CERTS
Consortium for Electric Reliability Technology Solutions

# A Business Model for Load Control Aggregation


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**UC Berkeley, California**


**CERTS REVIEW**

**Cornell University, Ithaca NY**

**August 7-8, 2012**

PSERC

# A Smart Grid Vision

“Homeostatic Utility Control is an overall concept which tries to maintain an internal equilibrium between supply and demand. Equilibrating forces are obtained over longer time scales (5 minutes and up) by economic principles through an Energy Marketplace using time-varying spot prices. “

F.C. Schweppe et al. “HOMEOSTATIC UTILITY CONTROL,”
IEEE Transactions on Power Apparatus and Systems,
Vol. PAS-99, No. 3, ***May/June 1980***

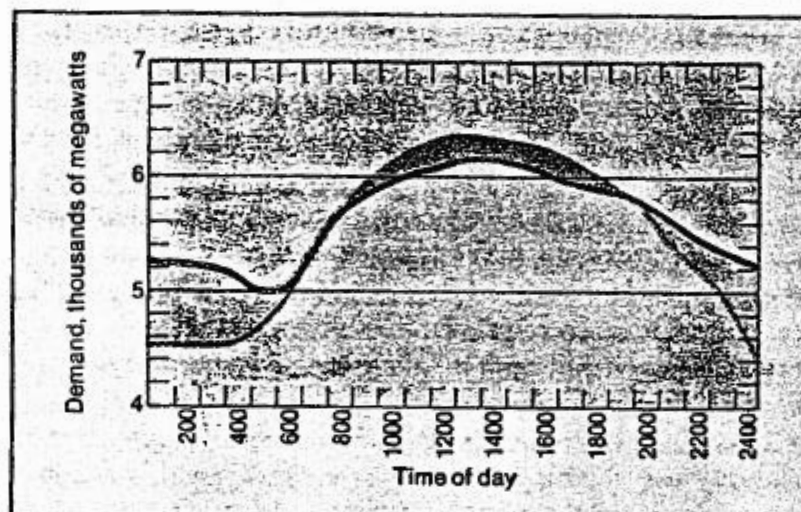
Power/energy

# Demand-side load management

## The rising cost of peak-demand power means that utilities must encourage customers to manage power usage

As electricity cost increases, more and more utilities are extending their activities into once-forbidden territory: the customer's side of the meter. In order to increase efficiency and hold the line on costs, they are controlling, directly and indirectly, when and how the electric energy is used—shifting from a

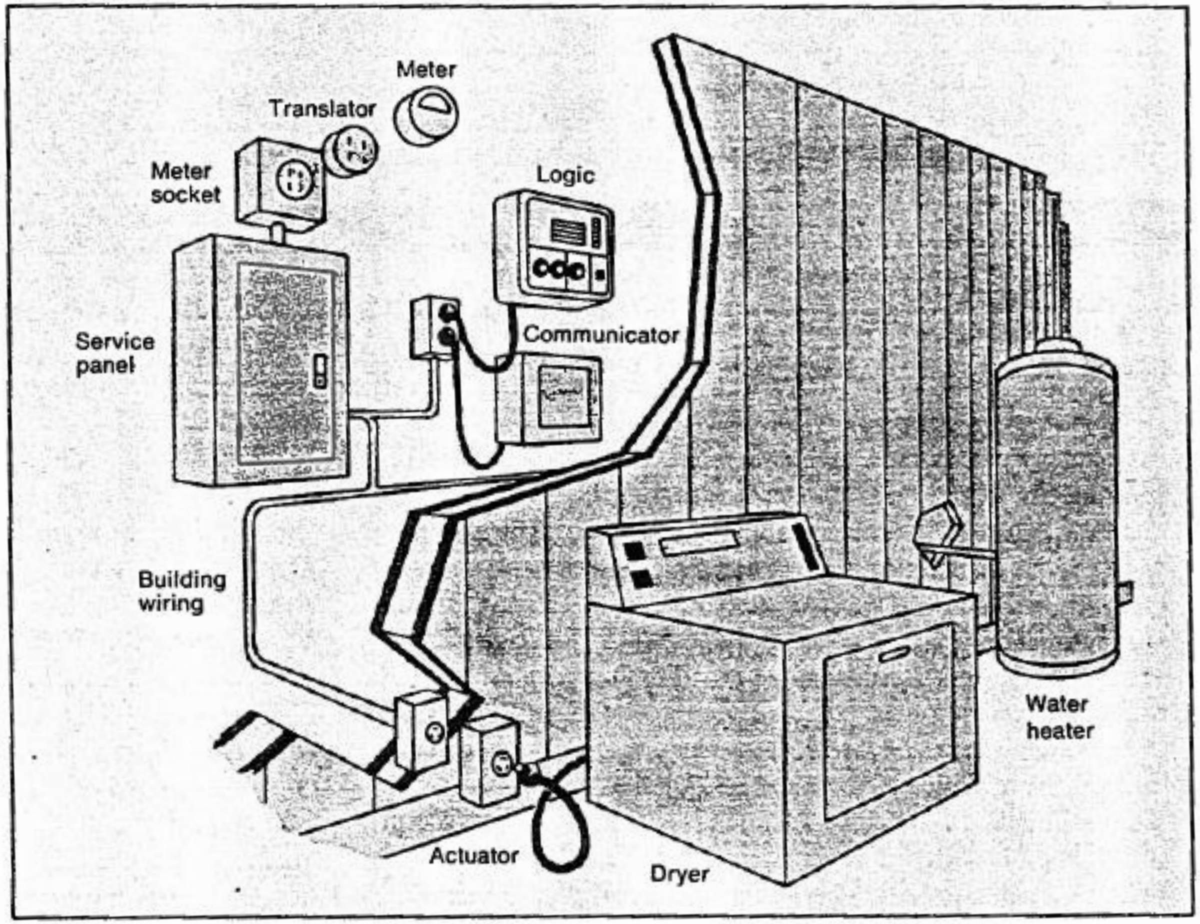
A simple peak/off-peak rate structure requires a two- or three-register meter, each measuring total consumption within a specific time. Weekends as well as nights are usually off-peak periods. Another rate pattern, encompassing multiple cost zones, incorporates peak, off-peak, and shoulder (occurring




Clark W. Gellings
Public Service Electric and Gas Co.



0018-9235/81/1200-0049$00.75©1981 IEEE




*[2] This load-control system for residential and small commercial buildings limits consumption during peak demand periods and is set by the customer according to a rate agreement with the utility. It will prevent appliances such as dryers or water heaters from operating simultaneously if their combined load exceeds the maximum allowed. The translator interprets meter data for the logic circuitry, which controls appliances through the communicator.*

FEATURE ARTICLE

# Smart Meters and Spot Pricing: Experiments and Potential

**ARTHUR H. ROSENFELD, DOUGLAS A. BULLEIT, and ROBERT A. PEDDIE**

*Abstract* — Responsive microprocessor meters are approaching a life-cycle cost that is cheaper than that of electromechanical time-of-use meters, and they are currently being tested in Britain and the U.S. The English residential Credit and Load Management Unit (CALMU) can respond to dynamic prices broadcast by the British Broadcasting Corporation and can in principle turn off individual equipment at prices preselected by the homeowner. In the U.S., a consortium led by Integrated Communication Systems, Inc. (ICS) has started similar experiments, and many "smart houses" are being planned. Responsive meters (and the thermal storage they will

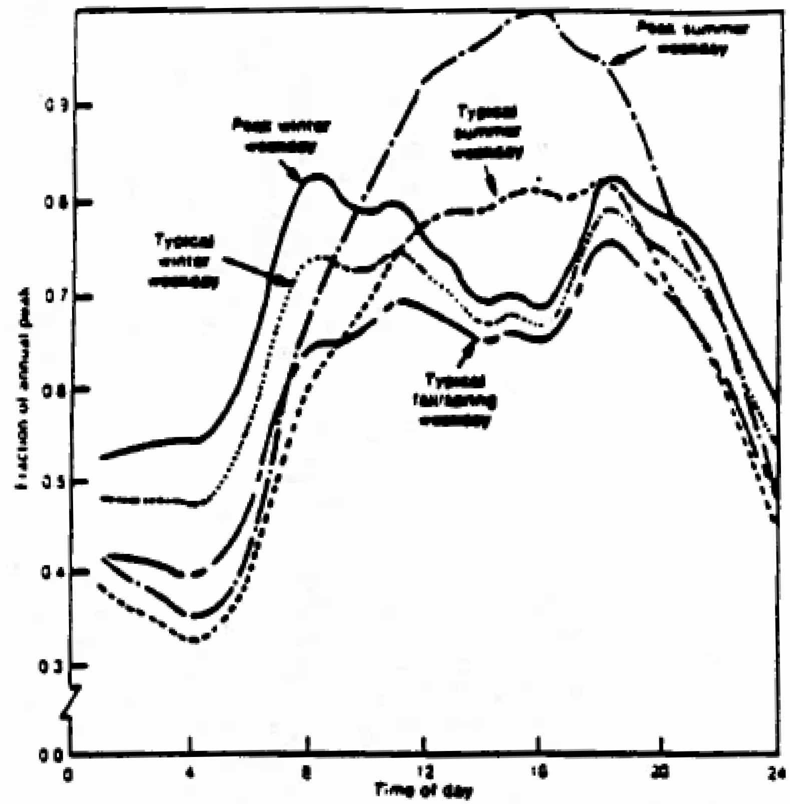
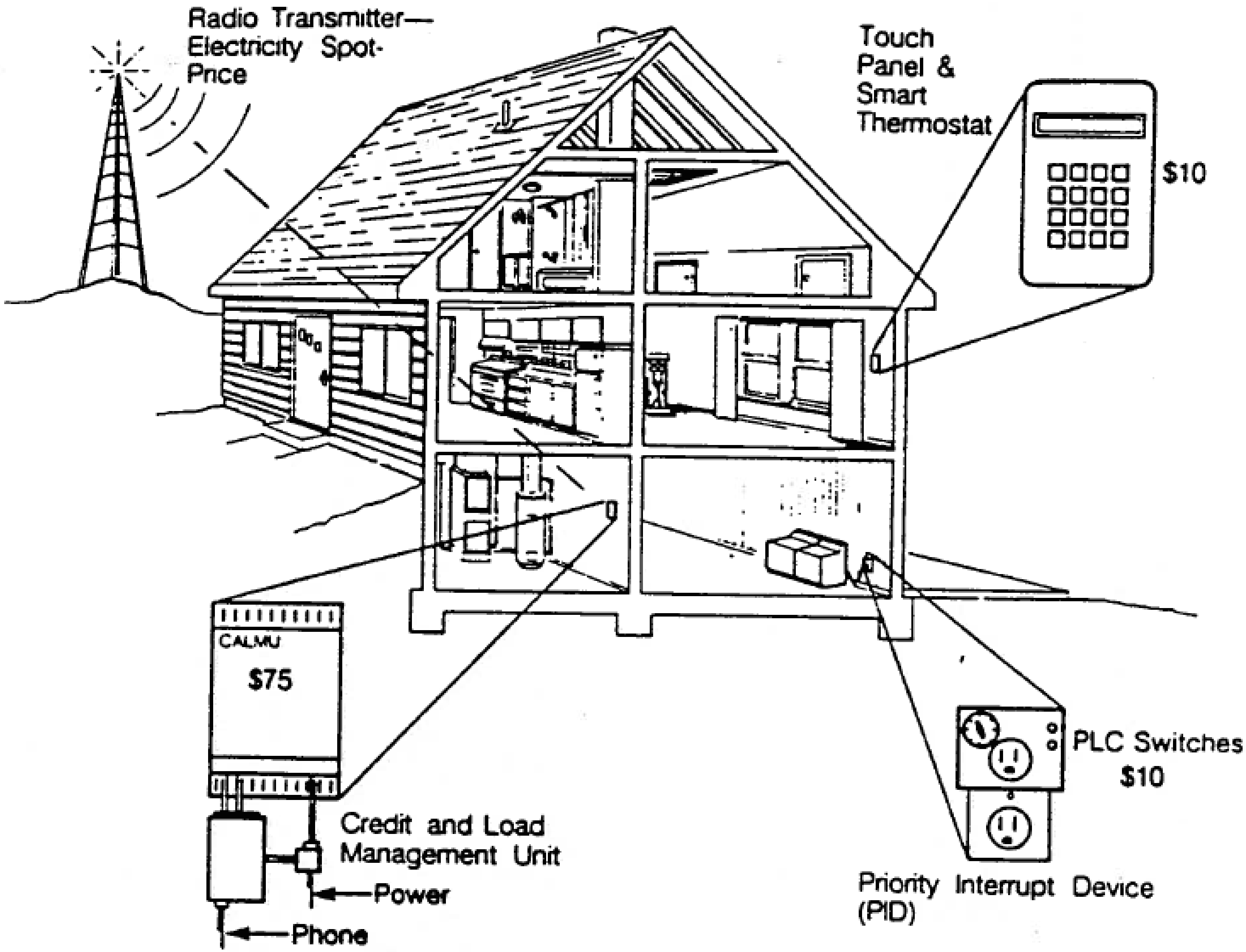



