PowerWorld Simulator Regions

(Applies to Version 24 with a May 21, 2025 or later patch)

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Regions Overview

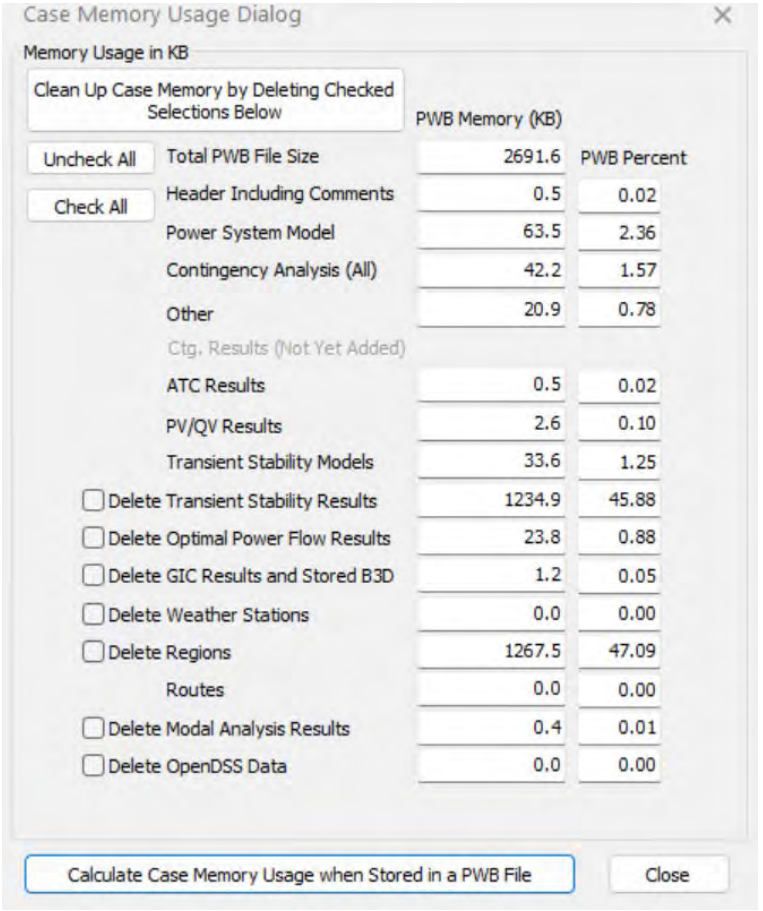
- Regions are a simple but quite powerful new PowerWorld data structure for grouping power system information by geographic region
- Regions are only defined geographically (i.e., latitude and longitude)
- A region is the geographic area defined by a boundary consisting of one or more simple polygons
  - A simple polygon is one that does not intersect itself and contains no holes
  - This structure matches what is used in shape files
  - Each of these polygons is called a **subgroup** (e.g., this allowing modeling islands); so a region can have more than one separate area
  - Regions can be used to summarize the power system components they contain, but are themselves power system independent
- Regions can be stored in the *.pwb file

Regions Overview, cont.

- Regions can be used with any PowerWorld case that has geographic information, and can easily be transferred between cases using aux files
- Power system objects (e.g., buses, generators, transmission lines and transformers) are automatically included in regions based on their geographic location
  - Power system objects are not assigned to regions
- Hence regions are power system independent and can be easily used with any power system
- Regions are objects, not display objects. However, they can, and often do, have associated oneline display objects

Aside: Clean Up Case Memory

- The addition of regions got us thinking about the need to give people a good way to see the memory used when storing a pwb file, and to easily get rid of unused information
  - Storing data in a *.pwb file is convenient but can lead to “case bloat!”
- The Case Memory Usage Dialog provides a convenient way to see the memory usage and to remove what isn’t needed



Background: Geographic Coordinate Systems

- Regions require latitude and longitude information both for the substations and the region boundary points
- Latitude and longitude values can be expressed in either degrees, minutes, seconds (DMS); or in decimal degrees; PowerWorld mostly uses decimal degrees
- The distance per degree latitude is 111.1 km, or 111.1 m per thousandth degree; distance per degree longitude varies with latitude'
- As long as the desired accuracy isn't too high (say 100 m), then latitude and longitude values can be thought of as globally unique
  - This will mostly be the case with Simulator

Background: Geographic Coordinate Systems

- Since the earth is not a perfect sphere, and the continents are moving (e.g., North America and Europe are moving apart at about 2.5 cm [an inch] per year), for higher accuracy a geodetic datum is needed (whether or not it is explicitly stated)
  - "A geodetic datum or reference frame is an abstract coordinate system with a reference surface (such as sea level) that serves to provide known locations to begin surveys and create maps." [a]
  - There are hundreds or thousands of geodetic datums!
- Luckily, there are common, global ones, with the most popular WGS84 (used in GPS systems); this is what Simulator mostly uses when importing and exporting geographic data

[a] geodesy.noaa.gov/datums/

Slide Set Example Cases and Regions

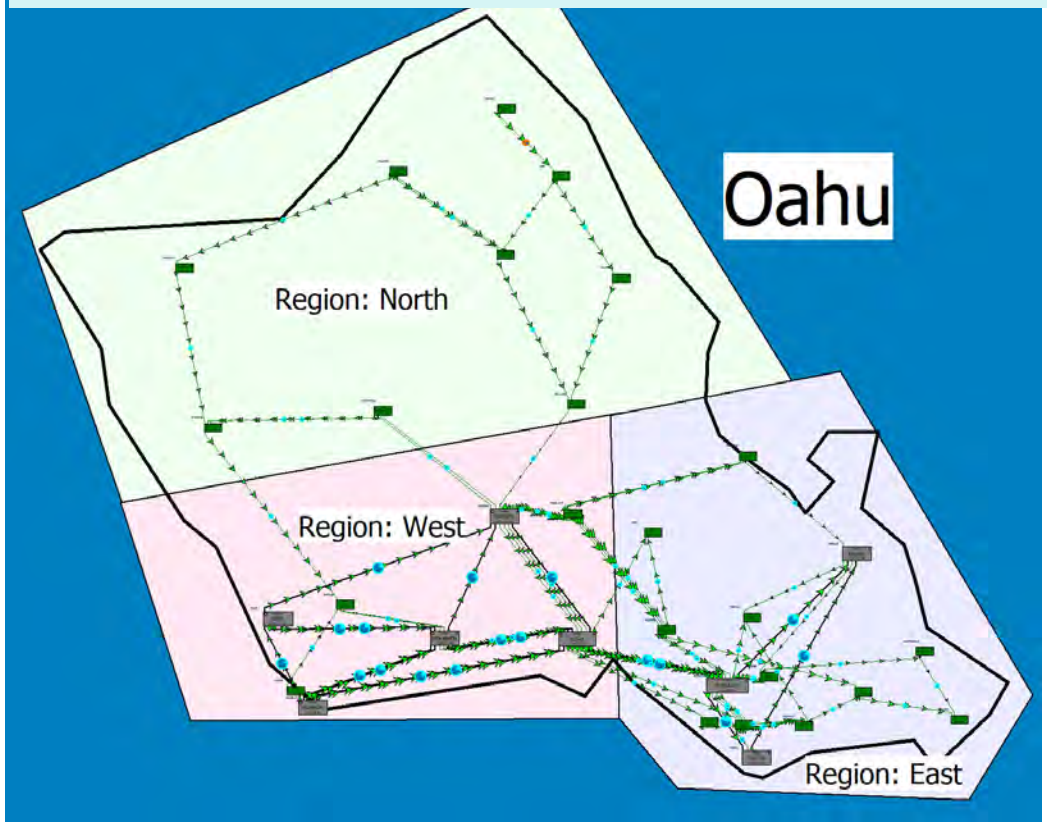
- To demonstrate regions these slides use several example cases:
  - Hawaii37Bus: a 37-bus synthetic electric grid covering the Hawaiian Island of Oahu; this case is used to demonstrate regions on a small-scale using hand-drawn regions
  - Hawaii37Bus_NoRegions: the Hawaii37Bus case except with no regions
  - Hawaii37Bus_FourRegions: the Hawaii37Bus case with four hand-drawn regions
  - Hawaii37Bus_DistrictRegions: the Hawaii37Bus case with GIS-based regions
  - CONUS82K (82K): an 82,000-bus synthetic electric grid covering the contiguous US (i.e., the lower 48 states including DC); this case is used to demonstrate regions at large-scale with recognized geographic boundaries
- All of the files used in this presentation are available at www.powerworld.com/knowledge-base/regions (in **Support Files**)

Data source for US States and Counties: www.census.gov/geographies/mapping-files/time-series/geo/carto-boundary-file.html

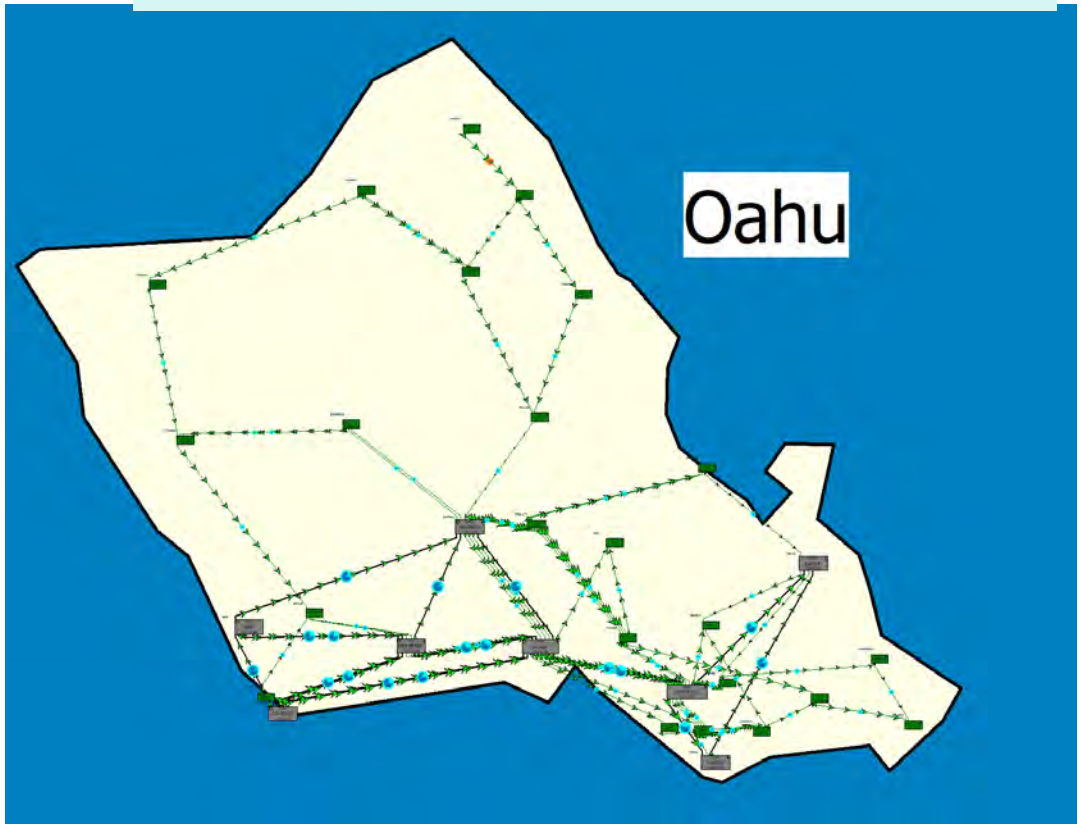
Hawaii37Bus Case

- This case has three regions, with each region having a simple name (North, West, East)

Hawaii37Bus With Three Regions

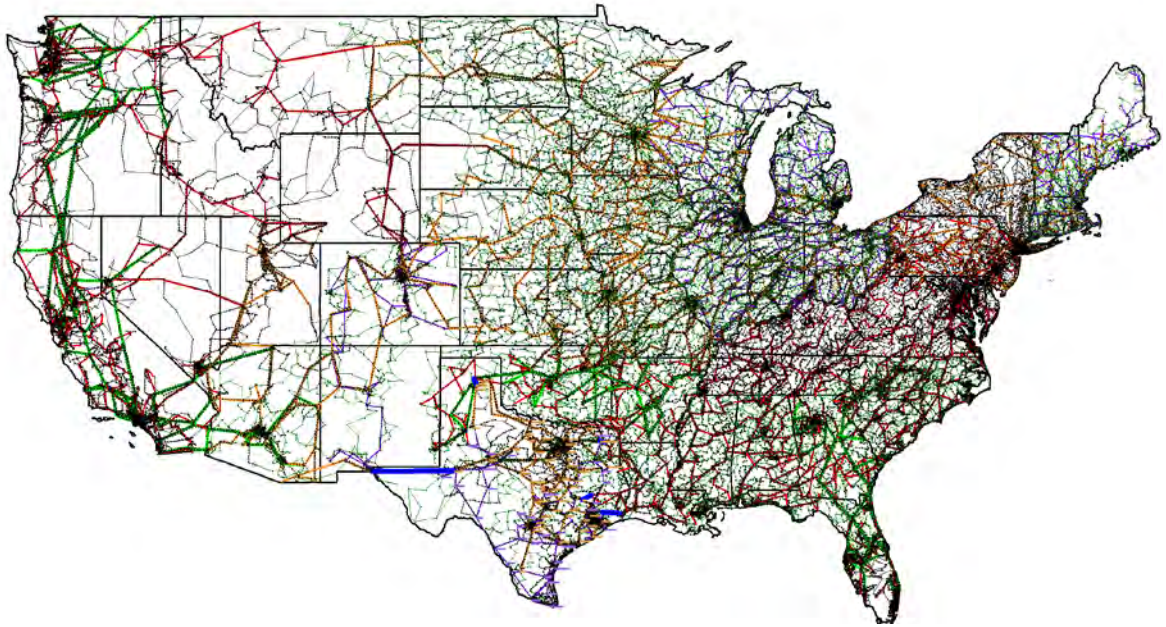


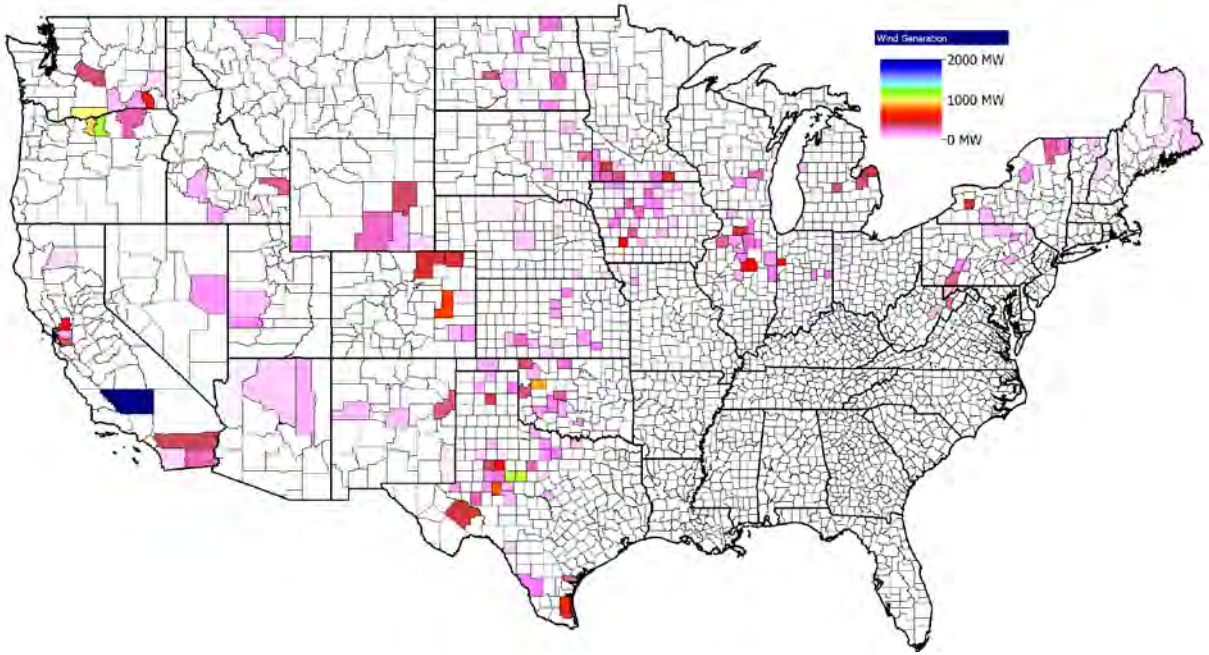
Hawaii37Bus_NoRegions



Conus82K Oneline and Counties Region Display

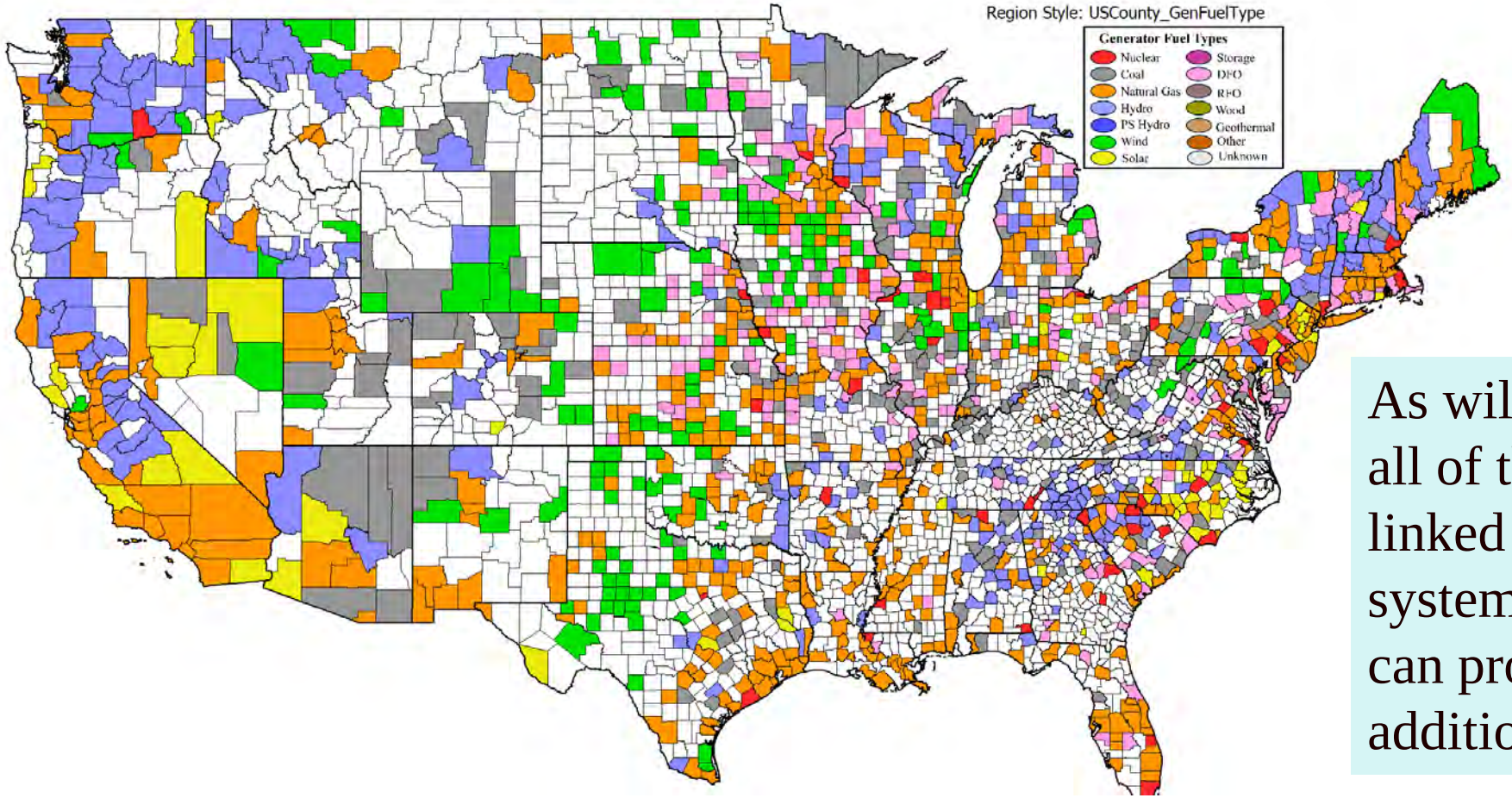
- The left image is a standard oneline for the 82K case, with the different colors used to show different transmission voltages; the right image uses regions based on the more than 3000 US counties (or equivalent) with the fill color proportional to region value (here wind generation in MW)





