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Modern Cost Allocation and Rate Design

Introduction to the Electricity Sector: Prof. Jenkins

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Introduction

The Regulatory Assistance Project (RAP) is a global NGO providing technical and policy assistance to government officials, agency staff, and others on energy and environmental issues.
Topics for Today

- Key Principles and Background
- Cost Causation
- Cost Allocation
- Rate Design
1 Key Principles and Background
Purposes of Utility Regulation

• Protect consumers
  • Prevent price discrimination
• Mimic the results of a competitive market
  • Create efficient economy-wide outcomes
• Achieve public policy goals
  • Provide universal access to necessary services
  • Almost anything else!
Simplified rate-making process

Determine revenue requirement

Net rate base
(Plant in service – depreciation reserve)

Rate of return

Depreciation expense
(Plant in service x depreciation rate)

Operating expense
(Fuel + purchased power + labor + labor overheads + supplies + services + income taxes)

Other taxes

= $ millions

Allocate costs among customer classes

Design retail rates

Residential

Commercial

Industrial

Street lighting

Dollars per month
Cents per kWh peak
Cents per kWh off-peak
Dollars per month
Cents per kWh peak
Cents per kWh off-peak
Dollars per month
Cents per kWh peak
Cents per kWh off-peak
Dollars per kW monthly
Dollars per light per month
Principles for Rate Structure

• Primary goals
  • Revenue sufficiency and stability
  • Fair cost apportionment
  • Efficient levels of usage
  • Feasibility and understandability
  • Public policy goals

• Modern practice
  • Cost allocation: primarily about group equity
  • Rate design: primarily about efficient forward-looking incentives, customer understanding and individual bill impacts
Practical Considerations

• Asymmetric information
  • Regulation is imperfect and structural incentives matter
• Administrative costs
  • Is there a feasible way to calculate granular marginal distribution costs?
• Data availability
  • FERC Uniform System of Accounts addressed the issues of the first half of the 20th century.
• Postage stamp pricing is prevalent rule
  • One uniform rate for each customer class for each utility, with no locational distinctions
Evolution of U.S. Electric System

- **1960-1980**
  - Combustion steam units, with significant hydro in some parts of the US
  - Emergence of nuclear power and combustion turbines
  - Oil crises
- **1980-2000**
  - PURPA implementation and then restructuring in many areas
  - Introduction of energy efficiency programs and demand-side resources
  - Emergence of combined cycle generation
- **2000-2020**
  - Major increase in natural gas extraction from hydraulic fracturing
  - Emergence of utility-scale wind and solar, advanced meters and smart grid
  - Beginnings of battery storage, distributed generation, customer energy management, electrification of heating and transportation
“Net Load” presents new shape
Demand-side strategies span many timescales

2 Cost Causation
Cost Causation in General

- Nearly every element of the electric system is driven by the shared requirements of many customers
  - Exceptions: basic meters, most service drops, some transformers
- Each function has distinct cost drivers
  - Fuel, spot energy and some contract purchase costs vary by time
  - Peak demand may drive the amount of generation capacity, while year-round load patterns determines capacity mix and thus costs
  - Peaks matter in T&D sizing, but timeframe is typically longer than 15-30 minutes
    - Heat buildup and line losses are key
- Administrative and general costs vary with scale of business
- Tradeoffs exist between capital, labor, fuel, and other expenses

Technology and engineering matter!
Cost Causation: Generation Capacity

• The traditional answer is that all generation capacity costs are “demand-related” and should be charged exclusively to narrow peak periods
  • This is incorrect if there’s more than one type of capacity, which has been the case since the 1960s
  • More expensive capacity is justified by energy savings over additional hours
• Wholesale pricing example from Alfred Kahn (1970)
  • Charging the costs of all generation capacity in a narrow period allowed inefficient bypass with combustion turbines
• Loss of energy expectation studies look at reliability risks year-round and can be used to estimate capacity value in each hour
Cost Causation: Shared Distribution

- Primary voltage line costs vary most directly with area covered
  - *Number of customers is irrelevant!*
- Transformer kVA/MVA ratings are soft limits, which can be exceeded
  - Depends on ambient temperature and loadings prior to peak
  - Two types of losses –
    - Core losses from energizing transformer
    - Load losses
- Conductors have current ratings, but can carry more energy at higher voltages
  - Higher voltage means higher power capabilities and lower losses, but additional protection is necessary
3 Cost Allocation
Key Principles

• How to define an equitable division of costs?
  • Cost causation – often historical
  • Costs follow benefits – typically present day

• Efficiency implications
  • Data and analysis from cost allocation process often informs rate design
  • Class cost allocations set boundaries that rate design must work within

• Older analytical techniques have trouble accounting for the features of the modern grid
Traditional ECOSS Process

Functionalization
- Generation
- Transmission
- Distribution
- Billing and customer service

Classification
- Demand-related
- Energy-related
- Customer-related

Allocation
- Residential
- Commercial
- Industrial
- Street lighting
Best Practices for All Frameworks

- Whether a cost is fixed or variable in the short term does not demonstrate causation
- Apportion shared assets on measures of usage
- Only customer-specific costs are customer-related
- Ensure broad sharing of administrative and general costs
- Move towards smarter customer classes
Fixed versus Variable Example

- Multiple ways to serve an increase in peak demand
  - Peaker – mix of fixed and variable
  - Battery storage – almost entirely fixed costs
  - Demand response – variable costs
Issues with Traditional Demand & Energy Allocators

• Demand at what hours?
  • System peak, equipment peak, or class peak?