*Fig. 1 Daily Load Shapes for Five Representative Weekdays (North Central Region, 1980). Source: INDUSTRIAL AND COMMERCIAL COGENERATION, Office of Technology Assessment, U.S. Congress (1983), which cites Decision Focus, Inc. (1980).*

# CREDIT & LOAD MANAGEMENT SYSTEM: CALMS



ELECTRIC UTILITY WEEK

McGraw Hill

An exclusive report on the electric utility industry

June 17, 1985

## MASS. DPU RULES BOSTON ED MUST OFFER INTERRUPTIBLE RATES TO ALL CUSTOMERS

Boston Edison must file by Oct. 1 new interruptible rates to be offered to all customers, the Massachusetts Dept. of Public Utilities has ordered. It would be the most extensive set of electric interruptible rates nationwide—as well as the first interruptible electric rates in the state.

All Massachusetts electric utilities will eventually be told to do the same, DPU chairman Paul Levy told *Electric Utility Week*. Declaring that customers should be offered a range of services at a range of prices, DPU told Boston Ed to file a "menu of prices, with the lower prices having longer and more frequent interruptions than the higher prices."

Interruptions would come at the point where the utility's marginal cost of providing power exceeded the price that the customer had selected, DPU said in its order (Docket 84-194).

Boston Ed would have to provide information on the likely timing, frequency, and duration of interruptions at each price, "so that the customer could make an informed decision. Customers, of course, would still have the option to receive firm service," said DPU. Boston Edison would offer no immediate comment on the DPU ruling.

# ENERGY MANAGEMENT

Eugene F. Gorzelnik

# High temperatures trigger control devices

**Temperature-activated load controller** senses outside air temperature to control customer air-conditioning units. At a 75% duty cycle, the load shed is about 1 kW per unit; few customers complain

The program initiated at Oklahoma Gas & Electric Co to manage its air-conditioning load has been so well accepted by its customers that the company has had to control customer response rather than try to create it. Through the end of June, almost 65,500

neer, Refrigeration & Air Conditioning Control Sales in GE's Appliance Control Dept. The device's operation is based on the principle that a utility's system load curve is temperature-dependent during the summer and winter peak-load periods (Fig 1).

temperatures if the home has a high insulation level and a high unit capacity, and a rise of 3° to 5°F if the home has a low insulation level and a low capacity.

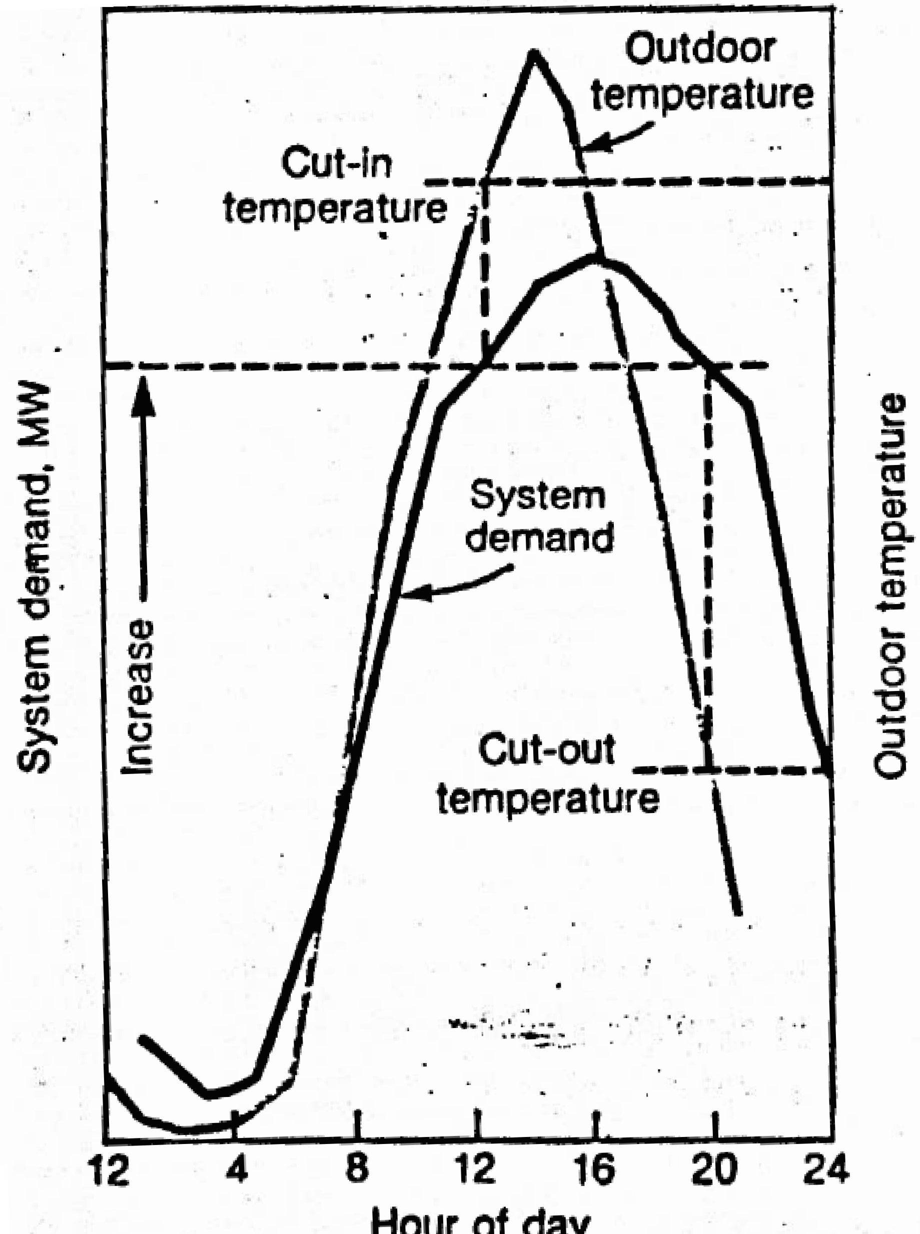
O'Day notes that this temperature rise generally is not objectionable. OG&E's Davis agrees. "Most customers," he says, "report that they can't tell when the control devices are working and when they are not. Needless to say," he adds, "they like the reduction in their electric bills." Davis observes that during tests conducted by OG&E, the use of a 50%

Electrical World, August 1984

The device operates on a 30-min time base and keeps the compressor on for a specified period of time. Thus, for a 75% duty cycle, O'Day observes, the compressor is on for 22½ minutes and off 7½ minutes. The outside control temperature and duty cycle are preset at the factory, following consultation with the user utility. In OG&E's case, the set points are 95°F and 75% duty cycle. Typically, OG&E's service area experiences about 200 hr/yr at or above 95°F.

Operating the leveler on a 30-min base also assures good humidity control, O'Day points out. As for temperature, he says, studies of typical homes during 75%-duty-cycle control periods shows a rise of 2° to 3°F above normal room

**Electrical World, August 1984**




**1. Load controller is based** on correlation between air temperature and system peak

## ENERGY MANAGEMENT

# Data link enhances energy, other services

**An advanced in-home communications system** now being developed and tested in Georgia will provide customers with real-time access to home energy-management services and a test of spot electricity pricing. It also will provide many other in-home electronic services, such as banking, shopping, and security.

Next month, the first of 200 homes in Roswell, Ga, a suburb of Atlanta, will begin field testing of Integrated Communication Systems' (ICS) advanced in-home communication system, called TranstexT. Cornerstone of the ICS system is its ability to improve the efficiency of home-energy consump-

to invest about $2.6-million in ICS, and to hold an 18% equity position.

The mission of ICS, Paul Spaduzzi vice president, business development, told a recent Southeastern Electric Exchange marketing meeting, is to accelerate the implementation of ICS nationwide and to differentiate Trans-

to establish a solid basis for future decisions, and to begin to evolve its own strategies. The fee is $60,000.

### Spot pricing

Georgia Power, says James Callaham, manager of retail market application, has received PSC approval to conduct a two-year spot pricing experiment starting this month. He explains that the price of electricity, which customers in the TranstexT experiment will pay, varies with GP's system lambda—the incremental cost of producing the next kWh.

Electrical World, January 1985

**Table 2.1** Pacific Gas and Electric Company Price Schedules

| Type | Fixed | Demand | | Energy Charge | | | Limits | | | Penalty | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chg. $/Mo. | Peak $/kW | Max | Peak | Shldr Cents/kWh | Offpk | Warn Min. | No. | Dur. Hrs. | 1st | 2nd $/kW |
| Firm Service: | | | | | | | | | | | |
| A1 | | | | 10.404 | 10.404 | 10.404 | | | | | |
| A6 | | | | 24.895 | 12.447 | 6.473 | | | | | |
| A10 | 50 | | 2.85 | 8.658 | 8.658 | 8.658 | | | | | |
| A11 | 50 | 8.10 | 2.85 | 12.746 | 10.197 | 5.405 | | | | | |
| E20 | 100 | 8.10 | 2.85 | 7.633 | 7.269 | 4.264 | | | | | |
| Curtailable Service (E20): | | | | | | | | | | | |
| A | 290 | 4.87 | 2.85 | 7.631 | 7.266 | 4.265 | 60 | 15 | 50 | 3.11 | 6.23 |
| B | 290 | 3.04 | 2.85 | 7.626 | 7.261 | 4.264 | 30 | 30 | 100 | 4.89 | 9.79 |
| C | 290 | | 2.85 | 7.494 | 7.136 | 4.226 | 10 | 45 | 200 | 8.45 | 16.90 |
| Interruptible Service (E20): | | | | | | | | | | | |
| A | 300 | | 2.85 | 6.886 | 6.557 | 4.128 | 60 | 15 | 50 | 11.12 | 22.24 |
| B | 300 | | 2.85 | 6.392 | 6.088 | 4.036 | 30 | 30 | 100 | 13.34 | 26.69 |
| C | 300 | | 2.85 | 5.701 | 5.428 | 3.908 | 10 | 45 | 200 | 16.46 | 32.91 |

Southern California Edison Company

# Fishing for a way to reduce the cost of your electric service?

Southern California Edison Company

# Interruptible Schedules

| Monthly Billing Credits | I-2 | I-3 | I-4 |
|---|---|---|---|
| 10-minute rate | $3.10/kW | $1.50/kW | $1.00/kW |
| 30-minute rate | 2.60/kW | 1.00/kW | .50/kW |
| 2-hour rate | — | .50/kW | .00/kW |
| Additional if interrupted during month | | 3.00/kW | 2.50/kW |

The number of periods of interruption will not exceed an average of 15 times or 180 hours per calendar year over a five-year period (except for Schedule I-4, which is for one year).

