Survalent.

Short Term Load Forecasting

User Guide

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LF-400 Short Term Load Forecasting User's Guide

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About This Publication

This manual describes how to use the Short-Term Load Forecasting package in Windows SCADA.

It is assumed that you have some background knowledge about SCADA systems.

Revisions

Date	Description
February 7, 2006	Initial version.
December 18, 2006	Added Day of Week to forecast algorithm. Added clarifications and updated figures.
October 11, 2007	Added new algorithm for simplified forecasting without weather data.
July 2, 2008	Minor clarifications.
April 16, 2015	Updates, including making day-type matching a user-selectable option and various updated figures.
November 6, 2017	Updated section 4.1.5 with new functionality. Updated screen captures throughout the document. Added the new logo.

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1 Introduction

This document describes how the Survalent Short Term Load Forecasting package for Windows SCADA operates and how you can use it to produce 1-day and 7-day forecasts of your load.

The optional Load Estimation feature can then allow you to use these forecasts to produce ongoing estimates of your load value, which can be used to replace missing load data in case of communications failure.

The conventional algorithm used by the forecasting program is based on matching of historical load and weather data. Correction for weather deviations is based on a linear model that is seasonal and both time and temperature dependent. By using equivalent temperatures, the model takes humidity and wind-chill effects into account.

Annual load growth can be accounted for in both the load/weather matching and the weather correction process.

An alternative algorithm may be selected, which eliminates the need for historical weather data and a weather forecast. In this case, the forecast is based on the historical load data from the same day of the week, going back for several weeks (you can specify how far back to go). This algorithm also requires much less load history, but it cannot account for any long-term effects such as annual load growth, nor for any outside factors other than how the load varies with the time of day and the day of the week.

1.1 General

The forecasting program can produce 3 types of forecasts: a 24-hour and 7-day (168-hour) forecast based on the full historical load and weather data, and a 24-hour forecast based only on recent load data. In the latter case, the forecasting program will also produce interpolated predictions for 15, 30, 45 and 60 minutes into the upcoming hour.

Typically, a 24-hour forecast is useful for planning and/or triggering load management strategies, as well as for Load Estimation purposes (see chapter 7, *Load Estimation*). A 7-day forecast is generally used in the determination of unit commitment schedules.

The forecasting program will generate separate forecasts for different user-specified load areas, with independent forecasting parameters for each load area. Editors are provided that allow you to specify the forecasting parameters for each load area.

Editing facilities are provided to allow you to enter the weather forecast. For those who have a source for weather forecast data, the system includes an import program that imports both forecast and historical data from text files. These files can be automatically retrieved via FTP, if required.

The load forecasting package includes a weather model estimation program that performs a regression analysis of your existing historical load and weather data, to generate an optimum (least-squared error) weather model for your system. The program produces a set of seasonal time- and temperature-dependent weather correction parameters based on your own historical data, which can be used to further refine the weather-based load forecast.

As a separate option, a load estimation program is available, which uses your load forecasts to produce continuously estimated load values for the present time. These can be used to replace telemetered load data during periods of failed communication, by means of a specialized function in the Periodic Calculations.

Chapter 2 describes the two load forecasting algorithms, including the historical load and weather matching process, the use of the weather model to refine the forecast, and the weighted-average algorithm that can be used instead if no weather data is available.

Chapter 3 describes how to define historical datasets in the SCADA system to collect the load (and weather) data required by the load forecasting program.

Chapter 4 describes the load forecasting editors, which define the forecasting parameters for each load area, the characteristics of the specific forecasts you require, the weather forecast data, and any holiday dates that you might want to specify.

Chapter 5 describes the output of the load forecasting program.

Chapter 6 describes the generation of a weather model from your historical data.

Chapter 7 describes the optional Load Estimation program, and how to use its output to replace missing load data.

Chapter 8 contains a list of references for further reading on the subject of load forecasting.

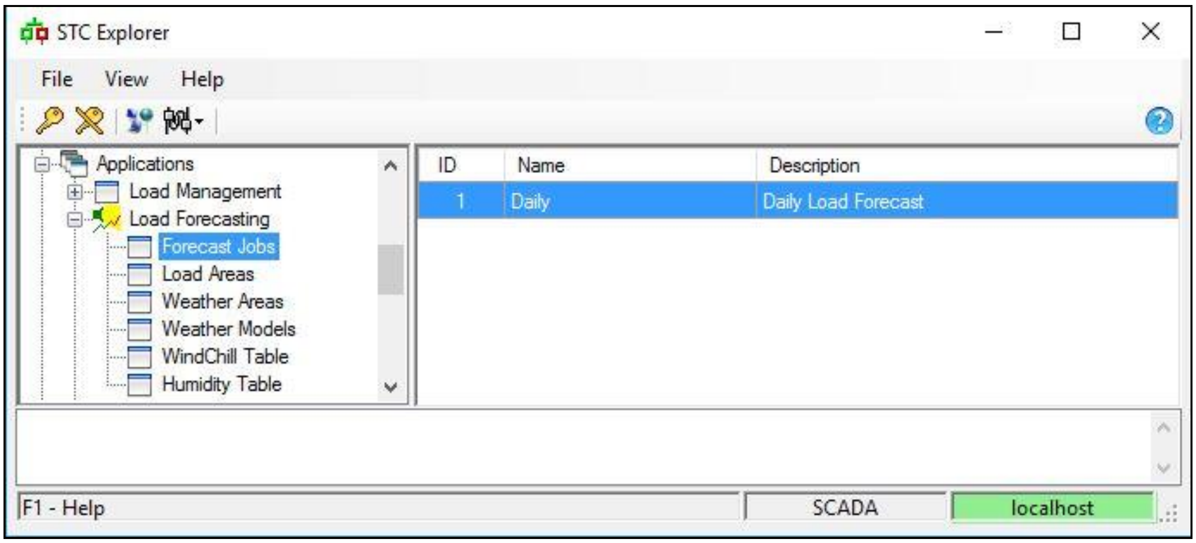
1.2 Database Editing

The database files used by the Load Forecasting program are part of the Windows SCADA database. These files are edited using the SCADA Explorer client software. For additional information on the installation and operation of SCADA Explorer, please refer to *DB-400, Windows SCADA Database Editing Overview*.

1.2.1 Load Forecasting Editors

The editors used for Load Forecasting can be found in the branch labeled Load Forecasting, in the Applications branch in the left-hand pane of the SCADA Explorer window (see Figure 1.2-1). Using each of the editors is described in the chapters that follow (refer to the chapter descriptions in section 1.1).

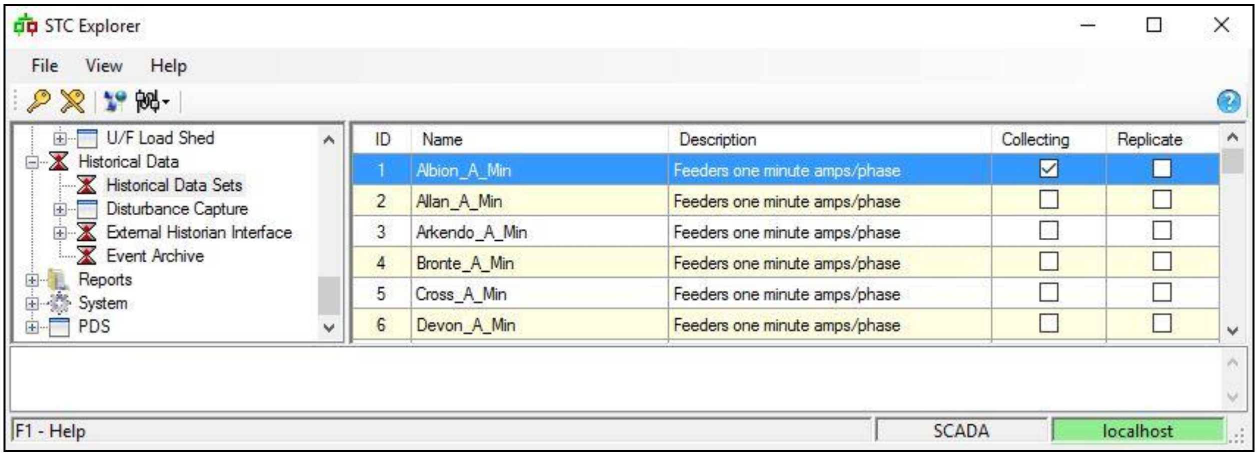
Figure 1.2-1 Load Forecasting Database Files



1.2.2 Historical Dataset Editor

In addition to the files above, the Load Forecasting package makes use of historical data sets to provide input data, and to receive the resulting forecast. Editing historical datasets is described in *DB-404, Windows SCADA Historical Database Editing Guide*.

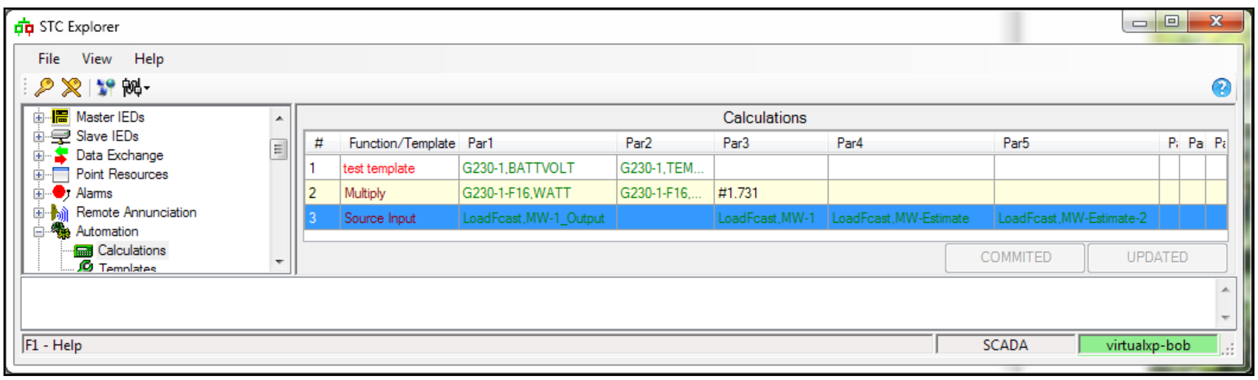
Figure 1.2-2 Typical Historical Database Files



1.2.3 Calculations Editor

If you are interested in using a forecast to provide an ongoing estimate of a load, you may need to be able to select between the measured load value and its estimated value. This can be accomplished using the Source Input Selection Calculation (function 34). See *DB-403, Windows SCADA Automation Database Editing Guide* for more information.

Figure 1.2-3 Source Input Calculations



The process of creating and using an estimated load is discussed more fully in chapter 7, *Load Estimation*.

2 Forecast Algorithms

This chapter describes the two available load forecasting algorithms. One will produce its forecast (for either 24 or 168 hours) based on a corresponding weather forecast and several years of weather and load history. The second algorithm will base its 24-hour forecast on a weighted average of the load over the past several weeks, considering only the same day of the week. This algorithm requires no weather data.

The first “classical” algorithm is capable of accurate forecasting in situations where the load has shown a historical relationship to temperature and any of up to 3 other variables, usually humidity, wind speed, and cloud cover. It can be adjusted to include equivalent-temperature tables, and permits differing weighting of the weather variables. It includes an advanced weather modeling feature that can be used to further improve the forecasts by incorporating information about how your load has historically varied with temperature changes at different times of the day and the year, at differing load levels.

The second, simpler algorithm is more suited to situations where load is not dependent on the weather, but instead shows regular daily and weekly patterns that do not change much over time. This forecast does not require as much historical data, but it cannot account for any external factors (other than the time of day and the day of the week).

2.1 Classical Forecast Algorithm

This weather-based forecast algorithm compares recent weather and load history plus the predicted weather against your historical weather and load data. It then uses the most similar historical periods it finds to predict what the load will be for the forecast period.

The historical data required by the load forecasting algorithm consists of several years of hourly samples of at least the following data:

- Load
- Temperature (dry bulb air temperature)

The program is also designed to use hourly samples of the following data, if they are available:

- Relative humidity
- Wind speed
- Cloud cover or opacity

The forecasting algorithm consists of the following two steps:

- Load and Weather Matching

  The matching routine of the forecasting program performs a least squares matching of the recent load-weather trend plus the weather forecast against the historical data.

- Weather Correction

  The load shapes for the resulting five best match dates are then adjusted for weather deviations, using the weather model, and combined to provide the forecast.

2.1.1 Load and Weather Matching

2.1.1.1 Matching for a 24-hour Forecast

For a 24-hour forecast, the matching routine looks for the five best “least squares” matches to the 48-hour period consisting of the most recent 24-hour load and weather trend plus the next 24-hour weather forecast. This consists of finding five values of h (h = time in history) that produce the smallest values of the following error function:

Equation 2-1

$$A * \sqrt{\frac{1}{48}\sum_{i=-23}^{1=24}\left[temp(c+i) - temp(h+i)\right]^2}$$

$$+ B * \sqrt{\frac{1}{48}\sum_{i=-23}^{i=24}\left[windspeed(c+i) - windspeed(h+i)\right]^2}$$

$$+C*\sqrt{\frac{1}{48}\sum_{i=-23}^{i=24}\left[cloud(c+i)-cloud(h+i)\right]^2}$$

$$+D*\sqrt{\frac{1}{48}\sum_{i=-23}^{i=24}\left[humidity(c+i)-humidity(h+i)\right]^2}$$

$$+E*\sqrt{\frac{1}{24}\sum_{i=-23}^{i=0}\left[load(c+i)-\left(load(h+i)*growth(h)\right)\right]^2}$$

where:

c	=	current time
h	=	time in history
i	=	hour number, -23 to 24
A, B, C, D, E	=	user-defined weighting factors
growth(h)	=	load growth factor (derived by prorating the estimated annual load growth)

Note that weather "inertia" (the effect the previous day has on today's weather) is accounted for by the fact that the previous 24-hour load-weather trend is included in the matching process.

2.1.1.2 Matching for a 7-Day Forecast

For a 7-day forecast, the matching routine looks for the five best "least squares" matches to the 10-day period consisting of the most recent 3-day load and weather trend plus the next 7-day weather forecast. This consists of finding five values of h (h = date in history) that produce the smallest values of the following error function:

Equation 2-2

$$A*\sqrt{\frac{1}{240}\sum_{i=-71}^{1=168}\left[temp(c+i)-temp(h+i)\right]^2}$$

$$+B*\sqrt{\frac{1}{240}\sum_{i=-71}^{i=168}\left[windspeed(c+i)-windspeed(h+i)\right]^2}$$

$$+C*\sqrt{\frac{1}{240}\sum_{i=-71}^{i=168}\left[cloud(c+i)-cloud(h+i)\right]^2}$$

$$+D*\sqrt{\frac{1}{240}\sum_{i=-71}^{i=168}\left[humidity(c+i)-humidity(h+i)\right]^2}$$

$$+E*\sqrt{\frac{1}{72}\sum_{i=-71}^{i=0}\left[load(c+i)-(load(h+i)*growth(h))\right]^2}$$

where:

c	=	current date
c	=	current time
h	=	time in history
i	=	hour number, -71 to 168
A, B, C, D, E	=	user-defined weighting factors
growth(h)	=	load growth factor (derived by prorating the estimated annual load growth)

This is the same matching algorithm, applied over the 10-day period instead of the two-day period used for a 24-hour forecast.

Note that as before, weather “inertia” (the effect of the previous week) is accounted for by the fact that the previous 3-day load/weather trend is included in the matching process.

2.1.2 Weather Correction

After the five best historical load/weather matches have been found, the forecasting program generates the forecast by weather-correcting each of the five historical load curves and then taking the average of these corrected curves to produce one forecast curve.

The weather correction process uses weather forecast data (obtained from the weather forecast editor) and consists of applying the following transformation to the historical load values:

Equation 2-3

$$MW(i)=(load(h)*growth(h))+(C[i,j]*dT(h))$$

where:

MW(i)	=	forecasted load at time i
h	=	historical match time that corresponds to i
load(h)	=	historical load value
growth(h)	=	load growth factor (prorated annual load growth)
C[i,j]	=	dMW / dT weather model value for time i and temperature j
dT(h)	=	effective temperature difference between time h and time i

The effective temperature difference dT(h) is computed as follows:

dT(h)	=	THI[T(h)] - THI[T(i)]	if T(i) > 24 °C (typ.)
	=	T(h) - T(i)	if -1 < T(i) < 24 °C (typ.)
	=	WCI[T(h)] - WCI[T(i)]	if T(i) < -1 °C (typ.)

where:

T(i)	=	forecasted dry bulb temperature at time i (from weather forecast)
T(h)	=	forecasted dry bulb temperature at time h (from historical data)
THI[]	=	temperature-humidity index (equivalent temperature from humidity table)
WCI[]	=	wind-chill index (equivalent temperature from windchill table)

At warm temperatures (typically above 24 °C), the weather correction factor may be computed using the temperature-humidity index (THI) in place of just the temperature. This takes into account the added discomfort of humidity at higher temperatures.

