

Puget Sound Company Overview

Puget Sound Energy is Washington State's largest and oldest energy utility, serving nearly 1 million electric customers and more than 650,000 natural gas customers, primarily within the Puget Sound region.

Puget Sound Energy became a combined energy company in 1977 with the merger of Puget Sound Power & Light Co. and Washington Energy Company (parent of Washington Natural Gas). We currently serve gas and/or electric to customers in 11 counties in Washington covering almost 7,000 square miles of service territory.

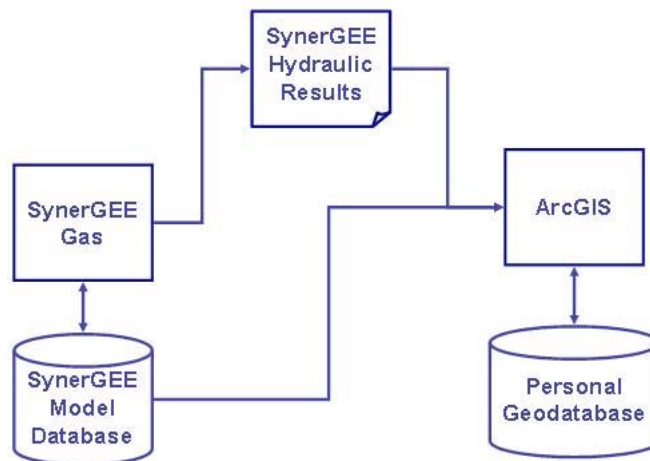
Purpose of the Project

This project was undertaken in support of a Cost of Service (COS) review to determine if rate adjustments were warranted. It was crucial to have a fair way to allocate this cost for specific customers when any particular pipe serves many. Taking advantage of our system model we contracted with Advantica to create a process that would determine the percent utilization of each facility that was used to serve a customer. Each segment cost could then be broken down and allocated appropriately.

Solution Overview

In reviewing the project requirements, there was no single application that could meet the required scope. The end solution had to provide solid hydraulic results accompanied by a flexible graphic representation of those results. Advantica's network analysis package, SynerGEE® Gas, could provide the hydraulic results, but was limited in its ability to provide the results thematically. As a result, Advantica designed a solution that integrated SynerGEE with ArcGIS.

A general overview of the solution is provided below.



Beginning with a balanced hydraulic model from SynerGEE, the exported model and a new pipe contribution report are imported into ArcView via a custom application built by Advantica. This combination coupled with further data gathering on pipe segments and customers create an environment to produce accurate COS calculations.

The remainder of this paper will provide more details on key parts of the solution.

Network Analysis

Network analysis or computer based modeling is a core technology that has been in use by natural gas utilities for more than 40 years. A hydraulic model provides a comprehensive look at a system's pressures, flows, gas properties, and customer portfolio. The model provides an engineer with insights into the network's deficiencies and capabilities. Historically, gas utility companies use the network analysis technology daily in planning groups to:

- Design and determine the need for capacity based capital improvements
- Support field operations planning (i.e. consequences of operating a valve, when to take a main out of service, bypass requirements)
- Approve proposed loads on the system
- Support gas supply through line pack calculations and in decisions to interrupt customers

In more recent years, network analysis's role in the gas utility has expanded to incorporate tasks that are focused on the company's financial planning. Utilities are relying on network models to determine the rate of return for a particular asset, the cost to service a new customer, the costs or benefits from purchasing gas from various supplies, including LNG. In today's world of increasing wholesale prices for natural gas and the added pressure to increase returns, network analysis has proven to be a very valuable resource.

Pipe Contribution

One of the key design aspects of our solution for calculating the cost of service was the determination of the pipes contributing to the service of a customer. In other words, which pipes contribute to the flow of natural gas from the gate station to an individual customer's service line? In order to determine the pipe flow path, we turned to network analysis for the answer. SynerGEE Gas, Advantica's network analysis software, provides PSE with flow and pressure calculations for their 120,000 node model. The program also provides flow direction for each pipe in the model. The limitation, however, involved the ability to single out an individual customer, and to visualize that customer's flow path along with the percent contribution of each pipe along the path. The percent contribution was vital to the solution since pipes are used to serve more than one customer within the system. In order to determine the cost of service for a particular customer, that customer's portion of the pipe's flow must be isolated.

