DOE/EIA-M063/2(2003)

Documentation of the Oil and Gas Supply Module (OGSM)

Volume II-Appendices

April 2003

Energy Information Administration
Oil and Gas Division
Office of Integrated Analysis and Forecasting

Appendix A. Data Inventory

An inventory of OGSM variables is presented in the following tables. These variables are divided into four categories:

Variables:	Variables calculated in OGSM
Data:	Input data
Parameters:	Estimated parameters
Output:	OGSM outputs to other modules in NEMS.

The data inventory for the Offshore Supply Submodule is presented in a separate table.

All regions specified under classification are OGSM regions unless otherwise noted.

Variables					
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**
	Code	**Text**			
OGCST_L48	ESTWELLSL48	ESTWELLS	Estimated lower 48 onshore drilling (successful and dry)	Wells	Lower 48 onshore
OGCST_L48	ESTSUCWELL48	ESTSUCWELLS	Estimated lower 48 onshore successful wells drilled	Wells	Lower 48 onshore
OGCST_L48	RIGSL48	RIGSL48	Available rigs	Rigs	Lower 48 onshore
OGCST_L48	DRILLL48	DRILLCOST	Successful well drilling costs	1987$ per well	Class(Exploratory,Developmental);6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGCST_L48	DRYL48	DRYCOST	Dry well drilling costs	1987$ per well	Class(Exploratory,Developmental);6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGCST_L48	LEASL48	LEQC	Lease equipment costs	1987$ per well	Class(Exploratory,Developmental);6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGCST_L48	OPERL48	OPC	Operating costs	1987$ per well	Class(Exploratory,Developmental);6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OG_DCF	DCFTOT	PROJDCF	Discounted cash flow for a representative project	1987$ per project	Class(Exploratory,Developmental);6 Lower 48 onshore regions,Fuel(2 oil, 5 gas); 3 Alaska regions, Fuel (oil,gas)
OG_DCF	PVSUM(1)	PVREV	Present value of expected revenue	1987$ per project	(Above)
OG_DCF	PVSUM(2)	PVROY	Present value of expected royalty payments	1987$ per project	(Above)
OG_DCF	PVSUM(3)	PVPRODTAX	Present value of expected production taxes	1987$ per project	(Above)
OG_DCF	PVSUM(4)	PVDRILLCOST	Present value of expected drilling costs	1987$ per project	(Above)
OG_DCF	PVSUM(5)	PVEQUIP	Present value of expected lease equipment costs	1987$ per project	(Above)
OG_DCF	PVSUM(8)	PVKAP	Present value of expected capital costs	1987$ per project	(Above)
OG_DCF	PVSUM(6)	PVOPERCOST	Present value of expected operating costs	1987$ per project	(Above)
OG_DCF	PVSUM(7)	PVABANDON	Present value of expected abandonment costs	1987$ per project	(Above)
OG_DCF	PVSUM(13)	PVTAXBASE	Present value of expected tax base	1987$ per project	(Above)
OG_DCF	XIDC	XIDC	Expensed Costs	1987$ per project	(Above)

Variables					
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**
	Code	**Text**			
OG_DCF	DHC	DHC	Dry hole costs	1987$ per project	(Above)
OG_DCF	DEPREC	DEPREC	Depreciable costs	1987$ per project	(Above)
OG_DCF	PVSUM(15)	PVSIT	Expected value of state income taxes	1987$ per project	(Above)
OG_DCF	PVSUM(16)	PVFIT	Expected value of federal income taxes	1987$ per project	(Above)
OG_DCF	OG_DCF	DCF	Discounted cash flow for a representative well	1987$ per well	(Above)
OGEXP_CALC	C_SGDDCF	SGDCFON	Discounted cash flow for shallow gas	1987$	Class(Exploratory,Developmental) ;6 Lower 48 onshore regions
OGEXP_CALC	OXDCF	ODCFON	Discounted cash flow for oil	1987$	Class(Exploratory,Developmental) ;6 Lower 48 onshore regions
OGEXP_CALC	WELLSL48	WELLSON	Lower 48 onshore wells drilled	Wells	Class(Exploratory,Developmental) ;6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGEXP_CALC	SRL48	SR	Lower 48 onshore success rates	Fraction	Class(Exploratory,Developmental) ;6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGEXP_CALC	SUCWELLL48	SUCWELSON	Successful Lower 48 onshore wells drilled	Wells	Class(Exploratory,Developmental) ;6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGEXP_CALC	DRYWELLL48	DRYWELON	Dry Lower 48 onshore wells drilled	Wells	Class(Exploratory,Developmental) ;6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGOUT_L48	NRDL48	NRD	Proved reserves added by new field discoveries	Oil-MMB Gas-BCF	6 Lower 48 onshore regions,Fuel(2 oil,2 gas);
OGOUT_L48	FR1L48	FR1	Finding rates for new field wildcat drilling	Oil-MMB per well Gas-BCF per well	6 Lower 48 onshore regions,Fuel(2 oil,2 gas)
OGOUT_L48	NDIRL48	I	Inferred reserves added by new field discoveries	Oil-MMB Gas-BCF	6 Lower 48 onshore regions,Fuel(2 oil,2 gas)
OGOUT_L48	FR2L48	FR2	Finding rates for other exploratory wells	Oil-MMB per well Gas-BCF per well	6 Lower 48 onshore regions,Fuel(2 oil,2 gas)

Variables					
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**
	Code	**Text**			
OGOUT_L48	EXTL48	EXT	Reserve extensions	Oil-MMB Gas-BCF	6 Lower 48 onshore regions,Fuel(2 oil, 2 gas)
OGOUT_L48	FR3L48	FR3	Finding rates for developmental drilling	Oil-MMB per well Gas-BCF per well	6 Lower 48 onshore regions,Fuel(2 oil, 2 gas)
OGOUT_L48	REVL48	REV	Reserve revisions	Oil-MMB Gas-BCF	6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGOUT_L48	RESADL48	RA	Total additions to proved reserves	Oil-MMB Gas-BCF	6 Lower 48 onshore regions,Fuel(2 oil, 5 gas)
OGOUT_L48 OGFOR_AK	RESBOYL48 BOYRESCOAK BOYRESNGAK	R	End of year reserves for current year	Oil-MMB Gas-BCF	6 Lower 48 onshore regions,Fuel(2 oil, 5 gas); 3 Alaska regions,Fuel(oil,gas)
OGOUT_L48 OGOUT_OFF	PRRATL48 PRRATOFF	PR	Production to reserves ratios	Fraction	6 Lower 48 onshore regions,Fuel(2 oil, 5 gas);4 Lower 48 offshore regions, Fuel(oil,gas)
OGOUT_L48 OGOUT_OFF	EXPRDL48 EXPRDOFF	Q	Production	Oil-MMB Gas-BCF	6 Lower 48 onshore regions,Fuel(2 oil, 5 gas);4 Lower 48 offshore regions, Fuel(oil,gas)
OGCOMP_AD	OGPRDAD	ADGAS	Associated-dissolved gas production	BCF	6 Lower 48 onshore regions, 3 Lower 48 offshore regions
CALC_ECF_DATA	PRV_COGEN	PRV_COGEN	Cogeneration electric capacity from production of EOR proved reserves	MW	6 Lower 48 supply regions; cogen characteristic (array position 1=capacity)
CALC_ECF_DATA	INF_COGEN	INF_COGEN	Cogeneration electric capacity from production of EOR inferred reserves	MW	6 Lower 48 supply regions; cogen characteristic (array position 1=capacity)
CALC_ECF_DATA	PRV_COGEN	PRV_COGEN	Cogeneration electric generation from production of EOR proved reserves	GWH	6 Lower 48 supply regions; cogen characteristic (array position 4=generation)
CALC_ECF_DATA	INF_COGEN	INF_COGEN	Cogeneration electric generation from production of EOR inferred reserves	GWH	6 Lower 48 supply regions; cogen characteristic (array position 4=generation)
OGCOST_AK	DRILLAK	DRILLCOST	Drilling costs	1987$ per well	Class(Exploratory,Developmental);3 Alaska regions,Fuel (oil, gas)

Variables					
Subroutine	Variable Name		Description	Unit	Classification
	Code	Text			
OGCOST_AK	LEASAK	EQUIP	Lease equipment costs	1987$ per well	Class(Exploratory,Developmental);3 Alaska regions,Fuel (oil, gas)
OGCOST_AK	OPERAK	OPCOST	Operating costs	1987$ per well	Class(Exploratory,Developmental);3 Alaska regions,Fuel (oil, gas)
OGFOR_AK	TOTGRR	TRR	Alaska total gross revenue requirements	Million 1987$	NA
OGFOR_AK	TOTDEP	TOTDEP	Alaska total depreciation	Million 1987$	NA
OGFOR_AK	MARTOT	MARGIN	Alaska total after tax margin	Million 1987$	NA
OGFOR_AK	RECTOT	DEFRETREC	Alaska total recovery of differed returns	Million 1987$	NA
OGFOR_AK	TXALLW	TXALLW	Alaska income tax allowance	Million 1987$	NA
XOGOUT_IMP	SUCWELL	SUCWELL	Successful Canadian wells drilled in WCSB	Wells	Fuel(gas)
XOGOUT_IMP	RESADCAN	RESADCAN	Canadian reserve additions in WCSB	Gas: BCF	Fuel(gas)
XOGOUT_IMP	FRCAN	FRCAN	Canadian finding rate for WCSB	Gas:BCF per well	Fuel(gas)
XOGOUT_IMP	RESBOYCAN	RESBOYCAN	WCSB Canadian reserves (BOY for t+1)	Gas: BCF	Fuel(gas)
XOGOUT_IMP	URRCAN	URRCAN	Remaining Canadian resources in WCSB	Gas: BCF	Fuel(gas)
XOGOUT_IMP	PRRATCAN	PR	Canadian production to reserves ratio in WCSB	Fraction	Fuel(gas)

Data						
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGINIT_BFW	ACCESS_YR	--	Year in which Federal access restrictions would be reduced in the Rocky Mountain Region in an increased ACCESS Case	Year	NA	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	ADVLTXL48	PRODTAX	Lower 48 onshore ad valorem tax rates	Fraction	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Colorado School of Mines. Oil Propert Evaluation, 1983, p. 9-7
OGFOR_OFF OGINIT_OFF	ADVLTXOFF	PRODTAX	Offshore ad valorem tax rates	Fraction	4 Lower 48 offshore subregions; Fuel (oil, gas)	Colorado School of Mines. Oil Propert Evaluation, 1983, p. 9-7
OGINIT_AK OGPIP_AK	ANGTSMAX	--	ANGTS maximum flow	BCF/D	Alaska	National Petroleum Council
OGINIT_AK OGPIP_AK	ANGTSPRC	--	Minimum economic price for ANGTS start up	1987$/MCF	Alaska	National Petroleum Council
OGINIT_AK OGPIP_AK	ANGTSRES	--	ANGTS reserves	BCF	Alaska	National Petroleum Council
OGINIT_AK OGPIP_AK	ANGTSYR	--	Earliest start year for ANGTS flow	Year	NA	National Petroleum Council
OGEXPAND_LNG OGINIT_LNG	BUILDLAG	--	Buildup period for expansion of LNG facilities	Year	NA	Office of Integrated Analysis and Forecasting
OGINIT_IMP	CPRDCAN	--	Canadian coproduct rate	Fraction	Canada; Fuel (oil, gas)	Not Used Derived using data from the Canadian Petroleum Association
OGFOR_L48 OGINIT_L48	CPRDL48	COPRD	Lower 48 onshore coproduct rate	Fraction	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGFOR_OFF OGINIT_OFF	CPRDOFF	COPRD	Offshore coproduct rate	Fraction	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP OGINIT_RES OGOUT_IMP	CURPRRCAN	PR	Canadian 1989 P/R ratio	Fraction	Canada; Fuel (gas)	Derived using data from the Canadian Petroleum Association

Data						
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGINIT_L48 OGINIT_RES OGOUT_L48	CURPRRL48	omega	Lower 48 initial P/R ratios	Fraction	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGINIT_OFF OGINIT_RES OGOUT_OFF	CURPRROFF	omega	Offshore initial P/R ratios	Fraction	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGOUT_L48	CURPRRTDM	--	Lower 48 initial P/R ratios at NGTDM level	Fraction	17 OGSM/NGTDM regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGINIT_RES OGOUT_L48	CURRESL48	R	Lower 48 onshore initial reserves	MMB BCF	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Derived from Annual Reserves Report Data
OGINIT_OFF OGINIT_RES OGOUT_OFF	CURRESOFF	R	Offshore initial reserves	MMB BCF	4 Lower 48 offshore subregions; Fuel (oil, gas)	Derived from Annual Reserves Report Data
OGINIT_L48 OGINIT_RES OGOUT_L48	CURRESTDM	--	Lower 48 natural gas reserves at NGTDM level	MMB BCF	17 OGSM/NGTDM regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGOUT_L48	DECFAC	DECFAC	Inferred resource simultaneous draw down decline rate adjustment factor	Fraction	NA	Office of Integrated Analysis and Forecasting
OGINIT_IMP	DECLCAN	--	Canadian decline rates	Fraction	Canada; Fuel (oil, gas)	Not Used Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48 WELL	DECLL48	--	Lower 48 onshore decline rates	Fraction	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGFOR_OFF OGINIT_OFF WELL	DECLOFF	--	Offshore decline rates	Fraction	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_AK OGPRO_AK	DECLPRO	--	Alaska decline rates for currently producing fields	Fraction	Field	Office of Integrated Analysis and Forecasting
OGINIT_IMP	DEPLETERT	--	Depletion rate	Fraction	NA	Not Used Office of Integrated Analysis and Forecasting

Data						
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGDEV_AK OGINIT_AK OGSUP_AK	DEV_AK	--	Alaska drilling schedule for developmental wells	Wells per year	3 Alaska regions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGDCF_AK OGFOR_L48 OGFOR_OFF OGINIT_BFW	DISC	disc	Discount rate	Fraction	National	Office of Integrated Analysis and Forecasting
OGINIT_IMP	DISRT	--	Discount rate	Fraction	Canada	Not Used Office of Integrated Analysis and Forecasting
OGCOST_AK OGINIT_AK	DRILLAK	DRILL	Alaska drilling cost (not including new field wildcats)	1990$/well	Class (exploratory, developmental); 3 Alaska regions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP	DRILLCAN	--	Canadian initial drilling costs	1987$	Canada; Fuel (oil, gas)	Not Used Office of Integrated Analysis and Forecasting
OGALL_OFF OGFOR_OFF OGINIT_OFF	DRILLOFF	DRILL	Offshore drilling cost	1987$	4 Lower 48 offshore subregions	Mineral Management Service
OGCOST_AK OGINIT_AK	DRLNFWAK	--	Alaska drilling cost of a new field wildcat	1990$/well	3 Alaska regions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGDCF_AK OGDEV_AK OGINIT_AK OGNEW_AK	DRYAK	DRY	Alaska dry hole cost	1990$/hole	Class (exploratory, developmental); 3 Alaska regions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP	DRYCAN	--	Canadian dry hole cost	1987$	Class (exploratory, developmental)	Not Used Office of Integrated Analysis and Forecasting
OGALL_OFF OGEXP_CALC OGFOR_OFF OGINIT_OFF	DRYOFF	DRY	Offshore dry hole cost	1987$	Class (exploratory, developmental); 4 Lower 48 offshore subregions	Minerals Management Service
OGFOR_OFF OGINIT_OFF	DVWELLOFF	--	Offshore development project drilling schedules	wells per year	4 Lower 48 offshore subregions; Fuel (oil, gas)	Minerals Management Service

Data						
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGFOR_L48 OGINIT_L48	DVWLCBML48	--	Lower 48 development project drilling schedules for coalbed methane	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	DVWLDGSL48	--	Lower 48 development project drilling schedules for deep gas	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	DVWLDVSL48	--	Lower 48 development project drilling schedules for devonian shale	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGINIT_IMP	DVWLGASCAN	--	Canadian development gas drilling schedule	wells per project per year	Canada	Not Used
OGINIT_IMP	DVWLOILCAN	--	Canadian development oil drilling schedule	wells per project per year	Canada	Not Used
OGFOR_L48 OGINIT_L48	DVWLOILL48	--	Lower 48 development project drilling schedules for oil	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	DVWLSGSL48	--	Lower 48 development project drilling schedules for shallow gas	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	DVWLTSGL48	--	Development project drilling schedules for tight gas	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGINIT_IMP XOGOUT_IMP	ELASTCAN	--	Elasticity for Canadian reserves	Fraction	Canada	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGINIT_RES OGOUT_L48	ELASTL48	--	Lower 48 onshore production elasticity values	Fraction	6 OGSm Lower 48 onshore regions	Office of Integrated Analysis and Forecasting

Data						
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGINIT_OFF OGINIT_RES OGOUT_OFF	ELASTOFF	--	Offshore production elasticity values	Fraction	4 Lower 48 offshore subregions	Office of Integrated Analysis and Forecasting
OGCOMP_EMIS OGINIT_EMIS	EMCO	--	Emission factors for crude oil production	Fraction	Census regions	EPA - Energy Technology Characterizations Handbook
OGCOMP_EMIS OGINIT_EMIS	EMFACT	--	Emission factors	MMB MMCF	Census regions	EPA - Energy Technology Characterizations Handbook
OGCOMP_EMIS OGINIT_EMIS	EMNG	--	Emission factors for natural gas production	Fraction	Census regions	EPA - Energy Technology Characterizations Handbook
OGCOST_AK OGINIT_AK	EQUIPAK	EQUIP	Alaska lease equipment cost	1990$/well	Class (exploratory, developmental); 3 Alaska regions; Fuel (oil, gas)	U.S. Geological Survey
OGEXP_CALC OGINIT_BFW	EXOFFRGNLAG	--	Offshore exploration & development regional expenditure (1989)	1987$	Class (exploratory, developmental); 4 Lower 48 offshore subregions	Office of Integrated Analysis and Forecasting
OGDEV_AK OGINIT_AK OGSUP_AK	EXP_AK	--	Alaska drilling schedule for other exploratory wells	wells per year	3 Alaska regions	Office of Integrated Analysis and Forecasting
OGINIT_IMP	EXPENSE	--	Fraction of drill costs that are expensed	fraction	Class (exploratory, developmental)	Not Used Canadian Tax Code
OGFOR_OFF OGINIT_OFF	EXWELLOFF	--	Offshore exploratory project drilling schedules	wells per year	4 Lower 48 offshore subregions	Minerals Management Service
OGFOR_L48 OGINIT_L48	EXWLCBML48	--	Lower 48 exploratory project drilling schedules for coalbed methane	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting

Data						
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGFOR_L48 OGINIT_L48	EXWLDGSL48	--	Lower 48 exploratory and developmental project drilling schedules for deep gas	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	EXWLDVSL48	--	Lower 48 exploratory project drilling schedules for devonian shale	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGINIT_IMP	EXWLGASCAN	--	Canadian exploratory gas drilling schedule	wells per year	Canada	Not Used
OGINIT_IMP	EXWLOILCAN	--	Canadian exploratory oil drilling schedule	wells per year	Canada	Not Used
OGFOR_L48 OGINIT_L48	EXWLOILL48	--	Lower 48 exploratory project drilling schedules for oil	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	EXWLSGSL48	--	Lower 48 exploratory project drilling schedules for shallow gas	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	EXWLTSGL48	--	Lower 48 exploratory project drilling schedules for tight gas	wells per year	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGDEV_AK OGFAC_AK OGINIT_AK OGSUP_AK	FACILAK	--	Alaska facility cost (oil field)	1990$/bls	Field size class	U.S. Geological Survey
OGINIT_IMP	FEDTXCAN	--	Canadian corporate tax rate	fraction	Canada	Not used. Petroleum Fiscal Systems in Canada - Energy, Mines & Resources
OGDCF_AK OGEXP_CALC OGFOR_L48 OGFOR_OFF OGINIT_BFW	FEDTXR	FDRT	U.S. federal tax rate	fraction	Canada	U.S. Tax Code

Data						
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGINIT_IMP	FLOWCAN	--	Canadian flow rates	bls, MCF per year	Canada; Fuel (oil, gas)	Not used. Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	FLOWL48	--	Lower 48 onshore flow rates	bls, MCF per year	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	EIA, Office of Oil and Gas
OGFOR_OFF OGINIT_OFF	FLOWOFF	--	Offshore flow rates	bls, MCF per year	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_LNG OGPROF_LNG	FPRDCST	--	Foreign production costs	1991$/MCF per year	LNG Source Country	National Petroleum Council
OGINIT_IMP XOGOUT_IMP	FRMINCAN	FRMIN	Canadian minimum economic finding rate	BCF per well	Canada	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGOUT_L48	FRMINL48	FRMIN	Lower 48 onshore minimum exploratory well finding rate	MMB BCF per well	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGINIT_OFF OGOUT_OFF	FRMINOFF	FRMIN	Offshore minimum exploratory well finding rate	MMB BCF per well	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
XOGOUT_IMP	FRTECHCAN	FRTECH	Canada technology factor applied to finding rate	fraction	Canada	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGOUT_L48	FR1L48	FR1	Lower 48 onshore new field wildcat well finding rate	MMB BCF per well	6 Lower 48 onshore regions; Fuel (2 oil, 2 gas)	Office of Integrated Analysis and Forecasting
OGINIT_OFF OGOUT_OFF	FR1OFF	FR1	Offshore new field wildcat well finding rate	MMB BCF per well	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGOUT_L48	FR2L48	FR3	Lower 48 onshore developmental well finding rate	MMB BCF per well	6 Lower 48 onshore regions; Fuel (2 oil, 2 gas)	Office of Integrated Analysis and Forecasting
OGINIT_OFF OGOUT_OFF	FR2OFF	FR3	Offshore developmental well finding rate	MMB BCF per well	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting

Data							
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGINIT_L48 OGOUT_L48	FR3L48	FR2	Lower 48 other exploratory well finding rate	MMB BCF per well	6 Lower 48 onshore regions; Fuel (2 oil, 2 gas)	Office of Integrated Analysis and Forecasting
OGINIT_OFF OGOUT_OFF	FR3OFF	FR2	Offshore other exploratory well finding rate	MMB BCF per well	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGFOR_AK OGINIT_AK OGNEW_AK	FSZCOAK	__	Alaska oil field size distributions	MMB	3 Alaska regions	U.S. Geological Survey
OGFOR_AK OGINIT_AK OGNEW_AK	FSZNGAK	--	Alaska gas field size distributions	BCF	3 Alaska regions	U.S. Geological Survey
OGINIT_L48	HISTADL48	--	Lower 48 historical associated-dissolved natural gas reserves	BCF	NA	Annual Reserves report
OGINIT_OFF	HISTADOFF	--	Offshore historical associated-dissolved natural gas reserves	BCF	NA	Annual Reserves Report
OGINIT_IMP XOGOUT_IMP	HISTFRCAN	--	Historical Canadian finding rate for gas	BCF per well	Canada	Office of Integrated Analysis and Forecasting
OGINIT_AK OGPRO_AK	HISTPRDCO	--	Alaska historical crude oil production	MB/D	Field	Alaska Oil and Gas Conservation Commission
OGINIT_IMP XOGOUT_IMP	HISTPRRCAN	--	Canadian gas production to reserves ratio for historical years	BCF	Canada; Fuel (gas)	Office of Integrated Analysis and Forecasting
OGINIT_L48	HISTPRRL48	--	Lower 48 historical P/R ratios	fraction	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Derived from Annual Reserves Report
OGINIT_OFF	HISTPRROFF	--	Offshore historical P/R ratios	fraction	4 Lower 48 offshore subregions; Fuel (oil, gas)	Derived from Annual Reserves Report

Data						
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGINIT_L48	HISTPRRTDM	--	Lower 48 onshore historical P/R ratios at the NGTDM level	fraction	17 OGSM/NGTDM regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP XOGOUT_IMP	HISTRESAD	--	Canadian gas reserves additions for historical years	BCF	Canada; Fuel (gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP XOGOUT_IMP	HISTRESCAN	--	Canadian beginning of year gas reserves for historical years	BCF	Canada; Fuel (gas)	Canadian Petroleum Association
OGINIT_IMP XOGOUT_IMP	HISTWELCAN	--	Canadian gas wells drilled in historical years	BCF	Canada; Fuel (gas)	Office of Integrated Analysis and Forecasting
OGINIT_L48	HISTRESL48	--	Lower 48 onshore historical beginning-of-year reserves	MMB BCF	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Annual Reserves Report
OGINIT_OFF	HISTRESOFF	--	Offshore historical beginning-of-year reserves	MMB BCF	4 Lower 48 offshore subregions; Fuel (oil, gas)	Annual Reserves Report
OGINIT_L48	HISTRESTDM	--	Lower 48 onshore historical beginning-of-year reserves at the NGTDM level	MMB BCF	17 OGSM/NGTDM regions; Fuel (2 oil, 5 gas)	Annual Reserves Report
WELL OGEXPAND_LNG OGINIT_IMP XOGOUT_IMP	IMPBYR	--	Base start-year for Foreign Natural Gas Supply Submodule	--	--	Office of Integrated Analysis and Forecasting
OGDCF_AK OGFOR_L48 OGFOR_OFF OGINIT_BFW	INFL	infl	U.S. inflation rate	fraction	National	Office of Integrated Analysis and Forecasting

Data							
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGINIT_L48 OGOUT_L48	INFRSVL48	I	Lower 48 onshore inferred reserves	MMB BCF	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGINIT_OFF OGOUT_OFF	INFRSVOFF	I	Offshore inferred reserves	MMB BCF	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP	INFRT	--	Canadian inflation rate	fraction	Canada	Not used. Office of Integrated Analysis and Forecasting
OGINIT_IMP	INVESTRT	--	Canadian investment tax credit	fraction	Canada	Not Used
OGDCF_AK OGINIT_AK	KAPFRCAK	EXKAP	Alaska drill costs that are tangible & must be depreciated	fraction	Alaska	U.S. Tax Code
OGFOR_L48 OGINIT_L48	KAPFRCL48	EXKAP	Lower 48 onshore drill costs that are tangible & must be depreciated	fraction	Class (exploratory, developmental)	U.S. Tax Code
OGFOR_OFF OGINIT_OFF	KAPFRCOFF	EXKAP	Offshore drill costs that are tangible & must be depreciated	fraction	Class (exploratory, developmental)	U.S. Tax Code
OGFOR_L48 OGINIT_L48	KAPSPNDL48	KAP	Lower 48 onshore other capital expenditures	1987$	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Not used
OGFOR_OFF OGINIT_OFF	KAPSPNDOFF	KAP	Offshore other capital expenditures	1987$	Class (exploratory, developmental); 4 Lower 48 offshore subregions	Minerals Mangement Service
OGFOR_L48 OGINIT_L48	LAGDRILL48	--	1989 Lower 48 drill cost	1987$	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting

Data						
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGFOR_L48 OGINIT_L48	LAGDRYL48	--	1989 Lower 48 dry hole cost	1987$	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	LAGLEASL48	--	1989 Lower 48 lease equipment cost	1987$	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	LAGOPERL48	--	1989 Lower 48 operating cost	1987$	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP	LEASCAN	--	Canadian lease equipment cost	1987$	Canada; Fuel (oil, gas)	Not used. Office of Integrated Analysis and Forecasting
OGFOR_OFF OGINIT_OFF	LEASOFF	EQUIP	Offshore lease equipment cost	1987$ per project	Class (exploratory, developmental); 4 Lower 48 offshore subregions	Minerals Mangement Service
OGEXPAND_LNG OGINIT_LNG	LIQCAP	--	Liquefaction capacity	BCF	LNG Source Country	National Petroleum Council
OGINIT_LNG OGPROF_LNG	LIQCST	--	Liquefaction costs	1991$/MCF	LNG Source Country	National Petroleun Council
OGEXPAND_LNG OGPROF_LNG	LIQSTAGE	--	Liquefaction stage	NA	NA	National Petroleum Council
OGINIT_BFW	LST_CONV	--	Share of the conventional resources in the Rocky Mountains that are subject to Federal lease stipulations	Percent	Fuel (oil, gas)	ARI
OGFOR_AK OGINIT_AK OGPRO_AK	MAXPRO	--	Alaska maximum crude oil production	MB/D	Field	Announced Plans
OGINIT_IMP OGOUT_MEX	MEXEXP	--	Exports from Mexico	BCF	3 US/Mexican border crossing	Office of Integrated Analysis and Forecasting

