Building Performance Data for Operators: What Can Work

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Feedback Concepts

Man-Machine Interaction in Building System Monitoring and Performance Improvement

- Human Factors engineering – operating a building becoming more like flying a plane
- Provide an effective supervisory function over automated processes
- Avoid Information Overload
- Use Energy as a Key Success Factor
- Enable “drill-down” and multi-variate analysis

Changing Landscape of Metering and Data Acquisition

- Digitalization
- Data interoperability
- Wireless
- Web-based viewing

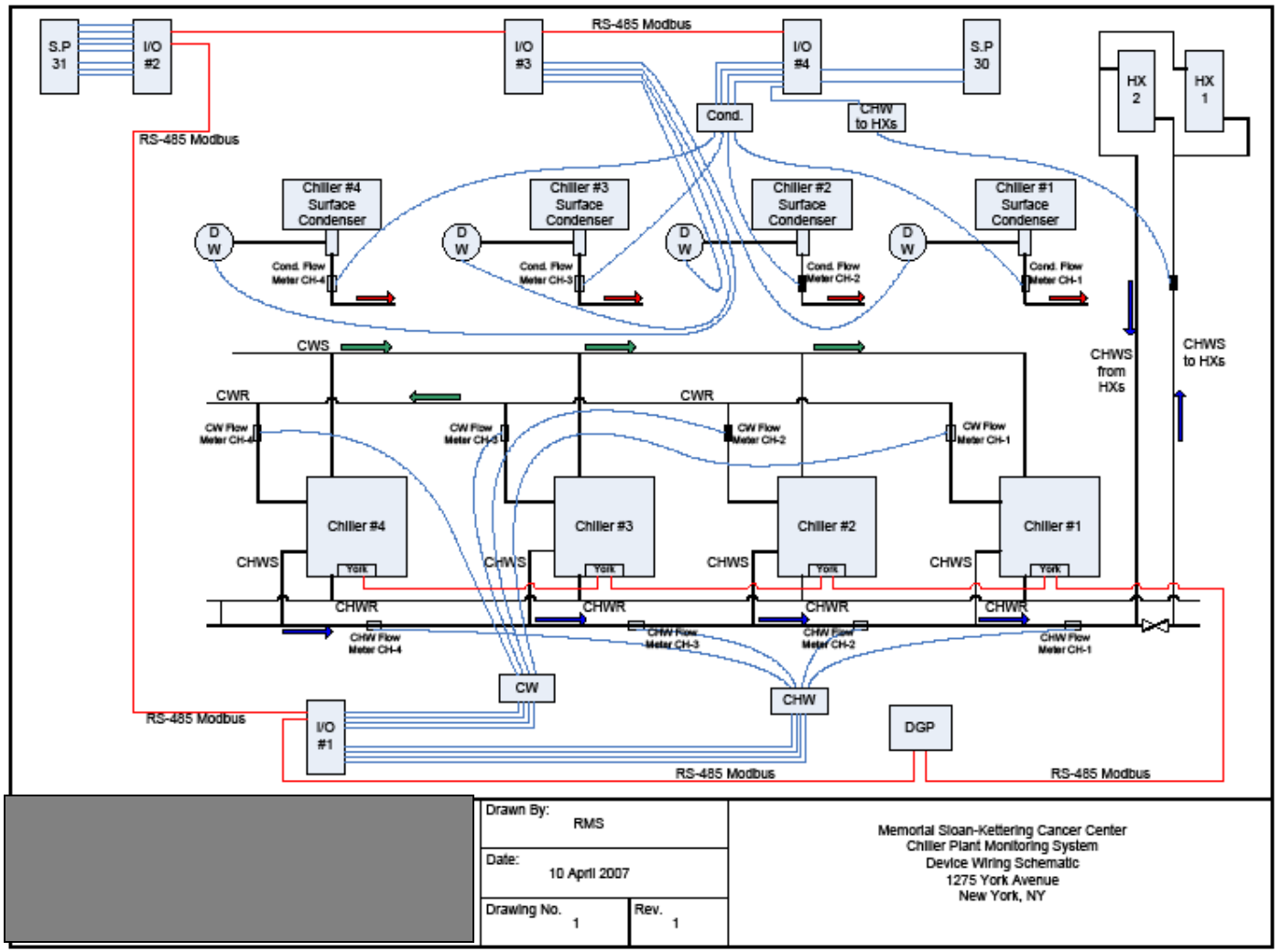
- **New technology makes new forms of data acquisition and monitoring feasible**

