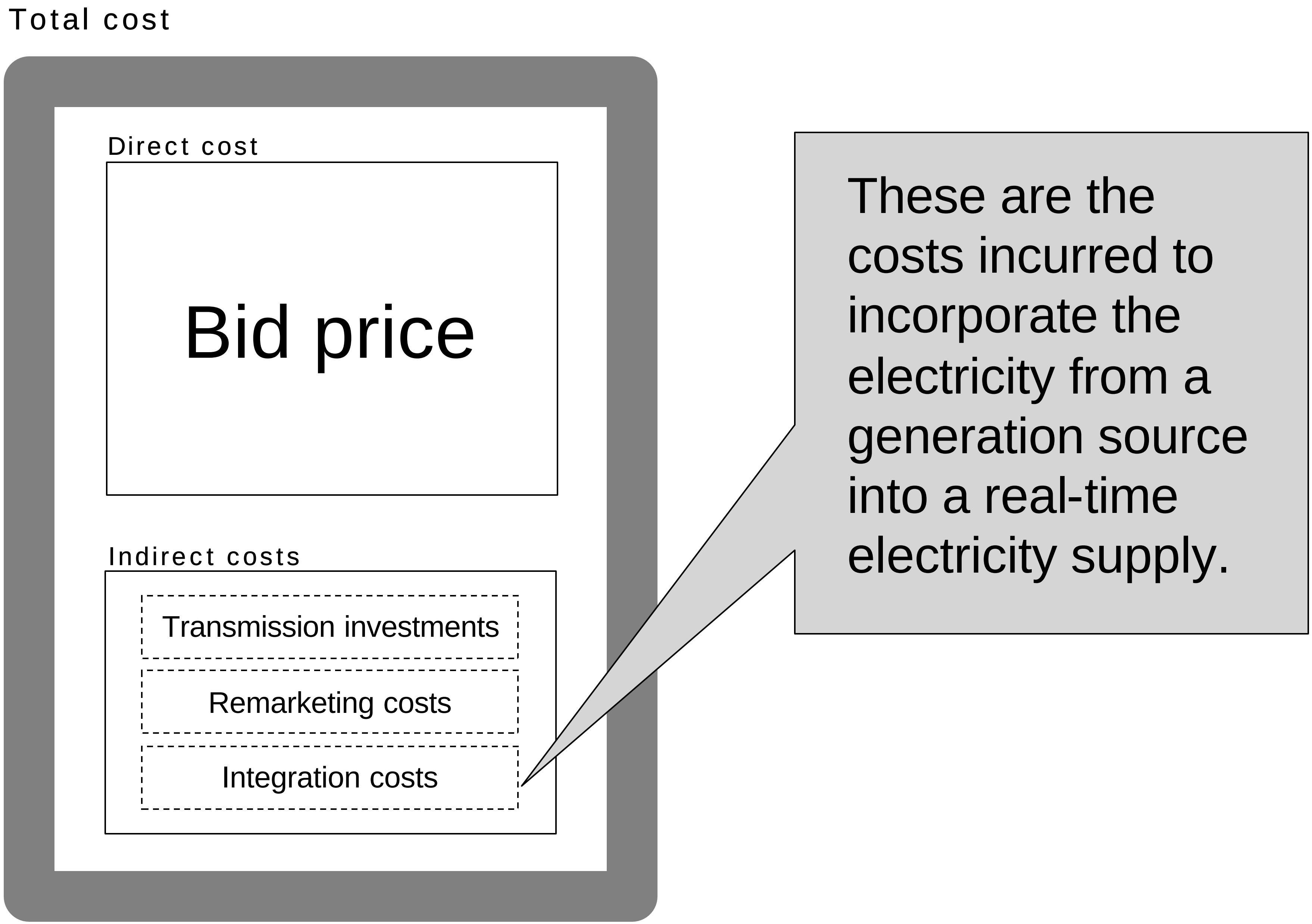
CALIFORNIA RENEWABLES PORTFOLIO STANDARD RENEWABLE GENERATION INTEGRATION ANALYSIS

PHASE 1: ONE YEAR ANALYSIS OF EXISTING RESOURCES

RESULTS AND RECOMMENDATIONS


Total cost
Direct cost
Bid price
Indirect costs
Transmission investments
Remarketing costs
Integration costs
These are the costs incurred to incorporate the electricity from a generation source into a real-time electricity supply.

Timeline

April 23, 2003
Released proposed analysis methodology

April 29, 2003
Discussion of proposed analysis methodology with Working Group

September 12, 2003
Presentation of methodology and results of 2002 California analysis

September 26, 2003
Release of complete report of Phase 1 results and recommendations

November 22, 2002

In CalWEA workshop Wind Valuation and Integration: Incorporating Wind in the Least-Cost/Best-Fit Process*, the Working Group is formed and the issue is discussed*

January 17, 2003

In a follow-up conference call, the Integration Methods Group is formed and tasked with developing the methodology

• • • • • •

Phase I • through 3rd Quarter 2003

Analysis of integration costs for existing renewable and non-renewable generation

Phase II • through 4th Quarter 2003

Evaluate attributes affecting integration analysis

Phase III • through 2nd Quarter 2004

Finalize methodology to identify integration costs and capacity credit to be applied to bids for new and existing renewables

Deliverable
Methodology

PHASE I:
Analysis of Integration Costs for Existing Generation

- *Develop and document methodologies for evaluating the integration costs and capacity credit.*
- *Complete the analyses for existing renewable and non-renewable generation types over a representative one year period and evaluate results.*
- *Primary investigators in Methods Group:*
  - *David Hawkins, California ISO*
  - *Brendan Kirby, ORNL*
  - *Yuri Makarov, California ISO*
  - *Michael Milligan, NREL*
- *The final report documenting the one year analysis results of existing generation resources is scheduled for release on September 26, 2003.*

PHASE II:
Evaluate Attributes Affecting Integration Analysis

- *Identify the key attributes of renewable generators that affect integration costs and capacity credit.*
- *Attributes may include:*
  - *various generator technologies*
  - *location*
  - *climate*
  - *level of penetration*
- *Completion of Phase II is expected in December 2003.*

PHASE III:
Finalize Methodology for Integration Costs and Capacity Credit for RPS Bids

- *Modify the methodology developed in Phase I so that the attributes identified in Phase II can be correctly modeled in the analysis.*
- *The final methodology will be released openly to the public and project bidders.*
- *Completion of Phase III is expected in June 2004.*

Further Information

- *Website:*
  - *http://cwec.ucdavis.edu/rpsintegration/*
- *You can subscribe to one of the following mailing lists through the website:*
  - *rpsintegration-workinggroup@cwec.ucdavis.edu*
    - an open mailing list for discussion of the development of the valuation methodologies; potentially high traffic volume
  - *rpsintegration-announcements@cwec.ucdavis.edu*
    - an open mailing list announcing key events relevant to the valuation methodologies

Goals of Phase I of the Integration Analysis Effort

- *Identify significant characteristics of California's load and installed renewable and conventional generators.*
- *Define and implement methodologies for evaluating the capacity credit for renewables.*
- *Determine the capacity credit of various renewable and conventional generators.*
- *Define and implement methodologies for evaluating integration costs.*
- *Determine cost adders for regulation and load following for various renewable and conventional technologies.*

One Minute Data Set

Plant Information “PI” Data System

- *Standardized commercial database system.*
- *Records data obtained from generators throughout the state.*
- *Database contains over 180,000 data fields.*
- *Data compression is used to minimize storage.*
- *Units are identified by specific tags (“PI tags”).*
- *Data was downloaded through a Microsoft Excel interface and output as two files per day.*

Data Extracted

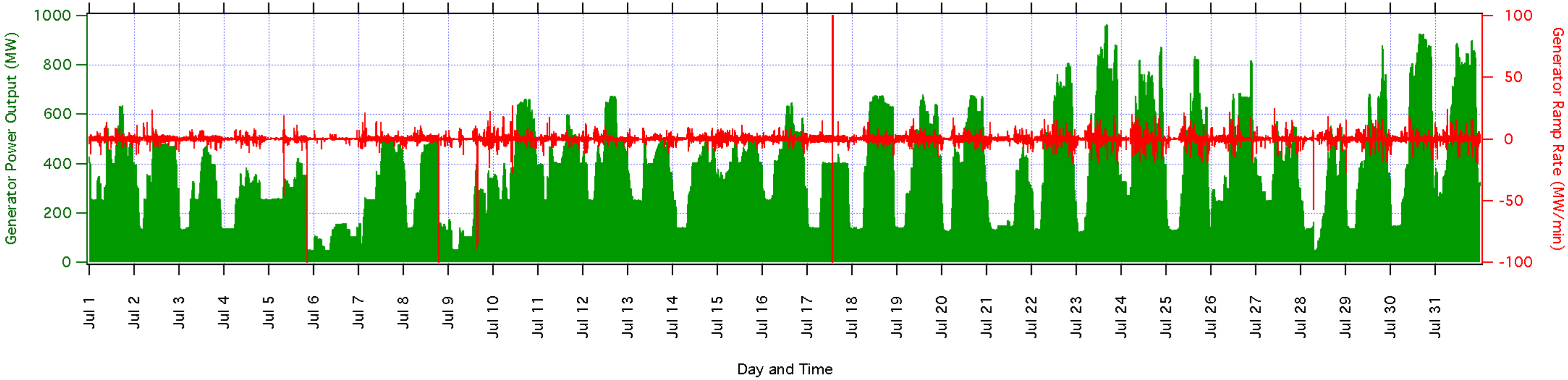
- *Annual One Minute Data (525,600 data points)*
- *System Conditions*
- *Representative Conventional Generators*
  - *Eleven Generators of Various Types and Sizes*
  - *Automatically Controlled Units*
  - *Dispatcher Controlled Units*
- *Representative Renewable Generators*
  - *Solar*
  - *Geothermal*
  - *Biomass*
  - *Wind Total and by Region*

System Conditions

- *Total Load and Generation (MW)*
- *Actual and Scheduled Frequency (Hz)*
- *Actual and Scheduled Interchange (MW)*
- *Dynamic Interchange Schedule (MW)*
- *Area Control Error (MW)*
- *Total Regulation (MW)*
- *Deviation from Preferred Operating Point (MW)*

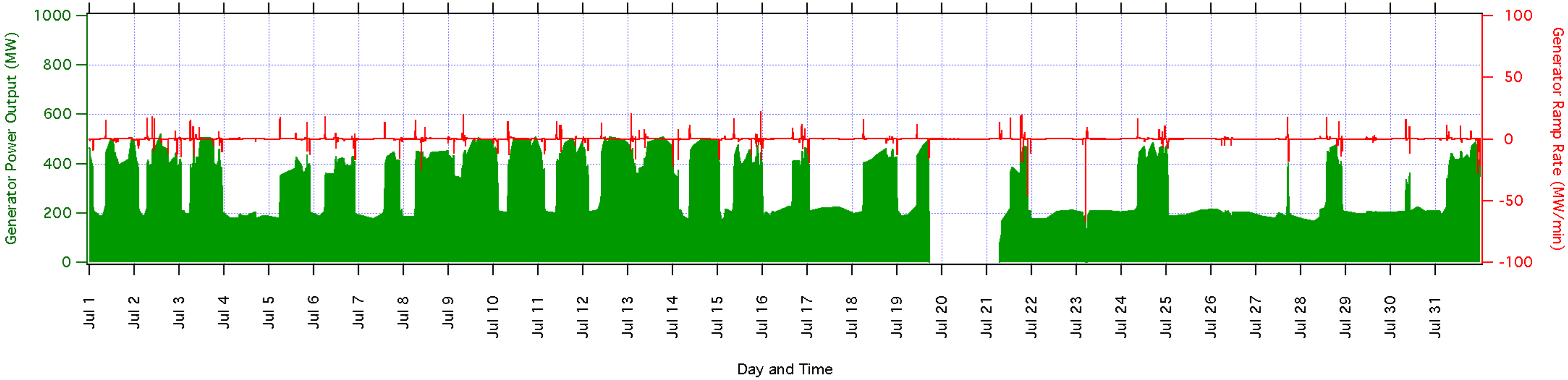
Automatically Controlled Generators

- *Movements are controlled automatically by a computerized control system.*



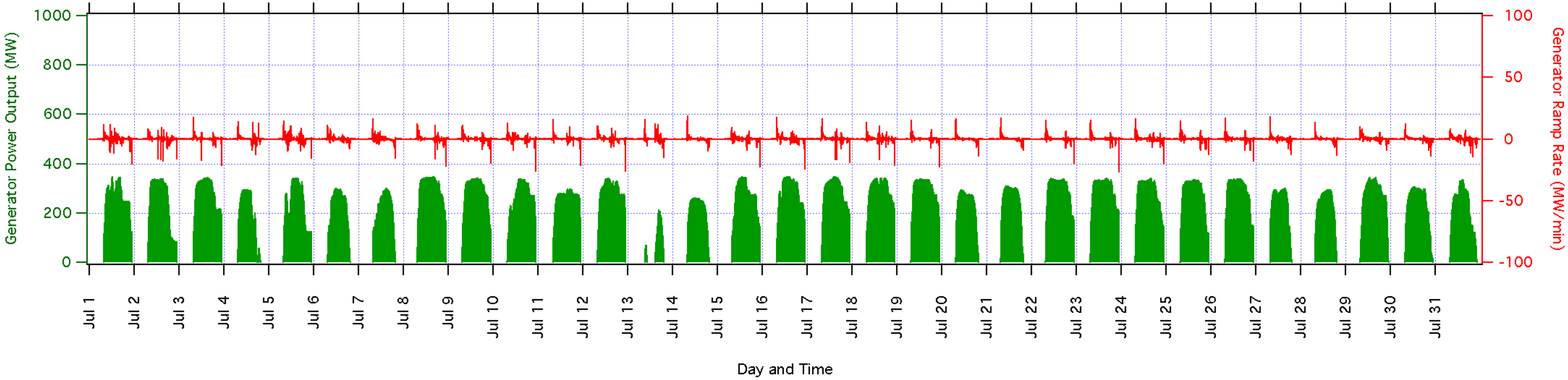
Dispatcher Controlled Generators

- *Movements controlled by dispatcher instructions.*



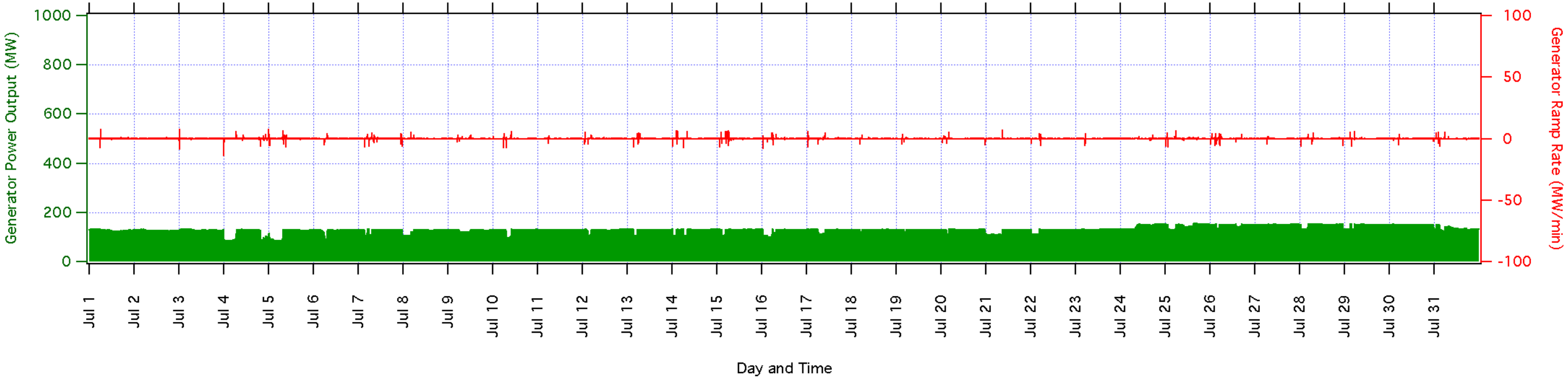
Solar

- *Aggregation of several generation units.*



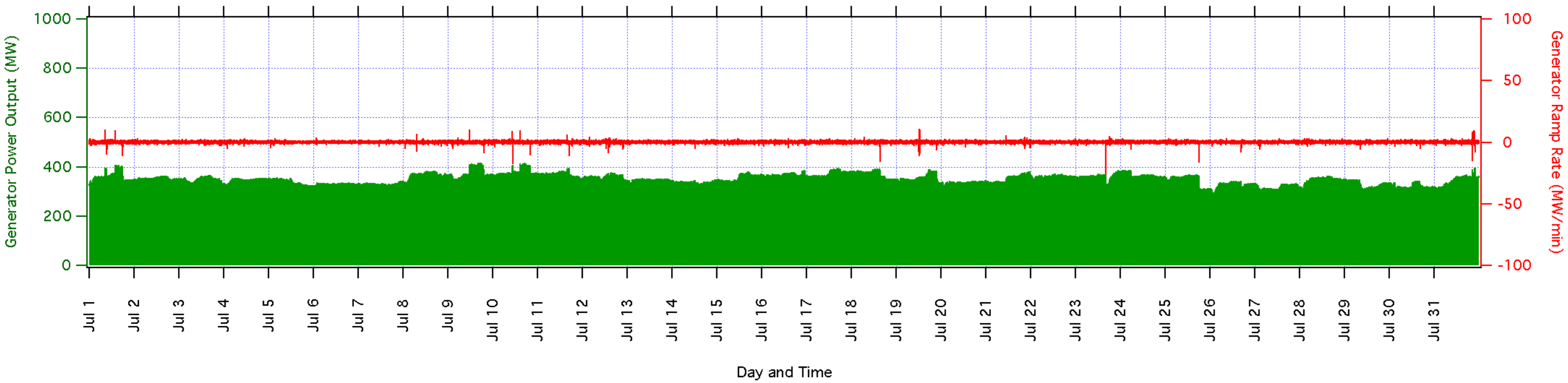
Geothermal

- *Aggregation of several generation units.*



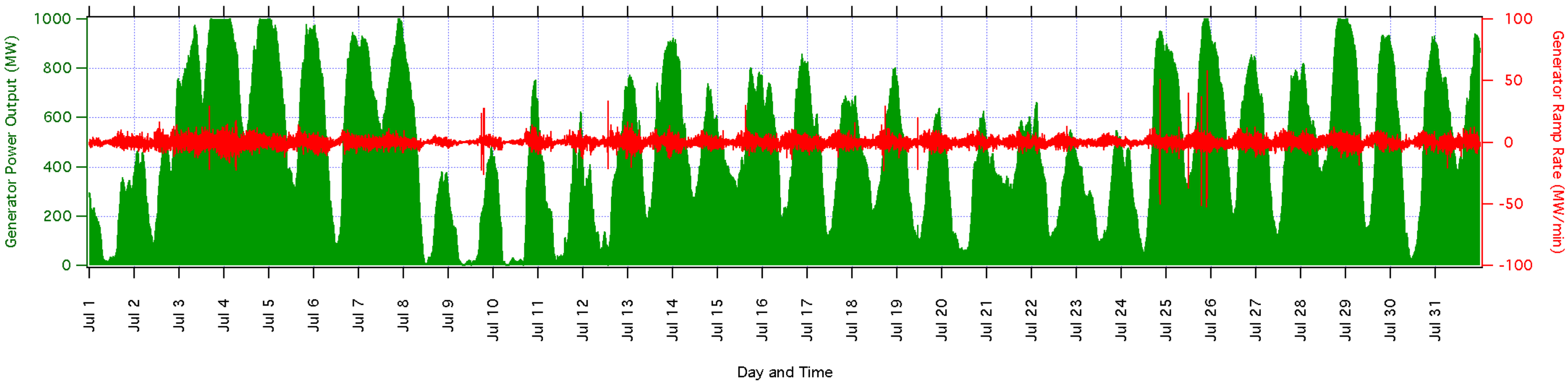
Biomass

- *Aggregation of several units.*



Wind

- *Aggregation of multiple wind turbines.*
- *Regional*
  - *Altamont*
  - *Tehachapi*
  - *San Gorgonio*
  - *Total*



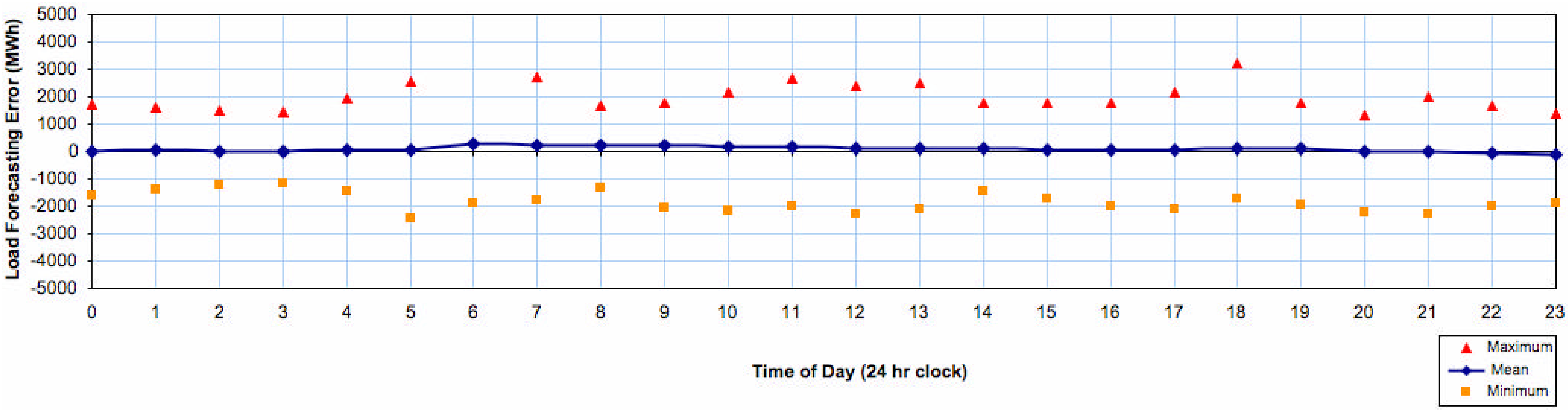
One Hour Data Set

One Hour Data Selection

- *OASIS: Open Access Same-Time Information System*
  - *Public, web-based system for selected CalSO data.*
    - http://oasis.caiso.com/
  - *Load forecasts and schedules.*
  - *Regulation capacity purchases.*
  - *Load following energy purchases.*
- *CalSO Non-Operational Generating Units Reports*
  - *Generator outages.*

