EC-LEDS
ENHANCING CAPACITY FOR LOW EMISSION DEVELOPMENT STRATEGIES

Geospatial Toolkit Hands-On Training

Functionality Overview

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Exercise 1

Vietnam GsT application install

1. Find "vietnam_gst.exe" on CD
2. Copy file to local hard drive
3. Double click "vietnam_gst.exe"
4. Follow prompts
5. Once installation is complete, open the Geospatial Toolkit

Hint: Geospatial Toolkits are also available for download online at http://www.nrel.gov/international/geospatial_toolkits.html

Exercise 1 Troubleshooting

Skip this step if the GsT opens after installation.

If you receive an error message and the GsT fails to open, follow the directions below:

1. Find "vcredist_x86.exe" on CD
2. Copy file to local hard drive
3. Double click "vcredist_x86.exe"
4. Follow prompts
5. Once installation is complete, open the GsT

Hint: The Microsoft Visual C++ 2010 Redistributable Package (x86) can also be downloaded from http://www.nrel.gov/international/geospatial_toolkits.html

Exercise 2

Exploring and identifying data in map layers

What are the monthly and annual global solar resource values for Latitude: 10.0, Longitude: 105.6?

1. Use "Zoom to Point" tool to navigate to point with latitude 10 and longitude 105.6. Zoom in at a factor of 10 (Scale=10)

2. Turn on "Global Solar" layer

3. Click the arrow to the right of the "Global Solar Layer" and select "Metadata." Note the information that appears.

4. Use the "Identify" tool to find the solar resource values for the location. *Expand the arrow under the annual global solar ("Annglo") heading to view monthly resource values.*

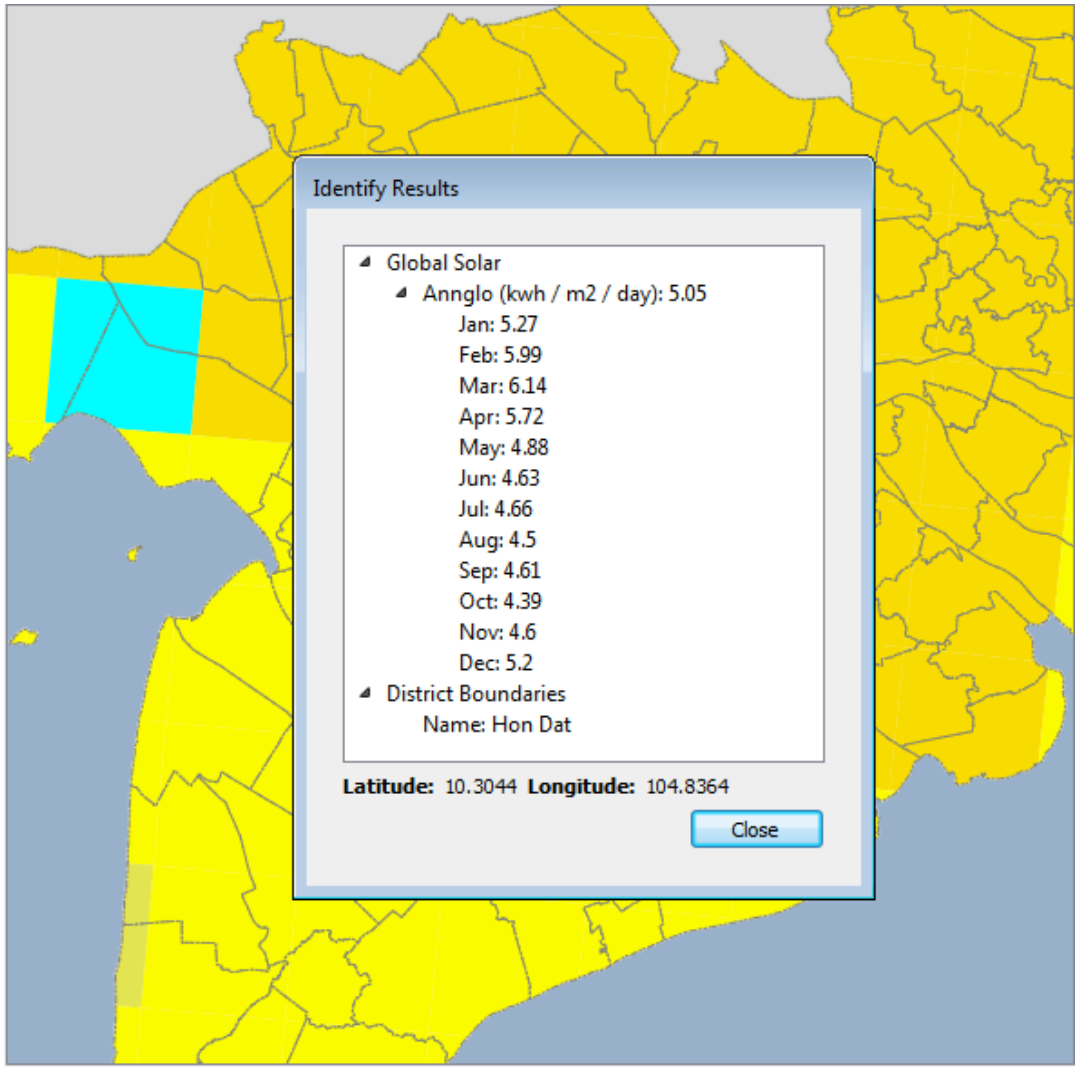
5. Close the "Identify" tool

6. Turn on the "District Boundaries" layer

7. Use the "Identify" tool again. *What additional information is displayed?*

Hint: The "Identify" tool only includes data for layers that are turned on.

