NARG Model Natural Gas Assessment

The Western Interstate Energy Board (WIEB) approved the California Energy Commission to undertake an assessment that will examine the natural gas market in North America, including the contiguous United States, Alaska, Canada, and Mexico. The assessment will emphasize and detail the following areas:

- Alaska, Arizona, California, Colorado, Idaho Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming,
- Alberta, British Columbia, and Saskatchewan.

The assessment will analyze the sufficiency of:

- Natural gas supply availability;
- Interstate pipeline utilization including identification of potential congested lines;
- Inferences as to how natural gas storage facilities may assist in meeting reliability goals; and
- Basis pricing differentials between resource basins and major natural gas markets.

The results of this assessment will serve as an input to the related analysis regarding electricity resources adequacy. The assessment will provide a better understanding of the natural gas supply and infrastructure availability to meet the requirements on natural gas to power electric generating facilities.

The Energy Commission staff uses the North American Regional Gas (NARG) model as its principal assessment tool. Staff has used this model since 1989 to evaluate the California natural gas market. This general equilibrium model predicts the quantities and prices of natural gas needed to balance supply and demand throughout North America over a 45-year forecast horizon. The analysis for the WEIB natural gas assessment will use the California Energy Commission's work with the NARG model.

The current model structure allows for the following forecast periods: One year periods between 2001 and 2015, two year periods between 2015 and 2025, and five year periods between 2025 and 2045. The WIEB assessment of the western natural gas market will be focused on the forecast output for 2001 through 2014.

NARG Model Structure and Assumptions

The level of detail in the NARG model has evolved over time. As new information becomes available, the Commission staff updates various parameters within the model. Commission staff continually tracks the natural gas resource base, pipeline infrastructure additional or abandonment, and the makeup of end user demand. The database developed for the WIEB study is using data from the National Petroleum Council, (NPC), the United States Energy Information Administration (EIA), Canada's National Energy Board, and the California Energy Commission.

The NARG model contains three super-regions: the United States, Canada, and Mexico. Each super region is further divided into regions to depict the structure of the natural gas market. Each region contains one to seven sub-regions. Each sub-region may contain four components or nodes: supply, demand, transportation (pipeline corridor) and processing, Figure1: Model Structure for Sub-Region.

