Overview of Electric Ratemaking

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What is a Public Utility?

The term Public Utility is one of popular usage rather than precise definition. The term commonly refers to that group of businesses which:

1. supply services that are vital to the welfare of society
   - Businesses that provide services vital to society are businesses that are “affected with a public interest” (hence the term “public utility”)

2. have been subjected to direct regulation over their rates and service practices.
   - Regulated rates should be “just and reasonable” in that they:
     1. are justified based on the cost of providing safe and reliable service (reasonable);
     2. are equitable and not “unduly discriminatory”;
     3. allow for a “fair” (just) return on the company’s assets (but preclude an unlimited opportunity to earn unfettered profit)

The term “public utility” does not imply “publicly-owned”; indeed, most electricity is sold by privately-owned (investor-owned) utilities.
Characteristics of a Public Utility

- Public utilities utilize production and/or network technologies that lead to significant benefits of concentrated, if not monopolized, production
  - “natural monopoly” refers to a situation wherein it is less costly for a single firm to produce a given level of market output as opposed to splitting that given level of output amongst multiple competing firms
- Public utilities are extremely capital intensive. It is not uncommon for public utilities to have three to four dollars of physical assets for every dollar of sales
  - For other manufacturing firms this ratio is closer to 80 cents per dollar of sales
- A key aspect of traditional public utility regulation is the concept of the service territory
  - The utility is obligated to serve customers within its authorized service territory
  - The utility cannot abandon service
- If an entity wants to apply to be a utility, or if an existing utility wants to build a major addition to its physical plant, the utility must apply for a certificate of convenience and necessity (CCN).

The “Regulatory Compact”

- **The Utility is obligated to:**
  - serve all who seek service within the authorized area of operation (i.e., the service territory) as long as those customers pay the regulated rates;
  - render service at fair and reasonable rates that are regulated by the state;
  - serve all qualified customers on equal terms without preference or undue discrimination; and
  - render adequate, safe, reliable, and satisfactory service throughout the authorized service territory
- **The Utility has a right to:**
  - provide exclusive monopoly service in the authorized service territory;
  - charge rates the are provide the utility the opportunity to recover all prudently incurred costs as well as the opportunity to earn a fair return on its investments;
  - impose reasonable conditions as to the terms under which service will be rendered; and
  - acquire plant and property necessary to providing service
What is a Public Utility: Bottom Line

• A Public Utility is an extremely capital-intensive enterprise that is obligated to provide services that are vital to the public welfare of society at prices and service-quality standards that are highly regulated by the government.

• Such a high degree of regulation effectively deprives the enterprise of certain private-property rights (“takes private property for public use”), which constitutionally must be accompanied with just compensation and due process (see 5th and 14th amendments to the U.S. Constitution).

The Administrative Commission

• Under public utility regulation, price, quality of service, profitability as well as entry and exit, are controlled by the state rather than being left to market forces.

• The traditional instrument used for the regulation of public utilities is the administrative commission.

• A tariff is a listing of the regulated price, along with terms and conditions of service, applied to a particular group of customers and approved by the commission.

• Regulated prices are “administratively determined” in that the commission determines the final outcome after all affected parties give input into the case and in that the case itself adheres to due process procedures.
Federal versus State Regulation

- State public utility commissions (PUCs) regulate retail sales
- The Federal Energy Regulatory Commission (FERC) regulates wholesale transmission services and power sales (for resale) in interstate commerce (wholesale exchanges that take place anywhere within an interconnection – as long as the interconnection itself crosses state boundaries)

Legal Basis for Regulation of Public Utilities

- The Commerce Clause of the U.S. Constitution (Article I, Section 8, Paragraph 3) gives the U.S. Congress the power to regulate interstate commerce.
  - The Supreme Court has interpreted this clause to mean that the Congress has the power to regulate interstate commerce, which may include anything that has a substantial direct or indirect effect upon interstate commerce.
  - Throughout our history, the U.S. Congress has enacted laws that have created federal regulatory commissions that conduct the direct, day-to-day regulatory processes governing public utility activities deemed interstate commerce.
    - The Federal Power Commission (FPC), established in 1920, was succeeded in 1977 by the Federal Energy Regulatory Commission (FERC).
    - The FERC is charged with the regulation of interstate natural gas pipelines, wholesale electricity exchanges and the use of electric transmission lines in interstate commerce.
Legal Basis for Regulation of Public Utilities

• The 10th Amendment to the U.S. Constitution states “The powers not delegated to the United States by the Constitution, nor prohibited by it to the States, are reserved to the States respectively, or to the people.”

• This allows for state regulation (by state utility commissions) of public utility activity that is not deemed interstate commerce.
  
  – Generally speaking, intrastate retail utility activities are subject to state regulation. Interstate wholesale activities are subject to federal regulation. Retail sales are sales to final customers; wholesale sales are sales to entities that will, in turn, resell to final customers (i.e., “sales for resale”)
  
  – Moreover, the same utility may be (indeed most are) subject to both state and federal commissions.

Legal Basis for Regulation of Public Utilities

• The 5th Amendment to the U.S. Constitution creates safeguards to corporations (including, of course, investor-owned utilities) from federal regulatory control by stating that citizens cannot “…be deprived of life, liberty, or property, without due process of law; nor shall private property be taken for public use without just compensation.”

• The 14th Amendment to the U.S. Constitution creates safeguards from state regulatory control by stating that no “…State [shall] deprive any person of life, liberty, or property, without due process of law…”
Key Supreme Court Case

- In 1944, in **FPC vs. Hope Natural Gas**, the Court ruled that:
  
  - From the investor or company point of view, it is important that (just) prices are set such that there be enough revenue not only for operating expenses but also for the capital costs of the business – these include service on the debt (interest) and dividends on stock.
  
