Proposed Modeling Scenarios

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Purposes for Which Natural Gas Market Assessments Are Used

Natural Gas Market Assessments and Forecasts support:

- Energy policy making and program implementation activities
- □ Relative economics of alternative electricity resource choices, such as
 - energy efficiency programs and standards
 - distributed generation choices (e.g., photovoltaics, combined heat and power)
 - ◆ new central station generation
- □ Energy costs for households and businesses
- □ Environmental impacts of natural gas market activity
- Electricity demand assessments
- Wholesale electricity and natural gas market procurement, including hedging
- Natural gas infrastructure requirements assessments



Electricity Analysis Office Natural Gas Unit

Long-range assessments of the demand for natural gas evaluate drivers of:

- end use gas demand
- gas demand to serve grid-delivered end use electric generation
- mix of electric generation resources (e.g., renewables, coal) which substitute for gas-fired generation (either utilization or construction)

and are affected by:

- world, national, regional and state energy and environmental policies
- economic choices utilities make for generation capacity expansion

Modeling the World Gas Market

World Gas Trade Model - simplified

- general equilibrium model iterates world-wide regional natural gas demand & supplies, "investing" in new pipelines, if economic
- perfect foresight in making return-on-investment decisions
- resulting prices are those that would have to be sustained to make investments economic (under the assumed future conditions)

Thousands of assumptions are made about future conditions of complex, interacting key drivers

Provide insights on potential market outcomes under different plausible future conditions



WGTM Reference Case

Econometric approach: equations that well explain past gas market activities are enlisted to predict the future

- Many assumptions for WGTM independent input variables re: U.S. energy activities come from EIA Annual Energy Outlook 2010 Reference Case output
- □ Therefore, WGTM Reference Case is conditional wrt some AEO 2010 Reference Case underlying conditions/assumptions, e.g.,

EIA AEO acknowledges that inherent uncertainties require Reference Case results not to be viewed in isolation

 alternate market projections must be reviewed to gain perspective on how variations in key assumptions can lead to different outlooks for energy markets



Proposed Scope and Design of Natural Gas Market Assessment

- Focus assessment on cases helpful to decisionmakers, rather than having a single point forecast be the primary product
- The "business as usual" Reference Case only a starting point: reflects expert opinion and current perception of current conditions
- Many future potential changes cannot be predicted accurately or even probabilistically, but are deeply uncertain
- Alternative cases are needed for additional insights, especially about potential future structural changes to the market conditions or regulations
- Staff requests parties comments on the proposed alternative cases' topic question, structure, and assumptions

Proposed Alternate Cases

Cases A & B are designed to explore California's potential vulnerabilities, or opportunities, across a plausible range of conditions that could drive future wholesale gas market prices

- A: High Gas Price Case assumes a plausible combination US-policy-driven and market conditions that would lead to higher national wholesale gas demand and higher gas prices
- B: Low Gas Price Case assumes a plausible combination of US-policy-driven and market conditions that would lead to lower national wholesale gas demand and lower gas prices

[see accompanying charts for more detailed description]



Proposed Alternative Cases (cont'd)

- Cases C & E are designed to explore California's potential vulnerabilities, or opportunities, across a plausible range of conditions that could drive future California gas demand, costs, and infrastructure additions
 - C: High CA Gas Demand Case assumes a plausible combination of CA-policydriven conditions that would lead to high gas demand
 - E: Low CA Gas Demand Case assumes a plausible combination of CA-policy-driven conditions that would lead to low gas demand

Each of the above cases will have a stressed sensitivity case for snapshot years that also assumes occasional low hydroelectricity conditions, high summer, low winter temperatures, and robust economic conditions (Cases D & F)

[see accompanying charts for more detailed description]



Proposed Alternate Cases (cont'd)

Cases G & H are policy-relevant sensitivities designed to guard against one-side biases

Explore key uncertainties testing the claim that shale gas is a "game changer" for the U.S. gas market

☐ G: Shale Environmental Mitigation Sensitivity Case – assumes plausible combination of higher environmental mitigation costs or constraints on shale gas production

Explore potential market impacts of pipeline pressure limitations on transportation capacity

□ H: Reduced Pipeline Pressure Case – assumes reduced pipeline pressures/capacities associated with new public safety limitations

[see accompanying charts for more detailed description]