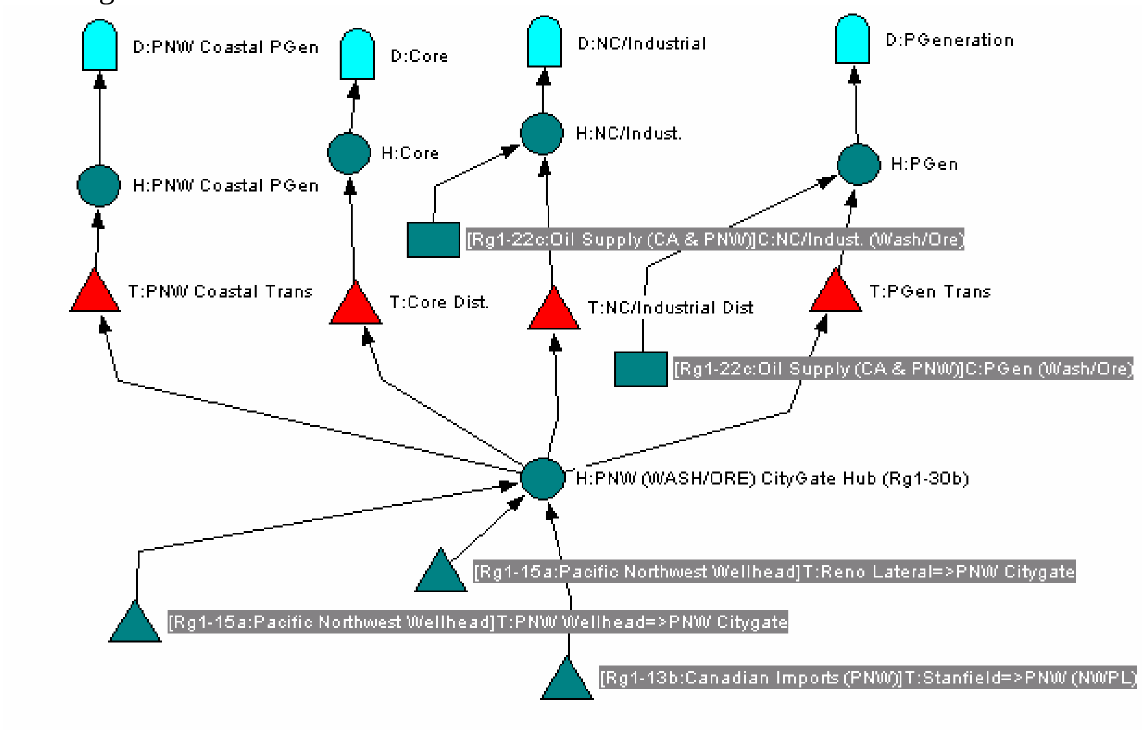

Figure 1: Model Structure for Sub-Region

The NARG model provides the user with the flexibility to add or delete pipelines and to modify supply and demand sub-regions. The user can make adjustments to the model at a specific time point during the forecast period, or alternatively the model will adjust the available supply, demand and pipeline capacity serving the natural gas market as additions or deletions based on the economic criteria set out in the data base.

The structure of the NARG model to be used for the Western interstate Energy Board (WIEB) includes:

- Demand Sub-Regions,
- Pipeline Corridors, and
- Supply Sub-Regions.

Demand Regions

The NARG model incorporates natural gas demand data from the contiguous United States, Alaska, Canada, and Mexico owing to the integrated nature of the North American natural gas market. For the WIEB assessment, the Energy Commission staff obtained natural gas demand data from the following sources:

- EIA (Alaska, contiguous United States natural gas demand)
- California Energy Commission (Western States' natural gas demand for electricity generation, California natural gas demand)
- Canadian National Energy Board (Canadian natural gas demand
- National Petroleum Council (Mexican natural gas demand)

The demand data are typically categorized in one of the following end use sectors:

- Core - Customers that rely solely on natural gas and cannot switch to an alternate fuel.
- Non-core - Customers that can switch to an alternate fuel (oil) if there is a price advantage to doing so.
- Power Generation – Fuel use for electricity generation. Some Power Generation customers have the ability to switch to an alternative fuel if it is more economical to do so.

There are exceptions to the end-use sectors described above. In the Canadian sub-regions, fuel use for electricity generation is included in the Non-core sector. In other regions, such as Alaska and Mexico, all natural gas demand is combined into one demand input per time period. Some demand sub-regions have additional demand sectors other than the Core, Noncore, and Power Generation sectors. These additional sectors correspond to demand nodes in the NARG model. Typically, the additional demand node is necessary to model demand that is served by different resources and/or transportation nodes than the Core, Noncore and Power Generation Sectors.

The model has 83 demand nodes distributed amongst 31 sub-regions. Twenty of these sub-regions are located in the WIEB natural gas assessment area. The map below illustrates the distribution of the 83 sub-regions in the NARG model that contain demand nodes. Appendix A provides a description of which geographical areas are included in each demand sub-region, as well as which demand nodes are contained in each sub-region.

The Energy Commission staff used the EIA 's *Annual Energy Outlook 2004*, baseline forecast, and the NEB's *Canada's Energy Future: Scenarios for Supply and Demand to 2025*, "Supply Push" scenario, for the bulk of the demand inputs for the United States and Canada. The EIA assumes that U.S. GDP will grow at an annual rate of 3.0 percent from 2002 to 2025. In the Supply Push scenario, the NEB assumes that Canadian GDP will grow at an annual rate of 2.7 percent from 2001 to 2010, 2.1 percent from 2011 to 2020, and 1.4 percent from 2021 to 2025.

The California natural gas demand forecast developed by the Energy Commission assumes that the GDP will grow at an annual rate of 2.9 percent from 2003-1013. During that time, a 1.4 percent annual rate of growth is assumed for household population.