CONUS 82K Oneline Showing Predominant Generator Fuel Type by County

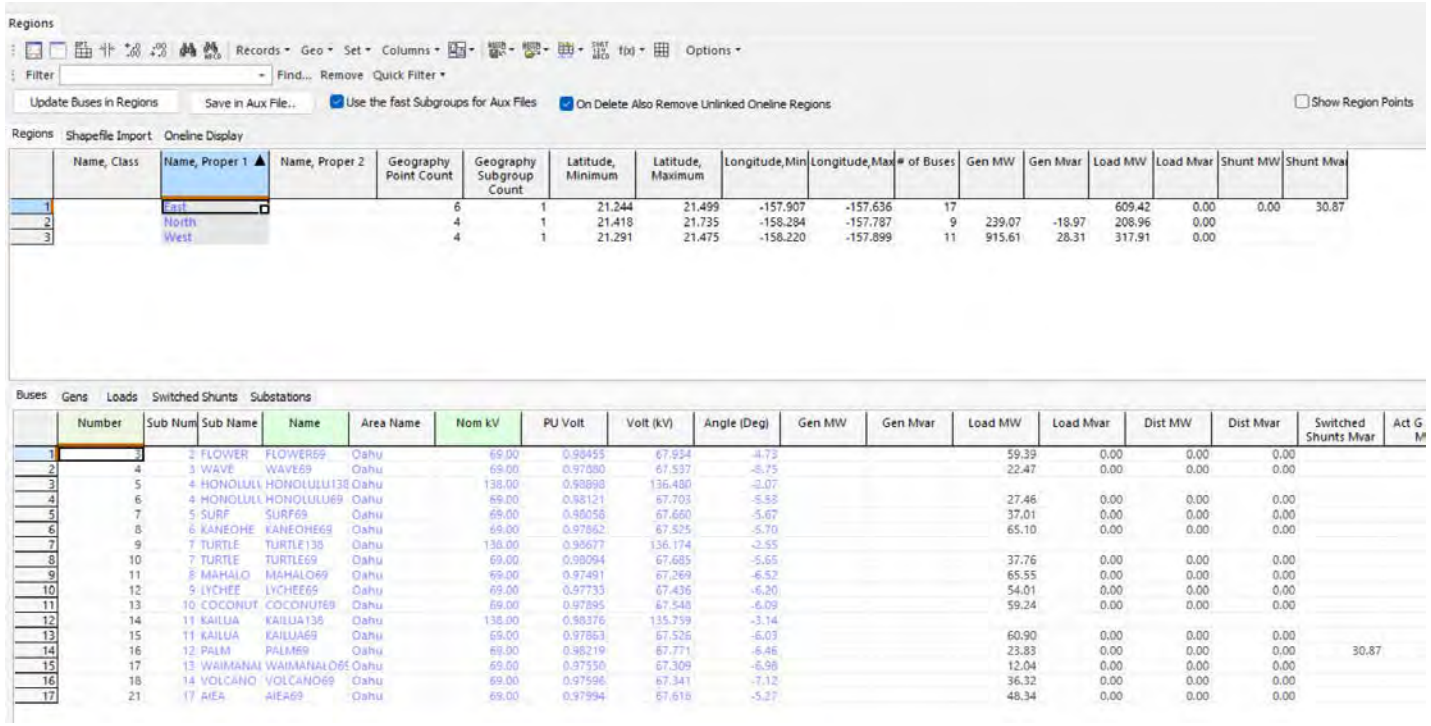
- Once regions are defined (e.g., loaded from an aux file) they can be quickly customized to show many different power system fields



As will be shown later, all of these regions are linked to the power system, so right-clicking can provide lots of additional information

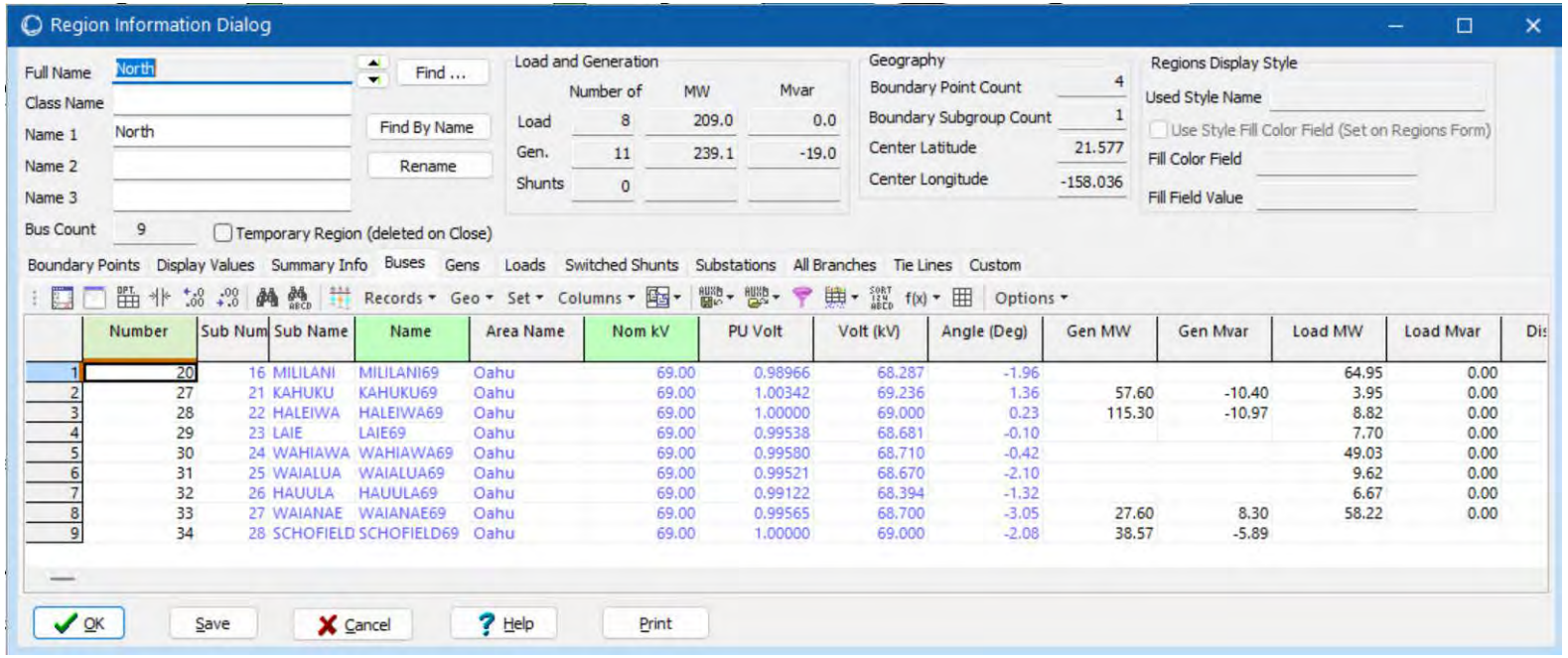
The Regions Dialog

- Regions can be shown either using the Regions Dialog or by using oneline objects
- To view the Regions Dialog from the Ribbon, select **Tools, Weather and Geography, Regions**
- The right image shows an example for the Hawaii37Bus case
- This dialog shows all the regions in the case; the bottom panel shows the power system objects in the region



The Region Information Dialog

- The Region Information Dialog shows additional information about each region; it can be displayed from the Region Display by right-clicking on any region and selecting **Show Dialog**
  - The Region Information Dialog has a number of pages for giving information on the region and its power system objects



Region Names

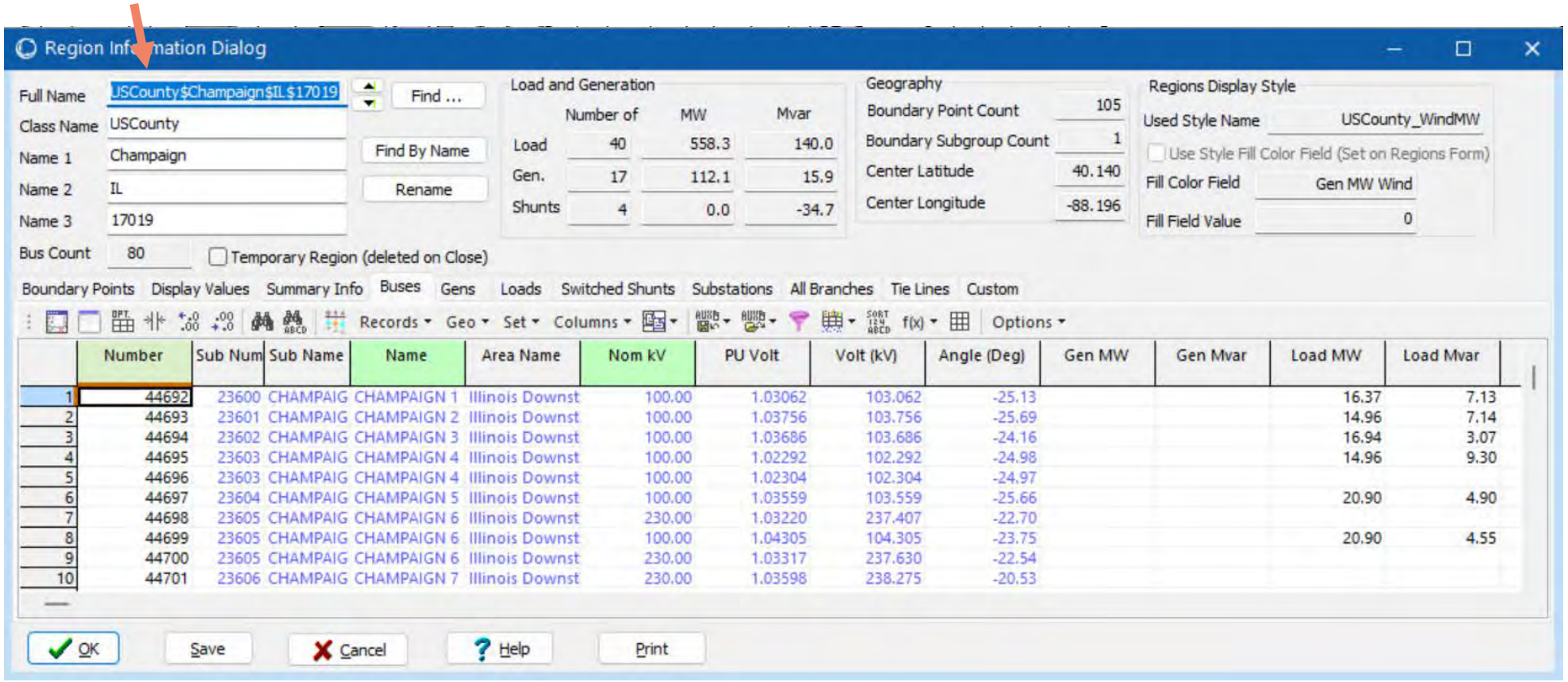
- Since actual geographic regions often have non-unique names (e.g., the name “Champaign” can refer to a city or county in several US states), in PowerWorld a region’s full name (name) is a combination of a class name and up to three proper names (Proper1, Proper2, and Proper3)
  - Sometimes all three names are needed to uniquely identify a geographic information system (GIS) region. For example, with US counties since some states allow independent cities, just the “county” name and state are insufficient (e.g., Saint Louis, MO). In the 82K example the US Census Bureau GEOIDs are used as the Proper3 name for unique identification.
  - The class name and either of the three proper names are optional, though usually Proper1 is non-empty

Region Names, cont.

- The region's full name is its key field and hence must be unique
  - All region name values are case insensitive; they cannot include commas and cannot include some other symbols (like $ since it is used as a field separator)
- The format for the full name is className$proper1$proper2$proper3
- If the full name does not contain a $ symbol, then it is defined as Proper1
- Any of the proper name fields can be omitted. For example, className$proper1$$proper3 has Proper1 and Proper3, with Proper2 blank

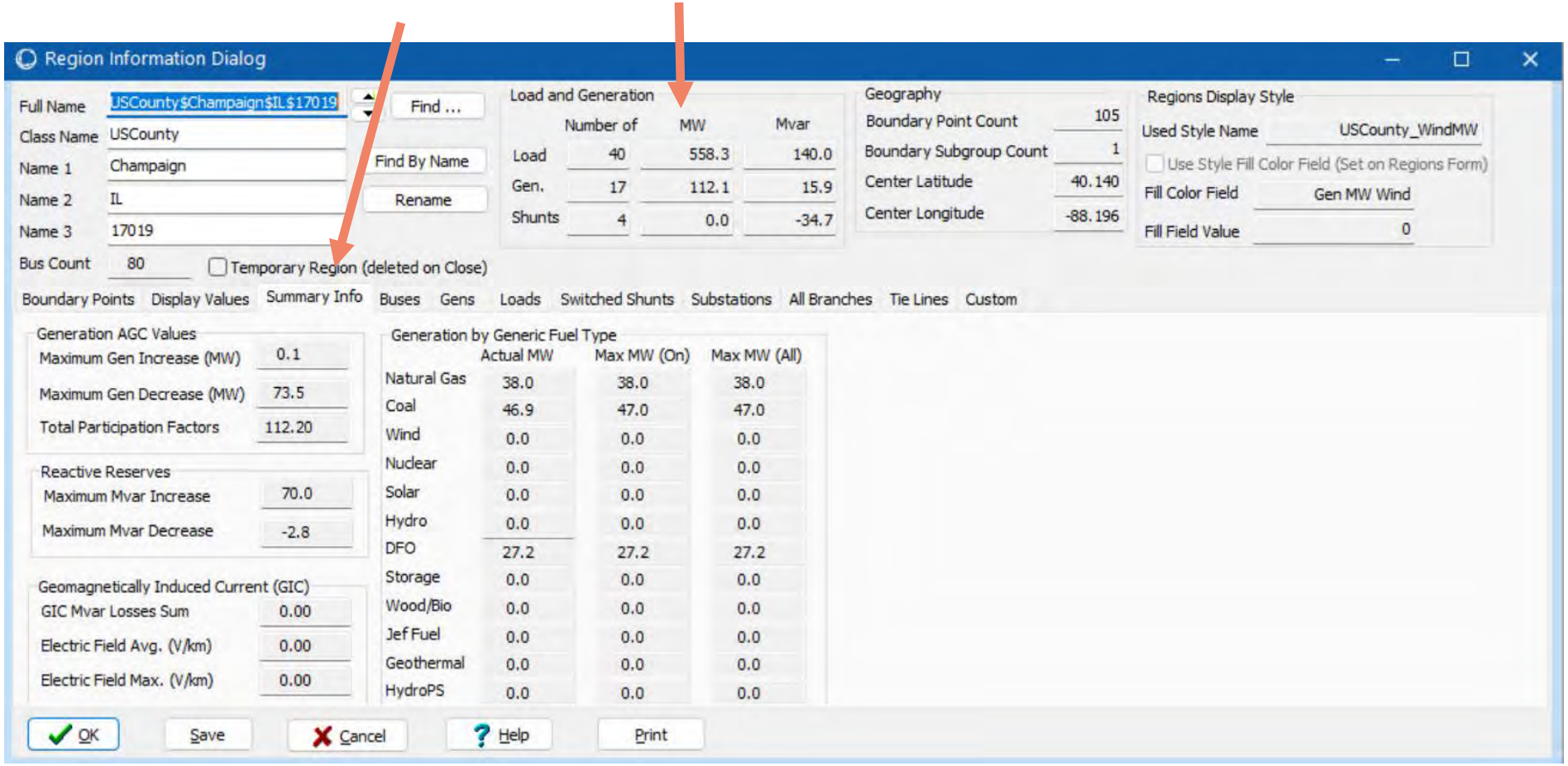
Region Name Example

- The below example shows a region information dialog for the 82K case, showing the US county of Champaign, IL
  - Note the use of the $ symbols in the Full Name