Uncertainty Analysis Helps Decisionmakers

Policy decisions often seek to strike a balance between competing objectives

Decisions carry risk because the future is highly uncertain

- □ Accurate probability of complex future outcomes unachievable
- Even knowing what factors matter, and to what degree, is a challenge
- Consequences of actions based on one forecast are uncertain another future can happen instead

Moderating the risks of decisionmaking requires understanding the ranges of forecasts and their consequences

Prudently selecting forecasts can moderate the risks of potential consequences of a specific decision

□ Decisionmaker's risk tolerance is important

		"Road N	/lap" to Natural Ga	s Demand-Related A	ssmptions for Staff	's Proposed Natural	Gas Market Assessme	nt: For Discussion a	t April 19.2011 IEPR	staff workshop
						ase and Scenarios				
		Focus on national d	rivers that lead to*	Focus on CA drivers that lead to @		Single-variable Sensitivity+	Single-variable Sensitivity#	Case not question- focused		
	Case No:	Α	В	С	D	E	F	G	н	Reference Case
are Selected and C	rs for Which Assumptions Combined to Create the Each Column	High Gas Price Case (output price is high, not input)	Low Gas Price Case (output price is low, not input)	High CA Gas Demand Case (output demand is high, not input)	Stressed High CA Demand Case (higher econ/demo; lower temps, hydro- generation)	Low CA Gas Demand Case (output demand is low, not input)	Stressed Low CA Demand Case (higher econ/demo; higher temps, hydro- generation)	Increased Environmental Mitigation Cost for Drilling and Production Case	Reduced Pipeline Pressure Case	Rice University CA-specific Constrained Reference Case
Demographics	GDP	Reference Case Values	Slower GDP and Manufacturing Output	Higher GDP growth	Higher GDP growth	Lower GDP growth	Lower GDP growth	Reference Case Values	Reference Case Values	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ D	Population Personal Income	Reference Case Values	Reference Case Values	Higher CA Population Growth	Higher CA Population Growth	Lower CA Population Growth	Lower CA Population Growth	Reference Case Values	Reference Case Values	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp200 8/all-wpp- indicators_components.htm
Weather	Temperature - degree days	Reference Case Values	Reference Case Values	Reference Case Values	Colder winter and hotter summer than in Reference Case	Reference Case Values	Warmer winter and cooler summer than in Reference Case	Reference Case Values	Use extreme weather so can see how lower capacity affects system at limits	Average 1989 to 2009 NOAA Recorded by state
Electricty, Natural Gas and Fuel Prices	Initial Electricity price by sector and elasticities	Reference Case Values	Reduce the coefficient on gas' share of electricity demand	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	elasticity of higher electricity demand = 1.089
Natural Ge Prices	Initial gas price by sector and elasticities	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	own price elasticity for NG is - 0.442
Electiricty,	Cross-price elasticities for substitute fuels (e.g., oil)	Reference Case Values OR Reverse the sign on Renewables	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	oil = 0.238 & coal = 0.108 & Renewables = -0.189
Precipitation	Amount of Hydroelectric generation	Reference Case Values	Reference Case Values	Reference Case Values	Low Hydro increases CA gas demand by 15%	Reference Case Values	High Hydro reduces CA gas demand by 12%	Reference Case Values	Reference Case Values	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use CA/US historical relationship between renewables and total electricity generation
via their upply	GHG Regulations	GHG and other EPA regs further push out coal	More Nukes or CCS allow Reduction in Gas Burn	Reference Case Values	Reference Case Values	Carbon adder on CA gas consumption?	Carbon adder on CA gas consumption?	Reference Case Values	Reference Case Values	None but gas-fired gen grows as much as if GHG were in place
gas demand r electricity s	Energy Efficiency	Reference Case Values	High EE reduces electricity and gas demand growth by half	Only half of load reduction desired by EE is achieved	Only half of load reduction desired by EE is achieved	EE reduces CA demand growth to 1% reality check with DAO	EE reduces CA demand growth to 1% reality check with DAO	Reference Case Values	Reference Case Values	US load grows at 1.12% compared to EIA Fig 69 3-yr rolln avg in same range; CA grows at 1.61%
Constraints (These drivers affect gas demand via their nd use electricity demand, and/or electricity supply alternatives).	Central Station Renewable Generation	50% fewer Renewables	Grow Renewables Excl Conv Hydro to 20% of US Demand	Assume CA gets only to 25% Renewables	Assume CA gets only to 25% Renewables	Assume CA gets to 50% Renewables	Assume CA gets to 50% Renewables	Reference Case Values	Reference Case Values	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolic by 2040 and 44% of CA (reality check against CA gas burn)
ives & Constraints (Thes and, end use electricity alternatives).	Combined Heat & Power	Reference Case Values	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Reference Case Values	Reference Case Values	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
Incentives & Con as demand, end u	Distributed Generation	Reference Case Values	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Impact depends on assumed fuel source and efficiency	Reference Case Values	Reference Case Values	all initially as assumed in AEO 2010 reference case (Zero DG in AEO 2010)/not explicitly broken out in RWGTM
GHG and Energy Policy Ince effects on end use gas de	Transportation Electricity/NG Use	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/no explicitly broken out in RWGTM
	Other	Go to top of 95% conf interval on all demand coefficients	Go to bottom of 95% conf interval on all demand coefficients	n/a	n/a	n/a	n/a	n/a	n/a	N/A
Environmental Protection and Public Safety	Environmental Compliance Costs	PCB ANPR requires major U.S. pipeline replacement and/or impose adder such as proposed in PA (\$0.40 to \$0.80 per MMBtu)	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Could add PA Compliance Charge (\$0.40 to \$0.80 per MMBtu) to O&M Cost	Reference Case Values	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
	Public Safety Compliance costs	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	could either add cost to PG&E backbone OR reduce capacity	None
≱	Technology	Slow the technology growth factor by half?	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
AlddnS	Production Cost	Could shift supply curves leftward to reduce supply available as public concern limits	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Reference Case Values	Could shift supply curves leftward to reduce supply available as public concern limits	Reference Case Values	RWGTM Supply Curves