Data						
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGINIT_IMP OGOUT_MEX	MEXIMP	--	Imports from Mexico	BCF	3 US/Mexican border crossing	Office of Integrated Analysis and Forecasting
OGINIT_BFW	NAC_CONV	--	Share of the conventional resources in the Rocky Mountains that are legally inaccessible	Percent	Fuel (oil, gas)	ARI
OGINIT_AK OGNEW_AK	NFW_AK	--	Alaska drilling schedule for new field wildcats	wells	NA	Office of Integrated Analysis and Forecasting
OGFOR_OFF OGINIT_OFF	NFWCOSTOFF	COSTEXP	Offshore new field wildcat cost	1987$	Class (exploratory, developmental); 4 Lower 48 offshore subregions	Minerals Management Service
OGFOR_OFF OGINIT_OFF	NFWELLOFF	--	Offshore exploratory and developmental project drilling schedules	wells per project per year	Class (exploratory, developmental); r=1	Minerals Management Service
OGINIT_L48 OGINIT_RES OGOUT_L48	NGTDMMAP	--	Mapping of NGTDM regions to OGSM regions	NA	17 OGSM/NGTDM regions	Office of Integrated Analysis and Forecasting
OGINIT_IMP	OGCNBLOSS	--	Gas lost in transit to border	BCF	6 US/Canadian border crossings	Not Used
OGINIT_IMP	OGCNCAPB	--	Canadian capacities at borders - base case	BCF	6 US/Canadian border crossing	Not used. Derived from Natural Gas Annual
OGINIT_IMP	OGCNCAPH	--	Canadian capacities at borders - high WOP case	BCF	6 US/Canadian border crossing	Not used. Derived from Natural Gas Annual
OGINIT_IMP	OGCNCAPL	--	Canadian capacities at borders - low WOP case	BCF	6 US/Canadian border crossing	Not used. Derived from Natural Gas Annual

Data						
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGINIT_IMP XOGOUT_IMP	OGCNCON	--	Canadian gas consumption	BCF	Canada; Fuel (gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP	OGCNDEM	--	Canadian demand calculation parameters	NA	NA	Not Used
OGINIT_IMP	OGCNDMLOSS	--	Gas lost from wellhead to Canadian demand	BCF	Canada	Not used. Office of Integrated Analysis and Forecasting
OGINIT_IMP	OGCNEXLOSS	--	Gas lost from US export to Canadian demand	BCF	Canada	Not used. Office of Integrated Analysis and Forecasting
OGINIT_IMP	OGCNFLW	--	1989 flow volumes by border crossing	BCF	6 US/Canadian border crossings	Not used. Office of Integrated Analysis and Forecasting
OGINIT_IMP	OGCNPARM1	--	Actual gas allocation factor	fraction	Canada	Not used. Office of Integrated Analysis and Forecasting
OGINIT_IMP	OGCNPARM2	--	Responsiveness of flow to different border prices	fraction	Canada	Not used. Office of Integrated Analysis and Forecasting
OGINIT_PRICE	OGCNPPRD	--	Canadian price of oil and gas	oil: 87$s/B gas: 87$s/mcf	Canada	NGTDM
OGPIP_AK OGPROF_LNG	OGPNGIMP	--	Natural gas import price	87$s/mcf	US/Canadian & US/Mexican border crossings and LNG destination points	NGTDM
OGINIT_IMP	OPERCAN	--	Canadian operating cost	$ 1987	Canada; Fuel (gas)	Not used. Office of Integrated Analysis and Forecasting
OGFOR_OFF OGINIT_OFF	OPEROFF	OPCOST	Offshore operating cost	1987$ per well per year	Class (exploratory, developmental); 4 Lower 48 offshore subregions	Mineral Management Service
OGDCF_AK OGINIT_AK	PRJAK	n	Alaska oil project life	Years	Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	PRJL48	n	Lower 48 project life	Years	Fuel (oil, gas)	Office of Integrated Analysis and Forecasting

Data							
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGFOR_OFF OGINIT_OFF	PRJOFF	n	Offshore project life	Years	Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_IMP	PROVTXCAN	PROVRT	Canadian provincial corporate tax rates	fraction	Canada	Not used. Petroleum Fiscal Systems in Canada - Energy, Mines & Resources
OGFOR_AK OGINIT_AK OGPRO_AK	PROYR	--	Start year for known fields in Alaska	Year	Field	Announced Plans
OGEXPAND_LNG OGINIT_LNG OGLNG_OUT	QLNG	--	LNG operating flow capacity	BCF	LNG destination points	National Petroleum Council
OGEXPAND_LNG OGINIT_LNG OGLNG_OUT	QLNGMAX	--	LNG maximum capacity	BCF	LNG destination Points	National Petroleum Council
OGDCF_AK OGINIT_AK	RCPRDAK	m	Alaska recovery period of intangible & tangible drill cost	Years	Alaska	U.S. Tax Code
OGINIT_IMP	RCPRDCAN	--	Canada recovery period of intangible & tangible drill cost	Years	Canada	Not used. Petroleum Fiscal Systems in Canada - Energy, Mines & Resources
OGFOR_L48 OGINIT_L48	RCPRDL48	m	Lower 48 recovery period for intangible & tangible drill cost	Years	Lower 48 Onshore	U.S. Tax Code
OGFOR_OFF OGINIT_OFF	RCPRDOFF	m	Offshore recovery period intangible & tangible drill cost	Years	Lower 48 Offshore	U.S. Tax Code
OGFOR_AK OGINIT_AK OGPRO_AK	RECRES	--	Alaska crude oil resources for known fields	MMB	Field	OFE, *Alaska Oil and Gas - Energy Wealth or Vanishing Opportunity*
OGINIT_LNG OGPROF_LNG	REGASCST	--	Regasification costs	1991$/MCF per year	Operational Stage; LNG destination points	National Petroleum Council
OGEXPAND_LNG OGINIT_LNG	REGASEXPAN	--	Regasification capacity	BCF	LNG destination points	National Petroleum Council
OGEXPAND_LNG OGINIT_LNG OGPROF_LNG	REGASSTAGE	--	Regasification stage	NA	NA	National Petroleum Council

Data						
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGINIT_IMP XOGOUT_IMP	RESBASE	Q	Canadian recoverable resource estimate	BCF	Canada	Canadian Geological Survey
OGINIT_IMP	ROYRATE	--	Canadian royalty rate	fraction	Canada	Not used. Petroleum Fiscal Systems in Canada - Energy, Mines & Resources
OGDCF_AK OGFOR_L48 OGINIT_BFW	ROYRT	ROYRT	Alaska royalty rate	fraction	Alaska	U.S. Geological Survey
OGINIT_AK OGSEVR_AK	SEVTXAK	PRODTAX	Alaska severance tax rates	fraction	Alaska	U.S. Geological Survey
OGFOR_L48 OGINIT_L48	SEVTXL48	PRODTAX	Lower 48 onshore severance tax rates	fraction	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Commerce Clearing House
OGFOR_OFF OGINIT_OFF	SEVTXOFF	PRODTAX	Offshore severance tax rates	fraction	4 Lower 48 offshore subregions; Fuel (oil, gas)	Commerce Clearing House
	SPENDIRKLAG	--	1989 Lower 48 exploration & development expenditures	1987$	Class (exploratory, developmental)	Office of Integrated Analysis and Forecasting
OGDCF_AK OGDEV_AK OGINIT_AK OGNEW_AK	SRAK	SR	Alaska drilling success rates	fraction	Alaska	Office of Oil and Gas
OGINIT_IMP	SRCAN	SR	Canada drilling success rates	fraction	Canada	Office of Integrated Analysis and Forecasting
OGEXP_CALC OGEXP_FIX OGFOR_L48 OGINIT_L48 OGOUT_L48	SRL48	SR	Lower 48 drilling success rates	fraction	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGALL_OFF OGFOR_OFF OGINIT_OFF OGOUT_OFF	SROFF	SR	Offshore drilling success rates	fraction	Class (exploratory, developmental); 4 Lower 48 offshore subregions; Fuel (oil, gas)	Minerals Management Service

Data						
Subroutine	**Variable Name**		**Description**	**Unit**	**Classification**	**Source**
	Code	**Text**				
OGEXPAND_LNG OGINIT_LNG	STARTLAG	--	Number of year between stages (regasification and liquefaction)	years	NA	Office of Integrated Analysis and Forecasting
OGINIT_BFW	STL_CONV	--	Share of the conventional resources in the Rocky Mountains that are subject to Standard Lease Terms	Percent	Fuel (oil, gas)	ARI
OGDCF_AK OGINIT_AK	STTXAK	STRT	Alaska state tax rate	fraction	Alaska	U.S. Geological Survey
OGEXP_CALC OGFOR_L48 OGINIT_L48	STTXL48	STRT	State tax rates	fraction	6 Lower 48 onshore regions	Commerce Clearing House
OGEXP_CALC OGFOR_OFF OGINIT_L48	STTXOFF	STRT	State tax rates	fraction	4 Lower 48 offshore subregions	Commerce Clearing House
OGCOST_AK OGINIT_AK	TECHAK	TECH	Alaska technology factors	fraction	Alaska	Office of Integrated Analysis and Forecasting
OGINIT_IMP	TECHCAN	--	Canada technology factors applied to costs	fraction	Canada	Not used. Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	TECHL48	TECH	Lower 48 onshore technology factors applied to costs	fraction	Lower 48 Onshore	Office of Integrated Analysis and Forecasting
OGFOR_OFF OGINIT_OFF	TECHOFF	TECH	Offshore technology factors applied to costs	fraction	Lower 48 Offshore	Office of Integrated Analysis and Forecasting
OGINIT_LNG OGPROF_LNG	TRANCST	--	LNG transporation costs	1990/MCF	NA	National Petroleum Council
OGDCF_AK OGINIT_AK	TRANSAK	TRANS	Alaska transportation cost	1990$	3 Alaska regions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGFOR_L48 OGINIT_L48	TRANSL48	TRANS	Lower 48 onshore expected transportation costs	NA	6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Not Used

Data							
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGFOR_OFF OGINIT_OFF	TRANSOFF	TRANS	Offshore expected transportation costs	NA	4 Lower 48 offshore subregions; Fuel (oil, gas)	Not Used
OGINIT_OFF OGOUT_OFF	UNRESOFF	Q	Offshore undiscovered resources	MMB BCF	4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGOUT_L48	URRCRDL48	Q	Lower 48 onshore undiscovered recoverable crude oil resources	MMB	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGINIT_L48 OGOUT_L48	URRTDM	--	Lower 48 onshore undiscovered recoverable natural gas resources	TCF	6 Lower 48 onshore regions	Office of Integrated Analysis and Forecasting
OGEXP_CALC OGINIT_BFW	WDCFIRKLAG	--	1989 Lower 48 exploration & development weighted DCFs	1987$	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Integrated Analysis and Forecasting
OGEXP_CALC OGINIT_BFW	WDCFIRLAG	--	1989 Lower 48 regional exploration & development weighted DCFs	1987$	Class (exploratory, developmental); 6 Lower 48 onshore regions;	Office of Integrated Analysis and Forecasting
OGEXP_CALC OGINIT_BFW	WDCFL48LAG	--	1989 Lower 48 onshore exploration & development weighted DCFs	1987$	Class (exploratory, developmental)	Office of Integrated Analysis and Forecasting
OGEXP_CALC OGINIT_BFW	WDCFOFFIRKLAG	--	1989 offshore exploration & development weighted DCFs	1987$	Class (exploratory, developmental); 4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Integrated Analysis and Forecasting

Data						
Subroutine	Variable Name		Description	Unit	Classification	Source
	Code	Text				
OGEXP_CALC OGINIT_BFW	WDCFOFFIRLAG	--	1989 offshore regional exploration & development weighted DCFs	1987$	Class (exploratory, developmental); 4 Lower 48 offshore subregions;	Office of Integrated Analysis and Forecasting
OGEXP_CALC OGINIT_BFW	WDCFOFFLAG	--	1989 offshore exploration & development weighted DCFs	1987$	Class (exploratory, developmental)	Office of Integrated Analysis and Forecasting
OGINIT_IMP XOGOUT_IMP	WELLAGCAN	WELLAG	1989 wells drilled in Canada	Wells per year	Fuel (gas)	Canadian Petroleum Association
OGEXP_CALC OGEXP_FIX OGINIT_L48	WELLAGL48	WELLSON	1989 Lower 48 wells drilled	Wells per year	Class (exploratory, developmental); 6 Lower 48 onshore regions; Fuel (2 oil, 5 gas)	Office of Oil & Gas
OGALL_OFF OGEXP_CALC OGINIT_OFF	WELLAGOFF	WELLSOFF	1989 offshore wells drilled	Wells per year	Class (exploratory, developmental); 4 Lower 48 offshore subregions; Fuel (oil, gas)	Office of Oil & Gas
OGINIT_IMP	WELLLIFE	--	Canadian project life	Years	Canada	Not used. Office of Integrated Analysis and Forecasting
OGDCF_AK OGINIT_AK	XDCKAPAK	XDCKAP	Alaska intangible drill costs that must be depreciated	fraction	Alaska	U.S. Tax Code
OGFOR_L48 OGINIT_L48	XDCKAPL48	XDCKAP	Lower 48 intangible drill costs that must be depreciated	fraction	NA	U.S. Tax Code
OGFOR_OFF OGINIT_OFF	XDCKAPOFF	XDCKAP	Offshore intangible drill costs that must be depreciated	fraction	NA	U.S. Tax Code

Parameters				
Subroutine	**Parameter Name**		**Associated Variable**	**Classification**
	Code	**Text**		
OGCST_L48	value from regression	b0	Constant coefficient	Lower 48 onshore
OGCST_L48	value from regression	b1	Crude oil wellhead price coefficient	Lower 48 onshore
OGCST_L48	value from regression	b2	Natural gas wellhead price coefficient	Lower 48 onshore
OGCST_L48	value from regression	ρ	Aurocorrelation parameter	Lower 48 onshore
OGCST_l48	ALPHA_RIG	ln(b0)	Constant coefficient	Lower 48 onshore
OGCST_l48	B0_RIG	b1	Lower 48 onshore rigs	Lower 48 onshore
OGCST_l48	B1_RIG	b2	Revenue per lower 48 onshore rig	Lower 48 onshore
OGCST_l48	alpha_drl alpha_dry	ln(δ0)	Constant coefficient for onshore drilling and dry costs	6 lower 48 onshore regions, 3 fuels (oil, shallow gas, deep gas)
OGCST_l48	b0_drl b0_dry	ln(δ1)	Average depth per well	depth category, 3 fuels (oil, shallow gas, deep gas)
OGCST_l48	b4_drl b4_dry	ln(δ2)	Region 1 and region 6 adjustment	3 fuels (oil, shallow gas, deep gas)
OGCST_l48	b1_drl b1_dry	δ3	Estimated number of Lower 48 wells drilled	3 fuels (oil, shallow gas, deep gas)
OGCST_l48	b3_drl b3_dry	δ4	Lower 48 onshore rigs	3 fuels (oil, shallow gas, deep gas)
OGCST_l48	b2_drl b2_dry	δ5	Time trend - proxy for technology	3 fuels (oil, shallow gas, deep gas)
OGCST_l48	rho_drl rho_dry	ρ	Autocorrelation parameter	3 fuels (oil, shallow gas, deep gas)
OGCST_L48	ALPHA_LEQ	ln(ε0)	Constant coefficient	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGCST_L48	B0_LEQ	ln(ε1)	Lower 48 successful wells by fuel (oil, gas)	Fuel (oil, shallow gas, deep gas)
OGCST_L48	B1_LEQ	ln(ε2)	Time trend - proxy for technology	Fuel (oil, shallow gas, deep gas)
OGCST_L48	B2_LEQ	ln(ε3)	Estimated successful wells	Fuel (oil, shallow gas, deep gas)
OGCST_L48	RHO_LEQ	ρ	Autocorrelation parameter	Fuel (oil, shallow gas, deep gas)
OGCST_L48	ALPHA_OPR	ln(ε0)	Constant coefficient	6 Lower 48 onshore regions; Fuel (oil, shallow gas, deep gas)
OGCST_L48	B0_OPR	ln(ε1)	Depth per well	Fuel (oil, shallow gas, deep gas)
OGCST_L48	B1_OPR	ln(ε2)	Lower 48 successful wells by fuel (oil, gas)	Fuel (oil, shallow gas, deep gas)
OGCST_L48	B2_OPR	ln(ε3)	Time trend - proxy for technology	Fuel (oil, shallow gas, deep gas)
OGCST_L48	RHO_OPR	ρ	Autocorrelation parameter	Fuel (oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m0	Constant coefficient - oil wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)

Parameters				
Subroutine	Parameter Name		Associated Variable	Classification
	Code	Text		
OGWELLS_L48	value from regression	m00	Regional coefficient - oil wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m1	Discounted cash flow - oil wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m2	Cashflow - oil wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	ρ	Autocorrelation parameter - oil wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m0	Constant coefficient - shallow gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m00	Regional coefficient - shallow gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m1	Discounted cash flow - shallow gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m2	Cashflow - shallow gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	ρ	Autocorrelation - shallow gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m0	Constant coefficient - deep gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m00	Regional coefficient - deep gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	m1	Discounted cash flow - deep gas wells	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGWELLS_L48	value from regression	ρ	Autocorrelation parameter	6 Lower 48 onshore regions; Fuel oil, shallow gas, deep gas)
OGCOMP_AD	ALPHA_AD	$\ln(\alpha 0)+\ln(\alpha 1)$	Constant coefficient plus regional dummy	Lower 48 regions (6 onshore, 3 offshore
OGCOMP_AD	BETA_AD	$\ln(\beta 0)+\ln(\beta 1)$	Crude oil production plus regional dummy	Lower 48 regions (6 onshore, 3 offshore)
XOGOUT_IMP	value from regression	B0	Constant coefficient	Canada national, Fuel(gas)
XOGOUT_IMP	value from regression	B2	Gas price	Canada national, Fuel(gas)
XOGOUT_IMP	not represented	B3	Years >1992 dummy constant	Canada national, Fuel(gas)

Outputs					
OGSM Subroutine	**Variable Name**	**Description**	**Unit**	**Classification**	**Passed To Module**
OGFOR_AK OGPIP_AK	OGANGTSMX	Maximum natural gas flow through ANGTS	BCF	NA	NGTDM
OGINIT_IMP	OGCNBLOSS	Gas lost in transit to border	BCF	6 US/Canadian border crossings	NGTDM (Not used)
OGINIT_IMP	OGCNCAP	Canadian capacities by border crossing	BCF	6 US/Canadian border crossings	NGTDM (Not used)
OGINIT_IMP XOGOUT_IMP	OGCNCON	Canada gas consumption	Oil: MMB Gas: BCF	Fuel(oil,gas)	--
OGINIT_IMP	OGCNDMLOSS	Gas lost from wellhead to Canadian demand	BCF	NA	NGTDM (Not used)
OGINIT_IMP	OGCNEXLOSS	Gas lost from US export to Canadian demand	BCF	NA	NGTDM (Not used)
OGINIT_IMP	OGCNFLW	1989 flow volumes by border crossing	BCF	6 US/Canadian border crossings	NGTDM (Not used)
OGINIT_IMP	OGCNPARM1	Actual gas allocation factor	fraction	NA	NGTDM (Not used)
OGINIT_IMP	OGCNPARM2	Responsiveness of flow to different border prices	fraction	NA	NGTDM (Not used)
OGINIT_IMP	OGCNPMARK UP	Transportation mark-up at border	1987$	6 US/Canadian border crossings	NGTDM (Not used)
OGINIT_RES XOGOUT_IMP	OGELSCAN	Canadian price elasticity	fraction	Fuel (oil, gas)	--
OGINIT_RES OGOUT_L48 OGOUT_OFF	OGELSCO	Oil production elasticity	fraction	6 Lower 48 onshore & 3 Lower 48 offshore regions	PMM
OGINIT_RES OGOUT_OFF	OGELSNGOF	Offshore nonassociated dry gas production elasticity	fraction	3 Lower 48 offshore regions	NGTDM
OGINIT_RES OGOUT_L48	OGELSNGON	Onshore nonassociated dry gas production elasticity	fraction	17 OGSM/NGTDM regions	NGTDM
OGOUT_EOR	OGEORCOGC	Electric cogeneration capacity from EOR	MWH	6 Lower 48 onshore regions	Industrial (not used)
OGOUT_EOR	OGEORCOGG	Electric cogeneration volumes from EOR	MWH	6 Lower 48 onshore regions	Industrial (not used)
OGCOMP_AD	OGPRDAD	Associated-dissolved gas production	BCF	6 Lower 48 onshore regions & 3 Lower 48 offshore regions	NGTDM
OGINIT_RES XOGOUT_IMP	OGPRRCAN	Canadian P/R ratio	fraction	Fuels (oil, gas)	NGTDM
OGINIT_RES OGOUT_L48	OGPRRCO	Oil P/R ratio	fraction	6 Lower 48 onshore & 3 Lower 48 offshore regions	PMM
OGINIT_RES OGOUT_OFF	OGPRRNGOF	Offshore nonassociated dry gas P/R ratio	fraction	3 Lower 48 offshore regions	NGTDM

Outputs					
OGSM Subroutine	**Variable Name**	**Description**	**Unit**	**Classification**	**Passed To Module**
OGINIT_RES OGOUT_L48	OGPRRNGON	Onshore nonassociated dry gas P/R ratio	fraction	17 OGSM/NGTDM regions	NGTDM
OGFOR_AK OGPIP_AK OGPRO_AK	OGQANGTS	Gas flow at U.S. border from ANGTS	BCF	NA	NGTDM
OGINIT_IMP XOGOUT_IMP OGOUT_MEX	OGQNGEXP	Natural gas exports	BCF	6 US/Canada & 3 US/Mexico border crossings	NGTDM
OGLNG_OUT XOGOUT_IMP OGOUT_MEX	OGQNGIMP	Natural gas imports	BCF	3 US/Mexico border crossings; 4 LNG terminals	NGTDM
OGINIT_RES XOGOUT_IMP	OGRESCAN	Canadian end-of-year reserves	oil: MMB gas: BCF	Fuel (oil, gas)	NGTDM
OGINIT_RES OGOUT_L48 OGOUT_OFF	OGRESCO	Oil reserves	MMB	6 Lower 48 onshore & 3 Lower 48 offshore regions	PMM
OGINIT_RES OGOUT_OFF	OGRESNGOF	Offshore nonassociated dry gas reserves	BCF	3 Lower 48 offshore regions	NGTDM
OGINIT_RES OGOUT_L48	OGRESNGON	Onshore nonassociated dry gas reserves	BCF	17 OGSM/NGTDM regions	NGTDM

OFFSHORE SUPPLY SUBMODULE			
VARIABLE	**BRIEF DESCRIPTION**	**UNITS**	**SOURCE**
PARAM (1)	Operating cost overhead	Fraction	ICF Resources Incorporated Various Industry Cost Surveys
PARAM (2)	G & A expenses on tangible and intangible investments	Fraction	ICF Resources Incorporated Various Industry Cost Surveys
PARAM (3)	Useful life on capital investment	Years	Internal Revenue Service
PARAM (4)	Royalty rate on producer revenue	Fraction	Minerals Management Service
PARAM (5)	Severence tax rate	Fraction	Minerals Management Service
PARAM (6)	Income tax credit on capital investment	Fraction	Internal Revenue Service
PARAM (7)	Federal income tax rate	Fraction	Internal Revenue Service
PARAM (8)	Discount factor	Multiplier	ICF Resources Incorporated
PARAM (9)	Year after tangible investment begins depreciating	Years	Internal Revenue Service
PARAM (10)	Co-product value adjustment factor	Fraction	Minerals Management Service
PARAM (11)	Year in which costs are evaluated		ICF Resources Incorporated
PARAM (12)	Current year in analysis		ICF, EIA
PARAM (13)	Convergence criterion for method of bisection	Value	ICF Resources Incorporated
PARAM (14)	Fraction of investment costs that are tangible	Fraction	Definition
PARAM (15)	Fraction of exploratory well costs that are GNG costs	Fraction	Various Industry Cost Surveys
NPYR	Total number of years in production for wells in a given field size class	year	DOE Fossil Energy Models ICF Resources Incorporated
ULT_PCT	Percent of ultimate recovery of a well that is produced each year	fraction	DOE Fossil Energy Models ICF Resources Incorporated
NUSGS	US Geological Survey defined field size class number		US Geological Survey
MIN_USGS	Minimum field size in a field size class defined by USGS	MMBOE	US Geological Survey
MAX_USGS	Maximum field size in a field size class defined by USGS	MMBOE	US Geological Survey
WEL_REC	Average per well ultimate recovery for fields in a USGS field size class	MMBOE	DOE Fossil Energy Models ICF Resources Incorporated
PLAY_NUM	Unit code assigned to the ‘plays’ defined in DWOSS		Minerals Management Service ICF Resources Incorporated
PLAY_COD	Alpha-numeric code for the ‘plays’ defined in DWOSS		ICF Resources Incorporated
PLAY_NAM	Description of the ‘plays’ defined in DWOSS		ICF Resources Incorporated Minerals Management Service
WAT_DEP	Average water depth for each of the water depth aggregated plays	feet	ICF Resources Incorporated Offshore Data Services Various Industry Sources
EXP_DEP	Average exploratory well drilling depth in each play	feet	Offshore Data Services Minerals Management Service
DEV_DEP	Average development well drilling depth in each play	feet	Offshore Data Services Minerals Management Service

OFFSHORE SUPPLY SUBMODULE			
VARIABLE	**BRIEF DESCRIPTION**	**UNITS**	**SOURCE**
EDSR	Exploration drilling success rate in each play	fraction	Offshore Data Services Various Industry Sources American Petroleum Institute
XDSR	Extension drilling success rate in each play	fraction	Offshore Data Services Various Industry Sources American Petroleum Institute
DDSR	Development drilling success rate in each play	fraction	Offshore Data Services Various Industry Sources American Petroleum Institute
GO_RATIO	Gas oil ratio for fields in each play	Scf/Bbl	Minerals Management Service
YIELD	Condensate yield for fields in each play	Bbl/MMcf	Minerals Management Service
APIGRAV	Crude oil gravity for fields in each play	Deg. API	Minerals Management Service
FLOWLINE	Length of gathering system for an average field in a play	Miles	Minerals Management Service ICF Resources Incorporated
OIL_TARF	Transportation tariff for oil for an average field in a play	$/Bbl	Minerals Management Service
GAS_TARF	Transportation tariff for gas for an average field in a play	$/Mcf	Minerals Management Service
NPOOL	Number of fields in a play		Minerals Management Service
OIL_GAS	The type of field - oil-bearing or gas-bearing		ICF Resources Incorporated
OIL_SIZE	Size of the field if an oil-bearing field	MMBbl	Minerals Management Service
GAS_SIZE	Size of the field if an gas-bearing fieldBcfMinerals Management Service		ICF Resources Incorporated
FSC	USGS Field Size Class to which the field belongs		US Geological Survey
WDC	Gulf of Mexico water depth category to which the field belongs		ICF Resources Incorporated Minerals Management Service
EDRATE	Exploration drilling rate	feet/day	Various Industry Sources
DDRATE	Development drilling rate	feet/day	Various Industry Sources
ITECH	Five technology choices relating to exploration drilling rig, development drilling rig, pre-drilling, production structure, and pipeline construction		Minerals Management Service ICF Resources Incorporated Various Literature Sources
EXPRIG	Exploration drilling rig		Calculated in Model
PRERIG	Pre-drilling rig		Calculated in Model
DEVRIG	Development drilling rig		Calculated in Model
EXPWEL	Number of exploratory wells		Calculated in Model
IYREXP	Year when exploratory drilling begins		Calculated in Model
EXPTIM	Time required for exploratory drilling		Calculated in Model
DELWEL	Number of delineation wells		Calculated in Model
IYRDEL	Year when delineation drilling begins		Calculated in Model
DELTIM	Time required for delineation drilling		Calculated in Model
DEVWEL	Number of development wells		Calculated in Model

OFFSHORE SUPPLY SUBMODULE			
VARIABLE	**BRIEF DESCRIPTION**	**UNITS**	**SOURCE**
DEVDRY	Number of dry development wells		Calculated in Model
IYRDEV	Year when development drilling begins		Calculated in Model
DEVTIM	Time required for development drilling		Calculated in Model
PREDEV	Number of pre-drilled development wells		Calculated in Model
PREDRY	Number of pre-drilled dry development wells		Calculated in Model
IYRPRE	Year when pre-drilling begins		Calculated in Model
PRETIM	Time required for pre-drilling		Calculated in Model
NSLOT	Number of slots		Calculated in Model
NSTRUC	Number of production structures		Calculated in Model
IYRSTR	Year when structure installation begins		Calculated in Model
STRTIM	Time required to complete the structure installation		Calculated in Model
NTEMP	Number of templates		Calculated in Model
IYRTEM	Year when template construction begins		Calculated in Model
TEMTIM	Time required to complete the template installation		Calculated in Model
IYRPIP	Year when the pipeline gathering system construction begins		Calculated in Model
PIPTIM	Time required to complete the pipeline gathering system installation		Calculated in Model
ULTREC	Cumulative ultimate recoverable reserves in a field	MMBOE	Calculated in Model
QAVOIL	Average oil production rate per year during the life of a field	Bbl	Calculated in Model
QOIL	Annual oil production volume for each year during the life of a field	Bbl	Calculated in Model
QCOIL	Cumulative oil production volume at the end of each year	Bbl	Calculated in Model
QAVGAS	Average gas production rate per year during the life of a field	Mcf	Calculated in Model
QGAS	Annual gas production volume for each year during the life of a field	Mcf	Calculated in Model
QCGAS	Cumulative gas production volume at the end of each year	Mcf	Calculated in Model
IYRPRD	Year when production begins in a field		Calculated in Model
PRDTIM	Time required for total production		Calculated in Model
MAXPYR	Year when the last well in a field ceases production		Calculated in Model
IYRABN	Year when the field and production structure are abandoned		Calculated in Model
GEOCST	Cost to conduct geological and geophysical evaluation	$	Calculated in Model
DNCEXP	Cost to drill an exploratory well	$/well	Calculated in Model