Offered to commercial and industrial customers with load > 500KW

# "GET CREDIT FOR TAKING TIME OFF."

# YES, I'LL TAKE THE CREDIT.

*Put the peel-off address label here.*

An Edison representative will phone to make arrangements to install the device. Please be sure to include your home or work phone number below:

( ____ ) __________________ home/work

Best time to contact me is: ______ a.m./p.m.

Please complete the following and check appropriate boxes. Tear off and return.

☐ I am an Edison residential customer with electric central air conditioning. Please put me on the new rate schedule D-APS 2 (Air Conditioner Cycling). I have read the brochure information regarding this rate.

Install a device on my air conditioning equipment for the savings option checked below so that I will receive a credit on my bill each month during the 6 summer months.

☐ A—$5.50 credit for each ton of my air conditioner

☐ B—$3.00 credit for each ton of my air conditioner

☐ C—$1.50 credit for each ton of my air conditioner

☐ I am interested but would like additional information about this program.

________________________________

Signature of owner/manager, if approval needed.

# "Read this. I'd like to see you get up to $165 just by signing up for Air Conditioner Cycling."

—George Burns

If you have central air conditioning, you can save money on your summer electric bills by participating in the Air Conditioner Cycling Program.

This program helps slow the growing demand for new power plants. When business and industry are in full production and residential customers are using electrical appliances and air conditioners, the demand for electricity reaches peak levels. Air Conditioner Cycling helps manage the growth of peaks and reduces the need to build new power plants.

**Here's how the program works.**

By choosing to participate in the new Air Conditioner Cycling Program, you'll get a credit toward your

| THERE ARE THREE SAVINGS OPTIONS. | **EXAMPLES*** | TOTAL SAVINGS OVER 6 SUMMER MONTHS. | | | | | |
|---|---|---|---|---|---|---|---|
| SAVINGS OPTION | MONTHLY SAVINGS FOR EACH TON OF A/C | 2.5-TON UNIT | 3-TON UNIT | 3.5-TON UNIT | 4-TON UNIT | 4.5-TON UNIT | 5-TON UNIT |
| A—off full time cycling is in effect | $5.50 | $82.50 | $99 | $115.50 | $132 | $148.50 | $165 |
| B—off 10 min. out of each 15 min. period | $3.00 | $45 | $54 | $63 | $72 | $81 | $90 |
| C—off 7½ min. out of each 15 min. period | $1.50 | $22.50 | $27 | $31.50 | $36 | $40.50 | $45 |

*Any size electric central air conditioner or heat pump in good working condition qualifies for this program.

# AIR CONDITIONER CYCLING PROGRAM

## Background

- Experimental Programs
  - Automatic Powershift, Residential 1977-1981
  - Automatic Powershift, Commercial/Industrial 1979-1981

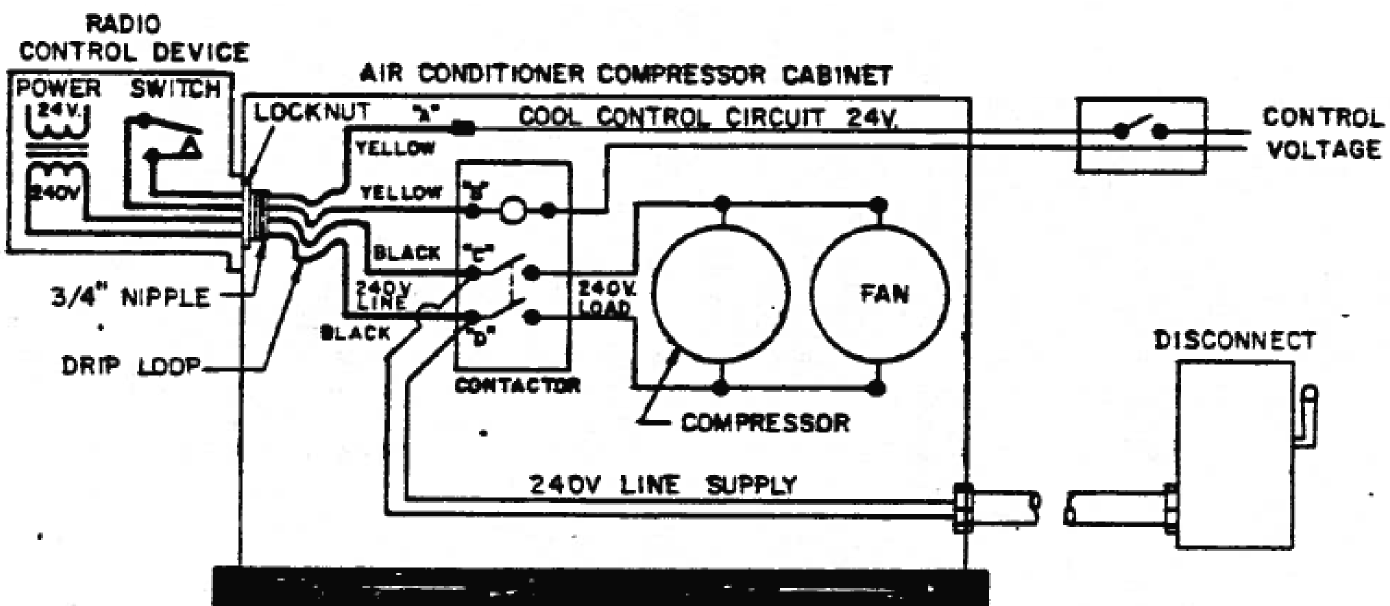
## Objectives

- Reduce Demand During System Capacity Shortage
- Established As A Part Of Our Resource Plan
- 130 MW By Year End 1984
  - Residential = 114 MW
  - Commercial/Industrial = 16 MW

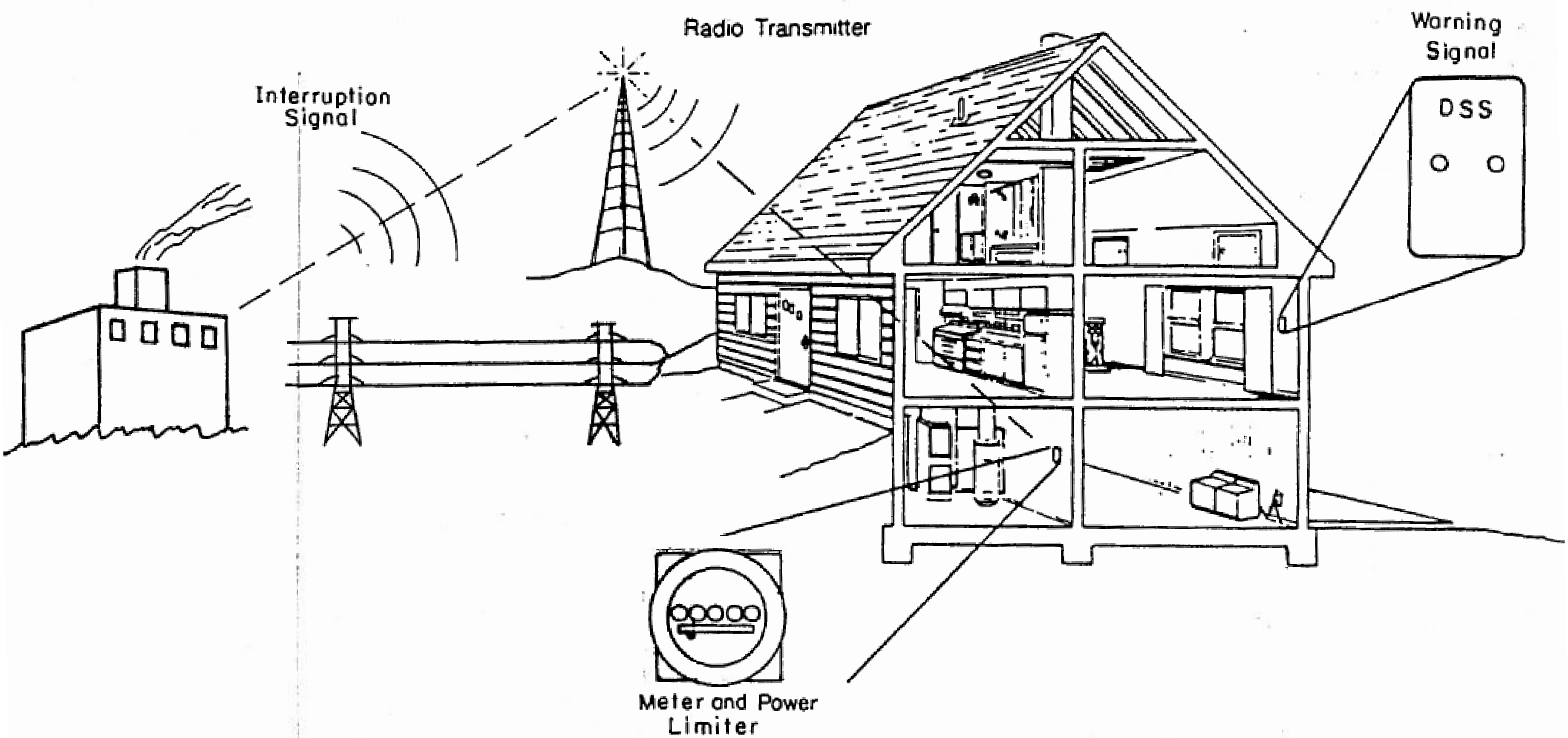
## Scope

- Voluntary Program
- Various Strategies And Rate Incentives (attached)
- Goal - Install 65,000 Devices By Year End 1984.