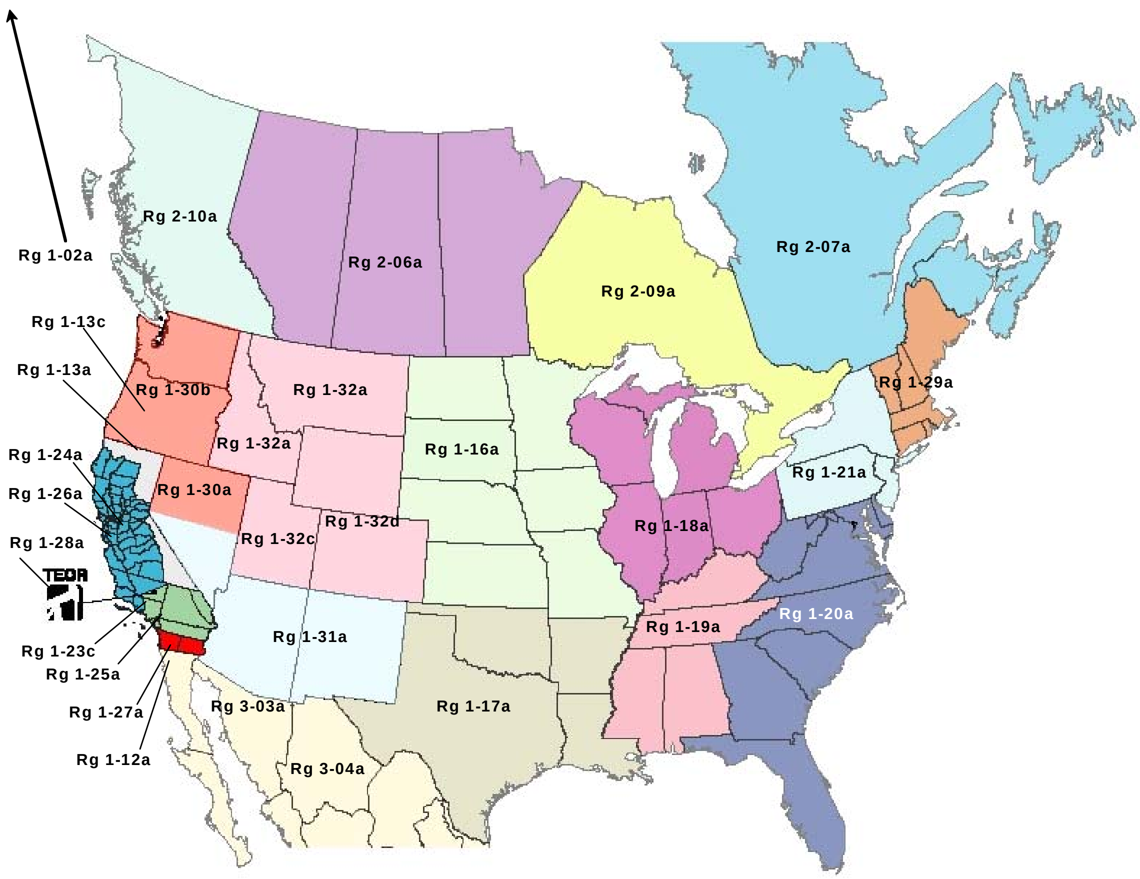

Figure 1: NARG Sub-Regions Containing Demand Nodes

Natural Gas Demand for Power Generation

Natural gas demand for electricity generation represents the fastest growing sector, and the determination of its impact on the natural gas market is one of the major goals for the study. From 2004 through 2013, natural gas demand for electricity generation will grow at an annual rate of 5.4 percent in the Western United States, compared to 1.3 percent annual growth for all other end use sectors. At this time , we are unable to make a similar comparison of Canadian end use sectors because the NEB forecast does not distinguish between natural gas demand for electricity generation and other non-core natural gas demand.

Fuel Switching

By the Energy Commission staff's definition, Core customers are those who cannot switch to alternative fuels (oil). In the U.S., the Core demand includes 100 percent of residential, commercial, and transportation (for natural gas vehicles) natural gas demand and 50 percent of industrial natural gas demand. The Noncore sector includes the remaining 50 percent of industrial natural gas demand and a percentage of industrial distillate and residual fuel oil demand, which increases over time. The Power Generation sector includes 100 percent of natural gas demand for electricity generation, as well as 100 percent of the distillate and residual fuel oil demand for electricity generation. In every region, except California, either natural gas or oil can meet the Non-core or Power Generation demand. The model uses commodity price to determine which fuel source will satisfy demand.

