ADVANCED RESOURCES INTERNATIONAL, INC.

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ECONOMICALLY RECOVERABLE NATURAL GAS RESOURCES BENEATH INVENTORIED ROADLESS AREAS ON FOREST SERVICE LANDS, ANALYSIS AND RESULTS

Results

Analysis of economically recoverable natural gas resources associated with the U.S. Forest Service's Inventoried Roadless Areas shows significant results (Table 1). Recovery of these resources would generate from $23 to $34 billion of economic activity. Further, growth in technically recoverable resources over time can be expected to lead to increases in total economically recovered resources.

Table 1
Economically Natural Gas Resources Associated with the U.S. Forest Service's Inventoried Roadless Areas

Resource Type	Technically Recoverable Resources*	Economically Recoverable Resources			
		$3 gas		$4 gas	
	(Tcf)	Recovered portion	Recovery (Tcf)	Recovered portion	Recovery (Tcf)
Conventional	5.3	70%	3.7	78%	4.1
Coalbed methane	2.2	71%	1.6	77%	1.7
Tight gas	3.8	63%	2.4	70%	2.7
Total	11.3	68%	7.7	75%	8.5

* TRR estimates for the year 2000.

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Purpose and Methodology

As reported in our memo to you of 20 November 2000, the mean technically recoverable natural gas resource within Inventoried Roadless Areas (IRAs) was estimated to be 11.3 Tcf. The purpose of this analysis is to examine what portion of that resource is economically recoverable natural gas resource.

This analysis is cursory in nature given the time urgency for obtaining results. The analysis was partially based on data found in the 1999 National Petroleum Council (NPC) study, *Natural Gas: Meeting the Challenges of the Nation's Growing National Gas Demand.* The NPC study contains a section (VII, pp. S-72 to S-77) that deals explicitly with natural gas resources in the Rocky Mountain region; because the technically recoverable resource associated with IRAs is found throughout the Rocky Mountain basins, trends present in the NPC study were directly applied to IRAs as described below.

Pricing Scenarios Two price scenarios were modeled: $3/Mcf and $4/Mcf natural gas prices. These prices would represent the average natural gas price over the next 30 years or so, during which the gas could be explored for and produced assuming unencumbered surface access. To model the price scenarios, the $3/Mcf scenario in this analysis was based on the NPC study "Increased Oil Price Case" (high price case). NPC's high price case averages slightly greater than $3/Mcf over the years 2000 to 2015. In this analysis the $4/Mcf price scenario was based upon extrapolation of the production and reserve trends manifested between the NPC "Reference Case" and the high price case to determine increases in economically-produced resources (produced reserves and production). Estimates in this analysis were scaled accordingly.

Technology Impacts In modeling technically recoverable resource, most analyses (e.g., those conducted by NPC, DOE's Energy Information Administration, and the Gas Research Institute) assume that over time, technology will improve resulting in increases in technically recoverable resources. Improvements are made by the industry in E&P technologies, e.g., seismic (3D, shear wave) data, drilling (horizontal, slim hole, microdrilling) and drill pad size. In Table 2, we generally modeled the collective effect of these impacts based upon the rates of increases in technically recoverable resource found in the 1999 NPC study. These rates range from 1.3 to 1.5%

Table 2
Changes in Technically Recoverable Resource Over Time Due To Improvements In Technology

Technically Recoverable Resources	2000	2015
	(Tcf)	(Tcf)
Conventional	5.3	6.3
Coalbed methane	2.2	2.7
Tight gas	3.8	4.5
Total	11.3	13.6

Resource Categories The analysis was conducted taking into account the specific natural gas resource types found in the Rocky Mountain region: conventional, coalbed methane and tight (low permeability) gas. For conventional resources, we previously estimated about 5.3 Tcf of technically recoverable resource associated with IRAs. Economically recoverable natural gas as a portion of technically recoverable resource generally runs from about 70% to, under optimal reservoir conditions, about 85%[1]. We used a 70% recovery factor at $3/Mcf and a 78% recovery factor at $4/Mcf to represent general conditions in Rocky Mountain basins. Economically recoverable resources are 3.7 Tcf and 4.1 Tcf, respectively (Table 1), under the two price scenarios. Technology impacts were assessed (Table 2) assuming a 1.5% annual growth rate in technically recoverable resource, based upon previous NPC studies (see NPC V. II, Table S-94).

Coalbed Methane (CBM) technically recoverable resource was previously estimated to be 2.2 Tcf beneath roadless areas. Economic recovery rates were determined based upon trends present in the NPC study (V.II, Fig. S-40 and from the NPC Reference Case and high price cases). At a price of $3/Mcf gas we calculate, based on the NPC study, a recovery factor of 71% (economic recovery of 1.6 Tcf of gas). At a $4/Mcf price, using the methodology described above, recovery increases to 77% or 1.7 Tcf of gas (Table 1). Changes in technically recoverable resource over time (Table 2) are based on increases in technically recoverable resource associated with the NPC high price case and average about 1.5% per year.

Tight gas Technically recoverable resource was estimated previously to be 3.8 Tcf beneath IRAs. For the $3/Mcf price scenario economic recovery rates for this resource category were based upon Advanced Resources' previous work (Naturally Fractured Tight Gas Reservoir Detection Optimization, US DOE Contract DE-AC21-93MC 300 86, Final Annual Report, July 1999) for the Frontier and Mesa Verde tight gas formations of the Greater Green River Basin. That Advanced Resources study described methodology for technology application to define "sweet spots" in those plays and quantifies technically and economically recoverable resource. From that study we determine an economic recovery factor of 63% for tight gas. Application of this factor to technically recoverable resource in the IRAs results in economically recoverable resource of 2.4 Tcf of natural gas. At $4/Mcf, the recovery factor increases to 70% or 2.7 Tcf of economically recoverable resource (Table 1). Changes in technically recoverable resource due to technology advancement over time were modeled based on the growth rates found in the NPC study (see NPC CD Rom, file S5Supply.xls) and average 1.3% per year.

Economic Impacts

Recovery of economic resources underlying IRAs could generate from $23 to $34 billion of economic activity based on economically recoverable resource of 7.7 Tcf (at $3/Mcf) and 8.5 Tcf (at $4/Mcf) respectively. Further, growth in technically recoverable resources over time, as shown in Table 2, can be expected to lead to increases in total economically recovered resources.

[1] DOE's Gas Systems Analysis Model (GSAM) determined a recovery factor of 68% based on historical data (GSAM Analysis Model Workshop, ICF Resources, 1997), which in turn is based on historically lower gas prices.