At cold temperatures (typically below –1 °C), the weather correction factor may be computed using the wind-chill index (WCI) in place of just the temperature. This takes into account the effects of wind on energy consumption at low temperatures.

2.1.2.1 Temperature-Humidity Index

The temperature-humidity index (THI) is generally taken to be a function of temperature and some measurement of atmospheric moisture.

For generality, the Survalent load forecasting package does not rely on a fixed formula. Instead, it obtains the equivalent temperatures by interpolating from a user-provided table. The table provides an apparent temperature based on dry-bulb temperature and relative humidity.

Figure 2.1-1 is a reproduction of an apparent temperature chart based on both relative humidity and wind speed. This chart is taken from page 473 of reference [1].

Figure 2.1-2 illustrates part of a table that was defined based on just the temperature and relative humidity data in the chart of Figure 2.1-1. (The sub chart of increment for wind speed is not included in this table.)

NOTE: This THI will automatically be used for temperatures that fall within the range defined in your table, and will not be used for other temperatures.

If you want to use this table (which is designed for metric units), it can be provided by your Survalent customer service contact. Or you may prefer to provide your own table, especially if you are going to work in Fahrenheit temperatures. Reference [1] gives a number of formulas for THI that you could use in generating your table. For example, a formula based on dry-bulb temperature (in the Fahrenheit scale) and relative humidity is given as follows:

Equation 2-4

$$THI = t - 0.55(1 - rh)(T - 58)$$

where:

THI	=	equivalent temperature (°F)
T	=	dry bulb temperature (°F)
rh	=	RH / 100
RH	=	relative humidity (%)

Alternatively, a table may be available in the units you desire from your local weather service.

Figure 2.1-1 Apparent Temperature Chart for Relative Humidity

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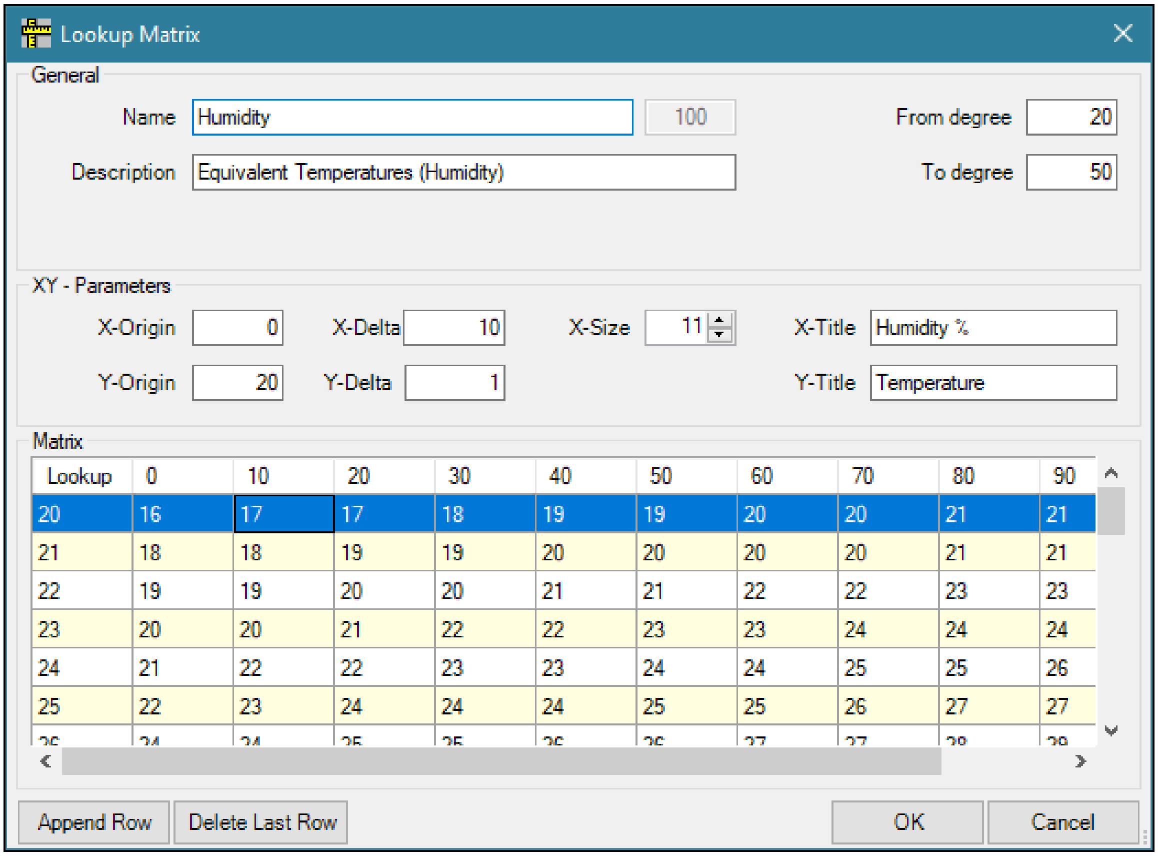
TABLE 2. Apparent temperature chart

Air Temperature (deg C)	Relative Humidity (%)											Increment for wind (m/s)				
	0	10	20	30	40	50	60	70	80	90	100	0-3	4	8	12	16
20	16	17	17	18	19	19	20	20	21	21	21	0	-1	-3	-4	-4
21	18	18	19	19	20	20	21	21	22	22	23	0	-1	-3	-4	-4
22	19	19	20	20	21	21	22	22	23	23	24	0	-1	-2	-3	-4
23	20	20	21	22	22	23	23	24	24	24	25	0	-1	-2	-3	-4
24	21	22	22	23	23	24	24	25	25	26	26	0	-1	-2	-3	-4
25	22	23	24	24	24	25	25	26	27	27	28	0	-1	-2	-3	-4
26	24	24	25	25	26	26	27	27	28	29	30	0	-1	-2	-3	-3
27	25	25	26	26	27	27	28	29	30	31	33	0	-1	-2	-3	-3
28	26	26	27	27	28	29	29	31	32	34	35	0	-1	-2	-3	-3
29	26	27	27	28	29	30	31	33	34	36	38	0	0	-1	-2	-3
30	27	28	28	29	30	31	32	34	35	38		0	0	-1	-2	-2
31	28	29	29	30	31	33	34	36	38			0	0	-1	-2	-2
32	29	29	30	31	33	35	36	39	41			0	0	-1	-1	-1
33	29	29	30	31	33	36	38	41	44			0	0	0	-1	-1
34	30	31	32	34	36	38	40	44	46			0	0	0	0	0
35	31	32	33	35	37	40	43	45				0	0	0	0	+1
36	32	33	35	37	39	42	45					0	0	0	+1	+1
37	32	34	36	38	41	44	48					0	0	0	+1	+2
38	33	35	37	40	43	47						0	0	0	+1	+2
39	34	36	38	41	44	49						0	0	+1	+2	+2
40	35	37	40	43	46							0	0	+1	+2	+3
41	36	38	41	44	49							0	0	+1	+2	+3
42	36	39	42	46								0	0	+1	+2	+3
43	37	40	44	48								0	0	+1	+2	+3
44	38	41	45	50								0	0	+1	+2	+3
45	39	42	47									0	0	+1	+2	+3
46	39	43	49									0	0	+1	+2	+4
47	40	44	50									0	0	+1	+3	+4
48	41	45	52									0	0	+1	+3	+4
49	42	47										0	0	+1	+3	+4
50	43	48										0	0	+1	+3	+4

Data from Steadman, 1979

Figure 2.1-2 Equivalent Temperature Table for Humidity



2.1.2.2 Wind Chill Index

The wind-chill index (WCI) is generally taken to be a function of temperature and wind speed.

As in the case of the temperature-humidity index, the Survalent load forecasting package obtains the wind chill equivalent temperature from a customer-entered table, rather than relying on a fixed formula.

Figure 2.1-4 is a reproduction of a wind-chill equivalent temperature chart. This example chart is taken from page 476 of reference [1].

Figure 2.1-3 illustrates part of the wind-chill table that is based on revised data from the US National Weather Service and Environment Canada. This table, which assumes metric units, can be provided by your customer service contact at Survalent.

NOTE: This WCI will automatically be used for temperatures that fall within the range defined in your table, and will not be used for other temperatures.

Alternatively, you may wish to define your own wind-chill table, or use one provided by your local weather service.

A formula that you could use for the wind chill equivalent temperature based on dry-bulb temperature and wind speed (again from reference [1]) is given as follows:

Equation 2-5

$$WCI = 33 - \frac{(10.45 + 10V^{0.5-V})(33 - T)}{22.04}$$

where:

WCI	=	equivalent temperature (°C)
V	=	wind speed (m/s)
T	=	dry bulb temperature (°C)

Note that this formula is not applicable to wind speeds less than 1.79 m/s (which is the estimated average speed of a human being walking briskly).

Figure 2.1-3 Equivalent Temperature Table for Wind Chill

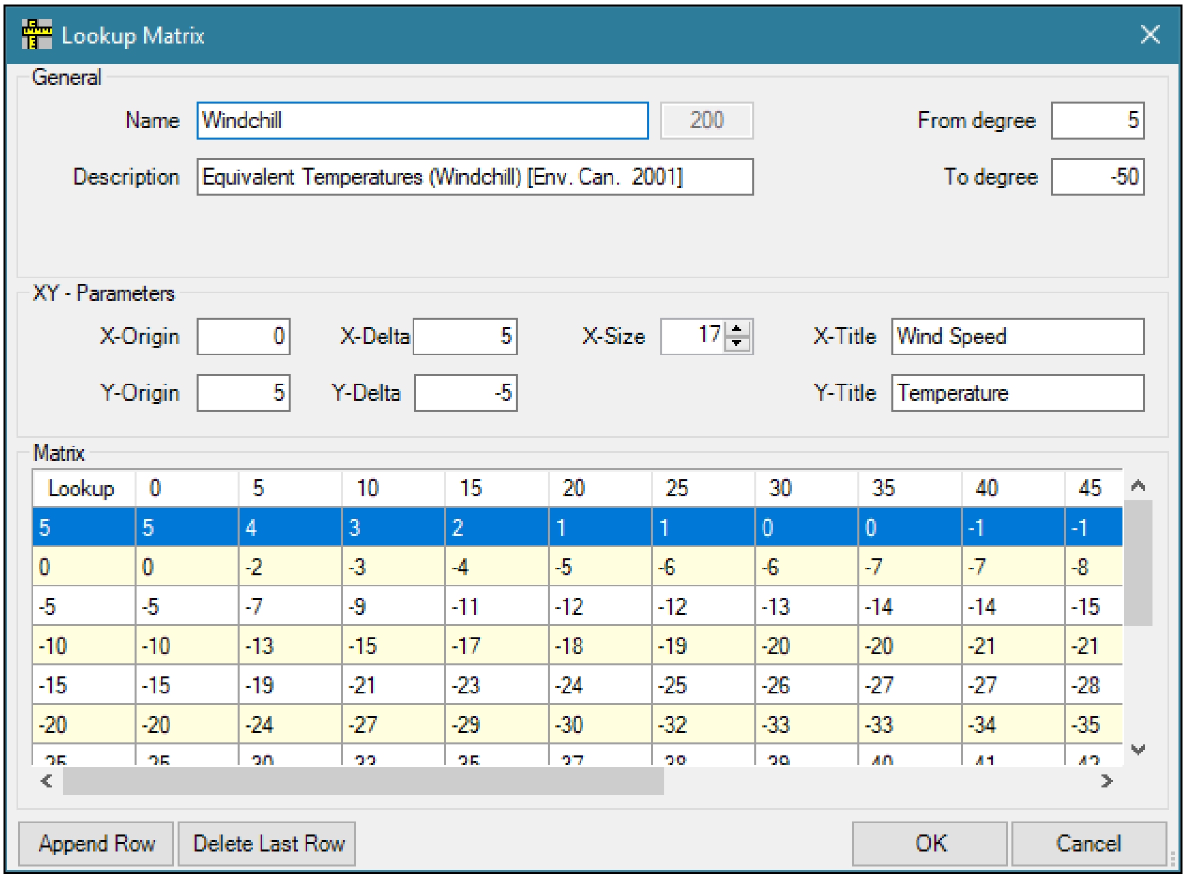


Figure 2.1-4 Apparent Temperature Chart for Wind Chill

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TABLE 4. Windchill equivalent temperature (degF)

Temperature (deg F)	Wind Speed (mph) Calm	5	10	15	20	25	30	35	40
32	34	32	27	24	21	17	14	12	10
30	32	30	25	21	18	15	12	10	7
28	30	28	23	19	15	12	9	6	4
26	28	26	21	17	13	9	6	3	1
24	26	24	19	14	10	7	3	0	- 3
22	25	22	16	12	8	4	1	- 3	- 6
20	23	20	14	9	5	1	- 2	- 6	- 9
18	21	18	12	7	2	- 2	- 5	- 9	-13
16	19	16	10	5	0	- 4	- 8	-12	-17
14	17	14	8	2	- 3	- 7	-12	-16	-20
12	15	12	6	0	- 5	-10	-15	-19	-24
10	13	10	4	- 2	- 8	-13	-18	-23	-28
8	11	8	1	- 5	-11	-16	-21	-26	-32
6	9	6	- 1	- 7	-13	-19	-24	-30	-36
4	7	4	- 3	-10	-16	-22	-28	-34	-40
2	5	2	- 5	-12	-19	-25	-31	-38	-44
0	3	0	- 7	-15	-22	-28	-35	-42	-49
- 2	1	- 2	-10	-17	-25	-31	-39	-46	-54
- 4	- 1	- 4	-12	-20	-28	-35	-42	-50	-58
- 6	- 3	- 6	-14	-22	-30	-38	-46	-54	-63
- 8	- 4	- 8	-16	-25	-33	-41	-50	-59	-67
-10	- 6	-10	-19	-28	-36	-45	-54	-63	
-12	- 8	-12	-21	-30	-39	-48	-58	-68	
-14	-10	-14	-23	-33	-42	-51	-62		
-16	-12	-16	-26	-36	-45	-55	-66		
-18	-14	-18	-28	-38	-49	-59			
-20	-16	-20	-30	-41	-52	-63			
-22	-18	-22	-32	-44	-55	-66			
-24	-20	-24	-35	-47	-58				
-26	-22	-26	-37	-49	-62				
-28	-24	-28	-39	-52	-65				
-30	-26	-30	-42	-55	-68				
-32	-27	-32	-44	-58					
-34	-29	-34	-47	-61					
-36	-31	-36	-49	-64					
-38	-33	-38	-51	-67					
-40	-35	-40	-54	-69					

Data from Steadman, 1971

2.1.3 Day Type Matching

In the load-weather matching process, the load forecasting program may optionally take day "types" into account. If selected, this option means that when searching the historical data for best matches for yesterday's load and weather plus today's weather forecast, the program only considers days in the past whose day types match the yesterday-today pair.

Three-day types are considered:

- Weekdays (Monday through Friday)
- Saturdays
- Sundays and holidays

For 24-hour forecasts, the matching is done for two consecutive days and the day types (but not necessarily the exact day of the week) of both days in the history must match yesterday + today. For 7-day forecasts, the entire 10-day series must match. This means that the 10-day historical periods chosen will all start on the same day of the week.

Note that all weekdays are considered to be the same type. This means that, in a 24-hour forecast for example, a Tuesday-Wednesday pair will match all 2-weekday pairs in the history. But a Sunday followed by a holiday Monday will only match pairs where both days are either a holiday or a Sunday.

If the day type matching option is not selected, then the search for best matches will not exclude good matches just because they fall on the wrong day of the week. This can yield many more potential matches, especially if you are generating a forecast at a time that includes a holiday (where there might otherwise not be many matching day combinations to choose from).

2.2 Simplified Forecast Algorithm

The simplified forecast algorithm produces a 24-hour forecast without the need for any weather data (either historical or forecast). This algorithm examines the load history going back over the number of weeks that you specify, looking only at the same day of the week as the forecast day. It combines all these 24-hour periods in a weighted average to predict what the load will be for the forecast period.

This algorithm requires only a relatively small amount of historical data, going back at least 1 week further than the number of weeks you have specified in the forecast parameters. Only hourly samples of the load values are required.

