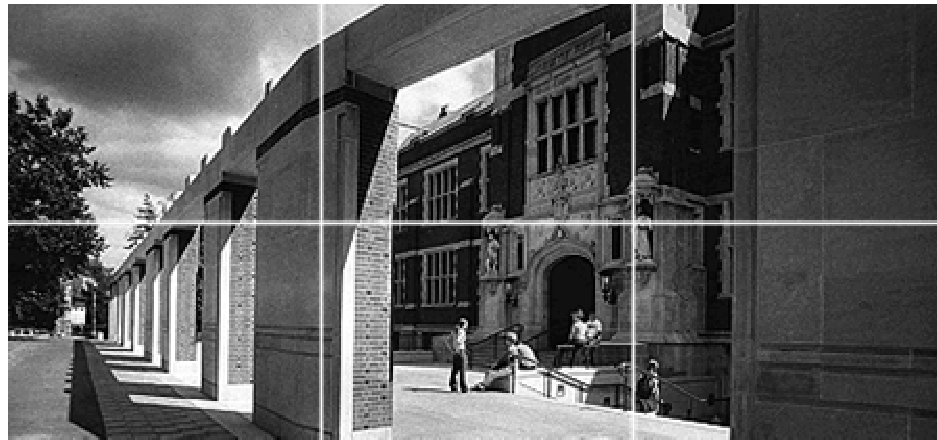




## **NJHEPS Princeton Energy Management Workshop**



Economics of Market Based Energy Management

Tom Nyquist P. E., Director of Engineering

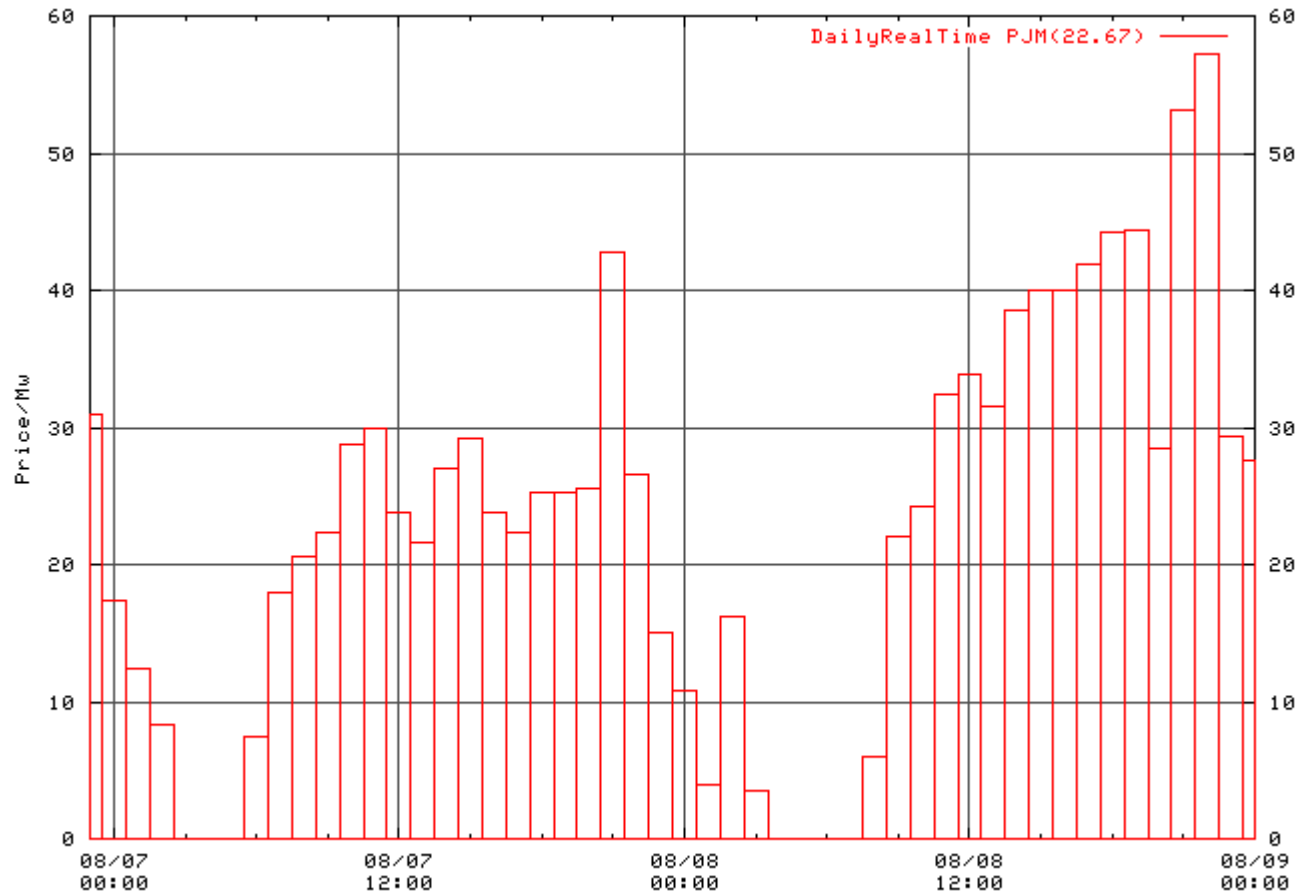


## Market Variables Affecting Energy Management Execution

- Import power prices
- “Congestion Costs”
- Spot daily gas markets
- Monthly gas markets
- CEG/CIG gas tariffs
- Fuel Oil Cost



PJM average 2 day pricing \$22.67 avg.