OFFSHORE SUPPLY SUBMODULE			
VARIABLE	**BRIEF DESCRIPTION**	**UNITS**	**SOURCE**
DNCDEL	Cost to drill a delineation well	$/well	Calculated in Model
DNCDEV	Cost to drill a development well	$/well	Calculated in Model
DNCDRY	Cost to drill a dry development well	$/well	Calculated in Model
DNCPRE	Cost to drill a pre-drilled development well	$/well	Calculated in Model
DNCPDR	Cost to drill a pre-drilled dry development well	$/well	Calculated in Model
STRCST	Cost to construct and install the production structure	$/struc	Calculated in Model
TEMCST	Cost to construct and install the template	$/temp	Calculated in Model
ABNCST	Cost to abandon the production structure	$/struc	Calculated in Model
PIPECO	Cost to install pipeline and gathering system	$/struc	Calculated in Model
PRDEQP	Cost to install topside production equipment	$/struc	Calculated in Model
STROPC	Cost to operate the production structure	$/struc/year	Calculated in Model
GEO_CST	Annual geological and geophysical costs	$/year	Calculated in Model
GNG_CAP	Annual geological and geophysical costs that are capitalized	$/year	Calculated in Model
GNG_EXP	Annual geological and geophysical costs that are expensed	$/year	Calculated in Model
EXPDCST	Annual exploratory drilling costs	$/year	Calculated in Model
DELDCST	Annual delineation drilling costs	$/year	Calculated in Model
DEVDCST	Annual development drilling costs	$/year	Calculated in Model
DDRDCST	Annual dry development drilling costs	$/year	Calculated in Model
PREDCST	Annual pre-drilled development drilling costs	$/year	Calculated in Model
PDRDCST	Annual dry pre-drilled development drilling costs	$/year	Calculated in Model
PDEQCST	Annual production equipment and facilities costs	$/year	Calculated in Model
STRYCST	Annual structure installation costs	$/year	Calculated in Model
TMPYCST	Annual template installation costs	$/year	Calculated in Model
PIPECST	Annual pipeline and gathering system installation costs	$/year	Calculated in Model
ABNDCST	Annual abandonment costs	$/year	Calculated in Model
OPCOST	Annual total operating costs	$/year	Calculated in Model
TANG	Annual total tangible investment costs	$/year	Calculated in Model
INTANG	Annual total intangible investment costs	$/year	Calculated in Model
INVEST	Annual total capital investment costs	$/year	Calculated in Model
REV_OIL	Annual gross oil revenues	$/year	Calculated in Model
REV_GAS	Annual gross gas revenues	$/year	Calculated in Model
REV_GROS	Annual total producer revenues	$/year	Calculated in Model
GRAV_ADJ	Annual gravity adjustment penalties	$/year	Calculated in Model

OFFSHORE SUPPLY SUBMODULE			
VARIABLE	**BRIEF DESCRIPTION**	**UNITS**	**SOURCE**
TRAN_CST	Annual transportation costs for oil and gas	$/year	Calculated in Model
REV_ADJ	Annual adjusted gross revenues	$/year	Calculated in Model
ROYALTY	Annual royalty payments	$/year	Calculated in Model
REV_PROD	Annual net producer revenues	$/year	Calculated in Model
GNA_CST	Annual GNA on investments	$/year	Calculated in Model
GNA_OPN	Annual GNA on operations	$/year	Calculated in Model
REV_NET	Annual net Revenues from operations	$/year	Calculated in Model
NET_BTCF	Annual net before-tax cash flow	$/year	Calculated in Model
FED_TAXS	Annual federal tax bill	$/year	Calculated in Model
FED_INTC	Annual federal income tax credits	$/year	Calculated in Model
NET_INCM	Annual net income from operations	$/year	Calculated in Model
DEPR	Annual depreciation values	$/year	Calculated in Model
GNGRC	Annual GNG cost recovery	$/year	Calculated in Model
ANN_ATCF	Annual after-tax cash flow	$/year	Calculated in Model
NPV_ATCF	Annual discounted after-tax cash flow	$/year	Calculated in Model
REPCST	Replacement cost	$/BOE	Calculated in Model
NETPV	Net present value of the after-tax cash flow	$	Calculated in Model
TYPE	Field type (oil or gas) transferred to the endogeneous component		Calculated in Exogeneous Part
MASP_TOT	Minimum acceptable supply price transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
RSRV_OIL	Recoverable oil reserves transferrd to the endogeneous component	MMBbl	Calculated in Exogeneous Part
RSRV_GAS	Recoverable gas reserves transferred to the endogeneous component	Bcf	Calculated in Exogeneous Part
MASP_EXP	Exloration part of MASP transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
MASP_DRL	Drilling part of MASP transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
MASP_STR	Structure part of MASP transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
MASP_OPR	Operations part of MASP transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
EXPL_WEL	Number of exploratory wells transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
DEVL_WEL	Number of development wells transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
DRY_HOLE	Number of dry holes transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part

OFFSHORE SUPPLY SUBMODULE			
VARIABLE	**BRIEF DESCRIPTION**	**UNITS**	**SOURCE**
STRUC_NO	Number of structures transferred to the endogeneous component	$/Bbl, $/Mcf	Calculated in Exogeneous Part
NREG	Number of Gulf of Mexico regions		Minerals Management Service
NFUEL	Types of fuels in the model (oil and gas)		EIA
NYEAR	Number of years analyzed for forecast		EIA
RATIO_RP	Reserves to production ratio		Minerals Management Service ICF Resources Incorporated
WLDRLEVL	Drilling activity level constraint	Wells	Offshore Data Services ICF Resources Incorporated
WLDRL_RT	Growth rate in drilling activity level	fraction	EIA, ICF
CUR_YEAR	Current year in the model		EIA
RES_GROW	Growth rate for proved reserves	fraction	EIA, ICF
ADT_EXPL	Advanced technology multiplier for exploration costs	fraction	EIA, ICF
ADT_DRLG	Advanced technology multiplier for drilling costs	fraction	EIA, ICF
ADT_STRC	Advanced technology multiplier for structure costs	fraction	EIA, ICF
ADT_OPER	Advanced technology multiplier for operations costs	fraction	EIA, ICF
OILPRICE	Oil price in the analysis year	$/Bbl	PMM (NEMS)
GASPRICE	Gas price in the analysis year	$/Mcf	NGTDM (NEMS)
XPVD_OIL	Existing proved oil reserves in current year	MMBbl	Minerals Management Service ICF Resources Incorporated
XPVD_GAS	Existing proved gas reserves in current year	Bcf	Minerals Management Service ICF Resources Incorporated
XPVD_AGS	Existing proved associated gas reserves in current year	Bcf	Minerals Management Service ICF Resources Incorporated
XPVD_CND	Existing proved condensate yield reserves in current year	MMBbl	Minerals Management Service ICF Resources Incorporated
INFR_OIL	Inferred oil reserves (remaining economic) each year	MMBbl	Calculated in Model
INFR_GAS	Inferred gas reserves (remaining economic) each year	Bcf	Calculated in Model
INGR_AGS	Inferred associated gas reserves (remaining economic) each year	Bcf	Calculated in Model
INFR_CND	Inferred condensate reserves (remaining economic) each year	MMBbl	Calculated in Model
MSP_INFO	Average supply price for the inferred oil reserves each year	$/Bbl	Calculated in Model
MSP_INFG	Average supply price for the inferred gas reserves each year	$/Mcf	Calculated in Model
BKED_OIL	Oil reserves booked every year include reserve adds	MMBbl	Calculated in Model
BKED_GAS	Gas reserves booked every year include reserve adds	Bcf	Calculated in Model

OFFSHORE SUPPLY SUBMODULE			
VARIABLE	**BRIEF DESCRIPTION**	**UNITS**	**SOURCE**
BKED_AGS	Associated gas reserves booked every year include reserve adds	Bcf	Calculated in Model
BKED_CND	Condensate reserves booked every year include reserve adds	MMBbl	Calculated in Model
WEL_EXPO	Number of exploratory oil wells drilled each year		Calculated in Model
WEL_DRYO	Number of dry holes oil wells drilled each year		Calculated in Model
WEL_DEVO	Number of development oil wells drilled each year		Calculated in Model
NUM_STRO	Number of oil production structures installed each year		Calculated in Model
WEL_EXPG	Number of exploratory gas wells drilled each year		Calculated in Model
WEL_DRYG	Number of dry holes oil wells drilled each year		Calculated in Model
WEL_DEVG	Number of development gas wells drilled each year		Calculated in Model
NUM_STRG	Number of gas production structures installed each year		Calculated in Model
BEG_RESO	Beginning of the year proved oil reserves	MMBbl	Calculated in Model
BEG_RESG	Beginning of the year proved gas reserves	Bcf	Calculated in Model
GRO_RESO	Growth in proved oil reserves	MMBbl	Calculated in Model
GRO_RESG	Growth in proved gas reserves	Bcf	Calculated in Model
ADD_RESO	Reserve additions to proved oil reserves	MMBbl	Calculated in Model
ADD_RESG	Reserve additions to proved oil reserves	Bcf	Calculated in Model
PROD_OIL	Oil production	MMBbl	Calculated in Model
PROD_GAS	Gas production	Bcf	Calculated in Model
END_RSVO	End of the year oil reserves	MMBbl	Calculated in Model
END_RSVG	End of the year gas reserves	Bcf	Calculated in Model
CST_EXPL	Annual exploration costs	MM$	Calculated in Model
CST_DRLG	Annual drilling costs	MM$	Calculated in Model
CST_STRC	Annual structure installation costs	MM$	Calculated in Model
CST_OPER	Annual operating costs	MM$	Calculated in Model

Unconventional Gas Recovery Supply Submodule					
Variable Name		Brief Description	Unit	Classification	Source
Code	Text				
-	BASLOC	Basin Location: The basin/play name	NA	UGR Type; Play	ARI/USGS
-	PNUM	Play Number: The play number established by ARI	-	UGR Type; Play	ARI
ATUNDRLOC	ATUL	Undrilled Locations - Advanced Technology: Number of locations available to drill under advanced technology	-	UGR Type; Play; Quality[1]	ARI
AVDEPTH	AVGDPTH	Average Depth:Average depth of the play	Feet	UGR Type; Play; Quality	ARI
BASINDIFF	BASNDIF	Basin Differential: This is a sensitivity on the gas price at a basin level. Depending on their proximity to market and infrastructure, the price varies throughout the country. The numbers are constant throughout the model.	1996$/ Mcf	UGR Type; Play; Quality	ARI
BNAREA	BASAR	Basin Area: Area in square miles	Square Miles	UGR Type; Play; Quality	ARI
CAPCSTDH	CCWDH	Capital Costs with Dry Hole Costs	1996$/ Mcf	UGR Type; Play; Quality	ARI
CTUNDRLOC	CTUL	Undrilled Locations - Current Technology: Current number of locations available to drill	-	UGR Type; Play; Quality	ARI
DCCOST	DACC	Drilling and completion costs	1996$	UGR Type; Play; Quality	ARI
DCCOSTGT	DCC_G2K	Drilling and completion cost per foot, well is greater than 2000 feet.	1996$/ Foot	UGR Type	ARI
DCCOSTLT	DCC_L2K	Cost per foot, well is less than 2000 feet.	1996$/ Foot	UGR Type	ARI
DEVCELLS	DEV_CEL	Developed Cells: Number of locations already drilled	-	UGR Type; Play; Quality	ARI

[1]The four "Quality" Categories are Total, Best 30%, Next Best 30%, and Worst 40%.

Unconventional Gas Recovery Supply Submodule					
Variable Name		**Brief Description**	**Unit**	**Classification**	**Source**
Code	**Text**				
DISCFAC	DIS_FAC	Discount Factor: This is the discount factor that is applied to the EUR for each well. The Present Value of a production stream from a typical coalbed methane, tight sands, or gas shales well is discounted at a rate of 15%.over a twenty year period.	Fraction	UGR Type	ARI
DISCRES	DISCRES	Discounted Reserves: The mean EUR per well multiplied by the discount factor.	Bcf	UGR Type; Play; Quality	Calculated
DRILLSCHED	DRL_SCHED	Drilling Schedule	Years	UGR Type; Play; Quality	ARI
DRILLSCHED	DRL_SCHED2	Drilling Schedule adjusted to account for technological progress	Years	UGR Type; Play; Quality	ARI
DRILLSCHED	DRL_SCHED3	Drilling Schedule: This variable ensures that adjustment for technology did not result in negative value for emerging basin Drilling Schedule.	Years	UGR Type; Play; Quality	ARI
DRILLSCHED	DRL_SCHED4	Drilling Schedule: This variable adjusts to account for the time-delaying effect of access limitations	Years	UGR Type; Play; Quality	ARI
DRRESADDS	DRA	Drilled Reserve Additions	Bcf	UGR Type; Play; Quality	Calculated
DRYHOLECOST	DHC	Dry Hole Costs	1996$/ Well	UGR Type; Play; Quality	Calculated
EMBASINYRS* FINFAC	EMERG#	The number of years taken off the drilling schedule for an advancement in technology.	Years	UGR Type; Play	ARI
EMERGBAS	EMRG	The parameter that determines if the play is an emerging basin. This designation was made by ARI (1=yes).	-	UGR Type; Play; Quality	ARI
ENCBMYRCST	ECBM_OC	Enhanced CBM Operating Costs Variable - $1.00	1996$/ Mcf	UGR Type[CBM]; Basin; Quality	ARI

Unconventional Gas Recovery Supply Submodule					
Variable Name		**Brief Description**	**Unit**	**Classification**	**Source**
Code	**Text**				
ENVIRONREG	ENV%	The percentage of the play that is not restricted from development due to environmental or pipeline regulations	Fraction	UGR Type; Play	ARI
ENVPIPREG	ENPRGS	Establishes if the play is pipeline or environmentally regulated (1=yes).	-	UGR Type; Play; Quality	ARI
EXNPVREV	ENPVR	Expected NPV Revenues: Gives the value of the entire discounted production stream for one well in real $.	1996$/ Well	UGR Type; Play; Quality	Calculated
FINFAC	TECHYRS	Number of years (from base year) over which incremental advances in indicated technology have occurred	Years	-	Calculated
FIXOMCOST	FOMC	Fixed Operating and Maintenance Costs	1996$/ Well	UGR Type; Play; Quality	Calculated
GA10	GAA10	Variable General and Administrative (G&A) Costs:	1996$/ Well	UGR Type; Play; Quality	Calculated
GABASE	RST	Variable G&A Costfactor - Currently 10% of equiprment costs, stimulation costs, and drilling costs	Fraction	UGR Type; Play; Quality	Calculated
H2OBASE	WOML_WTR	Water Producing Well Lease Equipment Costs	1996$/ Well	UGR Type; EUR Level	ARI
H2ODISP	WATR_DISP	Establishes if the play requires water disposal (1 = yes)	-	UGR Type; Play; Quality	ARI
HYPPLAYS	HYP%	Establishes whether or not the play is hypothetical (1=yes)	-	UGR Type; Play; Quality	ARI
LANDGG	DCC_G&G	Land / G&G Costs	1996$/ Well	UGR Type; EUR level	ARI
LANDGGH2O	WOMM_OMW	Operating & Maintenance - Medium well with H2O disposal	$1996/ Well	UGR Type; EUR Level	ARI
LANDGGH2O	WOMS_OMW	Operating & Maintenance - Small well with H2O disposal	$1996/ Well	UGR Type; EUR Level	ARI
LANDGGH2O	WOML_OMW	Operating & Maintenance - Large well with H2O disposal	$1996/ Well	UGR Type; EUR Level	ARI

Unconventional Gas Recovery Supply Submodule					
Variable Name		Brief Description	Unit	Classification	Source
Code	Text				
LEASSTIP	LEASSTIP	Lease Stipulated Share: The percentage of undrilled locations in a play that are subject to Federal lease stipulations	Percent	UGR Type; Play	ARI
LEASEQUIP	LSE_EQ	Lease Equipment Costs	$1996/ Well	UGR Type; Play; Quality	ARI
LSEQBASE	WOML_LE	Large Well Lease Equipment Costs	$1996/ Well	UGR Type; EUR Level	ARI
LSEQBASE	WOMS_LE	Small Well Lease Equipment Costs	$1996/ Well	UGR Type; EUR Level	ARI
LSEQBASE	WOMM_LE	Medium Well Lease Equipment Costs	$1996/ Well	UGR Type; EUR Level	ARI
MEANEUR	MEUR1	A weighted average of the EUR values for each (entire) basin	Bcf/Well	UGR Type; Play; Quality	Calculated
MEANEUR	MEUR1	A weighted average of the EUR values for the best 30% of the wells in the basin	Bcf/Well	UGR Type; Play; Quality	Calculated
MEANEUR	MEUR1	A weighted average of the EUR values for the middle 30% of the wells in the basin	Bcf/Well	UGR Type; Play; Quality	Calculated
MEANEUR	MEUR1	A weighted average of the EUR values for the worst 40% of the wells in the basin	Bcf/Well	UGR Type; Play; Quality	Calculated
MEANEUR	MEUR2	For Coalbed Methane, "MEUR1" adjusted for technological progress in the development of new cavity fairways	Bcf/Well	UGR Type; Play; Quality	Calculated
MEANEUR	MEUR3	For Enhanced Coalbed Methane, "MEUR2" adjusted for technological progress in the commercialization of Enhanced Coalbed Methane	Bcf/Well	UGR Type; Play; Quality	Calculated
MEANEUR	MEUR4	Mean EUR: This variable establishes whether or not the play is profitable and if so, allows the EUR to appear for development.	Bcf/Well	UGR Type; Play; Quality	Calculated

Unconventional Gas Recovery Supply Submodule					
Variable Name		Brief Description	Unit	Classification	Source
Code	Text				
MIN_ROI	MIN_ROI	A risk premium - the minimum rate of return that a project must be expected to achieve to offset risk of investment	1996$/ Mcf	UGR Type	ARI
NETPR	NET_PRC	Net Price ($/Mcf): Including Royalty and Severance Tax	1996$/ Mcf	UGR Type; Play; Quality	Calculated
NETPROFIT	NET_PROF	Net Profits ($/Mcf)	1996$/ Mcf	UGR Type; Play; Quality	Calculated
NETPROFIT	NET_PROF2	Net Profits (changed to 0 if < 0): Allows only the profitable plays to become developed	1996$/ Mcf	UGR Type; Play; Quality	Calculated
NEWWELLS	NW_WELLS	New Wells: The amount of wells drilled for the play in that year	Wells	UGR Type; Play; Quality	Calculated
NEWWELLS_LAG	NW_WELLS_LAG	New Wells Lagged: The amount of wells drilled for the play in the previous year	Wells	UGR Type; Play; Quality	Calculated
NEWWELLS	NW_WELLS2	New Wells: This variable ensures the wells drilled is a positive value.	Wells	UGR Type; Play; Quality	Calculated
NOACCESS	NOACCESS	No Access Share: The percentage of undrilled locations in a play that are legally inaccessible	Percent	UGR Type; Play	ARI
NYR_UNDEVWELLS	UNDV_WELLS2	Undeveloped wells available to be drilled for the next year	Wells	UGR Type; Play; Quality	Calculated
1.32*OGPRCL48	WHGP	Wellhead Gas Price	1996$/ Mcf	UGR Type; OGSM Region	NGTDM (Integrated); Input (Standalone)
OPCOSTH2O	OCWW$	Operating Costs with H2O - $0.30	1996$/ Mcf	UGR Type; H2O Disposal Level	ARI
OPCOSTH2O	OCNW$	Operating Costs without H2O - $0.25	$1996/ Mcf	UGR Type; H2O Disposal Level	ARI
OPCSTGASTRT	GASTR	Gas Treatment and Fuel costs - $0.25	$1996/ Mcf	UGR Type	ARI
OPCSTH2ODISP	WTR_DSPT	Water Disposal Fee: $0.05	$1996/ Mcf	UGR Type	ARI
OPCSTOMS	WOMS	H2O Costs, Small Well	$1996/ Mcf	UGR Type	ARI

Unconventional Gas Recovery Supply Submodule

Variable Name		Brief Description	Unit	Classification	Source
Code	Text				
PLAYPROBBASE	PLPROB	The play probability: Only hypothetical plays have a PLPROB < 100%.	Fraction	UGR Type; Play; Quality	ARI
PLAYPROB	PLPROB2	The play probability adjusted for technological progress, if initial play probability less than 1.	Fraction	UGR Type; Play; Quality	Calculated
PMPSFEQBASE	BASET	Variable cost of Pumping and Surface equipment when H2O disposal is required.	1996$/ Well	UGR Type; Play; Quality	ARI
PMPSURFEQ	PASE	Pumping and Surface Equipment Costs	1996$/ Well	UGR Type; Play; Quality	Calculated
PROD	PROD	Current Production	Bcf	UGR Type; Play; Quality	Calculated
PROD	PROD2	Production for the next year	Bcf	UGR Type; Play; Quality	Calculated
PROVRESV	PROV_RES	Proved Reserves	Bcf	UGR Type; Play; Quality	Calculated
PROVRESV	PROV_RES2	Proved Reserves for the next year	Bcf	UGR Type; Play; Quality	Calculated
RESADDS	R_ADD	Total Reserve Additions	Bcf	UGR Type; Play; Quality	Calculated
RESGRADDS	RGA	Reserve Growth Additions	Bcf	UGR Type; Play; Quality	Calculated
RESGRWTH	RES_GR	Establishes whether or not the play will have reserve growth (1=yes)	-	UGR Type; Play; Quality	ARI
RESWELLBCFB	RW101	Reserves per Well for the best 10% of the play (year 1): an EUR estimate	Bcf/Well	UGR Type; Play; Quality	ARI
RESWELLBCFB	RW201	Reserves per Well for the next (lesser) 20% of the play (year 1): an EUR estimate	Bcf/Well	UGR Type; Play; Quality	ARI
RESWELLBCFB	RW301	Reserves per Well for the next (lesser) 30% of the play (year 1): an EUR estimate	Bcf/Well	UGR Type; Play; Quality	ARI
RESWELLBCFB	RW401	Reserves per Well for the worst 40% of the play (year 1): an EUR estimate	Bcf/Well	UGR Type; Play; Quality	ARI

Unconventional Gas Recovery Supply Submodule					
Variable Name		**Brief Description**	**Unit**	**Classification**	**Source**
Code	**Text**				
RESWELLBCF	RW101	Reserves per Well for the best 10% of the play (years 2,20)	Bcf/Well	UGR Type; Play; Quality	Calculated
RESWELLBCF	RW201	Reserves per Well for the next (lesser) 20% of the play (years 2,20)	Bcf/Well	UGR Type; Play; Quality	Calculated
RESWELLBCF	RW301	Reserves per Well for the next (lesser) 30% of the play (years 2,20)	Bcf/Well	UGR Type; Play; Quality	Calculated
RESWELLBCF	RW401	Reserves per Well for the worst 40% of the play (years 2,20)	Bcf/Well	UGR Type; Play; Quality	Calculated
RES_GRTH_DEC	RGR	Reserve Growth Rate	Fraction	UGR Type; Year	ARI
ROYSEVTAX	RST	Variable Royalty and Severance Tax - Set at 17%	Fraction	UGR Type	ARI
RP	R/P_RAT	Reserves-to-Production (R/P) Ratio	Fraction	UGR Type; Play; Quality	Calculated
RP	RP_RAT2	R/P Ratio for the next year	Fraction	UGR Type; Play; Quality	Calculated
RSVPRD	RESNPROD	Reserves and Production	Bcf	UGR Type; Play; Quality	Calculated
STIMCOST	STIMC	Stimulation Costs: Provides the cost of stimulating a well in the specific basin by multiplying the given average stimulation cost by the number of stimulation zones.	1996$/ Well	UGR Type; Play; Quality	ARI
STIMCSTBASE	STIM_CST	Variable average cost of stimulating one zone. (Number of zones is a variable)	1996$/Z one	UGR Type	ARI
STIMUL	SZONE	Stimulation Zones: Number of times a single well is stimulated in the play	-	UGR Type; Play; Quality	ARI
SUCRATE	SCSSRT	Success Rate : The ratio of successful wells over total wells drilled (This can also be called the dry hole rate if you use the equation 1 - SCSSRT).	Fraction	UGR Type; Play; Quality	ARI

Unconventional Gas Recovery Supply Submodule					
Variable Name		Brief Description	Unit	Classification	Source
Code	Text				
TECHRECWELL	TRW1	The amount of technically recoverable wells available regardless of economic feasibility.	Wells	UGR Type; Play; Quality	Calculated
TECH_PROG_ SCHED_DR	REDAM%	Total percentage increase over development period due to advances in "Reduced Damage D&S" technology	Fraction	UGR Type	ARI
TECH_PROG_ SCHED_DR	FRCLEN%	Total percentage increase over development period due to advances in "Increased Fracture Length L&C" technology	Fraction	UGR Type	ARI
TECH_PROG_ SCHED_DR	PAYCON%	Total percentage increase over development period due to advances in "Improved Pay Contact" technology	Fraction	UGR Type	ARI
TECH_PROG_ SCHED_EX	EMERG%	The number of years added onto the drilling schedule because of the hindrance of the play being an emerging basin.	Years	UGR Type	ARI
TECH_PROG_ SCHED_PT	WDT%	Total percentage decrease in H2O disposal and treatment costs over the development period due to technological advances	Fraction	UGR Type	ARI
TECH_PROG_ SCHED_PT	PUMP%	Total percentage decrease in pumping costs over the development period due to technological advances	Fraction	UGR Type	ARI
TECH_PROG_ SCHED_PT	GTF%	Total percentage decrease in gas treatment and fuel costs over the development period due to technological advances	Fraction	UGR Type	ARI
TECH_PROG_ SCHED_PT	LOW%	The percentage of the play that is restricted from development due to environmental or pipeline regulations	Fraction	UGR Type	ARI
TECH_PROG_ SCHED_PT	LOWYRS	The number of years the environmental and or pipeline regulation will last.	Years	UGR Type	ARI
TECH_PROG_ SCHED_PT	ENH_CBM%	Enhanced CBM EUR Percentage gain	Fraction	UGR Type[CBM]	ARI

Unconventional Gas Recovery Supply Submodule					
Variable Name		Brief Description	Unit	Classification	Source
Code	Text				
TECH_PROG_ SCHED_EX	DEVPER	Development period for "Favorable Settings" technological advances	Years	UGR Type	ARI
TOTCAPCOST	TCC	Total Capital Costs: The sum of Stimulation Costs, Pumping and Surface Equipment Costs, Lease Equipment Costs, G&A Costs and Drilling and Completion Costs	1996$/ Well	UGR Type; Play; Quality	Calculated
TOTCOST	TOTL_CST	Total Costs ($/Mcf)	1996$/ Mcf	UGR Type; Play; Quality	Calculated
ULTRECV	URR	Ultimate Recoverable Resources	Bcf	UGR Type; Play; Quality	Calculated
UNDEVRES	UNDEV_RES	Undeveloped resources	Bcf	UGR Type; Play; Quality	Calculated
UNDEV_WELLS	UNDV_WELLS	Undeveloped wells available for development under current economic conditions	Wells	UGR Type; Play; Quality	Calculated
VAROPCOST	VOC	Variable Operating Costs	1996$/ Mcf	UGR Type; Play; Quality	Calculated
VAROPCOST	VOC2	Variable Operating Costs: Includes an extra operating cost for plays that will incorporate the technology of Enhanced CBM in the future	1996$/ Mcf	UGR Type; Play; Quality	Calculated
WELLSP	WSPAC_CT	Well Spacing - Current Technology: Current spacing in acres	Acres	UGR Type; Play; Quality; Technology Level	ARI
WELLSP	WSPAC_AT	Well Spacing - Advanced Technology: Spacing in acres under Advanced Technology	Acres	UGR Type; Play; Quality; Technology Level	ARI
.6*LANDGGH2O	WOMS_OM	Operating & Maintenance - Small well without H2O disposal	$1996/ Well	UGR Type; EUR Level	ARI
.6*LANDGGH2O	WOMM_OM	Operating & Maintenance - Medium well without H2O disposal	$1996/ Well	UGR Type; EUR Level	ARI
.6*LANDGGH2O	WOML_OM	Operating & Maintenance - Large well without H2O disposal	$1996/ Well	UGR Type; EUR Level	ARI

