



ECONOMICS OF MODERN POWER SYSTEMS

M8 – Intro to Network Pricing

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Learning Outcomes –



- Understand the deregulation process
- Learn economic regulation modes
- Familiarize with nomenclature
- Introduction to transmission and distribution network pricing
- Understand the first step of pricing structure: calculating the utilities' required revenue

Background: Why rate structure??

Transition to a New Paradigm

Greater interaction between customers and the grid through smart monitoring and communication

Tariff structure is the key for assuring the success of smart grid

Pricing signals are the way to exchange information between the grid and the consumers

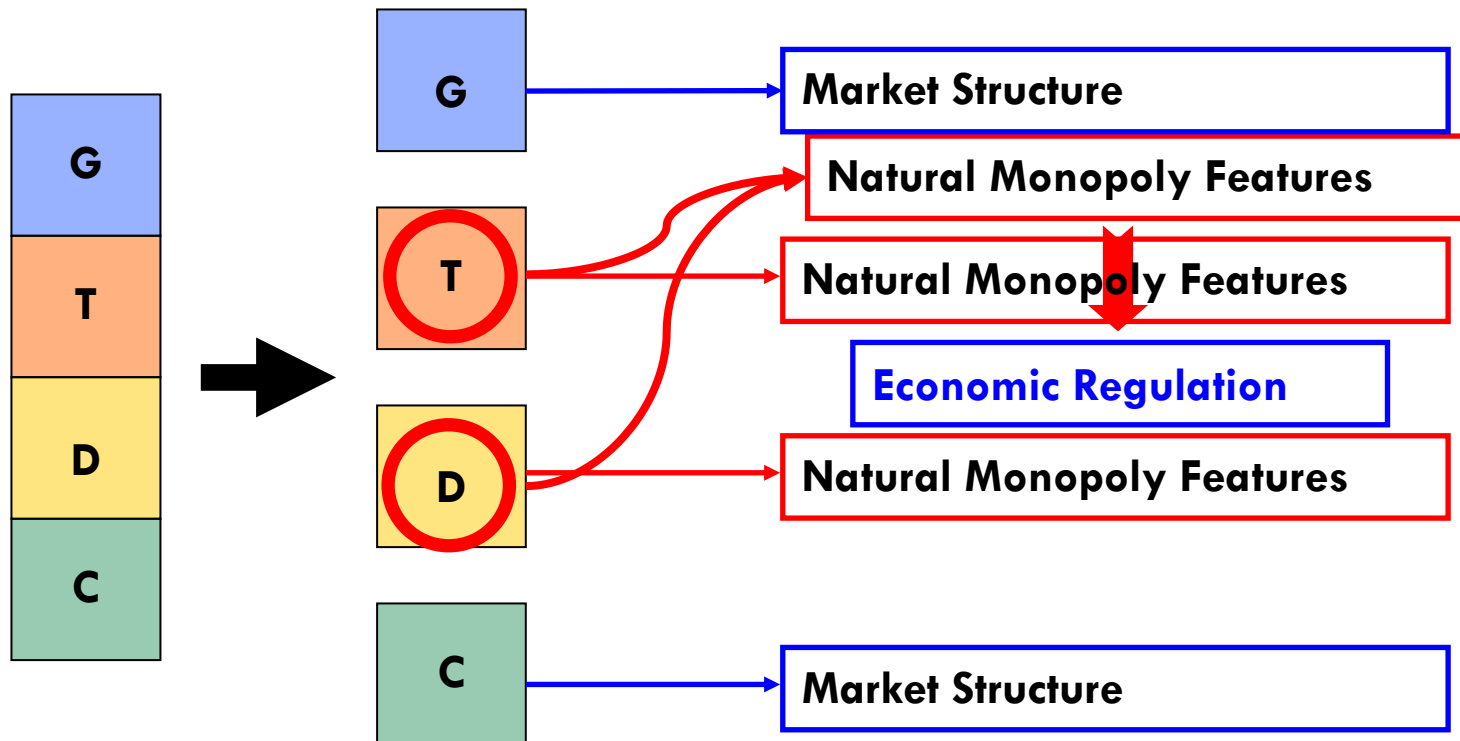




Introduction

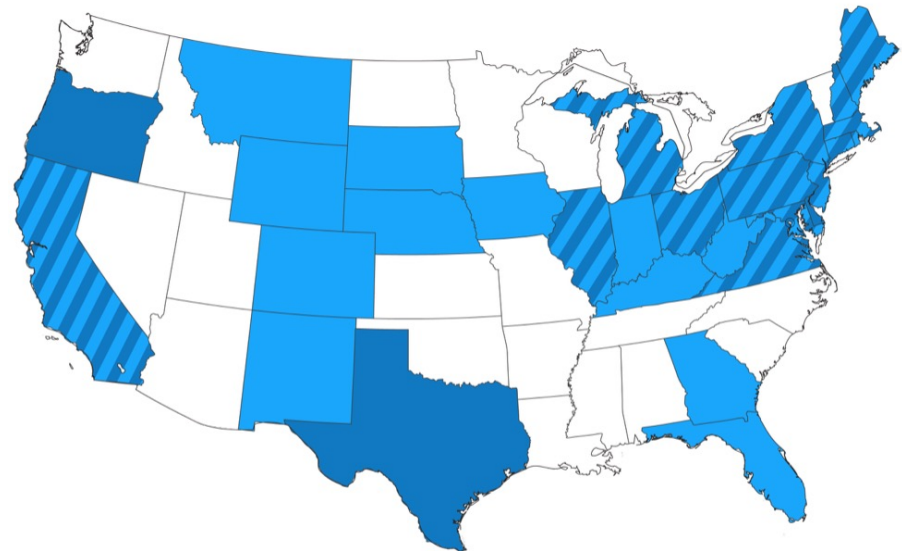
Background – Deregulation

- The deregulation of electrical power sector aimed to introduce market mechanisms and divided the sector



Background – Deregulation in US

- The groundwork for deregulation was laid out in by the Public Utilities Regulatory Policy Act (PURPA) 1978
 - ▣ **Introduce competition into the monopoly network**
- But the process only began after the Energy Policy Act of 1992
 - ▣ **Created the outline for a competitive wholesale electricity generation market**
- Deregulation has not been introduced in all states



Economic Regulation of T&D

- Economic regulation is a set of rules to avoid the companies from taking advantage of their customers (which can happen in monopoly)
- These rules determine
 - ▣ **How much profit** utilities could make
 - ▣ **How high they could set their rates** and
 - ▣ What **environmental standards** they needed to follow

Types of Economic Regulation of T&D

