PI Meets BI

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1. Introduction

1.0 Learning Objectives and Problem Statement

Integrating the PI System with Business Intelligence (BI) tools is an effective way to use your process data for reporting and analytics. BI client tools offer the ability to run retrospective analyses on a much larger set of your real-time PI System data. BI helps you learn from operational behaviors and patterns, identifying dependencies and correlations of various factors within your operations.

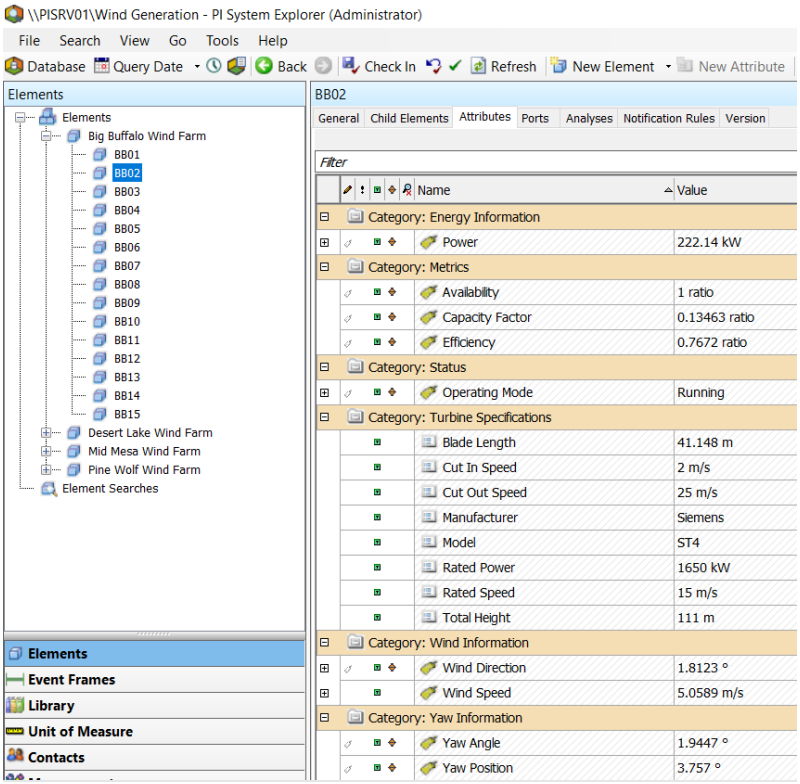
In this lab, we will showcase two tools for connecting your Business Intelligence tool of choice to your PI Data: the PI Integrator for Business Analytics and the PI SQL Client. Using each tool, we will show how to access PI data in three different ways:

1. Retrieving PI Data for assets over time
2. Retrieving Event Frame summary information
3. Retrieving PI Data within the time range of an Event Frame

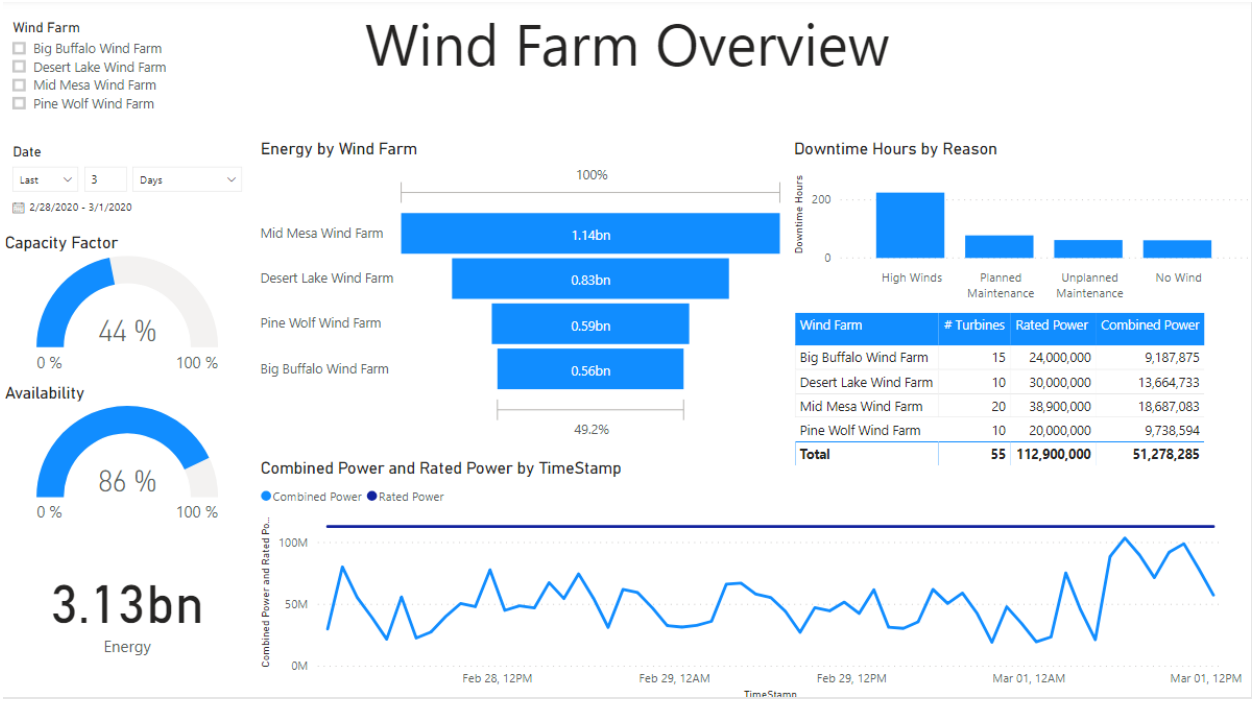
1.1 The Wind Generation Fleet

For this lab, we will be using a simulated Wind Generation dataset consisting of 55 Wind Turbines across 4 Wind Farms. You can view this by opening PI System Explorer (PSE) and navigating to the Wind Generation AF Database.

Each of the turbines is built from the same AF element template, Wind Turbine, which can be viewed in the Library under Element Templates. Each turbine has a variety of data associated with it, including PI Point real-time values and metadata such as manufacturer information.



By the end of the lab, we will have used this data to create a report in Power BI like the one shown below. Along the way, we will present best practices and tips for reporting on process data effectively.



Wind Farm	# Turbines	Rated Power	Combined Power
Big Buffalo Wind Farm	15	24,000,000	9,187,875
Desert Lake Wind Farm	10	30,000,000	13,664,733
Mid Mesa Wind Farm	20	38,900,000	18,687,083
Pine Wolf Wind Farm	10	20,000,000	9,738,594
Total	**55**	**112,900,000**	**51,278,285**

1.2 The PI Tools

There are many ways to extract PI System data depending on your needs. In this lab we will focus on the two tools best suited to creating datasets that can easily be brought into your Business Intelligence program of choice.

1.2.1 The PI Integrator for Business Analytics

PI Integrator for Business Analytics presents PI System data perfectly suited for business intelligence tools including, but not limited to, Tableau, Tibco Spotfire, QlikView, and Microsoft Power BI for reporting and analytics.

Native time-series data, asset context, and event context are exposed through web-configured views. Data are dimensionally modeled, cleansed, and presented with appropriate metadata so that BI tools can properly browse, query, and consume PI System data seamlessly. Data can also be directly integrated and loaded into data warehouse platforms. PI Integrator for Business Analytics eliminates the need for programming or SQL expertise and manages the complete data lifecycle, including access, updates, and data provenance.

1.2.2 The PI SQL Client (for OLEDB, ODBC, or JDBC)

PI SQL Client is a PI Developer Technology that offers data access to the PI System using SQL queries. There are three flavors to allow queries using OLEDB, ODBC, and JDBC, although the principles of operation are the same across the three. The PI SQL Client uses a cost-based optimizer to provide the most performant queries of the SQL-based data access tools.

 Note	Developer Technologies products are available for download from the OSIsoft Customer Portal Products page at no charge. You can develop applications using the Developer Technologies tools and your PI Server. If you do not have access to a PI Server, you can obtain development licenses for the PI Server through membership in the PI Developers Club. For details, see PI Developers Club FAQ. Deployment of an application into production requires a PI System Access (PSA) license. This is a runtime license that enables end users to access PI System data, including time series data in PI Data Archive and asset metadata in PI AF Server, using any of the Developer Technologies. For more information or questions, contact your Account Manager. In case of technical issues with the PSA license, use the OSIsoft Customer Portal Contact Us page.

1.2.3 Which tool should I use?

As you will see in this lab, both tools can produce similar datasets, so the choice on which tool to use will vary but may depend on some of the following factors.

In general, the PI Integrator provides a great platform for creating and updating structured datasets used for wide-audience reporting, data science and machine learning, and data warehousing use cases.

The PI SQL Framework, on the other hand, excels at targeted and varied reporting, where the data is accessed by a smaller group of people. Its flexibility also makes it a great choice for rapid development without requiring additional infrastructure

SQL familiarity

The PI Integrator provides a configuration-based approach to building the dataset that does not require any programming or SQL expertise.

The PI SQL Client requires the author to have some SQL familiarity, but also provides examples and wizards to help guide users. Those with SQL expertise can take advantage of additional functionality to create advanced queries.

Data set size and Audience

The PI Integrator publishes data to an external location on a schedule, and so it can handle large data sets that are frequently accessed by many individuals. Since the data only needs to be extracted once into the target system, no additional load is placed on the PI System when users access the data.

The PI SQL Client accesses data on-demand from the PI System, so expensive queries may put an additional load on the PI System. By executing the queries on-demand, however, the PI SQL Client provides a more flexible approach which may be beneficial during development.

Requirements to integrate with external datasets

When using the PI Integrator, additional datasets can be incorporated in the target system, such as a Data Lake or Data Warehouse.

When using the PI SQL Client, additional datasets can be incorporated in the client tool, such as Power BI.

User access to the PI System

The PI Integrator publishes data to external targets, so end-users require no direct access to the data.

The PI SQL Client requires that the querying system has access to the PI System.

2. Wind Turbine Overview Report

2.0 Objective

The objective of Sections 3, 4, and 5 is to publish calculated asset data in one-hour intervals using both the PI Integrator and PI SQL Client. This data will then be used to create a report showing the performance of the Wind Farms over a configurable time range. After building the data sets, the class members may choose which data set (PI Integrator or PI SQL Client) to use for building the report.

2.1 Tasks

- PI Integrator
    - Create an Asset View for Wind Turbine metadata
    - Create an Asset View for Wind Turbine process data
- PI SQL Client
    - Create a Catalog and Schema for holding report queries
    - Create a template-specific data model for the Wind Turbine
    - Create a view from the Table-Valued Functions
- Power BI
    - Import data from one of the sources
    - Transform the data as necessary
    - Join the metadata and process data tables
    - Build a report page
    - Create additional measures

3. Wind Turbine Data: PI Integrator Asset View

3.0 Overview

In the PI Integrator, a view is a modeled description of the PI System data you want to analyze.

- **Asset views** organize data around your assets and allow you to make comparisons between assets.
- **Event views** organize data around event frames and allow you to detect patterns in the event frames.
- **Streaming views** organize data around your assets and allow you to make this data available in near real time for predictive analytics.

In this section, two Asset Views will be created – one for Wind Turbine metadata, and the other for Wind Turbine process data. Since the metadata for the Wind Turbine is static, we will separate it from the changing process data so that the two views can be published on different schedules.

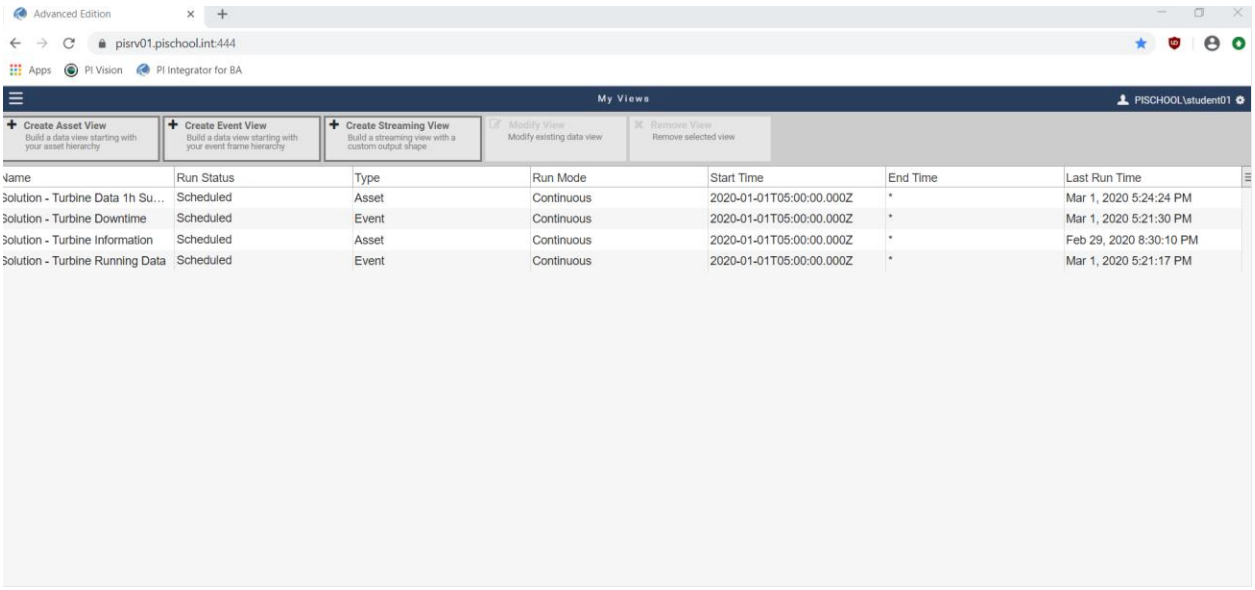
3.1 Create an Asset View for Wind Turbine metadata

The wind turbines have several attributes that contain static metadata, as shown below. In addition, each **Wind Turbine** also belongs to a specific **Wind Farm**. This is the information that will be captured in the first Asset View that we create.

Category: Turbine Specifications	
Blade Length	41.148 m
Cut In Speed	2 m/s
Cut Out Speed	25 m/s
Manufacturer	Siemens
Model	ST4
Rated Power	1650 kW
Rated Speed	15 m/s
Total Height	111 m

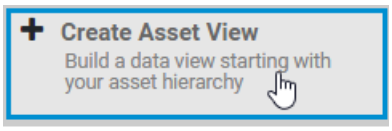
First, open Google Chrome and navigate to the PI Integrator webpage by using the bookmark for **PI Integrator for BA** or the URL:

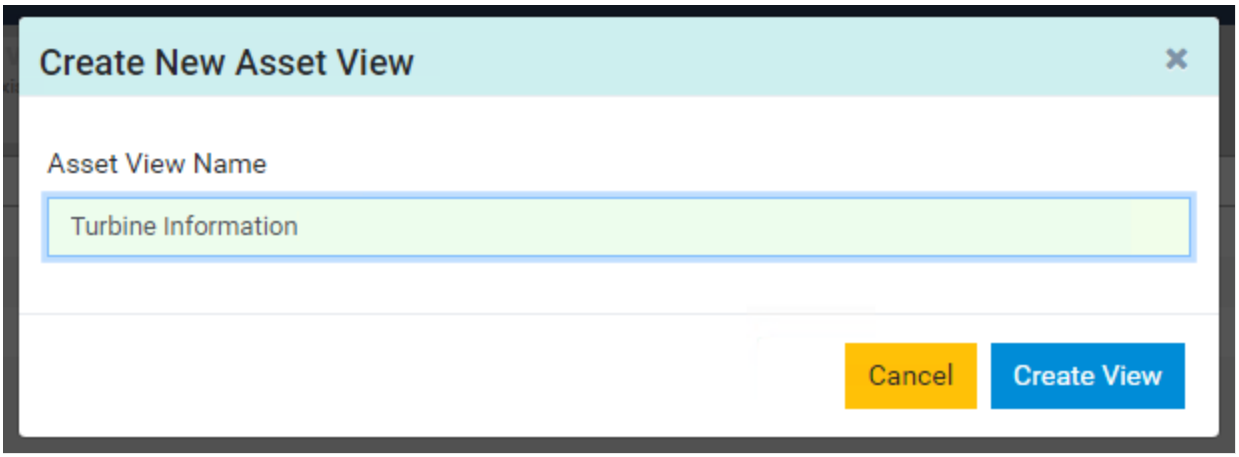
https://pisrv01.pischool.int:444



This is the home page where existing views can be managed or new views can be created. Four views already exist as solutions.

Next, click the button in the top menu for +**Create Asset View** and name the view **Turbine Information.**

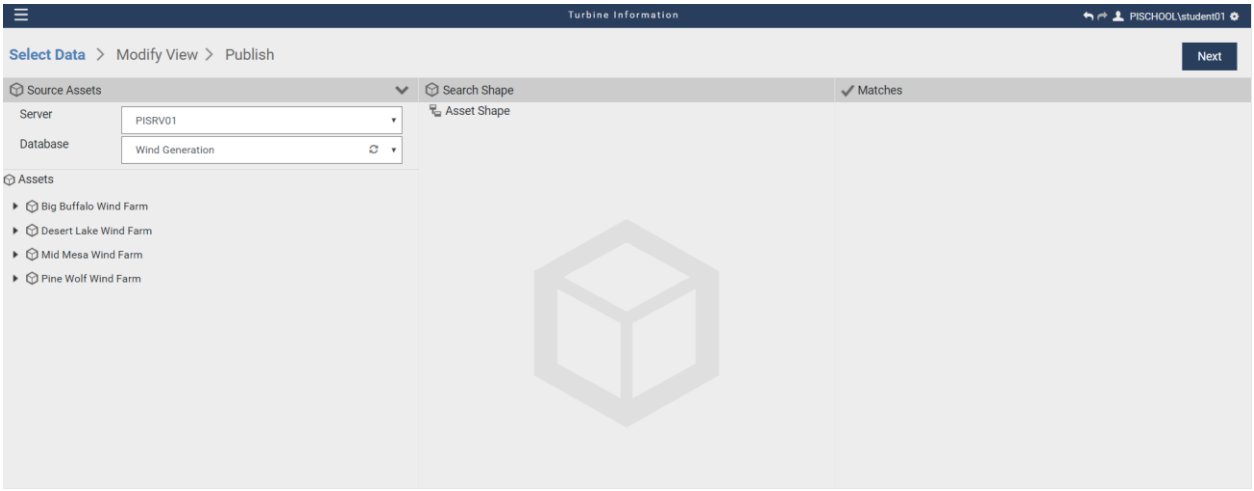




Tip	The view name becomes the name of the table or file in the target system. Some targets allow this to be updated after a view is published.

3.1.1 Create the Search Shape

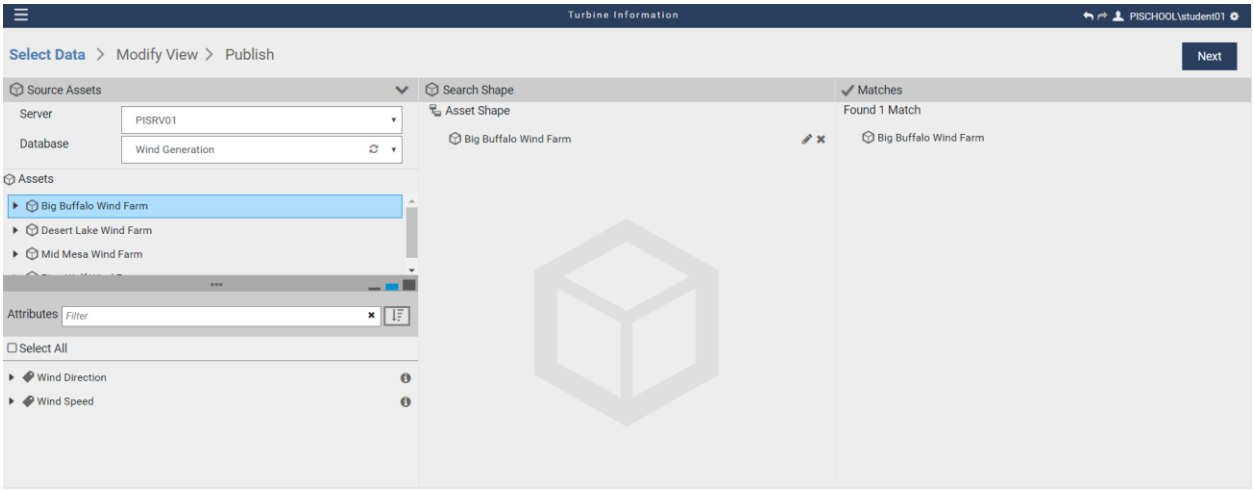
The first page that comes up in the view builder is where the search shape is defined. Click to *Create a New Shape*, and then choose the Server **PISRV01** and Database **Wind Generation**.



To create a search shape, drag an asset, event, or attribute from the **Source Assets** section on the left into the **Search Shape** section in the middle. The **Matches** section on the right will refresh to show how many matches were found in the selected database.

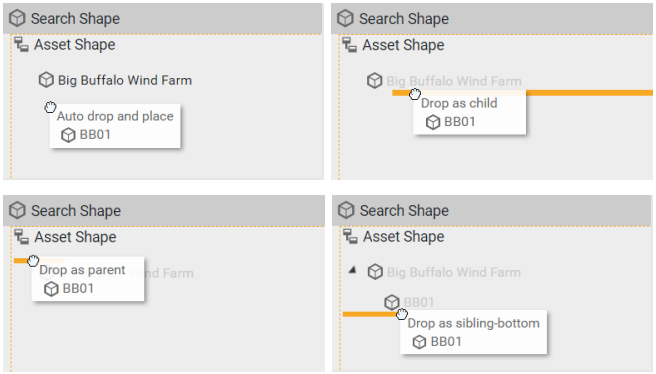
Tip	The search shape acts like a key and will return data from AF that match its structure. It also defines what data to include. By default, each entry in the shape will have a corresponding column in the output. For more information, see the section [What is a shape?] in the user guide.

For this shape, first drag the **Big Buffalo Wind Farm** asset into the middle section.

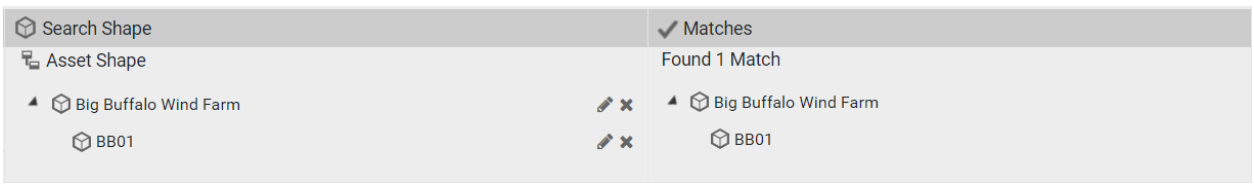


Notice that one match has been found: **Big Buffalo Wind Farm**

Next, expand the **Big Buffalo Wind Farm** asset on the left pane, and drag **BB01** into the middle section. Note that dropping the asset in different locations can have different behaviors:



Use either *Drop as child* or *Auto drop and place* to have **BB01** appear as a child of **Big Buffalo Wind Farm**. The shape should now look like below, and there should still be one match.

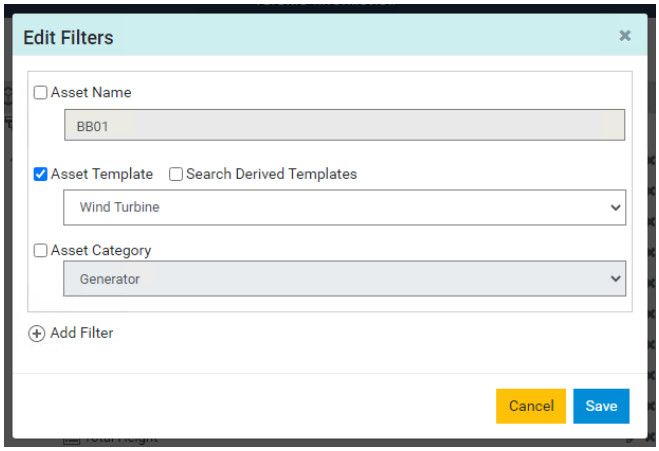


Right now, the shape is searching based on names. That means it is looking through the **Wind Generation** AF Database and finding cases where there is an element named **Big Buffalo Wind Farm** that has a child element named **BB01**.

To make the shape more powerful, we can use AF Templates instead of element names. To do this, click the pencil icon next to the item in the search shape.

First, click the pencil icon next to **BB01**

In the dialog that appears, uncheck **Asset Name** and check **Asset Template**. Choose the template **Wind Turbine** and click **Save.**

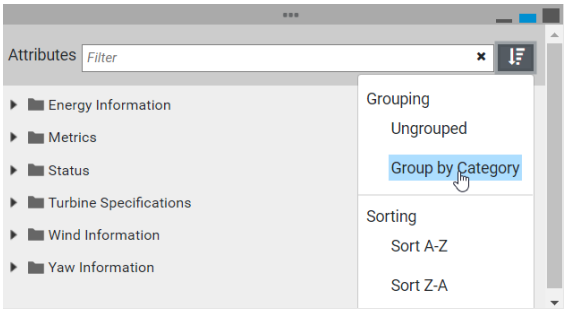


Note that the shape now has **15 Matches**. It is now finding all of the turbines within the **Big Buffalo Wind Farm**.

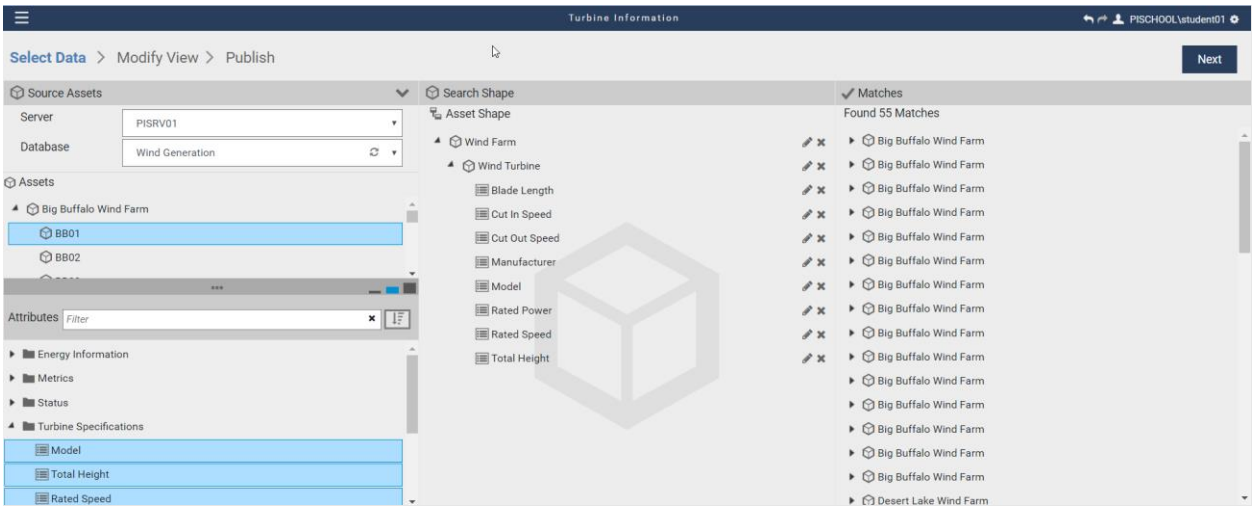
✓ Best Practice	When creating a shape, use templates instead of names wherever possible.

Repeat this process to use the **Wind Farm** template instead of **Big Buffalo Wind Farm**.

Now that the search shape is matching the needed assets, it is time to add the desired attributes to the shape. As with the assets, these are dragged and dropped from the left pane. Once an asset is selected, its attributes will be displayed underneath. If there are many attributes, it can be helpful to group by category.



For this example, drag the **Turbine Specifications** category onto the **Wind Turbine** in the shape.

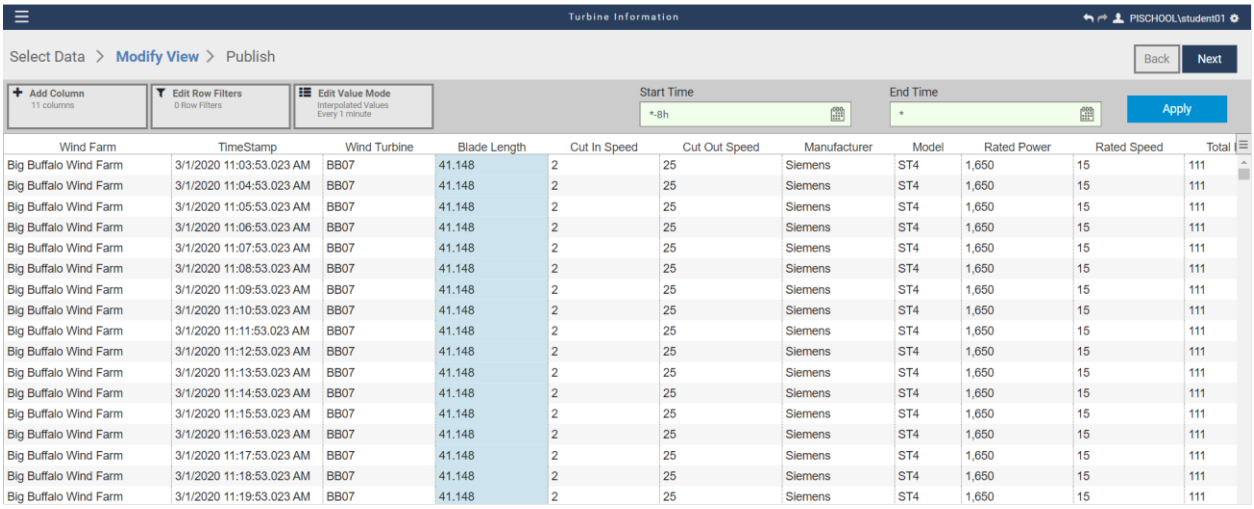


Just like with assets, these attributes are used in the filtering process. If an element does not have one of the attributes, then it will not be matched.

Tip	Although we won't use it in this lab, the attributes can be modified like the assets and can be marked as optional. If marked as optional, they will not be part of the matching criteria, which is useful when derived templates are used.

At this point, the shape is complete. Click **Next** to continue to the **Modify View** page.

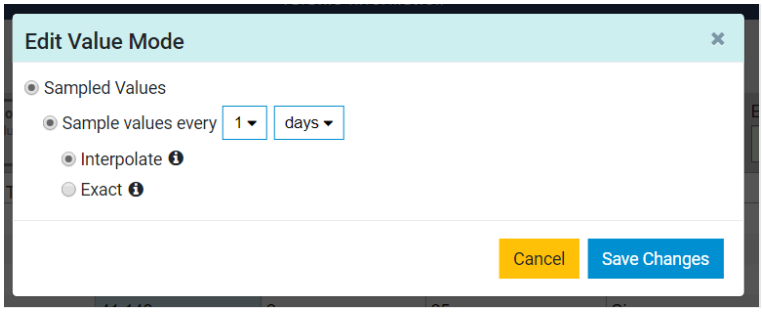
3.1.2 Modify the View



Wind Farm	TimeStamp	Wind Turbine	Blade Length	Cut In Speed	Cut Out Speed	Manufacturer	Model	Rated Power	Rated Speed	Total
Big Buffalo Wind Farm	3/1/2020 11:03:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:04:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:05:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:06:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:07:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:08:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:09:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:10:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:11:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:12:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:13:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:14:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:15:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:16:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:17:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:18:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:19:53.023 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111

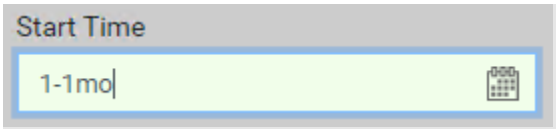
Using the information from the search shape and its matches, this page governs how the data will be published. Additional columns can be added, existing columns can be modified, and data range can be specified.

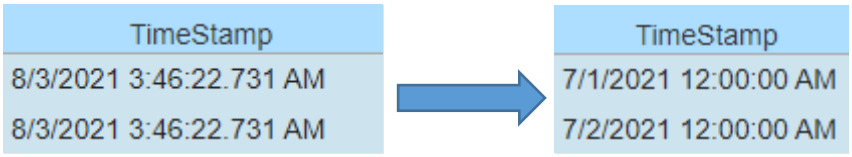
Since this view is publishing static data, set the sampling rate to 1 day by clicking **Edit Value Mode** and choosing **1 days** and click **Save Changes**.