Appendix B. Mathematical Description

Calculation of Costs

Estimated Wells

Onshore

$$ESTWELLS_t = \exp(b0) * POIL_t^{b1} * PGAS_t^{b2} * ESTWELLS_{t-1}^{\rho} * \exp(-\rho * b0) * POIL_{t-1}^{-\rho * b1} * PGAS_{t-1}^{-\rho * b2} \tag{1}$$

$$ESTSUCWELLS_t = \exp(c0) * POIL_t^{c1} * PGAS_t^{c2} * ESTSUCWELLS_{t-1}^{\rho} * \exp(-\rho * c0) * POIL_{t-1}^{-\rho * c1} * PGAS_{t-1}^{-\rho * c2} \tag{2}$$

Lower 48 Onshore Rigs

$$RIGSL48_t = \exp(b0) * RIGSL48_{t-1}^{b1} * REVRIG_{t-1}^{b2} \tag{3}$$

Onshore Drilling Costs

$$\begin{aligned} DRILLCOST_{r,k,t} = {} & \exp(\ln(\delta 0)_{r,k}) * \exp(\ln(\delta 1)_{d,k}) * \exp(\ln(\delta 2)_{r,k}) * ESTWELLS_t^{\delta 3_k} * RIGSL48_t^{\delta 4_k} * \exp(\delta 5_k * TIME_t) * \\ & DRILLCOST_{r,k,t-1}^{\rho_k} * \exp(-\rho_k * \ln(\delta 0)_{r,k}) * \exp(-\rho_k * \ln(\delta 1)_{d,k}) * \exp(-\rho_k * \ln(\delta 2)_{r,k}) * \\ & ESTWELLS_{t-1}^{-\rho_k * \delta 3_k} * RIGSL48_{t-1}^{-\rho_k * \delta 4_k} * \exp(-\rho_k * \delta 5_k * TIME_{t-1}) \end{aligned} \tag{4}$$

$$\begin{aligned} DRYCOST_{r,k,t} = {} & \exp(\ln(\delta 0)_{r,k}) * \exp(\ln(\delta 1)_{d,k}) * \exp(\ln(\delta 2)_{r,k}) * ESTWELLS_t^{\delta 3_k} * RIGSL48_t^{\delta 4_k} * \exp(\delta 5_k * TIME_t) * \\ & DRYCOST_{r,k,t-1}^{\rho_k} * \exp(-\rho_k * \ln(\delta 0)_{r,k}) * \exp(-\rho_k * \ln(\delta 1)_{d,k}) * \exp(-\rho_k * \ln(\delta 2)_{r,k}) * \\ & ESTWELLS_{t-1}^{-\rho_k * \delta 3_k} * RIGSL48_{t-1}^{-\rho_k * \delta 4_k} * \exp(-\rho_k * \delta 5_k * TIME_{t-1}) \end{aligned} \tag{5}$$

With increased access in Region 5 (Rocky Mountain Region)

$$DRILLCOST_{5,k,t} = DRILLCOST_{5,k,t} * \left(\frac{LSE\_CONV + SLT\_CONV}{1.06 * LSE\_CONV + SLT\_CONV} \right) \tag{6}$$

$$DRYCOST_{5,k,t} = DRYCOST_{5,k,t} * \left(\frac{LSE\_CONV + SLT\_CONV}{1.06 * LSE\_CONV + SLT\_CONV} \right) \tag{7}$$

Lease equipment costs

$$\begin{aligned} LEQC_{r,k,t} = {} & \exp(\ln(\epsilon 0)_{r,k}) * \exp(\ln(\epsilon 1)_k * DEPTH_{r,k,t}) * ESUCWELL_{k,t}^{\epsilon 2_k} * \exp(\epsilon 3_k * TIME_t) * LEQC_{r,k,t-1}^{\rho_k} \\ & \exp(-\rho_k * \ln(\epsilon 0)_{r,k}) * \exp(-\rho_k * \ln(\epsilon 1)_k * DEPTH_{r,k,t-1}) * ESUCWELL_{k,t-1}^{-\rho_k * \epsilon 2_k} * \exp(-\rho_k * \epsilon 3_k * \end{aligned} \tag{8}$$

With increased access in Region 5 (Rocky Mountain Region)

$$LEQC_{5,k,t} = LEQC_{5,k,t} * \left(\frac{LSE\_CONV + SLT\_CONV}{1.06 * LSE\_CONV + SLT\_CONV} \right) \tag{9}$$

Operating Costs

$$\begin{aligned} OPC_{r,k,t} = {} & \exp(\ln(\epsilon 0)_{r,k}) * \exp(\ln(\epsilon 1)_k * DEPTH_{r,k,t}) * ESUCWELL_{k,t}^{\epsilon 2_k} * \exp(\epsilon 3_k * TIME_t) * OPC_{r,k,t-1}^{\rho_k} * \\ & \exp(-\rho_k * \ln(\epsilon 0)_{r,k}) * \exp(-\rho_k * \ln(\epsilon 1)_k * DEPTH_{r,k,t-1}) * ESUCWELL_{k,t-1}^{-\rho_k * \epsilon 2_k} * \exp(-\rho_k * \epsilon 3_k * T \end{aligned} \tag{10}$$

With increased access in Region 5 (Rocky Mountain Region)

$$OPC_{5,k,t} = OPC_{5,k,t} * \left(\frac{LSE\_CONV + SLT\_CONV}{1.06 * LSE\_CONV + SLT\_CONV} \right) \tag{11}$$

Discounted Cash Flow Algorithm

Expected discounted cash flow

$$\begin{aligned} PROJDCF_{i,r,k,t} = {} & (PVREV - PVROY - PVPRODTAX - PVDRILLCOST - PVEQUIP - \\ & PVKAP - PVOPERCOST - PVABANDON - PVSIT - PVFIT)_{i,r,k,t} \end{aligned} \tag{12}$$

Present value of expected revenues

$$PVREV_{i,r,k,t} = \sum_{T=t}^{t+n} \left[Q_{r,k,T} * \lambda * (P_{r,k,T} - TRANS_{r,k}) * \left[\frac{1}{1+disc} \right]^{T-t} \right], \quad \lambda = \begin{cases} 1 & \text{if primary fuel} \\ COPRD & \text{if secondary fuel} \end{cases} \tag{13}$$

Present value of expected royalty payments

$$PVROY_{i,r,k,t} = ROYRT * PVREV_{i,r,k,t} \tag{14}$$

Present value of expected production taxes

$$PVPRODTAX_{i,r,k,t} = PVREV_{i,r,k,t} * (1 - ROYRT) * PRODTAX_{r,k} \tag{15}$$

Present value of expected costs
Drilling costs

$$\begin{aligned} PVDRILLCOST_{i,r,k,t} = \sum_{T=t}^{t+n} \Bigg[& \Big[DRILL_{1,r,k,t} * SR_{1,r,k} * WELL_{1,k,T} + DRILL_{2,r,k,t} * SR_{2,r,k} * \\ & WELL_{2,k,T} + DRY_{1,r,k,t} * (1 - SR_{1,r,k}) * WELL_{1,k,T} + \\ & DRY_{2,r,k,t} * (1 - SR_{2,r,k}) * WELL_{2,k,T} \Big] * \left(\frac{1}{1 + disc} \right)^{T-t} \Bigg] \end{aligned} \tag{16}$$

Lease equipment costs

$$PVEQUIP_{i,r,k,t} = \sum_{T=t}^{t+n} \left[EQUIP_t * \left(SR_{1,r,k} * WELL_{1,k,T} + SR_{2,r,k} * WELL_{2,k,T} \right) * \left[\frac{1}{1 + disc} \right]^{T-t} \right] \quad (17)$$

Capital costs

$$PVKAP_{i,r,k,t} = \sum_{T=t}^{t+n} \left[KAP_{i,r,k,T} * \left[\frac{1}{1 + disc} \right]^{T-t} \right] \quad (18)$$

Operating costs

$$PVOPERCOST_{i,r,k,t} = \sum_{T=t}^{t+n} \left[OPCOST_{i,r,k,t} * \sum_{k=1}^{T} \left[SR_{1,r,k} * WELL_{1,k,T} + SR_{2,r,k} * WELL_{2,k,T} \right] * \left(\frac{1}{1 + disc} \right)^{T-t} \right] \quad (19)$$

Abandonment costs

$$PVABANDON_{i,r,k,t} = \sum_{T=t}^{t+n} \left[COSTABN_{i,r,k} * \left[\frac{1}{1 + disc} \right]^{T-t} \right] \quad (20)$$

Present value of expected tax base

$$PVTAXBASE_{i,r,k,t} = \sum_{T=t}^{t+n} \left[(REV - ROY - PRODTAX - OPERCOST - ABANDON - XIDC - AIDC - DEPREC - DHC)_{i,r,k,t} * \left(\frac{1}{1 + disc} \right)^{T-t} \right]$$

Expected expensed costs

$$XIDC_{i,r,k,t} = DRILL_{1,r,k,t} * (1 - EXKAP) * (1 - XDCKAP) * SR_{1,r,k} * WELL_{1,k,t} + DRILL_{2,r,k,t} * (1 - DVKAP) * (1 - XDCKAP) * SR_{2,r,k} * WELL_{2,k,t}$$

Expected dry hole costs

$$DHC_{i,r,k,t} = DRY_{1,r,k,t} * (1 - SR_{1,r,k}) * WELL_{1,k,t} + DRY_{2,r,k,t} * (1 - SR_{2,r,k}) * WELL_{2,k,t} \quad (23)$$

Expected depreciable costs

$$DEPREC_{i,r,k,t} = \sum_{j=\beta}^{t} \left[\left[(DRILL_{1,r,k,T} * EXKAP + EQUIP_{1,r,k,T}) * SR_{1,r,k} * WELL_{1,k,j} + (DRILL_{2,r,k,T} * DVKAP + EQUIP_{2,r,k,T}) * SR_{2,r,k} * WELL_{2,k,j} + KAP_{r,k,j} \right] * DEP_{t-j+1} * \left(\frac{1}{1 + infl} \right)^{t-j} * \left(\frac{1}{1 + disc} \right)^{t-j} \right], \quad (24)$$

$$\beta = \begin{cases} T \text{ for } t \leq T+m-1 \\ t-m+1 \text{ for } t > T+m-1 \end{cases}$$

Present value of expected state income taxes

$$PVSIT_{i,r,k,t} = PVTAXBASE_{i,r,k,t} * STRT \tag{25}$$

Present value of expected federal income taxes

$$PVFIT_{i,r,k,t} = PVTAXBASE_{i,r,k,t} * (1 - STRT) * FDRT \tag{26}$$

Discounted cash flow for a representative developmental well

$$DCF_{2,r,k,t} = PROJDCF_{2,r,k,t} * SR_{2,r,k} \tag{27}$$

Discounted cash flow for a representative exploratory well

$$DCF_{1,r,k,t} = PROJDCF_{1,r,k,t} * SR_{1,r,k} \tag{28}$$

Lower 48 Onshore Expenditures and Well Determination

Expected DCF for shallow gas recovery

$$SGDCFON_{i,r,t} = \frac{\sum_k (WELLS_{i,r,k,t-1} * DCFON_{i,r,k,t})}{\sum_k WELLS_{i,r,k,t-1}}, \text{ for } k = 3,\ 5 \text{ to } 7 \tag{29}$$

Expected oil DCF

$$ODCFON_{i,r,t} = \frac{\sum_k (WELLS_{i,r,k,t-1} * DCFON_{i,r,k,t})}{\sum_k WELLS_{i,r,k,t-1}}, \text{ for } k = 1 \text{ to } 2 \tag{30}$$

Lower 48 Onshore Well Forecasting Equations

Exploratory Oil

$$\begin{aligned} WELLSON_{i,r,k,t} = {} & e^{m0_{i,k}} * DCFON_{i,r,k,t-1}^{m1_{i,k}} * (CASHFLOW_t * REMAINRES_{i,r,k,t})^{m2_{i,k}} * WELLSON_{i,r,k,t-1}^{\rho_{i,k}} \\ & * e^{-\rho * m0_{i,k}} * DCFON_{i,r,k,t-2}^{-\rho * m1_{i,k}} * (CASHFLOW_{t-1} * REMAINRES_{i,r,k,t-1})^{-\rho * m2_{i,k}} \end{aligned}$$

Developmental Oil

$$\begin{aligned} WELLSON_{i,r,k,t} = {} & e^{m0_{i,k}} * DCFON_{i,r,k,t-1}^{m1_{i,k}} * (CASHFLOW_t * REMAINRES_{i,r,k,t})^{m2_{i,k}} * WELLSON_{i,r,k,t-1}^{\rho_{i,k}} \\ & * e^{-\rho * m0_{i,k}} * DCFON_{i,r,k,t-2}^{-\rho * m1_{i,k}} * (CASHFLOW_{t-1} * REMAINRES_{i,r,k,t-1})^{-\rho * m2_{i,k}} \end{aligned}$$

Exploratory Shallow Gas

$$
\begin{aligned}
WELLSON_{i,r,k,t} = {} & e^{(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t}^{m1_{i,k}} * (CASHFLOW_t * REMAINRES_{r,k,t})^{m2_{i,k}} * WELLSON_{i,r,k,t-1}^{\rho_{i,k}} \\
& * e^{-\rho_{i,k}*(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t-1}^{-\rho_{i,k}*m1_{i,k}} * (CASHFLOW_{t-1} * REMAINRES_{r,k,t})^{-\rho_{i,k}*m2_{i,k}}
\end{aligned}
\tag{33}
$$

Developmental Shallow Gas

$$
\begin{aligned}
WELLSON_{i,r,k,t} = {} & e^{(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t}^{m1_{i,k}} * (CASHFLOW_t * REMAINRES_{r,k,t})^{m2_{i,k}} * WELLSON_{i,r,k,t-1}^{\rho_{i,k}} \\
& * e^{-\rho_{i,k}*(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t-1}^{-\rho_{i,k}*m1_{i,k}} * (CASHFLOW_{t-1} * REMAINRES_{r,k,t})^{-\rho_{i,k}*m2_{i,k}}
\end{aligned}
\tag{34}
$$

Exploratory Deep Gas

$$
\begin{aligned}
WELLSON_{i,r,k,t} = {} & e^{(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t-}^{m1_{i,k}} * (CASHFLOW_t * REMAINRES_{r,k,t})^{m2_{i,k}} * WELLSON_{i,r,k,t-1}^{\rho_{i,k}} \\
& * e^{-\rho_{i,k}*(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t-2}^{-\rho_{i,k}*m1_{i,k}} * (CASHFLOW_{t-1} * REMAINRES_{r,k,t})^{-\rho_{i,k}*m2_{i,k}}
\end{aligned}
$$

Developmental Deep Gas

$$
\begin{aligned}
WELLSON_{i,r,k,t} = {} & e^{(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t-}^{m1_{i,k}} * (CASHFLOW_t * REMAINRES_{r,k,t})^{m2_{i,k}} * WELLSON_{i,r,k,t-1}^{\rho_{i,k}} \\
& * e^{-\rho_{i,k}*(m0_{i,k}+\sum_r m00_{i,r,k}*REGr)} * DCFON_{r,k,t-2}^{-\rho_{i,k}*m1_{i,k}} * (CASHFLOW_{t-1} * REMAINRES_{r,k,t})^{-\rho_{i,k}*m2_{i,k}}
\end{aligned}
$$

Calculation of success rate

$$
\begin{aligned}
LSR_{i,r,t} = {} & a0_{i,r} + a1_i * \ln(CUMSUCWELLS_{i,r,t}) + a2_i * YEAR_t + \rho_i * \ln\left(\frac{SR_{i,r,t-1}}{1 - SR_{i,r,t-1}}\right) \\
& - \rho_i * \left[a0_{i,r} + a1_i * \ln(CUMSUCWELLS_{i,r,t-1}) + a2_i * YEAR_{t-1}\right]
\end{aligned}
\tag{37}
$$

$$
SR_{i,r,t} = \frac{e^{LSR_{i,r,t}}}{1 + e^{LSR_{i,r,t}}}
\tag{38}
$$

Calculation of successful onshore wells

$$
SUCWELSON_{i,r,k,t} = WELLSON_{i,r,k,t} * SR_{i,r,k}, \text{ for } i = 1, 2,\ r = \text{onshore regions},\ k = 1 \text{ thru } 7
\tag{39}
$$

Calculation of onshore dry holes

$$DRYWELON_{i,r,k,t} = WELLSON_{i,r,k,t} - SUCWELSON_{i,r,k,t}, \text{ for } i = 1, 2, \; r = \text{onshore regions}, \; k = 1 \text{ thru } 7 \tag{40}$$

Lower 48 Onshore Reserve Additions

New reserve discoveries

$$NRD_{r,k,t} = FR1_{r,k,t} * SW1_{r,k,t} \tag{41}$$

$$FR1_{r,k,t} = \exp(\alpha_{r,k}) * \exp(\beta 1_k * SW2_{r,k,t} + \beta 2_k * DEPTH_{r,k}) * UND_{r,k,t}^{\beta 3_k} \tag{42}$$

Inferred reserves

$$I_{r,k,t} = NRD_{r,k,t} * (RSVGR - 1) \tag{43}$$

Reserve extensions

$$EXT_{r,k,t} = FR2_{r,k,t} * SW2_{r,k,t} \tag{44}$$

$$\begin{aligned} FR2_{r,k,t} = {} & \exp(\alpha_{r,k}) * \exp(\beta 1_k * SW2_{r,k,t}) * \exp(\beta 2_{r,k} * DEPTH_{r,k,t}) * INFR_{r,k,t}^{\beta 3_{r,k}} * \exp(\beta 4_k * year_t) \\ & * FR2_{r,k,t-1}^{\rho_k} * \exp(\alpha_{r,k}) * \exp(\beta 1_k * SW2_{r,k,t-1}) * \exp(\beta 2_{r,k} * DEPTH_{r,k,t-1}) \\ & * INFR_{r,k,t-1}^{\beta 3_{r,k}} * \exp(\beta 4_k * year_{t-1}) \end{aligned} \tag{45}$$

Reserve revisions

$$FR3_{r,k,t} = REV_{r,k,t} / SW3_{r,k,t} \tag{46}$$

$$\begin{aligned} REV_{r,k,t} = {} & (e^{B0_{r,k}} * ((INFR_{r,k,t} + BOYRES_{r,k,t}) / BOYRES_{r,k,t})^{B1_{r,k}} \\ & * e^{(B2*WHP_{r,k,t})} * e^{(B3*WHP_{r,t,t}^2)} * e^{(B4*WHP_{r,k,t} / WHP_{r,k,t-1})} * e^{B5*CUMSW3_{r,k,t})}) - 1) \\ & * BOYRES_{r,k,t} \end{aligned} \tag{47}$$

Total reserve additions

$$RA_{r,k,t} = NRD_{r,k,t} + EXT_{r,k,t} + REV_{r,k,t} \tag{48}$$

End-of-year reserves

$$R_{r,k,t} = R_{r,k,t-1} - Q_{r,k,t} + RA_{r,k,t} \tag{49}$$

Lower 48 Onshore & Offshore Production to Reserves Ratio

$$PR_{t+1} = \frac{(R_{t-1} * PR_t * (1 - PR_t)) + (PRNEW * RA_t)}{R_t} \tag{50}$$

$$Q_{r,k,t+1} = [R_{r,k,t}] * [PR_{r,k,t} * (1 + \beta_{r,k} * \Delta P_{r,k,t+1})] \tag{51}$$

Associated-dissolved gas production

$$ADGAS_{r,t} = e^{\ln(\alpha 0)_r + \ln(\alpha 1)_r * DUM86_t} * OILPROD_{r,t}^{\beta 0_r + \beta 1_r * DUM86_t} \tag{52}$$

Cogeneration from EOR Production

Capacity for EOR Cogeneration

$$PRV\_COGEN_{r,1} = PRV\_STEAM_r * PRV\_COGENPEN * COGFAC \tag{53}$$

$$INF\_COGEN_{r,1} = INF\_STEAM_r * INF\_COGENPEN * COGFAC \tag{54}$$

Electricity Generated from EOR Cogeneration

$$PRV\_COGEN_{r,4} = PRV\_COGEN_{r,1} * PRV\_UTIL_{r,1,t,2} * \frac{24 * 365}{1000} \tag{55}$$

$$INF\_COGEN_{r,4} = INF\_COGEN_{r,1} * INF\_UTIL_{r,1,t,2} * \frac{24 * 365}{1000} \tag{56}$$

Alaska Supply

Expected Costs

Drilling costs

$$DRILLCOST_{i,r,k,t} = DRILLCOST_{i,r,k,T_b} * (1 - TECH1) ** (t - T_b) \tag{57}$$

Lease equipment costs

$$EQUIP_{r,k,t} = EQUIP_{r,k,T_b} * (1 - TECH2) ** (t - T_b) \tag{58}$$

Operating costs

$$OPCOST_{r,k,t} = OPCOST_{r,k,T_b} * (1 - TECH3)**(t - T_b) \tag{59}$$

Canadian Gas Trade

Calculation of successful wells drilled in Western Canada

$$SUCWELL_t = e^{(\beta0+\beta3)} * GPRICE_t^{\beta2} * SUCWELL_{t-1}^{\rho} * e^{[-\rho*(\beta0+\beta3)]} * GPRICE_{t-1}^{-\rho*\beta2} \tag{60}$$

Finding rate and reserve additions

$$FRCAN_t = e^{-115.706} * CUMGWELLS_t^{-0.763412} * e^{-0.000278607*SUCWELL+0.066231*YEAR} \tag{61}$$

$$RESADCAN_t = FRCAN_t * SUCWELL_t \tag{62}$$

End-of-year reserves

$$RESBOYCAN_{t+1} = CURRESCAN_t + RESADCAN_t - OGPRDCAN_t \tag{63}$$

Remaining economically recoverable resources

$$URRCAN_t = RESBASE_{resbasyr} * (1. + RESTECH)^T - CUMRCAN_{t-1} \tag{64}$$

Production to reserves ratio

$$PR_{t+1} = \frac{Q_t * (1 - PR_t) + PRNEW * RA_t}{R_t} \tag{65}$$

Offshore Supply

COSTING AND CASH-FLOW ROUTINES

Geological and Geophysical Costs Per Year:

$$GNG\_CAP_t = \frac{GNGCAP}{GNG\_TIM}, \; t = IYREXP \text{ to } (IYREXP + GNG\_TIM - 1) \tag{66}$$

$$GNG\_EXP_t = \frac{GNGEXP}{GNG\_TIM}, \; t = IYREXP \text{ to } (IYREXP + GNG\_TIM - 1) \tag{67}$$

Exploration Drilling Costs Per Year

$$EXPDCST_t = DNCEXP * \frac{EXPWEL}{EXPTIM}, \; t = IYREXP \text{ to } (IYREXP + EXPTIM - 1) \tag{68}$$

Delineation Drilling Costs Per Year

$$DELDCST_t = DNCDEL * \frac{DELWEL}{DELTIM}, \; t = IYRDEL \text{ to } (IYRDEL + DELTIM - 1) \tag{69}$$

Pre-drilled Development Well Costs Per Year

$$PREDCST_t = DNCPRE * \frac{PREDEV}{PRETIM}, \; t = IYRPRE \text{ to } (IYRPRE + PRETIM - 1) \tag{70}$$

Pre-drilled Dry Development Well Costs Per Year

$$PDRDCST_t = PREDRY * \frac{DELWEL}{PRETIM}, \; t = IYRPRE \text{ to } (IYRPRE + PRETIM - 1) \tag{71}$$

Development Drilling Costs Per Year

$$DEVDCST_t = DNCDEV * \frac{DEVWEL}{DEVTIM}, \; t = IYRDEV \text{ to } (IYRDEV + DEVTIM - 1) \tag{72}$$

Dry Development Drilling Costs Per Year

$$DDRDCST_t = DNCDRY * \frac{DEVDRY}{DEVTIM}, \; t = IYRDEV \text{ to } (IYRDEV + DEVTIM - 1) \tag{73}$$

Production Structure Installation Costs Per Year

$$STRYCST_t = STRCST * \frac{NSTRUC}{STRTIM}, \; t = IYRSTR \text{ to } (IYRSTR + STRTIM - 1) \tag{74}$$

Template Installation Costs Per Year

$$TMPYCST_t = TEMCST * \frac{NTEMP}{TEMTIM}, \; t = IYRTEM \tag{75}$$

Pipeline and Gathering System Installation Costs Per Year

$$PIPECST_t = PIPECO, \ t = IYRPIP \tag{76}$$

Production Structure Abandonment Costs Per Year

$$ABNDCST_t = ABNCST, \ t = IYRABN \tag{77}$$

Intangible Capital Investments Per Year

$$\begin{aligned} INTANG_t = \ & EXPDCST_t + DELDCST_t + 0.7 * PERIT * PREDCST_t + PDRDCST_t + 0.7 * PERIT * DEVDCST_t + \\ & DDRDCST_t + 0.9 * PERIT * STRYCST_t + ABNDCST_t + GNG\_EXP_t, \ t = 1 \text{ to } IYRABN \end{aligned} \tag{78}$$

Tangible Capital Investments Per Year

$$\begin{aligned} TANG_t = \ & PERT * PREDCST_t + 0.3 * PERIT * PREDCST_t + PERT * DEVDCST_t + 0.3 * PERIT * DEVDCST_t + \\ & PERT * STRYCST_t + 0.1 * PERIT * STRYCST_t + PIPECST_t + GNG\_\bigcap_t, \ t = 1 \text{ to } IYRABN \end{aligned} \tag{79}$$

Total Investments Per Year

$$INVEST_t = TANG_t + INTANG_t, \ t = 1 \text{ to } IYRABN \tag{80}$$

Gross Revenues Per Year

$$REV_{OIL_t} = QOIL_t * OILPRC_t, \ t = 1 \text{ to } IYRABN \tag{81}$$

$$REV\_GAS_t = QGAS_t * GASPRC_t, \ t = 1 \text{ to } IYRABN \tag{82}$$

$$REV\_GROS_t = REV\_OIL_t + REV\_GAS_t, \ t = 1 \text{ to } IYRABN \tag{83}$$

Gravity Penalties Per Year

$$GRAV\_ADJ_t = QOIL_t * GRADJ_t, \ t = 1 \text{ to } IYRABN \tag{84}$$

Transportation Costs Per Year

$$TRAN\_CST_t = QOIL_t * TARF\_OIL_t + QGAS_t * TARF\_GAS_t, \ t = 1 \text{ to } IYRABN \tag{85}$$

Adjusted Revenues Per Year

$$REV\_ADJ_t = REV\_GROS_t - GRAV\_ADJ_t - TRAN\_CST_t, \ t = 1 \text{ to } IYRABN \tag{86}$$

Royalty Payments Per Year

$$ROYALTY_t = REV\_ADJ_t * ROYL\_RAT, \ t = 1 \text{ to } IYRABN \tag{87}$$

$$ROYALTY_t = 0.00, \ IF \ QCBOE \leq RELIEF_{WDC} \tag{88}$$

Net Producer Revenue Per Year

$$REV\_PROD_t = REV\_ADJ_t - ROYALTY_t, \ t = 1 \text{ to } IYRABN \tag{89}$$

G & A on Investments and Operation Costs

$$GNA\_CST_t = TANG_t * GNATAN + INTANG_t * GNAINT, \ t = 1 \text{ to } IYRABN \tag{90}$$

$$GNA\_OPN_t = OPCOST_t * OPOVHD, \ t = 1 \text{ to } IYRABN \tag{91}$$

Net Revenue from Operations Per Year

$$REV\_NET_t = REV\_PROD_t - OPCOST_t - GNA\_CST_t - GNA\_OPN_t, \ t = 1 \text{ to } IYRABN \tag{92}$$

Net Income Before Taxes Per Year

$$NET\_BTCF_t = REV\_NET_t - INTANG_t - DEPR_t - GNGRC_t, \ t = 1 \text{ to } IYRABN \tag{93}$$

Federal Tax Bill Per Year

$$FED\_TAXS_t = NET\_BTCF_t * FTAX\_RAT, \ t = 1 \text{ to } IYRABN \tag{94}$$

Income Tax Credits Per Year

$$FED\_INTC_t = INVEST_t * XINTC, \ t = 1 \text{ to } IYRABN \tag{95}$$

Net Income After Taxes Per Year

$$NET\_INCM_t = NET\_BTCF_t - FED\_TAXS_t + FED\_INTC_t, \ t = 1 \text{ to } IYRABN \tag{96}$$

Annual After-Tax Cash Flow

$$ANN\_ATCF_t = NET\_INCM_t - TANG_t + DEPR_t + GNGRC_t, \ t = 1 \text{ to } IYRABN \tag{97}$$

Discounted After-Tax Cash Flow Per Year

$$NPV\_ATCF_t = \frac{ANN\_ATCF_t}{DISCRT^{I}}, \ t = 1 \text{ to } IYRABN \tag{98}$$