Incentive based regulation is generally implemented by controlling the overall price level of the operator. There are four basic schemes

- **Price-cap**
 - A price-cap regulation is a form of economic regulation that sets a cap on the price that the utility provider can charge. The company's average price increase is restricted by a price index
- **Revenue-cap**
 - Revenue cap regulation seeks to limit the amount of total revenue that can be earned by a firm operating in an industry with no or few other competitors
- **Yardstick (or benchmarking)**
 - Provides competition between comparable operators in separate markets. Regulators generally should choose performance measures and base on relative performance utilities are awarded or penalized
- **Rate-of-return or cost of service**
 - Provides the utility with the opportunity to recover prudently incurred costs, including a fair return on investment

Regulators often use combination of these four!

Nomenclature - Revenue

- Transmission

- Transmission Required Revenue (TRR)
- Transmission Allowed Revenue (TAR)
- Allowed Transmission Required Revenue (ATTR)

- Distribution

- Revenue Requirement (RR)

Nomenclature - Tariffs

- Wheeling charges
 - ▣ Wheeling is the transportation of electricity
 - ▣ Charge is a fee
 - ▣ More commonly used when we refer to the transmission grid
- Transmission Access Charge (TAC)
- Network charging or pricing
 - ▣ Usually refer to the distribution grid
- Electricity rate – final price paid by customers to utility

Side note: What does “charging” mean?

- Most people think it has to do with EV charging
- But it is much more than that...

Network Charging is related to the procedures and principles considered to compute the utility rates, i.e., how much the utility charges for providing electricity

