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Load Allocation Based Upon Automatic Meter Readings

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Why Distribution System Analysis?

- Demonstrate that all customer's voltages lie within ANSI voltage standards\
- Determine power losses
- Shunt capacitor placement
- Voltage regulator settings
- Accomplished with
  – Application of power-flow program (Windmil)

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ANSI Voltage Standards

- Range A – Normal Steady-State
  - Nominal Utilization Voltage = 115 volts
  - Maximum Utilization Voltage = 126 volts
  - Minimum Service Voltage = 114 volts
  - Minimum Utilization Voltage = 110 volts
- Range B – Emergency Steady-State
  - Nominal Utilization Voltage = 115 volts
  - Maximum Utilization Voltage = 127 volts
  - Minimum Service Voltage = 110 volts
  - Minimum Utilization Voltage = 107 volts

Distribution Analysis Programs

- Very good models of
  - Lines
    - Overhead
    - Underground
  - Transformers
  - Voltage Regulators
  - Capacitors
- Weak link
  - Loads

What is this thing called “Load”?

Can AMR Help in Defining Load?

- May, June and July 2006 data recorded
- 314 customers
  – 15 minute kW demand per customer
- 23 transformers
  – 15 minute diversified kW demand computed

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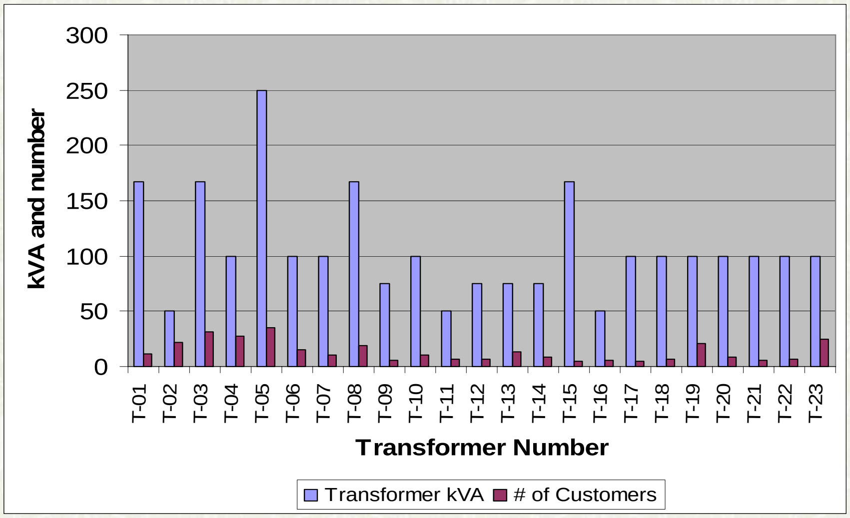
Transformer Rating and # of Customers



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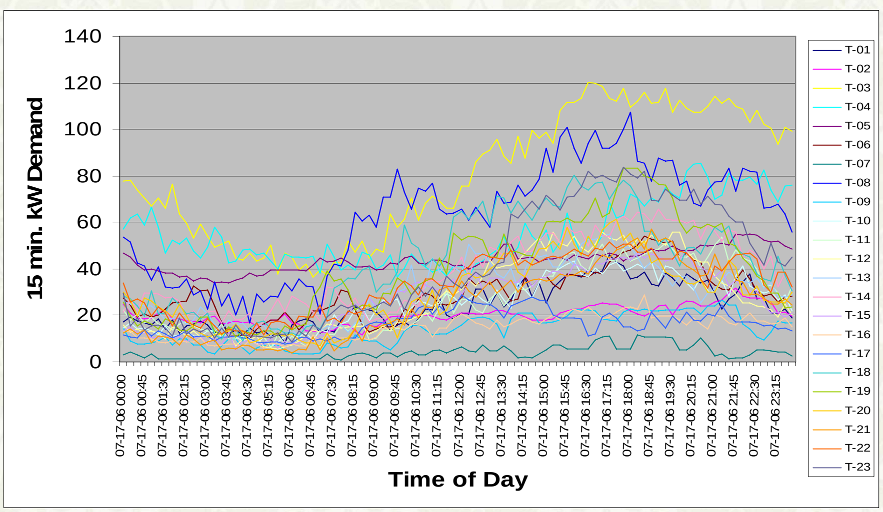
July 17, 2006



