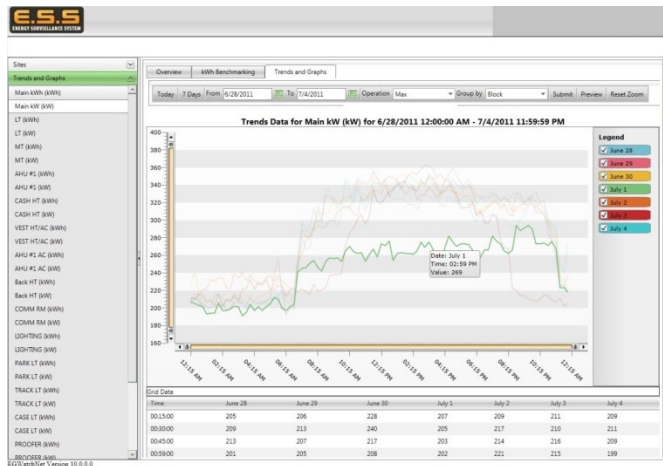


Measurement Tools & Verification of Savings Calculations

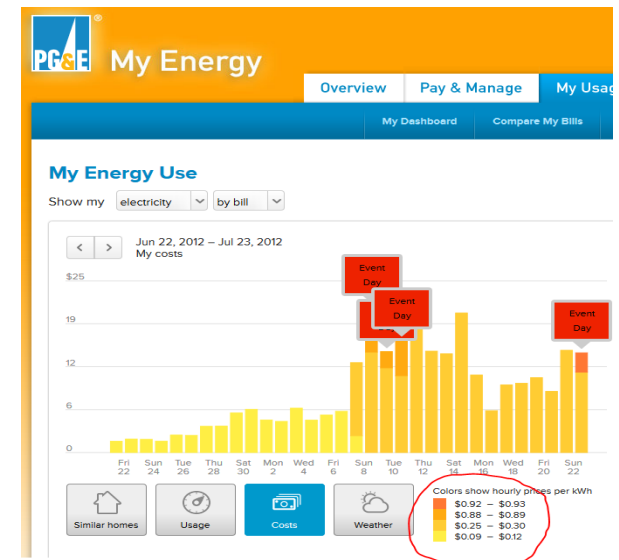
G. Sources of Data and Measurement

G. Sources of Data and Measurement Instruments



Whole Building Electric/Natural Gas

1. Monthly bills