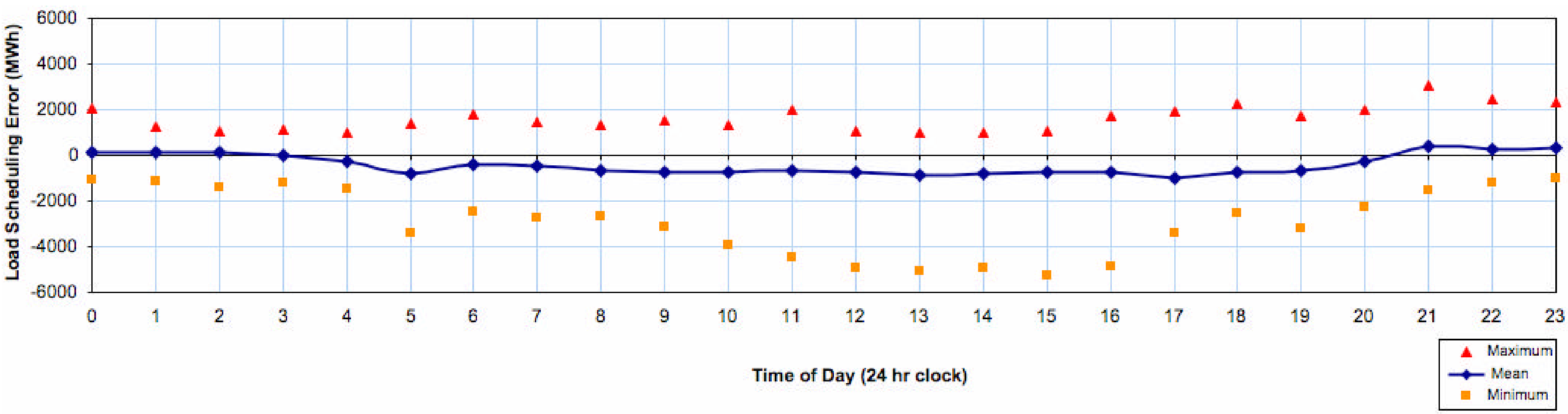
Forecast Hour Ahead Load

- *CaISO forecast of load for hour ahead market.*
- *Load is estimated 150 minutes ahead of time.*
- *Forecasted load can be about 2200 MW less than actual load for some hourly time periods.*
- *Forecasted load is nearly unbiased and average forecasting error is close to zero.*

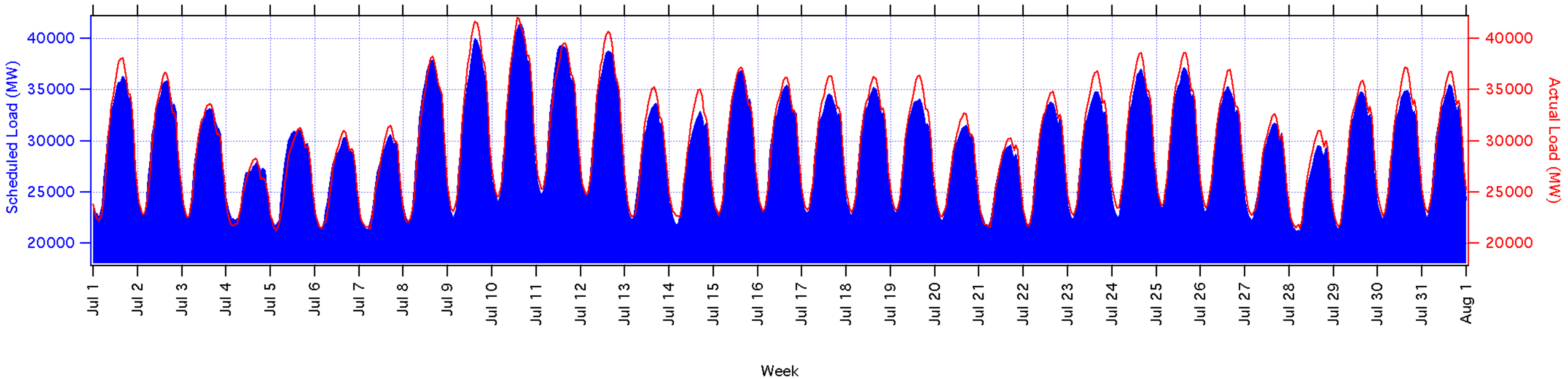


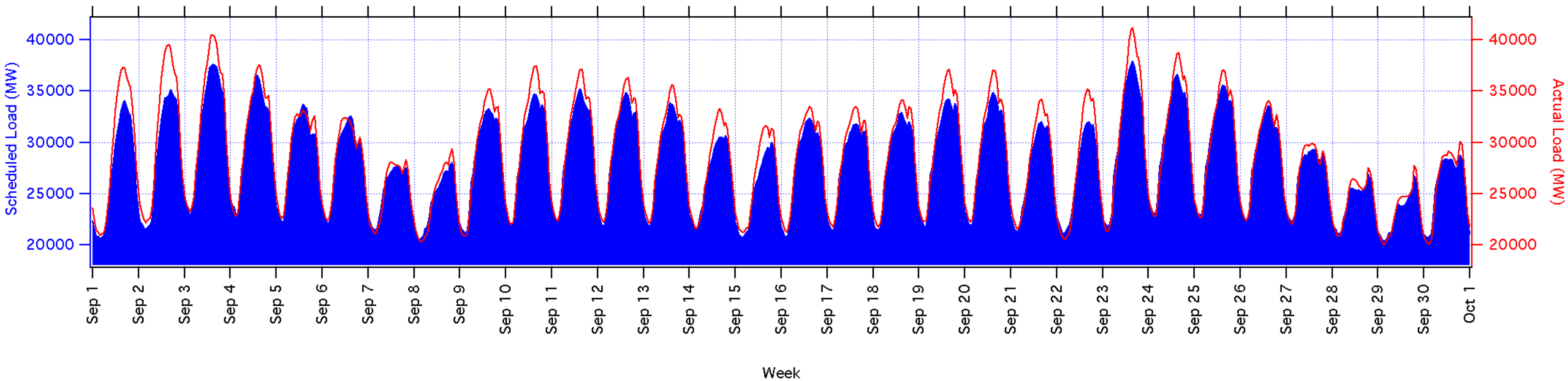
Scheduled Hour Ahead Load

- *Hour ahead schedules are submitted to CalSO by the scheduling coordinators.*
- *Scheduled load can be as much as 5000 MW less than the actual load during some hours of the year.*
- *The load scheduling error is defined as the scheduled load minus the actual load.*
- *Scheduling error is most negative during the day.*



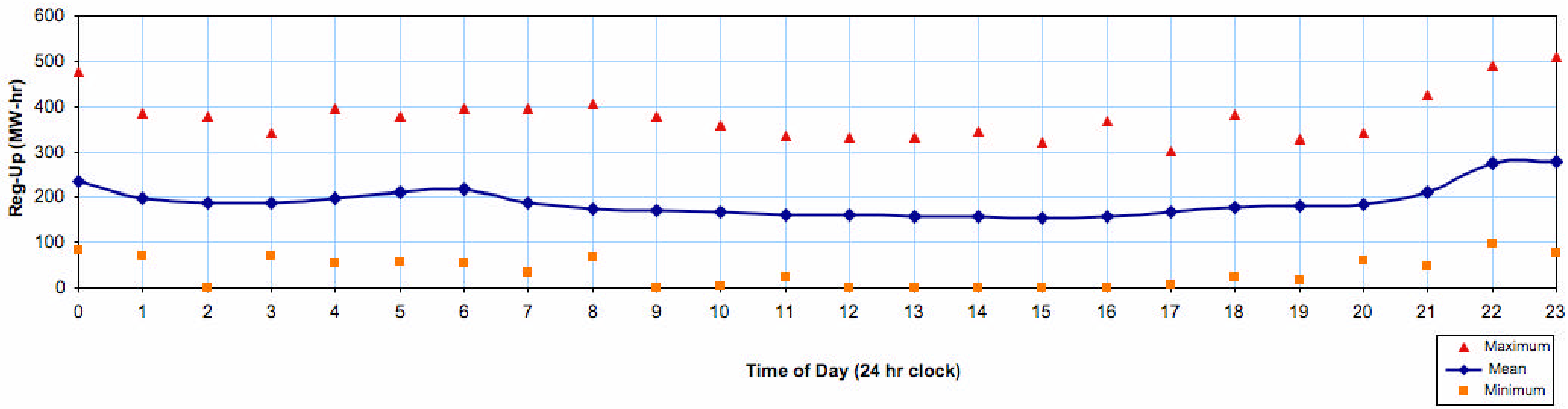
Scheduled Hour Ahead Load





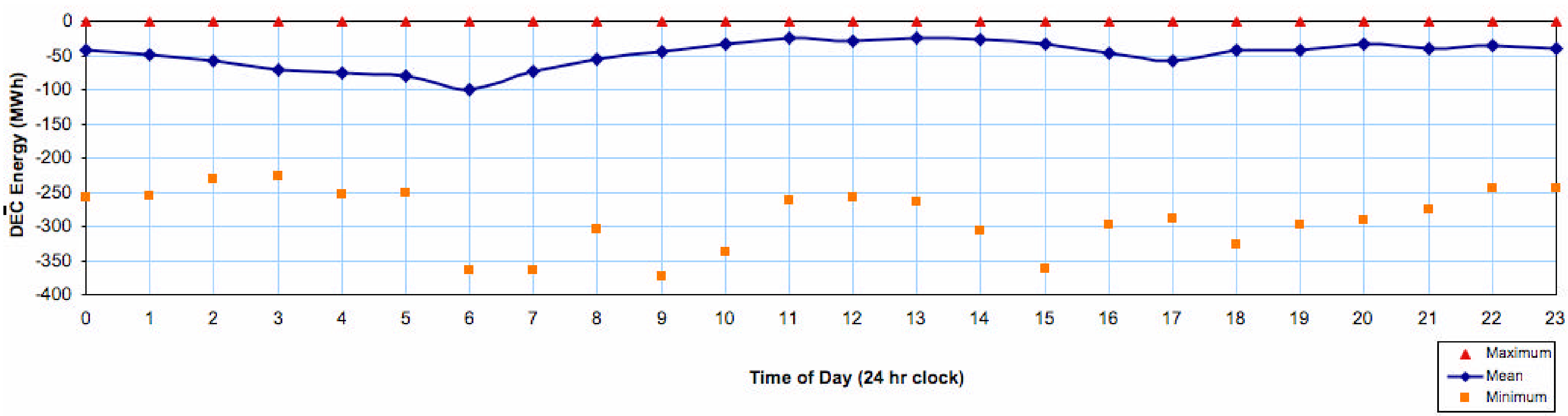
Regulation Purchases

- *Regulation is an ancillary service which is purchased hourly.*
- *One MW of regulation capacity service provided for one hour is denoted as one MW-hr (Note: Regulation is a capacity service and one MW-hr of capacity is not equivalent to one MWh of energy).*
- *CaISO purchases two kinds of regulation service.*
  - *Regulation up*
  - *Regulation down*
- *The OASIS data contains both the amount and the price for each of the services procured for every hour of the year.*



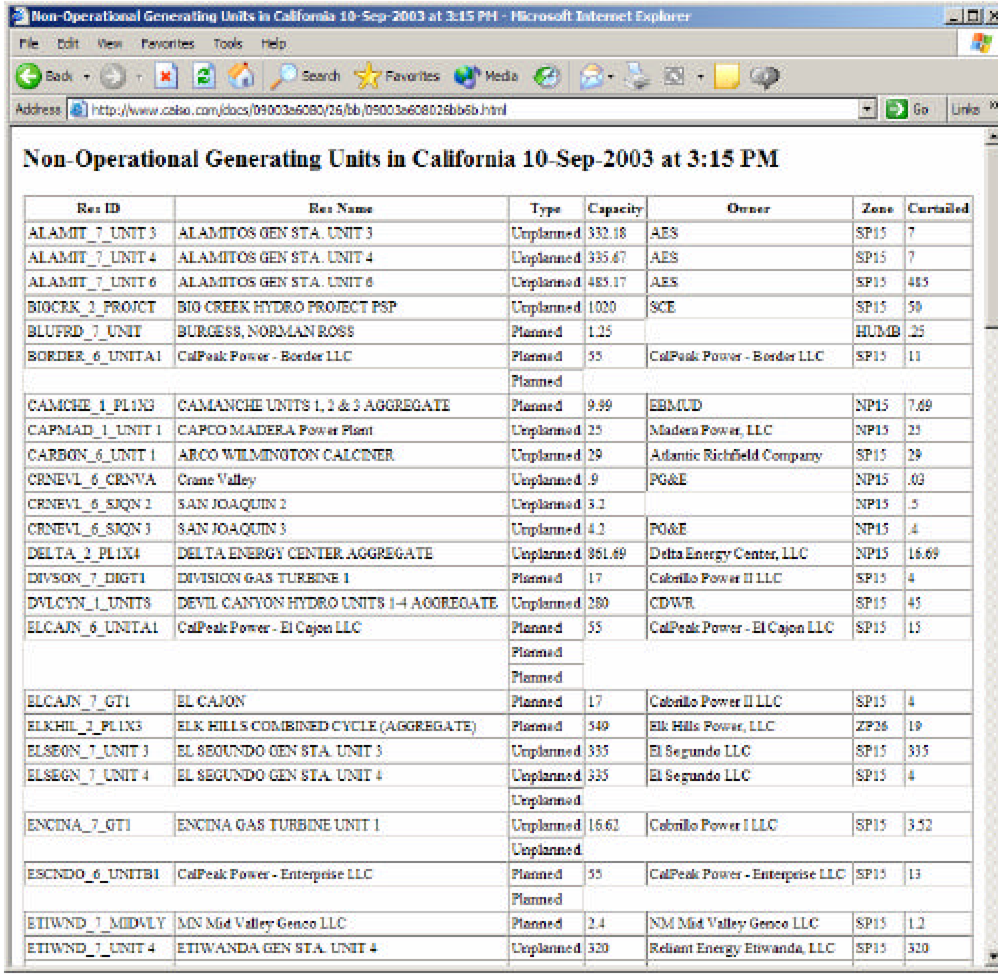
Supplemental Energy Purchases

- *The supplemental energy market provides two types of purchases.*
  - *Incremental (INC) energy*
  - *Decremental (DEC) energy*
- *The supplemental energy market operates every ten minutes, but data were averaged to hourly values for use in this analysis.*



Generator Outage Data

- *Publicly available reports on CalSO website*
- *Reports back to January 1, 2001*
- *Four reports published each day*
- *Includes:*
  - *Specific generator*
  - *Amount of capacity curtailed*
  - *Planned/unplanned outage*



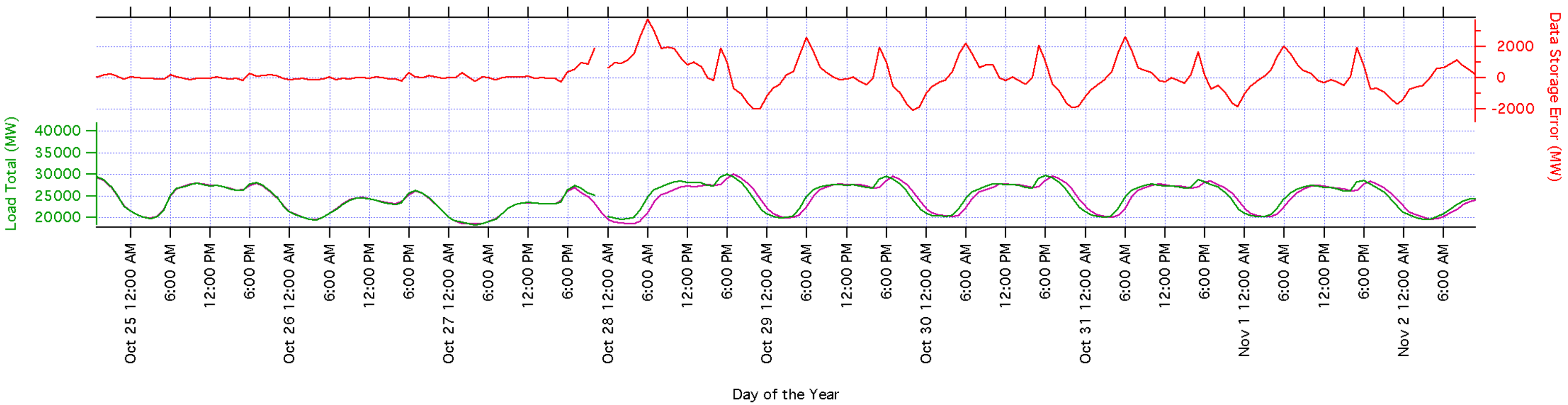
Non-Operational Generating Units in California 10-Sep-2003 at 3:15 PM

Res ID	Res Name	Type	Capacity	Owner	Zone	Curtailed
ALAMIT_7_UNIT 3	ALAMITOS GEN STA. UNIT 3	Unplanned	332.18	AES	SP15	7
ALAMIT_7_UNIT 4	ALAMITOS GEN STA. UNIT 4	Unplanned	335.67	AES	SP15	7
ALAMIT_7_UNIT 6	ALAMITOS GEN STA. UNIT 6	Unplanned	485.17	AES	SP15	485
BIGCRK_2_PROJCT	BIG CREEK HYDRO PROJECT PSP	Unplanned	1020	SCE	SP15	50
BLUFRD_7_UNIT	BURGESS, NORMAN ROSS	Planned	1.25		HUMB	.25
BORDER_6_UNITA1	CalPeak Power - Border LLC	Planned	55	CalPeak Power - Border LLC	SP15	11
		Planned				
CAMCHE_1_PL1X3	CAMANCHE UNITS 1, 2 & 3 AGGREGATE	Planned	9.99	EBMUD	NP15	7.69
CAPMAD_1_UNIT 1	CAPCO MADERA Power Plant	Unplanned	25	Madera Power, LLC	NP15	25
CARBGN_6_UNIT 1	ARCO WILMINGTON CALCINER	Unplanned	29	Atlantic Richfield Company	SP15	29
CRNEVL_6_CRNVA	Crane Valley	Unplanned	.9	PG&E	NP15	.03
CRNEVL_6_SJQN 2	SAN JOAQUIN 2	Unplanned	3.2		NP15	.5
CRNEVL_6_SJQN 3	SAN JOAQUIN 3	Unplanned	4.2	PG&E	NP15	.4
DELTA_2_PL1X4	DELTA ENERGY CENTER AGGREGATE	Unplanned	861.69	Delta Energy Center, LLC	NP15	16.69
DIVSON_7_DIGT1	DIVISION GAS TURBINE 1	Planned	17	Cabrillo Power II LLC	SP15	4
DVLCYN_1_UNITS	DEVIL CANYON HYDRO UNITS 1-4 AGGREGATE	Unplanned	280	CDWR	SP15	45
ELCAJN_6_UNITA1	CalPeak Power - El Cajon LLC	Planned	55	CalPeak Power - El Cajon LLC	SP15	15
		Planned				
		Planned				
ELCAJN_7_GT1	EL CAJON	Planned	17	Cabrillo Power II LLC	SP15	4
ELKHIL_2_PL1X3	ELK HILLS COMBINED CYCLE (AGGREGATE)	Planned	549	Elk Hills Power, LLC	ZP26	19
ELSEGN_7_UNIT 3	EL SEGUNDO GEN STA. UNIT 3	Unplanned	335	El Segundo LLC	SP15	335
ELSEGN_7_UNIT 4	EL SEGUNDO GEN STA. UNIT 4	Unplanned	335	El Segundo LLC	SP15	4
		Unplanned				
ENCINA_7_GT1	ENCINA GAS TURBINE UNIT 1	Unplanned	16.62	Cabrillo Power I LLC	SP15	3.52
		Unplanned				
ESCNDO_6_UNITB1	CalPeak Power - Enterprise LLC	Planned	55	CalPeak Power - Enterprise LLC	SP15	13
		Planned				
ETIWND_7_MIDVLY	MN Mid Valley Genco LLC	Planned	2.4	NM Mid Valley Genco LLC	SP15	1.2
ETIWND_7_UNIT 4	ETIWANDA GEN STA. UNIT 4	Unplanned	320	Reliant Energy Etiwanda, LLC	SP15	320

