Harvard Electricity Policy Group

Eighty-Ninth Plenary Session

Electricity 101

Should Dynamic Pricing Replace Demand Charges?

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Biography

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- Commissioner, US Federal Energy Regulatory Commission
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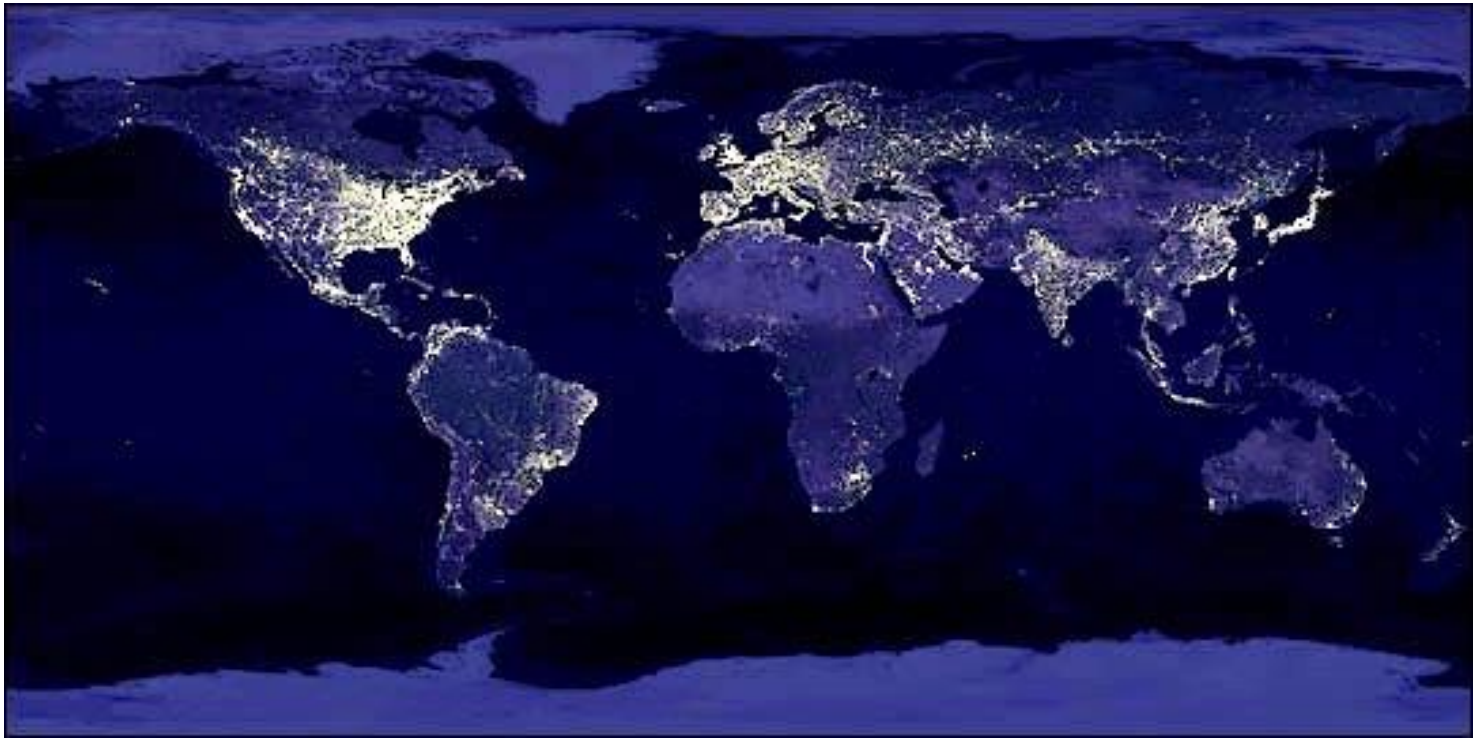
- Chair, United Nations ECE Expert Group on Cleaner Electricity Production

