DETERMINANTS OF COMMERCIAL BUILDING LOAD SHAPES

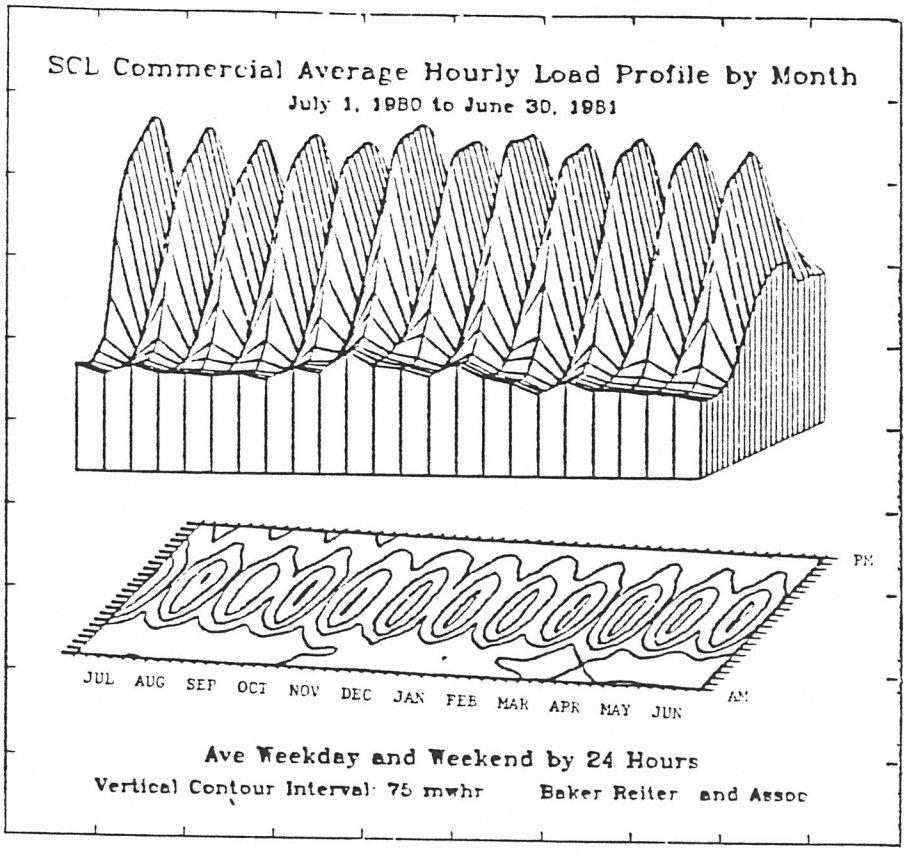
Presentation to

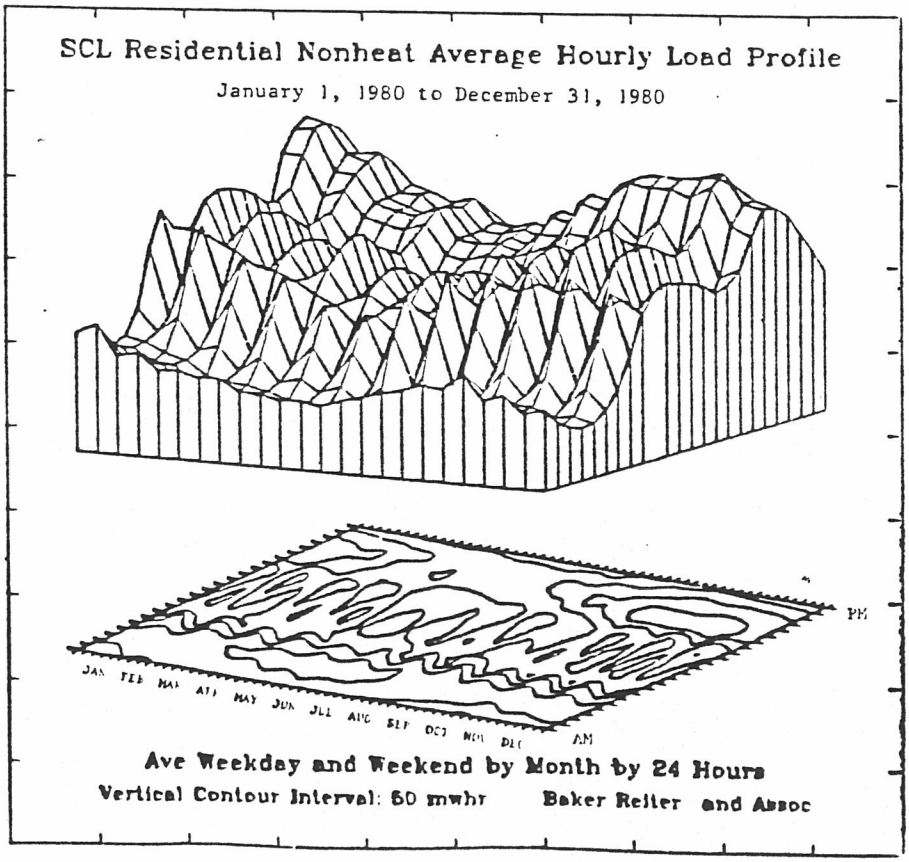
ELCAP Workshop II

By

Baker, Reiter and Associates

SCL Residential and Commercial Hourly Loads





Purpose:

- Examine the role of schedules in the determination of hourly loads for commercial buildings

Plan:

- Identify the patterns of variability in the commercial sector
- Characterize the determinants of this variability (or consistency)
- Apply these concepts to early commercial ELCAP sites
  - Evaluate the share of energy use attributable to scheduled loads
  - Evaluate the contribution of scheduling to variability
  - Evaluate the performance of schedules as a predictor of hourly building loads

Caveats:

- Should view this work as stimulating thinking on topic, not producing definitive answers

Preliminary Observations Concerning Commercial Sector Load Shape:

- Relatively uniform across months
- Striking weekday/weekend differences
- Diurnal patterns resemble trapezoids
- Patterns are consistent throughout the year

Questions Concerning Determinants of Shape:

- What are the determinants of consistency and variability and to what extent do building schedules account for both?
- Do we observe the same patterns and driving forces in individual buildings?
- Can we take advantage of this knowledge in predicting building loads?

The dictionary defines a schedule as:

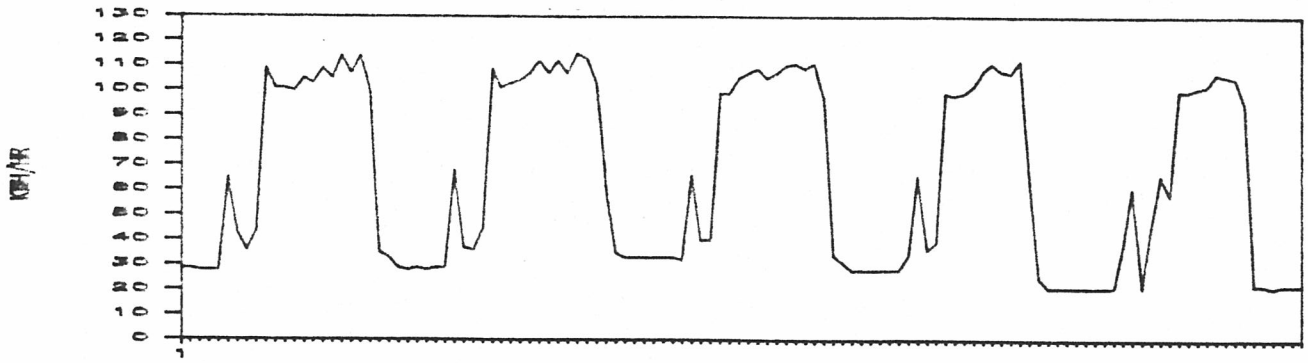
... a list of the times of recurring events

Key elements are predictable:

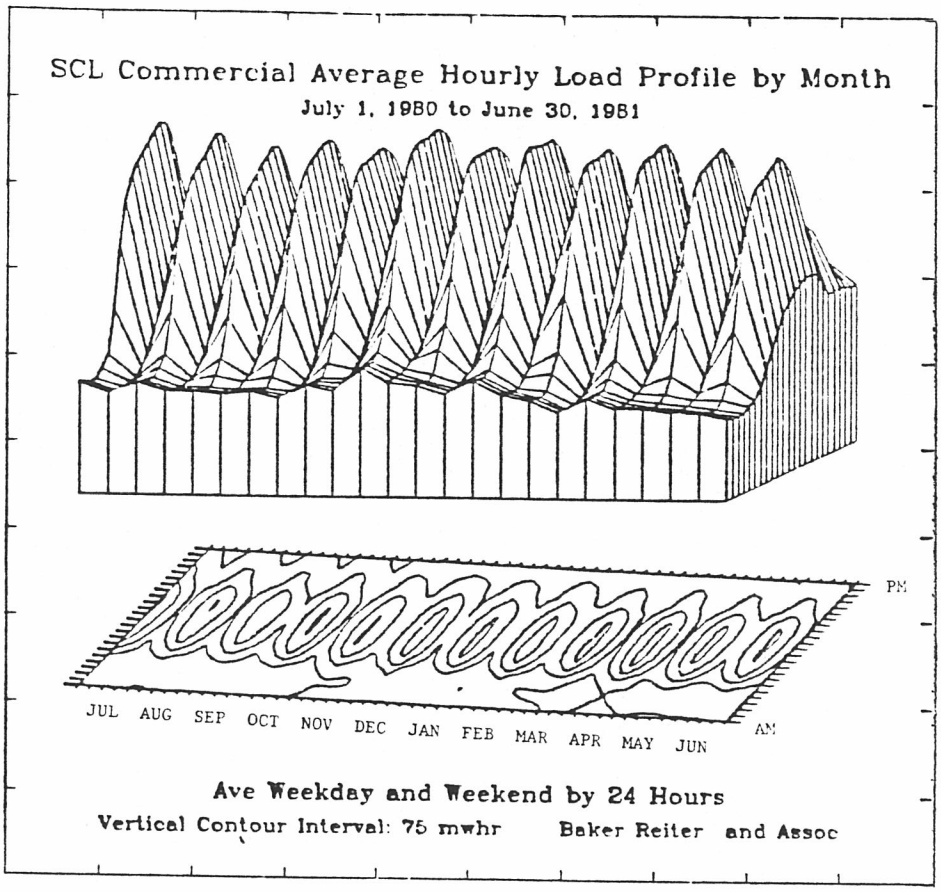
- onset
- duration
- magnitude ?