RESERVES DEVELOPMENT AND PRODUCTION TIMING

Inferred Oil Reserve Additions

IF POOLTYPE $_{ipool}$ = 'OIL', and IF OILPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$INFR\_OIL_{iyr} = INFR\_OIL_{iyr} + RSRV\_OIL_{ipool}, \ iyr = \text{Current Year}, \ ipool = 1 \text{ to } NFIELD \tag{99}$$

$$INFR\_AGS_{iyr} = INFR\_AGS_{iyr} + RSRV\_GAS_{ipool}, \ iyr = \text{Current Year}, \ ipool = 1 \text{ to } NFIELD \tag{100}$$

Inferred Gas Reserve Additions

IF POOLTYPE $_{ipool}$ = 'GAS', and IF GASPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$INFR\_GAS_{iyr} = INFR\_GAS_{iyr} + RSRV\_GAS_{ipool}, \ iyr = \text{Current Year}, \ ipool = 1 \text{ to } NFIELD \tag{101}$$

$$INFR\_CND_{iyr} = INFR\_CND_{iyr} + RSRV\_OIL_{ipool}, \ iyr = \text{Current Year}, \ ipool = 1 \text{ to } NFIELD \tag{102}$$

Average Supply Price for Inferred Oil Reserves

IF POOLTYPE $_{ipool}$ = 'OIL', and IF OILPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$MSP\_INFO_{iyr} = \frac{MSP\_INFO_{iyr} * INFR\_OIL_{iyr} + MASP\_TOT_{ipool} * RSRV\_OIL_{ipool}}{INFR\_OIL_{iyr} + RSRV\_OIL_{ipool}}, \ iyr = \text{Current Year}, \ ipool = 1 \text{ to } NFIELD \tag{103}$$

Average Supply Price for Inferred Gas Reserves

IF POOLTYPE $_{ipool}$ = 'GAS', and IF GASPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$MSP\_INFG_{iyr} = \frac{MSP\_INFG_{iyr} * INFR\_GAS_{iyr} + MASP\_TOT_{ipool} * RSRV\_GAS_{ipool}}{INFR\_GAS_{iyr} + RSRV\_GAS_{ipool}}, \ iyr = \text{Current Year}, \ ipool = 1 \text{ to } NFIELD \tag{104}$$

Wells Required for Inferred Oil Reserves

IF POOLTYPE $_{ipool}$ = 'OIL', and IF OILPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$WEL\_EXPO_{iyr} = WEL\_EXPO_{iyr} + EXPL\_WEL_{ipool}, \ iyr = \text{Current Year}, \ ipool = 1 \text{ to } NFIELD \tag{105}$$

$$WEL\_DEVO_{iyr} = WEL\_DEVO_{iyr} + DEVL\_WEL_{ipool}, \ iyr = Current \ Year, \ ipool = 1 \ to \ NFIELD \quad (106)$$

$$WEL\_DRYO_{iyr} = WEL\_DRYO_{iyr} + DRY\_HOLE_{ipool}, \ iyr = Current \ Year, \ ipool = 1 \ to \ NFIELD \quad (107)$$

Wells Required for Inferred Gas Reserves

IF POOLTYPE $_{ipool}$ = 'GAS', and IF GASPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$WEL\_EXPG_{iyr} = WEL\_EXPG_{iyr} + EXPL\_WEL_{ipool}, \ iyr = Current \ Year, \ ipool = 1 \ to \ NFIELD \quad (108)$$

$$WEL\_DEVG_{iyr} = WEL\_DEVG_{iyr} + DEVL\_WEL_{ipool}, \ iyr = Current \ Year, \ ipool = 1 \ to \ NFIELD \quad (109)$$

$$WEL\_DRYG_{iyr} = WEL\_DRYG_{iyr} + DRY\_HOLE_{ipool}, \ iyr = Current \ Year, \ ipool = 1 \ to \ NFIELD \quad (110)$$

Number of Structures Required for Inferred Oil Reserves

IF POOLTYPE $_{ipool}$ = 'OIL', and IF OILPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$NUM\_STRO_{iyr} = NUM\_STRO_{iyr} + STRUC\_NO_{ipool}, \ iyr = Current \ Year, \ ipool = 1 \ to \ NFIELD \quad (111)$$

Number of Structures Required for Inferred Gas Reserves

IF POOLTYPE $_{ipool}$ = 'GAS', and IF GASPRICE$_{iyr}$ ≥ MASP_TOT $_{ipool}$

$$NUM\_STRG_{iyr} = NUM\_STRG_{iyr} + STRUC\_NO_{ipool}, \ iyr = Current \ Year, \ ipool = 1 \ to \ NFIELD \quad (112)$$

Relative Price Differential for Oil Reserves Vs. Gas Reserves Development

$$RATIO1 = \frac{OILPRICE_{iyr} - MSP\_INFO_{iyr}}{OILPRICE_{iyr}}, \ iyr = Current \ Year \quad (113)$$

$$RATIO1 = \frac{GASPRICE_{iyr} - MSP\_INFG_{iyr}}{GASPRICE_{iyr}}, \ iyr = Current \ Year \quad (114)$$

$$PRP\_OIL_{iyr} = \frac{RATIO1}{RATIO1 + RATIO2}, \ iyr = Current \ Year \quad (115)$$

Oil Well Drilling Activity

$$RIGS_{iyr} = rig\_B0 + rig\_B1 * RIGS_{iyr-1} + rig\_B2 * gasprice_{iyr} + rig\_B3 * oilprice_{iyr} \quad (116)$$

$$ExpWell_{iyr} = exp\_B0 + exp\_B1 * RIGS_{iyr} \quad (117)$$

$$DevWell_{iyr} = dev\_B0 + dev\_B1 * ExpWell_{iyr-5} + dev\_B2 * RIGS_{iyr} + rig\_B3 * DevWell_{iyr-1} \quad (118)$$

$$WEL\_LIMT_{iyr} = DevWell_{iyr}, \; iyr = Current\ Year \quad (119)$$

$$WEL\_LIMO_{iyr} = PRP\_OIL_{iyr} * WEL\_LIMIT_{iyr}, \; iyr = Current\ Year \quad (120)$$

$$WEL\_DRLO_{iyr} = \begin{cases} WEL\_LIMO_{iyr} & \text{if } WEL\_LIMO_{iyr} \le WEL\_DEVO_{iyr}, \; iyr = Current\ Year \\ WEL\_DEVO_{iyr} & \text{if } WEL\_LIMO_{iyr} \ge WEL\_DEVO_{iyr}, \; iyr = Current\ Year \end{cases} \quad (121)$$

Gas Well Drilling Activity

$$WEL\_LIMG_{iyr} = WEL\_LIMIT_{iyr} - WEL\_LIMO_{iyr}, \; iyr = Current\ Year \quad (122)$$

$$WEL\_DRLG_{iyr} = \begin{cases} WEL\_LIMG_{iyr} & \text{if } WEL\_LIMG_{iyr} \le WEL\_DEVG_{iyr}, \; iyr = Current\ Year \\ WEL\_DEVG_{iyr} & \text{if } WEL\_LIMG_{iyr} \ge WEL\_DEVG_{iyr}, \; iyr = Current\ Year \end{cases} \quad (123)$$

Booked Oil Reserve Additions

$$RTIO\_OIL = \frac{WEL\_DRLO_{iyr}}{WEL\_DEVO_{iyr}}, \; iyr = Current\ Year \quad (124)$$

$$BKED\_OIL_{iyr} = RTIO\_OIL * INFR\_OIL_{iyr}, \; iyr = Current\ Year \quad (125)$$

$$BKED\_AGS_{iyr} = RTIO\_OIL * INFR\_AGS_{iyr}, \; iyr = Current\ Year \quad (126)$$

Booked Gas Reserve Additions

$$RTIO\_GAS = \frac{WEL\_DRLG_{iyr}}{WEL\_DEVG_{iyr}}, \; iyr = Current\ Year \quad (127)$$

$$BKED\_GAS_{iyr} = RTIO\_GAS * INFR\_GAS_{iyr}, \; iyr = Current\ Year \quad (128)$$

$$BKED\_CND_{iyr} = RTIO\_GAS * INFR\_CND_{iyr}, \; iyr = Current\ Year \quad (129)$$

Oil Production Accounting

Beginning of the Year Reserves

$$BEG\_RSVO_{iyr} = XPVD\_OIL + XPVD\_CND, \ iyr = 1 \tag{130}$$

$$BEG\_RSVO_{iyr} = END\_RSVO_{iyr-1}, \ iyr = \text{Current Year} \neq 1 \tag{131}$$

Production in the Year

$$RATIO\_RP_{iyr} = rp\_B0 + rp\_B1 * \ln(iyr + ModelStartYear - rp\_B2) \tag{132}$$

$$PROD\_OIL_{iyr} = \frac{BEG\_RSVO_{iyr}}{RATIO\_RP} \tag{133}$$

Reserves Growth

$$GRO\_RSVO_{iyr} = (BEG\_RSVO_{iyr} - PROD\_OIL_{iyr}) * RES\_GROW, \ iyr = \text{Current Year} \tag{134}$$

Reserve Additions

$$ADD\_RSVO_{iyr} = BKED\_OIL_{iyr} + BKED\_CND_{iyr}, \ iyr = \text{Current Year} \tag{135}$$

End of the Year Reserves

$$END\_RSVO_{iyr} = BEG\_RSVO_{iyr} + GRO\_RSVO_{iyr} + ADD\_RSVO_{iyr} - PROD\_OIL_{iyr}, \ iyr = \text{Current Year} \tag{136}$$

Gas Production Accounting

Beginning of the Year Reserves

$$BEG\_RSVG_{iyr} = XPVD\_GAS + XPVD\_AGS, \ iyr = 1 \tag{137}$$

$$BEG\_RSVG_{iyr} = END\_RSVG_{iyr}, \ iyr = \text{Current Year} \neq 1 \tag{138}$$

Production in the Year

$$PROD\_GAS_{iyr} = \frac{BEG\_RSVG_{iyr}}{RATIO\_RP}, \ iyr = \text{Current Year} \tag{139}$$

Reserves Growth

$$GRO\_RSVG_{iyr} = (BEG\_RSVG_{iyr} - PROD\_GAS_{iyr}) * RES\_GROW, \ iyr = \text{Current Year} \tag{140}$$

Reserve Additions

$$ADD\_RSVG_{iyr} = BKED\_GAS_{iyr} + BKED\_AGS_{iyr}, \; iyr = Current \; Year \tag{141}$$

End of the Year Reserves

$$END\_RSVG_{iyr} = BEG\_RSVG_{iyr} + GRO\_RSVG_{iyr} + ADD\_RSVG_{iyr} - PROD\_GAS_{iyr}, \; iyr = Current \; Year \tag{142}$$

Advanced Technology Impacts on Exploration

$$MASP\_EXP_{ipool,new} = \frac{MASP\_EXP_{ipool,old}}{ADT\_EXPL}, \; ipool = 1 \; to \; NFIELD \tag{143}$$

$$MASP\_TOT = MASP\_TOT - \left(MASP\_EXP_{ipool,old} - MASP\_EXP_{ipool,new}\right), \; ipool = 1 \; to \; NFIELD \tag{144}$$

Advanced Technology Impacts on Drilling

$$MASP\_DRL_{ipool,new} = \frac{MASP\_DRL_{ipool,old}}{ADT\_DRLG}, \; ipool = 1 \; to \; NFIELD \tag{145}$$

$$MASP\_TOT = MASP\_TOT - \left(MASP\_DRL_{ipool,old} - MASP\_DRL_{ipool,new}\right), \; ipool = 1 \; to \; NFIELD \tag{146}$$

Advanced Technology Impacts on Operations

$$MASP\_OPR_{ipool,new} = \frac{MASP\_OPR_{ipool,old}}{ADT\_OPER}, \ ipool = 1 \ to \ NFIELD \tag{147}$$

$$MASP\_TOT = MASP\_TOT - \left(MASP\_OPR_{ipool,old} - MASP\_OPR_{ipool,new}\right), \ ipool = 1 \ to \ NFIELD \tag{148}$$

Unconventional Gas Recovery Supply

<u>**Resource Base/Well Productivity**</u>

Legally Accessible Undrilled Locations Under Current Technology

$$CTUL = \left(BASAR*WSPAC\_CT - DEV\_CEL\right) * \left(1.0 - NOACCESS\right) \tag{149}$$

Legally Accessible Undrilled Locations Under Advanced Technology

$$ATUL = \left(BASAR*WSPAC\_AT - DEV\_CEL\right) * \left(1.0 - NOACCESS\right) \tag{150}$$

Weighted Average of the Expected Ultimate Recovery for Each (Entire) Basin

$$MEUR1_{1,1} = (.10 * RW10 + .20 * RW20 + .30 * RW30 + .40 * RW40) \tag{151}$$

Expected Ultimate Recovery for the Best 30% of the wells in the Basin

$$\begin{aligned} MEUR1_{iyr,2} = MEUR_{1,1} + (((((&RW10*(1/3)) + (RW20*(2/3) - MEUR1_{1,1}))/DEVPER) \\ &*TECHYRS)*(TECHYRS*(REDAM\%/20) + (TECHYRS*(FRCLEN\%/20)) \\ &+(TECHYRS*(PAYCON\%/20)) + 1)) \end{aligned} \tag{152}$$

Expected Ultimate Recovery for the middle 30% of the wells in the Basin

$$MEUR1_{iyr,3} = RW30 \tag{153}$$

Expected Ultimate Recovery for the Worst 40% of the Wells in the Basin

$$\begin{aligned} MEUR1_{iyr,4} = &(MEUR1_{1,1}) - (((RW30_1 - RW40_1)/DEVPER)*TECHYRS)*(TECHYRS)*(REDAM\%/20)) \\ &+(TECHYRS*(FRCLEN\%/20)) + (TECHYRS)*(PAYCON\%/20)) + 1) \end{aligned} \tag{154}$$

Expected Ultimate Recovery adjusted for Technological Progress in the Development of New Cavity Fairways

$$MEUR2 = \begin{cases} MEUR1 * CAVFRWY\% \Leftarrow IF(NEWCAVFRWY = 1) \\ MEUR1 \Leftarrow IF(NEWCAVFRWY = 0) \end{cases} \tag{155}$$

Expected Ultimate Recovery adjusted for Technological Progress in the Commercialization of Enhanced Coalbed Methane

$$MEUR3 = \begin{cases} MEUR2 * ENCBM\% \Leftarrow IF(ENCBM = 1) \\ MEUR2 \Leftarrow IF(ENCBM = 0) \end{cases} \tag{156}$$

Technically Recoverable Wells

$$TRW_1 = (ATUL * SCSSRT_1 * PLPROB2_1) \tag{157}$$

Undeveloped Resources

$$UNDEV\_RES_{iyr} = (MEUR3_{iyr} * TRW_{iyr}) \tag{158}$$

Reserves and Cumulative Production

$$RESNPROD_{iyr} = RESNPROD_{iyr-1} + RESADD_{iyr} \tag{159}$$

Ultimate Recoverable Resources

$$URR_{iyr} = RESNPROD_{iyr} + UNDEV\_RES_{iyr} \tag{160}$$

<u>Economics and Pricing</u>

Discounted Reserves

$$DISCRES_{iyr} = (DIS\_FAC * MEUR3_{iyr}) \tag{161}$$

Expected Net Present Value Revenues

$$ENPVR_{iyr} = \left(WHGP_{iyr} + BASNDIF\right) * \left(DISCRES_{iyr}\right) * 1,000,000 \tag{162}$$

Drilling and Completion Costs

$$DACC = \begin{cases} AVGDPTH * DCC\_L2K + DCC\_G\&G \Leftarrow IF(AVDPTH < 2000) \\ 2000 * DCC\_L2K + (AVGDPTH - 2000) * DCC\_G2K) + DCC\_G\&G \Leftarrow IF(AVDPTH \geq 2000) \end{cases} \tag{163}$$

Stimulation Costs

$$\text{STIMC} = \text{SZONE*STM\_CST} \tag{164}$$

Pumping and Surface Equipment Costs

$$\text{PASE} = \begin{cases} \text{BASET} + 5\text{*AVGDPTH} \Leftarrow \text{IF(WATR\_DISP} = 1) \\ 10000 \Leftarrow \text{IF(WATR\_DISP} \neq 1) \end{cases} \tag{165}$$

Lease Equipment Costs

$$\text{LSE\_EQ} = \begin{cases} \begin{bmatrix} \text{WOMS\_LE} + \text{WOML\_WTR} \Leftarrow \text{IF}\{(\text{WATR\_DISP} = 1)\text{AND}(\text{MEUR3} < .5)\} \\ \text{WOMM\_LE} + \text{WOML\_WTR} \Leftarrow \text{IF}\{(\text{WATR\_DISP} = 1)\text{AND}(\text{MEUR3} \geq .5)\text{AND}(\text{MEUR3} \leq 1.0)\} \\ \text{WOML\_LE} + \text{WOML\_WTR} \Leftarrow \text{IF}\{(\text{WATR\_DISP} = 1)\text{AND}(\text{MEUR3} > 1.0)\} \end{bmatrix} \\ \begin{bmatrix} \text{WOMS\_LE} \Leftarrow \text{IF}\{(\text{WATR\_DISP} = 0)\text{AND}(\text{MEUR3} < .5)\} \\ \text{WOMM\_LE} \Leftarrow \text{IF}\{(\text{WATR\_DISP} = 0)\text{AND}(\text{MEUR} \geq .5)\text{AND}(\text{MEUR3} \leq 1.0)\} \\ \text{WOML\_LE} \Leftarrow \text{IF}\{(\text{WATR\_DISP} = 0)\text{AND}(\text{MEUR3} > 1.0)\} \end{bmatrix} \end{cases} \tag{166}$$

General and Administrative Costs

$$\text{GAA10} = \text{RST*(LSE\_EQ} + \text{PASE} + \text{STIMC} + \text{DACC)} \tag{167}$$

Total Capital Costs

$$\text{TCC} = \left(\text{DACC} + \text{STIMC} + \text{PASE} + \text{LSE\_ EQ} + \text{GAA10}\right) \tag{168}$$

Dry Hole Costs

$$\text{DHC} = (\text{DACC} + \text{STIMC})\text{*}((1/\text{SCSSRT}) - 1) \tag{169}$$

Capital and Dry Hole Costs per Mcf Adjusted for Access Restrictions

$$\text{CCWDH} = \begin{cases} (\text{TTC} + \text{DHC})/(\text{DISCRES*1000000}) * \left(\dfrac{1 - \text{NOACCESS} + \text{LEASSTIP*.06}}{1 - \text{NOACCESS}}\right) & \begin{matrix} \Leftarrow \text{If}\{\text{ACCESS} = 0\} \\ \text{or} \\ \{\text{YEAR} < \text{ACCESS\_YR}\} \end{matrix} \\ (\text{TTC} + \text{DHC})/(\text{DISCRES*1000000}) \Leftarrow \text{Else} & \end{cases} \tag{170}$$

Variable Operating Costs

$$\text{VOC}=\begin{cases}\dfrac{\text{WTR\_DSPT*TECHYRS*(WDT\%/20)+WOMS*TECHYRS*(PUMP\%/20)}}{\text{+GASTR*TECHYRS*(GTF\%/20)+OCWW\$}} \Leftarrow \text{IF(WAT\_DISP} > .4) \\ \text{WTR\_DSPT*TECHYRS*(WDT\%/20)+WOMS*TECHYRS*(PUMP\%/20)} \\ \text{+GASTR*TECHYRS*(GTF\%/20)+OCNW\$} \Leftarrow \text{IF(WAT\_DISP} \leq .4)\end{cases} \tag{171}$$

Variable Operating Costs with Enhanced Coalbed Methane

$$\text{VOC2} = \begin{cases}\text{VOC+((ECBM\_OC+VOC)*(ENH\_CBM\%))/(1+ENH\_CBM\%)} \Leftarrow \text{IF(ECBMR=1)} \\ \text{VOC} \Leftarrow \text{IF(ECBMR} \neq 1)\end{cases} \tag{172}$$

Fixed Operating and Maintenance Costs

$$\text{FOMC} = \begin{cases}\begin{bmatrix}\underline{\text{IF(WATR\_DISP = 1)}} \\ \text{DIS\_FACT*WOMS\_OMW} + \text{VOC*DISCRES*1000000} \Leftarrow \text{IF(MEUR3} < .5) \\ \text{DIS\_FACT*WOMM\_OMW} + \text{VOC*DISCRES*1000000} \Leftarrow \text{IF(MEUR3} \geq .5\text{)AND(MEUR3} \leq 1.0) \\ \text{DIS\_FACT*WOMM\_OMW} + \text{VOC*DISCRES*1000000} \Leftarrow \text{IF(MEUR3} > 1.0)\end{bmatrix} \\ \begin{bmatrix}\underline{\text{IF(WATR\_DISP = 0)}} \\ .6 * \text{DIS\_FACT*WOMS\_OMW} + \text{VOC*DISCRES*1000000} \Leftarrow \text{IF(MEUR3} < .5) \\ .6 * \text{DIS\_FACT*WOMM\_OMW} + \text{VOC*DISCRES*1000000} \Leftarrow \text{IF(MEUR3} \geq .5\text{)AND(MEUR3} \leq 1.0) \\ .6 * \text{DIS\_FACT*WOMM\_OMW} + \text{VOC*DISCRES*1000000} \Leftarrow \text{IF(MEUR3} > 1.0)\end{bmatrix}\end{cases} \tag{173}$$

Total Costs

$$\text{TOTL\_CST} = \text{FOMC} / (\text{DISCRES} * 1000000) + \text{CCWDH} \tag{174}$$

Net Price

$$\text{NET\_PRC} = (1 - \text{RST}) * (\text{WHGP} + \text{BASNDIF}) \tag{175}$$

Net Profitability

$$NET\_PROF = NET\_PRC - TOTL\_CST - MIN\_ROI \tag{176}$$

$$\text{NET\_PROFIT2} = \begin{cases}\text{NET\_PROFIT} \Leftarrow \text{IF(NET\_PROFIT} > 0) \\ 0 \Leftarrow \text{IF(NET\_PROFIT} \leq 0)\end{cases} \tag{177}$$

<u>Model Outputs</u>

Undeveloped Wells

$$\text{UNDV\_WELLS} = \begin{cases} \text{TRW} * (\text{ENV\%} + (\text{LOW\%} / \text{LOWYRS}) * \text{TECHYRS}) \Leftarrow \text{IF}(\text{NET\_PROF2} > 0)\text{AND}(\text{ENPRGS} = 1) \\ \text{TRW} \Leftarrow \text{IF}(\text{NET\_PROF2} > 0)\text{AND}(\text{ENPRGS} = 0) \\ 0 \Leftarrow \text{IF}(\text{NET\_PROF2} = 0) \end{cases} \tag{178}$$

Expected Ultimate Recovery Adjusted for Profitability

$$\text{MEUR4} = \begin{cases} \text{MEUR3} \Leftarrow \text{IF}(\text{NET\_PROF2} > 0) \\ 0 \Leftarrow \text{IF}(\text{NET\_PROF2} = 0) \end{cases} \tag{179}$$

Drilling Schedule

$$\text{DRL\_SCHED} = \begin{cases} 0 \Leftarrow \text{IF}(\text{HYP\%} \neq 0) \\ 0 \Leftarrow \text{IF}(\text{HYP\%} = 0)\text{AND}(\text{NET\_PROF2} = 0) \\ \text{USLOW} \Leftarrow \text{IF}(\text{HYP\%} = 0)\text{AND}(\text{NET\_PROF2} > 0)\text{AND}(\text{NET\_PROF} < \text{LOW\$}) \\ \text{SLOW} \Leftarrow \text{IF}(\text{HYP\%} = 0)\text{AND}(\text{NET\_PROF2} \geq \text{LOW\$})\text{AND}(\text{NET\_PROF} < \text{SMAL\$}) \\ \text{MED} \Leftarrow \text{IF}(\text{HYP\%} = 0)\text{AND}(\text{NET\_PROF2} \geq \text{SMAL\$})\text{AND}(\text{NET\_PROF} < \text{MED\$}) \\ \text{FAST} \Leftarrow \text{IF}(\text{HYP\%} = 0)\text{AND}(\text{NET\_PROF2} \geq \text{MED\$})\text{AND}(\text{NET\_PROF} < \text{LAR\$}) \\ \text{SLOW} \Leftarrow \text{IF}(\text{HYP\%} = 0)\text{AND}(\text{NET\_PROF2} \geq \text{LAR\$}) \end{cases} \tag{180}$$

Drilling Schedule Adjusted for Technological Advancement

$$\text{DRL\_SCHED2} = \begin{cases} \text{DRL\_SCHED} + \text{EMRG\%} - \text{EMERG\#} \Leftarrow \text{IF}(\text{DRL\_SCHED} > 0)\text{AND}(\text{EMRG} = 1) \\ \text{DRL\_SCHED} \Leftarrow \text{IF}(\text{DRL\_SCHED} > 0)\text{AND}(\text{EMRG} \neq 1) \\ 0 \Leftarrow \text{IF}(\text{DRL\_SCHED} \leq 0) \end{cases} \tag{181}$$

$$\text{DRL\_SCHED3} = \begin{cases} \text{DRL\_SCHED} \Leftarrow \text{IF}(\text{DRL\_SCHED2} < \text{DRL\_SCHED}) \\ \text{DRL\_SCHED2} \Leftarrow \text{IF}(\text{DRL\_SCHED2} \geq \text{DRL\_SCHED}) \end{cases} \tag{182}$$

$$\text{DRL\_SCHED4} = \begin{cases} \text{DRL\_SCHED3} * \left(\dfrac{1 - \text{NOACCESS} + \text{LEASSTIP}*.10}{1 - \text{NOACCESS}}\right) & \begin{matrix} \Leftarrow \text{If}\{\text{ACCESS} = 0\} \\ \text{or} \\ \{\text{YEAR} < \text{ACCESS\_YR}\} \end{matrix} \\ \text{DRL\_SCHED3} \Leftarrow \text{Else} \end{cases} \tag{183}$$

New Wells

$$NW\_WELLS = \begin{cases} \begin{bmatrix} \underline{IF(DRL\_SCHED4 > 0} \\ \begin{cases} \underline{IF(YEAR > 1)AND(NW\_WELLS\_LAG > 0)} \\ 1.3 * NW\_WELLS\_LAG \Leftarrow IF(UNDV\_WELLS / DRL\_SCHED4 > 1.3 * NW\_WELLS\_LAG) \\ .7 * NW\_WELLS\_LAG \Leftarrow IF(UNDV\_WELLS / DRL\_SCHED4 < 0.7 * NW\_WELLS\_LAG) \\ UNDV\_WELLS / DRL\_SCHED4 \Leftarrow IF(UNDV\_WELLS / DRL\_SCHED4 \\ \qquad ((< 1.3 * NW\_WELLS\_LAG)AND(> 0.7 * NW\_WELLS\_LAG))) \end{cases} \\ \begin{cases} \underline{IF(YEAR = 1)OR(NW\_WELLS\_LAG = 0)} \\ UNDV\_WELLS / DRL\_SCHED4 \end{cases} \end{bmatrix} \\ \begin{bmatrix} \underline{IF(DRL\_SCHED4 = 0)} \\ 0 \end{bmatrix} \end{cases} \tag{184}$$

$$NW\_WELLS2 = \begin{cases} UNDV\_WELLS \Leftarrow IF(UNDV\_WELLS < NW\_WELLS) \\ NW\_WELLS \Leftarrow IF(UNDV\_WELLS \geq NW\_WELLS) \end{cases} \tag{185}$$

Reserve Additions from New Wells

$$DRA = NW\_WELLS2 * MEUR4 \tag{186}$$

Reserve Additions from New Growth

$$RGA = \begin{cases} RGR * PROV\_RES + .025 * (MEUR3 - MEUR2) \Leftarrow IF(RES\_GR = 1)AND(ENCBM = 1) \\ RGR * PROV\_RES \Leftarrow IF(RES\_GR = 1)AND(ENCBM = 0) \\ 0 \Leftarrow IF(RES\_GR \neq 1) \end{cases} \tag{187}$$

Total Reserve Additions

$$R\_ADD = DRA + RGA \tag{188}$$

Proved Reserves for the Next Year

$$PROV\_RES2 = \begin{cases} PRO\_RES + R\_ADD - PROD \Leftarrow IF((PROV\_RES + R\_ADD - PROD) > 0) \\ 0 \Leftarrow IF((PROV\_RES + R\_ADD - PROD) \leq 0) \end{cases} \tag{189}$$

Reserves-to-Production Ratio for the Next Year

$$RP\_RAT2 = \begin{cases} RP\_RAT - 1 \Leftarrow IF(RP\_RAT > 10) \\ RP\_RAT \Leftarrow IF(RP\_RAT \leq 10) \end{cases} \tag{190}$$

Production for the Next Year

$$\mathrm{PROD2} = \begin{cases} 0 \Leftarrow \mathrm{IF(RP\_RAT2 = 0)} \\ \mathrm{PRO\_RES / RP\_RAT2} \Leftarrow \mathrm{IF(RP\_RAT2 \neq 0)} \end{cases} \tag{191}$$

Undeveloped Wells for the Next Year

$$\mathrm{UNDV\_WELLS2} = \begin{cases} \left[\begin{array}{l} \underline{\mathrm{IF(ENPRGS = 1)}} \\ \mathrm{TRW - NW\_WELLS2} \end{array}\right. \\ \left[\begin{array}{l} \underline{\mathrm{IF(ENPRGS \neq 1)}} \\ 0 \Leftarrow \mathrm{IF(UNDV\_WELLS = 0)} \\ .1 \Leftarrow \mathrm{IF(UNDV\_WELLS \neq 0)AND(UNDV\_WELLS - NW\_WELLS = 0)} \\ \mathrm{NW\_WELLS2} \Leftarrow \mathrm{IF(UNDV\_WELLS \neq 0)AND(UNDV\_WELLS - NW\_WELLS \neq 0)} \end{array}\right. \end{cases} \tag{192}$$

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Appendix D. Model Abstract

1. Model Name
   Oil and Gas Supply Module

2. Acronym
   OGSM

3. Description
   OGSM projects the following aspects of the crude oil and natural gas supply industry:
   - production
   - reserves
   - drilling activity
   - natural gas imports and exports

4. Purpose
   OGSM is used by the Oil and Gas Division in the Office of Integrated Analysis and Forecasting as an analytic aid to support preparation of projections of reserves and production of crude oil and natural gas at the regional and national level. The annual projections and associated analyses appear in the Annual Energy Outlook (DOE/EIA-0383) of the Energy Information Administration. The projections also are provided as a service to other branches of the U.S. Department of Energy, the Federal Government, and non-Federal public and private institutions concerned with the crude oil and natural gas industry.