Case Study of a Chiller Plant

- Memorial SloanKettering Cancer Center in New York City
- Multi-building campus, 1.17 million square feet
- 6,000 ton steam-turbine chiller plant
  - Primary, secondary and tertiary pumped loops
  - > $4 million in annual steam cost
- Operational Improvement from a retrofitted Monitoring System that makes Key Performance Data available to Operators

Monitoring System Overlay

- Added flow points (13)
- temperatures from BAS
- Stand-alone monitoring system
- Remote support with full viewing
- $167,000 in capital cost + $50,000 annual

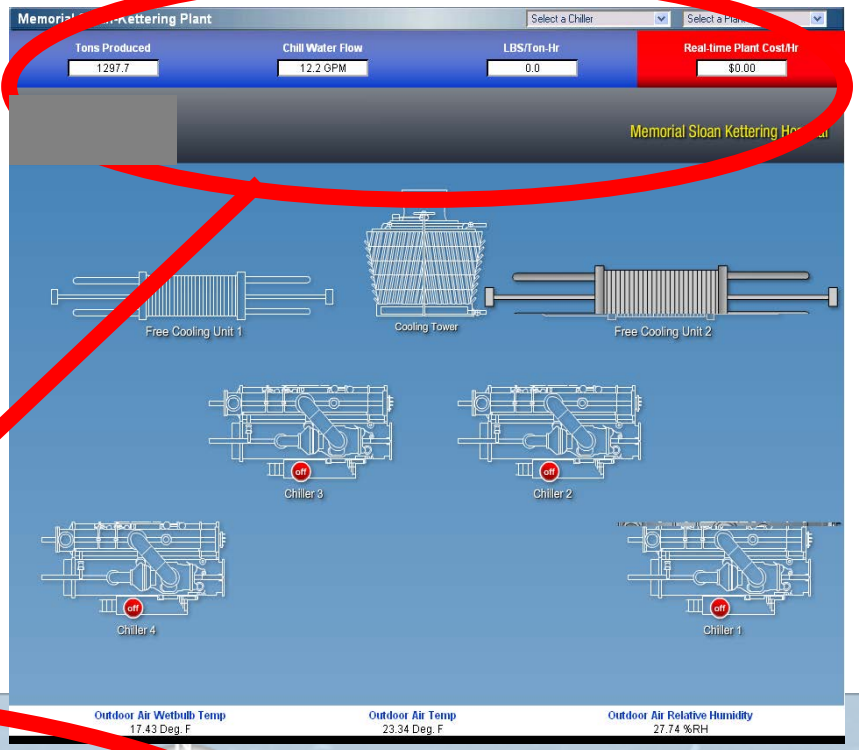


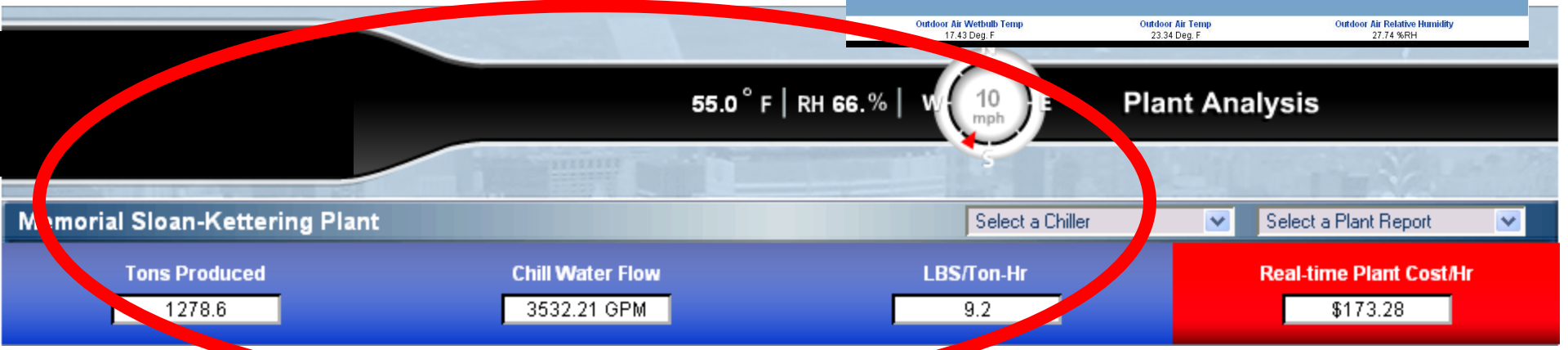
Entry Screen - Key Data Impossible to Miss