When it was first decided to investigate the capabilities of using SynerGEE, it was noticed that the ability to report on the pipe contribution for each customer or node in the hydraulic model was not available. At that point, PSE contacted Advantica to investigate the possibilities of enhancing the software to include the pipe contribution information. Advantica was receptive to the idea and added two new features to the program. The first feature that was added was a "backwards trace" of the pipe network from customer to source. This capability would enable PSE to select any node in the model

and have SynerGEE trace the pipe network from the node to the supply of gas. As SynerGEE traced back through the network it would determine how much of the gas flowing through each pipe along the flow path was contributing to the demand of the customer selected in the model. By determining the percent of gas going to the customer, SynerGEE could calculate the percent contribution of that pipe by dividing the portion of the customer gas in that pipe by the total flow through the pipe.

The second feature that was added was a Pipe Contribution Report. This feature required that results from the backwards trace be summarized in a format that was easy to read and easy to integrate with other sources of system data. Functionality was added to review the report directly in SynerGEE as well as to export the data into a format readily accessible by the Cost of Service application in ArcView.

The required steps in SynerGEE are:

- o Select the desired nodes for processing (the initial project only evaluated Non-interruptible gas customers, about 800 in the total model). The subset is easily stored and selected via a SynerGEE Partial Chapter.
- o Generate the Pipe Contribution Report (shown below). This must be done on a balanced model, making sure to select the reporting "range" of Selected Nodes only.

Pipe Contribution Report

Load node: ID7613 Load: 171.000 (SCFH)

Contributing pipes:

FID	From	To	Percentage of Pipe Flow Contributing to Load	Percentage of Load Flowing in pipe	Flow (SCFH)	Length (FEET)	Diameter (INCHES)	Roughness (INCHES)
EQ125109	ID7612	ID7613	100.000	100.000	171.000	0.25	8.249	0.0007
EQ125108	FT0648	ID7612	50.000	100.000	342.000	0.25	8.249	0.0007
DR2108	SP1208	FT0648	49.709	100.000	344.000			
PENGUIN	SP1208	SP0499	0.065	100.000	-262534.169	847.16	8.249	0.0007
SC008D00	SP0499	SP967	0.065	100.000	-263400.169	3002.64	8.249	0.0007
87115	SP967	SP500	0.055	100.000	-311143.921	797.36	8.249	0.0007
87116	SP500	SP966	0.055	100.000	-313544.921	855.77	8.249	0.0007
JACKSAVE	SP966	SP501	0.055	100.000	-313552.921	744.23	8.249	0.0007
WILSON	SP501	SP502	0.055	100.000	-313552.921	2355.00	8.249	0.0007
87051	SP502	SP845	0.053	100.000	-323447.921	920.96	8.249	0.0007
87052	SP845	SP846	0.053	100.000	-323447.921	260.45	8.249	0.0007
MCCCORD	SP846	SP0506	0.053	100.000	-323447.921	6800.00	8.249	0.0007
EQ092257	SP0506	SP1200	0.053	100.000	-323447.921	1675.78	8.249	0.0007
MCORD	SP1200	SP503	0.053	100.000	-323618.921	1250.75	8.249	0.0007
86966	SP113	SP503	0.053	100.000	323618.921	933.00	8.249	0.0007
87174	SP1167	SP113	0.053	100.000	323618.921	3223.57	8.249	0.0007

The report format is designed to show the results for each individual COS node. In the report above, the first node selected is ID7613. This node has a load of 171 SCFH. Following the brief node description, a tabular report of the pipe contribution results is displayed. Each pipe that serves the node is listed in the left hand column (FID). The pipe contribution results are displayed in columns four and five.

Percentage of Pipe Flowing Contributing to the Load – This is the percentage of the total pipe flow contributing to the node’s load. For FID EQ125109 this is 100 %. Reviewing the model will show that this node only has one pipe delivering gas to node ID7613 and that pipe is EQ125109. No other customers are located along this pipe.

Percentage of Load Flowing in Pipe – This value is based on the total node load rather than the total pipe flow. This value will provide the percentage of the node’s total flow that the pipe contributes. So rather than divide by the total pipe flow, this calculation uses the total node load.

Flow – Flow going through the pipe

Length, Diameter, and Roughness – Pipe attributes



The report and model must be exported from SynerGEE to the COS application in ArcView. The report is saved as a text file while the model is saved as a database file.