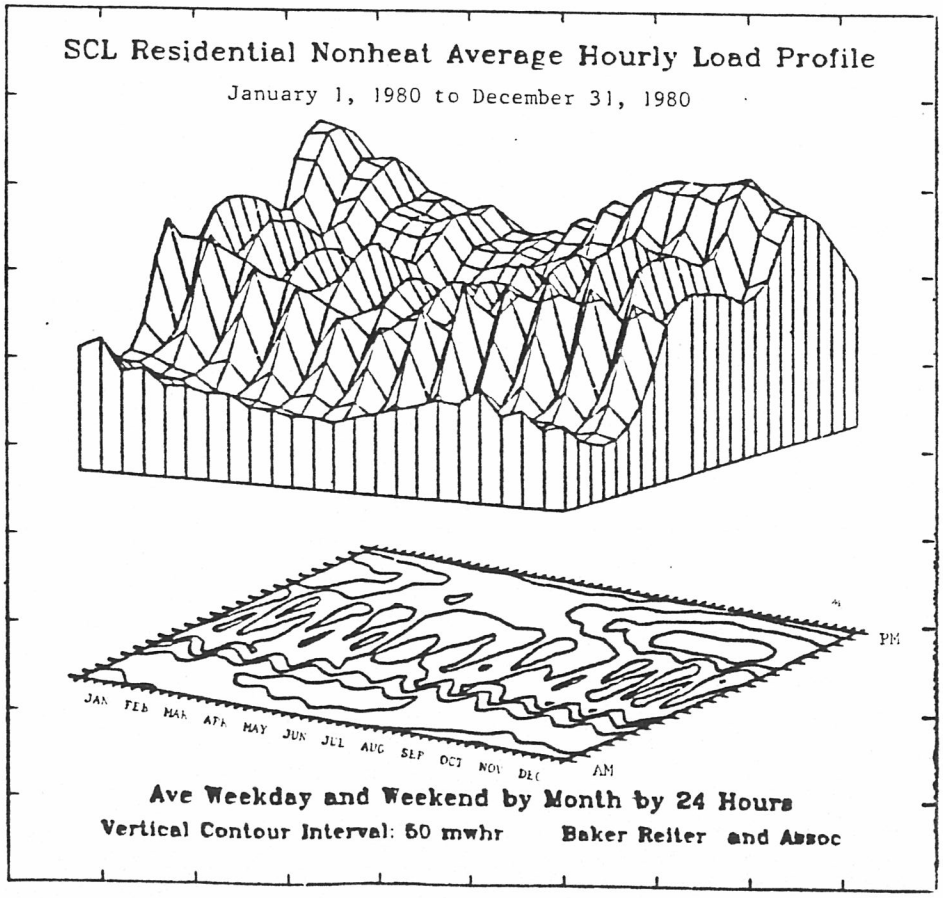
Application to buildings energy use:

- equipment schedule(s)
- building schedule(s)



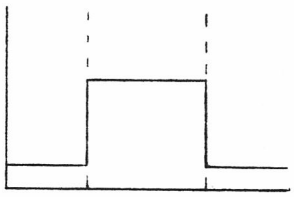
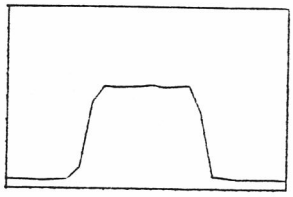
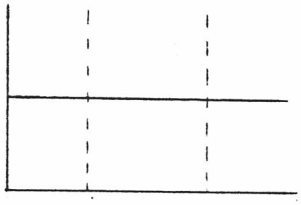
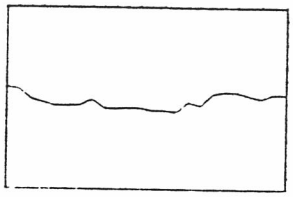
SCL Residential and Commercial Hourly Loads



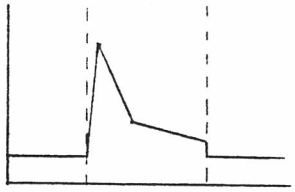
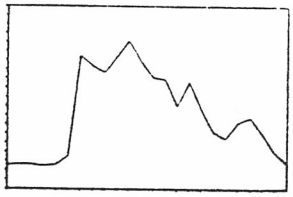
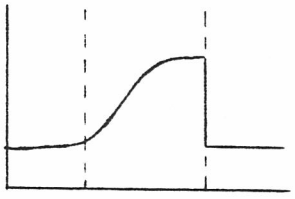
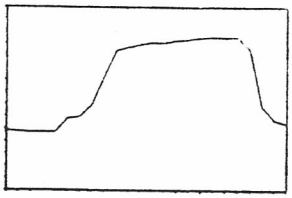


ARCHETYPAL LOAD SHAPES

I. Non-Temperature Sensitive -- Determined by Service hours

	Archtype	Example
Lites Equip		
Fans Refrig		

II. Temperature Sensitive -- Determined by Service Hours, Internal Loads and Outside Temperature

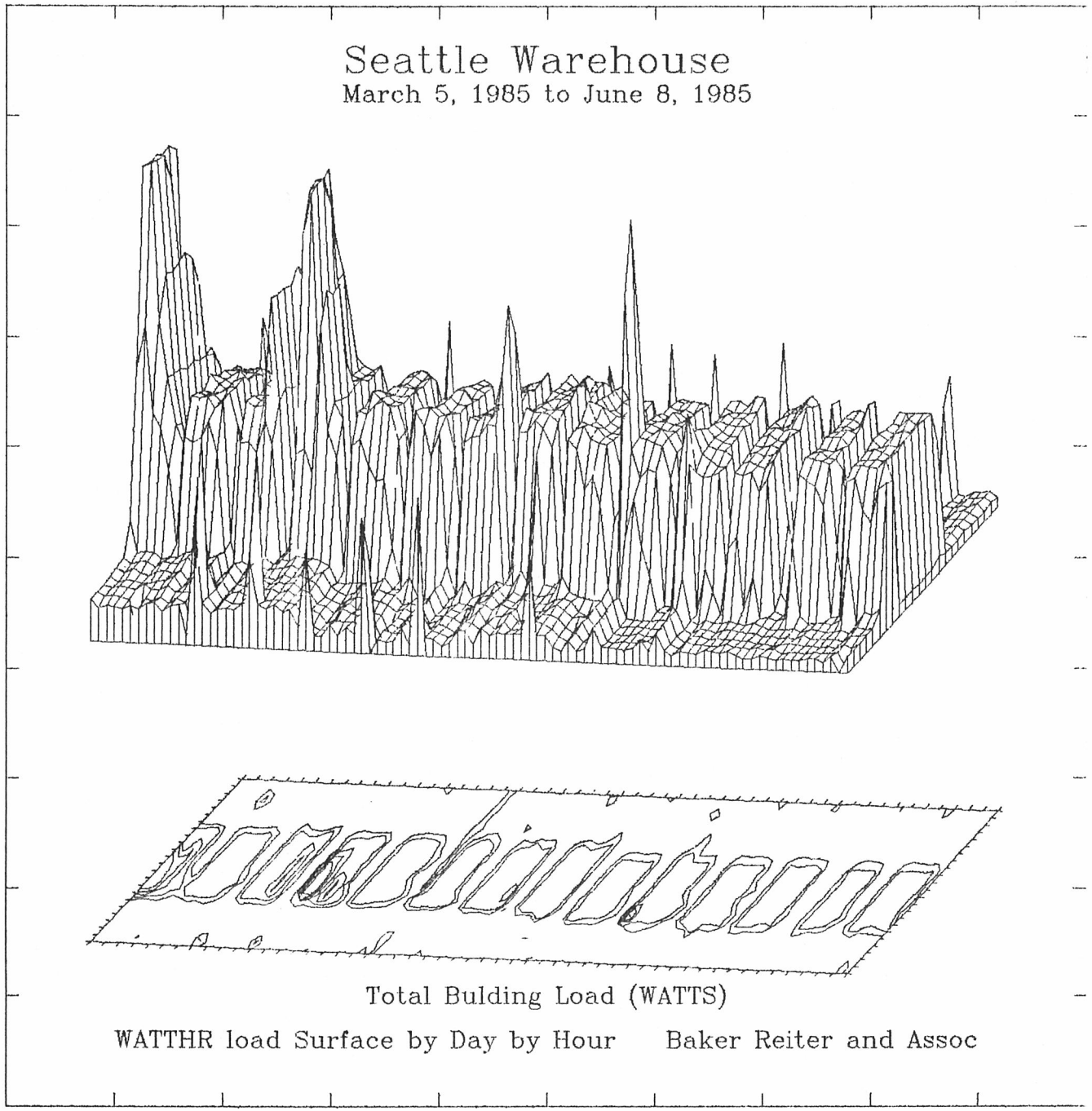
Heat		
Cooling		

SCHEDULES AS A DETERMINING FACTOR IN DIURNAL LOAD SHAPE

- Two classes of loads
  - Principally non-temperature dependent
  - Temperature dependent
- Non-temperature dependent fall into two basic classes
  - Schedule of operation tied to building service hours
  - Constant operation
- Business hours constrain structure of temperature dependent loads
- Unidirectional interaction between non-temperature dependent loads and temperature dependent loads
- Interactions affect magnitude and duration of temperature dependent loads
- Building load shape product of dominant end-use(s)