  - The return to the equity/stock owners should be:
    
    - commensurate with the returns on investments in other enterprises with similar risks
    
    - sufficient to assure confidence in the financial integrity of the utility so as to maintain its credit and to attract capital.

The Traditional Electric Utility

- For most of the last 100 years, electricity has been sold by vertically-integrated monopolies sanctioned, and regulated, by government.
  
  - Such a utility owns connected generation, transmission and distribution facilities (hence the phrase “vertically integrated”)
  
  - Such a utility is the only supplier allowed by the government to provide service to retail customers located within the utility’s specified service territory.
  
  - All service provided by such a utility is “bundled” service; i.e., a retail customer gets all (generated power, delivery of power, customer service – including billing and metering) or nothing.
  
  - Quality of service, cost of service, equity returns and prices (rates) are regulated by utility commissions.
Overview of the Regulatory Agency

Examples:
- State Public Utilities Commission, Public Regulatory Commission, Commerce Commission, Public Service Commission, Corporation Commission, Board, Dept. of Public Service
- Federal Energy Regulatory Commission (FERC), Federal Communications Commission (FCC)
- All Agencies Ultimately Charged with Setting “Just and Reasonable” Rates Under the U.S. Constitution

Overview of the Regulatory Agency

- Quasi-Judicial Body:
  - hears and decides contested cases such as rate cases and complaints with strict adherence to principles of Due Process. Similar to a Court of Law.

- Quasi-Legislative:
  - develops rules and regulations (“rulemaking”) as within their statutory authority that serve to implement new statutes containing greater detail than Acts of Congress or the State Legislature. Administrative Law. (Commission Regulations have the weight of law but Commission Orders are not binding precedent).
Overview of the Regulatory Agency

- Board or Commission: Usually an odd number of commissioners who are nominated or appointed by the executive branch (President or Governor) possibly subject to legislative confirmation.
- Advisory Staff
- General Counsel
- Litigation/Trial Staff
- Staff Counsel
- Hearing Officer – May be a Commissioner, Administrative Law Judge or some other authorized agent of the Commission
- Attorney General’s Office – Consumer Advocate

Commission Independence

- Independent from the regulated industries
- Political Independence
  - Independent from Governor or Legislature
  - Appointed Commissioners given staggered 6-year terms
  - Elected Commissioners answer to voters
- Financial Independence
  - Funding from special assessment on customer bills
  - Not tied to the state’s general tax fund
Rate Increase Applications

- Filed by the utility Company (may be scheduled by statute or order).
- Burden of proof is on the applicant (the utility).
- All components of the filing sponsored by a witness with prefiled, written testimony.
- Schedules, work papers, supporting data, cost of service study, and rate design filed with prefiled testimony.
- Minimum Filing Requirements
  - Presumption of prudence favors utility (exception would be affiliate transactions).

Motions to Appear and Show Cause

- As to why the company’s rates continue to be just and reasonable (not very common)
- May be initiated by motion of the Commission Staff or upon the Commission’s own motion (5 VAC 5-20-90).
- Burden of proof is on Commission Staff.
Rate Case Procedures and Rules

The Application to Adjust Rates – most commonly filed by the regulated utility (statutory deadline: many states have a prescribed time period to complete the case).

The Applicant has the Burden of Proof.

Notice of Filing published in newspapers and possibly posted at certain public places.

Time period for Petitions for Leave to Intervene – necessary to become a recognized Party of Record.

Parties generally include: Utility, Staff, AG, Customers (AARP, commercial and industrial groups).

Phases or Steps in the Process:

1. Filing of the Application and Supporting Written Testimony, Data, Analysis
2. Notice of Filing
3. Petitions for Leave to Intervene
4. Pre-hearing or Scheduling Conference
5. Discovery Phase – information or data requests
6. Filing of Written Testimony by Other Parties of Record
7. Filing of Written Rebuttal Testimony by Applicant
8. Possible round of responsive testimony by Other Parties of Record
9. The Evidentiary Hearing
10. Possible Legal Briefs
11. The Decision
12. Petition for rehearing or reconsideration
13. Possible Judicial Review
Know the Law

- Familiarize yourself with the relevant statutes and administrative codes (rules and regulations) and the tariffs in the jurisdictions where you conduct business.

- Example: minimum filing requirements for a general rate case are usually found in the state administrative code.

- FERC Uniform System of Accounts ("USOA") are found in the Code of Federal Regulations. States have adopted the FERC USOA possibly with some additions.

Basic Steps in Rate Making Process

1. **Determination of Revenue Requirements/Overall Cost of Service**
2. **Assign costs to Customer/Rate Classes Within a Jurisdiction**
3. **Design Cost-Based Rate Elements for Each Rate Classes’ Tariff**
4. **Components of Cost of Service Study**
   - Functionalize Costs
   - Classify Cost
5. **Jurisdictional Separations**
   - Allocation of Revenue Requirements Across the Jurisdictions in which the Company Operates: Federal and possibly multiple states.
Revenue Requirements

Definition

• What are the total annual revenues required by the firm to cover both its expenses and have the opportunity to earn a fair rate of return? OR

• What are the total annual costs to provide safe and reliable service to the company’s customers that the company is allowed to recover through rates? - Cost of Service concept

“The Formula”

Revenue Requirement, \( RR = O + T + d + r \cdot (V - D) \)

O = Operating Expenses (O&M/A&G)
T = Taxes (corporate income taxes + other taxes)
d = Annual Depreciation Expense
V = Gross Investment
D = Accumulated Depreciation (sum of past “d”)
r = % Overall Rate of Return (weighted-average cost of capital)
The Revenue Requirements Formula

"Return Dollars on Rate Base"

Expenses "Rate Base"

\[ RR = O + T + d + r \cdot (V - D) \]

Rate Base = the net investment in facilities, equipment and other property necessary to provide utility service (a stock concept)

Rate of Return = (r) the % return earned, or allowed to be earned, on the utility’s rate base (expressed as a percentage)

Return dollars = \( r \cdot (V - D) \) return dollars on rate base (a flow concept)

Network Technology Basics
Basic Components of Electricity
Production and Delivery

• Generation, Transmission and Distribution comprise the basic elements (operating functions) of the electric industry
  
  – Generation is the initial source where electricity is “produced”
  
  – Transmission is the high-voltage system of wires that transports electricity over long distance
  
  – Distribution is a low-voltage delivery area where electricity is delivered to final customers

A Simple Electric System
Basic Components of Electricity  
Production and Delivery

• Electrical Power is produced at generating stations and then power flows through a series of wires until it gets to a particular end “appliance” which performs a service for the final customer.