Example Results for Exercise 2



Exercise 3

Solar query

Find all areas near the district level that meet the following criteria:

Global Solar Resource > 4.5kWh/m²/day
Are not in protected areas
Are not in wetlands, water bodies, or urban areas
Are within 2km of roads
Contain slopes < 5%

1. Turn on "District Boundaries" layer

2. Zoom to the extent of any district

3. Open "Query" tool
4. Make query selections
5. Limit the geographic area of the query to the current map extent ←important step to minimize run time
6. Click "Run Query"
   (if no results are returned, zoom to a different area and execute the query)
7. Click "Close" once the query has completed

Exercise 4

Exploring Query Results

1. Note that your solar query result from Exercise 3 is saved as a ***new layer*** at the top of the layer tree.

2. Click the arrow to the right of your query result layer and click "Rename."

3. Rename solar query in Exercise 3 "My_Solar_Query."

4. Use the "Zoom full extent" tool. *Note that your query has been applied <u>only</u> to the original extent that you specified.*

5. Press the "Zoom previous" tool.

6. Drag and drop "My_Solar_Query" below the "District Boundaries" layer. *Note the change in the order in which the layers are drawn.*

7. Turn on the "Protected Areas," "Landuse," and "Roads" layers. *Use the Identify tool to verify that the query has excluded the areas you have specified.*

8. Click the arrow to the right of the "My_Solar_Query" layer. Change the transparency of the layer.

Exercise 5

Generate query results summary

1. Open the "Query result summary" tool

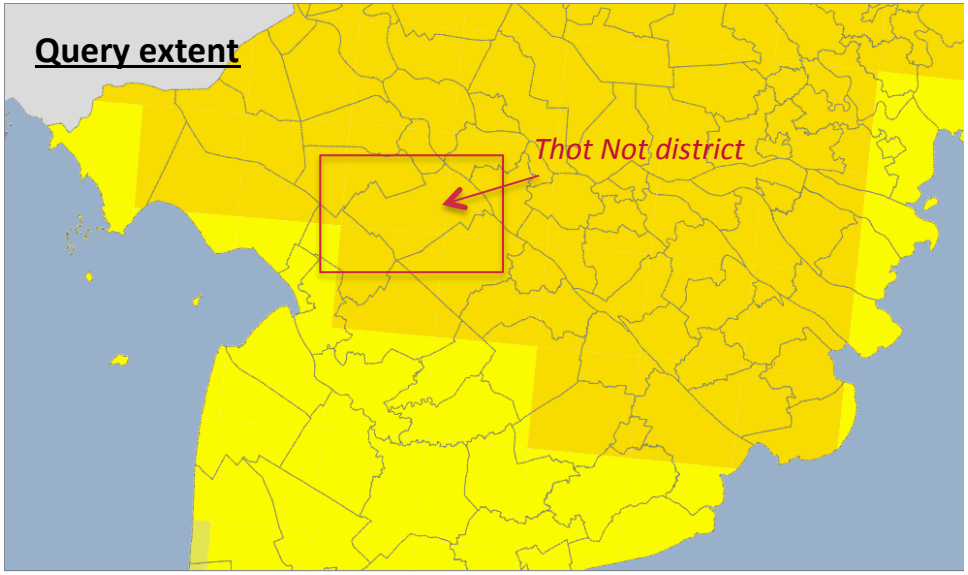
2. Select "My_Solar_Query" and click "Open."

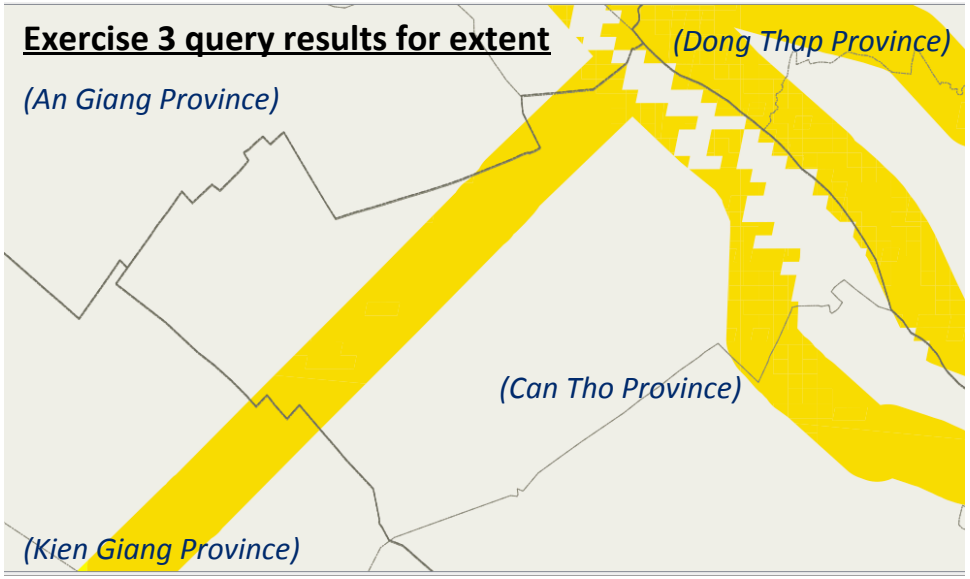
3. Select "Yes" to the prompt that appears.

