Using Monte Carlo Simulation to Evaluate GHP Project Opportunities

Presentation to the Utah Geothermal Technologies Workshop

3773 Cherry Creek North Drive
Suite 575
Denver Colorado 80209

www.ionconsulting.com

April 30, 2009

I:ON CONSULTING

Most western utilities are interested in geothermal

Utility	Mentioned Geothermal	GSHP?	Utility Commentary on Geothermal Resources
Avista	Yes	No	• Avista is planning on obtaining between 15 and 35 MW of geothermal power by 2017
Idaho Power	Yes	No	• Idaho power currently purchases power from a 45.5 MW plant operated by U.S Geothermal Power
NorthWestern Energy	Yes	No	• Northwestern stated that geothermal performed well in its resource planning analysis but chose not to include geothermal in its resource plan
PGE	Yes	No	• Portland General Electric Plans on adding 54 MW of geothermal
Puget Sound Energy	Yes	No	• There are few proven geothermal resources in our region. Because these resources are located outside Washington state (primarily in Idaho and Oregon), they face long-haul transmission issues to bring power from the point of generation to PSE's service territory.
PacifiCorp	Yes	No	• PacifiCorp plans on expanding the Blundell Geothermal Plant in Utah from 23 megawatts to 34 MW through the addition of a bottoming cycle • PacifiCorp will continue evaluate new geothermal resources through its RFP process
Public Service Colorado	Yes	No	• PSCCo. plans on developing 20 MW of binary cycle geothermal by 2016
LADPW	867	No	• LADPW is pursuing two 135 MW geothermal plants that would utilize the Green Path transmission link. These plants have an expected in service date of 2013.
Pacific Gas &Electric	Yes	No	• PGE assumes that 15% of renewable resources will come from geothermal by 2020 However, since most of these resource areas require significant transmission additions described in more detail in Volume 1, Section V.H.4, there is significant uncertainty regarding the availability of transmission capacity and consequent effect on geothermal resource deliveries.
S. Cal Edison	Yes	No	• SCE plans to integrate 910 MW of geothermal resources by 2020. This amounts to 33% of planned renewable additions
SMUD	Yes	No	• SMUD is pursuing the development of a 10 MW geothermal facility in Southern Oregon and a multistage 30 MW geothermal plant in northern Nevada. Transmission availability and cost cited as major barriers to development

Presentation objectives

Problem Statement:

Spreadsheet models allow a homeowner or developer and a utility to look at economic value on a static basis, but don't show risk sensitivities. This limits the ability for the utility and developer to discuss benefits on an apples to apples basis.

Proposed Solution:

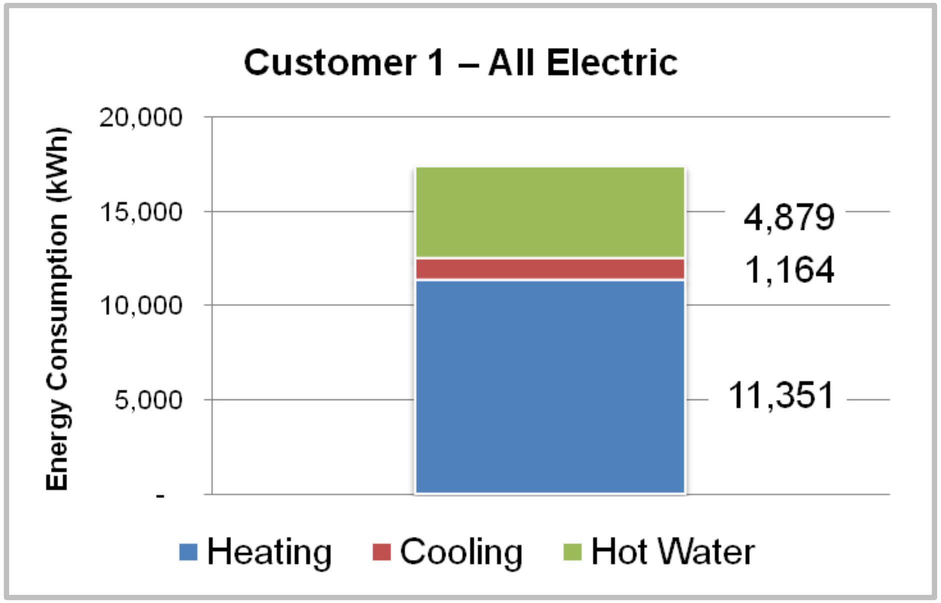
A simple Monte Carlo simulation model can help bridge the gap between the developer and utility and analyze mutual benefits under different scenarios

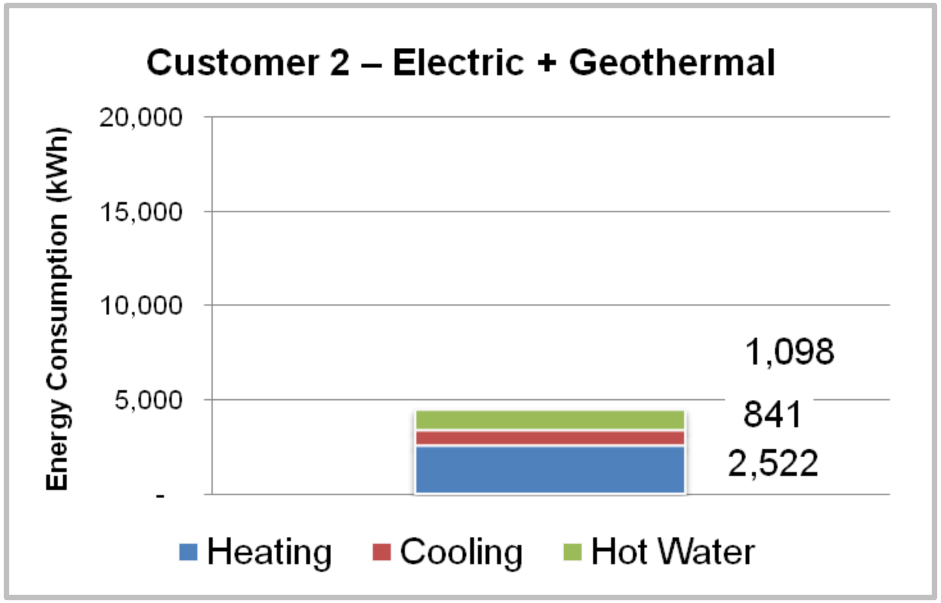
How It Would be Applied:

A spreadsheet model is generally sufficient, but a number of decision drivers make assessment of risk more important:

- Increasing costs of energy
- Increased customer preference for renewable solutions
- Utility on-going desire to identify win-win solutions that benefit both parties

Lets consider two customers, with and without a GHP system, and evaluate how price risk affects them and their host utility





We first develop a spreadsheet model to understand the economics of the GHP opportunity

Input assumptions (change only blue cells)	Input
average home size (sf)	2,000
efficiency of home (% better than building code)	10%
Energy consumption for space heating (MMBtu/sf/a), built to code minimum	0.022
Energy consumption for space heating (kWh/sf/a), built to code minimum	6.306
Energy consumption for space cooling (MMBtu/sf/a), built to code minimum	0.008
electric resistance heater cost ($)	500
electric resistance heater efficiency	100%
electric air conditioner cost ($)	1,150
electric air conditioner efficiency (SEER rating)	13
electric water heater cost ($)	350
electric water heater efficiency (energy factor)	0.90
gas furnace cost ($)	1,500
gas furnace efficiency (annual fuel utilization efficiency)	90%
gas water heater cost ($)	650
gas water heater efficiency (energy factor)	0.62
heat pump space conditioning unit cost ($/ton)	1,800
heat pump space hot water heater unit cost ($/ton)	900
geothermal and heat pump peripherals, water tank, pumps, & connections ($)	2,100
heat pump heating efficiency (COP)	4.50
heat pump cooling efficiency (EER)	18.00
heat pump water heating efficiency (energy factor)	2.00
desuperheater production	50%
geothermal capacity (ton)	3.00
geothermal conductivity (ft/ton)	200
geothermal drilling cost ($/ft)	14
energy cost, electricity, year 0 ($/kWh)	0.07
energy cost, gas, year 0 ($/Therm)	1.36
energy inflation (%)	3.00%
interest rate (for mortgage, NPV calculations)	6.25%

- **Key variables drive the value of GHP**
  - **Electricity price of local utility**
  - **Efficiency of home**
  - **Capital cost to implement**

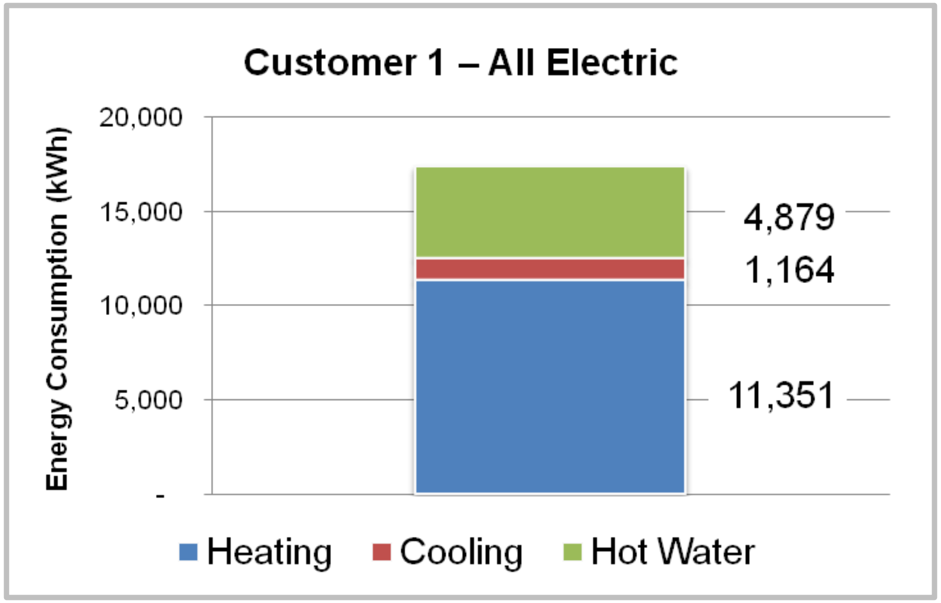
- **We have assumed an all-electric customer and ignored gas heating opportunity**

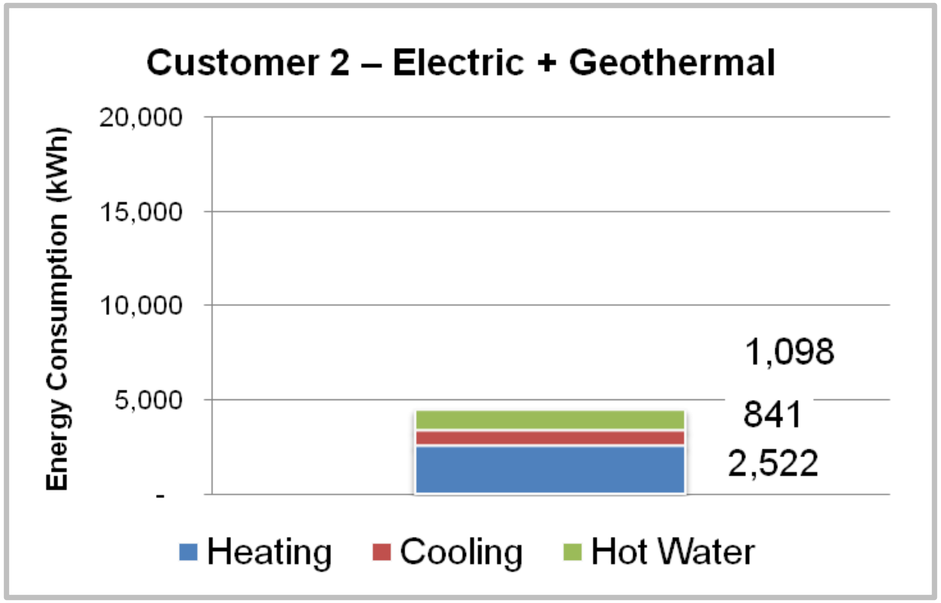
20 Year cash flow projections are developed

