PI World 2020 Lab

PI Meets BI

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Sav	ve the Date!	Error! Bookmark not defined.

1. Introduction

1.1 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

1.2 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.

File Search View Go Tools H	lelp				
🕽 Database 🛅 Query Date 🕞 🕓 🥥	Back 💿		Check	n 🍤 🖌 🛃 Refresh 🎁 New	Element - 🔄 New Attribu
lements	BE	02			
⊒ 🔠 Elements	Ge	eneral	Child E	lements Attributes Ports Analys	es Notification Rules Version
🖶 🗇 Big Buffalo Wind Farm					
🗇 BB01 🗇 BB02	Fi	iter			
() BB03		/	: 🗉 🔶 J	R Name	△ Value
🗇 BB04		G	Catego	ry: Energy Information	
🗇 BB05 🗇 BB06	Œ	0	•	🝼 Power	222.14 kW
🗿 BB07		6	Catego	ory: Metrics	
🗇 BB08 🎯 BB09		0	•	🍼 Availability	1 ratio
🗇 BB10		0	•	🍼 Capacity Factor	0.13463 ratio
🗇 BB11		0	•	Efficiency	0.7672 ratio
🗇 BB12 🗇 BB13		6	Catego	ry: Status	
🗇 BB14	Œ	4	•	Operating Mode	Running
□ □ BB15		Ē	Catego	ory: Turbine Specifications	
🗄 🗇 Desert Lake Wind Farm				🔳 Blade Length	41.148 m
🗄 🧿 Pine Wolf Wind Farm				💷 Cut In Speed	2 m/s
🚉 Element Searches				💷 Cut Out Speed	25 m/s
				💷 Manufacturer	Siemens
				I Model	ST4
				Rated Power	1650 kW
			B	I Rated Speed	15 m/s
			B	💷 Total Height	111 m
3 Elements		G	Catego	ry: Wind Information	
Event Frames		0	•	Wind Direction	1.8123 °
Jibrary			E	Wind Speed	5.0589 m/s
Unit of Measure				ory: Yaw Information	
		0	🗉 🔶	ngle 🖉 Yaw Angle	1.9447 °

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



1.3 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

1.3.1 The PI Integrator for Business Analytics

PI Integrator for Business Analytics presents PI System data perfectly suited to 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 webconfigured 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.

1.3.2 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 principals 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 <u>OSIsoft Customer Portal Products page</u> 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 <u>PI Developers Club</u> . For details, see <u>PI Developers Club FAQ</u> .
	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
	<u>Contact Us page</u> .

1.3.3 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 ondemand, 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 no end-users require direct access to the data.

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

2. Wind Turbine Overview Report

2.1 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 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.

2.2 Tasks

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

2.3 Preparing the Environment

Before beginning the class, it is important to backfill the data. This is accomplished within PI System Explorer.



First, open PI System Explorer from the desktop

In the title of the window (at the top), you should see **\\PISRV01\Wind Generation**. If you do not see this, it means that you are in a different database. Click the Database button in the menu ^{Database} and choose **Wind Generation**

Select Database ×								
👌 New Database 🗙 Delete Database 🚰 Database Properties 🚦								
Asset gerver: 🎯 PISRV01 🗸 🖷 😭 Connect								
Data <u>b</u> ases:								
Filter		• م						
Name	Description	Last Modified						
Configuration	A store for configuration	5/20/2020 2:49:50 PM						
NuGreen	PI BI Project Asset Model	2/5/2020 11:52:58 AM						
Wind Generation		5/20/2020 2:10:10 PM						
		OK Close						

Next, navigate to the Management section of PI System Explorer (bottom left)

Elements
Event Frames
🕽 Library
Unit of Measure
Contacts
🖁 Management

From here, click the **check mark** in the column heading to select all of the analyses, then click **Queue** on the right hand operations panel and fill in the following options

- Start: 1-1mo
- End: *
- Permanently delete existing data and recalculate

Click the **Queue** button to complete

File View Go Tools Help		1						
🕽 Database 🛅 Query Date 🔹 🕓 🚭 🔇 E	ack 🔘 💐 Che	kin 🖌	🗸 🛃 Refresh				2	
Management	Analyses							
Choose a type	224 total anal	ses sele	cted (224 on this page)				1 - 224 of 224 < >	Operations
Analyses	6				Tomolate	Packfilling		operations
 Notification Rules 	Status	-	Desert Lake Wind Farm\DL05			Ø		Enable Disable selected analyses
Analysis Searches			Desert Lake Wind Farm\DL01			0		Enable Disable automatic recalculation for selected analyses
+ >>			Desert Lake Wind Farm\DL04			0		Queue Cancel backfilling or recalculation for selected analyse
All			Desert Lake Wind Farm\DL03			0		
and the second se		H				0	3 —	Start 1-1mo
Enabled		H		Downtime	Downtime	0	4	End *
Disabled	V 0	H	Big Buffalo Wind Farm\BB01	Downtime	Downtime	0		What should we do with existing data?
New Search	V 0	H	Pine Wolf Wind Farm\PW10	Downtime	Downtime	0		 Leave existing data and fill in gaps
	V 0	H	Pine Wolf Wind Farm\PW09	Downtime	Downtime	0	5	Permanently delete existing data and recalculate
	V 📀	H	Mid Mesa Wind Farm\MM20	Downtime	Downtime	0		Recalculate dependent analyses
	V 📀	H	Pine Wolf Wind Farm\PW08	Downtime	Downtime	0	6 —	Queue
	V 🥥	H	Mid Mesa Wind Farm\MM19	Downtime	Downtime	0	•	Queue
	V 🥑	H	Pine Wolf Wind Farm\PW07	Downtime	Downtime	0		
	V 📀	H	Mid Mesa Wind Farm\MM18	Downtime	Downtime	0		Pending Operations
	V 📀	H	Pine Wolf Wind Farm\PW06	Downtime	Downtime	0		Recalculating 224 analyses Dismis
	🖌 🥝	H	Mid Mesa Wind Farm\MM17	Downtime	Downtime	0		Time Submitted: 5/20/2020 2:26:01 PM Queued by: PISCHOOL\student01
	V 📀	H	Pine Wolf Wind Farm\PW05	Downtime	Downtime	0		Complete
	V 📀	н		Downtime	Downtime	0		Complete
	V 📀		Pine Wolf Wind Farm\PW04	Downtime	Downtime	0		
Statement	. 🥑		Mid Mesa Wind Farm\MM15	Downtime	Downtime	0		
Elements	V 📀	H	Pine Wolf Wind Farm\PW03	Downtime	Downtime	0		
- Event Frames	V 📀	н		Downtime	Downtime	0		
🗒 Library	 Ø 	н			Downtime	0		
Durit of Measure	I I I I I I I I I I I I I I I I I I I	н			Downtime	0		
Contacts	 Ø 	н			Downtime	0		
		H			Downtime	0		
K Management	V 📀	н	Mid Mesa Wind Farm\MM10	Downtime	Downtime			

This will backfill all of the data back to the beginning of the previous month.

3. Wind Turbine Data: PI Integrator Asset View

3.1 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.

3.2 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.

🗉 📄 Cate	Category: Turbine Specifications								
	🔳 Blade Length	41.148 m							
	💷 Cut In Speed	2 m/s							
	Cut Out Speed	25 m/s							
	🔳 Manufacturer	Siemens							
	I 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: <u>https://pisrv01.pischol.int:444</u>

🗰 Apps 🔘 Pl Vision 《 Pl	Integrator for BA						
=			My Viev	va)		L PISCH00L\studen	101 1
Create Asset View Build a data view starting with your asset hierarchy	Create Event View Build a data view starting with your event frame hierarchy	Create Streaming View Build a streaming view with a custom output shape	Modify View Modify existing data view	Remove View Remove selected view			
ame	Run Status	Туре	Run Mode	Start Time	End Time	Last Run Time	
olution - Turbine Data 1h Su	Scheduled	Asset	Continuous	2020-01-01T05:00:00.000Z	*	Mar 1, 2020 5:24:24 PM	
olution - Turbine Downtime	Scheduled	Event	Continuous	2020-01-01T05:00:00.000Z	*	Mar 1, 2020 5:21:30 PM	
olution - Turbine Information	Scheduled	Asset	Continuous	2020-01-01T05:00:00.000Z		Feb 29, 2020 8:30:10 PM	

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.