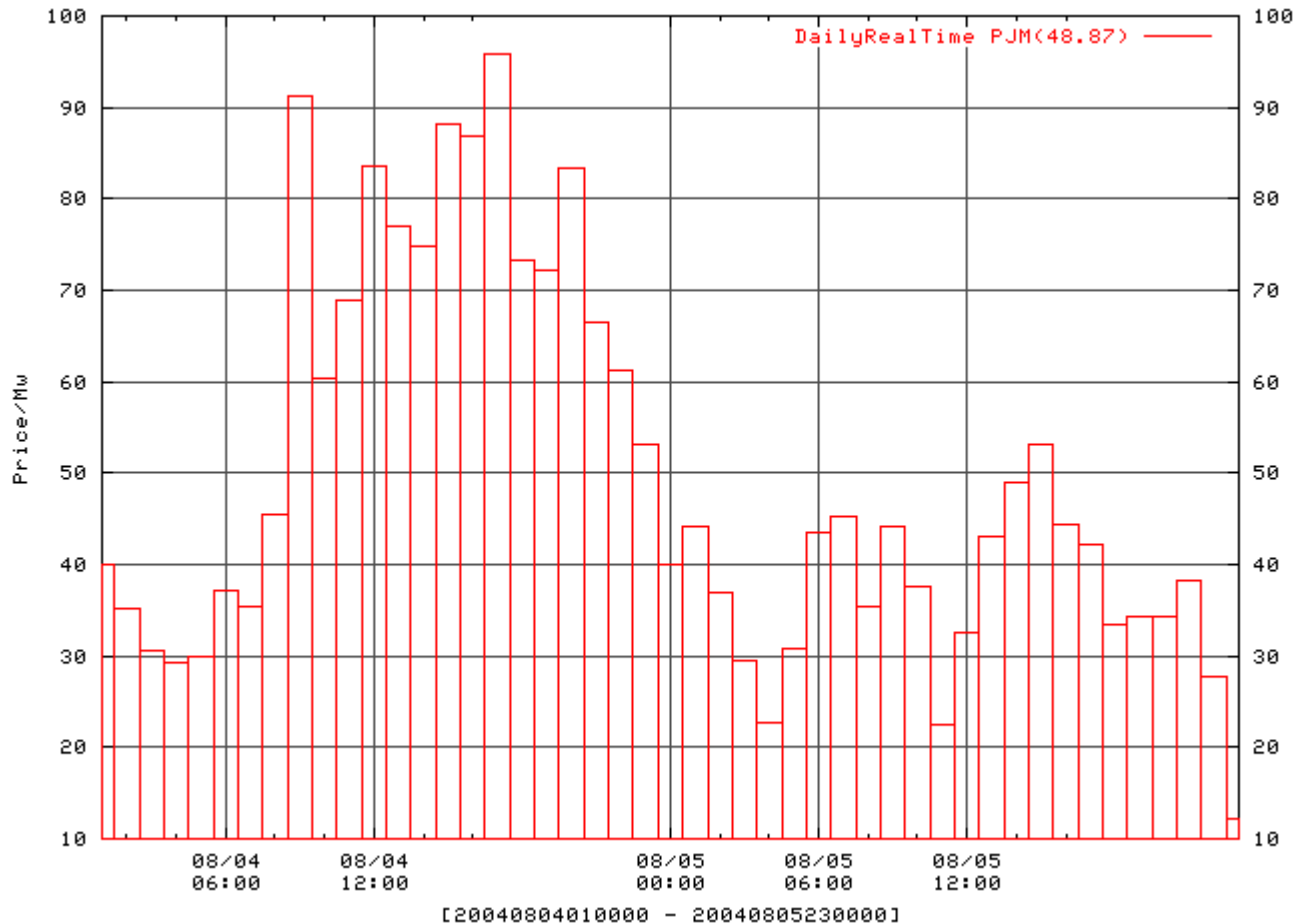


Mon Aug 09 22:12:43 2004

[20040806230000 - 20040809000000]