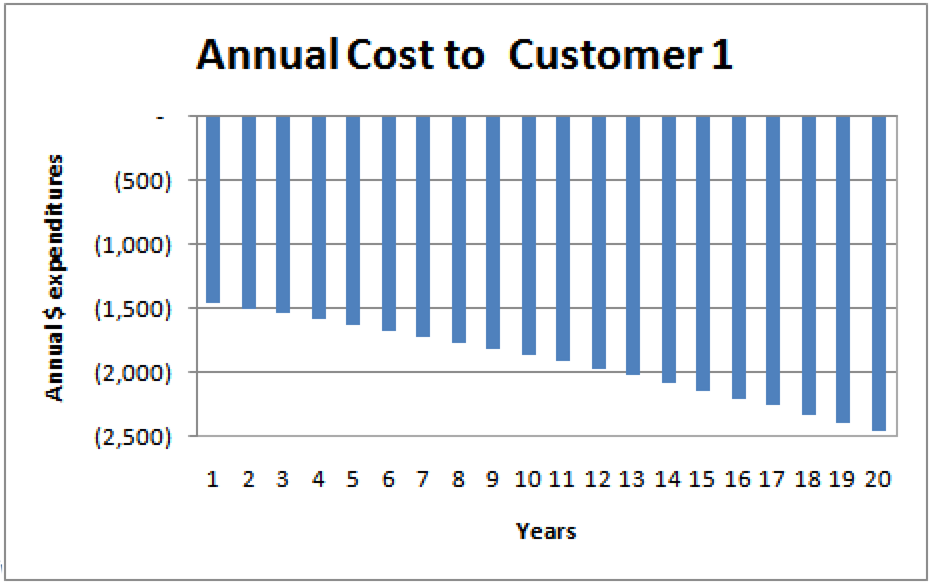
Scenario #1 - Geothermal space heating and cooling with additional DHW from desuperheater and separate heat pump (electr								
Year	1	2	3	4	5	10	15	20
Heat pump equipment ($)	(8,100)							
Geothermal and heat pump peripherals & drilling ($)	(10,500)							
CapEx ($)	(18,600)							
Mortgage payment on CapEx ($)	(1,388)	(1,388)	(1,388)	(1,388)	(1,388)	(1,388)	(1,388)	(1,388)
Heating energy consumption, electric (kWh)	2,803	2,803	2,803	2,803	2,803	2,803	2,803	2,803
Cooling energy consumption, electric (kWh)	934	934	934	934	934	934	934	934
Domestic hot water energy consumption, electric (kWh)	1,098	1,098	1,098	1,098	1,098	1,098	1,098	1,098
Total energy consumption, electricity (kWh)	4,834	4,834	4,834	4,834	4,834	4,834	4,834	4,834
Electricity cost ($/kWh)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.09)	(0.11)	(0.12)
Electricity purchase ($)	(338)	(349)	(359)	(370)	(381)	(442)	(512)	(593)
Net cash flow ($)	(1,726)	(1,736)	(1,747)	(1,757)	(1,768)	(1,829)	(1,899)	(1,981)
NPV rate (%)	6.25%							
NPV ($)	(21,692)							

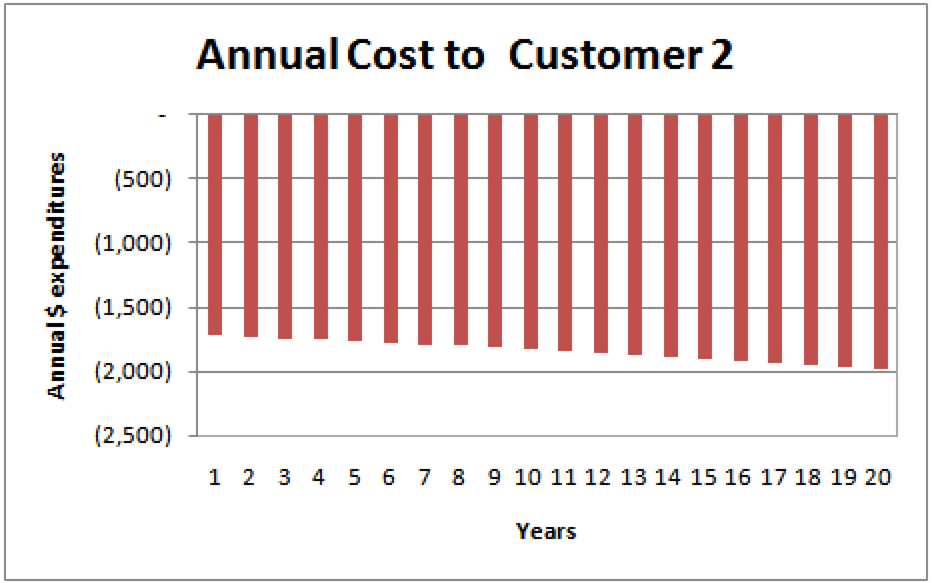
Scenario #3 - Baseline electric (electric space heating, cooling, and domestic hot water)								
Year	1	2	3	4	5	10	15	20
Electric heater cost ($)	(500)							
Electric cooler cost ($)	(1,150)							
Electric water heater cost ($)	(350)							
CapEx ($)	(2,000)							
Mortgage payment on CapEx ($)	(149)	(149)	(149)	(149)	(149)	(149)	(149)	(149)
Heating energy consumption, electric (kWh)	12,612	12,612	12,612	12,612	12,612	12,612	12,612	12,612
Cooling energy consumption, electric (kWh)	1,293	1,293	1,293	1,293	1,293	1,293	1,293	1,293
Hot water energy consumption, electric (kWh)	4,879	4,879	4,879	4,879	4,879	4,879	4,879	4,879
Total energy consumption, electricity (kWh)	18,784	18,784	18,784	18,784	18,784	18,784	18,784	18,784
Electricity cost ($/kWh)	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.09)	(0.11)	(0.12)
Electricity purchase ($)	(1,315)	(1,354)	(1,395)	(1,437)	(1,480)	(1,716)	(1,989)	(2,306)
Net cash flow ($)	(1,464)	(1,504)	(1,544)	(1,586)	(1,629)	(1,865)	(2,138)	(2,455)
NPV rate (%)	6.25%							
NPV ($)	(21,675)							