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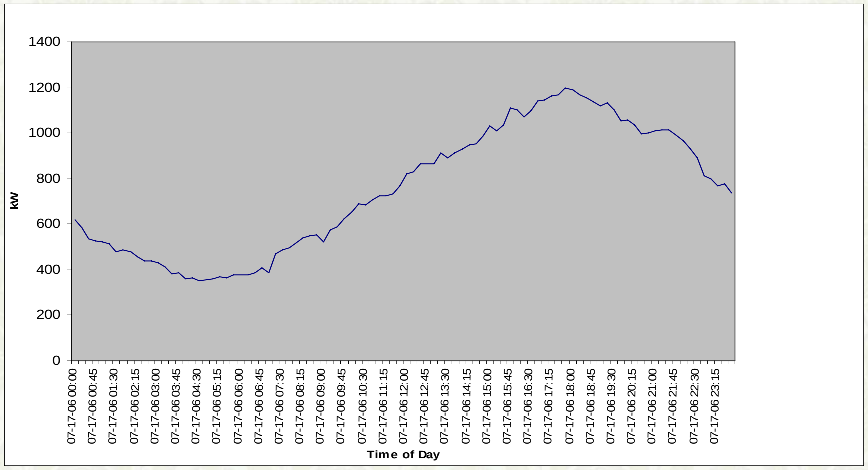
System Diversified Demand on July 17, 2006 (max at 17:45)



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What to do with all of this Data?

- Model using the IEEE 34 node test feeder
- http://ewh.ieee.org/soc/pes/dsacom/testfeeders.html
- Base case will model each transformer with its 15 minute demand at the time of the total peak (17:45, July 17, 2006)
- Computed kW and kVAr at the substation will be the same as if metered

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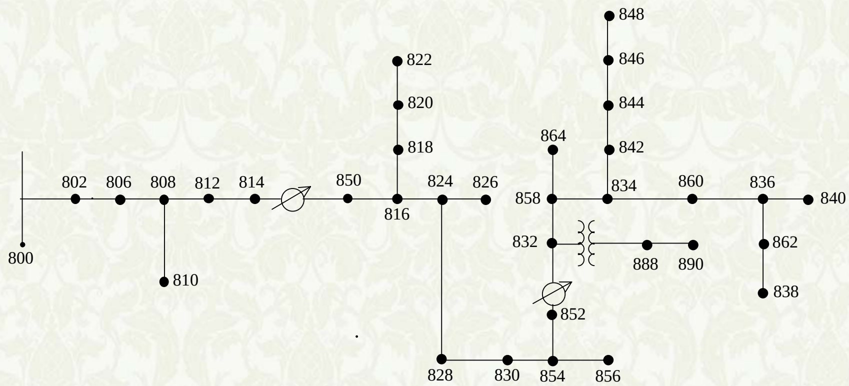
IEEE 34 Node Test Feeder



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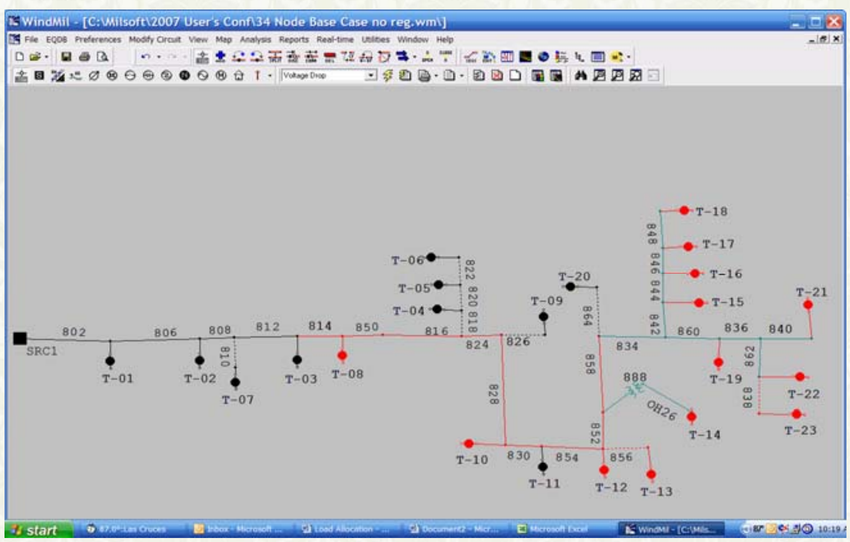
Modified 34 Node Test Feeder