supply available as public concern limits drilling

* Explore California's potential vulnerabilities, or opportunities, across a plausible range of conditions that could drive future wholesale market gas prices

Explore California's potential vulnerabilities, or opportunities, across a plausible range of conditions that could drive future California gas demand, costs, and infrastructure additions

Explore potential effects on natural gas price and supply of uncertainties related to possible constaints/environmental mitigation costs assigned to shale gas development.

Explore potential effects on supply adequacy/price of uncertainties related to pressure reductions in gas pipelines.

	Reference	Case
•	for Which Assumptions are Selected and Combined to Create the Cases in Each Column	Rice University CA-specific Constrained Reference Case
ny/ phics	GDP	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Cconverging GDP GDP GOVERNOW CONVERGING CONV		UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp- indicators_components.htm
	Personal Income	
Weather	Temperature - degree days	Average 1989 to 2009 NOAA Recorded by state
.y, ias	Initial Electricity price by sector and elasticities	elasticity of higher electricity demand = 1.089
Electiricty, Natural Gas and Fuel Prices	Initial gas price by sector and elasticities	own price elasticity for NG is -0.442
Electiricty, Natural Gas and Fuel Prices	Cross-price elasticities for substitute fuels (e.g., oil)	oil = 0.238 & coal = 0.108 & Renewables = -0.189
Precipitation	Amount of Hydroelectric generation	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
nand end iity	GHG Regulations	None but gas-fired gen grows as much as if GHG were in place
ives & as den mand,	Energy Efficiency	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
GHG and Energy Policy Incentives & traints (These drivers affect gas demarneir effects on end use gas demand, en electricity demand, and/or electricity supply alternatives).	Central Station Renewable Generation	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
rgy Pol e drivel n end u emand y alteri	Combined Heat & Power	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
nd Ene (These fects or ricity d	Distributed Generation	all initially as assumed in AEO 2010 reference case (Zero DG in AEO 2010)/not explicitly broken out in RWGTM
GHG and Energy Policy Incentives & Constraints (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).	Transportation Electricity/NG Use	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/not explicitly broken out in RWGTM
خ ن <	Other	N/A
Environ mental Protecti on and Public Safety	Environmental Compliance Costs	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
_	Public Safety Compliance costs	None
Supply	Technology	Learning factor rate: approx. 1%/yr improvement
Sup	Production Cost	RWGTM Supply Curves