2.2.1 Day of Week Matching

For each hourly forecast value, the matching routine looks back in history at 1-week intervals, up to the specified maximum number of weeks. This ensures that it is looking at the same day each week, except in the case of holidays.

If a day in the history is found to be a holiday and the forecast day is a holiday, then this is considered a match like any other. But if the forecast day is not a holiday, the holiday in history will be omitted from the forecast calculation. While searching back through the relatively small number of weeks, it is assumed that only a very few holidays might be found to fall on the same day of the previous few weeks (usually none at all). These can be omitted without compromising the forecast.

On the other hand, if the forecast day is a holiday itself, most historical days will not match, unless they also happen to be a holiday. Instead of omitting these days, the preceding Sunday's data is used.

For this algorithm, the day of the week is used as described above, and the day type matching option described in section 2.1.3 does not apply.

2.2.2 Weighted Average

The historical values retrieved from each of the past weeks are combined in a weighted average. The most weight is assigned to the most recent week, decreasing linearly each week, back to the specified number of weeks ago. Data that is going to be omitted from the calculation (as described above) is assigned a weight of zero.

This causes the forecast value to depend mainly on what the load has been in the most recent weeks, and progressively less on what it was in earlier weeks.

2.3 Day of the Week Calculation

The current day of the week can be calculated for you by the load forecasting program, and stored in an analog point where it can be sampled into your historical dataset.

The day of the week (Sunday through Saturday) is represented by a number from 1 to 7 as defined in Table 2.3-1. The current day of the week is used by the forecast program as described above, and should be present in your historical data. You can also display it in your SmartVU map, for reference by the operators.

To accomplish these last two functions, the day of week number must be stored in a database point. If you specify this point in a load forecast that is scheduled at least daily (refer to section 4.2.4 for information on scheduling forecasts), then the load forecast program will calculate the current day of the week when the forecast is run, and store it in the point.

The value zero is used to force the forecasting algorithm to calculate the day of week on the fly (see 2.1.3, and 2.2.1), and usually occurs if you do not refer to the point in any scheduled forecasts. The value –1 is usually entered into the historical dataset manually, to mark periods where valid data is not available (see 3.1.5).

Table 2.3-1 Day of the Week Values

Day Value	Day Name
1	Sunday
2	Monday
3	Tuesday
4	Wednesday
5	Thursday
6	Friday
7	Saturday
0	in Historical Data, indicates the day must be calculated when needed
–1	in Historical Data, indicates this sample is not to be used (bad data)

This sort of information can be conveniently displayed on your map as text instead of just a number, if you use a set of Enumerated Values for the analog point in question. In that case, use the day names for values from 1 to 7, and suitable text such as “unknown” or “failed” for 0 and –1.

Holidays are indicated by a day-of-week value that is 10 higher than the above values. For example, a holiday Monday is indicated by the value 12. If you want to make use of holidays you should make certain that your Enumerated Values include these higher values (as well as the invalid values from 8 to 10).

You must define holidays manually, as described in section 4.4. Whenever the current date matches one of your entered holiday dates, the calculated day of the week will be increased by 10.

3 Historical Data Collection

The Load Forecasting package uses historical load and weather data contained in the SCADA system's historical database. References to the historical data are specified for each load area on the Load Areas editor, which is described in section 4.1, *Load Area Editor*.

The historical datasets required by the load forecasting package are defined using the Historical Data Sets editor in SCADA Explorer. All the data required for a given load area must be collected in a single dataset. However, you can use the same dataset for multiple load areas.

Figure 3.1-1 shows an example of a dataset defined for use in load forecasting.

3.1 Definition of Historical Datasets

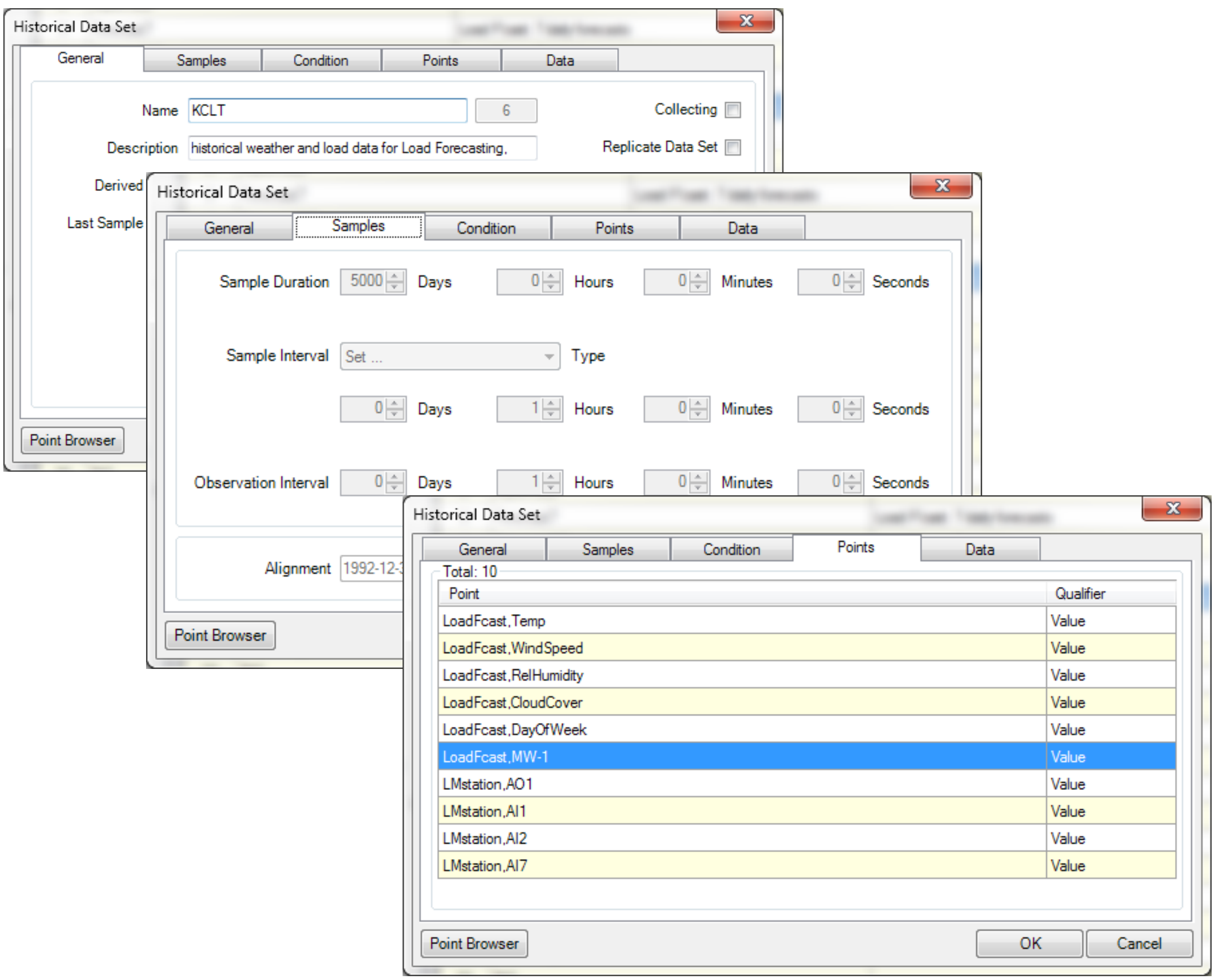
A historical dataset used for load forecasting must be defined as outlined below. Items not discussed may be set to suit.

Sample Interval

This must be set to 1 hour.

Sample Duration

If classical forecasts are going to be performed, this should be set for at least several years; five or more is recommended. More data will permit better matches and better forecasts. If you will only be generating simplified forecasts, this dataset can be of much shorter duration, perhaps as little as 1 week beyond the number of weeks you will be using in your forecast definitions.



Points

The classical load forecasting algorithm typically uses the following weather variables:

- Temperature
- Wind speed
- Relative humidity
- Cloud cover

These points can be either telemetered or written by an application that obtains weather data from a weather service (such as the weather import described in section 4.3). The names of these data points will be specified in the Load Areas editor, described in chapter 4, *Load Forecast Editors.*

The program also uses a **Day of Week** point**,** an analog point whose value represents the day of the week on which that sample was recorded. This point's value may be computed by the load forecasting program, as described in section 2.3, or you may just leave its value at zero. If left at zero, the Load Forecasting program will calculate the actual day of the week internally when required. But the point is desirable for historical purposes, described in section 3.1.5, *Day of Week*.

The **Load** data point itself (the MW reading) must also be in this dataset. In fact, any number of load data points may be included in this dataset, so long as these loads all depend on the same weather data. If not, and you have separate weather data for the different loads, you *could* put everything in a single historical dataset, but it might be less confusing to create a separate dataset for each area.

For each load area, the load data point in the dataset is specified in the Load Areas editor, described in chapter 4, *Load Forecast Editors*.

Each data point will be described in more detail below:

3.1.1 Temperature

The temperature point should represent dry bulb temperature. It may use either Celsius or Fahrenheit. Whichever temperature units you use, make sure that both the THI and WCI tables (if used) also use the same units (see section 2.1.2, *Weather Correction*).

Your weather forecast must also use these same units.

3.1.2 Wind Speed

The point containing wind speed may be scaled to any units you wish. It is usually scaled to either miles per hour (mph) or kilometers per hour (kph). Whatever units you use, make sure that the WCI (wind chill) table uses the same units (see section 2.1.2, *Weather Correction*).

Your weather forecast must also use these same units, if applicable.

3.1.3 Relative Humidity

The point containing relative humidity is typically scaled to percent, but it doesn't have to be. Whatever it is, make sure its units agree with those of the THI (humidity) table (see section 2.1.2, *Weather Correction*).

Your weather forecast must also use these same units, if applicable.

3.1.4 Cloud Cover

The point containing cloud cover may be scaled to represent a percentage, or anything else you prefer (e.g. a scale of 1 to 10).

Your weather forecast must also use these same units, if applicable.

3.1.5 Day of Week

The day of the week is represented by the value of this point, as described in section 2.3. If it is included in the historical dataset, its value will be used by the forecast algorithm (provided it is not zero). Otherwise, the forecast program will calculate the day of the week from the timestamps on the historical samples. See also 2.1.3, Day Type Matching and 2.2.1, *Day of Week Matching*.

Regardless of how or whether its current value is computed, the Day of Week point's importance in the dataset (even if you are not calculating or displaying its value) arises from the fact that there will eventually be some samples in your historical data that are not suitable for forecasting purposes. Perhaps the weather or load data was inaccurate during those periods, or the system's state was very non-typical. You will not want this data to be included in the matching process since it may adversely affect the forecast result.

If you have such data that should be excluded from the forecaster's matching process, you can accomplish this easily. Simply use the historical data editor to manually set the Day of Week value for those samples to –1. This will indicate to the load forecasting program that the samples are not to be used.

NOTE: Any samples with condition codes that are not **Normal**, **Manually Set**, or **Calculated** are automatically excluded from the matching process. This avoids corrupting your forecasts with "flat" data recorded during periods of failed communications.

You may mark just a single sample, if it is undesirable, or every sample in an entire 24-hour (or longer) period. Of course, if only a very few samples are affected, you may prefer to manually set them to more reasonable values, in which case the Day of Week can be set to the correct day (or zero), to allow that manually-corrected data to be used for forecasting purposes.

3.1.6 Load

The point containing load is usually scaled to represent MW, but can be anything you wish.

This value doesn't even have to be an electrical load. It could be gas or water demand, measured in cubic meters per second or some other units. As long as the variable has a daily and weekly pattern to it, and a dependency on some other value(s) that you can get a forecast for (not just the weather), then it can be forecast by the Survalent Load Forecasting program. In fact, if the variable also has a linear dependency on temperature (or some other external variable) as expressed in Equation 2-3, then a weather model can be estimated and used to refine the forecast. (See chapter 6, *Estimation of a Weather* Model.)

3.2 Loading Historical Data from Text Files

For conventional weather-based forecasts you need at least several years of historical load and weather data to get good results.

For forecasts that do not require weather history, your historical load data only needs to go back one week further than the number of weeks you want the forecast algorithm to use (although it can go back further of course).

None of this means you have to wait several years while your SCADA system is collecting the data before you can begin to use Load Forecasting. The SCADA system includes a general-purpose historical data loader program called HDLoad, which loads historical data into the SCADA system's historical database from text files. HDLoad is general-purpose in the sense that it can load any kind of historical data into the SCADA system's database, not just load and weather data.

If you have access to historical billing and weather data in machine-readable form, then you can probably quite easily transform it into the file format required by the HDLoad program. The required file format is described below.

If some of the data required is available on paper only (and cannot be scanned) then you may consider manually transcribing these into the required files (you might splurge and hire a summer student).

3.2.1 HDLoad File Format

The HDLoad file format is that of a text file, with the values separated by spaces or tabs. You may be able to export your data (for example, from a spreadsheet) in this form. A few items will need to be added to the beginning of the file, typically using a text editor:

- Comment lines
- Command statements

Anything following a semi-colon *other than a dollar sign* is treated as a comment. Comments may be placed anywhere in the file. They will be ignored by the HDLoad program.

Any line with a semi-colon and a dollar sign together (; $) at the beginning is considered a command statement. Command statements may only be placed at the beginning of the file. Command statements have one of the following formats:

- **;$DATASET='*name*'**

  This specifies the destination dataset, and is a required statement. The text *name* must exactly match the name of the desired dataset.

- **;$STARTTIME=yyyy-mm-dd hh:mm:ss**

  This specifies the starting date and time of the data, and is a required statement.

- **;$POINT='name'**

  This is the full name (station name and point name separated by a comma) of the point in the dataset which is to receive the data in this file. It is a required statement.

Notice that since only one point's data can be included in the file, several files will be needed to import all the data for the dataset.

Following the command statements is the data. The values in each sample line are separated by blanks. No alignment of values is required.

For generality, the HDLoad accepts data for the next sample by continuing to process the data to the end of the data line. This allows you to input a file containing multiple sample values per line (e.g. 24 hourly values per line).

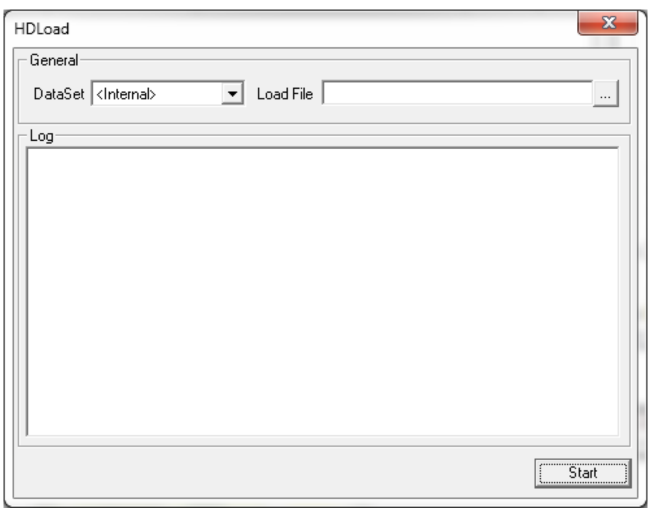
Figure 3.2-2 shows an example of an HDLoad file. It loads temperature values into a designated point of the dataset called KGSP.

3.2.2 Loading a File

The HDLoad program (HDLoad.exe) can be found in the SCADAServer folder, where the SCADA software is installed (usually this is C:/Program Files/Quindar/SCADAServer). Double-click the program file's icon to run it.

You will see the program window, as illustrated in Figure 3.2-1. Press the Browse button (**…**) to invoke the standard Windows dialog to Open the file you wish to import.

Figure 3.2-1 HDLoad Program Window



Select the desired file and press Open. The filename will be added to the Load File field.

Since your file will include a DATASET statement, you do not need to select the name of the Dataset to import into. Just leave the selection as <Internal>.

When you press the Start button, HDLoad will begin reading the file and storing data in the dataset. It will log the progress of the import in the lower portion of the window.

3.2.3 Procedure to Create and Load a Historical Dataset

Before you import your data, the dataset must be prepared to receive it.