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Transformer Node Data

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Table 1
Node Data

Xfm #	Phase	Demand kW	Daily kWH	Monthly kWH	# of Custs
T-01	C	41.27	584	14,410	11
T-02	C	23.71	488	9,698	22
T-03	A	117.78	1,914	39,233	31
T-04	A	63.15	1,325	22,348	28
T-05	A	43.55	1,050	26,901	35
T-06	A	47.03	704	15,728	15
T-07	B	5.54	98	2.554	10
T-08	C	100.22	1,482	34,098	19
T-09	B	21.37	334	6,869	6
T-10	C	39.07	604	12,192	10
T-11	A	48.65	644	15,276	7
T-12	B	54.70	674	13,105	7
T-13	B	49.32	743	18,348	13

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T-14	C	9	923	19,942	9
T-15	C	44.93	644	13,997	5
T-16	C	23.05	351	8,396	6
T-17	C	14.83	390	6,761	5
T-18	B	78.1	1,036	24,437	7
T-19	C	83.32	952	20,025	21
T-20	A	52.38	702	18,177	9
T-21	B	49.57	600	13,068	6
T-22	C	50.7	791	14,686	7
T-23	B	83.02	979	21,655	25
Total	A	372.6	6,339	137,662	125
Total	B	342.5	4,464	100,035	74
Total	C	483.8	7,205	154,204	115

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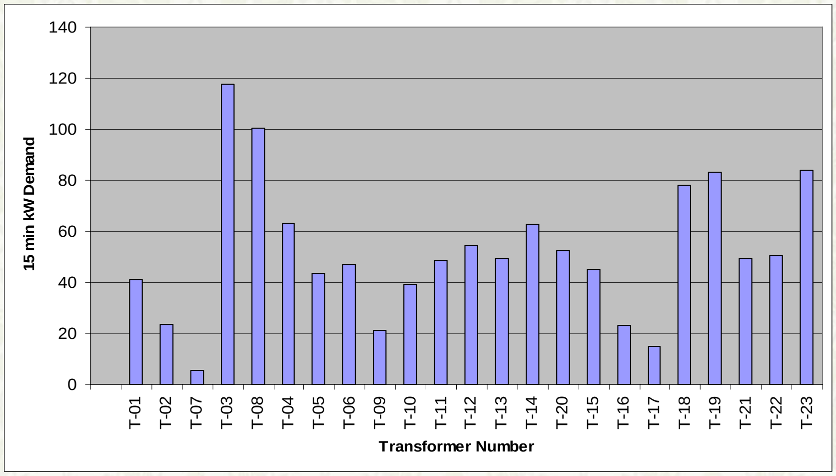
Base Case kW Demands
90% Power Factor Assumed



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Windmil IEEE 34 Node Feeder

- Base Case Results
  - Sa = 382.28 + j 130.96 kVA
  - Sb = 377.16 + j 127.73 kVA
  - Sc = 525.79 + j 229.27 kVA
  - Stotal = 1,285.27 + j 487.97 kVA
  - Sloss = 86 + j 62 kVA
  - Qcharging = -j 154 kVAr

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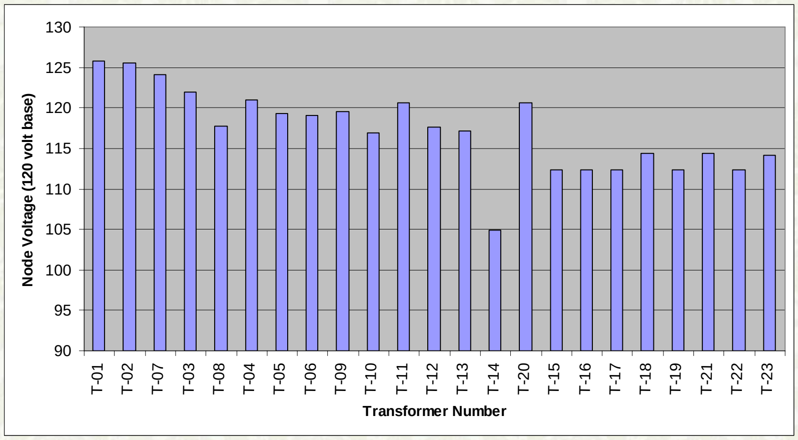
Base Case Node Voltages