The World at Night



Korean peninsula at night

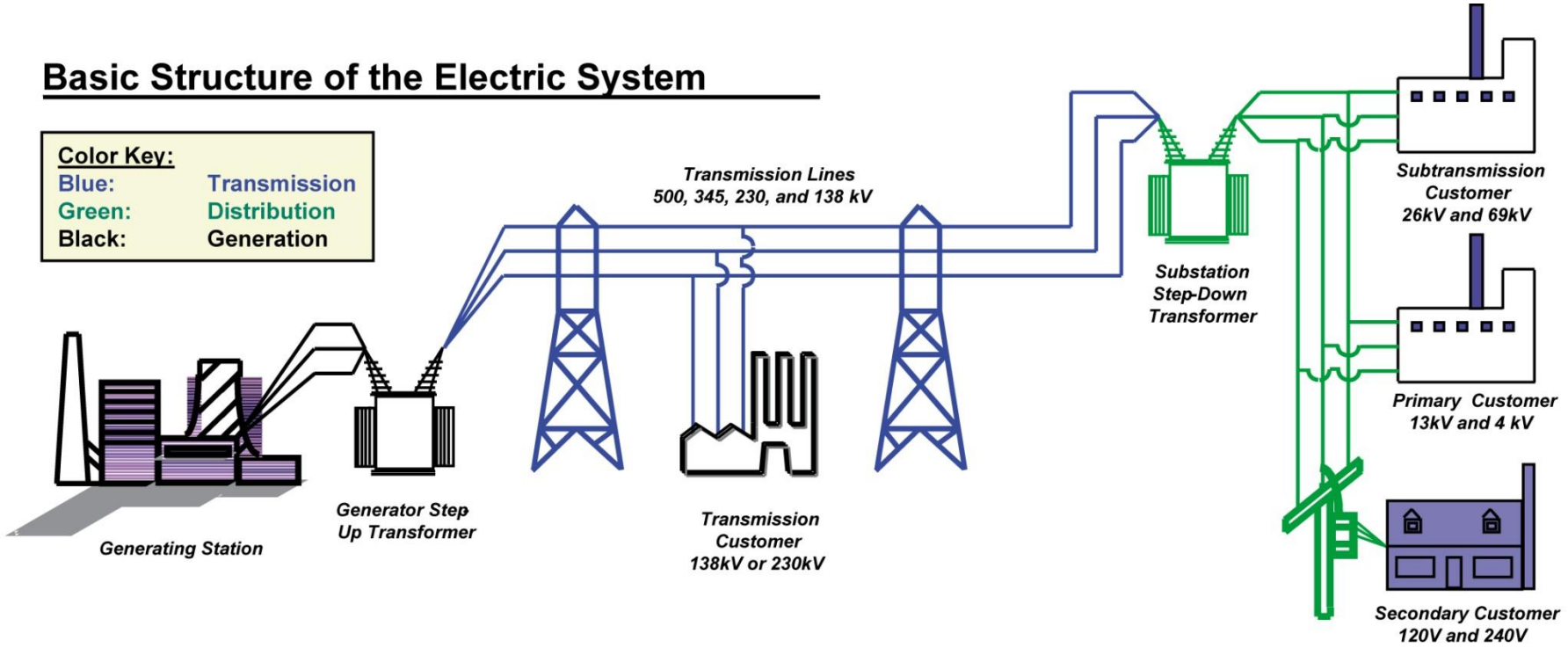
Electric Service = Power & Energy

- Power & Energy

- POWER
- 13 Strong men
- = 2 Draft horses
- = 1.34 horsepower
- = 1 kilowatt

- ENERGY
  - Watt
  - kiloWatt-Hour
  - 3.6 MJoules
  - Therms
  - BTU

Power System Overview



Electric Service is Power and Energy

- **Energy**
- The amount of energy used (or supplied) depends on the power and the time for which it is used:
- Energy=Power x Time
- In the home we measure electrical energy in kilowatt-hours (kWh). 1kWh is the energy used by a 1kW power appliance when it is switched on for 1 hour:
- 1kWh = 1kW × 1 hour = 1000W × 3600s = 3.6MJ
- For example:
- A 60W lamp switched on for 8 hours uses 0.06kW × 8 = 0.48kWh.
- A 3kW kettle switched on for 5 minutes uses 3kW × $^{5}/_{60}$ = 0.25

- **Power**
- Power is the rate of using or supplying energy
- Power= Energy/Time
- Power is measured in watts (W) Energy is measured in joules (J) or watt-hours or horsepower
  - 1.34 HP = 1,000 Watts= 1 kilo-Watt
- Time is measured in seconds (s)
- The typical power used in mains electrical circuits is much larger, so this power may be measured in kilowatts (kW), 1kW = 1000W. For example a typical mains lamp uses 60W and a kettle uses about 3kW.