The entire procedure for loading a historical dataset from one or more HDLoad files is as follows:

- Using the Historical Dataset editor, define a dataset with the desired points and time parameters, but do not check the “Collecting” flag. When you press OK, the system will allocate the disk space for the dataset but disable automatic data collection. It’s important to have automatic data collection turned off for any dataset that you’re loading. You may re-open the dataset with the editor to confirm the Allocated flag is now set, and the Collecting flag is not. *Close the editor before proceeding*
- Use HDLoad to load your first file
- Use HDLoad to load the other files
- Using the Historical data editor, change the Data Collect Code to “C”. This enables automatic collection of data from this time onward. At this time, you may also want to look at the data that has been imported, via the Data page of the editor

Figure 3.2-2 Example HDLOAD File Containing Temperature Data

```
; Survalent Utilities Load Data file
;
; Hourly historical load data for October 1993
; Created by A. Person on 10-JUN-2004
;
;$DATASET='KGSP'
;$POINTS='LoadFcast,Temp'
;$STARTTIME=1996-01-01 00:00:00
46     46    45    46    45    46    46    46    47 …
47     46    46    45    45    44    44    44    44 …
49     46    44    42    40    39    38    37    38 …
30     29    28    27    26    25    25    23    29 …
32     31    30    31    29    29    29    29    31 …
41     40    40    41    40    40    40    39    38 …
30     29    29    28    28    27    27    26    25 …
        .
        .
        .
```

3.3 Datasets for Load Forecast Output

The results of your load forecasts can be output to a historical dataset as well (see section 4.2.8, *Store Load Forecast Data In*). This must *not* be the same dataset as the one that contains the historical data Load Forecasting is using for its input.

Create a dataset to hold your forecast in the same way that a dataset was created to receive the imported load and weather history in section 3.2.3, Procedure to Create and Load a Historical Dataset.

Using the Historical Dataset editor, define a dataset with the desired points and timing parameters, but *do not check the "Collecting" flag*. When you press OK, the system will allocate the disk space for the dataset but disable automatic data collection. (You may re-open the dataset with the editor to confirm the Allocated flag is now set, and the Collecting flag is not.) Close the editor before proceeding.

NOTE: It's important to have automatic data collection turned off for any dataset that will be receiving load forecast results.

This dataset must be large enough to hold at least one full forecast of the size you intend to use, either 24 or 168 hours of hourly samples. Larger datasets will make it possible to retain more than one forecast, which might be desirable.

After a forecast is produced, this dataset will contain the forecast values, as samples with time stamps that run into the future.

4 Load Forecast Editors

Four database files may be involved in order to produce a Load Forecast. The first defines the “load area” that the forecast will apply to. This specifies the load point whose value is being forecast, and the input data that will be used to perform the forecast. A load area must be defined for each load point you need to forecast.

The second file needed is the definition of a forecast “job”. One or more jobs can be created for each load area. The forecast job specifies the nature of a particular forecast to be performed and optionally, a schedule for automatically performing it. You may create more than one forecast job for a load area, if you need more than one type of forecast for that load point (e.g., both 24- and 168-hour forecasts for the same point).

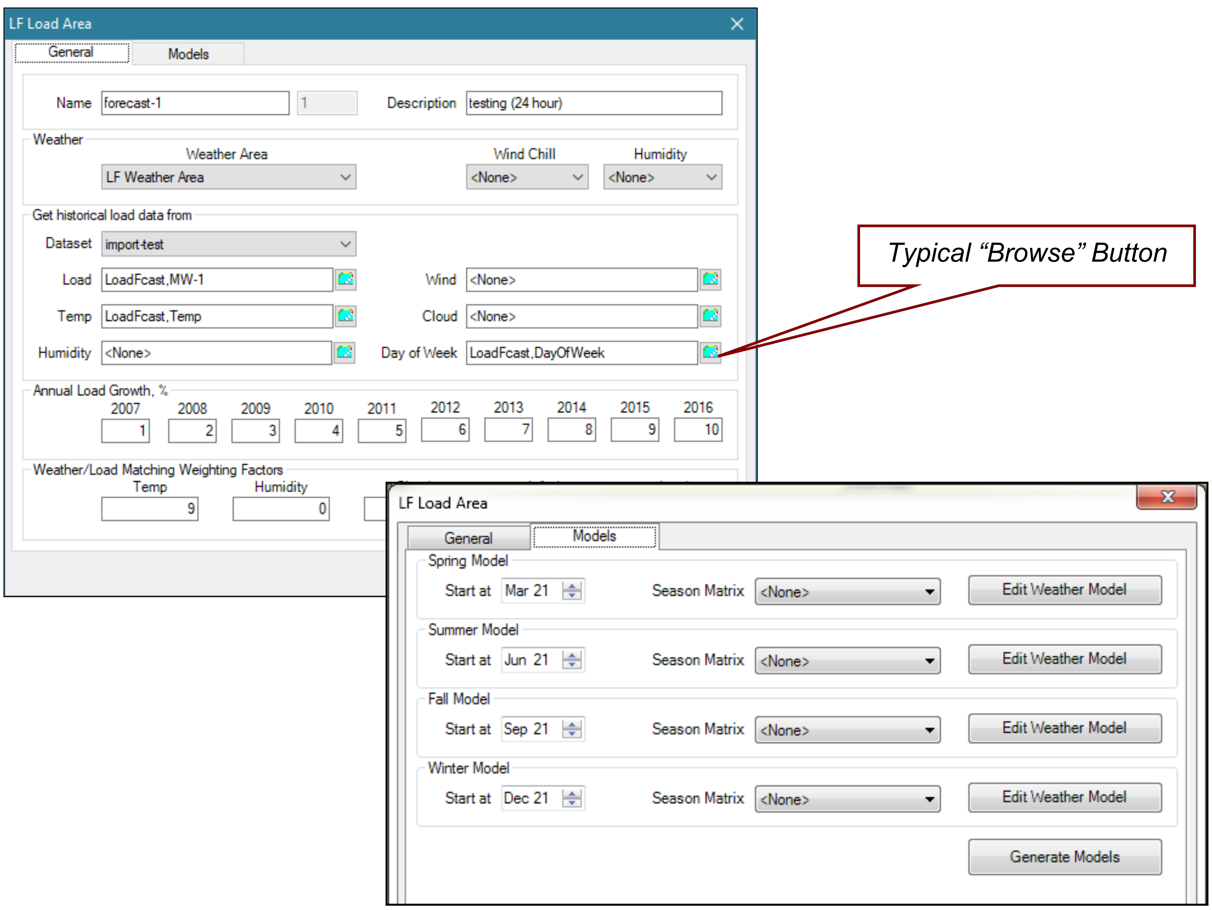
The third file is required if the forecast is to be based on weather data. It contains the weather forecast for the load area being forecast. This contains the detailed weather forecast that will be used to produce the load forecast. Several load areas may share a weather forecast, if the same weather data applies to them all. Alternatively, you may create a separate weather forecast for each load area if you get different weather data for each of them.

Since load forecasts can treat a day differently if it is a holiday, you may also want to enter the next several holiday dates into the fourth file. These database files can be edited via SCADA Explorer. The use of these editors is discussed in detail in this chapter.

4.1 Load Area Editor

The Load Area Editor, illustrated in Figure 4.1-1, allows you to customize the forecasting process for a given load area (i.e. a particular load point) that you wish to forecast. Each record you create defines the forecasting parameters for the load area. You can create as many load areas as you have load quantities you need forecasts for. The data entry fields in the Load Area editor are described below.

Figure 4.1-1 Load Area Editor



4.1.1 Name, ID and Description

Give the load area a brief name that will identify it in other lists that you will see in the database. You may also give it a description, to remind you of its function or which load it represents.

The ID number is automatically assigned by the system and cannot be changed.

4.1.2 Weather Area

If you will be using the classical weather-based forecast algorithm, select the weather forecast for the area that this load forecast applies to. See section 4.3 for more detail about Weather Areas.

4.1.3 Wind Chill and Humidity

If this forecast is to use the effective temperature tables for wind chill (at low temperatures) and humidity (at high temperatures) as described in section 2.1.2, select the tables you want to use from these drop-down lists. Normally, the same tables will apply to all forecasts, and you will select the tables you have supplied in your database.

You may choose <None> if you do not intend to use the equivalent temperature tables in this load forecast.

4.1.4 Get Historical Load Data From

In this section, you must specify where to find the historical load and weather data.

Dataset
This is the SCADA historical dataset that contains the historical load and weather data. Select the name of the dataset you wish to use.

Load Point
Using the Drag-and-Drop Point Browser (via the Browse button indicated) enter the name of the point in the dataset which contains the historical load values. This is the point the forecast is being made for.

NOTE: Although other load areas could share the same dataset, they then must have a different point name specified for the load data.

Day of Week Point
Drop the name of the point from this dataset whose value represents the day of the week. See section 2.3.

Temperature, Wind, Humidity and Cloud Points
In the remaining fields in this group, enter the points in the dataset that contain the historical values for the named quantities (or other external variables that your forecast will depend on). You may omit any of these points except for the temperature, if you do not have historical data for those quantities. (You may omit temperature as well, if you only plan to generate forecasts using the simple algorithm that does not use any weather data.)

4.1.5 Annual Load Growth

These 10 values are annual load growth factors, and are labelled for the years that they apply to. Each factor is expressed as a percentage (year over year). They are used in adjusting historical load data during the matching process to account for load growth over time. Positive or negative values are permitted.

Fill in the annual growth percentages if you have them, or estimate values by looking over your own historical load data. If you cannot estimate these factors adequately, you may leave these fields blank (in which case zero will be used).

Note: Due to the shorter history used by the simple algorithm described in section 2.2, these values are not used for forecasts generated without weather data.

The first time you open this editor each new year, a field will appear for the most recent year’s growth factor, and the oldest year’s value will be discarded. Enter the new value now, or at any future convenient time. You may modify the growth factors for past years at any time.

4.1.6 Weather/Load Matching Weighting Factors

These are weighting factors that are used in the weather-based matching process described in section 2.1. Weighting factors are required for any of the following where you have specified a point name:

- Temperature
- Humidity
- Load
- Wind speed
- Cloud cover

Only the relative magnitudes of the weighting factors are important. Whether you enter them as fractions, percentages or anything else does not matter, so long as they all mean the same thing. Proportionately larger values will make the corresponding point's value more important in the matching process.

NOTE: After you have generated some forecasts, you may wish to tune these weighting factors to improve the accuracy of the forecasts.

As a starting point, you could make the Load and Temperature values large (perhaps equally so, at 5 or 10), and the others much smaller (even one or zero).

4.1.7 Weather Models

The weather-based matching process (described in section 2.1.1) may optionally use four seasonal weather models. Each table contains the time and temperature-range dependence of the load on temperature in the form of a matrix of dMW / dT values. Each table may be created or modified manually if you need to. But usually, you will use the built-in model estimation capability to generate your initial weather model tables. Refer to chapter 6, *Estimation of a Weather* Model.

On the Models tab of the editor, specify the start dates you wish to use for the four seasonal weather models. These are the first days of:

- Spring
- Summer
- Fall
- Winter

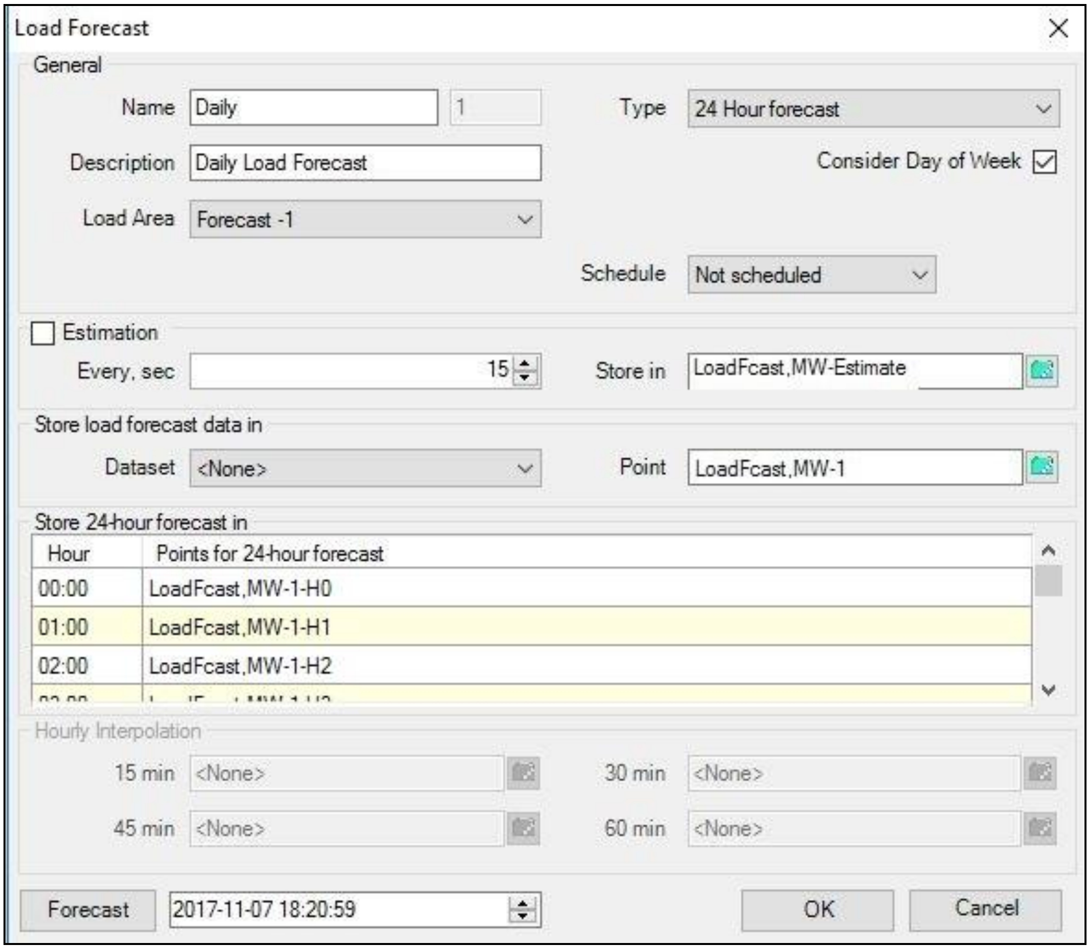
For each season, select the weather model table you wish to use from the drop-down list and specify the desired starting date for each season. You could use the conventional dates, or choose dates that better correspond to the times that your local weather patterns tend to change.

The Generate and Edit buttons are used in creating the weather models. This is described in section 6.2 Generating Your Weather Models.

4.2 Forecast Job Editor

You must create a Load Forecast Job for each forecast you want, defining which type you require and the time at which you want it performed. This definition of the job also specifies where the forecast results will be stored. An example of a forecast job is shown in Figure 4.2-1. The various fields are described below.

Figure 4.2-1 Forecast Job Editor



4.2.1 Name, ID and Description

Give the forecast a brief name that will identify it to you. Then give it a longer description, to remind you of its purpose. The ID number is automatically assigned by the system and cannot be changed.

4.2.2 Type

You must select which type of forecast you want to perform for this job:

- **24 Hour forecast:** A forecast for the next 24 hours, created using the weather-based classical algorithm described in section 2.1
- **7 Day forecast:** A forecast for the next 168 hours, using the above algorithm
- **24 Hour, No Weather:** A forecast for the next 24 hours, created using the simplified algorithm described in section 2.2, without any weather data

4.2.3 Consider Day of Week

Select this option if you want the forecast to include the day of week in its matching algorithm, as described in 2.1.3, Day Type Matching. If not, leave this box un-checked.

This option is not available if the forecast type selected is 24-hour, no weather.

4.2.4 Schedule

This pull-down list allows you to specify when this forecast is to be automatically performed. Choose one of the following:

- **Not Scheduled**
  Select this if you do not require this load forecast to be automatically performed. In this case, you will only see the forecast results after you click on the Forecast button, described below.

- **Daily at**
  Select this for typical 24-hour forecasts that must be repeated each day. Then enter the time of day at which you want the forecast to be updated. Typically, you would choose a time well after the weather forecast for the day had been updated, but earlier than the portion of the day you are most interested in predicting.

- **Hourly at**
  This selection will cause the forecast to be updated every hour of the day, at the number of minutes past the hour that you specify. Normally this would only be used with a 24-hour forecast if the forecast is being used for ongoing Load Estimation, as described in chapter 7.

NOTE: In order for scheduled, weather-based forecasts to succeed, there must be a valid weather forecast available at that time. Normally this means that a weather forecast import will be scheduled shortly before the load forecast. See section 4.3.4, *Weather Import Settings*, for details.

4.2.5 Load Area

Select the load area (as defined in section 4.1, *Load Area Editor*) whose forecast will be performed by this forecast job. If you select <None>, no forecast will be performed.

4.2.6 Estimation

If this forecast is going to be used by the optional Load Estimation program described in chapter 7, *Load Estimation*, tick this checkbox. You must also specify an estimation interval, in seconds, as well as the name of the analog point that will receive the estimated value. This must not be the same point as the load point specified in the Load Area (the actual load and the estimated load must not be the same point).

