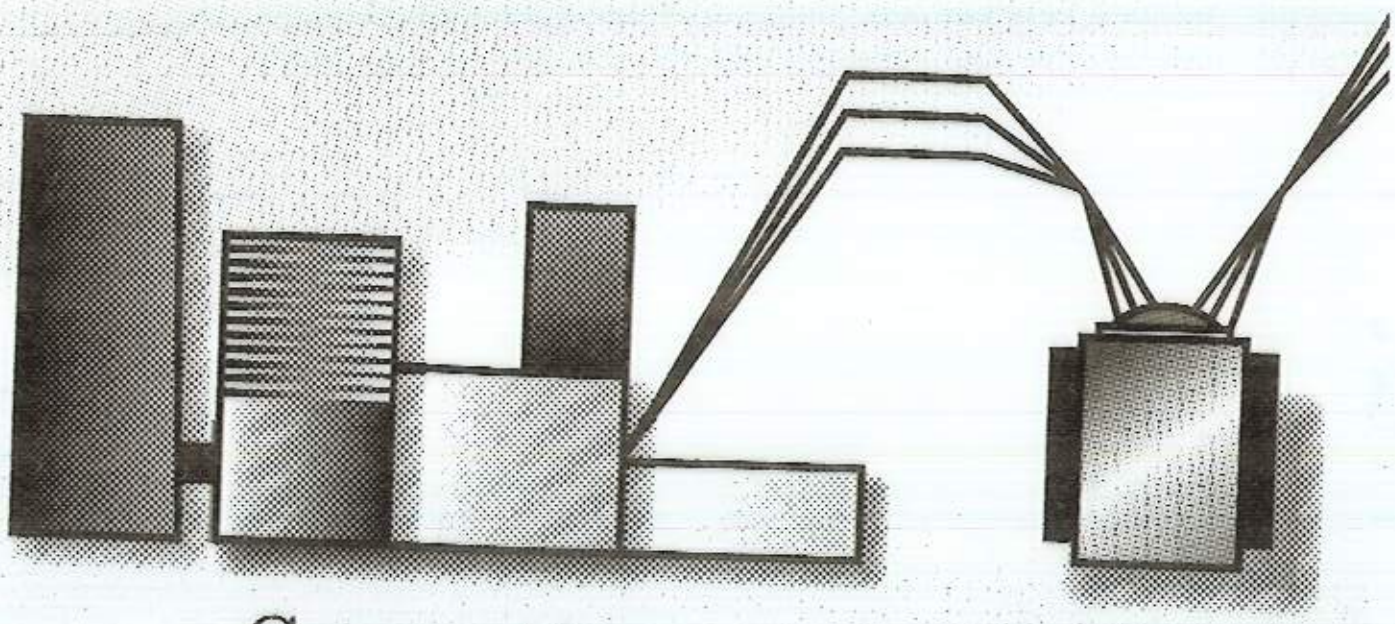
Chapter 27 Part 1

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



Generating station

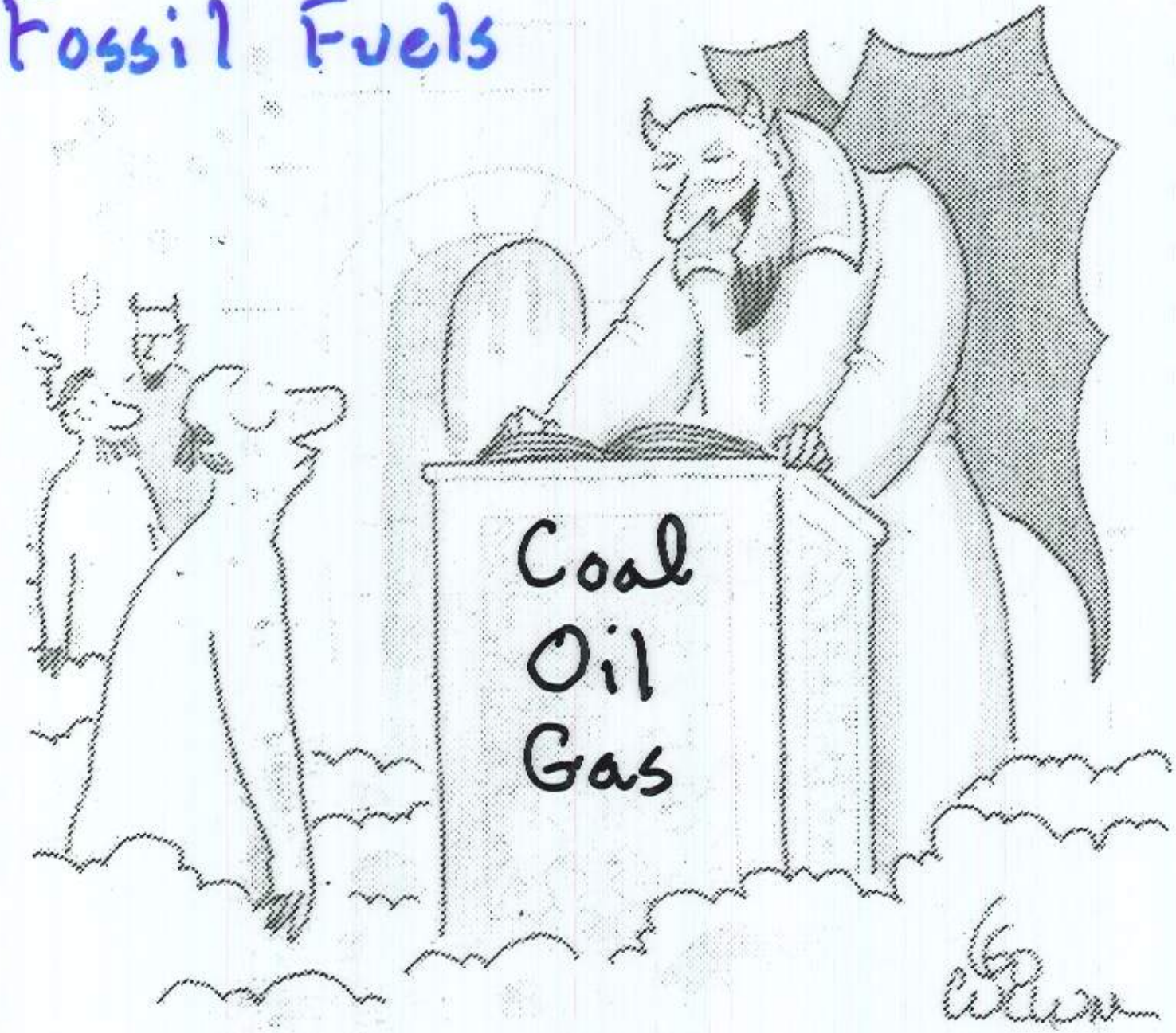
20-30KV

Generator step-up transformer

Δ-Y

230kV to lines

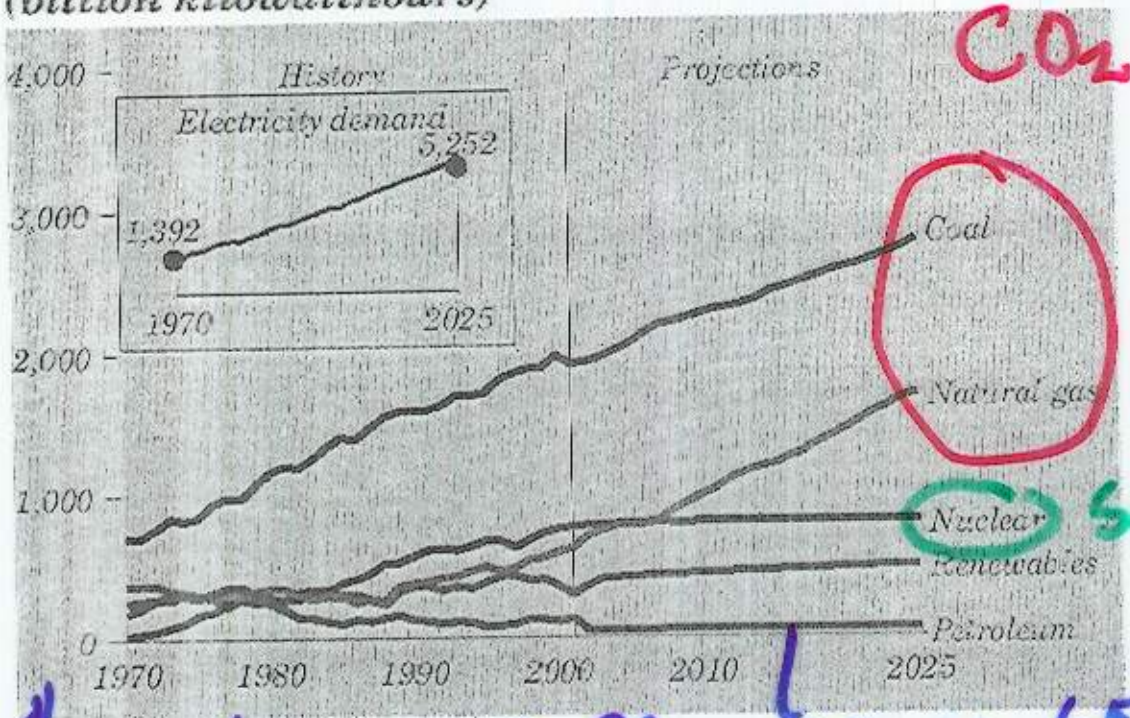
Fossil Fuels