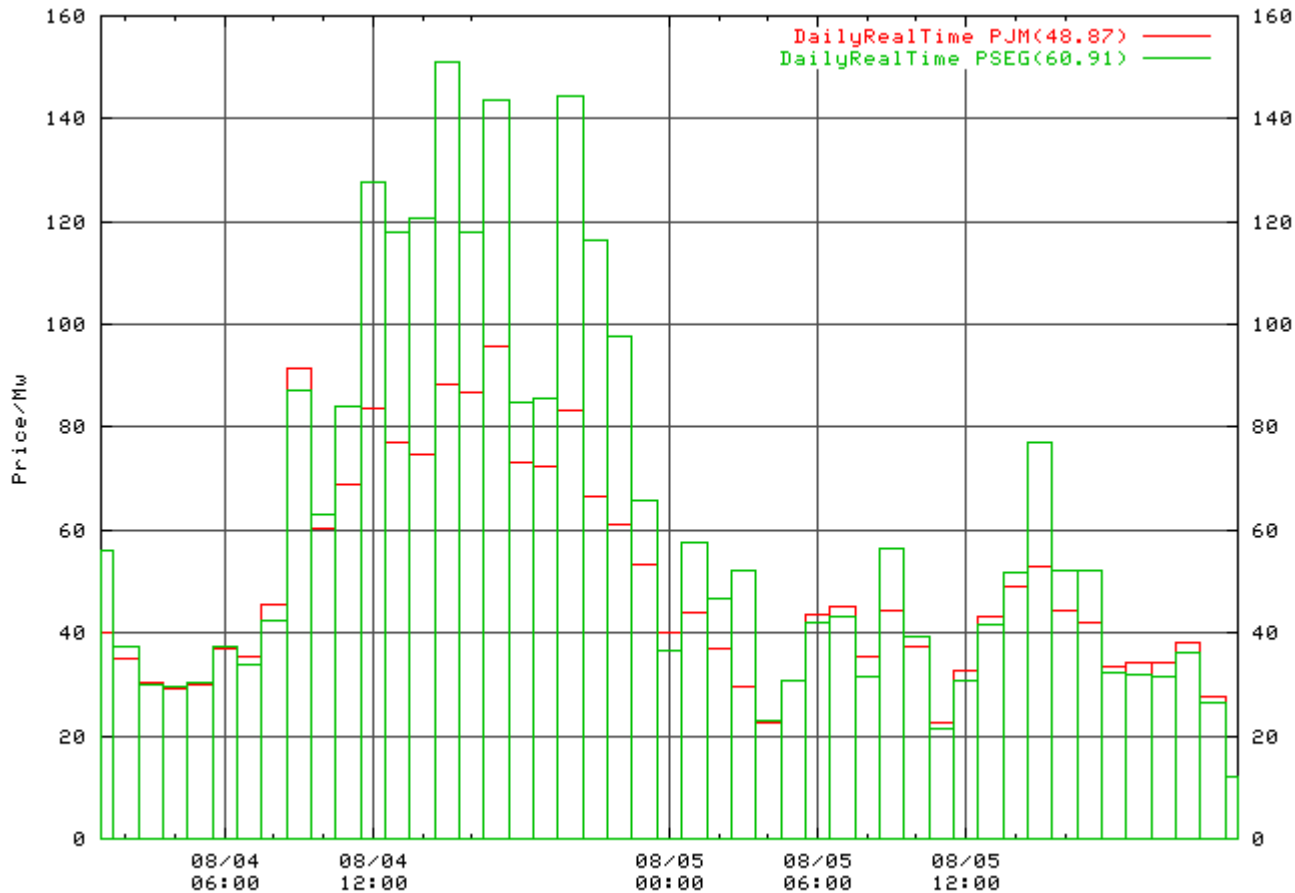


PJM average 2 day pricing \$48.87 avg.  
Aug 4-6



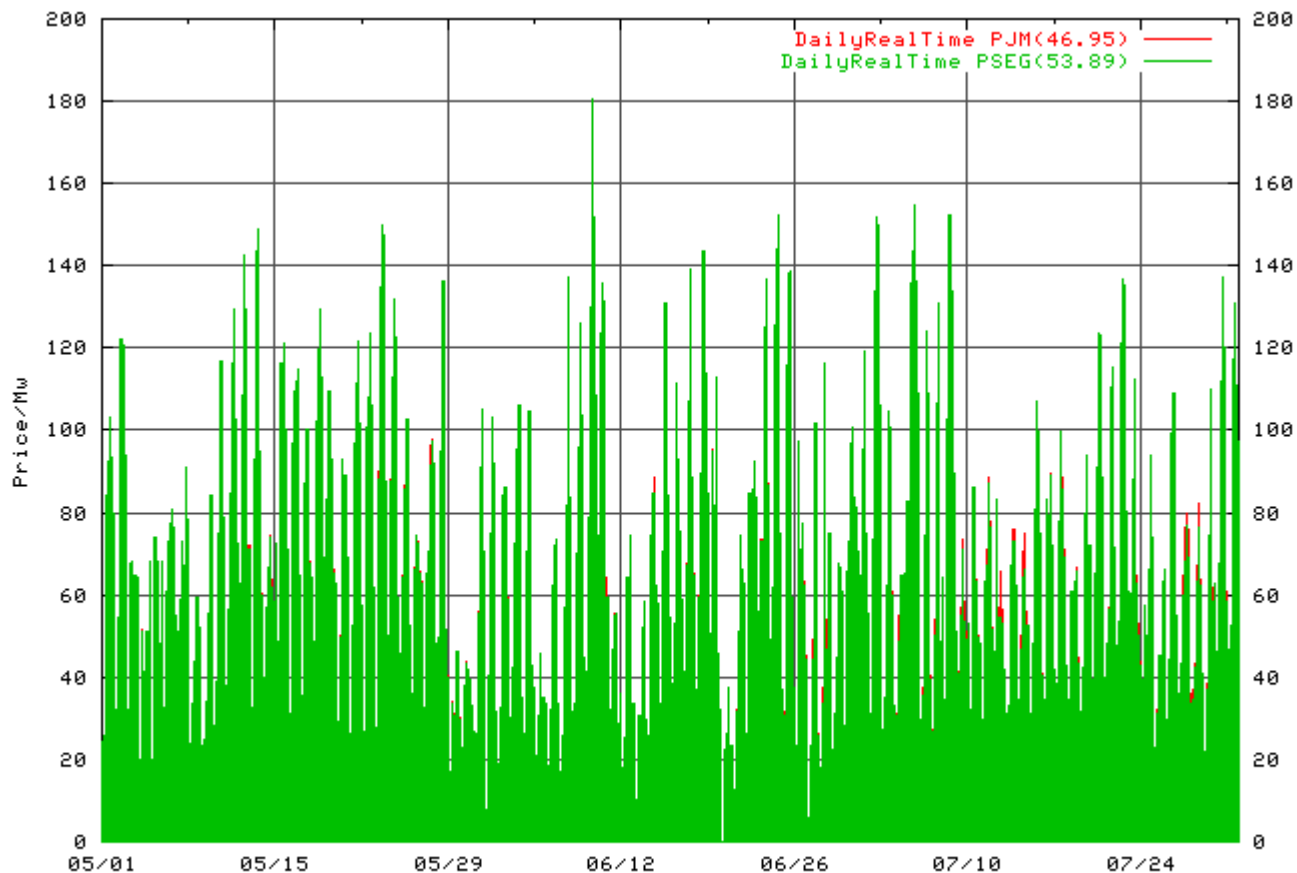


PJM/PSEG average 2 day pricing  
\$48.87 PJM avg, \$60.91 PSEG avg  