NOTE: For Load Estimation to be performed, you must Schedule a forecast job, and also designate it for Estimation.

4.2.7 Hourly Interpolation

In the case of forecasts without weather data, four analog pseudo-points can be specified here. These points will receive interpolated values for the 15-, 30-, 45- and 60-minute points in the upcoming hour of the day. The values are updated each time the forecast is run, and at the start of each new hour after that.

The interpolated values are derived by the same curve-fitting method used by the Load Estimation feature in described in section 7.1. But instead of calculating a value for the current time, it calculates values for the four 15-minute points during the current hour. As in the case of Load Estimation, these interpolated values cannot be produced if there has not been a load forecast within the previous 24 hours. If this happens, the points will be marked Telemetry Failed.

4.2.8 Store Load Forecast Data In

You may optionally select a dataset which will receive the hourly forecast results. If you do, then specify a point (by name) in this dataset to hold the hourly values.

This dataset must *not* be the same one that contains your historical data. See section 5.4, Output to a Historical Dataset for more information about setting up this dataset.

4.2.9 Points for 24-Hour Forecast

These are the names of 24 analog pseudo-points that can optionally receive the 24-hourly values of the most recent load forecast, whether the load forecast is scheduled or requested manually. This feature is not available for 7-day load forecasts.

4.2.10 Forecast

The Forecast button is used to manually perform a forecast using the current job's settings. The specified type of forecast is performed immediately.

The forecast will be performed for the period (24 hours or 7 days) whose start time you specify in the adjacent time and date field (which defaults to the beginning of today). Note that a valid weather forecast must already be available for this time period before you press the button, if you have selected a weather-based forecast type.

When the results are ready, they are displayed immediately as a graph, and the values in the historical dataset and/or the 24 pseudo-points are updated. See chapter 5, *Load Forecast Output*.

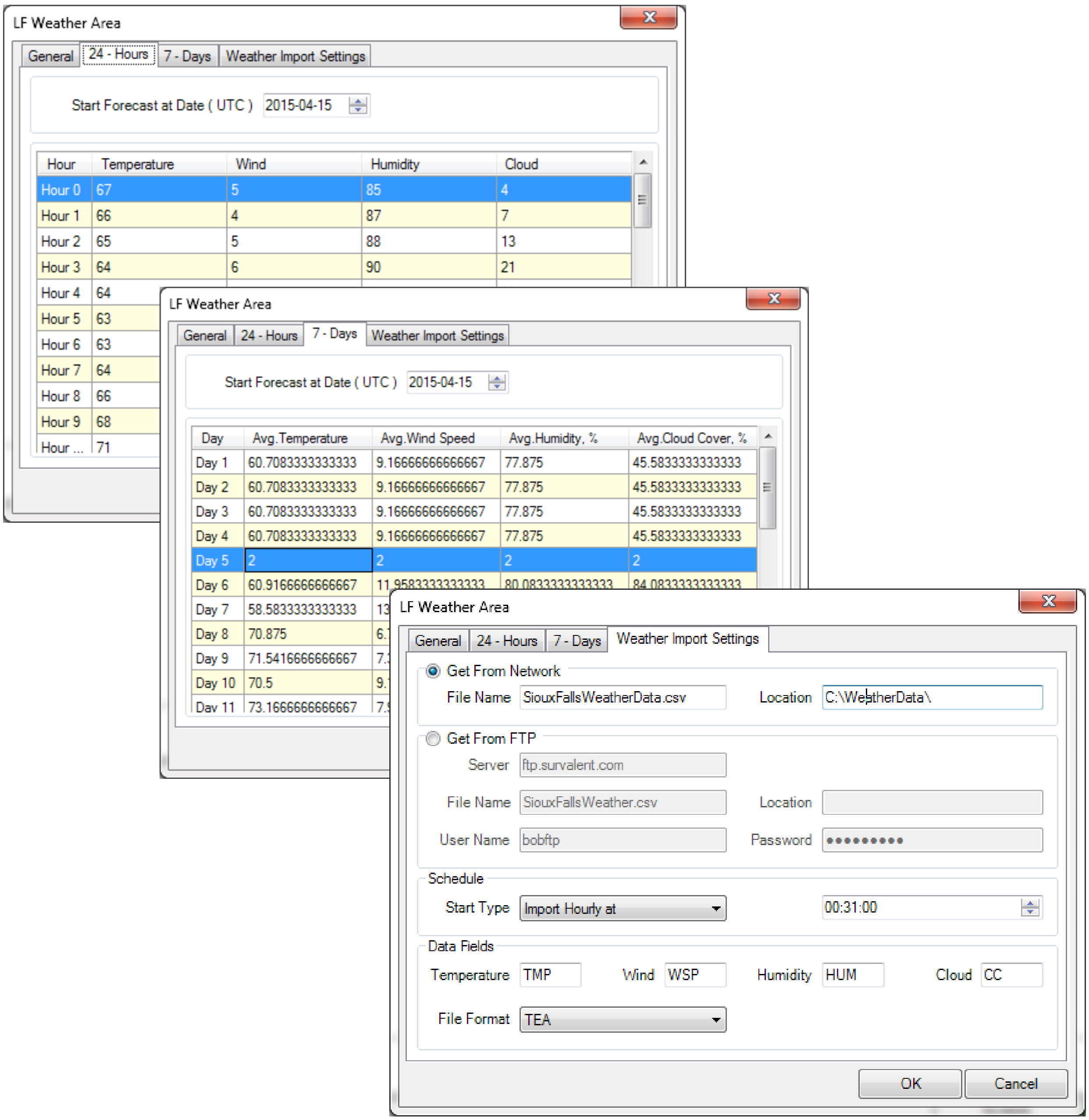
NOTE: The Hourly Interpolation point values are marked as Failed on any manual forecast, since it would not be clear to the operator what hour they refer to.

4.3 Weather Forecast Editor

The Weather Forecast Editor can be invoked from the Weather Areas branch in SCADA Explorer. You must create at least one record, to contain the weather forecast data used by your load area(s). Several load areas may share the weather data, if it applies to them all, otherwise you can create as many different weather areas as you require.

The Weather Forecast Editor is shown in Figure 4.3-1. It includes three tabs, one for up to 48 sets of hourly forecast data that are used by the 24-hour load forecast, and one for up to 31 sets of daily forecast data, which are used by the 7-day forecast. The third tab contains fields that define the way weather forecast data can be imported.

Figure 4.3-1 Weather Forecast Editor



4.3.1 General

In the top portion of the Weather Forecast editor some general information can be entered, as described here.

Name, ID and Description
You must give the forecast a brief name that will identify it on other drop-down lists. Then you may give it a longer description, to remind you of its purpose. The ID number is automatically assigned by the system and cannot be changed.

Last Import
This is the date and time of the last successful import of this weather data, as recorded by the weather import program.

4.3.2 24-Hour Weather Forecast

The 24-Hour Weather Forecast editor allows you to define an hourly forecast for up to 48 hours.

The data fields of this page are identified with the times from midnight last night, going forward 48 hours. This will ensure that there is at least 24 hours of forecast available for all load forecasts performed up to midnight tonight.

The data columns are described below.

Temperature
This is a column of 48 hourly temperature readings. The units displayed in this column will be those you specified above.

Wind Speed
This is a column of 48 hourly wind speed values. The units displayed in this column will be those you specified above.

Humidity
This is a column of 48 hourly relative humidity readings, in percent.

Cloud Cover
This is a column of 48 hourly cloud cover readings. The units may be whatever you like (although they are labeled as %).

4.3.3 7-Day Weather Forecast

The Daily Weather Forecast editor allows you to enter a daily forecast for up to a month.

The data fields of this page are identified with the numbers 1-31, corresponding to the 31 days following the date the weather forecast was imported, as shown in the Last Import field (see 4.3.1). Ensure that you update this weather forecast frequently enough such that there is always at least 7 days of forecast weather available, at the time a load forecast is to be performed.

The data fields on the Daily Forecast page are as follows:

- **Average Temp**
  This is a column of 31 daily temperature readings, in the units you have specified above.

- **Average Wind**
  This is a column of 31 daily wind speed readings, in the units you have specified above.

- **Average Humidity**
  This is a column of 31 daily humidity readings, in percent.

- **Average Cloud Cover**
  This is a column of 31 daily cloud cover values, in your own units.

4.3.4 Weather Import Settings

Weather data can be imported into the SCADA system, if you wish. On this page you must specify where the data is to be found, and when and how it is to be imported.

First, specify one of two possible places the weather data file will come from:

- **Get from FTP Site**

  Choose this if you need to get your weather data file via FTP. Then enter the name or IP address of the FTP server, and the name and location (folder or directory) of the file you need to retrieve. Last, enter any username and password that might be required to access this file on the FTP server.

- **Get From Network**

  Choose this if the file is directly available on a computer on your LAN, or even the SCADA host itself. Enter the name of the file, and the path to its location (for example, C:\weatherfiles\ ). Note that a trailing "****" is generally required in the Location field.

  To specify how the data is to be imported, once this file has been retrieved, you must provide the information under:

Data Fields

First, select the **File Format** that your data file uses. Then enter the names of the fields (or columns) that contain the data for **Temperature**, **Wind Speed**, **Humidity** and **Cloud Cover** that you require in your weather forecast. More information can be found below, depending on the particular file format you are using.

Note: At present, only the TEA format discussed in section *4.3.5.1, TEA Weather Data File,* is supported by the weather forecast import facility.

Schedule

This allows you to specify when the weather forecast data will be imported, updating the existing weather forecast. Depending on the file format in use, you may select one of:

- **Not Scheduled** - Weather data will not be automatically imported
- **Daily** - The weather data file will be imported once per day, at the specified time
- **Hourly** - The weather data file will be imported at the specified number of minutes past each hour

The imported file is used to update the contents of the weather forecast for this weather area. If it contains data for the next 48 hours, those values will be stored in the appropriate locations in the weather area’s forecast.

If it also contains data from the recent past, that will be used to update the historical weather data in the dataset(s) used by *each* Load Area that is using this weather area for its weather forecast. This means that if your imported files contain past as well as future weather data, you may not need telemetered weather inputs in order to gather your weather history. The history can come from your weather forecast provider instead.

4.3.5 Weather Import File Formats

The weather import program presently supports just one file format for importing weather forecast data. This format is used by The Energy Authority to provide weather data to its clients; hence we refer to it as TEA format. It is described below.

With some development, the weather data import program can be extended to support other weather file formats. Please direct inquiries in this regard to the sales department of Survalent Technology.

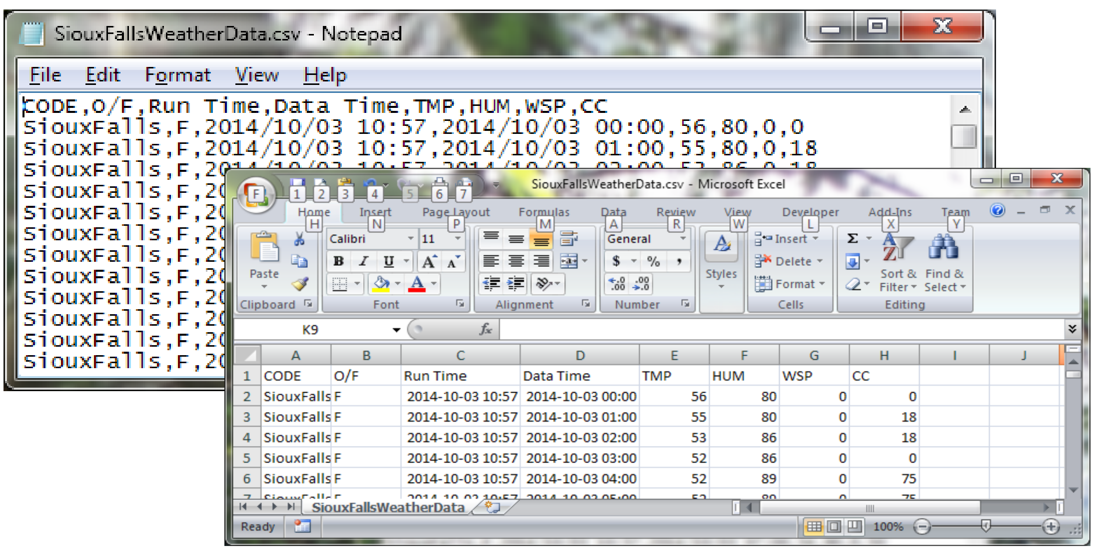
4.3.5.1 TEA Weather Data File

The TEA weather data file is a comma-separated text file, as illustrated in Figure 4.3-2.

Each row in the file contains the values for a single hourly time-stamped sample. The columns correspond to the measured data points (indicated by 3-letter headings in the example), as well as the time of the sample and a code identifying the weather area to which the data applies.

The O/F (old / future data) and Run Time fields are ignored by the import program.

Figure 4.3-2 TEA Weather Import File (CSV)



The file is organized as a list of hourly samples of the data items listed, in chronological order. The samples are grouped by weather area (the column named CODE); several weather areas’ data may be contained in a single file.

The value of CODE must match the name that you have given the weather area in your database.

The first part of the list (for each weather area) contains several days of historical weather data. The contents of this file are stored directly into your historical dataset(s), where it can be viewed using the Historical Data editor. If you have a weather service that provides such a data file, then you do not need to have a weather station to measure your weather variables.

Below this is found the weather forecast for the next few days. The contents of this portion of the file (at least, the next 48 hours) are stored into the hourly weather forecast file of your SCADA database, where it can be viewed using the Weather Forecast editor described in section 4.3.2, *24-Hour Weather* Forecast.

The historical samples and forecast values are stamped with the timestamps from the imported file, which is assumed to be in the local time zone of the SCADA host computer.

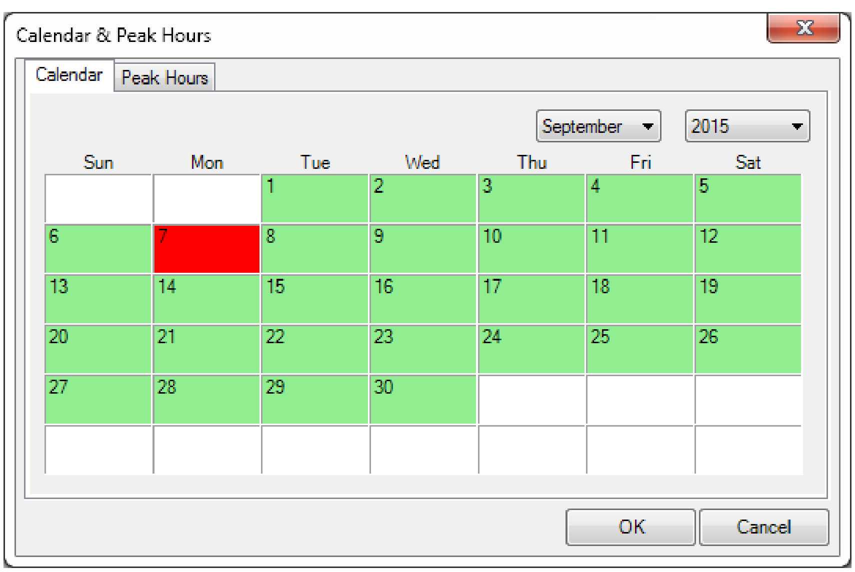
4.4 Holidays

Days of the week are represented as a number from 1–7, corresponding to Sunday through Saturday (see section 2.3 for a detailed description). When calculated by the load forecasting program, these numbers are increased by 10 if the day is one of the holidays entered in the database. The day of the week and its holiday status are used in the simplified forecast algorithm discussed in section 2.2 (while only the day *type* is presently used by the weather-based algorithm of section 2.1).

You must designate upcoming holidays manually, in order for the system to correctly set their day number. This is done by marking the holiday dates in the Holiday Editor shown in Figure 4.4-1. This editor can be found in the Load Forecasting branch of SCADA Explorer, and is labeled Calendar. It provides a month-by-month calendar view of the previous year, the current year, and the next year.

At any convenient time, specify any dates in the upcoming year or two that you want to treat as holidays in the load forecasting process. This will allow the system to correctly adjust the value of the day of week for those days.

Figure 4.4-1 Holiday Calendar



To designate a holiday, select the desired year and month using the pull-down lists. Click on any unmarked (green) date to mark it as a holiday. I t will turn red. To remove a holiday, click on the marked date to reset it to green.

The value of the day-of-the-week point may be optionally included in the historical dataset recording the load and weather history. If these historical values include the correct holiday designations, it will allow the forecasting program to match a designated holiday against the correct days in history when calculating its forecast values.

NOTE: You don’t need to enter past dates in this editor. To correctly handle past holidays, simply set appropriate values for the Day of Week point in your historical data.