"Yes, it is eternal damnation, but there'll be some opportunities along the WAY

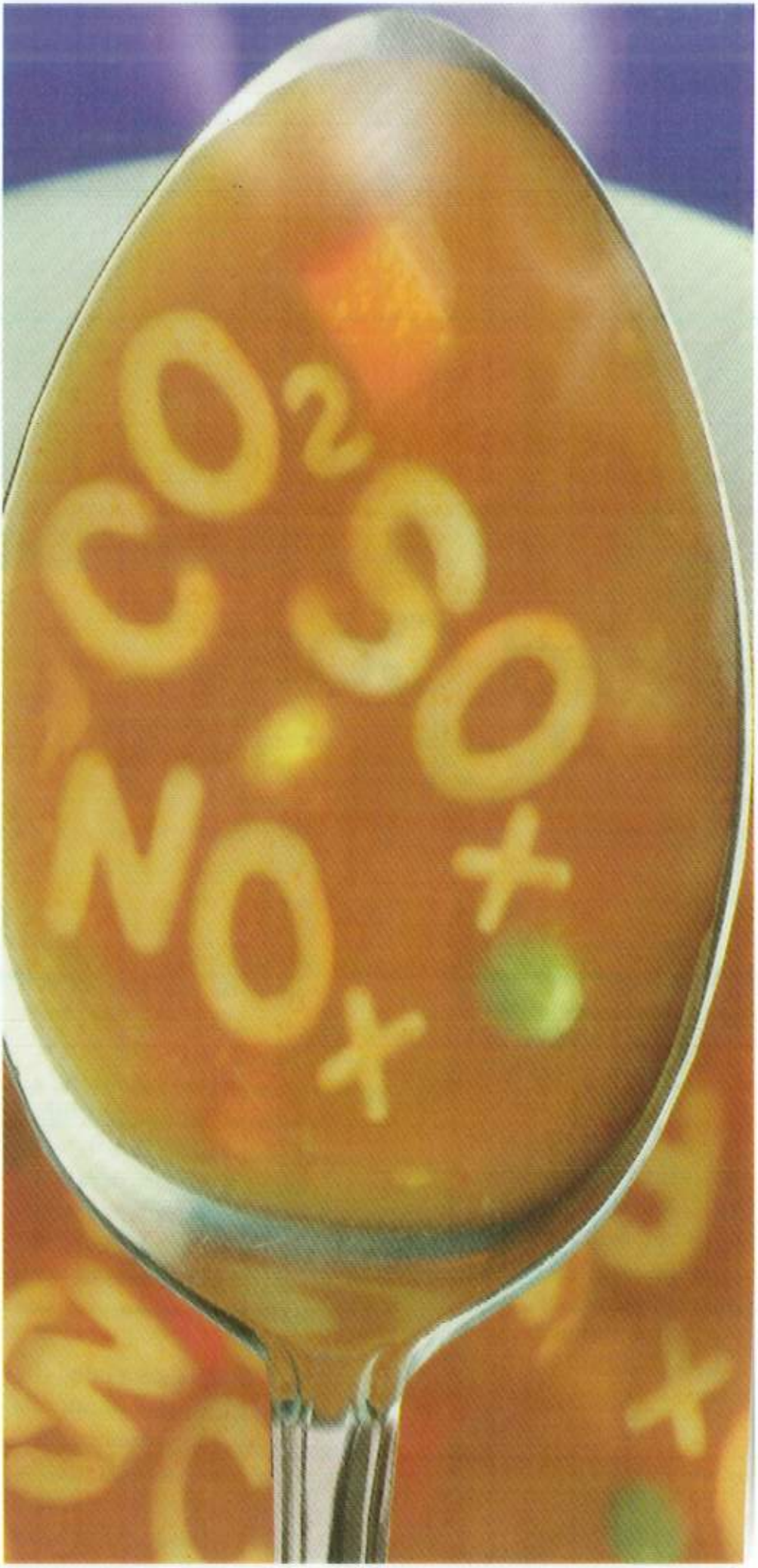
United States Energy Outlook Through 2025 (cont.)

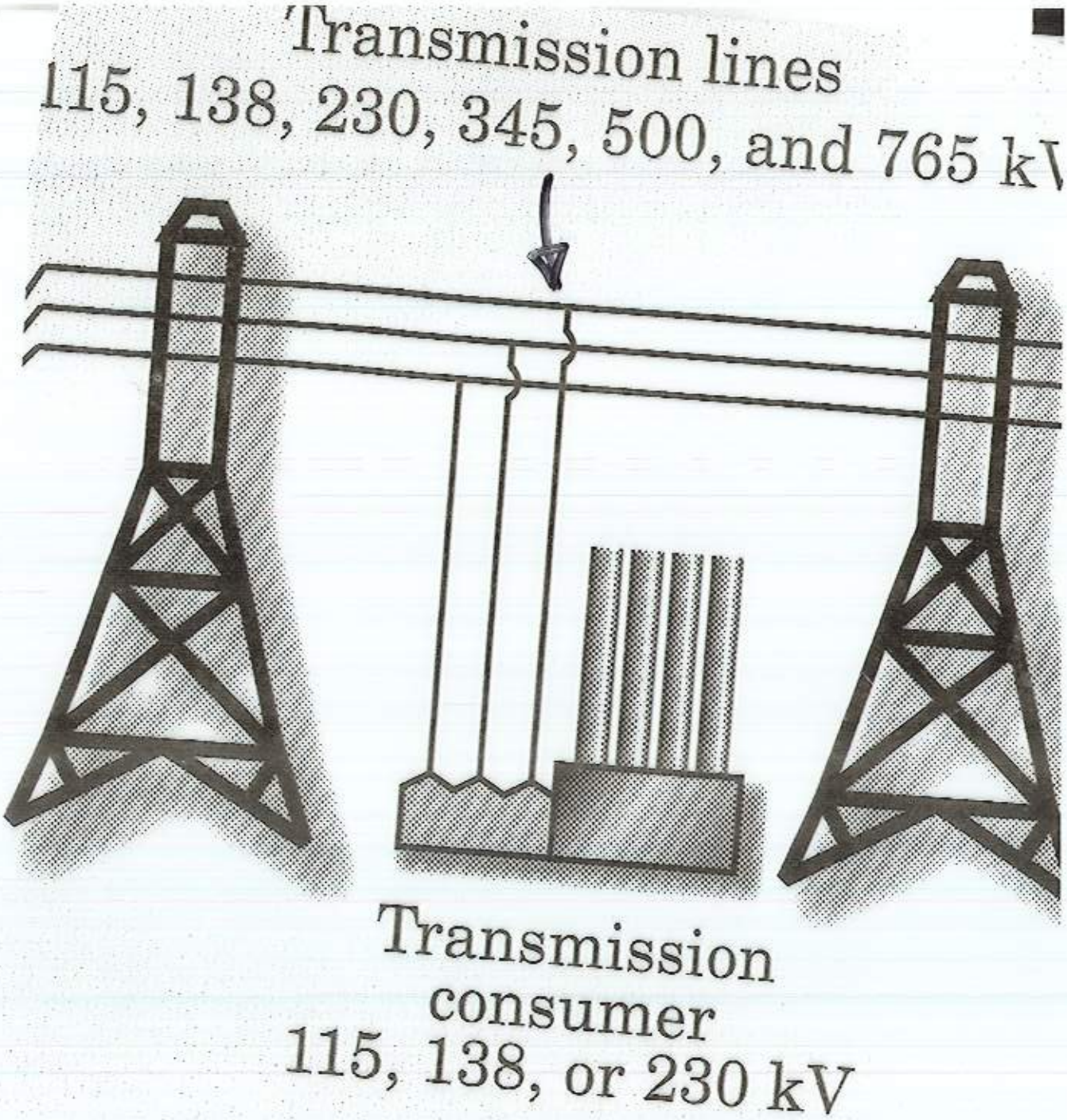
Figure 4. Electricity generation by fuel, 1970-2025 (billion kilowatthours)