How much HP does your house need?

US Average home has 27 kinds of electric devices (EEI)

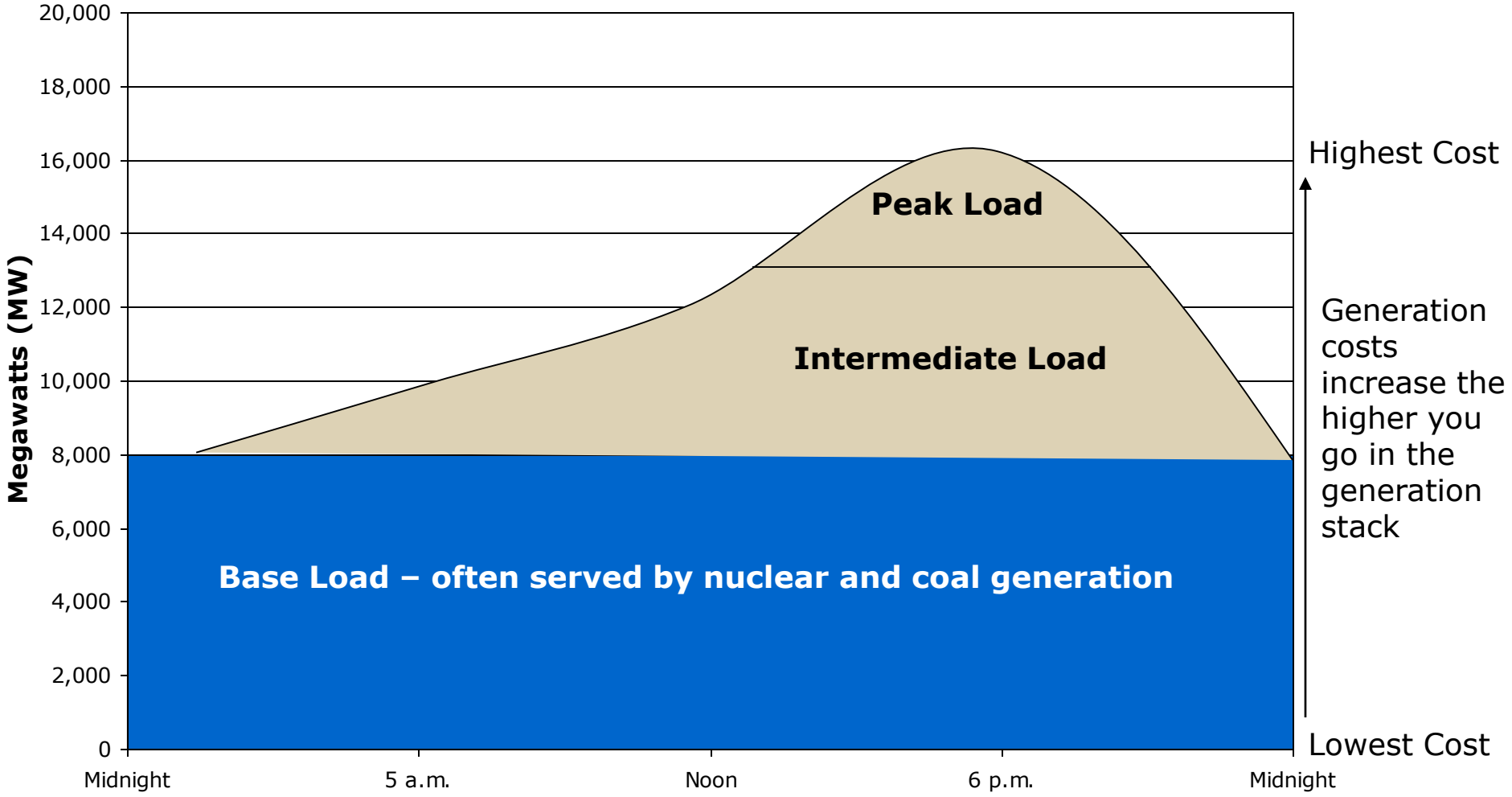
- Water heater 3 kW
- Lighting 1 kW
- Microwave 1.7 kW
- Dishwasher 1-2 kW
- Clothes dryer 3-5 kW
- Dish Washer 1-2 kW
- Iron 2 kW
- Toaster 1 kW
- Kettle 2 kW
- Refrig/Freezer 1 kW
- Vacuum 1.2 kW
- Hair dryer 1.5 kW
- TV (3 sets) 1 kW
- Air Con (4 rms) 6 kW
- Garage door 1 kW
- 27 kW = 36 HP