We can now see the cash flow and NPV implications for each of our same two customers under our assumed conditions









A simple scenario matrix table gives some indication of sensitivity

Model output

Scenario #1 - Geothermal space heating and cooling with additional DHW from desuperheater and separate heat pump (electric)

Scenario #2 - Geothermal space heating and cooling with DHW from desuperheater and electric resistance (electric)

Scenario #3 - Baseline electric (electric space heating, cooling, and domestic hot water)

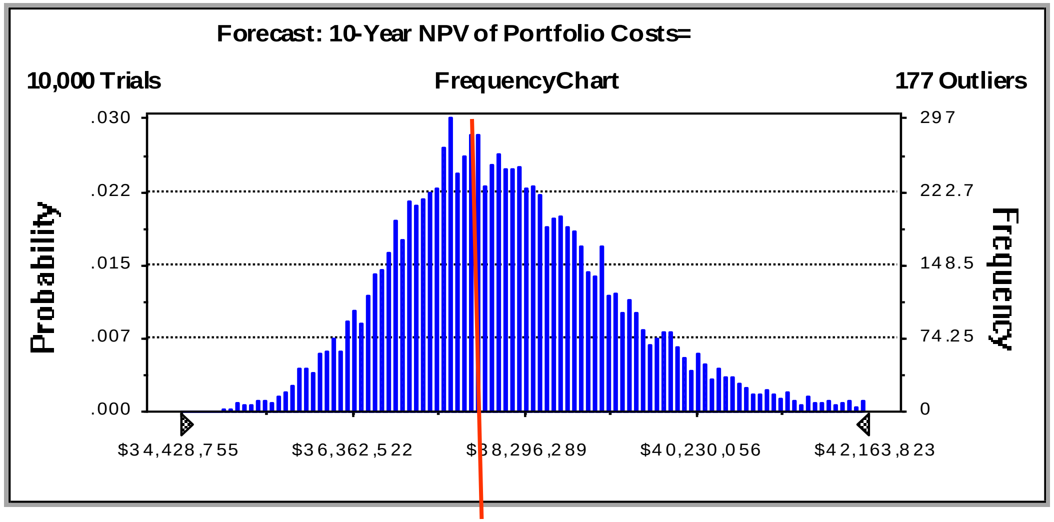
Scenario #4 - Baseline gas and electric (gas space heating, electric cooling and domestic hot water)

Electricity cost sensitivity analysis (note: gas scenario not included). Costs represent 20-year space heating, space cooling, and domestic hot water costs (NPV, $). Green cells indicate lowest cost scenario.

$/kWh	0.04	0.045	0.05	0.055	0.06	0.065	0.07	0.075	0.08	0.085	0.09	0.095	0.1	0.105	0.11	0.115	0.12	0.125
Scenario #1	(19,498)	(19,864)	(20,230)	(20,595)	(20,961)	(21,327)	(21,692)	(22,058)	(22,424)	(22,789)	(23,155)	(23,521)	(23,886)	(24,252)	(24,618)	(24,983)	(25,349)	(25,715)
Scenario #2	(20,109)	(20,576)	(21,043)	(21,510)	(21,977)	(22,445)	(22,912)	(23,379)	(23,846)	(24,313)	(24,780)	(25,248)	(25,715)	(26,182)	(26,649)	(27,116)	(27,583)	(28,051)
Scenario #3	(13,149)	(14,570)	(15,991)	(17,412)	(18,833)	(20,254)	(21,675)	(23,095)	(24,516)	(25,937)	(27,358)	(28,779)	(30,200)	(31,621)	(33,042)	(34,463)	(35,884)	(37,304)
Max NPV (bes	(13,149)	(14,570)	(15,991)	(17,412)	(18,833)	(20,254)	(21,675)	(22,058)	(22,424)	(22,789)	(23,155)	(23,521)	(23,886)	(24,252)	(24,618)	(24,983)	(25,349)	(25,715)

- **The matrix shows that if electricity prices to customer exceed $0.75, a geothermal heat pump system that produces space heating, cooling, and domestic hot water has the lowest life cycle cost (NPV) to homeowner**
  - **Helps developer see breakeven points**
  - **Doesn’t provide much insight to risk**
  - **Doesn’t help the utility to evaluate the project**

A Monte Carlo analysis would enable the all parties to better understand the risks as well as the sensitivities



Statistic	Value
Trials	10,000
Mean	$38,200,426
Median	$38,005,753
Standard Deviation	$1,600,045

- **Quantifies descriptive statistics**
- **Can predict expectations within desired confidence interval**
- **Can lead to more constructive discussion between utility and developer**

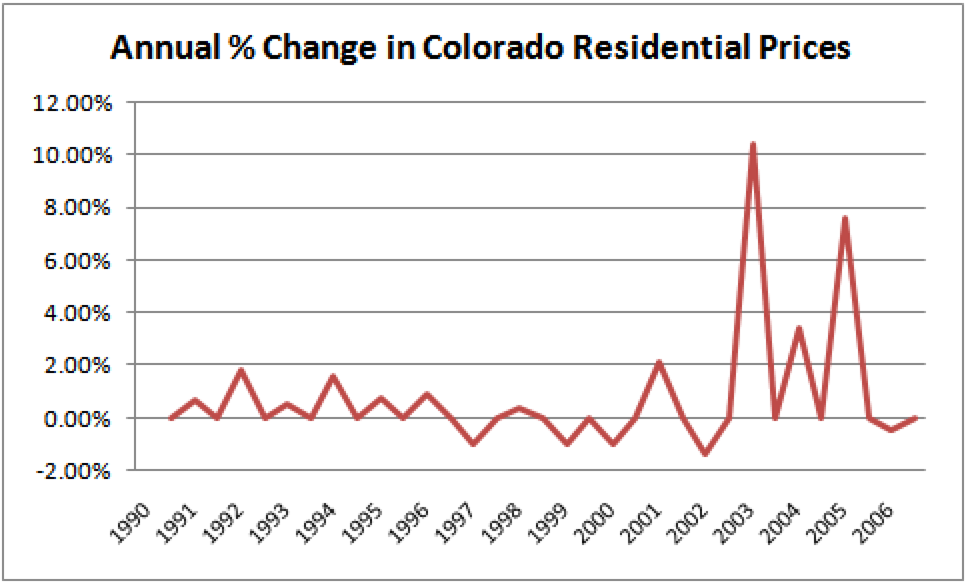
Lets examine the risk exposure to each party from two simplified variables