• After the power is produced at the generation station, the voltage is stepped up at a substation (point of receipt) and then transmitted over high-voltage transmission lines.

• From the transmission lines, power voltage is decreased (stepped down) at a substation (point of delivery) and then transmitted over lower voltage distribution lines to final customers.

• Primary and Secondary Distribution voltage

• Final transformation in the system delivers at 110/120v at location of small general service and residential customers.

Transformers

• The advantage of AC over DC is that, in an AC system, voltage can be increased or decreased through a transformer as the current moves from one circuit to another
  – A basic transformer is constructed of two separate coils, or windings of wires: a primary coil (on the source side) and a secondary coil (on the load side)
    • If there are more turns on the primary coil than the number of turns on the secondary coil, the transformer will be a step-down transformer (voltage is reduced)
    • If there are less turns on the primary coil than the number of turns on the secondary coil, the transformer will be a step-up transformer (voltage is increased)

• With transformers, power can then be transmitted over long distances on high voltage lines (high voltage greatly reduces line losses) and then the voltage can be reduced for delivery to final customers.
The Need for Generation Capacity

- Both instantaneous customer demand (or “load”) and generation capacity (potential supply) is measured in mega-watts (MW).

- A generator’s capacity is the maximum power it can produce at a given instant – although the actual power produced by a generator can be less than its capacity.

  - capacity value is the ability to satisfy load (meet demand) when needed.

- Because electricity cannot effectively be stored – and because power supplied must match demand (load) at every instant – there must be enough generation capacity to meet the maximum instantaneous demand regardless of when it occurs.

- In addition, there must also exist “back-up” reserve generation capacity in case there are unexpected outages in some generation plants or unexpected increases in load.

Types of Generation Technologies

- Different generation technologies are differentiated by their:

  1. capacity, or capital, costs (cost of the machine itself)

  2. operating costs (cost of running the machine and producing kilowatt-hours, kWh)

  3. start-up times (time it takes to go from a cold start to actually producing kWh);

  4. heat rates (the amount of BTUs it takes to generate one kWh)

  5. ramp rates (the rate at which power output can change per unit of time)

  6. capacity factor (ratio of actual kWh produced to maximum kWh that could be produced if run all year at maximum capacity)
Types of Generation Technologies

• **Base-load generating units (steam plants)** are normally used to satisfy the minimum or base load of the system and, as a consequence, produces electricity at an essentially constant rate and runs continuously. Base-load units are generally the cheapest to operate but the most expensive to build – they are run, at capacity, 24/7 (very high capacity factors).

• **Peak-load generating units (CT units)**, normally the most expensive to operate (but the cheapest to build), are used to meet requirements during the periods of greatest or peak load on the system. Because of their quick start capabilities they are also good as reserves (very low capacity factors).

• **Intermediate-load generating units** meet system requirements that are greater than base load but less than peak load. Intermediate-load units are used during the transition between base-load and peak load requirements.

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Generation Technologies and Costs

<table>
<thead>
<tr>
<th>Technology</th>
<th>Capital Costs</th>
<th>Operating Costs</th>
<th>Start-Up Times</th>
<th>Ability To Adjust Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Res. Hydro</td>
<td>High</td>
<td>Very Low</td>
<td>Instant</td>
<td>Very Quick</td>
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<tr>
<td>Nuclear</td>
<td>Very High</td>
<td>Very Low</td>
<td>Slow</td>
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<tr>
<td>Coal</td>
<td>High</td>
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<td>Combined-Cycle (CC)</td>
<td>Medium</td>
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<td>Gas Turbines</td>
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<tr>
<td>Simple Gas CTs (“Peakers”)</td>
<td>Low</td>
<td>High</td>
<td>Quick</td>
<td>Quick</td>
</tr>
</tbody>
</table>
Resistance and Line Losses

- Just like clogged screens or garbage can impede (resist) the steady flow of water through the pipe, various factors can yield resistance to the flow of electricity.
- Resistance is directly proportional to the length of wire and inversely proportional to the cross section area (“thickness”) of the wire.
  - Additionally, resistance rises as a metal conductor is heated.
- The resistance imposed on the electrons causes heat – i.e., some of the electrical energy is converted to heat; so some of the electricity is actually lost through this conversion.
  - Losses can range from 2% to 10% depending on the voltage and the length of the line – the longer the circuit, the greater the losses.
  - Also, losses per unit of delivered power are lower when delivered on higher voltage lines – again, the advantage of AC (see slides 13-14).
  - Losses also occur in transformers.