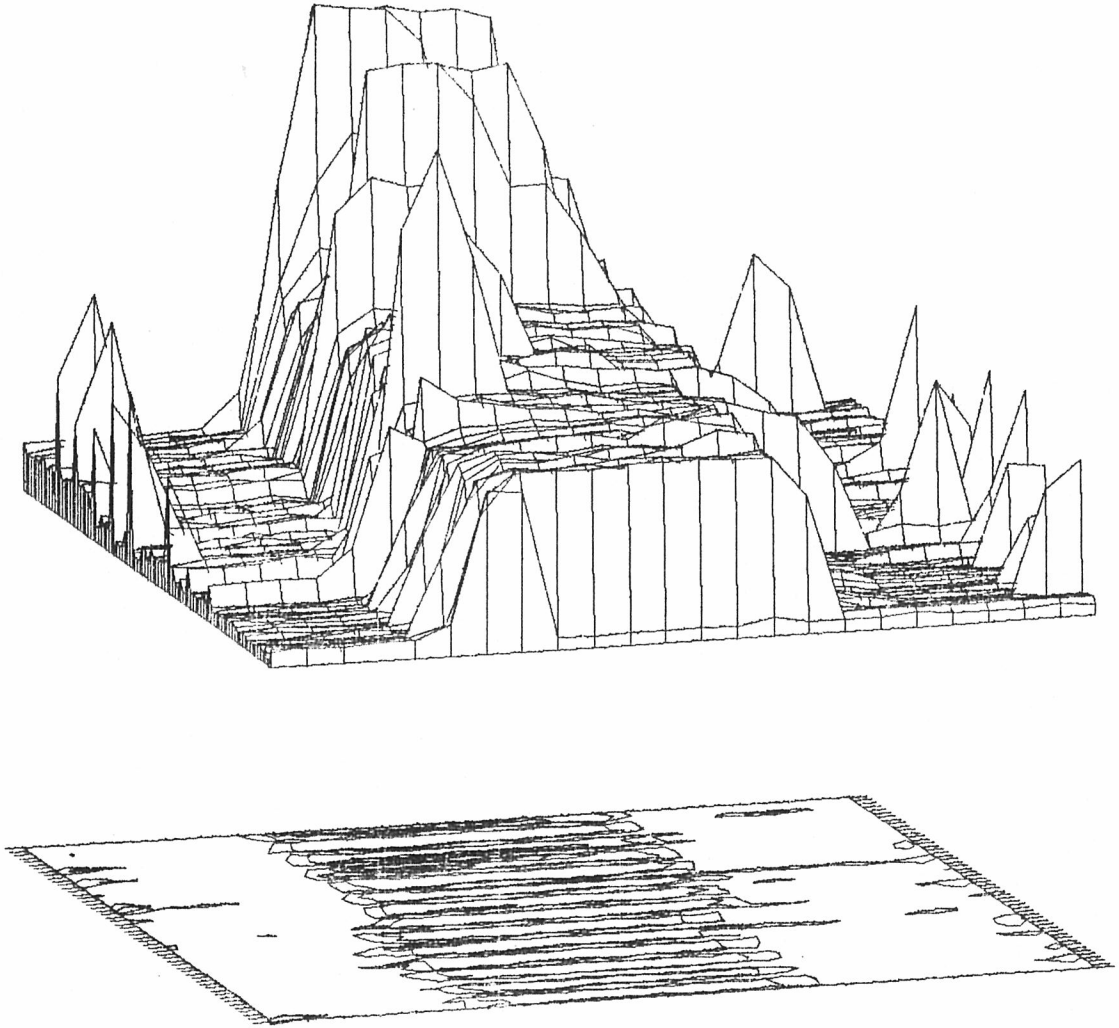
STEPS IN THE ANALYSIS OF SCHEDULES

- Identification of diurnal load shapes
- Classification of daytypes
- Evaluation of contribution of scheduled loads to building energy use
- Assessment of stability of schedules over months of the year
- Evaluation of contribution of scheduling to variability in hourly loads
- Construct schedule-based predictors of hourly loads


Seattle Warehouse
March 5, 1985 to June 8, 1985
Total Bulding Load (WATTS)
WATTHR load Surface by Day by Hour
Baker Reiter and Assoc

Seattle Warehouse

March 5, 1985 to June 8, 1985



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WATTHR load Surface by Day by Hour Baker Reiter and Assoc

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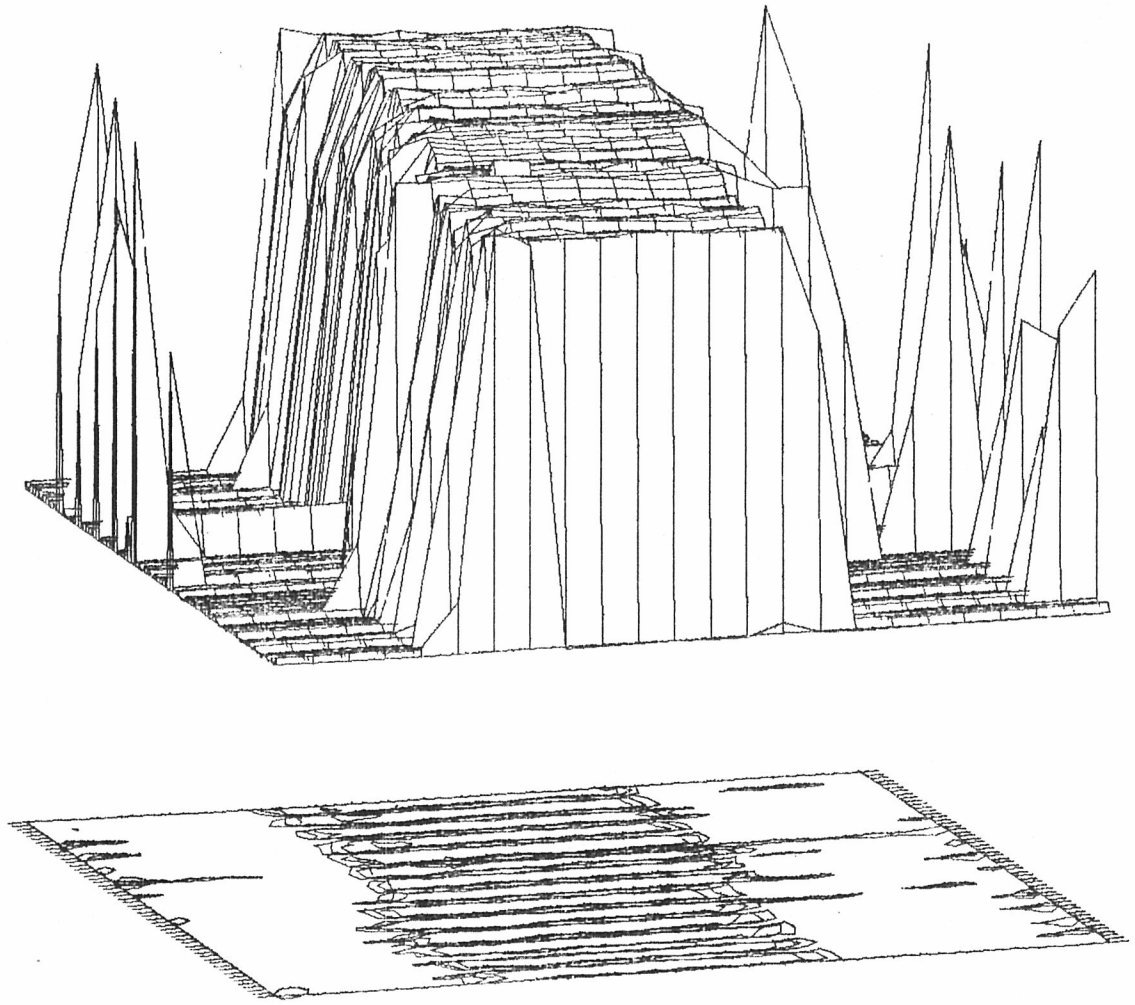
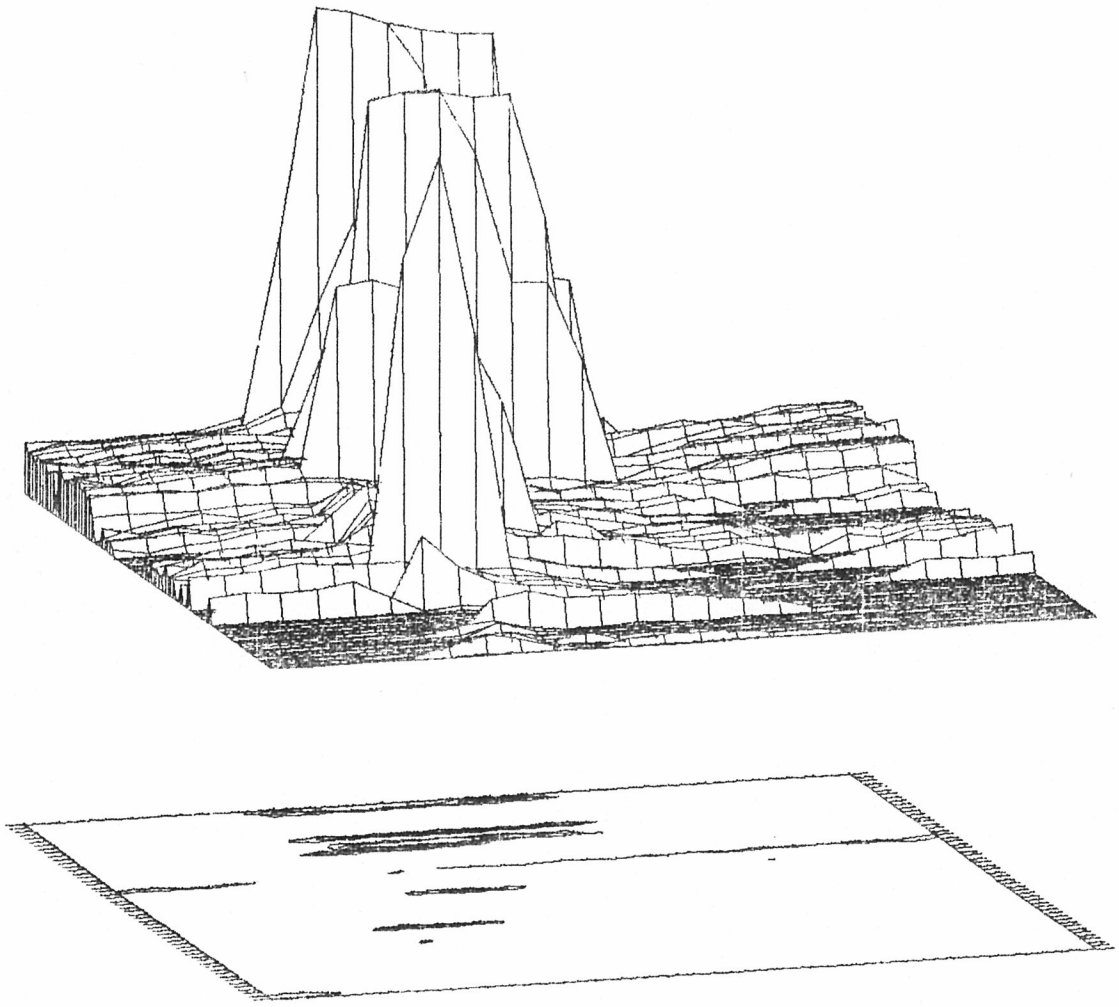