Region Information Dialog, Summary Info Page

- On the Region Information Dialog the top panel gives some power system information, with more provided on the **Summary Info** page



Adding Regions to a Case

- There are five ways to include regions in a case
  - Load a *.pwb file that already has regions defined – this will likely be the most common approach
  - Load them from an *.aux file
  - Load them from a shapefile
    - As noted by Wikipedia, “The shapefile format is a geospatial vector data format for geographic information system (GIS) software. It is developed and regulated by Esri as a mostly open specification for data interoperability among Esri and other GIS software products”; shapefiles are an old format, but are still widely used
  - Manually draw the region on a oneline
  - Use the oneline “right-click” menu to quickly insert a (most likely) “temporary” rectangular region

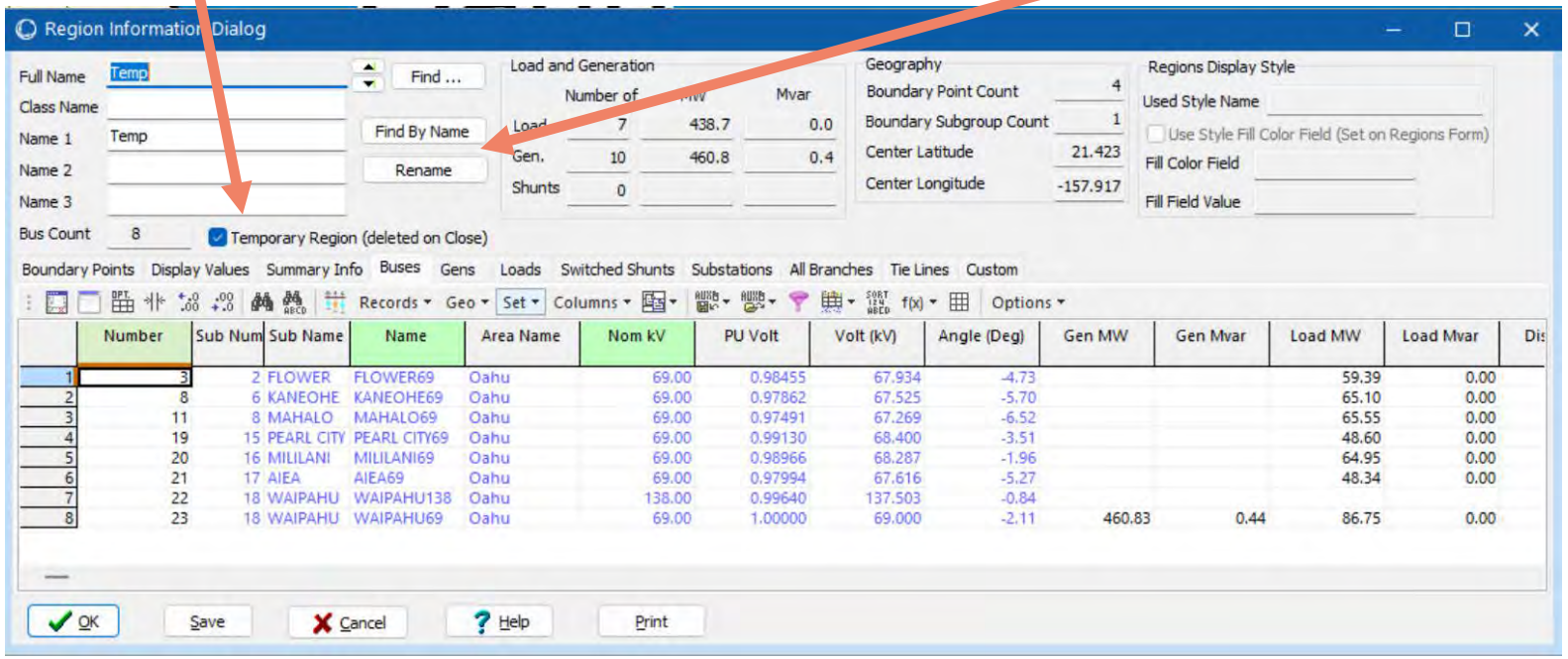
Adding Regions to a Case: Temporary Rectangular Regions

- To see an example of quickly inserting a region, open the Hawaii37Bus_NoRegions case; right-click on an empty portion of the oneline and select **View Temporary Rectangular Region**
- Then, while holding the left mouse button down, drag the cursor to define a desired regions
- This creates a region that contains the objects in the rectangle

A Rectangular Region can be created in the **Run Mode** or in the **Edit Mode**

Adding Regions to a Case: Temporary Rectangular Regions

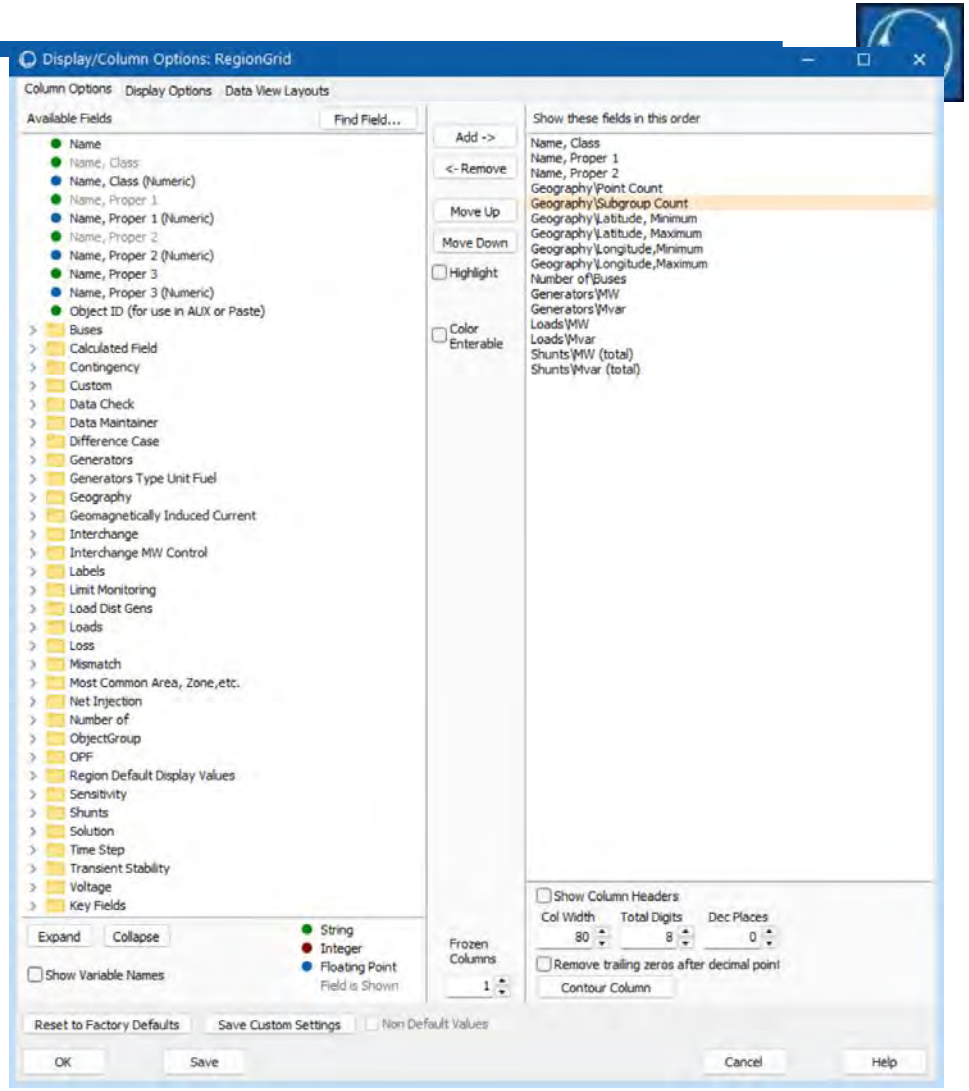
- By default, this is a temporary region, meaning it is automatically deleted when the dialog is closed; you can make this a permanent region either by unchecking the **Temporary Region** checkbox, or renaming it



To rename a region, enter a new **Class Name**, **Name 1, Name 2,** and/or **Name 3** (any of which can be blank) and select **Rename**; the new name must be unique

Regions Versus Areas and Zones

- Regions are designed to compliment the traditional area and zone object types; they have some similarities and some differences
- A key similarity is both summarize the contained power system objects, so they have many similar fields that be shown using the **Display/Column** options

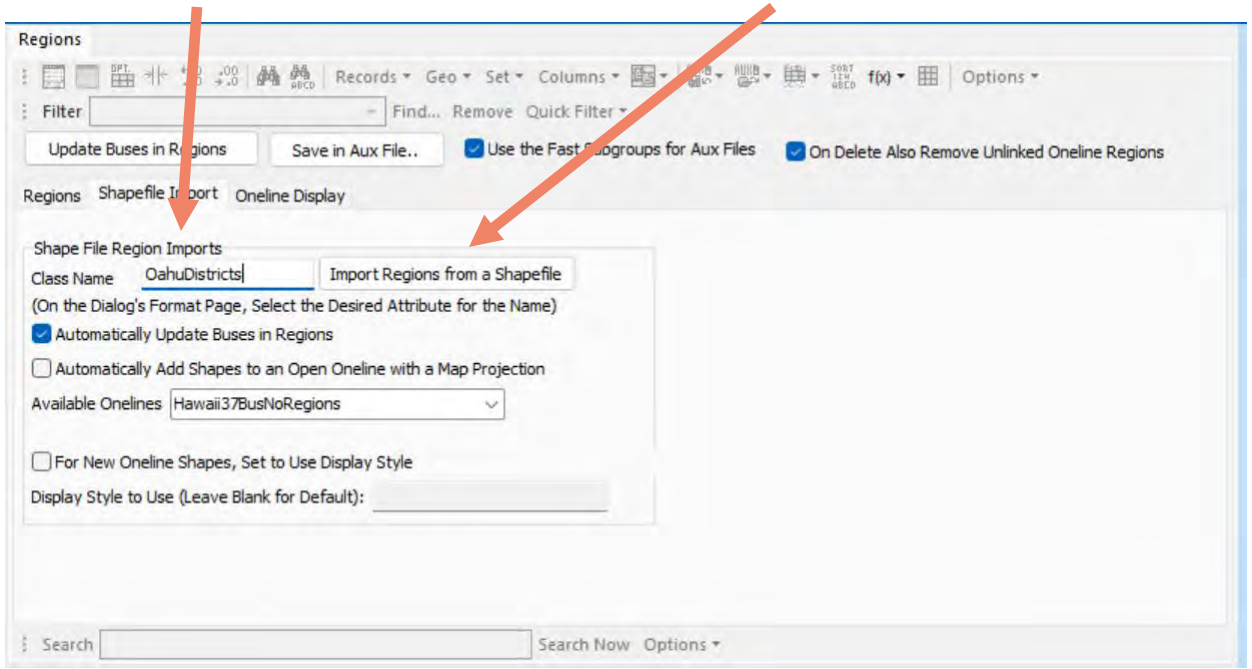


Regions Versus Areas and Zones, cont.

- Key differences are
  - Areas/Zones
    - Power system objects can only be in a single area and a single zone
    - Power system objects are assigned
    - Areas/zones are power system dependent, and need to be updated when the power system number of objects are changed
    - Do not require geographic coordinates
  - Regions
    - A power system object can be in any number of regions
    - Power systems objects are in regions based on their geographic location
    - Regions are power system independent, so regions can be easily used with other cases
    - Require the case have geographic coordinates

Adding Regions to a Case: Shapefiles

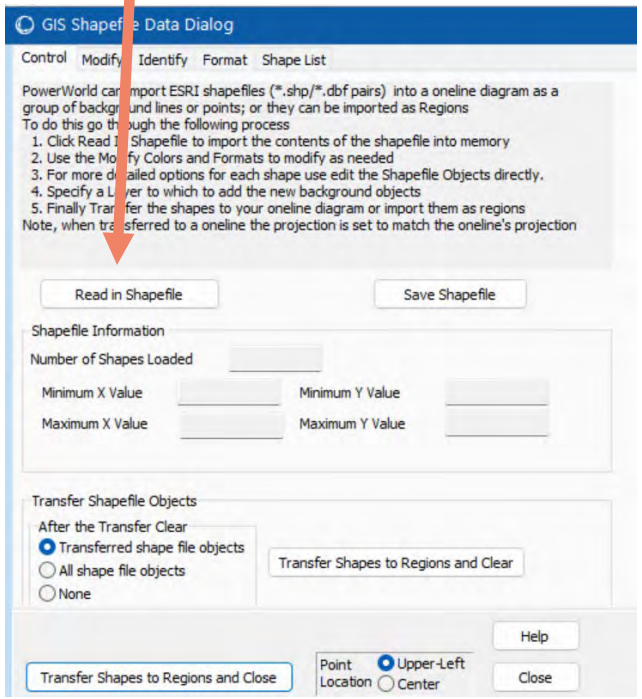
- Regions can be easily added to a case using the common shapefile format; this is done by opening the Regions Dialog and selecting the **Shapefile Import** page
  - If desired enter a **Class Name** that will be used with all the imported regions, and click the **Import Regions from Shapefile** button



This example uses the **Hawaii37Bus_NoRegions** case and the included shape file that defines the districts for the Hawaiian island of Oahu

Adding Regions to a Case: Shapefiles, cont.

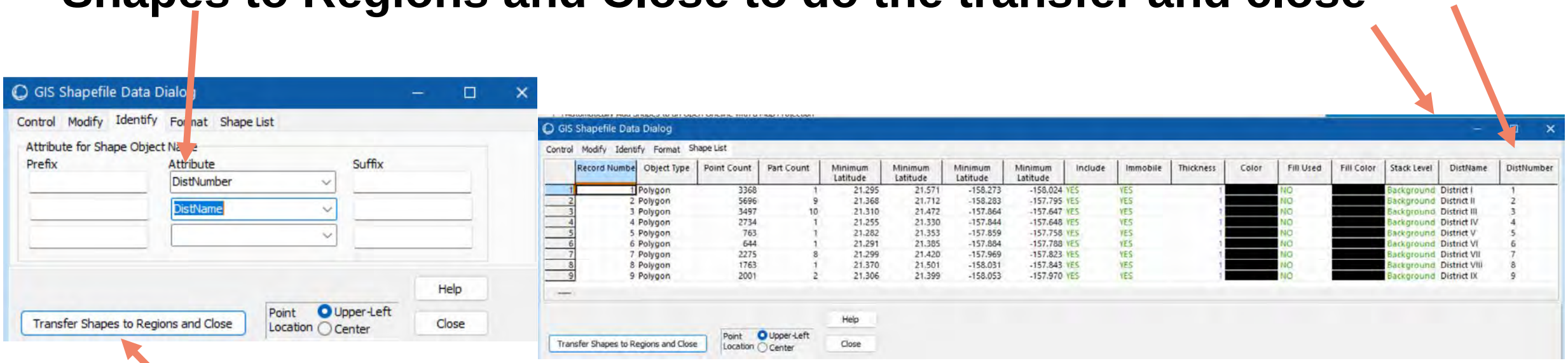
- This displays the GIS Shapefile Data Dialog; select the **Read in Shapefile** to read in a shapefile; once read in, the **Shape List** page lists the polygons in the shapefile, and the **Identify** page is used to specify the fields from the shapefile that will be used in the region



Reading in shapefiles has been greatly simplified in Version 24, with Simulator now handling much of the projection conversions; still, only polygon objects can be imported

Adding Regions to a Case: Shapefiles, cont.

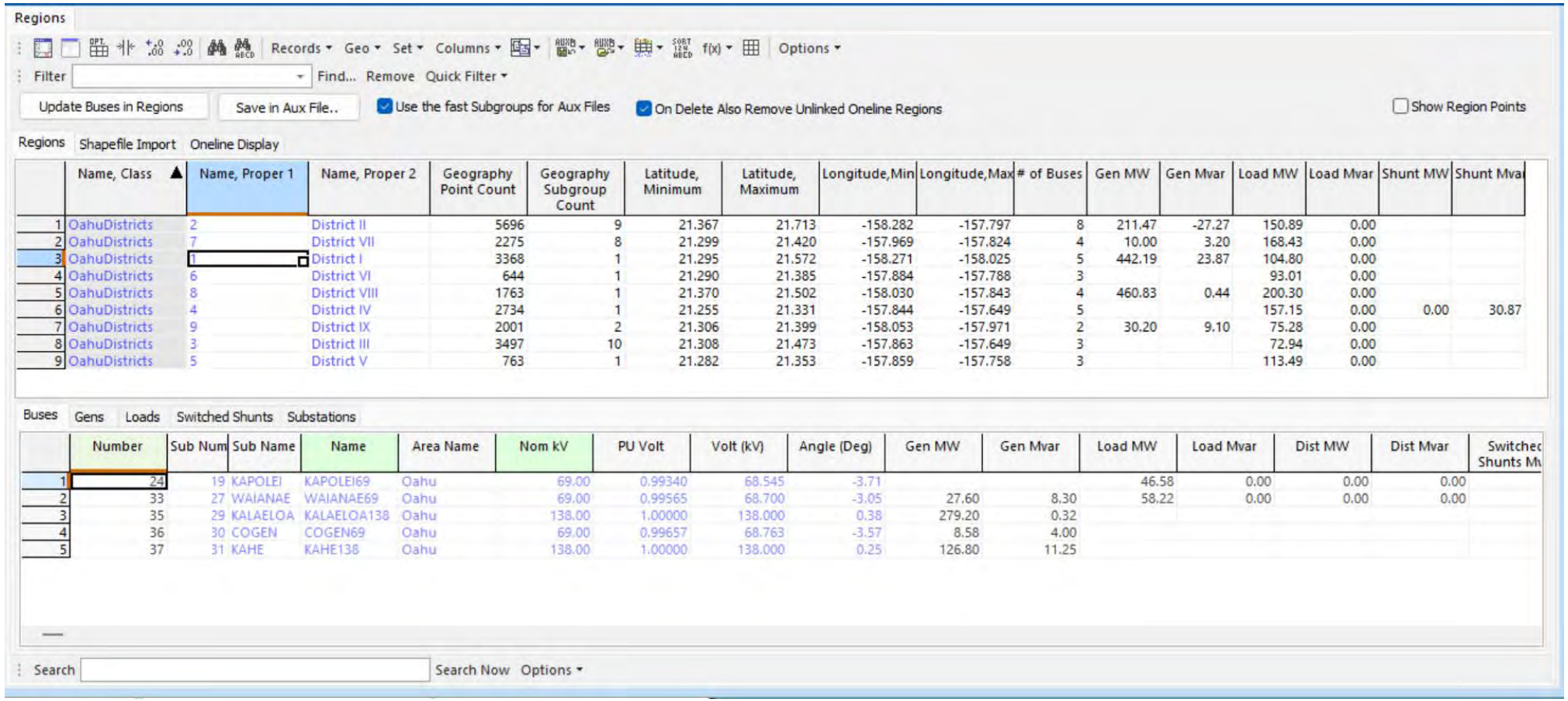
- Here the DistNumber is used as the new region's Name 1 field and and DistName as the Name 2 field for the region; click **Transfer Shapes to Regions and Close to do the transfer and close**



Click to transfer shapes to regions, and then close the dialog

Adding Regions to a Case: Shapefiles, cont.