4. Note the information on all three tabs.
   - What is the calculated nameplate capacity and total land area meeting the constraints for the extent you chose?
   - Which provinces within the extent you chose have areas meeting the constraints?
   - *Note: results are calculated only for the specified geographic area*

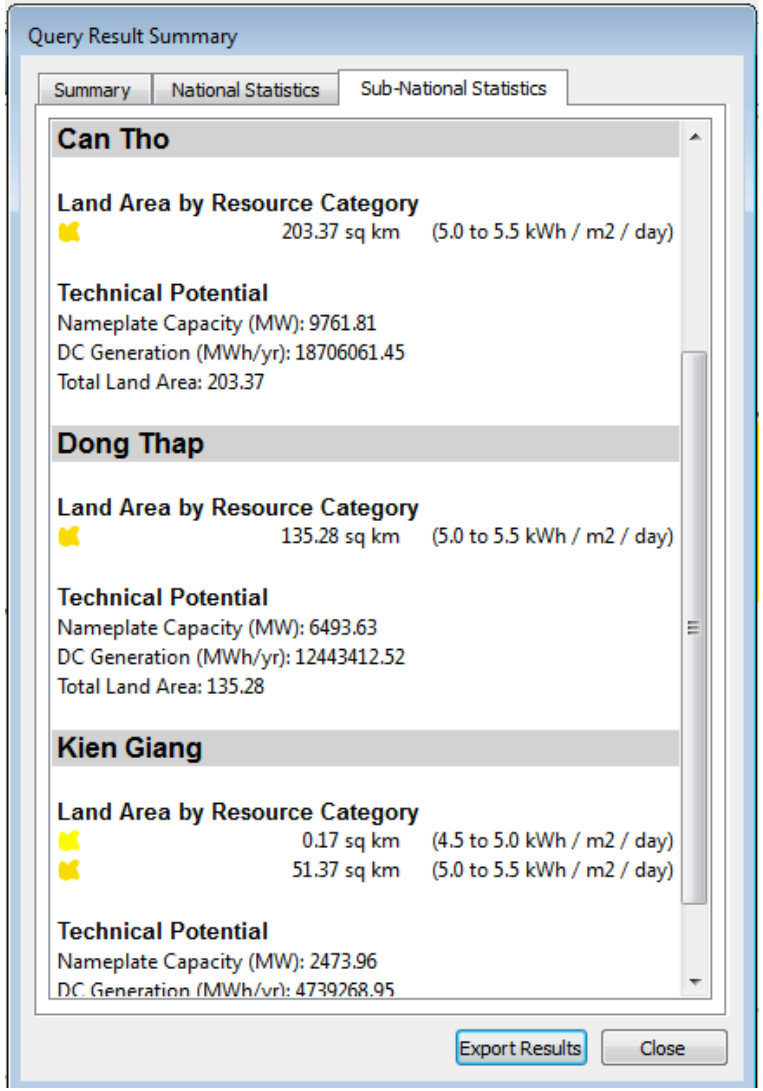
Hints:
- If no land in a province meets the query criteria, that province will not appear in the results summary.
- Query results summaries can be exported into .csv files.

Example Results for Exercises 3-5





Exercise 5 query result summary (excerpt)



Exercise 6

Saving, removing, and adding layers

Save a layer:

1. Click the arrow to the right of "My_Solar_Query." Select "Save layer as a shapefile."

2. When prompted, name the file My_GsTSolar_Query.shp and save it to your desktop.

Remove a layer from the GsT:

3. Click the arrow to the right of "My_Solar_Query." Select "Remove" and select "Yes" to the following prompt.

Add a layer to the GsT:

4. Select "Add shapefile layer."
5. Select My_Solar_Query.shp from your desktop.
6. Click "Open."

Hint: You can also use GsT data and query results in other GIS software. See the Help documentation for more information. 

Exercise 6 (continued)

Hints: Adding and removing your own data

- If you have GIS data in the correct format, you can add this data as layers to the GsT.
- The GsT uses shapefile GIS format.
- When you add your own data to the GsT, you will not be able to customize line or fill colors.
- The projection for your data must match the GsT's projection. The GsT will not automatically re-project data.
- Adding incorrectly formatted files will not damage the GsT but will result in your data being incorrectly displayed. You can remove the layer if it does not display correctly in the toolkit.
- *You should attempt to use your own data with the GsT only if you are familiar with GIS data formats, can verify that your files are compatible with the GsT, and (if necessary) use external GIS tools to change your data's projection to match the GsT's projection.*
- Refer to the Help documentation for more information.

Exercise 7

Wind query

Find all areas near the provincial level that meet the following criteria:

Wind Resource >= 300 W/m2 and <= 600 W/m2

Are not in protected areas

Are within 10km of transmission lines

Contain slopes <= 5%

1. Zoom full extent and turn on "Province Boundaries" layer (turn off other layers)
2. Open "Query" tool
3. Make appropriate selections
4. Under "Geographic Area," select "State/Province" and choose a province.
5. Click "Run Query"
   (if no results are returned, execute the query for a different province)
6. Rename your query "My_Wind_Query"
7. Generate a results summary for this query

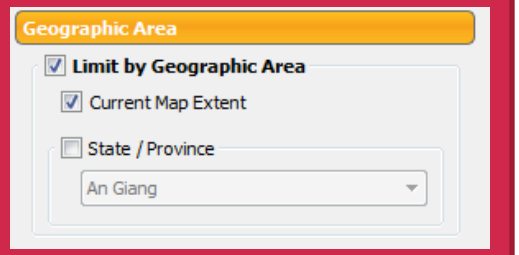
Hint: For queries on wind resource, the GsT displays the wind power density rather than wind class. Refer to the Help documentation for more information.

Exercise 7 (continued)