2. Time of use meters (large facilities)
3. Smart meters (everyone else)

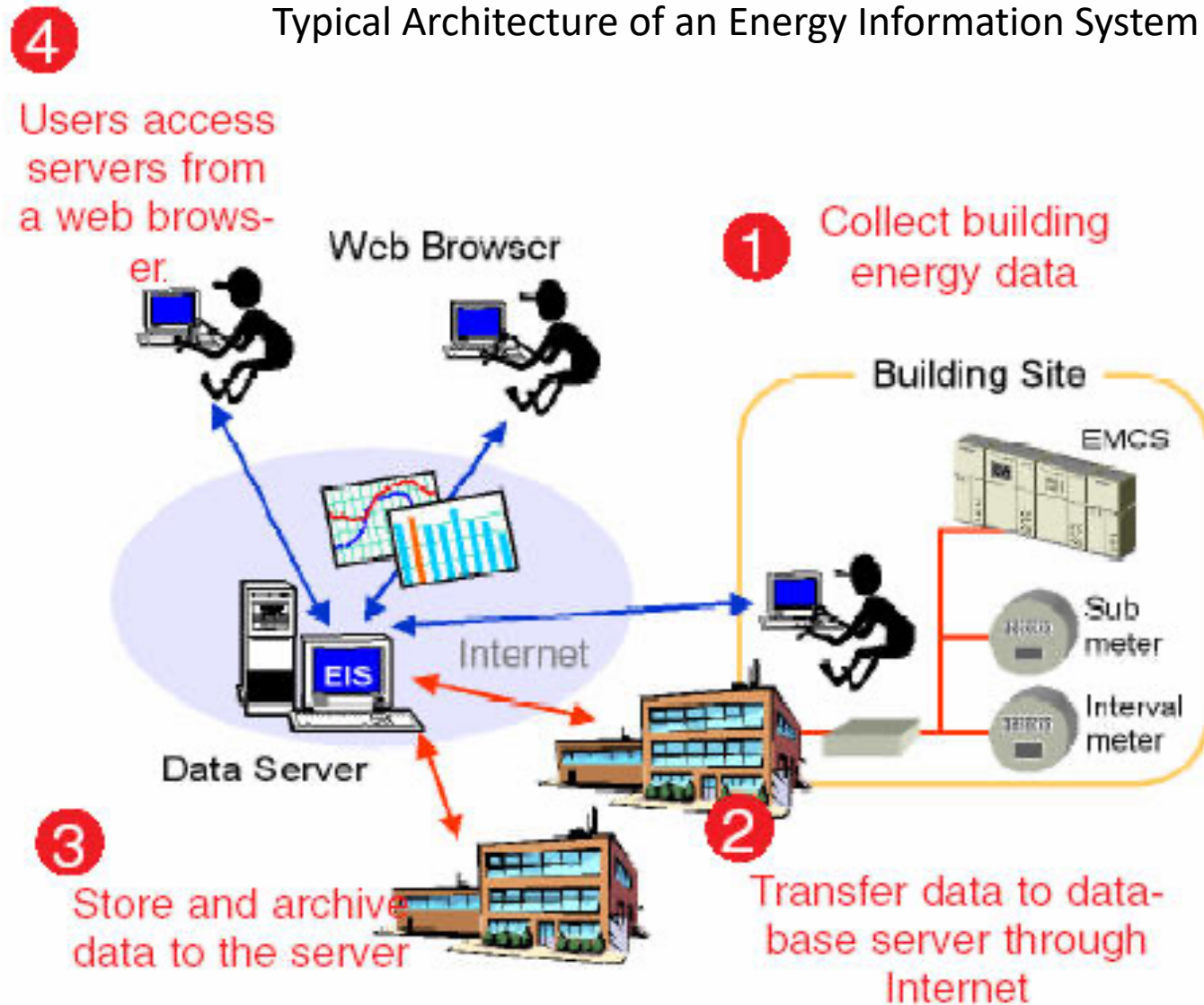


Whole Building

4. Advanced metering or Energy Information systems (EIS)

- a. customer owned, non-revenue grade
- b. System of meters, communication nodes, data storage
- c. User Display Screens