×
•
Create View



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

3.2.1 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 View, and then choose the Server **PISRV01** and Database **Wind Generation**.

≡		Turbine Inform	ation	← ← 🔔 PISCHOOL\student01 💠
Select Data > N	Modify View > Publish			Next
Source Assets		 Search Shape 	~	/ Matches
Server	PISRV01	🖫 Asset Shape		
Database	Wind Generation C 🗸			
🗇 Assets				
▶ 🕞 Big Buffalo Wind	Farm			
▶ ۞ Desert Lake Wind	d Farm			
🕨 🕼 Mid Mesa Wind F	Farm			
► 🕞 Pine Wolf Wind F	arm			

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 the refresh to show how many matches were found in the selected database.



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

Ξ		Turbine Information	← ♪ PISCHOOL\student01 �
Select Data > N	Aodify View > Publish		Next
Source Assets	· · · · · · · · · · · · · · · · · · ·	Search Shape	✓ Matches
Server	PISRV01 v	Na Asset Shape	Found 1 Match
Database	Wind Generation 2 🗸	💮 Big Buffalo Wind Farm 🥒 🕱	💮 Big Buffalo Wind Farm
() Assets			
► 🕞 Big Buffalo Wind	Farm	*	
▶ ۞ Desert Lake Wind	d Farm		
Mid Mesa Wind F	Farm		
· · · · · · · · · · · · · · · · · · ·			
Attributes Filter	×		
Select All			
► ♥ Wind Direction			
Wind Speed			

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:

😚 Search Shape	🛇 Search Shape
R Asset Shape	🖥 Asset Shape
🛱 Big Buffalo Wind Farm	Big Buffalo Wind Farm
CAuto drop and place	Drop as child
😚 Search Shape	😚 Search Shape
🖫 Asset Shape	程 Asset Shape
Drop as parent BB01	Big Buffalo Wind Farm BB01 Drop as sibling-bottom BB01

The shape should now look like below, and there should still be one match

Search Shape		✓ Matches
🖥 Asset Shape		Found 1 Match
Big Buffalo Wind Farm	🖋 🗙	Big Buffalo Wind Farm
➡ BB01	🖋 🗙	➡ BB01

Right now, the shape is searching based on names. That means it is looking through the **Wind Generation** AF Database and finding case 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 \checkmark next to the item in the search shape.

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

😚 Search Shape		✓ Matches
🖥 Asset Shape		Found 1 Match
 Big Buffalo Wind Farm 	ø ×	▲ 😚 Big Buffalo Wind Farm
🚱 ВВ01	<i>#</i> ×	😚 BB01

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

Edit Filters	×	2
BB01		
Asset Template Search Derived Templates Wind Turbine	×	
Add Filter		
	Cancel Save	

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



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

💬 Search Shape	✓ Matches
🖥 Asset Shape	Found 55 Matches
A 🕤 Wind Farm	▶ 😚 Big Buffalo Wind Farm
🕅 Wind Turbine 🖉 🕷	🕨 😚 Big Buffalo Wind Farm
	🕨 🈚 Big Buffalo Wind Farm
	▶ 🚱 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.

Ξ		Turbine Information	,		S 🔿 1 PISCHOOL\student01
Select Data > Modify View > Publish		5			Next
Source Assets	✓ ③ se	earch Shape		✓ Matches	
Server PISRV01	, ⁶ A	sset Shape		Found 55 Matches	
Database Wind Generation	C	🕽 Wind Farm	/×	Big Buffalo Wind Farm	
		Wind Turbine	/ ×	Big Buffalo Wind Farm	
∂ Assets		I Blade Length	ø ×	 Big Buffalo Wind Farm 	
 Big Buffalo Wind Farm 	<u>^</u>	Cut In Speed	/×	Big Buffalo Wind Farm	
💮 BB01		Cut Out Speed	ø ×	Big Buffalo Wind Farm	
© BB02		🔳 Manufacturer	#×	Big Buffalo Wind Farm	
· · · · · ·		I Model	/ ×	Big Buffalo Wind Farm	
Attributes Filter	×	Rated Power	1 ×	Big Buffalo Wind Farm	
Philer	• 4z	Rated Speed	1 ×	Big Buffalo Wind Farm	
Energy Information		🗐 Total Height	1 ×	▶ ③ Big Buffalo Wind Farm	
Metrics				Big Buffalo Wind Farm	
Status				🕨 🕥 Big Buffalo Wind Farm	
Turbine Specifications				Big Buffalo Wind Farm	
Model				 Big Buffalo Wind Farm 	
🥅 Total Height				 Big Buffalo Wind Farm 	
Rated Speed	-			O Desert Lake Wind Farm	

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.

•	Although we won't use it in this lab, the attributes can be modified like the assets and can be marked as optional.
Тір	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.

3.2.2 Modify the View

≡				Turbine Infor	nation				<table-cell-rows> 🏞 👤 Pischool</table-cell-rows>	L\student01
Select Data > Moo	dify View > Publish								Back	Next
Add Column 11 columns	Edit Row Filters 0 Row Filters	Edit Value Mode Interpolated Values Every 1 minute]	5	Start Time *-8h	**	End Time		Ap Ap	pply
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 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:04:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:05:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:06:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:07:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:08:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:09:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:10:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:11:53.023 A	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:12:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:13:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:14:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:15:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:16:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:17:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:18:53.023 AI	M BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	3/1/2020 11:19:53.023 AI	M 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**.

Edit Value Mode			×
 Sampled Values Sample values every 1 Interpolate ¹ Exact ¹ 	∙ days •		
		Cancel	Save Changes



Notice that the TimeStamps do not have clean values. This is because the **Start Time** is ***-8h**. Set the Start Time to **1-Jan-20** and notice that the timestamps are now much neater.

Start Time	
1-Jan-20	



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

≡	Turbine Information 🗖 🛧 PISCHOOL/at								PISCHOOL\student01	
Select Data > Moo	dify View > Publish									Back Next
+ Add Column	T Edit Row Filters	Edit Value Mode			Start Time		End T	īime		
11 columns	0 Row Filters	Interpolated Values Every 1 day			1-Jan-20	000 	*		000 	Apply
Wind Farm	TimeStamp	Wind Turbine	Blade Length	Cut In Speed	Cut Out Speed	Manufacturer	Model	Rated Power	Rated Speed	Total Height
Big Buffalo Wind Farm	1/1/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/2/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/3/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/4/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/5/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/6/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/7/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/8/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/9/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/10/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/11/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/12/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/13/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/14/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/15/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/16/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111
Big Buffalo Wind Farm	1/17/2020 12:00:00 AM	BB07	41.148	2	25	Siemens	ST4	1,650	15	111

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

3.2.3 Publish the View

≡	Turbine Information	∽ ☆ 上 PISCHOOL\student01 �
Select Data > Modify View > Publish		Back
Target Configuration PI View	Summary Share and Matches • There are 55 Matching Instances • There are no Time Series attributes selected Timeframe and Interval • You 55 Match Time is 4020-01-01705-00:00.000Z • You 51 Mine Interval gets an interpolated measurement Every 1 gets Publish	

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

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.

Target Configuration	Summary
SQL Server 🔻	Shape and Matches
	There are 55 Matching Instances
Run Mode	There are no Time Series attributes selected
Run Once	Timeframe and Interval
Run on a Schedule	 Your Start Time is 2020-01-01T05:00:00.000Z Your End Time is *
First Run	Your Time Interval gets an interpolated measurement Every 1 day
*	
Recur every 1 ▼ days ▼	Publish

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.