Hint: Tips for minimizing query run time

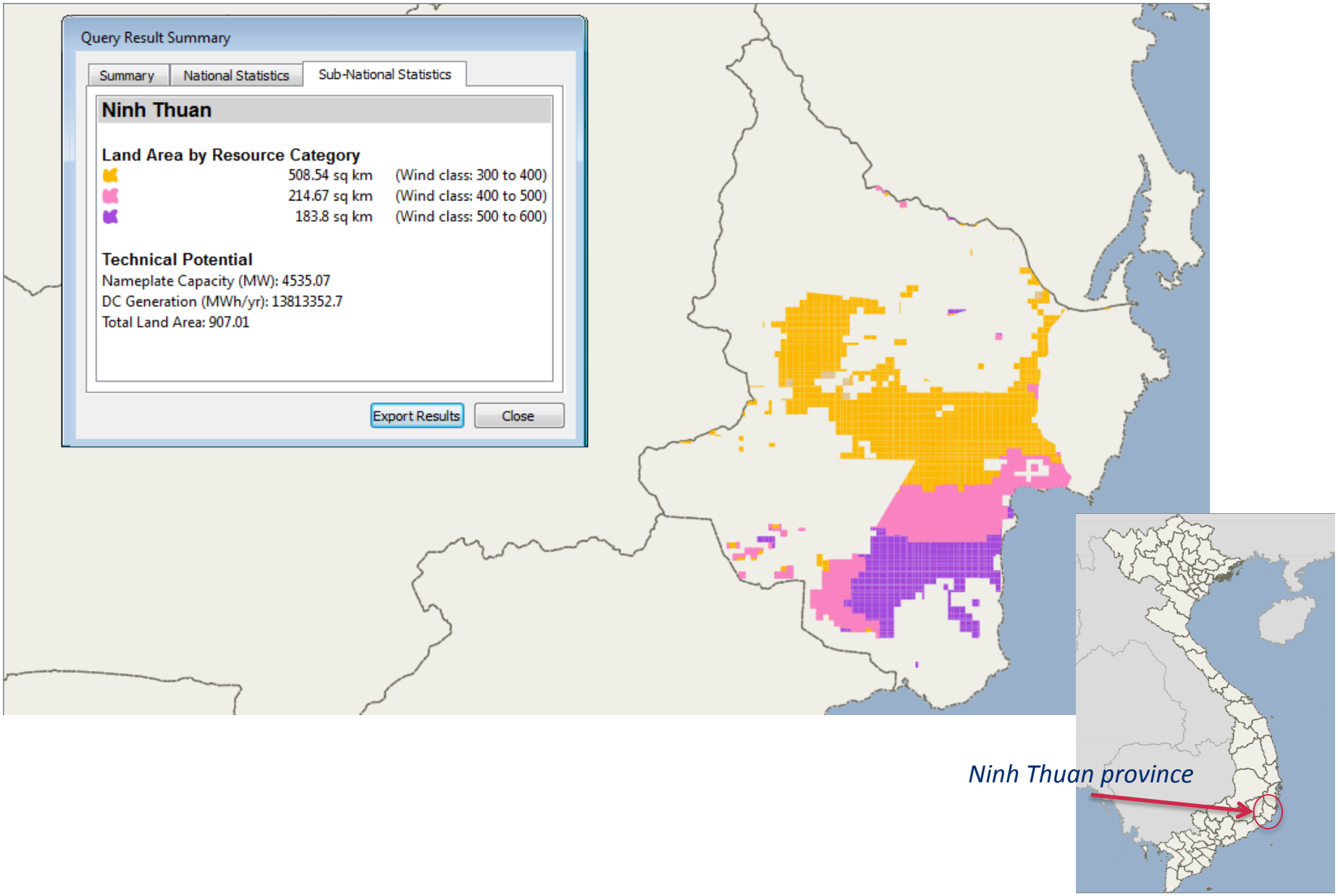
- Use the Zoom tools to analyze smaller areas (e.g., provinces, districts). *The smaller the analysis area, the faster the query.*

- Select "Limit by Geographic Area" (current map extent or province) when running queries at the sub-national level.



- Specify fewer than three criteria in a given query

Example Results for Exercise 7



Exercise 8

Biomass query

Find Gross Potential Energy, Net Potential Energy, MWh Potential, and MW Potential for all crop residues at any point in Vietnam

1. Open "Query" tool
2. Make biomass resource selections
3. Define query point and buffer distance
4. Review the Inputs default values and "Inputs help." *Note that Available Resource is calculated when the query is run.*

   →Note: default values provided in the Inputs tab can be modified by users based on local conditions.
5. Click "Run Query" and follow prompts
6. Review the "Results" and "Results Help"