Lighting Load (WATTS)

WATTHR load Surface by Day by Hour Baker Reiter and Assoc

Seattle Warehouse

March 5, 1985 to June 8, 1985



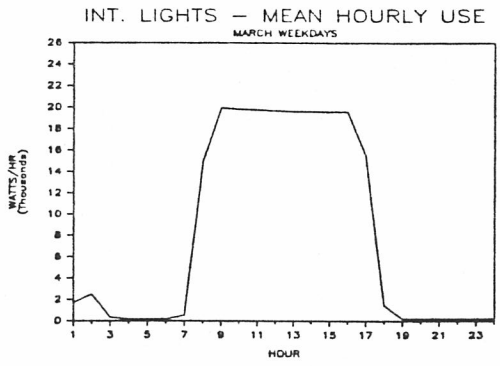
Heating Load (WATTS)

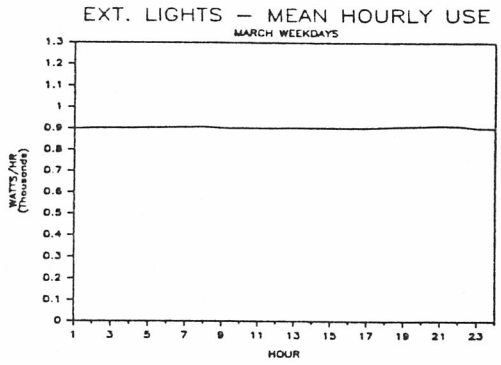
WATTHR load Surface by Day by Hour Baker Reiter and Assoc