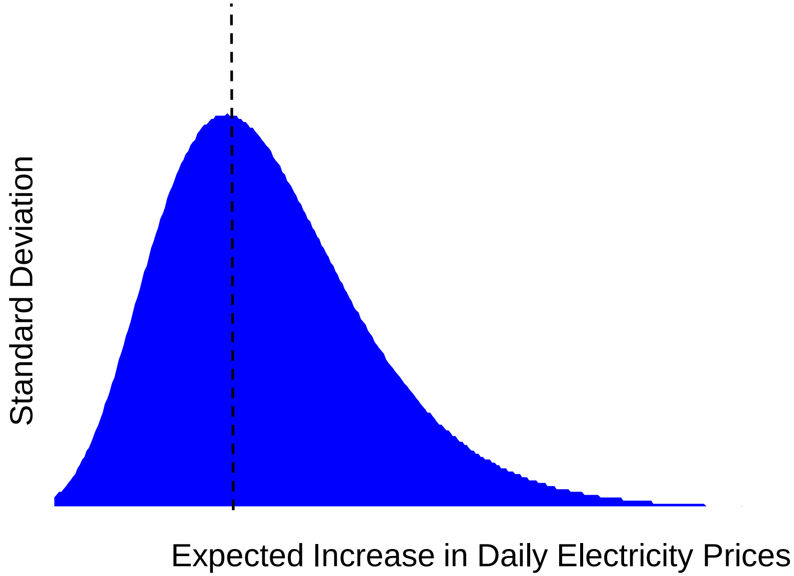
Electricity Cost to Consumer	A "average" cost, subject to minor periodic rate increases, but fairly stable We will use the fully loaded average $/KWh (Total customer annual bill divided by total kWh delivered)
Utility's Cost to Serve Consumer	A marginal cost, incremental cost to the utility to serve this specific new development We will assume it is the spot market price of electricity on the wholesale market

<u>VERY simplified analysis</u>

Used here to illustrate the impact of two variables with <u>all else being equal</u>

Electricity cost to consumer can be looked at historically and described using statistical descriptors