5 Load Forecast Output

This chapter describes how the load forecast program outputs the resulting forecasts to you. In addition, the results are retained internally in the SCADA database, for use by other programs (such as Load Estimation, as discussed in chapter 7).

There are three possible ways that the program may output the results of a load forecast:

- Load forecast graph
- 24 analog pseudo points
- Historical dataset

A manually requested forecast always produces a graph for you to inspect, while scheduled forecasts do not. Both manual and scheduled forecasts can be configured to output their results to a historical dataset. This allows you to produce your own report or graph.

In addition, a 24-hour load forecast can output to 24 analog pseudo points, allowing you to see the results immediately, for example as numbers or bar graphs on your SmartVU map. This is done for both scheduled and manual forecasts.

In the case of the 24-hour simplified forecast (without weather data), it can also produce 4 interpolated values for the 15-, 30-, 45- and 60-minute points of the current hour. These are stored in 4 analog points you specify.

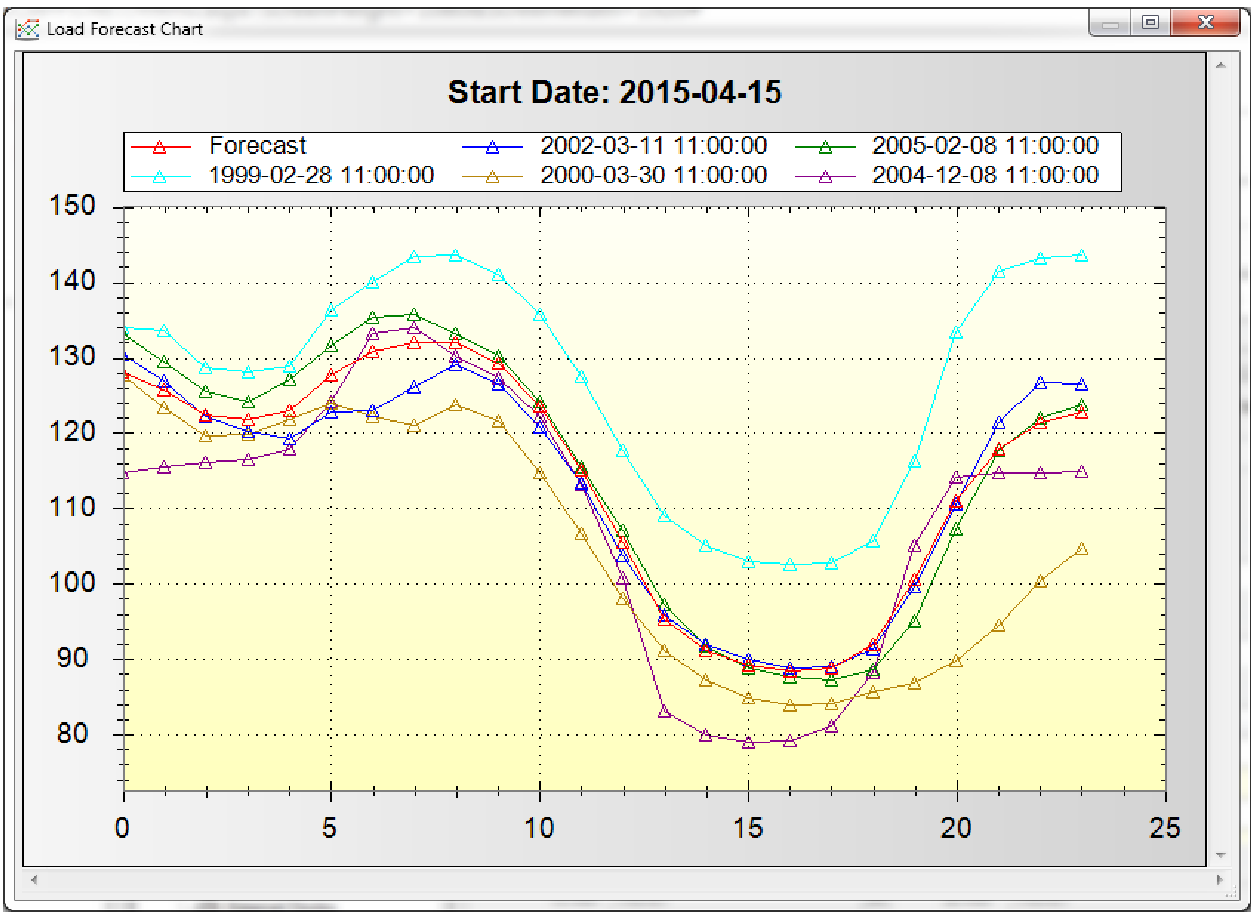
5.1 Load Forecast Graph

You can manually request a load forecast when you have the forecast job dialog open (see section 4.2.10). Enter the desired start time for a forecast (e.g., last night at midnight, or today at 8 a.m.), and press the Forecast button. This will cause the program to perform the forecast immediately. When the forecast is complete, a graph window similar to Figure 5.1-1 will appear.

This graph shows the 24-hourly forecast values as one trace, along with the 5 traces corresponding to the best-matching days which were used to produce this forecast. Recall from chapter 2 that these 5 days were chosen because their 48-hour weather pattern best matched yesterday's weather and load and today's weather forecast (taking into account the weighting factors). These five load curves (adjusted by the load growth factors and the weather model for the current season, if any) are then used to produce the forecast load values.

You may print this graph, or copy it to the Windows clipboard, to be pasted into another application (as a graphic), if you like.

Figure 5.1-1 24-Hour Load Forecast Graph



You can also read the numeric value from the graph at any point, by placing the mouse pointer over any data point you may be interested in.

5.2 Eliminating Erroneous Data

By inspecting the 5 match traces from the load forecast graph (described in 5.1), you can gain an appreciation for how reasonable the data that your forecast is based on may be. If you find one or more “bad” values are included in one of the match traces, it indicates that some of your historical data may be wrong in some way. Take note of the date and time of that trace (from the legend provided and the position of the bad data on the horizontal axis).

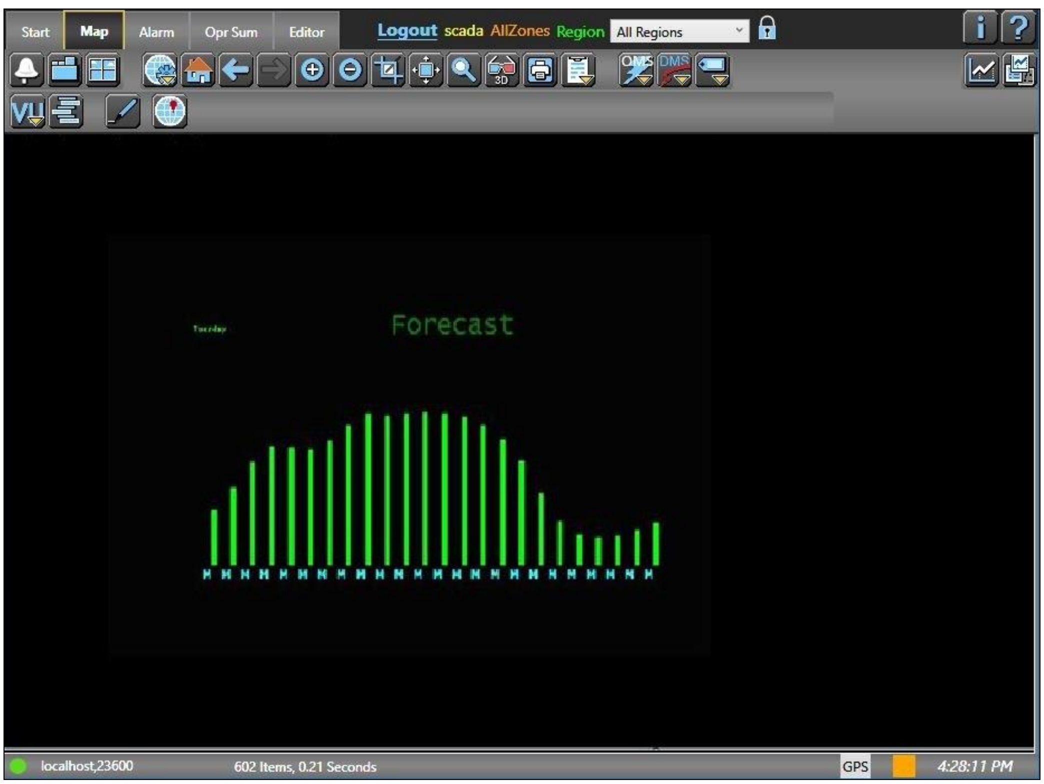
You can then locate the bad sample(s) in your historical dataset, using the historical dataset editor. You may choose either to manually correct the bad values, or to manually mark these samples as “do not use”, by setting the day-of-week point to –1 for those intervals. (Note that setting the day-of-week this way will mark *all* points in this dataset not to be used at that point in time.)

5.3 Load Forecast Data Points

In the case of a 24-hour forecast, the forecast load values are also output into a set of 24 pseudo analog points. The 24 points that receive the forecast values are specified on the Forecast Job editor. See section 4.2, These points are updated on every 24-hour forecast, whether scheduled or manually requested.

You can view the forecast represented by these points by placing 24 analog PMacros in a view on your SmartVU map. You may even create a kind of bar graph, by using an array of analog bar PMacros.

Figure 5.3-1 Analog Bar Graph in a SmartVU Map



5.4 Output to a Historical Dataset

The load forecast program can store either 24-hour or 7-day forecasts into a historical dataset. This allows you to record and graphically view not only the most recent forecast but older ones as well.

To make use of this feature, create an output dataset containing the load point, with a one-hour sample interval, but *do not* specify “Collecting” (you do not want the historical data program to write values into this dataset). Set the dataset’s duration to as long as you want to keep the forecast data. (If you set the duration to six months, for example, you’ll later be able to review the forecasts for the last six months.) Specify this dataset name in the field Store Load Forecast Data In Dataset, on the Forecast Job Editor (as seen in 4.2.8, *Store Load Forecast Data In*). Specify the load point’s name in the adjacent Point field.

When a load forecast is performed, the load forecast program creates as many new sample records as needed to store the forecasted values. If a sample record already exists (because you are repeating the forecast), the sample record is over-written. All of the sample records that are written will contain timestamps that are in the future. This does not bother the trend graphing facilities of SmartVU.

Notes:

- The output dataset must *not* be the same one that contains your historical data.
- *Make sure you enter the Store Forecast In Dataset field correctly. If you specify the name of another dataset by mistake, that dataset will receive the load forecast sample records for times in the future. When the future comes, the real samples that you want will* not *be taken*
- The output dataset can be shared by several load areas, but each must write its resulting values to a different load point in that dataset. Be sure to create the dataset with all the necessary points included in it.

6 Estimation of a Weather Model

The weather model for your system consists of seasonal matrices of temperature- and time-dependent weather correction factors. These factors are contained in the four weather model tables (matrices) specified in the Load Area editor (see section 4.1).

This chapter describes how to generate a least square error estimate of these weather tables based on your own historical load and weather data.

The weather model can optionally be used by the 24- and 168-hour classical load forecasting algorithms, as described in chapter 2.

6.1 Theory

First we'll talk about the math behind the model estimation program. If you hate math, just skim this section and go on to section 6.2, *Generating Your Weather Models*.

In the weather model, the weather correction of any historical load value (at hour **i** and temperature **j**) consists of the following linear transformation:

Equation 6-1

$$L_c = L_u + C[i, j] * dT$$

where:

Lc	= weather corrected load value
Lu	= uncorrected load value
C[i,j]	= load change per degree of equivalent temperature difference, for hour i and temperature j
dT	= difference in equivalent temperature

The matrix of C[i,j] values represents the change in MW per degree of temperature difference, at different times and temperatures. A separate matrix is allowed for each of the four seasons, because weather effects are expected to be somewhat different in each season. You specify the starting date for each season, and can therefore control which matrix is used at any time of year.

This group of four matrices is your weather model. What you need are the four sets of values of C[i,j] for all i and j that will produce the best forecasts for your site.

The mean-square forecast error is represented by:

Equation 6-2

$$E[i, j] = \left(\overline{L_a - L_c}\right)^2$$

where:

La	= actual load
Lc	= weather corrected load from best historical match using Equation 6-1

It can be shown that this error is minimized by:

Equation 6-3

$$C[i, j] = \frac{\overline{L_a dT} - \overline{L_u dT}}{\overline{dT^2}}$$

for each i,j.

If you accept least mean-square error as a valid objective function for this problem (and most people would), then Equation 6-3 specifies the optimum weather model for your system.

For a complete solution, the historical data must have a sufficiently good sample set of La and Lu data for each [i,j] pair (i.e. lots of load vs. weather data for each [time, temperature] combination).

6.1.1 Resolution

Equation 6-3 could be used to obtain C[i,j] matrices to any resolution of time and temperature, theoretically. But if you try to resolve too finely, you will find that:

- It takes a lot of compute time, and
- Unless you have a tremendous amount of historical data, the sample sets of La and Lu for many combinations of [i,j] will be too small to provide good values for C[i,j].

Because of this, we recommend that you choose somewhat lower resolution in generating your weather models. This will have the effect of increasing the number of samples for each combination of [i,j].

Good results have been obtained using a time resolution of 3 hours and a temperature resolution of 3 Celsius degrees (or 5 Fahrenheit degrees). In other words, calculate the best C[i,j] matrices where each value of i represents a 3-hour time range, and each value of j represents a 3 C° (or 5 F°) temperature range.

Note: You establish the time and temperature resolution of your models when you define the matrices in which the results will be stored, as described below.

6.2 Generating Your Weather Models

Before you can generate your estimated weather models, you first need to specify the four matrices that will hold the data. The dimensions of the matrices will depend on the resolution of your model; the small range of time and temperature that each correction factor applies to.

If the desired matrices do not already exist, you will have to create them before you can generate your weather model.

6.2.1 Creating the Matrices

Before you attempt to generate your weather model, you must ensure there is a set of matrices to hold the correction factors you will generate. Navigate to the Weather Models branch under Load Forecasting, in SCADA Explorer. Right-click in the right-hand pane, and choose New. You will be presented with the Season Matrix Edit dialog shown in Figure 6.2-1.

You do not have to fill in the data values for this matrix (that is the job of the program discussed in the next section). But do fill in the fields discussed here.

You will most likely need to create four such matrices, for the four seasons of the year. If your load forecasts will be relying on weather data from more than one Weather Area (discussed in section 4.3), then you may need to allow for more than one weather model. In this case, create a set of four matrices for each model. You may need even more weather models if you have several load areas, and their dependency on weather data is different from one another.

Name, Description
Choose a name for each matrix, so that it can be identified in the pull-down list in the Load Areas editor. You may also wish to specify a description, especially if you have more than one matrix for a given season.

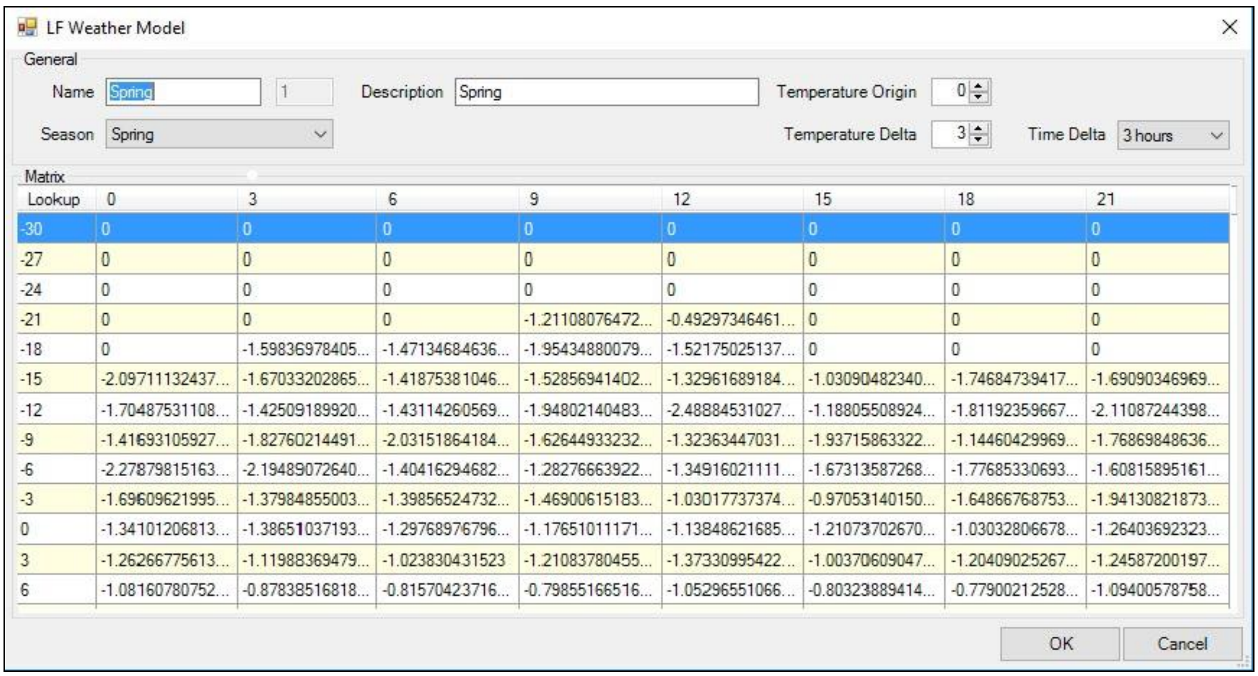
Season
Assign each matrix to one of the four seasons, using the pull-down list.