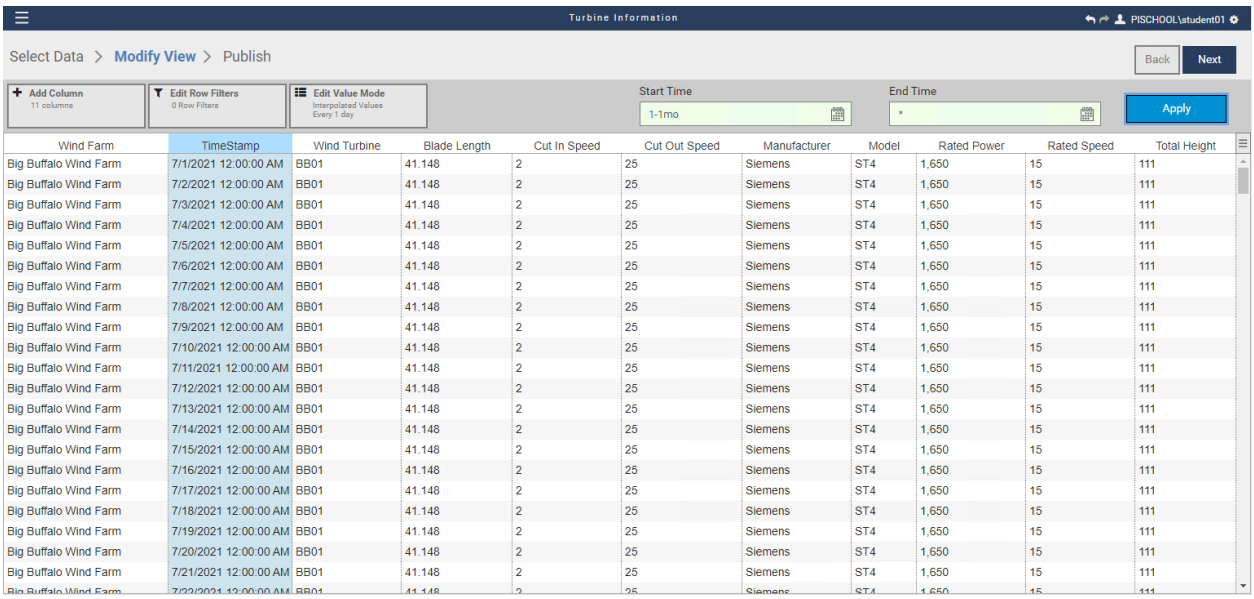
Tip	It's often best to use **Interpolate** with tag data. If **Exact** is chosen, then all attributes must have a compressed value in the archive that exactly matches the timestamp, which is often not the case.

Notice that the TimeStamps do not have clean values. This is because the **Start Time** is ***-8h**. Set the Start Time to **1-1mo** and click **Apply**. Notice that the timestamps are now much neater.



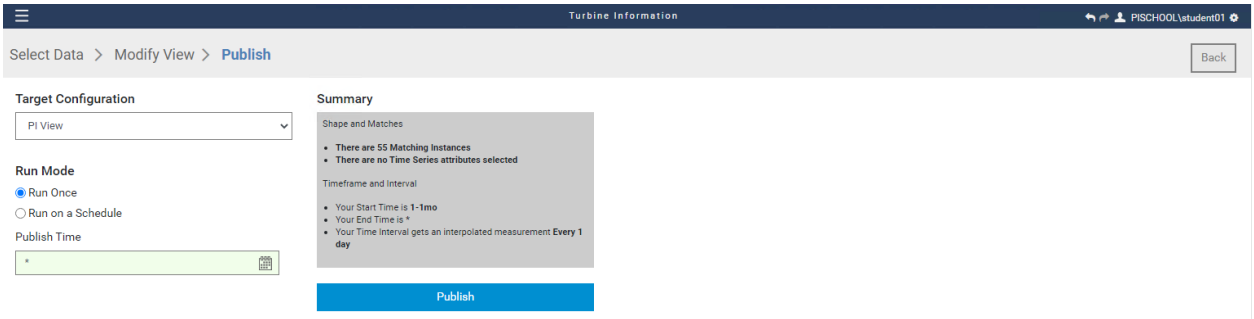


At this point, the view should look similar to below.



Click **Next** to move to the **Publish** page.

3.1.3 Publish the View

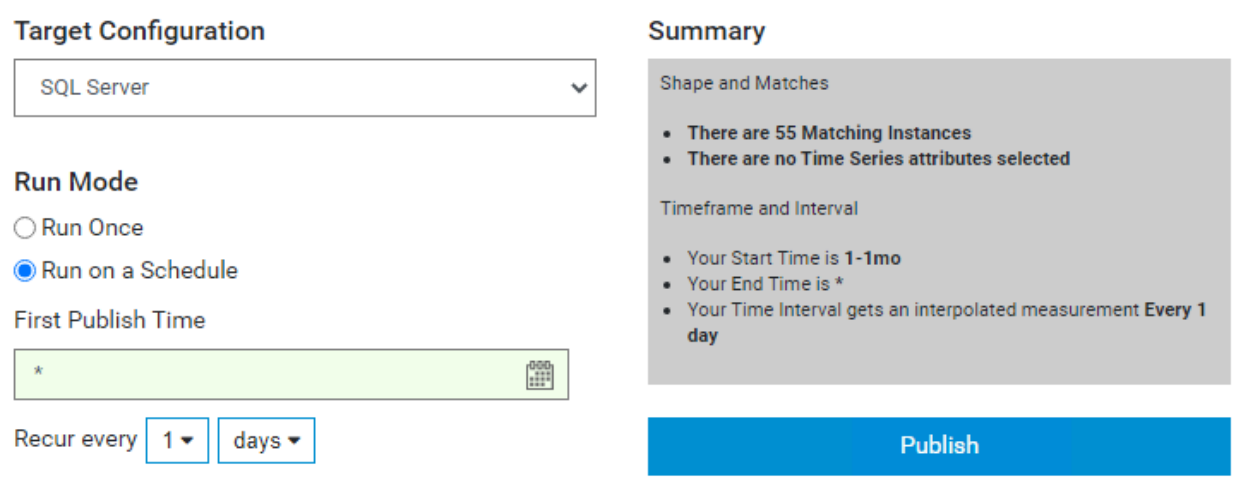


On this page, the target and schedule are set. The **Target Configuration** provides the list of pre-configured targets, such as specific databases, data lakes, or folders. If the **PI View** target is chosen, then users can access the data using the PI ODBC Driver. In this class, the **SQL Server** target will be used exclusively.

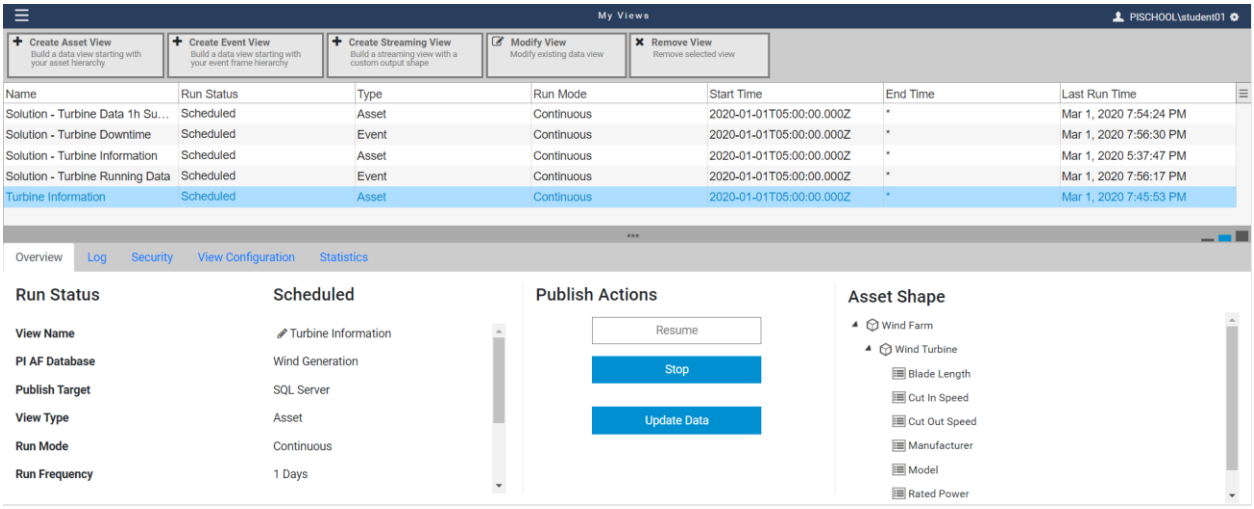
Choose **SQL Server** from the dropdown list.

Tip	To learn more about the targets available for the PI Integrator for Business Analytics see Set up your publish targets.

For the **Run Mode**, choose to **Run on a Schedule**, and have the view **Recur every 1 day**. Doing this will ensure that any changes to the asset structure can be reflected in the published data.



Click **Publish** to create the dataset. On the home page, look for the new view **Turbine Information**. Its **Run Status** will update to **Publishing** and then to **Scheduled** once the data has been published.



3.2 Create an Asset View for Wind Turbine Process Data

Now that we have a view created for the Turbine metadata, the next step is to create a view for the process data. In this example, we will publish summary data at intervals of one hour.

✓ Best Practice	Don't sample data more frequently than necessary. Instead, tailor the data sets to the intended use case. In a monthly or weekly report, hourly summaries (avg, total, min, max) often provide enough time resolution while using fewer resources.

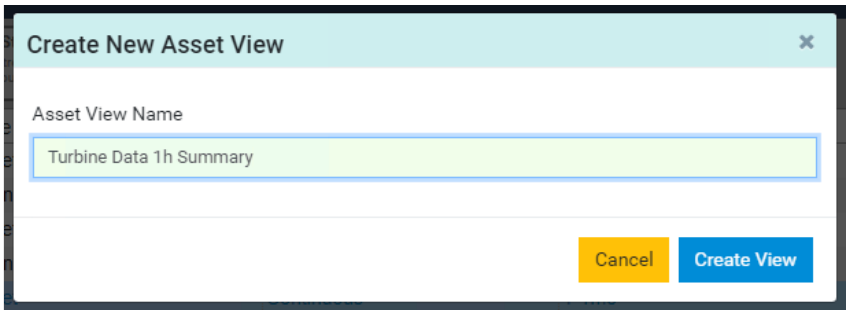
This will follow the same process as the previous section to capture the following data. For this lab, the Availability and Efficiency are kept as ratio for simplicity and will be represented as percentages using the built-in functionality of Power BI.

⊟ Category: Energy Information		
⊞	Power	39.204 kW
⊟ Category: Metrics		
	Availability	1 ratio
	Capacity Factor	0.02376 ratio
	Efficiency	0.80947 ratio
⊟ Category: Status		
⊞	Operating Mode	Running
⊞ Category: Turbine Specifications		
⊟ Category: Wind Information		
⊞	Wind Direction	37.283 °
⊞	Wind Speed	4.4725 m/s
⊟ Category: Yaw Information		
	Yaw Angle	-5.5419 °
	Yaw Position	31.741 °

3.2.1 Create the Search Shape

Again, navigate to the PI Integrator home page and click **Create Asset View.**

Name this view **Turbine Data 1h Summary**.



Create a new shape, again choosing Server **PISRV01** and Database **Wind Generation**. Since the previous view already includes the name of the Wind Farm, we can skip adding that to our shape. Instead, add **BB01** to the search shape and modify it to use the template **Wind Turbine** instead of its name.

Now, add the following attributes into the search shape.

Verify that the view has still found all **55 Matches** and click **Next**.

3.2.2 Modify the View

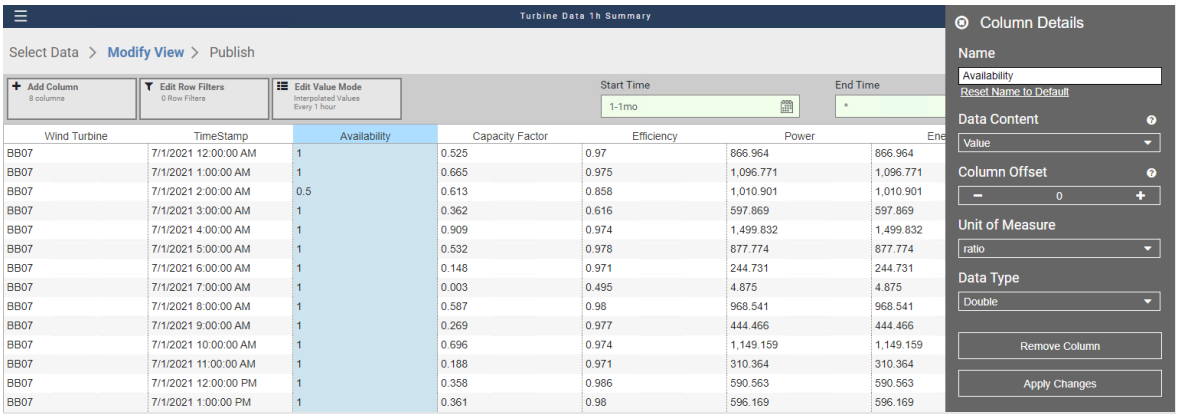
In this view, the goal is to publish summary information at one hour intervals. For this data, each existing column will be configured to publish out an average value over the interval, and an additional column will be created to totalize power, which gives energy over that interval.

To begin, click **Edit Value Mode** and choose to sample values every **1 hour.**

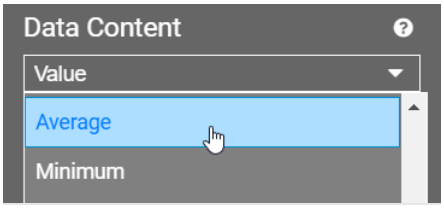
As before, update the **Start Time** to **1-1mo** and click **Apply**.

The view is now retrieving interpolated values at 1-hour intervals. The next steps will change the columns to perform a summary calculation instead of retrieving the interpolated value.

Click the **Availability** column. Notice the **Column Details** pane appears on the right.



Change the **Data Content** from **Value** to **Average**.

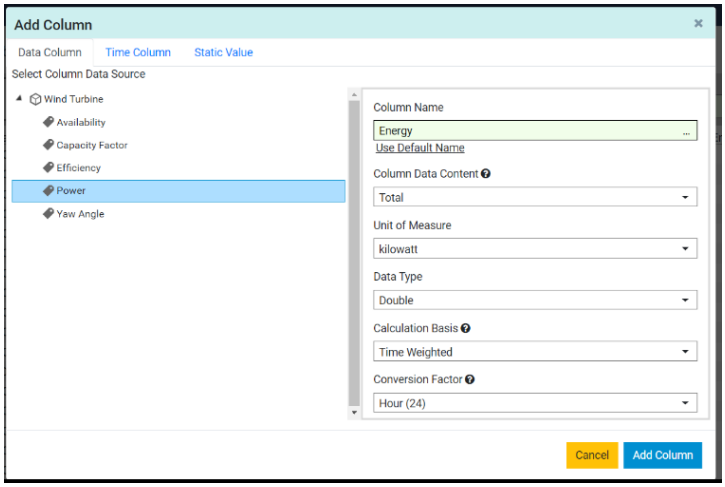


Click **Apply Changes** at the bottom. The column is now calculating an average over the 1-hour interval.

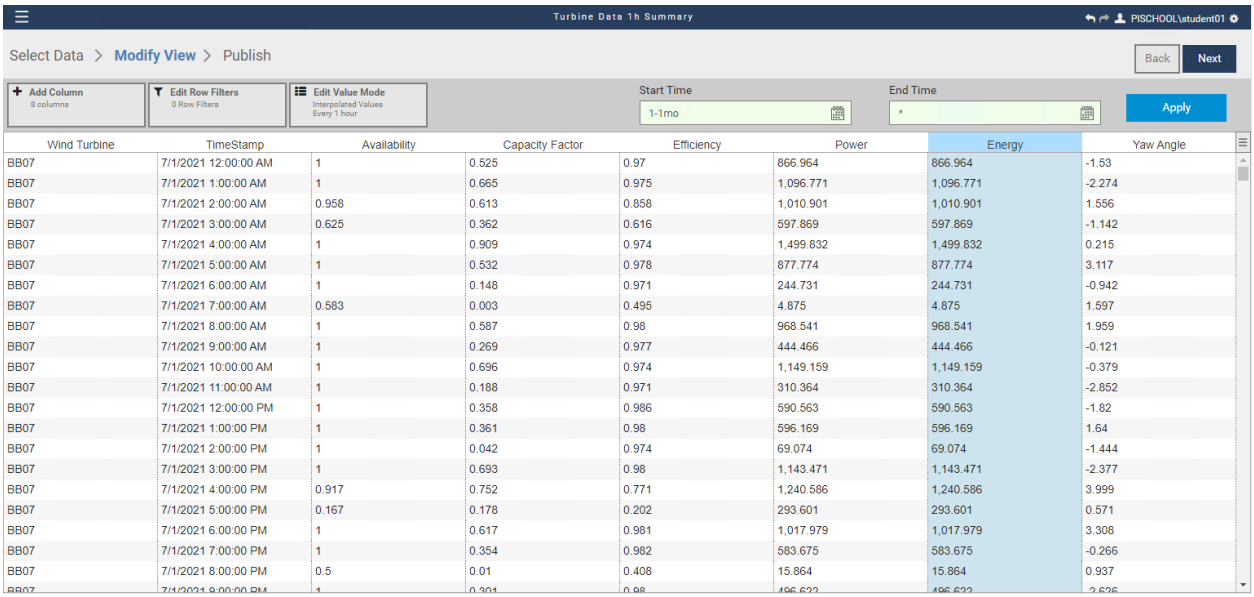
Repeat this process for **Capacity Factor**, **Efficiency**, **Power**, and **Yaw Angle**.

✓ Best Practice	Summary calculations are most accurate when performed at this stage. If needed, add additional columns to perform other summaries.

To create Energy (a total of Power), click **Add Column** on the top left. This brings up a window to add additional columns. Choose the **Power** attribute, a **Column Data Content** of **Total**, and set the **Conversion Factor** to **Hour (24)**. Name this column **Energy**. Click **Add Column**. This column will now contain the total kWh over the interval.



The page should now look similar to below.

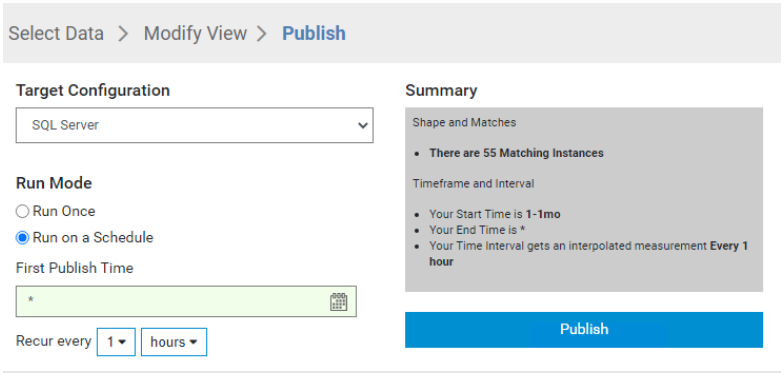


Wind Turbine	TimeStamp	Availability	Capacity Factor	Efficiency	Power	Energy	Yaw Angle
BB07	7/1/2021 12:00:00 AM	1	0.525	0.97	866.964	866.964	-1.53
BB07	7/1/2021 1:00:00 AM	1	0.665	0.975	1,096.771	1,096.771	-2.274
BB07	7/1/2021 2:00:00 AM	0.958	0.613	0.858	1,010.901	1,010.901	1.556
BB07	7/1/2021 3:00:00 AM	0.625	0.362	0.616	597.869	597.869	-1.142
BB07	7/1/2021 4:00:00 AM	1	0.909	0.974	1,499.832	1,499.832	0.215
BB07	7/1/2021 5:00:00 AM	1	0.532	0.978	877.774	877.774	3.117
BB07	7/1/2021 6:00:00 AM	1	0.148	0.971	244.731	244.731	-0.942
BB07	7/1/2021 7:00:00 AM	0.583	0.003	0.495	4.875	4.875	1.597
BB07	7/1/2021 8:00:00 AM	1	0.587	0.98	968.541	968.541	1.959
BB07	7/1/2021 9:00:00 AM	1	0.269	0.977	444.466	444.466	-0.121
BB07	7/1/2021 10:00:00 AM	1	0.696	0.974	1,149.159	1,149.159	-0.379
BB07	7/1/2021 11:00:00 AM	1	0.188	0.971	310.364	310.364	-2.852
BB07	7/1/2021 12:00:00 PM	1	0.358	0.986	590.563	590.563	-1.82
BB07	7/1/2021 1:00:00 PM	1	0.361	0.98	596.169	596.169	1.64
BB07	7/1/2021 2:00:00 PM	1	0.042	0.974	69.074	69.074	-1.444
BB07	7/1/2021 3:00:00 PM	1	0.693	0.98	1,143.471	1,143.471	-2.377
BB07	7/1/2021 4:00:00 PM	0.917	0.752	0.771	1,240.586	1,240.586	3.999
BB07	7/1/2021 5:00:00 PM	0.167	0.178	0.202	293.601	293.601	0.571
BB07	7/1/2021 6:00:00 PM	1	0.617	0.981	1,017.979	1,017.979	3.308
BB07	7/1/2021 7:00:00 PM	1	0.354	0.982	583.675	583.675	-0.266
BB07	7/1/2021 8:00:00 PM	0.5	0.01	0.408	15.864	15.864	0.937

Click **Next** to proceed to publishing.

3.2.3 Publish the View

Configure the view to use the **SQL Server** target and recur every **1 Hour**.



4. Wind Turbine Data: PI SQL Client Element Model

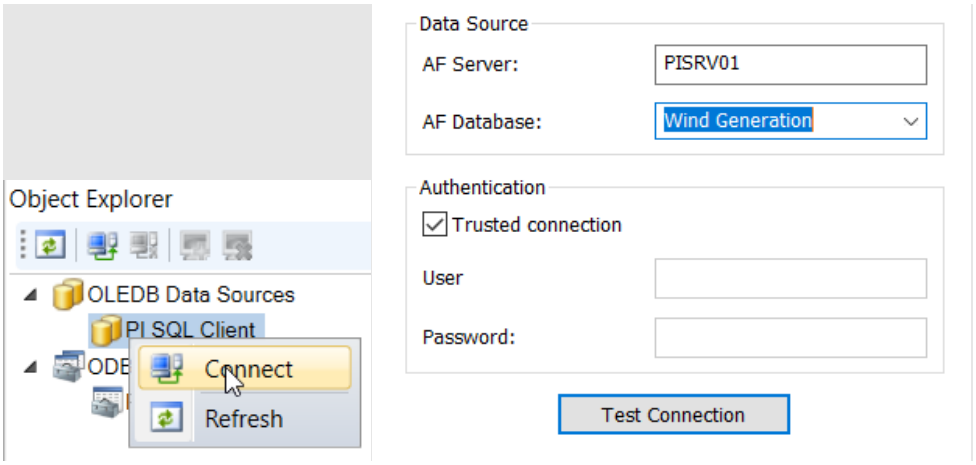
4.0 Overview

In this section, two datasets will be created like those published in Section 3 – one for Wind Turbine metadata, and the other for Wind Turbine process data.

Queries written for the PI SQL Client can be executed from any application supporting OLEDB, ODBC, or JDBC as long as the computer has the appropriate driver installed. During development, the **PI SQL Commander Lite** application will be used, as it is tightly integrated with the PI SQL Client and includes wizards and sample queries to aid development.

4.1 Connect to the AF Server

Open **PI SQL Commander Lite** from the desktop and right click on **PI SQL Client** under **OLEDB Data Sources** and click **Connect**. Fill in the AF Server **PISRV01** and choose AF Database **Wind Generation** from the dropdown. Click OK.



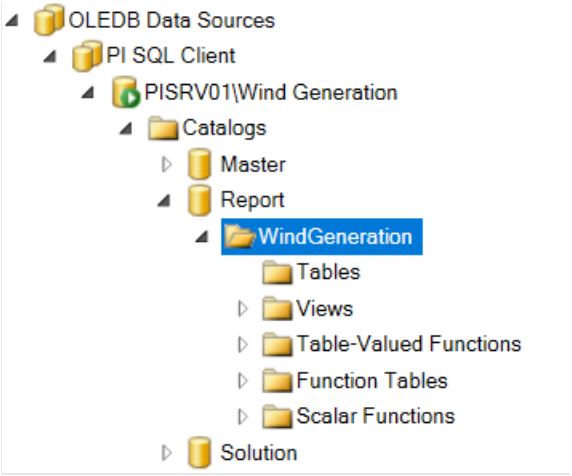
Tip	For development purposes, there is no difference between OLEDB and ODBC, as they are just translation layers that interface with the Real Time Query Processing (RTQP) engine on the AF server.

4.1.1 Create a Catalog and Schema for the Report

Since there may be many use cases for querying the database, it is helpful to create **Catalogs** and **Schemas** to keep related queries organized. An additional Catalog **Solution** already exists and contains the solutions for this lab.

For this lab, **right click Catalogs** and create a catalog called **Report.**

Then, **right click Report** and create a schema called **WindGeneration**.

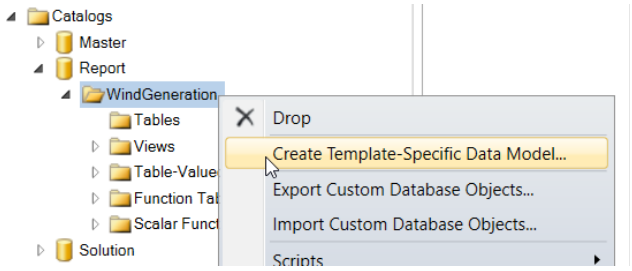


4.2 Create a Template-Specific Data Model for the Wind Turbine

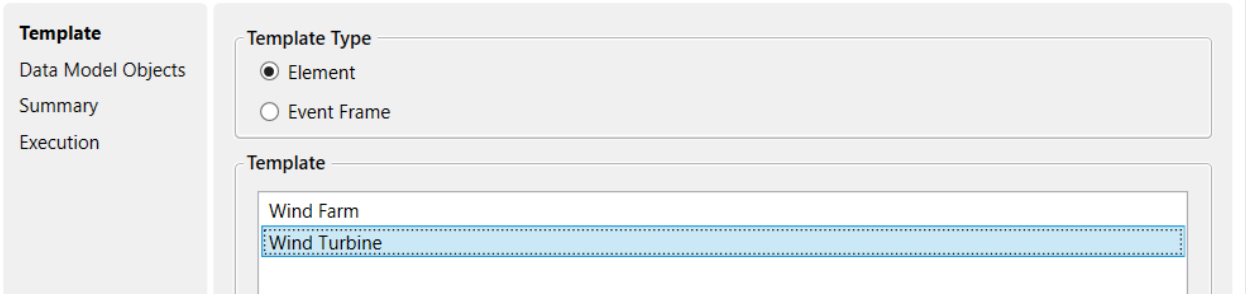
The PI SQL Commander Lite has built-in wizards to aid the creation of datasets for reporting purposes. These **Template-Specific Data Models** produce similar datasets to the PI Integrator and will be the focus of this lab.

Tip	Unlike the PI Integrator, the PI SQL Client can be used for general purpose queries against the PI System. These types of queries are outside the scope of this lab, but the **Query Compendium** contains good examples to help get started.

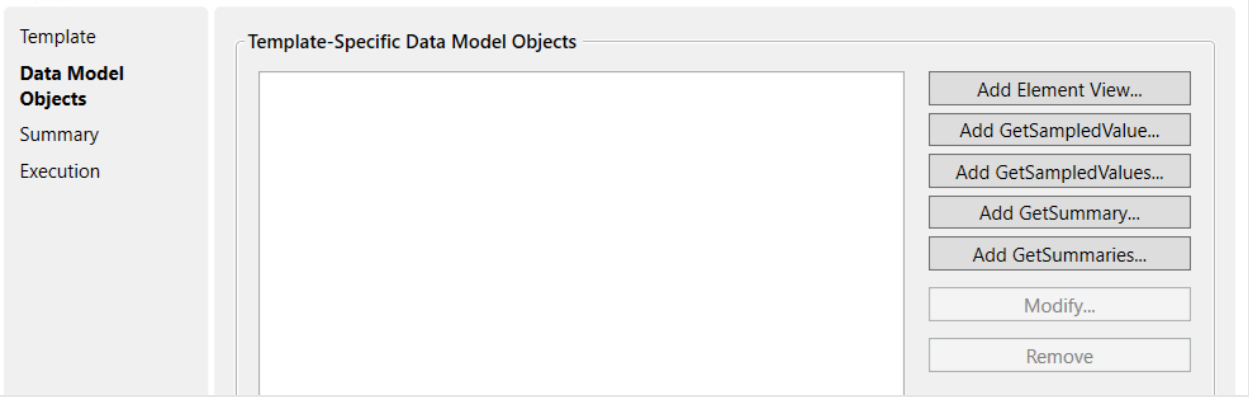
To create the data model, **right click** on the schema **WindGeneration** and click **Create Template-Specific Data Model**.



For **Template Type,** choose **Element**, and for **Template** choose **Wind Turbine**, then click **Next**.



The next page is where the Data Model Objects are specified. In this stage, an Element View will be added to capture the turbine metadata and a Get Summaries call will be used to get aggregate data.



For the **Data Model Objects**, first click **Add Element View**. This will open a column definition window.

Set the **View Name** to **Turbine Information**.

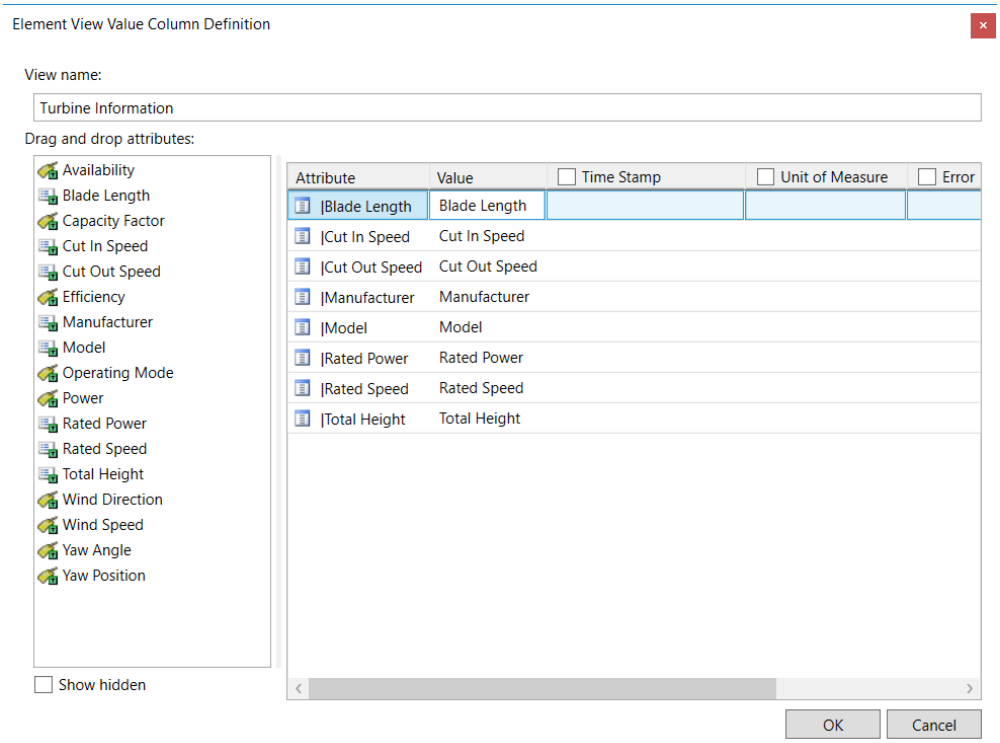
Select the metadata attributes (using **Ctrl+click**) and drag them into the main pane. The attributes to be selected are:

- Blade Length
- Cut In Speed
- Cut Out Speed
- Manufacturer
- Model
- Rated Power
- Rated Speed
- Total Height

Tip	Metadata attributes usually show the symbol  since they normally have static values. This distinguishes them from attributes which are associated with a PI Tag and display the symbol  .

In the header of the table, **deselect Timestamp, Unit of Measure,** and **Error**.

The window should look similar to the below image. The name of the Wind Farm (the parent element) is not included at this stage but will be added in later steps.



Click **OK**.

Next, click on **Add GetSummaries…** (not GetSummary…).

Drag the following attributes into the table:

- Availability
- Capacity Factor
- Efficiency
- Power
- Yaw Angle
- Power *(yes, add it a second time)*

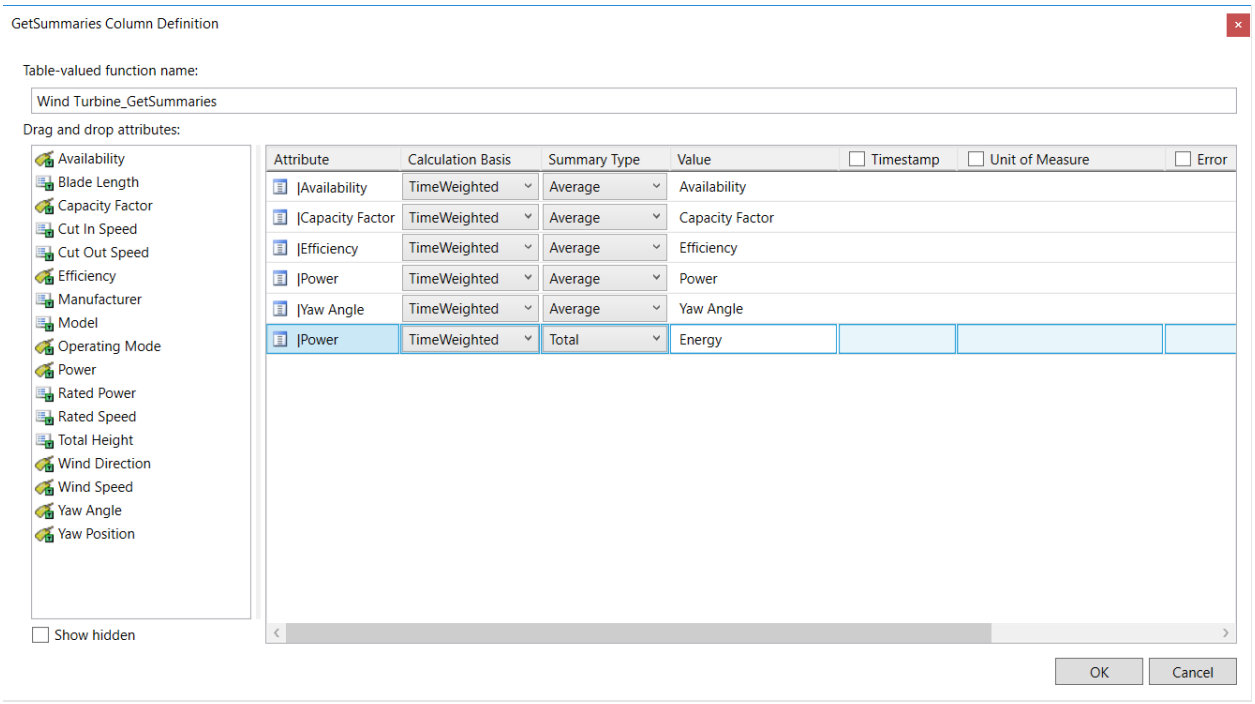
Configure all attributes except the second Power with **Calculation Basis: TimeWeighted** and **Summary Type: Average**.