• Energy-classified costs are usually allocated using annual kWh usage
  • Fails to reflect time-varying costs

• Time-based allocation addresses these issues
Hourly Generation Allocation

Daily dispatch for illustrative hourly allocation example

- Peaker
- Solar
- Storage
- Charging of storage

Hour of day

Megawatts

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Minimum System Fallacy

- Shared distribution system expenses, such as primary conductors, poles and substations, do not meaningfully depend on the number of customers
  - A ten-story office building can be 20 small customers or one large customer
  - An industrial facility and a mixed use residential/small C&I neighborhood can have similar load profiles
- Shared distribution system expenses vary with area covered, as well as load
  - Location generally cannot be included in pricing under “postage stamp” rates
Advanced Metering Costs

• “Meters” do more than measure kWh
  • Enables new rate designs and demand response programs
  • Enables volt/VAR optimization
  • Data improves system planning
  • Communications system has multiple uses

• City of Burbank: transformer right-sizing lowered line losses by 1%, saving $1 million per year
Determining Customer Classes

Types:
- Residential
  - Single-Family
  - Multi-Family
  - Solar?
  - Heating?
- Commercial
- Industrial
- Irrigation
- Street Lighting
Traditional MCOSS Process

• Created in the 1970s
  • Adopted in a handful of states

• The basics
  • Functionalize, like ECOSS
  • Estimate marginal unit costs for each function
  • Compute sum of marginal costs by class
  • Reconcile to total revenue requirement
MCOSS Issues and Innovations

• Issues
  • Mixing timeframes is theoretically incoherent
  • Treatment of replacement costs and maintenance
  • Difficult to estimate marginal costs with joint products and many potential solutions
  • Reconciliation methods
• Innovations going forward
  • Hourly marginal costs
  • Can shift conceptually to a “total service long-run incremental cost” study
3 Rate Design
Cost Allocation and Rate Design

Credit: https://xkcd.com/552/

Cost allocation does not dictate rate design, but it does waggle its eyebrows suggestively while mouthing “look over there.”
Principles of Smart Rate Design

1. Customers should be able to connect to grid for no more than the cost of connecting to grid

2. Customers should pay for grid services and power supply in proportion to how much they use these services and how much power they consume

3. Customers who supply power to grid should be fairly compensated for full value of power they supply
Rate Design Specifics

- Start with long-run marginal system costs
  - Long-run efficiency, rate stability, and competition outside of electric sector
- Build in short-run marginal costs where feasible
  - Mandatory hourly pricing for large C&I in NY
  - Critical peak pricing, variable peak pricing, or peak time rebates
- “Residual” system costs, certain program costs and A&G costs are harder questions
  - Can be considered part of LRMC
  - Underpriced externalities can help guide efficient answer
Customer Charges and Demand Charges

- Customer charges: flat monthly charge
  - Limit to marginal cost of connection and billing
  - Risks customers disconnecting from grid
  - Inefficient from broader competition perspective
- Demand charges: 15- or 30-minute customer peak
  - Generally unfair and inefficient for shared system costs
  - Potential exceptions
    - Dedicated site infrastructure
    - Needle peaking and timer peaking
    - Small benefit from lower variance peak usage
Issues with Ramsey Pricing

• Theoretical weaknesses
  • New justification for price discrimination and anti-competitive behavior
  • Lowers management incentives to control costs

• Implementation concerns
  • What are the residual costs?
  • What about externalities?
  • Who ends up paying more?
  • What is the least elastic customer segment and type of charge?
Understandability and Transitions

- Customers must be able to understand their rates and manage their bills
  - Data provision and online tools can help
- Gradual transitions can diffuse knowledge and help acceptance
  - Start with opt-in and move to opt-out or mandatory
  - Shadow billing and hold harmless protection
- Companion programs are important
  - Cost-effective energy management technology programs to enable customer response and minimize risk of negative bill impacts
  - Special low-income programs can be as simple as timers for electric water heaters offered for free
Net Metering Puzzle

- Many jurisdictions adopted net metering in 2000s
  - Monthly netting and retail rate credit rollover
- Issues
  - Potential for revenue shifting increases with DG adoption
    - Different perspectives on value (or avoided costs) of clean DG
  - Costs of integrating high levels of variable DG
  - Inefficiencies in baseline rate design
Net Metering Solutions

- Netting period changes can be linked to time-varying rates
  - Under monthly netting, customer with zero kWh net consumption only pays customer charge
  - Moving to TOU period netting can be significant
- Delink export credit value from import rates
  - Top down in California
  - Bottom up (VDER) in New York
- Bi-directional distribution rate
  - Charge A&G costs to both imports and exports
Hawaiian Electric TOU Rate

Interim Time-of-Use Rates*
(For illustrative purposes only)

*Illustration reflects September 2019 electric rates with applicable surcharges.
## Illustrative Impact of TOU Rate Design and Netting

<table>
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<th>Rate Element</th>
<th>Rate</th>
<th>Unit</th>
<th>Time Period</th>
<th>Load</th>
<th>Generation</th>
<th>Net</th>
<th>Billed Amount</th>
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<td>Customer Charge</td>
<td>11.50</td>
<td>$/Month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$ 11.50</td>
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<tr>
<td>Off-Peak</td>
<td>0.136</td>
<td>$/KWh</td>
<td>9 AM to 5 PM</td>
<td>195.3</td>
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<tr>
<td>Mid-Peak</td>
<td>0.329</td>
<td>$/KWh</td>
<td>Other Times</td>
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<td>42</td>
<td>156.6</td>
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<td>534</td>
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About RAP

The Regulatory Assistance Project (RAP)® is an independent, non-governmental organization dedicated to accelerating the transition to a clean, reliable, and efficient energy future.

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