Temperature Origin and Delta
Decide on the resolution and origin of the temperature axis of the matrix, as discussed in section 6.1.1, *Resolution.* Enter the desired Temperature Delta (we recommend 3 °C, or 5 °F).

For the Origin, select a temperature that will represent the lowest expected temperature in this season. After you have generated a model for this season (in section 6.2.2), if you see several rows containing only zeroes at the top of your model, you may wish to increase this origin. If you do not see any rows of all zeroes, decrease this origin until you do. (Otherwise, there may be lower temperatures available in your historical data, and you should try to generate a model that will include those temperatures as well.)

Time Delta
Select the desired Time Delta (we recommend 3 hours). Refer to section 6.1.1, *Resolution*, for more information.

Figure 6.2-1 Season Matrix Editor



Lookup	0	3	6	9	12	15	18	21
-30	0	0	0	0	0	0	0	0
-27	0	0	0	0	0	0	0	0
-24	0	0	0	0	0	0	0	0
-21	0	0	0	-1.21108076472...	-0.49297346461...	0	0	0
-18	0	-1.59836978405...	-1.47134684636...	-1.95434880079...	-1.52175025137...	0	0	0
-15	-2.09711132437...	-1.67033202865...	-1.41875381046...	-1.52856941402...	-1.32961689184...	-1.03090482340...	-1.74684739417...	-1.69090346969...
-12	-1.70487531108...	-1.42509189920...	-1.43114260569...	-1.94802140483...	-2.48884531027...	-1.18805508924...	-1.81192359667...	-2.11087244398...
-9	-1.41693105927...	-1.82760214491...	-2.03151864184...	-1.62644933232...	-1.32363447031...	-1.93715863322...	-1.14460429969...	-1.76869848636...
-6	-2.27879815163...	-2.19489072640...	-1.40416294682...	-1.28276663922...	-1.34916021111...	-1.67313587268...	-1.77685330693...	-1.60815895161...
-3	-1.69609621995...	-1.37984855003...	-1.39856524732...	-1.46900615183...	-1.03017737374...	-0.97053140150...	-1.64866768753...	-1.94130821873...
0	-1.34101206813...	-1.38651037193...	-1.29768976796...	-1.17651011171...	-1.13848621685...	-1.21073702670...	-1.03032806678...	-1.26403692323...
3	-1.26266775613...	-1.11988369479...	-1.023830431523	-1.21083780455...	-1.37330995422...	-1.00370609047...	-1.20409025267...	-1.24587200197...
6	-1.08160780752...	-0.87838516818...	-0.81570423716...	-0.79855166516...	-1.05296551066...	-0.80323889414...	-0.77900212528...	-1.09400578758...

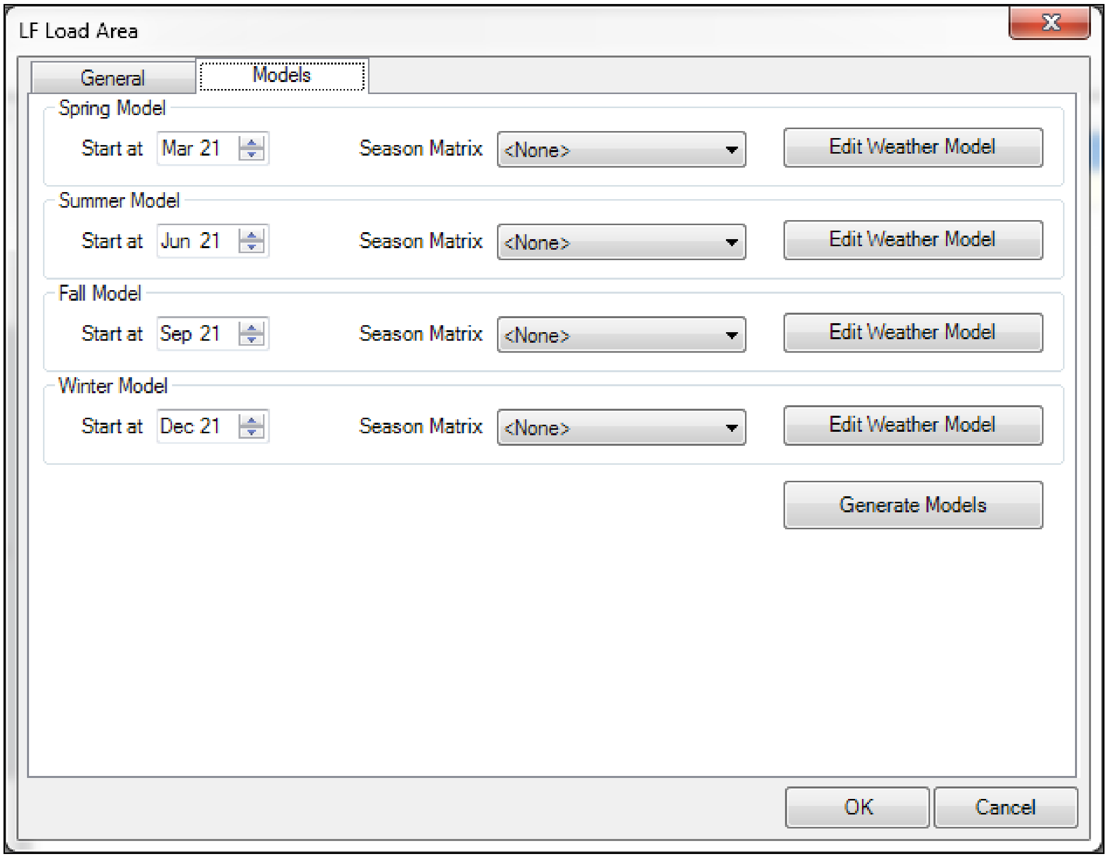
Save the matrices you have created. Next, you will populate them with weather correction factors generated from your own historical data. (In the figure above, this has already been done.)

6.2.2 Generating the Weather Model Data

Open the Load Area edit dialog (as described in section 4.1) that is going to use the weather models you wish to generate. Turn to the Models tab, illustrated in Figure 6.2-2.

Check that the desired four seasonal weather matrix names are listed under the correct seasons, and that appropriate start dates are specified for each. You could use the conventional dates, or choose dates that better correspond to the times that your local weather patterns tend to change.

Figure 6.2-2 Generating the Weather Model



To populate the four matrices, you have created and selected, simply press the Generate button to begin the estimation process. Note that the generation of your weather model may take a few minutes. Please be patient. A message will appear when the process is complete.

The model estimation program stores its results in the set of four seasonal C[i,j] matrices that you have specified. You may inspect the results by pressing the Edit button under each season. This will open the same Season Matrix editor as shown in Figure 6.2-1.

6.2.3 Modifying your Model

You may change the information you entered in section 6.2.1, *Creating the Matrices*, or even modify the correction factors themselves, if you wish. Note that if you change the resolution or origin, you must generate the model data again.

To understand the data, you see in the matrix, recall that each time/temperature entry represents a unique combination of time period and temperature band. For example, each of the time periods may be 3 hours long, each temperature band may be 3 °C wide, with a temperature range beginning at the temperature origin you specified.

You may see a large number of zeroes in your model. Although it may be true that the dependency of load on temperature is near zero for that combination of temperature range and time range, it may simply be true that there were no occurrences of that combination of time and temperature in your historical data. In that case, a correction factor cannot be generated (and your history would suggest that one is not needed).

Some of the correction factors may not seem right to you. They may be unusually large, or significantly different from the factors in nearby cells in the matrix. This can result if there are too few occurrences of this time and temperature combination in your historical data. The correction factor will be based on these few samples, and they might not be very typical for one reason or another. This is more likely to occur if you have insufficient historical data, or if you have specified an excessively fine time or temperature resolution.

If you do not want to further reduce the resolution of your model, there's not much else you can do about this except to use your judgment and manually adjust the C[i,j] values. To do this, you can try graphing the C[i,j] values and modify the values to smooth out anomalies. At the very least, you can simply make the C[i,j] values smaller, or even zero. (This just means you get less or no weather correction of your historical data at that point. You will still get a useable forecast.)

6.3 Examples of Weather Models

The following figures show an actual weather model that was produced by the weather model estimation program for a system in Ontario. In the 3-D graphs, the two horizontal axes represent time and temperature. The vertical axis represents the corresponding sensitivities of the system to equivalent temperature (i.e. the system's dMW / dT).

The figures are graphs obtained after loading the model matrices into Microsoft Excel. We used the SCADA Add-In (an optional program discussed in document number SQ-402) to extract each season's matrix into Excel.

Note that in the Spring model, for example, the dMW / dT values are positive at higher temperatures and negative at lower temperatures. For this system, in the spring when it's:

- Warm the load increases when it gets even warmer (temperature increases)
- Cold the load increases when it gets even colder (temperature decreases)

You can draw similar conclusions about the shape of the other 3 surfaces.