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Daily kWH Allocation Factors

$$kWH_{total} = \sum_{k=1}^{23} kWH_k$$

Compute P and Q allocation factors

$$PAF_a = \frac{\text{Metered kW}_a \text{ at sub}}{kWH_{total}} = \frac{382.28}{6339} = 0.06031 \text{ kW/kWH}$$

$$\text{QAF}_a = \frac{\text{Metered kvar}_a \text{ at sub}}{kWH_{total}} = \frac{130.96}{6339} = 0.02066 \text{ kvar/kWH}$$

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Transformer #3

Apply P and Q allocation factors to transformer #3 to compute initial kW_a and $kvar_a$

$kW_a = 0.06031 \cdot 1914 = 115.4$ kW

$kvar_a = 0.02066 \cdot 1914 = 39.5$ kvar

New values of kW_a and $kvar_a$ are computed after each iteration because computed P and Q at the substation do not match metered readings. After three iterations the final values are:

$kW_a = 112.20$ kW

$kVAr_a = 52.98$ kvar

REA A and B Factors

$kW = A \cdot B$

where:

$$A = C \cdot \left(1 - 0.4 \cdot C + 0.4 \cdot \left(C^2 + 40 \right)^{0.5} \right)$$

$$B = 0.005925 \cdot \left(kWH_{transformer} \right)^{0.885}$$

C = number of consumers connected to the transformer

$kWH_{transformer}$ = total daily or monthly kWH through the transformer

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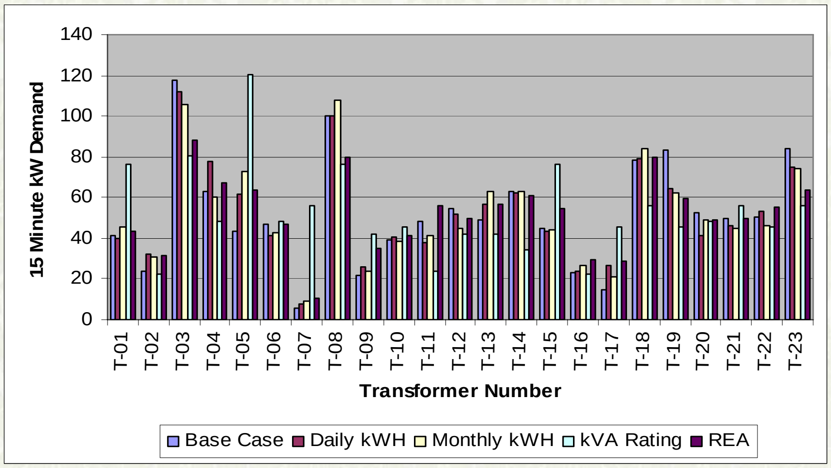
kW Demand vs. Allocation Method



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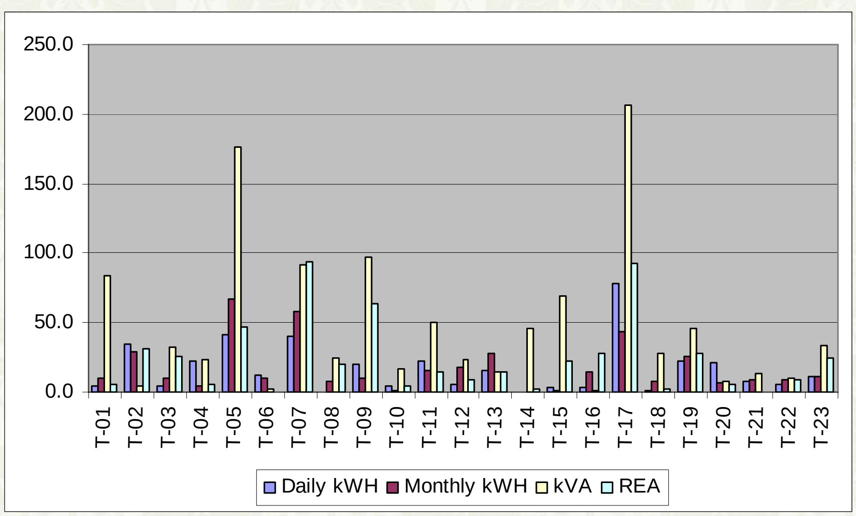
Percent kW Demand Error