5. Date of Last Update
   2002

6. Part of Another Model
   National Energy Modeling System (NEMS)

7. Model Interface References
   Coal Module
   Electricity Module
   Industrial Module
   International Module
   Natural Gas Transportation and Distribution Model (NGTDM)
   Macroeconomic Module
   Petroleum Market Module (PMM)

8. Official Model Representative
   - Office: Integrating Analysis and Forecasting
   - Division: Oil and Gas Analysis
   - Model Contact: Ted McCallister
   - Telephone: (202) 586-4820

9. Documentation Reference
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10. Archive Media and Installation Manual
    NEMS2003

11. Energy Systems Described
    The OGSM forecasts oil and natural gas production activities for six onshore and three offshore regions as well as three Alaskan regions. Exploratory and developmental drilling are treated separately, with exploratory drilling further differentiated as new field wildcats or other exploratory wells. New field wildcats are those wells drilled for a new field on a structure or in an environment never before productive. Other exploratory wells are those drilled in already productive locations. Development wells are primarily within or near proven areas and can result in extensions or revisions. Exploration yields new additions to the stock of reserves and development determines the rate of production from the stock of known reserves.

    The OGSM also projects natural gas trade via pipeline with Canada and Mexico, as well as liquefied natural gas (LNG) trade. U.S. natural gas trade with Canada is represented by seven entry/exit points and trade with Mexico by three entry/exit points. The four currently existing LNG receiving terminals are represented as well as possible new construction of LNG regasification facilities in each coastal region.

12. Coverage
    - Geographic: Six Lower 48 onshore supply regions, three Lower 48 offshore regions, and three Alaskan regions.
    - Time Units/Frequency: Annually 1990 through 2025
    - Product(s): Crude oil and natural gas
    - Economic Sector(s): Oil and gas field production activities and foreign natural gas trade

13. Model Features
    - Model Structure: Modular, containing six major components
      - Lower 48 Onshore Supply Submodule
      - Unconventional Gas Recovery Supply Submodule

- Offshore Supply Submodule
- Foreign Natural Gas Supply Submodule

- Alaska Oil and Gas Supply Submodule

- Modeling Technique: The OGSM is a hybrid econometric/discovery process model. Drilling activities in the United States are determined by the discounted cash flow that measures the expected present value profits for the proposed effort and other key economic variables. LNG imports are projected on the basis of unit supply costs for gas delivered into the Lower 48 pipeline network.
- Special Features: Can run stand-alone or within the NEMS. Integrated NEMS runs employ short term natural gas supply functions for efficient market equilibration.

14. Non-DOE Input Data

- Alaskan Oil and Gas Field Size Distributions - U.S. Geological Survey

- Alaska Facility Cost By Oil Field Size - U.S. Geological Survey

- Alaska Operating cost - U.S. Geological Survey

- Basin Differential Prices - Natural Gas Week, Washington, DC

- State Corporate Tax Rate - Commerce Clearing House, Inc. *State Tax Guide*

- State Severance Tax Rate - Commerce Clearing House, Inc. *State Tax Guide*

- Federal Corporate Tax Rate, Royalty Rate - U.S. Tax Code

- Onshore Drilling Costs - (1.) American Petroleum Institute. *Joint Association Survey of Drilling Costs (1970-1999)*, Washington, D.C.; (2.) Additional unconventional gas recovery drilling and operating cost data from operating companies

- Shallow Offshore Drilling Costs - American Petroleum Institute. *Joint Association Survey of Drilling Costs (1970-1999)*, Washington, D.C.

- Shallow Offshore Lease Equipment and Operating Costs - Department of Interior. Minerals Management Service (Correspondence from Gulf of Mexico and Pacific OCS regional offices)

- Shallow Offshore Wells Drilled per Project - Department of Interior. Minerals Management Service (Correspondence from Gulf of Mexico and Pacific OCS regional offices)

- Shallow and Deep Offshore Technically Recoverable Oil and Gas Undiscovered Resources - Department of Interior. Minerals Management Service (Correspondence from Gulf of Mexico and Pacific OCS regional offices)

- Deep Offshore Exploration, Drilling, Platform, and Production Costs - American Petroleum Institute, *Joint Association Survey of Drilling Costs (1995)*, ICF Resource Incorporated (1994), Oil and Gas Journals

- Canadian Royalty Rate, Corporate Tax Rate, Provincial Corporate Tax Rate- Energy Mines and Resources Canada. *Petroleum Fiscal Systems in Canada*, (Third Edition - 1988)

- Canadian Wells drilled - Canadian Petroleum Association. *Statistical Handbook*, (1976-1993)

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- Canadian Recoverable Resource Base - National Energy Board. *Canadian Energy Supply and Demand 1990 - 2010*, June 1991

- Canadian Reserves - Canadian Petroleum Association. *Statistical Handbook*, (1976-1993)

- Unconventional Gas Resource Data - (1) USGS *1995 National Assessment of United States Oil and Natural Gas Resources*; (2) Additional unconventional gas data from operating companies

- Unconventional Gas Technology Parameters - (1) Advanced Resources International Internal studies; (2) Data gathered from operating companies

15. DOE Input Data
    - Onshore Lease Equipment Cost - Energy Information Administration. *Costs and Indexes for Domestic Oil and Gas Field Equipment and Production Operations (1980 - 1999)*, DOE/EIA-0815(80-99)

    - Onshore Operating Cost - Energy Information Administration. *Costs and Indexes for Domestic Oil and Gas Field Equipment and Production Operations (1980 - 1999)*, DOE/EIA-0815(80-99)

    - Emissions Factors - Energy Information Administration

    - Oil and Gas Well Initial Flow Rates - Energy Information Administration, Office of Oil and Gas

    - Wells Drilled - Energy Information Administration, Office of Oil and Gas

    - Expected Recovery of Oil and Gas Per Well - Energy Information Administration, Office of Oil and Gas

    - Undiscovered Recoverable Resource Base - Energy Information Administration. *The Domestic Oil and Gas Recoverable Resource Base: Supporting Analysis for the National Energy Strategy*, SR/NES/92-05

    - Oil and Gas Reserves - Energy Information Administration. *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves*, (1977-2000), DOE/EIA-0216(77-00)

16. Computing Environment
    - Hardware Used: PC
    - Operating System: Windows 95/Windows NT
    - Language/Software Used: FORTRAN
    - Memory Requirement: Unknown
    - Storage Requirement: 992 bytes for input data storage; 180,864 bytes for output storage; 1280 bytes for code storage; and 5736 bytes for compiled code storage
    - Estimated Run Time: 9.8 seconds

17. Reviews conducted

    Independent Expert Reviews, Model Quality Audit; Unconventional Gas Recovery Supply Submodule - Presentations to Mara Dean (DOE/FE - Pittsburgh) and Ray Boswell (DOE/FE - Morgantown), April 1998 and DOE/FE (Washington, DC)

18. Status of Evaluation Efforts

    Not applicable

19. Bibliography

    See Appendix C of this document.

Appendix E. Parameter Estimation

The major portion of the lower 48 oil and gas supply component of the OGSM consists of a system of equations that are used to forecast exploratory and developmental wells drilled. The equations, the estimation techniques, and the statistical results are documented below. Documentation is also provided for the estimation of the drilling, lease equipment, and operating cost equations as well as the associated-dissolved gas equations and the Canadian oil and gas wells equations. Finally, the appendix documents the estimation of oil and gas supply price elasticities for possible use in short run supply functions. The econometric software packages, SAS and TSP, were used for the estimations.

Lower 48 Estimated Wells Equations

The equations for onshore total and successful wells were estimated using time series data for the onshore Lower 48 over the time period 1970 through 1998. The equations were estimated with correction for first order serial correlation using version 4.4 of TSP.

$$LESTWELLS_t = b0 + b1 * LPOIL_t + b2 * LPGAS_t + \rho * LESTWELLS_{t-1} - \rho * (b0 + b1 * LPOIL_{t-1} + b2 * LPGAS_t$$

Dependent variable: $lnESTWELLS_t$
Number of observations: 29

(Statistics based on transformed data)		(Statistics based on original data)	
Mean of dep. var. =	.773259	Mean of dep. var. =	10.5283
Std. dev. of dep. var. =	.571719	Std. dev. of dep. var. =	.458516
Sum of squared residuals =	.327719	Sum of squared residuals =	.421251
Variance of residuals =	.012605	Variance of residuals =	.016202
Std. error of regression =	.112270	Std. error of regression =	.127287
R-squared =	.967485	R-squared =	.930147
Adjusted R-squared =	.964984	Adjusted R-squared =	.924773
Durbin-Watson =	2.12057	Durbin-Watson =	1.92563

ρ (autocorrelation coef.) = .935763
Standard error of ρ = .056575
t-statistic for ρ = 16.5402
Log likelihood = 22.8104

Parameter	Estimate	Standard Error	t-statistic	P-value
b0	9.24194	.345360	26.7603	[.000]
b1	.384673	.150670	2.55308	[.011]
b2	.364478	.104591	3.48478	[.000]

$$LESTSUCWELLS_t = b0 + b1 * LPOIL_t + b2 * LPGAS_t + \rho * LESTSUCWELLS_{t-1}$$
$$- \rho * (b0 + b1 * LPOIL_{t-1} + b2 * LPGAS_{t-1})$$

Dependent variable: $lnESTSUCWELLS_t$
Number of observations: 29

(Statistics based on transformed data)		(Statistics based on original data)	
Mean of dep. var. =	1.26568	Mean of dep. var. =	10.1632
Std. dev. of dep. var. =	.645064	Std. dev. of dep. var. =	.450947
Sum of squared residuals =	.333911	Sum of squared residuals =	.373656
Variance of residuals =	.012843	Variance of residuals =	.014371
Std. error of regression =	.113326	Std. error of regression =	.119881
R-squared =	.973012	R-squared =	.935106
Adjusted R-squared =	.970936	Adjusted R-squared =	.930114
Durbin-Watson =	2.10554	Durbin-Watson =	2.02018

ρ (autocorrelation coef.) = .887343
Standard error of ρ = .077178
t-statistic for ρ = 11.4974
Log likelihood = 22.8072

Parameter	Estimate	Standard Error	t-statistic	P-value
b0	8.79205	.307779	28.5661	[.000]
b1	.401503	.144735	2.77406	[.006]
b2	.389798	.106397	3.66361	[.000]

Lower 48 RIGS Equations

Onshore

$$LRIGSL48_t = b0 + b1 * LRIGSL48_{t-1} + b2 * LREVRIG_{t-1} + \rho * LRIGSL48_{t-2} - \rho * (b0 + b1 * LRIGSL48_{t-2} + b2 * LREVRIG_{t-3})$$

Equation Variable/Parameter	Output Variable/Parameter
LRIGSL48	LNRIGS
b0	C
b1	LNRIGS(-1)
b2	LNREVRIG(-1)
ρ	RHO

```
                   FIRST-ORDER SERIAL CORRELATION OF THE ERROR

                   MAXIMUM LIKELIHOOD ITERATIVE TECHNIQUE
NOTE:  Lagged dependent variable(s) present
                   ********************
                   MAXIMUM LIKELIHOOD ESTIMATION IS NOT
                   IMPLEMENTED FOR LAGGED DEPENDENT VARIABLES
                   DUE TO TREATMENT OF THE FIRST OBSERVATION.
                   METHOD OF ESTIMATION IS CHANGED TO
                   COCHRANE-ORCUTT ITERATIVE TECHNIQUE

                   CONVERGENCE ACHIEVED AFTER    6 ITERATIONS
Dependent variable: LNRIGS
Current sample:  3 to 26
Number of observations:  24

(Statistics based on transformed data)
          Mean of dep. var. = 4.38969
     Std. dev. of dep. var. = .234933
   Sum of squared residuals = .058026
      Variance of residuals = .276313E-02
   Std. error of regression = .052566
                  R-squared = .954291
         Adjusted R-squared = .949937
              Durbin-Watson = 1.62731
Rho (autocorrelation coef.) = .439691
      Standard error of rho = .232287
        t-statistic for rho = 1.89288
             Log likelihood = 38.2445
(Statistics based on original data)
          Mean of dep. var. = 7.83784
     Std. dev. of dep. var. = .389324
   Sum of squared residuals = .058026
      Variance of residuals = .276313E-02
   Std. error of regression = .052566
                  R-squared = .983357
         Adjusted R-squared = .981772
              Durbin-Watson = 1.62731
```

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
C	-3.37088	.762161	-4.42280	[.000]
LNRIGS(-1)	.803012	.053301	15.0655	[.000]
LNREVRIG(-1)	.312270	.051418	6.07313	[.000]
RHO	.439691	.232287	1.89288	[.058]

Drilling Cost Equations

Drilling costs were hypothesized to be a function of drilling, depth, and a time trend that proxies for the cumulative effect of technological advances on costs. The equations were estimated in log-linear form using Three Stage Least Squares (3SLS) technique. The forms of the equations are:

Onshore Regions

$$
\begin{aligned}
LDRILLCOST_{r,k,t} = {} & \ln(\delta 0)_{r,k} + \ln(\delta 1)_k + \delta 3 * LESTWELLS_t + \delta 4 * LRIGSL48_t + \delta 5 * TIME_t + \\
& \rho_k * LDRILLCOST_{r,k,t-1} - \rho_k * \big(\ln(\delta 0)_{r,k}) + \ln(\delta 1)_k + \\
& \delta 3 * LESTWELLS_{t-1} + \delta 4 * LRIGSL48_{t-1} + \delta 5 * TIME_{t-1}\big)
\end{aligned}
$$

Results

Mapping of variable names from the above equation to the following SAS output.

Variable/Parameter	Successful		Dry	
	Oil	Gas	Oil	Gas
LDRILLCOST	LNOILCST	LNGASCST	LNDOIL_C	LNDGAS_C
$\ln(\delta 0)_r$	$REGOIL_r$	$REGGAS_r$	$REGDOIL_r$	$REGDGAS_r$
$\ln(\delta 1)$	OILDPTH	GASDPTH	DO_DPTH	DG_DPTH
$\delta 3$	OGD_WELL	OGD_WELL	OGD_WELL	OGD_WELL
$\delta 4$	OGD_RIGS	OGD_RIGS	OGD_RIGS	OGD_RIGS
$\delta 5$ (1977-1997)	TECH1	TECH1	TECH1	TECH1
$\delta 5$ (1998-2000)	TECH2	TECH2	TECH2	TECH2
ρ	RHO_O	RHO_G	RHO_DO	RHO_DG

THREE STAGE LEAST SQUARES
========================

EQUATIONS: OIL GAS DOIL DGAS

INSTRUMENTS: REGION1 REGION6 REGION2 REGION3 REGION4 REGION5
YEAR(-1) LNOILCST(-1) LNGASCST(-1) LNDOIL_C(-1) LNDGAS_C(-1)
LNRIGS(-1) LNWELLS(-1) OIL_DPTH(-1) GAS_DPTH(-1) DOILDPTH(-1)
DGASDPTH(-1) LNPOIL LNPGAS

CONVERGENCE ACHIEVED AFTER 7 ITERATIONS

Number of observations = 820 E'PZ*E = 367.313
Standard Errors computed from heteroscedastic-consistent matrix
(Robust-White)

Parameter	Estimate	Standard Error	t-statistic	P-value
REGOIL1	43.3811	6.68122	6.49298	[.000]
REGOIL2	43.7288	6.68380	6.54251	[.000]
REGOIL3	43.6083	6.68436	6.52393	[.000]
REGOIL4	43.5965	6.68403	6.52249	[.000]
REGOIL5	43.8860	6.68394	6.56589	[.000]
REGOIL6	44.3143	6.68132	6.63256	[.000]
OGD_RIGS	-.365150	.068521	-5.32904	[.000]
OGD_WELL	.696055	.060253	11.5522	[.000]
TECH1	-.018699	.327445E-02	-5.71071	[.000]
TECH2	-.017772	.322826E-02	-5.50528	[.000]
OILDPTH	.231790E-03	.554909E-05	41.7708	[.000]
RHO_O	.741813	.014752	50.2853	[.000]
REGGAS1	43.4793	6.68130	6.50761	[.000]
REGGAS2	43.7806	6.68332	6.55073	[.000]
REGGAS3	43.6409	6.68286	6.53027	[.000]
REGGAS4	43.5936	6.68327	6.52279	[.000]
REGGAS6	43.9905	6.67932	6.58607	[.000]
REGGAS5	43.8513	6.68317	6.56145	[.000]
GASDPTH	.241401E-03	.532126E-05	45.3653	[.000]
RHO_G	.718273	.016328	43.9913	[.000]
REGDOIL1	43.0952	6.68180	6.44964	[.000]
REGDOIL2	43.1928	6.68444	6.46170	[.000]
REGDOIL3	43.0319	6.68461	6.43747	[.000]
REGDOIL4	43.0583	6.68410	6.44190	[.000]
REGDOIL5	43.3859	6.68462	6.49040	[.000]
REGDOIL6	43.8253	6.68145	6.55924	[.000]
DO_DPTH	.247234E-03	.575148E-05	42.9862	[.000]
RHO_DO	.648979	.017910	36.2362	[.000]
REGDGAS1	43.1978	6.68176	6.46503	[.000]
REGDGAS2	43.2389	6.68418	6.46885	[.000]
REGDGAS3	43.0726	6.68356	6.44456	[.000]
REGDGAS4	43.0458	6.68355	6.44055	[.000]
REGDGAS5	43.3591	6.68440	6.48661	[.000]
REGDGAS6	43.3583	6.68056	6.49022	[.000]
DG_DPTH	.257674E-03	.519692E-05	49.5820	[.000]
RHO_DG	.638074	.019178	33.2714	[.000]

```
Standard Errors computed from quadratic form of analytic first
derivatives (Gauss)

Equation: OIL
Dependent variable: LNOILCST

       Mean of dep. var. = 12.6541  Std. error of regression = .159992
  Std. dev. of dep. var. = 1.10148                 R-squared = .979042
Sum of squared residuals = 20.9899             Durbin-Watson = 1.95003 [<.568]
   Variance of residuals = .025597

Equation: GAS
Dependent variable: LNGASCST

       Mean of dep. var. = 12.7895  Std. error of regression = .179482
  Std. dev. of dep. var. = 1.13764                 R-squared = .975134
Sum of squared residuals = 26.4154             Durbin-Watson = 1.90601 [<.323]
   Variance of residuals = .032214

Equation: DOIL
Dependent variable: LNDOIL_C

       Mean of dep. var. = 12.2531  Std. error of regression = .227375
  Std. dev. of dep. var. = 1.21336                 R-squared = .965533
Sum of squared residuals = 42.3936             Durbin-Watson = 1.93831 [<.501]
   Variance of residuals = .051699

Equation: DGAS
Dependent variable: LNDGAS_C

       Mean of dep. var. = 12.3904  Std. error of regression = .222973
  Std. dev. of dep. var. = 1.25330                 R-squared = .968732
Sum of squared residuals = 40.7680             Durbin-Watson = 1.98926 [<.768]
   Variance of residuals = .049717
```

Onshore Lease Equipment Cost Equations

Lease equipment costs were hypothesized to be a function of total successful wells and a time trend that proxies for the cumulative effect of technological advances on costs. The form of the equation was assumed to be log-linear. The equations were estimated in log-linear form using Three Stage Least Squares (3SLS) technique. Where necessary, equations were estimated in generalized difference form to correct for first order serial correlation. The forms of the equations are:

Onshore Regions

$$LLEQC_{r,k,t} = \ln(\epsilon 0)_{r,k} + \ln(\epsilon 1)_k * DEPTH_{r,k,t} + \epsilon 2_k * LESUCWELL_{k,t} + \epsilon 3_k * TIME_t + \rho_k * LLEQC_{r,k,t-1} - \rho_k * (\ln(\epsilon 0)_{r,k} + \ln(\epsilon 1)_k * DEPTH_{r,k,t-1} * \epsilon 2_k * LESUCWELL_{k,t-1} + \epsilon 3_k * TIME_{t-1})$$

Results

Mapping of variable names from the above equation to the following TSP output.

Variable/Parameter	Shallow Oil	Shallow Gas	Deep Oil	Deep Gas
LLEQC	LSO_LEQ	LSG_LEQ	LDO_LEQ	LDG_LEQ
$\ln(\varepsilon 0)_1$	SOREG1	SGREG1	--	--
$\ln(\varepsilon 0)_2$	SOREG2	SGREG2	DOREG2	DGREG2
$\ln(\varepsilon 0)_3$	SOREG3	SGREG3	DOREG3	DGREG3
$\ln(\varepsilon 0)_4$	SOREG4	SGREG4	DOREG4	DGREG4
$\ln(\varepsilon 0)_5$	SOREG5	SGREG5	DOREG5	DGREG5
$\ln(\varepsilon 0)_6$	SOREG6	SGREG6	--	--
$\varepsilon 1$	SODEPTH	SGDEPTH	DODEPTH	DGDEPTH
$\varepsilon 2$	SOWELL	SGWELL	DOWELL	DGWELL
$\varepsilon 3$	TECH	TECH	TECH	TECH
ρ	SORHO	SGRHO	DORHO	DGRHO

THREE STAGE LEAST SQUARES

EQUATIONS: SOIL SGAS

INSTRUMENTS: REGION1 REGION2 REGION3 REGION4 REGION5 REGION6
SG_DPTH SO_DPTH SG_DPTH(-1) SO_DPTH(-1) YEAR LSG_LEQ(-1)
LSO_LEQ(-1) LSUCWELL(-1) RPGAS RPOIL RPGAS(-1) RPOIL(-1)

Number of Observations = 150

Parameter	Estimate	Standard Error	t-statistic	P-value
SOREG1	33.7741	6.08076	5.55426	[.000]
SOREG2	33.5586	6.07805	5.52127	[.000]
SOREG3	33.5302	6.08331	5.51184	[.000]
SOREG4	33.7847	6.08023	5.55649	[.000]
SOREG5	33.7353	6.07598	5.55223	[.000]
SOREG6	34.2506	6.07892	5.63432	[.000]
SODEPTH	.181898E-03	.104214E-04	17.4544	[.000]
SOWELL	.141601	.042041	3.36814	[.001]
TECH	-.012422	.294173E-02	-4.22259	[.000]
SORHO	.658138	.062543	10.5229	[.000]
SGREG1	32.8085	6.03814	5.43355	[.000]
SGREG2	33.0401	6.03673	5.47318	[.000]
SGREG3	33.0801	6.03622	5.48027	[.000]
SGREG4	33.4552	6.03766	5.54108	[.000]
SGREG5	33.6282	6.03247	5.57453	[.000]
SGREG6	32.8046	6.03793	5.43309	[.000]
SGDEPTH	.600314E-04	.815549E-05	7.36086	[.000]
SGWELL	.141891	.043189	3.28537	[.001]
SGRHO	.665599	.055584	11.9747	[.000]

Standard Errors computed from quadratic form of analytic first derivatives (Gauss)

Equation: SOIL
Dependent variable: LSO_LEQ

Mean of dep. var. = 11.2220
Std. dev. of dep. var. = .331759
Sum of squared residuals = .899774
Variance of residuals = .599849E-02
Std. error of regression = .077450
R-squared = .945171
Durbin-Watson = 1.90518 [<.859]

Equation: SGAS
Dependent variable: LSG_LEQ

Mean of dep. var. = 10.2228
Std. dev. of dep. var. = .379077
Sum of squared residuals = 1.32409
Variance of residuals = .882729E-02
Std. error of regression = .093954
R-squared = .938205
Durbin-Watson = 2.22580 [<.999]

THREE STAGE LEAST SQUARES

EQUATIONS: DOIL DGAS

INSTRUMENTS: REGION2 REGION3 REGION4 REGION5 DG_DPTH DO_DPTH DG_DPTH(-1) DO_DPTH(-1) YEAR LDG_LEQ(-1) LDO_LEQ(-1) LSUCWELL(-1) RPGAS RPOIL RPGAS(-1) RPOIL(-1)

Number of Observations = 100

Parameter	Estimate	Standard Error	t-statistic	P-value
DOREG2	19.9806	2.34600	8.51690	[.000]
DOREG3	19.9910	2.34584	8.52190	[.000]
DOREG4	20.0289	2.34601	8.53743	[.000]
DOREG5	20.0239	2.34668	8.53284	[.000]
DODEPTH	.262492E-04	.151868E-04	1.72842	[.084]
DOWELL	.332898	.019588	16.9950	[.000]
TECH	-.588957E-02	.116272E-02	-5.06534	[.000]
DGREG2	20.7534	2.38702	8.69425	[.000]
DGREG3	20.7847	2.38684	8.70805	[.000]
DGREG4	20.7550	2.38656	8.69663	[.000]
DGREG5	20.8759	2.38549	8.75119	[.000]
DGDEPTH	.163290E-04	.530570E-05	3.07763	[.002]
DGWELL	.143733	.028666	5.01403	[.000]
DGRHO	.703937	.055202	12.7519	[.000]

Standard Errors computed from quadratic form of analytic first derivatives (Gauss)

Equation: DOIL
Dependent variable: LDO_LEQ

```
       Mean of dep. var. = 12.0125
  Std. dev. of dep. var. = .179325
Sum of squared residuals = .715547
   Variance of residuals = .715547E-02
Std. error of regression = .084590
               R-squared = .776599
           Durbin-Watson = 1.89374 [<.882]
```

Equation: DGAS
Dependent variable: LDG_LEQ

```
       Mean of dep. var. = 10.7517
  Std. dev. of dep. var. = .145721
Sum of squared residuals = .228672
   Variance of residuals = .228672E-02
Std. error of regression = .047820
               R-squared = .891237
           Durbin-Watson = 1.24518 [<.020]
```

Onshore Operating Cost Equations

Operating costs were hypothesized to be a function of drilling, depth, and a time trend that proxies for the cumulative effect of technological advances on costs. The form of the equation was assumed to be log-linear. The equations were estimated in log-linear form using Three Stage Least Squares (3SLS) technique. The forms of the equations are:

Onshore Regions

$$LOPC_{r,k,t} = \ln(\varphi0)_{r,k} + \ln(\varphi1)_k * DEPTH_{r,k,t} + \varphi2_k * LESUCWELL_{k,t} + \varphi3_k * TIME_t + \rho_k * LOPC_{r,k,t-1} - \rho_k * (\ln(\varphi0)_{r,k} + \ln(\varphi1)_k * DEPTH_{r,k,t-1} * \varphi2_k * LESUCWELL_{k,t-1} + \varphi3_k * TIME_{t-1})$$

Results

Mapping of variable names from the above equation to the following TSP output

Variable/Parameter	Shallow Oil	Shallow Gas	Deep Oil	Deep Gas
LOPC	LSOILC	LSGASC	LDOILC	LDGASC
$\ln(\varphi0)_1$	SOREG1	SGREG1	--	--
$\ln(\varphi0)_2$	SOREG2	SGREG2	DOREG2	DGREG2
$\ln(\varphi0)_3$	SOREG3	SGREG3	DOREG3	DGREG3
$\ln(\varphi0)_4$	SOREG4	SGREG4	DOREG4	DGREG4
$\ln(\varphi0)_5$	SOREG5	SGREG5	DOREG5	DGREG5
$\ln(\varphi0)_6$	SOREG6	SGREG6	--	--
$\varphi1$	SODEPTH	SGDEPTH	DODEPTH	DGDEPTH
$\varphi2$	SOWELL	SGWELL	DOWELL	DGWELL
$\varphi3$	TECH	TECH	TECH	TECH
ρ	SORHO	SGRHO	DORHO	DGRHO