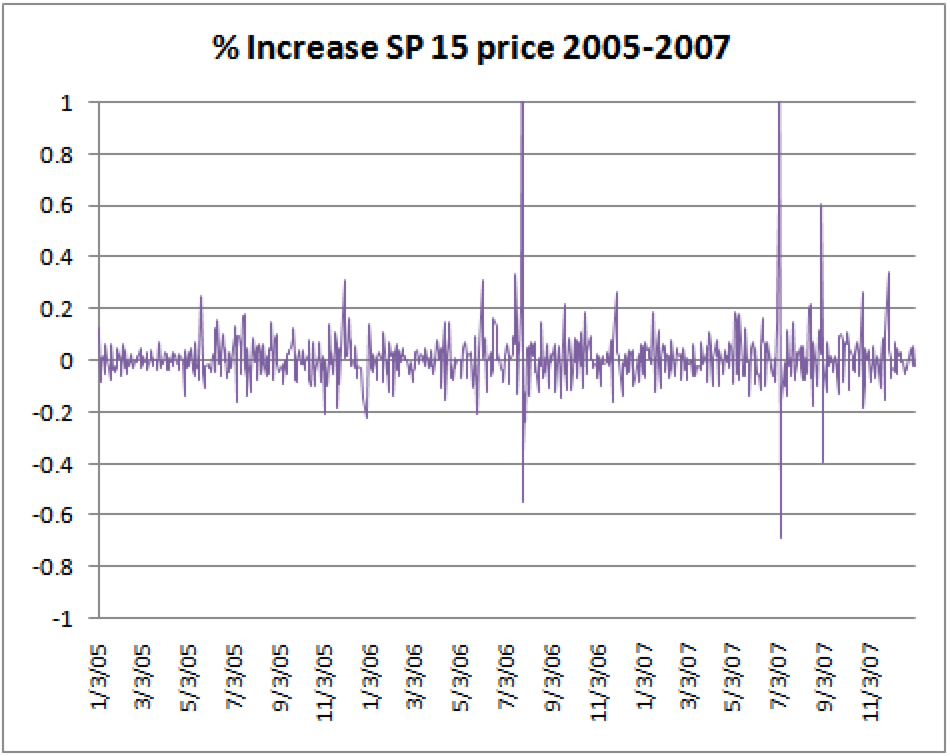


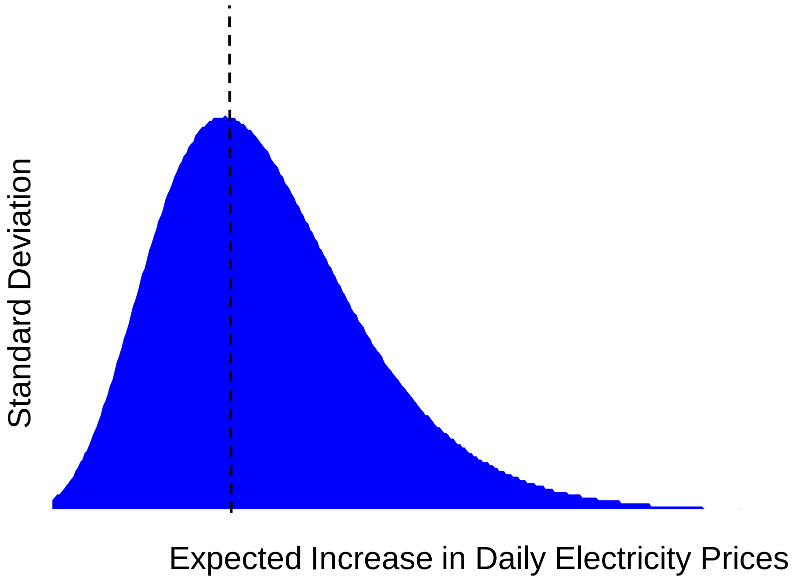


Mean	0.79%
Standard deviation	2.35%

Mean	0.79%
Standard deviation	2.35%

Utility's cost to serve consumer can also be looked at historically and described using statistical descriptors

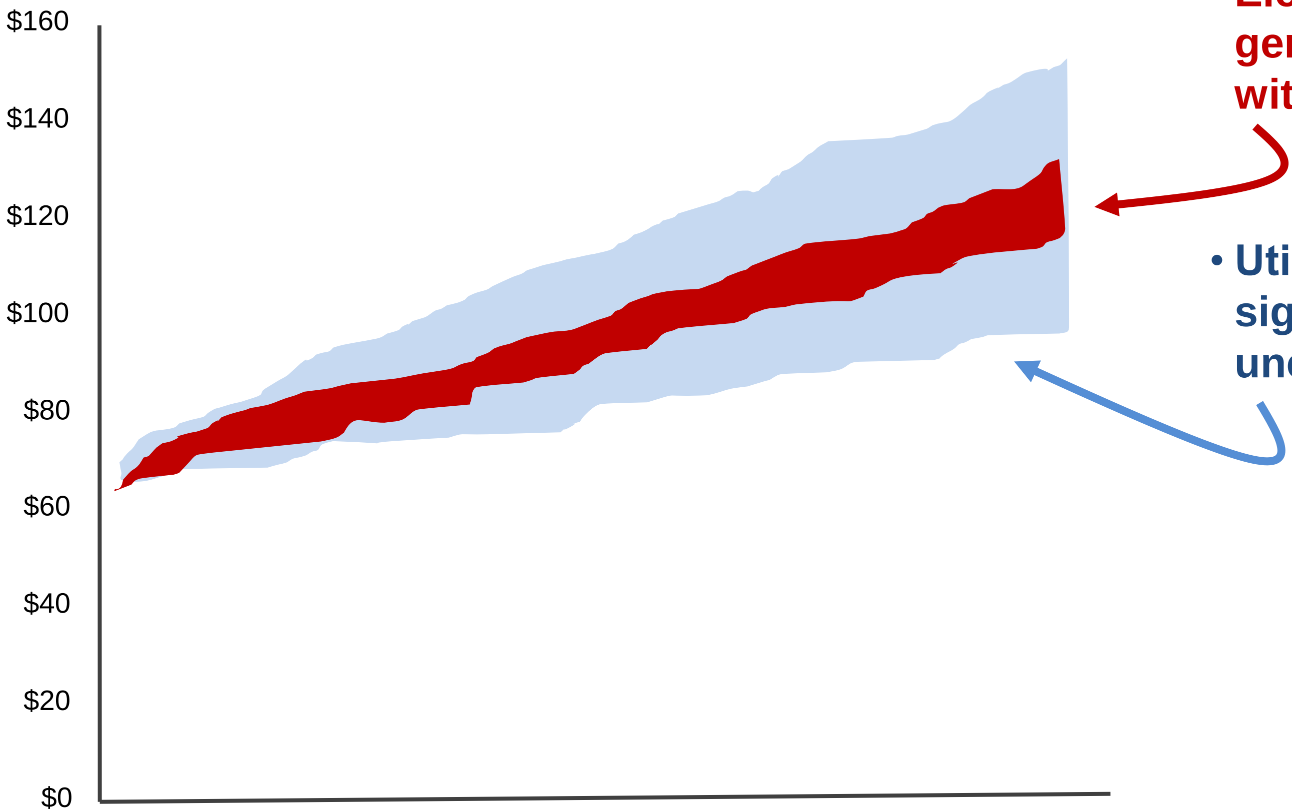




Mean	0.65%
Standard Deviation	12.64%

Mean	0.65%
Standard Deviation	12.64%

Summary of what we are forecasting…..



- **Electricity cost to customer is generally increasing upward with some volatility**
- **Utility's cost to serve has significantly greater price uncertainty and volatility**

We will use the Monte Carlo analysis to tell us….

- Costs, benefits, and risk to the utility and to the developer
- An indication where the risks are shared and where one party assumes greater risk exposure
- Potential bridge to engage in constructive dialog to create win-win opportunities

- We will do this by creating 1,000 separate spreadsheet models and randomly picking a different value for the electric cost to consumer and the utility's marginal cost to serve from our forecasted expectations for each of the 1,000 spreadsheet models
  - Most computers can perform this analysis of 1,000 models in a matter minutes, or even seconds
  - Our model is highly simplified, and ignores many other important variables that would affect future benefits
    - Inflation, load growth, gas prices etc
    - ***However, we could easily incorporate these other variables if we so desired***

Preview of what we are going to quantify

		Year (1)	Year (2)	Year (n).....	
MWh produced from geothermal	A				
Cost of GHP energy produced	B				
Cost of electricity purchased from utility	C				
Cost of spot wholesale prices to the utility	D				
Annual Cash Flows					
To developer	[C-B]				
To utility	[D-C]				

- 20 Year Planning Horizon
- Quantify change in NPV for developer and utility for different assumed values of electric prices and wholesale prices
- Assuming a 100-200 home development would scale up the impact

Focusing on a specific quantified outcome such as the 20 year NPV, provides additional insight