California average solar array is 4-6 kW

The Wisconsin Idea 1912

- “In dealing with complex economic subjects the legislature lays down general principles…appointive commissioners (with) the responsibility for administration of these principles. …reliance on trained experts…
- …as ridiculous to elect…on a state-wide ballot, a professor of comparative philology.”
- The Commission is given the authority to determine in a scientific way whether certain issues are or are not reasonable….”

Load Curve – generation follows load



U.S. Electricity Industry structure: Two Models in the U.S.

- Vertical Integrated companies
- Generation monopoly
- Transmission monopoly
- Distribution monopoly
- Electricity metering and billing monopoly
- Monopoly in retail sales and price of electricity based on cost of service

- ”Restructured” or “Unbundled” Companies
- Competitive generators operating under FERC regulation under either
  - C-O-S rates as monopoly
  - Market based certificate
    - In FERC regulated ISO market
    - Demonstrating no “market power”
- Transmission is regulated monopoly and “Independent” of generator or affiliated with distribution company
- Distribution service is regulated monopoly
- Retail power sale is competitive at market prices

Rates Need to Recover Revenue Requirement

+ $ Plant investment
- $Depreciation Reserve
= $ Net Plant Investment
+ Other Items
= $ Rate Base

$ Annual Operating and Maintenance Expense (Est.)
+ Depreciation expense = Depr. Rate (%/year) x $ Rate Base
+ Taxes
+ Return on Rate Base = Rate of Return (%/year) x $ Rate Base
+ $ Annual Revenue Requirement ($/year)

Bonbright's Criteria for Rate Structure

"Principles of Public Utility Rates" by James C. Bonbright

- Practical attributes of simplicity, understandability, public acceptability, and feasibility of application
- Freedom from controversies as to proper interpretation
- Effectiveness of yielding total revenue requirements under the fair return standard (i.e., fair, just and reasonable rates)
- Revenue (and cash flow) stability from year to year
- Stability of rates themselves, minimal unexpected changes seriously adverse to existing customers
- Fairness of the specific rates in the apportionment of total costs of service among different consumers
- Avoidance of "undue discrimination" in rate relations
- Efficiency in discouraging wasteful use while promoting justified types and amounts of use:
  - In control of total amounts of service
  - In the control of relative uses of alternative types of service

My Family Bills

- Mostly Fixed monthly
  - Mortgage/rent
  - Property tax
  - Car lease/payment
  - Tuition
  - Cable TV
  - Wireline telephone
  - Mobile telephone
  - Home alarm
  - Insurance
    - Auto
    - Home
    - Life
- Variable Monthly
  - Food
  - Clothing
  - Entertainment
  - Hobbies
  - Gasoline
  - Electric (exp. “budget billed”)
  - Natural gas (exp. “budget billed”

Comment on Electric Rate Design

Ratemaking is prospective, rates are set in advance of service being provided

Rates are set today which will recover the “cost of service” in the future

Rate design is more art than science and rates fulfill several functions besides collecting the full cost of service

Basic “cost of service” methods have been in use since 1890’s

Fixed charges are not a new issue

"Any number of examples may be cited to show the similarity of the electric demand charge and the charges made for other services. ..When a man leases a house, he pays the rent each month whether he is living in the house or is away on vacation."