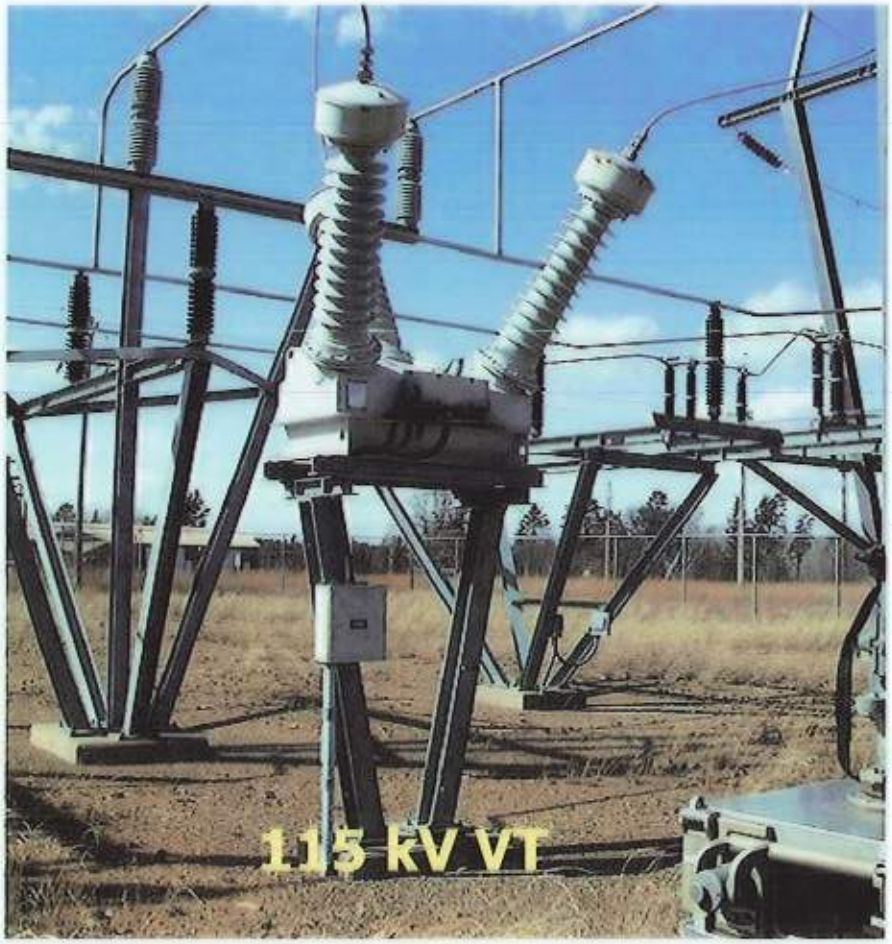


$32/barrel oil: Pbm 77-13 6.5¢/kW-hr

$96/barrel oil | Now 20¢/kW-hr


CO_2
SO_2
NO_x


Transmission lines
115, 138, 230, 345, 500, and 765 kV
Transmission
consumer
115, 138, or 230 kV


115 kV VT

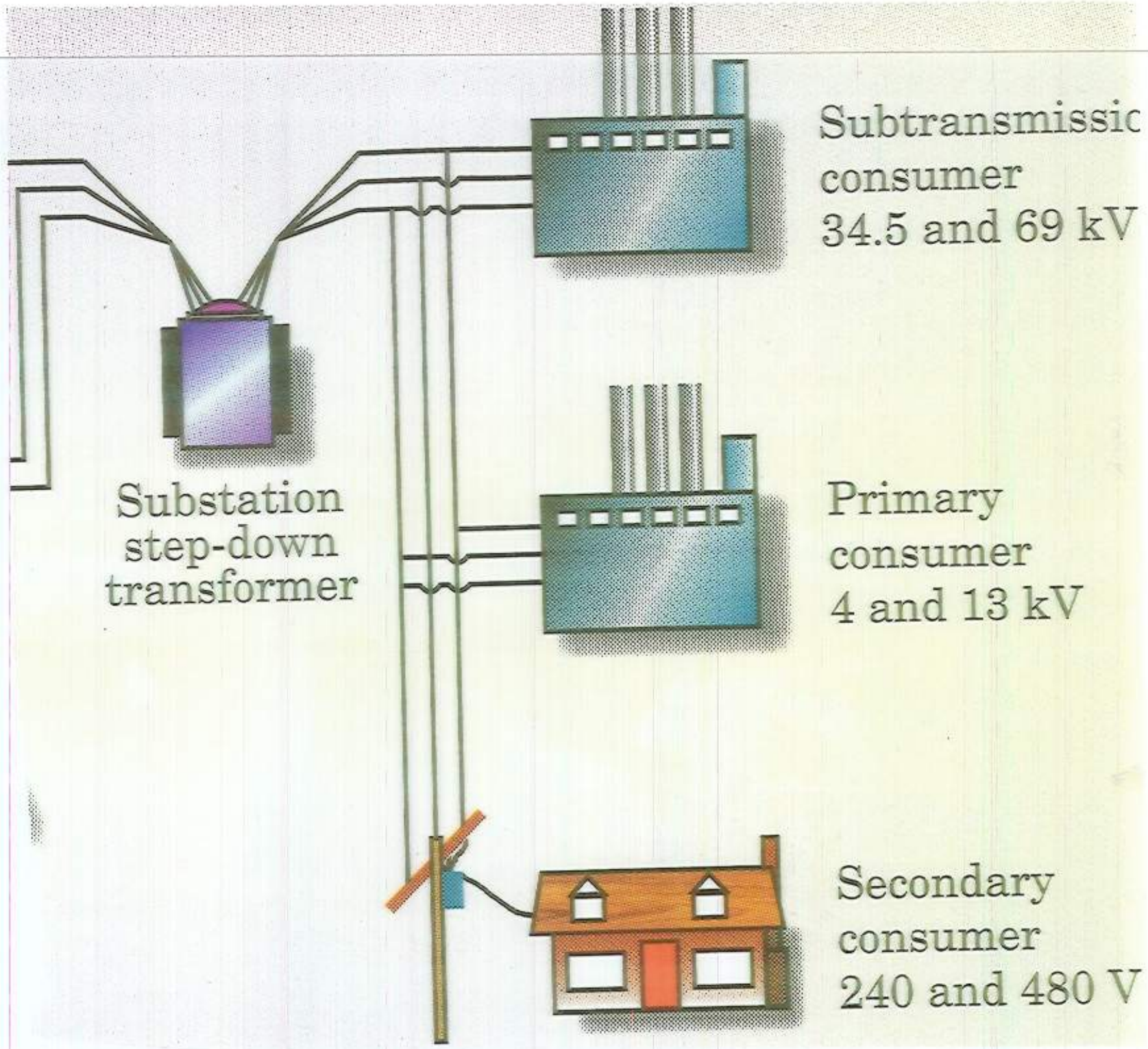
Measure V, I, PQ
at all locations

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**

100's of KV


Subtransmissic
consumer
34.5 and 69 kV
Substation
step-down
transformer
Primary
consumer
4 and 13 kV
Secondary
consumer
240 and 480 V

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 ↑?

ergy

Figure 27-7 All-electric home that consumers a maximum of 9400 kW°h in January, and a minimum of 2100 kW°h in July.

Basic Rate
Peak Rate
Region of country Rate

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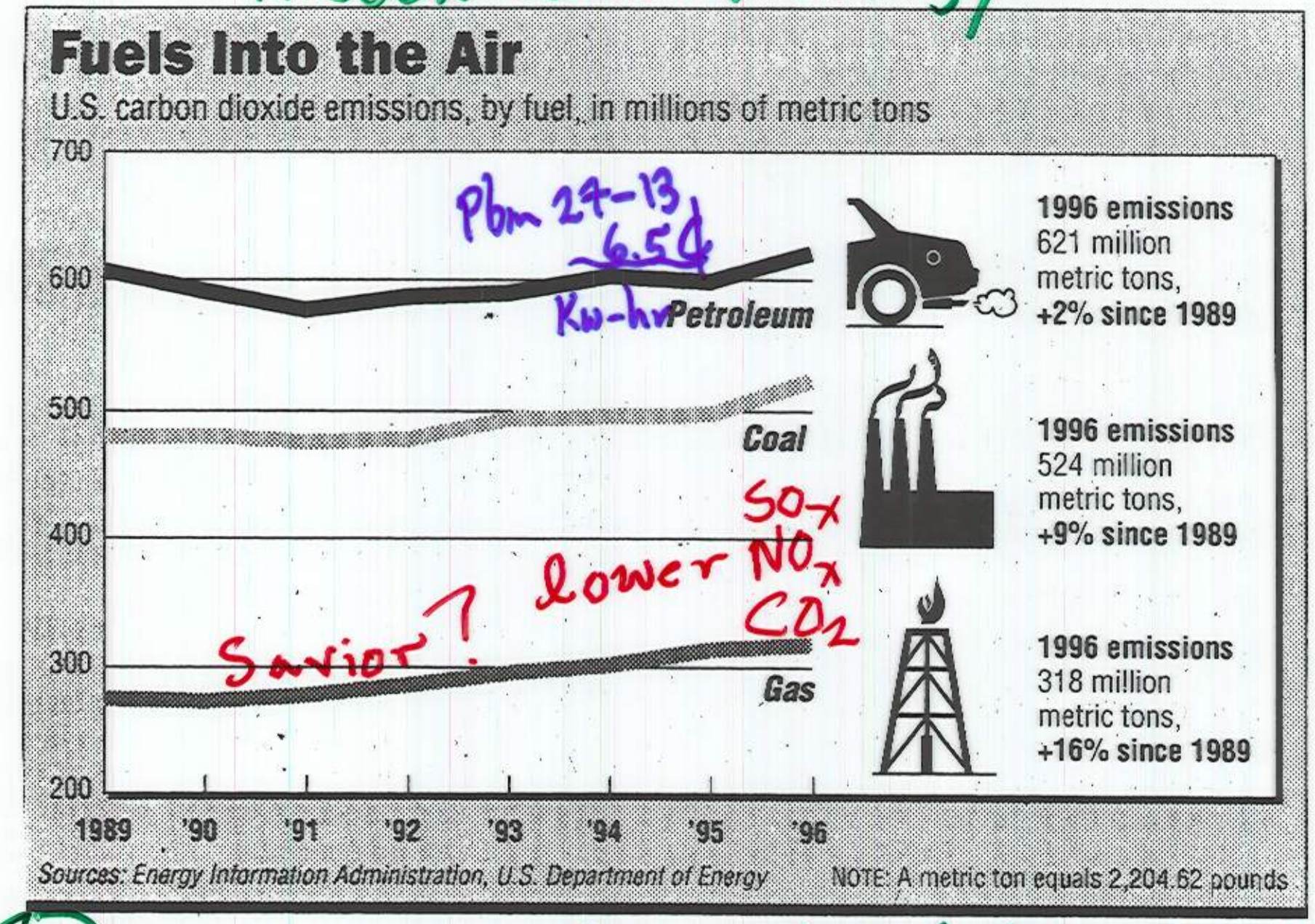
Electrical Machines, Drives, and Power Systems