Data Processing

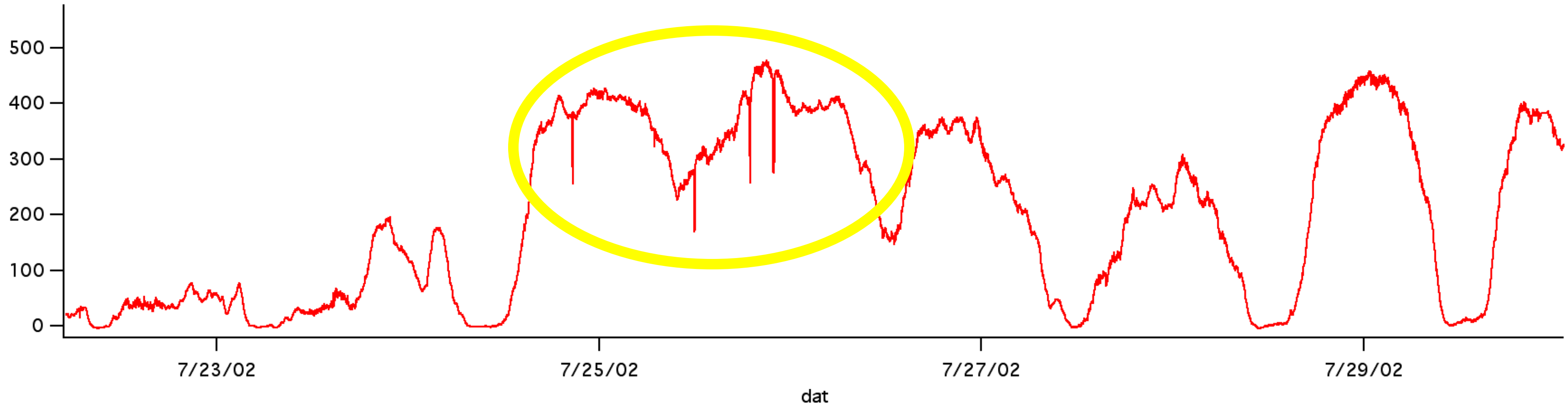
Data Processing

- *Organized raw data from two daily files into annual one minute files.*
- *Corrected data errors.*
  - *Dropouts and spikes.*
  - *Time change (standard to daylight savings).*
- *Created hourly average data from the one minute files.*



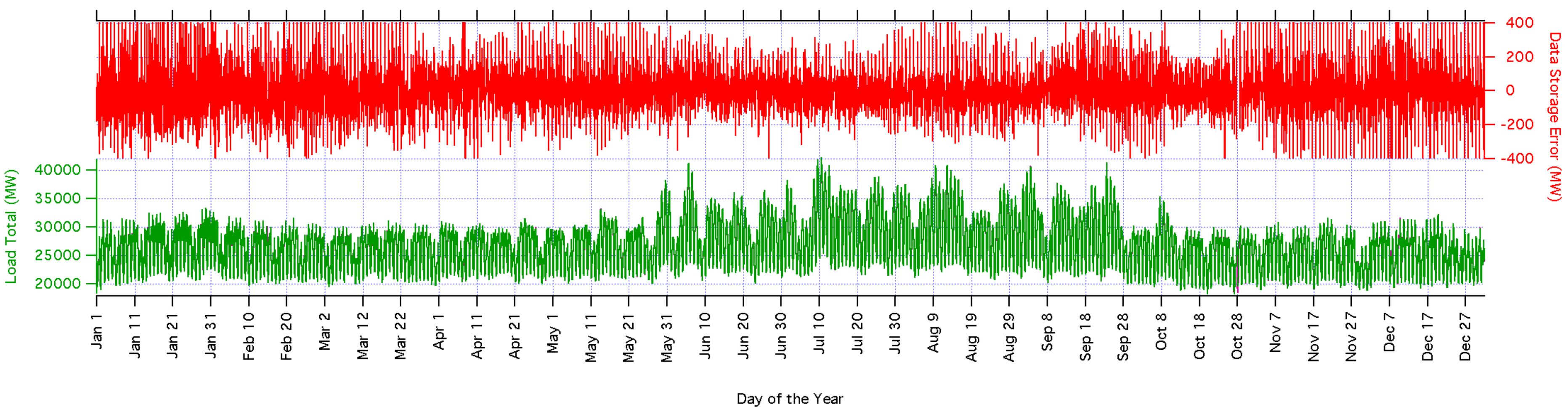
Data Corrections

- *Performed a visual inspection of the data set and corrected obvious errors.*
- *Identified bad data were removed and left as blanks.*
- *There are 525,600 data points per signal.*
- *Not all bad data could be corrected.*



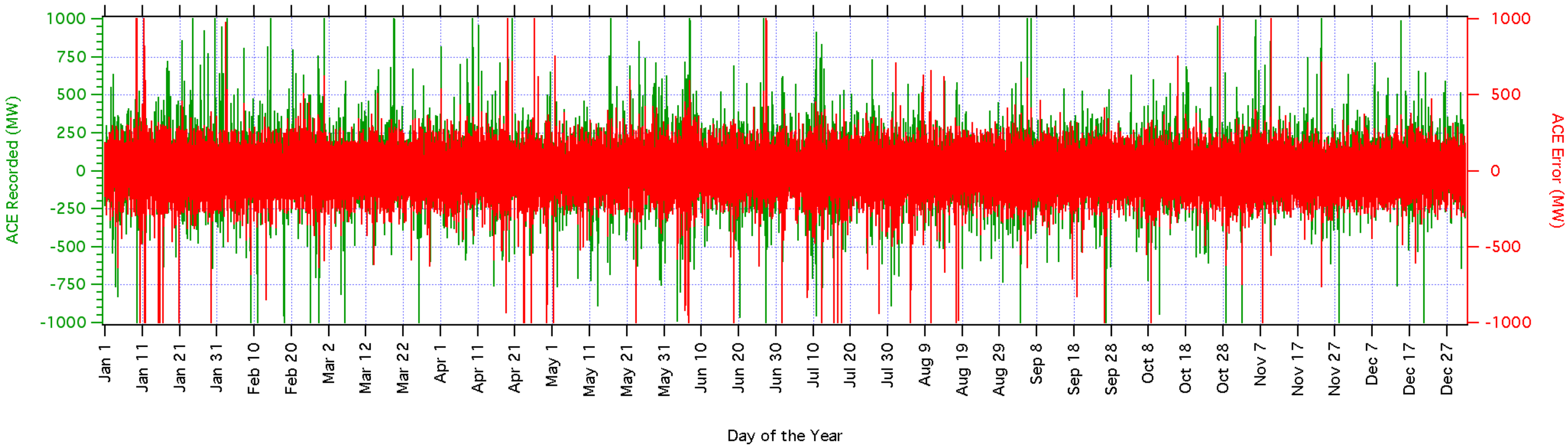
Load Data Storage Error

- *Compared load from one minute data set against load from OASIS hourly data set.*
- *Calculated data storage error for hourly data.*
- *The standard deviation of data storage error is 160 MW or ±0.6% of the average annual load.*



ACE Error

- *Calculated ACE from one minute system data using control area tie line flows and frequencies.*
- *Calculated the error between the recorded values of ACE as stored in PI system and the calculated ACE from data.*
- *The standard deviation of ACE error is 140 MW or ± 0.5% of average system load.*



Capacity Credit Analysis

Overview of Approach

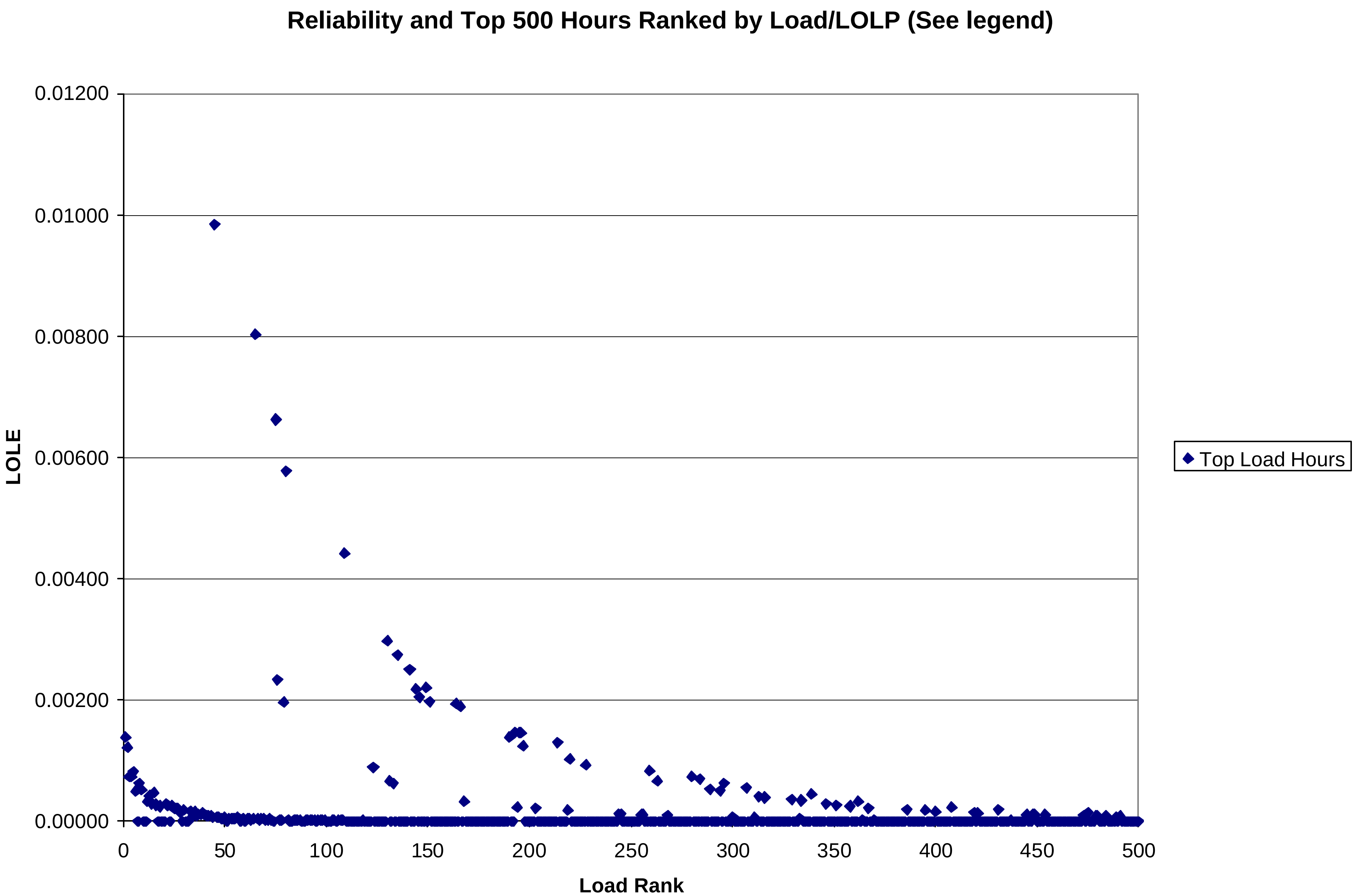
- *Method:*
  - *Reliability model used to calculate effective load carrying capability (ELCC) for each intermittent renewable generator*
  - *For each intermittent renewable generator (solar, wind), calculated 24 statistical distributions per week, one for each hour of the day (1,248 distributions/year)*
  - *One geothermal case also used this method*
  - *Each distribution based on actual generation data*

- *Non-intermittent renewable technologies require different representation in model*
- *Use capacity and forced outage data, similar to conventional generators*

- *Method*
  - *Calibrated system load so that standard risk (1 day/10 years) LOLE with renewables, and without hypothetical gas benchmark unit*
  - *Compared each renewable generator, one at a time, to a hypothetical gas benchmark plant*
  - *This was done by removing the renewable plant of interest, then substituting the hypothetical gas plant at several alternative sizes until the reliability target was met*

Overview of Approach

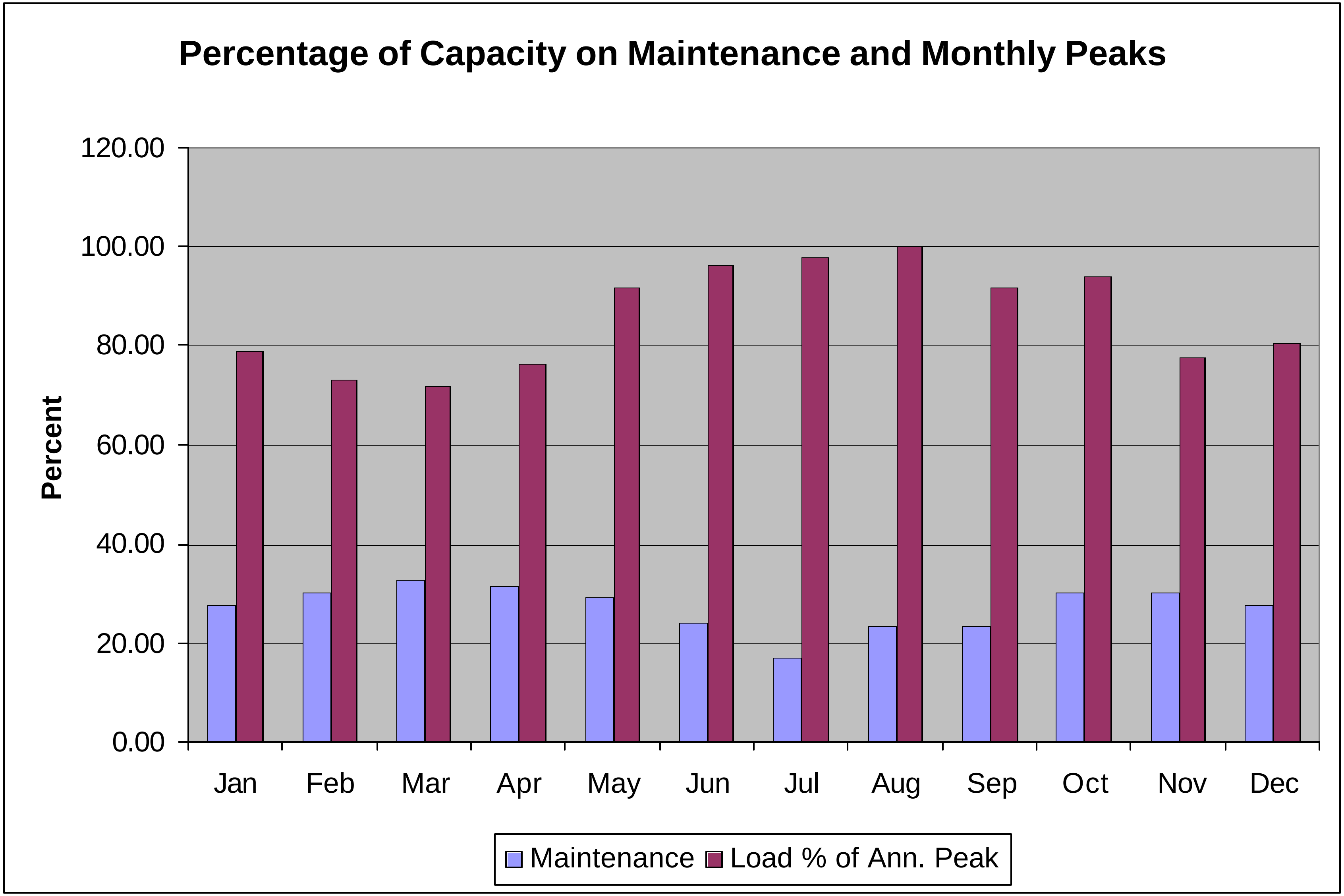
- *Data:*
  - *Conventional generator capacity and forced outage rates from Resource Data International's (RDI) BaseCase database (unable to obtain data from CalSO)*
  - *Maintenance outage schedules derived from data on CalSO web site*
  - *Renewable data from CalSO PI system*



Reliability and Top 500 Hours Ranked by Load/LOLP (See legend)
0.01200
0.01000
0.00800
0.00600
0.00400
0.00200
0.00000
LOLE
0
50
100
150
200
250
300
350
400
450
500
Load Rank
Top Load Hours

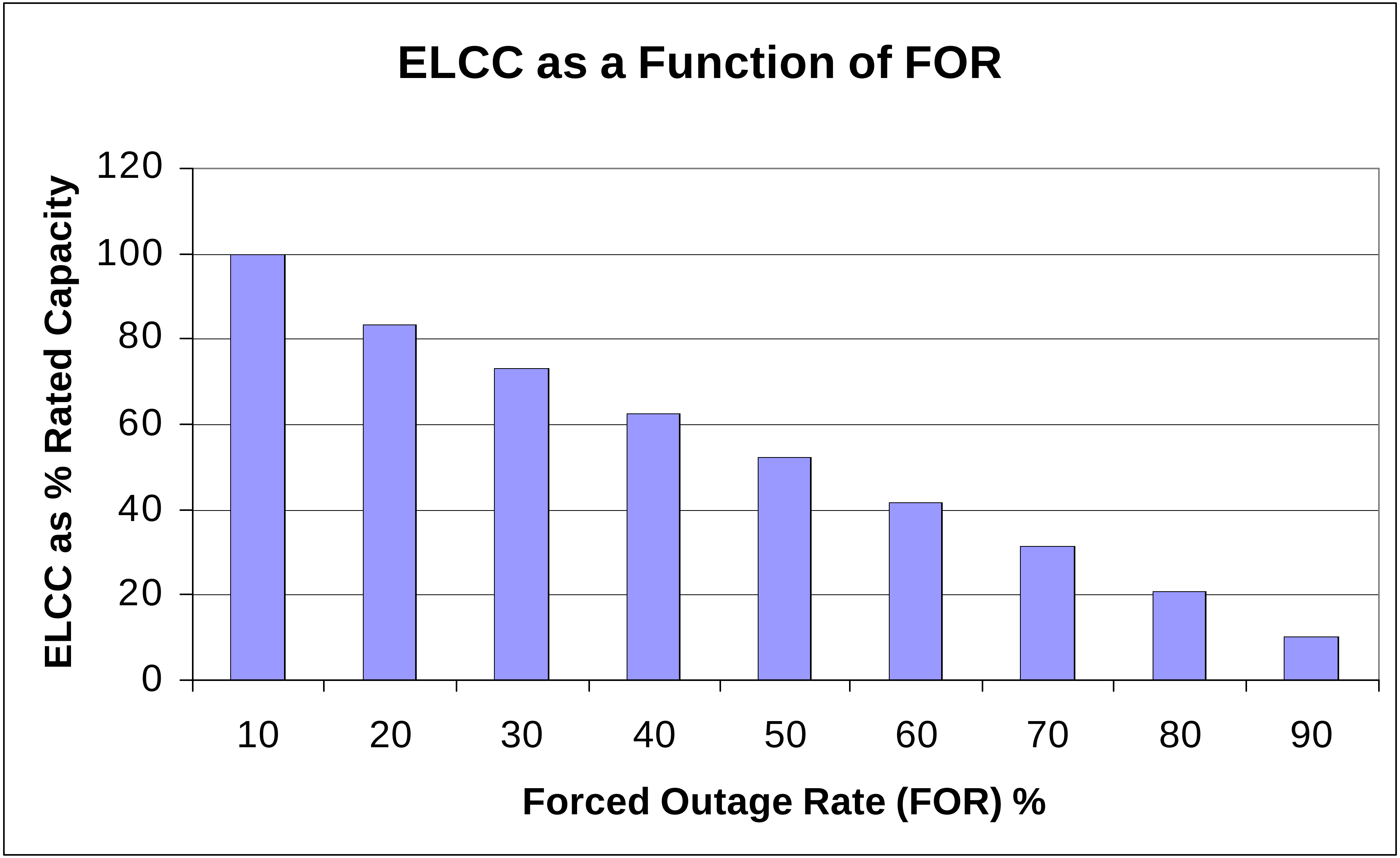
Disparity Between High-Load Hours and High-Risk Hours

- *Caused by uncoordinated maintenance scheduling*
- *Peak hour occurs in August*
- *Highest risk hours in October when many units out for maintenance*
- *Recommend a separate study of the CA system to determine impacts of alternative maintenance scheduling to minimize risk*

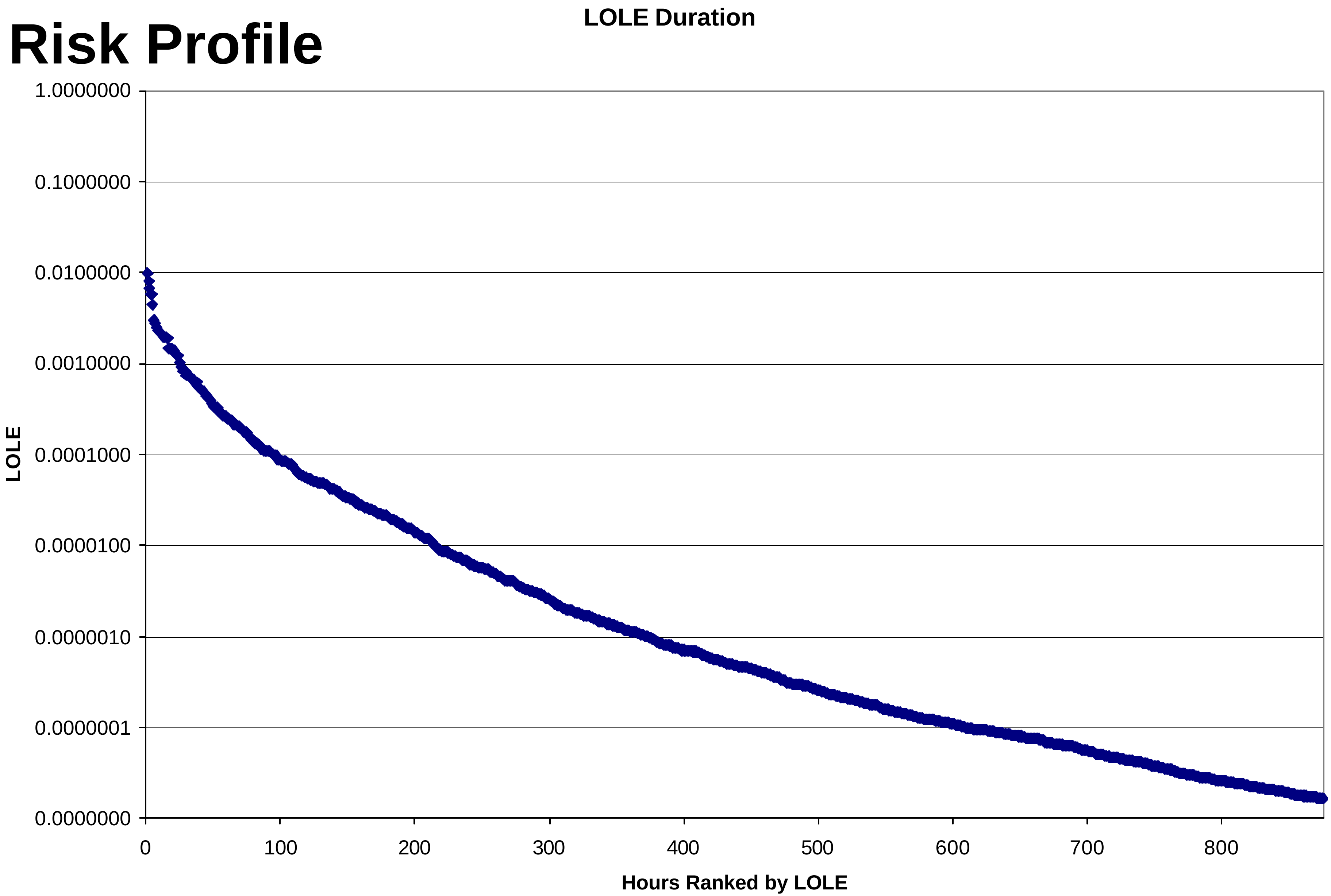


Percentage of Capacity on Maintenance and Monthly Peaks
Percent
120.00
100.00
80.00
60.00
40.00
20.00
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Maintenance
Load % of Ann. Peak