≡			My			PISCHOOL\student
Build a data view starting with	Create Event View Build a data view starting with your event frame hierarchy	Create Streaming View Build a streaming view with a custom output shape	Modify View Modify existing data view	Remove View Remove selected view		
ame R	Run Status	Туре	Run Mode	Start Time	End Time	Last Run Time
olution - Turbine Data 1h Su S	Scheduled	Asset	Continuous	2020-01-01T05:00:00.000	Z *	Mar 1, 2020 7:54:24 PM
olution - Turbine Downtime S	Scheduled	Event	Continuous	2020-01-01T05:00:00.000	Z *	Mar 1, 2020 7:56:30 PM
olution - Turbine Information S	Scheduled	Asset	Continuous	2020-01-01T05:00:00.000	Z *	Mar 1, 2020 5:37:47 PM
olution - Turbine Running Data S	Scheduled	Event	Continuous	2020-01-01T05:00:00.000	Z *	Mar 1, 2020 7:56:17 PM
urbine Information S	Scheduled	Asset	Continuous	2020-01-01T05:00:00.000	z *	Mar 1, 2020 7:45:53 PM
Overview Log Security	View Configuration Statis					-
contention Log Coounty	view configuration Statis	SUCS				
	Schedule		Publish A	ctions	Asset Shape	
Run Status	Schedule	d	Publish A	Ctions	Asset Shape	
Run Status View Name	Scheduler Turbine Info	d	Publish A			
Run Status View Name	Schedule	d	Publish A		▲ ۞ Wind Farm	
Run Status View Name PI AF Database Publish Target	Scheduler Turbine Info	d	Publish A	Resume	 Wind Farm Wind Turbine 	
Run Status View Name PI AF Database Publish Target	Scheduler Turbine Info Wind Generation	d	Publish A	Resume	 Wind Farm Wind Turbine Blade Length 	
Run Status View Name PI AF Database Publish Target View Type	Scheduler P Turbine Info Wind Generation SQL Server	d	Publish A	Resume Stop	 Wind Farm Wind Turbine Blade Length Cut In Speed 	
Run Status View Name PI AF Database	Scheduler Turbine Info Wind Generatii SQL Server Asset	d	Publish A	Resume Stop	 Wind Farm Wind Turbine Blade Length Cut In Speed Cut Out Speed 	

3.3 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.

\checkmark	Don't sample data more frequently than necessary. Instead, tailor the data sets to the intended use case.
Best Practice	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.

	📄 Catego	ory: Energy Information	
Ŧ	J 🗉 🔶	Power	39.204 kW
Ξ	📄 Catego	ory: Metrics	
	ø 🗉 🔶	nterita Availability	1 ratio
	J 🗉 🔶	Capacity Factor	0.02376 ratio
	J 🗉 🔶	Efficiency	0.80947 ratio
Ξ	📄 Catego	ory: Status	
Ŧ	J 🗉 🔶	Operating Mode	Running
Ð	📄 Catego	ry: Turbine Specifications	
	📄 Catego	ry: Wind Information	
Ŧ	J 🗉 🔶	Wind Direction	37.283 °
Ŧ		Wind Speed	4.4725 m/s
	📄 Catego	ry: Yaw Information	
	J 🗉 🔶	🍼 Yaw Angle	-5.5419 °
	J 🗉 🔶	🍼 Yaw Position	31.741 °

3.3.1 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 New Asset View	×
Asset View Name	
Turbine Data 1h Summary	
Access Permissions 🕄	
Administrators	v
C.	ancel Create View

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.

🛇 Search Shape	
🖫 Asset Shape	
🛇 Wind Turbine	# *

Now, add the following attributes into the search shape

😚 Search Shape	
🔁 Asset Shape	
Wind Turbine	Ø 🗙
🗬 Availability	ø ×
Capacity Factor	Ø X
Efficiency	ø ×
Power	ø ×
Yaw Angle	Ø ×

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

3.3.2 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-Jan-20** 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

≡					Turbine Data	1h Summary			Olumn Detail	ails
Select Data > Modi	fy View > Publish								Name Availability	
+ Add Column 7 columns	Edit Row Filters 0 Row Filters	Edit Value Mode Interpolated Values Every 1 hour				Start Time 1/1/20 12:00 AM	[000	End Time	Reset Name to Defau	lit O
Wind Turbine		Stamp		Availability		Capacity Factor	Effici		Value	
BB04 BB04	1/1/2020 12:00: 1/1/2020 1:00:0		1		0.322 0.367		0.467	530.687 605.426	Column Offset	0
BB04	1/1/2020 2:00:0	0 AM	1		0.149		0.458	245.121	– 0	+
BB04	1/1/2020 3:00:0	0 AM	1		0.017		0.565	28.223	11-14 - 6 8 4	
BB04	1/1/2020 4:00:0	0 AM	1		0.079		0.453	129.691	Unit of Measure	
BB04	1/1/2020 5:00:0	0 AM	1		0.002		0.59	3.673	ratio	
BB04	1/1/2020 6:00:0	0 AM	1		0.016		0.634	25.905	Data Type	
BB04	1/1/2020 7:00:0	0 AM	1		0.37		0.458	611.041		
BB04	1/1/2020 8:00:0	0 AM	1		0.864		0.864	1,426.312	Double	
BB04	1/1/2020 9:00:0	MA 0	1		0.051		0.556	84.009		
BB04	1/1/2020 10:00:	00 AM	1		0.866		0.866	1,428.256	Remove	Column
BB04	1/1/2020 11:00:	DO AM	1		0.847		0.847	1,397.576		
BB04	1/1/2020 12:00:	00 PM	1		0.33		0.545	544.537	Apply C	hanges
BB04	1/1/2020 1:00:0	0 PM	1		0.039		0.603	64.596		
BB04	1/1/2020 2:00:0	0 PM	1		0.098		0.547	161.629		
BB04	1/1/2020 3:00:0	0 PM	1		0.149		0.617	245.062		
BB04	1/1/2020 4:00:0	0 PM	1		0.624		0.68	1,029.18		

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.



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 **Data Content** of **Total**, and set the **Conversion Factor** to **Hour (24)**. Name this column **Energy**. This column will now contain the total kWh over the interval.

Add Column					×
Add Column Data Column Select Column D Wind Turb & Availab & Capacit & Efficien & Power & Yaw An	Time Column ata Source ne lity y Factor cy	Static Value		Column Name Energy Use Default Name Column Data Content Column Data Content Column Data Content Column Data Content Column Data Type Double Coleculation Basis Column Data Column C	×
			Ŧ	Time Weighted Conversion Factor O Hour (24)	• •
				Cancel Add	l Column

The page should now look similar to below

			Turbine D	ata 1h Summary			S 🕈 🕈 💄 PISCHOOL\stude	nt01 (
Select Data > Mo	dify View > Publish						Back	lext
+ Add Column	T Edit Row Filters	Edit Value Mode		Start Time		End Time		
8 columns	0 Row Filters	Interpolated Values Every 1 hour		1/1/20 12:00 AM		.*	Apply	
Wind Turbine	TimeStamp	Availability	Capacity Factor	Efficiency	Power	Energy	Yaw Angle	
BB01	1/1/2020 12:00:00 AM	1	0.72	0.793	1,188.083	1,188.083	-3.264	
BB01	1/1/2020 1:00:00 AM	1	0.521	0.799	860.231	860.231	-0.187	
BB01	1/1/2020 2:00:00 AM	1	0.471	0.804	777.332	777.332	0.715	
BB01	1/1/2020 3:00:00 AM	1	0.132	0.742	218.145	218.145	-5.59	
BB01	1/1/2020 4:00:00 AM	1	0.051	0.788	84.592	84.592	-3.627	
BB01	1/1/2020 5:00:00 AM	1	0.075	0.796	123.773	123.773	-1.088	
BB01	1/1/2020 6:00:00 AM	1	0.012	0.765	19.321	19.321	4.653	
BB01	1/1/2020 7:00:00 AM	1	0.148	0.802	244.211	244.211	-2.359	
BB01	1/1/2020 8:00:00 AM	1	0.797	0.807	1,315.736	1,315.736	-7.443	
BB01	1/1/2020 9:00:00 AM	1	0.486	0.797	801.187	801.187	-2.699	
BB01	1/1/2020 10:00:00 AM	1	0.341	0.728	563.398	563.398	-2.875	

Click Next to proceed to publishing

3.3.3 Publish the View

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

Select Data > Modify View > Publish	
Target Configuration	Summary
SQL Server 🔻	Shape and Matches
	There are 55 Matching Instances
Run Mode	Timeframe and Interval
Run Once	Your Start Time is 2020-01-01T05:00:00.000Z
Run on a Schedule	 Your End Time is * Your Time Interval gets an interpolated measurement Every 1
First Run	hour
*	
Recur every 1 hours	Publish

4. Wind Turbine Data: PI SQL Client Element Model

4.1 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. For authoring, 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.

