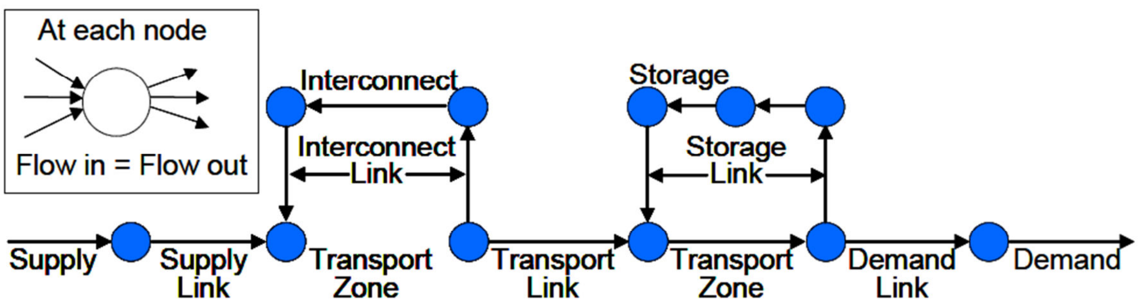
APPENDIX A. GPCM STRUCTURE

The GPCM model framework is a node-arc network. Some key definitions utilized in the report are indicated below:

"Nodes" and "arcs" are generic terms. Generally speaking, a node is any physical asset. Suppliers and customers are both represented by nodes, one where gas is produced and one where gas is consumed. Pipelines are also represented by nodes. They are divided into sections called "pipeline zones" – sometimes "transport zones" – across which gas flows according to the associated physical characteristics of that part of the pipeline. These physical characteristics are defined in the database.

Arcs are the connections between any two nodes in the model. For example, two pipeline zones (nodes) are connected by a "pipeline link." sometimes called a "transport link," which defines the amount of gas that can flow between the two zones on the same pipeline. An "interconnect link" joins zones (nodes) on different pipelines. A supplier is connected to the pipeline system via a "supply link" and a customer is connected via a "demand link," both of which serve the same function. The diagram below shows the layout.

Figure A1. GPCM Node-Arc Structure



Nodes represent production regions and supply basins, pipeline zones, interconnects, storage facilities, delivery points, and either specific large customers or groupings of smaller customers. Arcs represent gas transactions and flows, and are constrained by capacity limitations. Compressors, delivery meters, and receipt meters are rolled up into pipeline zones and arcs connect the pipeline zones to form the regional pipeline networks. Figure A1 is a schematic of the node-arc structure of the GPCM model.

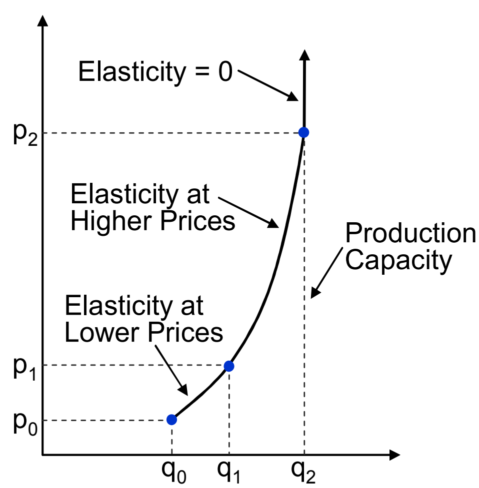
In general, constraints occur in the nodes, often certain pipeline segments, but also interconnects, rather than the arcs that connect the nodes. In the case of interconnect links, or arcs that connect nodes on different pipelines, the total size of the link is, in many cases, smaller than the total capacity on either side. While increasing the capacity of some interconnect links may have changed flows, there were no instances in which the size of the interconnect link constituted a constraint as we've defined it for purposes of Target 2. As such, our analysis of the constraints has focused almost entirely on the pipeline nodes, *i.e.*, pipeline zones.

All major interstate, intrastate, inter-provincial, and cross-border pipelines are included in GPCM. Pipeline zones form the basic building block for modeling each pipeline. Long-haul pipelines, even those with postage stamp rates, are differentiated by zones, enabling flows between contiguous market areas to be defined, capacity constraints to be identified, and price differentials within relevant boundaries to be modeled. Each pipeline's tariff provides the basis for estimating the minimum and maximum transportation prices, as well as relevant fuel retention rates by location, *i.e.*, shrinkage. Pipeline transportation service is prioritized in accord with character of service: all firm transportation is cleared first before any non-firm transportation is cleared in zonal markets. The clearing of non-firm transportation is performed under volumetric rates that range from a high equal to the 100% equivalent load factor rate, including transport commodity and shrinkage, to a low equal to a pipeline's firm transport commodity charge.

GPCM reflects storage dynamics as three distinguishable transaction components: injection, storage and withdrawal. Storage is constrained by total storage capacity and daily injection and withdrawal capacities and is shaped by a monthly schedule with a constant unit cost per period. The ability to model individual storage facilities on a monthly basis allowed consideration of inventory balances, withdrawal and injection rates, and facility constraints. Storage transactions were modeled as bundled under a single rate structure.

GPCM supply curves relate the amount of gas produced to the price: the higher the price the more gas that will be produced subject to resource and reservoir limitations. The slope of the supply curve determines price elasticity, *i.e.* the change in gas supply that can be obtained for a small change in price. In the customary monthly reporting mode, GPCM supply curves are made up of segments that exhibit high elasticity at lower prices, low elasticity at higher prices, and at some point zero elasticity, where resource and production limits mean that no additional supply can be obtained regardless of price as illustrated below.

Figure A2. GPCM Supply Curves



The behavior of gas customers is captured via demand curves that are also embedded in the model. For purposes of this analysis, the demand for both RCI and electric generators are *a priori* inputs on a winter or summer peak day. Vertical demand curves were utilized to capture this dynamic. The objective function of the LP model is system cost minimization, which determines the economic equilibrium of prices and flows across all the market locations and for all time periods. Model solutions identify congestion points, locations where additional gas cannot move from one point to the other despite a downstream demand for that gas.