Generic 100 MW Plant



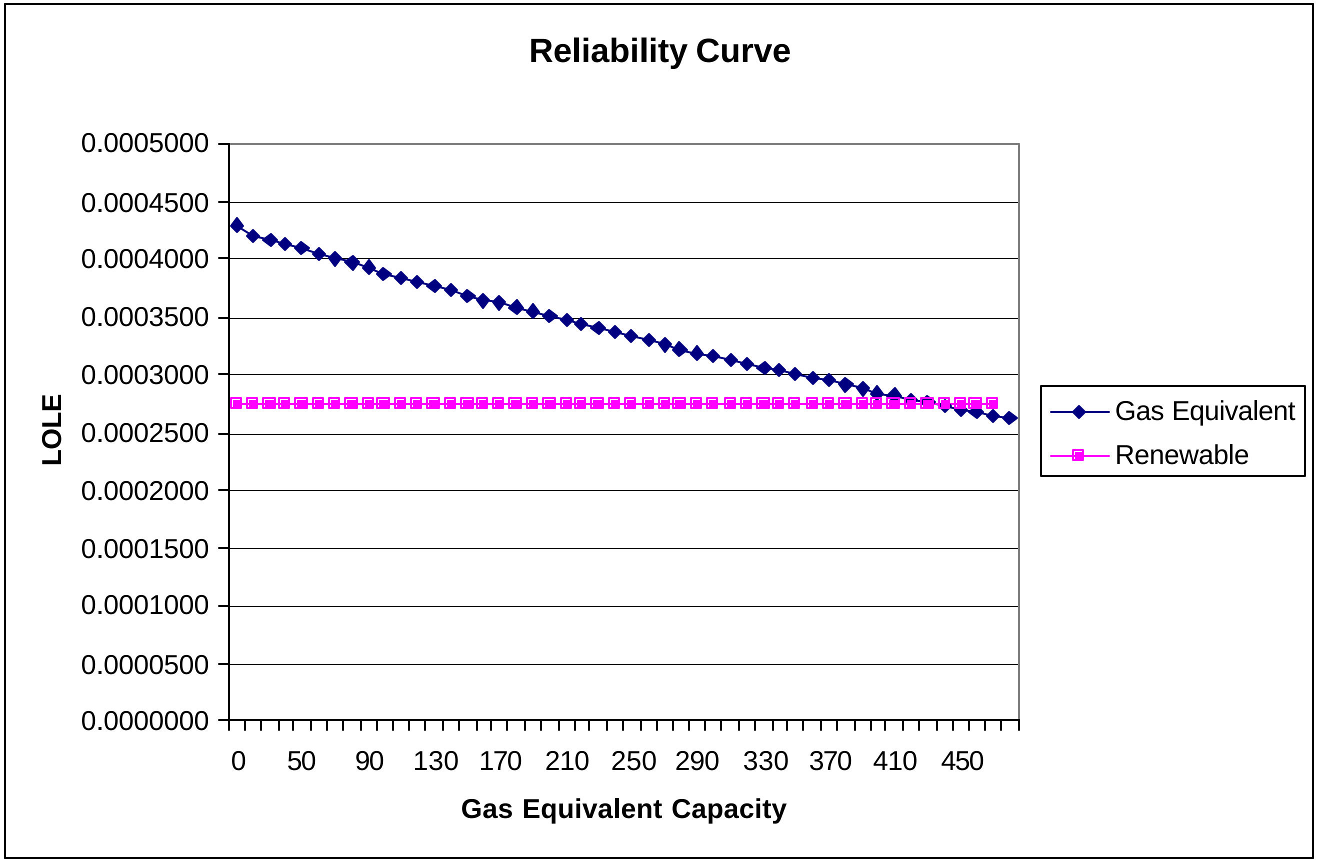
Risk Profile



ELCC Results

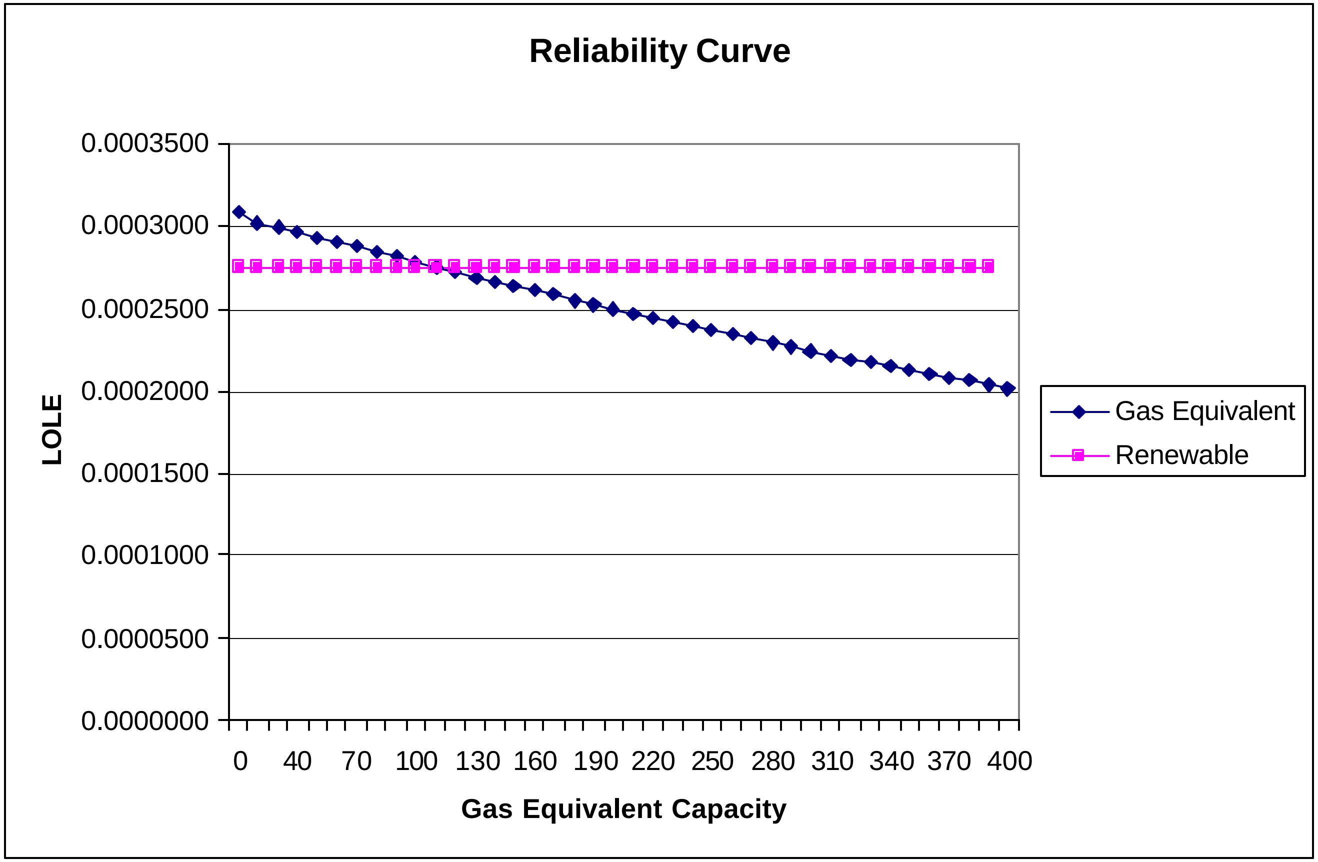
Biomass

ELCC = 98.2%



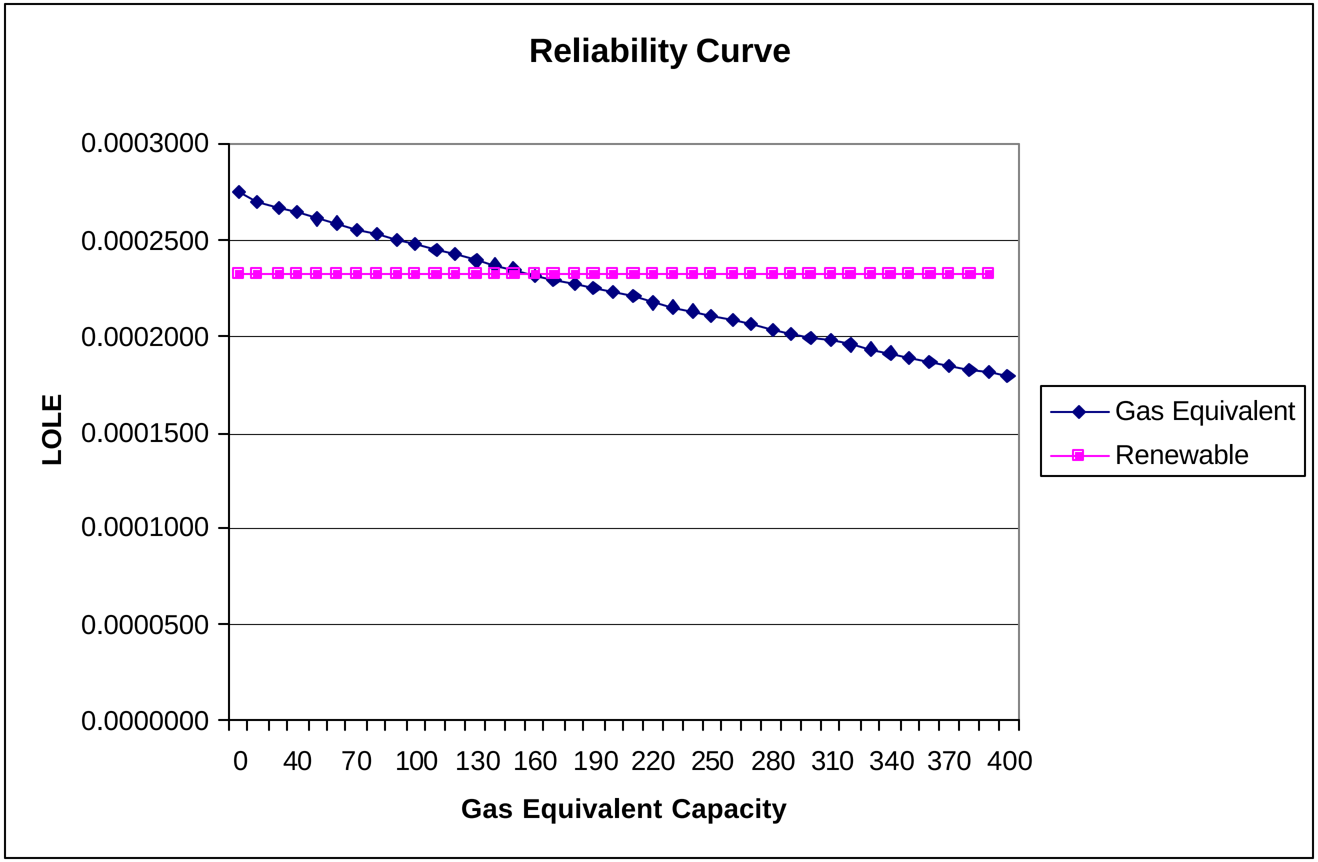
Geothermal Based on Actual Hourly Data

ELCC = 70.5%



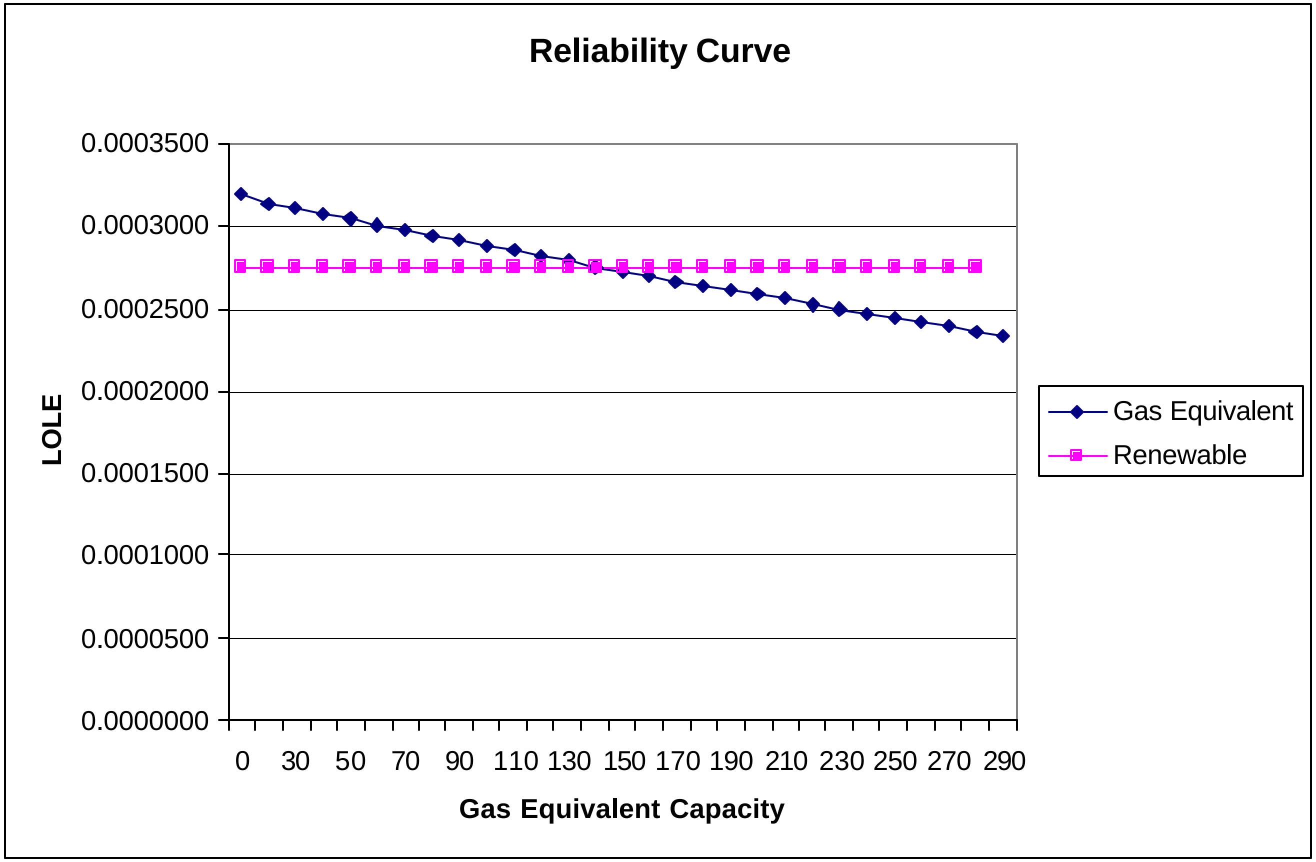
Example Geothermal, No Steam Constraint

ELCC = 102.6% (of gas reference plant)



