UTILITY RATE STRUCTURE

- Electricity and Natural Gas Service
- Residential
- Commercial
- Industrial
- Examples
Electricity Use Characteristics

- Variety of customers with differing use patterns:
  - **residential** - lighting, HVAC, hot water, cooking, laundry
  - **commercial** - lighting, HVAC, refrigeration, cooking
  - **industrial** - electric motors, lighting, HVAC, furnaces
  - **institutional** - hospitals, schools - lighting, HVAC
  - **street lights** - step function electricity usage
  - **churches, temples, synagogues, mosques** - large power use for only a short time each week.
  - **mass transit** - subway and commuter rail - rush hour peaks
Use Characteristics (Cont’d)

- All of these users individual demands sum to produce the electric utility's overall demand pattern.
- For most utilities, the peaks in demand occur:
  - seasonal peak- summer/ air-conditioning season
  - daily peak- hottest part of the afternoon (summer) or suppertime (winter)
- The utility must have sufficient capacity (or prearranged purchase agreements with another utility) to meet all peaks, not just average power or average peak.
- Peak demand affects large users’ power bills significantly.
Utility Costs to Provide Electricity

- **Physical plant** - powerplants and hydro generating stations should be capable of meeting overall peak electricity needs. Otherwise, utility must have (expensive) arrangements for purchasing power from another utility through the grid that interconnects U.S. and Canada.

- **Transmission lines** - transmission is carried out at high voltages so that less current can be used to provide a given amount of power. This minimizes $I^2R$ (resistance dissipation) losses.

- **Substations** - sites with transformers to step down transmission voltage to what customers can use.
Utility Costs (Cont’d)

- **Local distribution systems** - carry electricity from substation to customers. Depending on customer needs, additional step-down transformers are required. Equipment includes utility poles, lines, transformers and capacitors.

- **Meters** - Each customer has a meter, with costs ranging from under $100 (residential) to over $2,000 (industrial).

- **Energy** - to produce electricity, utilities need to arrange for (usually buy) energy inputs. Energy types, from least to most expensive, are hydro, nuclear, coal, fuel oil, and natural gas.
Utility Costs (Cont’d)

- Salaries
- Maintenance
- Insurance
- Taxes
- Debt retirement- this category (like U.S. deficit) can be quite expensive...
- Profits to shareholders- rates normally set by a public service commission in each state. About 80% of electricity produced in the U.S. is generated by private, investor-owned utilities. Net income constitutes about 11% of total revenues for private utilities
Residential Electric Utility Rates

- **Character of Service** - single-phase @ 120 or 120/240 V
- **Administrative charge** (meter charge or minimum bill) - a charge to the customer that is (in theory) determined by the cost to provide service to the customer *whether he actually uses electricity or not*. APCo - $8.91/mo
- **Energy charge** (charge per kWh) - the charge per kWh of electric energy used. Depending on customer type and utility, this can be fixed, or vary:
- **Seasonal energy charge** - demand is higher in warm season, so to discourage electricity consumption, energy charge is higher in (typically) June - October than in other months (Alabama Power).
Residential Rates (Cont’d)

- **Time of day pricing**- demand is higher in day, so to discourage daytime power use, energy charge per kWh is higher in day than night.

- **Declining block pricing**- doesn’t cost utility that much to provide additional kWh beyond a certain initial amount, so energy charge per kWh declines above a certain kWh usage. This is an example of “supply-side” management- company wants to sell as many kWh as possible, and there are returns to scale. (Alabama Power, winter)

- **Increasing block pricing**- to avoid building new generating equipment, energy charge increases above a certain kWh usage- an example of "demand-side" management.
Energy Cost Recovery (ECR)- added cost per kWh to account for fuel cost-
- Lots of rainfall- cheap hydro used more, ECR is low
- Coal strike- coal more expensive- ECR is high

Hot weather- need to use more natural gas in combustion (gas) turbines for peak loads- natural gas is more expensive than coal, so ECR goes up.

ECR is about 1.5¢/kWh for Alabama Power typically.
State tax- this is 4% in Alabama.
The typical U.S. residential customer paid 8.45¢/kWh in 2002.
Example 1

**Given:** An Alabama Power residential customer uses 863 kWh of electricity in January with an ECR of 1.6 ¢/kWh.

**Find:** January power bill.

**Sol’n:** Use rate FD (Go to pdf file for APCo Rate FD)
Medium/Commercial Rates (LPM)

- Used by most commercial and small industrial customers
- **Character of Service** - Single or three-phase, rates vary depending on whether utility or customer owns step-down transmission equipment.
- **Energy charge** - similar to residential, often more sharply declining block (see APCO Rate LPM).
- **Demand Charge** (billing capacity) - Utility has to have sufficient equipment to meet customer's peak demand, not just average demand, so there is a charge **per kW** of peak demand. The monthly bill often reflects the customer's annual peak using a “ratchet charge”.