		High Price Case	
	rs for Which Assumptions are Selected and Combined of Create the Cases in Each Column	High Gas Price Case (output price is high, not input)	Rice University CA-specific Constrained Reference Case
ny/ phics	GDP	Reference Case Values	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ Demographics	Population	Reference Case Values	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp-indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Reference Case Values	Average 1989 to 2009 NOAA Recorded by state
as -	Initial Electricity price by sector and elasticities	Reference Case Values	elasticity of higher electricity demand = 1.089
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Precipitation	Amount of Hydroelectric generation	Reference Case Values	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
aints ffects ity ves).	GHG Regulations	GHG and other EPA regs further push out coal	None but gas-fired gen grows as much as if GHG were in place
Constraints their effect: electricity ternatives).	Energy Efficiency	Reference Case Values	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
GHG and Energy Policy Incentives & Constraints (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).	Central Station Renewable Generation	50% fewer Renewables	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
cy Ince gas der mand, tricity	Combined Heat & Power	Reference Case Values	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
Energy Policy vers affect gas use gas dema and/or electri	Distributed Generation	Reference Case Values	all initially as assumed in AEO 2010 reference case (Zero DG in AEO 2010)/not explicitly broken out in RWGTM
and Ener e drivers end use and, and/	Transportation Electricity/NG Use	Reference Case Values	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/not explicitly broken out in RWGTM
GHG and (These driv on end demand,	Other	Go to top of 95% conf interval on all demand coefficients	N/A
Environmen tal Protection and Public Safety	Environmental Compliance Costs	PCB ANPR requires major U.S. pipeline replacement and/or impose adder such as proposed in PA (\$0.40 to \$0.80 per MMBtu)	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
Env Pr an	Public Safety Compliance costs	Reference Case Values	None
	Technology	Slow the technology growth factor by half?	Learning factor rate: approx. 1%/yr improvement
VlddnS	Production Cost	Could shift supply curves leftward to reduce supply available as public concern limits drilling	RWGTM Supply Curves

		Low Price Case	
Below are Key Drivers	for Which Assumptions are Selected and Combined to		
	Create the Cases in Each Column	Low Gas Price Case (output price is low, not input)	Rice University CA-specific Constrained Reference Case
my/ aphics	GDP	Slower GDP and Manufacturing Output	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ Demographics	Population	Reference Case Values	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp-indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Reference Case Values	Average 1989 to 2009 NOAA Recorded by state
Electiricty, Natural Gas and Fuel Prices	Initial Electricity price by sector and elasticities	Reduce the coefficient on gas' share of electricity demand	elasticity of higher electricity demand = 1.089
Electiricty, atural Gas ar Fuel Prices	Initial gas price by sector and elasticities	Reference Case Values	own price elasticity for NG is -0.442
Ele Naturi Fue	Cross-price elasticities for substitute fuels (e.g., oil)	Reference Case Values	oil = 0.238 & coal = 0.108 & Renewables = -0.189
Precipitation	Amount of Hydroelectric generation	Reference Case Values	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
ints fects :y es).	GHG Regulations	More Nukes or CCS allow Reduction in Gas Burn	None but gas-fired gen grows as much as if GHG were in place
onstra neir eff ectricit	Energy Efficiency	High EE reduces electricity and gas demand growth by half	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
ntives & C nand via th end use el supply alte	Central Station Renewable Generation	Grow Renewables Excl Conv Hydro to 20% of US Demand	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
y Incelas dem nand, e tricity s	Compined Heat & Power	Impact depends on assumed fuel source and efficiency	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
gy Polic affect g gas den or elec	Distributed Generation	Impact depends on assumed fuel source and efficiency	all initially as assumed in AEO 2010 reference case (Zero DG in AEO 2010)/not explicitly broken out in RWGTM
GHG and Energy Policy Incentives & Constraints (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).	Transportation Electricity/NG Use	Reference Case Values	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/not explicitly broken out in RWGTM
GHG (The: or dem	Other	Go to bottom of 95% conf interval on all demand coefficients	N/A
Environ mental Protecti on and Public Safety	Environmental Compliance Costs	Reference Case Values	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
En mi Pro or or Sa	Public Safety Compliance costs	Reference Case Values	None
ply	Technology	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
Supply	Production Cost	Reference Case Values	RWGTM Supply Curves