- Here are the transferred regions; note that the buses have been automatically included with the regions



	Name, Class	Name, Proper 1	Name, Proper 2	Geography Point Count	Geography Subgroup Count	Latitude, Minimum	Latitude, Maximum	Longitude,Min	Longitude,Max	# of Buses	Gen MW	Gen Mvar	Load MW	Load Mvar	Shunt MW	Shunt Mvar
1	OahuDistricts	2	District II	5696	9	21.367	21.713	-158.282	-157.797	8	211.47	-27.27	150.89	0.00		
2	OahuDistricts	7	District VII	2275	8	21.299	21.420	-157.969	-157.824	4	10.00	3.20	168.43	0.00		
3	OahuDistricts	1	District I	3368	1	21.295	21.572	-158.271	-158.025	5	442.19	23.87	104.80	0.00		
4	OahuDistricts	6	District VI	644	1	21.290	21.385	-157.884	-157.788	3			93.01	0.00		
5	OahuDistricts	8	District VIII	1763	1	21.370	21.502	-158.030	-157.843	4	460.83	0.44	200.30	0.00		
6	OahuDistricts	4	District IV	2734	1	21.255	21.331	-157.844	-157.649	5			157.15	0.00	0.00	30.87
7	OahuDistricts	9	District IX	2001	2	21.306	21.399	-158.053	-157.971	2	30.20	9.10	75.28	0.00		
8	OahuDistricts	3	District III	3497	10	21.308	21.473	-157.863	-157.649	3			72.94	0.00		
9	OahuDistricts	5	District V	763	1	21.282	21.353	-157.859	-157.758	3			113.49	0.00		

	Number	Sub Num	Sub Name	Name	Area Name	Nom kV	PU Volt	Volt (kV)	Angle (Deg)	Gen MW	Gen Mvar	Load MW	Load Mvar	Dist MW	Dist Mvar	Switched Shunts Mv
1	24	19	KAPOLEI	KAPOLEI69	Oahu	69.00	0.99340	68.545	-3.71			46.58	0.00	0.00	0.00	
2	33	27	WAIANAE	WAIANAE69	Oahu	69.00	0.99565	68.700	-3.05	27.60	8.30	58.22	0.00	0.00	0.00	
3	35	29	KALAELOA	KALAELOA138	Oahu	138.00	1.00000	138.000	0.38	279.20	0.32					
4	36	30	COGEN	COGEN69	Oahu	69.00	0.99657	68.763	-3.57	8.58	4.00					
5	37	31	KAHE	KAHE138	Oahu	138.00	1.00000	138.000	0.25	126.80	11.25					

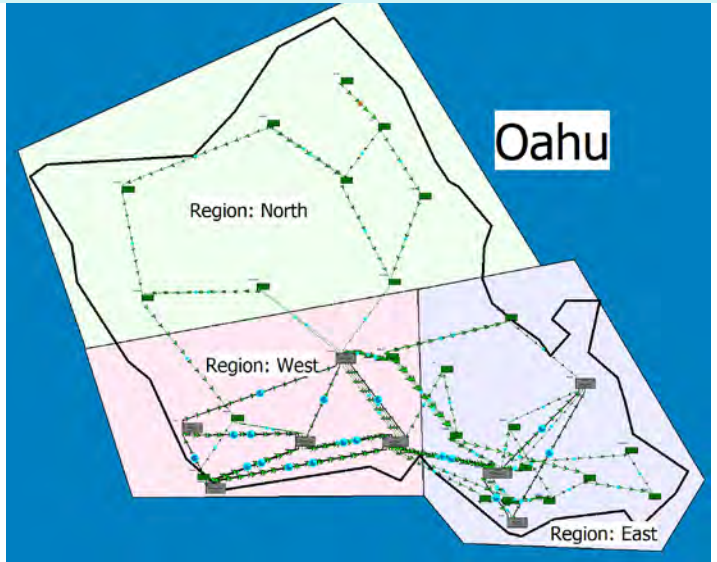
Deleting Regions

- Regions can be easily deleted using the **Regions** page of the Region Display; select the desired regions to delete (using filtering as needed), right-click and select **Delete**
  - **Delete All** can be used to quickly delete all of the regions that are shown with the current filtering
- For example, the 82K case has more than 3000 regions that contain more than a million total boundary points. If the goal is to just show, for example, the 102 counties in Illinois, setup up a filter to show all with a Name 2 <> 'IL', select **Delete All** to delete all but the IL counties
  - This reduces the number of boundary points to about 18,000;

Showing Regions on Onelines: Part 1

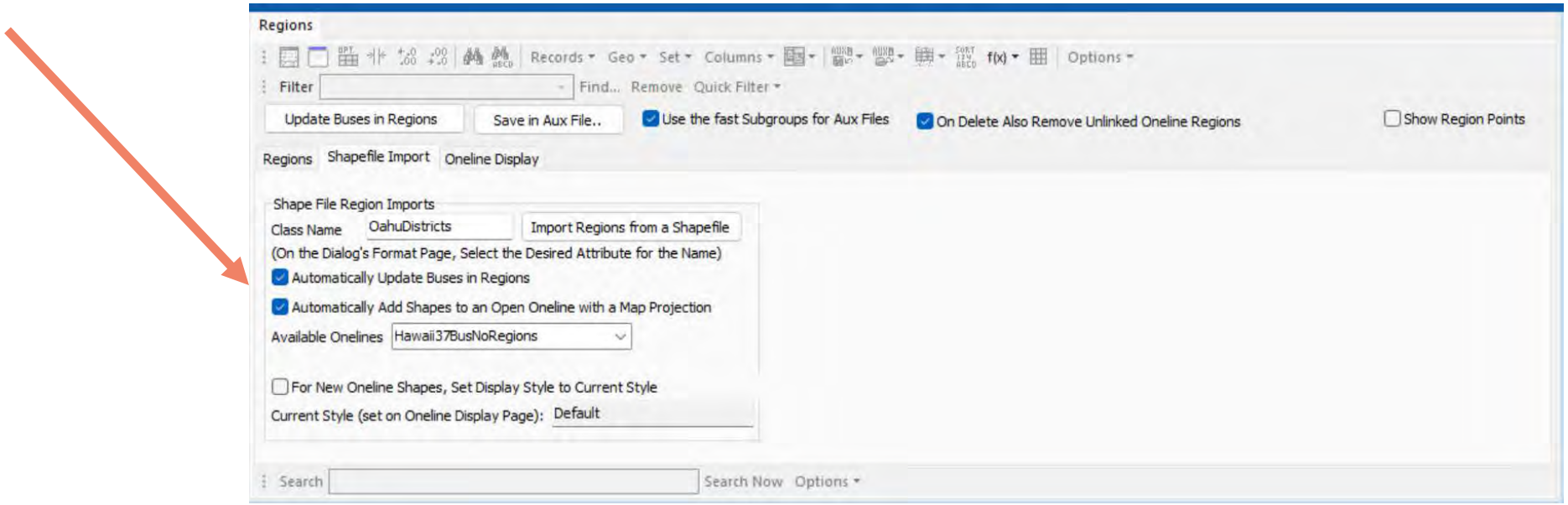
- While this shapefile example shows how regions can be created from shapefiles, it didn't show how regions can be shown on onelines; luckily, this is an easy extension of the previous procedure
- Regions are shown on onelines using Region Display Objects (RDOs); these are mostly similar to other display objects, but there are some differences
  - The RDO shape is defined from its linked region; it can't be changed independently
  - The RDO's display attributes (fill color, border width/color) can be set by either 1) using a style (covered later), 2) from the region's display attributes, or 3) from the RDO's display attributes

Example showing three RDOs



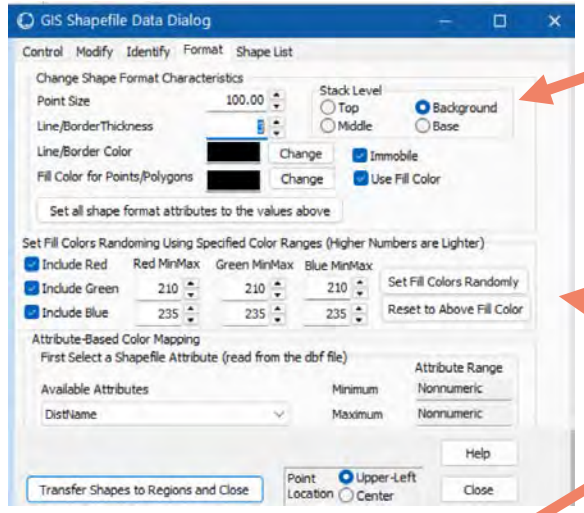
Adding Regions to a Case: Inserting RDOs When Loading Shapefiles

- When loading regions from a shape file, the associated RDOs can be easily added to an open oneline checking the Automatically Add Shapes To an Open Oneline with a Map Projection
  - Then click the **Import Regions from a Shapefile** as before



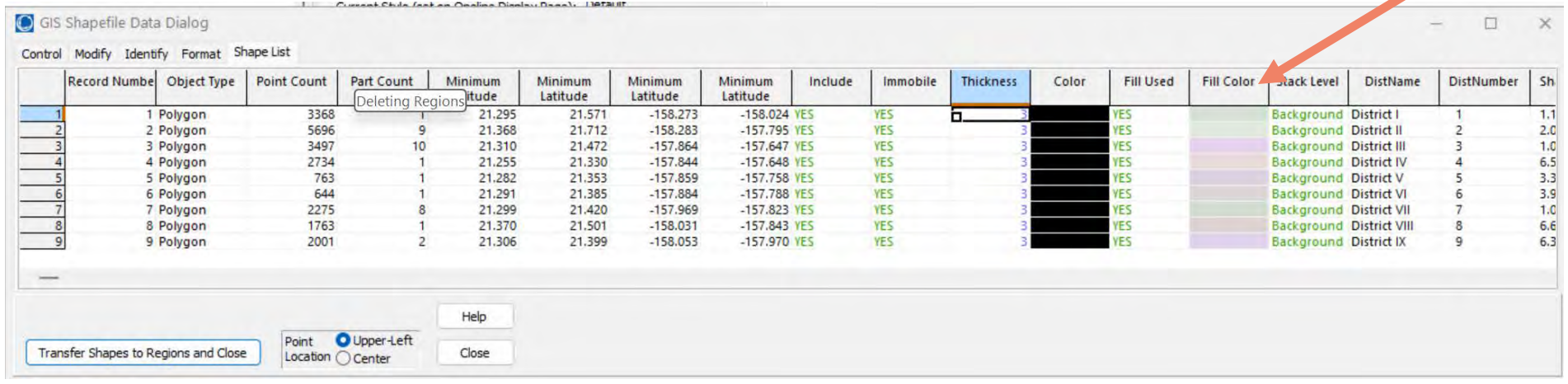
Adding Regions to a Case: Inserting RDOs When Loading Shapefiles

- The on the GIS Shapefile Data Dialog use the **Format** page to customize the appearance of the RDOs
- The region display attributes can also be set on the **Shape List** page



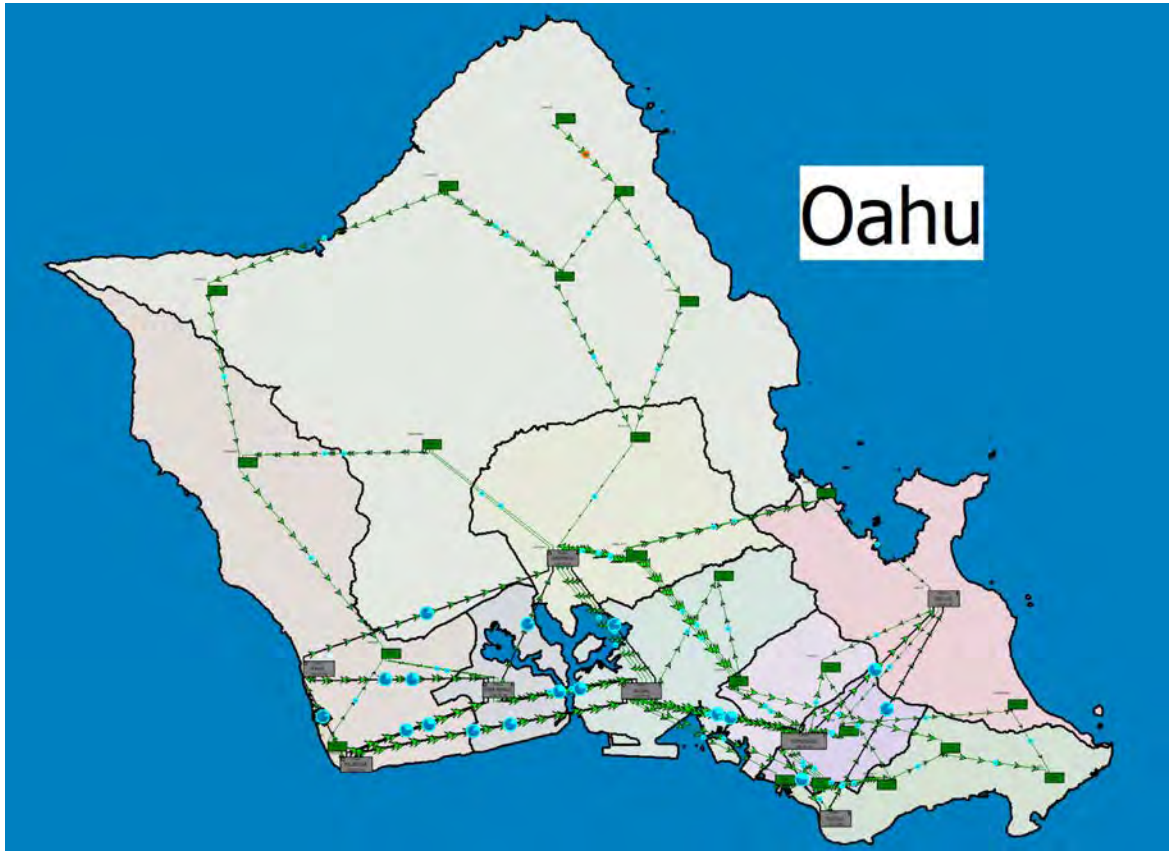
The **Stack Level** tells the location of the RDOs as they are drawn

This button sets the fill colors randomly using a specified palette to make them easier to see showing three RDOs

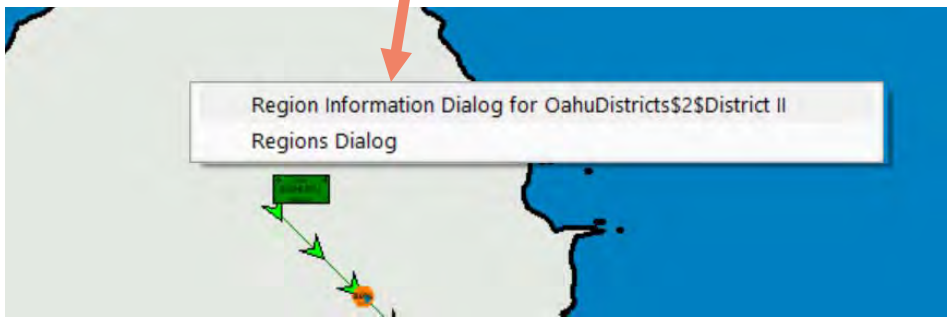


Adding Regions to a Case: Inserting RDOs When Loading Shapefiles

- This shows the case oneline with the new regions; note, since the district boundaries are more detailed, the original Oahu background as been removed