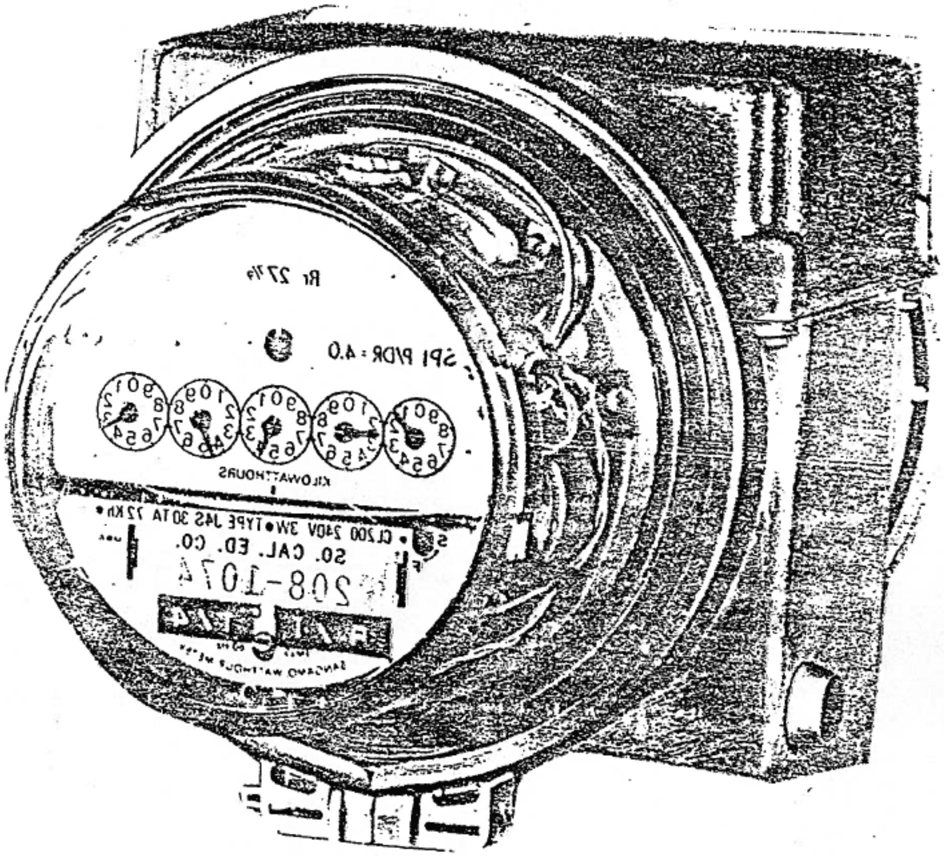
# LOAD MANAGEMENT CONTROL DEVICE

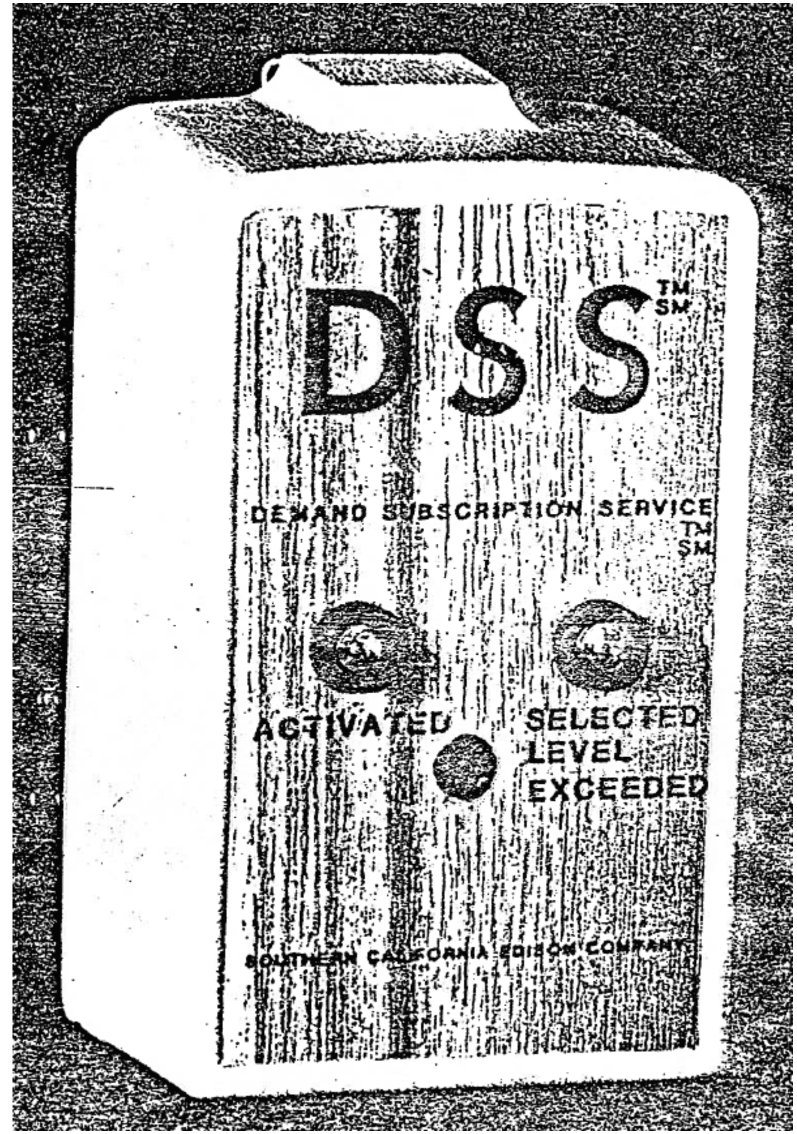



# Demand Subscription Service




Demand Subscription Service: Radio controlled fuse limits customer's power supply to his subscribed level.


KILOWATTHOURS
SO. CAL. ED. CO.


DSS TM SM
DEMAND SUBSCRIPTION SERVICE TM SM
ACTIVATED
SELECTED LEVEL EXCEEDED
SOUTHERN CALIFORNIA EDISON COMPANY

# DEMAND SUBSCRIPTION SERVICE℠

## To Restore Your Electrical Service You Should:

1. Immediately turn off or unplug all electrical appliances and devices which may create a hazard if they are restored to service without supervision.
   (Examples: electric irons, mixers, fans, workshop equipment and other such household appliances.)

2. Turn off a sufficient number of electrical appliances and devices to reduce your demand for electricity to your Level of Service.

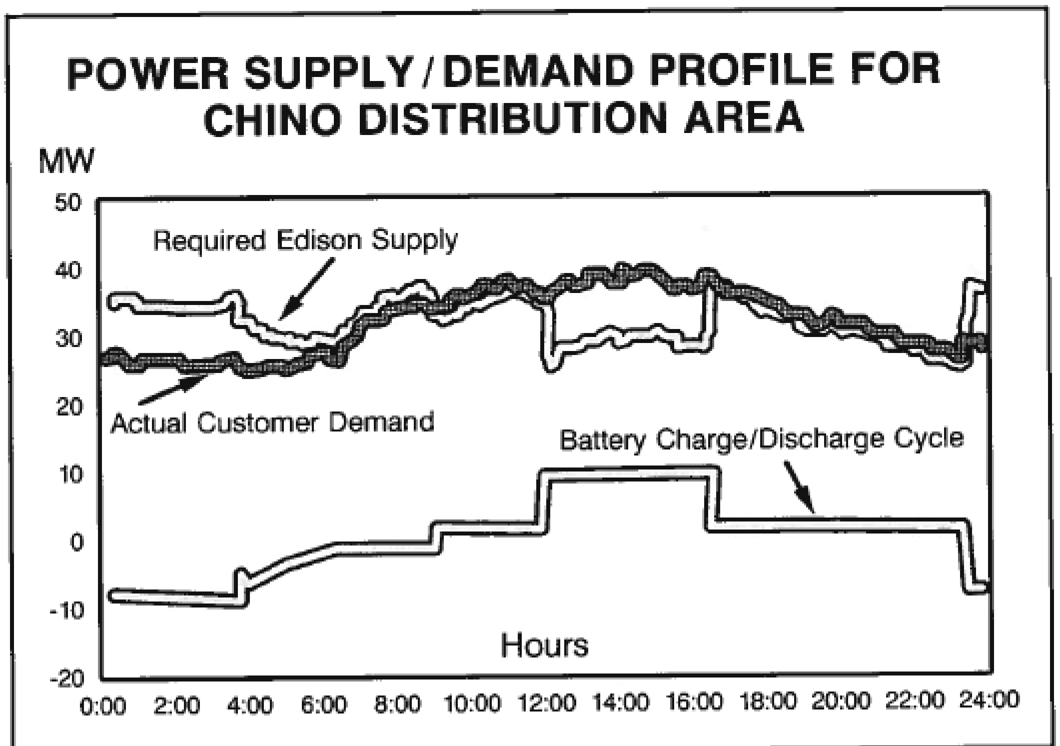
3. Push the "Reset" button which is located on bottom left side of your Demand Subscription Service Device.

If you are unable to restore your electrical service, or if you experience any difficulties with your Demand Subscription Service Device, call ______________________
and identify yourself as a Demand Subscription Service Customer.

*Southern California Edison* SCE

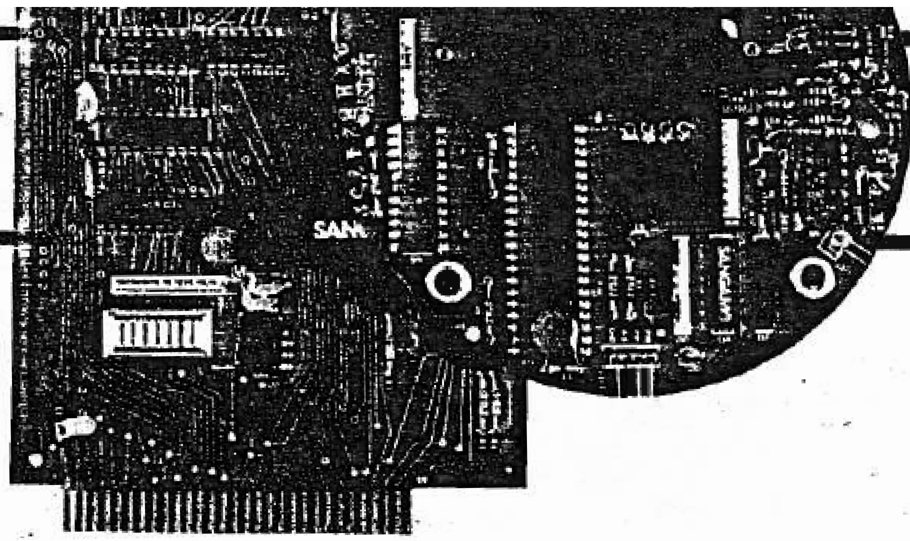
# The World's Largest Battery Energy Storage Facility Now On Line

**The 10 MW/40 MWh Chino Battery Energy Storage Facility has been completed and its two-year demonstration test plan has begun. Already, the plant has achieved its full power rating and has helped to lighten Edison's peak load.**




Southern california Edison, Research Newsletter, 4th Quarter, 1988

Special Report



# Electronic meter carves a niche for itself

**By Eugene F. Gorzelnik, Senior Editor**

The explosion in the knowledge and availability of electronic devices in all areas of human endeavor in the 1960s and 1970s has triggered signifi-

This report is limited to examining the forces that have been and are shaping the face of the electric meters of today and tomorrow, and the direction in

measures and integrates the current and voltage, including any waveform distortions caused by harmonics that a conventional meter can miss, and stores the

Electrical World, January 1983

Vol. 18, March 1989 Southern California Edison Special Issue on NetComm

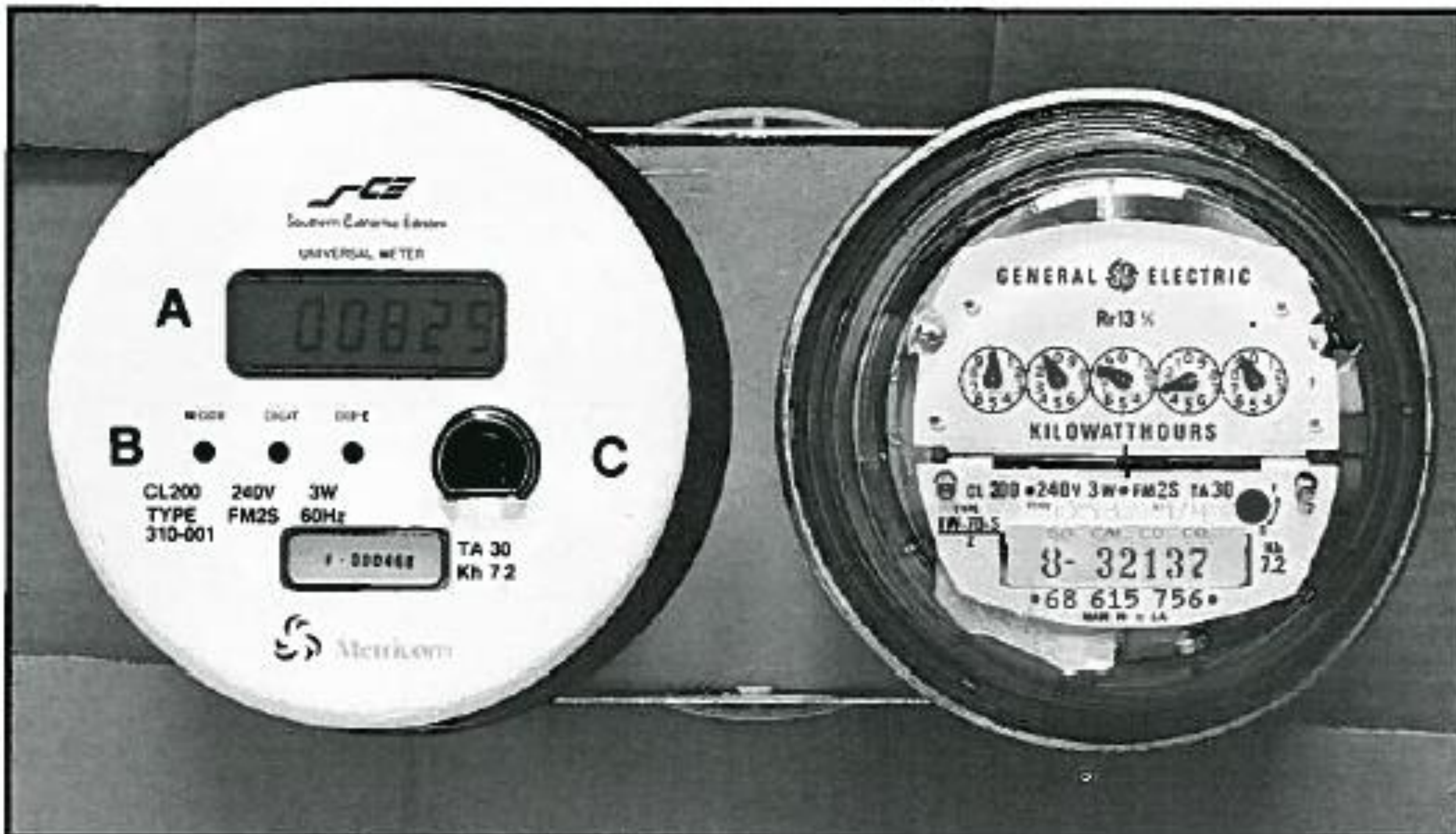
# NetComm — Origins, Progress, Plans for the Future