Aug 4-6





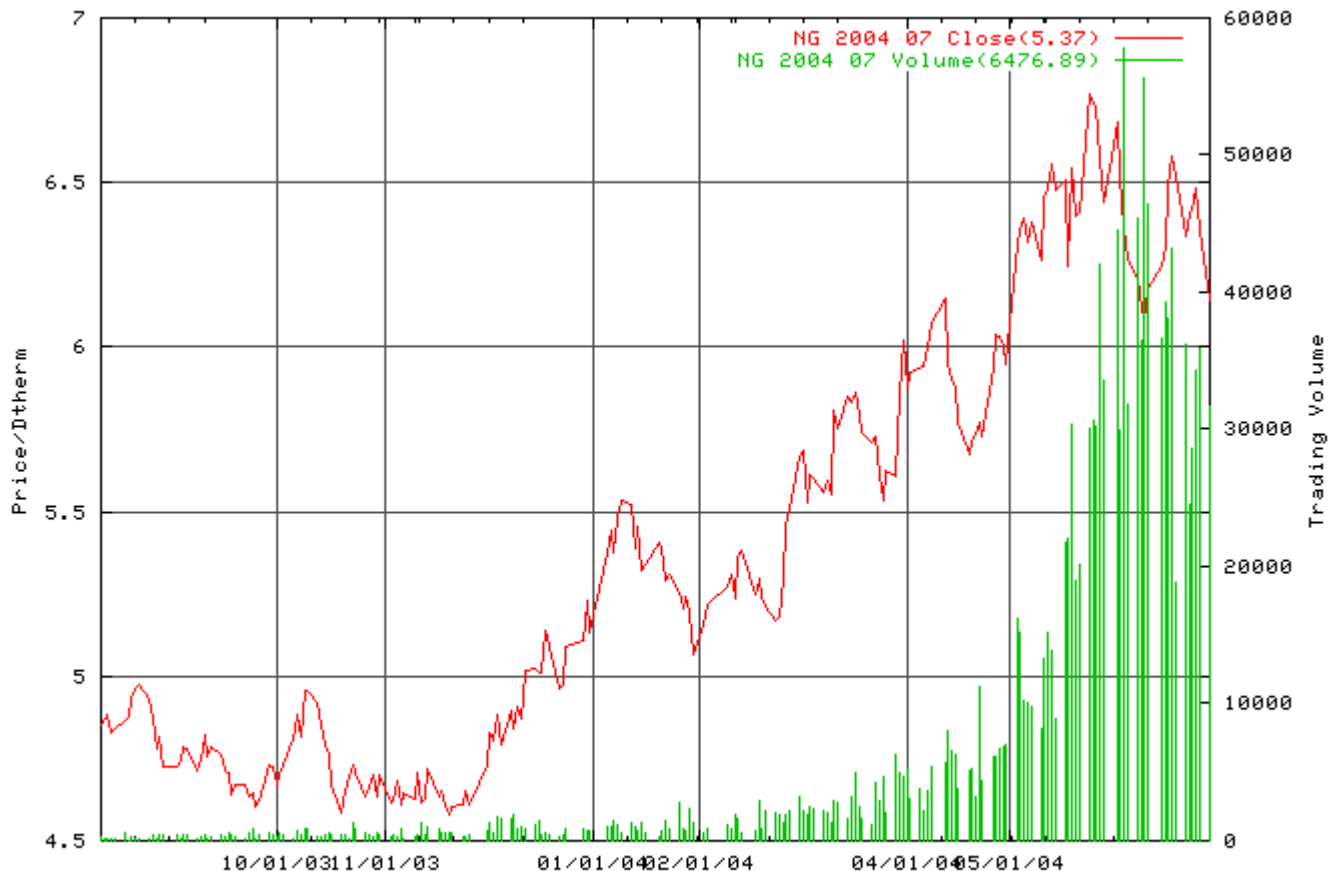
PJM/PSEG average 3 month pricing  
\$46.95 PJM avg, \$53.89 PSEG avg  
May, June, July



[20040501010000 - 20040731230000]