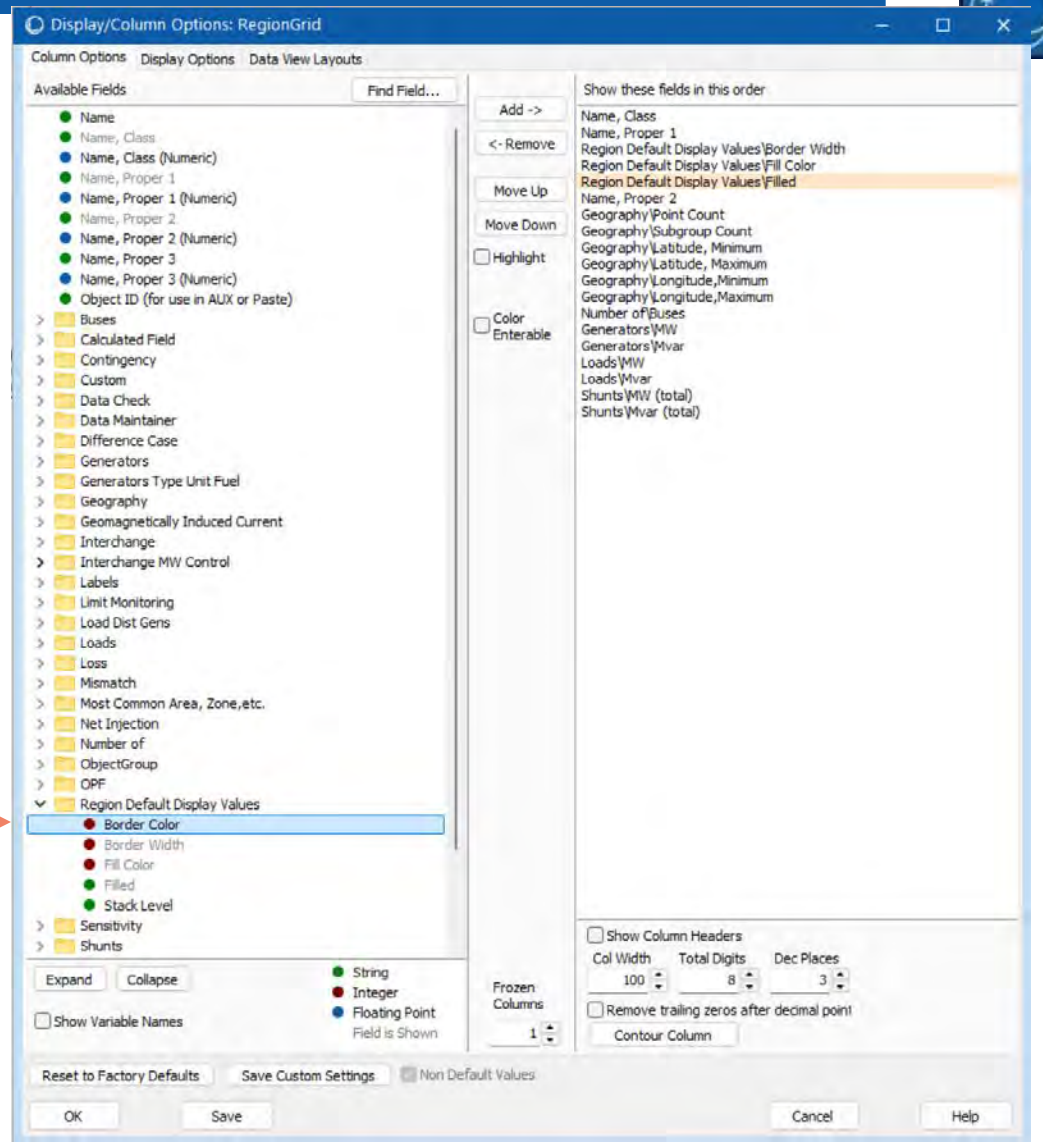
Right-clicking on any empty space in a region brings up a local-menu that can used to display either the Region Information Dialog or the Regions Dialog



This case is stored as **Hawaii37Bus_DistrictRegions**

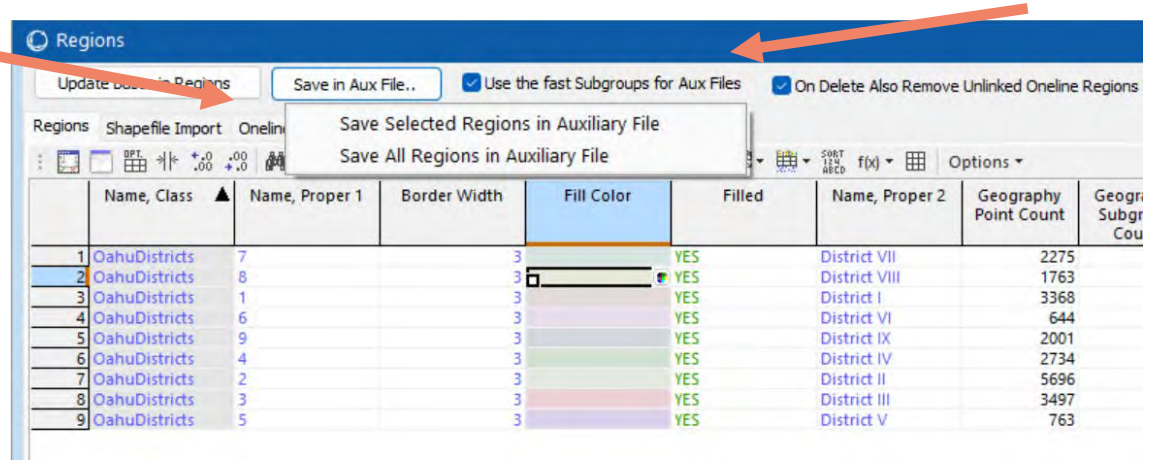
View Region Fields Including Display Fields

- On the Regions Dialog **Regions** page any fields associated with a region can be shown using the standard approach of the **Display/Column** options
- Many of these fields are associated with showing summaries of the power system objects in the region (similar to what is done with areas/zones)
- There are also fields for customizing the regions' appearance on onelines



Saving and Loading Regions Using Aux Files

- Regions can be easily saved and loaded using aux files
- Regions are saved in aux files using the Save in Aux File button on the Region display, either all the regions or selected regions can be saved
- There are three aux file object types associated with regions
  - **Region**: contains the region fields
  - Either **PWRegionSubGroupAux** or **RegionGeoPoint**: contains the region boundary points; which format is used is specified by the **Use the Fast Subgroups for Aux Files** checkbox; this should be checked unless you intend to manually edit the aux file
  - **RegionDisplayStyle**: contains the region display styles (covered later)



Aux File PWRegionSubGroupAux vs RegionGeoPoint Types

- The **PWRegionSubGroupAux** type is designed to allow large numbers of boundary points to be loaded quickly; one of the key fields, SubGroupLatLonList, is a potentially long list of all the latitude and longitude points in the subgroup
  - It can be manually edited, but it is more difficult
  - Because of its compact design, aux files using this type are smaller, and load many times faster than the **RegionGeoPoint** types
  - The latitude and longitude points for each subgroup are listed in sequential order

```
DATA (PWRegionSubGroupAux, [Name,SubGroupNum,SubGroupLatLonList])
{
"OahuDistricts$7$District VII"        1 "21.3092,-157.9021,21.3091,-157.9021,21.3091,-157.9021,21.3090,-157.9024,21.3089,-157.9024,21.3089,-157.9025,21.
"OahuDistricts$7$District VII"        2 "21.3070,-157.8912,21.3069,-157.8914,21.3070,-157.8914,21.3071,-157.8918,21.3073,-157.8922,21.3074,-157.8924,21.
"OahuDistricts$7$District VII"        3 "21.3092,-157.8954,21.3092,-157.8955,21.3092,-157.8957,21.3093,-157.8958,21.3094,-157.8959,21.3096,-157.8959,21.
"OahuDistricts$7$District VII"        4 "21.3085,-157.8732,21.3080,-157.8735,21.3082,-157.8737,21.3079,-157.8739,21.3078,-157.8739,21.3077,-157.8738,21.
"OahuDistricts$7$District VII"        5 "21.3647,-157.9498,21.3646,-157.9498,21.3647,-157.9496,21.3646,-157.9496,21.3645,-157.9499,21.3645,-157.9499,21.
"OahuDistricts$7$District VII"        6 "21.3709,-157.9586,21.3709,-157.9585,21.3709,-157.9583,21.3710,-157.9582,21.3710,-157.9579,21.3712,-157.9577,21.
```

Aux File PWRegionSubGroupAux vs RegionGeoPoint Types, cont.

- In contrast the **RegionGeoPoint** type is designed to allow for easy editing of the region boundary point; points are listed also listed in sequential order, with each row containing a single point
  - Manual editing is straightforward
  - Since each line contains the region name, the file size is larger
  - Because of the need to read many lines, aux files with this type load substantially slower
- Both types can be used in a single aux file
- Aux files are loaded using the standard approach of **File, Load Auxiliary**

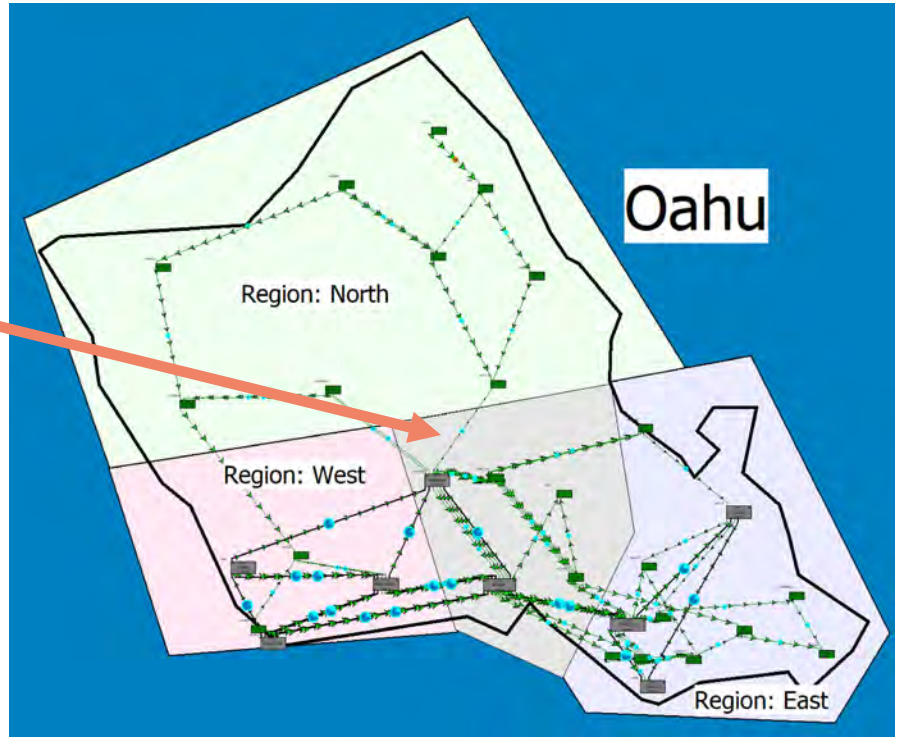
```
DATA (RegionGeoPoint, [Region,Subgroup,Latitude,Longitude])
{
"OahuDistricts$7$District VII" 1 21.30921 -157.90206
"OahuDistricts$7$District VII" 1 21.30912 -157.90209
"OahuDistricts$7$District VII" 1 21.30906 -157.90212
"OahuDistricts$7$District VII" 1 21.30896 -157.90235
"OahuDistricts$7$District VII" 1 21.30894 -157.90242
"OahuDistricts$7$District VII" 1 21.30889 -157.90246
"OahuDistricts$7$District VII" 1 21.30873 -157.90249
"OahuDistricts$7$District VII" 1 21.30868 -157.90255
"OahuDistricts$7$District VII" 1 21.30875 -157.90289
"OahuDistricts$7$District VII" 1 21.30879 -157.90292
"OahuDistricts$7$District VII" 1 21.30901 -157.90343
"OahuDistricts$7$District VII" 1 21.30905 -157.90347
"OahuDistricts$7$District VII" 1 21.30908 -157.90348
"OahuDistricts$7$District VII" 1 21.30912 -157.90333
"OahuDistricts$7$District VII" 1 21.30913 -157.90307
"OahuDistricts$7$District VII" 1 21.30918 -157.90294
"OahuDistricts$7$District VII" 1 21.30919 -157.90292
"OahuDistricts$7$District VII" 1 21.30916 -157.90279
"OahuDistricts$7$District VII" 1 21.30919 -157.90268
"OahuDistricts$7$District VII" 1 21.30917 -157.90249
```

A Key Takeaway: Adding Regions is Simple!!

- Provided you have the aux file (which we can provide for things like US counties), adding regions to an existing case is super simple (provided is has latitude and longitude information)
- Just select **File, Load Auxiliary**
- If you don’t have an aux file, a shapefile is fine (provided it uses the common WGS_1984), which can then be saved as an aux file

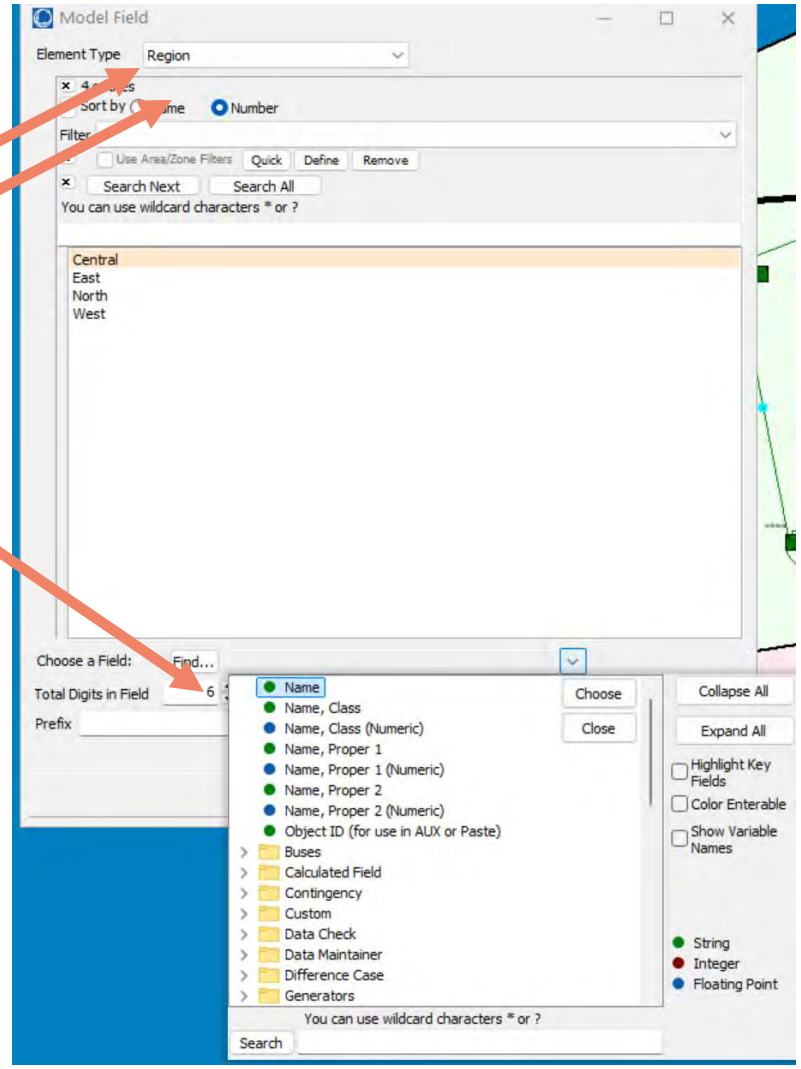
Manually Inserting Regions in the Edit Mode

- Regions can be inserted and edited in the **Edit Mode** in a manner similar to what is done with **Background Lines**
  - New regions are inserted by selecting **Draw, Aggregation, Region**
  - The case Hawaii37Bus_FourRegion is the original three region case with a new region, Central, added in the middle, with the boundaries of West and East modified
  - Region can only be edited graphically if they are not specified as being Immobile on the Region Dialog; GIS-based regions are almost always immobile



Adding Fields to Show Region Values

- There are two ways to show region values on onelines
  - Using Geographic Data Views (GDVs, covered later)
  - In the **Edit Mode** select **Draw, Field, Generic Model Field** to manually insert fields; this is best if just a few fields are desired

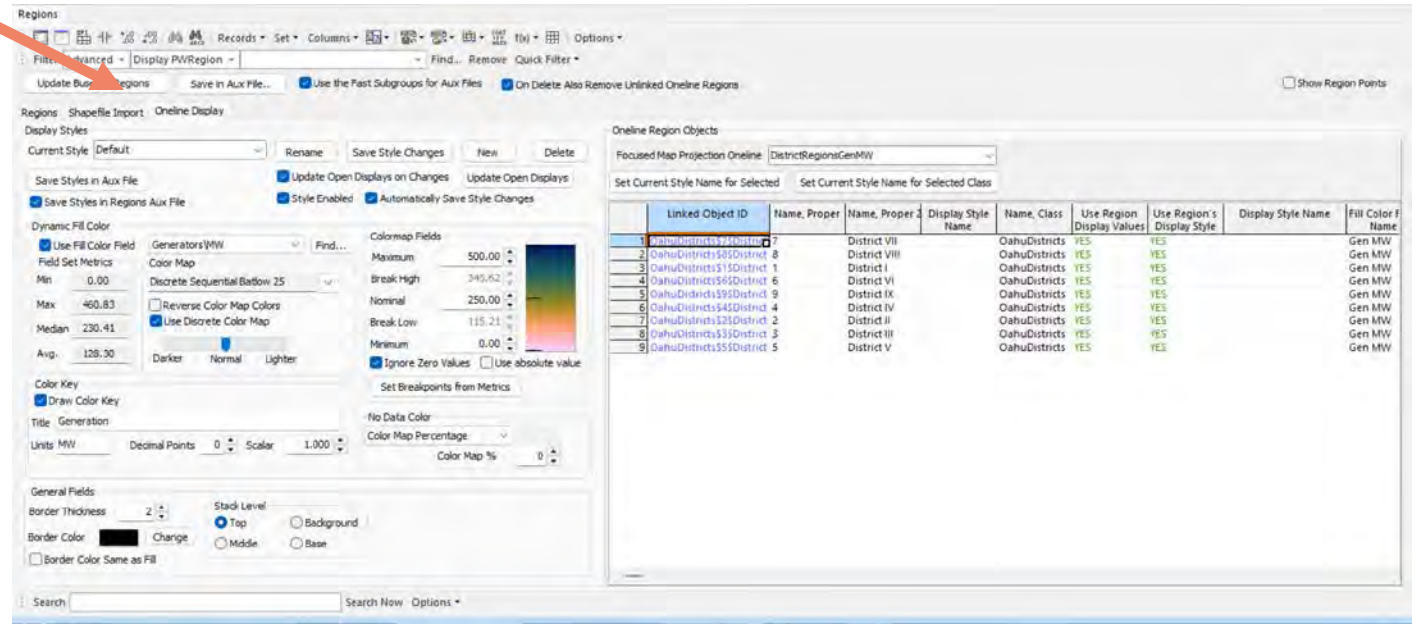


Adding new RDOs to a Oneline

- For regions that are already defined, they can be quickly added to a new or an already existing oneline that has a map projections
- As an example, open the Hawaii37Bus_DistrictRegions case, then create a new oneline. Then, use the **Oneline Display Options, Geographic Coordinates** page to set is map projection to Mercator (be sure to click **OK** to save the change; also the provided **MercatorBase** oneline already has this set), and then open the Regions Display and goto the **Regions** page
- Right-click on any entry and select **Add All Regions to Oneline**; since this case already has regions defined, new RDOs can be added; the next few slides discuss customization using Display Styles