Basic Components of Electricity
Production and Delivery

Long distance delivery is over high-voltage transmission lines.
In order to mitigate line losses.
The Need to Build for the Peak

- Electricity cannot be effectively stored

- Electrical networks must instantaneously balance real power from generation with load (i.e., supply must always equal demand); this act is referred to as “load balancing”
  - Supply > Demand $\Rightarrow$ frequency $> 60$ cycles/sec $\Rightarrow$ equipment can be ruined
  - Supply < Demand $\Rightarrow$ frequency $< 60$ cycles/sec $\Rightarrow$ system can crash

- Sufficient generation capacity is required to meet maximum instantaneous demand regardless of when it happens

Key System Operations: Primary Services are Power and Delivery; Ancillary Services Support Reliability

- **Maintain Frequency at 60 hertz**
  - Real power from generators must equal total demand at every instant in time (an instant is typically a two second scan)
  - Must set aside certain generators that can quickly adjust power output (i.e., have quick ramp rates), either up or down, on an instant to instant basis

- **Maintain Specified Voltage Levels on Lines**
  - Reactive power absorbed by inductive load must equal reactive power generated (by capacitors or the generators themselves) so that voltage doesn’t drop or spike

- **Have Access Generation Reserves**
  - Must set aside – and have access to – extra quick-starting generation capacity (over and above the expected peak demand) that can be called on quickly in case of unexpected generation outages or unexpected surges in demand
Key System Operations: Primary Services are Power and Delivery; Ancillary Services Support Reliability

• The entity that performs these key system operations is referred to as the “Balancing Authority” or “Control Area Operator.”

  An entity that maintains load-resource balance within a control area defined by a metered boundary.

• A Control Area is an electrical region, bounded by metering equipment, that is capable of controlling its own generation in order to balance load and maintain planned interchange schedules with other [control areas] and assists in controlling the frequency of the interconnected system.

More on Control Areas

• In the traditional world, a balancing authority is synonymous with a particular utility and …

  … the control area represents the physical network owned and operated by a particular utility, which is required to reliably deliver power to the customers in the utility’s service territory (who the utility is obligated to serve).

• In the non-traditional world, a Regional Transmission Organization (RTO) is a balancing authority for a consolidated regional control area, which is comprised of “zones”

  – Each zone within the RTO is effectively the old control area of a particular utility that has joined the RTO and relinquished operational control of its transmission to the RTO.
Control Area Operations

All expected power interchanges between control areas (for each hour) must be scheduled ahead of time to ensure that there is enough available transmission capacity.

Interconnections Between Utilities’ Control Areas

- Through time, four major “interconnection areas” have evolved in the U.S. and Canada [Western interconnection, Eastern interconnection, Texas interconnection (most of Texas), and Quebec interconnection]
  
  - **Within** each interconnection, different utilities (or control areas) are interconnected via transmission (hence the name “interconnection”)
  
  - There is very little interconnection (transfer of power) **between** the four different interconnections
    
    - Such connection is through AC-DC-AC inter-ties (the four different interconnections are not “in-phase” with each other). These ties can be “switched off” *and* the capacity of these ties is extremely limited
  
  - For all practical (and technical) purposes, the U.S. does not have a single national grid along which power exchanges can take place
Upstream and Downstream Capacity Requirements

• Every component of the network must have sufficient capacity to meet the maximum demand of all load connected to that component of the network.
• Generation capacity must meet maximum demand of the entire system.
• Transmission capacity must meet maximum demand of all load (customers) connected.
• Transformer capacity must meet maximum demand of all customers behind that transformer.
• Primary and secondary distribution.

Capacity requirement example

• Primary distribution system must have sufficient capacity to meet the maximum demand of all primary voltage customers plus all secondary voltage customers connected/relaying on the primary voltage network.
• Secondary distribution system must be sized to meet maximum demand of secondary voltage customers on that portion of the system, but not the demand of primary voltage customers.
### Information From Load Curves

- A **Load Curve** describes the pattern of instantaneous demand through a particular period of time (i.e., through a cycle):
  - A daily cycle (for a daily load curve) is 24 hours
  - An average monthly cycle (for a monthly load curve) is 730 hours
  - An annual cycle (for an annual load curve) is 8,760 hours

### Information From Load Curves

- **Average Load** is derived by taking the total kWh of energy used through the cycle and dividing by the total number of hours through the cycle.
  - For example, if a customer consumes 7,300 kWh during a month, then that customer’s average load (instantaneous demand) is 10 kW
  - Average load is analogous to average speed on a trip
Information From Load Curves

- **Peak Load** is the maximum instantaneous demand (load) during the cycle (measured in kW or mW)

  - **Non-Coincidental Peak Load (NCP)** is a customer’s (or customer classes’) maximum load irrespective of when it happens

  - **Coincidental Peak Load (CP)** is a customer’s (or customer classes) load at the moment in time that the total system is experiencing its peak load

System and Class Loads: CP vs. NCP

![Graph showing system and class loads: CP vs. NCP](image-url)
System and Class Loads

- Note that the sum of the class CPs equal the system peak

- Note that, if one class’s NCP is greater than that class’s CP, the sum of the NCPs will be greater than the sum of the class CPs

- A class NCP is either greater than or equal to its respective CP
  - If the class NCP is greater than the class CP, then the class peaks at a time different from the system peak (like B in the previous slide)
  - If the class NCP is equal to the class CP, then the class peaks at the same time as the system peak (like A in the previous slide)
  - The class NCP cannot be less than its respective CP

A Simple Electric System
Basic Steps in Rate Making Process

1. Determination of Revenue Requirements/Overall Cost of Service
2. Allocate costs to Customer/Rate Classes Within a Jurisdiction
3. Design Cost-Based Rate Elements for Each Rate Classes’ Tariff
4. Components of Cost of Service Study
   - Functionalize Costs
   - Classify Cost
5. Jurisdictional Separations
   - Allocation of Revenue Requirements Across the Jurisdictions in which the Company Operates

Rate Class Cost of Service Study

- An analytical approach to the apportionment of the total cost of service (Revenue Requirement)
- Supports the process of determining and allocating the cost of providing utility service to each customer rate class and provides a framework for recovering costs through proper rate design
- The costs of the utility must be studied by the cost analyst using inputs from various areas of utility operations (e.g., accounting records, engineering analyses, customer billing records, demand forecasts, cost simulation models)
Types of Cost of Service Studies