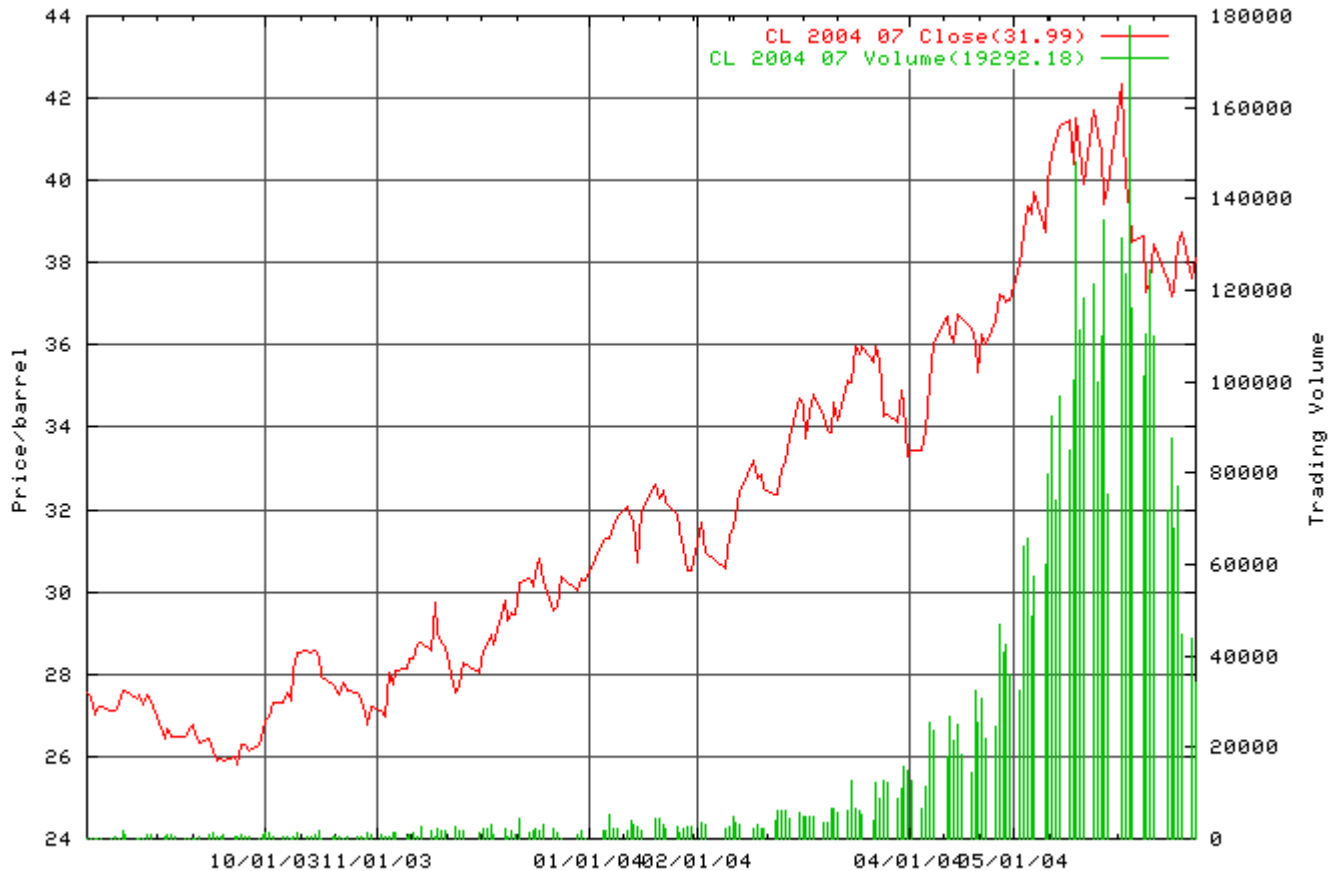
## NYMEX Henry Hub gas 365 day trailing, Jul-04 contract with volume



[20030811000000 - 20040628000000]



## NYMEX Light Sweet Crude 365 day trailing, Jul-04 contract with volume



[20030811000000 - 20040622000000]

Mon Aug 09 22:49:54 2004



## Load Variables Affecting Energy Management Execution

- Campus Load Profiles
- Chilled Water Load Profiles
- Campus Steam Load Profiles
- Turbine Efficiency
- HRSG Efficiency
- Duct Burner Efficiency



## Plant Variables Affecting Energy Management Execution

- Steam/Electric base load chillers
- Individual Chiller Efficiency
- Chiller part load characteristics



## Business Rules Affecting Energy Management Execution

- Chiller Changeover Rules  
Base/Load Follow
- Min/Max Flow requirements
- Duct Burner Low Fire Rules
- Aux Boiler Rules of Engagement  
-Winter/Summer
- Market Gas Ordering and Balancing
- Turbine Economic Shutdown Rules
- Operator Interactive Rules



## Dispatch Challenge

How do we match power, steam, and chilled water demands to plant assets economically at any point in time, and while adhering to the business rules and operational constraints?