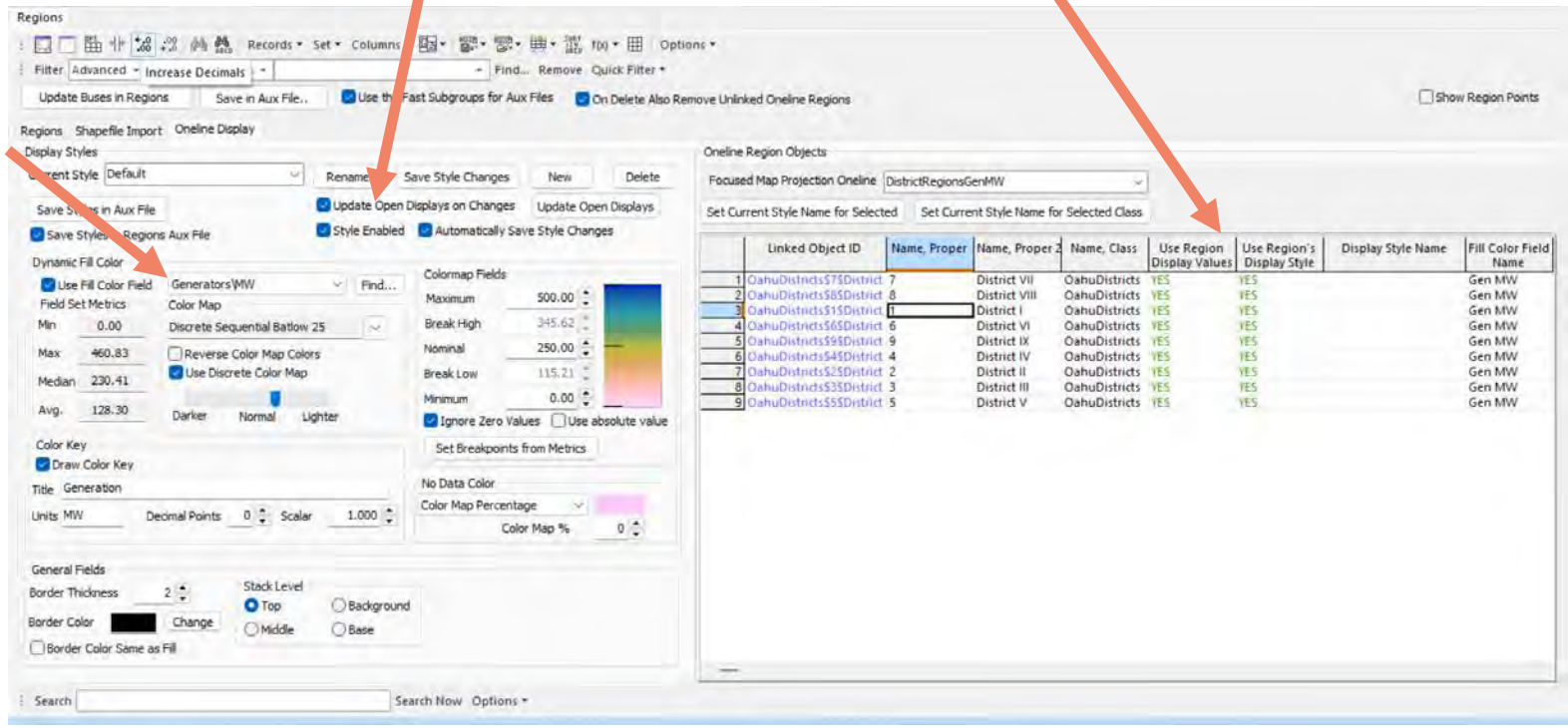
Adding new RDOs to a Oneline, cont.

- A natural enhancement to just showing RDOs using a static background color is to make their background color a function of some power system attribute, such as the total MW generation in a region
- These customizations are done using Display Styles, which are somewhat similar to the styles used with the Geographic Data View (GDV) objects
- Display Styles are defined and enabled using the **Oneline Display** page
- The Display Styles are saved with the regions in the pwb files



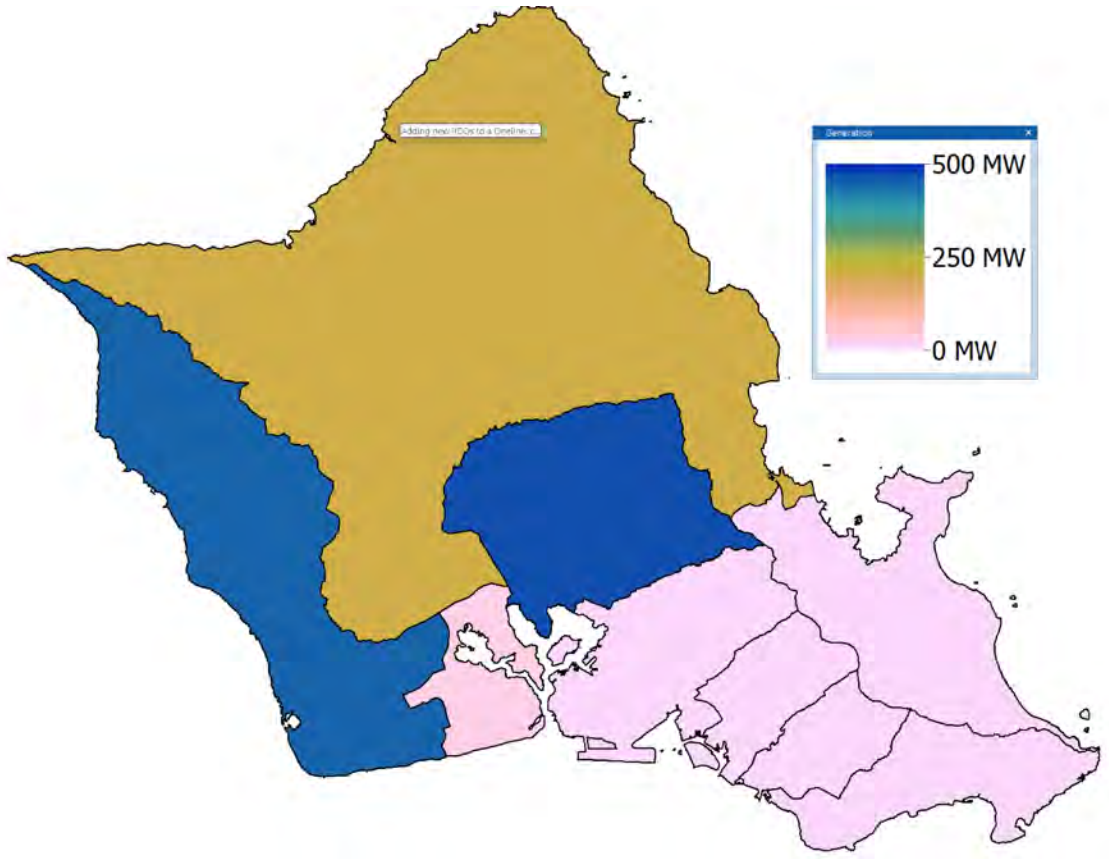
Using Region Display Styles

- To use the Display Styles 1) a style must be defined (with the "Default" style always available, 2) its **Style Enabled** checkbox needs to be set, 3) a Fill Color field needs to be set, and 4) the RDOs need to be set to use the Region's Display style
  - Many of these values are set by default, and once the values are set they can be used with many difference power system cases



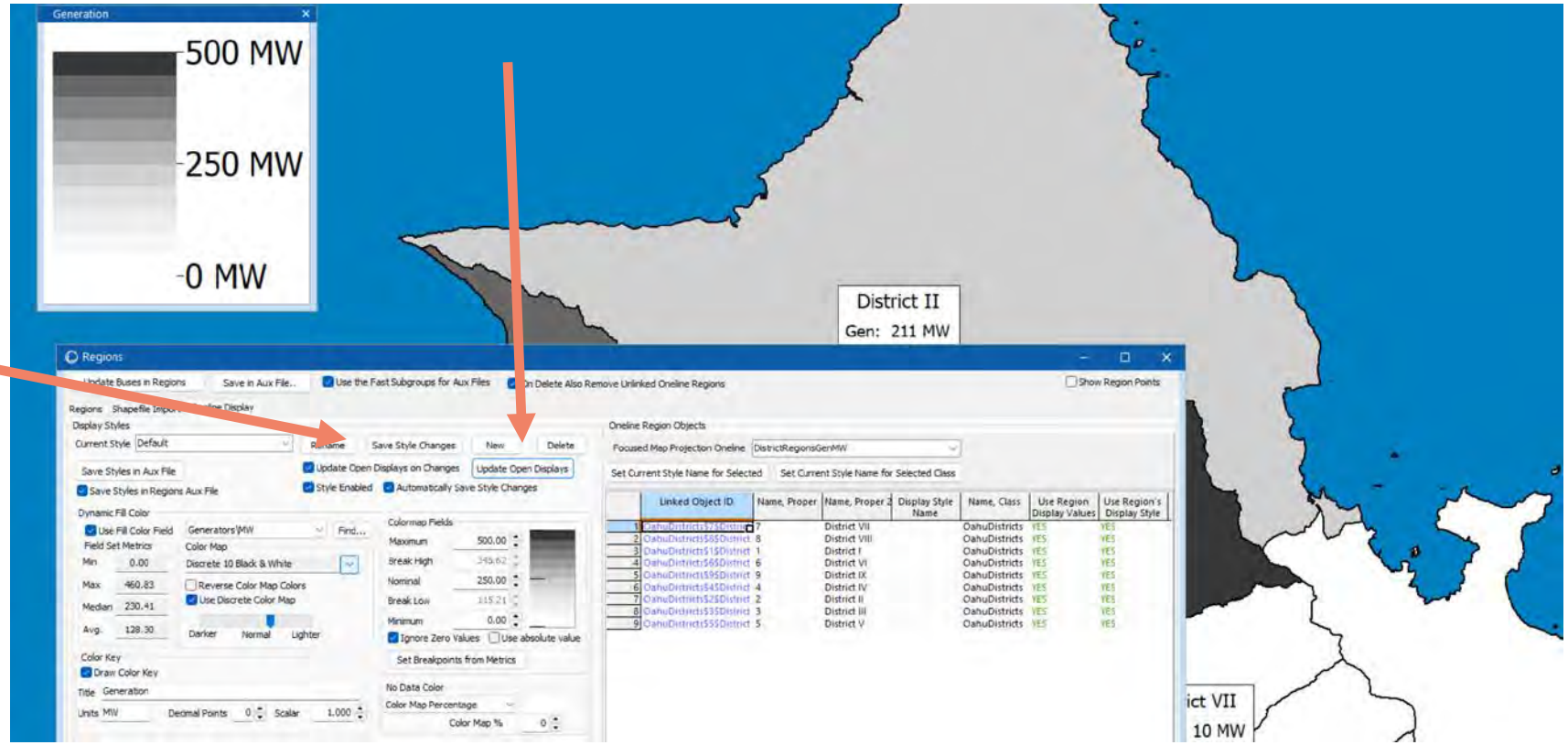
Using Region Display Styles, cont.

- The below image shows the new display with the fill colors showing the generation in each district
- Region GDVs can be used to add additional field values
  - They are added like other GDVs; that is, on the **Regions** page right-click and select **Geographic Views, Select Column the Geographic Data View**



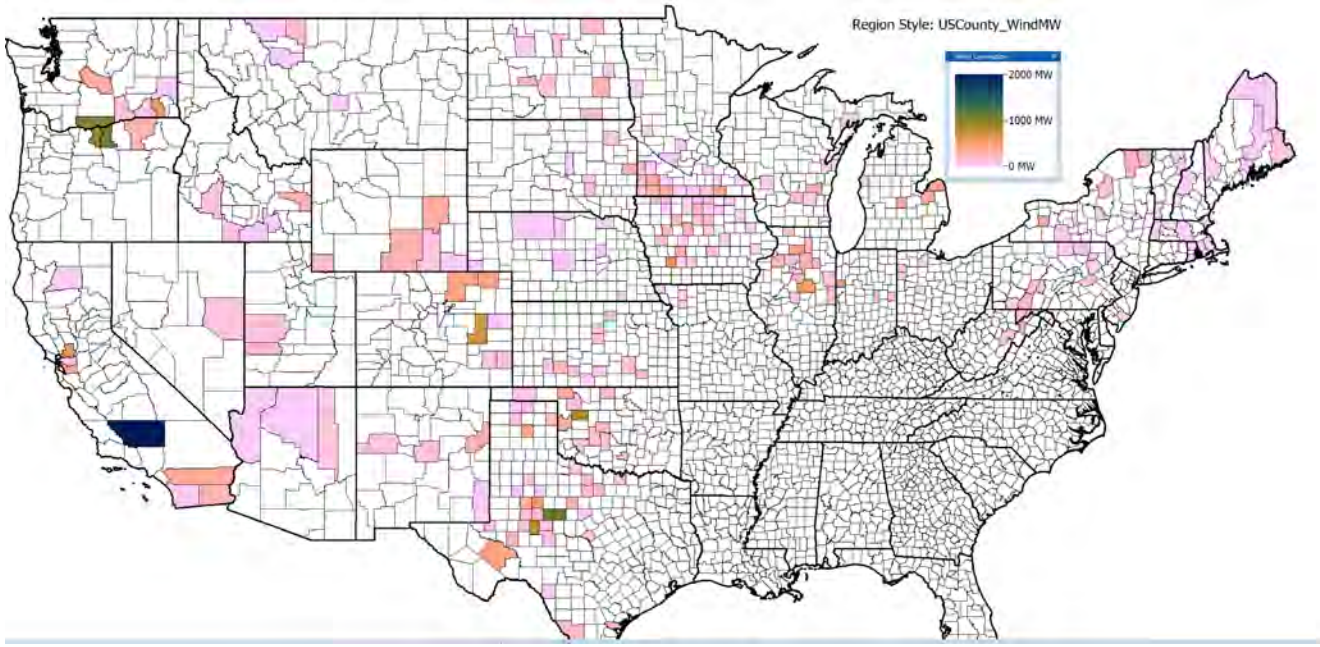
Regions Dialog Update Open Displays Button

- When modifying the appearance of a display the **Update Open Displays** button can be used to immediately update any open displays;
- Style changes are either saved automatically (if **Automatically Save Style Changes** is checked or by clicking on **Save Style Changes**



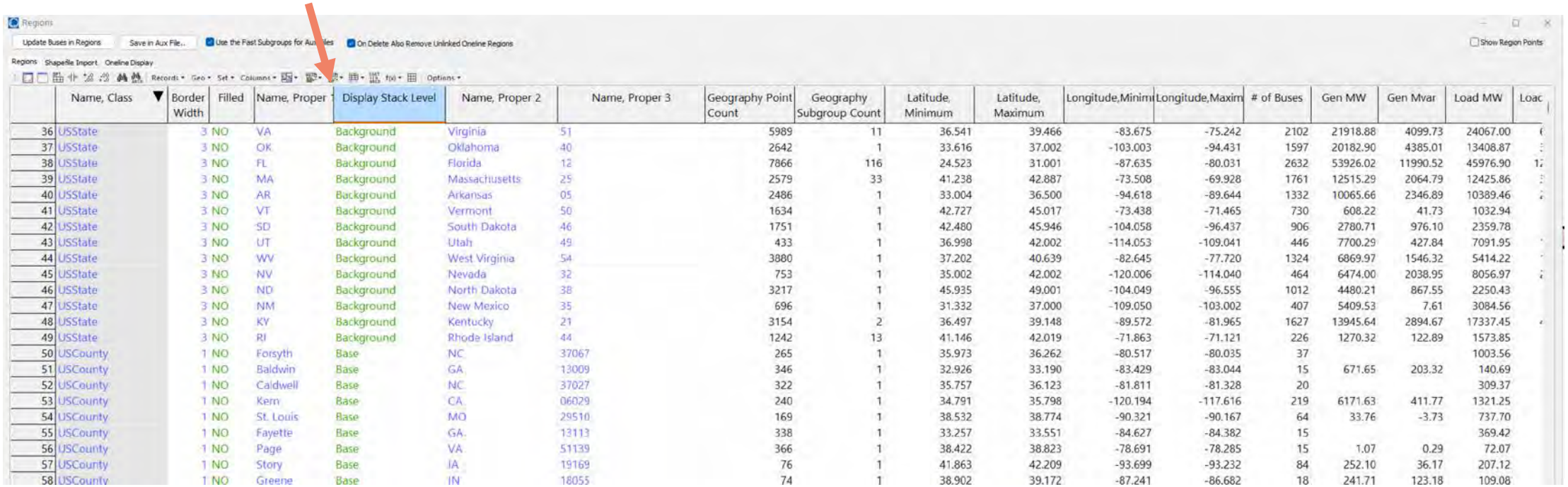
CONUS82K Example

- To see a much larger example, open the CONUS82K grid
  - This is an entirely fictitious grid with generation and load similar to the actual CONUS grids around 2016
- The case has regions that show the US counties, with the Display Style set to color each county based on its amount of wind generation; the case also has regions defined for each of the states, with just their borders shown



CONUS82K Regions Dialog

- Since there are both regions for the states and the counties, the Regions Dialog can be used to summarize, or view more details, on both types of objects
  - For the display, the state boundaries are drawn at the Background Stack Level, which is above the Base Level, so the state borders are visible