e⁻ price depends on sources energy & laws

2*

Why industrial costs << residental cost

Hidden Costs of energy

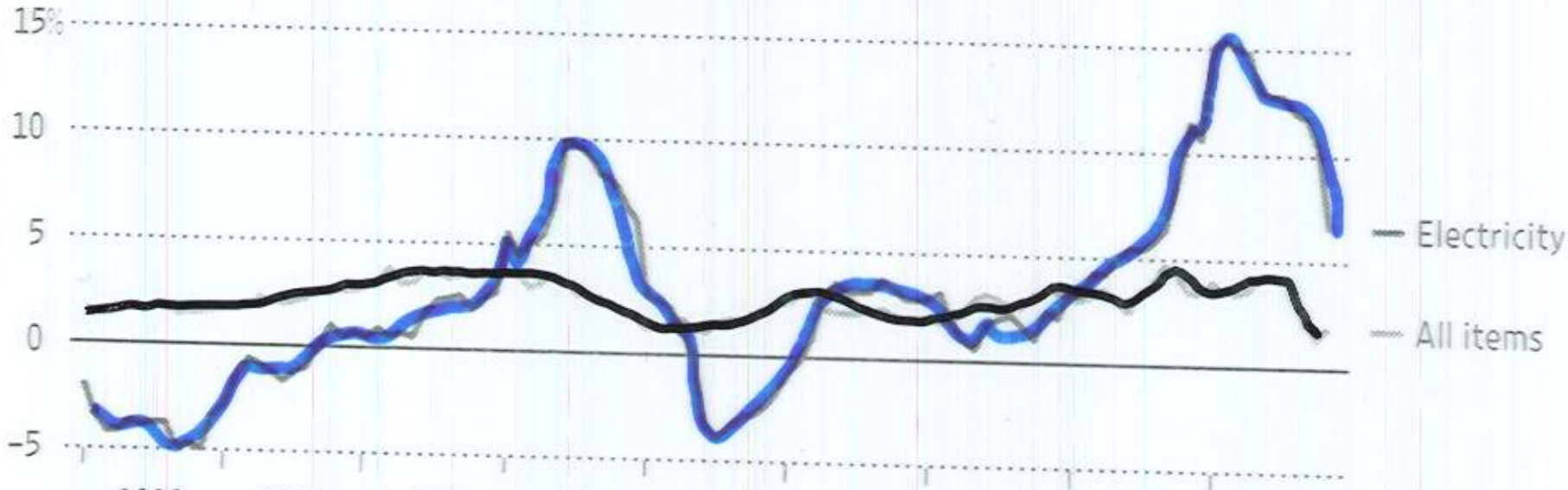


Nuclear the best (lowest)

A Taste for Juice

As the cost of electricity has risen in recent years, investor interest in utilities surged.

Consumer price indexes, year-to-year change



1998	1999	2000	2001	2002	2003	2004	2005	2006	
$51.79	$92.55	$60.14	$35.32	$18.24	$10.58	$22.32	$33.59	$86.30	Deal value, in billions*

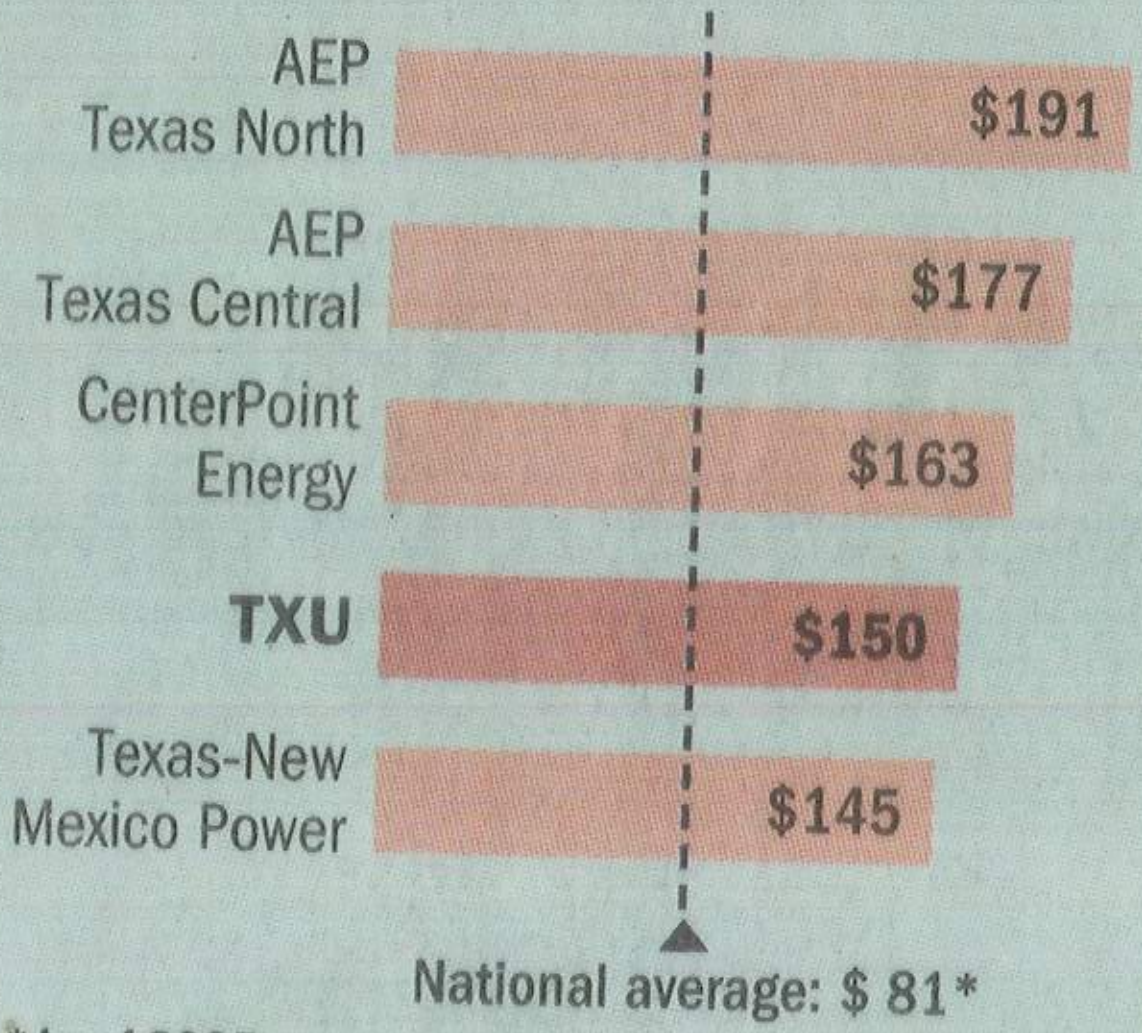
*Total value of deals for utility and energy targets, excluding debt

Sources: Bureau of Economic Analysis; Dealogic

MW-hr Costs

High Voltage

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



*As of 2005

Source: Public Utility Commission of Texas

How do you tell a power engr

Rent 40 horses for 1hr?