Building Subsystems

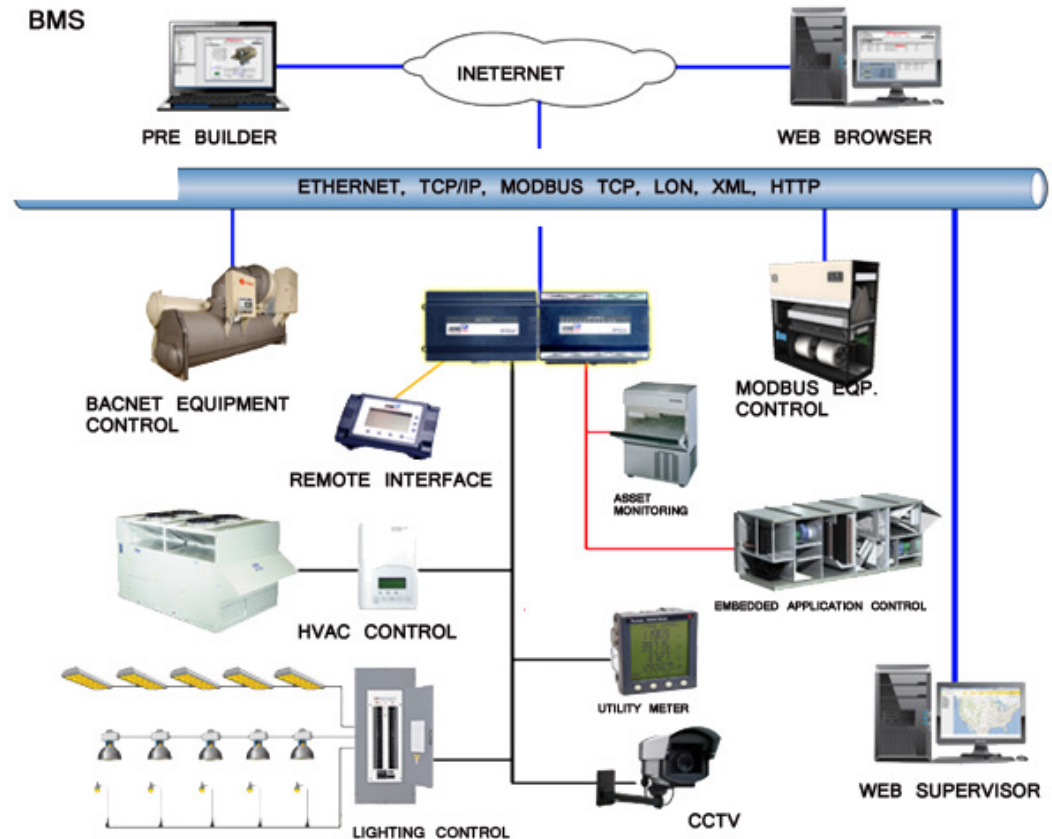
Building automation system (BAS)

- Metasys (Johnson Controls)
- Alerton Technologies
- Siemens Building Technologies
- Trane

See www.ddc-online.org

Energy Management and Information Systems

- PowerLogic ION Enterprise Software
- Obvius
- others



Building Subsystems



A Sub-Meter by Badger Meter Inc.

Typical data available

1. Sub-meters

a. electric

b. BTU meters from central plants

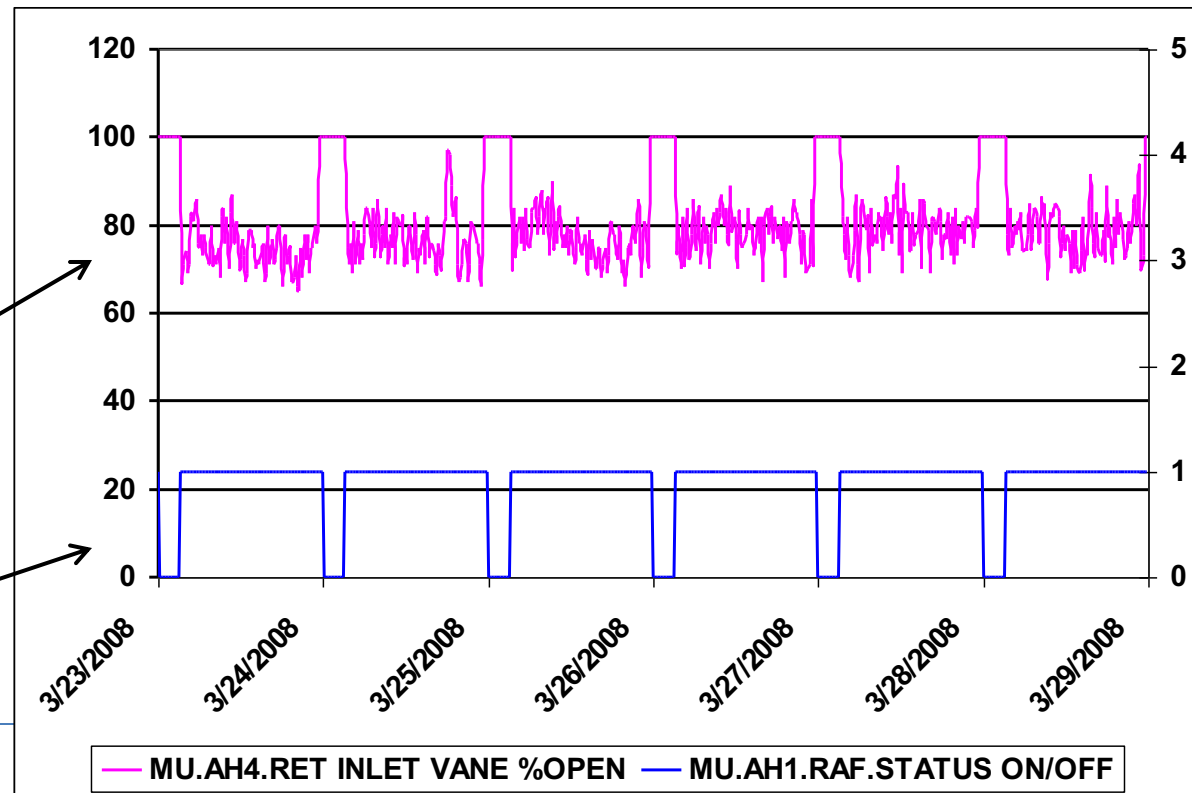
2. Status/feedback signals (from BAS)