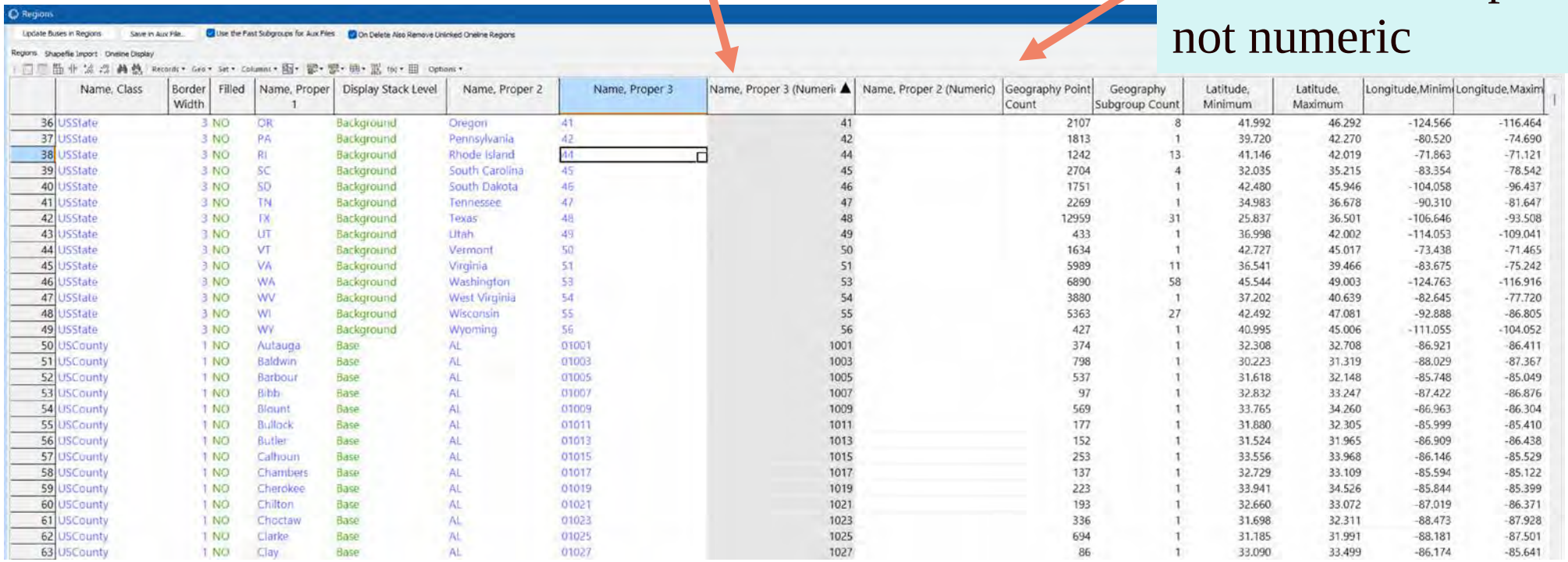


	Name, Class	Border Width	Filled	Name, Proper 1	Display Stack Level	Name, Proper 2	Name, Proper 3	Geography Point Count	Geography Subgroup Count	Latitude, Minimum	Latitude, Maximum	Longitude,Minim	Longitude,Maxim	# of Buses	Gen MW	Gen Mvar	Load MW	Loac
36	USState	3	NO	VA	Background	Virginia	51	5989	11	36.541	39.466	-83.675	-75.242	2102	21918.88	4099.73	24067.00	
37	USState	3	NO	OK	Background	Oklahoma	40	2642	1	33.616	37.002	-103.003	-94.431	1597	20182.90	4385.01	13408.87	
38	USState	3	NO	FL	Background	Florida	12	7866	116	24.523	31.001	-87.635	-80.031	2632	53926.02	11990.52	45976.90	
39	USState	3	NO	MA	Background	Massachusetts	25	2579	33	41.238	42.887	-73.508	-69.928	1761	12515.29	2064.79	12425.86	
40	USState	3	NO	AR	Background	Arkansas	05	2486	1	33.004	36.500	-94.618	-89.644	1332	10065.66	2346.89	10389.46	
41	USState	3	NO	VT	Background	Vermont	50	1634	1	42.727	45.017	-73.438	-71.465	730	608.22	41.73	1032.94	
42	USState	3	NO	SD	Background	South Dakota	46	1751	1	42.480	45.946	-104.058	-96.437	906	2780.71	976.10	2359.78	
43	USState	3	NO	UT	Background	Utah	49	433	1	36.998	42.002	-114.053	-109.041	446	7700.29	427.84	7091.95	
44	USState	3	NO	WV	Background	West Virginia	54	3880	1	37.202	40.639	-82.645	-77.720	1324	6869.97	1546.32	5414.22	
45	USState	3	NO	NV	Background	Nevada	32	753	1	35.002	42.002	-120.006	-114.040	464	6474.00	2038.95	8056.97	
46	USState	3	NO	ND	Background	North Dakota	38	3217	1	45.935	49.001	-104.049	-96.555	1012	4480.21	867.55	2250.43	
47	USState	3	NO	NM	Background	New Mexico	35	696	1	31.332	37.000	-109.050	-103.002	407	5409.53	7.61	3084.56	
48	USState	3	NO	KY	Background	Kentucky	21	3154	2	36.497	39.148	-89.572	-81.965	1627	13945.64	2894.67	17337.45	
49	USState	3	NO	RI	Background	Rhode Island	44	1242	13	41.146	42.019	-71.863	-71.121	226	1270.32	122.89	1573.85	
50	USCounty	1	NO	Forsyth	Base	NC	37067	265	1	35.973	36.262	-80.517	-80.035	37			1003.56	
51	USCounty	1	NO	Baldwin	Base	GA	13009	346	1	32.926	33.190	-83.429	-83.044	15	671.65	203.32	140.69	
52	USCounty	1	NO	Caldwell	Base	NC	37027	322	1	35.757	36.123	-81.811	-81.328	20			309.37	
53	USCounty	1	NO	Kern	Base	CA	06029	240	1	34.791	35.798	-120.194	-117.616	219	6171.63	411.77	1321.25	
54	USCounty	1	NO	St. Louis	Base	MO	29510	169	1	38.532	38.774	-90.321	-90.167	64	33.76	-3.73	737.70	
55	USCounty	1	NO	Fayette	Base	GA	13113	338	1	33.257	33.551	-84.627	-84.382	15			369.42	
56	USCounty	1	NO	Page	Base	VA	51139	366	1	38.422	38.823	-78.691	-78.285	15	1.07	0.29	72.07	
57	USCounty	1	NO	Story	Base	IA	19169	76	1	41.863	42.209	-93.699	-93.232	84	252.10	36.17	207.12	
58	USCounty	1	NO	Greene	Base	IN	18055	74	1	38.902	39.172	-87.241	-86.682	18	241.71	123.18	109.08	

Regions Dialog: Viewing Proper Names Numerically

- While the proper names are stored as strings, they can be viewed numerically, which can be helpful for sorting or filter; if a proper name is not numeric then its numeric representation is shown as a blank

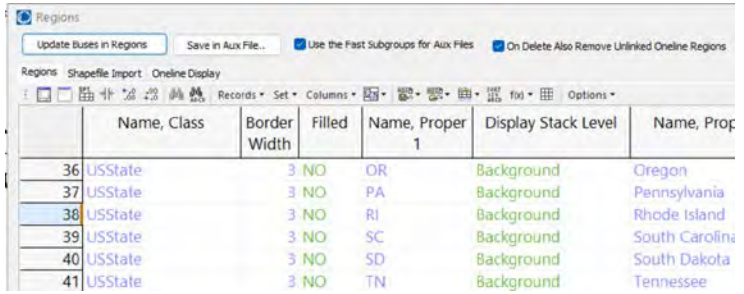
Blank since Proper 2 is not numeric



	Name, Class	Border Width	Filled	Name, Proper 1	Display Stack Level	Name, Proper 2	Name, Proper 3	Name, Proper 3 (Numeri	Name, Proper 2 (Numeric)	Geography Point Count	Geography Subgroup Count	Latitude, Minimum	Latitude, Maximum	Longitude,Minim	Longitude,Maxim
36	USState	3	NO	OR	Background	Oregon	41	41		2107	8	41.992	46.292	-124.566	-116.464
37	USState	3	NO	PA	Background	Pennsylvania	42	42		1813	1	39.720	42.270	-80.520	-74.690
38	USState	3	NO	RI	Background	Rhode Island	44	44		1242	13	41.146	42.019	-71.863	-71.121
39	USState	3	NO	SC	Background	South Carolina	45	45		2704	4	32.035	35.215	-83.354	-78.542
40	USState	3	NO	SD	Background	South Dakota	46	46		1751	1	42.480	45.946	-104.058	-96.437
41	USState	3	NO	TN	Background	Tennessee	47	47		2269	1	34.983	36.678	-90.310	-81.647
42	USState	3	NO	TX	Background	Texas	48	48		12959	31	25.837	36.501	-106.646	-93.508
43	USState	3	NO	UT	Background	Utah	49	49		433	1	36.998	42.002	-114.053	-109.041
44	USState	3	NO	VT	Background	Vermont	50	50		1634	1	42.727	45.017	-73.438	-71.465
45	USState	3	NO	VA	Background	Virginia	51	51		5989	11	36.541	39.466	-83.675	-75.242
46	USState	3	NO	WA	Background	Washington	53	53		6890	58	45.544	49.003	-124.763	-116.916
47	USState	3	NO	WV	Background	West Virginia	54	54		3880	1	37.202	40.639	-82.645	-77.720
48	USState	3	NO	WI	Background	Wisconsin	55	55		5363	27	42.492	47.081	-92.888	-86.805
49	USState	3	NO	WY	Background	Wyoming	56	56		427	1	40.995	45.006	-111.055	-104.052
50	USCounty	1	NO	Autauga	Base	AL	01001	1001		374	1	32.308	32.708	-86.921	-86.411
51	USCounty	1	NO	Baldwin	Base	AL	01003	1003		798	1	30.223	31.319	-88.029	-87.367
52	USCounty	1	NO	Barbour	Base	AL	01005	1005		537	1	31.618	32.148	-85.748	-85.049
53	USCounty	1	NO	Bibb	Base	AL	01007	1007		97	1	32.832	33.247	-87.422	-86.876
54	USCounty	1	NO	Blount	Base	AL	01009	1009		569	1	33.765	34.260	-86.963	-86.304
55	USCounty	1	NO	Bullock	Base	AL	01011	1011		177	1	31.880	32.305	-85.999	-85.410
56	USCounty	1	NO	Butler	Base	AL	01013	1013		152	1	31.524	31.965	-86.909	-86.438
57	USCounty	1	NO	Calhoun	Base	AL	01015	1015		253	1	33.556	33.968	-86.146	-85.529
58	USCounty	1	NO	Chambers	Base	AL	01017	1017		137	1	32.729	33.109	-85.594	-85.122
59	USCounty	1	NO	Cherokee	Base	AL	01019	1019		223	1	33.941	34.526	-85.844	-85.399
60	USCounty	1	NO	Chilton	Base	AL	01021	1021		193	1	32.660	33.072	-87.019	-86.371
61	USCounty	1	NO	Choctaw	Base	AL	01023	1023		336	1	31.698	32.311	-88.473	-87.928
62	USCounty	1	NO	Clarke	Base	AL	01025	1025		694	1	31.185	31.991	-88.181	-87.501
63	USCounty	1	NO	Clay	Base	AL	01027	1027		86	1	33.090	33.499	-86.174	-85.641

Updating the Buses in the Regions

- Simulator does its best to keep track of the buses in each region. There are three situations in which the buses in a region can change
  - The region boundaries are changed
  - Buses are deleted or inserted
  - Buses' geographic locations are changed (often their location is derived from that of their substation)
- Some of these changes cannot be detected automatically, so a button is provided to manually update them

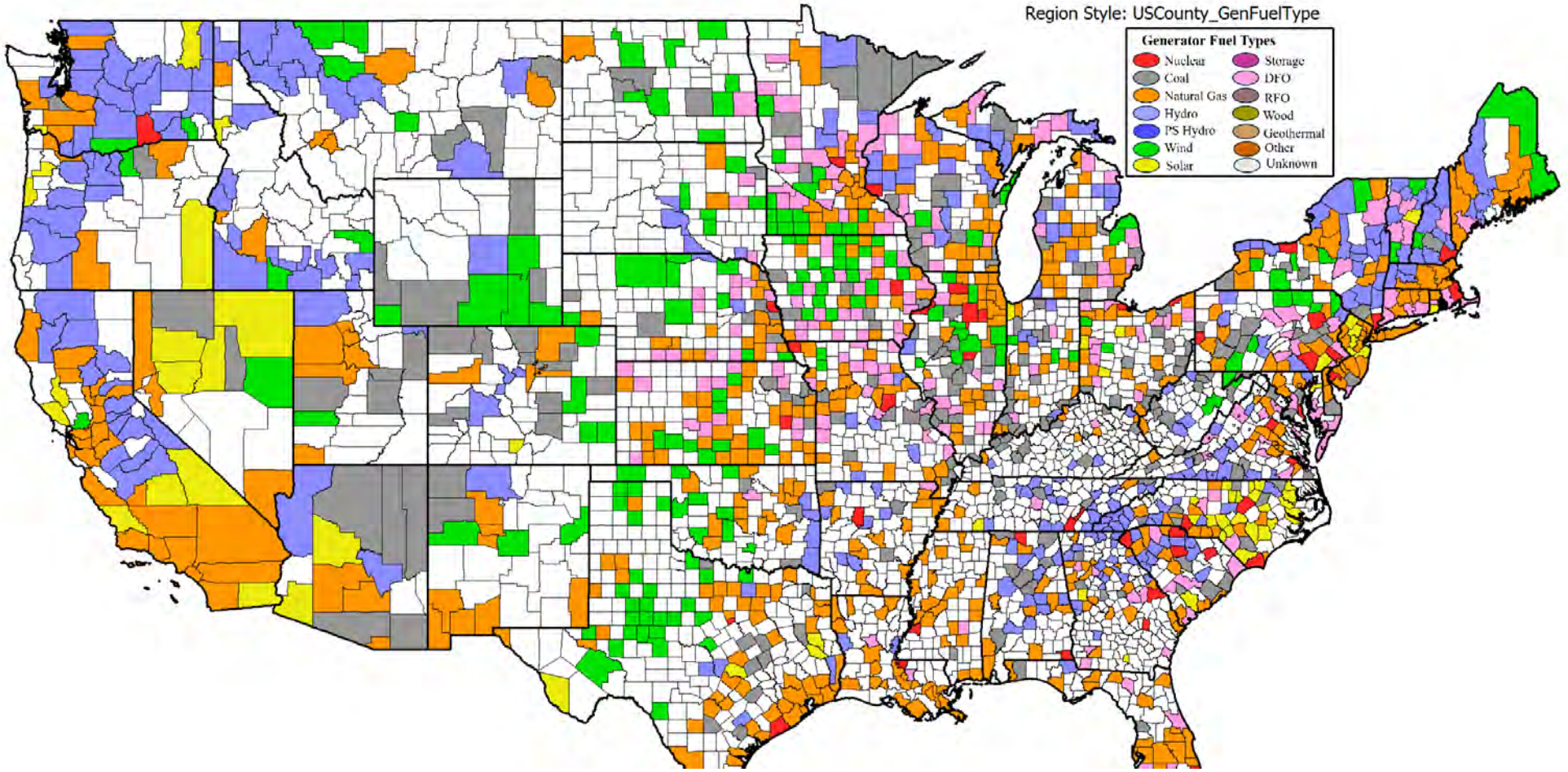


	Name, Class	Border Width	Filled	Name, Proper 1	Display Stack Level	Name, Prop
36	USState	3	NO	OR	Background	Oregon
37	USState	3	NO	PA	Background	Pennsylvania
38	USState	3	NO	RI	Background	Rhode Island
39	USState	3	NO	SC	Background	South Carolina
40	USState	3	NO	SD	Background	South Dakota
41	USState	3	NO	TN	Background	Tennessee

- Computationally this can depend on the number of buses and the number of region boundary points; with the CONUS82K case with one million boundary points it takes a few seconds to refresh

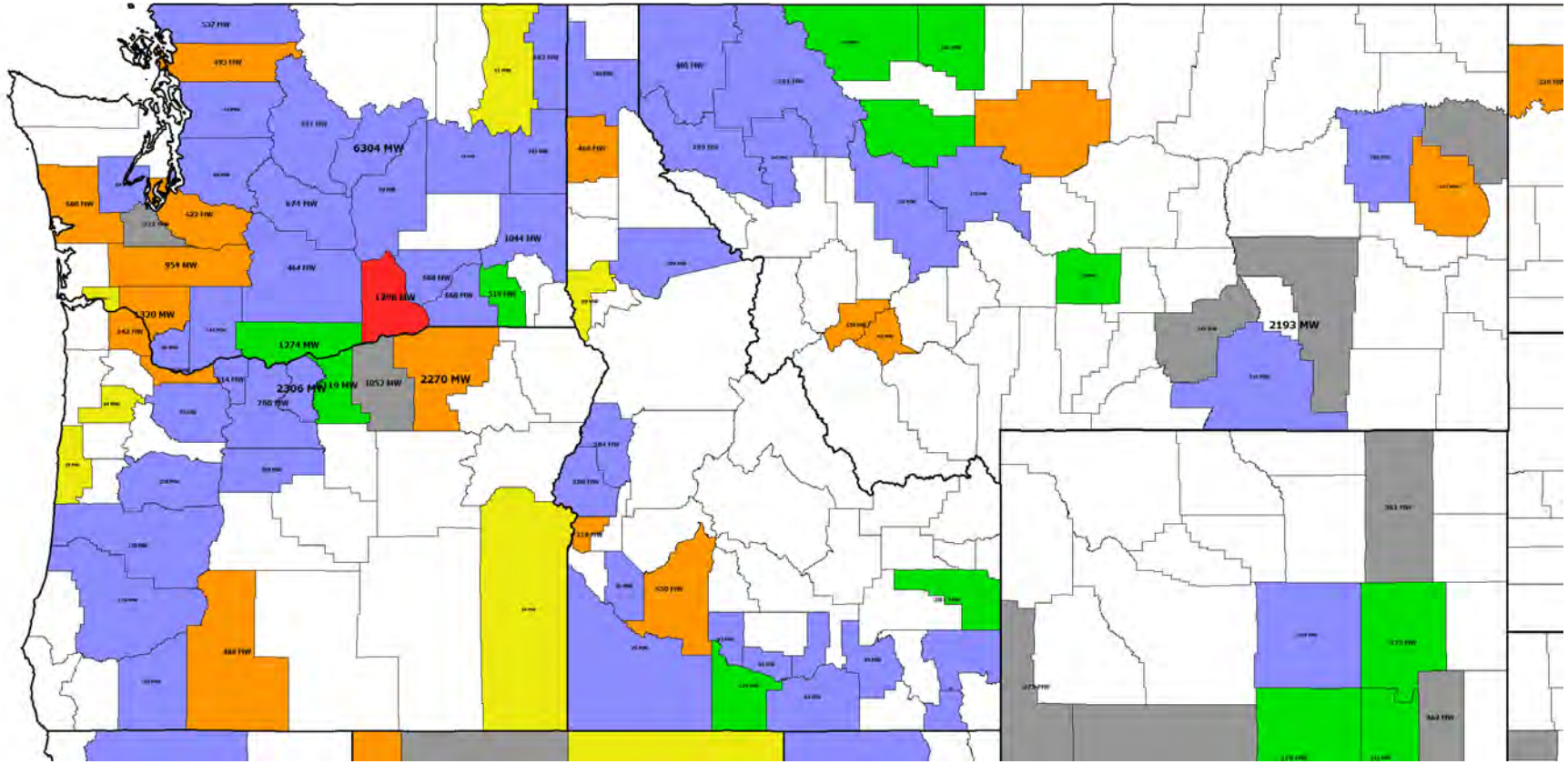
CONUS82K Showing Fuel Type

- Just by changing the display style other fields can be easily shown, such as the predominant generator fuel type in each county