Key current performance data in easy format

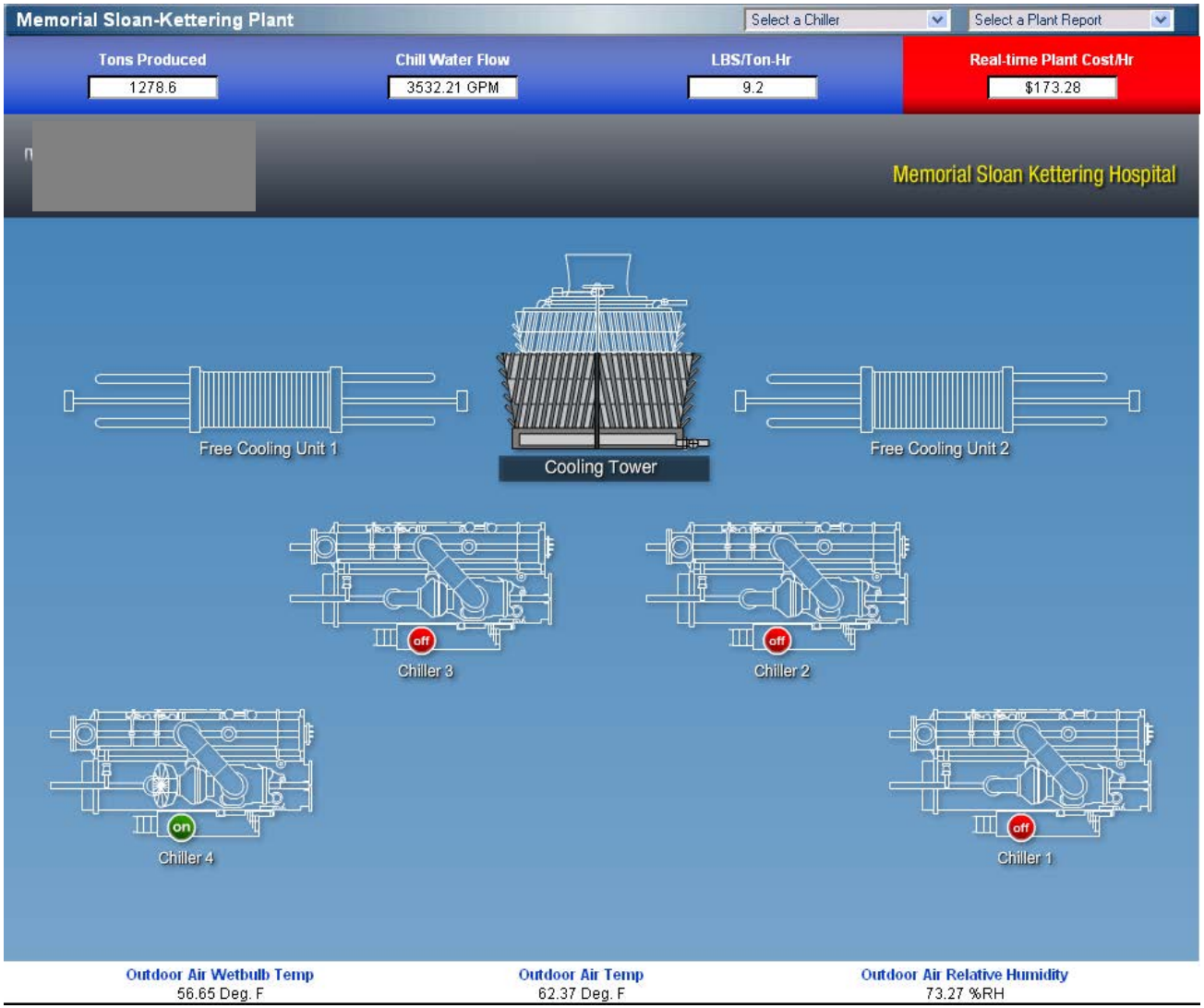
New reads: tons and steam flow, steam rate

Operators readily see key performance outcomes – gain new awareness of priorities