- The vast majority of jurisdictions use Embedded (i.e., based on actual book data and actual class load characteristics) COS for cost allocation

- Marginal COS is used for the development of time-of-use pricing and, in a small minority of jurisdictions, for actual cost allocation

- Not an exact science – reasonable people can disagree – “Range of Reasonableness”

Steps in an Embedded Cost of Service Study

- Step 1: Functionalize
- Step 2: Classify
- Step 3: Rate Class Allocation

Key Question to be asked at every step in the process:

- What (or who) caused the costs to be incurred? (cost causation)
Step 1: Functionalization

- The process of dividing the total revenue requirement into functional components as related to the operations of the utility (operating functions)
  - Generation (AKA Production)
  - Transmission
  - Distribution
  - Meters and Services
  - General Plant (eventually must be apportioned to the other non-general functions)

- Usually, the rate-base component of revenue requirements is functionalized first; then the expense components are functionalized

STEP 2: Classification

- The process of separating the functionalized costs into classifications based on the components of utility service being provided

- In other words, this is the process of separating the functionalized costs into classifications based on what the costs are sensitive to

- Primary Cost Classification Categories
  - Demand-Related Costs (AKA Capacity-Related Costs)
    - Those costs that vary with the kW of instantaneous demand (and therefore peak capacity needs)
  - Energy-Related Costs
    - Those costs that vary with the kWh of energy
  - Customer-Related Costs
    - Those costs that vary with the number of customers
STEP 2: Classification

- **Examples of Demand-Related Costs**
  - Costs of Generation Capacity
  - Costs of the transmission lines
  - Costs of the distribution lines and transformers (again, as we get closer to the customer, some of the distribution lines are classified as customer-related costs)

- **Examples of Energy-Related Costs**
  - Fuel
  - Generation variable O&M (e.g., lubricants)

- **Examples of Customer-Related Costs**
  - Metering
    - Depreciation expense on the meters
    - Labor needed to go out and read the customers' meters
  - Billing and account processing
    - Depreciation expense on needed information equipment
    - Fielding customer complaints and questions
  - Costs associated with facilities required to attach the customer to the network (service lines and some of the smaller distribution lines)
Step 2: Classification

The separation of functionalized costs into cost causation components

“Fixed Components”
- Demand-related
- Customer-related

“Variable Components”
- Energy (AKA Commodity)-related
CLASSIFICATION OF COSTS (Example)

- Classify Generation
  - O&M and A&G – 85% demand, 15% energy
  - Fuel – 100% energy
  - Depreciation, Taxes and Return Dollars – 100% demand
  - Purchased Power is classified on an "As-Billed Basis"
    - the portion of the purchased-power bill owed to demand charges is classified as a demand-related cost and the portion of the bill owed to energy charges is classified as an energy-related cost (here we'll just assume all purchased power is 60% demand and 40% energy)

- Classify Transmission
  - 100% demand

- Classify Distribution Sub Stations
  - 100% demand

- Classify Distribution Lines and Transformers
  - 80% demand
  - 20% customer

- Classify Meters and Services
  - 100% customer related

Step 3: Rate Class Allocation

- The process of assigning the functionalized and classified revenue requirements (cost of service) to the different customer rate classes.
  - A rate class is a relatively homogeneous group of customers that possess similar characteristics and who face the same set of prices (e.g., residential, small power, irrigation, industrial power)
  - Characteristics include such things as: energy consumed; load characteristics and end use; delivery voltage; metering characteristics; other conditions of service
  - In order to conduct a class cost-of-service study, the demand characteristics of the total system, as well as individual rate classes, must be analyzed.
  - Such analysis is referred to as “load research”
Step 3: Rate Class Allocation

- The process of assigning costs to the different jurisdictions and the different customer rate classes.

- Once the various customer class categories have been designated, particular functionalized and classified costs are allocated among the rate classes based on an allocation method which is deemed the most consistent with cost causation
  - Different cost components require different allocation methods

- A particular allocation method (i.e., allocation factor) is a set of percentages that sum to 100%
  - Demand-Related Allocation Methods
  - Energy-Related Allocation Methods
  - Customer-Related Allocation Methods

Basic Steps in Rate Making Process

1. Determination of Revenue Requirements/Overall Cost of Service
2. Assign costs to Customer/Rat Rate Classes Within a Jurisdiction
3. Design Cost-Based Rate Elements for Each Rate Classes’ Tariff
4. Components of Cost of Service Study
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   - Allocation of Revenue Requirements Across the Jurisdictions in which the Company Operates
Rate Design

- A tariff is a document, approved by the responsible regulatory agency, listing the terms and conditions under which utility services will be provided to customers within a particular class. Tariff sheets typically include:

  - a schedule of all the rate elements (individual prices) plus the provisions necessary for billing
  - the service characteristics (e.g., voltage, single or three phase) and metering methods
  - Rules and regulations, i.e., a statement of the general practices the utility follows in carrying out its business with its customers

RATE DESIGN

- We now turn to the issue of determining rate elements found in a tariff. Rate elements are individual “price tags” which the utility places on the service(s) it renders

- A tariff is a document, approved by the responsible regulatory agency, listing the terms and conditions under which utility services will be provided to customers within a particular class. Tariff sheets typically include:

  - a schedule of all the rate elements (individual prices) plus the provisions necessary for billing
  - the service characteristics (e.g., voltage, single or three phase) and metering methods
  - Rules and regulations, i.e., a statement of the general practices the utility follows in carrying out its business with its customers
RATE DESIGN