THREE STAGE LEAST SQUARES

EQUATIONS: SOIL SGAS

INSTRUMENTS: REGION1 REGION6 REGION2 REGION3 REGION4 REGION5
SG_DPTH SO_DPTH SG_DPTH(-1) SO_DPTH(-1) RPGAS RPOIL RPGAS(-1)
RPOIL(-1) YEAR SUCWELL(-1) LSGASC(-1) LSOILC(-1)

Number of Observations = 120

Parameter	Estimate	Standard Error	t-statistic	P-value
SOREG1	19.7329	4.73937	4.16362	[.000]
SOREG2	19.8498	4.73884	4.18873	[.000]
SOREG3	19.4884	4.73855	4.11274	[.000]
SOREG4	19.5184	4.73874	4.11891	[.000]
SOREG5	19.9332	4.73466	4.21007	[.000]
SOREG6	19.9044	4.74014	4.19913	[.000]
SODEPTH	.946487E-04	.953023E-05	9.93141	[.000]
SOWELL	.609541E-05	.927934E-06	6.56879	[.000]
TECH	-.541966E-02	.237814E-02	-2.27895	[.023]
SORHO	.769252	.056975	13.5015	[.000]
SGREG1	19.5708	4.73677	4.13167	[.000]
SGREG2	20.0209	4.73384	4.22933	[.000]
SGREG3	19.9579	4.73792	4.21237	[.000]
SGREG4	20.1155	4.73428	4.24891	[.000]
SGREG5	20.2424	4.73299	4.27687	[.000]
SGREG6	19.6084	4.73393	4.14210	[.000]
SGDEPTH	.478768E-04	.439728E-05	10.8878	[.000]
SGWELL	.403359E-05	.590399E-06	6.83197	[.000]
SGRHO	.600537	.069593	8.62923	[.000]

Standard Errors computed from quadratic form of analytic first derivatives (Gauss)

Equation: SOIL
Dependent variable: LSOILC

Mean of dep. var. = 9.51393
Std. dev. of dep. var. = .311544
Sum of squared residuals = .560455
Variance of residuals = .467046E-02
Std. error of regression = .068341
R-squared = .951571
Durbin-Watson = 1.80935 [<.779]

Equation: SGAS
Dependent variable: LSGASC

Mean of dep. var. = 9.51859
Std. dev. of dep. var. = .288909
Sum of squared residuals = .179297
Variance of residuals = .149414E-02
Std. error of regression = .038654
R-squared = .981949
Durbin-Watson = 2.29087 [<1.00]

THREE STAGE LEAST SQUARES

EQUATIONS: DOIL DGAS

INSTRUMENTS: REGION2 REGION3 REGION4 REGION5 DG_DPTH DO_DPTH
DG_DPTH(-1) DO_DPTH(-1) RPGAS RPOIL YEAR LDGASC(-1) LDOILC(-1)
SUCWELL(-1)

Number of Observations = 80

Parameter	Estimate	Standard Error	t-statistic	P-value
DOREG2	16.4358	2.96641	5.54064	[.000]
DOREG3	16.2109	2.96659	5.46448	[.000]
DOREG4	16.2038	2.96615	5.46292	[.000]
DOREG5	16.4152	2.96584	5.53476	[.000]
DODEPTH	-.108916E-04	.118388E-04	-.919992	[.358]
DOWELL	.551732E-05	.675628E-06	8.16621	[.000]
TECH	-.321269E-02	.148901E-02	-2.15760	[.031]
DORHO	.655473	.062263	10.5275	[.000]
DGREG2	15.8203	2.95966	5.34532	[.000]
DGREG3	15.7774	2.95868	5.33259	[.000]
DGREG4	15.7656	2.95892	5.32817	[.000]
DGREG5	15.9259	2.95919	5.38187	[.000]
DGDEPTH	.335244E-04	.439767E-05	7.62323	[.000]
DGWELL	.458022E-05	.500397E-06	9.15317	[.000]
DGRHO	.379875	.096118	3.95220	[.000]

Standard Errors computed from quadratic form of analytic first derivatives (Gauss)

Equation: DOIL
Dependent variable: LDOILC

Mean of dep. var. = 9.97100
Std. dev. of dep. var. = .158303
Sum of squared residuals = .155270
Variance of residuals = .194088E-02
Std. error of regression = .044055
R-squared = .921664
Durbin-Watson = 1.81815 [<.791]

Equation: DGAS
Dependent variable: LDGASC

Mean of dep. var. = 9.99262
Std. dev. of dep. var. = .119709
Sum of squared residuals = .076420
Variance of residuals = .955244E-03
Std. error of regression = .030907
R-squared = .932548
Durbin-Watson = 2.08376 [<.977]

Lower 48 Onshore Well Equations

Each of the onshore wells equations were estimated using panel data, i.e., data across regions over time. For oil and shallow gas, this included data for each of the six onshore regions over the sample period 1978-1999; for deep gas, this included data for onshore regions 2 through 5 over the same time period. The estimation procedures employed tested and corrected for the two econometric problems of cross sectional heteroscedasticity and first order serial correlation. Where necessary, the estimation corrected for first-order serial correlation. The econometric software package used for all estimations was TSP Version 4.4.

Oil Exploratory

$$\ln WELLSON_{i,r,k,t} = m0_{i,k} + m1_{i,k} \ln DCFON_{i,r,k,t-1} + m2_{i,k} \ln(CASHFLOW_t * \frac{r\_UND_{r,k,t}}{UND\_78_{r,k}}) + \rho_{i,k} \ln WELLSON_{i,r,k,(t-1)}$$

$$-\rho_{i,k}(m0_{i,k} + m1_{i,k} \ln DCFON_{i,r,k,t-2} + m2_{i,k} \ln(CASHFLOW_{t-1} * \frac{r\_UND_{r,k,t-1}}{UND\_78_{r,k}}))$$

i=1, r=1-6, k=1

```
Dependent variable: LNWELLSON
Number of observations:  126

(Statistics based on transformed data)  (Statistics based on original data)
          Mean of dep. var. = .118976          Mean of dep. var. = 6.48730
     Std. dev. of dep. var. = .498710     Std. dev. of dep. var. = 2.59229
   Sum of squared residuals = 13.0170   Sum of squared residuals = 22.1971
      Variance of residuals = .106697      Variance of residuals = .181944
   Std. error of regression = .326645   Std. error of regression = .426548
                  R-squared = .642125                  R-squared = .974217
         Adjusted R-squared = .633325         Adjusted R-squared = .973583
              Durbin-Watson = 1.38493              Durbin-Watson = 1.16243
Rho (autocorrelation coef.) = .974045
             Log likelihood = -44.6886
```

Parameter	Estimate	Standard Error	t-statistic	P-value
m0	-4.11050	2.30789	-1.78106	[.075]
m1	.658667	.146343	4.50086	[.000]
m2	.647987	.171629	3.77551	[.000]
ρ	.974045	.013188	73.8582	[.000]

Oil Development

$$\ln WELLSON_{i,r,k,t} = m0_{i,k} + m1_{i,k} \ln DCFON_{i,r,k,t-1} + m2_{i,k} \ln(CASHFLOW_t * \frac{r\_UND_{r,k,t}}{UND\_78_{r,k}}) + \rho_{i,k} \ln WELLSON_{i,r,k,(t-1)}$$

$$-\rho_{i,k}(m0_{i,k} + m1_{i,k} \ln DCFON_{i,r,k,t-2} + m2_{i,k} \ln(CASHFLOW_{t-1} * \frac{r\_UND_{r,k,t-1}}{UND\_78_{r,k}}))$$

i=2, r=1-6, k=1

```
Dependent variable: LNWELLSON
Number of observations:  126

(Statistics based on transformed data)  (Statistics based on original data)
          Mean of dep. var. = .209870          Mean of dep. var. = 7.80525
     Std. dev. of dep. var. = .468331     Std. dev. of dep. var. = .948487
   Sum of squared residuals = 7.68401   Sum of squared residuals = 14.4782
      Variance of residuals = .062984      Variance of residuals = .118673
   Std. error of regression = .250966   Std. error of regression = .344490
                  R-squared = .752121                  R-squared = .873092
         Adjusted R-squared = .746026         Adjusted R-squared = .869972
              Durbin-Watson = 1.33747              Durbin-Watson = 1.06188
Rho (autocorrelation coef.) = .973768
             Log likelihood = -11.4489

                         Standard
Parameter  Estimate        Error       t-statistic   P-value
WT         -19.3787      12.7311       -1.52215      [.128]
SODDCF_1   1.67339       .778327       2.14999       [.032]
CF_ORES    .997636       .141236       7.06359       [.000]
RHO        .973768       .013409       72.6204       [.000]
```

Shallow Gas Exploratory

$$\ln WELLSON_{i,r,k,t} = m0_{i,k} + m00 * REG6 + m1_{i,k} \ln DCFON_{i,r,k,t} + m2_{i,k} \ln(CASHFLOW_t * \frac{r\_UND_{r,k,t}}{UND\_78_{r,k}}) + \rho_{i,k} \ln WELLSON_{i,r,k,(t-1)}$$

$$-\rho_{i,k}(m0_{i,k} + m00 * REG6 + m1_{i,k} \ln DCFON_{i,r,k,t-1} + m2_{i,k} \ln(CASHFLOW_{t-1} * \frac{r\_UND_{r,k,t-1}}{UND\_78_{r,k}}))$$

i=1, r=1-6, k=3

```
Dependent variable: LNWELLSON
Number of observations:  126

(Statistics based on transformed data)  (Statistics based on original data)
          Mean of dep. var. = .874096          Mean of dep. var. = 11.8714
     Std. dev. of dep. var. = 1.04666     Std. dev. of dep. var. = 2.43030
   Sum of squared residuals = 33.8060   Sum of squared residuals = 47.2647
      Variance of residuals = .279388      Variance of residuals = .390617
   Std. error of regression = .528572   Std. error of regression = .624994
                  R-squared = .783270                  R-squared = .936914
         Adjusted R-squared = .776106         Adjusted R-squared = .934829
              Durbin-Watson = 1.98468              Durbin-Watson = 1.68344
Rho (autocorrelation coef.) = .931479
             Log likelihood = -101.968
```

Parameter	Estimate	Standard Error	t-statistic	P-value
m0	2.00949	1.89009	1.06317	[.288]
m00	-1.51272	.460843	-3.28250	[.001]
m1	.256212	.118362	2.16464	[.030]
m2	.223124	.128128	1.74142	[.082]
ρ	.931479	.029305	31.7857	[.000]

Shallow Gas Development

$$\ln WELLSON_{i,r,k,t} = m0_{i,k} + m00_r * REG_r + m1_{i,k} \ln DCFON_{i,r,k,t} + m2_{i,k} \ln(CASHFLOW_t * \frac{r\_UND_{r,k,t}}{UND\_78_{r,k}}) + \rho_{i,k} \ln WELLSON_{i,r,k,(t-1)}$$

$$-\rho_{i,k}(m0_{i,k} + m00_r * REG_r + m1_{i,k} \ln DCFON_{i,r,k,t-1} + m2_{i,k} \ln(CASHFLOW_{t-1} * \frac{r\_UND_{r,k,t-1}}{UND\_78_{r,k}}))$$

i=2, r=1-6, k=3

```
Dependent variable: LNWELLSON
Number of observations:  132

(Statistics based on transformed data)  (Statistics based on original data)
          Mean of dep. var. = .377436           Mean of dep. var. = 9.66442
     Std. dev. of dep. var. = 2.31304      Std. dev. of dep. var. = 7.61400
   Sum of squared residuals = 34.7313    Sum of squared residuals = 39.8986
      Variance of residuals = .280091       Variance of residuals = .321763
   Std. error of regression = .529236    Std. error of regression = .567241
                  R-squared = .950614                   R-squared = .994896
         Adjusted R-squared = .947826          Adjusted R-squared = .994608
              Durbin-Watson = 2.06402               Durbin-Watson = 1.93301
Rho (autocorrelation coef.) = .960851
             Log likelihood = -100.463
```

Parameter	Estimate	Standard Error	t-statistic	P-value
m0	-19.6781	2.61942	-7.51239	[.000]
$m00_2$	2.38009	.652606	3.64705	[.000]
$m00_3$	3.82728	1.01405	3.77425	[.000]
$m00_4$	3.70514	.741413	4.99740	[.000]
$m00_5$	3.68481	.645295	5.71028	[.000]
m1	1.43354	.143177	10.0124	[.000]
m2	.891069	.261191	3.41157	[.001]
ρ	.960851	.023548	40.8042	[.000]

Deep Gas Exploratory

$$\ln WELLSON_{i,r,k,t} = m0_{i,k} + m00_r * REG_r + m1_{i,k} \ln DCFON_{i,r,k,t-1} + m2_{i,k} \ln(CASHFLOW_t * \frac{r\_UND_{r,k,t}}{UND\_78_{r,k}}) + \rho_{i,k} \ln WELLSON_{i,r,k,(t-1)}$$

$$-\rho_{i,k}(m0_{i,k} + m00_r * REG_r + m1_{i,k} \ln DCFON_{i,r,k,t-2} + m2_{i,k} \ln(CASHFLOW_{t-1} * \frac{r\_UND_{r,k,t-1}}{UND\_78_{r,k}}))$$

i=1, r=1-6, k=4

```
Dependent variable: LNWELLSON
Number of observations:  84

(Statistics based on transformed data)  (Statistics based on original data)
          Mean of dep. var. = 2.48656           Mean of dep. var. = 4.16816
     Std. dev. of dep. var. = .865887      Std. dev. of dep. var. = 1.13827
   Sum of squared residuals = 12.1810    Sum of squared residuals = 12.4260
      Variance of residuals = .158195       Variance of residuals = .161376
   Std. error of regression = .397738    Std. error of regression = .401717
                  R-squared = .807740                   R-squared = .884812
         Adjusted R-squared = .792759          Adjusted R-squared = .875837
              Durbin-Watson = 1.86878               Durbin-Watson = 1.85192
Rho (autocorrelation coef.) = .416712
             Log likelihood = -38.4730
```

Parameter	Estimate	Standard Error	t-statistic	P-value
m0	-1.05695	.463644	-2.27965	[.023]
$m00_3$	-2.97762	.863622	-3.44783	[.001]
$m00_4$	-3.91130	1.08098	-3.61831	[.000]
$m00_5$	-3.82831	1.11250	-3.44118	[.001]
m1	.542708	.125775	4.31490	[.000]
m2	.683554	.132650	5.15308	[.000]
ρ	.416712	.127773	3.26135	[.001]

Deep Gas Development

$$\ln WELLSON_{i,r,k,t} = m0_{i,k} + m00_r * REG_r + m1_{i,k} \ln DCFON_{i,r,k,t-1} + m2_{i,k} \ln(CASHFLOW_t * \frac{r\_UND_{r,k,t}}{UND\_78_{r,k}}) + \rho_{i,k} \ln WELLSON_{i,r,k,(t-1)}$$

$$-\rho_{i,k}(m0_{i,k} + m00_r * REG_r + m1_{i,k} \ln DCFON_{i,r,k,t-2} + m2_{i,k} \ln(CASHFLOW_{t-1} * \frac{r\_UND_{r,k,t-1}}{UND\_78_{r,k}}))$$

i=2, r=1-6, k=4

```
Dependent variable: LNDGDW
Number of observations:  84

(Statistics based on transformed data)  (Statistics based on original data)
          Mean of dep. var. = 5.96878            Mean of dep. var. = 18.3746
     Std. dev. of dep. var. = 4.64393       Std. dev. of dep. var. = 12.6247
   Sum of squared residuals = 44.3324     Sum of squared residuals = 45.7795
      Variance of residuals = .575745        Variance of residuals = .594540
   Std. error of regression = .758779     Std. error of regression = .771064
                  R-squared = .975370                    R-squared = .996543
         Adjusted R-squared = .973451           Adjusted R-squared = .996273
              Durbin-Watson = 1.90480                Durbin-Watson = 1.86901
Rho (autocorrelation coef.) = .695235
             Log likelihood = -93.6694
```

Parameter	Estimate	Standard Error	t-statistic	P-value
m0	-21.4843	6.15762	-3.48906	[.000]
$m00_3$	-.687584	.191756	-3.58573	[.000]
$m00_4$	-2.49963	.244572	-10.2204	[.000]
$m00_5$	-2.65629	.296266	-8.96592	[.000]
m1	1.74053	.376262	4.62584	[.000]
m2	.520042	.149166	3.48633	[.000]
ρ	.695235	.078834	8.81901	[.000]

Lower 48 Onshore Success Rates

Exploratory and developmental success rate equations were estimated using pooled cross section/time series for the six onshore regions over the 1978-1998 time period. Since success rates are bounded between 0 and 1, the logistical form of the dependent variable was employed in the estimation. Estimation corrected for cross sectional heteroscedasticity and first order serial correlation. The form of the estimating equation is the same for both exploratory and development and is given by:

$$\begin{aligned}\ln\left(\frac{SR_{i,r,t}}{1-SR_{i,r,t}}\right) &= u0_{i,r} + u1_i \ln CUMSUCWELLS_{i,r,t} + u2_i\, YEAR_t \\ &+ \rho_i \ln\left(\frac{SR_{i,r,t-1}}{1-SR_{i,r,t-1}}\right) - \rho_i\,(u0_{i,r} + u1_i \ln CUMSUCWELLS_{i,r,t-1} \\ &+ u2_i\, YEAR_{t-1})\end{aligned}$$

Exploratory Success Rate

Dependent variable: $\ln[SR_{1,r,t} / (1- SR_{1,r,t})]$
Number of observations: 126

(Statistics based on transformed data)		(Statistics based on original data)	
Mean of dep. var. =	-.592305	Mean of dep. var. =	-1.89733
Std. dev. of dep. var. =	.480823	Std. dev. of dep. var. =	.689322
Sum of squared residuals =	24.5124	Sum of squared residuals =	26.1424
Variance of residuals =	.209508	Variance of residuals =	.223439
Std. error of regression =	.457720	Std. error of regression =	.472693
R-squared =	.152520	R-squared =	.560102
Adjusted R-squared =	.094573	Adjusted R-squared =	.530024
Durbin-Watson =	1.77160	Durbin-Watson =	1.71986
Rho (autocorrelation coef.) =	.700128		
Log likelihood =	-77.6700		

Parameter	Estimate	Standard Error	t-statistic	P-value
$u0_{1,1}$	-66.5787	23.7772	-2.80010	[.005]
$u0_{1,2}$	-66.2847	23.7551	-2.79034	[.005]
$u0_{1,3}$	-66.6297	23.7804	-2.80188	[.005]
$u0_{1,4}$	-66.8373	23.7878	-2.80973	[.005]
$u0_{1,5}$	-66.4170	23.8018	-2.79042	[.005]
$u0_{1,6}$	-66.9183	23.8988	-2.80008	[.005]
u1	-.193080	.082515	-2.33993	[.019]
u2	.033820	.012223	2.76686	[.006]
ρ	.700128	.068339	10.2449	[.000]

Development Success Rate

Dependent variable: $\ln[SR_{2,r,t} /(1- SR_{2,r,t})]$
Number of observations: 126

(Statistics based on transformed data)		(Statistics based on original data)	
Mean of dep. var.	.945705	Mean of dep. var.	2.60106
Std. dev. of dep. var.	.347367	Std. dev. of dep. var.	.480625
Sum of squared residuals	7.78649	Sum of squared residuals	7.93766
Variance of residuals	.066551	Variance of residuals	.067843
Std. error of regression	.257975	Std. error of regression	.260467
R-squared	.483842	R-squared	.725106
Adjusted R-squared	.448550	Adjusted R-squared	.706310
Durbin-Watson	1.63320	Durbin-Watson	1.62286
Rho (autocorrelation coef.)	.658906		
Log likelihood	-5.10940		

Parameter	Estimate	Standard Error	t-statistic	P-value
$u0_{1,1}$	-69.4808	16.9452	-4.10033	[.000]
$u0_{1,2}$	-70.2935	16.9688	-4.14252	[.000]
$u0_{1,3}$	-70.3074	16.9515	-4.14756	[.000]
$u0_{1,4}$	-69.8139	16.9585	-4.11674	[.000]
$u0_{1,5}$	-69.5172	17.0016	-4.08887	[.000]
$u0_{1,6}$	-68.1987	17.0193	-4.00713	[.000]
u1	-.105456	.054917	-1.92029	[.055]
u2	.036470	.876880E-02	4.15902	[.000]
ρ	.658906	.071044	9.27462	[.000]

Lower 48 Onshore Finding Rates

NEW FIELD WILDCAT FINDING RATE FOR LOWER 48 ONSHORE OIL

Oil discoveries per successful oil new field wildcat were hypothesized to be a function of drilling activity and the volume of remaining undiscovered resources. The coefficient on the resource base in the regression was permitted to vary across regions. The variables depth and the time trend were not included based on the results of a preliminary regression. The preliminary results also indicated the presence of heteroscadisticity and autocorrelation. The results presented below correct for these problems.

FORM OF FORECASTING EQUATION:

$$FR1_{r,t} = e^{-26.9339} * R\_UND_{r,t}^{\beta_r} * e^{-0.00571516 * NFW_{r,t}}$$

for r = 1 through 5.

FIRST-ORDER SERIAL CORRELATION OF THE ERROR

Dependent variable: LNFR1
Number of observations: 120 **(NOTE: Region 6 *not included* in estimation.)**

(Statistics based on transformed data)		(Statistics based on original data)	
Mean of dep. var.	-2.59266	Mean of dep. var.	-3.28180
Std. dev. of dep. var.	2.38697	Std. dev. of dep. var.	2.65368
Sum of squared residuals	47.1465	Sum of squared residuals	47.2363
Variance of residuals	.420951	Variance of residuals	.421753
Std. error of regression	.648808	Std. error of regression	.649425
R-squared	.930464	R-squared	.943633
Adjusted R-squared	.926118	Adjusted R-squared	.940110
Durbin-Watson	1.93284	Durbin-Watson	1.92988
Rho (autocorrelation coef.)	.224849		
Standard error of rho	.092236		
t-statistic for rho	2.43775		
Log likelihood	-114.348		

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
WT	-26.9339	4.29611	-6.26935	[.000]
R_UND1	3.33362	.587722	5.67210	[.000]
R_UND2	2.93735	.505347	5.81254	[.000]
R_UND3	3.39351	.597694	5.67767	[.000]
R_UND4	3.03254	.527563	5.74820	[.000]
R_UND5	2.85992	.494264	5.78622	[.000]
NFW	-.571516E-02	.171252E-02	-3.33728	[.001]
DUMMY	-6.88513	.213466	-32.2539	[.000]

LNFR1 = natural log of new field wildcat finding rate
WT = overall constant
R_UNDr = natural log of remaining undiscovered resources (coefficients vary by region)
NFW = number of new field wildcats
DUMMY = 1 if discoveries were "guesstimated", 0 otherwise (not included in forecasting equation)

NEW FIELD WILDCAT FINDING RATE FOR LOWER 48 ONSHORE CONVENTIONAL GAS

Gas discoveries per successful gasl new field wildcat were hypothesized to be a function of drilling activity, well depth, and the volume of remaining undiscovered resources. The coefficient on the resource base in the regression was permitted to vary across regions. The time trend was not included based on the results of a preliminary regression. The preliminary results also indicated the presence of heteroscadisticity and autocorrelation. The results presented below correct for these problems.

FORM OF FORECASTING EQUATION:

$$FR1_{r,t} = e^{-21.7035} * R\_UNDr_{r,t}^{\beta_r} * e^{-0.00516455*NFW_{r,t}+0.000129571*NFW\_FT_{r,t}} * FR1_{r,t-1}^{0.145920} * e^{-0.145920*(-21.7035)}$$
$$* R\_UNDr_{r,t-1}^{-0.145920*\beta_r} * e^{-0.145920*(-0.00516455*NFW_{r,t-1}+0.000129571*NFW\_FT_{r,t-1})}$$

for r = 1 through 6.

FIRST-ORDER SERIAL CORRELATION OF THE ERROR

```
Dependent variable: LNFR1
 Number of observations:  138

        Mean of dep. var. = -.216048           Adjusted R-squared = .833108
   Std. dev. of dep. var. = 2.52105                 Durbin-Watson = 1.92241
 Sum of squared residuals = 134.712   Rho (autocorrelation coef.) = .145920
    Variance of residuals = 1.06072                Schwarz B.I.C. = 221.288
 Std. error of regression = 1.02991                Log likelihood = -194.188
                R-squared = .845290
```

Parameter	Estimate	Standard Error	t-statistic	P-value
WT	-21.7035	4.73362	-4.58496	[.000]
R_UND1	2.32999	.536208	4.34530	[.000]
R_UND2	1.95811	.440443	4.44576	[.000]
R_UND3	2.13446	.488132	4.37271	[.000]
R_UND4	2.20902	.507742	4.35068	[.000]
R_UND5	2.06663	.489513	4.22182	[.000]
R_UND6	2.44430	.545646	4.47964	[.000]
NFW	-.516455E-02	.204831E-02	-2.52137	[.012]
NFW_FT	.129571E-03	.633813E-04	2.04431	[.041]
DUMMY	-7.44068	.366714	-20.2902	[.000]
RHO	.145920	.085721	1.70225	[.089]

LNFR1 = natural log of new field wildcat finding rate, FR1, where FR1 is equal new reserve discoveries divided by successful new field wildcats drilled
WT = overall constant
R_UNDr = natural log of remaining undiscovered resources in region r, for r=1-6
NFW = number of successful new field wildcats drilled
NFW_FT = average depth of new field wildcat
DUMMY = 1, if discoveries were "guesstimated", 0, otherwise. (not used in forecasting equation)

LOWER 48 ONSHORE OTHER EXPLORATORY FINDING RATES

The other exploratory finding rate equations for oil and natural gas were each estimated using a panel data set for the six onshore regions over the 1978-2000 time period. Equations were estimated with corrections for cross sectional heteroscedasticity and first order serial correlation.

OTHER EXPLORATORY FINDING RATE EQUATION FOR OIL

FORM OF FORECASTING EQUATION:

$$FR2_{r,t} = e^{-75.5168} R\_INFR_{r,t}^{0.573281} e^{-0.00316826*OEXPWL_{r,t}+0.035384*YEAR} FR2_{r,t-1}^{0.778131}$$
$$e^{(-0.778131)*(-75.5168)} R\_INFR_{r,t}^{-0.778131*0.573281} e^{-0.778131*(-0.00316826*OEXPWL_{r,t}+0.035384*YEAR)}$$

for r = 1 through 6.

```
FIRST-ORDER SERIAL CORRELATION OF THE ERROR

Dependent variable: LNFR2
Number of observations:  144

(Statistics based on transformed data)  (Statistics based on original data)
          Mean of dep. var. = -.086546          Mean of dep. var. = -.504517
     Std. dev. of dep. var. = .681084      Std. dev. of dep. var. = 1.34277
   Sum of squared residuals = 51.4726   Sum of squared residuals = 52.5306
      Variance of residuals = .367662      Variance of residuals = .375218
   Std. error of regression = .606351   Std. error of regression = .612551
                  R-squared = .225585                  R-squared = .798491
         Adjusted R-squared = .208991         Adjusted R-squared = .794173
              Durbin-Watson = 2.26177              Durbin-Watson = 2.23205
Rho (autocorrelation coef.) = .778131
      Standard error of rho = .054817
        t-statistic for rho = 14.1950
             Log likelihood = -133.047
```

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
WT	-75.5168	36.9216	-2.04533	[.041]
R_INFR	.573281	.161476	3.55026	[.000]
OEXPWL	-.316826E-02	.676785E-03	-4.68134	[.000]
YEAR	.035384	.018350	1.92829	[.054]

LNFR2 = natural log of other exploratory finding rate
WT = overall constant
R_INFR = natural log of remaining inferred reserves
OEXPWL = successful other exploratory wells
YEAR = calendar year

OTHER EXPLORATORY FINDING RATE EQUATION FOR CONVENTIONAL GAS

FORM OF FORECASTING EQUATION:

$$FR2_{r,t} = e^{-61.0930} R\_INFR_{r,t}^{0.349387} e^{-0.00275498*OEXPWL_{r,t}+0.0000525444*OEXP\_FT_{r,t}+0.030048*YEAR} FR2_{r,t-1}^{0.802450}$$
$$e^{(-0.802450)*(-61.0930)} R\_INFR_{r,t}^{-0.802450*0.349387} e^{-0.802450*(-0.00275498*OEXPWL_{r,t}+0.0000525444*OEXP\_FT_{r,t}+0.030048*YEAR)}$$

for r = 1 through 6.