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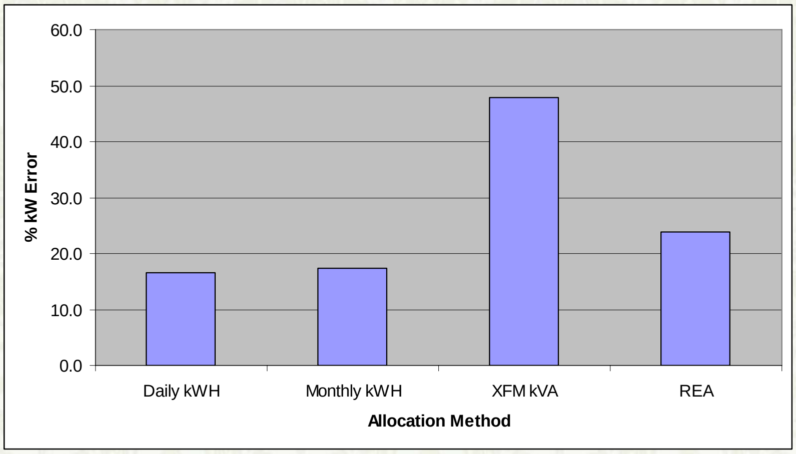
Average kW Error Compared to Metered Load kW



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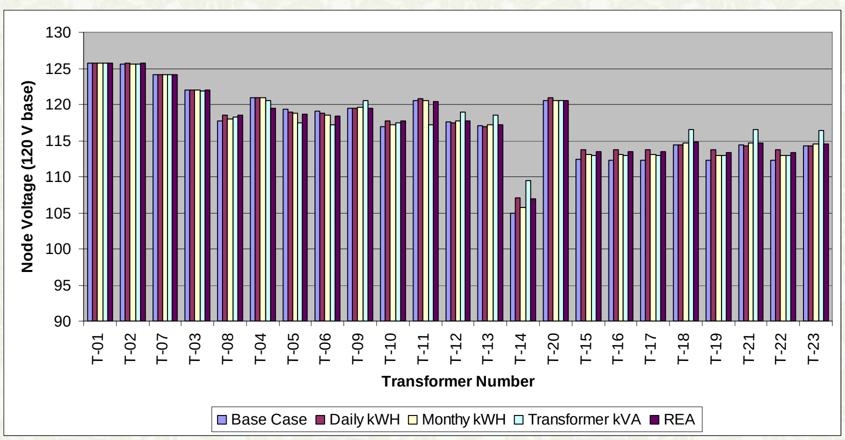
Node Voltages by Allocation Methods



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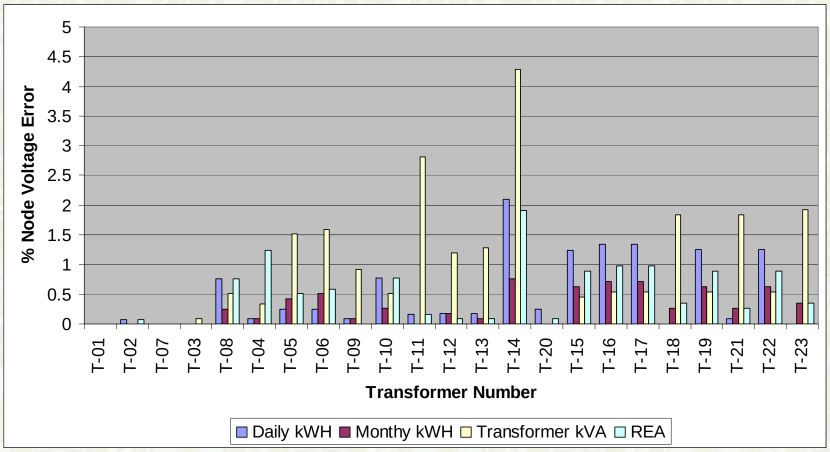
Node Voltage Errors Compared to Base Case