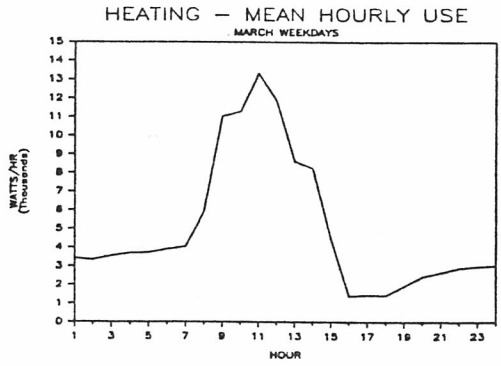
DIURNAL LOAD SHAPES

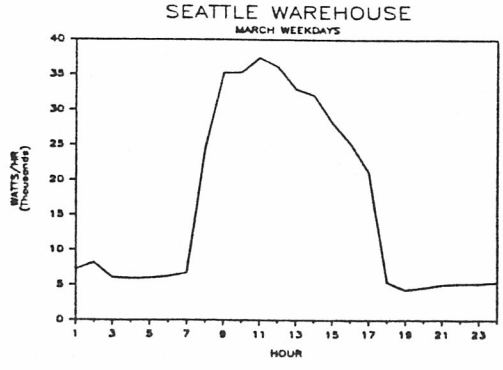
Seattle Warehouse

Week Day Loads

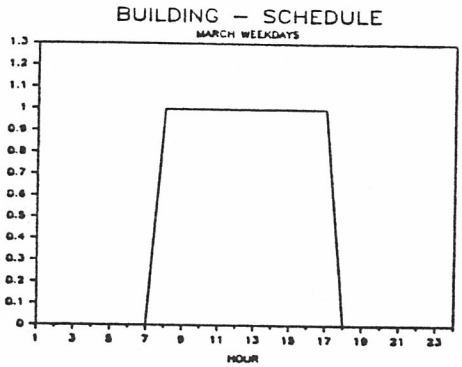


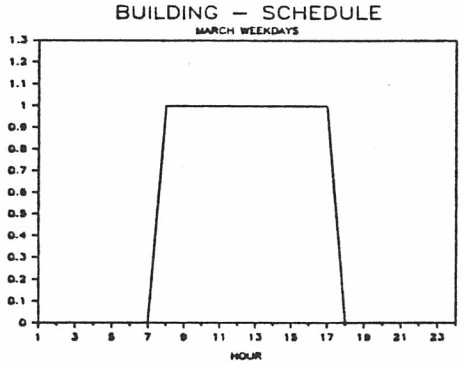


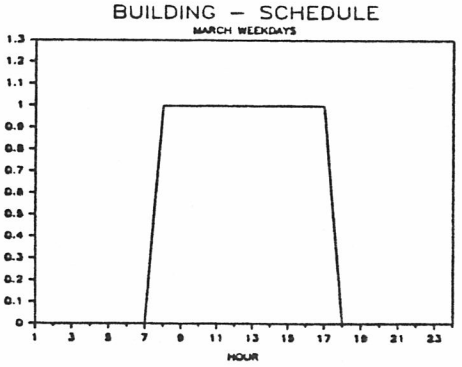


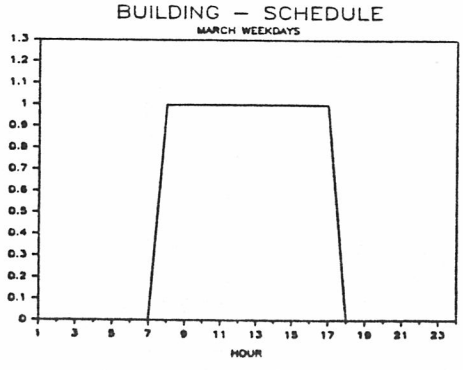


Schedule





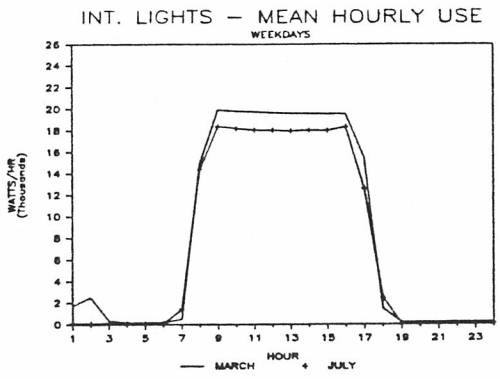


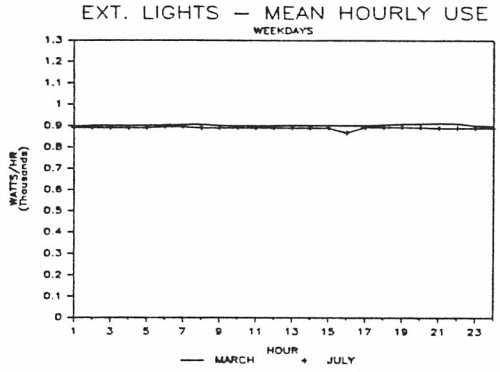


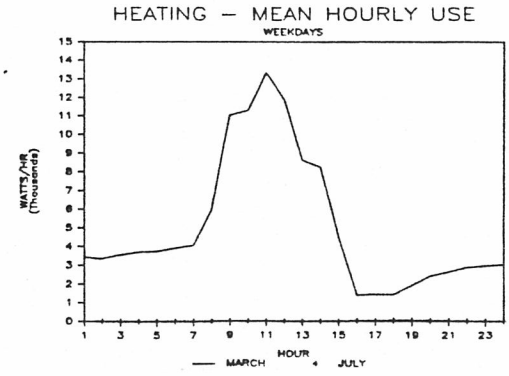
SEASONAL COMPARISON OF DIURNAL LOAD SHAPES

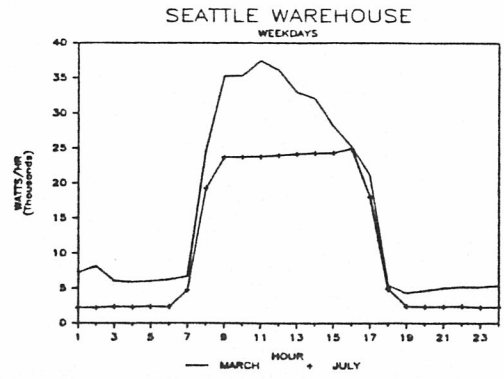
Seattle Warehouse

Week Day Loads







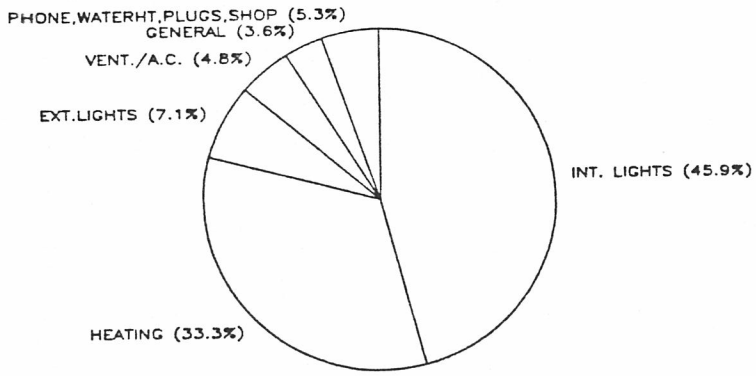


DISTRIBUTION OF ENERGY USE

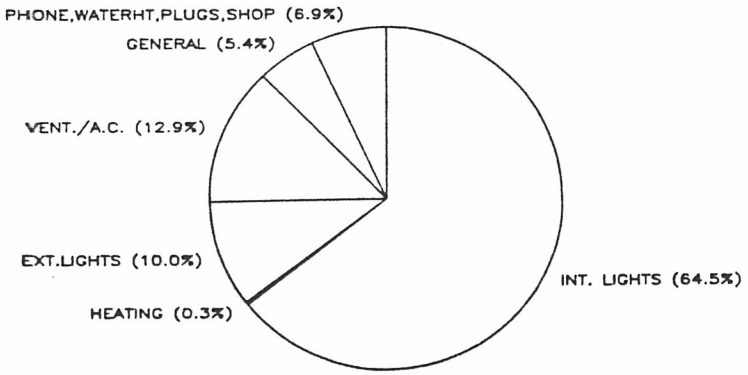
Seattle Warehouse

End Use

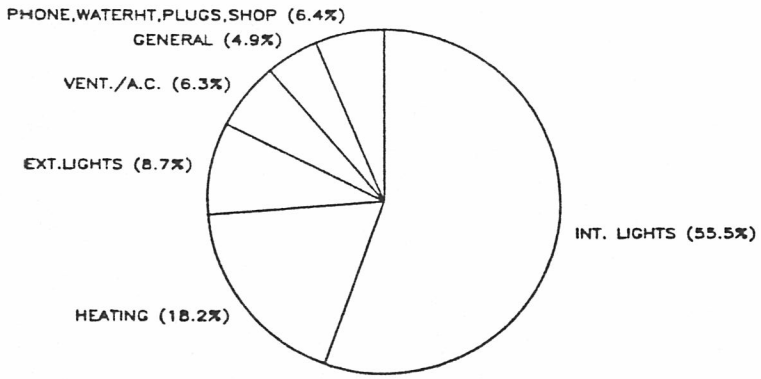
MARCH



JULY

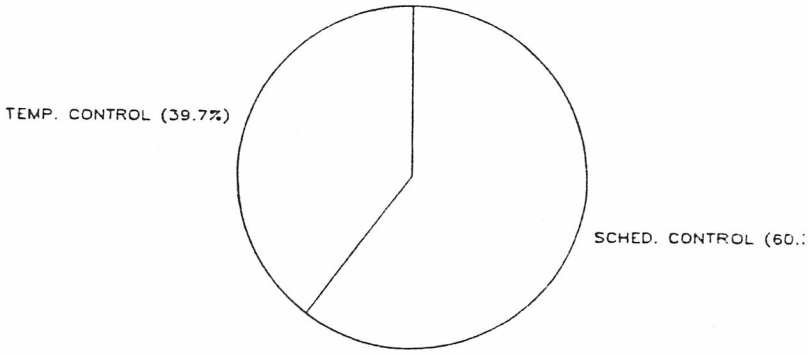


YEAR TO DATE



Sched vs Temp

MARCH



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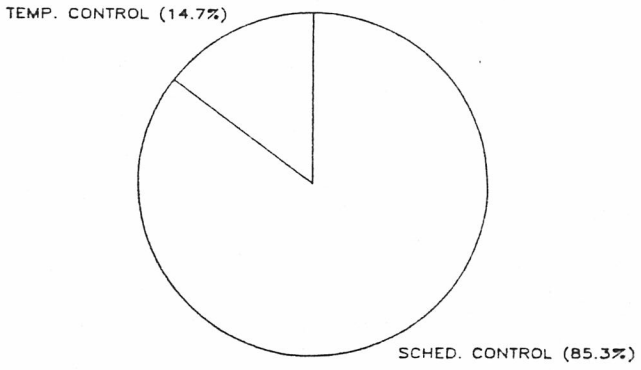

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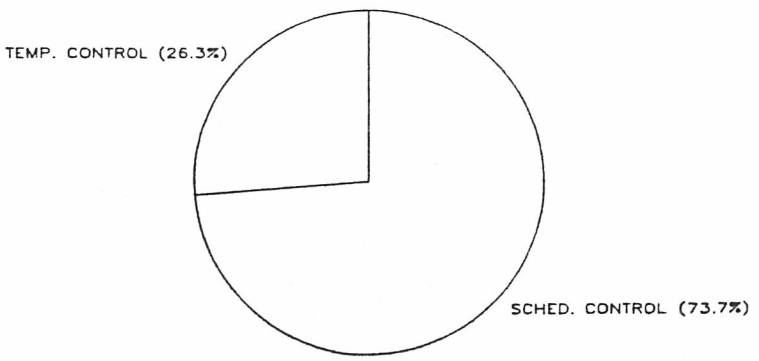
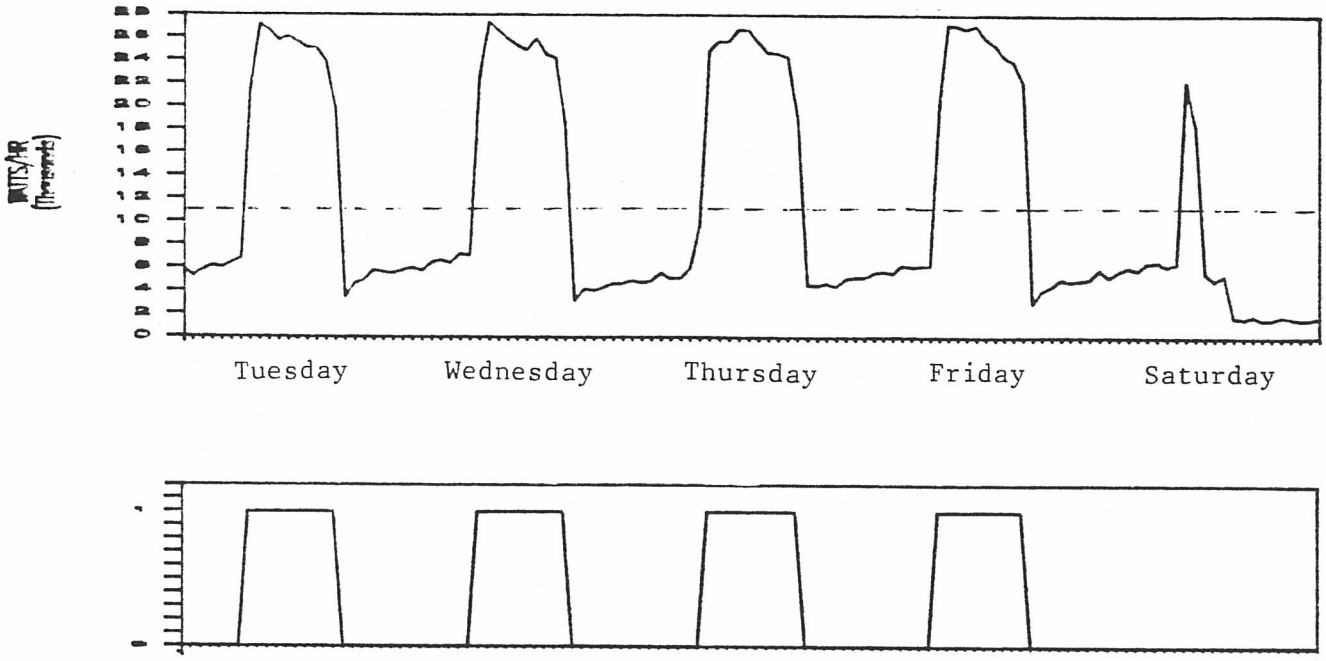


CONSTRUCTION OF SCHEDULING FUNCTION

Seattle Warehouse



CONCEPTUAL:

BLDG LOAD = BASE + INCREMENT (during operating hours) + OTHER

REGRESSION:

BLDG LOAD = CONSTANT + (COEFF * BLDG SCHED) + RESID

RESID = f (INDOOR TEMP, OUTSIDE TEMP, INTERACTIONS, ...)

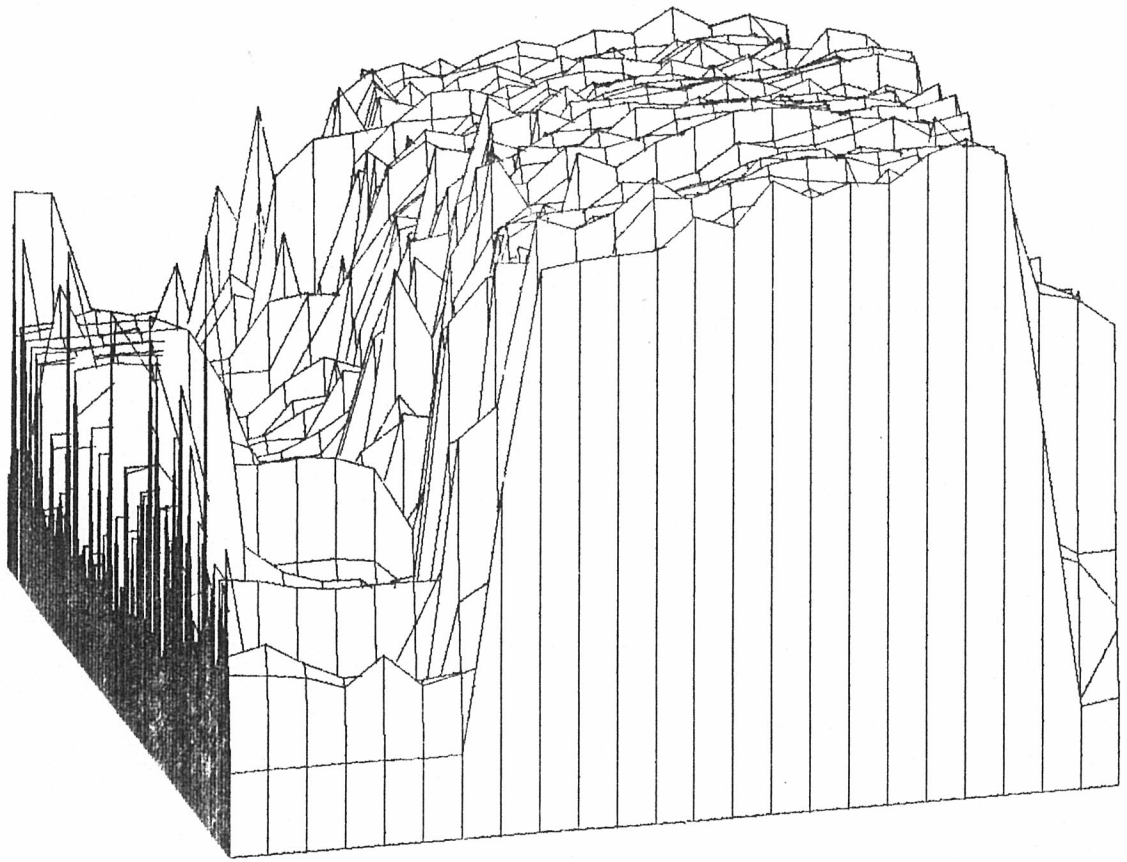
RESULTS:

BLDGLOAD (watts) = 5005 + (18836 * BLDG SCHED)

R2 = .60 F = 4502.