Challenges in T&D Pricing



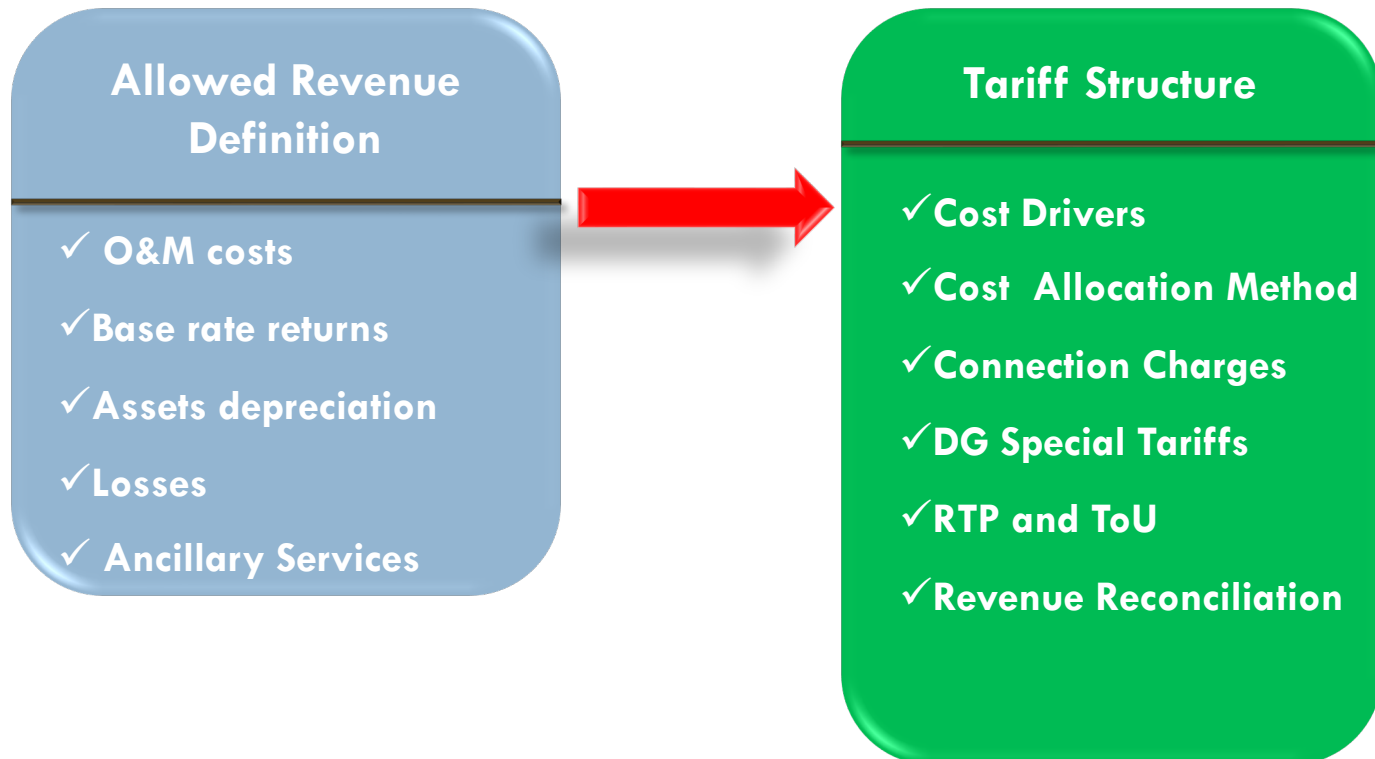
**The transmission and distribution tariffs/rates
must collect allowed/required revenue**



How to allocate it among the network users?

Tariff Design Process

The tariff design is a two-folded process:



Key Aspects of the Tariff Structures

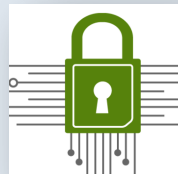
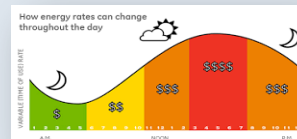
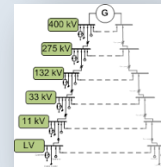
What is the cost allocation method ?

- Postage Stamp;
- MW-Mile;
- Average Costs;
- Incremental Costs:

Long Run Incremental Costs;
Marginal Costs;

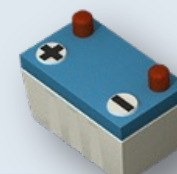
What are the cost drivers?

- Location
- Voltage Level
- Time of use
- Quality



Who pays?

- Load
- Generators
- Prosumers
- Storages



*We will analyze this two process for T&D
in a general way, but we may have some
differences.*



Step 1: Calculating Revenue

Who does the regulation of T&D?

- Public Utility Commission (PUCs) or their equivalent in each state serve as a replacement for the competitive market
- In exchange for granting the exclusive right to sell electricity, PUCs determine how much utility is allowed to invest, how much it can charge and what its profit margin can be
- Example:
 - ▣ NC – NC Utilities Commission
 - ▣ Ratemaking authority

Who does the regulation of T&D?

