Chapter 27 Part 1

- Power Network
- Loads
- Pricing
  - Residential Rates
  - Industrial Rates
Generating station

20-30kV

Generator step-up transformer

Δ - Y

230kV

to lines
There'll be some opportunities alone the way.

"Yes, it is eternal damnation, but"

Gas
Oil
Coal

Fossil Fuels
Transmission lines
115, 138, 230, 345, 500, and 765 kV

Transmission consumer
115, 138, or 230 kV
Measure $V$, $I$, $P$, $Q$

at all locations
Bulk Transmission System

**Hardware: Substations**

- power transformers
  - insulating medium (oil, air, cast)
  - MVA ratings/cooling systems
  - 2/3/auto windings
  - tap changers
    - no-load
    - load (LTC)
  - phase shifts
Subtransmission consumer 34.5 and 69 kV

Primary consumer 4 and 13 kV

Secondary consumer 240 and 480 V

Substation step-down transformer
Higher Bills

Electricity sales to all users jumped to $296 billion last year from $203 billion in 1994, creating incentives to find ways to cut costs.

Demand↑
Supply limited; Cost will?

Energy
Region of Country
Park Rte
Basic Rte

Figure 7.7
All-electric home that consumes a maximum of 9400 kWh in January, and a minimum of 2100 kWh in July.
The price depends on sources, energy & laws.

Why industrial costs are residential cost.
Fuels Into the Air

U.S. carbon dioxide emissions, by fuel, in millions of metric tons:
- Coal: 621 million
- Gas: 524 million
- Petroleum: 318 million
- Nuclear: 16% since 1999

H3PO4
Nuclear is the best (least)

Note: Energy information administered by U.S. Department of Energy.
Sources: Energy Information Administration.
# High Voltage

August 2006 electric bill for a household using 1,000 kilowatt-hours of power, for selected Texas companies:

<table>
<thead>
<tr>
<th>Company</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP Texas North</td>
<td>$191</td>
</tr>
<tr>
<td>AEP Texas Central</td>
<td>$177</td>
</tr>
<tr>
<td>CenterPoint Energy</td>
<td>$163</td>
</tr>
<tr>
<td>TXU</td>
<td>$150</td>
</tr>
<tr>
<td>Texas-New Mexico Power</td>
<td>$145</td>
</tr>
</tbody>
</table>

National average: $ 81 *

*As of 2005

Source: Public Utility Commission of Texas
How do you tell a power engi

Born to raise rates
Loads

Classified by type of customer

- Industrial
- Commercial
- Residential
Loads

Classified by electrical characteristics

- Constant power (motor)
- Constant impedance (incandescent lighting and heating)
- Constant current (power electronics and aggregated loads)
Loads

Classified by service voltage

- High Voltage – take service at transmission voltage level (greater than 100 kV)
- Primary – take service at primary distribution voltage level (35 kV and less)
- Secondary – take service at secondary voltage level (600 volt or less)
Loads vs. t

Demand

lightest load any source

time of day

Peak load

Hydro import

Gas Turbine

Types of loads & Power Quality

15% of electricity

Lighting

delivered by power electronics

Heating

Motors

2% of electricity

+115

Home 3 prong plug

NG

-115
Power Trip

How electricity was priced in five-minute intervals in the ISO New England market on Jan. 12.

Note: ISO New England runs markets to balance power supply and demand in its region. Utilities, power producers, large consumers, trading companies and alternative suppliers participate in those markets.

Source: ISO New England
Dying Breed of Electric Meter

Smart Meter switch to be replaced
can be controlling appliance
Peak vs off peak
Charge different rates

Reader
Web meter
Transition
Repo Man / Bill Collector

Figure 27-2 Combined energy and demand meter (Courtesy of Sangamo)
1st Tale of Two Factories
- Same Energy Demand Avg
- Same Peak Demand

Fig. 2.5 pg 732

PF = \frac{1}{2}

Bad Factory

Charge more
Why?

Current draw >? I needed for
D bigger infrastructure
P billed
What's a utility to do?

Charge extra for PF < 0.85
Why fix it "too good"
Which is the best option for the specific fault?

C&D Phase fault

Berkeley Relay
Cost issue

Smaller C&D price at 275 Kvar

Less cost
Shoot lower PF = .85 just at cost point
Required Factory Power doesn't vary
New P.F.

195/0.85

Still Draws Q_0ld
Still Draws Q_0ld

P 195 kW
Q 121 kvar
S 230 kVA
P 195 kW
Q 228 kvar
S 300 kVA

Overall power factor corrected to 0.85.
C delivers Q
C need deliver 2× less Q
→ C cost 2× lower
→ Switch 10× lower

etc
Power Trip

How electricity was priced in five-minute intervals in the ISO New England market on Jan. 12.

Note: ISO New England runs markets to balance power supply and demand in its region. Utilities, power producers, large consumers, trading companies and alternative suppliers participate in those markets.

Source: ISO New England

Household $28/mo @ 54\(\frac{\text{C}}{\text{kW-hr}}\)
$260/mo @ 50\(\frac{\text{C}}{\text{kWh}}\)
<table>
<thead>
<tr>
<th>Source</th>
<th>Magnetic</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Typical</td>
<td>Maximum</td>
</tr>
<tr>
<td></td>
<td>(milligauss)</td>
<td></td>
</tr>
<tr>
<td>High-tension lines</td>
<td>20–25*</td>
<td>90†</td>
</tr>
<tr>
<td>Electric railroad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 kV, 60 Hz</td>
<td>35*</td>
<td>300†</td>
</tr>
<tr>
<td>11 kV, 25 Hz</td>
<td>126*</td>
<td>650†</td>
</tr>
<tr>
<td>Transformer substation</td>
<td>15–25*</td>
<td>—</td>
</tr>
<tr>
<td>Distribution lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12 kV)</td>
<td>1–3*</td>
<td>20†</td>
</tr>
<tr>
<td>Secondary lines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(240/120 V)</td>
<td>5–10</td>
<td>100–200†</td>
</tr>
<tr>
<td>Pole-to-home</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>House wiring</td>
<td>0.5–1*</td>
<td>5–10†</td>
</tr>
</tbody>
</table>

Source: Ref. 4. All fields are at body level. Magnetic fields depend on current load as well as geometry. Fields from parallel wires fall off as $1/r^2$ at large distances $r$ from the line. Magnetic fields from current loops and transformers fall off as $1/r^3$. People are shielded from electric fields inside metal railroad cars, but usually not from magnetic fields.

*Measured average values.
†Measured peak values.
Tale of two factories

Figure 27-5 A low plant power factor requires larger utility company lines and equipment.

Who runs a "bad" factory?

factory X

1000 kW
1000 kVA

factory Y

1000 kW
2000 kVA

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