Configure the second **Power** with **Calculation Basis: TimeWeighted** and **Summary Type: Total**. This attribute will become our Energy calculation.

In the header of the table, **deselect Timestamp, Unit of Measure,** and **Error**.

For consistency with the PI Integrator views, remove the "_Average" suffix from the **Value** column. This field will become the column name, so also rename the second **Power** to **Energy**.

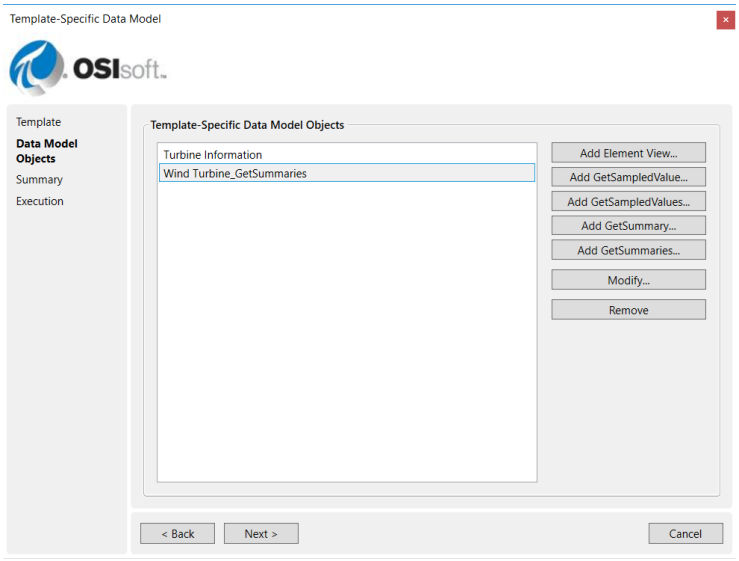
The window should look similar to below.



Tip	The **Total** Summary Type will always use a calculation basis of 1 Day.

Click **OK**.

There should now be two Data Model Objects defined as shown below

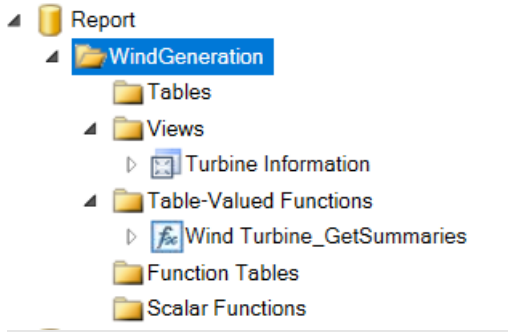


On the Data Model Objects page, click **Next**

This brings up a summary page that shows the query that will be executed. Click **Execute** to create the objects. Once the execution completed successfully click **Done**.

Tip	This query can be built and executed without using the wizard. The statements within the query can also be executed individually without creating the Data Model Objects.

At this stage, the two data objects should be listed within WindGeneration as shown below:

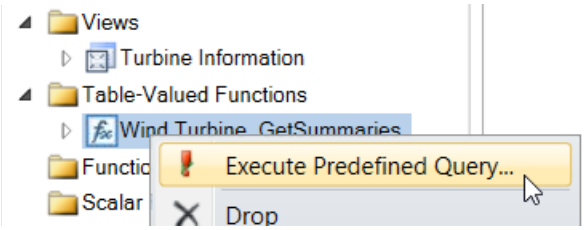


Tip	A copy of the resulting query is stored in the following file and can be executed if you ran into any issues. C:\PI World\Solutions\PI SQL Client\4.3 - Create Initial Data Model.sql

4.3 Enhance the Data Objects

4.3.1 Execute Predefined Queries

PI SQL Commander Lite makes it easy to see a sample query for most objects by **Right Clicking** and choosing **Execute Predefined Query**. Do this for the View and Table-Valued Function (TVF) to see the result.



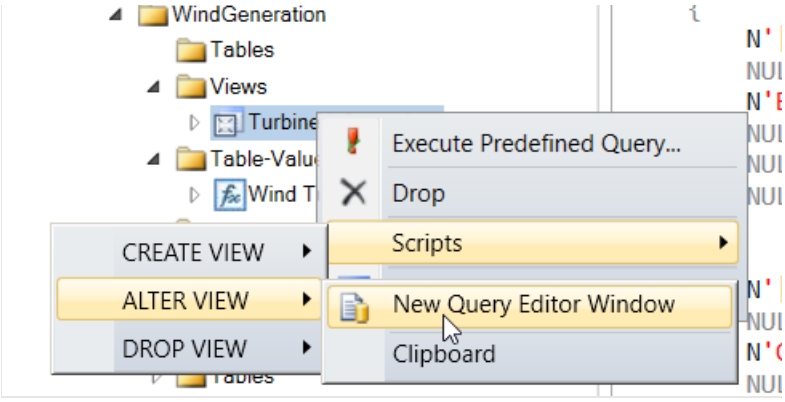
Two pieces of information are missing from our data:

1. The **Turbine Information** does not include the **Wind Farm**.
2. The **Wind Turbine_GetSummaries** returns **Energy** in kWd instead of kWh. If the more commonly used unit kWh is preferred for the report this can be transformed easily once the data is imported into Power BI.

4.3.2 Update the Turbine Information View

To add the Wind Farm information, edit the view.

Right click Turbine Information > **Scripts** > **Alter View** > **New Query Editor Window**.



To get the Wind Farm, append **ParentName(e.PrimaryPath) AS [Wind Farm]** to the SELECT statement.

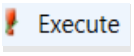
The default columns **e.Description,** and **e.Comment** may also be removed since they are not needed for the intended report.

Optionally, for consistency with the PI Integrator, change the **Name** column to use the alias **Wind Turbine** by adding **e.Name AS [Wind Turbine]**.

Line 3 should be as follows

```
SELECT e.ID, e.Name AS [Wind Turbine], v.*,
ParentName(e.PrimaryPath) AS [Wind Farm]
```

```
ALTER VIEW [Report].[WindGeneration].[Turbine Information]
AS
SELECT e.ID, e.Name AS [Wind Turbine], v.*, ParentName(e.PrimaryPath) AS [Wind Farm]
FROM [Master].[Element].[Element] e
INNER JOIN [Master].[Element].[ElementTemplate] et ON et.ID = e.TemplateID
INNER JOIN [Master].[Element].[Value]
<
    N'Wind Turbine'  --Template
```

Click  or F5 to execute the query and alter the view.

Execute the Predefined query once more to ensure that the view does not throw any errors.

4.3.3 Create a view from the Table-Valued Function

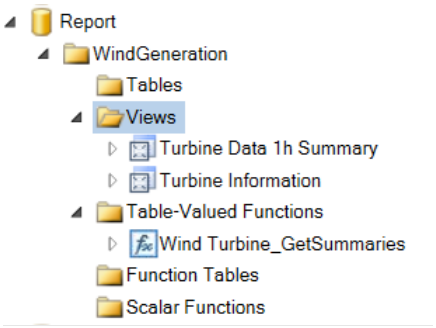
The Table-Valued Function is not easily usable within Power BI. To make it easier for end-users, create a view.

Using the Predefined Query as a starting place, create the following query:

```
CREATE VIEW [Report].[WindGeneration].[Turbine Data 1h Summary]
AS
SELECT e.[Wind Turbine], s.*
FROM [Report].[WindGeneration].[Turbine Information] e
CROSS APPLY [Report].[WindGeneration].[Wind Turbine_GetSummaries]
(
   e.ID,  --Element ID
   '1-1mo',  --Start Time
   '*',  --End Time
   '1h',  --Time Step
   N'MostRecentTime'  --Time Type
) s
```

Click **Execute**.

Refresh the Views and two views should now exist:



Execute the Predefined query for the new view to ensure that the view does not throw any errors.

5. Wind Turbine Report

5.0 Overview

This section will detail creating a report in Power BI using the data prepared in Sections 3 or 4. Students may choose to use either the dataset published by the PI Integrator or the views created for the PI SQL Client.

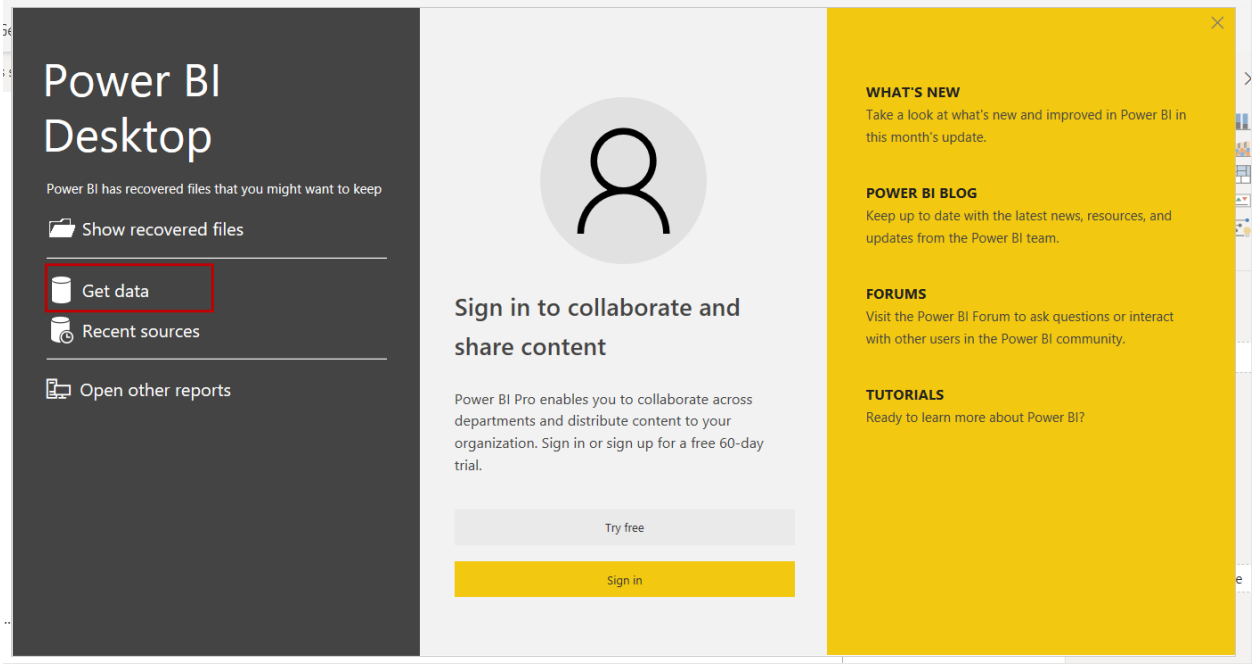
5.1 Tasks

- Create a new Power BI Report
    - Connect the report to PI Integrator Data
    - Connect the report to PI SQL Client Data
- Transform the data as necessary
- Join the metadata and process data tables
- Build a report page
- Create additional measures

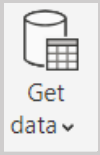
5.2 Importing the Data into Power BI

To build the report, first open Power BI Desktop from the Desktop.

On the splash screen, choose **Get Data**.

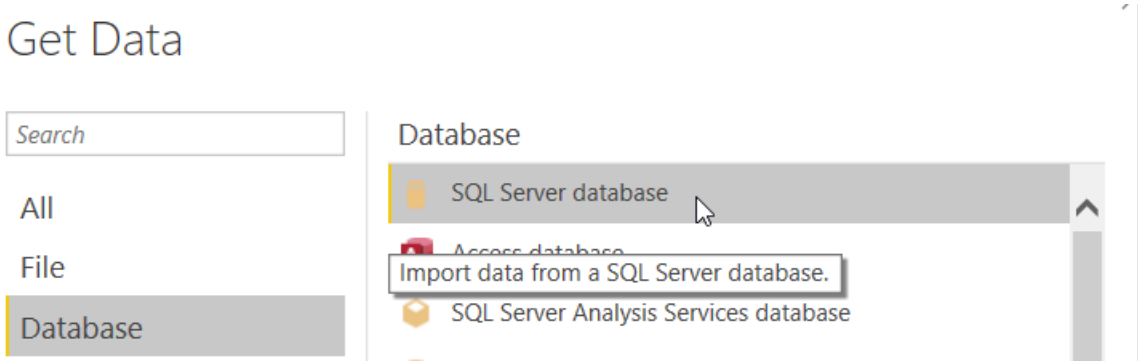


After choosing **Get data**, a new screen appears to assist with the data source connection.

Tip	To bring this up in the future, click on **Get data** in the ribbon. 

5.2.1 Option 1 – Connect the report to PI Integrator Data

To use the data published by the PI Integrator, select the **Database** category and choose **SQL Server database** from the list and click **Connect**.



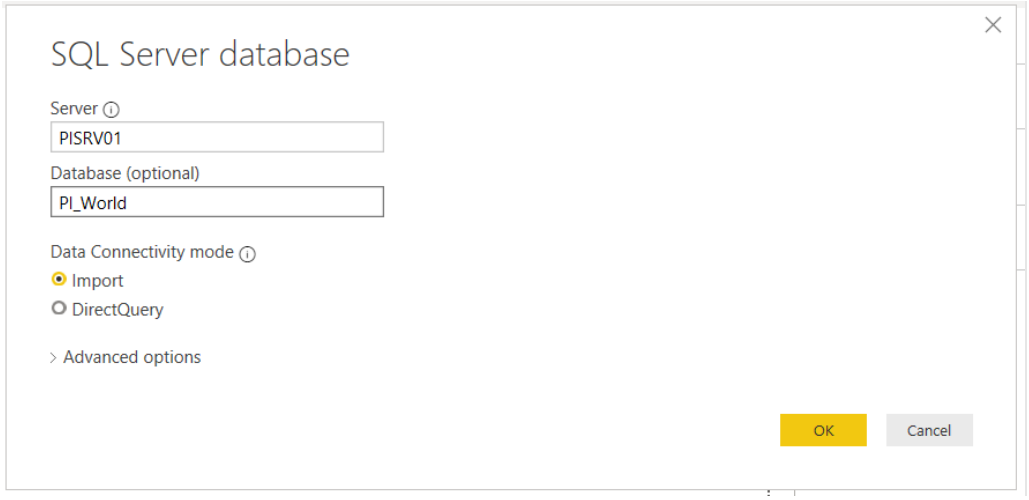
On the database connection screen, choose:

Server**: PISRV01**

Database**: PI_World**

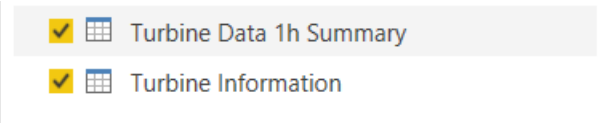
Data Connectivity Mode: **Import**

Tip	To find out which database on the SQL Server is used to create the views open the PI Integrator website and navigate to the **Administration** page. Click the **Targets** tab and select the SQL Server from the **Publish Targets** list. Check the entry for **Database** in the Target Configuration pane.

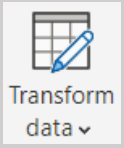


Click **OK** to move to the Navigator window.

In this window, choose the two tables that we created before: **Turbine Data 1h Summary** and **Turbine Information**.



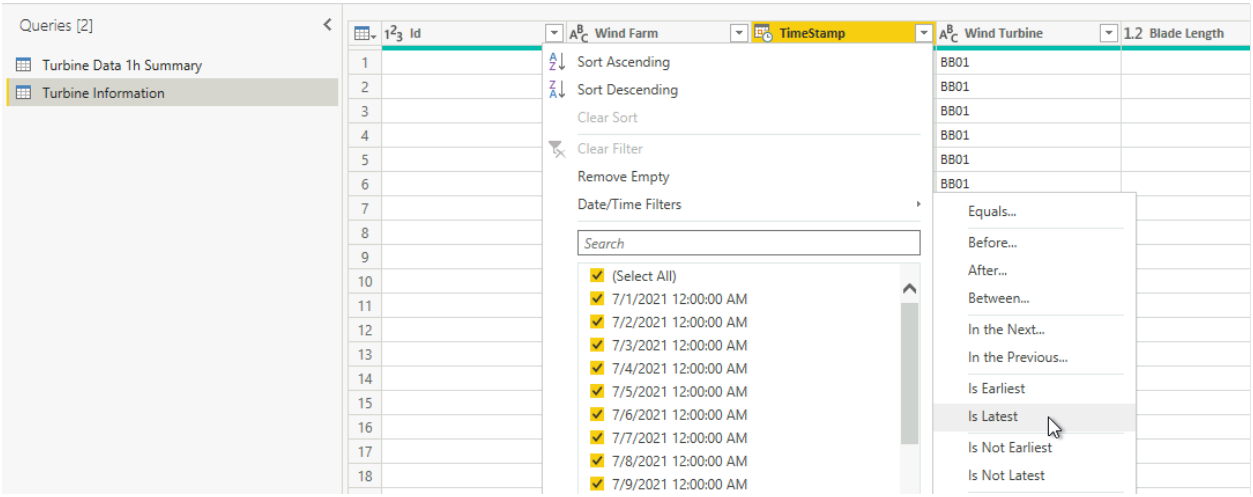
After selecting these two tables, click **Transform Data**. This is important as it allows the **Turbine Information** table to be filtered to return only the latest result.

Tip	If **Load** was clicked, don't worry, just click **Transform Data** from the Home tab of the ribbon. 

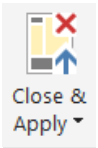
This opens the Power Query Editor window.

At this stage, select **Turbine Information** from the list of queries on the left.

Choose the dropdown on the **TimeStamp** column > **Date/Time Filters** > **Is Latest**

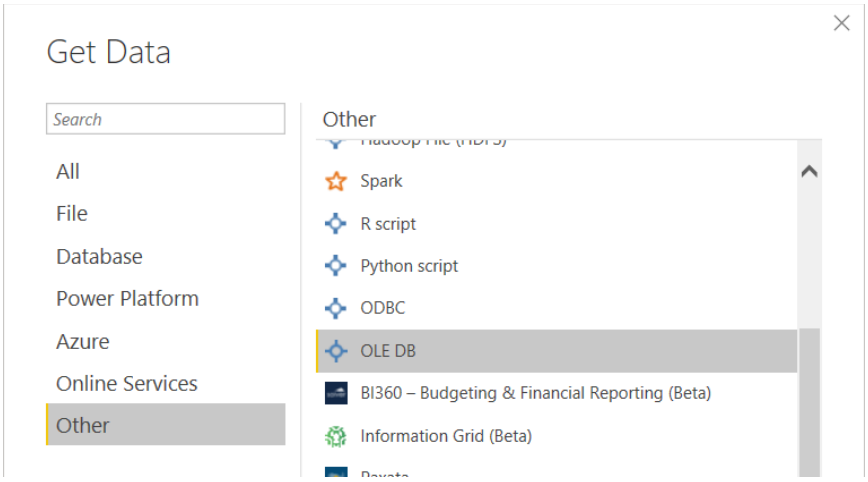


Now the table will include only the latest result. Click **Close & Apply** from the Home tab of the ribbon to return to the report.



5.2.2 Option 2 – Connect the report to PI SQL Client Data

To use the data from the PI SQL Client, click on **Get data** in the Home ribbon and choose **OLE DB** from the **Other** category of connections and click **Connect**.



On the database connection screen, click **Build** to build a connection string. Choose:

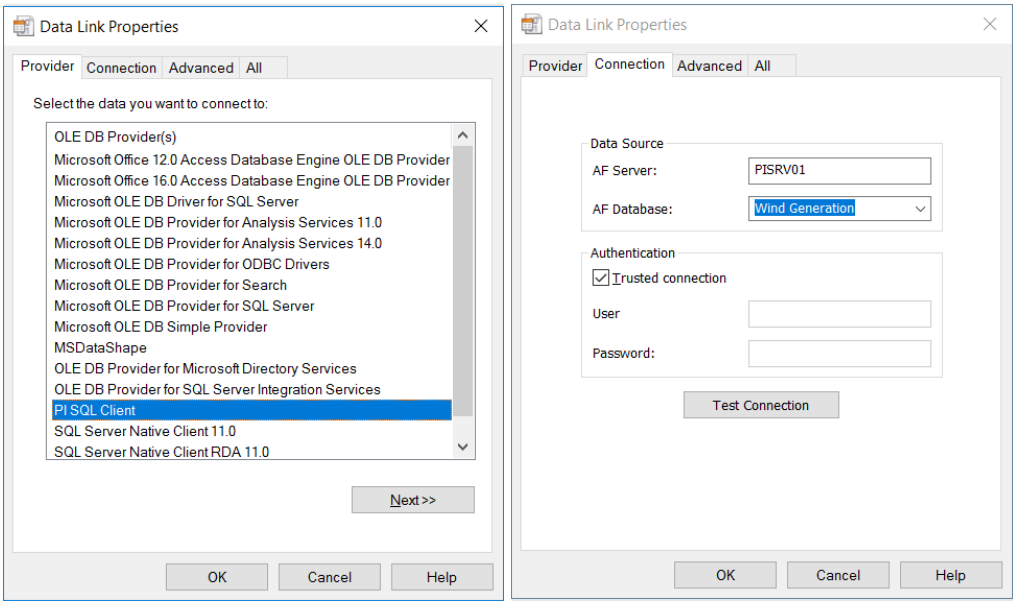
Provider tab: **PI SQL Client**

Connection tab:

AF Server**: PISRV01**

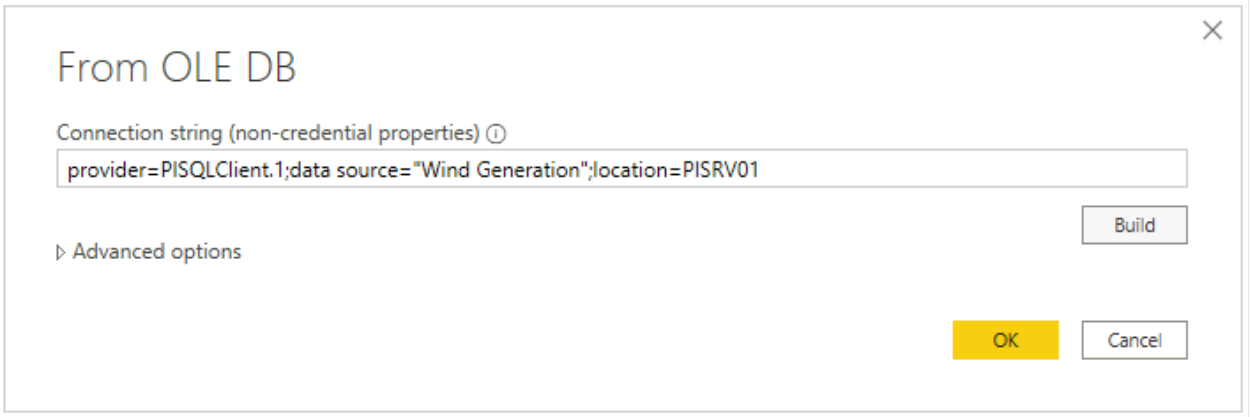
AF Database**: Wind Generation**

Trusted Connection: **Checked**



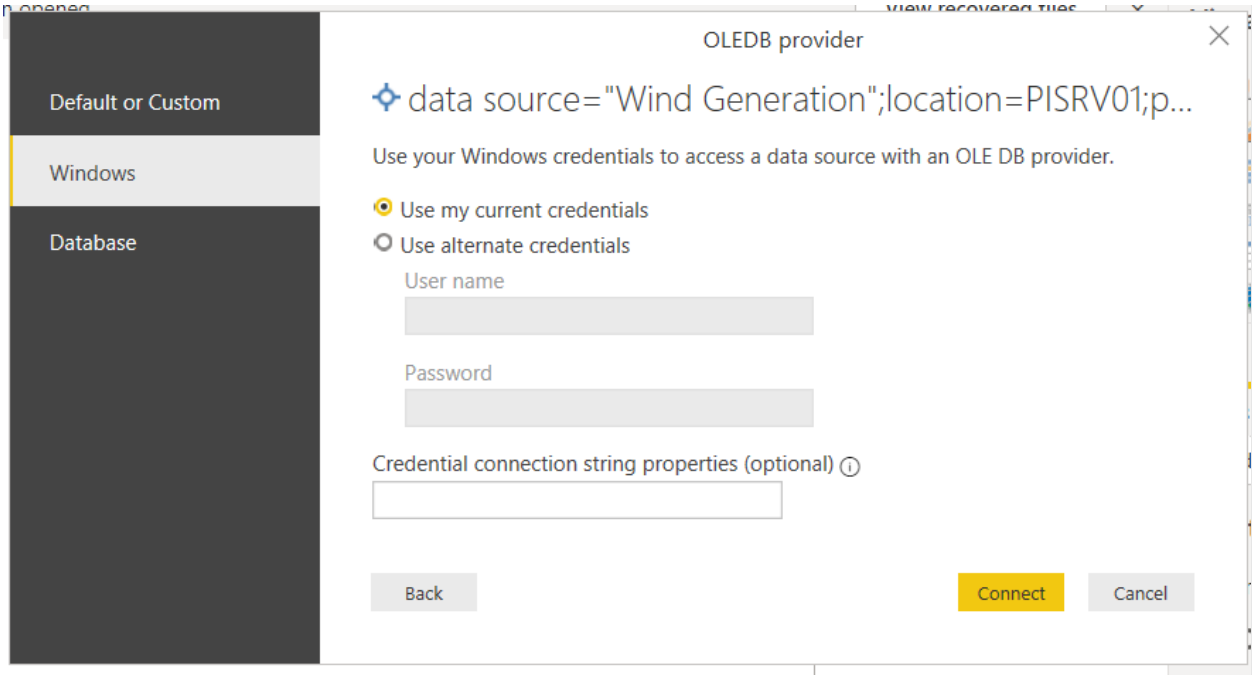
This should generate a connection string like shown below:

provider=PISQLClient.1;data source="Wind Generation";location=PISRV01



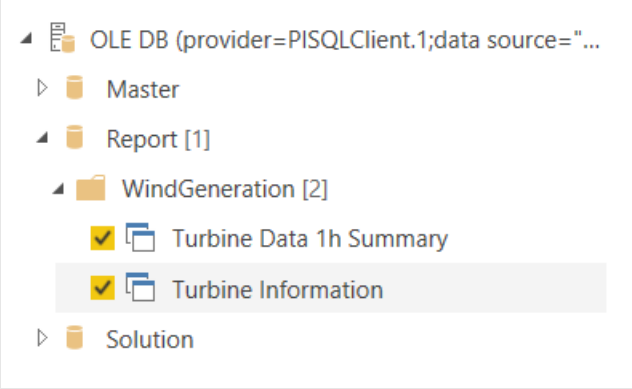
Click **OK** to move to the credentials section.

Here, choose **Windows** on the left and select **Use my current credentials**



Click **Connect** to move to the Navigator Window.

In this window, navigate to **Report** > **WindGeneration** and choose the two tables that we created before: **Turbine Data 1h Summary** and **Turbine Information**



After selecting these two views, click Load.

5.3 Connect the two tables

At this point, the report will have two tables, either from the SQL Server (PI Integrator) or PI SQL Client.

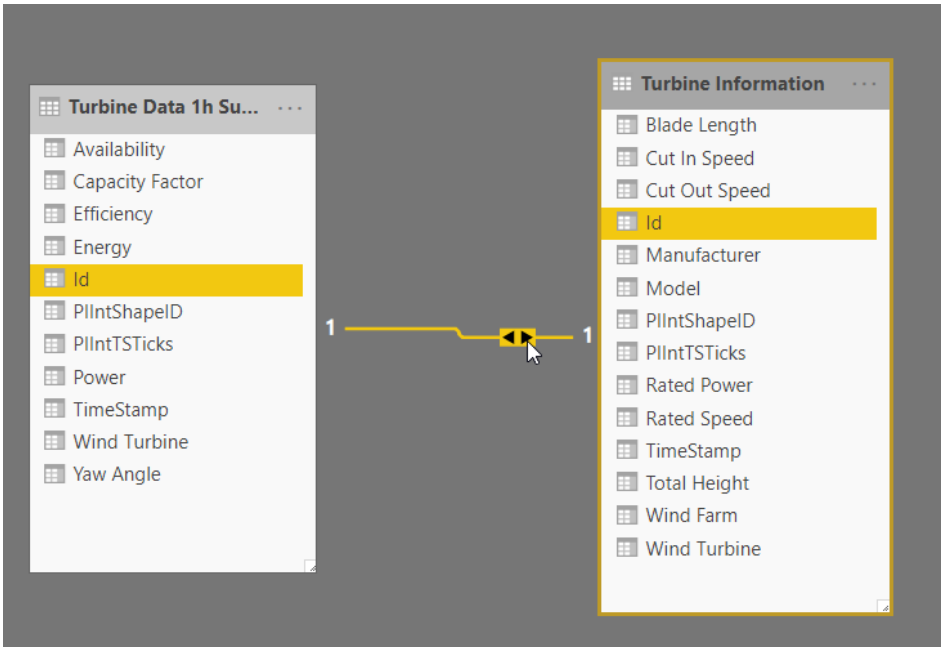
Tip	If both sets of tables have been imported, choose one set and delete the other. To do this navigate to Data using the icon on the left side of the window. The tables are listed on the right side of the window. Right click the tables to be deleted and select Delete.

Since there are two tables, it is important to define the relationship between them. In this example, we want to use the **Wind Turbine** field to link the two tables.

To view the links between tables, navigate to the Model using the icon on the left side of the window

Power BI will try to guess how tables should be connected, but it doesn't always choose correctly. Especially for the PI Integrator tables, Power BI will usually choose to join on the ID columns, which have no relation between tables.

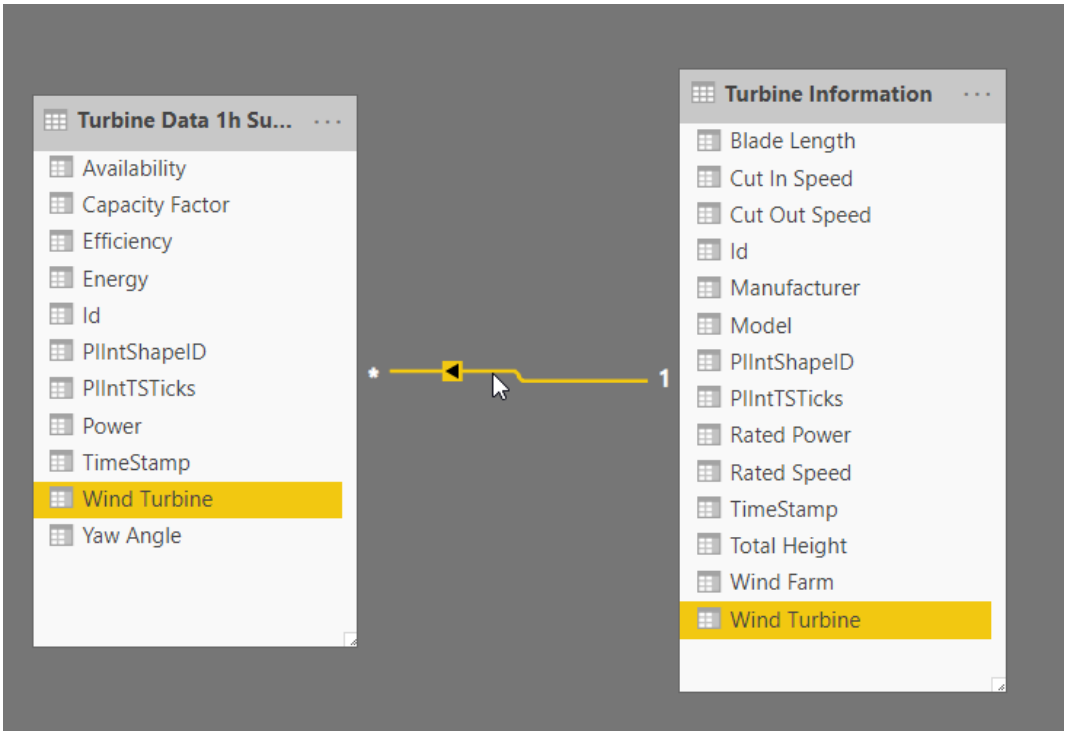
To see the relationship, move the mouse over the link between the two tables.