ME 416/515
**LPM (Cont’d)**

- **Monthly peak demand** is determined using a “demand meter” that measures the average (integrated) demand over a 5 to 30 minute interval and stores the value of the highest monthly peak. (APCO uses a 15-min peak interval.)

- **Ratchet charge** - the practice of billing a customer for some fraction of his highest peak demand in the previous 12 months or the most recent monthly peak, whichever is highest. APCo’s monthly billing capacity is 90% of the highest billing capacity for the months of June through October falling in the previous 11 months, or the current month's peak demand, whichever is highest.
The monthly billing capacity shall be the measured maximum integrated fifteen (15) minute capacity during each billing period of approximately thirty (30) days measured in KW; provided however, that such capacity shall be taken at not less than ninety percent (90%) of the measured maximum capacity requirements established during the billing months of June through October falling within the eleven (11) months preceding the billing period or seventy-five percent (75%) of the contracted capacity, whichever is greater. No billing capacity shall be for less than 5 KW for secondary service from the distribution system, nor 25 KW for primary service, nor 100 KW for secondary service from the sub-transmission system.
LPM (Cont’d)

- **Minimum bill** - For APCO, minimum bill is the minimum billing capacity charge plus tax (see below and rate sheet).
  - *In consideration of the readiness of the Company to furnish such service, no monthly bill will be rendered for less than the charge for capacity plus applicable provisions of Rate T (Tax Adjustment).*

- **Energy Cost Recovery** (ECR) - similar to residential rate

- **Taxes** - Alabama has a 4% tax.

- Including all of these charges, the average U.S. medium light and power (predominantly commercial) customer paid 7.89 ¢/kWh in 2002.
Large User Rates (LPL, etc.)

- Large industry and very large commercial establishments.
- Character of service - Three-phase and high voltage - the higher the voltage the lower the rate.
- Charges similar to Medium (LPM service, except that the demand charge reflects the power factor of the customer).
- APCO has a number of industrial rates - see pdf
- Considering all charges, the average cost of electricity to U.S. large light and power users was 4.83 ¢/kWh in 2002 (compare to 8.45 ¢/kWh for residential customers and 7.89 ¢/kWh for medium (commercial) customers).
Power Factor

- Power factor applies to AC current, where the impedance has real and imaginary terms, which gives rise to a phase angle between the voltage and current.
- Inductors cause the voltage to lag behind current by a phase angle $\theta$, and capacitors cause the voltage to lead the current by phase angle $\theta$.
- For most industrial applications, the inductive nature of motor windings, transformers, fluorescent lighting, induction furnaces, etc. give rise to a lagging power factor, which can be visualized by the power triangle.
Power Factor Triangle

Power Factor = \( \cos \theta = \frac{kW}{kVA} \)
Industrial Rates (Cont’d)

- Only the real (kW) part of the power is used, but the power company must supply enough current to provide the total apparent power (KVA).
- Excess current is partly lost in transmission, step-down transformation, and flow through customer wiring consequently the power company has to generate more kW in order to cover the excessive kVA of its customers.
- The demand charge is based on kVA, which, for the same power (kW) consumption, gets larger as kVA gets smaller.
- The ratchet charge is also applied to rate LPL.
“Character of Service” Effects

- How much the voltage is stepped down before delivery to the customer affects the demand charge:
  - $5.43 per KVA (secondary), or
  - $4.75 per KVA (primary), or
  - $4.26 per KVA (transmission) for all KVA of billing capacity; plus

- These categories are defined in the Character of Service section of the rate sheet.

- Note that Rate LPL has highest demand charges but significantly lower energy block prices.
Example 2

**Given**: An LPM secondary service customer of APCo has a 4000 kVA contract capacity. The customer used 18,420 kWh with a 15-min peak demand of 45.6 kW in December, and the highest peak of the previous 11 months was 55 kW in July. The December ECR is 1.5 ¢/kWh.

**Find**: (a) the December power bill  (b) the cost per kWh.

**Sol’n**: (a) Use Rate LPM- see pdf or class notes.
Residential Natural Gas Rates

- Base monthly charge (whether gas used or not). Alagasco: residential base monthly charge $\approx$ $8.00.
- Charges based on units of 100 ft$^3$ (100 ft$^3$ = 1 CCF), and typically are based on a declining block schedule.
- For Alagasco, the blocks are the first 50 CCF, the next 150 CCF, and all above 200 CCF.
- Weather adjustment- utility is allowed to adjust for actual weather conditions- gas is more expensive if weather is unusually warm (because gas company cannot generate as much revenue through gas sales to cover its fixed costs).
- State tax- this is 4% in Alabama.
Natural Gas for Large Customers

- Small commercial and industrial rates are similar to residential rates except blocks are larger and rates are lower. Alagasco uses blocks of first 150, next 600 and over 750 CCF.

- Large commercial and industrial customers use a base unit of 1 MCF = 1000 ft³.

- Large users rates depend on service priority in times of high demand (cold weather). Low priority customers get cut off first (interruptible service), and thus pay a significantly lower rate per MCF. Higher priority (non-interruptible) customers pay more.