■ Role of Rates
- 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

■ Attributes of a Sound Rate Design (Bonbright 1961)
- Rates should be fair, reasonable and not unduly discriminatory
  - Based on cost
  - Equitable
    - Horizontal Equity: “Equals treated equally”
    - Vertical Equity: “Unequals treated unequally”
- Rates should be stable
- Rates should be easily understood
- Rates should not induce wasteful behavior

RATE DESIGN

■ Base Rates
- Base Rates are determined during a general rate case (the primary subject of this course to this point)
- Base Rates are fixed in the tariff until the next general rate case comes along.
- This presentation is focused on Base Rates, but special rate mechanisms are worthy of mention.
- Trackers, Riders, and Adjustment Mechanisms: special rate elements used to recover costs that vary greatly outside the control of the utility.
Development of Base Rates

- Step 1: Calculate overall Revenue Requirement
- Step 2: Class Cost of Service Study
  - Functionalization
  - Classification
  - Allocation to Rate Classes
- Step 3: We now have a revenue requirement (or cost of service) for each customer class or “rate class”
  - Identify desired rate elements for each class and how much annual cost is to be recovered from that element.
  - Determine the (adjusted) annual billing determinants for each rate element (#customer months, kWh, kW month).

How are rate classes determined?

- Customers are grouped together into a rate class based on common characteristics (meter type, demand size, voltage level, others)
- Residential: Single Family
- Residential: Multi-family dwelling
- General Service or Commercial Class: small, medium, large (usually based on kW demand and/or voltage level)
- Industrial Rate Class
- Others: Street Lighting, Irrigation, Water Pumping, Standby Service.
Fundamental Rate Elements

- Demand Charge
  - Measured in dollars per kW of monthly metered customer billing demand (maximum demand during the month)

- Energy Charge
  - Measured in dollars per kWh of monthly customer energy use

- Customer Charge
  - Measured in dollars per customer per month

Each of the above, could be segmented by season and/or time of use.

---

**kW versus kWh: the kW**

- Kilowatt (kW)
  - Is the measure of electrical capacity required by the customer at any instantaneous moment. The kW equates to real power (as opposed to reactive power).
  - The instantaneous demand, or draw on the system, is referred to as the load (analogous to speed). Load removes power from a circuit; such a removal of power is owed to some electrical device that performs a useful service.
  - For example, compare – at an instantaneous moment – a 40 watt light bulb to a 250 watt light bulb
  - One kilowatt (kW) equals 1000 watts. One megawatt (MW) equals 1000 kilowatts
  - The term “watt” was named to honor James Watt, the inventor of the steam engine. One watt is a very small amount of power. It would require nearly 750 watts to equal one horsepower.
**kW versus kWh: the kWh**

- Kilowatt-Hour (kWh)
  - A kWh is a unit of energy representing the duration of a kW over time (analogous to distance)
    - One Megawatt-Hour (MWh) equals 1,000 kWh; and one kWh equals 1,000 watt-hours
  - Suppose that a 200 watt bulb (instantaneous demand) is kept on for 10 hours (period of time).
    - The total kWh of electrical energy used is:
      » (200 watts) * (10 hours) or 2,000 watt-hours
      » This is the same as two kWh

---

**Fundamental Rate Elements: Demand Charges**

- **Demand Charge**
  - Derived by taking the demand-related costs and dividing these costs by class “billing demand”
    - Billing Demand is the sum of the individual customers' (in the class) demands (typically the individual customers' NCP demands)
      - Monthly Billing Demand = sum of all customer's individual NCPs (within a particular rate class) in a particular month
      - Unless all customers peak at the same time, we will have monthly Billing Demand > monthly Class NCP
      - Annual Billing Demand = sum of the Monthly Billing Demands over all 12 months in the year
      - Average Monthly Billing Demand = Annual Billing Demand / 12
    - The manner in which the demand charge is calculated must be consistent with the manner in which individual customers are metered; otherwise, the utility will over or under collect.
Fundamental Rate Elements: Energy and Customer Charges

- Energy charges are derived by taking the class energy-related costs and dividing these costs by annual class energy use.

- Customer Charges are derived by taking the class customer-related costs and dividing by the class "customer months"

  - A class’s customer months is calculated by multiplying the total number of customers in the class by 12

Fundamental Rate Elements

- In general, the units that are divided into a class of costs (to calculate a rate element) are referred to as "Billing Determinants"

  - The billing determinant for the demand charge is, therefore, the total class metered demand

  - The billing determinant for the energy charge is, therefore, the total class energy use

  - The billing determinant for the customer charge is, therefore, the total class customer months
Calculating Rate Elements

- We will now calculate basic rate elements for the Residential Class (using the COS data from the previous presentation)

- Most Residential Customers do not have demand meters
  - We cannot put into effect a demand charge
  - Demand-related costs must be recovered either through the energy or customer charge

---

### Residential Class Characteristics

#### PHYSICAL CHARACTERISTICS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Energy Use (MWh)</td>
<td>31,153,834</td>
</tr>
<tr>
<td>Total Customers</td>
<td>2,015,919</td>
</tr>
<tr>
<td>Total Customer-Months</td>
<td>24,191,028</td>
</tr>
</tbody>
</table>

| Avg. Monthly kWh per customer | 1,288             |

#### REVENUE REQUIREMENT (000 $)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand-Related Costs</td>
<td>1,407,862</td>
</tr>
<tr>
<td>Energy-Related Costs</td>
<td>801,492</td>
</tr>
<tr>
<td>Customer-Related Costs</td>
<td>409,992</td>
</tr>
<tr>
<td>Total Revenue Requirement</td>
<td>2,619,347</td>
</tr>
</tbody>
</table>
## Residential Pricing Strategy I