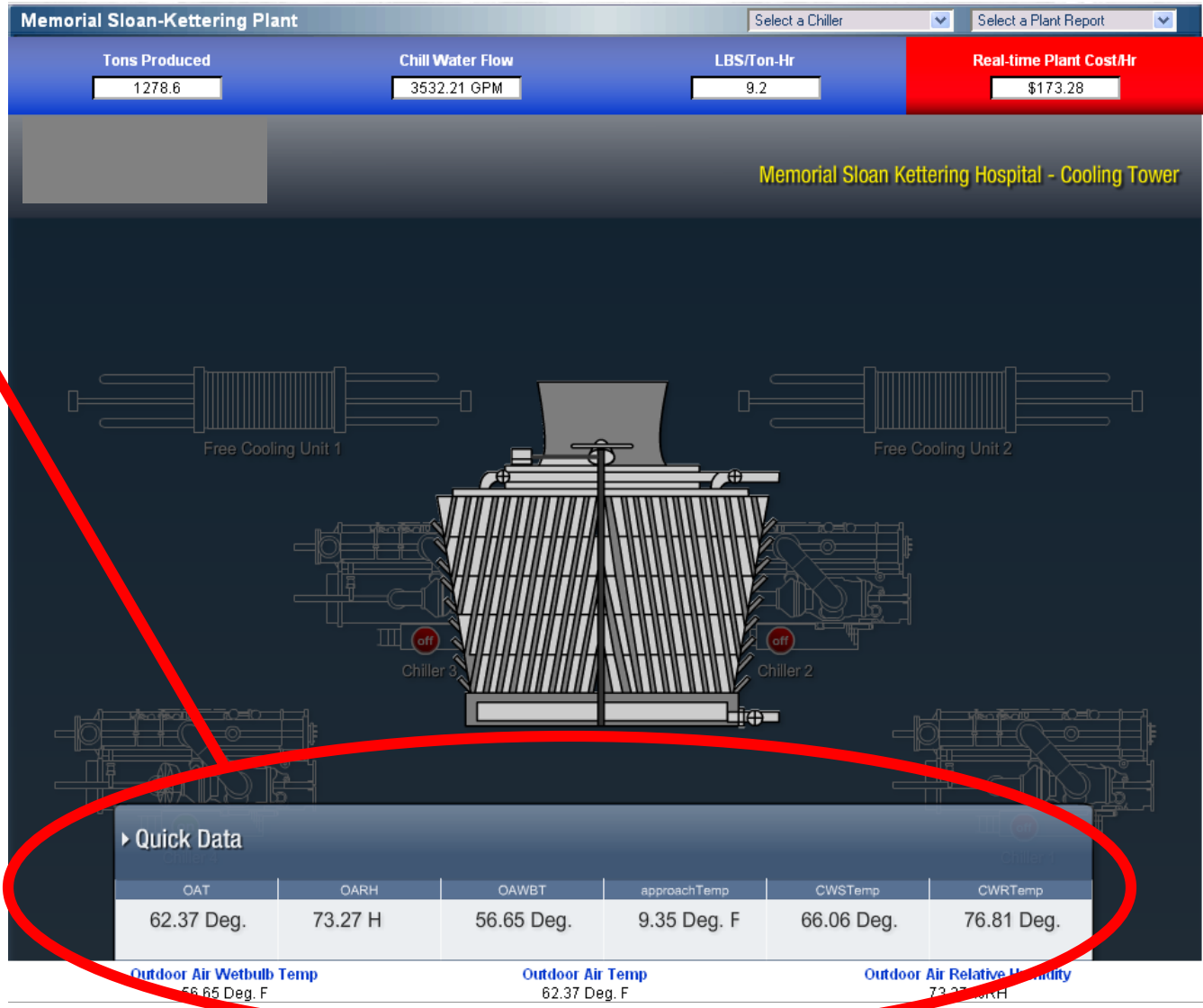
Easy “drill-down” to next level



- Click on icon to select component for further data

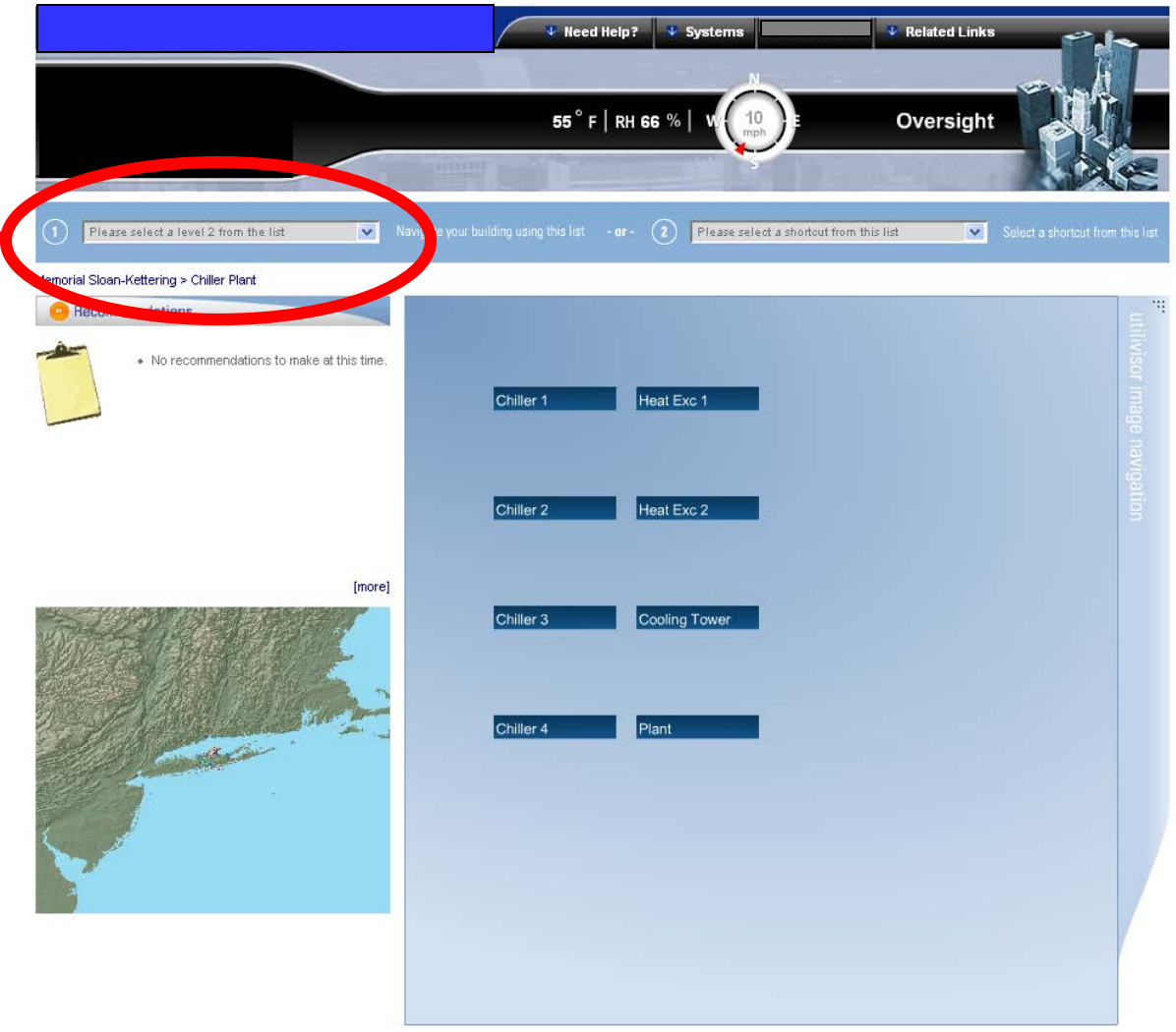
Again, key data in easy format

- Pre-configured data output
- Next level allows configurable data



“Drill-down” via Selectable Multivariate Data

- Easy selection from drop-down “pick-list”
- Allows specification of time period for review