4.2 Connect to the AF Server

Open **PI SQL Commander Lite** 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

	Data Source	
	AF Server:	PISRV01
	AF Database:	Wind Generation \checkmark
Object Explorer	Authentication	
2 B B B	✓ Trusted connection	
OLEDB Data Sources	User	
PI SQL Client	Password:	
▲ ODE Connect Refresh	Test	: Connection

For authoring 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.

4.2.1 Create a Catalog and Schema for the Report

Tip

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**.



4.3 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.



4

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**

Catalogs Master Report			
 WindGeneration Tables 	×	Drop	
▷ 🚞 Views		Create Template-Sp	ecific Data Model
Table-Value		Export Custom Data	
 Function Tat Scalar Funct 		Import Custom Data	-
Solution		Cariata	

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

Template Data Model Objects Summary Execution	Template Type Element Event Frame
	Template Wind Farm Wind Turbine

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.

Template	Template-Specific Data Model Objects	
Data Model Objects	Add Element View	
Summary	Add GetSampledValue	
Execution	Add GetSampledValues.	
	Add GetSummary	
	Add GetSummaries	
	Modify	
	Remove	

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.

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.

ew name:					
Turbine Information					
rag and drop attributes:					
🍊 Availability	Attribute	Value	Time Stamp	Unit of Measure	Erro
Hade Length Gapacity Factor	 Blade Length Cut In Speed 	Blade Length Cut In Speed			
📲 Cut In Speed 📲 Cut Out Speed 🌾 Efficiency	ICut Out Speed IManufacturer	Cut Out Speed Manufacturer			
Manufacturer	I [Model	Model Rated Power			
🔏 Operating Mode 循 Power	IRated PowerIRated Speed	Rated Power			
🖼 Rated Power 🔚 Rated Speed 骗 Total Height	ITotal Height	Total Height			
🚮 Wind Direction					
c循 Yaw Angle c循 Yaw Position					

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

Wind Turbine GetSummaries								
rag and drop attributes:	·							
🐔 Availability	Attribute	Calculation Basis	Summary	Туре	Value	Timestamp	Unit of Measure	Erro
📲 Blade Length	Availability	TimeWeighted ~	Average	~	Availability			
Kapacity Factor	ICapacity Factor	TimeWeighted ~	Average	~	Capacity Factor			
🔚 Cut In Speed 🔚 Cut Out Speed	Efficiency	TimeWeighted ~	Average	~	Efficiency			
Efficiency	IPower	TimeWeighted ~	Average	~	Power			
Manufacturer	IYaw Angle	TimeWeighted ~	Average	~	Yaw Angle			
🔚 Model 🍊 Operating Mode	I Power	TimeWeighted ~	Total	~	Energy			
🔏 Power							J	
Rated Power								
📑 Rated Speed								
骗 Total Height								
Kind Direction								
Kind Speed								
🐔 Yaw Angle								
Kaw Position								

•	The Total Summary Type will always use a calculation basis of 1 Day
Тір	

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



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:





4.4 Enhance the Data Objects

4.4.1 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

4.4.2 Update the Turbine Information View

To add the Wind Farm information, edit the view.

```
Right click Turbine Information > Scripts > Alter View > New Query 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 [Solution].[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 **Execute** 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

4.4.3 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-Jan-20', --Start Time
'*', --End Time
'th', --Time Step
N'MostRecentTime' --Time Type
) s
```

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.





You can navigate to the Library section by using Ctrl-3 key combination.

Тір	
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5. Wind Turbine Report

5.1 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.

5.2 Tasks

- Create a new Power BI Report
 - o Connect the report to PI Integrator Data
 - o 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

5.3 Create a new Power BI Report

To build the report, first open Power BI Desktop.

On the splash screen, choose Get Data.


5.3.1 Option 1 – Connect the report to PI Integrator Data

After choosing **Get data**, a new screen appears to assist with the data source connection. To bring this up in the future, click on **Get data** in the ribbon



To use the data published by the PI Integrator, choose **SQL Server database** from the list.

Get Data		
Search	Database	
All	SQL Server database	^
File	Import data from a SQL Server database.	
Database	SQL Server Analysis Services database	
	Oracle database	

On the database connection screen, choose:

Server: PISRV01

Database: PI_World

Data Connectivity Mode: Import

SQL Server database		
Server ① PISRV01		
Database (optional) PI_World		
PI_Wond		
Data Connectivity mode 🕡		
• Import		
O DirectQuery		
> Advanced options		
	ОК	Cancel

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**.

It is important that the **Turbine Information** table be filtered to return only the latest result. If **Load** was clicked, don't worry, just click **Transform Data** from the Home tab of the ribbon



This opens the 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** > **IsLatest**

Queries [4]	<		1 ² 3 Id	- A	^B c Wind Farm 💌 💌 Tir	meStamp	→ A ^B _C	Wind Turbine	▼ 1.2 Blade	Lengt
Turbine Information		1		₽↓	Sort Ascending		BB	01		
Turbine Data 1h Summary		2		Z↓	Sort Descending		BB	01		
Turbine Data 1h Summary (2)		3			Clear Sort			Equals		
Turbine Information (2)		4			Clear Filter		-	Before		
		5 6		Remove Empty			After			
		7			Date/Time Filters	Þ		Between		
		8			Search			In the Next		
		9			Colored All			In the Previous		
		10			✓ (Select All)	~				
		11			✓ 1/1/2020 12:00:00 AM			ls Earliest		
		12			✓ 1/2/2020 12:00:00 AM			Is Latest		
		13			✓ 1/3/2020 12:00:00 AM			Is Not Earliest		
		14			 1/4/2020 12:00:00 AM 1/5/2020 12:00:00 AM 			ls Not 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



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

Click on Get data in the ribbon.



To use the data using PI SQL Client, choose **OLE DB** from the **Other** category of connections.

Search	Other	
All	Spark	
File	R script	
Database	Python script	
Power Platform	♦ ODBC	
Azure	♦ OLE DB	
Online Services	BI360 – Budgeting & Financial Reporting (Beta)	

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

Provider: PI SQL Client

AF Server: PISRV01

AF Database: Wind Generation

Trusted Connection: Checked

ovider Connection Advanced All							
Select the data you want to connect to: OLE DB Provider(s)							
Microsoft Office 12.0 Access Database Engine OLE D	P. Dravidar	Data Source					
Microsoft Office 12.0 Access Database Engine OLE DI Microsoft Office 16.0 Access Database Engine OLE DI		AF Server:		PISRV01			
Microsoft OI E DB Driver for SQL Server	b Provider						
Microsoft OLE DB Driver for SQL Server Microsoft OLE DB Provider for Analysis Services 11.0		AF Database:		Wind Gen	eration	\sim	
Microsoft OLE DB Provider for Analysis Services 11.0 Microsoft OLE DB Provider for Analysis Services 14.0							
Microsoft OLE DB Provider for Analysis Services 14.0 Microsoft OLE DB Provider for ODBC Drivers		Authentication	n				
Microsoft OLE DB Provider for OBBC Drivers		Trusted co	onnection				
Microsoft OLE DB Provider for SQL Server							
Microsoft OLE DB Frovider for Ode Derver		User					
MSDataShape							
OLE DB Provider for Microsoft Directory Services		Password:					
OLE DB Provider for SQL Server Integration Services							
PI SQL Client			Test C	Connection			
SQL Server Native Client 11.0							
SQL Server Native Client RDA 11.0	~						
	Next>>						
	I CALLY						

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

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

n oneneg								
	OLEDB provider ×							
Default or Custom	\diamond data source="Wind Generation";location=PISRV01;p							
Windows	Use your Windows credentials to access a data source with an OLE DB provider.							
	 Use my current credentials 							
Database	O Use alternate credentials							
	User name							
	Password							
	Credential connection string properties (optional) 🕕							
	Back Connect Cancel							

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.