Cost of Service Application

One of the goals for this project was to create a process that enabled the user to visually see the gas flow path from customer to source and easily integrate those results with other data sources. The chosen platform for this data display and integration was ESRI’s ArcView application. ArcView’s powerful mapping engine and open environment enables any user to import and export data easily and efficiently.

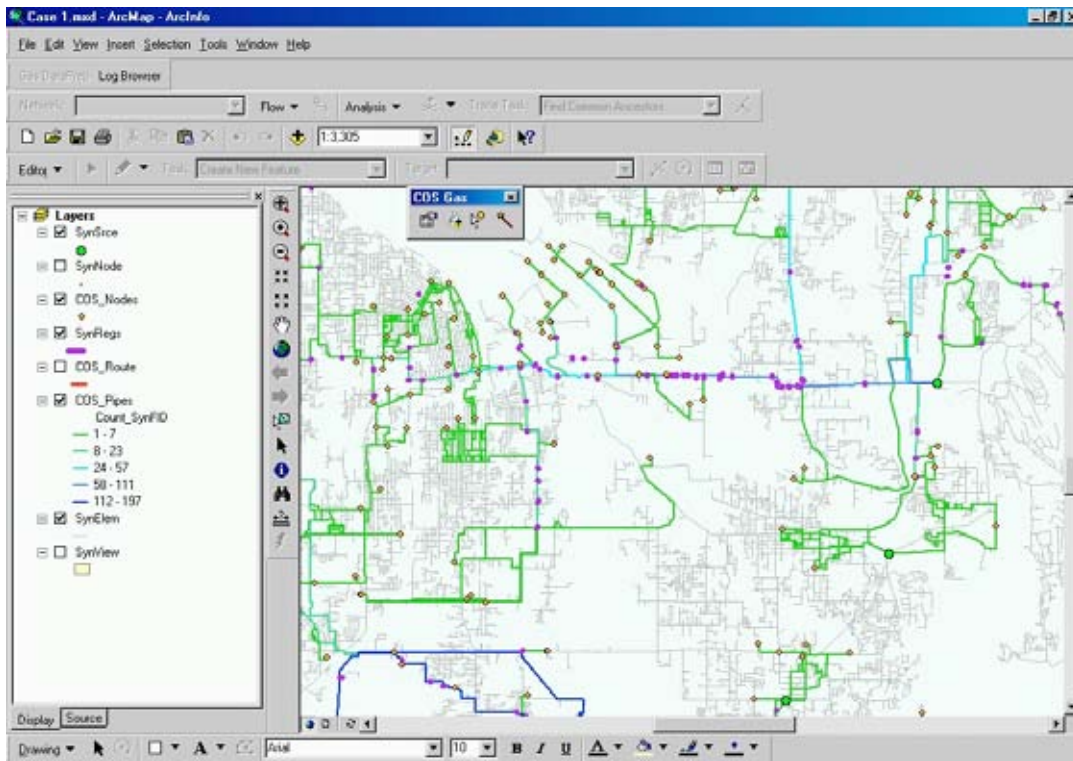
In order to integrate the SynerGEE pipe and regulator data along with the Pipe Contribution Report, Advantica created a custom application within the ArcView environment. This application pulls all this data together and creates a tool that enables the user to create plots of the gas flow path for each customer, thematically map cost of service data, and export shape files or tables of information for each customer.

The COS application toolbar contains four buttons, a brief description of each is provided below.



-  - COS Node Selection – enables the user to select a COS Node and view the gas flow pathway from the source to the COS Node.
-  - Build Project – enables the user to convert the SynerGEE dataset to a format compatible with ArcView. Also establishes initial ArcView project file.



-  - Shape File Converter – enables the user to convert any SynerGEE model to a shape file. The shape file can then be opened in ArcView.
-  - Convert Contribution Report – enables the user to convert any Pipe Contribution report from SynerGEE® to a table in ArcView.


The order of events that must occur to visualize the results in ArcView is first the Project must be Built – this operation combines the model graphics (mdb export) and the pipe contribution report (text file save) into a personal geodatabase. This Build activates the COS node selection option allowing analyzing of a single customer to its source supply.