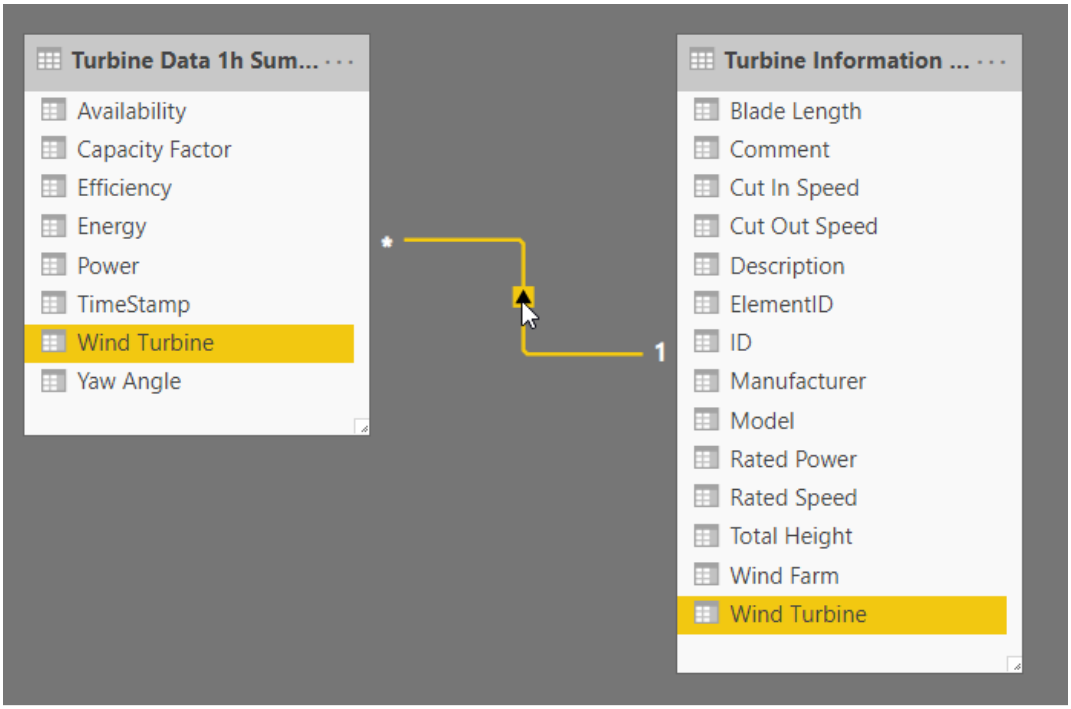
If the link is incorrect, **Right Click** on it and choose **Delete**.

To create a new link, drag a field from one table onto the corresponding field from another table.

For the PI Integrator tables, the relationship should look like below:



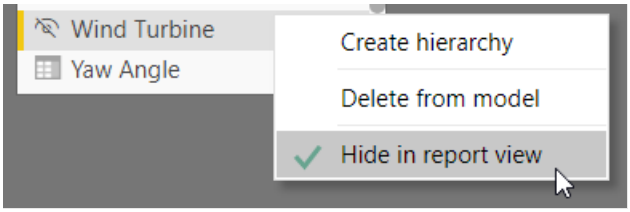
For the PI SQL Client, the relationship should look like below:



Since the directionality of the relationship is such that filters applied to the **Turbine Information** table affect the **Turbine Data 1h Summary**, but not vice-versa, it is

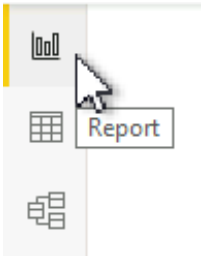
important that users do not use the **Wind Turbine** field from the 1h data table for filtering. To ensure this doesn't happen, the column can be hidden from the report view.

Right Click and choose **Hide in report view** for the **Wind Turbine** in the table **Turbine Data 1h Summary**



5.4 Starting Your Report

To start creating the actual report, click the **Report** button at the left side of the window.



Right click the page tab to rename the page to **Wind Generation Overview**. We will add more pages to the report later on and by naming them we will ensure easy navigation.

Start putting content to the report by adding a Title. From the Home tab of the ribbon, click **Text Box**.

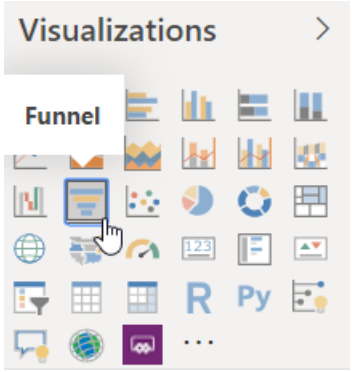
Set the font size in the second drop down menu form the left to **36**.

Type **Wind Generation Overview** and adjust the box size by dragging a corner.

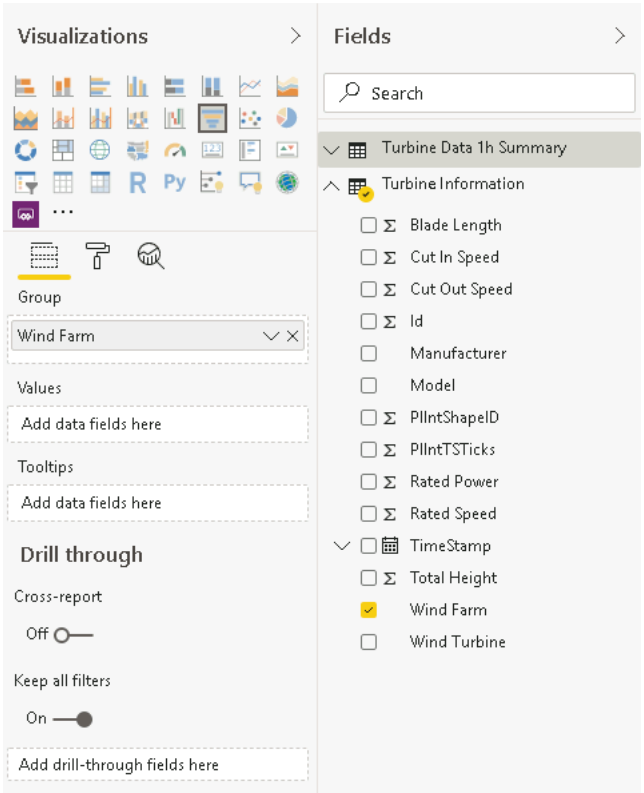
Tip	To create new visualizations, first click into the blank report area. Otherwise an existing visualization might be accidentally changed if it is still selected.

5.4.1 Create a Funnel Chart to show Energy by Wind Farm

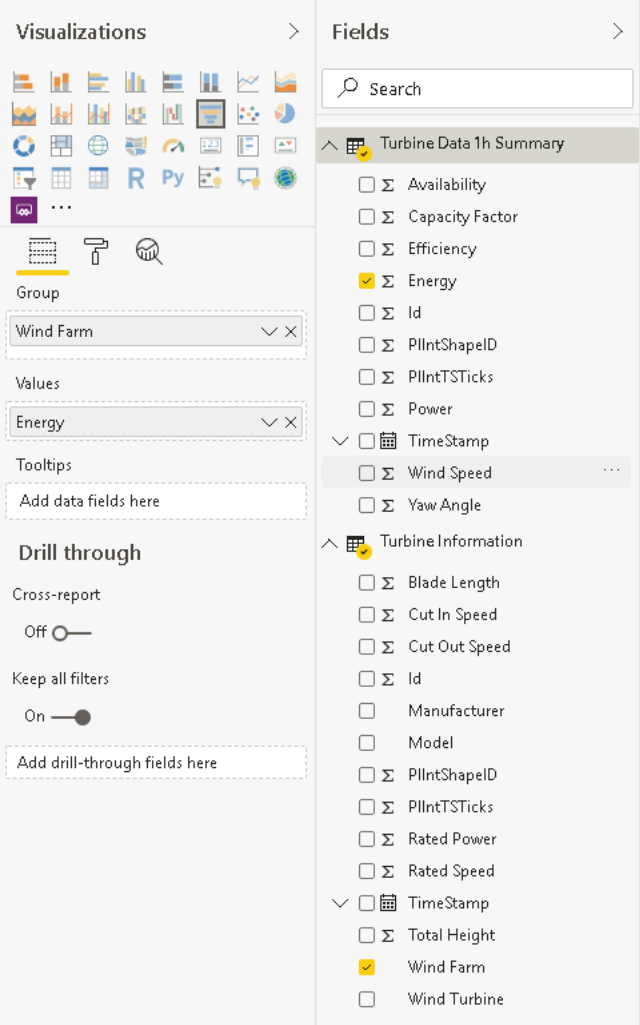
Click on the **Funnel Chart** under **Visualizations** on the right side of the window to add a funnel chart to the report.



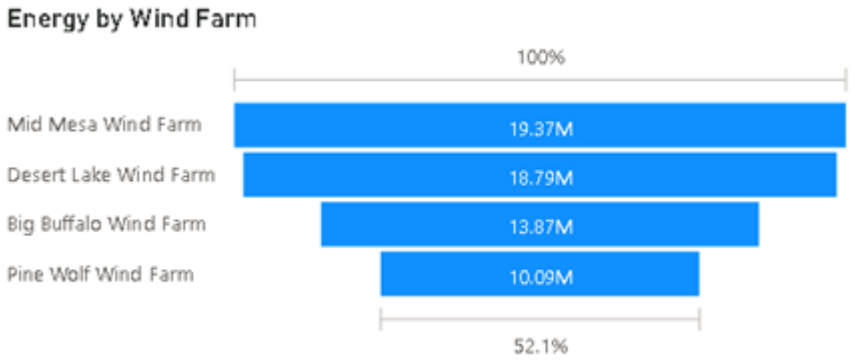
For **Group**, add the **Wind Farm** from Turbine Information by dragging and dropping.



For the **Values**, add the **Energy** field from Turbine Data 1h Summary.



The Funnel Chart should look similar to one shown below.

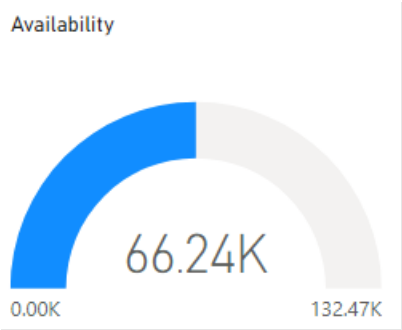


5.4.2 Create Gauges to Show Availability and Capacity Factor

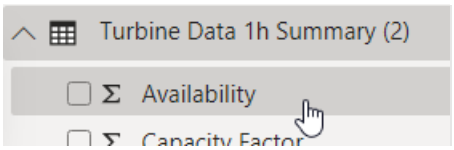
Create a new visualization by clicking into blank space on the report and then clicking on the **Gauge** icon in **Visualizations**.

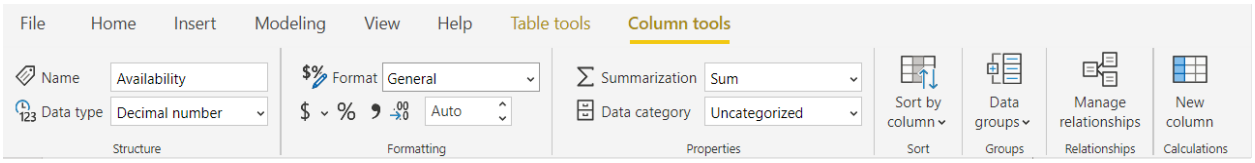
For **Value** choose **Availability** from the Turbine Data 1h Summary.

Notice that the value does not match what should be expected.

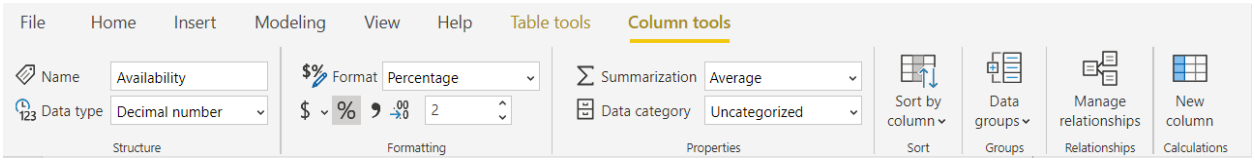


The reason for this is that Power BI generally defaults to **Sum** as the default summarization, but availability is more useful as an **Average**. To change this behavior, click on **Availability** in the Fields section on the right, and then in the ribbon navigate to **Column Tools**.

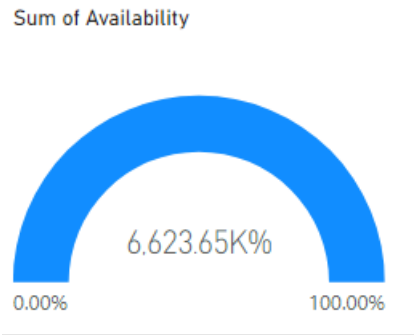




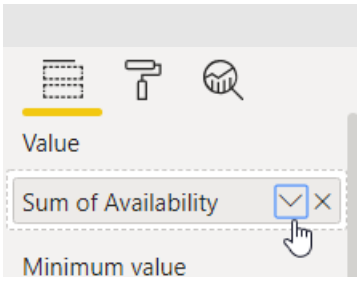
In the center, change the **Summarization** to **Average** and set the **Format** to **Percentage**. By publishing the data as a ratio, Power BI can convert the data to a percentage. This helps Power BI choose default ranges for gauges and add the percent symbol (%) to the values.

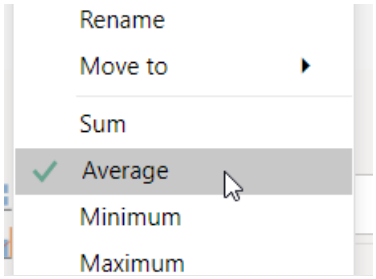


Notice, however, that the data in the Gauge has not changed, but the title has updated to **Sum of Availability**.

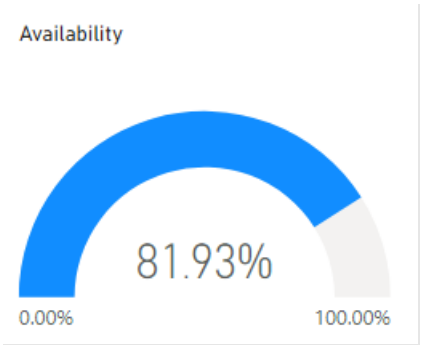


Changing the default summarization in Power BI does not alter existing visualizations. To do this, click the dropdown on the value and choose **Average**.





The visual now shows an appropriate Availability.

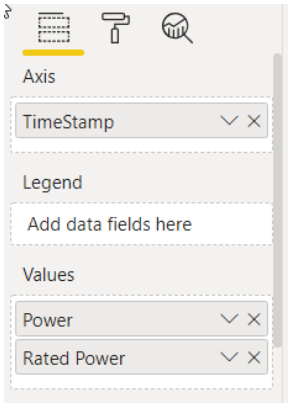


Repeat this process to add **Capacity Factor** to the report page.

Tip	For the second Gauge, try changing the settings under Column tools before choosing Capacity Factor as Value. This way the summarization does not need to be changed for the Visualization individually.

5.4.3 Add a Trend Showing Power over Time

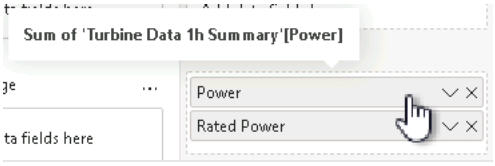
Add a Line Chart to the report.

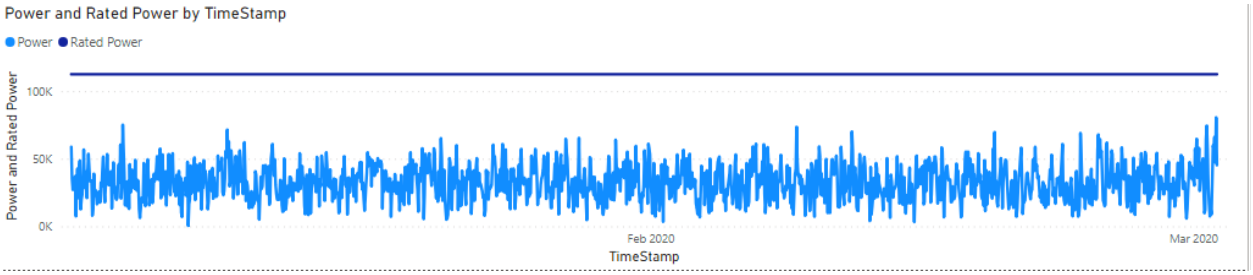


For the Axis, choose **Timestamp** from **Turbine Data 1h Summary**. In the dropdown, change from **Date Hierarchy** to **Timestamp**.

For the Values, choose **Power** from **Turbine Data 1h Summary**. Also add **Rated Power** from the **Turbine Information**.

Ensure that **Power** and **Rated Power** are aggregated as a **Sum**. Hint: This can be checked by holding the mouse over the entries in the Value category.

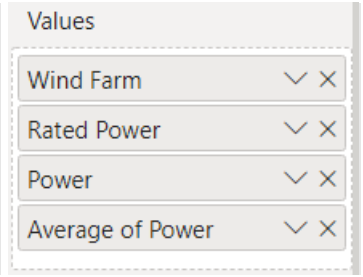




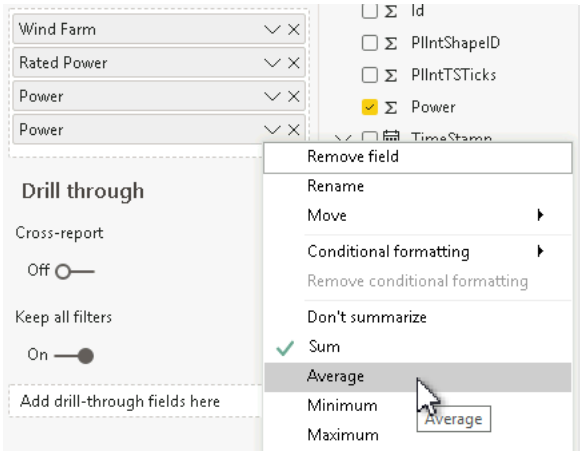
5.4.4 Create a New Measure for Combined Power

In the previous visualization, Power was aggregated as a sum. In most cases, data that contains rates – flow rate, speed, power, etc. – should be averaged over time and not summed. This can be seen by creating the following table.

Wind Farm	Rated Power	Power	Average of Power
Big Buffalo Wind Farm	24,000.00	10,248,116.39	464.77
Desert Lake Wind Farm	30,000.00	12,088,731.96	822.36
Mid Mesa Wind Farm	38,900.00	16,685,102.44	567.52
Pine Wolf Wind Farm	20,000.00	9,324,097.01	634.29
Total	**112,900.00**	**48,346,047.81**	**597.97**



Hint: For Value choose Wind Farm and Rated Power from Turbine Information and two times Power from Turbine Data 1h Summary. Expand the drop down menu for the second Power and choose Average instead of Sum.



Notice that when aggregated by Wind Farm, the **Power** (sum) has a wildly inaccurate number. This is because every row for the wind farm is being summed together.

Notice also that the **Average of Power** also isn't quite showing the expected value. Instead of showing the average power for the wind farm, it is showing the average power across all the turbines.

In the previous visual (the Power Trend) the correct result was attained because the power was summed up across each distinct timestamp, and was not aggregated across timestamps.

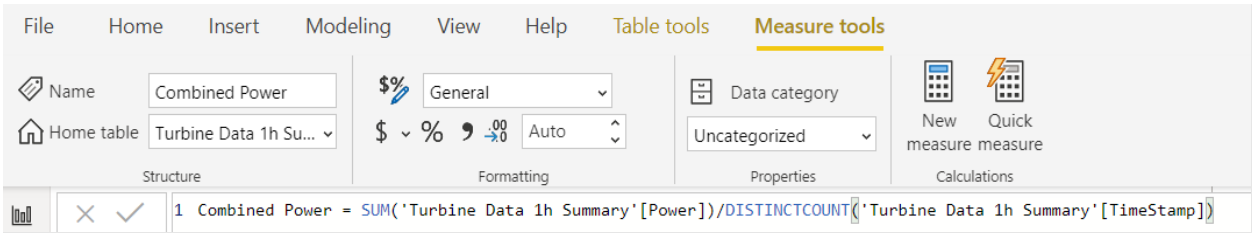
The same result can be created using the following formula:

$$Combined\ Power = \frac{Sum(Power)}{DistinctCount\ (Timestamp)}$$

To create this in Power BI, click **New Measure** from the Home tab of the ribbon and use the following formula

```
Combined Power = SUM('Turbine Data 1h Summary'[Power])/DISTINCTCOUNT('Turbine Data 1h Summary'[TimeStamp])
```

In the **Measure tools** tab, ensure that the **Home Table** is set to Turbine Data 1h Summary.



Tip	The formula can be entered directly in the formula field. The name of the measure will update to Combined Power when the Commit button on the left of the formula field is pressed.

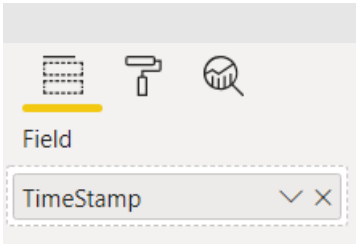
Adding this value to the table shows that the result matches expectations.

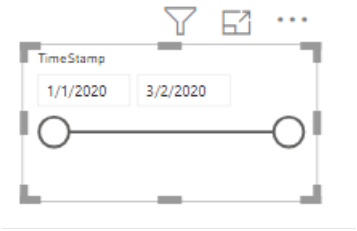
Wind Farm	Rated Power	Power	Average of Power	Combined Power
Big Buffalo Wind Farm	24,000.00	10,248,116.39	464.77	6,971.51
Desert Lake Wind Farm	30,000.00	12,088,731.96	822.36	8,223.63
Mid Mesa Wind Farm	38,900.00	16,685,102.44	567.52	11,350.41
Pine Wolf Wind Farm	20,000.00	9,324,097.01	634.29	6,342.92
Total	**112,900.00**	**48,346,047.81**	**597.97**	**32,888.47**

5.4.5 Add a date slicer

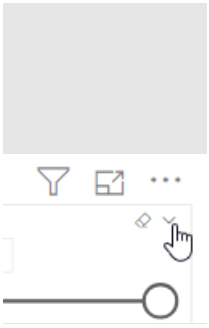
Use a date slicer to allow dynamic date filtering in the report.

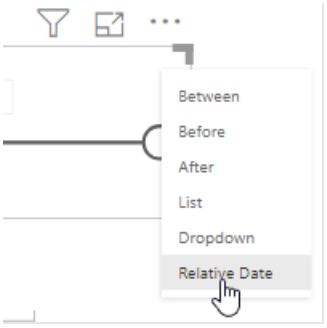
Add a slicer visualization and use the **TimeStamp** from Turbine Data 1h Summary as the Field.



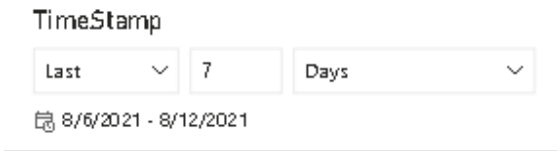


When hovering on the slicer, use the dropdown at the top right to change the type of filtering applied. For this report, choose **Relative Date**.



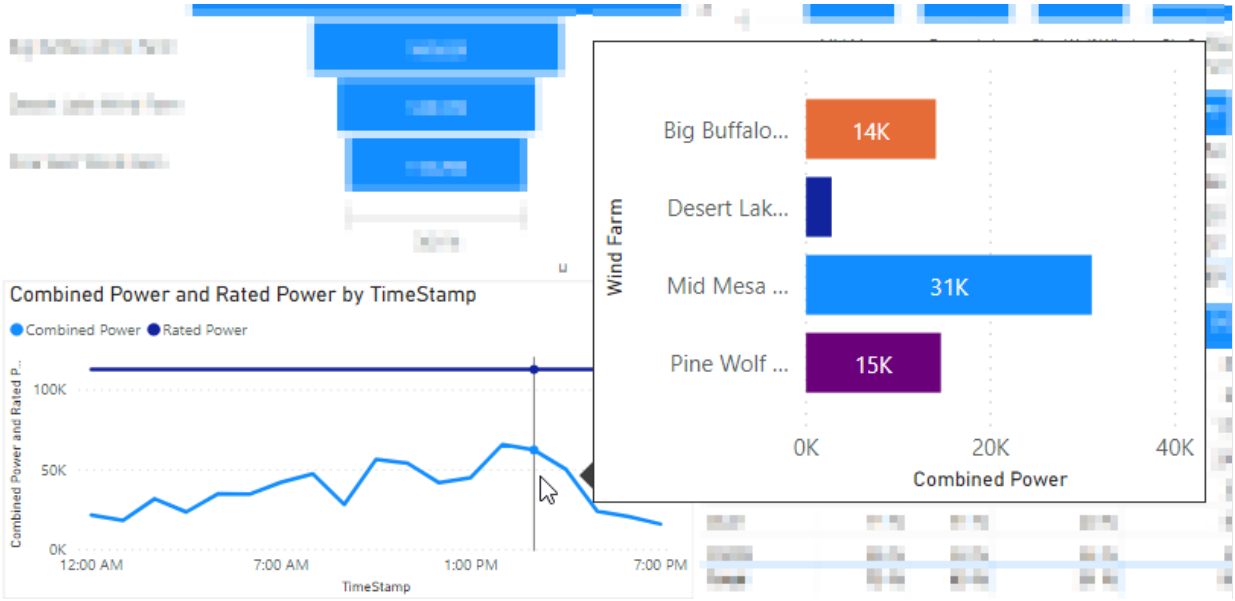


Set the slicer to show the **Last 7 Days**. The report will now update to show the selected time range


TimeStamp
Last
7
Days
8/6/2021 - 8/12/2021

5.5 Create a Tooltip Page to Show More Details

Tooltip pages can be used to show detailed information in a custom view. Once created, these pages can be added to visuals, and will replace the default tooltip. For this exercise, a tooltip page will be created that shows a detailed breakdown of each wind farm's contribution to the total power.



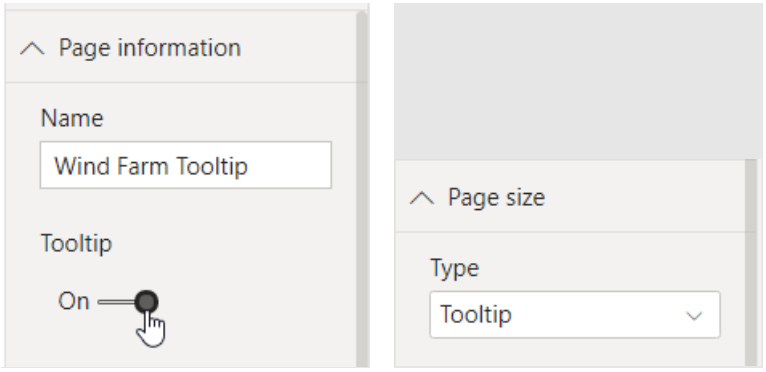
5.5.1 Create and Format the Page

First, create a new report page by clicking the **New Page** icon  in the bottom of the screen. Name this page **Wind Farm Tooltip** (right click on the page tab and select Rename Page).

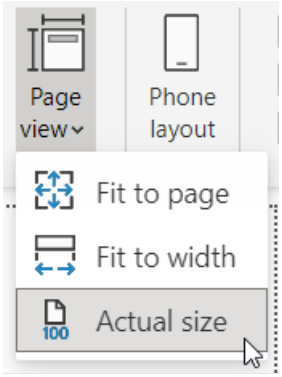
Next, configure the page as a tooltip page. To do this, click on the background and then click on the **Format** icon  in the **Visualizations** pane on the right.

Under the **Page information** section, set the slider for **Tooltip** to **On**.

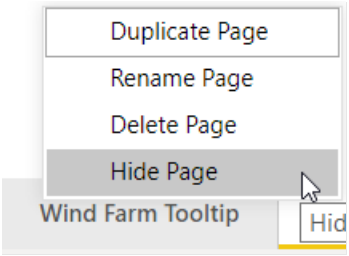
Under the **Page size** section, choose **Tooltip** from the **Type** dropdown.



To make formatting easier, set the **Page View** to **Actual Size** in the **View** tab of the ribbon.



To ensure users do not navigate directly to this page, **right click the page tab** in the bottom of the screen and choose **Hide Page**.

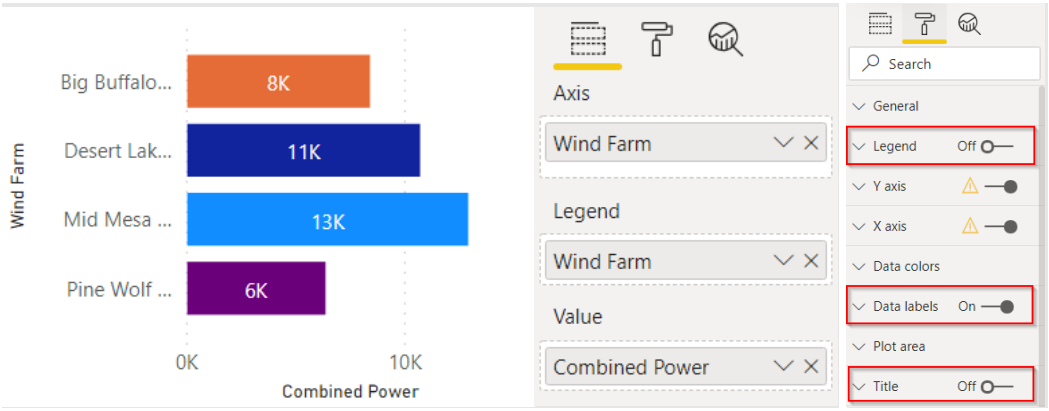


5.5.2 Add Visuals to the Tooltip Page

Add a **Stacked Bar Chart** to the page, and configure it as follows:

- Axis: **Wind Farm** from Turbine Information
- Legend: **Wind Farm** from Turbine Information
- Value: **Combined Power** from Turbine Data 1h Summary

In the **Format** section, **turn off** the **Legend** and **Title** and **turn on** the **Data Labels**

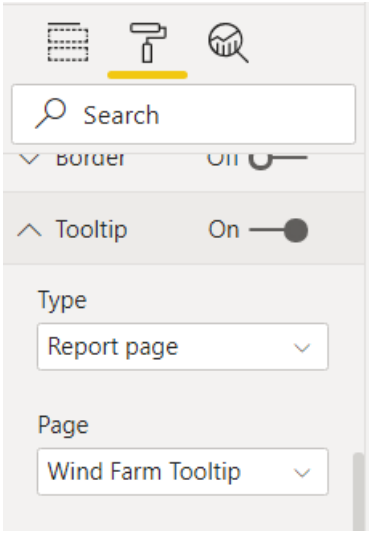


5.5.3 Configure the Power Trend to Use the Tooltip Page

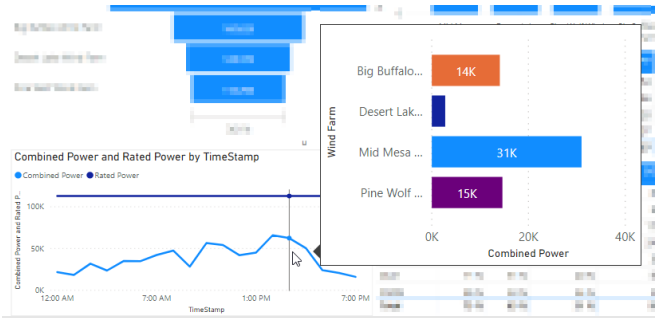
On the **Wind Generation Overview** report page, click on the **Power Trend** visual.

In the **Format** section, **turn on** the **Tooltip** and choose

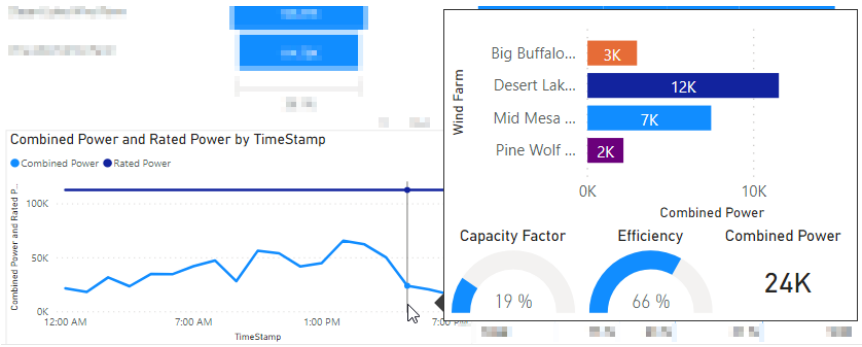
- Type: **Report page**
- Page: **Wind Farm Tooltip**



Once this is done, the tooltip page should appear when hovering over the trend.



This functionality can be extended by adding other graphics to the tooltip page as necessary.



6. Wind Turbine Downtime: PI Integrator Event View

6.0 Overview

So far, the published data has focused on data coming directly from assets. Often, Event Frames can provide valuable information for reports that may be difficult to include otherwise.