5.4 Connect the two tables

At this point, the report will have two tables, either from the SQL Server (PI Integrator) or PI SQL Client. If both sets of tables have been imported, choose one set and delete the other.

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, click on 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:







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



5.5 Add Visuals to the Report

Start by adding a Title. From the Home tab of the ribbon, choose **Text Box**.

Set the font size to 36

Type Wind Generation Overview



5.5.1 Create a Funnel Chart to show Energy by Wind Farm

Click on the Funnel Chart under Visualizations 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



5.5.2 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 continuity in visualizations.

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

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

Availability 66.24K 0.00K 132.47K

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**.

$\Box \Sigma$ Availability
S Canacity Factor

File Hom	ne Insert M	odeling	View Help	Table	tools Column tools					
🖉 Name 🛛 A	vailability	\$% Form	at General	~	∑ Summarization Sum	~	∎ţ			
123 Data type	ecimal number 🛛 🗸	\$ ~ %	9 .00 Auto	\$	Data category Uncategorized	~	Sort by column →	Data groups 🗸	Manage relationships	New column
St	ructure		Formatting		Properties		Sort	Groups	Relationships	Calculations

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.

File	Home Insert	Mo	deling	View	Help	Table	tools	Column to	ools					
🖉 Name	Availability		\$% Fa	rmat Perce	entage	~	∑ Su	mmarization	Average	~	₽ţ			
123 Data t	ype Decimal number	~	\$ ~ 9	6 9 .00	2	Ĵ	🗄 Da	ita category	Uncategorized	~	Sort by column →	Data groups 🗸	Manage relationships	New column
	Structure			Forma	atting			Pro	perties		Sort	Groups	Relationships	Calculations

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

5.5.3 Add a trend showing Power over time

ଲ Add a Line Chart \bowtie to the report. Axis For the Axis, choose Timestamp from Turbine Data 1h Summary. In the dropdown, change from **Date Hierarchy** to **Timestamp**. TimeStamp $\sim \times$ For the Values, choose Power from Turbine Data 1h Summary. Also add Rated Legend **Power** from the **Turbine Information** Add data fields here Ensure that **Power** and **Rated Power** are aggregated as a **Sum** Values Power $\vee \times$ Rated Power Power and Rated Power by TimeStamp Power Rated Power and Rated Por 508 TimeStamp

Values

5.5.4 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.

				values	
Wind Farm	Rated Power	Power	Average of Power	Wind Farm	× ×
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	Rated Power	$\sim \times$
Mid Mesa Wind Farm	38,900.00	16,685,102.44	567.52	Power	~ x
Pine Wolf Wind Farm	20,000.00	9,324,097.01	634.29	Fower	<u> </u>
Total	112,900.00	48,346,047.81	597.97	Average of Power	$\sim \times$

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 measure i 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

File	e Hom	e Insert	Modeling	View	Help	Table t	tools	Measure tools		
,		Combined Powe Turbine Data 1h	/	General % ୨ ⊰%	Auto	~ ~		Data category tegorized 🗸	New Qu measure mea	lick
	St	ructure		Form	atting			Properties	Calculations	5
000	$\times \checkmark$	1 Combined	Power = SUM('	Turbine Dat	a 1h Su	mmary'[Po	wer])/D	ISTINCTCOUNT('Tu	rbine Data 1h	n Summary'[TimeStamp])

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

5.5.5 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

Field	
TimeStamp 🗸	×

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

TimeS	tam	Р		
Last	~	7	Days	~
2/25	/2020) - 3/2/20)20	

5.6 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.



5.6.1 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**

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

\wedge Page information	
Name	
Wind Farm Tooltip	∧ Page size
Tooltip	Туре
On —	Tooltip ~

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

Page view~		Phone layout	
. 🕄	Fit	to page	
₽	Fit	to width	
100	Ac	tual size	1

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**



5.6.2 Add visuals to the tooltip page

Add a **Stacked Bar Chart** Let 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



5.6.3 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

🔎 Search				
∧ Boldel	UII U —			
∧ Tooltip	On —			
Туре				
Report page	~			
Page				
Wind Farm Tooltip \sim				

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

6.1 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.

6.2 Tasks

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

6.3 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**

≡				Turbine Downtime		n r In PISCHOOL\student01 Ø
Select Data >	Modify View > Publish					Next
바방 Source Events		~	바람 Search Shape		✓ Matches	
Server	PISRV01	Ŧ	바망 Event Shape			
Database	Wind Generation	* *				
Enter Event nam	ne or string match pattern					
Event Frames A	Assets					
▶ ^H Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3	Í				
▶ H Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3					
▶ ^{Hed} Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3					
▶ ^{HH} Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3					
▶ ^{HH} Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3					
▶ Htt Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3					

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

≡			Turbine Downtime	state and the state of the sta
Select Data >	Modify View > Publish			Next
Hid Source Events		~	바랭 Search Shape	✓ Matches
Server	PISRV01	•	High Event Shape	Found 1 Match
Database	Wind Generation 2	•	1행 Downtime - Big Buffalo Wind Farm - BB01 - High Winds - 2019-12-30 🌶 🗙	배영 Downtime - Big Buffalo Wind Farm - BB01 - High Winds - 2019-12-30
Downtime Event Frames	Assets			
▶ 🖽 Downtime - Big	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3			
▶ ^{Hel} Downtime - Big	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3			
▶ 변체 Downtime - Bin	Ruffalo Wind Farm - RR01 - Hinh Winds - 2019-12-3 Show More			

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

≡			Turbine Downtime	<table-cell-rows> 🖻 📩 PISCHOOL\student01 👁</table-cell-rows>
Select Data >	Modify View > Publish			Next
바방 Source Events		\mathbf{v}	바령 Search Shape	✓ Matches
Server	PISRV01	•	^H 성 Event Shape	Found 1 Match
Database	Wind Generation 2	-	🔺 🇺 Downtime - Big Buffalo Wind Farm - BB01 - High Winds - 2019-12-30 🖋 🕱	▶ Hổ Downtime - Big Buffalo Wind Farm - BB01 - High Winds - 2019-12-30
		•	🔊 BB01 % 🖋 🗙	
T Downtime				
Event Frames	Assets			
▲ Howntime - Big	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3	-		
🔊 BB01		Q		
▶ H划 Downtime - Ria I	Ruffalo Wind Farm - RR01 - Hinh Winds - 2019-12-3 Show More	•		

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

≡	Turbine Downtime			
Select Data > Modify View > Publish				Next
Httl Source Events	~	변경 Search Shape		✓ Matches
Server PISRV01	v	바령 Event Shape		Found 100+ Matches
Database Wind Generation	ο,	▲ ™ Downtime	<i>∦</i> ×	Hig Downtime - Pine Wolf Wind Farm - PW03 - Planned Maintenance
		I Reason	₫×	Howman - Big Buffalo Wind Farm - BB02 - High Winds - 2019-12
Downtime		🔊 Wind Turbine	°6 🖋 🗙	High Downtime - Big Buffalo Wind Farm - BB01 - High Winds - 2019-12
Event Frames Assets				High Downtime - Big Buffalo Wind Farm - BB03 - High Winds - 2019-12
▲ Hig Downtime - Big Buffalo Wind Farm - BB01 - High Winds - 2019-12-3.				High Downtime - Big Buffalo Wind Farm - BB04 - High Winds - 2019-12
@ BB01	Q			High Downtime - Big Buffalo Wind Farm - BB05 - High Winds - 2019-12
Hit Downtime - Bin Buffalo Wind Farm - BB01 - Hinh Winds - 2019-12-3				▶ 바莺 Downtime - Big Buffalo Wind Farm - BB06 - High Winds - 2019-12
Show More				▶ 🗺 Downtime - Big Buffalo Wind Farm - BB07 - High Winds - 2019-12
				High Downtime - Big Buffalo Wind Farm - BB08 - High Winds - 2019-12
				High Downtime - Big Buffalo Wind Farm - BB09 - High Winds - 2019-12
Attributes Filter	×			Howman - Big Buffalo Wind Farm - BB10 - High Winds - 2019-12
Select All				High Downtime - Big Buffalo Wind Farm - BB13 - High Winds - 2019-12
	0			▶ 🔤 Downtime - Big Buffalo Wind Farm - BB14 - High Winds - 2019-12
III Turbine	0			▶ 148 Downtime - Big Buffalo Wind Farm - BB12 - High Winds - 2019-12
III Wind Farm				▶ 时 Downtime - Big Buffalo Wind Farm - BB15 - High Winds - 2019-12
				▶ 바‡ Downtime - Big Buffalo Wind Farm - BB11 - High Winds - 2019-12 ▼