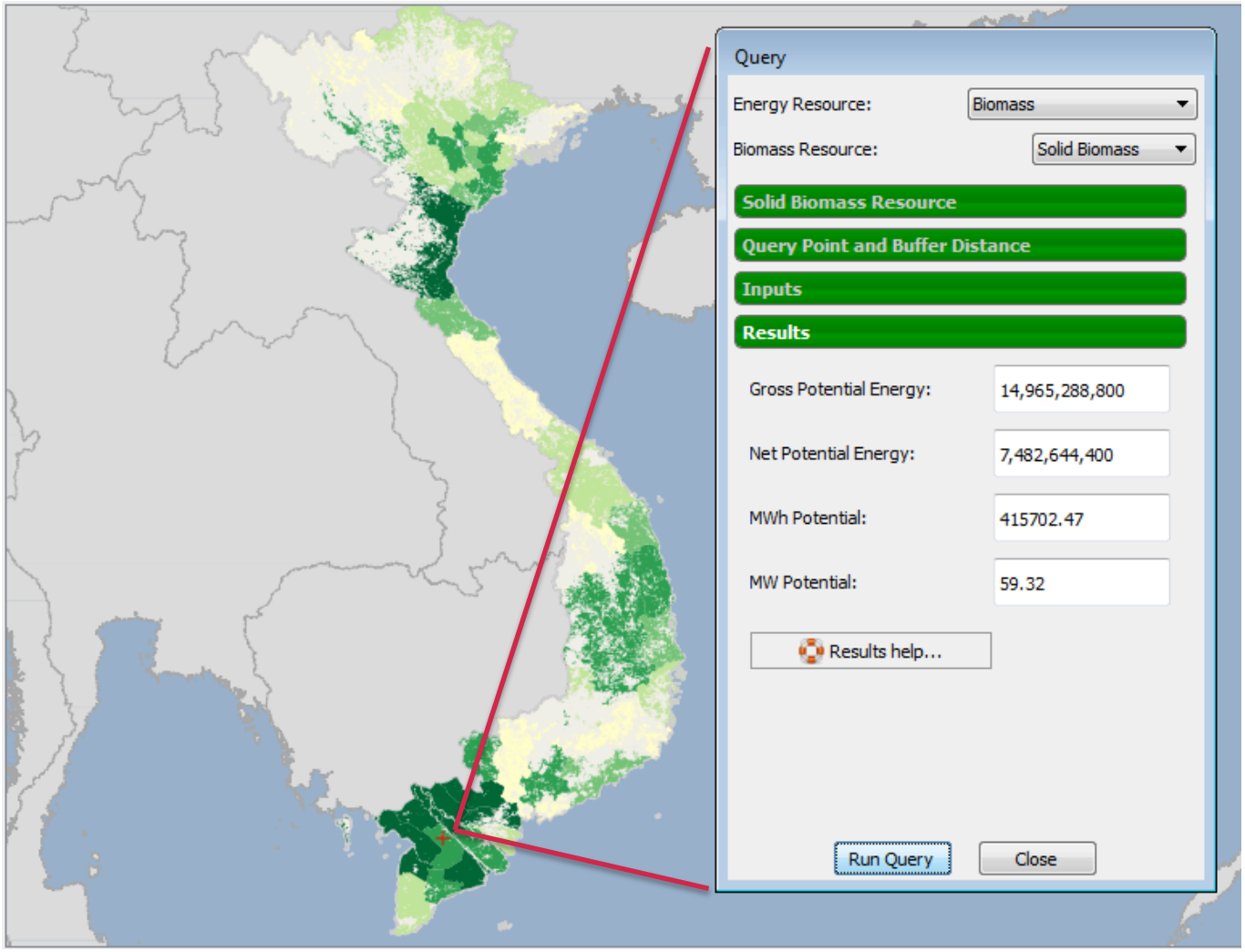
Optional

7. Change the buffer distance and execute the query

Hint: Unlike solar and wind queries, the biomass query does not produce a new results layer, and results are not exportable.

Example Results for Exercise 8

Query point: Latitude 10.0, Longitude 105.6; Buffer: 25km



HOMER in the GsT

- Provides a *very preliminary* evaluation of technology options for off-grid power systems.
  - *If you plan to make decisions based on the HOMER results, your should run the model outside of the GsT (using inputs from the GsT as a starting point).*

- Simulates hundreds of hybrid system configurations but displays only the six systems having the lowest cost of generating electricity.

- The GsT uses HOMER version 2.19. The most up-to-date version is 2.68. To download the latest version of HOMER, visit http://homerenergy.com/index.html.

Exercise 9

Using the GsT's HOMER Tool

According to the HOMER optimization model, what technology (system type) has the lowest LCOE near location lat: 10.0, long: 105.6 and the "Community II" application type (all other user inputs at defaults)?

1. Zoom to point

2. Turn on the "Electrification" layer ← This step is not necessary to run the HOMER tool

3. Enable the "HOMER" tool

4. Click at or near the target location
   (Try selecting a district with a low electrification rate)

5. Set "Type of application to model" to "Community II." Read the description and review the default inputs.

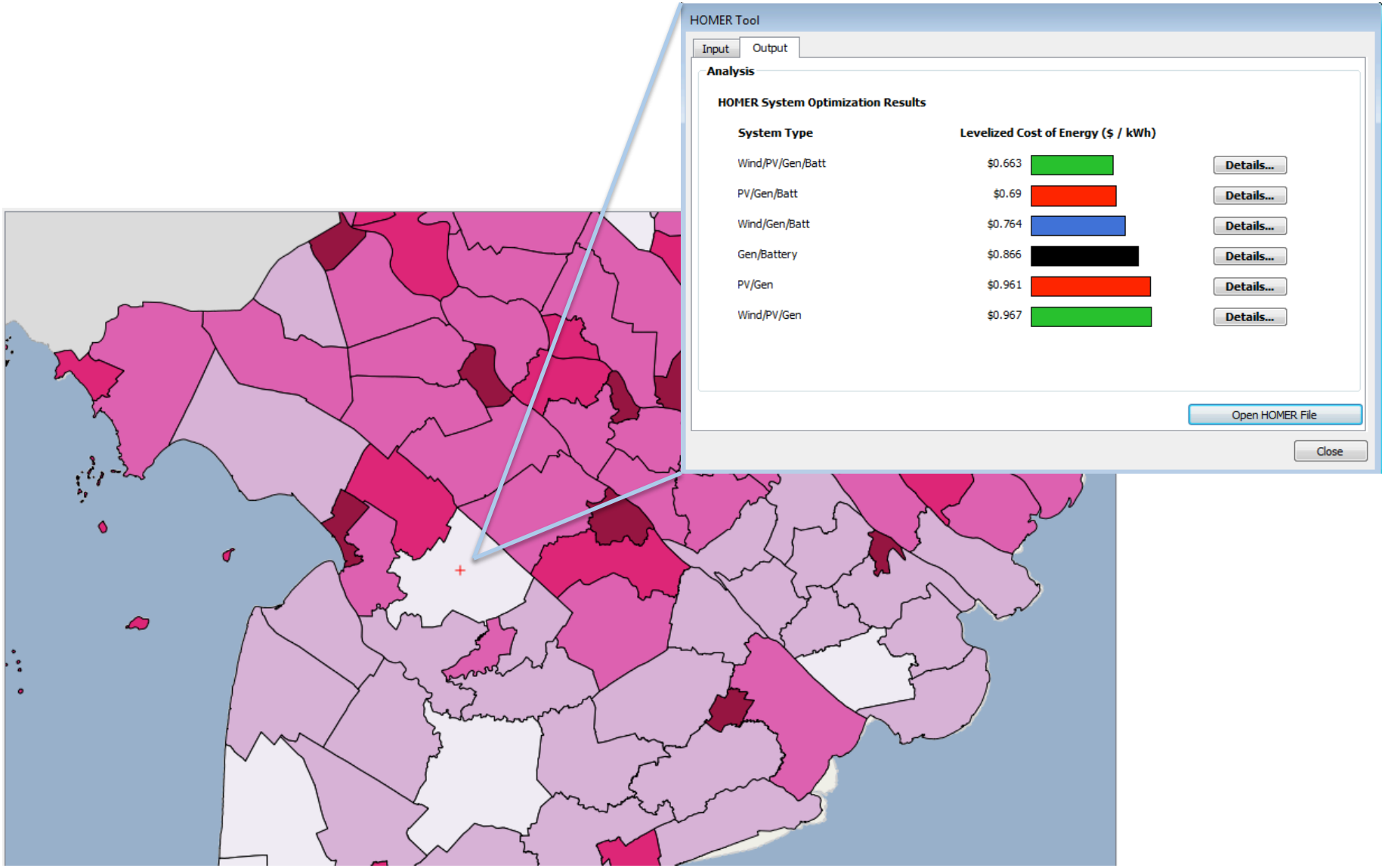
6. Click "Run Homer Analysis" and note results.