**Collect all energy-related costs through a per kWh energy charge**

**Collect all other costs through a fixed monthly customer charge**

### Calculation of Energy Charge

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy-Related Costs (000s of dollars)</td>
<td>801,492</td>
</tr>
<tr>
<td>Divided by MWh (000s of kWh)</td>
<td>31,153,834</td>
</tr>
</tbody>
</table>

Yields Energy Charge ($ per kWh): 0.02573

Multiply by 100 (cents per kWh): 2.573

### Calculation of Customer Charge

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand-Related Costs</td>
<td>1,407,862</td>
</tr>
<tr>
<td>plus Customer-Related Costs</td>
<td>409,992</td>
</tr>
</tbody>
</table>

Yields Costs to be Recovered: 1,817,854

Multiply by 1000 to put into dollars: 1,817,854,269

Divide by Customer-Months: 24,191,028

Yields Monthly Customer Charge ($/customer/month): 75.15

## Residential Pricing Strategy II

**Collect all energy-related & demand-related costs through a per kWh energy charge**

**Collect only customer-related costs through a fixed monthly customer charge**

### Calculation of Energy Charge

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy-Related Costs (000s of dollars)</td>
<td>801,492</td>
</tr>
<tr>
<td>plus Demand-Related Costs (000s of dollars)</td>
<td>1,407,862</td>
</tr>
</tbody>
</table>

Yields Costs to be Recovered: 2,209,354

Divided by MWh (000s of kWh): 31,153,834

Yields Energy Charge ($ per kWh): 0.07092

Multiply by 100 (cents per kWh): 7.092

### Calculation of Customer Charge

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer-Related Costs</td>
<td>409,992</td>
</tr>
</tbody>
</table>

multiply by 1000 to put into dollars: 409,992,269

Divide by Customer-Months: 24,191,028

Yields Monthly Customer Charge ($/customer/month): 16.95
Residential Pricing Strategy III

Collect all energy-related & demand-related costs -- and half of the customer-related costs -- through a per kWh energy charge

Collect half of the customer-related costs through a fixed monthly customer charge

Calculation of Energy Charge

Energy-Related Costs (000s of dollars) 801,492
plus Demand-Related Costs (000s of dollars) 1,407,862
plus half of the Customer-Related Costs (000s of dollars) 204,996

Yields Costs to be Recovered 2,414,351
Divided by MWh (000s of kWh) 31,153,834

Yields Energy Charge ($ per kWh) 0.07750
Multiply by 100 (cents per kWh) 7.750

Calculation of Customer Charge

Half of the Customer-Related Costs 204,996
multiply by 1000 to put into dollars 204,996,134
Divide by Customer-Months 24,191,028

Yields Monthly Customer Charge ($/customer/month) 8.47

Residential Bill Impacts

<table>
<thead>
<tr>
<th>Strategy I</th>
<th>Energy Charge = 0.02573 ($ per kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge = 75.48 ($ per month)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Component</th>
<th>Fixed Component</th>
<th>Total Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below-Average User (600 kWh per month) $15.44</td>
<td>$75.48</td>
<td>$90.92</td>
</tr>
<tr>
<td>Average User (1288 kWh per month) $33.14</td>
<td>$75.48</td>
<td>$108.62</td>
</tr>
<tr>
<td>Above-Average User (2,000 kWh per month) $51.45</td>
<td>$75.48</td>
<td>$126.94</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strategy II</th>
<th>Energy Charge = 0.07118 ($ per kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge = 16.95 ($ per month)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Component</th>
<th>Fixed Component</th>
<th>Total Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below-Average User (600 kWh per month) $42.71</td>
<td>$16.95</td>
<td>$59.66</td>
</tr>
<tr>
<td>Average User (1288 kWh per month) $91.68</td>
<td>$16.95</td>
<td>$108.63</td>
</tr>
<tr>
<td>Above-Average User (2,000 kWh per month) $142.36</td>
<td>$16.95</td>
<td>$159.31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strategy III</th>
<th>Energy Charge = 0.07776 ($ per kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge = 8.47 ($ per month)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Energy Component</th>
<th>Fixed Component</th>
<th>Total Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below-Average User (600 kWh per month) $46.66</td>
<td>$8.47</td>
<td>$55.13</td>
</tr>
<tr>
<td>Average User (1288 kWh per month) $100.15</td>
<td>$8.47</td>
<td>$108.63</td>
</tr>
<tr>
<td>Above-Average User (2,000 kWh per month) $155.52</td>
<td>$8.47</td>
<td>$163.99</td>
</tr>
</tbody>
</table>
Simple Two-Part Tariff

Total Bill = (customer charge) + (energy charge)*(kWh consumed)

\[ Y = \alpha + \beta X \]

Average Use = 1,288 kWh/month

**Strategies:**

- **Strategy I** (large \( \alpha \), small \( \beta \))
  - Average Use = 1,288 kWh/month
  - Total Bill = $75.15

- **Strategy II** (small \( \alpha \), large \( \beta \))
  - Average Use = 1,288 kWh/month
  - Total Bill = $16.95

Costs and consumption are compared to determine the most economical option.
“Strategy 1” is known as “Straight Fixed-Variable Rate Design”

- Recover ALL of the fixed costs (demand-related and customer-related) through the customer charge.
- Recover ONLY the variable costs (energy-related) through the energy kWh charge.
- Will result in a very high customer charge.
- Advocated for the purpose of stabilizing revenues.
Pros and Cons of Increasing Customer Charge

- Pro: some argue that cost-causation promotes higher customer charge.
- Pro: stabilizes company's revenue flow.

- Con: increases the bills for below-average kWh customers.
- Con: there is a positive correlation between kWh consumption and kW demand-related costs.
- Con: could cause very low usage, low income households to discontinue service.