**This special issue of *Research Newsletter* is entirely devoted to NetComm, a high-priority project of Southern California Edison's Research Division. NetComm links customers' electronic meters to utility computers via a network of high-frequency radios to perform a variety of metering, monitoring, and diagnostic functions. NetComm's two-way communication capabilities will allow Edison to offer a more cost-sensitive rate structure and will allow the customers to make price-conscious choices regarding electrical consumption. NetComm's innovative technology is currently undergoing field testing in Edison's Valencia District with future applications planned for the 1990s.**

The NetComm (for ***Net**work* ***Comm**unications*) Project began in the fall of 1986 when Southern California Edison's Research Division received an unsolicited proposal from a start-up Silicon Valley electronics firm called Metricom, Inc. (Figure 1). That proposal held the potential to deliver three important system improvements that Edison had long sought: accurate electronic meters, time-of-use rates through two-way communication with the customers, and the ability to perform a number of distribution automation functions.

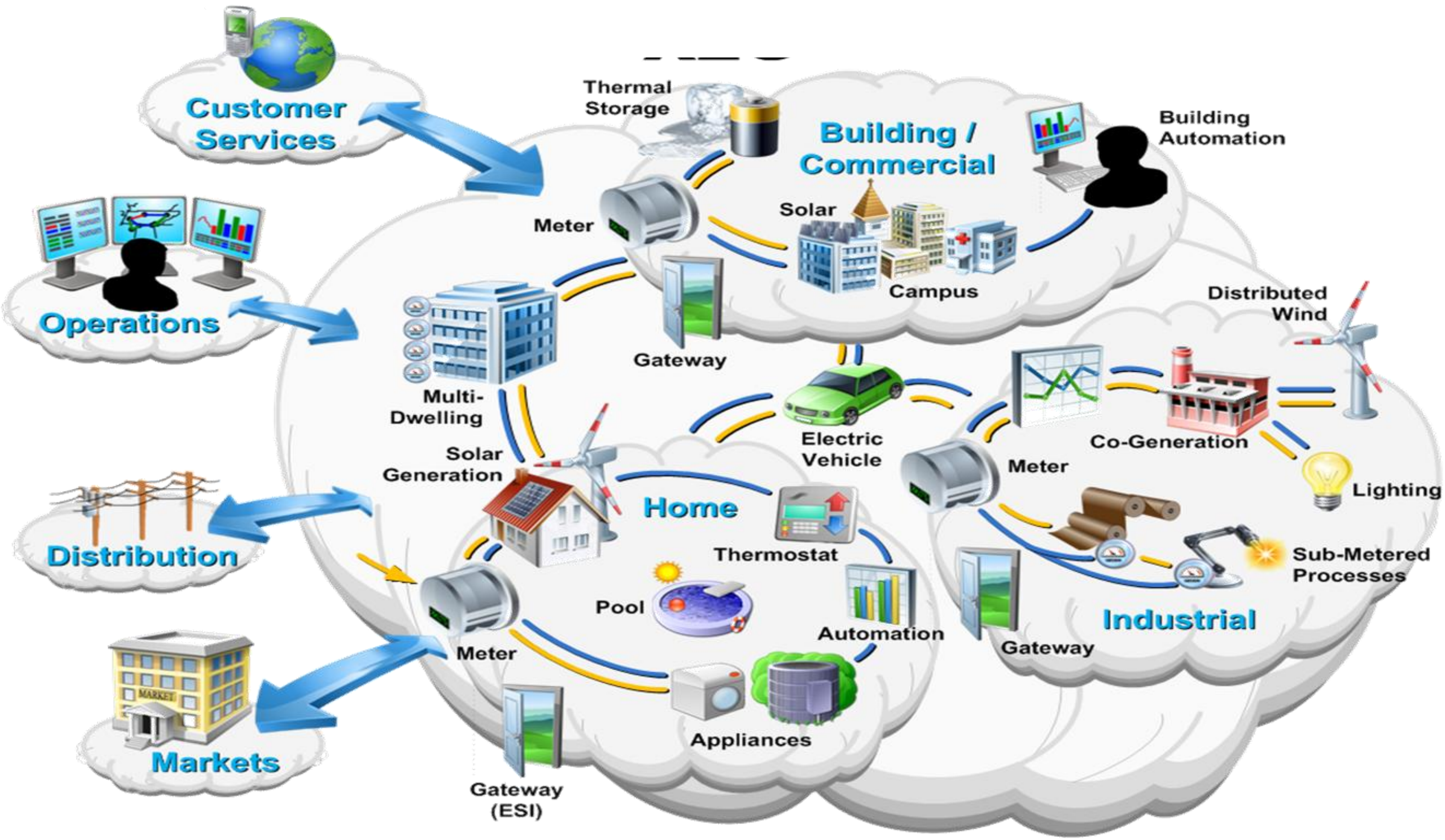
The NetComm project was conceived as an ambitious undertaking. Its potential effects on improving the quality of customer services and distribution automation are far reaching. Ultimately the NetComm system will consist of new all-electronic meters, new distribution sensors and control devices, and one or more computers

*Continued on Page 2*



UNIVERSAL METER
A
B
C
CL200 240V 3W
TYPE FM2S 60Hz
310-001
TA 30
Kh 7.2
GENERAL ELECTRIC
KILOWATTHOURS
8- 32137
68 615 756

# Future Electricity System



# General Observations About Demand Response

- While today's metering and control technology is cheaper, technology was never a barrier to implementation of demand response
- The focus has been (as now) on demonstration of capability, rather than on developing a business model that will facilitate implementation.
- The key elements to making demand response a reality are:
  - A regulatory framework
  - Institutional structure
  - A sustainable business model that will incentivize customer choice at the retail level

# Economic *Paradigms for Demand Response*

- Provide real time prices to retail customers
  - Politically objectionable
  - Customers do not like and are not used to price uncertainty
  - While RT price response can be automated it still puts the burden on the customer
  - Treating electricity as a commodity works well at wholesale level but retail customers would rather think of electricity as a service
- Provide quality differentiated service based on contracted load control options.
  - Quality differentiated service and optional price plans are common in other service industries (air transportation, cell phone, insurance)
  - Customers have experience with choosing between alternative service contracts
  - Customers prefer uncertainty in service rather than uncertain prices

# The Challenge

- Need Business model and economic paradigm for a utility or third party aggregator to bridge the gap between wholesale commodity market and retail service
- Aggregated retail load control can be bid into the wholesale markets for balance energy and ancillary services.
  - Load control through direct device control (thrmostats, airconditioners, water heaters, EV battery charge)
    - Intrusive
    - Faster response enables higher valued products (e.g. regulation)
  - Or control of power through the meter with customer dynamic control of allocation to devices in the home.

# PRIORITY SERVICE METHODS

# PRISM

## ELECTRIC POWER RESEARCH INSTITUTE

**1982-1990**

EPRI

December 1991

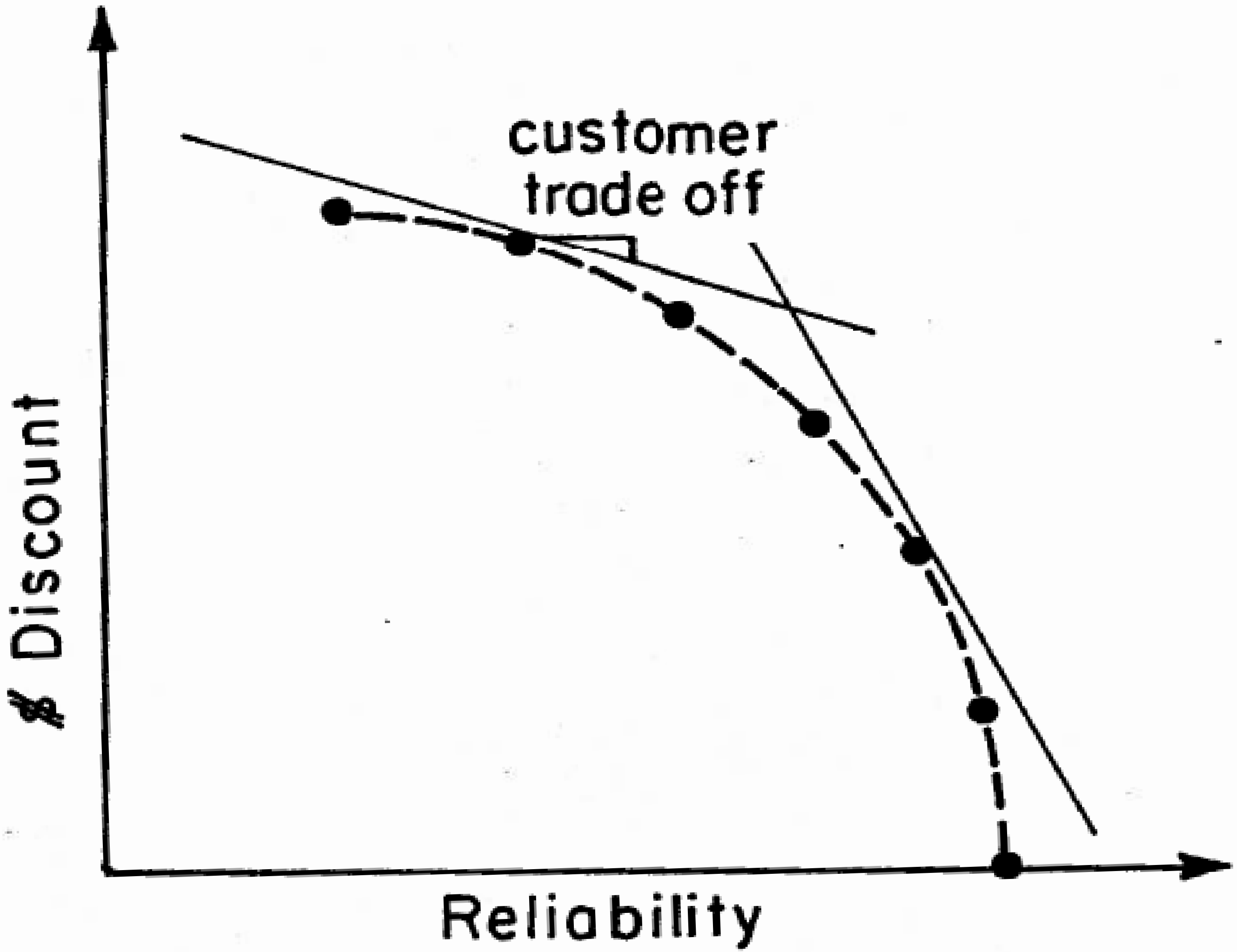
# Innovators
with EPRI technology


## *EPRI/UTILITY COLLABORATION IMPROVES BOTH SYSTEM RELIABILITY AND CUSTOMER SATISFACTION*

**"The challenge was to make curtailable service more attractive to subscribers and more cost effective for Niagara Mohawk. The solution was to offer customers more choices with appropriate incentives."**