Pipeline Corridors

The NARG model represents the natural gas pipeline infrastructure through the transportation nodes. These transportation nodes link the supply sub-regions to the demand sub-regions in the model.

The NARG model configures each pipeline or pipeline corridor (transportation node) by the development of a profile that covers transport capacity, transportation rates (tariff), and criteria for pipeline expansion. The model will allow the transportation cost to vary with use and/or new pipeline infrastructure. For example, when natural gas flows exceed the listed capacity, the model applies a penalty to the cost of transportation to account for costs incurred in expanding the pipeline capacity. The basic structure of the major pipeline corridors are shown in Figure 2 Natural Gas Pipeline Structure.

Natural Gas Resource Base

The natural gas resource base used in the NARG model is based on work recently completed by the National Petroleum Council in their evaluation of the North American natural gas market. The natural gas resource base is composed of proven and potential natural gas that could exist in the various supply sub-regions.

The current NARG model contains 42 supply sub-regions containing proven and potential natural gas resources. These sub-regions also contain data to account for competing fuels such as liquefied natural gas and fuel oil.

Proven natural gas reserves are those natural gas resources that analysis of geologic and engineering data demonstrates with reasonable certainty are recoverable under existing economic and operating conditions. The total volume that a field is expected to produce is equal to cumulative production (the volume the field has produced) plus the remaining recoverable reserves. Production history has shown that as a field is under production the amount of recoverable reserves tends to grow due to data collected through operating experience and improvement if production and well completion technology. The NARG model does account for the increase in proven reserves over time.