		High CA Gas Demand	
· ·	or Which Assumptions are Selected and Combined to reate the Cases in Each Column	High CA Gas Demand Case (output demand is high, not input)	Rice University CA-specific Constrained Reference Case
my/ aphics	GDP	Higher GDP growth	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ Demographics	Population	Higher CA Population Growth	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp-indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Reference Case Values	Average 1989 to 2009 NOAA Recorded by state
as I	Initial Electricity price by sector and elasticities	Reference Case Values	elasticity of higher electricity demand = 1.089
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Precipitation	Amount of Hydroelectric generation	Reference Case Values	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
raints eir se oply	GHG Regulations	Reference Case Values	None but gas-fired gen grows as much as if GHG were in place
Const via th end us city sup	Energy Efficiency	Only half of load reduction desired by EE is achieved	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
GHG and Energy Policy Incentives & Constraints (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).	Central Station Renewable Generation	Assume CA gets only to 25% Renewables	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
Policy Incenting affect gas der duse gas dem gand, and/or el alternatives).	Combined Heat & Power	Impact depends on assumed fuel source and efficiency	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
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G E	Other	n/a	N/A
Environ mental Protecti on and Public Safety	Environmental Compliance Costs	Reference Case Values	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
	Public Safety Compliance costs	Reference Case Values	None
Supply	Technology	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
Sup	Production Cost	Reference Case Values	RWGTM Supply Curves

		Low CA Gas Demand	
	for Which Assumptions are Selected and Combined to Create the Cases in Each Column	Low CA Gas Demand Case (output demand is low, not input)	Rice University CA-specific Constrained Reference Case
	GDP	Lower GDP growth	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ Demographics	Population	Lower CA Population Growth	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp-indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Reference Case Values	Average 1989 to 2009 NOAA Recorded by state
.y, bas	Initial Electricity price by sector and elasticities	Reference Case Values	elasticity of higher electricity demand = 1.089
Electiricty, Vatural Gar and Fuel Prices	Initial gas price by sector and elasticities	Reference Case Values	own price elasticity for NG is -0.442
Electiricty, Natural Gas and Fuel Prices	Cross-price elasticities for substitute fuels (e.g., oil)	Reference Case Values	oil = 0.238 & coal = 0.108 & Renewables = -0.189
Precipitation	Amount of Hydroelectric generation	Reference Case Values	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
raints eir se oply	GHG Regulations	Carbon adder on CA gas consumption?	None but gas-fired gen grows as much as if GHG were in place
Const I via th end us city sup	Energy Efficiency	EE reduces CA demand growth to 1% reality check with DAO	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
G and Energy Policy Incentives & Constrai (These drivers affect gas demand via their effects on end use gas demand, end use lectricity demand, and/or electricity suppl alternatives).	Central Station Renewable Generation	Assume CA gets to 50% Renewables	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
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GH e	Other	n/a	N/A
Environ mental Protecti on and Public Safety	Environmental Compliance Costs	Reference Case Values	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
En Pri Or Sa	Public Safety Compliance costs	Reference Case Values	None
ply	Technology	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
Supply	Production Cost	Reference Case Values	RWGTM Supply Curves

	Str	essed CA High Gas Demand	
	for Which Assumptions are Selected and Combined to Create the Cases in Each Column	Stressed High CA Demand Case (higher econ/demo; lower temps, hydro-generation)	Rice University CA-specific Constrained Reference Case
ny/ iphics	GDP	Higher GDP growth	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ Demographics	Population	Higher CA Population Growth	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp-indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Colder winter and hotter summer than in Reference Case	Average 1989 to 2009 NOAA Recorded by state
as -	Initial Electricity price by sector and elasticities	Reference Case Values	elasticity of higher electricity demand = 1.089
rict al G Fue Ses	Initial gas price by sector and elasticities	Reference Case Values	own price elasticity for NG is -0.442
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5 and Energy Policy Incentives & Constra These drivers affect gas demand via their effects on end use gas demand, end use ectricity demand, and/or electricity supp alternatives).	Central Station Renewable Generation	Assume CA gets only to 25% Renewables	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
Policy Incentivaffect gas der duse gas der and, and/or el alternatives).	Combined Heat & Power	Impact depends on assumed fuel source and efficiency	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
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GHG and Energy Policy Incentives & Constraints (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).	Transportation Electricity/NG Use	Reference Case Values	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/not explicitly broken out in RWGTM
GH	Other	n/a	N/A
Environ mental Protecti on and Public Safety	Environmental Compliance Costs	Reference Case Values	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
En Prc or Pr	Public Safety Compliance costs	Reference Case Values	None
λlc	Technology	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
Supply	Production Cost	Reference Case Values	RWGTM Supply Curves