Figure 6.3-1 Spring Model

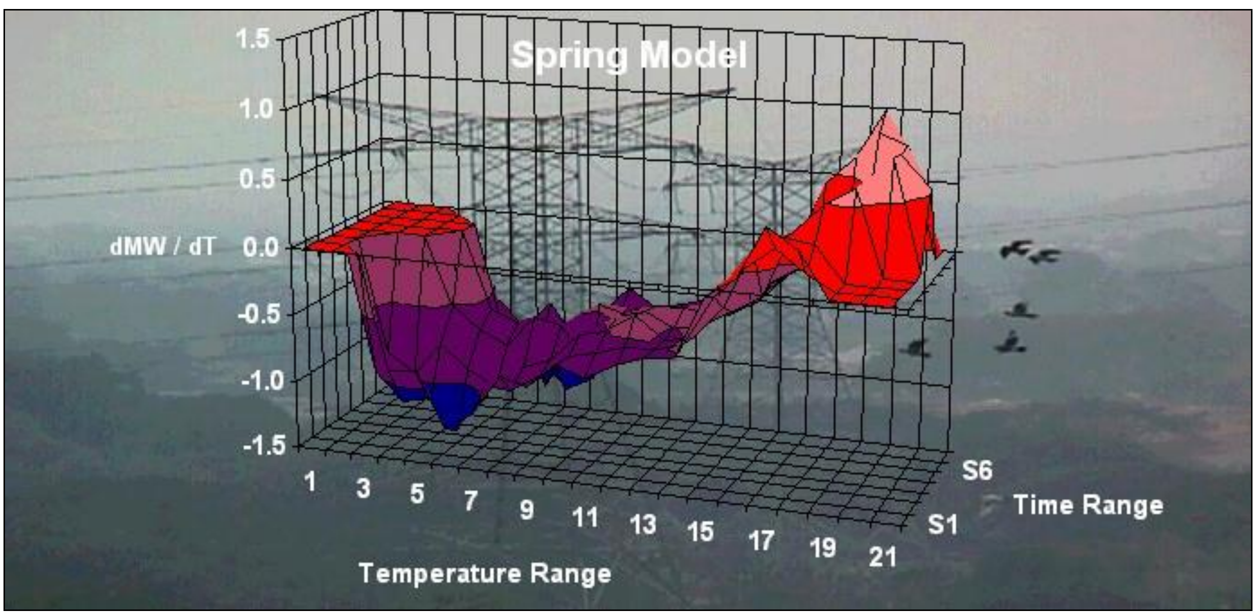


Figure 6.3-2 Summer Model

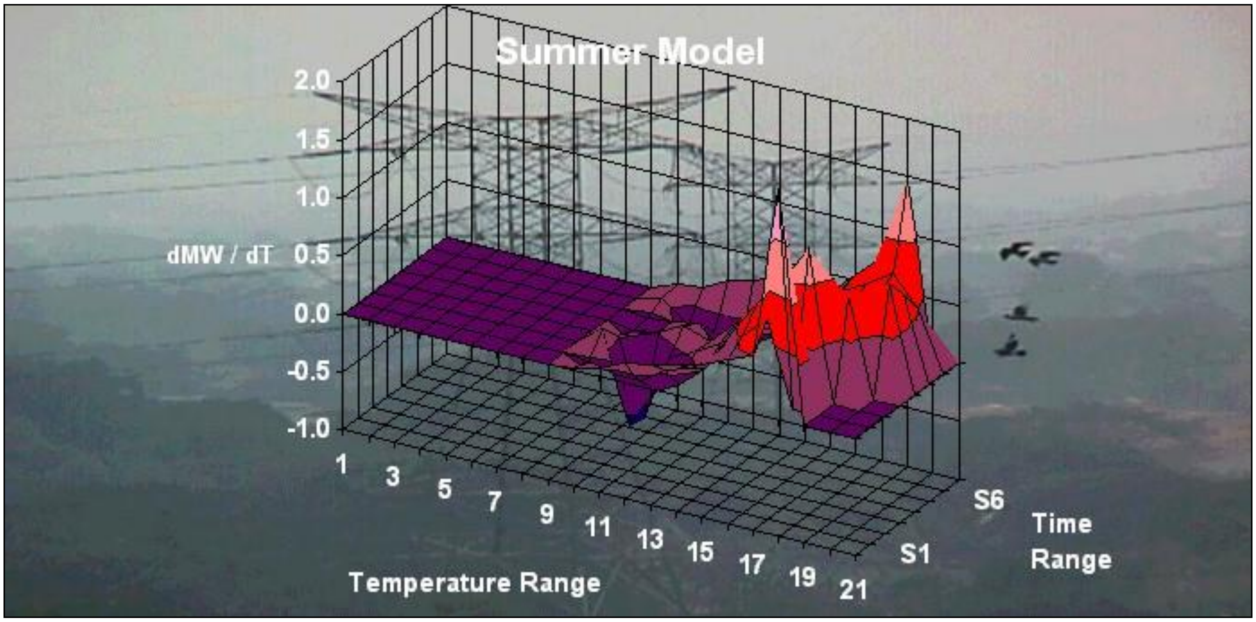


Figure 6.3-3 Fall Model

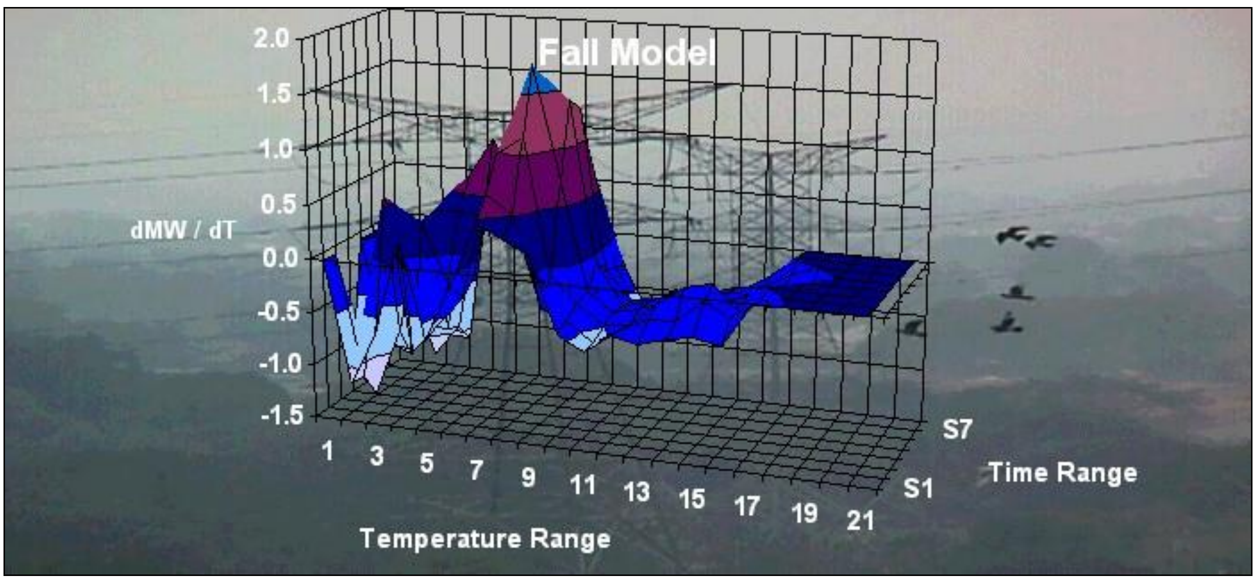
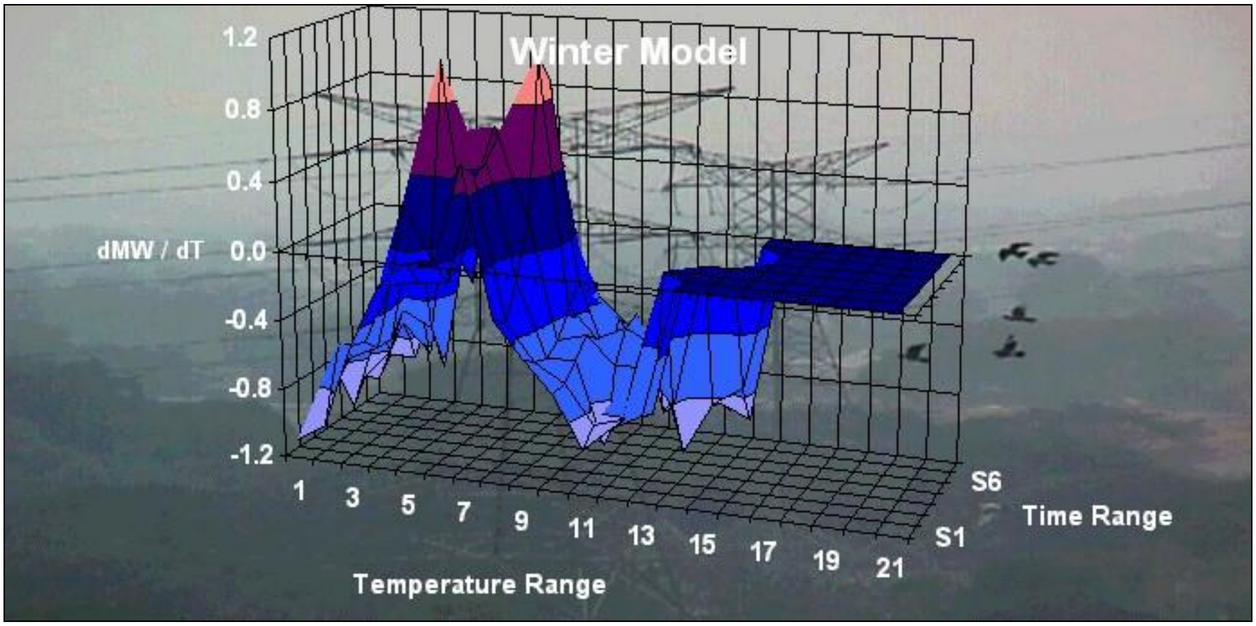


Figure 6.3-4 Winter Model



7 Load Estimation

Load Estimation is performed by a separate, optional application. It uses your scheduled load forecast to continually estimate the present value of the load point. By means of a special calculation function, the estimated value can be used to substitute for the actual telemetered value during periods where telemetry has failed.

NOTE: The Load Estimation feature requires an additional software option license, in addition to Load Forecasting.

Although we refer to this feature as Load Estimation, it can be used to provide an ongoing estimate of any value that the Load Forecasting package can produce a forecast for.

The result (estimated value) is stored in a point that you provide for this purpose. This allows you to view the estimated value alongside the actual value (while the actual value is available), or to select between the actual and estimated value (as described in section 7.4) to be transferred to an “output” point to be used by the operators or by other programs or calculations.

7.1 Theory

This section describes how the Load Estimation program generates ongoing estimates of your point's value. (It's a verbal description. There's no detailed mathematics here.)

The program relies on the results of a Load Forecast performed for the point in question. That is, if you want to estimate the value for an input point, you first must define an hourly forecast job for that point.

For purposes of the forecasting function, you will need to have hourly historical samples of the load value going back over several years. You will similarly need hourly samples of the weather variables that affect this load. Then, you create a Load Area to specify the point that is being forecast and the location of its historical data, as well as a Weather Area to contain the weather forecast for the period that you want to forecast. Lastly, you define a Forecast Job to specify the type of forecast to perform, and its repeat schedule.

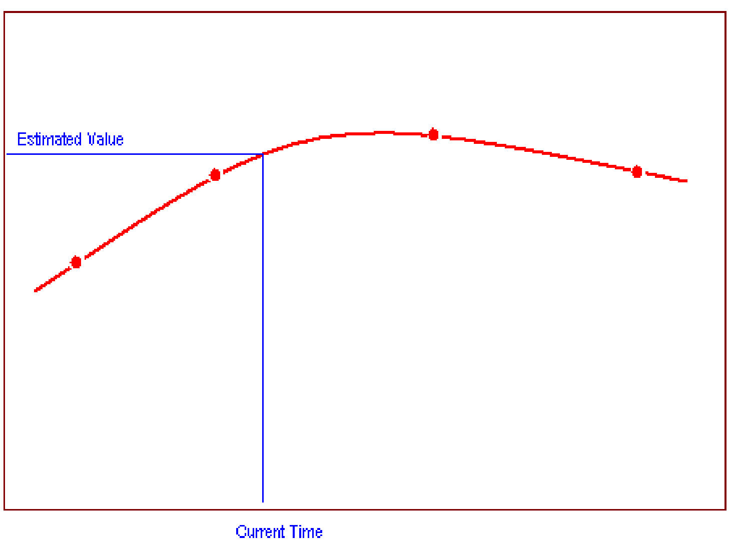
All this has been described in chapters 2, 3 and 4. In particular, details regarding the database editing requirements can be found in section 4.1, *Load Area Editor*, section 4.2, Forecast Job Editor, and section 4.3, Weather Forecast Editor.

The load forecast will yield an estimate of the load point's value at each hour going forward from the time of the forecast. To produce a periodic estimate of this value, the Load Estimation program first determines how long it has been since the most recent load forecast was performed. It selects the next two load forecast values in time, and the preceding two values. If there are no forecast values for the preceding two hours (because the forecast was performed less than 2 hours ago, as is normally the case when the load forecasts are being repeated every hour), then the program uses the most recent one or two actual values from the historical data instead.

In either case, the program uses these four values to produce a curve that represents the recent past and near future behavior of the load value. A cubic curve-fitting algorithm is used to produce a curve that is guaranteed to pass through the four chosen points.

The estimator then locates the present time on this curve (which always falls between the second and third points). The value at this point is output as the estimated load.

Figure 7.1-1 Interpolation of Estimated Value



This entire estimation process is repeated every few seconds, at the interval you specify. Each hour, new points are chosen from the 24-hour forecast and historical data.

On a new hour, the forecast is updated and the time of the forecast is recorded. The load estimation program then advances (by one hour) the four values that it uses to bracket the current time.

When the load point becomes Telemetry Failed (marked with an “F”) due to a loss of communication with the RTU, then load forecasting stops. This freezes the most recent forecast and ensures that it is not updated using failed data. When the load point is no longer telemetry failed (i.e. once values are again being received from the RTU), load forecasting resumes.

While the load point is failed, the Load Estimation program continues to generate its estimates, based on the last available forecast values. Each estimate will be based on two previous and two future values from the load forecast. When the forecasts resume, estimation will continue using new forecasts as they become available.

If the load point remains telemetry failed for longer than the duration of the most recent forecast (24 hours), then estimation must stop. The output of the estimator will be marked Telemetry Failed when this occurs, since it can no longer be updated.

7.2 Database

7.2.1 Load Forecast Editing for Load Estimation

For load estimation purposes, a 24-hour forecast job for the desired load point should be defined. Instead of generating this forecast just once per day, however, as you might do for load management planning, this forecast should be scheduled hourly. This means that a new forecast will be generated every hour, going forward 24 hours from the present time.

The Load Estimation program will then have a recent forecast to use throughout the day as the basis for estimating values. See section 7.3.

The duration of the forecast (in this case, 24 hours) determines how long the system can continue to provide estimates after the load point has failed.

7.2.2 Historical Database

The Load Forecasting process requires a lot of historical data for the quantity being forecast, as well as for the variables that the quantity depends upon (i.e. weather). Normally, this historical dataset is an active dataset, collecting new samples. This increases the amount of data available for forecasts in the future.

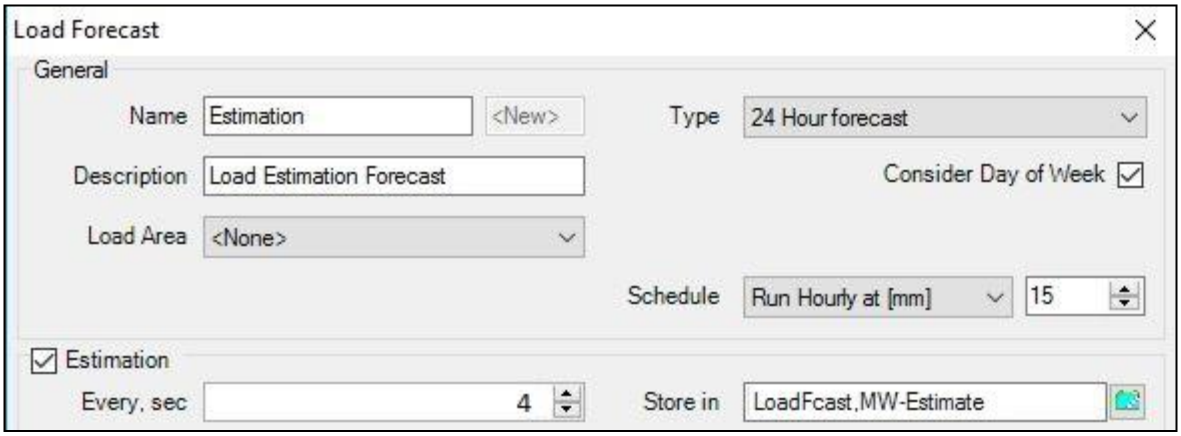
During the first two hours after a new load forecast, the Load Estimation program requires the most recent 1 or 2 hourly samples of the load value to be present in the dataset. This data will automatically be there if the dataset is actively collecting samples (see section 3.1,Definition of Historical Datasets). The estimation program will then have recent history to use as the basis for the estimated value. See section 7.3.

7.2.3 Defining an Estimation Process

Once you have defined a Load Forecast job, and scheduled it to run hourly, it can be used as the basis for estimation.

To enable estimation, tick the checkbox labeled Estimation, as shown in Figure 7.2-1. Then enter the number of seconds between estimates (use a reasonable number that represents how often you need the estimate to be updated). Lastly, specify the database point that will be used to hold the estimated value.

Figure 7.2-1 Configuring a Load Forecast Job for Estimation



The estimator program will store its result in the specified point. It is up to you to display that value in the places where your operators will need it, or to use it as an input to a command sequence, calculation or setpoint copy operation.

7.3 Producing Estimates

The Load Estimation program calculates an estimated value for each load point that is designated as an estimate (see section 7.2.3. So long as a useable forecast is available, a value will be calculated according to the method described in 7.1, Theory. This value will be stored in the output point specified in the Forecast Job definition, as shown in Figure 7.2-1.

If the load point's condition is Normal, then the output point (estimated value) is also set to Normal, unless it's manually set. If you manually set the estimate point, the estimation program does not update it. This allows you to override the estimation program's value with a value of your own, if you desire. (In this case, the condition code "M" will be seen.)

If the load point's condition is Telemetry Failed (F) or Calculated from Manually Set (*****), then the estimate output is set to "*****". This is done to indicate that a good estimated value is available, while the telemetered input point is *not* available. The Source Input Selection calculation (discussed in section 7.4.1, *Source Input Selection Calculation*) relies on this condition code to determine which input values are available for use.

NOTE: When working with Load Estimation, think of the "*****" condition code as indicating Estimated, rather than Calculated from Manually Set.

The reason for treating a "*" condition of the load point the same as "F" will become clear when you make use of the Source Input Selection Calculation later.

While the load input point is not available (condition code F or *****), no new forecasts are being produced. The Load Estimation program continues to generate its estimates, based on the most recent forecast. During the period that this forecast applies to, estimated values for the load point will continue to be interpolated, and marked by a "*****" condition. If telemetry recovers and the forecasts resume, estimation will continue, using the new forecasts as they become available. The "*****" indication will disappear again.

If the telemetry failure persists longer than the duration of the available forecast (usually 24 hours), the estimation program will no longer be able to provide estimates. At this time, the value of the estimate output point is left unchanged, but its condition code is set to "F" to indicate that the estimate is not available.

7.4 Using Estimates

The output of the Load Estimation program is stored in the point specified in the Forecast Job, as shown in Figure 7.2-1. The simplest way to make use of this information is to display it in your SmartVU map alongside the telemetered value it corresponds to. The operator can compare it to the actual value, and decide which to use at any given time. This would normally be the telemetered value, unless that point was showing an “F” (indicating a telemetry failure) or “*****”.

As long as the estimated point’s condition code appears Normal, its value is probably valid, but is not considered to be “in use”, since the input (telemetered) point’s condition is also Normal. But when the input point becomes Failed, the next update to the estimated point should show a condition code of “*****” (Calculated from Manually Set), which can be taken to mean Estimated. This indicates that the value has been calculated, and that the program acknowledges that the input point has failed, making the estimate significant.

These condition codes provide the operator with a clue to the relative state of the telemetered and estimated values.

If you want to simplify the SmartVU displays, you might prefer to show a single point, whose value is copied from either the telemetered or estimated point, depending upon the two condition codes. You could implement the testing and copying using Periodic or Boolean calculations, or the Command Sequencing language.

For example, Command Sequencing’s (limited) ability to test the condition codes would enable you to write a program that copies either the telemetered or the estimated value into a third point, the “output” point. This output point is then the one that would be displayed on the map. Such a program would have to repeat the process every few seconds for all points that were being estimated.

7.4.1 Source Input Selection Calculation

Although you could achieve the selection logic you need with Command Sequencing (for example), a tool has been provided in the Periodic Calculations to make this process simpler. This is calculation function number 34, Source Input Selection. It is described in more detail in *DB-403, Automation Database Editing Guide*.

This function allows you to specify up to three input points, an output point, and a status point. The “primary” input point is the one whose value is copied to the output point if it is available (i.e. not Telemetry Failed). The output point’s condition code is set depending on the condition of this input: Normal, or Calculated from Manually Set, as applicable.

If the primary point is Failed, the secondary input point is used (if it is specified). The output point’s condition code is set in the same way but based on the secondary input.

If the secondary point is not specified, or is also Failed, then the function examines the Estimated input point. *If this point is marked as Estimated* (*****), then its value is used. In this case, the output point’s condition is also set to Estimated.

If the estimated input is not marked as Estimated, then it is not used. In this case, no value is copied to the output point, and the output's condition code is set to Failed. This prevents the output from using an estimated value that has not actually been generated since the failure of the input point(s).

The status point (if one is specified) is set to show which of the inputs is in use:

State	Meaning
0	Output = primary input
1	Output = alternate input
2	Output = estimated input
3	Output is telemetry failed

You can add the status point to your map, if you want to indicate the source of the output point's value.

8 References

[1] J.E. Oliver and R.W. Fairbridge (editors), "Encyclopedia of Climatology", pp 470-477, 837-838, 928-929, Van Nostrand Reinhold, 1987.

The following is a small reading list for methodologies of load forecasting:

[2] S. Rahman, "Formulation and Analysis of a Rule-Based Short-Term Load Forecasting Algorithm", Proc. IEEE, Vol. 78, May 1990.

[3] A.D. Paplexopoulos, T.C. Hesterberg, "A Regression-Based Approach to Short-Term System Load Forecasting", IEEE Trans. Power Syst., Vol. 5, No. 4, November 1990.

[4] K.L. Ho, Y.Y Hsu, C.C. Liang, T.S. Lai, K.K. Chen, "Short Term Load Forecasting of Taiwan Power System Using a Knowledge Based Expert System", IEEE Trans. Power Syst., Vol. 5, No. 4, November 1990.

[5] G. Gross, F.D. Galiana, "Short Term Load Forecasting", Proc. IEEE, Vol. 75, December 1987.

[6] W.R Christiaanse, "Short Term Load Forecasting Using General Exponential Smoothing", IEEE Trans. PAS, March/April 1971.

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