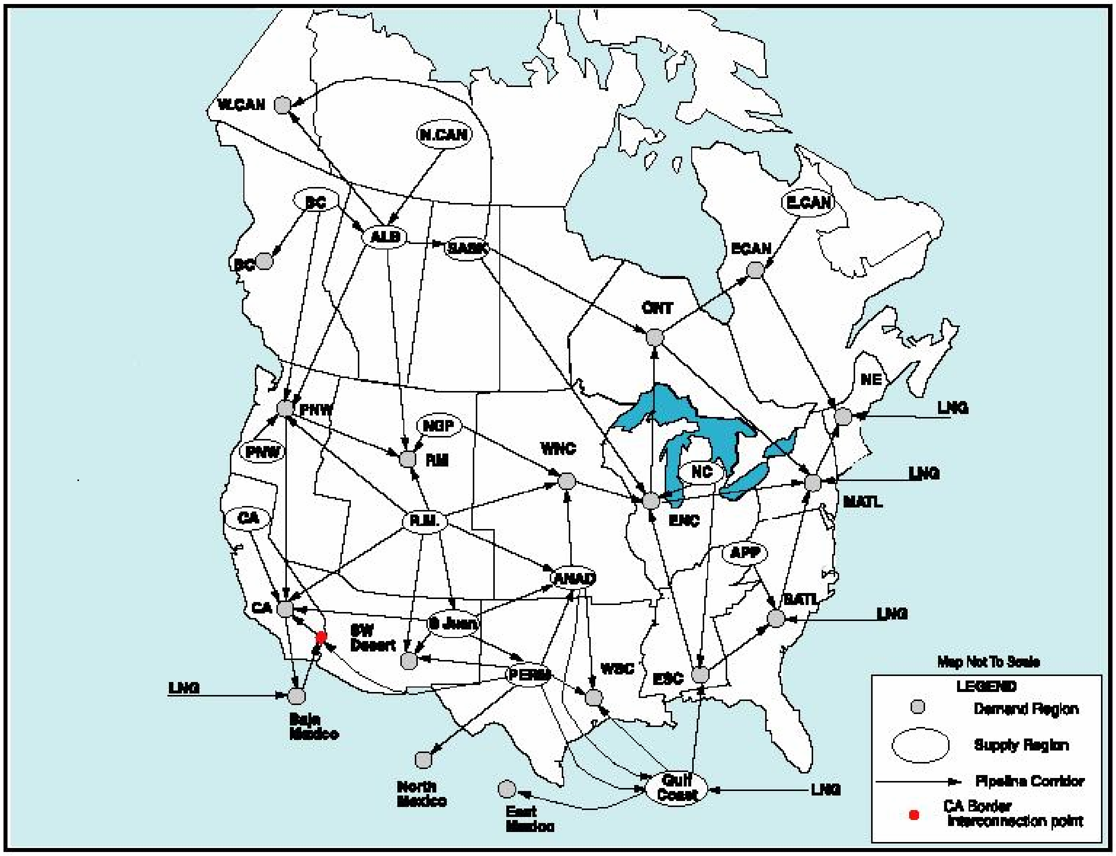

Figure 2: Natural Gas Pipeline Structure

The potential natural gas resource is composed of the estimated quantities of natural gas that based on geologic evidence that is supported by projections that can reasonably be expected to exist and be recoverable under existing economic and operating conditions.

Supply Regions

The National Petroleum council report Balancing National Gas Policy Fueling The Demands of a Growing Economy completed in September, 2003 complete a comprehensive reassessment of the natural gas reserves for North America. This resource database has been used to update the natural gas resource used in the current NARG model. Figure 3 illustrates a supply sub-region. The hexagons represent differ supply resources.

Proven Natural Gas Reserves

The current NARG database contains an estimated 271 trillion cubic feet (Tcf) of proven natural gas reserves for North America, Table 1: Natural Gas Resources

Estimated By Supply Region (Trillion of Cubic Feet). These reserves are located in the lower 48 states (56.8 percent), Canada (27.7 percent), Alaska (0.7 percent), and Mexico (14.7 percent). In the lower 48 states the Gulf of Mexico has the greatest amount of proven natural gas reserves followed by the Rocky Mountains, Anadarko Basin, San Juan Basin and Permian Basin.