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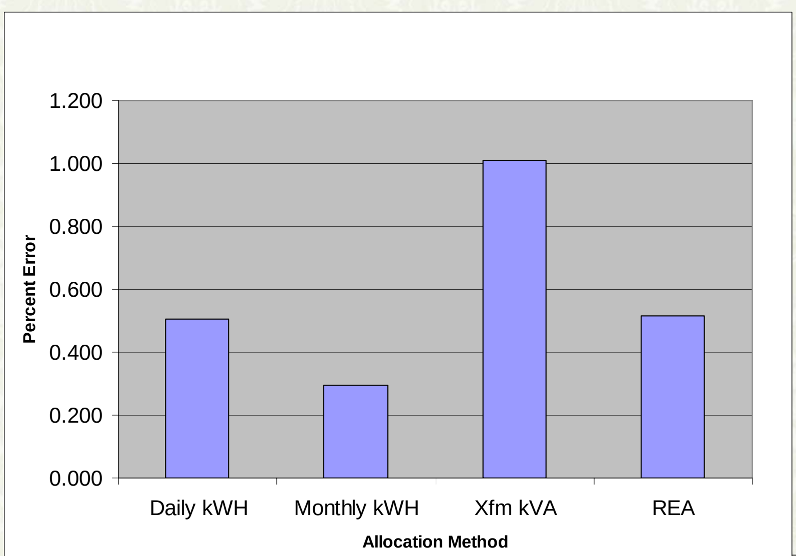
Average Node Voltage Errors



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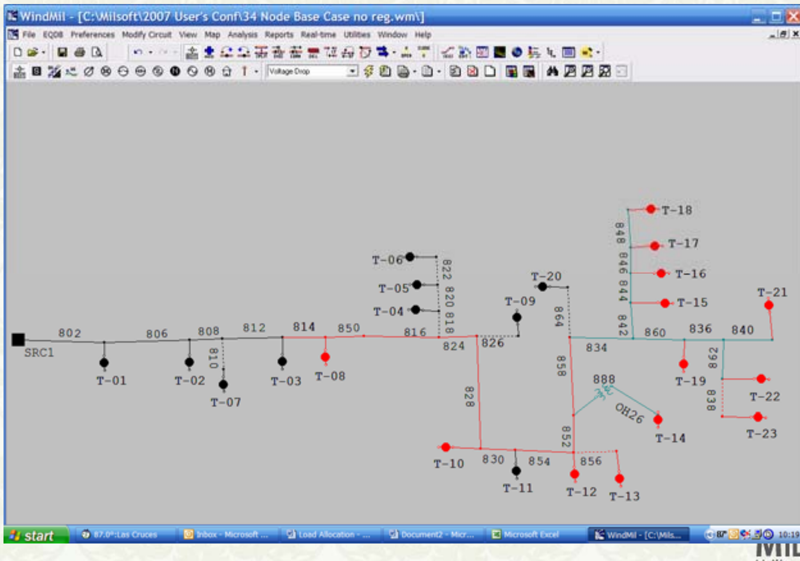
Test Feeder Control Points



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Control Points

- Line 818
  - Phase A: 155 kW + j65 kvar
- Line 842
  - Phase B: 78 kW + j37 kvar
  - Phase C: 83 kW + j39 kvar

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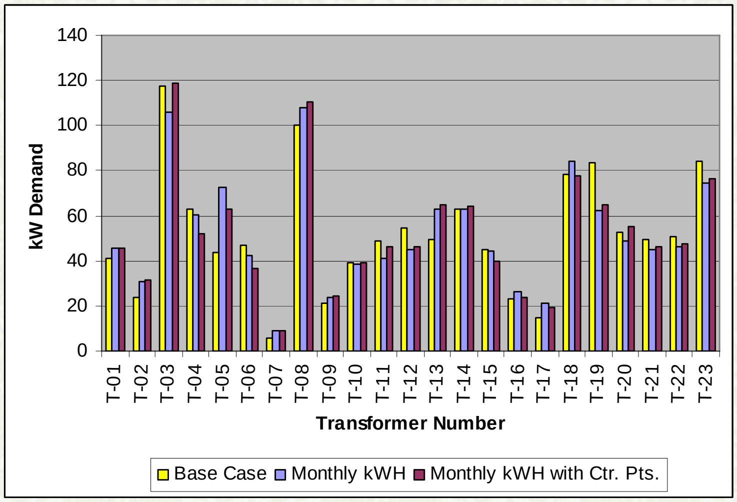
Transformer kW Demand Comparison