Optional

7. Click on "Input" tab
8. Rerun the analysis using a different application type
9. How have the results changed?

Hint: For detailed information about the inputs and outputs to the HOMER tool scenarios, select "View HOMER Input Summary" on the Input tab and "Details" on the Output tab. You can also "Open HOMER File" to view the model.

Example Results for Exercise 9



Exercise 10

Generate a Custom Map

1. Zoom to the extent of any province and turn on the "Wind Resource" and "Electrification" layers.

2. Adjust the transparency of the "Electrification" layer so that the "Wind Resource" layer is also visible.

3. Click "Save map as PDF" button

4. Set "Map Title", "Map Name", and "Page Size"

5. Click "OK"

6. Specify location and name of file and save

7. Open file

Hint: The PDF will show the current map extent.

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Illustrative Applications

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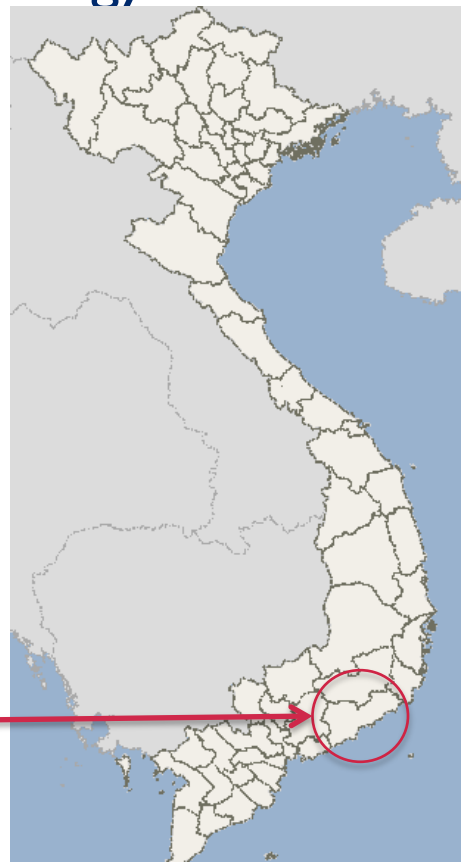
GsT Exploration Related to Policy

- Visual exploration to explore patterns
- GsT analysis can be limited to local areas to identify local potential
- Different exclusion or prioritization criteria can be applied, and impact on resource availability displayed

Exercise 11

Using the GsT to inform a provincial-level renewable energy target

- Apply a series of filters to each technology available and evaluate impact
  - Minimum exclusions
  - Stricter exclusions
- Sensitivity analysis
- This exercise will use the Binh Thuan province as an example



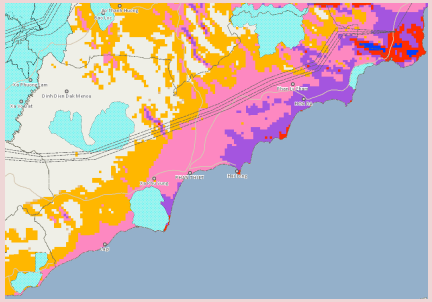
Exercise 11

Using the GsT to inform provincial-level renewable energy targets

Scenario 1: Minimal exclusions

1. Turn on the "Province Boundaries" layer
2. Open the Query tool and set:
   - Wind resource range: 300 – 1000 W/m^2
   - Exclude protected areas
   - Limit geographic area to the Binh Thuan province
   - Run Query
3. Rename query result layer to 'WindScenario1'
4. Run a query results summary for WindScenario1
5. Review results

Wind Scenario 1 Results

	Scenario 1		
Visualization			
Query Constraints	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas		
Nameplate Capacity (MW):	23,439		
Total Land Area (sq km):	4,688		
DC Generation (MWh/yr):	72,902,801		

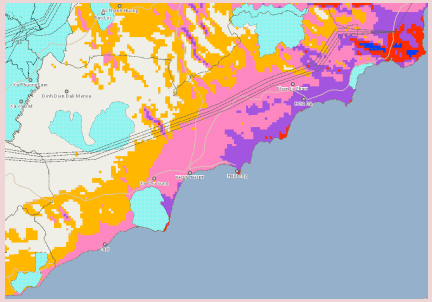
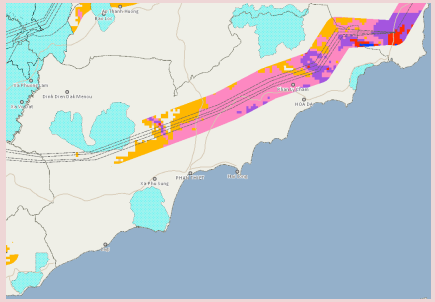
Exercise 11 (cont.)