■ **Jeff Wicks**
General Manager-Marketing
Niagara Mohawk Power Corporation

# PRICE MENU



# Key Principles

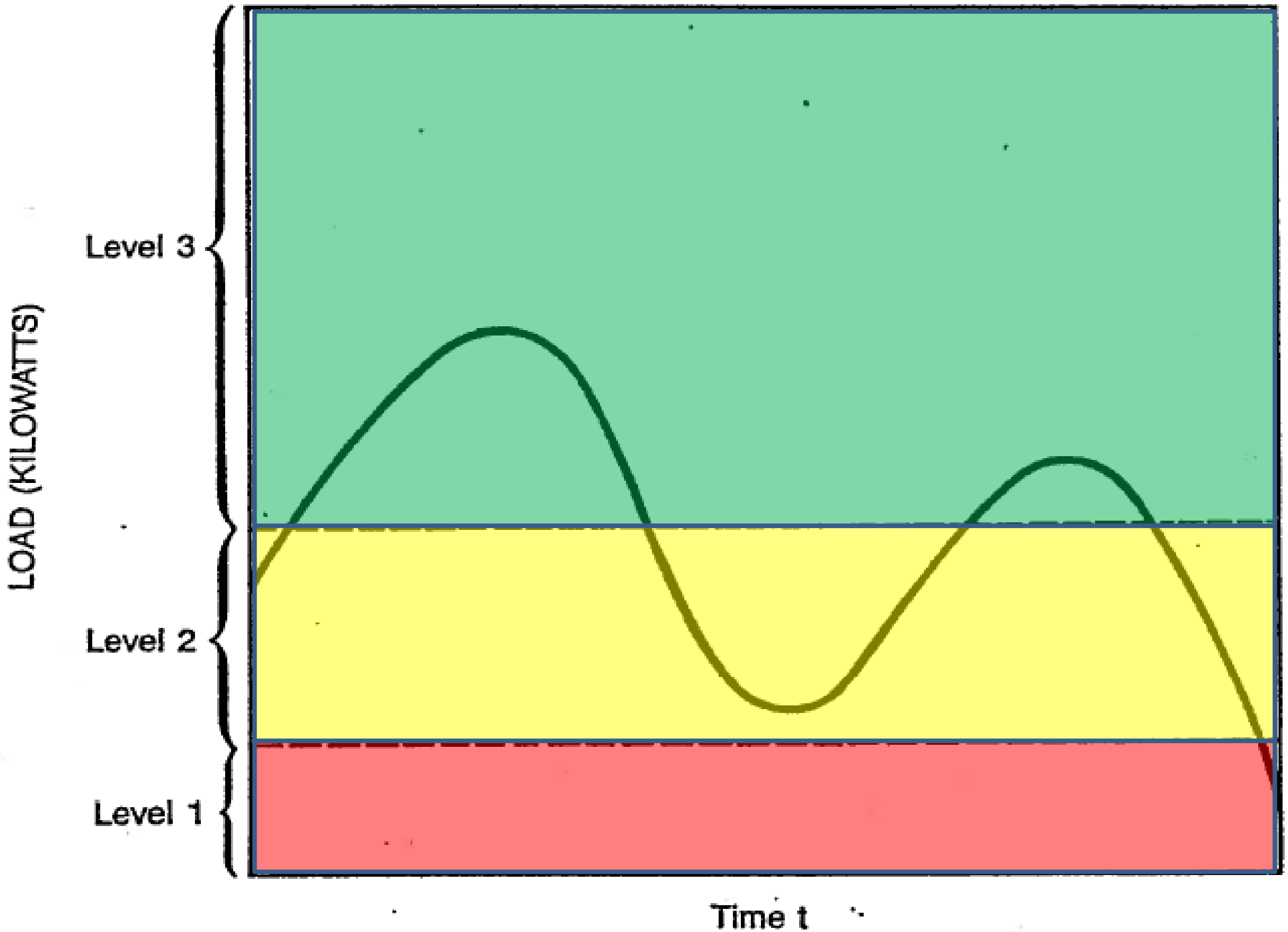
- Market Segmentation (Explicit consideration of customer preference diversity)
- Product Differentiation (Based on supply cost and value of service)
- “Menu” of service contracts that induce efficient matching of products and applications through customer selections
- Customer preferences revealed through choices

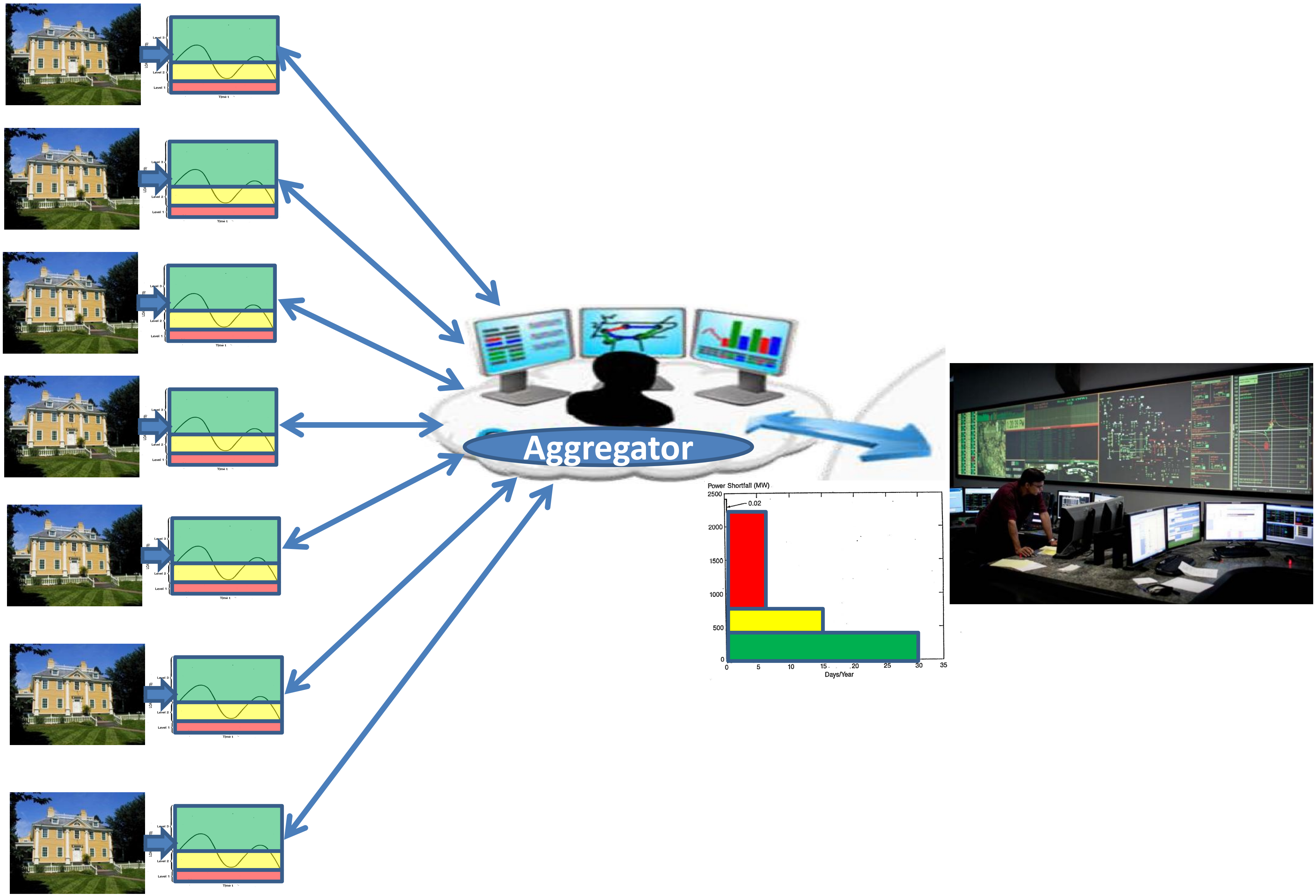
# Tarrif Structure

- Demand Charge (per KW) differentiated according to supply reliability
- Energy charge (per KWh) applied to all energy consumption

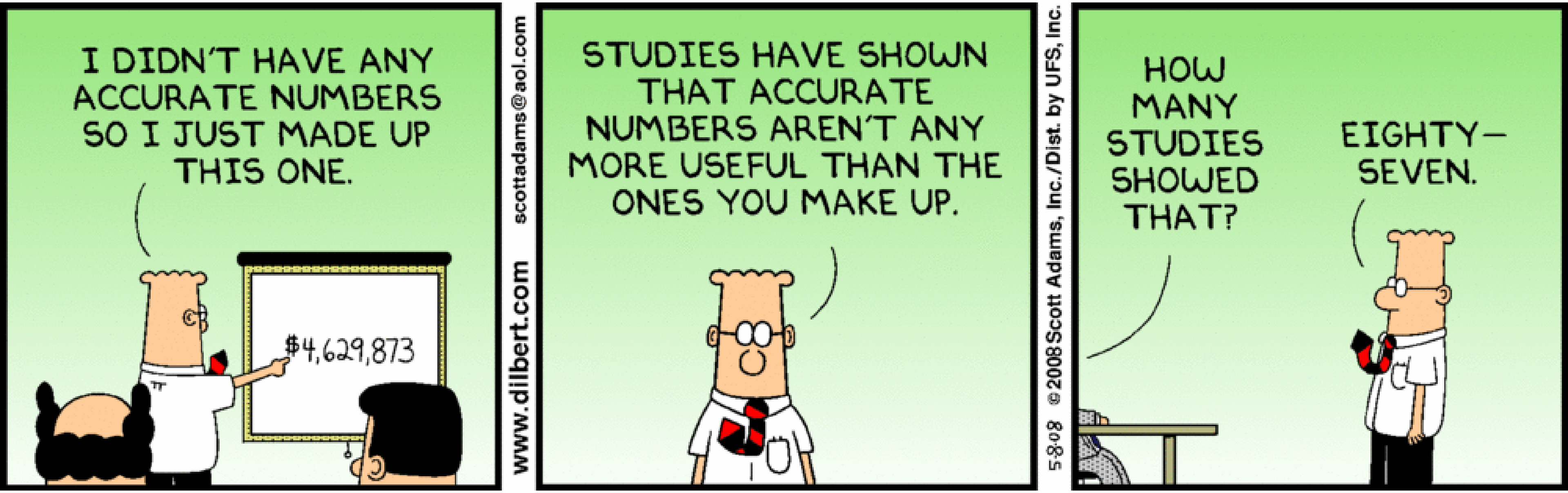
(Proliferation of distributed behind the meter resources, e.g. PV, that can inject energy into the grid and offset energy charges raise the need for a two part tariff with demand charge for connection)

# Stratification of Demand into Service Priorities




Aggregator
Power Shortfall (MW)
0.02
2500
2000
1500
1000
500
0
0
5
10
15
20
25
30
35
Days/Year

# Illustrative Example



ILLUSTRATIVE EXAMPLE OF BENEFITS OF RELIABILITY BASED PRICING
Profile of Demands (MW) and Interruption Costs

| | Customer Type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total MW | Interruption Cost ($/kW) |
| MW of Demand | 100 | — | — | 100 | — | — | — | — | 200 | 200 |
| | — | — | 100 | 100 | 100 | 100 | — | — | 400 | 50 |
| | 100 | 100 | 100 | — | — | 100 | 100 | 100 | 600 | 10 |
| | — | 100 | — | 100 | 100 | — | 100 | 100 | 500 | 3 |
| | — | 100 | 100 | — | — | 100 | — | 100 | 400 | 1 |
| | 100 | — | — | — | 100 | — | 100 | — | 300 | 0.5 |

Only the last two columns characterizing the shortage cost histogram in the population are needed for price menu design

## THE AVAILABLE SERVICE RELIABILITY OPTIONS

### Menu of Service Options

| | *Average Number of Days/Year Interrupted* | | | | | |
|---|---|---|---|---|---|---|
| | *0.02* | *0.1* | *1* | *5* | *15* | *30* |
| Demand charge ($/kW/yr) | 84 | 72 | 48 | 30 | 12 | 0 |