- PUCs determine the utility total revenue requirement, know as **rate case**
 - ▣ Amount of money it must collect to cover its costs and make a reasonable profit
- Utilities file rate cases **every few years**
 - ▣ US: some states have fixed schedule (2-5 years), but must do not
 - ▣ World wide: fixed schedule

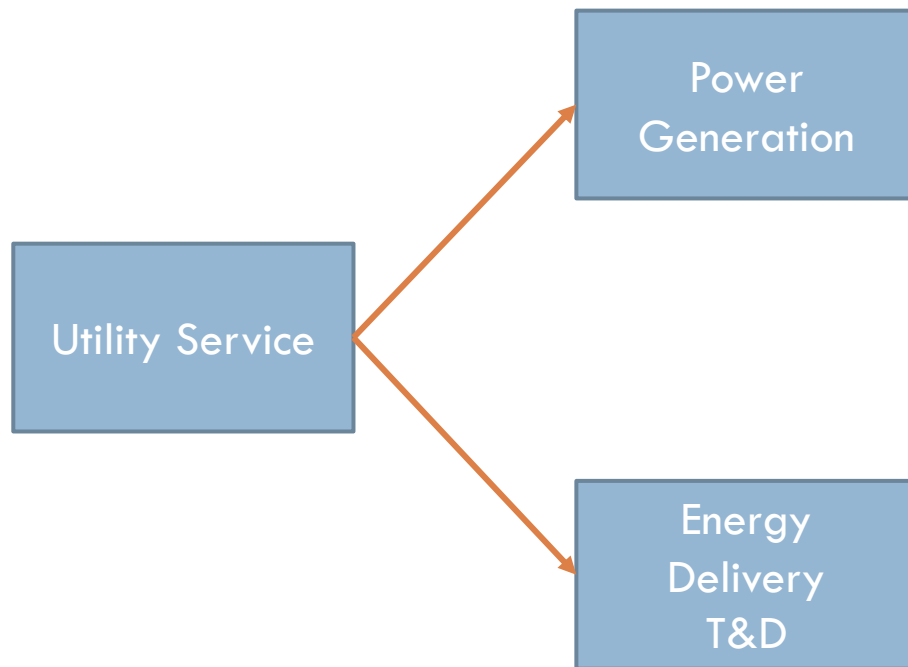


Revenue Requirement

- The utility's revenue requirement will be based on
 - ▣ Value of utility's assets
 - ▣ Cost of debt and equity financing
 - ▣ Operating and administrative expenses



Cost of Electric Utility Service



- Fuel and operational cost for owned power plants or
- Buying power from independent producers
- Example: Hawaii
(~60-70%) of cost of service
- Grid operations, customer service, depreciation, etc..
- Example: Hawaii
(~40-30%) of cost of service

Revenue Formula

$$RR_t = \underbrace{(RB_t)R_t}_{\text{Rate of return}} + \underbrace{OC_t}_{\text{Operating costs}} + T_t$$

Where

t : test year

RR_t : required revenue

RB_t : rate base

R_t : rate of return

OC_t : operating costs

T_t : taxes

Rate base is the value of the company's assets minus accumulated depreciation

Allowed rate of return drives a utility's profitability

Costs or expenses are simply passed through including fuel in cases where regulated utility own power plants

Note: This is just a standard version, formula usually boils down to this form, but we may have additional terms for specific utilities.

Test Year

- The test year is a measure of the operations and investment in **some specified 12-month period**
- A test year may be a recent **historic** 12-month period (historic test year)
- A test year may be a **projected** 12-month period (future test year)
- The financial statements in a test year are developed by the utility
 - ▣ Historic test years derive from the company's books and records
 - ▣ Future test years come from the utility's budget

Rate Base

- Rate base represents the investor-supplied **plant facilities and other investments** required to supply utility service to customers
- The principal **method for valuing rate base** is **original cost at the time plant** is placed into service
- Categories of plant in rate base - **production (generation), transmission, distribution, and general**
- Also includes franchises, rights-of-way, land, structures, wires, furniture, tools, equipment, vehicles, software development, etc.