Using the GsT to inform provincial-level renewable energy targets

Scenario 2: Moderate exclusions

6. In Query window, set;
   - Wind resource range: 300 – 1000 W/m^2
   - Exclude protected areas
   - 5km transmission line buffer
   - Limit geographic area to the Binh Thuan province
   - Run Query
7. Rename query result layer to 'WindScenario2'
8. Run a query results summary for WindScenario2
9. Review results. Visually explore where differences are occurring between Scenarios 1 and 2.

Wind Scenario 2 Results

	Scenario 1	Scenario 2	
Visualization			
Query Constraints	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas •Transmission line buffer: 5 km	
Nameplate Capacity (MW):	23,439	6,883	
Total Land Area (sq km):	4,688	1,377	
DC Generation (MWh/yr):	72,902,801	21,414,642	

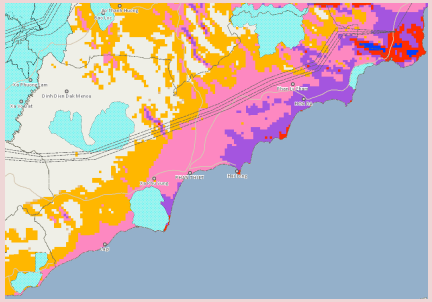
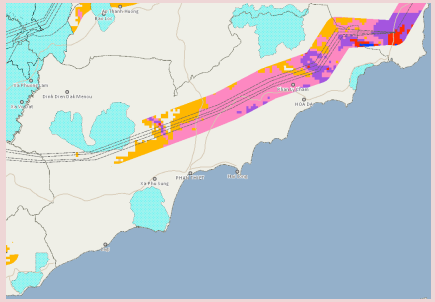
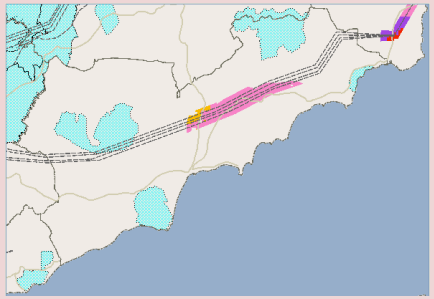
Exercise 11—Optional

Using the GsT to inform provincial-level renewable energy targets

Scenario 3: Strict exclusions

10. In Query window, set;
    - Stricter exclusions (Wind)
    - Wind resource range 300 - 1000 W/m2
    - Exclude protected areas
    - Exclude land use: forest, urban, wetlands and water
    - Limit to within 5 km of roads and 2 km of transmission
    - Limit geographic area to the Binh Thuan province
    - Run Query
11. Rename query result layer to 'WindScenario3'
12. Run a query results summary for WindScenario3
13. Review results. Visually explore where differences are occurring between Scenarios 1, 2, and 3.

Wind Scenario 3 Results

	Scenario 1	Scenario 2	Scenario 3
Visualization			
Query Constraints	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas •Transmission line buffer: 5 km	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas •Exclude land use: forest, urban, wetlands and water •Transmission line buffer: 2 km •Road buffer: 5 km
Nameplate Capacity (MW):	23,439	6,883	1,591
Total Land Area (sq km):	4,688	1,377	318
DC Generation (MWh/yr):	72,902,801	21,414,678	4,966,570

Notes on Exercise 11:

Variation: Meeting a regional-level renewable energy production targets

- Different regions may have different resource quality
- Encouraging development in lower resource areas may require incentives to offset lower generation potential
- Other social or economic drivers may support developing resources even in areas of lower technical or economic potential
  - *As an additional exercise, overlay the "Electrification," "Poverty," and "Cities"* data on the query results for Exercise 11. Where might renewable energy complement other development objectives?*

**Cities serve as proxies for electrical load centers*

Exercise 12

Analysis of grid integration options for variable renewable energy resources (rural vs. urban)

- *No query for this, but can manipulate data to infer.*
  - *Use distance to roads as a proxy for rural vs. urban*

1. Open the Query Tool
   - Set Wind resource range 300 - 1000 W/m^2
   - Exclude protected areas
   - Limit to within 20 km of roads
   - Limit geographic area to the Binh Thuan province
   - Run query
2. Rename query result layer to 'UrbanWind'

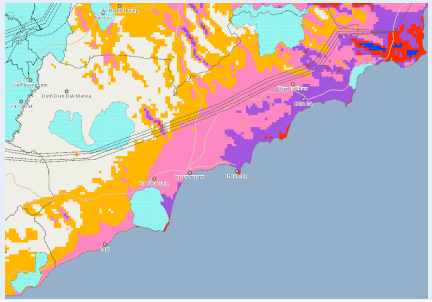
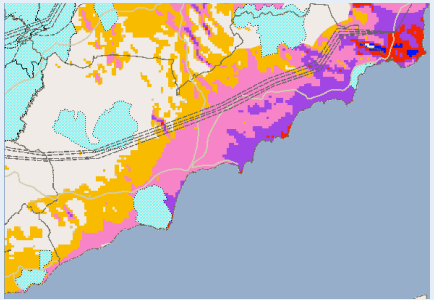
Exercise 12 (cont.)

3. Run a query results summary for ‘UrbanWind’

4. Review results and compare to ‘WindScenario1’

5. Rural wind can be estimated by subtracting ‘Urban Wind’ from ‘WindScenario1’

Exercise 12 Results

	Scenario 1	"Urban Wind"	"Rural Wind"
Visualization			(Calculated)
Query Constraints	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas	•Minimum Wind Resource: 300 W/m^2 at 65m •Exclude protected areas •Road buffer: 20km	(Calculated)
Nameplate Capacity (MW):	23,439	22,168	1,271
Total Land Area (sq km):	4,688	4,434	254
DC Generation (MWh/yr):	72,902,801	69,153,991	3,748,810

Note: Rural wind applications may require additional exploration as turbine size, required minimum wind resource quality, etc. can differ as compared to urban wind applications.

