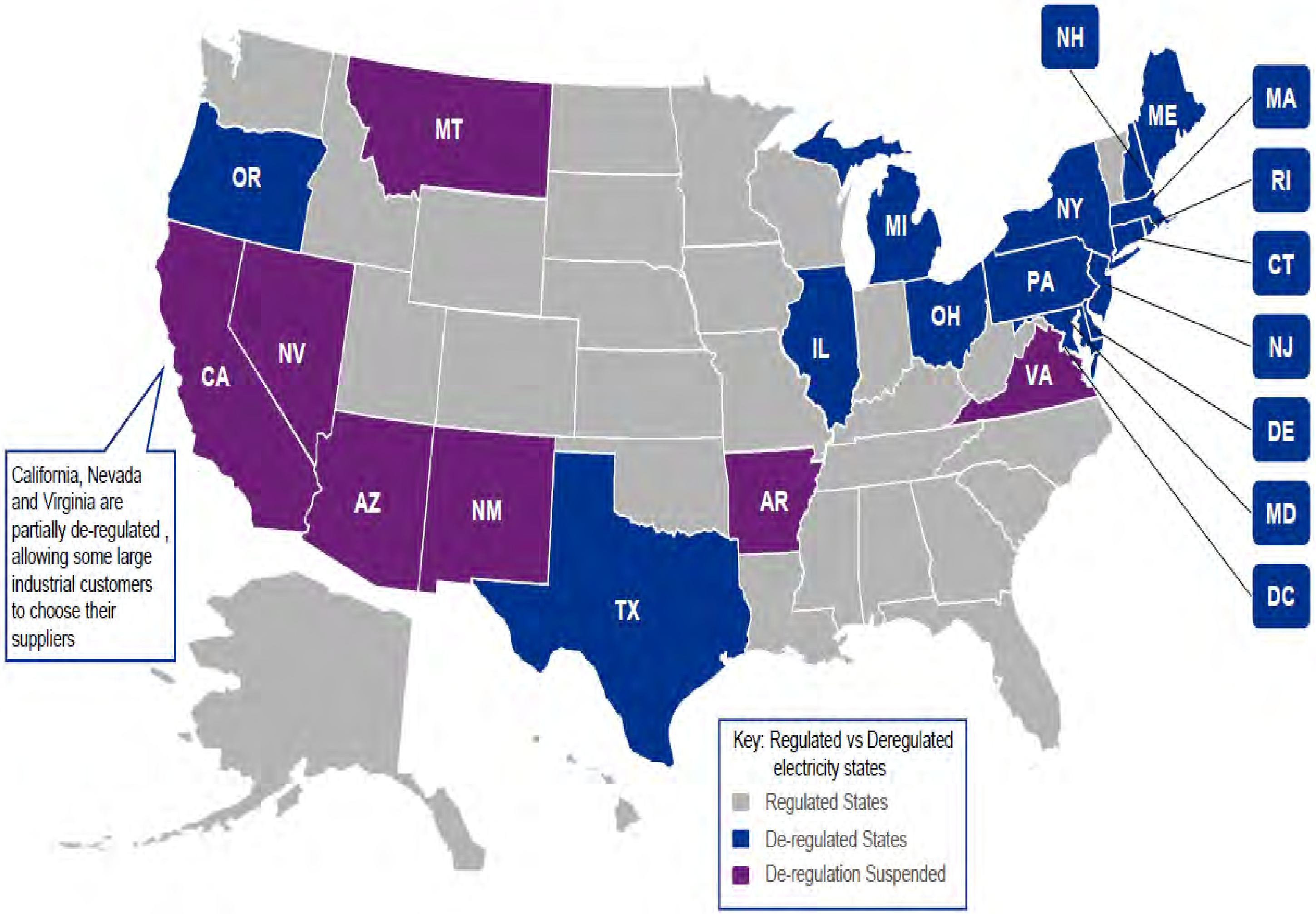
- How closely do rate attributes align with costs?
- What is the impact on customer bills?
- Which customers are structural winners and losers?
- What is the impact on customer bill volatility?
- Do the rates allow customers to save by shifting load to save costs?
- What types of rate attributes present implementation challenges for the billing systems?
- Are there certain non-starters to avoid?
- How will customers perceive features?
- Does the feature potentially enhance (or diminish) the customer experience?
- Can technology help the customer respond to the rate?