CONUS82K Showing Fuel Type with GDVs

- Like any other Simulator oneline, geographic data views can be easily added and customized; the below example uses the generator fuel type coloring with GDVs showing the total county generation



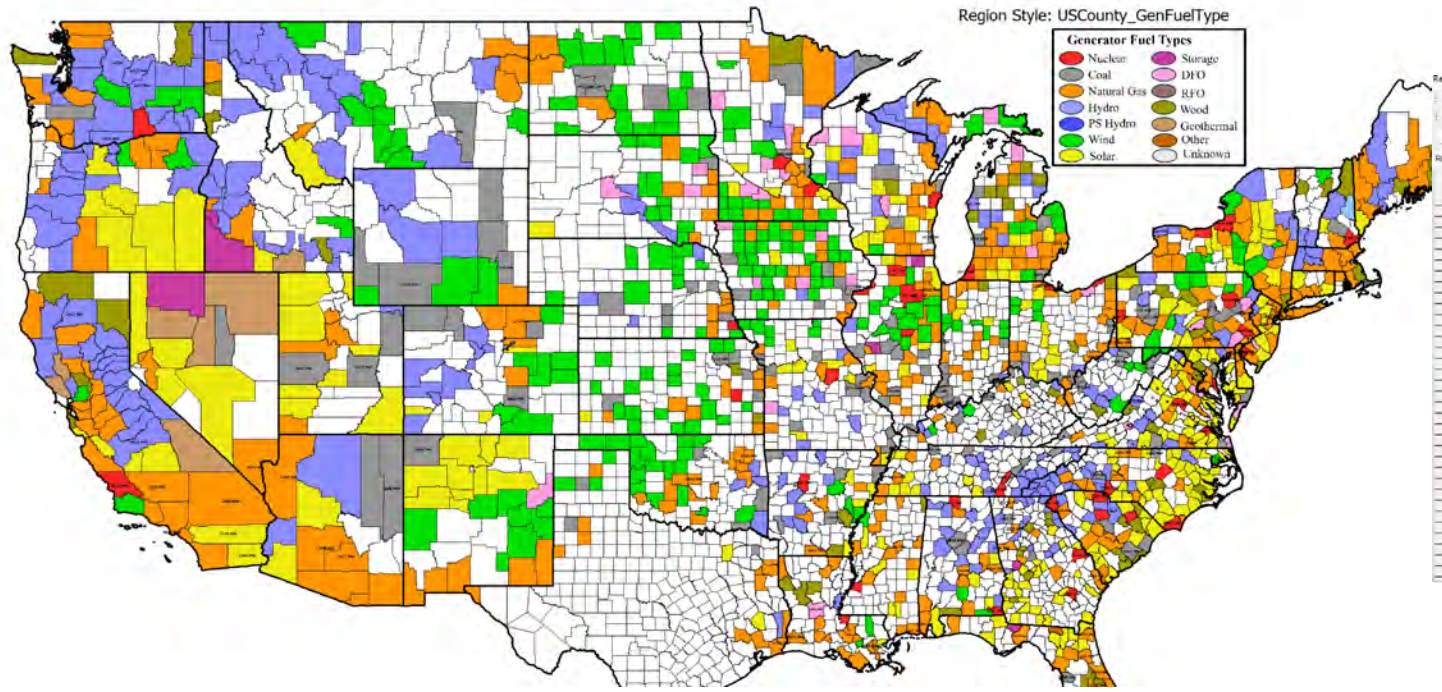
Here the county-level generation is shown in the Pacific Northwest, with dynamic sized used with the GDVs

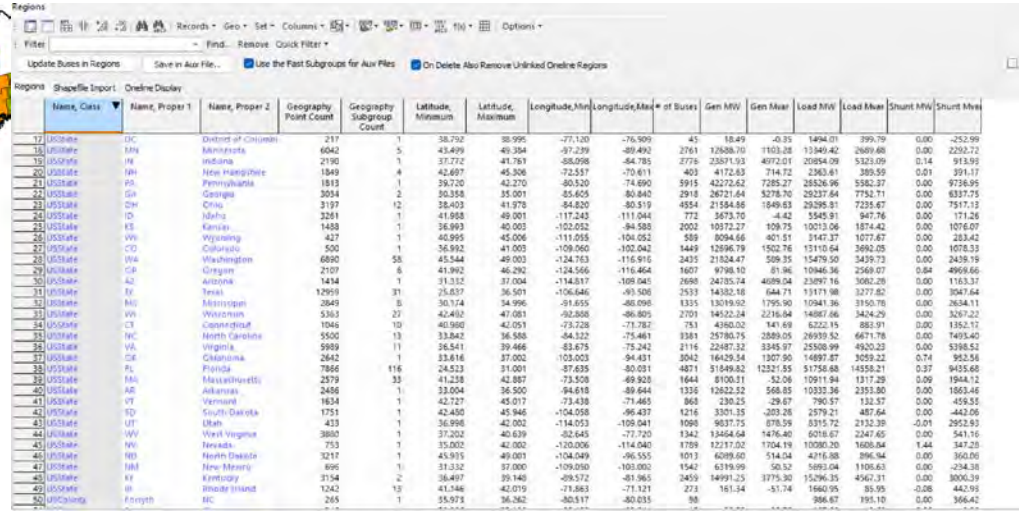
Moving Regions and Region Display Styles to Other Cases

- Moving regions, and associated display styles between cases is simple using aux files; then the same oneline display can be used
- The process is
  - On the Regions Dialog make sure the **Save Styles in Aux File** box is checked
  - Click **Save in Aux File** (this process only needs to be done once unless the regions or styles are changed)
  - Load the new case, which must have geographic coordinates defined, and use **File, Load Auxiliary** to load the aux file

Example: 123,000 Bus Case Modeled a Combined North America East-West Grid

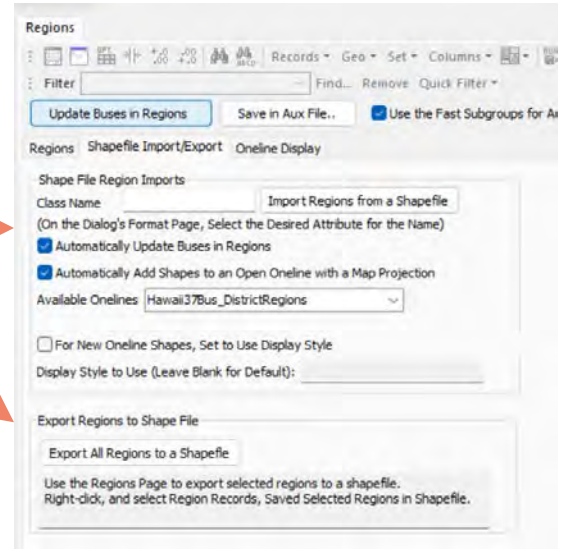
- Loading the region aux took about ten seconds, which included linking all the buses to the regions
  - The case has Canadian and Mexican buses, but since the example didn't include regions outside of CONUS, they are not linked; most of Texas is empty because the study did not include ERCOT

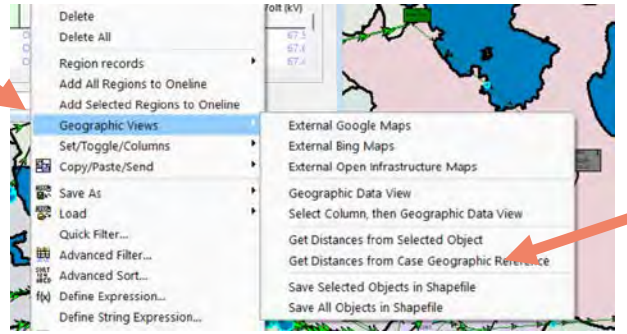




Saving Regions (and Other Objects) in Shapefiles

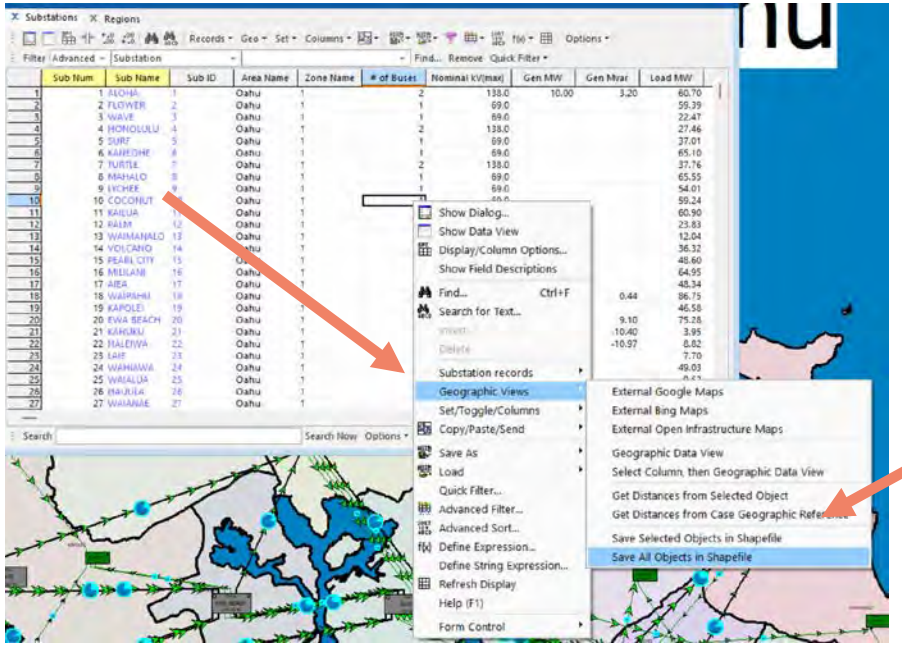
- Starting with the version 24, June 4, 2025 patch, Simulator allows regions and pretty much any other geographically-based power system object to be stored in a shapefile
- For regions this option is available either from the (renamed) Shapefile Import/Export page, or in the right-click menu of the Regions page
  - The geographic information and all the fields shown on the display are exported
- In shapefiles the names of fields are limited to 10 characters





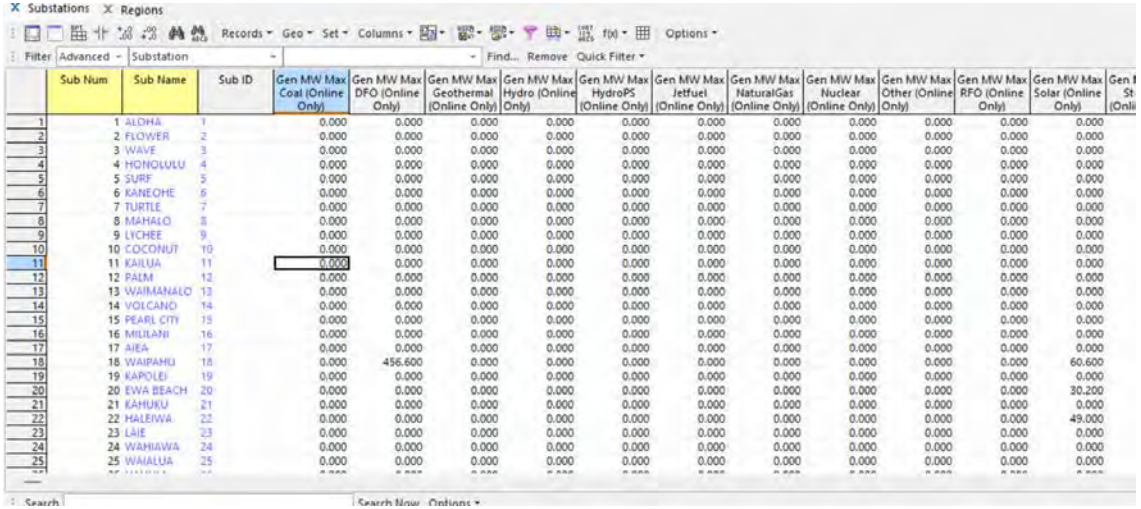
Saving Other Case Information Data in Shapefiles

- Using the same right-click functionality as with the regions display, geographic information and fields can be saved in shape files from pretty much any other Case Information display that shows geographic information
  - Currently only a single geographic point is stored per object plus all the fields shown on the Case Info display
- Because of the shapefile 10 character field limitation, some field names may need to be truncated; to map these fields back to their original names, a *.csv file is also created



Example: Substation Fields in Shapefile

- This example shows some truncated substation fields



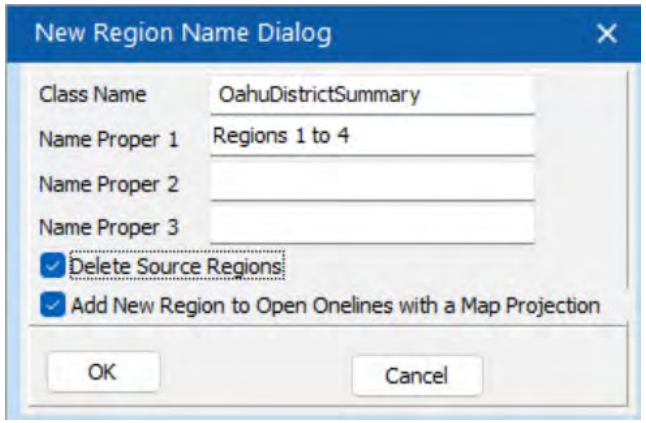
Sub Num	Sub Name	Sub ID	Gen MW Max Coal (Online Only)	Gen MW Max DFO (Online Only)	Gen MW Max Geothermal (Online Only)	Gen MW Max Hydro (Online Only)	Gen MW Max HydroPS (Online Only)	Gen MW Max Jetfuel (Online Only)	Gen MW Max NaturalGas (Online Only)	Gen MW Max Nuclear (Online Only)	Gen MW Max Other (Online Only)	Gen MW Max RFO (Online Only)	Gen MW Max Solar (Online Only)
1	ALOHA	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	FLOWER	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	WAVE	3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	HONOLULU	4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	SURF	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	KANEOHE	6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	TURTLE	7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	MAHALO	8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	LYCHEE	9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	COCONUT	10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	KAILUA	11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	PALM	12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	WAIMANALO	13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	VOLCANO	14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	PEARL CITY	15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	MILILANI	16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	AIEA	17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	WAIPAHU	18	0.000	456.600	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	60.600
19	KAPOLEI	19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	EWA BEACH	20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	30.200
21	KAHUKU	21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	HALEIWA	22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	49.000
23	LAIE	23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	WAHIAWA	24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	WAIALUA	25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- If fields are the same up to 10 characters, the last characters are replaced by numbers to make them unique

	A	B
1	PowerWorld Field Name	Shapefile Field Name (10 Characters Max
2	Sub Num	SubNum
3	Sub Name	SubName
4	Sub ID	SubID
5	Gen MW Max Coal (Online Only)	GenMWMaxCo
6	Gen MW Max DFO (Online Only)	GenMWMaxDF
7	Gen MW Max Geothermal (Online Only)	GenMWMaxGe
8	Gen MW Max Hydro (Online Only)	GenMWMaxHy
9	Gen MW Max HydroPS (Online Only)	GenMWMaxH0
10	Gen MW Max Jetfuel (Online Only)	GenMWMaxJe
11	Gen MW Max NaturalGas (Online Only)	GenMWMaxNa
12	Gen MW Max Nuclear (Online Only)	GenMWMaxNu
13	Gen MW Max Other (Online Only)	GenMWMaxOt
14	Gen MW Max RFO (Online Only)	GenMWMaxRF
15	Gen MW Max Solar (Online Only)	GenMWMaxSo
16	Gen MW Max Storage (Online Only)	GenMWMaxSt
17	Gen MW Max Unknown (Online Only)	GenMWMaxUn
18	Gen MW Max WasteHeat (Online Only)	GenMWMaxWa
19	Gen MW Max Wind (Online Only)	GenMWMaxWi
20	Area Name	AreaName
21	Zone Name	ZoneName
22	# of Buses	#ofBuses
23	Nominal kV(max)	NominalkV(
24	Gen MW	GenMW
25	Gen Mvar	GenMvar
26	Load MW	LoadMW
27	Load Mvar	LoadMvar
28	Shunt MW	ShuntMW
29	Shunt Mvar	ShuntMvar
30		

Combining Regions

- Starting with the version 24, June 8, 2025 patch existing regions can easily be combined, with or without retaining the source regions.
- On the Regions Dialog, Regions Page, select the regions to combine (filtering can be used to show the desired regions); then right-click and select **Region Records, Combine Selected Regions**. This displays the New Region Name Dialog; enter the name for the new region
  - Optionally the source regions can be deleted; also, the name of the combined regions can be the same as one of the source regions



Currently the regions are combined, retaining the original region subgroups

Summary and Going Forward

- Starting with Simulator Version 24, especially patches on or after May 21, 2025, there is now a large amount of support for analysis and visualization using geographic regions
- The use of geographic regions requires that the case have at least some power system components with geographic coordinates (those without geographic data are ignored)
- Since regions are case independent, they and their associated displays can be easily used with other cases
- Now that basic regions are supported, we expect a lot of new functionality being developed in the next few months! Suggestions are encouraged!