a. Variable load

- VFD speed signal
- inlet guide vane position

b. Constant Load

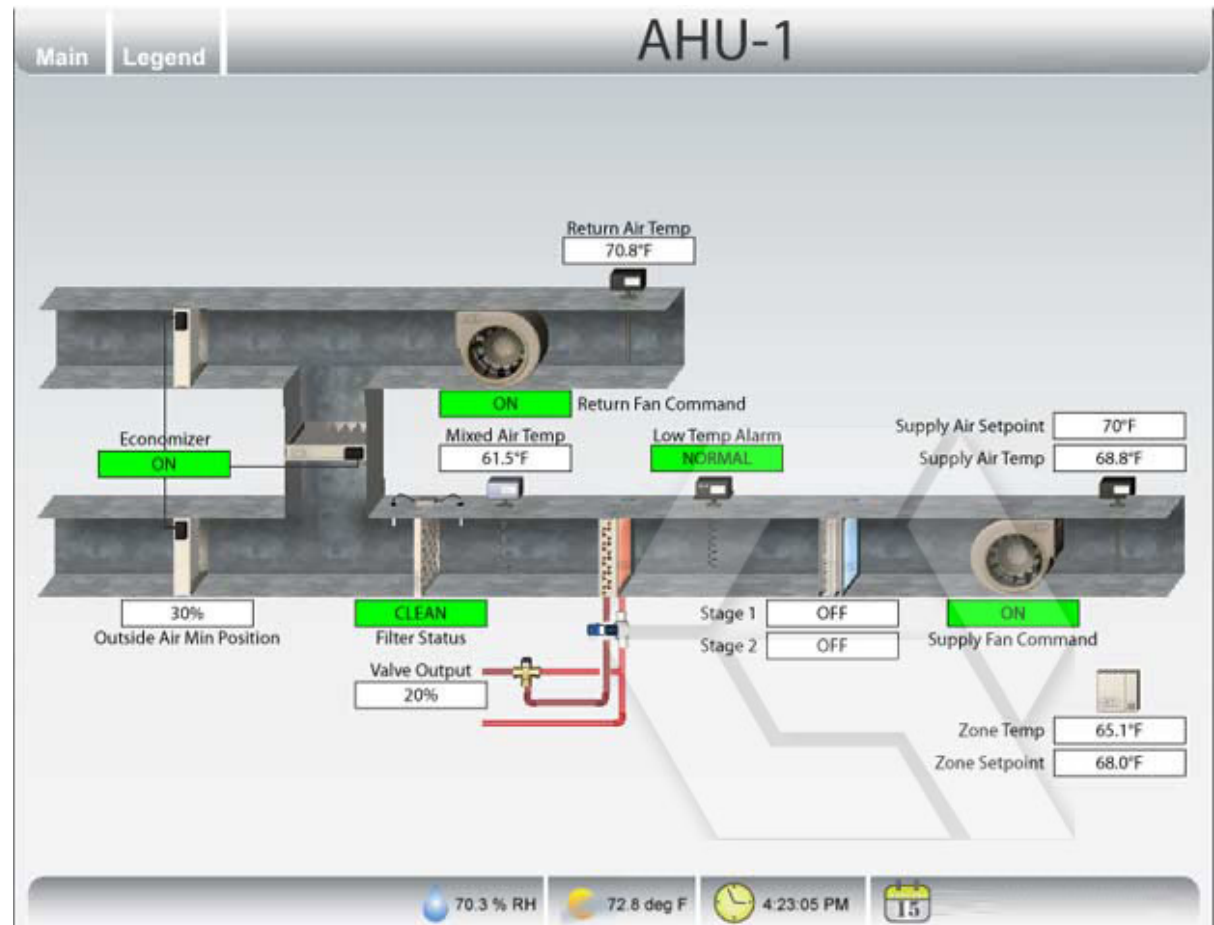
- equipment on/off



Building Subsystems

Sensor data:

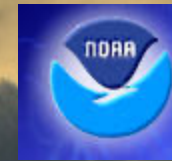
- a. Ambient temperature (local)
- b. Indoor temperature
- c. Supply and Return temperatures (water or air)
- d. Make sure to check sensor calibration and for gaps or missing values in sensor data



Weather Data

Websites – NOAA, weather underground

- TMY data (from NREL)



September 2013

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 Actual: 74 59 Precip: 0.00 Average: 75 55 Precip: 0.00	2 Actual: 78 63 Precip: 0.00 Average: 75 55 Precip: 0.00	3 Actual: 75 62 Precip: 0.00 Average: 75 55 Precip: 0.01	4 Actual: 77 61 Precip: 0.00 Average: 75 55 Precip: 0.00	5 Actual: 77 59 Precip: 0.00 Average: 75 55 Precip: 0.00	6 Actual: 87 54 Precip: 0.00 Average: 75 55 Precip: 0.01	7 Actual: 80 58 Precip: 0.00 Average: 75 55 Precip: 0.00
8 Actual: 77 56 Precip: 0.00 Average: 75 55 Precip: 0.00	9 Actual: 77 56 Precip: 0.00 Average: 75 55 Precip: 0.01	10 Actual: 75 59 Precip: 0.00 Average: 75 55 Precip: 0.00	11 Actual: 