	St	ressed CA Low Gas Demand	
	for Which Assumptions are Selected and Combined to Create the Cases in Each Column	Stressed Low CA Demand Case (higher econ/demo; higher temps, hydro-generation)	Rice University CA-specific Constrained Reference Case
my/ aphics	GDP	Lower GDP growth	IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ Demographics	Population	Lower CA Population Growth	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp-indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Warmer winter and cooler summer than in Reference Case	Average 1989 to 2009 NOAA Recorded by state
y, y	Initial Electricity price by sector and elasticities	Reference Case Values	elasticity of higher electricity demand = 1.089
Electiricty, latural Ga and Fuel Prices	Initial gas price by sector and elasticities	Reference Case Values	own price elasticity for NG is -0.442
Electiricty, Natural Gas and Fuel Prices	Cross-price elasticities for substitute fuels (e.g., oil)	Reference Case Values	oil = 0.238 & coal = 0.108 & Renewables = -0.189
Precipitation	Amount of Hydroelectric generation	High Hydro reduces CA gas demand by 12%	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
raints eir se oply	GHG Regulations	Carbon adder on CA gas consumption?	None but gas-fired gen grows as much as if GHG were in place
Constraints I via their end use city supply	Energy Efficiency	EE reduces CA demand growth to 1% reality check with DAO	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
G and Energy Policy Incentives & Constrair (These drivers affect gas demand via their effects on end use gas demand, end use lectricity demand, and/or electricity supply alternatives).	Central Station Renewable Generation	Assume CA gets to 50% Renewables	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
oolicy Incentii affect gas de 1 use gas dem Ind, and/or e alternatives).	Combined Heat & Power	Impact depends on assumed fuel source and efficiency	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
ergy Pc ivers a in end i deman	Distributed Generation	Impact depends on assumed fuel source and efficiency	all initially as assumed in AEO 2010 reference case (Zero DG in AEO 2010)/not explicitly broken out in RWGTM
GHG and Energy Policy Incentives & Constrain (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).	Transportation Electricity/NG Use	Reference Case Values	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/not explicitly broken out in RWGTM
<u>.</u>	Other	n/a	N/A
Environ mental Protecti on and Public Safety	Environmental Compliance Costs	Reference Case Values	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
Er Pri Or Sz	Public Safety Compliance costs	Reference Case Values	None
	Technology	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
Supply	Production Cost	Reference Case Values	RWGTM Supply Curves

Increased Environmental Mitigation Costs Single Variable Sensitivity

	for Which Assumptions are Selected and Combined to		
	Create the Cases in Each Column	Drilling and Production Case	Rice University CA-specific Constrained Reference Case
, ics			IMF through 2015; after GDP grows using relation between US
	GDP	Reference Case Values	and UK historical growth at different per capita income levels,
my, aph			converging across countries over time
Economy/ Demographics			UN median case 2008 Revision avg growth to 2050 = 0.703%
Ecc	Population	Reference Case Values	http://esa.un.org/unpd/wpp2008/all-wpp-
Ď			indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Reference Case Values	Average 1989 to 2009 NOAA Recorded by state
%, as I	Initial Electricity price by sector and elasticities	Reference Case Values	elasticity of higher electricity demand = 1.089
rict al G Fue ces	Initial gas price by sector and elasticities	Reference Case Values	own price elasticity for NG is -0.442
Electiricty, Natural Gas and Fuel Prices	Cross-price elasticities for substitute fuels (e.g., oil)	Reference Case Values	oil = 0.238 & coal = 0.108 & Renewables = -0.189
Precipitation	Amount of Hydroelectric generation	Reference Case Values	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
raints eir se oply	GHG Regulations	Reference Case Values	None but gas-fired gen grows as much as if GHG were in place
Const via th end ug city sup	Energy Efficiency	Reference Case Values	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
GHG and Energy Policy Incentives & Constraints (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).	Central Station Renewable Generation	Reference Case Values	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
Policy Incenti affect gas der d use gas derr and, and/or e' alternatives).	Combined Heat & Power	Reference Case Values	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
ergy Pc ivers af n end t deman alf	Distributed Generation	Reference Case Values	all initially as assumed in AEO 2010 reference case (Zero DG in AEO 2010)/not explicitly broken out in RWGTM
G and Ene (These dri effects or lectricity o	Transportation Electricity/NG Use	Reference Case Values	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/not explicitly broken out in RWGTM
е е	Other	n/a	N/A
v c d tti al N	Fautranmental Compliance Costs	Could add PA Compliance Charge (\$0.40 to \$0.80	includes Marcellus NY moratorium + limits on Montana Front
Environ mental Protecti on and Public Safety	Environmental Compliance Costs	per MMBtu) to O&M Cost	Range + no OCS expansion
En Pro	Public Safety Compliance costs	Reference Case Values	None
	Technology	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
Supply	Production Cost	Could shift supply curves leftward to reduce supply available as public concern limits drilling	
			- I