Rate Realignment

- It is not practical to remove the entire subsidy at one time because of the impact on customers.
- To minimize rate shock, it would be more prudent to phase-out the subsidy over a period of time since the current rate subsidy was implemented over a period of time.
- A subsidy exist when there is a difference between current recovery level and what the recovery level would be if set at full cost of service (parity ratio).
- Subsidies can be either positive or negative, when recovery levels are set above or below cost to serve.

Competitive Markets Differences

- Allows consumers to have a right to choose their Retailer Electricity Provider (REP).
- Need to unbundle rates by utility functions:
  - Generation.
  - Transmission.
  - Distribution.
- Provider of Last Report.
- Limited Support for Low Income, Energy Efficiency, and Other Social Programs.



Privileged and Confidential

Competitive Market Structures

Structure	Description	Advantages	Disadvantages	States
Fully Competitive	Requires separation into Generation, Transmission, and Distribution. Limited interaction with customers.	Fully deregulated market.	Requires educated population.	Texas
Market Pass Through	Establish individual negotiated settlement agreements between utilities and PUCs. Rate structures vary by utility.	Better pricing for customers.	High dependence on supply.	New York
Auction	Default service is provided by a host utility and procured via auction. Contacts may vary in terms of length.	Prices are set based on forward market.	Increase in prices for end customer.	Many
Other	Based on historical 12-month period, retail market is capped at either load (Michigan) or prices (California).	Favorable rates for customers.	Decrease in profits for companies.	