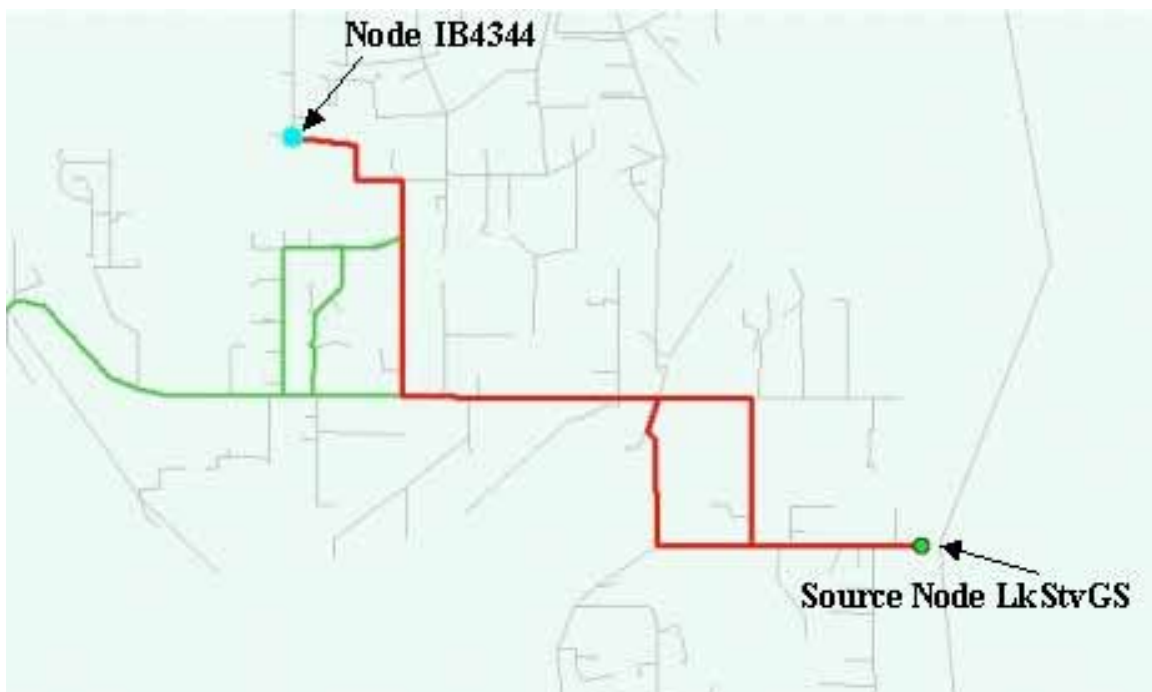


In the picture above the symbology is as follows:

-  - Source nodes in the model. All COS results are calculated from the COS node to a source node.
-  - COS node as specified in SynerGEE. These are the nodes that PSE has specified to determine the cost of service.
- The multicolored pipes represent the COS pipes. This a total visual representation of all the pipes that service at least one of the COS nodes. For this data set, the model contained 129,374 total pipes. Of the 129,374 pipes, 13,966 are COS pipes that service at least one node.

- o  - Represents regulators in the system (pipe with no length, diameter, roughness)
- o  - The gray pipe represents the all the SynerGEE® pipes

To trace a specific customer, click on the Select COS Node toolbar button . Using your mouse, select one of the orange COS nodes. When a node has been selected, ArcView will highlight the pipes that the gas travels through from the source node to the COS node.



Using standard ArcView functions nodes can be labeled, maps can be created, individual runs can be exported, and attribute data can be extracted for use in other applications.

Cost of Service Calculations

With the pipe contributions now calculated, additional data was added for each segment and each customer. Using the visual created from ArcView it was possible to supplement and confirm the information originally contained within the SynerGEE model. Attributes added to the pipe contribution table included installation date and pipe material. The process also validated segment length and diameter. To get a complete COS, the service connection for each customer was researched and information on pipe length, diameter, material, and year installed were all gathered. Since the gas records span more than 100 years there was no one "system" that contained all the pertinent information for calculating a COS. Thus portions of this process were rather manpower intensive. After everything was in place, the COS team applied cost to each segment and service connection depending on all of the available variables. The service cost was applied at

100% while each of the segment's percent utilization was multiplied by the total cost to obtain the incremental cost for that customer.

In Conclusion

This project hinged on the ability to accurately determine utilization of pipe. The integration of SynerGEE and ArcView made an extremely difficult project manageable. The ability of tools to support planning, operations, and financial processes is indicative of how solutions can and need to serve the enterprise.