Colo MW-hr only? $50

Calif | L.I ? $500

Loads

Classified by type of customer

- **Industrial**
- **Commercial**
- **Residential**

Loads

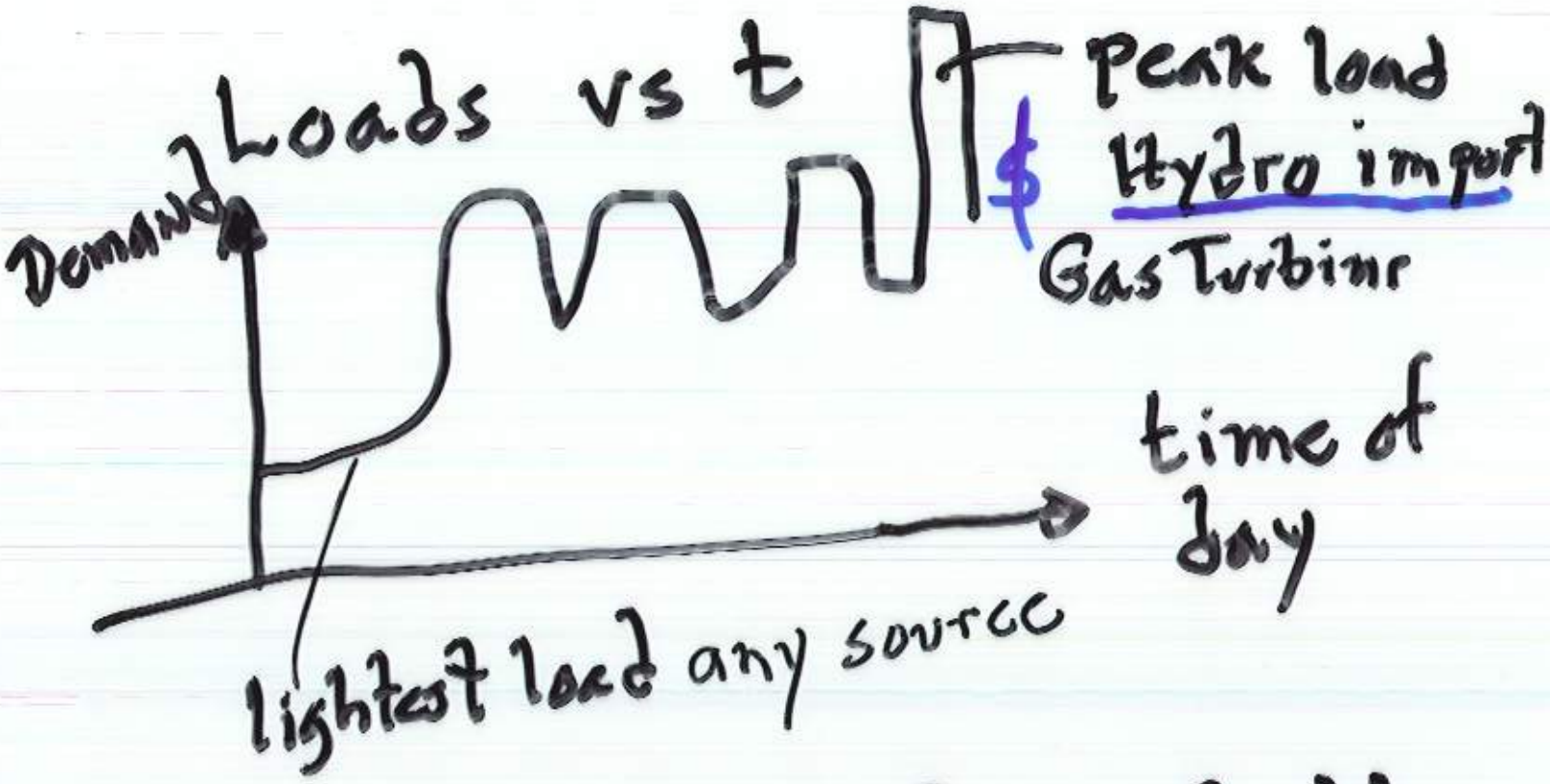
Classified by electrical characteristics