In this section, downtime events will be prepared using the PI Integrator, and will be incorporated into the report in the next section. Steps for the PI SQL Client are included in the Appendix.

6.1 Tasks

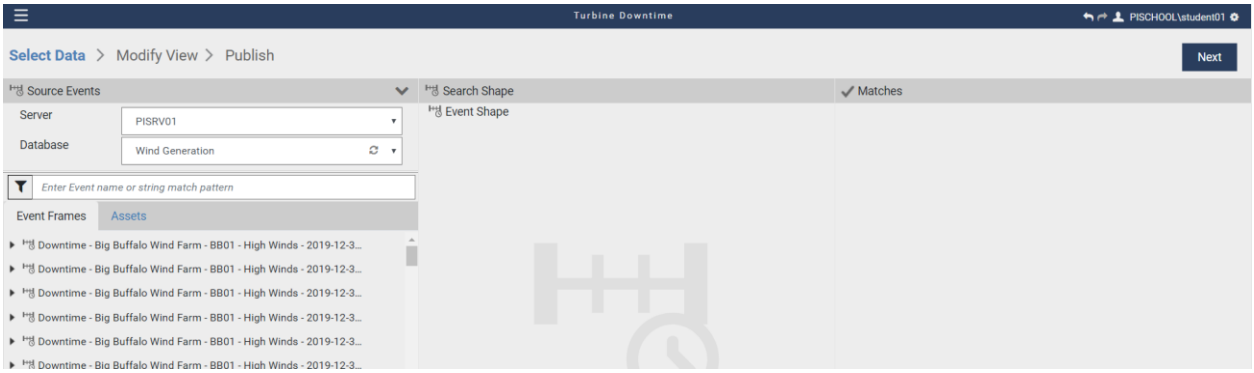
- Create a new Event View
- Configure the Event View shape
- Set up the publishing schedule

6.2 Create a new Event View

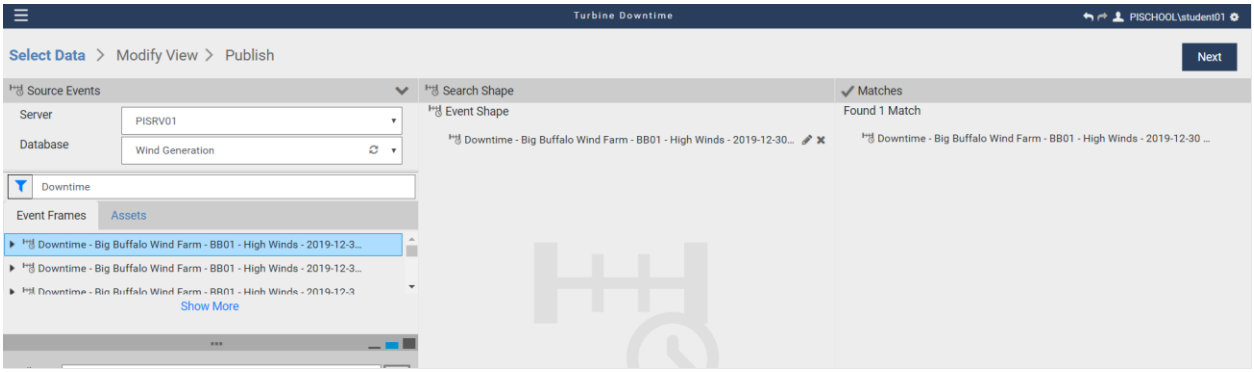
Navigate to the PI Integrator webpage and from the home screen, click **+ Create Event View**.

Name the View: **Turbine Downtime**

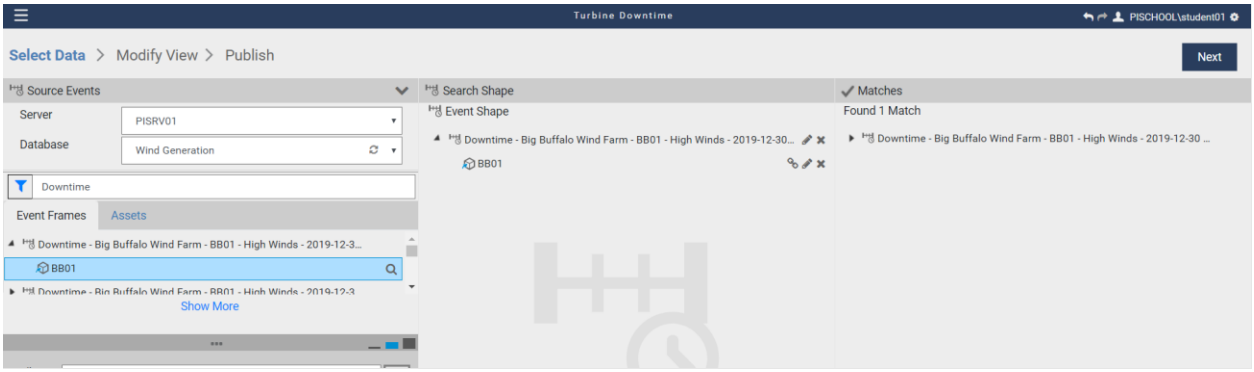
Click to Create a New Shape, and then choose the Server **PISRV01** and Database **Wind Generation**



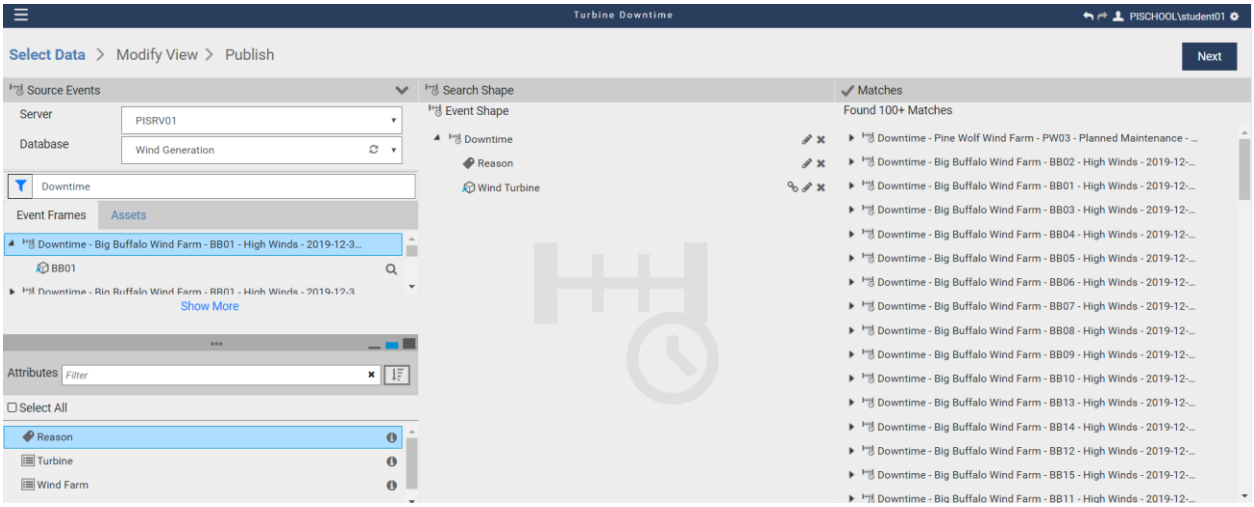
Filter the list of Event Frames by typing in **Downtime** in the filter box, and then drag one of the downtime events into the Search Shape.



Expand the downtime Event in the left pane to show the referenced element. Add this element into the Event Shape.



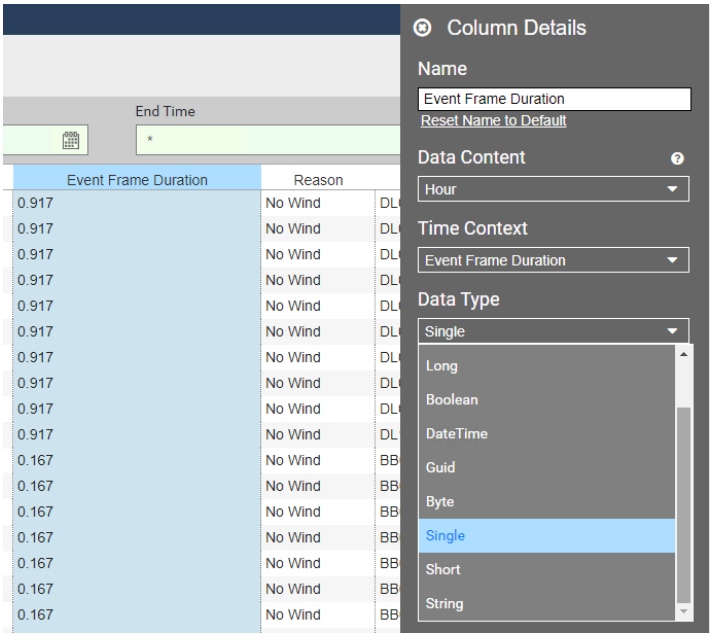
Add the attribute for **Reason** (click on the Event Frame to bring up its attributes)**,** and configure the shape so that both the Event Frame and the Element are matched using templates instead of the names.



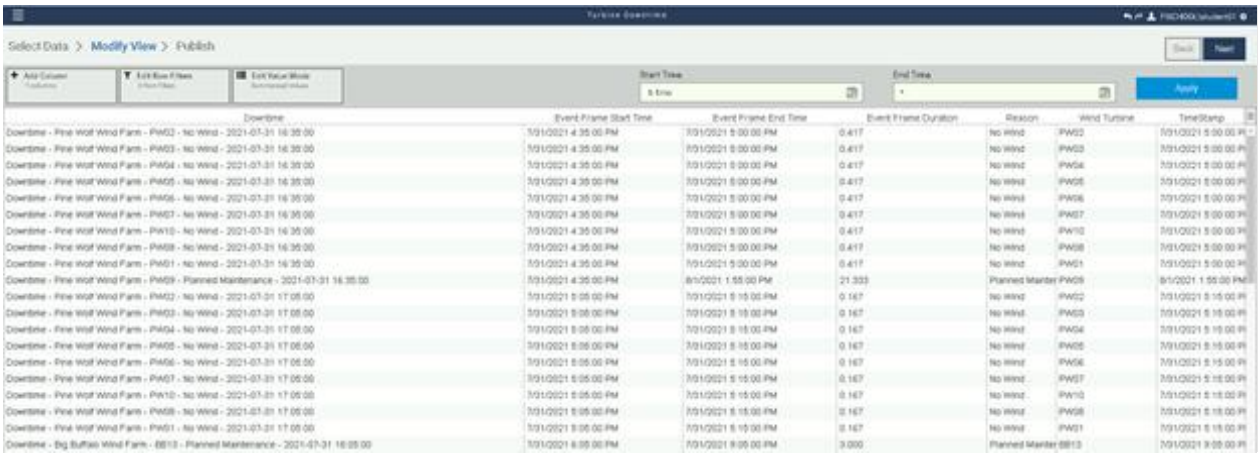
Click Next to go to the Modify View Page.

6.3 Modify and Publish the View

Change the data type for Event Frame Duration from Integer to **Single**. This will prevent the duration from being rounded to the nearest hour. Remember to click **Apply Changes**.

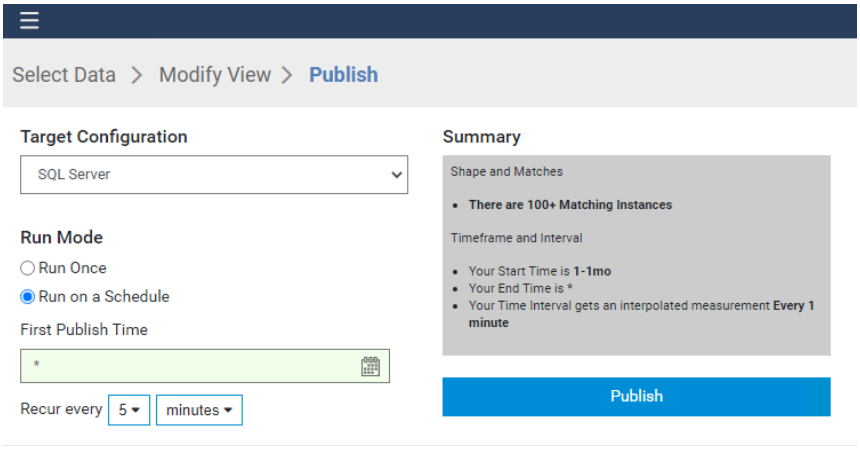


Set the Start Time to **1-1mo** and click **Apply**.



Click **Next** to advance to the Publish page.

Set the target to **SQL Server** and **Run on a Schedule**, with Recur every **5 minutes**



Click **Publish**.

7. Incorporate Downtime Data into the Report

7.0 Overview

In this section, the downtime information will be incorporated into the report.

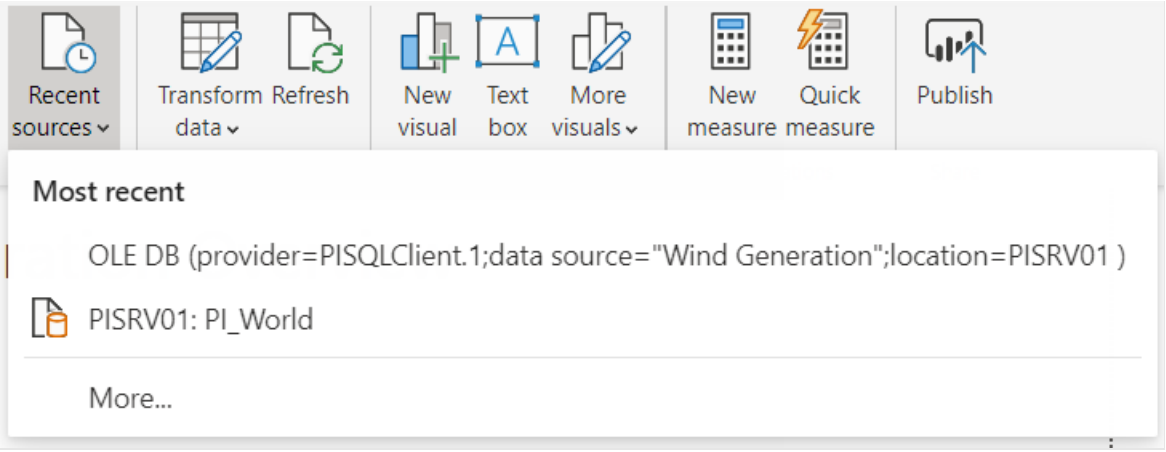
7.1 Identify the Tasks

- Add the downtime data to Power BI, either from the PI SQL Client or PI Integrator
- Add a relationship to Join the Turbine Downtime table to the Turbine Information table
- Create a chart to show downtime for each wind farm
- Create a Date Table to allow filtering of all data
- Create a Tooltip page to show extra detail

7.2 Add the Downtime Data to the Report

Using the same procedure as in Section 5, add the table/view **Turbine Downtime** into the report.

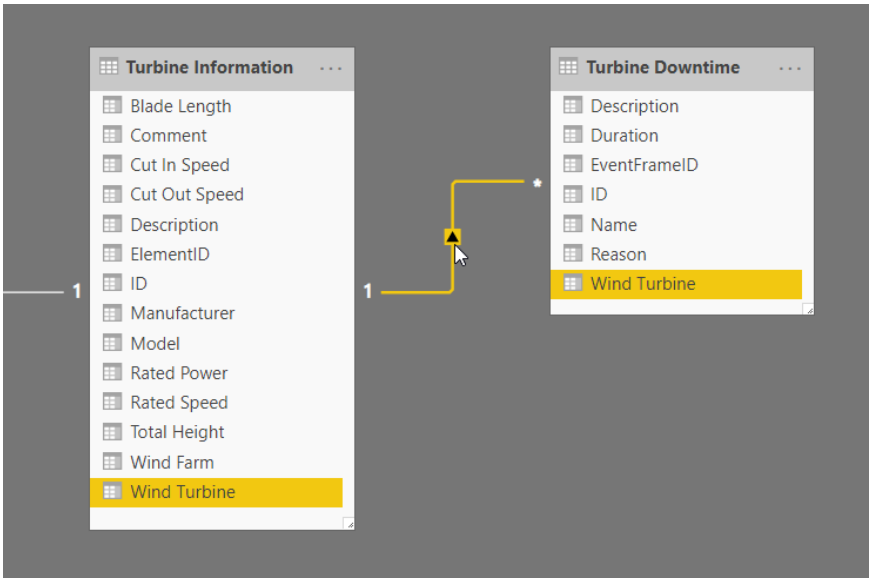
For convenience, you may use the **Recent Sources** dropdown from the Home tab of the ribbon. Hint: The first option in the screenshot is the PI SQL Client and the second is the SQL database the PI Integrator is using for the views.



Note	Remember to choose **Import** in the Connection settings window.

7.3 Connect the Downtime Table to the Model

After importing the table, navigate to the Model  section on the left bar. Verify that the **Turbine Downtime** table has a relationship with the **Turbine Information** table using the **Wind Turbine** field. If necessary, delete the existing relationship and create a new one.



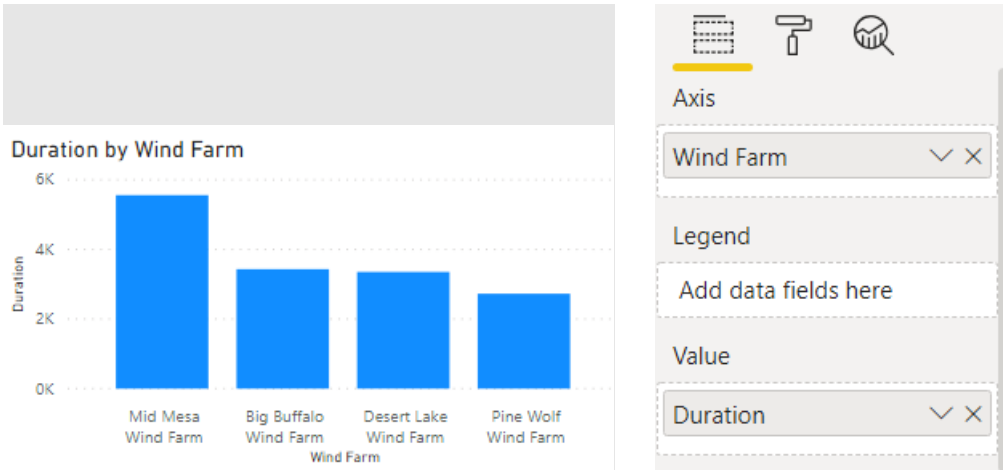
7.4 Create a Chart of Downtime by Wind Farm

In the Report View, add a Clustered Column Chart  with the following fields:

Axis: **Wind Farm** from Turbine Information

Values: **Duration** from Turbine Downtime

Note	Column names might differ depending on the source (PI Integrator or PI SQL Client). Coming from the Integrator this will be called **Event Frame Duration** if the column name was not changed.



Notice that the duration is properly split between the four wind farms.

7.5 Create a Date Table

Adjust the date slicer to choose a different date range. Notice that the **Downtime** duration in the previous chart **does not update**.

This happens because the slicer is configured with the Timestamp from the Turbine Data 1hr Summary table, and so it does not affect the Turbine Downtime table.

To create a date slicer that will alter all the tables, it is best to create a separate **Date Table**.

First, enter the Data section by clicking the  icon on the left side.

In the Ribbon, click on **New Table** 

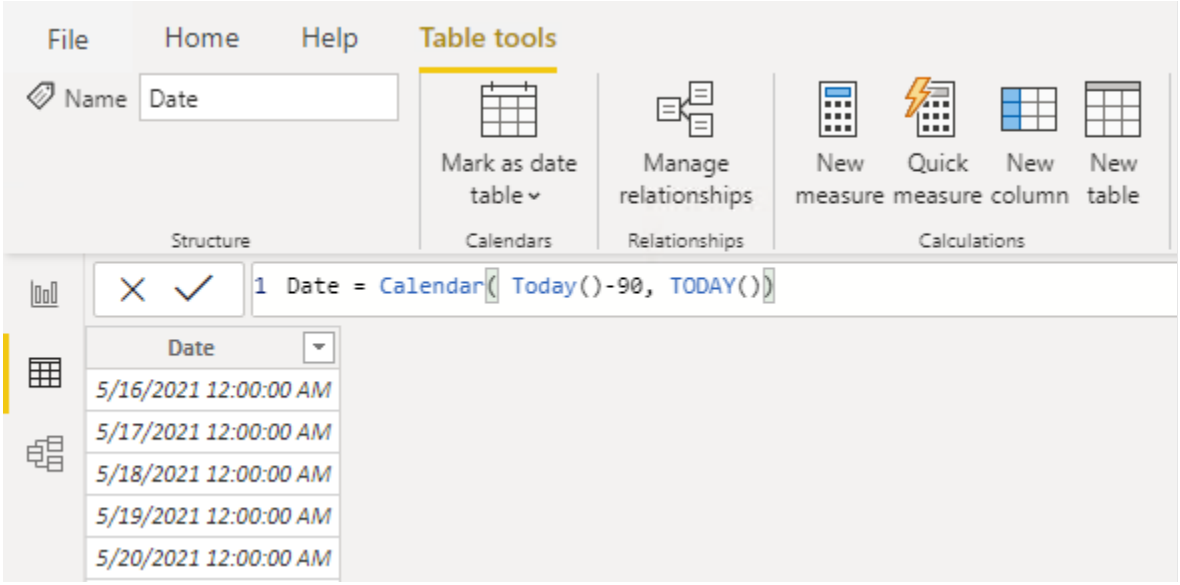
.

Enter the following definition for the table:

```
Date = Calendar( TODAY()-90, TODAY())
```

Hit **Enter**.

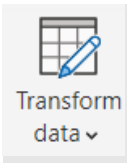
This will create a table with dates for the last 90 days.



This table can now be joined to any table that has date data.

To make the joining process smoother, add a date column to both the **Turbine Data 1h Summary** and **Turbine Downtime** tables.

7.5.1 Add Date Column to Turbine Data 1h Summary

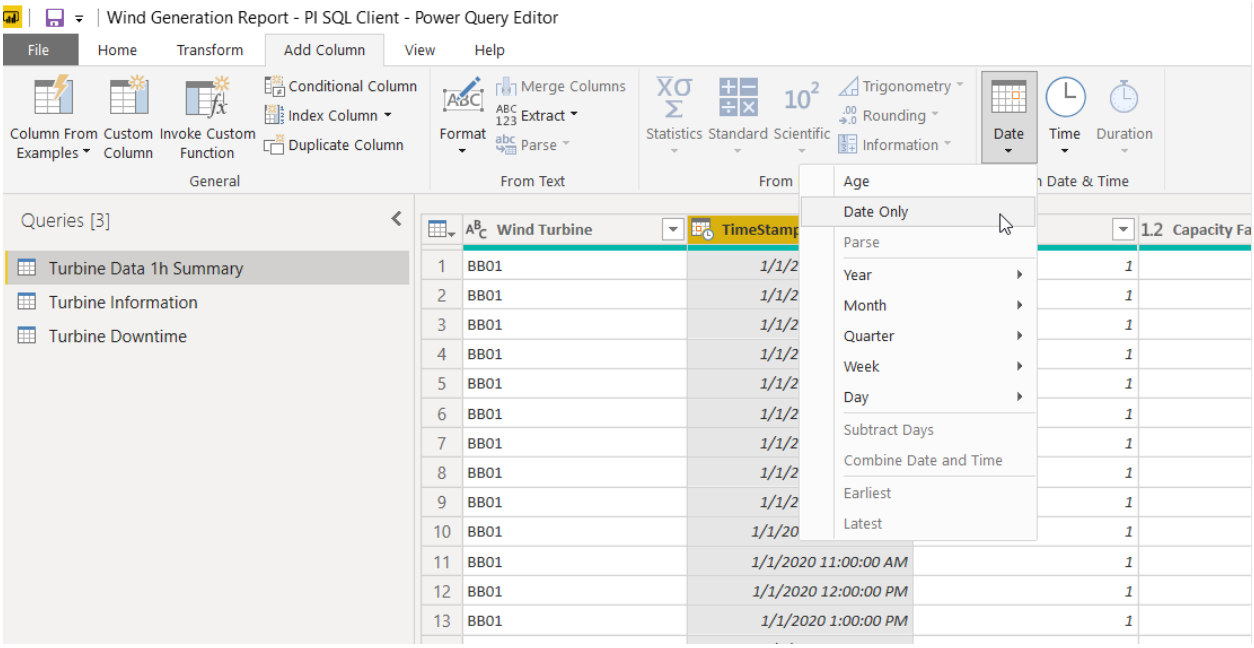
To add a date column, click **Transform Data** 

in the Home ribbon to open the query editor.

Select the Table **Turbine Data 1h Summary** from the left.

Select the **TimeStamp** Column.

In the Ribbon, navigate to the **Add Column** tab and choose **Date** > **Date Only**.



This will create a column called **Date**.

7.5.2 Add Date Column to the Turbine Downtime Table

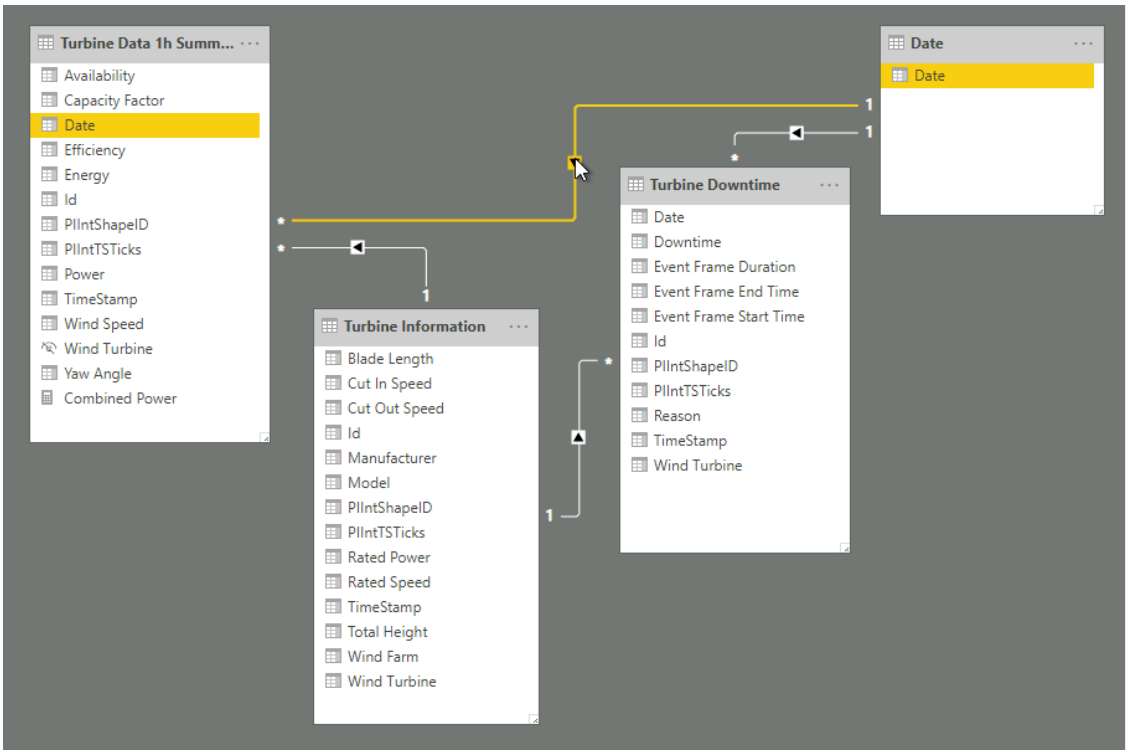
For event frame tables, the process is similar. Unlike the timed data, summary event frames only have a start and end time, not individual timestamps. A robust approach for this type of linking is included in the Appendix, but for this lab, the **Start Time** will be used.

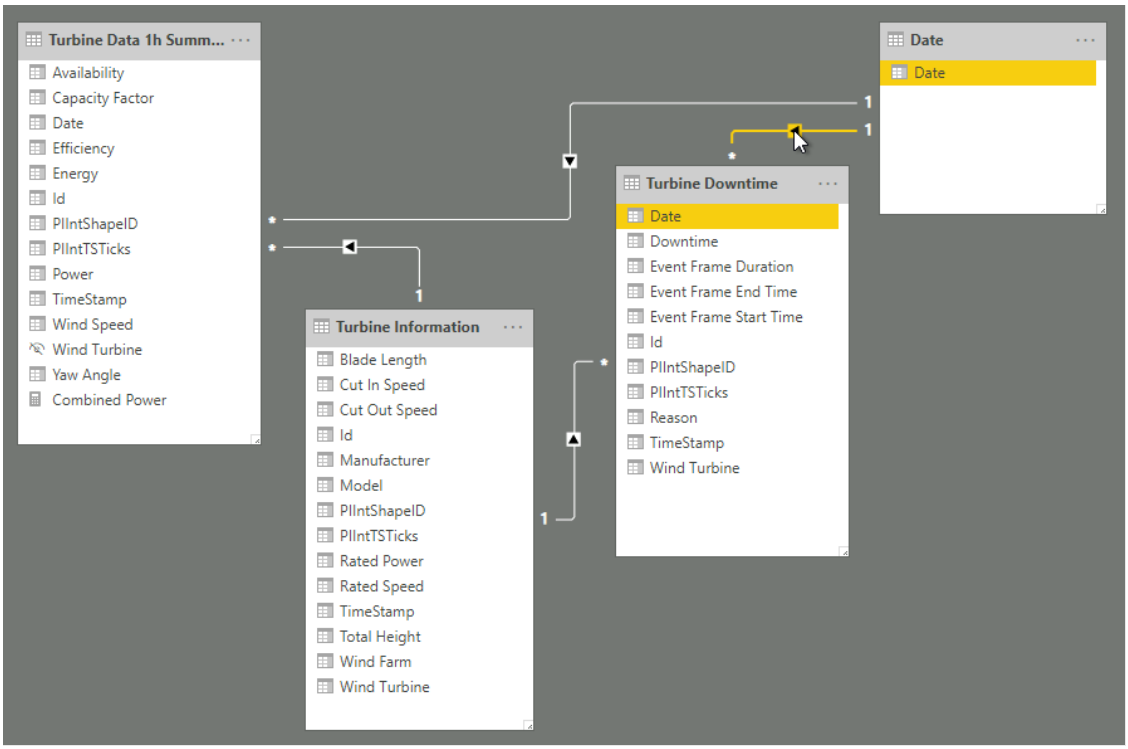
Follow the above procedure to create a **Date** column from the **Start Time**.

Click **Close & Apply** in the Home tab.

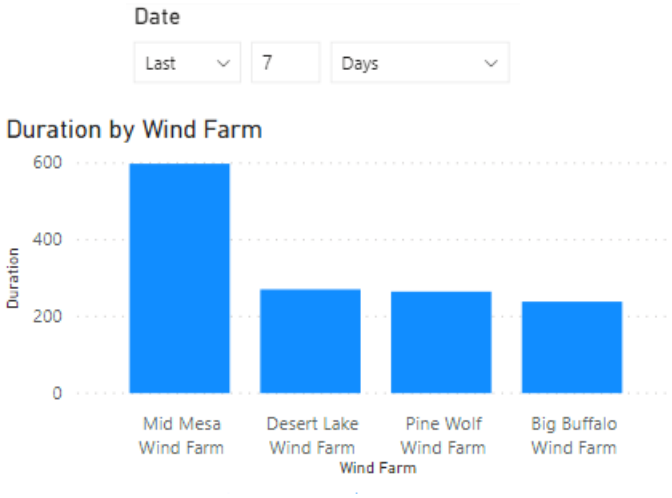
7.5.3 Link the Date Table

Create relationships between the Date table and the other tables.





Now, update the Date slicer to use the **Date** column from the date table, and watch as the Duration updates properly.



8. Wind Turbine Running Performance: PI Integrator Event View (Sampled)

8.0 Overview

In the previous sections, the data sets have focused on summarized data and events to capture an overview of the data while sampling as infrequently as possible. Some analysis, however, requires high resolution data that has not been summarized.

In the PI System, Event Frames have been configured to track when each wind turbine is running (without curtailments or downtime). In this section, a data set for Wind Turbine Running Performance will be created, with high resolution data published at five-minute intervals while the events are active. This data will then be used to track the operating characteristics of the wind turbines.

Steps for the PI SQL Client are included in the Appendix.

8.1 Tasks

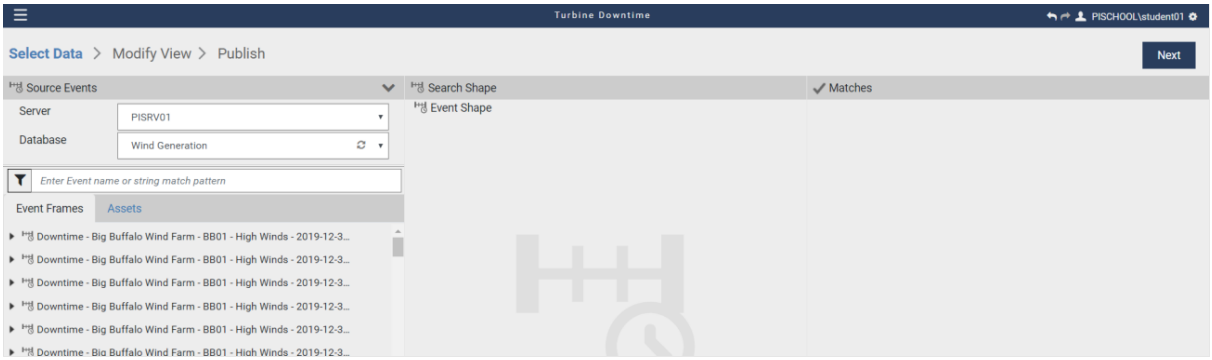
- Create a new Event View
- Add a Row Filter
- Configure the Event View to publish sampled data
- Set up the publishing schedule

8.2 Create a new Event View

Navigate to the PI Integrator webpage and from the home screen, click **+ Create Event View**.