Exercise 13

Analysis of site specific opportunities to complement thermal generation or reduce emissions

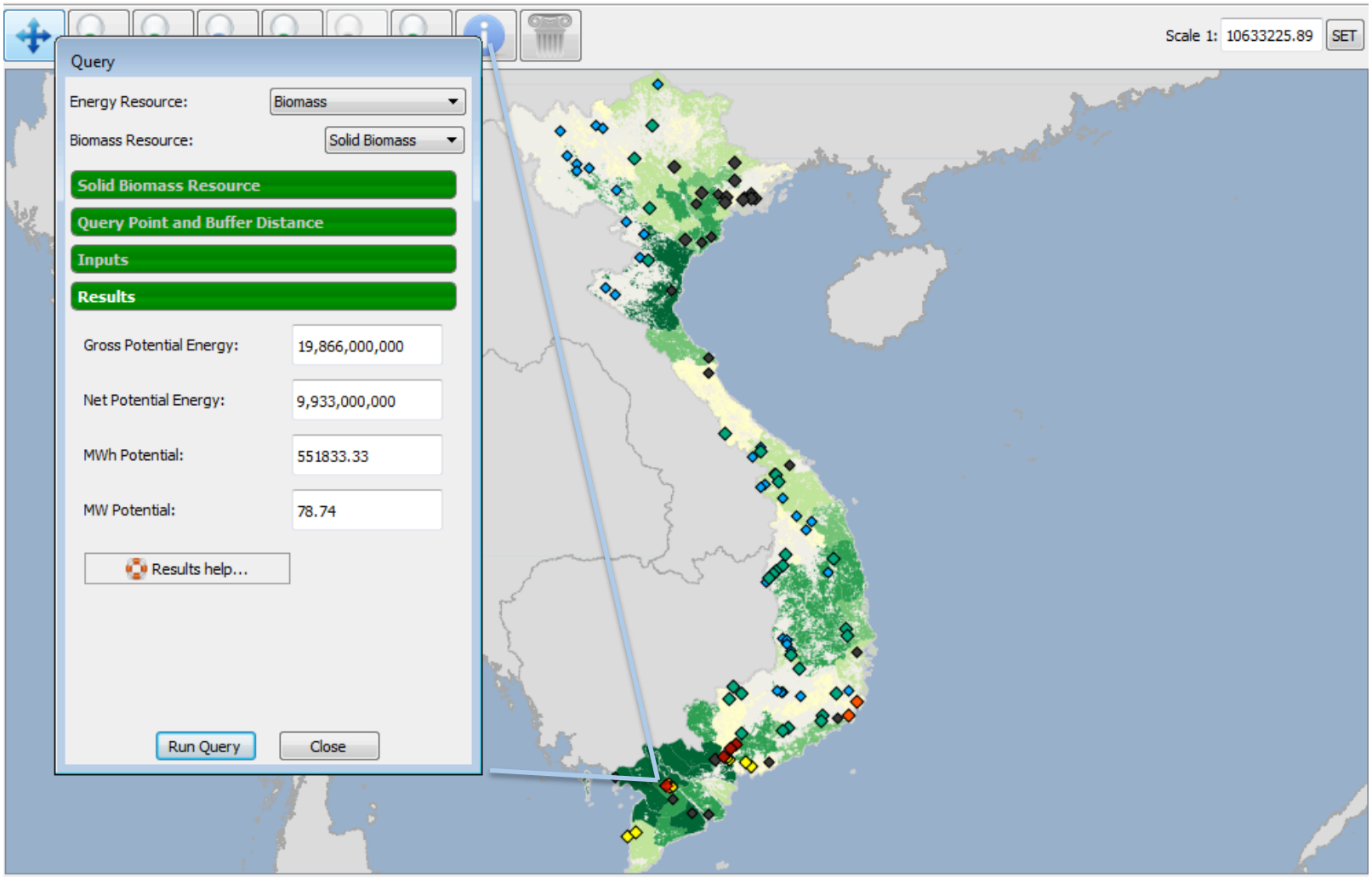
1. Zoom to full extent
2. Turn on "Power Plants" and "All Crop Residues;" turn off other layers
3. Open Query Tool and select 'Biomass'
4. Go to 'Solid Biomass Resource' and select 'All Crop Residues'

Exercise 13 (cont.)

5. Go to ‘Query Point and Buffer Distance’ and select ‘Define location by clicking on map’
6. Click on a power plant location
7. Click ‘Run Query’
8. Review displayed results
9. This residue is potentially available to supplement generation at a thermal plant

Example Result for Exercise 13

Omon 1 Power Plant *(Query point: Latitude 10.1935, Longitude 105.4667; Buffer: 25km)*



Discussion Notes

- Within full GIS software, additional functionality is available to enhance this type of analysis
- Other data layers can guide these types of analysis
  - Population density
  - Population growth trends
  - Grid planning
- Analysis is only as good as the data going into it (example – land cover data)

Exercise 14

Change countries

1. Open your internet browser and navigate to http://www.nrel.gov/international/geospatial_toolkits.html.

2. Select a Geospatial Toolkit from the list and click the executable (EXE) file. Follow the prompts.

3. On the "Choose Components" screen, select ONLY the data package (do not select "GsT application" or uninstall the software).

4. Follow prompts and open the GsT.

5. In the GsT, click the "Change country data" icon and select the new country. *The GsT will automatically shut down and restart with the new country data.*

Hint: GsT data varies according to country. Depending on the country data, some functionalities (e.g., biomass queries) may not appear in all GsTs.

Open space

- Continue to explore the GsT on your own

- Explore the GsT for your country
  - What existing datasets are you aware of that could be incorporated into the GsT for your country? Where do these data layers reside (public sources, government, etc.)?
  - *Philippines GsT coming soon!*

Contacts

For technical questions and troubleshooting on the GsT:

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Additional Resources:

- NREL GsTs: http://www.nrel.gov/international/geospatial_toolkits.html
- OpenEI GsT resources: http://en.openei.org/wiki/Geospatial_Toolkit