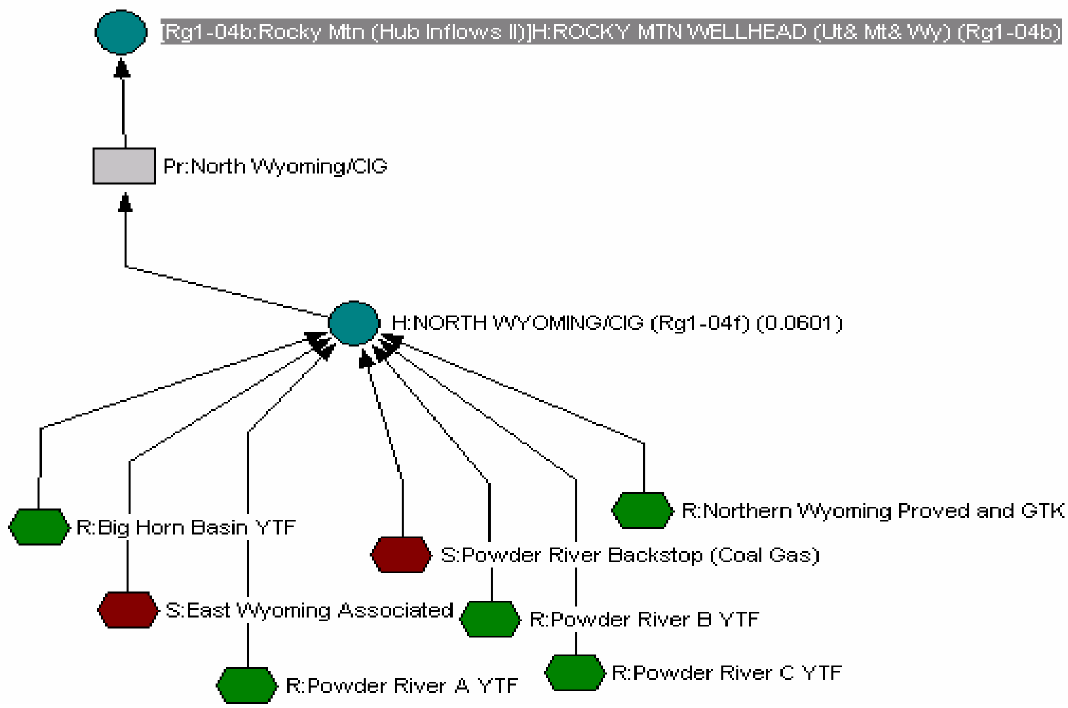

Figure 3: NARG Model Natural Gas Supply Sub-Region

Potential North American Natural Gas Resources

The potential natural gas resources in the NARG model database have been estimated to be 1,381 Tcf. The Gulf of Mexico has the largest potential of 451 Tcf or 33 percent of the North American total. The major of this resource potential exists in what is referred to as deep water plays. The higher cost associated with the exploration and development of these deep water plays will make development dependent of the market price. The NARG will evaluate the development of this potential against the cost of alternative natural gas sources, production from other supply regions in the United States, Canada, and imports of liquefied natural gas (LNG).

Natural Gas Production

Natural gas production in North America in 2002 was 27.6 trillion cubic feet (Tcf). The United States was 19.9 Tcf (19.5 for the lower 48 and 0.4Tcf for Alaska), Canada 6.5 Tcf and Mexico 1.2 Tcf.

Future natural gas production will continue to come from the current producing regions and could expand in some of the regions based on the potential natural gas resources. This additional production may come from what is referred to as frontier regions in the artic (Alaska North Slope, Canada's Mackenzie Delta) and deep water fields in the Gulf of Mexico.

Supply Region	**Proven**	**Potential**	**Total**
Canada			
British Columbia	9	23	33
Alberta	54	86	140
Canada East	9	44	53
Northern Canada	0	62	62
Saskatchewan	3	2	5
Total Canada	***75***	***217***	***292***
Mexico			
Mexico	40	48	88
Total Mexico	***40***	***48***	***88***
United States			
Alaska	2	278	280
Anadarko	22	97	119
Appalachia	6	61	67
California North	1	7	7
California South	0	7	7
Gulf of Mexico	71	451	522
North Central	4	33	37
Northern Great Plains	0	8	8
Permian Basin	10	13	23
Pacific Northwest	0	1	1
Rocky Mountains	24	127	151
South Atlantic	0	1	1
San Juan	16	32	48
Total United States	***156***	***1,116***	***1,272***
North America Total	**271**	**1,381**	**1,653**

Table 2 Natural Gas Resources Estimated By Supply Region (Trillion of Cubic Feet)

The supply forecast of natural gas from these areas will be dependent on the costs associated with exploration and development. The NARG data base contains cost estimated for the various production areas within each of the supply sub-regions. Based on the ability of the these areas to compete on a cost basis in the end use market will determine the level of natural gas production forecast in each of the sub-regions.

NARG Exploration Development and Operation Costs

The United States Geological Survey (USGS) data for capital and operating cost natural gas field development was used to establish the cost curves used in the NARG model. The cost data used included capital and operating costs. Capital costs include the "out of pocket" costs associated with drilling and completing a field including the costs of drilling unsuccessful or dry holes. The operating costs include the costs applied to operating the well.