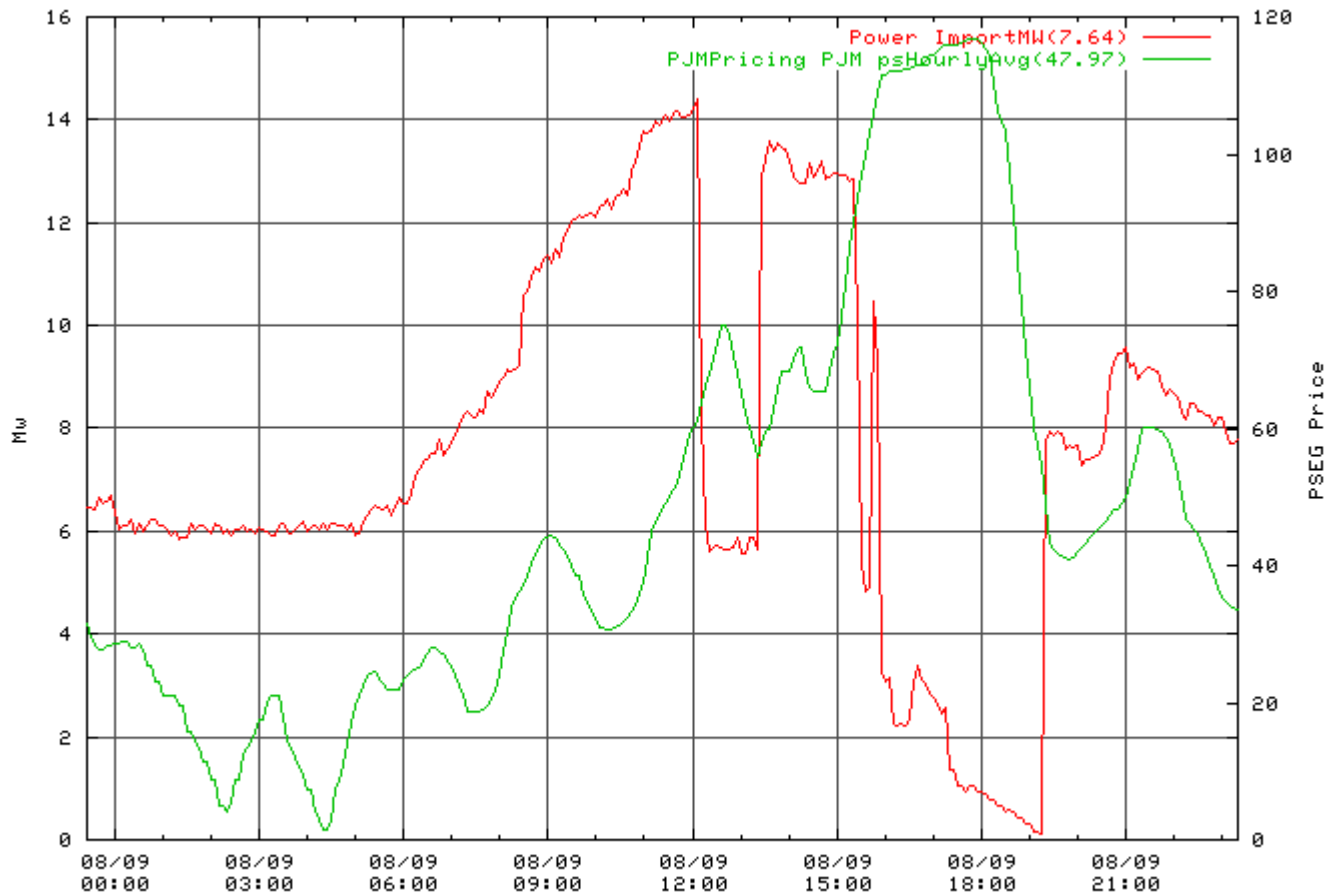
## Dispatch Challenge

- Integration – Execution of market based strategies using:
  - Real time market analytics
  - Predictive strategies
  - Market forwards, underlying fuel futures
  - Process analytics and feedback
  - Internet technologies
  - Database technologies
  - Procurement and risk management
  - Efficiency Management



# Import Power and Market Price

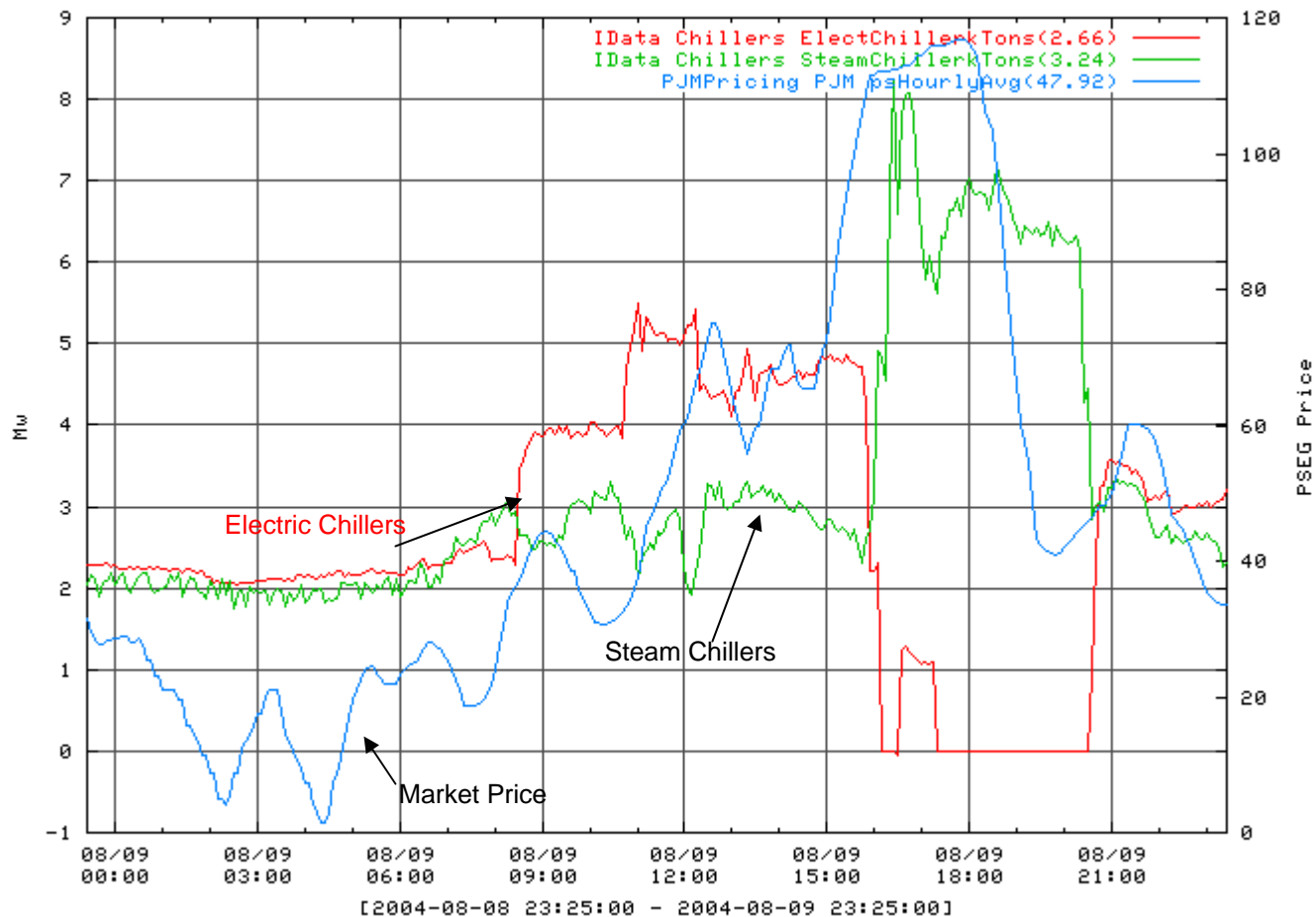
Range of Import – 14 Mw, Range of Price-\$110/Mw