Name the View: **Turbine Running Data**

Click to Create a New Shape, and then choose the Server **PISRV01** and Database **Wind Generation**.



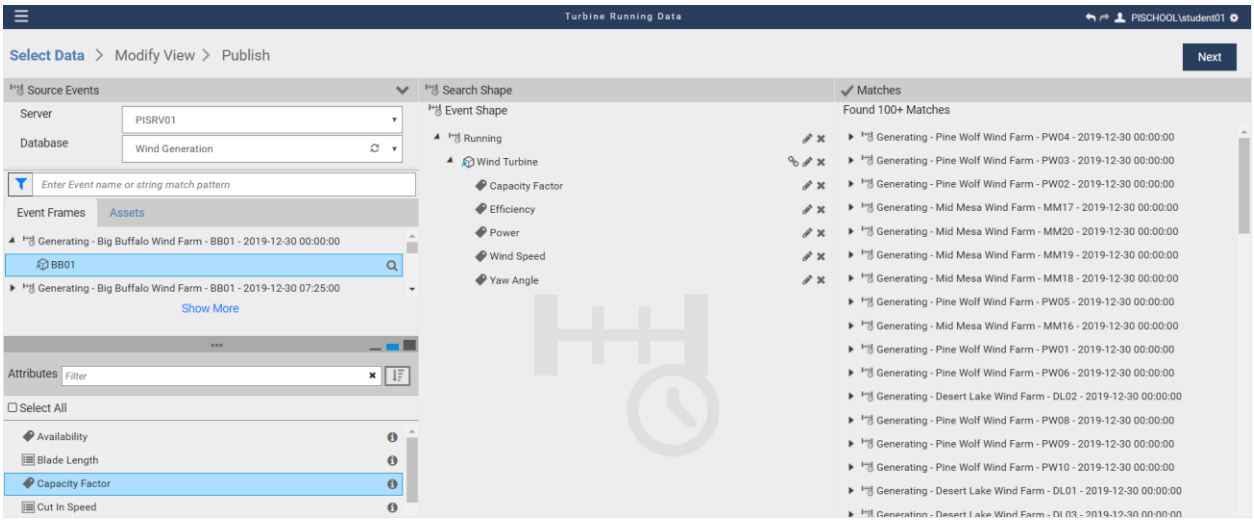
Filter the list of Event Frames by typing in **Generating** in the filter box, and then drag one of the generating events into the search shape.

Expand the downtime Event in the left pane to show the referenced element. Add this element into the Event Shape.

Add the following attributes from the Element:

- **Capacity Factor**
- **Efficiency**
- **Power**
- **Wind Speed**
- **Yaw Angle**

Configure the shape so that both the Event and the Element are matched using templates instead of the names. The template name for the generating events is **Running**.

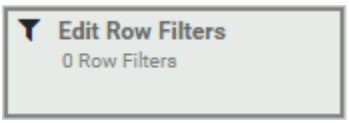


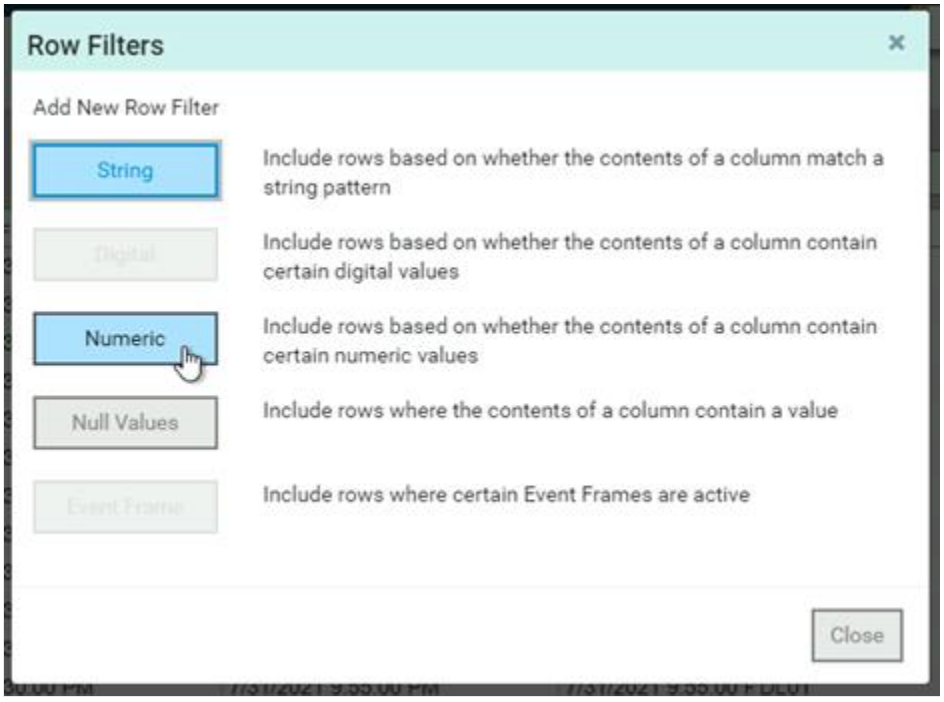
Click **Next** to go to the Modify View Page.

8.3 Add a Row Filter

The PI Integrator for Business Analytics also allows to filter the data before it is published. In our case we want to exclude the rows with very low power values.

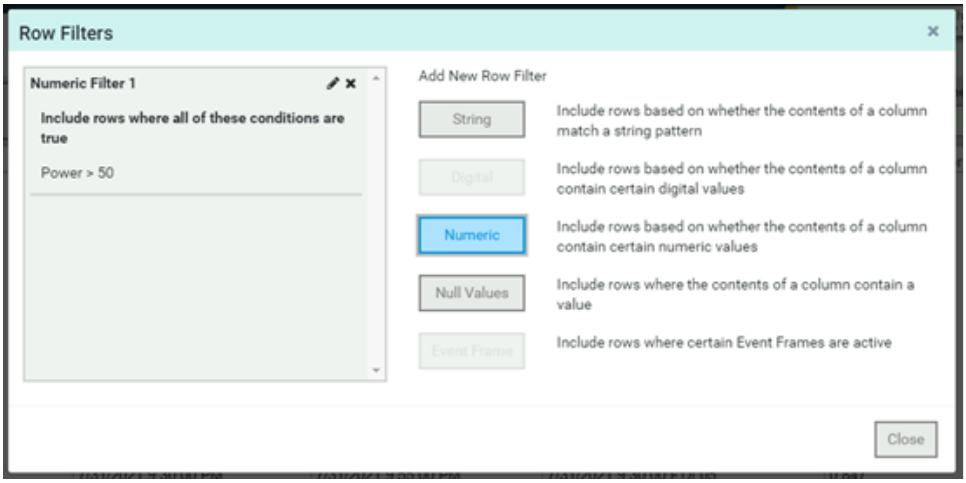
Click **Edit Row Filters** to open the options for adding a new row filter and choose **Numeric**.





In the configuration window set the condition **Power > 50** as shown below and click **Save Numeric Row Filter**. Note: It might be necessary to adjust the filter as the data varies between the environments. If no rows are returned try a less restrictive filter, like Power > 5.

The filter condition appears in the Row Filters window.

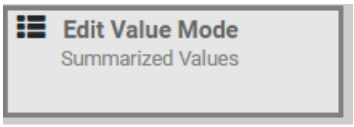


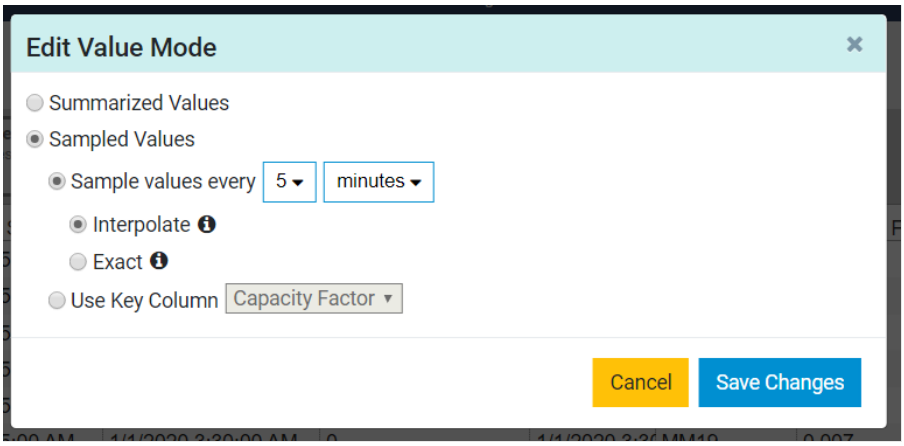
Click **Close**.

Tip	If a combination of filter criteria is required, additional criteria can be added by clicking **+ Add Another Filter Criteria**.

8.4 Configure the Event View to Publish Sampled Data

Click the **Edit Value Mode** button to sample values every **5 Minutes**.



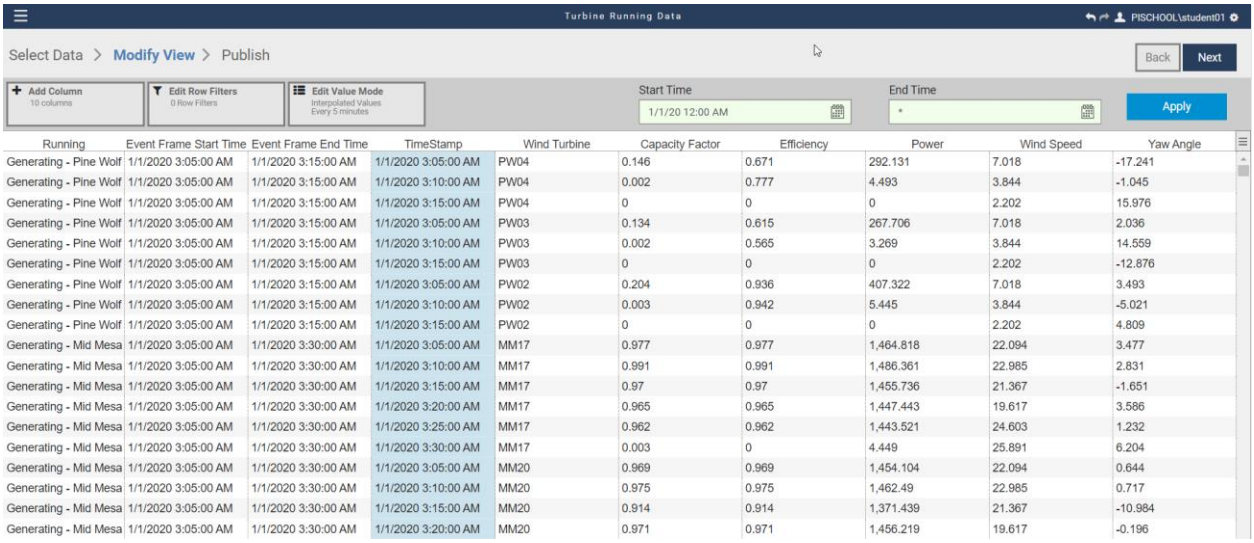


The view will now publish data at 5-minute intervals while the event is active.

Tip	We have seen the capability of using row filters in the last section. In some scenarios, we could also build an asset view and apply the event frame start trigger criteria to achieve the same result. However, event frames can have more complex triggering conditions which can not be easily recreated as row filters.

Remove the **Event Frame Duration** column, as it will not be needed. To do this, click on the column and select Remove Column from the Column Details menu on the right.

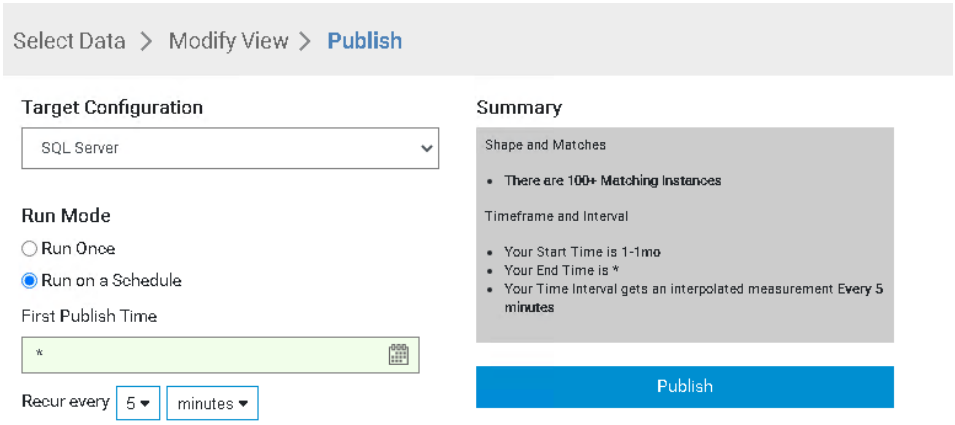
For consistency with the other views, set the **Start Time** to **1-1mo** and click **Apply**.



Running	Event Frame Start Time	Event Frame End Time	TimeStamp	Wind Turbine	Capacity Factor	Efficiency	Power	Wind Speed	Yaw Angle
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:05:00 AM	PW04	0.146	0.671	292.131	7.018	-17.241
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:10:00 AM	PW04	0.002	0.777	4.493	3.844	-1.045
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:15:00 AM	PW04	0	0	0	2.202	15.976
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:05:00 AM	PW03	0.134	0.615	267.706	7.018	2.036
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:10:00 AM	PW03	0.002	0.565	3.269	3.844	14.559
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:15:00 AM	PW03	0	0	0	2.202	-12.876
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:05:00 AM	PW02	0.204	0.936	407.322	7.018	3.493
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:10:00 AM	PW02	0.003	0.942	5.445	3.844	-5.021
Generating - Pine Wolf	1/1/2020 3:05:00 AM	1/1/2020 3:15:00 AM	1/1/2020 3:15:00 AM	PW02	0	0	0	2.202	4.809
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:05:00 AM	MM17	0.977	0.977	1,464.818	22.094	3.477
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:10:00 AM	MM17	0.991	0.991	1,486.361	22.985	2.831
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:15:00 AM	MM17	0.97	0.97	1,455.736	21.367	-1.651
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:20:00 AM	MM17	0.965	0.965	1,447.443	19.617	3.586
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:25:00 AM	MM17	0.962	0.962	1,443.521	24.603	1.232
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:30:00 AM	MM17	0.003	0	4.449	25.891	6.204
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:05:00 AM	MM20	0.969	0.969	1,454.104	22.094	0.644
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:10:00 AM	MM20	0.975	0.975	1,462.49	22.985	0.717
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:15:00 AM	MM20	0.914	0.914	1,371.439	21.367	-10.984
Generating - Mid Mesa	1/1/2020 3:05:00 AM	1/1/2020 3:30:00 AM	1/1/2020 3:20:00 AM	MM20	0.971	0.971	1,456.219	19.617	-0.196

Click **Next** to advance to the Publish page.

Set the target to **SQL Server** and **Run on a Schedule**, with Recur every **5 minutes**

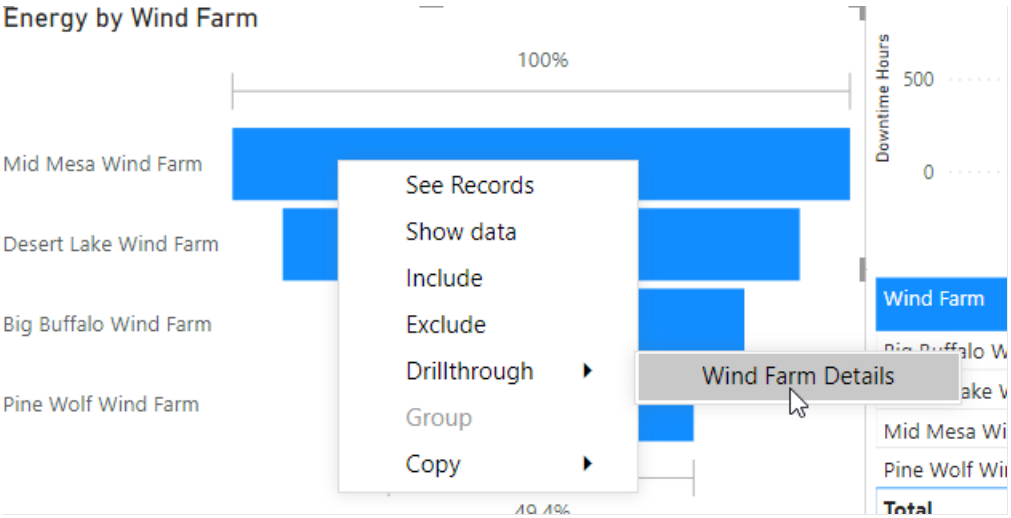


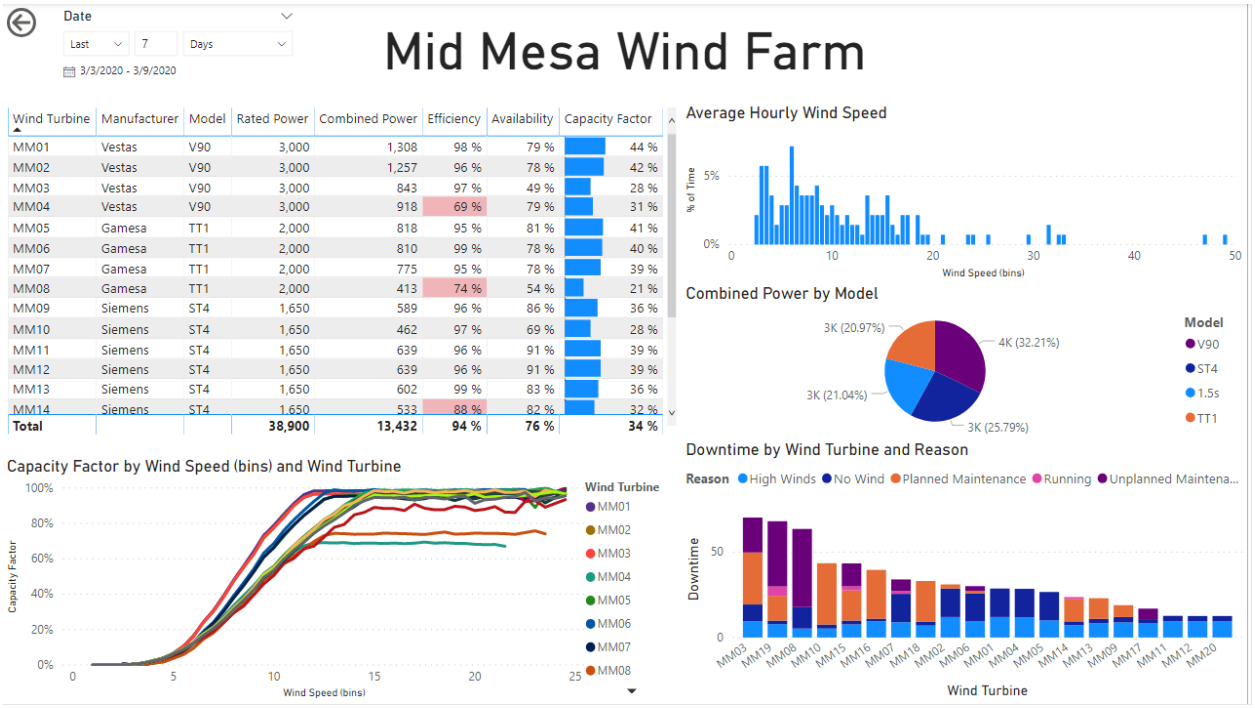
Click on **Publish**.

9. Incorporate the Running Data into the Report

9.0 Overview

In the previous section, high resolution data was published while the turbine was running. In this section, that data will be incorporated into the report. This section will also show how to create Drillthrough report pages, which can be opened from other visuals throughout the report.





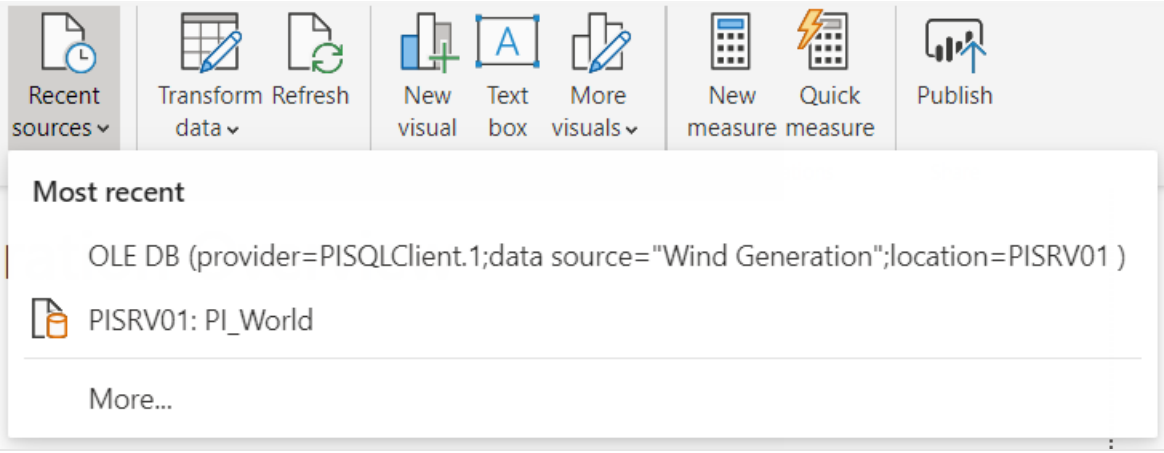
9.1 Tasks

- Load the Turbine Running Data
- Create a new report page for Wind Farm Details
- Set the page to use Drillthrough
- Add visuals to the report page

9.2 Add the Turbine Running Data

Using the same procedure as in Section 5, add the table/view **Turbine Running Data** into the report.

For convenience, you may use the **Recent Sources** dropdown from the Home tab of the ribbon.

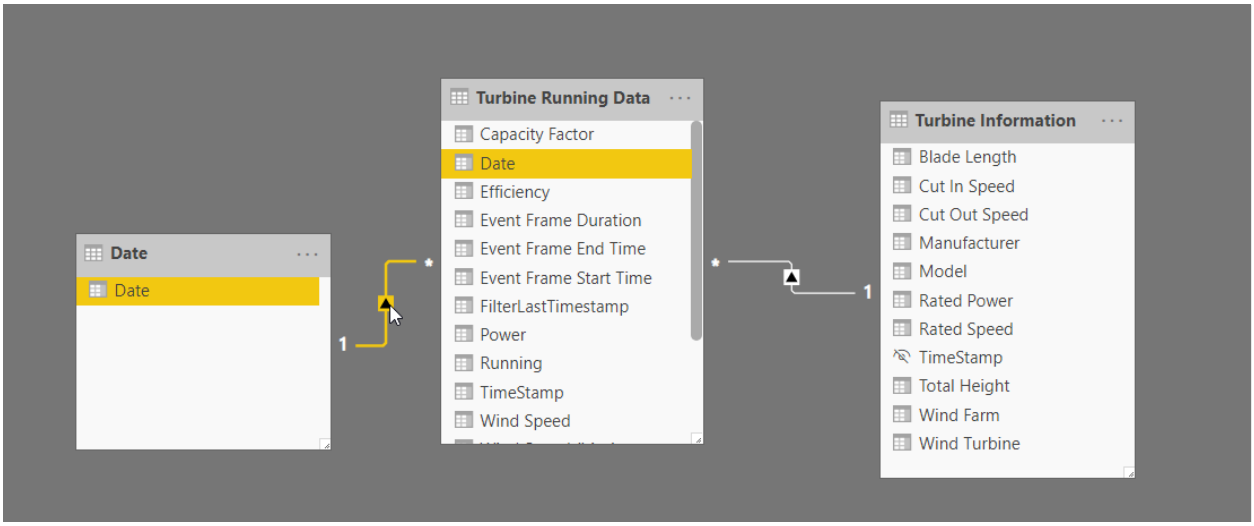


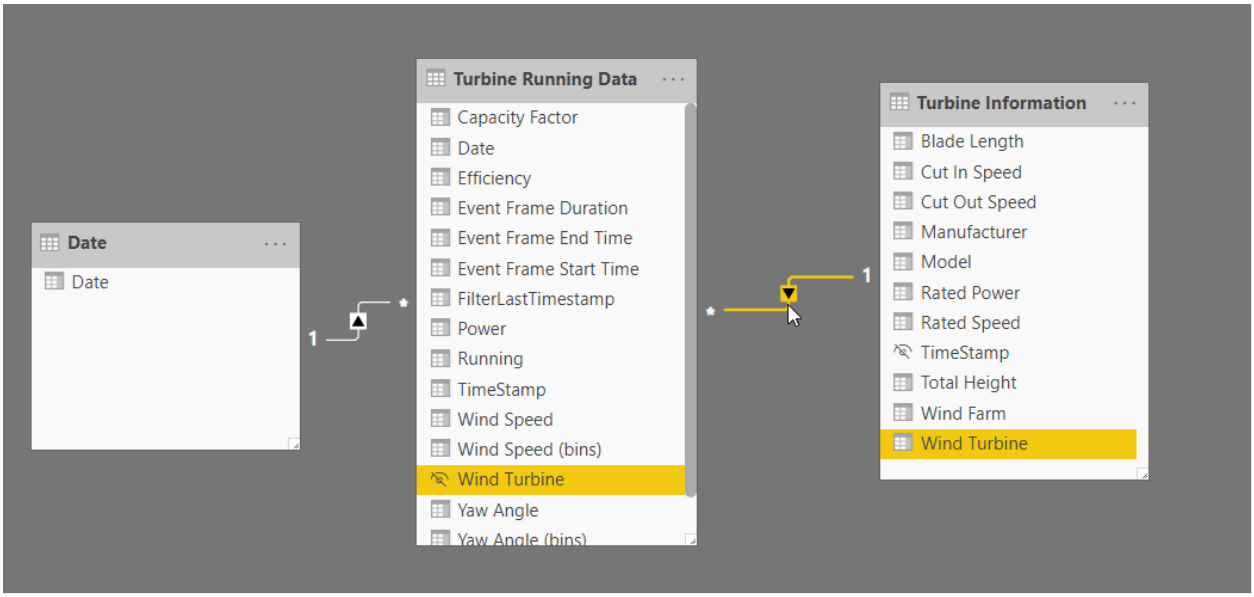
In order to join this table into the data model, follow the steps from Section 7.6.1 to add a **Date** column based on the **Timestamp**. Hint: Click the Transform data button to get started.

Join **Turbine Running Data** to **Date** on the **Date** field.

Join **Turbine Running Data** to **Turbine Information** on the **Wind Turbine** field.

Tip	Before creating any new joins for the new table, delete any automatically created joins on the id columns.



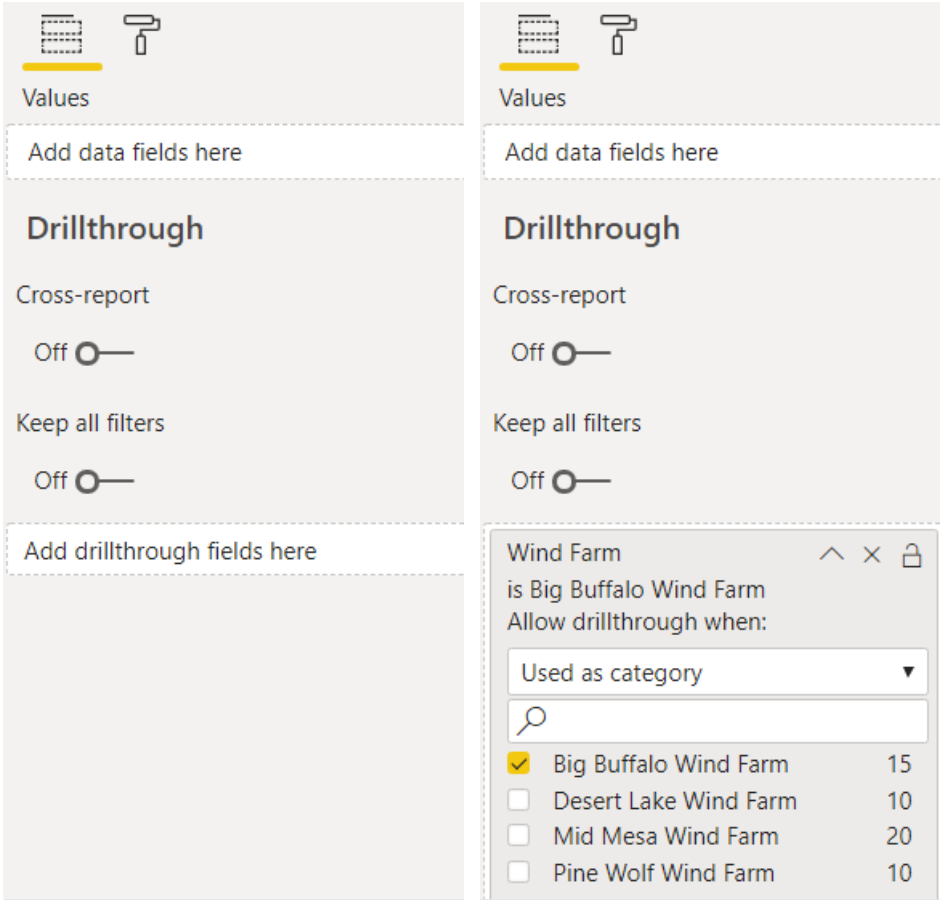

Date
Date
1
*
Turbine Running Data
Capacity Factor
Date
Efficiency
Event Frame Duration
Event Frame End Time
Event Frame Start Time
FilterLastTimestamp
Power
Running
TimeStamp
Wind Speed
Wind Speed (bins)
Wind Turbine
Yaw Angle
Yaw Angle (bins)
*
1
Turbine Information
Blade Length
Cut In Speed
Cut Out Speed
Manufacturer
Model
Rated Power
Rated Speed
TimeStamp
Total Height
Wind Farm
Wind Turbine

9.3 Create a drillthrough report page for Wind Farm Details

Create a new report page by clicking the **New Page** icon  in the bottom of the screen. Name this page **Wind Farm Details**.

On the **Visualizations** pane on the right, drag **Wind Farm** from Turbine Information onto the Drillthrough fields. This configures drillthrough to this page from any visual that uses the **Wind Farm** as a category.

Ensure the **Keep all filters** is **Off**. This will prevent additional filtering of the page.

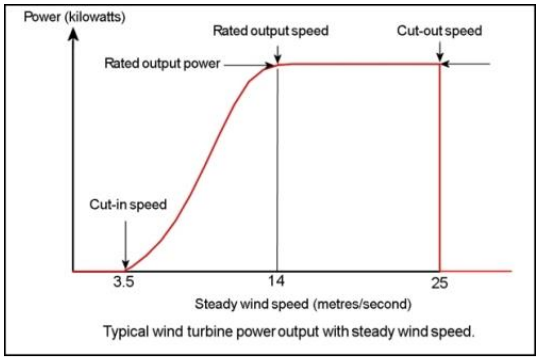


Note, you may need to click in the backgroud to get this to show.

Notice that a **Back Button**  now exists in the top left corner. This can be used by **Ctrl+Click** from within Power BI Desktop, or can be clicked on normally if the report is published online.

9.4 Add a Line Chart Showing Capacity Factor vs Wind Speed

Wind turbine power is strongly affected by the wind speed and generally follows the trend as shown below under ideal operation:



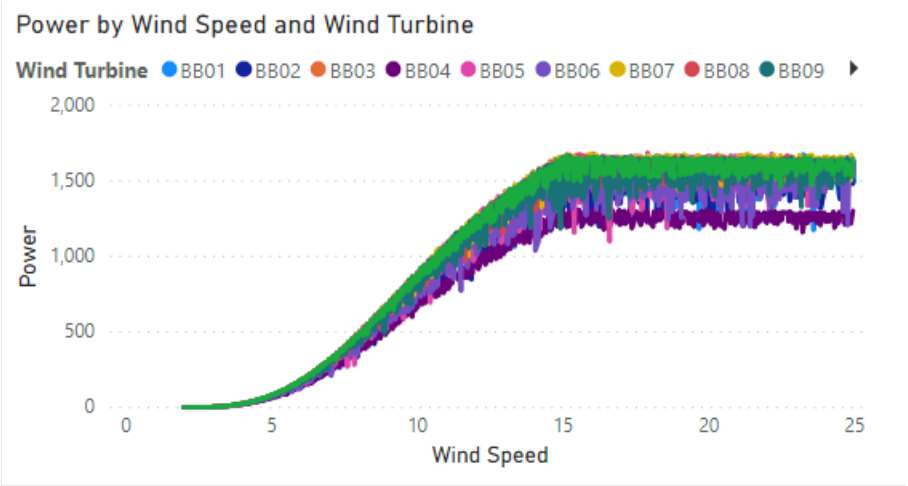
Source: http://www.wind-power-program.com/turbine_characteristics.htm

With the high-resolution running data available, create a line chart to show this trend for the wind turbines in each farm.