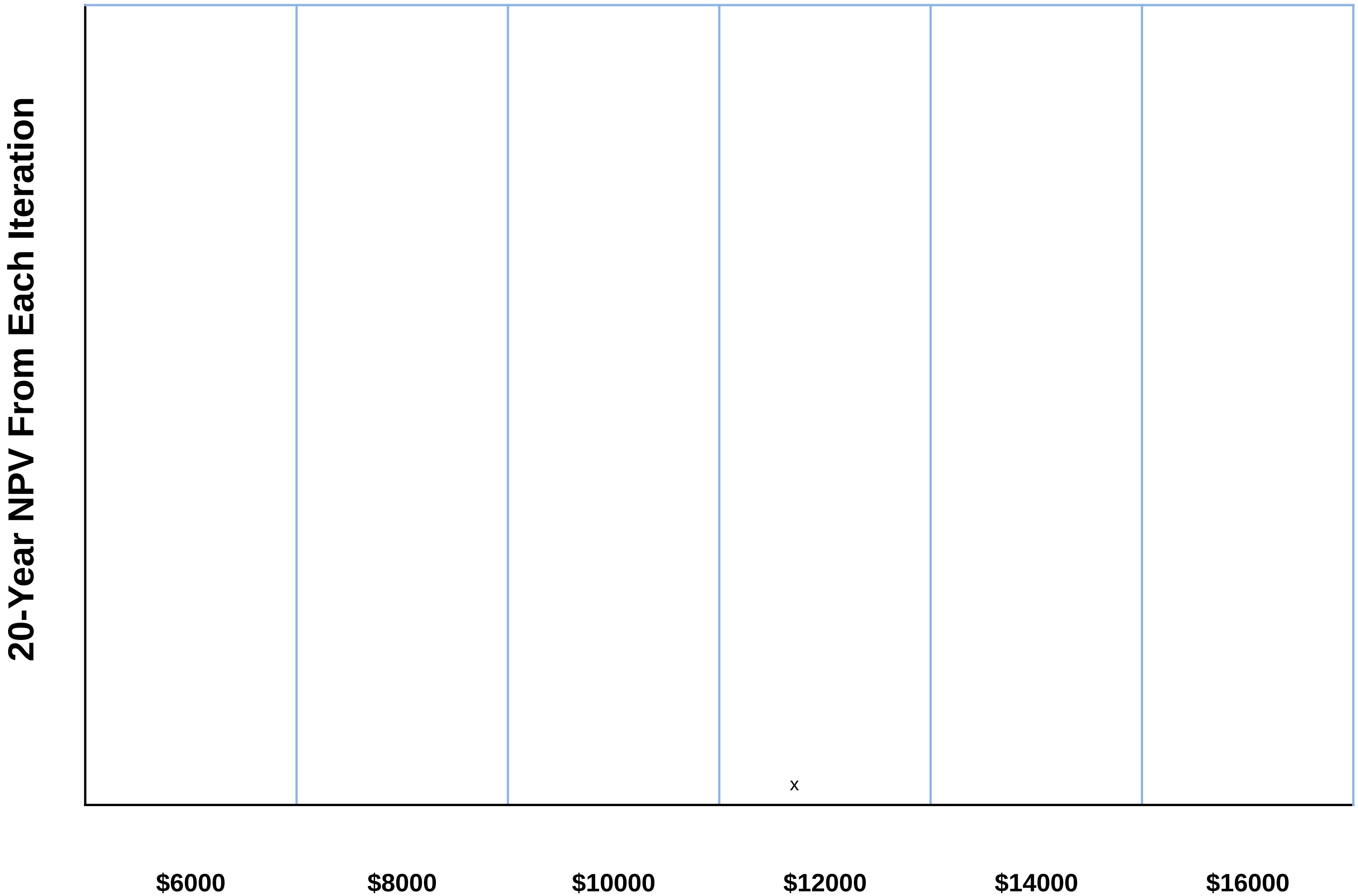
20-Year NPV From Each Iteration

- **What we are going to do is to count the number of times the 20 year NPV value falls between certain ranges of outcomes**

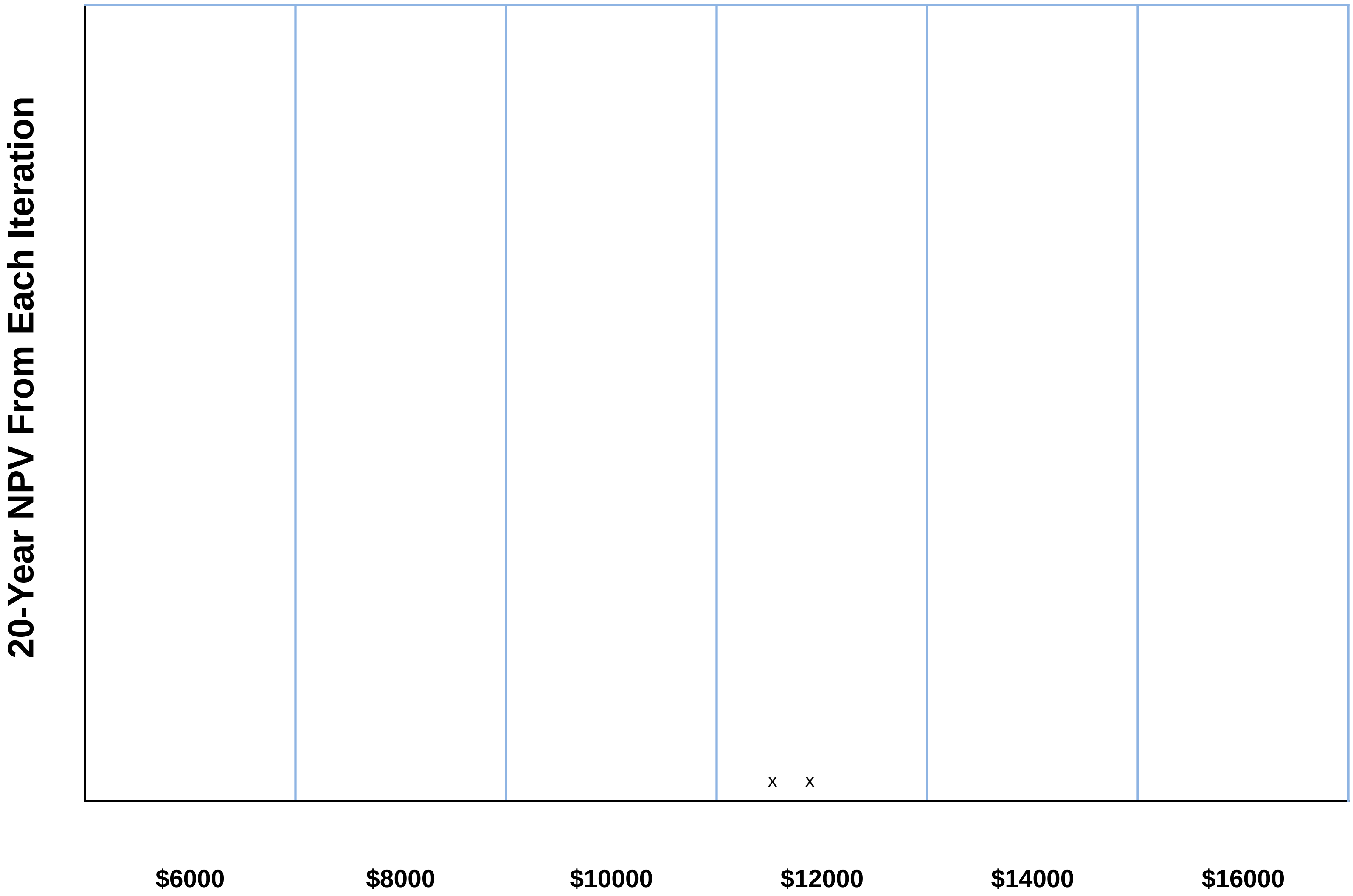
- **Each iteration will recalculate the values from the spreadsheet model, and give us a different estimated value for the 20-year NPV of the costs based upon new estimates for the independent variables**