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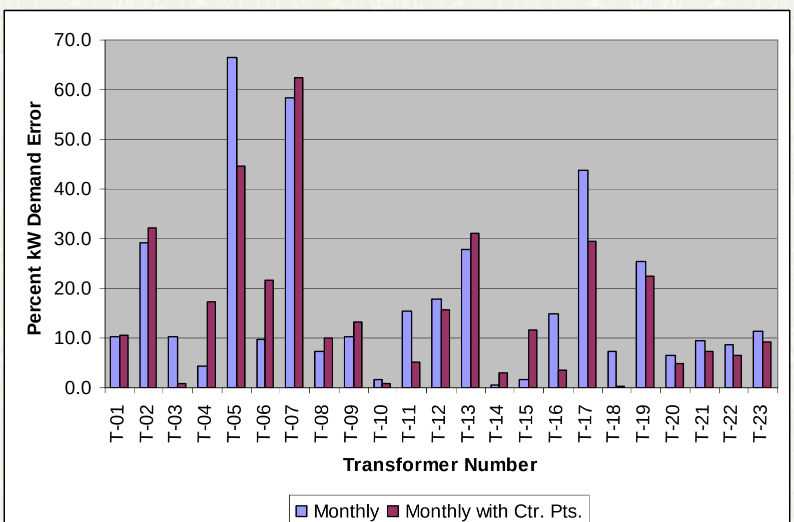
Percent kW Demand Errors



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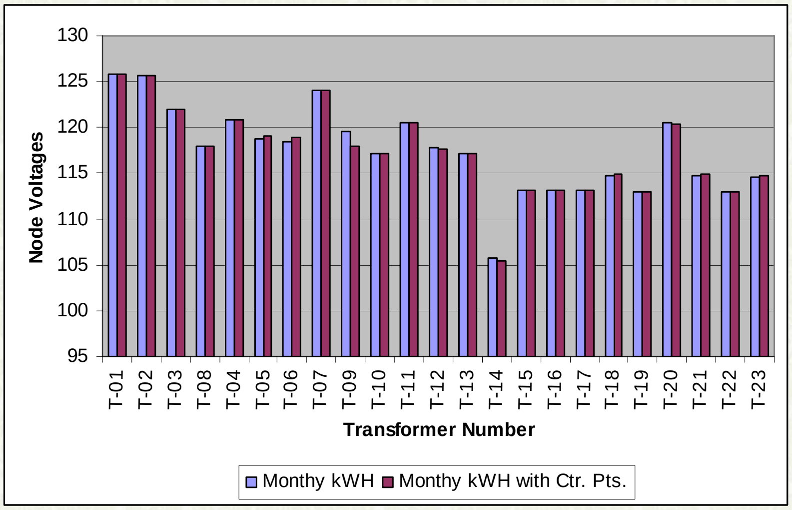
Transformer Voltages Comparison



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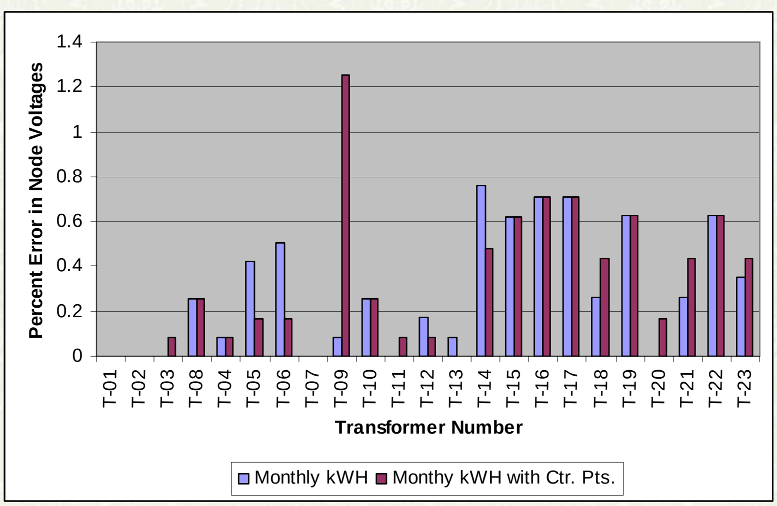
Transformer Voltage Percent Errors



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Conclusions

- AMR 15 minute kW demand readings give a wealth of information about the loading of a distribution feeder
- AMR 15 minute kvar demand readings are needed to allow an accurate modeling of load power factors
- The modeling of loads is critical to the accuracy of the power-flow study

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Conclusions (cont.)

- When the 15 minute kW demands are known at the time of feeder maximum diversified demand the loads do not have to be allocated and the most accurate study can be made
- When allocation of loads is necessary, the allocation method based upon the monthly kWH gives the smallest error for node voltages and relatively smallest error for kW demand.
- Use of control points gives mixed results and does not significantly improve study accuracy

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