- **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)**



Types of loads & Power Quality

15% of electricity

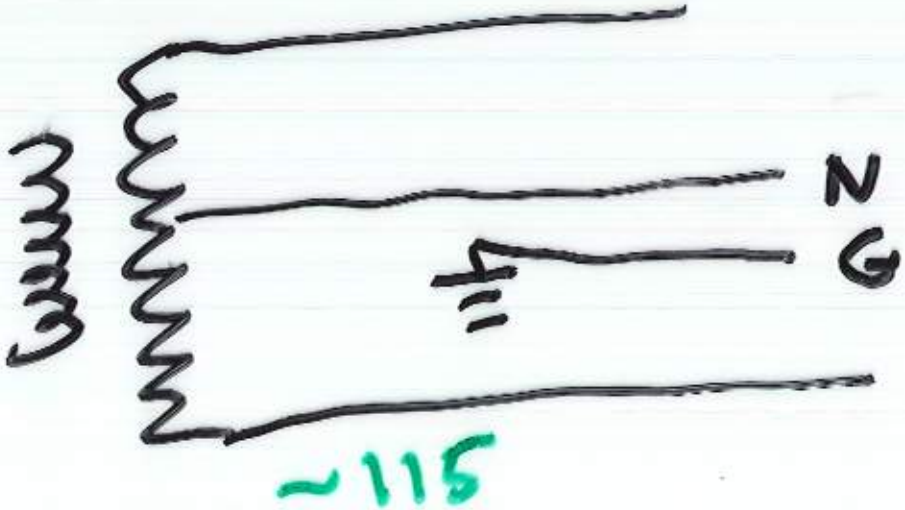
Lighting
Heating
Motors

delivered by power electronics

2/3 of electricity

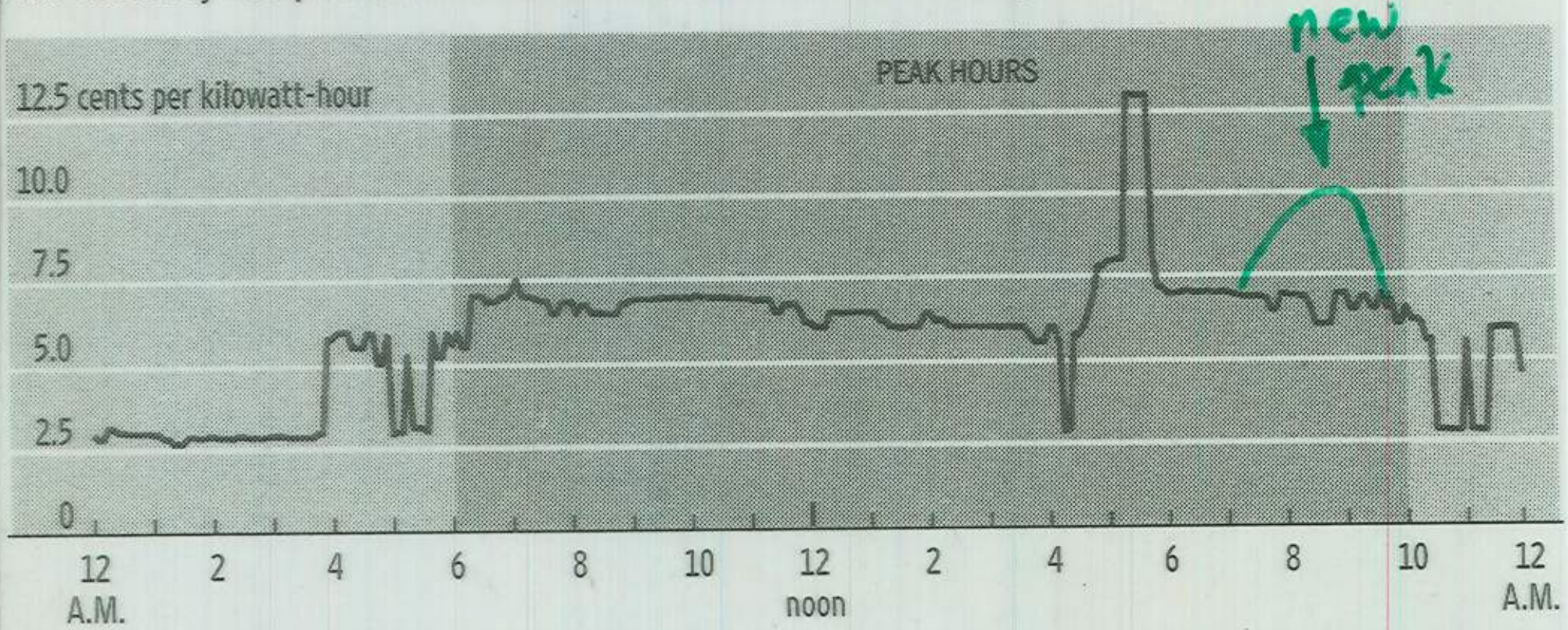
+115

Home 3 prong plug



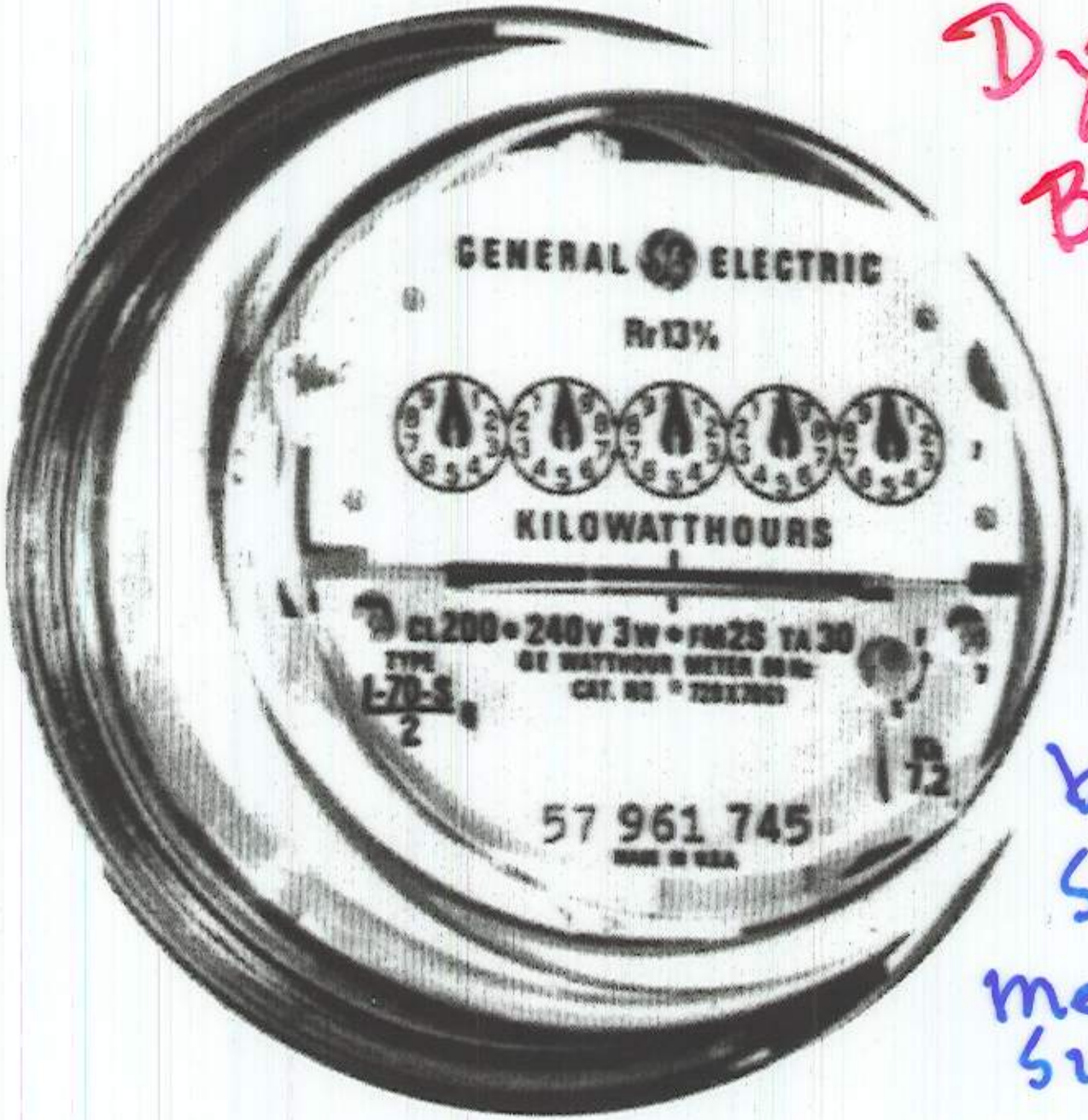
Power Trip

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 P meter to be replaced by smart meter switch

Residential Meter: Table 27 B look!

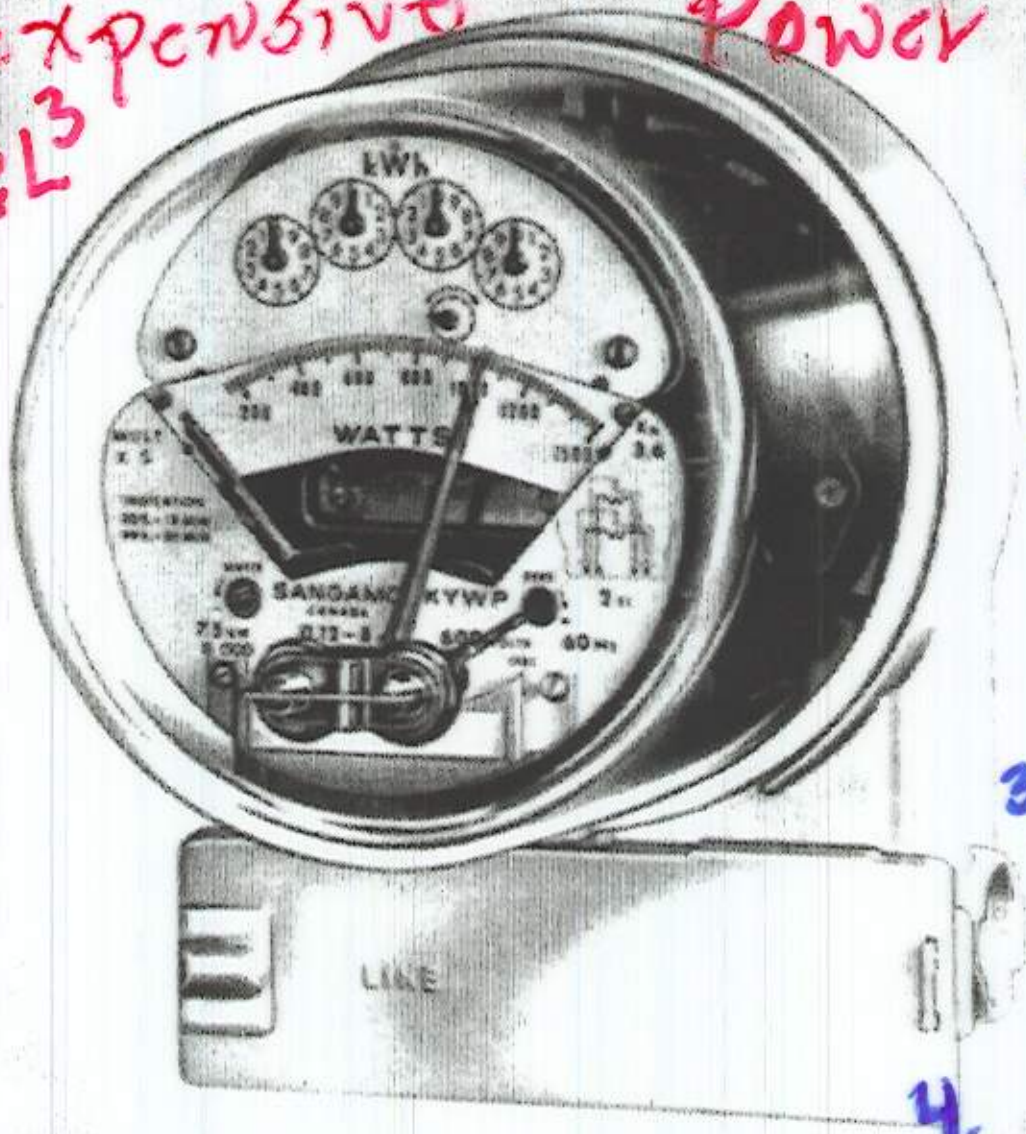
Most expensive Power Rate

Charge by: L^3

Law

Lawyers

Legislature



1 minimum for infrastructure

2. Rate 1 for first 100 KW-hr

3. Rate 2 for next 200 Kw-hr

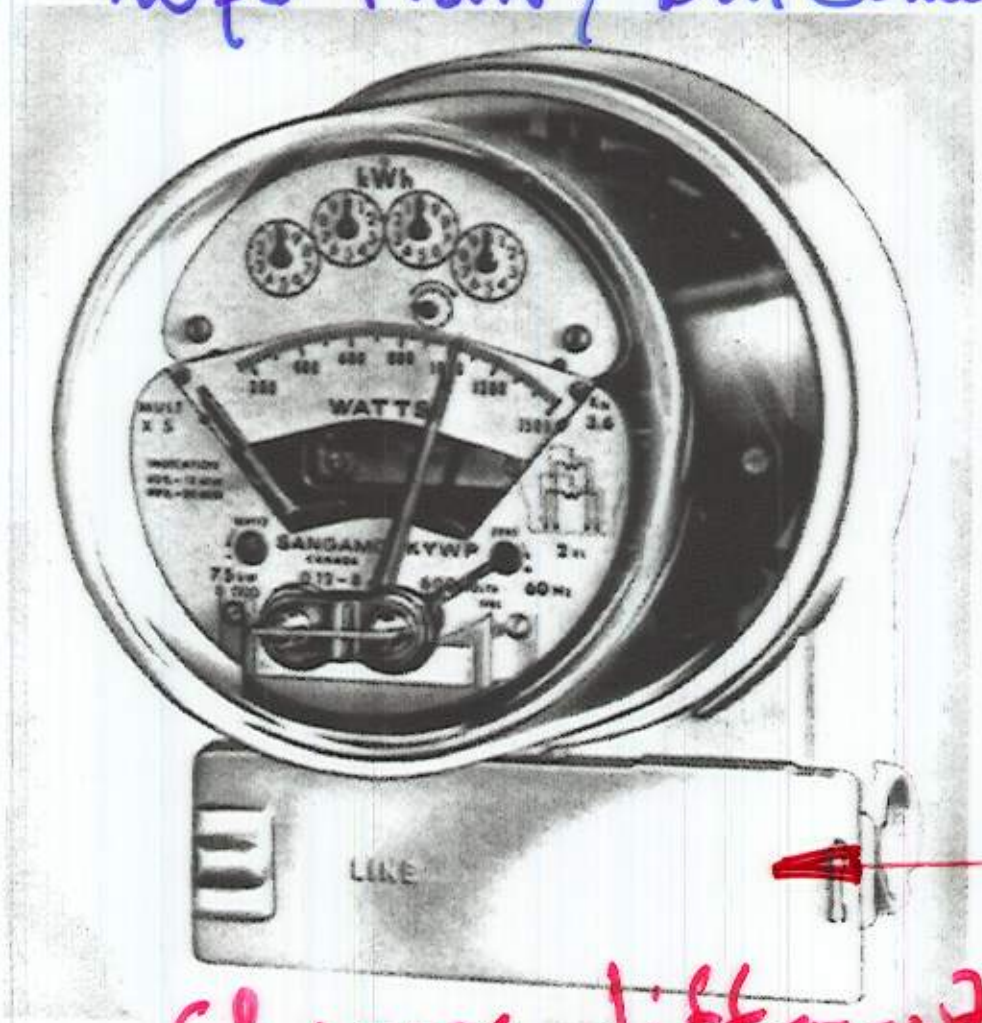
4. Rate 3 All the rest

Cheapest rate

573 Contract

Figure 27-2 Combined energy and demand meter. *(Courtesy of Sangamo)*

e⁻ Repo Man / Bill Collector



transition
Web
meter
reader!