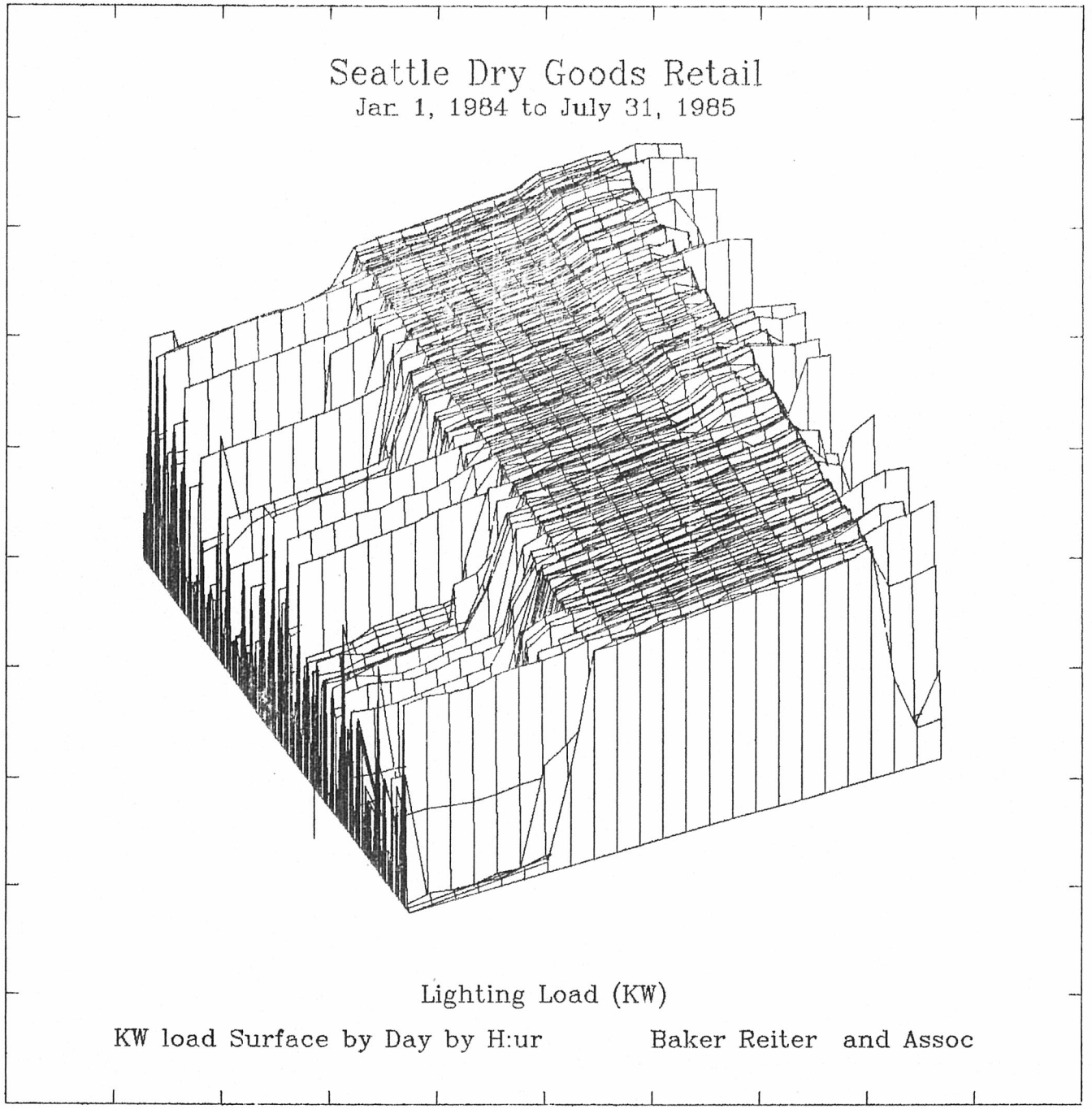
Seattle Dry Goods Retail

Jan. 1, 1984 to July 31, 1985



Total Building Load (KW) (NO STOCKING)

KW Load Surface by Day by Hour Baker Reiter and Assoc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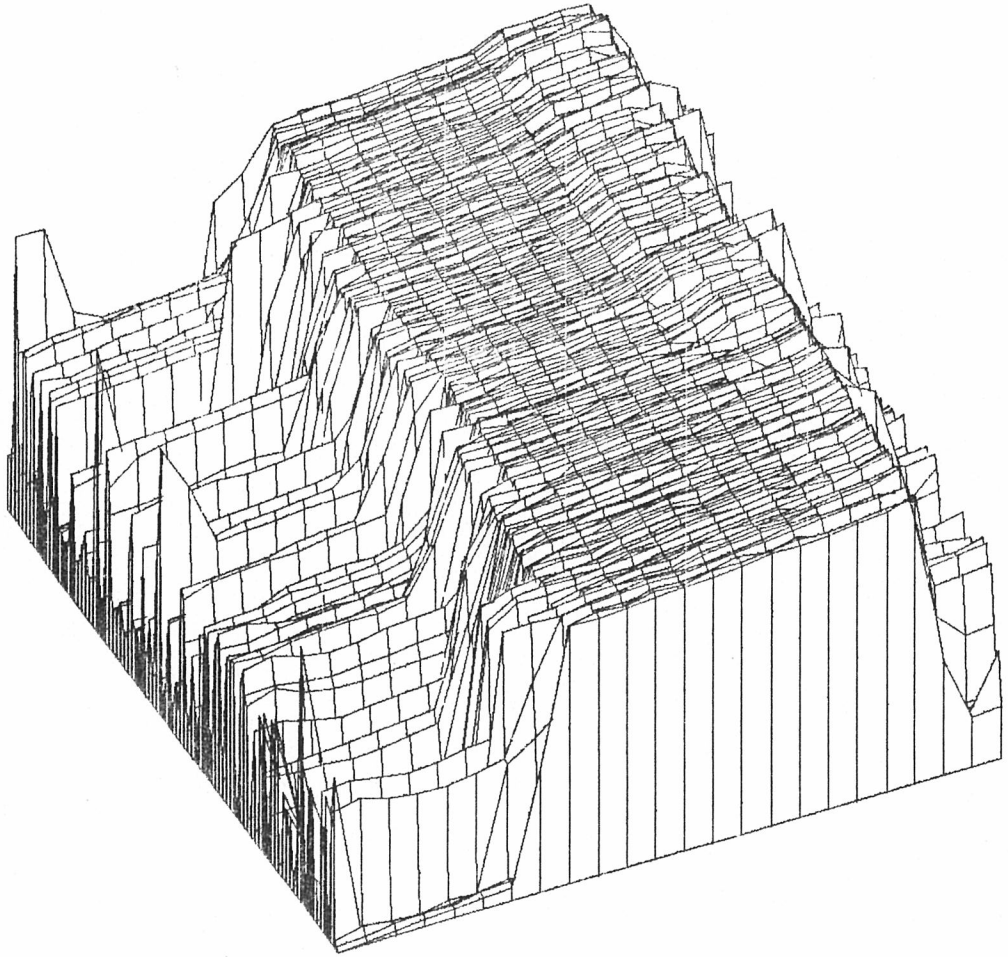

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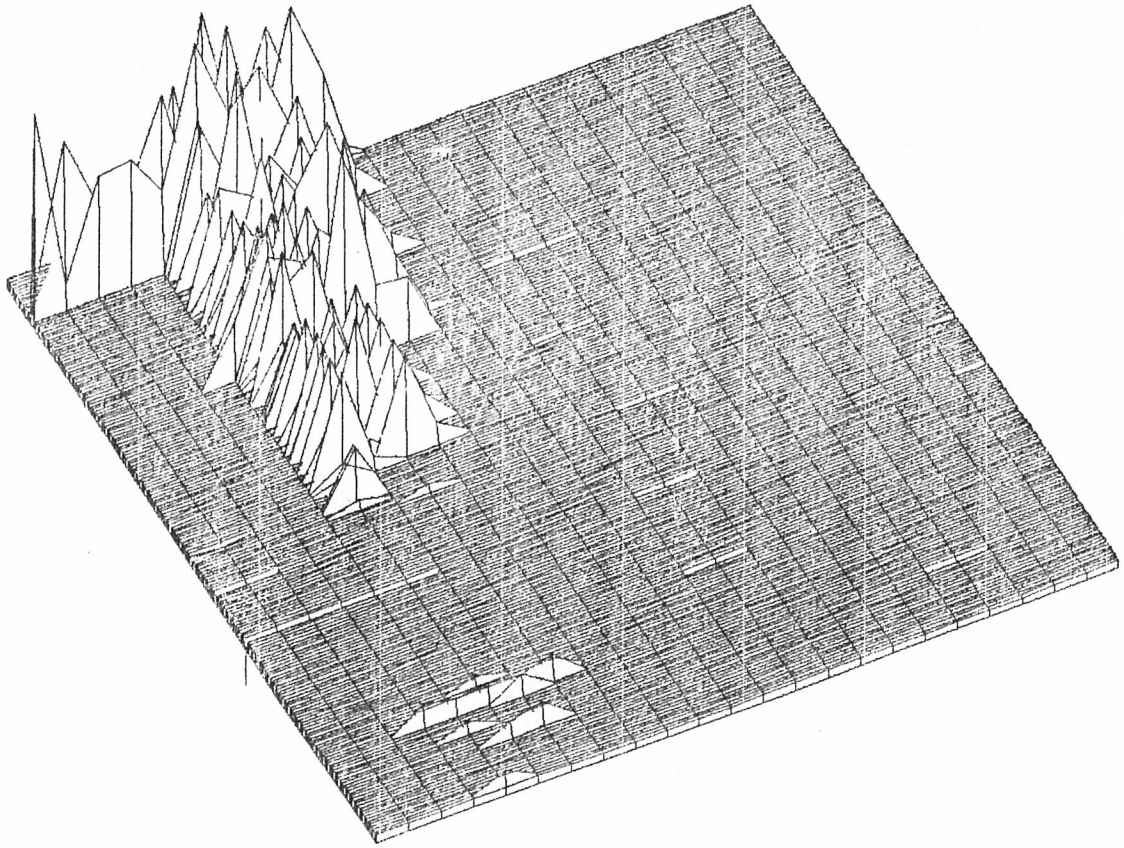