Click Next to go to the Modify View Page

6.4 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-Jan-20

Ξ.	Turbine Down	time		5 et 1	PISCHOOL\student01
Select Data > Modify View > Publish					Back Next
+ Add Column I C Edit Row Filters I Edit Value Mode	St	lart Time	End Time		-
7 columns 0 Row Filters Summarized Values		1-Jan-20	*	000	Apply
Downtime	Event Frame Start Tim	e Event Frame End Time	Event Frame Duration	TimeStamp Reason	Wind Turbine
Downtime - Pine Wolf Wind Farm - PW03 - Planned Maintenance - 2019-12-30 03:20:00	12/30/2019 3:20:00 AM	12/30/2019 10:45:00 AM	7.417	12/30/2019 10:4! Planned Ma	ii PW03
Downtime - Big Buffalo Wind Farm - BB02 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB02
Downtime - Big Buffalo Wind Farm - BB01 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:25:00 AM	1.667	12/30/2019 7:25: High Winds	BB01
Downtime - Big Buffalo Wind Farm - BB03 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB03
Downtime - Big Buffalo Wind Farm - BB04 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB04
Downtime - Big Buffalo Wind Farm - BB05 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB05
Downtime - Big Buffalo Wind Farm - BB06 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB06
Downtime - Big Buffalo Wind Farm - BB07 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB07
Downtime - Big Buffalo Wind Farm - BB08 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30 High Winds	BB08
Downtime - Big Buffalo Wind Farm - BB09 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB09
Downtime - Big Buffaio Wind Farm - BB10 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB10
Downtime - Big Buffalo Wind Farm - BB13 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB13
Downtime - Big Buffalo Wind Farm - BB14 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB14
Downtime - Big Buffalo Wind Farm - BB12 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB12
Downtime - Big Buffalo Wind Farm - BB15 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:25:00 AM	1.667	12/30/2019 7:25: High Winds	BB15
Downtime - Big Buffalo Wind Farm - BB11 - High Winds - 2019-12-30 05:45:00	12/30/2019 5:45:00 AM	12/30/2019 7:30:00 AM	1.750	12/30/2019 7:30: High Winds	BB11
Downtime - Desert Lake Wind Farm - DL06 - No Wind - 2019-12-30 06:30:00	12/30/2019 6:30:00 AM	12/30/2019 6:35:00 AM	0.083	12/30/2019 6:35: No Wind	DL06

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

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

≡	Turbin
Select Data > Modify View > Publish	
Target Configuration	Summary
SQL Server 🔻	Shape and Matches
	There are 100+ Matching Instances
Run Mode	Timeframe and Interval
Run Once	• Your Start Time is 2019-12-30T10:45:00.000Z
Run on a Schedule	 Your End Time is * Your Time Interval gets an interpolated measurement Every 1
First Run	minute
* 1000	
Recur every 5 minutes	Publish

Click Publish

7. Incorporate Downtime Data into the Report

7.1 Overview

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

7.2 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

7.3 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.



7.4 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.



7.5 Create a Chart of Downtime by Wind Farm

In the Report View, add a Clustered Column Chart ¹¹ with the following fields:

Axis: Wind Farm from Turbine Information

Values: **Duration** from Turbine Downtime



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

7.6 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 \blacksquare icon on the left side.	
	New
In the Ribbon, click on the Table Tools tab and choose New Table	table
Enter the following definition for the table:	

```
Date = Calendar( Date(2020, 1, 1), TODAY())
```

Hit Enter

This will create a table with dates from 1-Jan-2020 to Today.

File	e Home Help	Table tools
$\langle \rangle$	Name Date	Mark as date Manage New Quick New New
		Mark as date Manage New Quick New table • relationships measure measure column table
	Structure	Calendars Relationships Calculations
000	× ✓ 1 Date = 0	alendar(Date(2020, 1, 1), TODAY())
m	Date 💌	
	1/1/2020 12:00:00 AM	
ŧ.	1/2/2020 12:00:00 AM	
28	1/3/2020 12:00:00 AM	
	1/4/2020 12:00:00 AM	\gtrsim
	1/5/2020 12:00:00 AM	
	1/6/2020 12:00:00 AM	
	1/7/2020 12:00:00 AM	
	1/8/2020 12:00:00 AM	
	1/9/2020 12:00:00 AM	

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

7.6.1 Add Date Column to Turbine Data 1h Summary



To add a date column, click **Transform Data** query editor.

in the ribbon to open the

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

🕶 📔 🚽 🛛 Wind Generation Report - PI SQL Client -	Power Query Editor			
File Home Transform Add Column	iew Help			
Column From Custom Invoke Custom Examples * Column Function	ABC 122 Extract • Format BC Parse •	XO ∑ III Statistics Standard Scientific III Inform	ling - Data	Time Duration
General	From Text	From Age		n Date & Time
Queries [3]		Date Only Date Only Parse	v 🕞	 1.2 Capacity Fa
💷 Turbine Data 1h Summary	1 BB01	1/1/2 Year	•	1
Turbine Information	2 BB01	1/1/2 Month	•	1
III Turbine Downtime	3 BB01	1/1/2 Quarter	•	1
	4 BB01	1/1/2 Week	•	1
	5 BB01	1/1/2 Day		1
	6 BB01	1/1/2 Subtract	Dave	1
	7 BB01	1/1/2	Date and Time	1
	8 BB01	1/1/2	Date and Time	1
	9 BB01	1/1/2 Earliest		1
	10 BB01	1/1/20 Latest		1
	11 BB01	1/1/2020 11:00:00 AN	1	1
	12 BB01	1/1/2020 12:00:00 PN	1	1
	13 BB01	1/1/2020 1:00:00 PN	1	1

This will create a column called Date

7.6.2 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

7.6.3 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 .



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

7.8 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.

7.9 Tasks

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

7.10 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**

≡				Turbine Downtir	ne		☆
Select Data >	Modify View > Publish						Next
바방 Source Events		~	He Search Shape			✓ Matches	
Server	PISRV01	•	바방 Event Shape				
Database	Wind Generation 2	٣					
Enter Event nam	ne or string match pattern						
Event Frames A	Assets						
▶ ^H 성 Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3	í					
▶ ^H Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3						
▶ He Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3						
▶ ^H Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3						
▶ ^H Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3						
▶ Htt Downtime - Big B	Buffalo Wind Farm - BB01 - High Winds - 2019-12-3						

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

Ξ			Turbine Running Data		n n 1 PISCHOOL\student01
Select Data >	Modify View > Publish				Next
He Source Events		~	바랭 Search Shape		✓ Matches
Server	PISRV01	•	Httl Event Shape		Found 1 Match
Database	Wind Generation	2 ·	바뱅 Generating - Big Buffalo Wind Farm - BB01 - 2019-12-30 00:00:00	ø x	바행 Generating - Big Buffalo Wind Farm - BB01 - 2019-12-30 00:00:00
Enter Event na	me or string match pattern				
Event Frames	Assets				
▶ ^{I+} I Generating - Big	g Buffalo Wind Farm - BB01 - 2019-12-30 00:00):00			
▶ ^{He} d Generating - Big	g Buffalo Wind Farm - BB01 - 2019-12-30 07:25	5:00			
▶ ™d Generating - Big	9 Buffalo Wind Farm - BB01 - 2019-12-30 08:40	0:00			

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

Ξ			Turbine Running Data		🖘 🏕 上 PISCHOOL\student01 👁
Select Data >	Modify View > Publish				Next
Hig Source Events		~	Hd Search Shape		✓ Matches
Server	PISRV01	•	Httl Event Shape		Found 1 Match
Database	Wind Generation	ο.	Generating - Big Buffalo Wind Farm - BB01 - 2019-12-30 00:00:00 BB01	# x % # x	▶ 11행 Generating - Big Buffalo Wind Farm - BB01 - 2019-12-30 00:00:00
Enter Event na	ame or string match pattern]	00 1	
Event Frames	Assets				
▲ Hig Generating - B	lig Buffalo Wind Farm - BB01 - 2019-12-30 00:00:00				
@ BB01		Q			
▶ ^{I+d} Generating - B	lig Buffalo Wind Farm - BB01 - 2019-12-30 07:25:00				