Charges different rates:
peak vs off peak

CAN be controlling appliances

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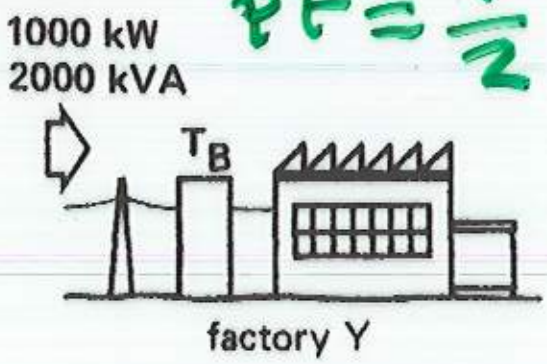
Electrical Machines, Drives, and Power Systems

1st Tale of Two Factorics

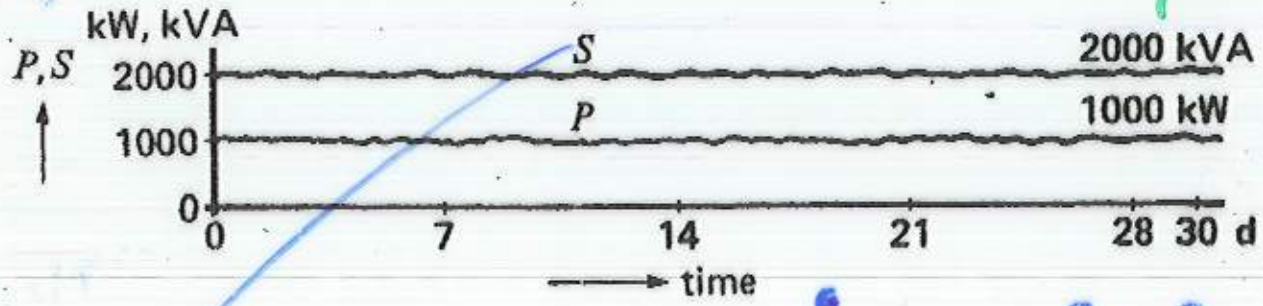
- Same Energy demand Av
- Same Peak demand

Fig 27.5 pg 732

PF = 1/2 Bad Factory



Charge more
Why?



Current draw >> i needed for P billed
⇒ bigger infrastructure

Whats a utility to do?

Charge extra for PF < .85

Why fix it "too good"

Which is best power factor?

(a)

(b)

Capacitor for Q light power factor

Power factor improvement

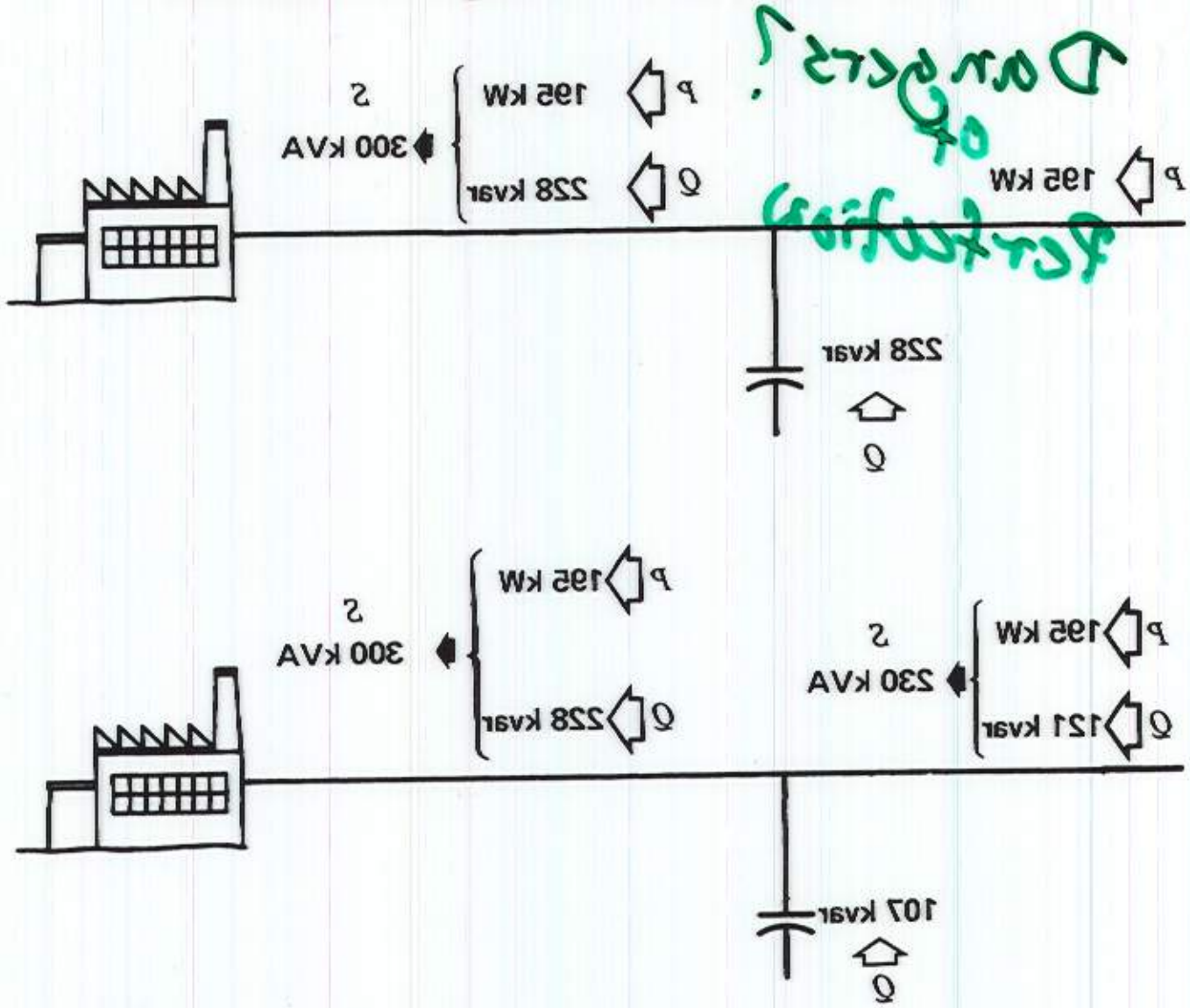
Load power factor improvement

Q light power factor

Power factor improvement

Power factor improvement

Figure 27-10 a. Overall power factor corrected to unity (Example 27-5). b. Overall power factor corrected to 0.85.