First, add a line chart  to the page and populate as follows:

- Axis: **Wind Speed** from Turbine Running Data
- Legend: **Wind Turbine** from Turbine Information
- Values: **Power** from Turbine Running Data (make sure the summarization is set to **Average**)

This should create the following trend for the turbines within **Big Buffalo Wind Farm**.



This shows the expected power curve, but a few improvements could be implemented to address the following shortcomings:

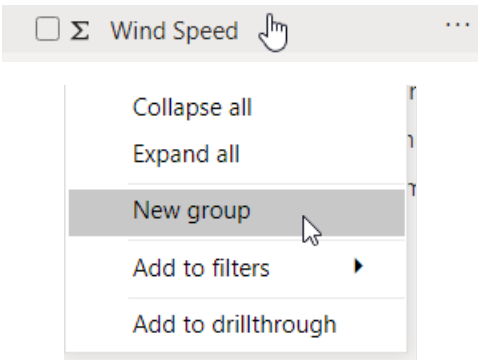
1. The trend is noisy and makes the different turbines difficult to distinguish from one another.

2. Using Power for the values makes it difficult to distinguish between a poorly performing turbine and a turbine with a lower rated power.

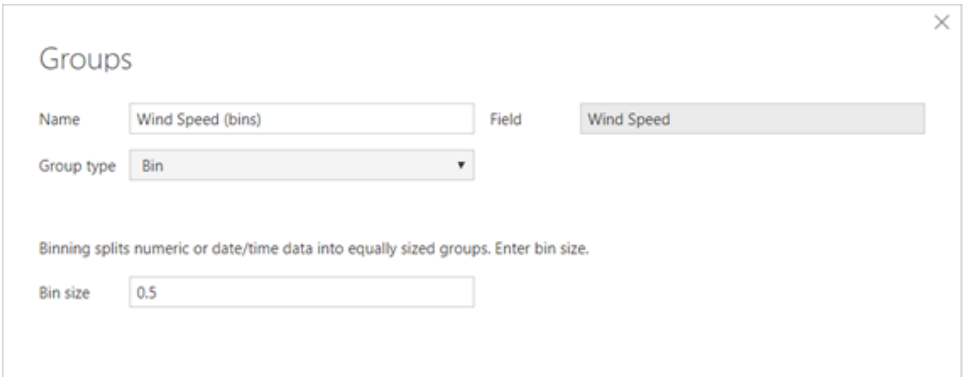
9.4.1 Group Wind Speed Values into Bins

To address shortcoming 1 above, Power BI has the functionality to create groups (or bins) from a given column.

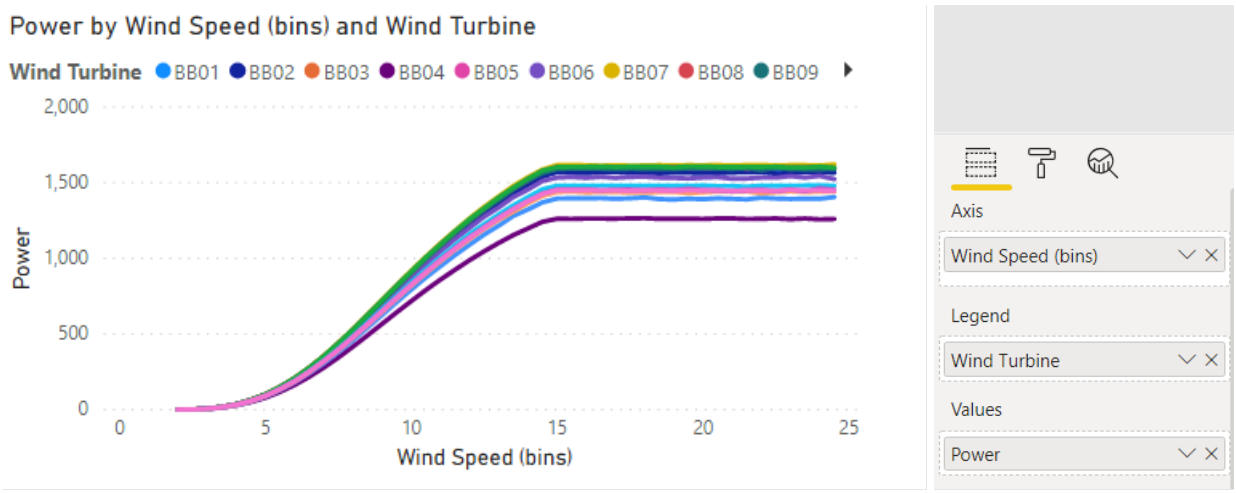
To configure the line chart to use Wind Speed bins instead of the raw Wind Speed value, **Right Click** on **Wind Speed** in the Fields section and choose **New Group**



Set the **Bin Size** to 0.5 to create bins with a width of 0.5 m/s and click **OK**.

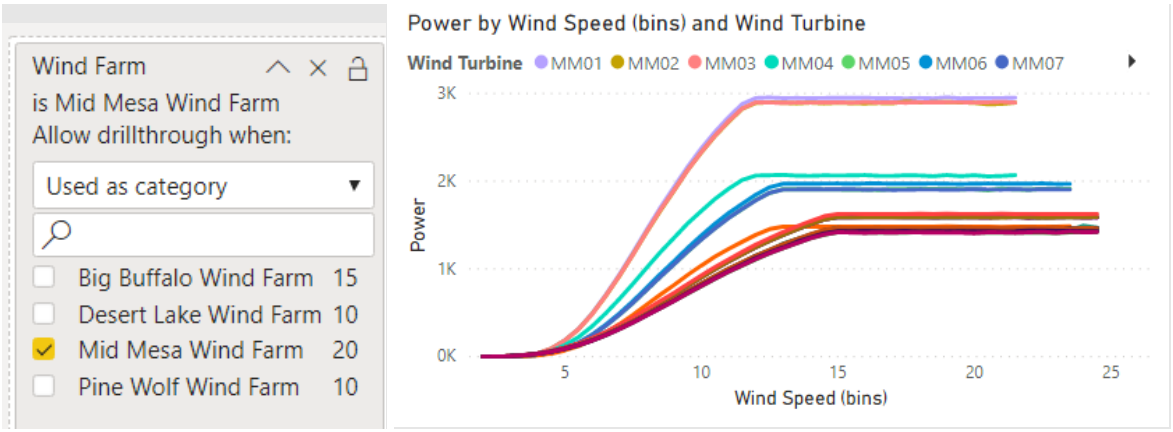


This creates a new field named **Wind Speed (bins)** which can be used as the axis for the line chart



9.4.2 Normalize the Performance Measurement

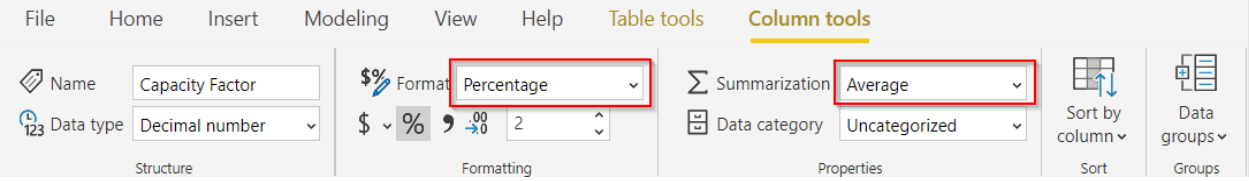
To address shortcoming 2, first notice how the chart appears when showing a wind farm that has many different models. To do this, change the drillthrough field **Wind Farm** to **Mid Mesa Wind Farm**. Note, you may need to deselect all visuals by clicking in the backgroud to get this to show.

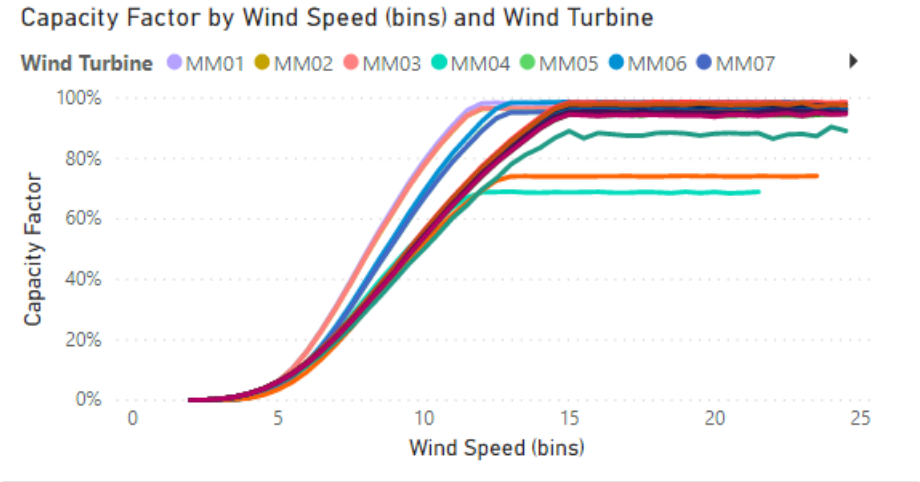


The turbines in this wind farm have Rated Powers between 1500 kW and 3000 kW, which makes it difficult to see which turbines are underperforing.

To solve this, the power could be shown as a **percentage of the Rated Power**. For this case, the calculation has already been performed in the PI System, and is available as the **Capacity Factor**. If this were not already in place, a new measure could have been created.

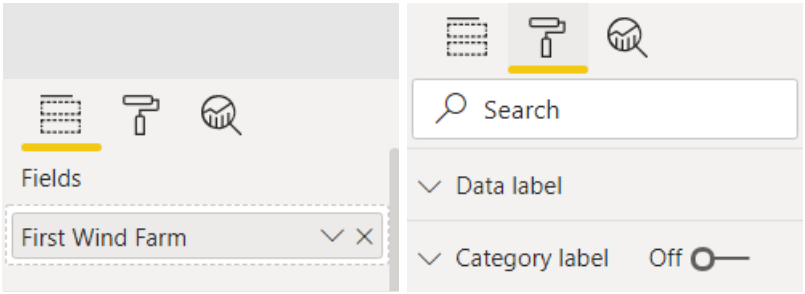
Update the chart to use **Capacity Factor** for **Values** instead of Power. Remember to set the summarization to **Average** and format the column to **Percentage**. Hint: Click on Capacity Factor in the Fields section to get the Column tools to show up in the ribbon.

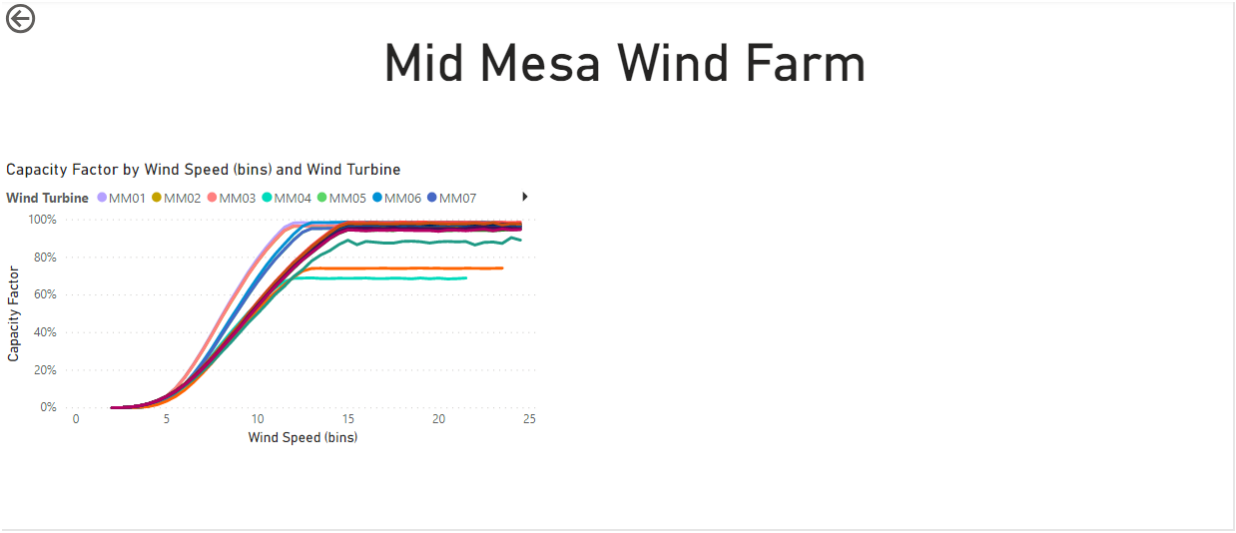

File
Home
Insert
Modeling
View
Help
Table tools
Column tools
Name
Capacity Factor
Data type
Decimal number
Structure
Format
Percentage
2
Formatting
Summarization
Average
Data category
Uncategorized
Properties
Sort by column
Sort
Data groups
Groups


Capacity Factor by Wind Speed (bins) and Wind Turbine
Wind Turbine
MM01
MM02
MM03
MM04
MM05
MM06
MM07
100%
80%
60%
40%
20%
0%
Capacity Factor
0
5
10
15
20
25
Wind Speed (bins)

9.5 Add a Title and Test Drillthrough

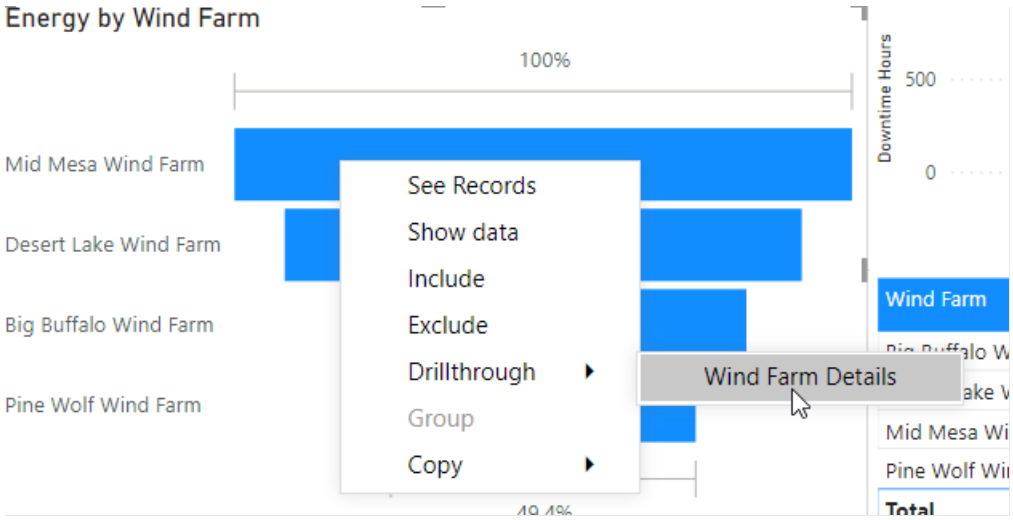
Add a title to the page by adding a value **card** using the field **Wind Farm** from Turbine Information. Position this at the top of the page and in the **Format** section **turn off** the **Category label**.





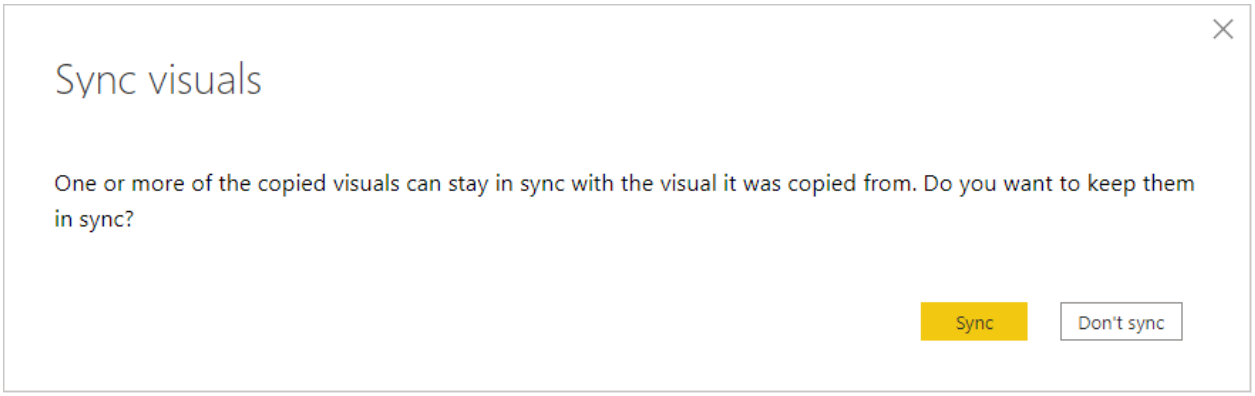
To test the drillthrough, navigate to the **Wind Generation Overview** page and right click on one of the bars for the **Energy by Wind Farm** funnel chart.

Choose **Drillthrough** > **Wind Farm Details** and the page that was just created should appear.

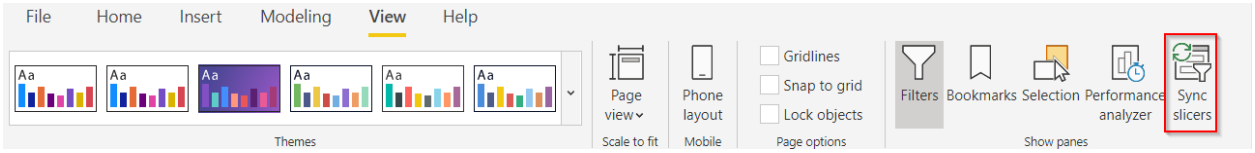

Energy by Wind Farm
100%
Mid Mesa Wind Farm
Desert Lake Wind Farm
Big Buffalo Wind Farm
Pine Wolf Wind Farm
See Records
Show data
Include
Exclude
Drillthrough
Group
Copy
Wind Farm Details
Downtime Hours
500
0
Wind Farm
Mid Mesa Wi
Pine Wolf Wi
Total
49.4%

9.6 Copy and Sync the Date Slicer

Copy the **Date** slicer from the **Wind Generation Overview** onto the **Wind Farm Details** page. A prompt to **Sync Visuals** should appear, which will let the slicers stay in sync across the pages. Choose **Sync** so that the pages will share the slicer.

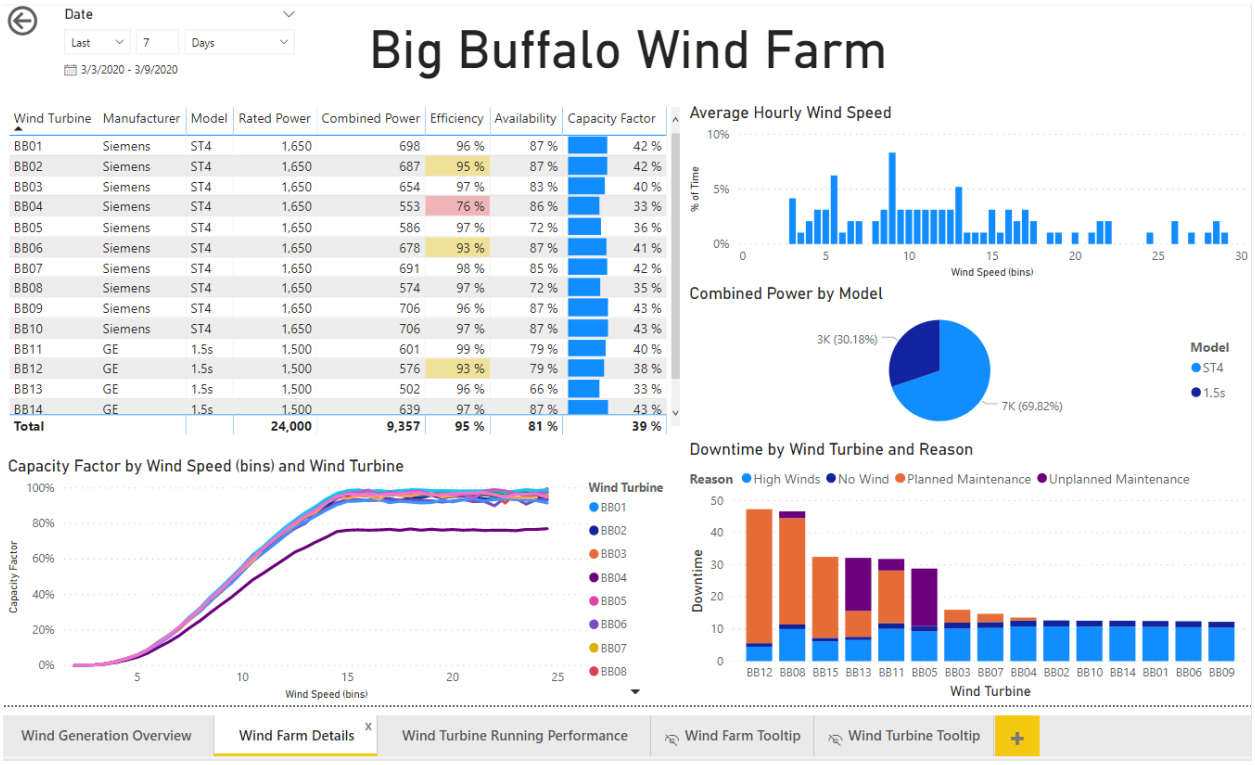


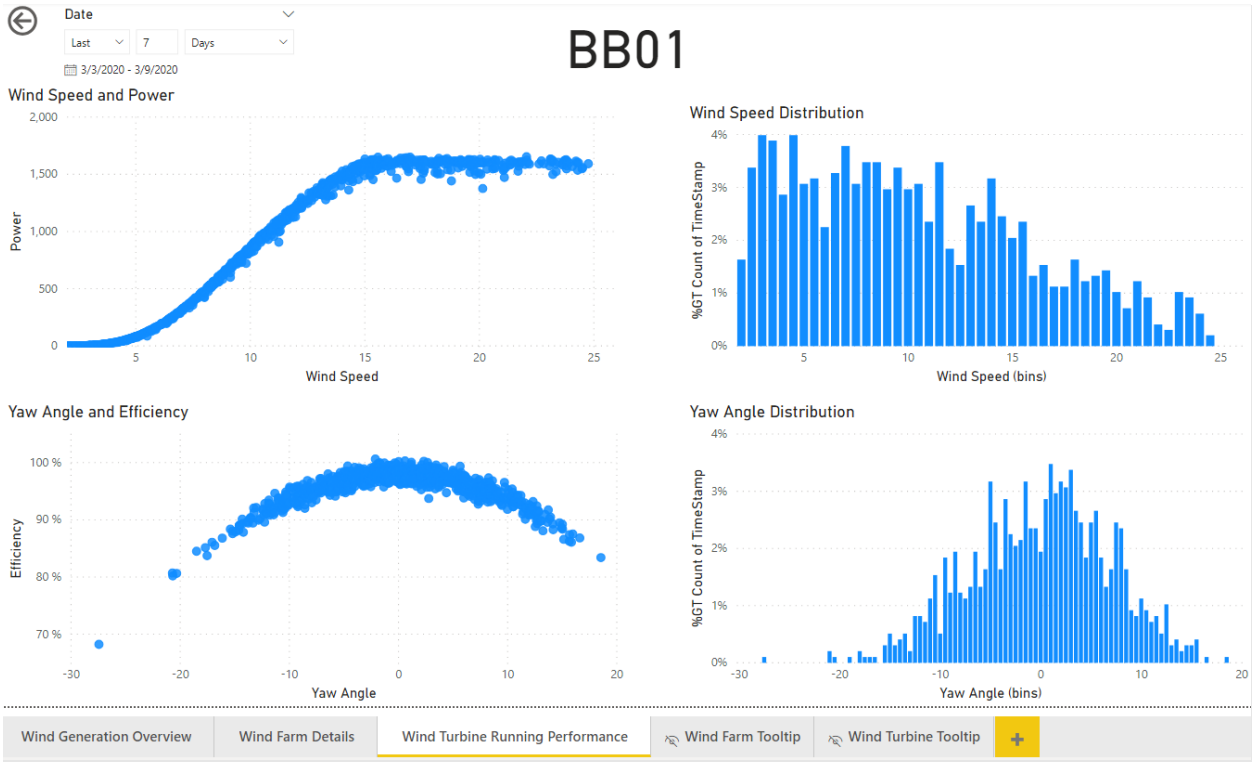
To sync slicers at a later point or disable syncing, open the **Sync Slicers** pane from the **View** tab of the ribbon.

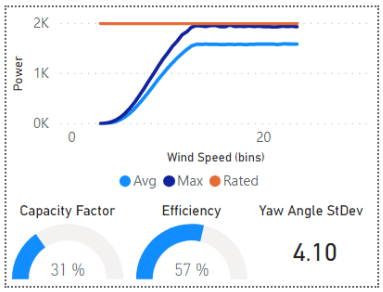


9.7 Continue Building the Report

With the remaining time, customize the report by adding additional visuals, pages, and tooltips. The images below show a few examples of the charts that can be created, and they are included in the solution report.







Wind Generation Overview
Wind Farm Details
Wind Turbine Running Performance
Wind Farm Tooltip
Wind Turbine Tooltip

10. Appendix: Wind Turbine Downtime: PI SQL Client Event Frame Model

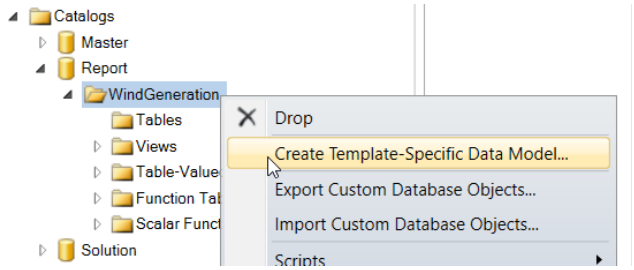
10.0 Overview

This section will prepare the downtime event summaries using PI SQL Client.

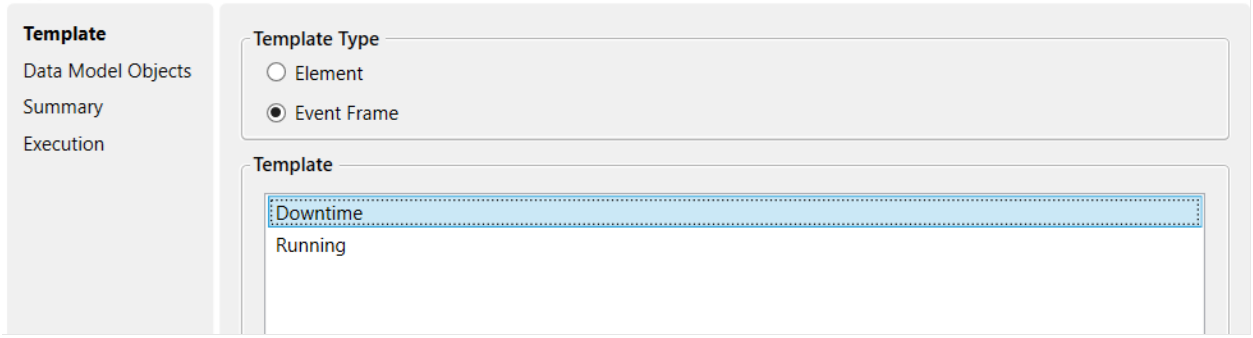
10.1 Create a Template-Specific Data Model for the Downtime Event

Open PI SQL Commander Lite and navigate to the Report > WindGeneration schema. Hint: If you have just opened PI SQL Commander Lite you might need to right click on PISRV01\WindGeneration and connect first.

To create the data model, **right click** on the schema **WindGeneration** and click **Create Template-Specific Data Model**.



For **Template Type,** choose **Event Frame**, and for **Template** choose **Downtime**, then click **Next**.



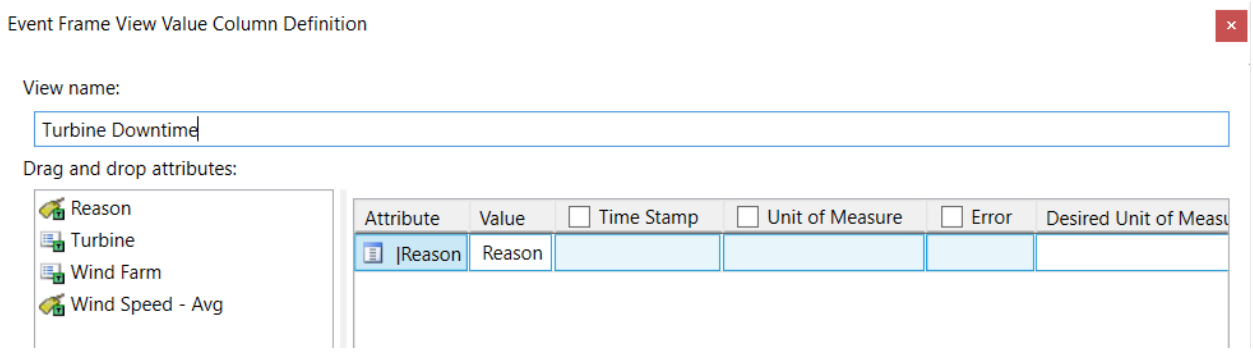
On the next page, click to **Add Event Frame View**. This will open a column definition window.

Set the **View Name** to **Turbine Downtime**.

Select the **Reason** attribute and drag it into the table.

In the header of the table, **deselect Timestamp, Unit of Measure,** and **Error**.

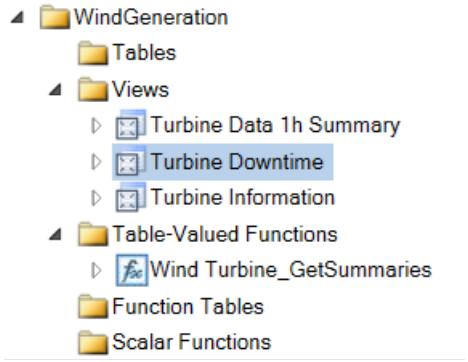
The window should look similar to below.



Click **OK**.

There should now be one Data Model Object defined. Click **Next** to proceed to the summary page, and click **Execute** to create the view. Once the execution completed successfully, click **Done**.

At this stage, a new view should be listed within WindGeneration as shown below:



10.2 Update the Turbine Downtime View

As with the Turbine Information view, the Turbine Downtime view does not have all the required information by default. Specifically, it is missing a Wind Turbine column and a Duration column.

To add this information, we will edit the view.

Right click Turbine Downtime > **Scripts** > **Alter View** > **New Query Editor Window**.

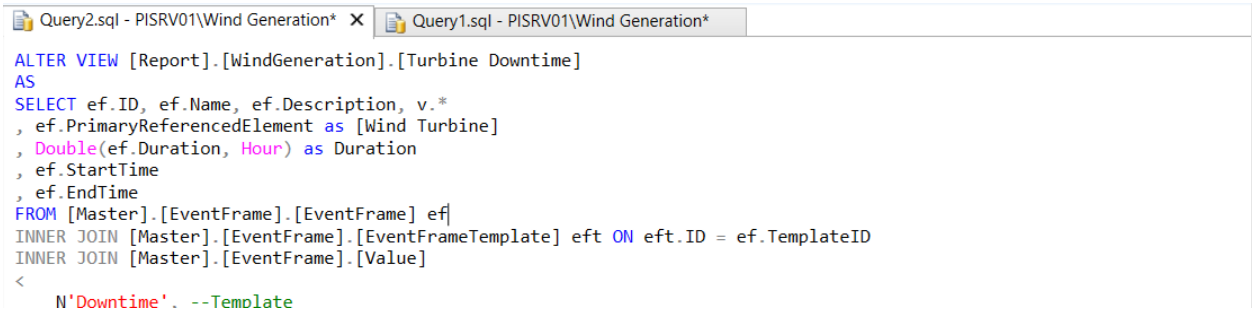
In the query, modify line 3 to include **ef.PrimaryReferencedElement as [Wind Turbine]**.

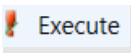
To include the duration, modify line 3 to also include **Double(ef.Duration, Hour) as Duration**.

To include the start and end time, modify line 3 to also include **ef.StartTime, ef.EndTime**.

The full statement should be as follows:

```
SELECT ef.ID, ef.Name, ef.Description, v.*
, ef.PrimaryReferencedElement as [Wind Turbine]
, Double(ef.Duration, Hour) as Duration
, ef.StartTime
, ef.EndTime
```



Click 

or F5 to execute the query and alter the view.

Execute the Predefined query once more to ensure that the view does not throw any errors.

11. Appendix: Wind Turbine Running Performance: PI SQL Client Model

11.0 Overview

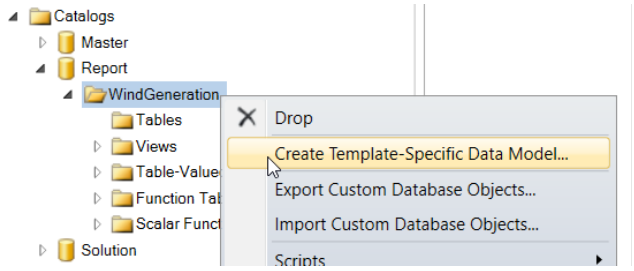
This section will prepare a view of the running events with 5-minute sampled data using PI SQL Client.