- Each customer type minimizes service charge + expected interruption cost
- Menu prices are designed to induce appropriate customer selections

## BASIS FOR SELECTING PREFERRED SERVICE OPTION
**Minimize (service charge + expected interruption cost)/kW**

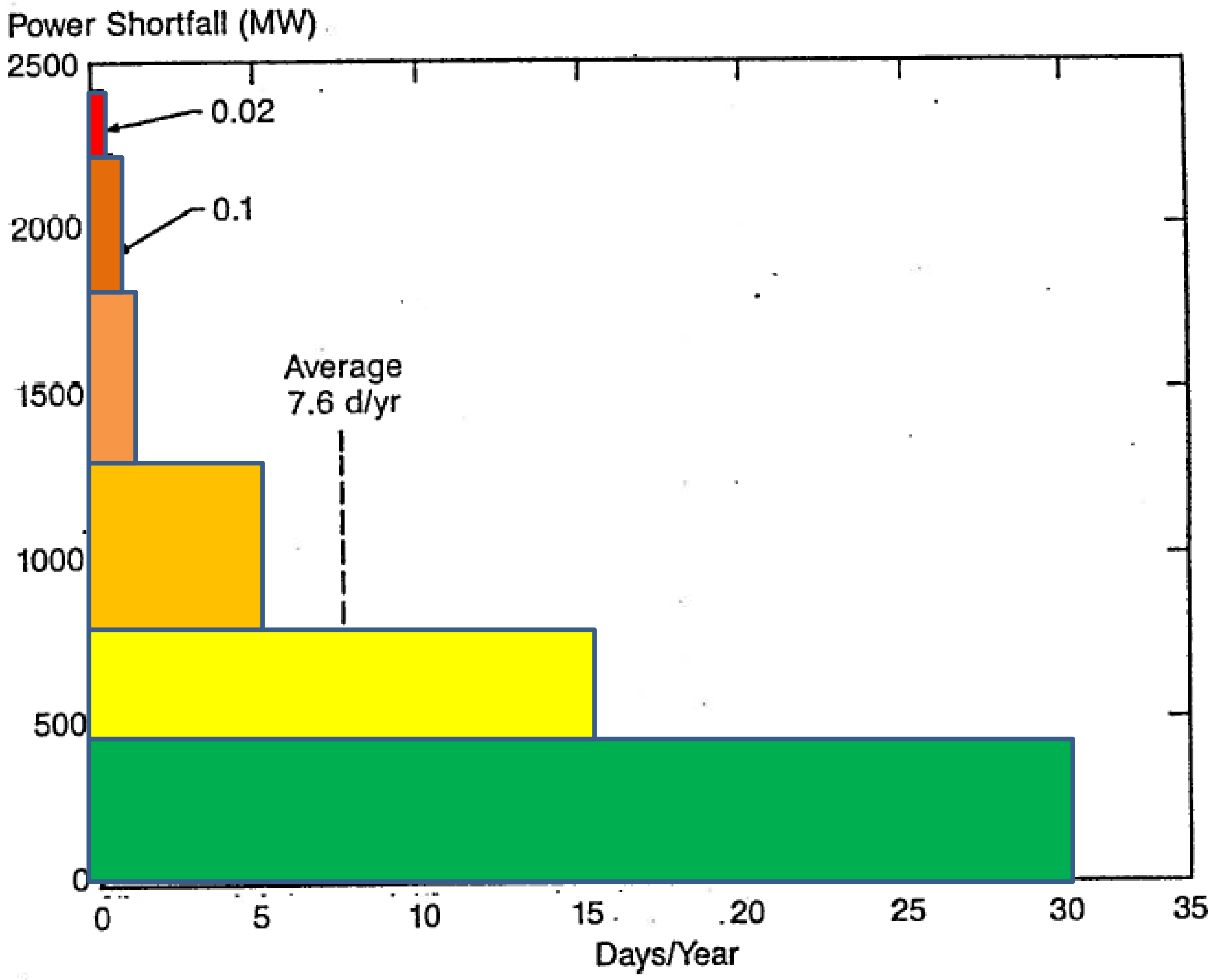
| | Expected No. of Interruptions per Year | | | | | |
|---|---|---|---|---|---|---|
| $ Cost/kW interrupted | *0.02* | *0.1* | *1* | *5* | *15* | *30* |
| 200 | 88 | 92 | 248 | 1030 | 3012 | 6000 |
| 50 | 85 | 77 | 98 | 280 | 762 | 1500 |
| 10 | 84.2 | 73 | 58 | 98 | 162 | 300 |
| 3 | 84.1 | 72.3 | 51 | 45 | 57 | 90 |
| 1 | 84.0 | 72.1 | 49 | 35 | 27 | 30 |
| 0.50 | 84.0 | 72.05 | 48.5 | 32.5 | 19.5 | 15 |

Customers' selections ◯

## THE DISTRIBUTION OF CUSTOMERS' RELIABILITY SELECTIONS
(matches deliverable service reliability)

| | | | | | | |
|---|---|---|---|---|---|---|
| Interruption cost $/kW interrupted | 200 | 50 | 10 | 3 | 1 | 0.5 |
| Interruptions per year selected | 0.02 | 0.1 | 1 | 5 | 15 | 30 |
| Total MW selecting that level | 200 | 400 | 600 | 500 | 400 | 300 |
| Interruptible MW at that frequency | 2400 | 2200 | 1800 | 1200 | 700 | 300 |

# Supply Shortage Profile  Or Aggregator's Wholesale Offers Profile



## COMPARING TOTAL CUSTOMER COSTS WITH & WITHOUT SERVICE RELIABILITY DIFFERENTIATION

*With Random Outages ($ millions)*

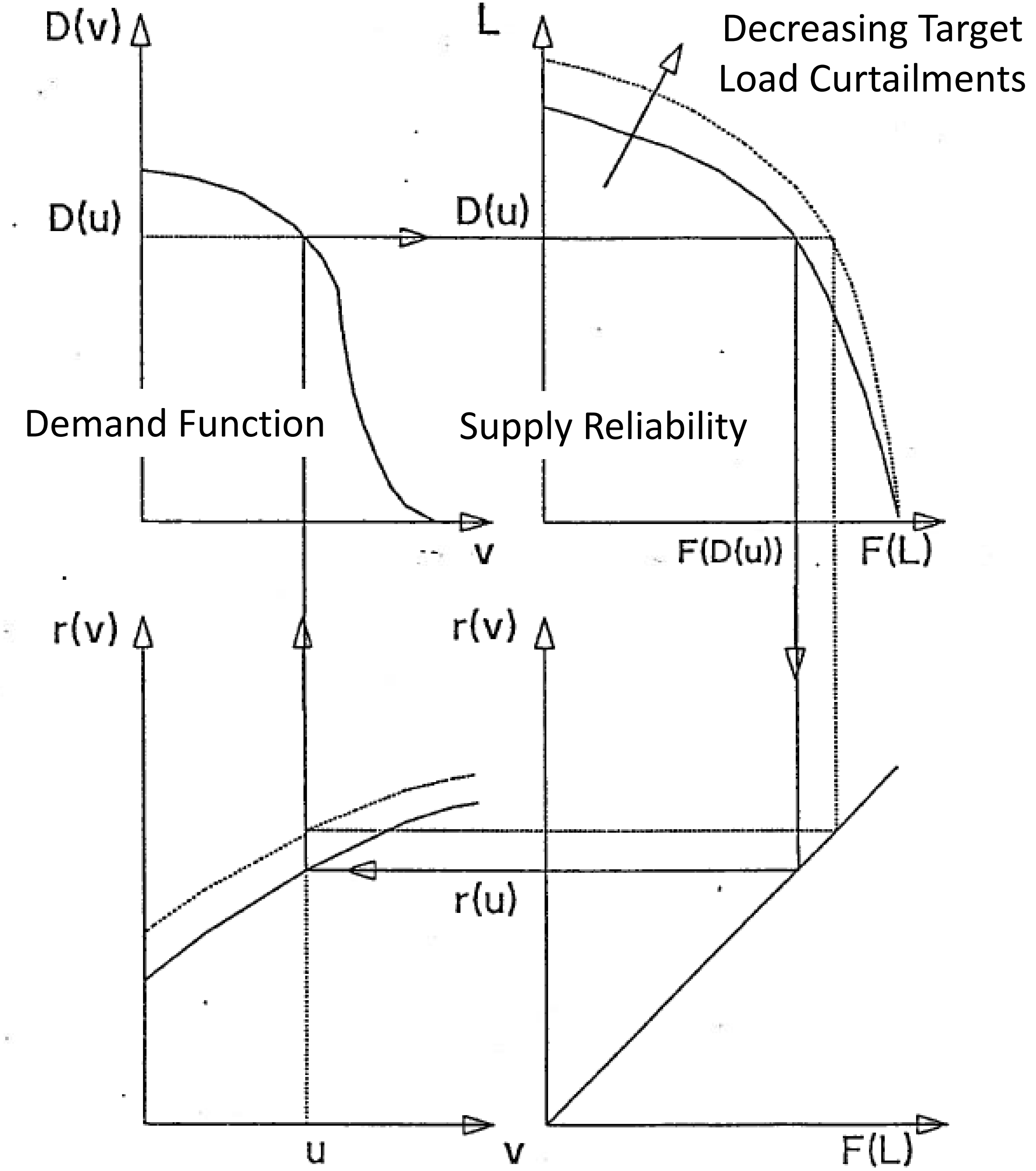
| | *Customer Type* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* |
| Charge/yr | 11.8 | 11.8 | 11.8 | 11.8 | 11.8 | 11.8 | 11.8 | 11.8 |
| Shortage (cost/yr) | 160.0 | 10.6 | 46.4 | 192.3 | 40.7 | 46.4 | 10.3 | 10.6 |
| Total (cost/yr) | 171.8 | 22.4 | 58.1 | 204.1 | 52.4 | 58.1 | 22.0 | 22.4 |

*With Service Reliability Menu ($ millions)*

| | *Customer Type* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* |
| Charge/yr | 13.2 | 9.0 | 13.2 | 18.6 | 10.2 | 13.2 | 7.8 | 9.0 |
| Shortage (cost/yr) | 2.9 | 4.0 | 3.0 | 2.4 | 3.5 | 3.0 | 4.0 | 4.0 |
| Total (cost/yr) | 16.1 | 13.0 | 16.2 | 21.0 | 13.7 | 16.2 | 11.8 | 13.0 |

# Determining the Supply Probability r(v) Under Efficient Rationing

r(v) = Probability of supply assigned to a MW with valuation v/hr.