- Caywood, Russell, Electric Utility Rate Economics McGraw-Hill, New York 1956

Explaining Fixed Charges is an Old Issue too

"It is unfortunate that the customer cannot always see the need for demand and minimum charges, although they are justified from the standpoint of economics. Rates including demand charges are relatively complicated. The customer does not understand that these charges are in reality capacity charges covering the cost of being ready to serve him at any time he desires."

"He often contends that in paying demand and minimum charges he is paying for something he does not get. True, he does not get kilo-watt hours, but he does get electric service, which is the product sold by the electric utility.

Caywood, Russell Electric Utility Rate Economics , McGraw-Hill, New York 1956

Actually, the Issue Goes Back Further , before 1917

- "The problem of securing a good rate schedule for residence-supply is particularly difficult, compared to industrial-supply customers…The former require a very simple tariff for them to understand, while their service is in peak-load hours and of short duration so that their cost of energy is apt to be comparatively high – although they cannot readily see how."

- Barker, Harry , Public Utility Rates, McGraw-Hill, London 1917

Early attempts at fixed charge

- "Norwich" Tariff
  - Fixed charge based on a % of property tax to cover demand and customer charge. Used 15%-15% of "value"
  - Plus energy charge of 1-3 cents/kwh
- "Telephone" Tariff
  - An "advance charge" of 70% of capacity of lamps at $70 per kilowatt per year and
  - Secondary charge of 2 cents/ kwh

Early fixed charges attempts

- Wisconsin System 1914
  - Based on
  - Monthly meter read 100 kwh
  - Connected load 1.1 kW
  - Using a factor of 60% for “active load” and for the first
  - 12 cents/ kWh first 30 hrs
  - 6 cents/kWh next 60 hrs
  - 2 cents/kwh nexr use
- Detroit System 1908
  - Scheme based on the number of rooms in a residence.
  - 12.6 cents/kwh up to 2 kwh per month per room for “principle” rooms and 3.6 cents /kwh in excess
  - Net minimum charge was $0.76 per month.

Early fixed charge attempts

- Canadian Cities System
  - Two part rate with residence lighting based on square footage.
  - Primary charge of 3 cents per 100 SF plus 2 cents/kwh for each 1,000 SF additional.
- Kapp Rate System
  - Two-rate system metering
  - Peak rate
  - and
  - Off-peak rate

Early rate designs

- Flat Demand Rate
  - No meter required
  - $/kW or HP / month
  - Based on connected load
  - May be “blocked” (declining) for larger loads.
- Straight Line Meter rate
  - Single price per kilowatt-hour regardless of total use.
  - Simple
  - Does not recognize customer or demand cost.

Early rate designs

- Block Meter Rate
  - Price per kilowatt-hour with declining blocks
    - First 25 kwh @ 5 cents
    - Next 100 kwh @ 3 c
    - Additional @ 2 c
  - Does not recognize demand
  - A modification with minimum charge is “initial charge rate”
- Step Meter Rate
  - Fixed price for total consumption, with prices decreasing as total consumption increases.
    - 1- 25 kwh @ 5 cents all use
    - 25-1325 kwh @ 3 c for all use
    - 126 or more kwh @ 2 c all use

Later rate designs

- Hopkinson Demand Rate
  - Two part rate: demand and energy
  - Demand charge
    - 2 cents per kw
  - Energy charge
    - 1 cent per kwh

    Note either demand or energy charge may be blocked
- Wright Demand rate
  - Also “hours use” rate
  - First 50 hours use per month or 50 kwh per kw of demand @ 3 cents
  - Next 100 hours use @ 2 cents
  - Additional @ 1 cent
    - Note: “Demand” means customer is demanding

A word to the wise

- “Some regulation inadvertently produces the opposite of the intended results.”

Natural Capitalism by Paul Hawken, Amory Lovins, L. Hunter Lovins

Chapter 13 Sub-section on Regulatory failures

Consistency

- “Those rare stalwarts who demand consistency even of themselves will be hopelessly outnumbered by newer experts, by more recently appointed commissioners, and by other persons not bound by embarrassing prior commitments. (P. 188)

- James Bonbright, Principles of Public Utility Rates, Columbia University Press, 1961

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