11.1 Create a Template-Specific Data Model for the Running Event

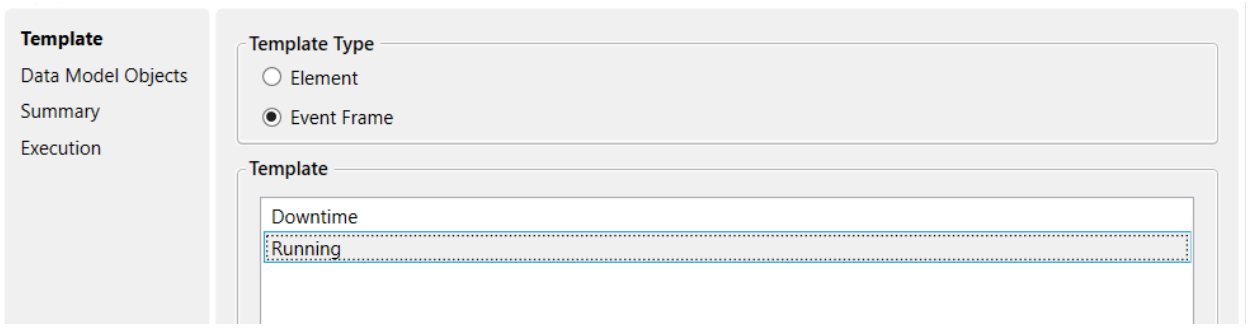
This section will create a view of the event frames using the Running template.

Open PI SQL Commander Lite and navigate to the **Report** > **WindGeneration** schema.

To create the data model, **right click** on the schema **WindGeneration** and click **Create Template-Specific Data Model**.



For **Template Type,** choose **Event Frame**, and for **Template** choose **Running**, then click **Next**.

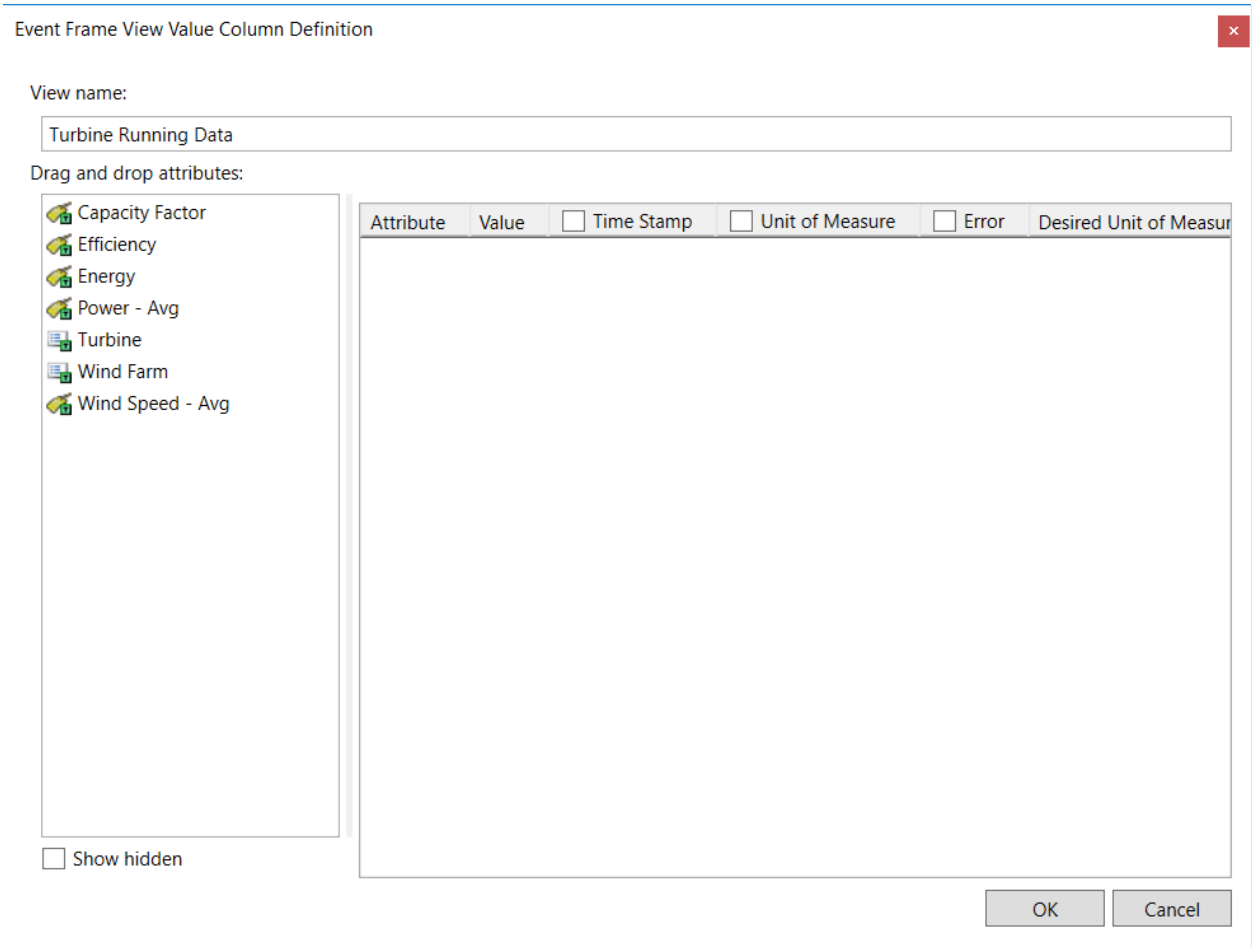


On the next page, click to **Add Event Frame View**. This will open a column definition window.

Set the **View Name** to **Turbine Running Data**.

In the header of the table, **deselect Timestamp, Unit of Measure,** and **Error**.

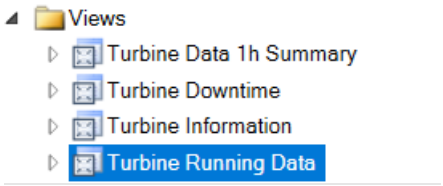
For this example, do not add any attributes. The next section will describe how data will be populated.



Click **OK**.

There should now be one Data Model Object defined. Click **Next** to proceed to the summary page, and click **Execute** to create the view. Once the execution completed successfully, click **Done**.

At this stage, a new view should be listed within WindGeneration as shown below:

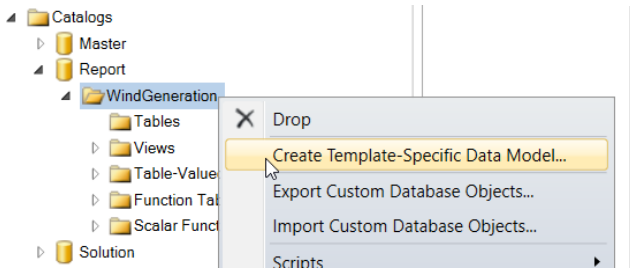


Execute the predefined query for this view. Notice that event frames are returned.

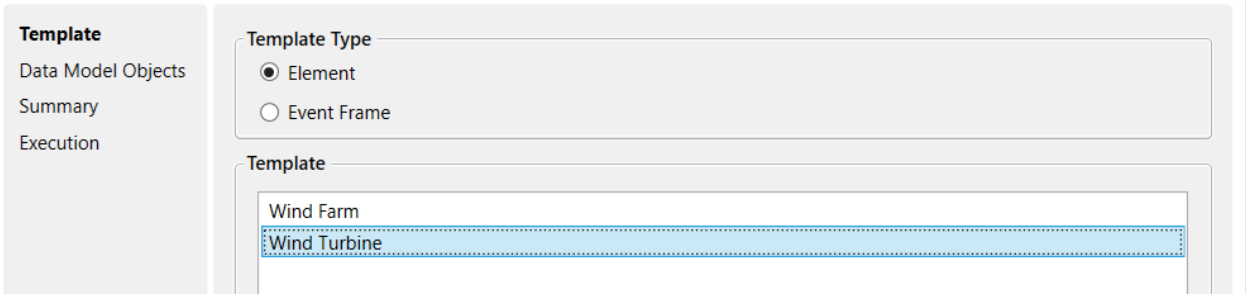
11.2 Get Sampled Data for the Wind Turbine

This section will use a template-specific data model to generate sampled values for the Wind Turbine.

To create the data model, **right click** on the schema **WindGeneration** and click **Create Template-Specific Data Model**.



For **Template Type,** choose **Element**, and for **Template** choose **Wind Turbine**, then click **Next**.

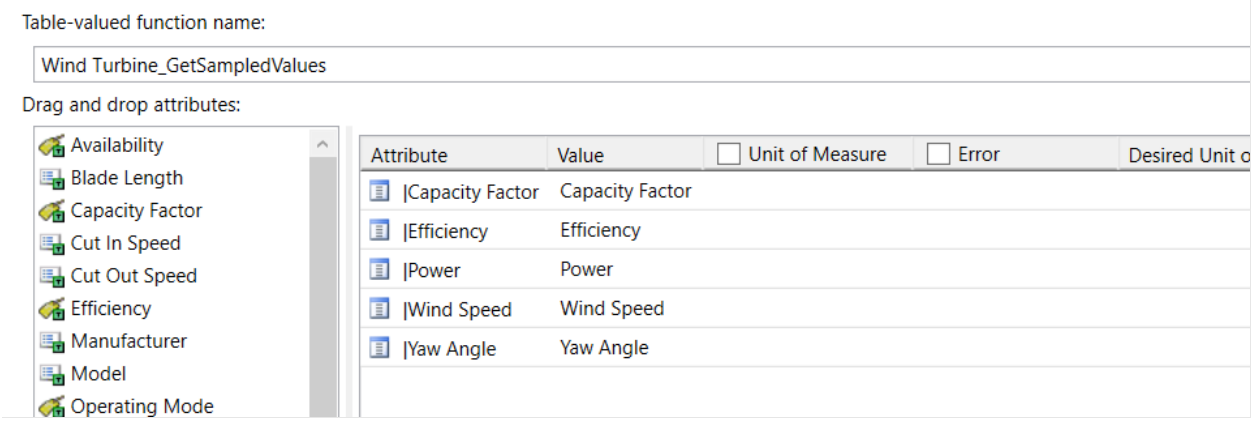


For the **Data Model Objects**, click **Add GetSampledValues…** (not GetSampledValue…).

Drag the following attributes into the table:

- Capacity Factor
- Efficiency
- Power
- Wind Speed
- Yaw Angle

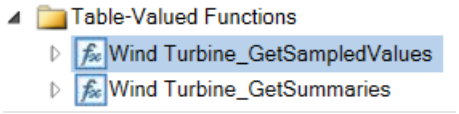
Uncheck the **Unit of Measure** and **Error** columns.



Click **OK**.

There should now be one Data Model Objects defined. On the Data Model Objects page, click **Next** to proceed to the summary page and click **Execute** to create the object. Once the execution completed successfully, click **Done**.

At this stage, the a new Table-Valued function should exist as shown below:



11.3 Update the Turbine Running Data View

In this section, the Turbine Running Data view will be altered so that 5-minute sampled data is added for each event.

First, execute the predefined query for **Wind Turbine_GetSampledValues**.

```
SELECT e.Name, s.*
FROM
(
    SELECT TOP 100 ID, Name, Template
    FROM [Master].[Element].[Element]
) e
CROSS APPLY [Report].[WindGeneration].[Wind Turbine_GetSampledValues]
(
    e.ID,  --Element ID
    'y',  --Start Time
    't',  --End Time
    '1h'  --Time Step
) s
WHERE e.Template = N'Wind Turbine'
```

Notice the structure of the query. The **CROSS APPLY** creates sampled data for each Element ID over a time range defined by a start time, an end time, and a time step.

This **CROSS APPLY** will be used to create 5-minute data for each of the event frames.

To add this information, we will edit the view.

Right click Turbine Running Data > Scripts > Alter View > New Query Editor Window.

```
ALTER VIEW [Report].[WindGeneration].[Turbine Running Data]
AS
SELECT ef.Name
, ef.StartTime
, ef.EndTime
, ef.PrimaryReferencedElement as [Wind Turbine]
, s.*
FROM [Master].[EventFrame].[EventFrame] ef
INNER JOIN [Master].[EventFrame].[EventFrameTemplate] eft ON eft.ID = ef.TemplateID
CROSS APPLY [Report].[WindGeneration].[Wind Turbine_GetSampledValues]
(
    ef.PrimaryReferencedElementID,  --Element ID
    ef.StartTime,  --Start Time
    ef.EndTime,  --End Time
    '5m'  --Time Step

) s
WHERE ef.Template  = N'Running'
    OR eft.InheritancePath LIKE N'\Running\%'
    AND ef.StartTime >= '1-1mo'
```

Modify the query as follows:

- Update line 3 to the following:

```
SELECT ef.ID, ef.Name, ef.Description,
ef.PrimaryReferencedElement as [Wind Turbine], s.*
```

- Include the Cross Apply, using the
  - **ef.PrimaryReferencedElementID**
  - **ef.StartTime**
  - **ef.EndTime**

```
CROSS APPLY [Report].[WindGeneration].[Wind
Turbine_GetSampledValues]
(
   ef.PrimaryReferencedElementID,  --Element ID
   ef.StartTime,  --Start Time
   ef.EndTime,  --End Time
   '5m'  --Time Step

) s
```

  - Include the Start Time in the Where statement:

```
ef.StartTime >= '1-1mo'
```

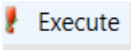
The final query should be as follows:

```
ALTER VIEW [Report].[WindGeneration].[Turbine Running Data]
AS
SELECT ef.ID, ef.Name, ef.Description, ef.PrimaryReferencedElement
as [Wind Turbine], s.*
FROM [Master].[EventFrame].[EventFrame] ef
INNER JOIN [Master].[EventFrame].[EventFrameTemplate] eft ON eft.ID
= ef.TemplateID
CROSS APPLY [Report].[WindGeneration].[Wind
Turbine_GetSampledValues]
(
    ef.PrimaryReferencedElementID,  --Element ID
    ef.StartTime,  --Start Time
    ef.EndTime,  --End Time
    '5m'  --Time Step

) s
WHERE ef.Template  = N'Running'
   OR eft.InheritancePath LIKE N'\Running\%'
   AND ef.StartTime >= '1-1mo'
```

```
ALTER VIEW [Report].[WindGeneration].[Turbine Running Data]
AS
SELECT ef.ID
, ef.Name
, ef.Description
, ef.PrimaryReferencedElement as [Wind Turbine]
, s.*
FROM [Master].[EventFrame].[EventFrame] ef
INNER JOIN [Master].[EventFrame].[EventFrameTemplate] eft ON eft.ID = ef.TemplateID
CROSS APPLY [Report].[WindGeneration].[Wind Turbine_GetSampledValues]
(
    ef.PrimaryReferencedElementID,  --Element ID
    ef.StartTime,  --Start Time
    ef.EndTime,  --End Time
    '5m'  --Time Step

) s
WHERE ef.Template  = N'Running'
    OR eft.InheritancePath LIKE N'\Running\%'
    AND ef.StartTime >= '1-1mo'
```

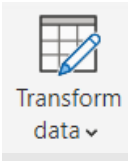
Click  or F5 to execute the query and alter the view.

Execute the Predefined query for the view to ensure there are no errors.

12. Appendix: Linking Dates

Since events may span many days, neither the start time nor the end time are suitable for converting to a date.

Instead, the solution is to create a linking table that will have separate rows for each day an event frame is active.

To create this, open the Query Editor by clicking 

from the ribbon if it is not already open.

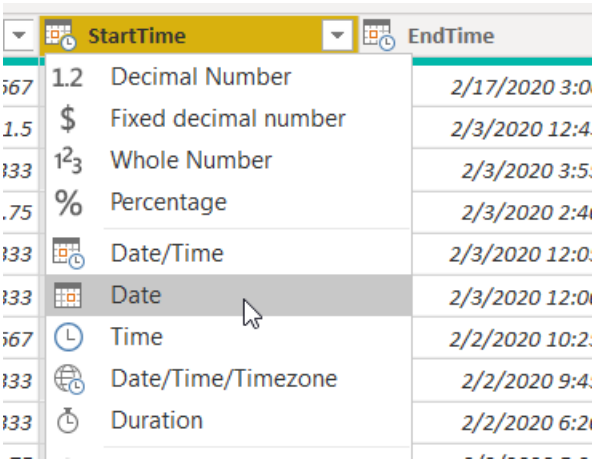
Right Click on the **Turbine Downtime** table and copy it.

Then Right Click and Past it to create **Turbine Downtime (2)**.

Rename this table to **Turbine Downtime (Linking).**

If you followed 7.6.1 to create a **Date** column, delete this column as we are creating a new column with this name.

Change data type of the **Start Time** and **End Time** columns to Date by clicking the  symbol in the column header and choosing **Date**.



Note that the columns may have different names depending on which tool was used to publish.

For the **End Time** click the dropdown arrow and choose **Remove Empty**. This will remove in-progress event frames. An alternate approach could be to replace empty values with the current time.

Next, navigate to the **Add Column** tab of the ribbon and choose **Custom Column**. Enter the following formula to create a list of all dates between the Start Time and End Time.

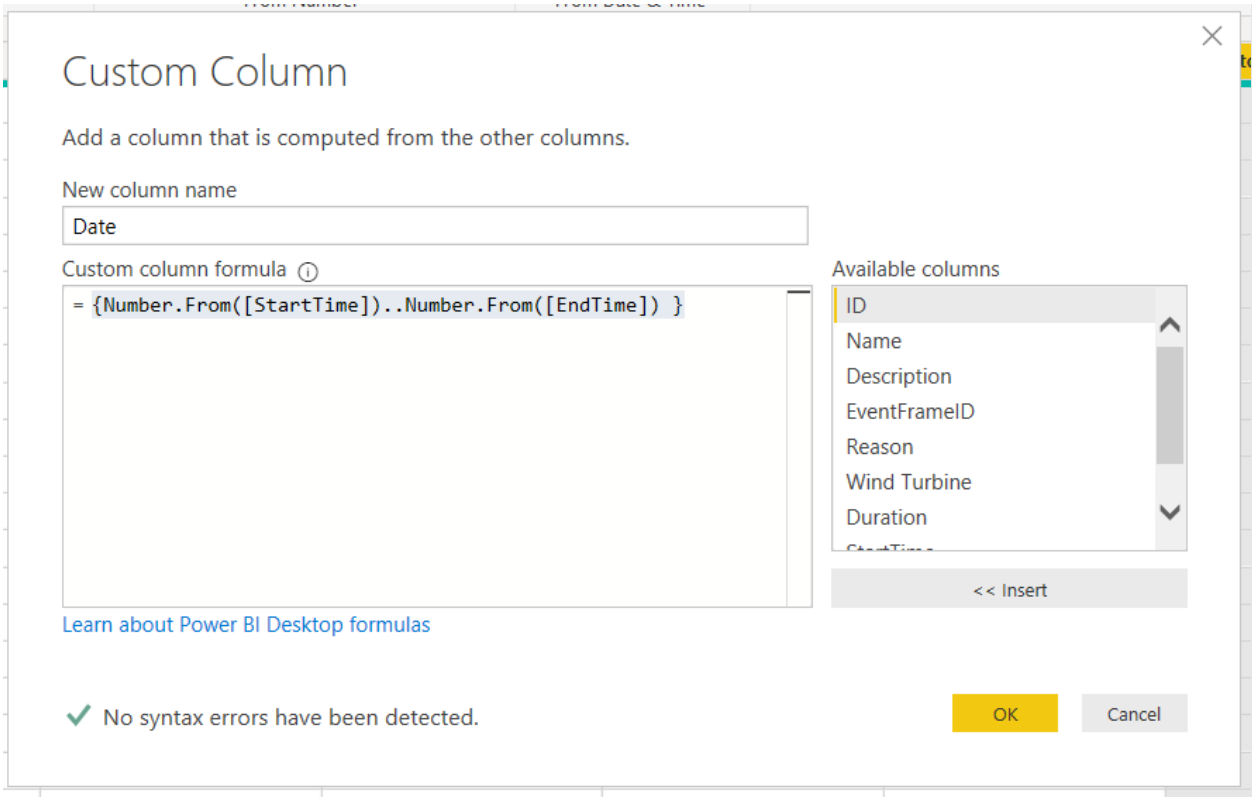
Using the Integrator view:

{Number.From([Event Frame Start Time])..Number.From([Event Frame End Time]) }

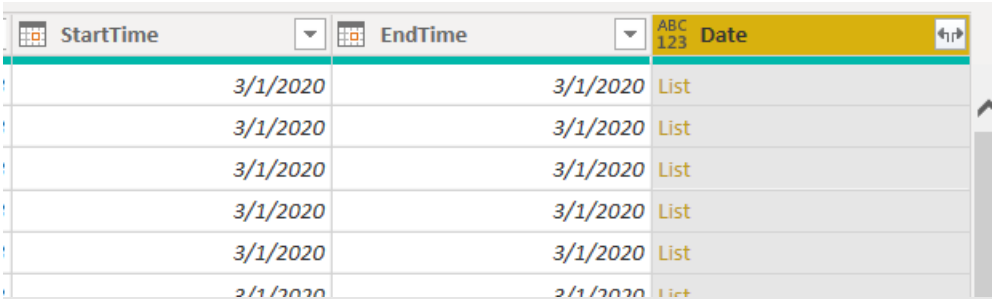
Using the PI SQL Client view:

{Number.From([StartTime])..Number.From([EndTime]) }

Name the Column **Date**.



Click **OK**. The column **Date** should now show many lists.

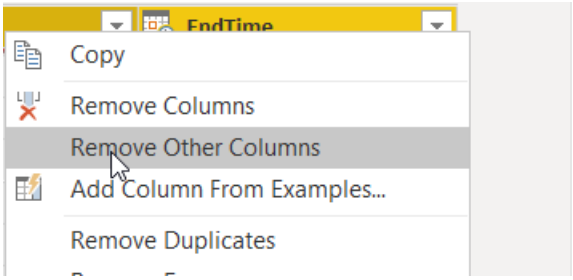


Click the button on the right side of the column header and choose **Expand to New Rows**. This will create a new row for each date in the range.

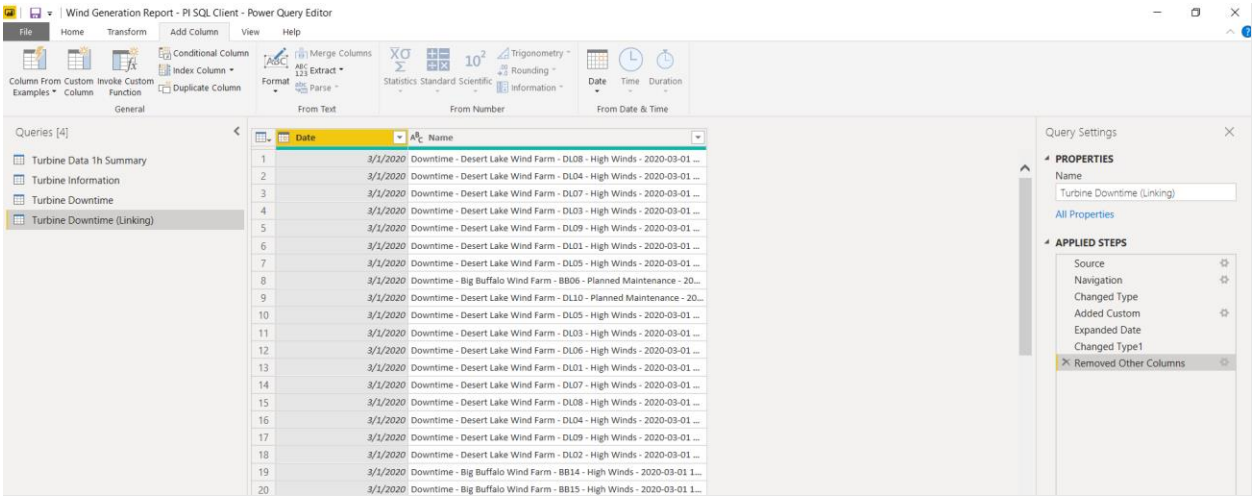
Next, change the data type from a number to a date by clicking the ABC 123 icon on the left of the header and choose **Date**.

Finally, select the columns for the Event Frame Name (called Downtime) and Date.

Right click the column header of a selected column and choose **Remove Other Columns**

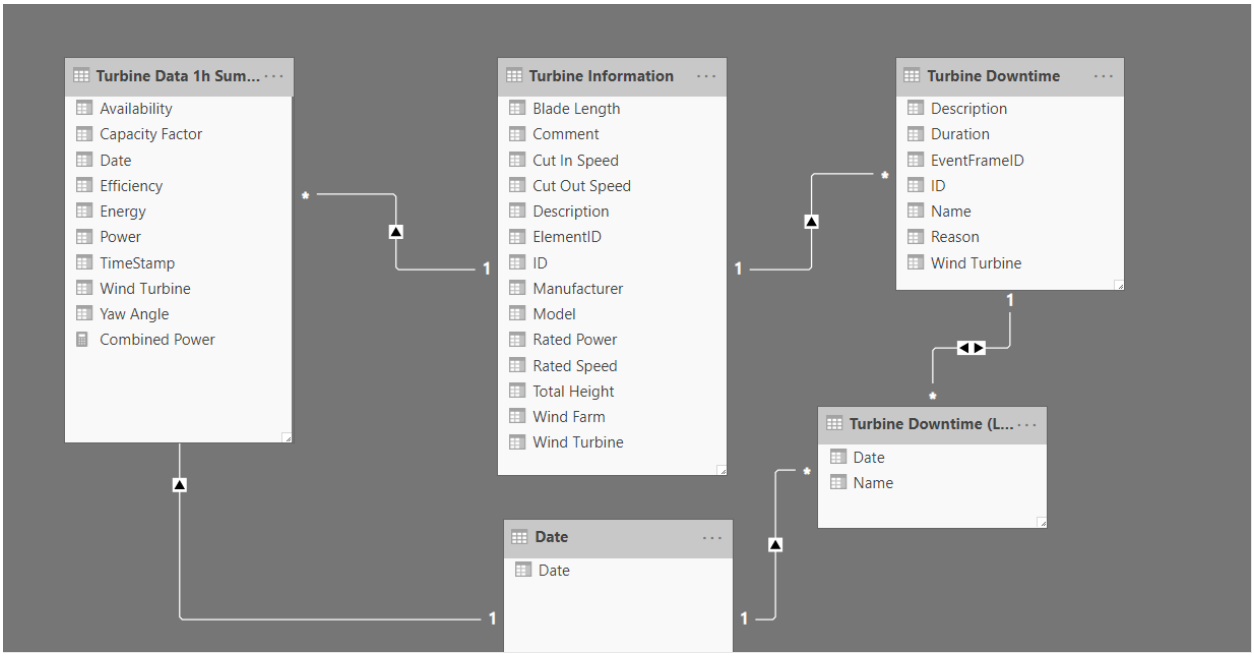


The table should now contain only dates and Event Frame Names.



12.0 Link the Date Table

Create relationships between the Turbine Downtime (Linking) table and the other tables. First delete the relationship that has been created between the Turbine Downtime table and the Date table in 7.6.3. For the relationship between the Downtime table and the linking table, double click it and set the **Cross Filter direction** to **Both**.



13. Appendix: PI SQL Framework: All Queries

For reference, all PI SQL Framework Queries used in this lab are included below. Before executing, replace **[Report].[WindGeneration]** with the appropriate catalog and schema if they differ.

13.0 Wind Turbine_GetSampledValues

```
CREATE FUNCTION [Report].[WindGeneration].[Wind
Turbine_GetSampledValues]
(
    @ElementID Guid,
    @StartTime DateTime,
    @EndTime DateTime,
    @TimeStep String
)
AS
SELECT *
FROM [Master].[Element].[GetSampledValues]
<
    N'Wind Turbine', --Template
    {
        N'|Capacity Factor', -- AttributeTemplatePath
        N'Capacity Factor', -- ValueColumnName
        NULL, -- UnitOfMeasureColumnName
        NULL, -- ErrorColumnName
        NULL -- UnitOfMeasure
    },
    {
        N'|Efficiency',
        N'Efficiency',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Power',
        N'Power',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Wind Speed',
        N'Wind Speed',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Yaw Angle',
        N'Yaw Angle',
        NULL,
        NULL,
        NULL
    }
```

```
>
(
    @ElementID,
    @StartTime,
    @EndTime,
    @TimeStep
)
```

13.1 Wind Turbine_GetSampledValues

```
CREATE FUNCTION [Report].[WindGeneration].[Wind
Turbine_GetSampledValues]
(
    @ElementID Guid,
    @StartTime DateTime,
    @EndTime DateTime,
    @TimeStep String
)
AS
SELECT *
FROM [Master].[Element].[GetSampledValues]
<
    N'Wind Turbine', --Template
    {
        N'|Capacity Factor', -- AttributeTemplatePath
        N'Capacity Factor', -- ValueColumnName
        NULL, -- UnitOfMeasureColumnName
        NULL, -- ErrorColumnName
        NULL -- UnitOfMeasure
    },
    {
        N'|Efficiency',
        N'Efficiency',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Operating Mode',
        N'Operating Mode',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Power',
        N'Power',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Wind Speed',
        N'Wind Speed',
        NULL,
        NULL,
        NULL
    },
```

```
    {
        N'|Yaw Angle',
        N'Yaw Angle',
        NULL,
        NULL,
        NULL
    }
>
(
    @ElementID,
    @StartTime,
    @EndTime,
    @TimeStep
)
```

13.2 Turbine Information

```
CREATE VIEW [Report].[WindGeneration].[Turbine Information]
AS
SELECT e.Name as [Wind Turbine], v.*, ParentName(e.PrimaryPath) AS
[Wind Farm]
FROM [Master].[Element].[Element] e
INNER JOIN [Master].[Element].[ElementTemplate] et ON et.ID =
e.TemplateID
INNER JOIN [Master].[Element].[Value]
<
    N'Wind Turbine', --Template
    {
        N'|Blade Length', -- AttributeTemplatePath
        NULL, -- TimeStampColumnName
        N'Blade Length', -- ValueColumnName
        NULL, -- UnitOfMeasureColumnName
        NULL, -- ErrorColumnName
        NULL -- UnitOfMeasure
    },
    {
        N'|Cut In Speed',
        NULL,
        N'Cut In Speed',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Cut Out Speed',
        NULL,
        N'Cut Out Speed',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Manufacturer',
        NULL,
        N'Manufacturer',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Model',
        NULL,
        N'Model',
        NULL,
```

```
        NULL,
        NULL
    },
    {
        N'|Rated Power',
        NULL,
        N'Rated Power',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Rated Speed',
        NULL,
        N'Rated Speed',
        NULL,
        NULL,
        NULL
    },
    {
        N'|Total Height',
        NULL,
        N'Total Height',
        NULL,
        NULL,
        NULL
    }
> v
ON e.ID = v.ElementID
WHERE e.Template  = N'Wind Turbine'
    OR et.InheritancePath LIKE N'\Wind Turbine\%'
```

13.3 Turbine Data 1h Summary

```
CREATE VIEW [Report].[WindGeneration].[Turbine Data 1h Summary]
AS
SELECT e.[Wind Turbine], s.*
FROM [Report].[WindGeneration].[Turbine Information] e
CROSS APPLY [Report].[WindGeneration].[Wind Turbine_GetSummaries]
(
    e.ID,  --Element ID
    '1-1mo',  --Start Time
    '*',  --End Time
    '1h',  --Time Step
    N'MostRecentTime'  --Time Type
) s
```

13.4 Turbine Downtime

```
CREATE VIEW [Report].[WindGeneration].[Turbine Downtime]
AS
SELECT ef.Name
, ef.PrimaryReferencedElement as [Wind Turbine]
, Double(ef.Duration, Hour) as Duration
, ef.StartTime
, ef.EndTime
, v.*
FROM [Master].[EventFrame].[EventFrame] ef
INNER JOIN [Master].[EventFrame].[EventFrameTemplate] eft ON eft.ID
= ef.TemplateID
INNER JOIN [Master].[EventFrame].[Value]
<
    N'Downtime', --Template
    {
        N'|Reason', -- AttributeTemplatePath
        NULL, -- TimeStampColumnName
        N'Reason', -- ValueColumnName
        NULL, -- UnitOfMeasureColumnName
        NULL, -- ErrorColumnName
        NULL -- UnitOfMeasure
    }
> v
ON ef.ID = v.EventFrameID
WHERE ef.Template  = N'Downtime'
    OR eft.InheritancePath LIKE N'\Downtime\%'
```

13.5 Turbine Running Data

```
CREATE VIEW [Report].[WindGeneration].[Turbine Running Data]
AS
SELECT ef.Name
, ef.StartTime
, ef.EndTime
, ef.PrimaryReferencedElement as [Wind Turbine]
, s.*
FROM [Master].[EventFrame].[EventFrame] ef
INNER JOIN [Master].[EventFrame].[EventFrameTemplate] eft ON eft.ID
= ef.TemplateID
CROSS APPLY [Report].[WindGeneration].[Wind
Turbine_GetSampledValues]
(
    ef.PrimaryReferencedElementID,  --Element ID
    ef.StartTime,  --Start Time
    ef.EndTime,  --End Time
    '5m'  --Time Step
) s
WHERE ef.Template  = N'Running'
    OR eft.InheritancePath LIKE N'\Running\%'
    AND ef.StartTime >= '1-1mo'
```