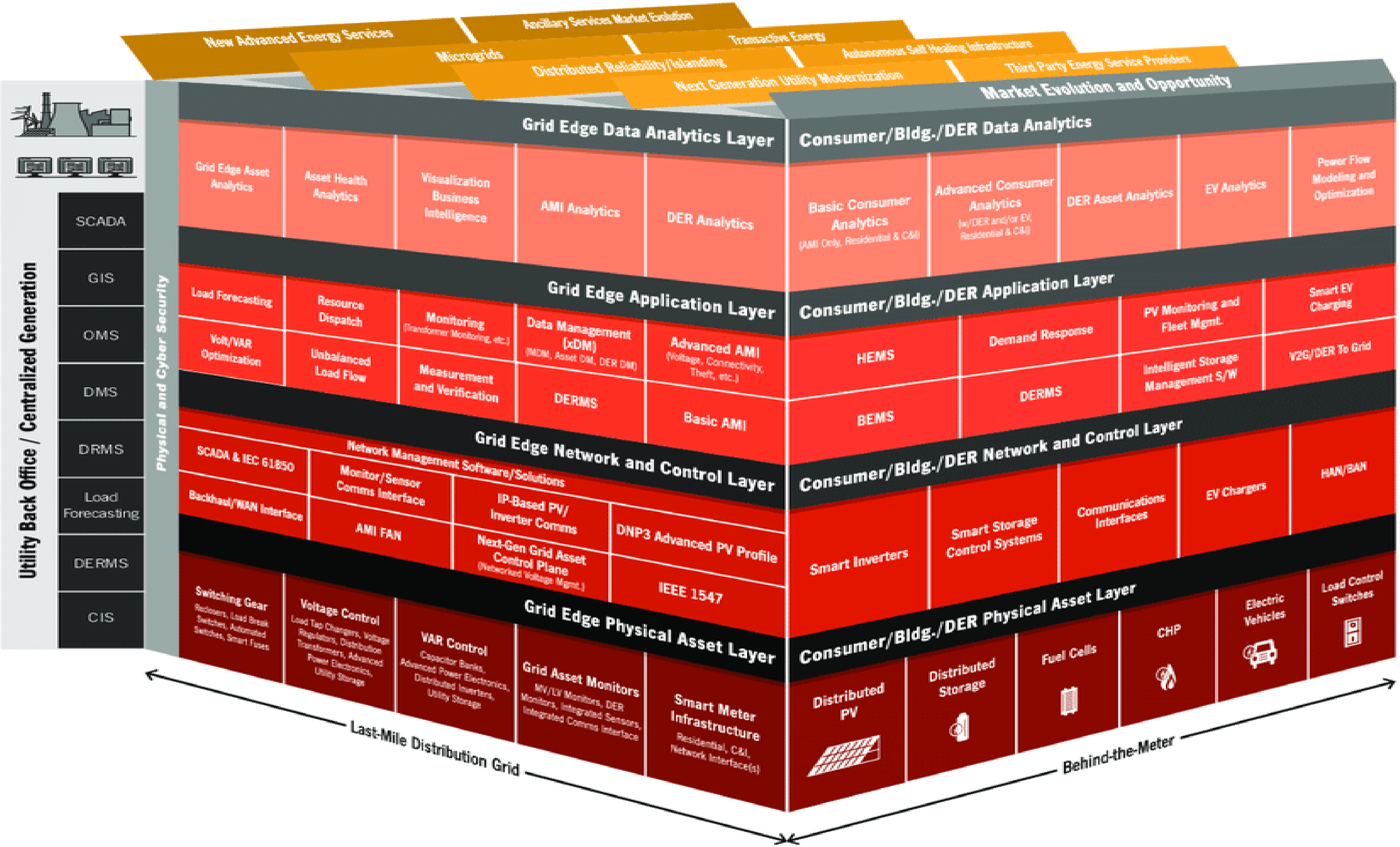
Competitive Market Rate Types

Plans	Description	Advantages	Disadvantages
Fixed	Fixed rate for the duration of the contract, which varies from months to years.	No price volatility.	Could pay above market prices, if a decline in commodity prices.
Variable	Different price each month based on factors (e.g., weather, load profiles, supply, demand)	No contract, plus save money if commodity prices decline.	Sudden sharp customer bill spikes if commodity prices increase.
Renewable	Electricity from renewable sources to offset consumption.	Limited price volatility and low emissions.	Customers typically pay higher prices.
Index	Prices are pegged against an index (NYMEX NG futures) using a mathematical formula.	Save money if commodity prices decline.	Possible surge in price greater than variable plan.
Slab	Rate is stepped up or down based on usage range.	Incentives customer to target range their usage.	Hard to predict what you might pay.
Custom	Negotiated individual rate based on customer load profile.	Aligned with customer load profile and protect against short term price volatility.	May result in high bills unless monitoring usage.

Challenges

- How much revenue should a specific customer class be responsible for paying?
- What is the appropriate price signal which is being sent to the customer?
- Should a customer have a choice between different rate designs?
- Should economically disadvantaged customers pay a lower price?