74 64 Precip: 0.00 Average: 75 55 Precip: 0.01	12 Actual: 72 61 Precip: T Average: 75 55 Precip: 0.00	13 Actual: 68 59 Precip: T Average: 75 55 Precip: 0.01	14 Actual: 68 58 Precip: 0.00 Average: 75 55 Precip: 0.00
15 Actual: 73 60 Precip: 0.00 Average: 75 55 Precip: 0.01	16 Actual: 73 58 Precip: 0.00 Average: 75 54 Precip: 0.01	17 Actual: 73 57 Precip: 0.00 Average: 75 54 Precip: 0.00	18 Actual: 79 52 Precip: 0.00 Average: 75 54 Precip: 0.01	19 Actual: 82 51 Precip: 0.00 Average: 75 54 Precip: 0.01	20 Actual: 73 53 Precip: 0.00 Average: 74 54 Precip: 0.01	21 Actual: 68 55 Precip: 0.61 Average: 74 54 Precip: 0.01
22 Actual: 70 52 Precip: 0.00 Average: 74 54 Precip: 0.00	23 Actual: 77 53 Precip: 0.00 Average: 74 54 Precip: 0.01	24 Actual: 73 54 Precip: 0.00 Average: 74 54 Precip: 0.01	25 Actual: 69 57 Precip: 0.00 Average: 74 54 Precip: 0.01	26 Actual: 72 55 Precip: 0.00 Average: 73 54 Precip: 0.01	27 Actual: 74 54 Precip: 0.00 Average: 73 54 Precip: 0.02	28 Actual: 76 56 Precip: 0.00 Average: 73 53 Precip: 0.02
29 Actual: 75 59 Precip: 0.00 Average: 73 53 Precip: 0.01	30 Actual: 72 59 Precip: 0.00 Average: 73 53 Precip: 0.02					