[2004-08-08 23:25:00 - 2004-08-09 23:20:00]



# Chiller Dispatch and Market Price





REQUEST: **Stop Cogen**

CHILLERS: **Electric**

Price \$ **34.69**

Load	Chiller 1 (In) Follow	Chiller 2 (In) Base	Chiller 3 (In) Follow	Chiller 4 (In) Follow	Chiller 5 (In) Base	Chiller 6 (In) Base
Request						
Actual						

Dispatch Changes

Chiller: **All Clear**

Turbine: **All Clear**

- Overview
- Turbine
- Boilers / HRSG
- Chillers
- Market
- Fuel Data
- Logs
- Welcome

Show the past  Hours

- Current Events
- Past Events
- Settings

Showing 46 Events

TimeStamp	Category	Event Description	Select Category
08-09-2004 20:15:50	Chiller 6	Chiller6 is requested to [RUN]	<input checked="" type="checkbox"/> Alarms
08-09-2004 20:15:50	Chiller 6	Chiller6 Load Type changed to BASE	<input checked="" type="checkbox"/> Chillers
08-09-2004 20:15:49	Chillers	Dispatch Changed: Confirmation Requested	<input checked="" type="checkbox"/> Cogen
08-09-2004 20:15:49	Chiller 4	Chiller4 is requested to [STOP]	<input checked="" type="checkbox"/> Chiller 1
08-09-2004 20:15:49	Chiller 4	Chiller4 Load Type changed to FOLLOW	<input checked="" type="checkbox"/> Chiller 2
08-09-2004 20:15:48	Chillers	Chiller selection changed to [ELECTRIC]	<input checked="" type="checkbox"/> Chiller 3
08-09-2004 20:15:48	Chiller 3	Chiller3 is requested to [STOP]	<input checked="" type="checkbox"/> Chiller 4
08-09-2004 20:15:48	Chiller 3	Chiller3 Load Type changed to FOLLOW	<input checked="" type="checkbox"/> Chiller 5
08-09-2004 20:15:48	Chiller 2	Chiller2 is requested to [RUN]	<input checked="" type="checkbox"/> Chiller 6
08-09-2004 20:15:48	Chiller 2	Chiller2 Load Type changed to BASE	<input checked="" type="checkbox"/> Login
08-09-2004 19:56:50	Chiller 4	Chiller4 is requested to [RUN]	
08-09-2004 19:56:47	Chiller 3	Chiller3 is requested to [RUN]	
08-09-2004 19:56:47	Chiller 3	Chiller3 changed to [IN SERVICE]	
08-09-2004 19:56:46	Chiller 4	Chiller4 changed to [IN SERVICE]	
08-09-2004 19:56:33	Login	Ictec Logged IN [192.168.165.4] 1174106612	
08-09-2004 19:13:32	Cogen	Dispatch All Clear	
08-09-2004 19:13:32	Cogen	Dispatch Acknowledged	
08-09-2004 19:12:25	Cogen	Turbine reduction confirmed	
08-09-2004 19:05:44	Cogen	COGEN mode changed to [MAX REDUCE]	
08-09-2004 19:05:43	Cogen	Dispatch Changed: Confirmation Requested	
08-09-2004 17:15:48	Chiller 5	Chiller5 Shutdown	
08-09-2004 16:27:55	Chiller 5	Chiller5 Started	
08-09-2004 16:26:48	Chiller 3	Chiller3 Started	
08-09-2004 16:24:48	Chiller 3	Chiller3 Shutdown	

Showing the past 8.0 hours

Save Events

Refresh



Princeton University - Ictec HMI [1.2]

**REQUEST: Stop Cogen**

**CHILLERS: Electric**

**Price \$ 34.69**

	Chiller 1 (In)	Chiller 2 (In)	Chiller 3 (In)	Chiller 4 (In)	Chiller 5 (In)	Chiller 6 (In)
Load	Follow	Base	Follow	Follow	Base	Base
Request	<span style="color: green;">ON</span>	<span style="color: green;">ON</span>	<span style="color: red;">OFF</span>	<span style="color: red;">OFF</span>	<span style="color: green;">ON</span>	<span style="color: green;">ON</span>
Actual	<span style="color: green;">ON</span>	<span style="color: green;">ON</span>	<span style="color: red;">OFF</span>	<span style="color: red;">OFF</span>	<span style="color: green;">ON</span>	<span style="color: red;">OFF</span>