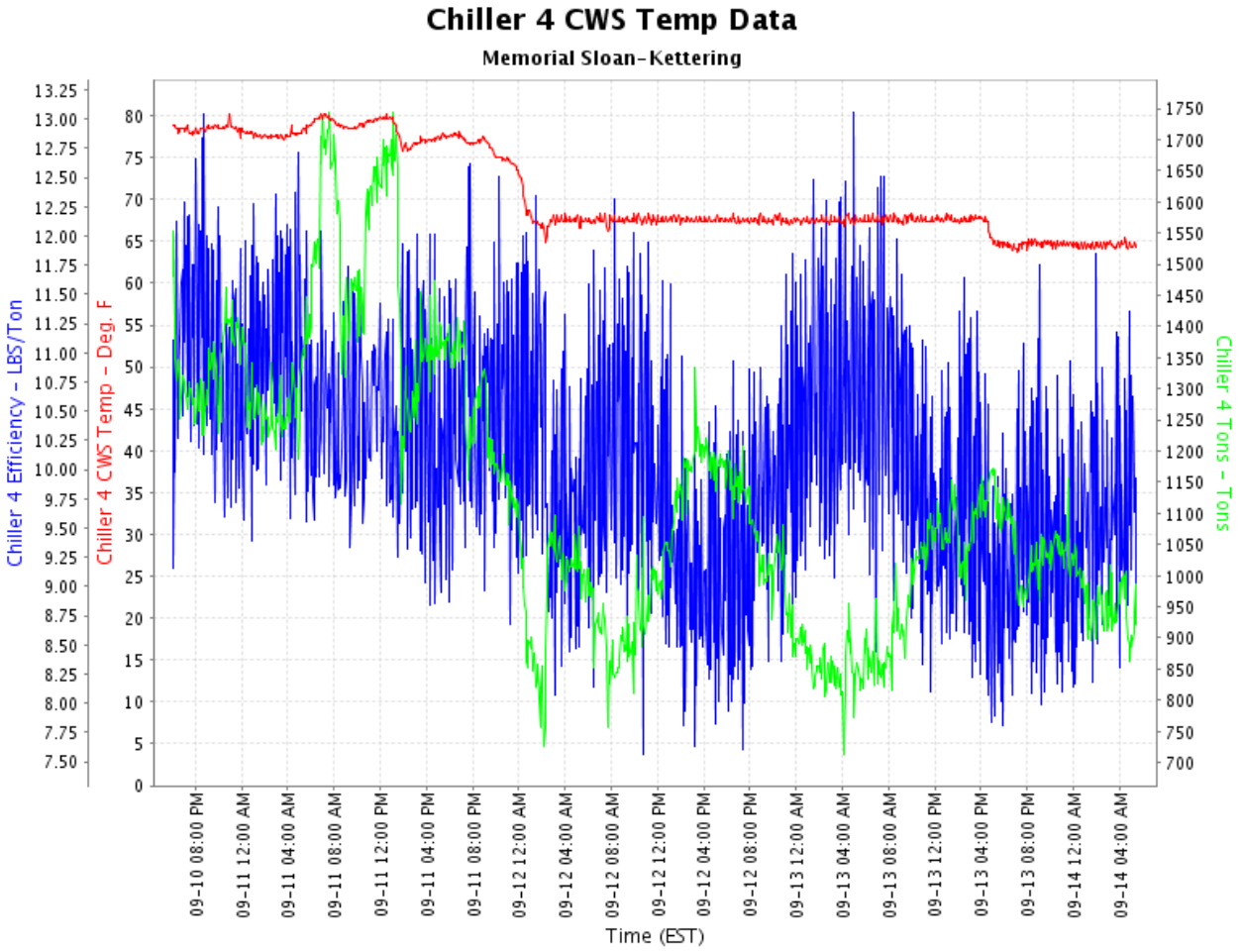
Selectable Multivariate Data

- Rich data available for “drill-down”

Level 3	Point	Value	Timestamp
Chiller 4 Status	*Chiller 4 Status*	ON	01-08 12:15 PM
Chiller 4 Tons *Multiplied Set Point:* ◦ Chiller 4 CHW Flow ◦ *Chiller #4 CHW Delta T* *Alarm Setup*	*Chiller 4 Tons*	1228.76 Tons	01-08 12:15 PM
Chiller 4 Stm Flow	*Chiller 4 Stm Flow*	8899.0 LBSStm	01-08 12:15 PM
Chiller 4 Efficiency	*Chiller 4 Efficiency*	7.24 LBS/Ton	01-08 12:15 PM
Chiller 4 CHW Flow	Chiller 4 CHW Flow	3389.7 GPM	01-08 12:15 PM
Chiller 4 CHWS Temp	Chiller 4 CHWS Temp	44.3 Deg. F	01-08 12:15 PM
Chiller 4 CHWR Temp	Chiller 4 CHWR Temp	53.0 Deg. F	01-08 12:15 PM
Chiller 4 CW Flow	Chiller 4 CW Flow	3656.91 GPM	01-08 12:15 PM
Chiller 4 CWS Temp	Chiller 4 CWS Temp	63.4 Deg. F	01-08 12:15 PM
Chiller 4 CWR Temp	Chiller 4 CWR Temp	71.2 Deg. F	01-08 12:15 PM
Chiller 4 Cond Flow	*Chiller 4 Cond Flow*	17.79 GPM	01-08 12:15 PM
Chiller 4 Vac Pump Flow	Chiller 4 Vac Pump Flow	0.0 GPM	01-08 12:15 PM
Chiller 4 Evap Ref Press	Chiller 4 Evap Ref Press	34.7 PSI(g)	01-08 12:15 PM
Chiller 4 Evap Ref Temp (Calc)	*Chiller 4 Evap Ref Temp (Calc)*	39.7 Deg. F	01-08 12:15 PM
Chiller 4 Cond Ref Press	Chiller 4 Cond Ref Press	74.7 PSI(g)	01-08 12:15 PM
Chiller 4 Cond Ref Temp (Calc)	*Chiller 4 Cond Ref Temp (Calc)*	72.35 Deg. F	01-08 12:15 PM
Chiller #4 CHW Delta T *Subtracted Point:* ◦ Chiller 4 CHWR Temp (MINUEND) ◦ Chiller 4 CHWS Temp (SUBTRAHEND) *Alarm Setup*	*Chiller #4 CHW Delta T*	8.7 Deg. F	01-08 12:15 PM
Chiller #4 CW Delta T	*Chiller #4 CW Delta T*	7.8 Deg. F	01-08 12:15 PM
Chiller #4 Evap App Temp	*Chiller 4 Evap App Temp*	4.59 Deg. F	01-08 12:15 PM
Chiller #4 Cond App Temp	*Chiller 4 Cond App Temp*	1.15 Deg. F	01-08 12:15 PM
CT Approach Temp	*Tower Approach Temp*	9.65 Deg. F	01-08 12:05 PM
Chiller 4 Status_cnt	Chiller 4 Status_cnt	255.0 cnt	01-08 12:15 PM
Chiller 4 Cond Flow (INT)	Chiller 4 Cond Flow (INT)	17.79 cnt	01-08 12:15 PM