Calendar Legend

Sunny Clear, Mostly Sunny, Partly Sunny, Cloudy, Rain, Snow, Thunderstorms, Hazy Fog, Sleet, Chance of, Unknown

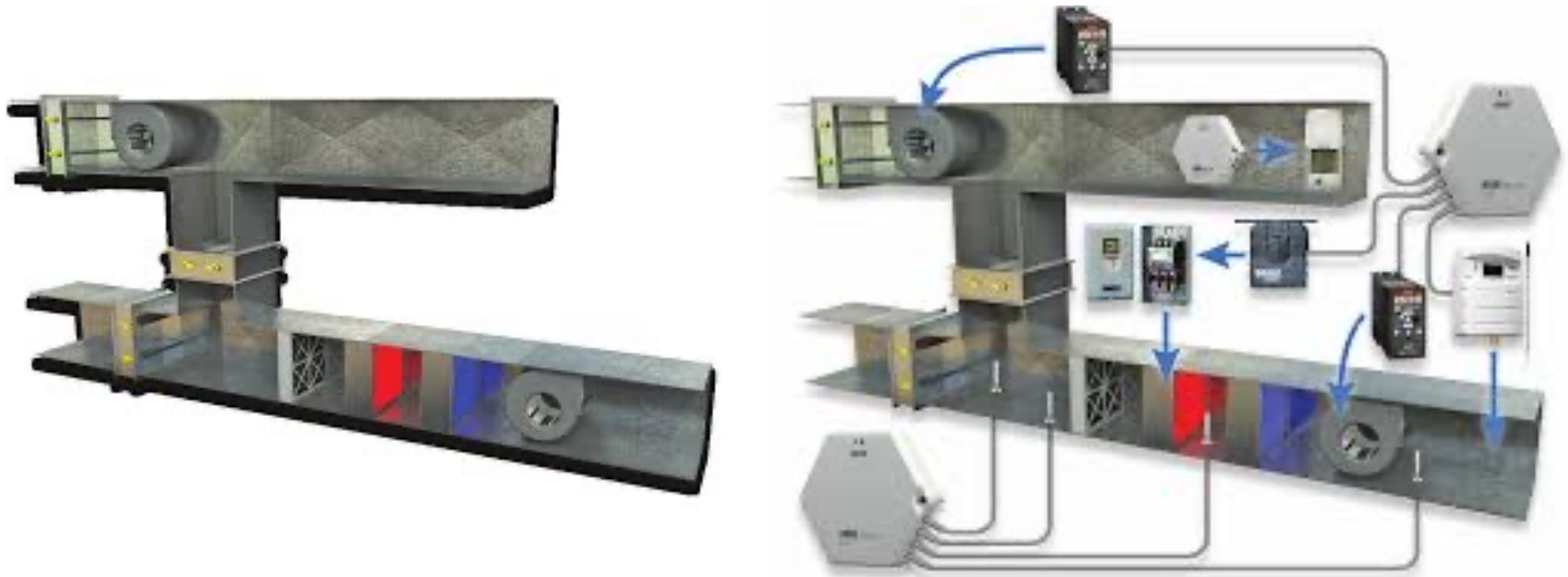
Data Category: Conditions, High Temp., Low Temp., Precip. (inches), Precip. Avg. Temp., Temp. in °F