FIRST-ORDER SERIAL CORRELATION OF THE ERROR

Dependent variable: LNFR2
Number of observations: 132

Mean of dep. var.	= 3.76883	Adjusted R-squared	= .937784
Std. dev. of dep. var.	= 2.52737	Durbin-Watson	= 1.43192
Sum of squared residuals	= 50.2993	Rho (autocorrelation coef.)	= .802450
Variance of residuals	= .399201	Schwarz B.I.C.	= 138.012
Std. error of regression	= .631824	Log likelihood	= -123.363
R-squared	= .940158		

Parameter	Estimate	Standard Error	t-statistic	P-value
WT	-61.0930	30.8322	-1.98147	[.048]
R_INFR	.349387	.075475	4.62918	[.000]
OEXPWL	-.275498E-02	.736171E-03	-3.74232	[.000]
OEXP_FT	.525444E-04	.259261E-04	2.02670	[.043]
YEAR	.030048	.015468	1.94260	[.052]
RHO	.802450	.050412	15.9177	[.000]

LNFR2 = natural log of two-year weighted average FR2, i.e.,

FR2 = (extensions in t + extensions in t-1) divided by
(other exploratory wells in t + other exploratory wells in t-1)

WT = overall constant
R_INFR = natural log of remaining inferred reserves
OEXPWL = successful other exploratory wells drilled
OEXP_FT = average depth of other exploratory wells
YEAR = calendar year

Lower 48 Onshore Crude Oil and Natural Gas Revisions

Reserve revisions are an extremely important source of reserve additions. For instance, over the period 1990-97, revisions added almost nine Tcf to conventional gas reserves in the onshore Gulf Coast Region alone. Unfortunately, the determinants of revisions are not well understood and thus projecting revisions is somewhat problematic.

In contrast to previous efforts that sought to project revisions per developmental well directly, this effort defines the dependent variable as

LN((REVISIONS+BOYRESERVES)/BOYRESERVES)

where BOYRESERVES are reserves at the beginning of the year. This formulation associates revisions with their base from which reserves are revised up or down.

The analysis also includes a measure of inferred reserves as an explanatory variable. Specifically, the variable is REMAIN which is defined as

LN((INFERRED_RESERVES+BOYRESERVES)/BOYRESERVES)

Revisions occur in part because of new information. In this spirit, previous efforts have attempted to associate revisions to current developmental drilling. This analysis notes that past developmental drilling may provide information that leads to current revisions. Accordingly, the analysis uses cumulative developmental drilling (including current drilling) as an explanatory variable. As a result, the equations forecast total revisions as opposed to revisions per well drilled.

The analysis also employs price as an explanatory variable. In the case of oil, the relationship was found to be nonlinear. This was not the case for natural gas.

General Form of the Equation:

$$\begin{aligned} REVISION_{r,k,t} = {} & (e^{B0_{r,k}} * ((R\_INFR_{r,k,t} + BOYRES_{r,k,t}) / BOYRES_{r,k,t})^{B1_{r,k}} \\ & * e^{(B2*WHP_{r,k,t})} * e^{(B3*WHP^2_{r,t,t})} * e^{(B4*WHP_{r,k,t}/WHP_{r,k,t-1})} * e^{B5*CUMDWL_{r,k,t})}) - 1) \\ & * BOYRES_{r,k,t} \end{aligned}$$

where

r = region
k = fuel (oil, gas)
t = year
R_INFR = remaining inferred reserves at beginning of year
BOYRES = beginning of year proved reserves
WHP = wellhead price
CUMDWL = cumulative number of development wells through the end of year t

Results: Crude Oil

Dependent variable: LN((REVISION+BOYRESERVES)/BOYRESERVES))

Number of observations: 144

Mean of dep. var.	= 1.66286	LM het. test	= .041794 [.838]
Std. dev. of dep. var.	= 1.35983	Durbin-Watson	= 1.99243 [<.925]
Sum of squared residuals	= 142.136	Jarque-Bera test	= .198033 [.906]
Variance of residuals	= 1.11044	Ramsey's RESET2	= 1.91558 [.169]
Std. error of regression	= 1.05377	F (zero slopes)	= 7.34196 [.000]
R-squared	= .462477	Schwarz B.I.C.	= 243.148
Adjusted R-squared	= .399486	Log likelihood	= -203.389

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
REG1	-.541106	.153139	-3.53344	[.001]
REG2	-.248586	.054247	-4.58245	[.000]
REG3	-1.10624	.221213	-5.00079	[.000]
REG4	-.933665	.154836	-6.03004	[.000]
REG5	-.355171	.132484	-2.68085	[.008]
REG6	-.369608	.156335	-2.36421	[.020]
REMAIN1	.297223	.110831	2.68178	[.008]
REMAIN2	.113628	.062487	1.81843	[.071]
REMAIN3	.587352	.131341	4.47197	[.000]
REMAIN4	.504829	.096822	5.21399	[.000]
REMAIN5	.134031	.065475	2.04705	[.043]
REMAIN6	.190950	.118029	1.61783	[.108]
REALWHP	.738073E-02	.249324E-02	2.96030	[.004]
REALWHP_SQ	-.121759E-03	.481235E-04	-2.53013	[.013]
DELTA_WELLHEAD_PRICE	.041220	.013957	2.95340	[.004]
CUM_DEV_WELLS	.143406E-05	.221573E-06	6.47218	[.000]

REGr = B0: regional constant
REMAINr = B1: measure of inferred reserves
REALWHP = B2: wellhead price
REALWHP_SQ = B3: wellhead price squared
DELTA_WELLHEAD_PRICE = B4: ratio of wellhead prices in year t and t-1
CUM_DEV_WELLS = B5: cumulative developmental wells

Results: Conventional Natural Gas

Dependent variable: LN((REVISION+BOYRESERVES)/BOESERVES))
Number of observations: 114

Mean of dep. var.	= .194646	LM het. test	= .166320 [.683]
Std. dev. of dep. var.	= 1.47659	Durbin-Watson	= 2.11519 [<.984]
Sum of squared residuals	= 109.717	Jarque-Bera test	= 1.73406 [.420]
Variance of residuals	= 1.10825	Ramsey's RESET2	= .016533 [.898]
Std. error of regression	= 1.05273	F (zero slopes)	= 8.80791 [.000]
R-squared	= .554678	Schwarz B.I.C.	= 195.098
Adjusted R-squared	= .491703	Log likelihood	= -159.576

Variable	Estimated Coefficient	Standard Error	t-statistic	P-value
REG1	-1.17839	.206320	-5.71145	[.000]
REG2	-1.16502	.249514	-4.66916	[.000]
REG3	-.738633	.210781	-3.50427	[.001]
REG4	-1.19530	.297404	-4.01911	[.000]
REG5	-.102103	.124333	-.821210	[.413]
REG6	-.285817	.110373	-2.58955	[.011]
REMAIN1	.740842	.156798	4.72480	[.000]
REMAIN2	.617670	.141332	4.37036	[.000]
REMAIN3	.425990	.134749	3.16135	[.002]
REMAIN4	.906342	.247037	3.66885	[.000]
REMAIN5	.039167	.124313	.315070	[.753]
REMAIN6	.287130	.125106	2.29509	[.024]
REALWHP	.017753	.887748E-02	1.99978	[.048]
CUM_DEV_WELLS	.540568E-05	.966544E-06	5.59279	[.000]
CUM_DEV_WELLS_REG4	-.260401E-04	.107545E-04	-2.42131	[.017]

REGr = B0: regional constant
REMAINr = B1: measure of inferred reserves
REALWHP = B2: wellhead price
CUM_DEV_WELLS = B5: cumulative developmental wells

Price Elasticities of Short Run Supply

As noted in chapter 4, the PMM and NGTDM calculate production levels through the use of short-run supply functions that require estimates of the price elasticities of supply. The section below documents the estimations.

Onshore Lower 48 Oil

Price elasticities were estimated using the AR1 technique in TSP which corrects for serial correlation using the maximum likelihood iterative technique of Beach and MacKinnon (1978). Equations for onshore regions 1 and 6 were estimated separately due to the regions' unique characteristics. The functional form is given by:

$$\begin{aligned} LCRUDE_t = \; & a0 + a1 * LOILRES_t + a2 * LPOIL_t + \rho * LCRUDE_{t-1} \\ & - \rho * (a0 + a1 * LOILRES_{t-1} + a2 * LPOIL_{t-1}) \end{aligned}$$

where,

LCRUDE	=	natural log of crude oil production
LOILRES	=	natural log of beginning of year oil reserves
LPOIL	=	natural log of the regional wellhead price of oil in 1987 dollars
ρ	=	autocorrelation parameter
t	=	year.

Region 1

Results

Variable	Estimated Coefficient	Standard Error	t-statistic
a0	-.977125	.680644	-1.43559
LOILRES	.814563	.114311	7.12584
LPOIL	.08385	.040682	2.06115
ρ	.334416	.297765	1.12309

```
SAMPLE:  1978 to 1990
NUMBER OF OBSERVATIONS = 13

Dependent variable:  LCRUDE
(Statistics based on transformed data)
  Mean of dependent variable = 3.03941
 Std. dev. of dependent var. = .365187
    Sum of squared residuals = .015765
       Variance of residuals = .157651E-02
    Std. error of regression = .039705
                   R-squared = .990477
          Adjusted R-squared = .988573
     Durbin-Watson statistic = 1.58775
   F-statistic (zero slopes) = 502.556
  Log of likelihood function = 25.1414

(Statistics based on original data)
  Mean of dependent variable = 4.43559
 Std. dev. of dependent var. = .142410
    Sum of squared residuals = .015832
       Variance of residuals = .158323E-02
    Std. error of regression = .039790
                   R-squared = .936035
          Adjusted R-squared = .923242
     Durbin-Watson statistic = 1.57879
```

Region 6

Results

Variable	Estimated Coefficient	Standard Error	t-statistic
a0	6.69155	2.14661	3.11727
LOILRES	-.123763	.255535	-.484329
LPOIL	.031845	.038040	.837163
ρ	.833915	.135664	6.14691

```
SAMPLE:  1978 to 1990
NUMBER OF OBSERVATIONS = 13

Dependent variable:  LCRUDE
(Statistics based on transformed data)
  Mean of dependent variable = 1.13005
 Std. dev. of dependent var. = .605103
    Sum of squared residuals = .013218
       Variance of residuals = .132176E-02
    Std. error of regression = .036356
                   R-squared = .997230
          Adjusted R-squared = .996676
     Durbin-Watson statistic = .896816
   F-statistic (zero slopes) = 1657.10
  Log of likelihood function = 25.7519

(Statistics based on original data)
  Mean of dependent variable = 5.78242
 Std. dev. of dependent var. = .061666
    Sum of squared residuals = .014455
       Variance of residuals = .144552E-02
    Std. error of regression = .038020
                   R-squared = .707387
          Adjusted R-squared = .648864
     Durbin-Watson statistic = .892422
```

For onshore regions 2 through 5, the data were pooled and regional dummy variables were used to allow the estimated production elasticity to vary across the regions. Region 2 is taken as the base region. The form of the equation is given by:

$$\begin{aligned} LCRUDE_t = {} & a0 + a1*LOILRES_t + a2*LPOIL_t + a3*LPDUM3_t + a4*LPDUM4_t + \\ & a5*LPDUM5_t + \rho*LCRUDE_{t-1} - \rho*(a0 + a1*LOILRES_{t-1} + \\ & a2*LPOIL_{t-1} + a3*LPDUM3_{t-1} + a4*LPDUM4_{t-1} + a5*LPDUM5_{t-1}) \end{aligned}$$

where,

LPDUMr	=	DUMr*LPOIL
DUMr	=	a dummy variable that equals 1 if region=r and 0 otherwise
r	=	onshore regions 2 through 5
ρ	=	autocorrelation parameter
t	=	year.

Regions 2 through 5

Results

Variable	Estimated Coefficient	Standard Error	t-statistic
a0	1.38487	.646290	2.14279
LOILRES	.549313	.077877	7.05360
LPOIL	.105051	.032631	3.21932
LPDUM3	-.077217	.034067	-2.26660
LPDUM4	-.028657	.034318	-.835047
LPDUM5	-.089397	.032700	-2.73387
ρ	.867072	.080470	10.7751

```
SAMPLE:  1978 to 1990
NUMBER OF OBSERVATIONS = 52

Dependent variable:  LCRUDE
(Statistics based on transformed data)
  Mean of dependent variable = .936528
 Std. dev. of dependent var. = .612526
    Sum of squared residuals = .109259
       Variance of residuals = .237519E-02
    Std. error of regression = .048736
                   R-squared = .994731
          Adjusted R-squared = .994159
     Durbin-Watson statistic = 1.42150
   F-statistic (zero slopes) = 1602.00
  Log of likelihood function = 83.7253

(Statistics based on original data)
  Mean of dependent variable = 5.93153
 Std. dev. of dependent var. = .428916
    Sum of squared residuals = .110274
       Variance of residuals = .239725E-02
    Std. error of regression = .048962
                   R-squared = .988524
          Adjusted R-squared = .987277
     Durbin-Watson statistic = 1.40740
```

The estimated coefficient on LPOIL is the price elasticity of crude oil production for region 2. The elasticity for region r (r = 3,4,5) is obtained by adding the coefficient on $LPDUM_r$ to the coefficient on LPOIL.

Lower 48 Dry Non-Associated Natural Gas

The data for onshore regions 1 through 6 were pooled and a single regression equation estimated with dummy variables used to allow the slope coefficients to vary across regions. Region 1 was taken as the base region. The equation was estimated using the non-linear two stage least squares procedure in TSP. The form of the equation is given by:

$$LPROD = A0 + (A1 + \sum_r Ar * DUMr) * LGASRES + (B1 + \sum_r Br * DUMr) * LPGAS + C * DEDSHR$$

where,

LPROD	=	natural log of natural gas production
LGASRES	=	natural log of beginning of year natural gas reserves
LPGAS	=	natural log of the regional wellhead price of natural gas in 1987 dollars
DEDSHR	=	natural log of the share of natural gas production that is accounted for by pipeline sales(included to capture the effect of open access on production)
DUMr	=	dummy variable that equals 1 if region = r and 0 otherwise
r	=	onshore regions 2 through 6.

Results

Variable	Estimated Coefficient	Standard Error	t-statistic
A0	-3.02039	3.46358	-.872044
A1	.962078	.206360	4.66213
A2	.067699	.016754	4.04076
A3	.049399	.017549	2.81494
A4	.062093	.018170	3.41733
A5	.450603E-02	.016987	.265262
A6	.047330	.054670	.865738
B1	.852276	.326959	2.60668
B2	-.589608	.331977	-1.77605
B3	-.645398	.306376	-2.10623
B4	-.730398	.341712	-2.13747
B5	-.733917	.265693	-2.76228
B6	-.388545	.471104	-.822833
C	-.305243	.082627	-3.69421

```
SAMPLE:  1985 to 1990
NUMBER OF OBSERVATIONS = 36
```

```
Dependent variable:  LPROD
  Mean of dependent variable = 13.7972
 Std. dev. of dependent var. = 1.08967
    Sum of squared residuals = .089311
       Variance of residuals = .405960E-02
    Std. error of regression = .063715
                   R-squared = .997851
          Adjusted R-squared = .996581
     Durbin-Watson statistic = 2.42140
```

The price elasticity of natural gas production for onshore region 1 is given by the estimated parameter B1. The price elasticity for any other onshore region r (r = 2 through 6) is derived by adding the estimate for Br to the value of B1.

Offshore Gulf of Mexico Crude Oil

Price elasticities were estimated using OLS. The functional form is given by:

$$LCRUDE = a0 + a1 * LOILRES + a2 * LPOIL + a3 * LCRUDE(-1) + a4 * DUM$$

where,

LCRUDE	=	natural log of crude oil production
LOILRES	=	natural log of beginning of year oil reserves
LPOIL	=	natural log of the regional wellhead price of oil in 1987 dollars
LCRUDE(-1)	=	natural log of crude oil production in the previous year
DUM	=	a dummy variable that equals 1 for years after 1986 and 0 otherwise.

Results

Variable	Estimated Coefficient	Standard Error	t-statistic
a0	-6.48638	2.65947	-2.43897
LOILRES	.821851	.313405	2.62233
LPOIL	.115556	.051365	2.24969
LCRUDE(-1)	.974244	.137890	7.06538
DUM	.079112	.045683	1.73175

```
SAMPLE:  1978 to 1991
NUMBER OF OBSERVATIONS = 14

Dependent variable:  LCRUDE
 Mean of dependent variable = 5.65758
Std. dev. of dependent var. = .106897
   Sum of squared residuals = .021640
      Variance of residuals = .240446E-02
   Std. error of regression = .049035
                  R-squared = .854325
         Adjusted R-squared = .789581
    Durbin-Watson statistic = 1.47269
                 Durbin's h = 1.04017
     Durbin's h alternative = .725714
  F-statistic (zero slopes) = 13.1954
 Schwarz Bayes. Info. Crit. = -5.52974
```

```
Log of likelihood function = 25.4407
```

Pacific Offshore Crude Oil

Price elasticities were estimated using the AR1 procedure in TSP which corrects for first order serial correlation using a maximum likelihood iterative technique. The regression equation is given by:

$$LCRUDE_t = a0 + a1*LOILRES_t + a2*LPOIL_t + \rho*LCRUDE_{t-1} - \rho*(a0 + a1*LOILRES_{t-1} + a2*LPOIL_{t-1})$$

where,

LCRUDE	=	natural log of crude oil production
LOILRES	=	natural log of beginning of year crude oil reserves
LPOIL	=	natural log of the regional wellhead price of crude oil in 1987 dollars
ρ	=	autocorrelation parameter
t	=	year.

Results

Variable	Estimated Coefficient	Standard Error	t-statistic
a0	1.34325	.443323	3.02995
LOILRES	.310216	.067090	4.62390
LPOIL	.181190	.067391	2.68865
ρ	-.355962	.320266	-1.11146

```
SAMPLE:  1977 to 1991
NUMBER OF OBSERVATIONS = 15

Dependent variable:  LCRUDE
(Statistics based on transformed data)
        Mean of dependent variable = 5.31728
       Std. dev. of dependent var. = .646106
          Sum of squared residuals = .209786
             Variance of residuals = .017482
          Std. error of regression = .132220
                         R-squared = .971382
                Adjusted R-squared = .966613
           Durbin-Watson statistic = 1.61085
         F-statistic (zero slopes) = 161.152
        Log of likelihood function = 10.6711

(Statistics based on original data)
        Mean of dependent variable = 4.001171
       Std. dev. of dependent var. = .231415
          Sum of squared residuals = .220359
             Variance of residuals = .018363
          Std. error of regression = .135511
                         R-squared = .711359
                Adjusted R-squared = .663252
           Durbin-Watson statistic = 1.61258
```

Associated Dissolved Gas Equations

Associated dissolved gas production was hypothesized to be a function of crude oil production. The form of the equation was assumed to be log-linear. The equations were estimated in log-linear form using ordinary least squares (OLS) technique available in TSP. The forms of the equations are :

$$LADGAS_{r,t} = \ln(\alpha 0)_r + \ln(\alpha 1)_r * DUM86_t + \left(\beta 0_r + \beta 1_r * DUM86_t\right) * LOILPROD_{r,t}$$

Results

```
                                           Onshore Region   1
                                           *****************

                             Method of estimation = Ordinary Least Squares

 Dependent variable: LADGAS
 Current sample:  11 to 24
 Number of observations:  14

  Mean of dependent variable = 5.12499
 Std. dev. of dependent var. = .164729
    Sum of squared residuals = .038353
       Variance of residuals = .319609E-02
    Std. error of regression = .056534
                   R-squared = .891278
          Adjusted R-squared = .882218
     Durbin-Watson statistic = 1.75215
   F-statistic (zero slopes) = 98.3730
  Schwarz Bayes. Info. Crit. = -5.52297
  Log of likelihood function = 21.4347

            Estimated    Standard
 Variable  Coefficient     Error       t-statistic
 ln(α0)    2.07491       .307892       6.73908
 β0        .701885       .070766       9.91832

                                           Onshore Region   2
                                           *****************

                             Method of estimation = Ordinary Least Squares

 Dependent variable: LADGAS
 Current sample:  35 to 48
 Number of observations:  14

  Mean of dependent variable = 6.49697
 Std. dev. of dependent var. = .266043
    Sum of squared residuals = .048056
       Variance of residuals = .400467E-02
    Std. error of regression = .063282
                   R-squared = .947773
          Adjusted R-squared = .943420
     Durbin-Watson statistic = 1.22587
   F-statistic (zero slopes) = 217.764
  Schwarz Bayes. Info. Crit. = -5.29744
  Log of likelihood function = 19.8560

            Estimated    Standard
 Variable  Coefficient     Error       t-statistic
 ln(α0)    -3.07832      .649092       -4.74250
 β0        1.56944       .106353       14.7568

                                           Onshore Region   3
                                           *****************

                             Method of estimation = Ordinary Least Squares

 Dependent variable: LADGAS
 Current sample:  65 to 72
 Number of observations:  8

  Mean of dependent variable = 5.92117
 Std. dev. of dependent var. = .188982
    Sum of squared residuals = .013619
       Variance of residuals = .226982E-02
    Std. error of regression = .047643
                   R-squared = .945524
          Adjusted R-squared = .936445
     Durbin-Watson statistic = 2.19391
```

```
  F-statistic (zero slopes) = 104.141
 Schwarz Bayes. Info. Crit. = -5.85588
 Log of likelihood function = 14.1514

           Estimated    Standard
Variable  Coefficient     Error       t-statistic
ln(α0)    -1.65468      .742561       -2.22834
β0        1.42210       .139354       10.2050
```

Onshore Region 4
****

Method of estimation = Ordinary Least Squares

```
Dependent variable: LADGAS
Current sample:  82 to 96
Number of observations:  15

 Mean of dependent variable = 6.51049
Std. dev. of dependent var. = .080768
   Sum of squared residuals = .065307
      Variance of residuals = .502359E-02
   Std. error of regression = .070877
                  R-squared = .284921
         Adjusted R-squared = .229915
    Durbin-Watson statistic = 1.28517
  F-statistic (zero slopes) = 5.17980
 Schwarz Bayes. Info. Crit. = -5.07564
 Log of likelihood function = 19.4913

           Estimated    Standard
Variable  Coefficient     Error       t-statistic
ln(α0)    4.49271       .886765       5.06640
β0        .315372       .138569       2.27592
```

Onshore Region 5
****

Method of estimation = Ordinary Least Squares

```
Dependent variable: LADGAS
Current sample:  107 to 120
Number of observations:  14

 Mean of dependent variable = 5.49207
Std. dev. of dependent var. = .176267
   Sum of squared residuals = .169883
      Variance of residuals = .014157
   Std. error of regression = .118983
                  R-squared = .579402
         Adjusted R-squared = .544352
    Durbin-Watson statistic = 1.15658
  F-statistic (zero slopes) = 16.5308
 Schwarz Bayes. Info. Crit. = -4.03469
 Log of likelihood function = 11.0168

           Estimated    Standard
Variable  Coefficient     Error       t-statistic
ln(α0)    5.34284       .048562       110.021
β1        .047917       .011785       4.06581
```

Onshore Region 6
****

Method of estimation = Ordinary Least Squares

```
Dependent variable: LADGAS
Current sample:  131 to 144
Number of observations:  14

 Mean of dependent variable = 5.20320
Std. dev. of dependent var. = .126146
   Sum of squared residuals = .030218
      Variance of residuals = .302183E-02
   Std. error of regression = .054971
                  R-squared = .853924
         Adjusted R-squared = .810102
    Durbin-Watson statistic = 1.16621
  F-statistic (zero slopes) = 19.4859
 Schwarz Bayes. Info. Crit. = -5.38435
 Log of likelihood function = 23.1034

           Estimated    Standard
Variable  Coefficient     Error       t-statistic
```

ln(α0)	-12.1971	2.95896	-4.12210
ln(α1)	10.7230	3.27845	3.27075
β0	2.99621	.508887	5.88778
β1	-1.83291	.565439	-3.24157

Offshore California
****

Method of estimation = Ordinary Least Squares

Dependent variable: LADGAS
Current sample: 146 to 157
Number of observations: 12

```
 Mean of dependent variable = 3.46459
Std. dev. of dependent var. = .235388
   Sum of squared residuals = .130029
      Variance of residuals = .016254
   Std. error of regression = .127490
                  R-squared = .786657
         Adjusted R-squared = .706654
    Durbin-Watson statistic = 1.46033
  F-statistic (zero slopes) = 9.83279
 Schwarz Bayes. Info. Crit. = -3.69661
 Log of likelihood function = 10.1222
```

Variable	Estimated Coefficient	Standard Error	t-statistic
ln(α0)	-42.1148	14.1531	-2.97566
ln(α1)	43.1508	14.3122	3.01497
β0	10.7112	3.34207	3.20497
β1	-10.0929	3.38203	-2.98428

Offshore Gulf of Mexico
****

Method of estimation = Ordinary Least Squares

Dependent variable: LADGAS
Current sample: 159 to 170
Number of observations: 12

```
 Mean of dependent variable = 6.38670
Std. dev. of dependent var. = .092892
   Sum of squared residuals = .026872
      Variance of residuals = .298574E-02
   Std. error of regression = .054642
                  R-squared = .721601
         Adjusted R-squared = .659735
    Durbin-Watson statistic = 2.45155
  F-statistic (zero slopes) = 11.3951
 Schwarz Bayes. Info. Crit. = -5.48036
 Log of likelihood function = 19.5823
```

Variable	Estimated Coefficient	Standard Error	t-statistic
ln(α1)	4.21386	1.49771	2.81354
β0	1.07834	.466028E-02	231.391
β1	-.697473	.258646	-2.69663

Deep Water Offshore Capacity Calculations

Offshore Rig Capacity

$$RIGS_{iyr} = rig\_B0 + rig\_B1 * RIGS_{iyr-1} + rig\_B2 * gasprice_{iyr} * oilprice_{iyr}$$

SHALLOW GULF OF MEXICO
SUMMARY OUTPUT

Regression Statistics

Multiple R	0.940699806
R Square	0.884916126
Adjusted R Square	0.863991785
Standard Error	17.59934768
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	2	26198.32115	13099.16057	42.29123074	6.84825E-06
Residual	11	3407.107426	309.7370387		
Total	13	29605.42857			

	Coefficients	Standard Err	t Stat	P-value
rig_B0	40.41165127	18.68442172	2.162852663	0.053438227
rig_B1	0.659018507	0.127907369	5.152310707	0.000317101
rig_B2	0.325356839	0.226266653	1.43793544	0.178287245

DEEP GULF OF MEXICO
SUMMARY OUTPUT

Regression Statistics

Multiple R	0.915805268
R Square	0.838699289
Adjusted R Square	0.809371887
Standard Error	7.233624408
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	2	2992.7786	1496.3893	28.59780391	4.3853E-05
Residual	11	575.5785428	52.32532208		
Total	13	3568.357143			

	Coefficients	Standard Err	t Stat	P-value
rig_B0	1.268646529	4.855788005	0.26126481	0.798715313
rig_B1	0.746267646	0.134599527	5.544355639	0.000174227
rig_B2	0.127405993	0.072965835	1.746104769	0.108620602

Exploration Drilling Capacity

$$ExpWell_{iyr} = exp\_B0 + exp\_B1 * RIGS_{iyr-2}$$

SHALLOW GULF OF MEXICO
SUMMARY OUTPUT

Regression Statistics

Multiple R	0.865412882
R Square	0.748939457
Adjusted R Square	0.728017745
Standard Error	7.656151727
Observations	14

ANOVA

	df	SS	MS	F	Significance F
Regression	1	2098.314375	2098.314375	35.79723582	6.38039E-05
Residual	12	703.3999111	58.61665926		
Total	13	2801.714286			

	Coefficients	Standard Err	t Stat	P-value
exp_B0	-12.92183034	7.48294464	-1.726837624	0.109823235
exp_B1	0.212515201	0.03551937	5.983079125	6.38039E-05

DEEP GULF OF MEXICO
SUMMARY OUTPUT

Regression Statistics

Multiple R	0.919628409
R Square	0.84571641
Adjusted R Square	0.823675897
Standard Error	0.597951585
Observations	9

ANOVA

	df	SS	MS	F	Significance F
Regression	1	13.71939954	13.71939954	38.37099503	0.000447675
Residual	7	2.502822684	0.357546098		
Total	8	16.22222222			

	Coefficients	Standard Err	t Stat	P-value
Intercept	-0.953938927	0.583703816	-1.634285919	0.146215273
X Variable 1	0.125866051	0.020319222	6.194432583	0.000447675

Developmental Drilling Capacity

$$DevWell_{iyr} = dev\_B0 + dev\_B1 * ExpWell_{iyr-5} + dev\_B2 * RIGS_{iyr} + rig\_B3 * DevWell_{iyr-1}$$

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.730
R Square	0.533
Adjusted R Square	0.358
Standard Error	13.683
Observations	12

ANOVA

	df	SS	MS	F	Significance F
Regression	3	1711.117	570.37	3.046	0.092
Residual	8	1497.800	187.225		
Total	11	3208.917			

	Coefficients	Standard Err	t Stat	P-value	Lower 95%	Upper 95%
dev_B0	-16.130	23.094	-0.698	0.505	-69.386	37.126
dev_B1	0.727	0.271	2.684	0.028	0.102	1.352
dev_B2	0.648	0.308	2.101	0.069	-0.063	1.359
dev_B3	0.264	0.232	1.139	0.288	-0.271	0.799