Calculating Unbundled Rate Elements

- We now calculate the unbundled rate elements by dividing each functionalized component of a classified cost by the same billing determinants (bt)

- $T = $1 + $2 \ (total\ cost = sum\ of\ functionalized\ components)$

- $T/bt = \frac{$1}{bt} + \frac{$2}{bt}$

- Bundled price = sum of unbundled component prices
<table>
<thead>
<tr>
<th>Line No.</th>
<th>Description</th>
<th>[A]</th>
<th>[B]</th>
<th>[C]</th>
<th>[D]</th>
<th>[E]</th>
<th>[F]</th>
<th>[G]</th>
<th>[H]</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>Energy-Related</td>
<td>801,492</td>
<td>801,492</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2)</td>
<td>Demand-Related</td>
<td>1,407,862</td>
<td>978,543</td>
<td>122,036</td>
<td>34,678</td>
<td>272,605</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td>Customer-Related</td>
<td>409,992</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>115,031</td>
<td>294,961</td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td>Total Costs</td>
<td>2,619,346</td>
<td>1,780,035</td>
<td>122,036</td>
<td>34,678</td>
<td>387,636</td>
<td>294,961</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td>Customer Charge</td>
<td>16.95</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>4.76</td>
<td>12.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td>Energy Charge</td>
<td>0.07092</td>
<td>0.05714</td>
<td>0.00392</td>
<td>0.00111</td>
<td>0.00875</td>
<td>0.00000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Class MWh</td>
<td>31,153,834</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total Class Customer-months</td>
<td>24,191,028</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>93</td>
</tr>
</tbody>
</table>

Calculating Rate Elements for Customers with Demand Charges

- We will now calculate basic rate elements for the Intermediate General Service Class (using the COS data from the previous presentation)

- Larger Customers do have demand meters
  - We can put into effect a demand charge
  - Separate charges for energy and demand
  - Fixed cost recovery between the energy and demand charge may be controversial
### Intermediate GS Class Characteristics

#### PHYSICAL CHARACTERISTICS

- Total Energy Use (MWh): 12,716,651
- Total Customers: 36,003
- Total Customer-Months: 432,036
- Avg. Monthly kWh per customer: 29,434
- Class NCP: 2,762
- Billing Demand (MW): 3,453
- Average Monthly MW per customer: 0.10
- Average Monthly kW per customer: 96

#### REVENUE REQUIREMENT (000 $)

- Demand-Related Costs: 557,869
- Energy-Related Costs: 327,160
- Customer-Related Costs: 21,583
- Total Revenue Requirement: 906,612

### Intermediate GS Rate Elements

#### Calculation of Energy Charge

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy-Related Costs (000s of dollars)</td>
<td>327,160</td>
</tr>
<tr>
<td>Divided by MWh (000s of kWh)</td>
<td>12,716,651</td>
</tr>
<tr>
<td>Yields Energy Charge ($ per kWh)</td>
<td>0.02573</td>
</tr>
<tr>
<td>Multiply by 100 (cents per kWh)</td>
<td>2.573</td>
</tr>
</tbody>
</table>

#### Calculation of Customer Charge

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer-Related Costs (000s of dollars)</td>
<td>21,583</td>
</tr>
<tr>
<td>multiply by 1000 to put into dollars</td>
<td>21,583,000</td>
</tr>
<tr>
<td>Divide by Customer-Months</td>
<td>432,036</td>
</tr>
<tr>
<td>Yields Monthly Customer Charge ($/customer/month)</td>
<td>49.96</td>
</tr>
</tbody>
</table>

#### Calculation of Demand Charge

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand-Related Costs (000s of dollars)</td>
<td>557,869</td>
</tr>
<tr>
<td>divided by Billing Demand (MW = 000s of kW)</td>
<td>3452.5</td>
</tr>
<tr>
<td>Yields Annual Demand Charge ($ per kW -- per year)</td>
<td>161.584</td>
</tr>
<tr>
<td>Divided by 12</td>
<td></td>
</tr>
<tr>
<td>Yields Monthly Demand Charge ($ per kW -- per month)</td>
<td>13.47</td>
</tr>
</tbody>
</table>
### Average Intermediate GS Customer’s Monthly Bill

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy Component</strong></td>
<td>Energy Charge ($ per kWh)</td>
<td>0.02573</td>
</tr>
<tr>
<td></td>
<td>Multiplied by Avg. Customer Monthly kWh</td>
<td>29,434</td>
</tr>
<tr>
<td></td>
<td>Yields Energy Component of Bill ($)</td>
<td>757.25</td>
</tr>
<tr>
<td><strong>Demand Component</strong></td>
<td>Demand Charge ($ per kW -- per month)</td>
<td>13.47</td>
</tr>
<tr>
<td></td>
<td>Multiplied by Avg. Customer Monthly kW</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>Yields Demand Component of Bill ($)</td>
<td>1,291.26</td>
</tr>
<tr>
<td><strong>Customer Component</strong></td>
<td>Monthly Customer Charge</td>
<td>49.96</td>
</tr>
</tbody>
</table>

**TOTAL BILL**

$ per Month 2,098.46

### Alternative Demand Charge Calculations:

Annual Billing Demand = 41,430,000 kW
Average Monthly Billing Demand = Annual Billing Demand ÷ 12 = 3,452,500 kW

Annual Demand-Related Costs $557,869,000
Divided by Average Monthly Billing Demand 3,452,500 kW
Yields Annual Demand Charge ($/kW/year) $161.58
Divided by 12
Yields Monthly Demand Charge ($/kW/mo) $13.47

Annual Demand-Related Costs $557,869,000
Divided by Annual Billing Demand 41,430,000 kW
Yields Monthly Demand Charge ($/kW/month) $13.47
Variant of Demand Charge: 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 Example: the higher of the current month’s demand or 70% of the highest demand from the past 13 months.
  - Note: the 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

Demand 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.
THANK YOU.

APPENDIX:
Northern States Power Company Rates