Questions of Perfection

Shoot lower PF = .85 just at cost point

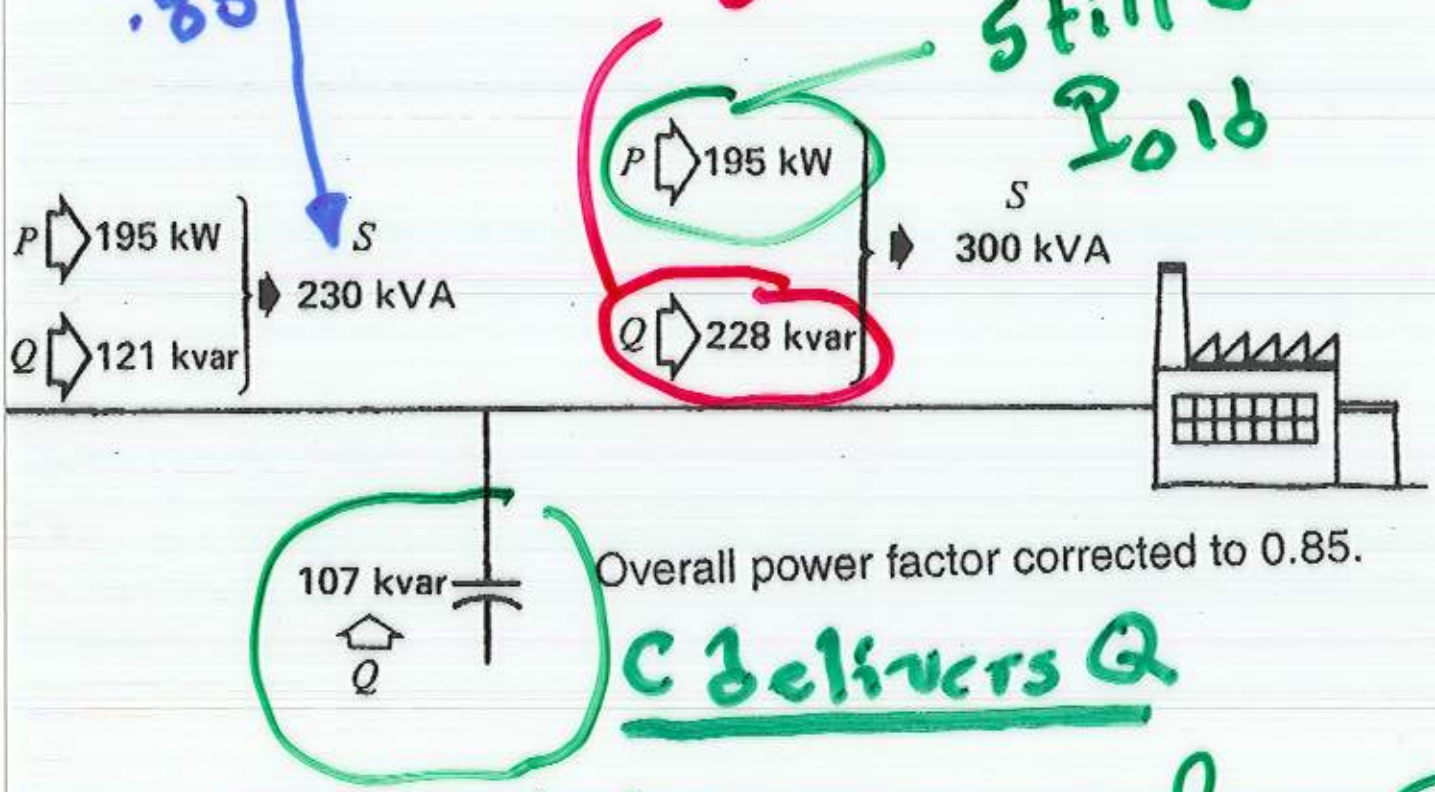
Required Factory Power doesn't vary

Fig 27.10 Pg 739

$\frac{195}{.85}$ new P.F.

Still draws Q_{old}

Still draws P_{old}



Overall power factor corrected to 0.85.

C delivers Q

C need deliver 2* less Q

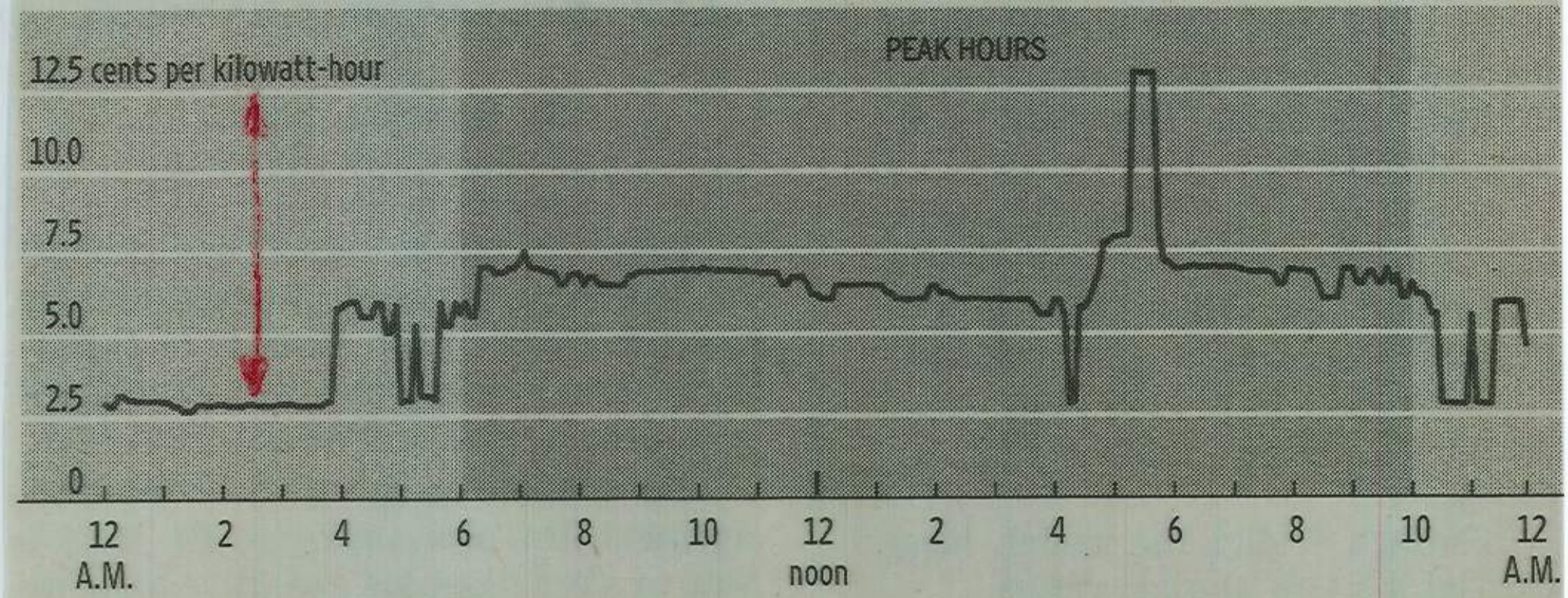
→ C cost 2* lower

→ 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 @ 5¢/kw-hr

200/mo @ 50¢/kw-hr

Table 1. RMS Magnetic and Electric Fields

Source	Magnetic Typical	Magnetic Maximum	Electric Typical	Electric Maximum
	(milligauss)		(volt per meter)	
High-tension lines	20–25*	90†	1000	7000
Electric railroad				
13 kV, 60 Hz	35*	300†	350	700
11 kV, 25 Hz	126*	650†	300	600
Transformer substation	15–25*	—	—	—
Distribution lines (12 kV)	1–3*	20†	5–40	60
Secondary lines (240/120 V)	5–10	100–200†	—	—
Pole-to-home	1	4	—	—
House wiring	0.5–1*	5–10†	1–5	10

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.

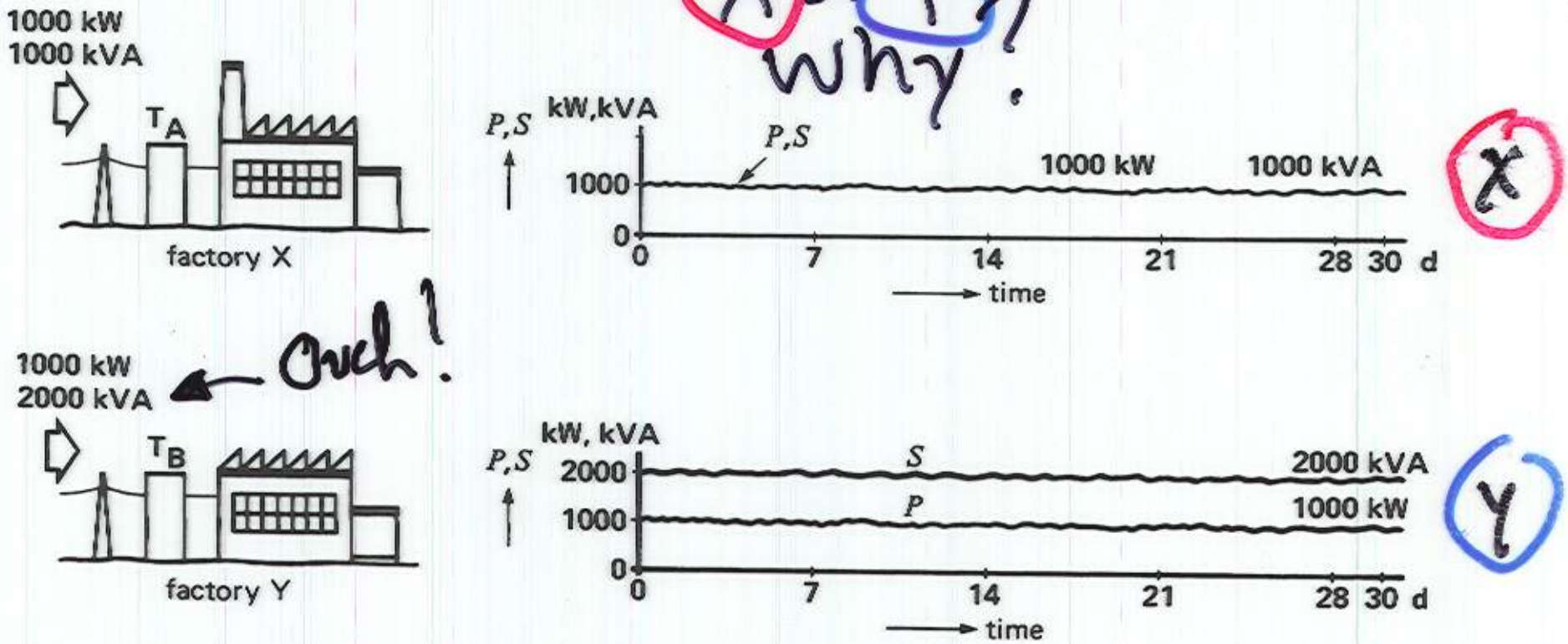
†Measured peak values.


STOP

Tale of two factories

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

Who runs a "bad" factory? X or Y? why?



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"Not to worry. Diversity can only enrich our culture."