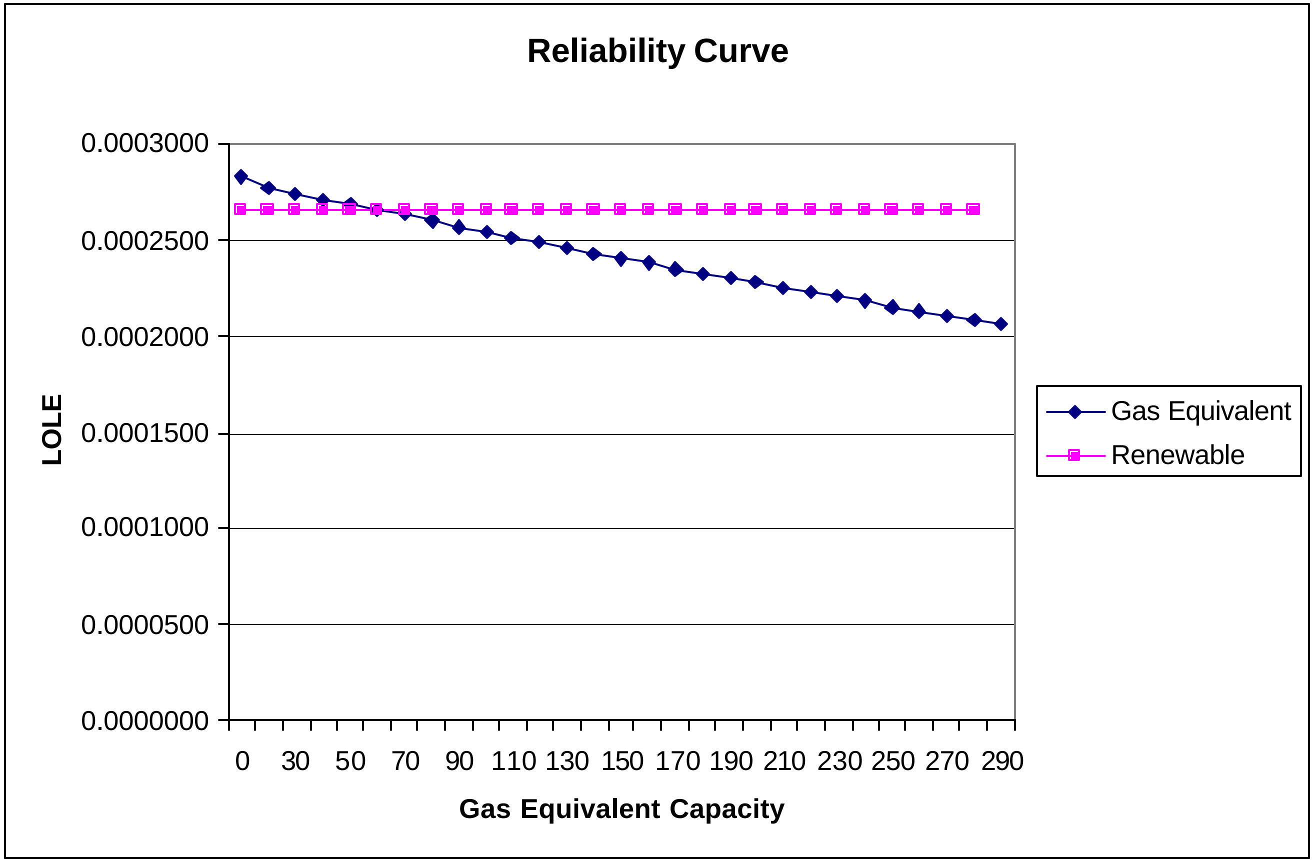
Solar

ELCC = 39.8%



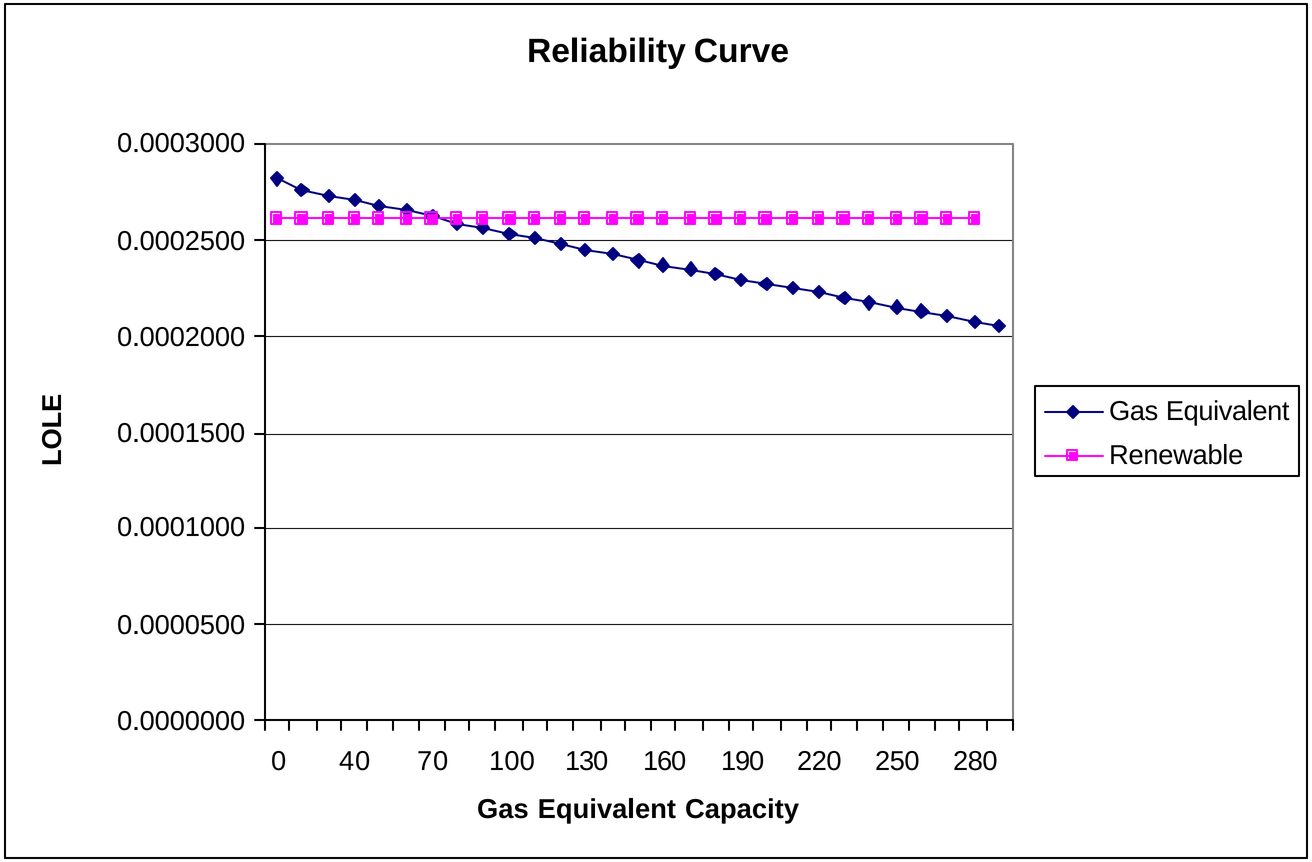
Wind-A

ELCC = 14.2%



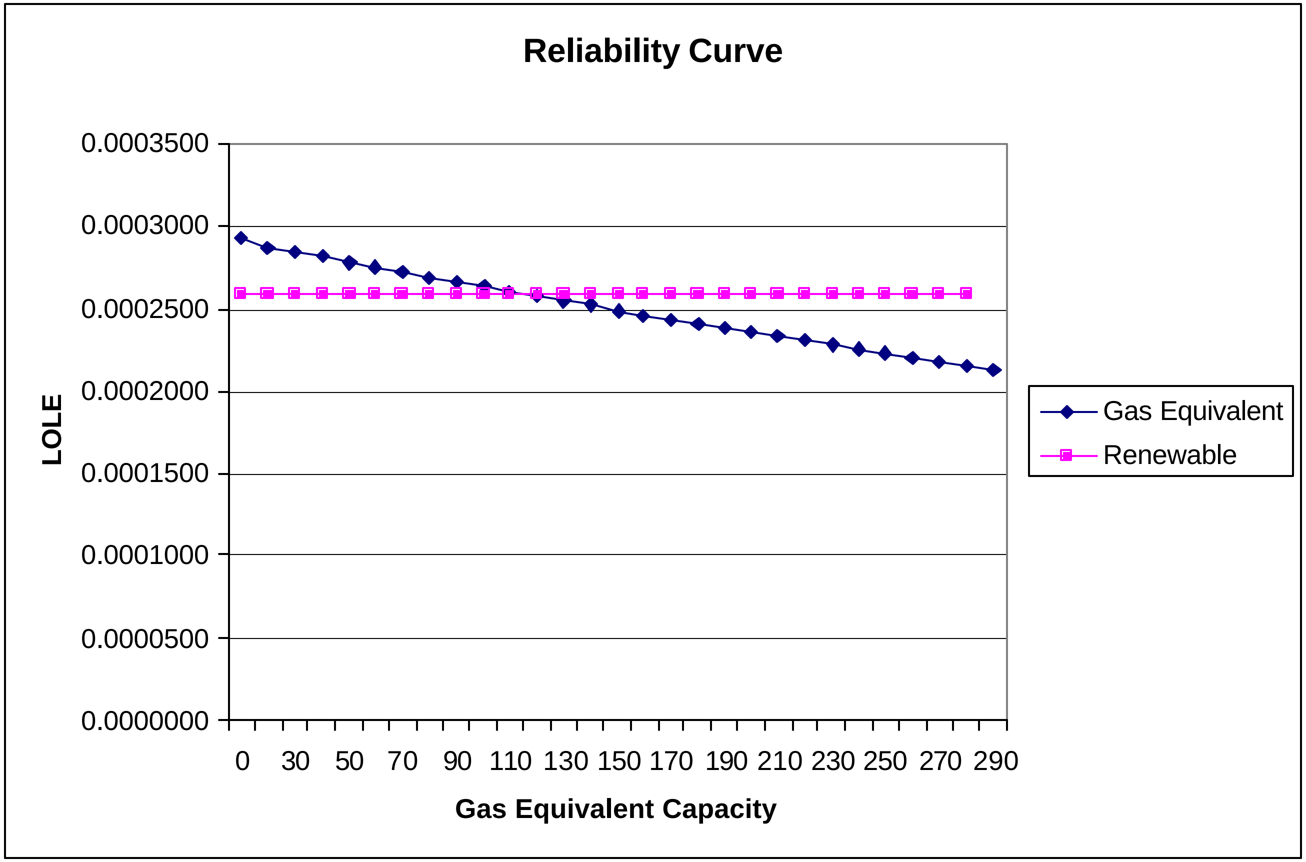
Wind-G

ELCC = 23.9%

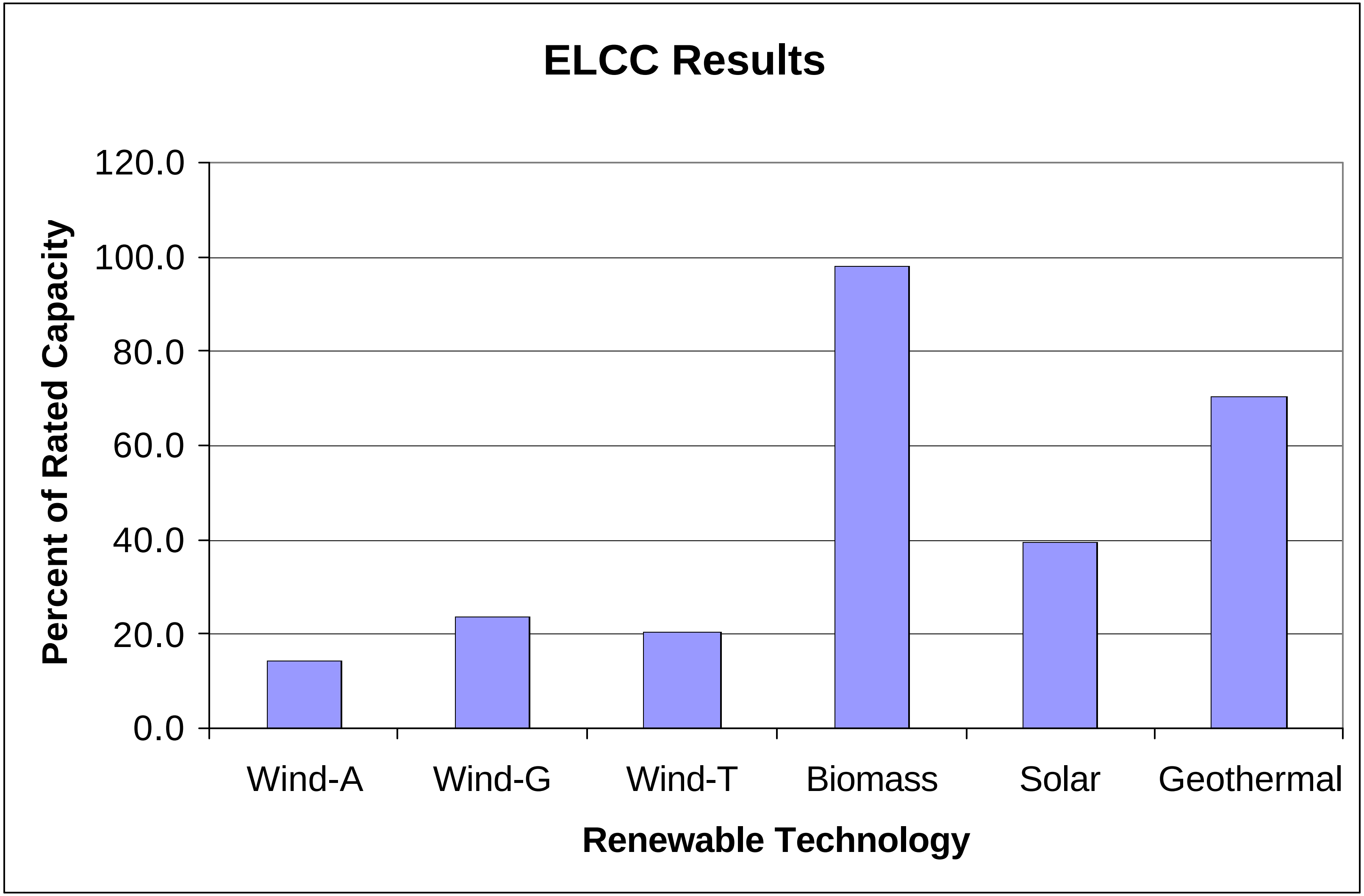


Wind-T

ELCC = 20.5%



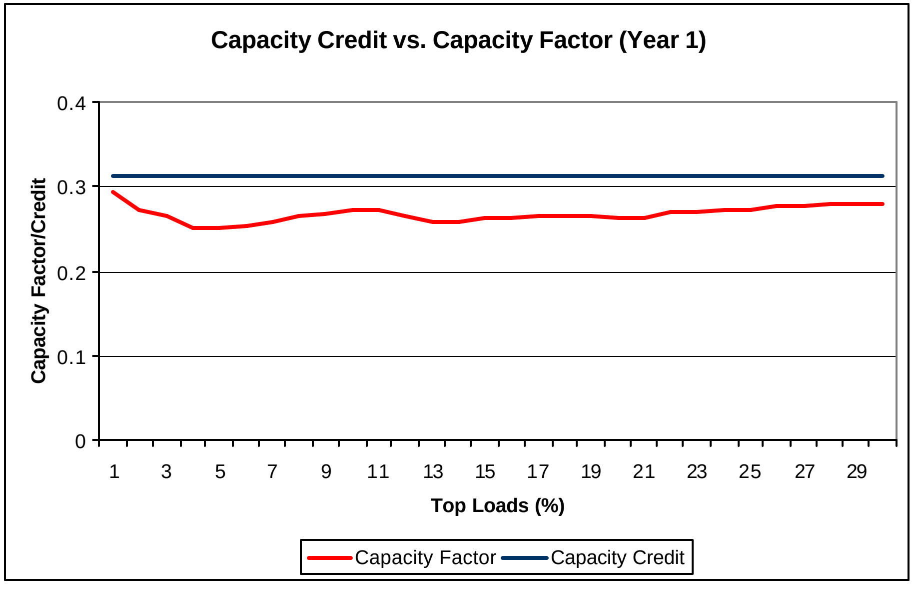
Summary by Technology

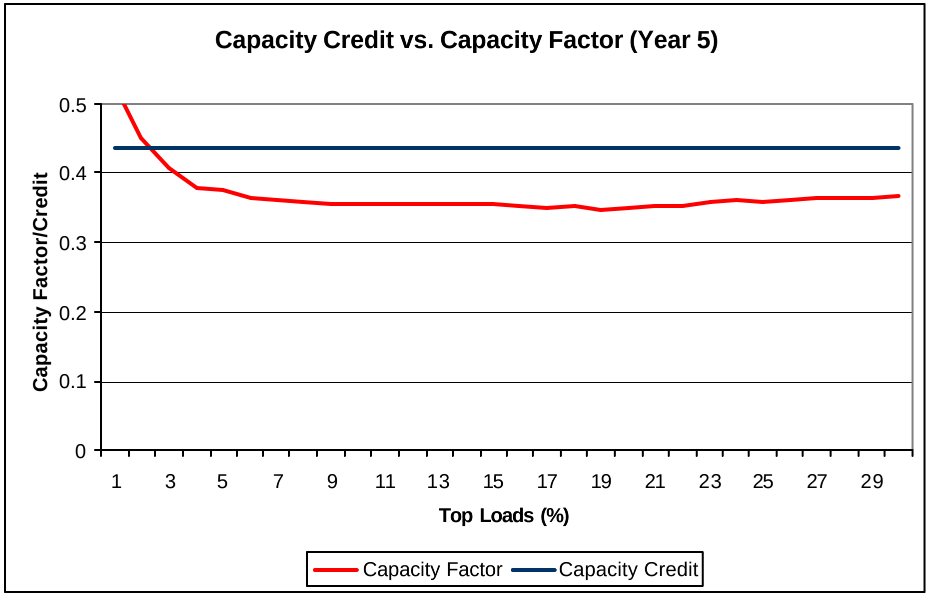


Next Step

- *Calculate the cumulative capacity factor for each renewable based on some combination of*
  - *Highest load hours*
  - *Highest risk hours*
- *Compare with ELCC values*
- *Select appropriate time frame based on comparison so capacity factor over that period are close to*
  - *Note that the time frame need not be contiguous*
- *This needs to be further explored in Phase 2 because results so far don’t work well*

Example of Simple Methods to Estimate ELCC

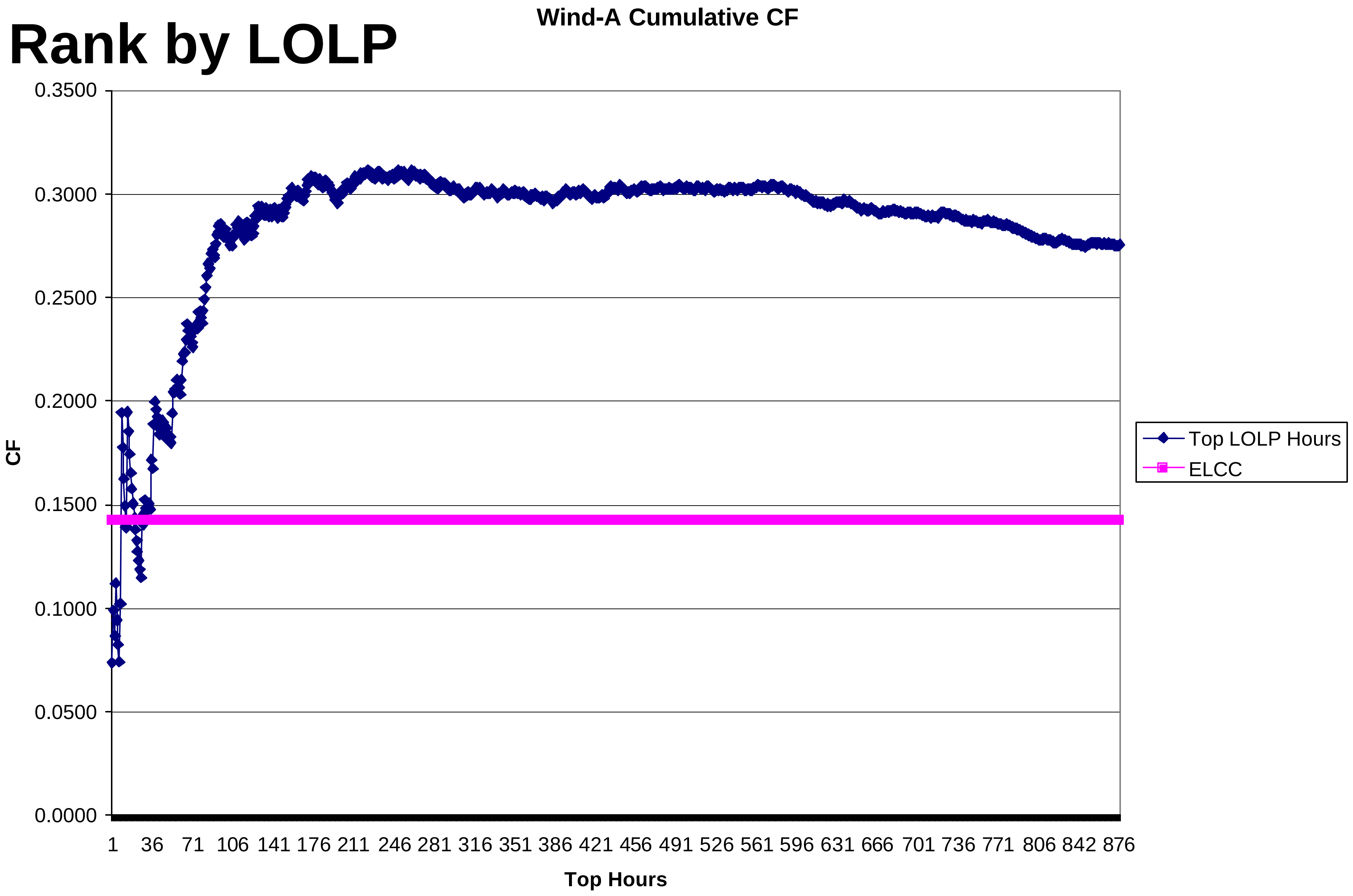




This is a non-California example that shows a “reasonable” way to approximate ELCC

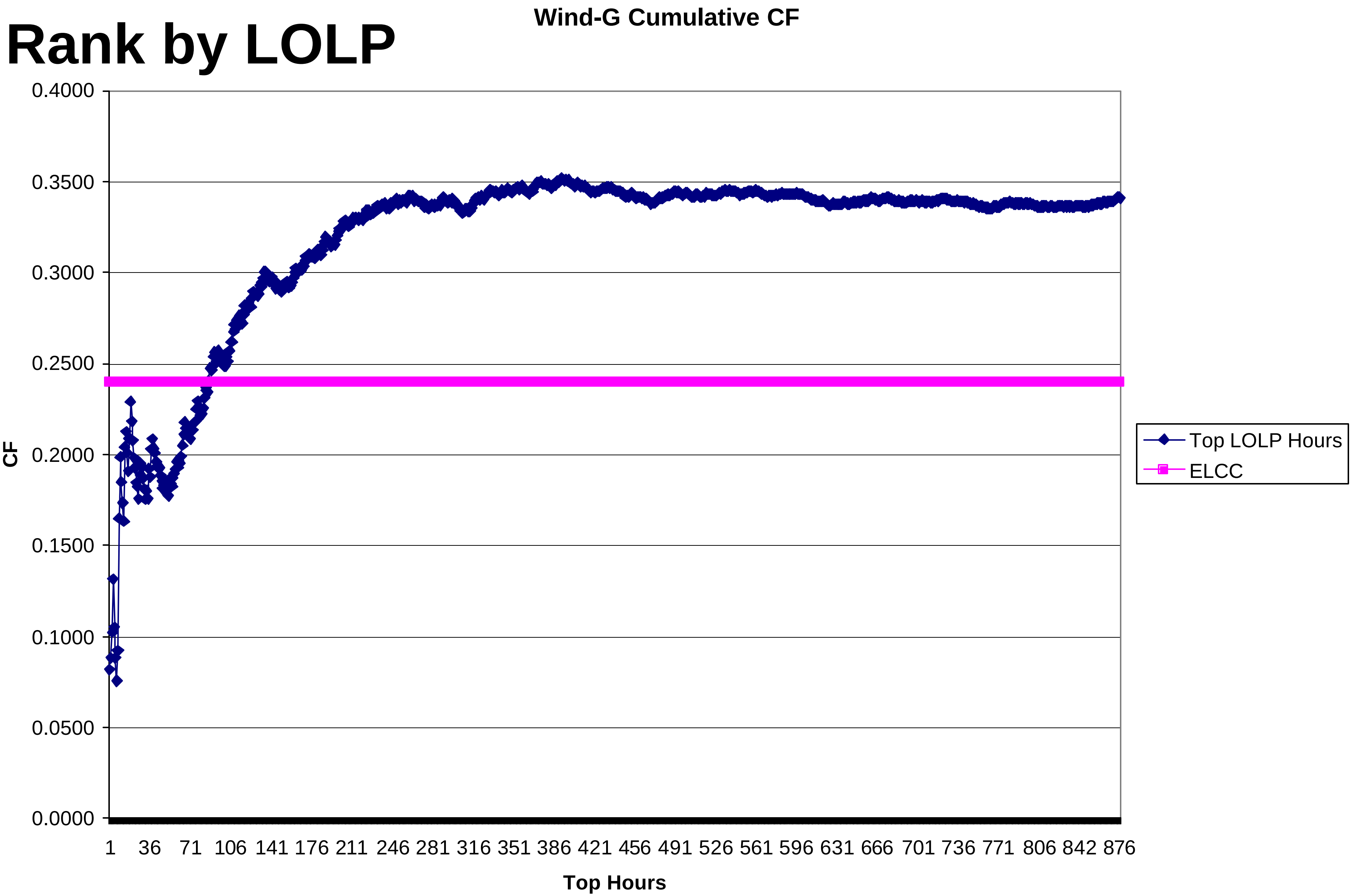
Application of Simple Methods to California