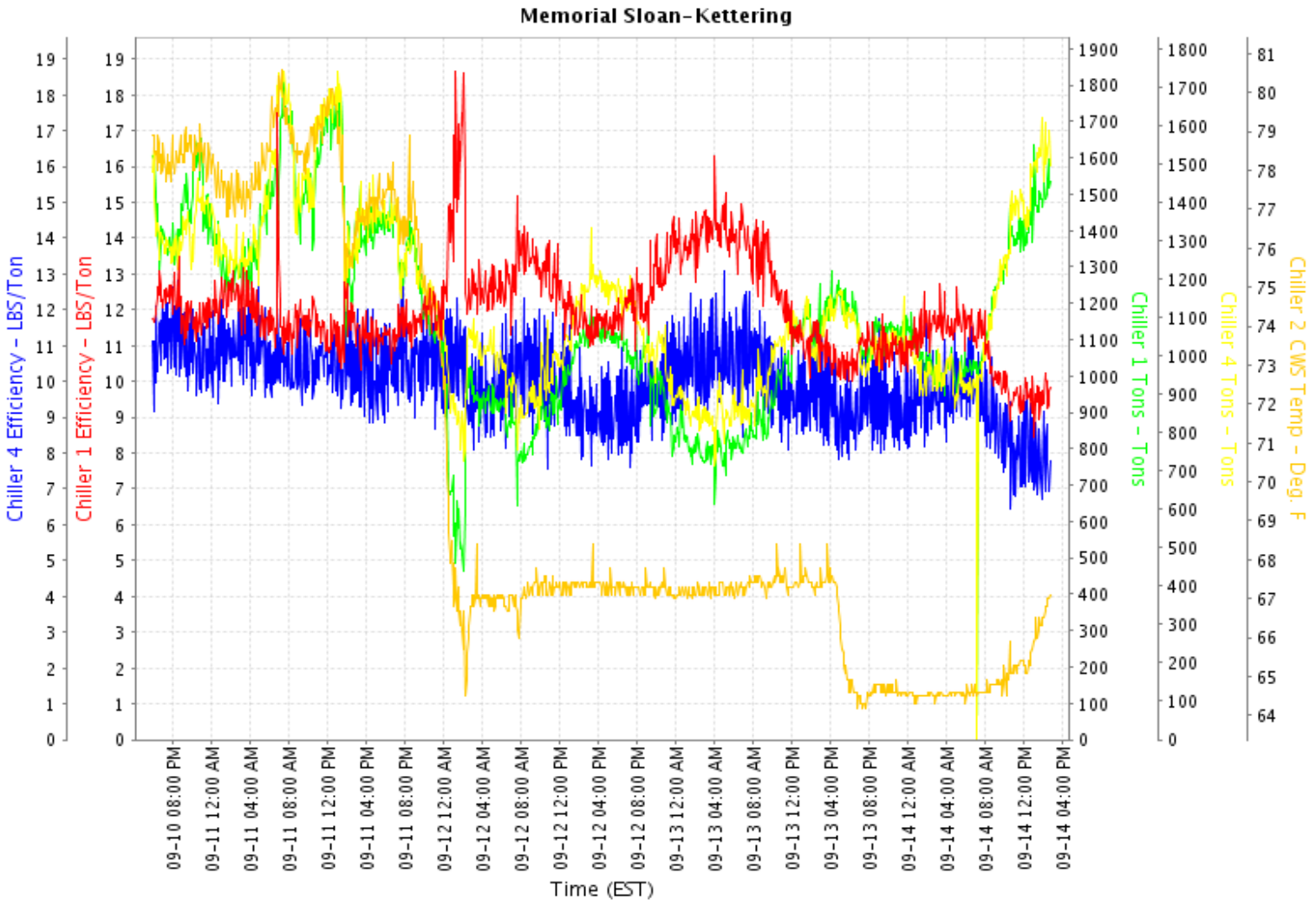
Selectable Multivariate Data – Automatic Graphing

- Multi-variate graphing as a standard presentation format
- Powerful for operators to see relationships
- Develop and test hypotheses