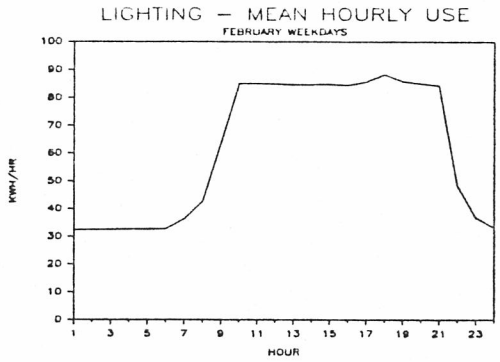
Heating Load (KW)

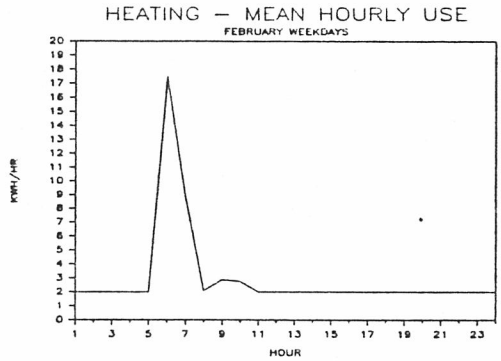
KW load Surface by Day by Hour Baker Reiter and Assoc

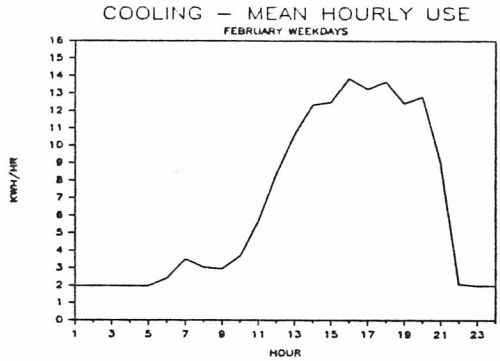
DIURNAL LOAD SHAPES

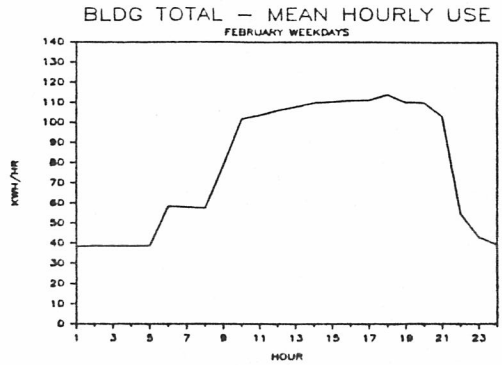
Seattle Retail Store

Week Day Loads

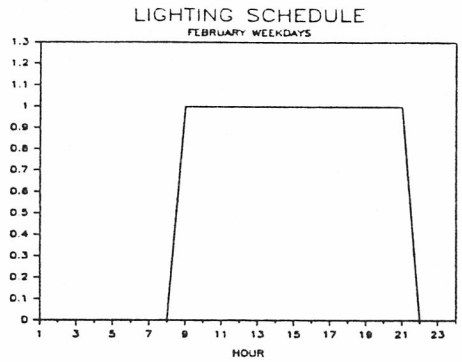


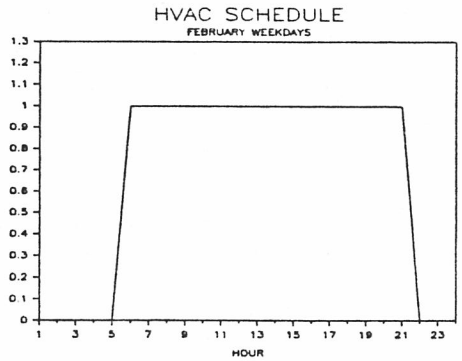


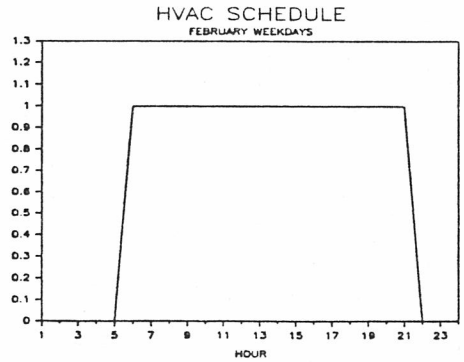


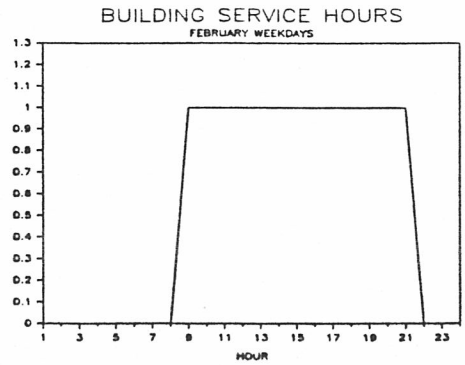


Schedule





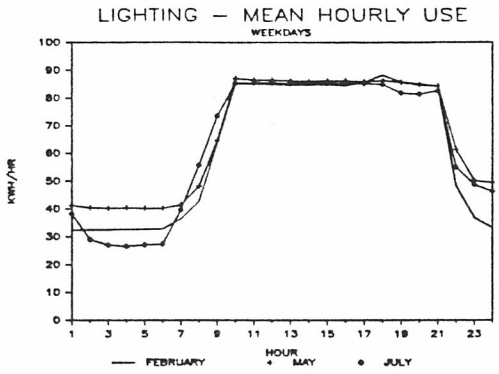


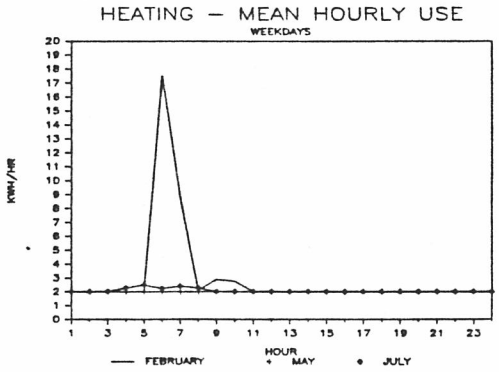


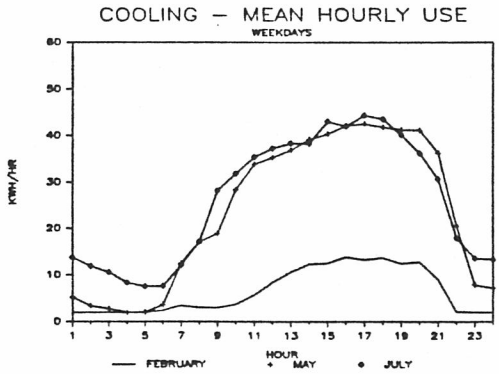
SEASONAL COMPARISON OF DIURNAL LOAD SHAPES

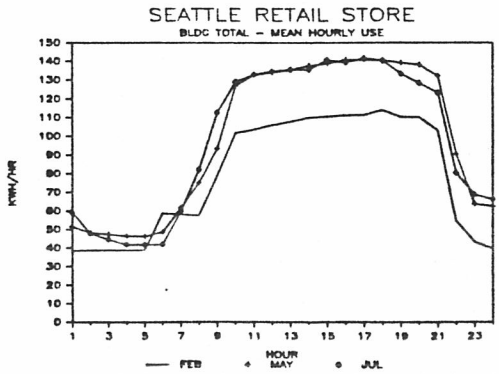
Seattle Retail Store

Week Day Loads







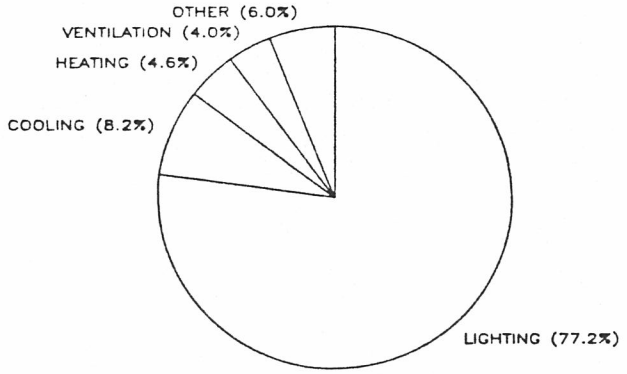


DISTRIBUTION OF ENERGY USE

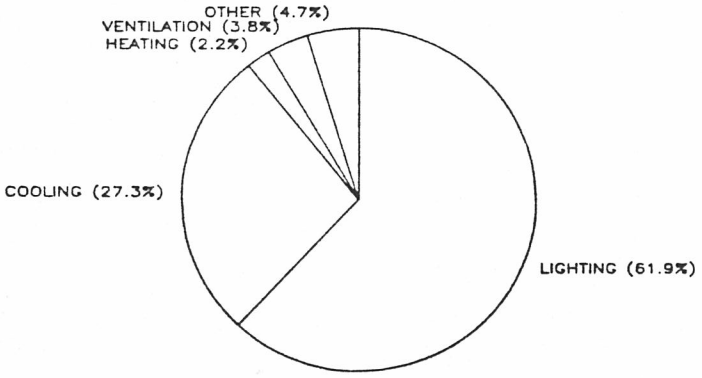
Seattle Retail Store

End Use

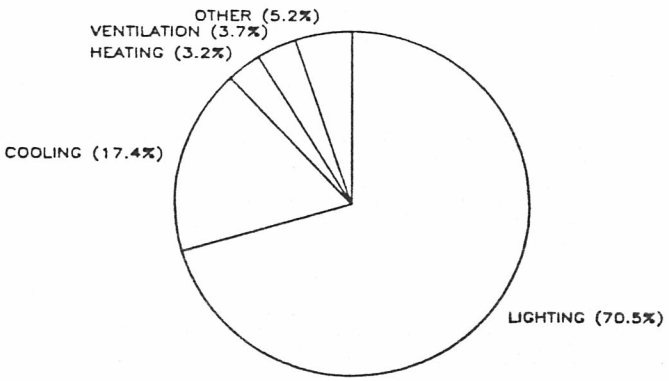
FEBRUARY



JULY

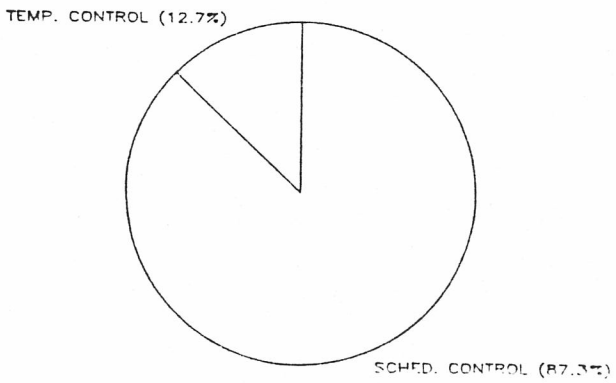


YEAR TO DATE



Sched vs Temp

FEBRUARY



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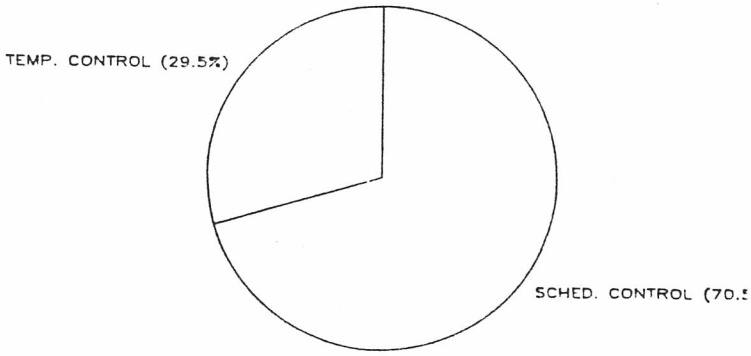