Rank by LOLP



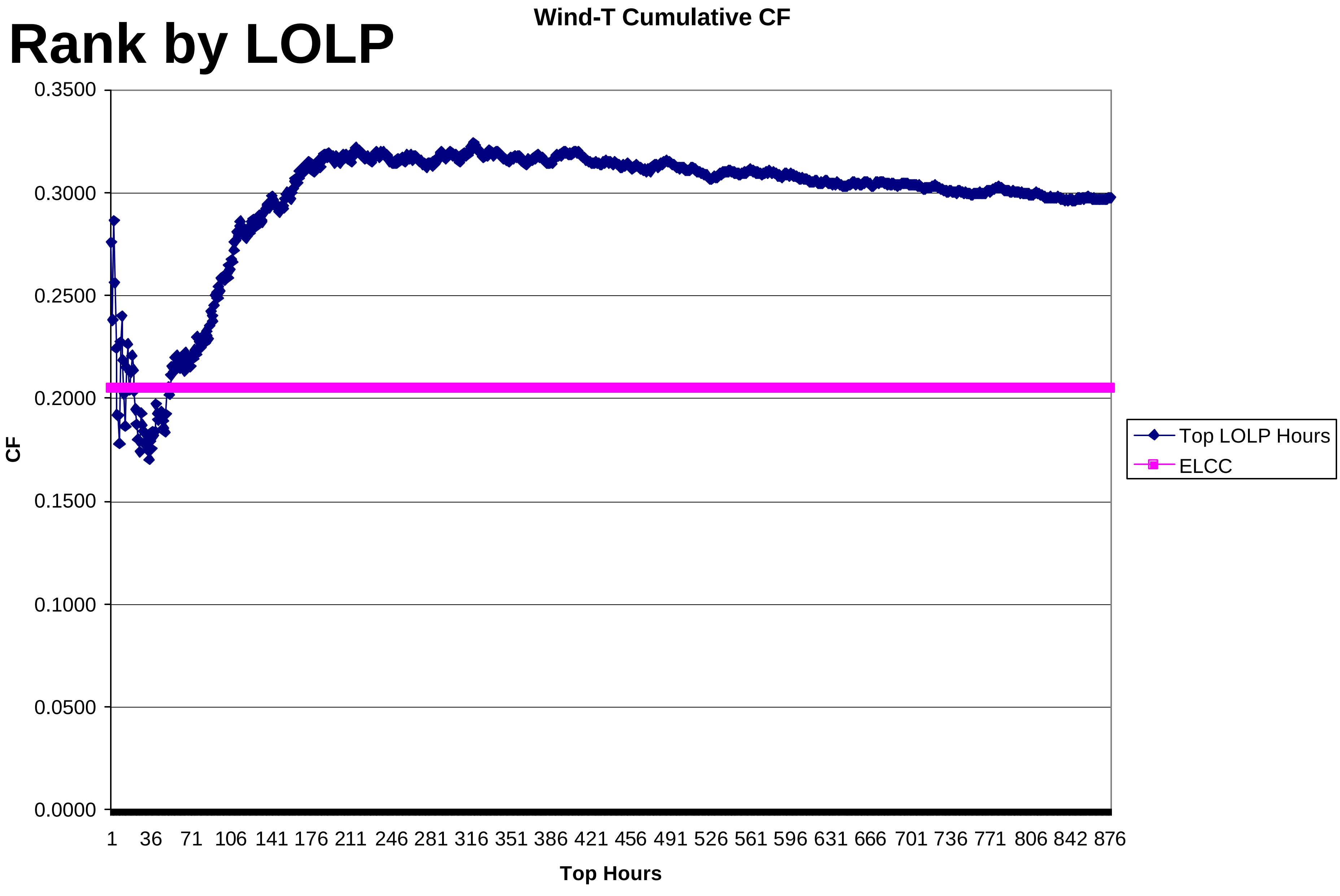
Wind-A Cumulative CF
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
CF
1 36 71 106 141 176 211 246 281 316 351 386 421 456 491 526 561 596 631 666 701 736 771 806 842 876
Top Hours
Top LOLP Hours
ELCC

Rank by LOLP



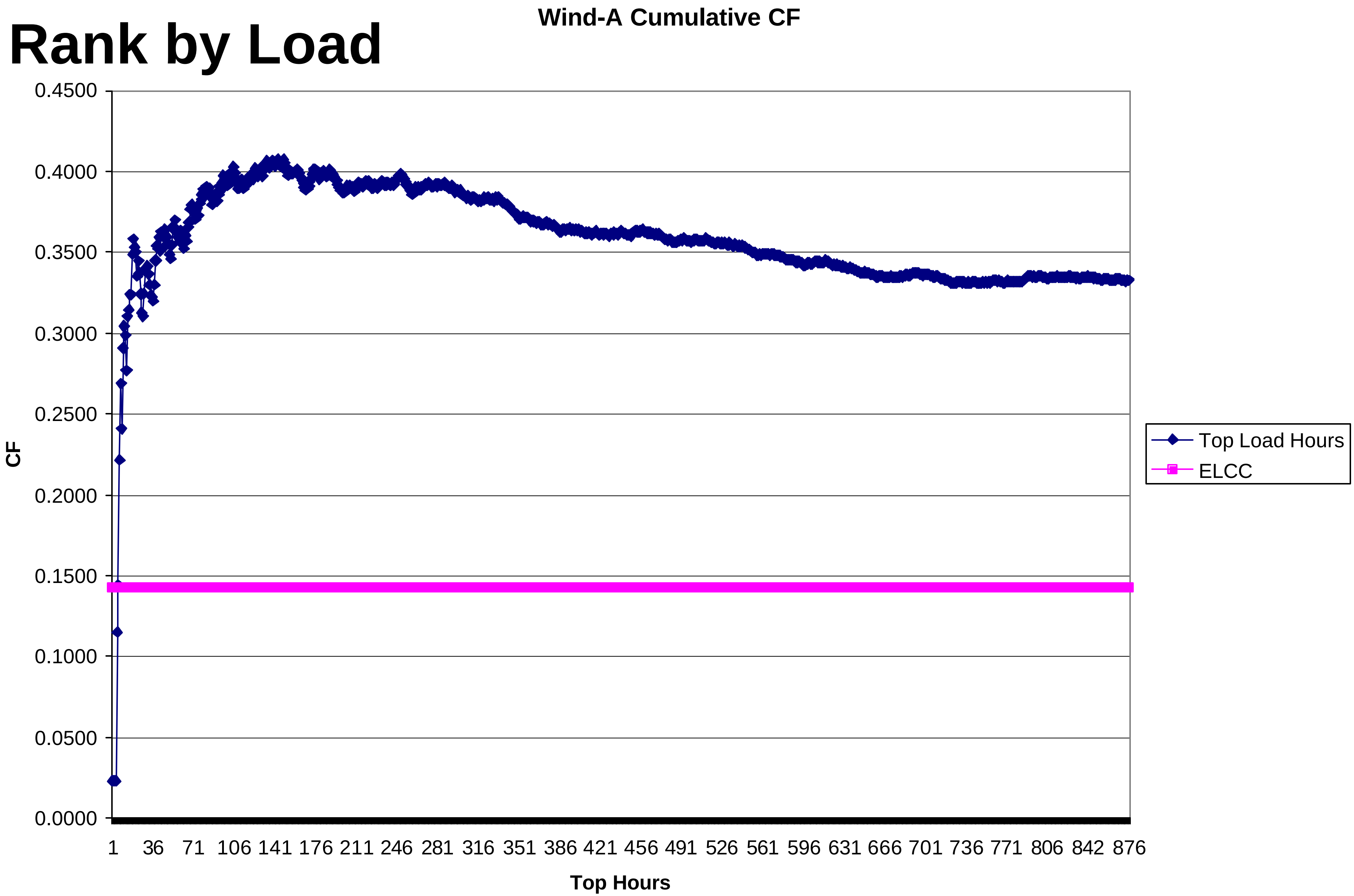
Wind-G Cumulative CF
CF
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
1
36
71
106
141
176
211
246
281
316
351
386
421
456
491
526
561
596
631
666
701
736
771
806
842
876
Top Hours
Top LOLP Hours
ELCC

Rank by LOLP



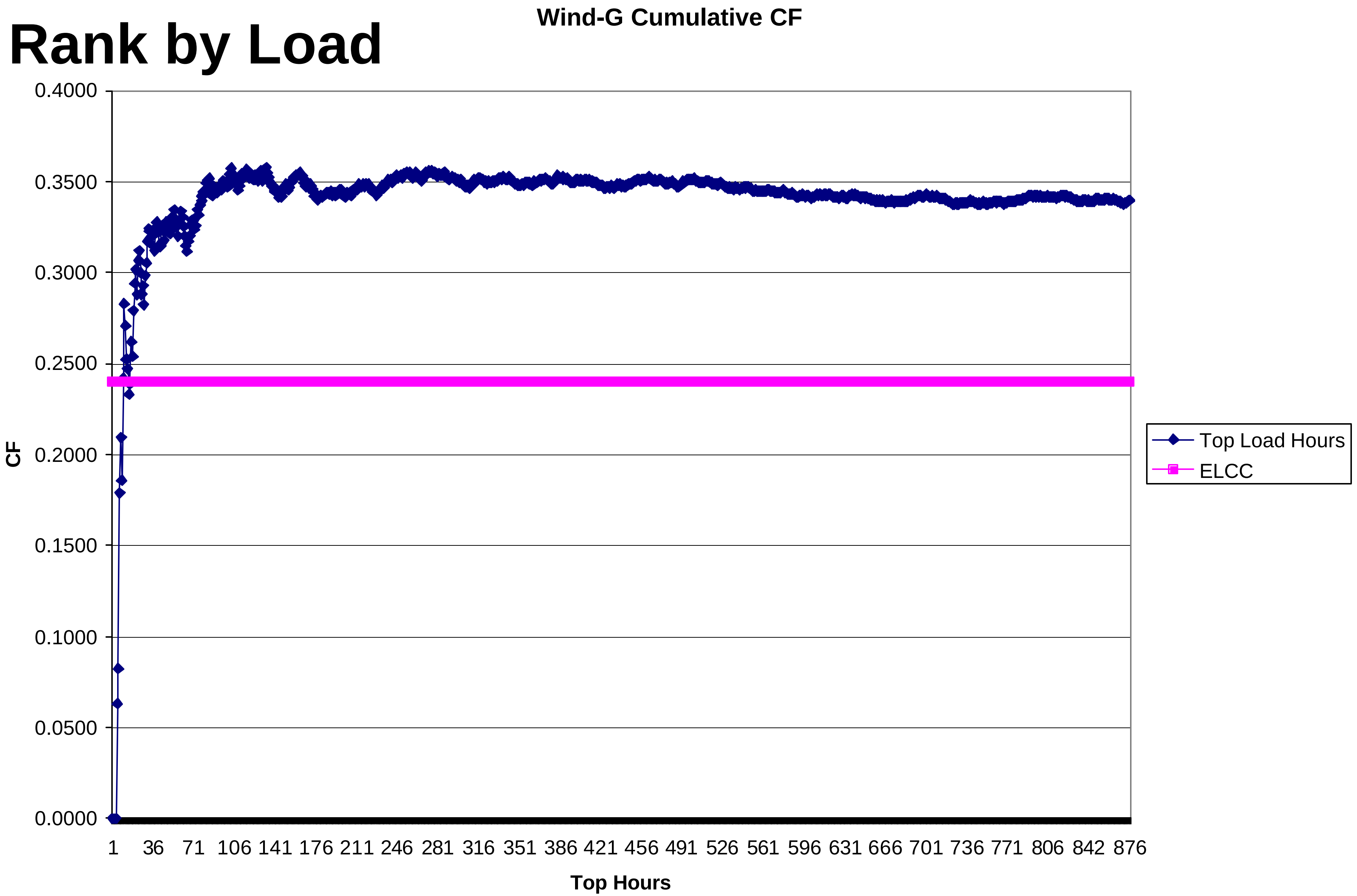
Wind-T Cumulative CF
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
CF
1 36 71 106 141 176 211 246 281 316 351 386 421 456 491 526 561 596 631 666 701 736 771 806 842 876
Top Hours
Top LOLP Hours
ELCC

Rank by Load



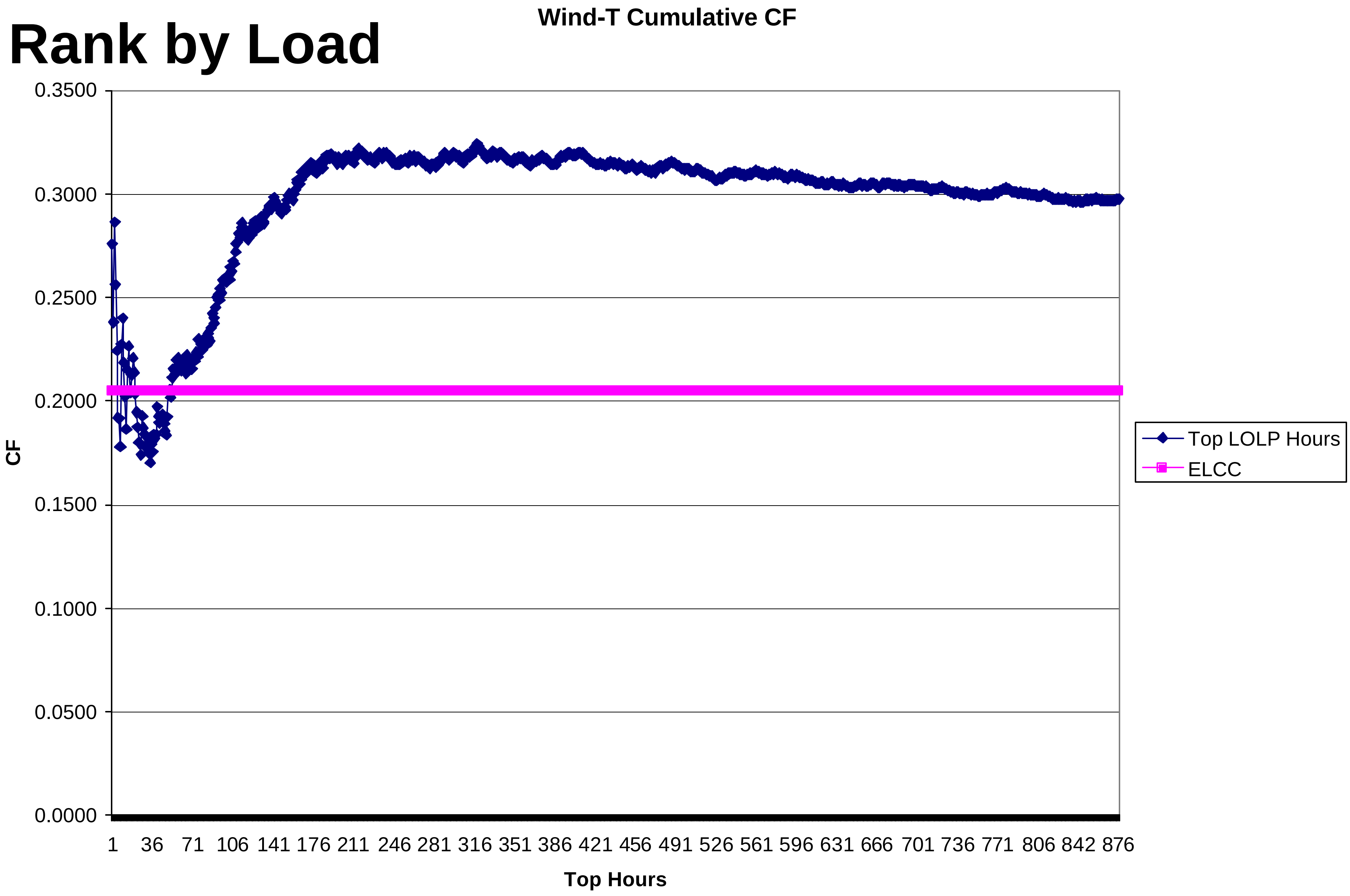
Wind-A Cumulative CF
0.4500
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
CF
1
36
71
106
141
176
211
246
281
316
351
386
421
456
491
526
561
596
631
666
701
736
771
806
842
876
Top Hours
Top Load Hours
ELCC

Rank by Load



Wind-G Cumulative CF
0.4000
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
CF
1 36 71 106 141 176 211 246 281 316 351 386 421 456 491 526 561 596 631 666 701 736 771 806 842 876
Top Hours
Top Load Hours
ELCC

Rank by Load



Wind-T Cumulative CF
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
CF
1 36 71 106 141 176 211 246 281 316 351 386 421 456 491 526 561 596 631 666 701 736 771 806 842 876
Top Hours
Top LOLP Hours
ELCC

Recommendation on Method

- *Simplified methods to approximate ELCC have not been successful so far*
- *May need to calculate ELCC instead of a simpler approach*
- *Will continue to examine this issue in Phase 2*

Renewable Bids – Capacity Credit

- *If there is not sufficient data for a proposed renewable plant*
  - *Use “class average” for that technology and location until actual operating data is available*
- *If data exists, use up to 3 years rolling average*
- *Use reliability model to calculate ELCC, or use simplified method if available*

Established Renewable Generators

- *Use 3-year rolling average capacity credit*
- *This amounts to a performance test*
  - *When the rolling average declines the capacity credit also declines*
  - *When the rolling average increases the capacity credit also increases*

- *Determine the monetary value of capacity ($/kW-year, as determined by separate study)*
- *Apply the monetary value to the ELCC or approximation from either the class average (new sites) or rolling average (established sites)*

Recommendations

- *CEC/CPUC utilize existing in-house reliability model for future capacity work*
- *Corroborate these results with more accurate CA data and CEC's model, including dis-aggregated renewable data*
- *Use ELCC and rolling 3-year average unless simpler approximations can be found*
- *Separate reliability study to look at the impact of maintenance timing on risk*

Regulation Analysis Results

Regulation Analyses

- *We implemented both of the regulation analysis methodologies that were proposed.*
- *A detailed description of both methods was published in April and is available on the web.*
- *We evaluated each of the renewable generator types.*
- *We selected representative conventional generators under dispatcher control for comparison purposes.*

Regulation Method 2 Status

- *This method was proposed by Yuri Makarov of the CalSO.*
- *The one year analyses for California are not yet complete.*
  - *The computer programming necessary to implement this method is completed, except for the cost analysis.*
  - *The regulation capacity results have been completed for each resource, but have not been approved for release by CaISO.*
  - *The regulation cost analyses have not been completed.*
  - *The integration cost adders have not been calculated.*
- *A final report providing detailed documentation of the final results from this method is expected in the near future.*
- *Method 2 will not be presented today.*

Regulation Method 1 Status

- *This method was proposed by Brendan Kirby of Oak Ridge National Laboratory (ORNL) .*
- *The one year analyses for California are complete.*
  - *The computer programming necessary to implement the one year analysis is completed.*
  - *The regulation capacity and cost calculations have been completed for each resource.*
  - *The integration cost adders for each resource type have been calculated.*
- *The final report documenting the results of this analysis are expected to be published by September 26.*

Analysis Methodology Selection

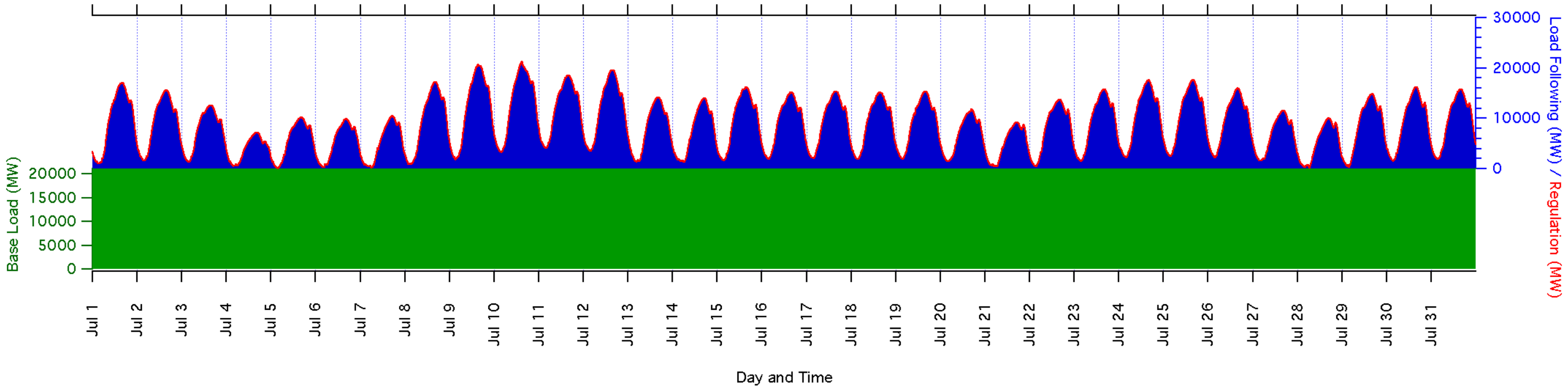
- *Must select a single analysis methodology for implementation in subsequent Phases.*
- *The selection criteria for the methods were based on:*
  - *Was the method independent of a specific institution or company?*
  - *Could the method be applied fairly and consistently?*
  - *Did the method provide results using a minimal amount of data?*
  - *Was the method transparent and analyst independent?*
  - *Has the method been published and peer reviewed?*

Regulation Analysis Recommendations

- *We recommend that Method 1 be adopted as the general analysis tool for use in evaluating regulation ancillary services costs under the RPS.*
- *We recommend that the results from Method 2 be reviewed and compared when they are finalized.*

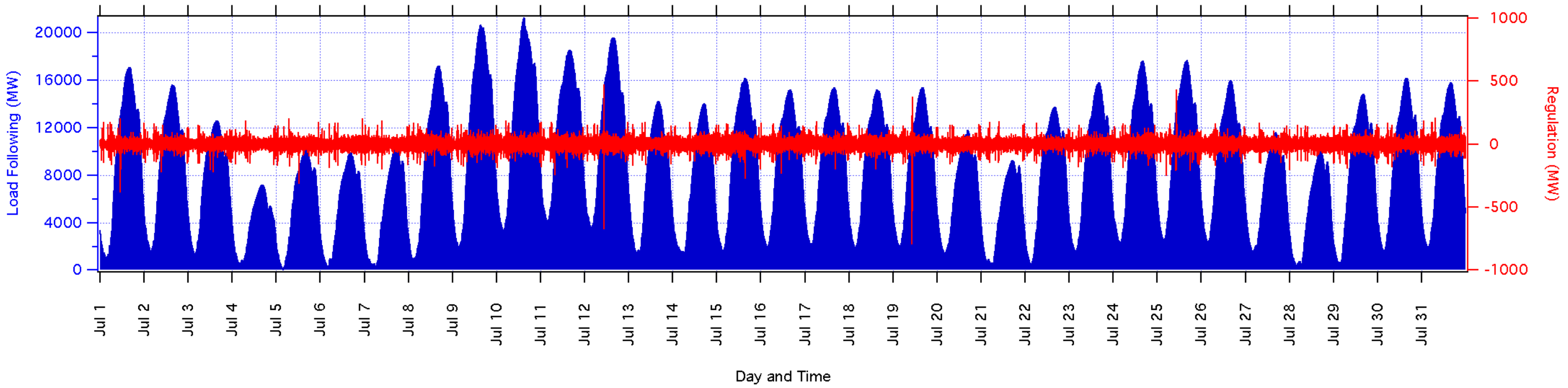
Decomposition of Control Area Loads

- *Control area load & generation were decomposed into three parts:*
  - *Base Load*
  - *Load Following*
  - *Regulation*