Another example of significant multivariate observation

- Chiller 4 more efficient at light load
- Control upgrade issue



Chiller 1 vs Chiller 4 Efficiency Data at Varying Loads

Operator Response

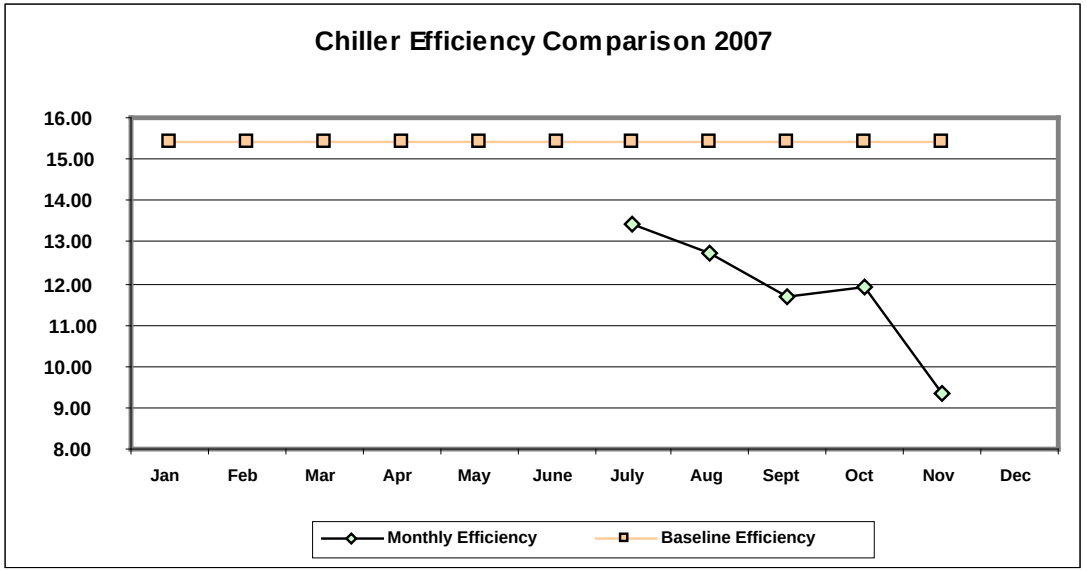
- High degree of involvement, use, and learning
- Communication between operators
- Remote support encourages interactivity
- Improved job satisfaction and performance
- Identification of needs for new controls

Early Operator-driven Operational Improvements

- Refrigerant Charge
- Chiller Staging
- Individual Chiller Efficiencies
- Condenser Temperatures
- Water-side Economizer

Data Availability: Immediate Impacts

- Having performance data resulted in immediate actions and impacts
- Numerous operator stories
- $100,000 / mo savings



Memorial Sloan Kettering- Chiller (Mechanical Cooling) Performance Report

2007 From	To	# Days	Chiller Output Ton-Hrs	Steam Usage Mlbs	Chiller Efficiency lbs/Ton	Baseline Efficiency lbs/Ton	Average Cost $/Mlb.	Chiller Operating Cost	Baseline Operating Cost	Savings $	Savings %
12/26	1/26					15.440					
1/26	2/26					15.440					
2/26	3/27					15.440					
3/27	4/25					15.440					
4/25	5/25					15.440					
5/25	6/26					15.440					
6/26	7/26	13	962,205	12,897	13.404	15.440	$ 17.23	$ 222,215.31	$ 255,976.55	$ 33,761.24	13.2%
7/26	8/24	29	2,400,368	30,556	12.730	15.440	$ 17.54	$ 535,876.23	$ 649,966.74	$ 114,090.51	17.6%
8/24	9/25	32	2,291,842	26,753	11.673	15.440	$ 14.86	$ 397,556.05	$ 525,845.12	$ 128,289.07	24.4%
9/25	10/24	29	1,930,290	22,973	11.902	15.440	$ 17.61	$ 404,573.12	$ 524,856.44	$ 120,283.31	22.9%
10/24	**11/27**	**34**	**588,241**	**5,484**	**9.323**	**15.440**	**$ 23.60**	**$ 129,418.98**	**$ 214,324.20**	**$ 84,905.22**	**39.6%**
11/27	12/26					15.440					
	Total	**137**	**8,172,946**	**98,664**				**$ 1,689,639.70**	**$ 2,170,969.05**	**$ 481,329.35**	
	Average	**31**	**1,634,589**	**19,733**	**12.072**	**15.440**	**$ 17.80**	**$ 337,927.94**	**$ 434,193.81**	**$ 96,265.87**	**23.5%**

Interpreting Early Results

- Conjoint Man-Machine Systems provide superior results
- Short, fast feedback loops that incorporate Operators
  - “trim” system for dynamic operating conditions
  - Find improved operating points
  - Better decision-making about equipment starts and sequencing
- Powerful learning with documentation of results

Questions?

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