Reduced Pipeline Pressure Single Variable Sensitivity

Below are Key Drivers	for Which Assumptions are Selected and Combined to	·	Rice University CA-specific Constrained Reference Case
ny/ iphics	GDP		IMF through 2015; after GDP grows using relation between US and UK historical growth at different per capita income levels, converging across countries over time
Economy/ Demographics	Population	Reference Case Values	UN median case 2008 Revision avg growth to 2050 = 0.703% http://esa.un.org/unpd/wpp2008/all-wpp- indicators_components.htm
	Personal Income		
Weather	Temperature - degree days	Use extreme weather so can see how lower capacity affects system at limits	Average 1989 to 2009 NOAA Recorded by state
y, as I	Initial Electricity price by sector and elasticities	Reference Case Values	elasticity of higher electricity demand = 1.089
lectiricty atural Ga and Fuel Prices	Initial gas price by sector and elasticities	Reference Case Values	own price elasticity for NG is -0.442
Electiricty, Natural Gas and Fuel Prices	Cross-price elasticities for substitute fuels (e.g., oil)	Reference Case Values	oil = 0.238 & coal = 0.108 & Renewables = -0.189
Precipitation	Amount of Hydroelectric generation	Reference Case Values	No Explicit Precip Assumption other than renewables INCLUDING conv hydro and use of CA/US historical relationship between renewables and total electricity generation
raints eir se oply	GHG Regulations	Reference Case Values	None but gas-fired gen grows as much as if GHG were in place
Const I via th end us city sup	Energy Efficiency	Reference Case Values	US load grows at 1.12% compared to EIA Fig 69 3-yr rollng avg in same range; CA grows at 1.61%
G and Energy Policy Incentives & Constrair (These drivers affect gas demand via their effects on end use gas demand, end use lectricity demand, and/or electricity supply alternatives).	Central Station Renewable Generation	Reference Case Values	Renewables Excl Conv Hydro becomes 12.5% of U.S. portfolio by 2040 and 44% of CA (reality check against CA gas burn)
Policy Incentii affect gas der d use gas derr and, and/or ei alternatives).	Combined Heat & Power	Reference Case Values	AEO 2010 shows CHP purch and own use but not by generation fuel/not explicitly broken out in RWGTM
ergy Pc ivers at in end u deman	Energy Efficiency Energy Efficiency Central Station Renewable Generation Combined Heat & Power Distributed Generation Transportation Electricity/NG Use	Reference Case Values	all initially as assumed in AEO 2010 reference case (Zero DG in AEO 2010)/not explicitly broken out in RWGTM
GHG and Energy Policy Incentives & Constraints (These drivers affect gas demand via their effects on end use gas demand, end use electricity demand, and/or electricity supply alternatives).		Reference Case Values	AEO 2010 shows electricity demand for transportation in CA of 0.49 Gwh growing at 4.1%/not explicitly broken out in RWGTM
G A	Other	n/a	N/A
Environme ntal Protection and Public Safety	Environmental Compliance Costs	Reterence Case Values	includes Marcellus NY moratorium + limits on Montana Front Range + no OCS expansion
Environme ntal Protection and Public Safety	Public Safety Compliance costs	could either add cost to PG&E backbone OR reduce capacity	None
рlу	Technology	Reference Case Values	Learning factor rate: approx. 1%/yr improvement
Supply	Production Cost	Reference Case Values	RWGTM Supply Curves