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

≡			Turbine Running Da	ta	SCHOOL\student01
Select Data >	Modify View > Publish				Next
He Source Events		~	Hit Search Shape		✓ Matches
Server	PISRV01	•	바皮 Event Shape		Found 100+ Matches
Database	Wind Generation	C .	A He Running	ø ×	Ind Generating - Pine Wolf Wind Farm - PW04 - 2019-12-30 00:00:00
	wind Generation	~ 1	🔺 🔊 Wind Turbine	°o 🖋 🗙	High Generating - Pine Wolf Wind Farm - PW03 - 2019-12-30 00:00:00
T Enter Event na	me or string match pattern		Capacity Factor	ø ×	Hig Generating - Pine Wolf Wind Farm - PW02 - 2019-12-30 00:00:00
Event Frames	Assets		Efficiency	ø ×	High Generating - Mid Mesa Wind Farm - MM17 - 2019-12-30 00:00:00
Hill Generating - Bi	g Buffalo Wind Farm - BB01 - 2019-12-30 00:00:00		Power	₫ ×	Hig Generating - Mid Mesa Wind Farm - MM20 - 2019-12-30 00:00:00
BB01		Q	Wind Speed	₫ ×	Hig Generating - Mid Mesa Wind Farm - MM19 - 2019-12-30 00:00:00
	g Buffalo Wind Farm - BB01 - 2019-12-30 07:25:00	~	I Yaw Angle	₫ ×	Hig Generating - Mid Mesa Wind Farm - MM18 - 2019-12-30 00:00:00
g concluding bi	Show More				Hig Generating - Pine Wolf Wind Farm - PW05 - 2019-12-30 00:00:00
					High Generating - Mid Mesa Wind Farm - MM16 - 2019-12-30 00:00:00
					▶ 118 Generating - Pine Wolf Wind Farm - PW01 - 2019-12-30 00:00:00
ttributes Filter		×			Ind Generating - Pine Wolf Wind Farm - PW06 - 2019-12-30 00:00:00
					▶ ^H ở Generating - Desert Lake Wind Farm - DL02 - 2019-12-30 00:00:00
Select All					▶ ¹⁴ 8 Generating - Pine Wolf Wind Farm - PW08 - 2019-12-30 00:00:00
Availability		0			▶ 1년 Generating - Pine Wolf Wind Farm - PW09 - 2019-12-30 00:00:00
🔳 Blade Length		0			▶ ^H ổ Generating - Pine Wolf Wind Farm - PW10 - 2019-12-30 00:00:00
Capacity Factor	r	0			▶ 배성 Generating - Desert Lake Wind Farm - DL01 - 2019-12-30 00:00:00
🔳 Cut In Speed		0			Hill Generating - Desert Lake Wind Farm - DL03 - 2019-12-30 00:00:00

Click Next to go to the Modify View Page

7.11 Configure the Event View to publish sampled data

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

Edit Value Mode Summarized Values	
Edit Value Mode	×
 Summarized Values Sampled Values Sample values every 5 minutes • Interpolate • Exact • Use Key Column Capacity Factor • 	
	Cancel Save Changes

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

Remove the Event Frame Duration column, as it will not be needed.

For consistency with the other views, set the Start Time to 1-Jan-20

=				Turbine	Running Data			•	PISCHOOL\studen
Select Data > M	lodify View > Pub	olish				ß			Back
Add Column	T Edit Row Filters	Edit Value M			Start Time		End Time		-
10 columns	0 Row Filters	Interpolated Val Every 5 minutes			1/1/20 12:00 AM		•		Apply
Running	Event Frame Start Time	Event Frame End Time	TimeStamp	Wind Turbine	Capacity Factor	Efficiency	Power	Wind Speed	Yaw Angle
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
Senerating - 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
enerating - 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
Senerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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
enerating - 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

Select Data > Modify View > Publish

Target Configuration		Summary
SQL Server	•	Shape and Matches
		There are 100+ Matching Instances
Run Mode		Timeframe and Interval
Run Once		• Your Start Time is 2020-01-01T05:00:00.000Z
Run on a Schedule		Your End Time is * Your Time Interval gets an interpolated measurement Every 5
First Run		minutes
* [000		
Recur every 5 minutes		Publish

Click on **Publish**

8. Incorporate the Running Data into the Report

8.1 **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







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8.2 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

8.3 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.

Recent sources ~	Transform Refr data v		ext More	New measure	Quick measure	Publish
Most red		=PISQLClient.1;d	ata source="	Wind Ger	neration";I	ocation=PISRV01)
PISF	RV01: PI_World	I				
Мо	re					

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**.

Join Turbine Running Data to Date on the Date field

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



8.4 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

Values Add data fields here	Values Add data fields here
Drillthrough	Drillthrough
Cross-report	Cross-report
Off O —	Off O —
Keep all filters	Keep all filters
Off O —	Off O —
Add drillthrough fields here	Wind Farm
Add drillthrough fields here	is Big Buffalo Wind Farm Allow drillthrough when:
Add drillthrough fields here	is Big Buffalo Wind Farm Allow drillthrough when: Used as category •
Add drillthrough fields here	is Big Buffalo Wind Farm Allow drillthrough when:
Add drillthrough fields here	is Big Buffalo Wind Farm Allow drillthrough when: Used as category ▼ ✓ Big Buffalo Wind Farm 15

Notice that a **Back Button** on we 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.

8.5 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: <u>http://www.wind-power-program.com/turbine_characteristics.htm</u>

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.

8.5.1 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

	S			
Name	Wind Speed (bins)	Field	Wind Speed	
Group type	Bin	•		
Binning split	s numeric or date/time data into	o equally sized groups. Enter bi	in size.	

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



Power by Wind Speed (bins) and Wind Turbine

8.5.2 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**



8.6 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**.

	■ <mark>7</mark> @
	🔎 Search
Fields	∨ Data label
First Wind Farm $\checkmark \times$	✓ Category label Off O—

Mid Mesa Wind Farm



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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.


8.7 Copy and sync the date slicer

Copy the **Date** slicer from the **Wind Generation Overview** onto the **Wind Farm Details** page. An 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.



8.8 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.

Big Buffalo Wind Farm

Wind Turbine	Manufacturer	Model	Rated Power	Combined Power	Efficiency	Availability	Capacit	y Factor	^
BB01	Siemens	ST4	1,650	698	96 %	87 %		42 %	
BB02	Siemens	ST4	1,650	687	95 %	87 %		42 %	
BB03	Siemens	ST4	1,650	654	97 %	83 %		40 %	
BB04	Siemens	ST4	1,650	553	76 %	86 %		33 %	
BB05	Siemens	ST4	1,650	586	97 %	72 %		36 %	
BB06	Siemens	ST4	1,650	678	93 %	87 %		41 %	
BB07	Siemens	ST4	1,650	691	98 %	85 %		42 %	
BB08	Siemens	ST4	1,650	574	97 %	72 %		35 %	
BB09	Siemens	ST4	1,650	706	96 %	87 %		43 %	
BB10	Siemens	ST4	1,650	706	97 %	87 %		43 %	
BB11	GE	1.5s	1,500	601	99 %	79 %		40 %	
BB12	GE	1.5s	1,500	576	93 %	79 %		38 %	
BB13	GE	1.5s	1,500	502	96 %	66 %		33 %	
BB14	GE	1.5s	1.500	639	97 %	87 %		43 %	~
Total			24,000	9,357	95 %	81 %		39 %	





 \bigotimes

Date

Last \vee 7

3/3/2020 - 3/9/2020

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Downtime by Wind Turbine and Reason









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

9.1 Overview

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

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

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**

🚞 Catalogs			
⊳ 间 Master			
🔺 🧻 Report			
WindGeneration			
🚞 Tables	\times	Drop	
▷ 🚞 Views		Create Template-Sp	ecific Data Model
👂 🚞 Table-Value		3	
Function Tat		Export Custom Data	abase Objects
D b b Scalar Funct		Import Custom Data	abase Objects
Image: Solution		Scripts	•

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

Template Data Model Objects	Template Type
Data Model Objects	C Element
Summary Execution	Event Frame
Execution	Template Downtime Running

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

Set the View Name to Turbine Downtime

4

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

Event Frame View Value Column Definition

View name:

 Turbine Downtime

 Drag and drop attributes:

 Image: Comparison of the stamp in the stamp in

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.