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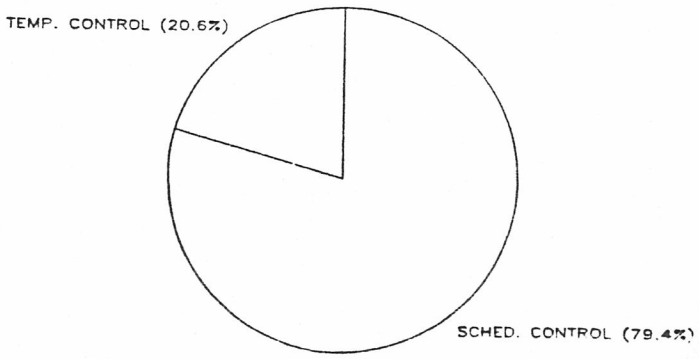
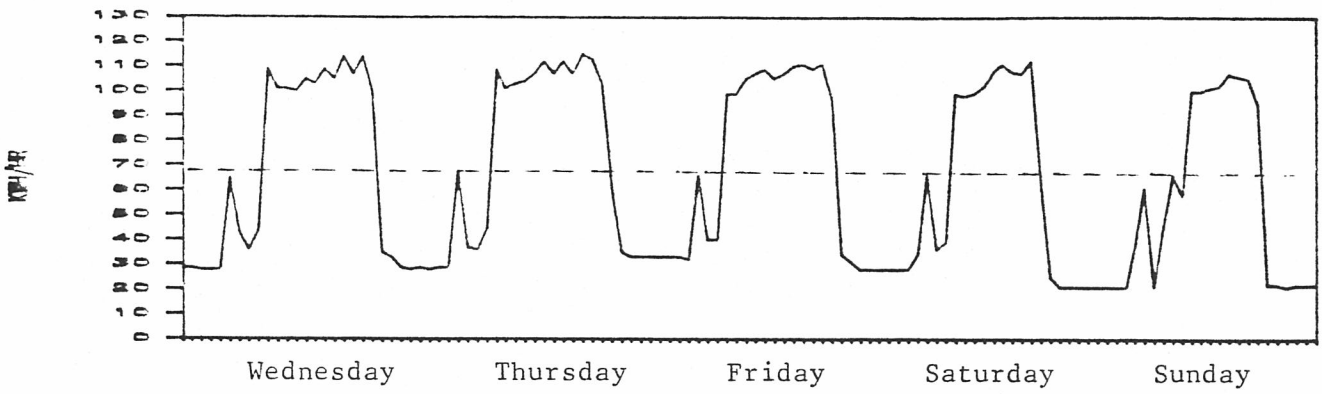
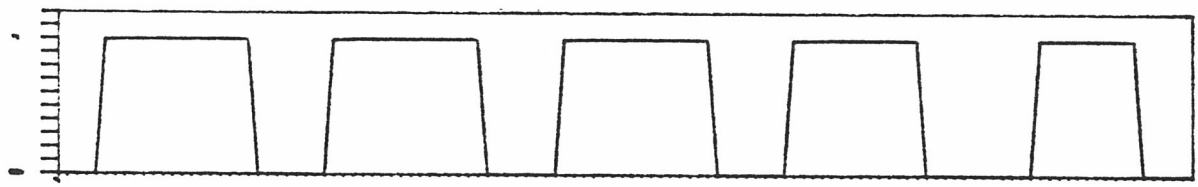
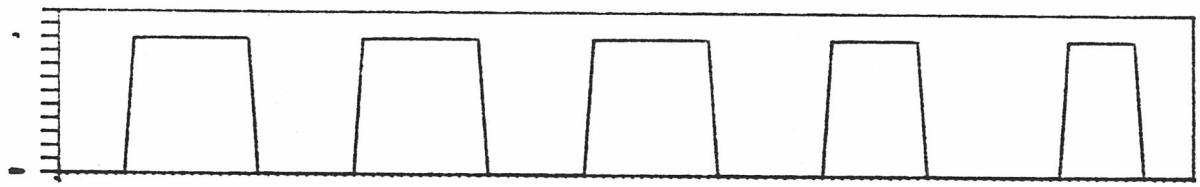


CONSTRUCTION OF SCHEDULING FUNCTION

Seattle Retail Store







CONCEPTUAL:

BLDG LOAD = BASE + INCR (heat sched) + INCR (light/bldg) + OTHER

REGRESSION:

BLDG LOAD = CONST + (COEFF1 * HVAC SCHED) + (COEFF2 * LITE SCHED)
+ RESID

RESID = f (INDOOR TEMP, OUTSIDE TEMP, INTERACTIONS, ...)

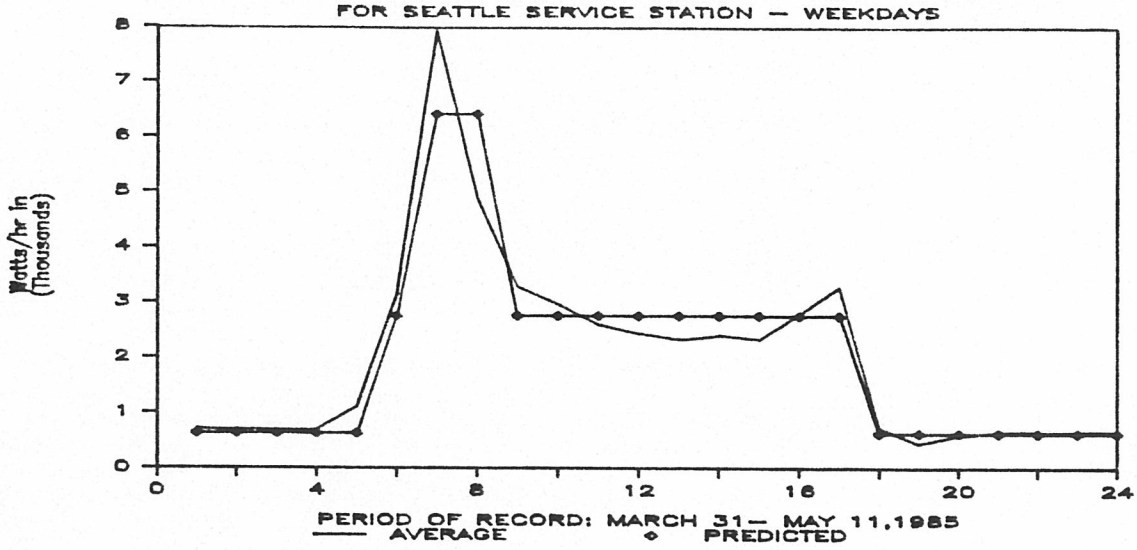
RESULTS:

BLDGLOAD (watts) = 44 + (15 * HVAV SCHED) + (57 * LITE SCHED)

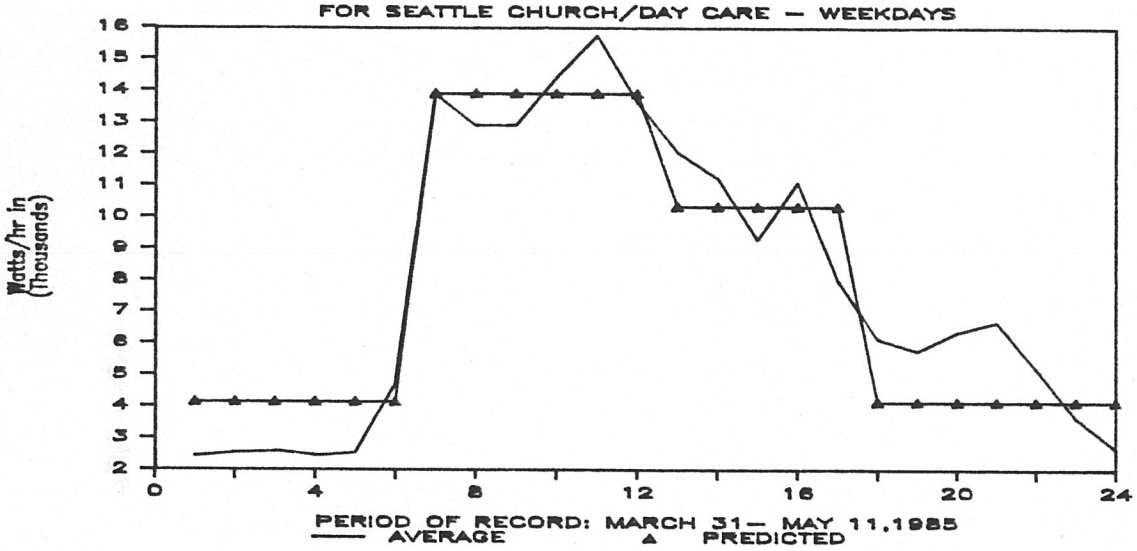
R2 = .72 F = 6548.

AVERAGE AND PREDICTED LOADS

FOR SEATTLE SERVICE STATION — WEEKDAYS



FOR SEATTLE CHURCH/DAY CARE — WEEKDAYS



SEATTLE FAST FOOD RESTAURANT