Regulation & Load Following Differ

	REGULATION	*LOAD FOLLOWING*
Patterns	***Random, uncorrelated***	***Largely correlated***
Generator control	***Requires AGC***	***Manual***
Maximum swing (MW)	***Small***	***10 – 20 times more***
Ramp rate (MW/minute)	***5 – 10 times more***	***Slow***
Sign changes	***20 – 50 times more***	***Few***



Regulation Data Requirements

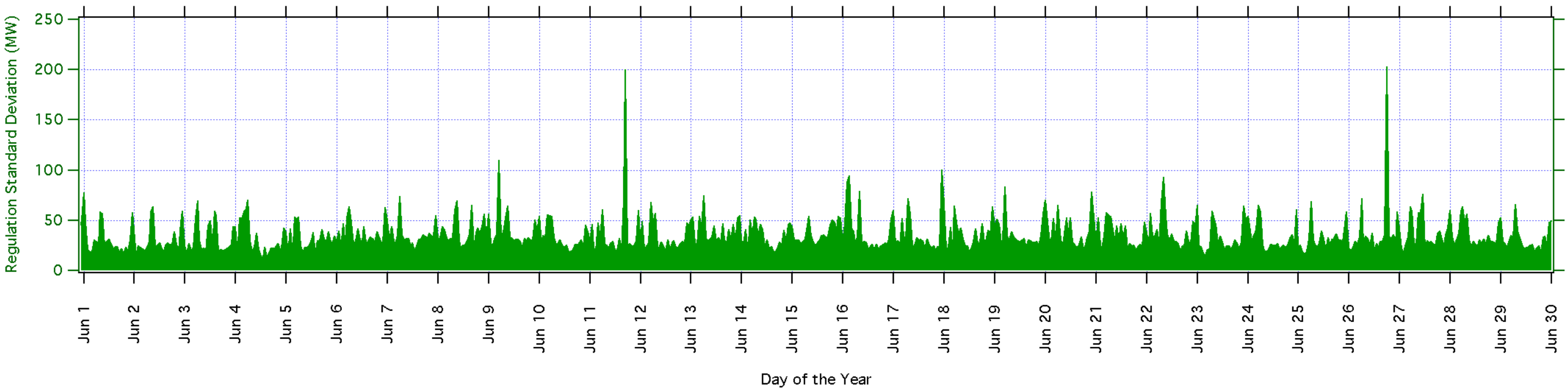
- *One minute total system load data*
- *One minute resource generation data*
- *Hourly system regulation purchases*
- *Hourly system regulation price*

Allocating Regulation Cost to Individuals

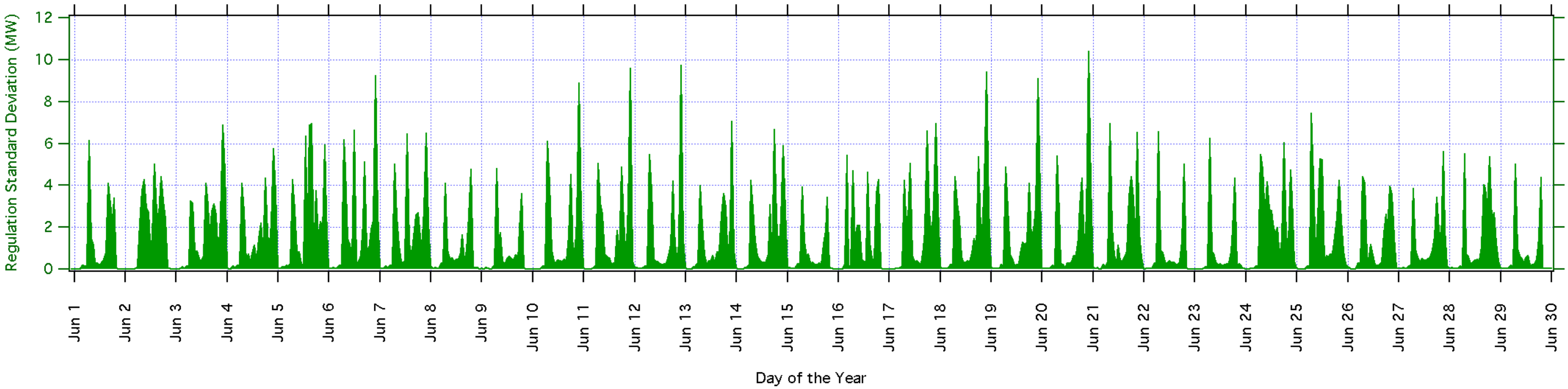
- *Determine the hourly system regulation requirement.*
  - *One minute data for total system load.*
  - *Separate regulation (capacity) from load following (energy).*
  - *Calculate hourly standard deviation values.*
- *Determine the hourly individual regulation requirements.*
- *Allocate the individual hourly regulation requirements.*
- *Obtain the hourly system regulation purchase amount.*
- *Allocate the total regulation purchase to individuals.*
- *Obtain the hourly regulation price.*
- *Determine the hourly individual regulation cost.*

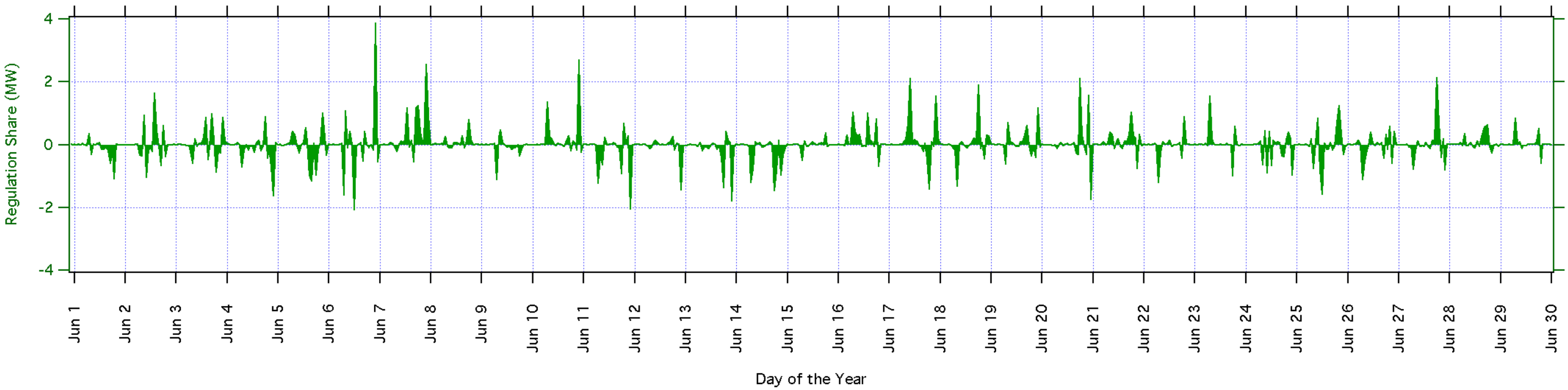
System Regulation Standard Deviation

- *Calculate the average hourly standard deviation for regulation of the system (total load).*
- *These results were compared against actual purchases by CaISO and were used to allocate the regulation impact of each generator.*

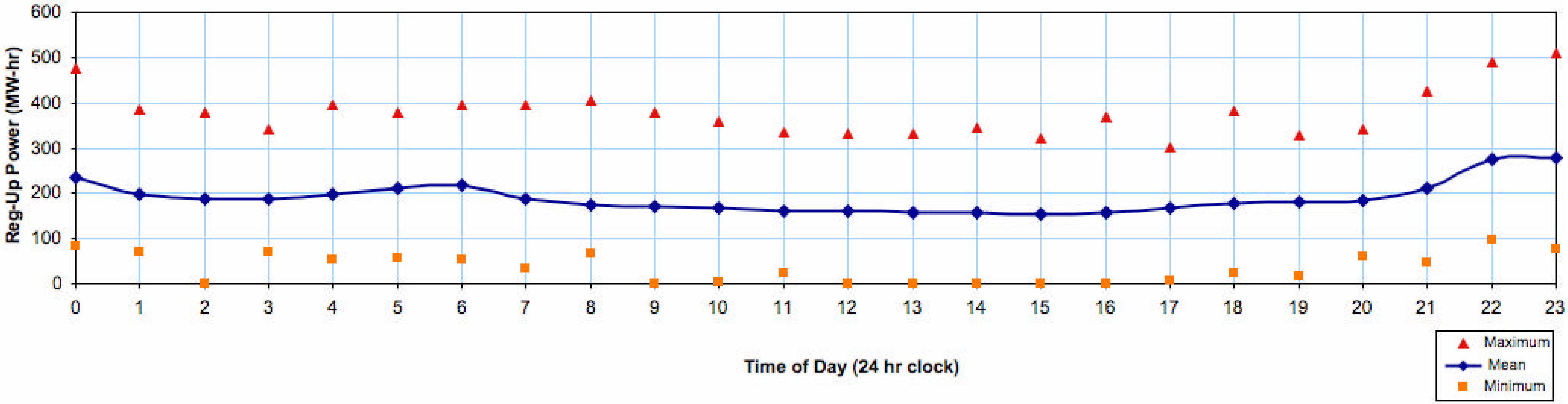


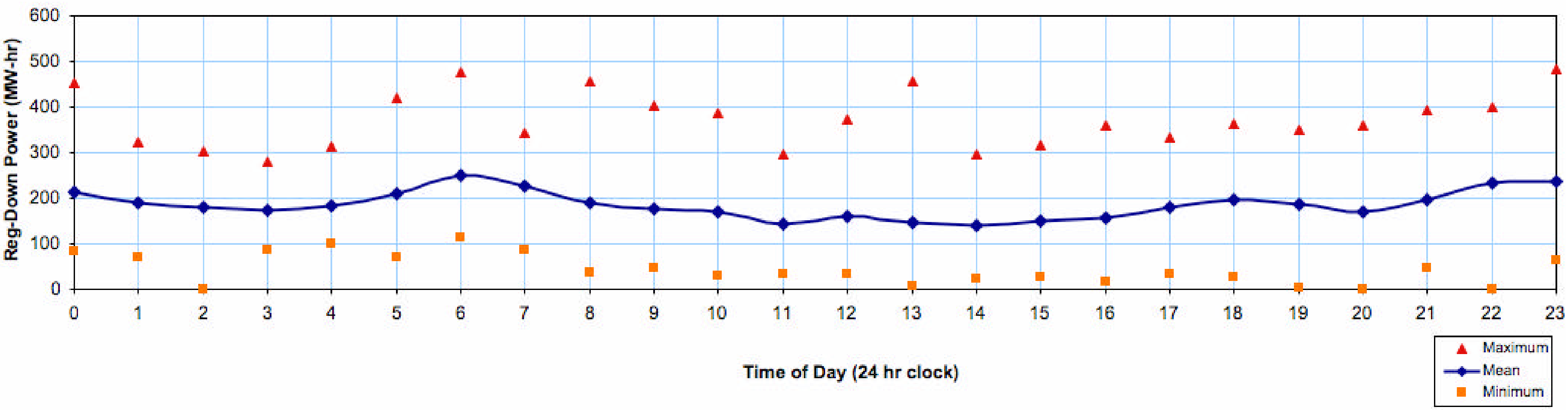
Solar Regulation Standard Deviation and Allocated Regulation Share





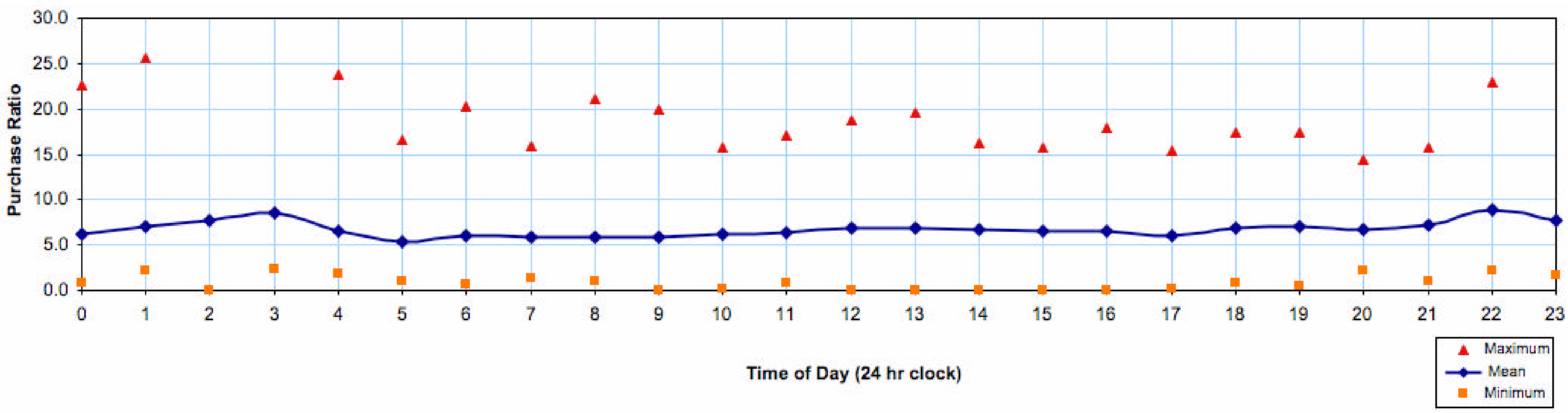
Actual Regulation Purchases



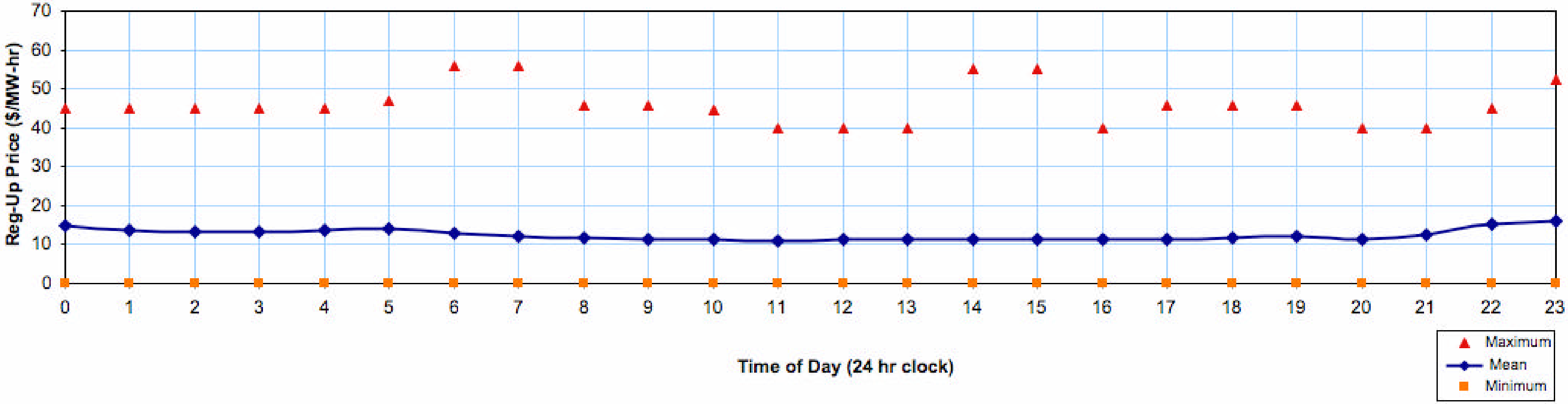


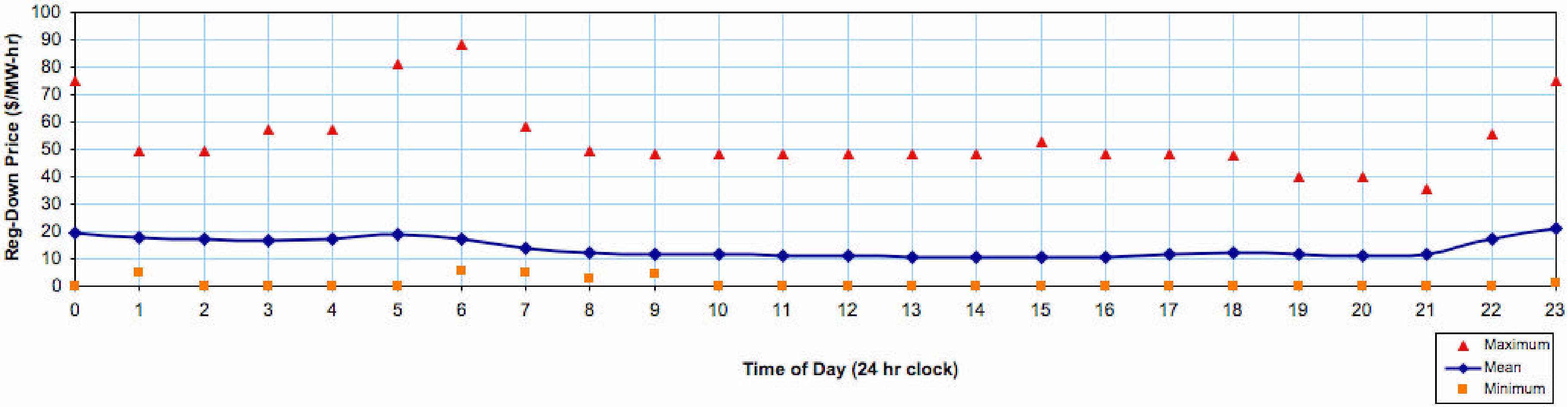
Regulation Purchase Ratio

- *The regulation purchase ratio compares the actual purchase against the calculated standard deviation.*
- *The average annual purchase ratio was 6.5 for Reg-Up and 6.7 for Reg-Down.*
- *The purchase ratio was used to adjust the results from each resource of interest to actual data for each hour.*

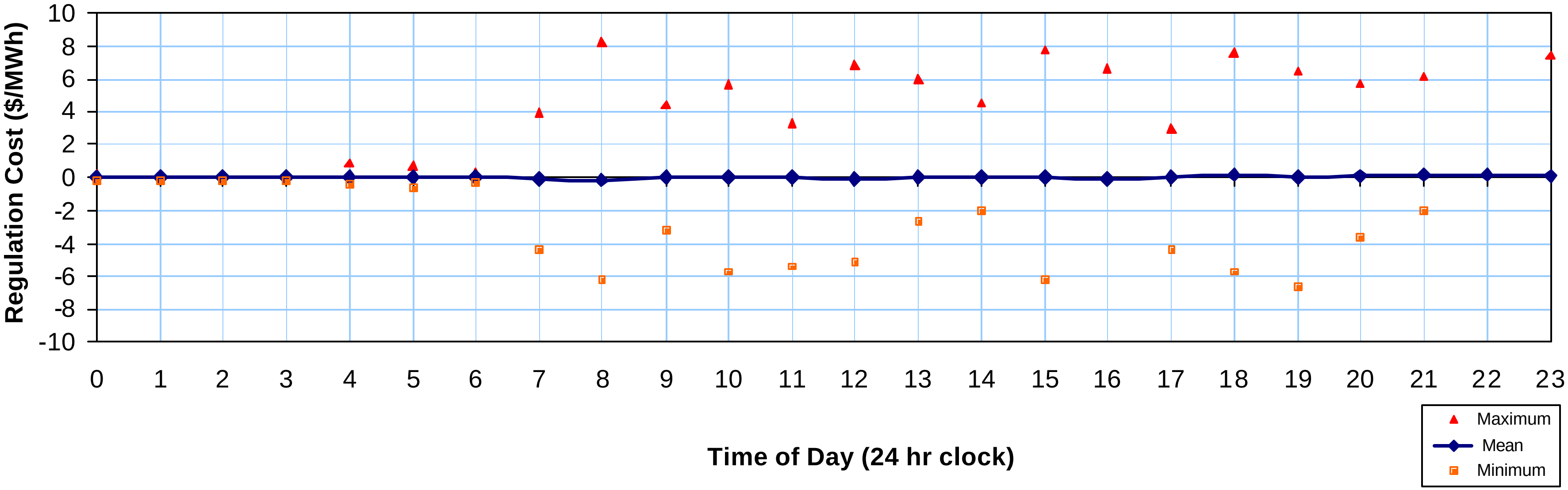


Actual Regulation Prices





Allocated Regulation Cost of Solar



Regulation Cost Results

- *A negative value means there is a cost imposed on the system.*
- *A positive value means there is a benefit provided to the system.*
- *The baseline for comparison is a generator with constant output and a regulation price of zero.*

Resource of Interest	Regulation Cost ($/MWh) (mils/kWh)
Total Load	-0.20
Medium Gas	0.04
Solar	0.02
Geothermal	-0.05
Biomass	0.00
Wind (Altamont)	0.00
Wind (San Gorgonio)	-0.21
Wind (Tehachapi)	-0.07
Wind (Total)	-0.08

Load Following Analysis Results

Load Following

- *Deviations between the scheduled generation and the actual load requirements are compensated through purchases from the CaISO supplemental energy market.*
- *The system operator must compensate for aggregate scheduling error; individual errors must be viewed in the context of the full system.*
- *Market participants provide CaISO with bids for the hour ahead energy market and create the "stack" of available generators.*
- *The purpose of the load following analysis was to determine if the renewable generators affected the size or composition of the "stack" and therefore changed the cost for the load following service.*

Is Load Following an Integration Cost?