Rate of Return

- Represents the **amount allowed to be earned**, expressed as a percentage of the utility's rate base
- The rate of return (ROR) or return of equity (ROE) is intended to allow the utility to:
 - ▣ **Meet its obligations** to present investors (interest and dividends)
 - ▣ **Compete on reasonable terms** in the financial markets for future capital requirements
 - ▣ Primarily consists of debt, preferred stock and common equity

Rate of Return (cont'd)

- Most controversial part of the formula
 - ▣ Only portion of the RR that utility ultimately keeps as profit
- Since utilities are regulated, their allowed ROE is set by PUCs
- Average ROE across 93 industries and almost 8,000 firms for the US market is 14.49%
 - ▣ But for utility companies the average is 10.13% because they are viewed as less risky investments
- Rate of return varies from state to state, PUC has exclusive authority to regulate utility operations as they choose
 - ▣ Highest ROE belongs to Alabama Power Co., at 13.75%
 - ▣ Lowest belongs to United Illuminating Co. (CT) at 9.15%.

*Source: AEE's Power Portal
database as of July 2018*

Rate of Return (cont'd)

- How do PUCs calculate rate of return?
 - ▣ Base on return of the market as whole
 - ▣ Risk-free rate of return
 - ▣ Inflation expectations
 - ▣ Utility capital structure: equity and debt

Capital Structure

- A utility's capital structure identifies the source of funds and the cost of those funds, i.e., **debt and equity**
- The utility uses these **funds to purchase assets** for the provisioning of service
- **Debt** is where the utility has **borrowed money and pays a interest rate** on the amount owed
- **Equity** is where utility has **gone to the market and sold shares of stock** (ownership) of the company

Operating Expenses

- Operating expenses comprise the **costs of using and maintaining the utility's electric plant** in providing utility service
 - ▣ For transmission and distribution, operating expenses primarily consists of labor, materials, supplies and other necessary expenditures
 - ▣ Fuel costs
- Expenses are presumed to be reasonable and necessary for **efficient operation**
- Pro forma changes often include:
 - ▣ Salary and wage costs
 - ▣ Postage expenses
 - ▣ Rate case expenses
 - ▣ Pension costs
 - ▣ Depreciation expenses
 - ▣ Property taxes

More on that later...

Depreciation

- Depreciation is the way in which the electric utility **recovers its capital investment costs**
 - ▣ The recognition in financial statements that physical assets are consumed in the process of providing service
 - ▣ Measures the loss in service value not restored by current maintenance
- **Depreciation expense** increases the revenue requirement
- While **accumulated depreciation** is a deduction to the utility's rate base, reducing the revenue requirement

Taxes

- Taxes are a major component of a utility's cost of service for ratemaking purposes
 - ▣ Include federal and state income taxes, as well as many other taxes, such as property, payroll, franchise and sales taxes
- “Gross-up Factor” approach
 - ▣ *Gross up is a simple matter of determining the tax rate and adjusting the payout to reflect the amount that will be deducted, i.e., increasing the gross amount of a payment to account for deductions*
 - ▣ Adjustment to incorporate income taxes when determining the overall revenue requirement
 - ▣ Formula
$$1 / (1 - \text{Tax Rate})$$
 - ▣ Example: $1 / (1 - 35\%) = 1 / .65 = 1.538$

Operational Expenses

Or Operational Expenditure – OPEX

Or O&M Costs

Operational Expenses

- The operational expenses are a pass through cost
 - ▣ Paid by customers
- How do the regulatory commissions calculate the O&M costs?
- How do they collect the data to perform this calculation?
- Do they use any reference or benchmark to establish these costs according to, for instance, the total concession area, number of consumers, total load, etc?

Operational Expenses

- Tendency for a regulatory action not based solely on information provided by the utilities
 - ▣ Possibility of **information manipulation** by the utilities
- Recall that this term of the RR is how much the utility gets from customers to operate its assets
- O&M **should not be too high**
 - ▣ If utility can operate with less than it was established in the required revenue than it could profit
 - ▣ Customers would be paying more than they should
- But it **cannot be too low**
 - ▣ These costs must ensure that utilities maintain the required quality levels
- Four approaches for determining **O&M costs efficiently**



Operational Expenses (cont'd)

- Performance based O&M regulatory revenue (UK)
 - ▣ Based on historical O&M costs complemented by incentives from improved services, reduced network losses, increased DG connection, etc...
- Efficiency model company (Latin America) Pioneer - Chile
 - ▣ O&M costs are set based on a “virtual” efficient company that operate under optimal investment and operational plans
- Benchmarking techniques (Europe & Brazil)
 - ▣ Most common is the Data Envelopment Analysis
- Norm based cost (India)
 - ▣ For lines, costs are set on a per km base, value is modulate based on voltage level
 - ▣ For substations, expenses per bay and again modulated by voltage level