Actual: 90 | 58
Precip: 0.00
Average: 71 | 53
Precip: 0.03

Microsoft Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	DATE	Max Temperature	Mean Temperature	Min Temperature	Max Dew Point	Mean Dew Point	Min Dew Point	Max Humidity	Mean Humidity	Min Humidity	Max Pressure	Mean Pressure	Min Pressure	Max Visibility	Mean Visibility
2	9/1/2013	74	67	59	67	62	58	100	82	64	29.97	29.94	29.9	10	10
3	9/2/2013	76	70	63	69	65	63	100	85	69	29.97	29.94	29.9	10	10
4	9/3/2013	75	69	62	65	62	56	100	79	57	30.02	29.97	29.95	10	10
5	9/4/2013	77	69	61	66	63	59	100	77	54	30.05	30	29.95	10	10
6	9/5/2013	77	68	59	63	61	58	100	75	50	30.03	29.99	29.96	10	10
7	9/6/2013	87	71	54	65	59	55	100	68	35	29.99	29.92	29.83	10	10
8	9/7/2013	89	74	58	63	57	51	100	68	36	29.88	29.85	29.81	10	10
9	9/8/2013	77	67	56	64	60	57	100	80	60	29.88	29.84	29.77	10	10
10	9/9/2013	77	67	56	64	60	56	100	79	58	29.82	29.77	29.73	10	10
11	9/10/2013	75	67	59	64	61	57	100	82	64	29.91	29.82	29.76	10	10
12	9/11/2013	74	69	64	64	62	59	93	79	64	30	29.96	29.91	10	10
13	9/12/2013	72	67	61	64	63	61	100	87	73	29.99	29.95	29.91	10	10
14	9/13/2013	68	64	59	62	60	59	100	91	81	29.92	29.87	29.8	10	10
15	9/14/2013	68	63	58	62	60	58	100	91	81	29.86	29.81	29.78	10	10
16	9/15/2013	73	67	60	64	60	57	100	83	66	29.88	29.85	29.81	10	10
17	9/16/2013	73	66	58	63	61	58	100	81	61	29.91	29.87	29.81	10	10
18	9/17/2013	73	65	57	61	59	55	100	77	53	29.89	29.87	29.84	10	10
19	9/18/2013	79	66	52	61	56	48	100	69	38	29.92	29.88	29.84	10	10
20	9/19/2013	82	67	51	59	56	50	100	69	37	29.87	29.82	29.76	10	10
21	9/20/2013	73	63	55	66	62	56	100	90	79	29.88	29.83	29.8	10	10
22	9/21/2013	68	62	55	65	62	55	100	89	78	29.91	29.85	29.82	10	10
23	9/22/2013	70	61	52	60	56	53	100	79	57	30.01	29.97	29.91	10	10
24	9/23/2013	77	65	53	66	60	54	100	79	57	30.03	29.99	29.94	10	10
25	9/24/2013	73	64	54	64	58	53	100	81	61	30.01	29.96	29.91	10	10
26	9/25/2013	69	63	57	55	49	46	87	68	48	29.94	29.9	29.84	10	10
27	9/26/2013	72	64	55	51	44	34	72	49	26	29.99	29.91	29.85	10	10
28	9/27/2013	74	64	54	51	46	39	77	53	29	30.11	30.06	30	10	10
29	9/28/2013	76	66	56	55	47	41	78	54	29	30.09	30.06	30.02	10	10
30	9/29/2013	75	67	59	61	57	54	87	74	61	30.12	30.09	30.06	10	10
31	9/30/2013	72	66	59	63	60	51	93	83	72	30.09	30.04	29.98	10	10