- *Supplemental energy market participants are paid for incremental and decremental energy.*
  - *Failure to follow a schedule may generate INCs or DECs, but those will be settled by the market.*
  - *Those market costs are explicit.*
- *If the renewable generators affect the size or composition of the "stack", they change the cost for the load following service and incur an integration cost.*

Method Required Minimal Data

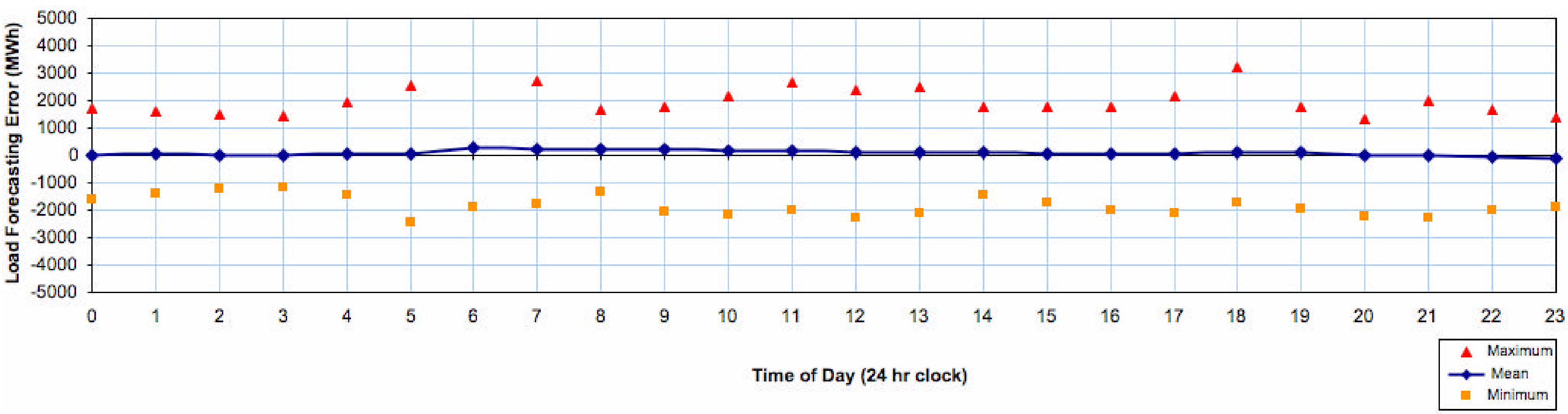
- *Hourly system loads, schedules, and forecasts.*
- *Hourly renewable resource generation data.*

Load Following Analysis

- *Bids and schedules for the hour ahead market are provided 150 minutes ahead of time.*
- *The load following analysis used hourly average values of the 10 minute supplemental energy market data.*
- *Resource schedules for the hour ahead market were derived by using a simple, “naïve” persistence model,*
- *The load following analysis used two persistence models:*
  - *Geothermal, biomass, and wind schedules were derived by simply shifting actual generation forward by 150 minutes.*
  - *Solar schedules were derived by shifting actual generation forward by 24 hours.*

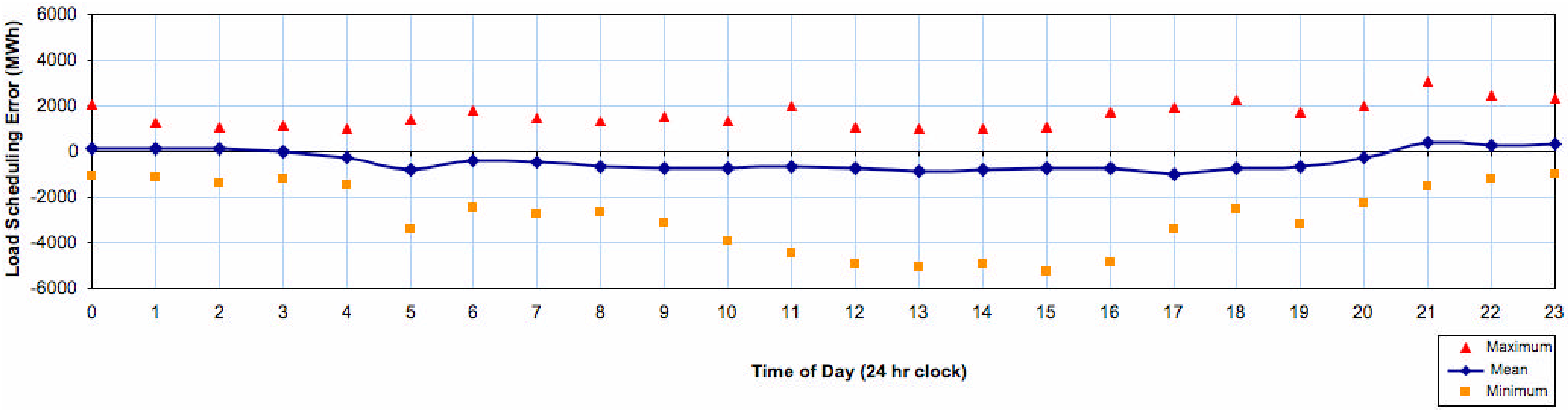
Forecast Hour Ahead Load

- *CaISO provides a forecast of total system load for the hour ahead market.*
- *The forecast represents the best estimate of the generation required in the hour ahead market.*
- *The forecasted load is not equal to the scheduled load.*
- *The load forecasting error is equal to the forecast load minus the actual load.*

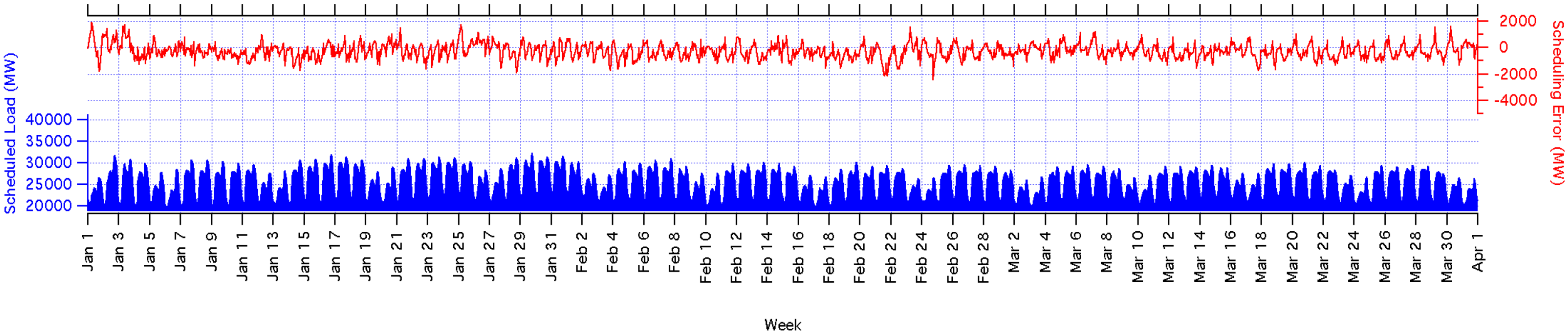


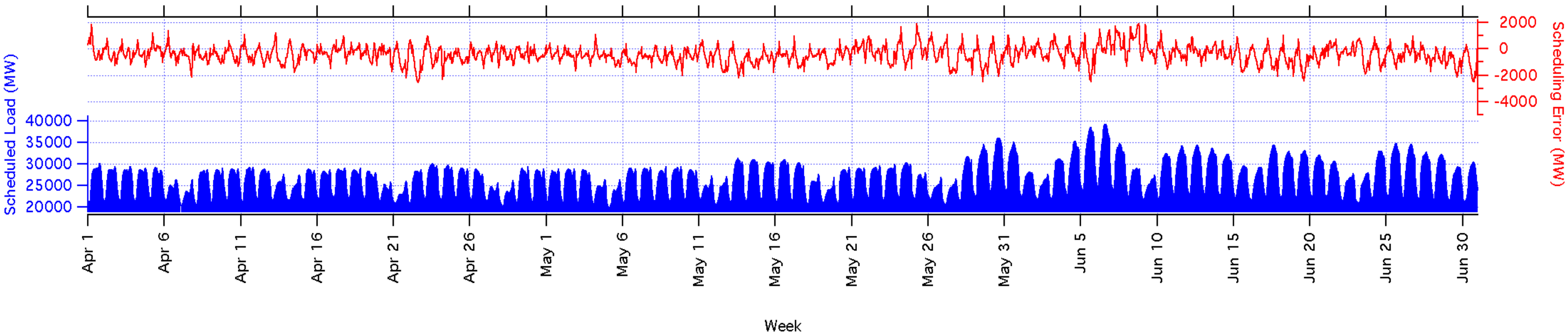
Scheduled Hour Ahead Load

- *Hour ahead schedules are submitted to CaISO by the scheduling coordinators.*
- *The scheduled load is strongly biased relative to the actual load.*
- *Scheduled load can be as much as 5000 MW less than the actual load during some hours of the year.*
- *Scheduling bias is most negative during the afternoon peak and averaged -880 MW between noon and 6 pm.*
- *The load scheduling error is defined as the scheduled load minus the actual load.*

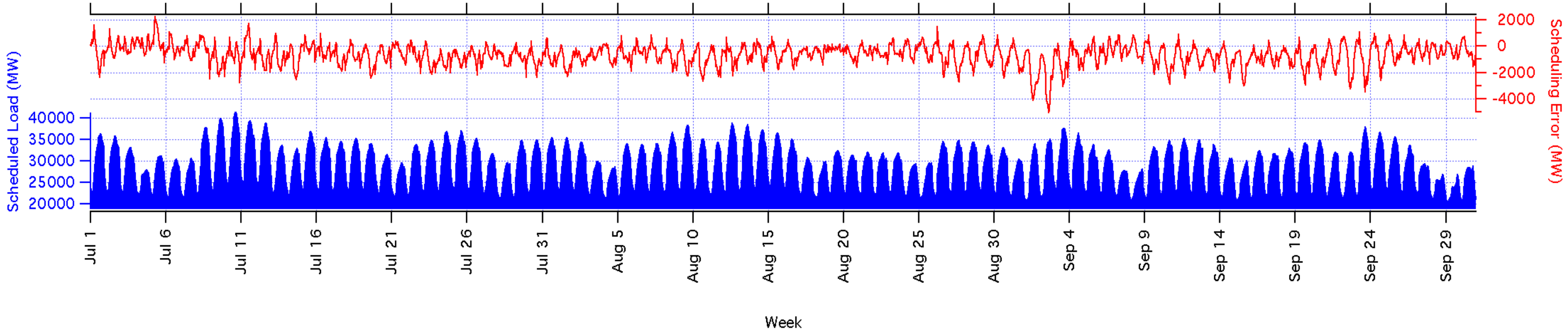


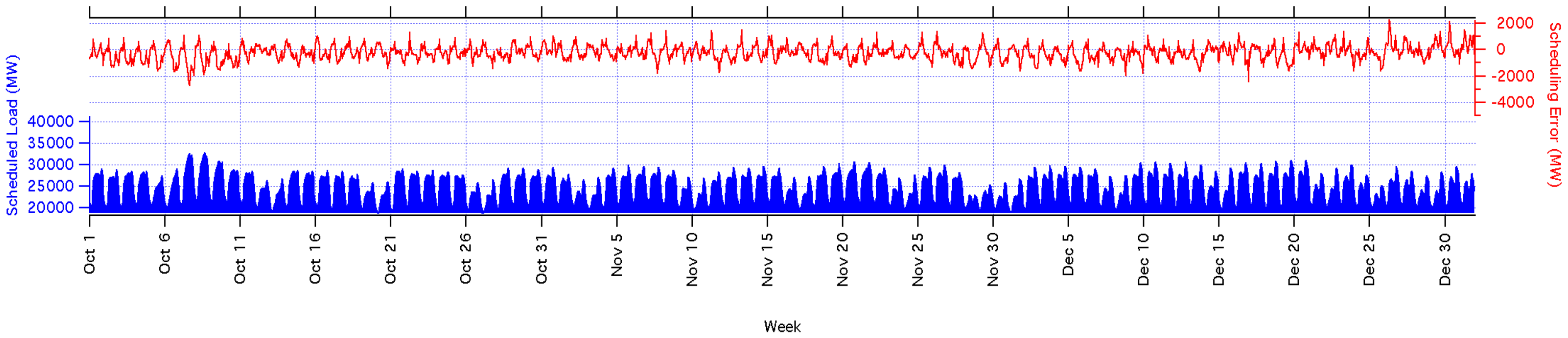
Scheduling Error





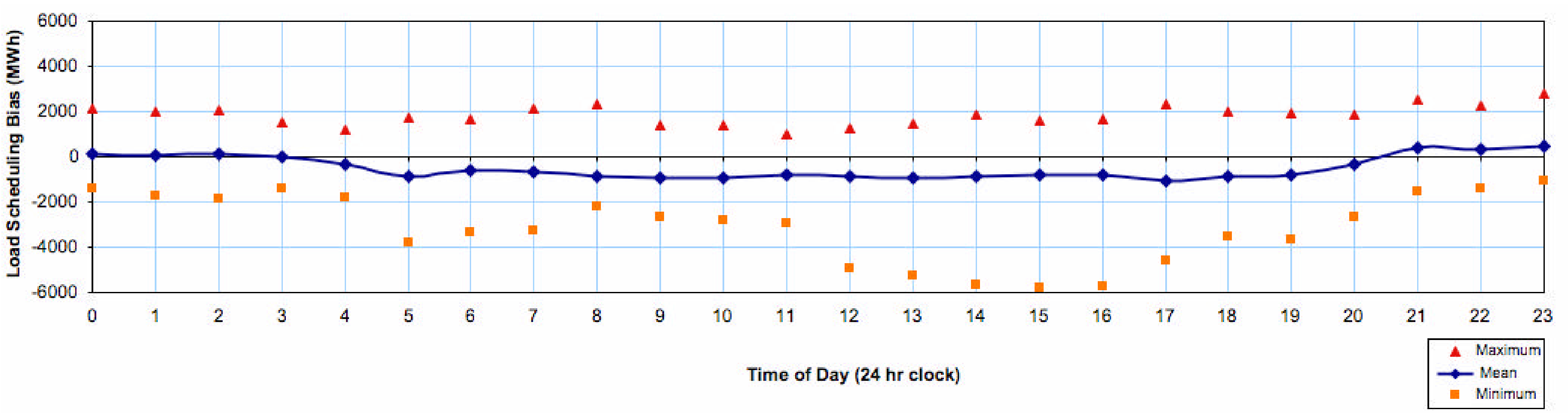
Scheduling Error



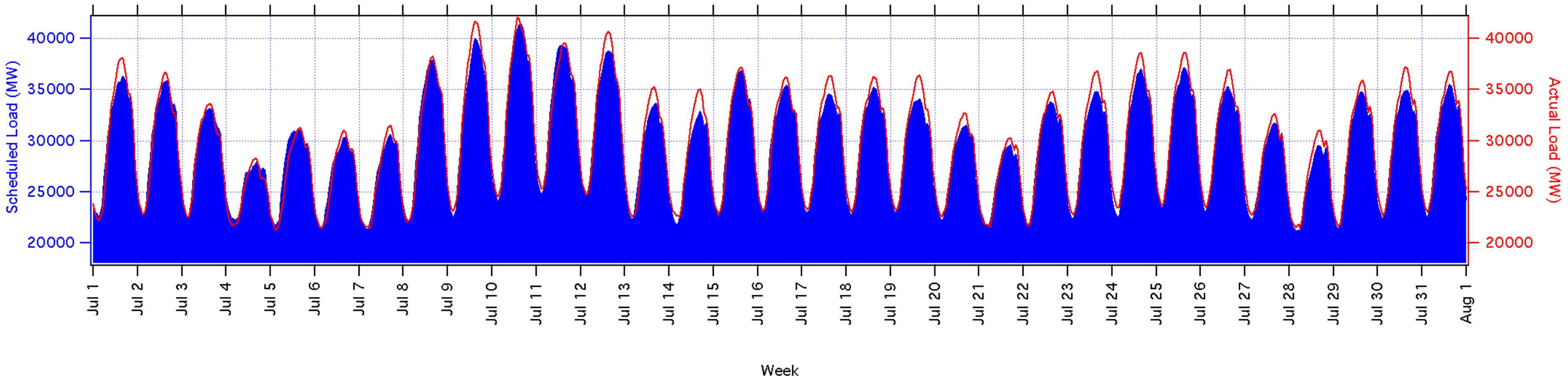


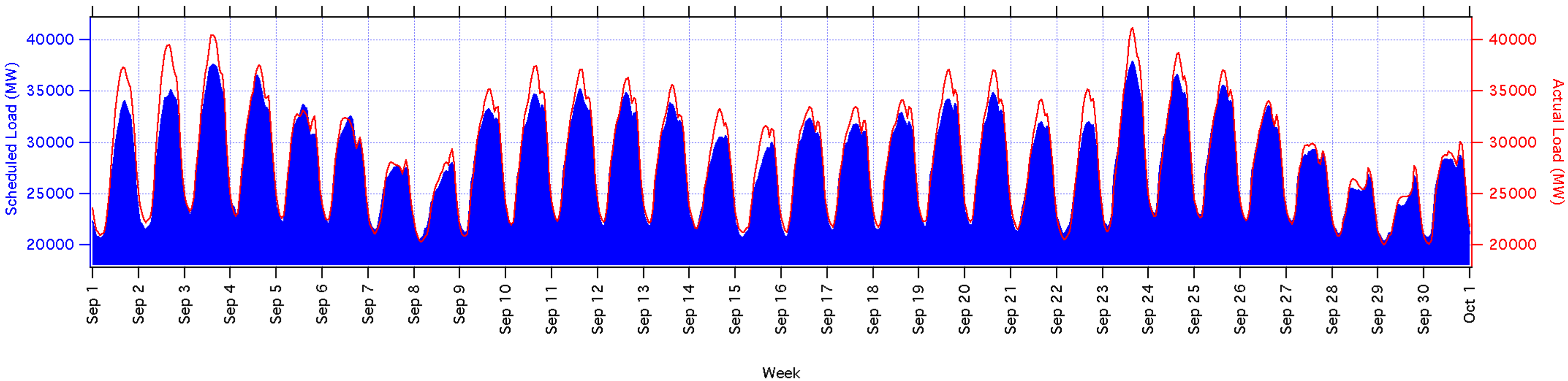
Scheduling Bias

- *The scheduled load is strongly biased relative to the forecast load.*
- *The load scheduling bias is defined as the scheduled load (from the scheduling coordinators) minus the forecast load (from CaISO).*
- *The scheduling coordinators consistently schedule less generation than is needed according the load forecast by CaISO.*
- *The average scheduling bias between the peak hours of noon and 6:00 pm is -880 MW less than forecast.*
- *The average minimum scheduling bias during the peak hours is -5075 MW.*



Scheduled Hour Ahead Load





Load Following Results

- *Calculated the forecast error.*
- *Calculated the forecast error including the resource scheduling error.*
- *Compared to scheduling bias during peak hours from noon to 6 pm.*
- *Changes are small compared to the scheduling bias.*
- *Effect of renewables on stack appears negligible at this level of penetration.*

Forecast Error Including the Scheduling Error For Each Resource of Interest	Average Minimum Error (MW)	Average Maximum Error (MW)
Scheduling Bias	-5076	1747
Forecast Error	-1909	2220
Forecast-Solar	-1870	2220
Forecast-Geothermal	-1878	2221
Forecast-Biomass	-1897	2218
Forecast-Wind (Altamont)	-1909	2272
Forecast-Wind (San Gorgonio)	-1898	2226
Forecast-Wind (Tehachapi)	-1884	2281
Forecast- Wind (Total)	-1870	2377

Load Following Recommendations

- *The load following analysis indicates that the effect of renewable scheduling errors at existing levels of penetration is negligible compared to the scheduling bias.*
- *Scheduling bias is determined by the scheduling coordinators.*
- *We recommend that no load following cost adders be used for RPS bid evaluation in the near term.*
- *We recommend that additional analysis be conducted to determine the potential load following costs associated with higher levels of penetration.*

Summary of Conclusions

Capacity credit

- *Simplified methods have not been successful so far, so it may be necessary to calculate the ELCC.*
- *In the next phase of this study:*
  - will perform analyses with disaggregated data
  - will determine monetary value
  - will confirm results using other reliability models

Regulation

- *Adopted Method 1.*
- *Regulation cost adders were determined for renewables based on existing generators.*
- *Recommend that these adders be used in the short term until Phases 2 and 3 are complete.*

Load following

- *Load following impact of existing renewable generation is small relative to scheduling bias. Renewables therefore have negligible effect on supplemental energy stack at this level of penetration.*
- *Consequently, recommend no load following cost adder be used in the short term.*

Phase 1 report

- *Will be released on September 26, 2003 at*
  http://cwec.ucdavis.edu/rpsintegration
- *Includes detailed results and discussion of the Phase 1 analysis.*
- *Will address questions from today's workshop and formally posed through*
  rpsintegration-Q@cwec.ucdavis.edu

Phase 2

- *Continue analyses and determine the impact of:*
  - various generator technologies
  - location
  - climate
  - level of penetration

Further Information

- *Website:*

  http://cwec.ucdavis.edu/rpsintegration/

- *You can subscribe to one of the following mailing lists through the website:*

  rpsintegration-workinggroup@cwec.ucdavis.edu

  an open mailing list for discussion of the development of the valuation methodologies; potentially high traffic volume

  rpsintegration-announcements@cwec.ucdavis.edu

  an open mailing list announcing key events relevant to the valuation methodologies

- *Direct general questions and discussion about the study to:*

  rpsintegration-workinggroup@cwec.ucdavis.edu

- *Submit formal questions and comments to:*

  rpsintegration-Q@cwec.ucdavis.edu

  All submissions and responses will be saved and openly posted as public record.

Outstanding issues and questions

Capacity credit

- Are there other existing reliability models which can be applied in the capacity credit analysis?
- What is the monetary value of capacity ($/kW-year)?
- What is the CPUC capacity value study investigating?

Load following

- Can the Intermittent Resources Protocol create integration costs?
- What is the process by which the scheduling bias is selected?
- What is the effect of the scheduling bias on integration cost?

General

- What forms of small hydro are eligible for the RPS?