**Dispatch Changes**  
**Chiller:** All Clear  
**Turbine:** All Clear

Overview
Turbine
Boilers / HRSG
Chillers
Market
Fuel Data
Logs
Welcome

Steam
Electric
Data Trends

**Chiller #2**

58.7% Loaded ON

Request Mode: Run

Load Type: Base

Efficiency: 0.5

Flow: 4.8

Tons: 2,053.6

Supply Temp: 40.6

Power Usage: 1,105.8

Status: In Service

**Chiller #5**

60.2% Loaded ON

Request Mode: Run

Load Type: Base

Efficiency: 0.8

Flow: 2.4

Tons: 1,083.9

Supply Temp: 39.5

Power Usage: ----

Status: In Service

**Chiller #6**

0.0% Loaded OFF

Request Mode: Run

Load Type: Base

Efficiency: 0.8

Flow: 0.0

Tons: 0.0

Supply Temp: 52.3

Power Usage: ----

Status: In Service

Chiller #2
Chiller #5
Chiller #6

Chiller2 i ktons(1.79)

k-Tons

08/09 00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00

**Chillers Headers**

	Front	Rear
Supply	41.1 F	40.8 F
Return	50.7 F	50.7 F
Supply Press	139.8 Psig	
Return Press	87.7 Psig	

**Chiller Totals**

Total Tons	5.50 ktons
Total Steam	12.75
Total Flow	12.07
Equad	10.10

Chiller Dispatch ACK

Unable to Dispatch

[Edit Here](#)

Submit

**Equad 10.10**



## ICAP/Transmission Strategies

- 5 highest PJM hours for ICAP  
Installed capacity charges
- Transmission charges based on  
highest hour
- Campus wide ICAP Strategies
  - Local Distributed Generation
  - Campus Load Reduction  
through Marty's group
  - Steam Chillers



## Economic Performance Improvements

- Implementation
- Learn Process and Establish Rules
- Improved Meter Data for Dispatch
- Create Operator Interactive HMI
- Model loads

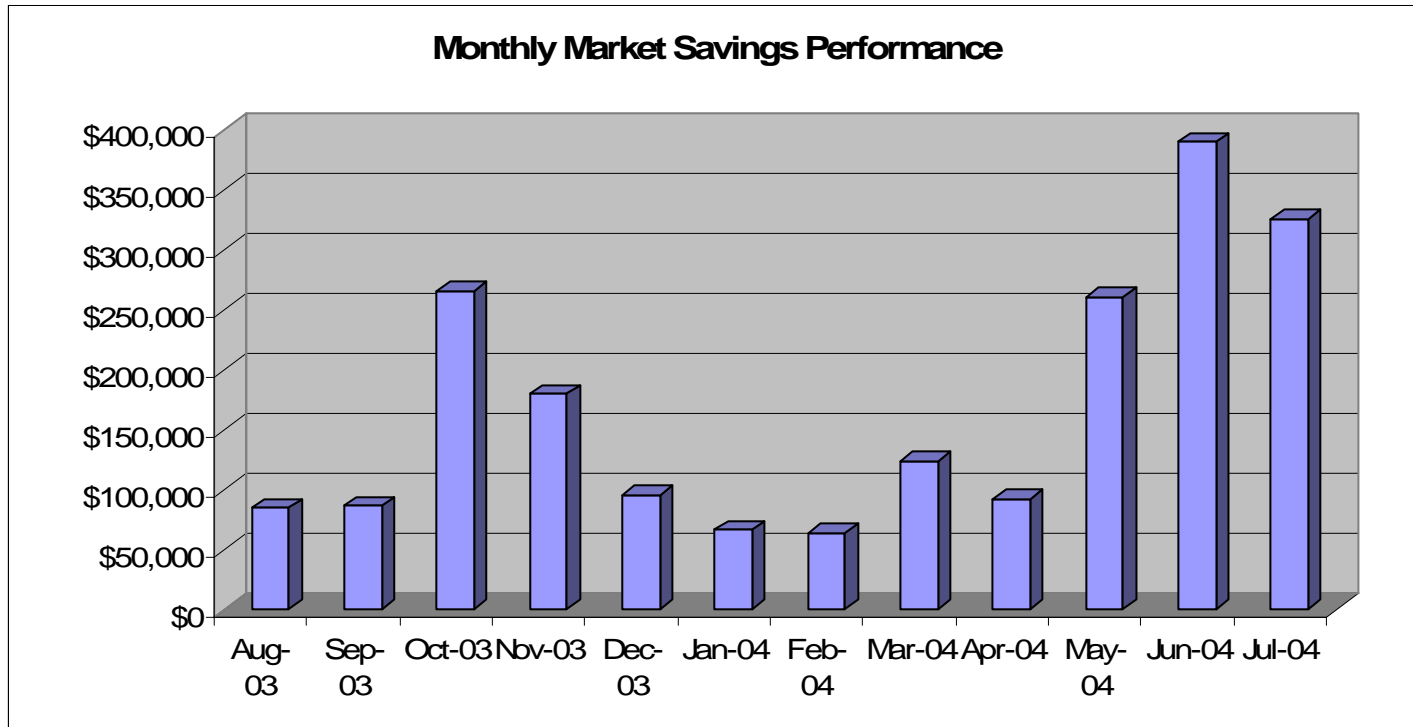


## Future Improvements and Goals

- Wholesale Power Market Transparency
- Create Market Benefits from Optionality
- Chiller Plant Thermal Storage
- Dual Fuel Option for Duct Burner
- Forward purchases of power and fuels
- Increase Shutdown Opportunities



## First Year Performance



**\$2,037,132**