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



9.3 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 Window

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

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

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

```
Query2.sql - PISRV01\Wind Generation* X
Query1.sql - PISRV01\Wind Generation*
ALTER VIEW [Report].[WindGeneration].[Turbine Downtime]
AS
SELECT ef.ID, ef.Name, ef.Description, v.*
, ef.PrimaryReferencedElement as [Wind Turbine]
, Double(ef.Duration, Hour) as Duration
, ef.StartTime
, ef.EndTime
FROM [Master].[EventFrame].[EventFrame] ef]
INNER JOIN [Master].[EventFrame].[EventFrameTemplate] eft ON eft.ID = ef.TemplateID
INNER JOIN [Master].[EventFrame].[Value]
```

Click **Execute** 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

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

10.1 Overview

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

10.2 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**

🚞 Catalogs			
⊳ 间 Master			
🔺 🧻 Report			
WindGeneration			
🚞 Tables	XC)rop	
▷ 🚞 Views	. 0	reate Template-Si	pecific Data Model
Table-Value	3		
Function Tat	E	xport Custom Dat	abase Objects
D Scalar Funct	Ir	mport Custom Da	tabase Objects
Image: Solution	S	cripts	•

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

Template Data Model Objects Summary Execution	Template Type O Element Image: Template Type
Execution	Template
	Downtime Running

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.

Event Frame View Value Column Definition

View name:

Turbine Running Data							
Drag and drop attributes:							
 ✓ Gapacity Factor ✓ Efficiency ✓ Energy ✓ Power - Avg ✓ Turbine ✓ Wind Farm ✓ Wind Speed - Avg 	Attribute	Value	Time Stamp	Unit of Measure	Error	Desired	Unit of Measur
						ОК	Cancel

×

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.

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

4	iews
	Turbine Data 1h Summary
	Turbine Downtime
	Turbine Information
	Turbine Running Data

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

10.3 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**

Catalogs		
Master		
🔺 🧻 Report		
WindGeneration		
🚞 Tables	\times	Drop
▷ 🚞 Views		Create Template-Specific Data Model
▷ 🚞 Table-Value		2
Function Tal		Export Custom Database Objects
D Scalar Funct		Import Custom Database Objects
Image: Solution		Scripts >

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

Template	Template Type
Data Model Objects	Template Type Element
Summary	O Event Frame
Execution	Template Wind Farm Wind Turbine

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

Table-valued function name:



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.

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

	Table-Valued Functions
\triangleright	∱ Wind Turbine_GetSampledValues
\triangleright	Mind Turbine_GetSummaries

10.4 Update the Turbine Running Data View

4

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



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 Window

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
 - o ef.PrimaryReferencedElementID
 - ef.StartTime
 - ef.EndTime

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

) s

The final query should be as follows:

```
ALTER VIEW [Solution] [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 [Solution]. [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-Jan-20'
```

```
ALTER VIEW [Solution].[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 [Solution].[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-Jan-20'
```

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

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

11. 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.

Transform I

To create this, open the Query Editor by clicking data 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).**

Change data type of the Start Time and End Time columns to Date by clicking the

symbol in the column header and choosing Date

-	📴 s	tartTime 🗾 😇	EndTime
567	1.2	Decimal Number	2/17/2020 3:0
1.5	\$	Fixed decimal number	2/3/2020 12:4
333	1 ² 3	Whole Number	2/3/2020 3:5:
.75	%	Percentage	2/3/2020 2:4
333		Date/Time	2/3/2020 12:0
333	::::	Date	2/3/2020 12:0
567		Time VS	2/2/2020 10:2
333	₿	Date/Time/Timezone	2/2/2020 9:4:
333	Ō	Duration	2/2/2020 6:2
			- /- /

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

New column name		
Date		
Custom column formula 🕠	Available columns	
<pre>= {Number.From([StartTime])Number.From([EndTime]) }</pre>	ID Name Description EventFrameID Reason Wind Turbine Duration CountTime	~
Learn about Power BI Desktop formulas		

Click OK. The column Date should now show many lists

StartTime	💌 🛄 EndTime	-	ABC Date 123	
	3/1/2020	3/1/2020	List	
1	3/1/2020	3/1/2020	List	1
1	3/1/2020	3/1/2020	List	
1	3/1/2020	3/1/2020	List	
1	3/1/2020	3/1/2020	List	
	2/1/2020	2/1/2020	Liet	

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, Start Time, and End Time

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

File Home Transform Add Column	View Help					
Jumn From Custom Invoke Custom Axamples * Column Function General	ABC ABC 123 Extract *	In the second se	Date Time Duration			
Queries [4]					Query Settings	
	🔲 🗸 🔟 Date	 A^B_C Name 	·			
Turbine Data 1h Summary	1	3/1/2020 Downtime - Desert Lake Wind Farm - DL08 - High Winds - 2020-03-01 3/1/2020 Downtime - Desert Lake Wind Farm - DL04 - High Winds - 2020-03-01		^	PROPERTIES	
Turbine Information	2				Name	
Turbine Downtime		3/1/2020 Downtime - Desert Lake Wind Farm - Di			Turbine Downtime (Linking)	
Turbine Downtime (Linking)		3/1/2020 Downtime - Desert Lake Wind Farm - D			All Properties	
		3/1/2020 Downtime - Desert Lake Wind Farm - Di				
		3/1/2020 Downtime - Desert Lake Wind Farm - D	.01 - High Winds - 2020-03-01		4 APPLIED STEPS	
		3/1/2020 Downtime - Desert Lake Wind Farm - Di			Source	1
		3/1/2020 Downtime - Big Buffalo Wind Farm - BB			Navigation	3
		3/1/2020 Downtime - Desert Lake Wind Farm - Di			Changed Type Added Custom	
		3/1/2020 Downtime - Desert Lake Wind Farm - Di	.05 - High Winds - 2020-03-01			
		3/1/2020 Downtime - Desert Lake Wind Farm - D	.03 - High Winds - 2020-03-01		Expanded Date	
		3/1/2020 Downtime - Desert Lake Wind Farm - D	•		Changed Type1	
		3/1/2020 Downtime - Desert Lake Wind Farm - D	.01 - High Winds - 2020-03-01		× Removed Other Columns	
	14	3/1/2020 Downtime - Desert Lake Wind Farm - Di	.07 - High Winds - 2020-03-01			
	15	3/1/2020 Downtime - Desert Lake Wind Farm - Di	.08 - High Winds - 2020-03-01			
	16	3/1/2020 Downtime - Desert Lake Wind Farm - Di	.04 - High Winds - 2020-03-01			
		3/1/2020 Downtime - Desert Lake Wind Farm - Di	.09 - High Winds - 2020-03-01			
		3/1/2020 Downtime - Desert Lake Wind Farm - D	.02 - High Winds - 2020-03-01			
	19	3/1/2020 Downtime - Big Buffalo Wind Farm - BB	14 - High Winds - 2020-03-01 1			
	20	3/1/2020 Downtime - Big Buffalo Wind Farm - BB	15 - High Winds - 2020-03-01 1			

11.1.1 Link the Date Table

Create relationships between the Date table and the other tables. For the relationship between the Downtime table and the linking table, double click it and set the **Cross Filter direction** to **Both**



12. 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.

12.1 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' 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
)
```

12.2 Wind Turbine_GetSampledValues

```
CREATE FUNCTION [Solution] [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
```

12.3 Turbine Information

> (

)

```
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\%'
```

12.4 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-Jan-20', --Start Time
    '*', --End Time
    '1h', --Time Step
    N'MostRecentTime' --Time Type
) s
```

12.5 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' 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\%'
```

12.6 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-Jan-20'
```



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