# Deriving the Optimal Price Menu

Find a price finction *p(r)* such that

$$r(v) = \underset{r}{Arg\,Max}\{r \cdot v - p(r)\}$$

Self –Selection conditions:

$$\frac{dp}{dr} = v$$

$$v \cdot r - p(r) \geq 0$$

$$dp(v) = v \cdot dr(v)$$

$$p(v) = p_0 + \int_0^v u\,dr(u)$$

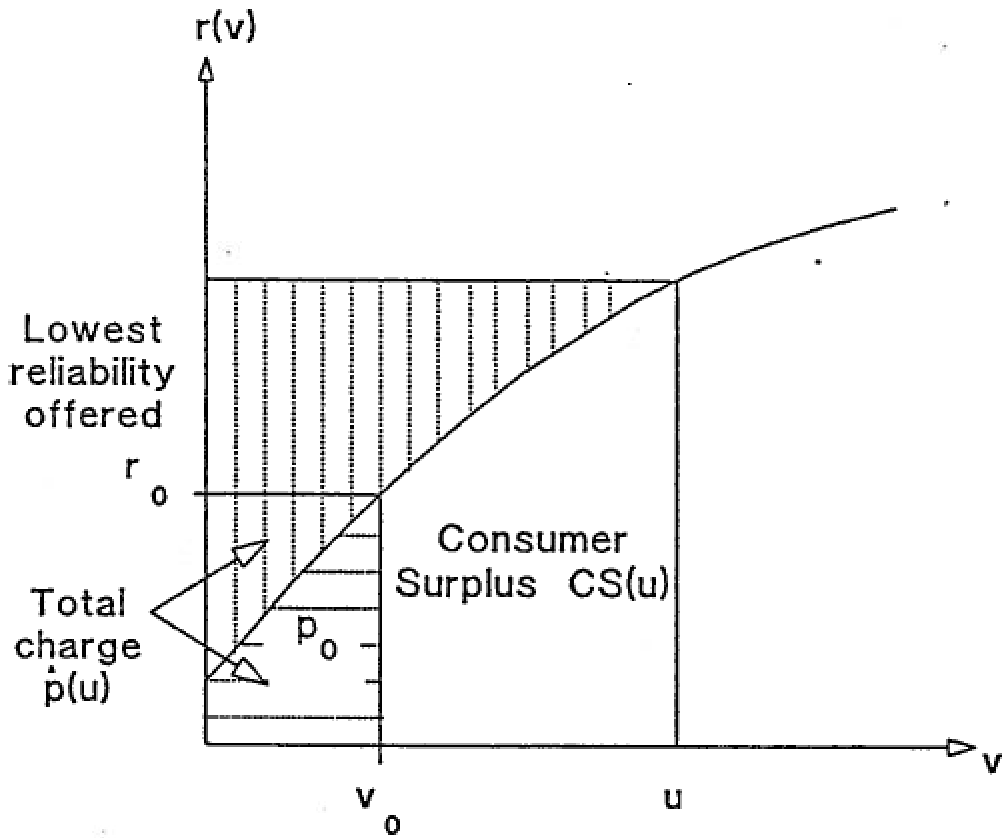
Efficient Rationing Condition:

$$r(v) = F(D(v))$$

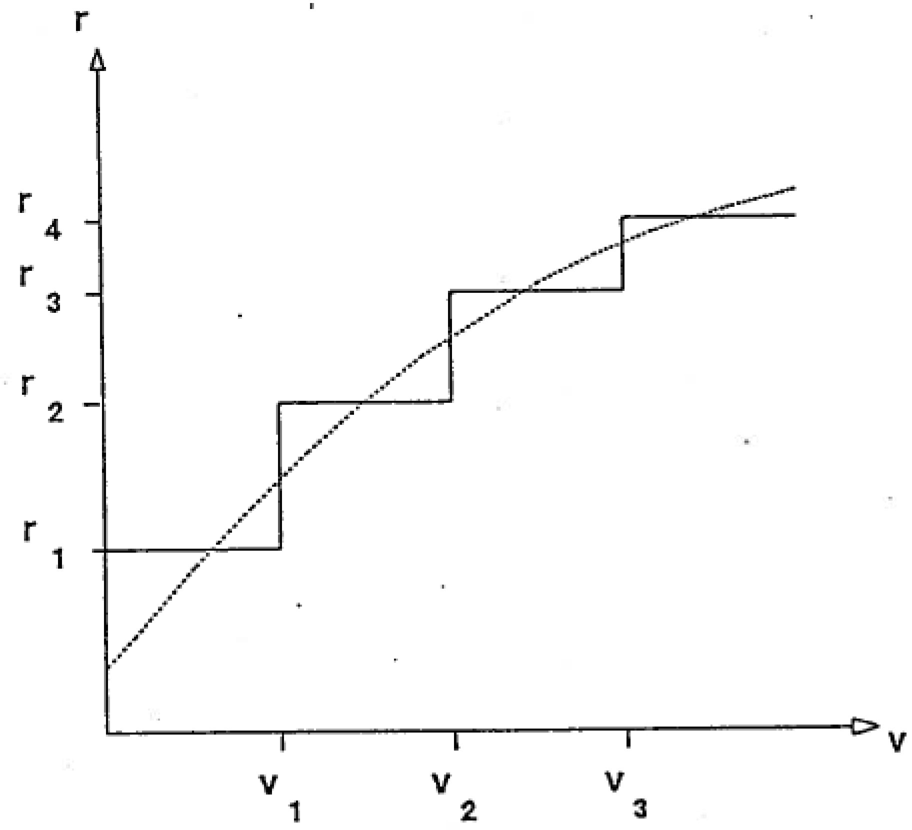
$$p(r)$$

Free parameter determining the minimum valuation served

# Graphical Illustration of Pricing Formula



# Discrete Approximation




Efficiency losses of discritization ~ O( $1/N^2$ )

## THE IMPLEMENTATION OF PRIORITY SERVICE CAN TAKE SEVERAL ORGANIZATIONAL FORMS

Demand subscription

- Frequency of interruption

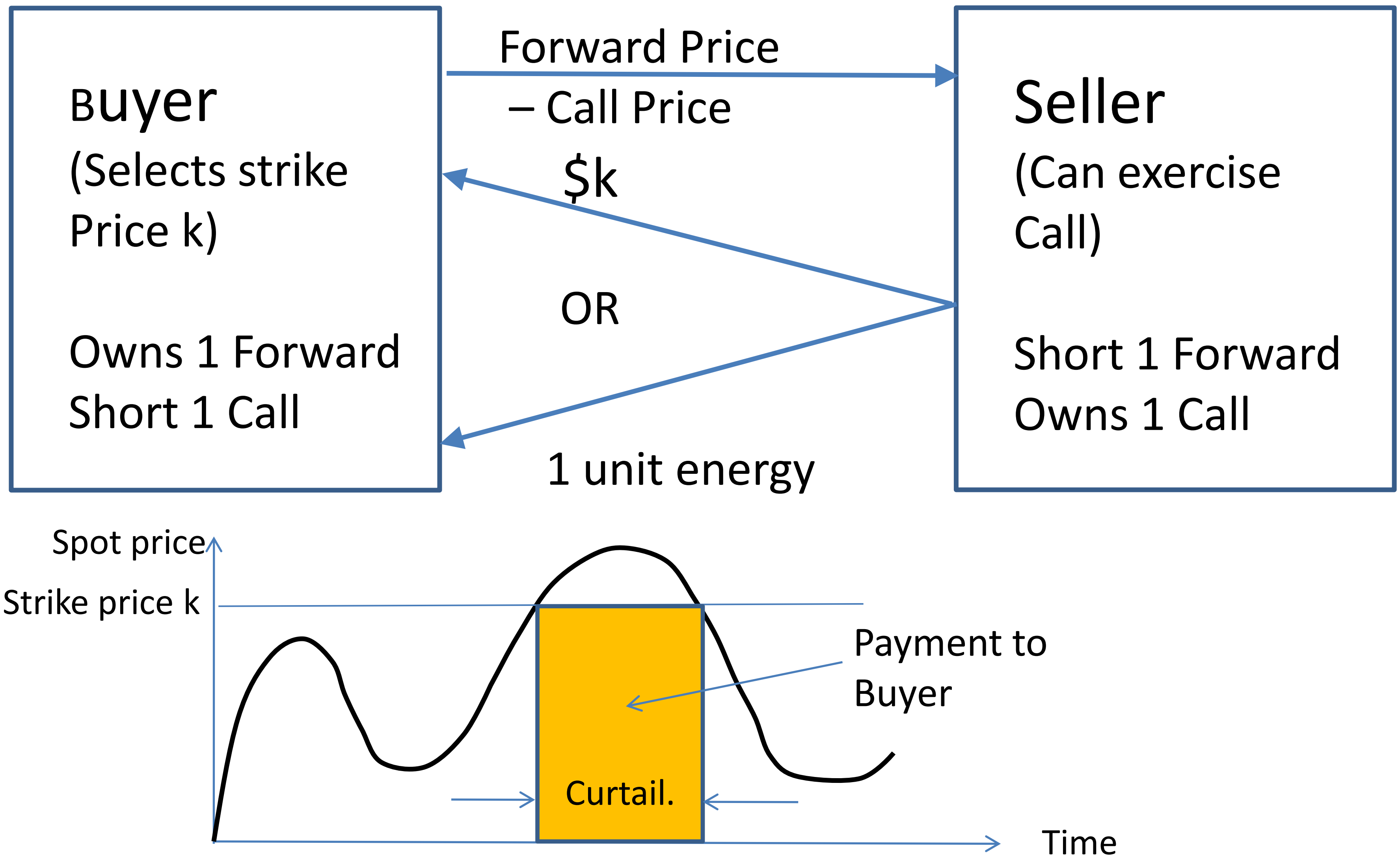
Priority insurance

- Interruption compensation

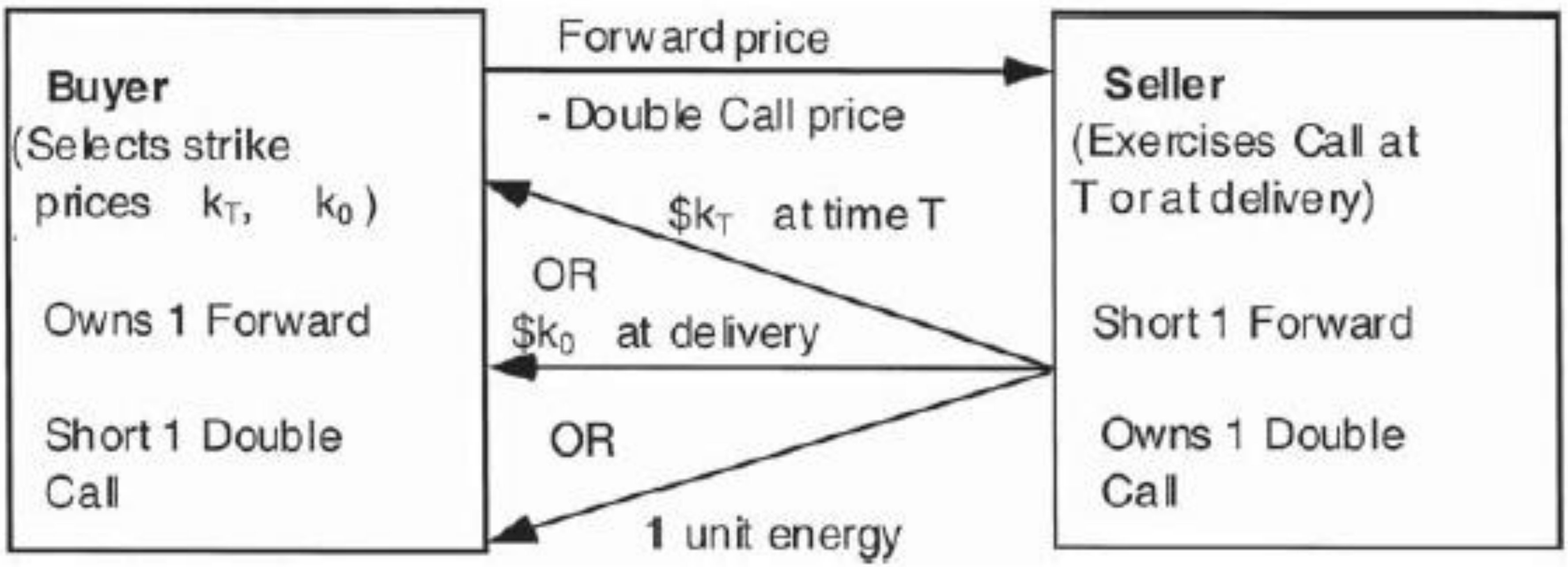
Priority points

- Rank order of service

# Modeling Interruptible Service Contracts as a Callable Forward Contracts (strike price determines priority)



# Modeling Interruptible Service Contracts with an early notification option as a Double-Callable Forward Contract



# Research Directions

- Optimization of aggregator's contract portfolio and deployment strategy
- Coupling of demand subscription contracts with intermittent supply resources
- Statistical modeling of intermittent supplies and operational hedging thorough demand subscription contracts, using  Copula distributions
- Exploiting financial analogs for risk pooling, risk tranching and pricing
- Unit commitment and optimal dispatch with demand subscription


***This is like deja vu all over again.***

-- **Yogi Berra**