Grid Edge


New Advanced Energy Services
Ancillary Services Market Evolution
Microgrids
Transactive Energy
Distributed Reliability/Islanding
Autonomous Self Healing Infrastructure
Next Generation Utility Modernization
Third Party Energy Service Providers
Market Evolution and Opportunity
SCADA
GIS
OMS
DMS
DRMS
Load Forecasting
DERMS
CIS
Utility Back Office / Centralized Generation
Physical and Cyber Security
Grid Edge Data Analytics Layer
Grid Edge Asset Analytics
Asset Health Analytics
Visualization Business Intelligence
AMI Analytics
DER Analytics
Consumer/Bldg./DER Data Analytics
Basic Consumer Analytics (AMI Only, Residential & C&I)
Advanced Consumer Analytics (w/DER and/or EV, Residential & C&I)
DER Asset Analytics
EV Analytics
Power Flow Modeling and Optimization
Grid Edge Application Layer
Load Forecasting
Resource Dispatch
Monitoring (Transformer Monitoring, etc.)
Data Management (xDM) (MDM, Asset DM, DER DM)
Advanced AMI (Voltage, Connectivity, Theft, etc.)
Volt/VAR Optimization
Unbalanced Load Flow
Measurement and Verification
DERMS
Basic AMI
Consumer/Bldg./DER Application Layer
HEMS
Demand Response
PV Monitoring and Fleet Mgmt.
Smart EV Charging
BEMS
DERMS
Intelligent Storage Management S/W
V2G/DER To Grid
Grid Edge Network and Control Layer
SCADA & IEC 61850
Network Management Software/Solutions
Monitor/Sensor Comms Interface
Backhaul/WAN Interface
IP-Based PV/Inverter Comms
AMI FAN
DNP3 Advanced PV Profile
Next-Gen Grid Asset Control Plane (Networked Voltage Mgmt.)
IEEE 1547
Consumer/Bldg./DER Network and Control Layer
Smart Inverters
Smart Storage Control Systems
Communications Interfaces
EV Chargers
HAN/BAN
Grid Edge Physical Asset Layer
Switching Gear Reclosers, Load Break Switches, Automated Switches, Smart Fuses
Voltage Control Load Tap Changers, Voltage Regulators, Distribution Transformers, Advanced Power Electronics, Utility Storage
VAR Control Capacitor Banks, Advanced Power Electronics, Distributed Inverters, Utility Storage
Grid Asset Monitors MV/LV Monitors, DER Monitors, Integrated Sensors, Integrated Comms Interface
Smart Meter Infrastructure Residential, C&I, Network Interface(s)
Consumer/Bldg./DER Physical Asset Layer
Distributed PV
Distributed Storage
Fuel Cells
CHP
Electric Vehicles
Load Control Switches
Last-Mile Distribution Grid
Behind-the-Meter

Changes

Grid Edge Technologies
New Energy Ecosystems
Grid Defection
Aging Infrastructure
Blockchain
Performance Based Regulation
Internet of Everything
Microgrids
Price Volatility
Changing Energy Mix
Automated Delivery
New Energy Ecosystems
Volatile Weather
Fixed Cost Recovery
Smart Grid 2.0
Artificial Intelligence
Electrification of Transportation
Virtual and Augmented Reality
P2P Electricity Exchanges
Incentive Business Models
Performance Based Regulation
Demand-shifting Services
Empowered Prosumers
Advanced Energy Management Systems
New Regulatory Frameworks
Grid Edge Technologies

Mockup

Customer Class Characteristics (Annual)				
Physical			Financial	
Total Energy	18,000,000		Demand Costs	$900,000
Billed Demand	144,000		Energy Costs	$1,440,000
Total Customers	12,000		Customer Costs	$480,000

Pricing Strategies:

- Strategy I: Collect all energy costs through a per kWh charge, and all other costs through a fixed charge.
- Strategy II: Collect all financial costs based on their physical cost causation.
- Strategy III: Collect all energy, demand, and half of the customer costs through a per kWh charge, with the rest through a fixed charge.
- For an average customer, figure out bill impact for each strategy.

Questions

Christopher Mickelson
christopher.mickelson@gmail.com
/mickelson-christopher

Appendix

Principles of Public Utility Rates	James Bonbright (1961)
Public Utility Economics	Paul Garfield and Wallace Love Joy (1963)
The Economics of Regulation	Alfred Kahn (1988)
Charging for Distribution Utility Services: Issues in Rate Design	Frederick Weston (2000)
Smart Rate Design for a Smart Future	Jim Lazar and Wilson Gonzalez (2015)
Distributed Energy Resources Rate Design and Compensation	National Association of Regulatory Utility Commissioners Staff Subcommittee on Rate Design (2016)
Smart Non-Residential Rate Design	Carl Linvill, Jim Lazar, Max Dupuy, Jessica Shipley, and Donna Brutkoski (2017)