Appendix A

Demand Sub-Regions in the NARG/MarketBuilder Model

Sub-Region	Sub-Region Name	Geographic Areas in Sub-Region	Demand Nodes
Rg 1-02a	**ALASKA WELLHEAD**	**Alaska**	Alaska Demand Asian Demand
Rg 1-12a	**US TO BAJA**	**Hermosillo, Mexicali, Naco, Rosarito**	Baja Mexico Demand
Rg 1-13a	**CANADIAN IMPORTS (MALIN @ CA BORDER)**	**Oregon**	Malin Power Generation
Rg 1-13c	**PNW @ STANFIELD**	**British Columbia, Oregon**	Kingsgate Power Generation Stanfield Power Generation
Rg 1-16a	**WEST NORTH CENTRAL**	**Iowa, Kansas, Minnesota, Missouri, Nebraska,** **North Dakota, South Dakota**	Core Noncore/Industrial Power Generation
Rg 1-17a	**WEST SOUTH CENTRAL**	**Arkansas, Louisiana, Oklahoma, Texas**	Core Noncore/Industrial Power Generation
Rg 1-18a	**EAST NORTH CENTRAL**	**Illinois, Indiana, Michigan, Ohio, Wisconsin**	Core Noncore/Industrial Power Generation
Rg 1-19a	**EAST SOUTH CENTRAL**	**Alabama, Kentucky, Mississippi, Tennessee**	Core Noncore/Industrial Power Generation
Rg 1-20a	**SOUTH ATLANTIC**	**Delaware, DC, Florida, Georgia, Maryland,** **North Carolina, South Carolina, Virginia,** **West Virginia**	Core Noncore/Industrial Power Generation
Rg 1-21a	**MID ATLANTIC**	**New Jersey, New York, Pennsylvania**	Core Noncore/Industrial Power Generation
Rg 1-23c	**WHEELER RIDGE**	**Southern California**	SoCal Nonutility Demand

Rg 1-24a	**NORCAL MARKET ALLOCATION**	**Northern California**	Non-LDC Demand
Rg 1-25a	**SOUTHERN CALIFORNIA GAS COMPANY**	**Southern California**	Core Noncore/Industrial Power Generation
Rg 1-26a	**PACIFIC GAS AND ELECTRIC COMPANY**	**Northern California**	Core Noncore/Industrial Power Generation Coolwater Bypass Demand
Rg 1-27a	**SAN DIEGO GAS AND ELECTRIC COMPANY**	**Southern California**	Core Noncore/Industrial Power Generation Otay Mesa
Rg 1-28a	**ENHANCED OIL RECOVERY**	**Southern California**	EOR Steaming Power Generation
Rg 1-29a	**NEW ENGLAND**	**Connecticut, Maine, Massachusetts,** **New Hampshire, Rhode Island, Vermont**	Core Noncore/Industrial Power Generation
Rg 1-30a	**PNW (NORTHERN NEVADA)**	**Northern Nevada**	Core Noncore/Industrial Power Generation
Rg 1-30b	**PNW (WA/OR)**	**Washington, Oregon**	Core Noncore/Industrial Power Generation PNW Coastal Power Generation
Rg 1-31a	**SOUTHWEST DESERT (AZ/NM)**	**Arizona, New Mexico**	Core Noncore/Industrial Northern AZ/NM Power Gen Southern AZ/NM Power Gen Utility Power Generation
Rg 1-31b	**SOUTHWEST DESERT (S. NEVADA)**	**Southern Nevada**	Core Noncore/Industrial Power Generation

Rg 1-32a	**ROCKY MOUNTAINS (IDAHO)**	**Idaho**	Core Noncore/Industrial Power Generation
Rg 1-32b	**ROCKY MOUNTAINS (Montana)**	**Montana**	Core Noncore/Industrial Power Generation
Rg 1-32c	**ROCKY MOUNTAINS (Utah)**	**Utah**	Core Noncore/Industrial Power Generation
Rg 1-32d	**ROCKY MOUNTAINS (WY/CO)**	**Colorado, Wyoming**	Core Noncore/Industrial Power Generation
Rg 2-06a	**WESTERN CANADA**	**Alberta, Manitoba, Saskatchewan**	Japan Export Core Noncore/Industrial Oil Sands Extraction
Rg 2-07a	**EASTERN CANADA**	**New Brunswick, Newfoundland, Nova Scotia,** **Prince Edward Island,Quebec**	Core Noncore/Industrial
Rg 2-09a	**ONTARIO**	**Ontario**	Core Noncore/Industrial
Rg 2-10a	**BRITISH COLUMBIA**	**British Columbia**	Core Noncore/Industrial
Rg 3-03a	**CENTRAL & NE MEXICO DEMAND**	**Juarez, McAllen, Reynoso, Samalayuca**	Central Mexico Demand Northeast Mexico Demand
Rg 3-04a	**REST-OF-MEXICO DEMAND**	**Altimira, Campeche, Mexico City, Tabasco**	Rest of Mexico Demand