

Using “Dashboards” to Harness Your Meteorological Tower Data

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INTRODUCTION

Measured data is the lifeblood of Wind Plant development and operation. If not well managed, the mass of data that accumulates can easily become overwhelming. If data quality is neglected, important information can be irrevocably lost. As developers increase their Met Tower fleet size across remote locations, it becomes more difficult to effectively monitor and maintain data quality and recovery.

The WindLogics Tower Data Management team has developed a prototype dashboard to allow wind developers to gain immediate perspective over their field measurement assets. Intelligent quality checking, data aggregation, and visualization, make it possible to derive actionable intelligence about met towers to facilitate operations, maintenance, analysis, and business decision-making.

DESIGN

The main objective of this system is to process data from multiple data sources and evaluate their quality in a uniform manner. In order to do this in a rigorous way, a data model was developed to manage the “metadata” associated with each tower.

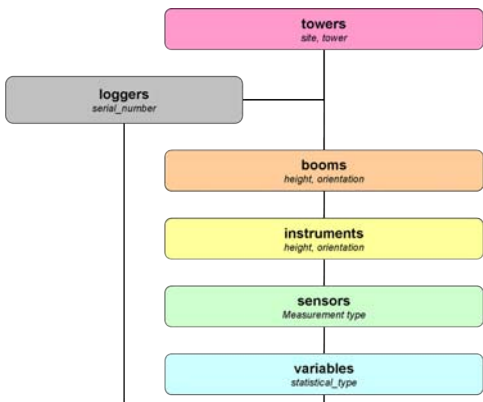


Figure 1: Tower Data Model

Metadata is data that describes other data. In the case of met towers, it is important to have accurate information about the physical measurement devices and tower configuration.

A data model (shown in Figure 1) was developed which describes the physical structure and components of the met tower. The data model was normalized to avoid redundant data entry, which can result in loss of data integrity. Uniqueness requirements were put in place to enforce physical reality (e.g. multiple instruments can not exist at the same height and orientation).

The primary component of each data record is the tower itself. It may have multiple booms associated with it, and each boom may have multiple instruments. In the case of sonic anemometers, multiple sensors are associated with an instrument. The variables are the measured values associated with each sensor, such as average values and standard deviation. These variables are collected by a logger. It is possible to have more than one logger on a tower, which could redundantly process variables or could process a different set of variables.

METHODS

Many potential points of failure exist in the path from the met tower to the data center. The WindLogics tower dashboard determines at which milestone the failure occurs and diagnoses common root causes. The table is sorted by time (since the last data reported), colored according to failure status, and with a shape depicting a diagnosis category.

Tower	Diagnosis	Diagnosis Details	Time Since Last Record [Days]	Average Data Quality [%]
0578	QC Failure	Time Zone Not Set	+	+
6471	File Not Received	File Not Received	▷	▷
0085	QC Failure	Incomplete meta information	+	+
8414	QC Failure	Ingest not set up	+	+
1860	Manual Upload	Last File: Feb 19 2008 8:58PM	△ 27.72	△ 97.43
0501	QC Failure	Timestamp is in the future	+ 6.76	+ 94.14
2470	Low Battery	Daily Voltage: 11.5 : 14.5	▽ 2.76	▽ 99.86
0416	Sensor Failure	See Sensor Diagnosis Table	✖ 1.13	✖ 93.90
8502	Sensor Failure	See Sensor Diagnosis Table	✖ 0.97	✖ 65.90
8315	No Problem	-	○ 0.80	○ 100.00
0171	No Problem	-	○ 0.80	○ 99.58
4790	No Problem	-	○ 0.80	○ 100.00
7559	Potential Icing	Daily Temperature: -23.5 : -11.5	* 0.76	* 94.27
3058	No Problem	-	○ 0.59	○ 100.00

Figure 2: Tower Status Table

Common failure situations (shown in Figure 2):

•Initialization

If required metadata is missing, the data will not be processed, as tower 0085 or 0578. Lag time between customer data entry and WindLogics ingest set up is shown in 8414. Tower 6471 shows a tower which has been set up, but has never reported.

•Logger Failure

The logger may fail for many reasons. However, if the logger's solar charged battery is low due to cloud cover, as in tower 2470, it may not be prudent to dispatch a maintenance team.

•Transmission Failure

Where possible, file arrival times are recorded at various milestones in the data transmission path. In the case of tower 1860, the tower has not reported in over 27 days. However, this is not critical for a tower for which data storage cards are collected manually.

•Processing Failure

When data is processed, the return value of the process is monitored, and error messages are logged. For tower 0501, the data extraction failed because a data measurement had a timestamp in the future.

•Sensor Failure

If a tower has a sensor with data quality which does not meet the data quality threshold of 95%, this flag is set, as seen in 7559, 0416, and 8502.

•Weather conditions (e.g. Icing)

Data flags can occur during icing conditions, as in tower 7559. In this case, a maintenance visit may not be necessary.

Tower	Variable Name	Variable Diagnosis	Freezing?	Avg Data Quality [%]
0416	twp_avg_3_s_ch09	Intermittent Flat-line	True	84.03
	spd_avg_30p04_S_ch06	Flatline at Offset Value	True	92.36
	spd_avg_30p04_W_ch05	Flatline at Offset Value	True	93.06
	spd_avg_40p02_S_ch04	Flatline at Offset Value	True	93.06
	spd_avg_48p57_S_ch02	Flatline at Offset Value	True	92.36
7536	twp_avg_3_s_ch10	Intermittent Flat-line		43.75
	spd_avg_30p11_NW_ch05	Flatline at Offset Value		0.00
	twp_avg_3_s_ch10	Intermittent Flat-line		11.11
8502	dir_avg_47p75_N_ch07	Flatline at Offset Value		85.42
	spd_avg_48p12_SW_ch02	Flatline at Offset Value		0.00
	spd_avg_48p12_NW_ch01	Flatline at Offset Value		0.00

Figure 3: Sensor Status Table

METHODS (continued)

The WindLogics Tower Data Management system has been developed to manage data quality in real time. As new files are received, they are automatically processed. As the data is ingested, data quality flags are added. Flags are added for values out of the normal expected range, and for data which does not vary as much as it is expected to over time. Comparison between measurements can also be used to detect anomalies.

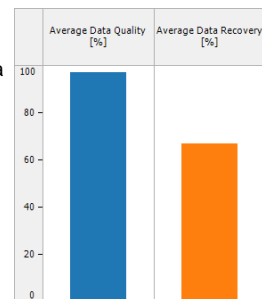
Figure 3 shows the sensor status dashboard which evaluates data quality at the sensor level. For the towers flagged with sensor issues, the flags over the past 24 hours are analyzed to describe the nature of the data issue. In cases where freezing temperatures are recorded, the freezing flag is set to notify the user of the conditions.

RESULTS

To gauge the current status of the field measurement fleet, two metrics are used to indicate overall system health. “Data Quality” shows the overall average data quality of the measurements as of last reporting. “Data Recovery” shows the average data quality over the last 24 hours, where non-reporting towers are given a zero data quality. These statistics can be displayed at varying levels of detail.

The current status, and diagnosis category of each tower is shown on a map to facilitate maintenance planning.

Aside from current data metrics, historical data recovery statistics can also be shown to report recovery over time.



CONCLUSIONS

Prototype dashboards have been developed which provide “at-a-glance” information about the data quality and data recovery of a met tower fleet. This approach facilitates the timely maintenance of a met tower fleet, enables management oversight of field measurement campaigns, and saves time and money in project development.