Measurement Devices



Electrical Metering

$$\text{Watts} = \text{Amps} \times \text{Volts} \times \text{Power Factor}$$

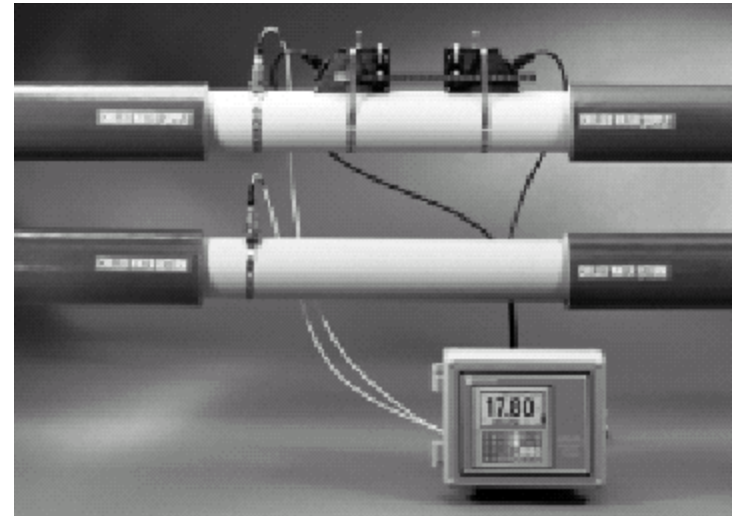
- Power factor is important. For restrictive loads (e.g. incandescent lighting), PF = 1.0 and amps and volts are all that must be measured. For inductive loads, PF must be measured or estimated
- Harmonic distortion may also influence readings

Always measure the **true RMS Watts**, not simply amps and volts, to include all possible power factor and harmonic influences.

Thermal Energy Meters

Thermal energy meters measure energy rate provided by hot and cold water, often from a central plant to a building.

- Require 2 temperature sensors and a flow meter
- Temperature and flow sensors may be intrusive or surface-mounted
- Sources of error from three measurement elements
- Expensive!



Measurement Devices

Data loggers

1. HOBO
2. Pace
3. Dent
4. Etc.



Outdoor Air Temperature Sensor



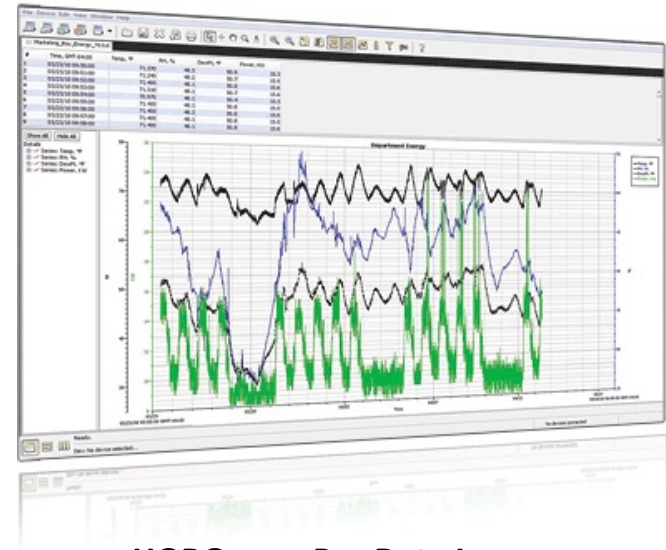
Indoor Temperature Logger



4-Channel Data Logger



Electrical Power Logger



HOBOWare Pro Data Logger Software

Measurement Devices

Spot measurement instruments

1. Powersight
2. Fluke Meters
3. Raytek Laser Thermometer
4. Source: PG&E Tool Lending Library

<http://www.pge.com/pec/tll/>



PowerSight Power Analyzer



Raytek Laser Thermometer

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Laney College - Commercial HVAC Systems

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Webinars (e.g., BEST Talks)

Faculty Profile Videos

Reports & Case Studies

Marketing Resources

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