$6000 $8000 $10000 $12000 $14000 $16000

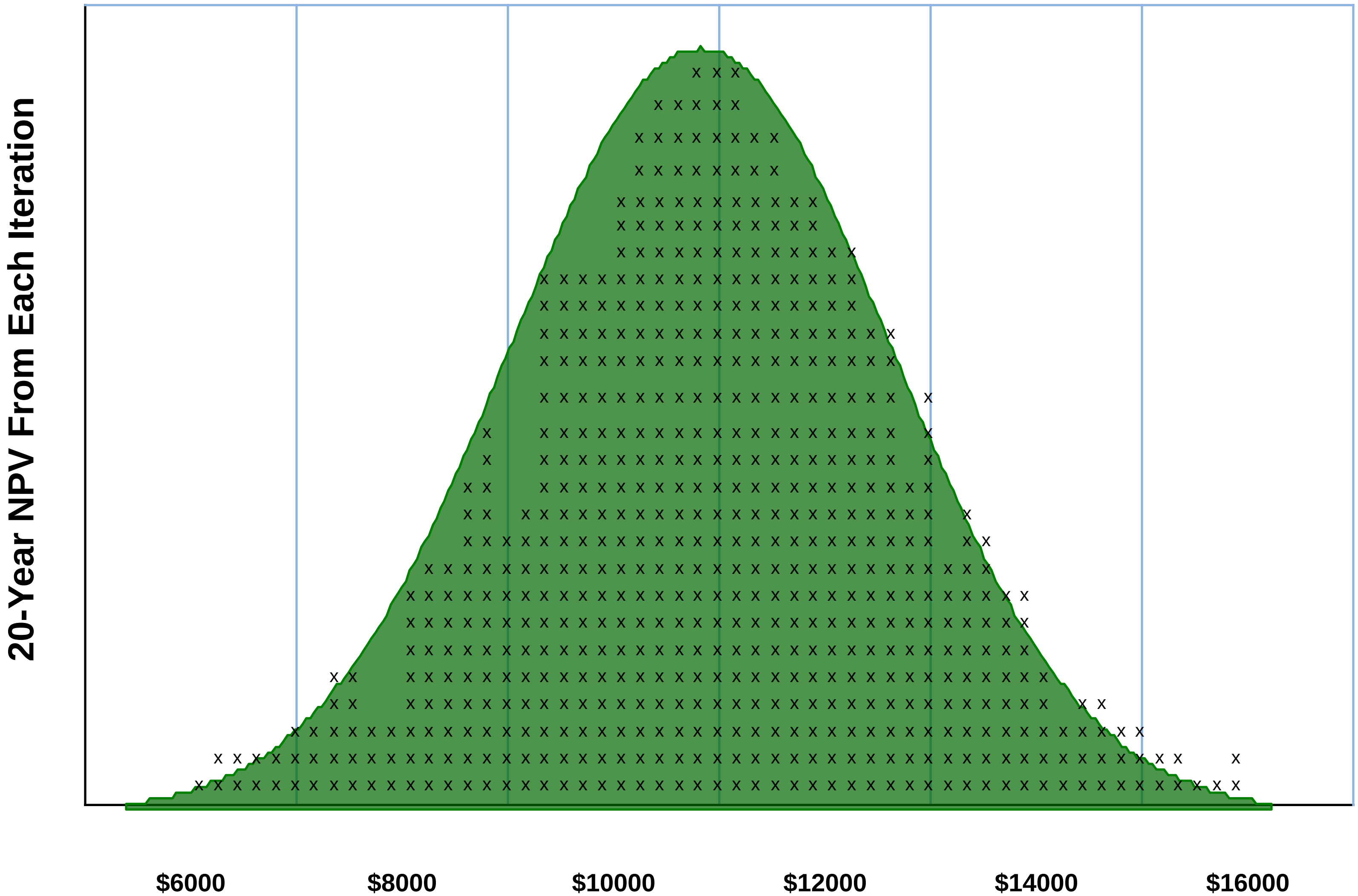
Focusing on a specific quantified outcome such as the 20 year NPV, provides additional insight



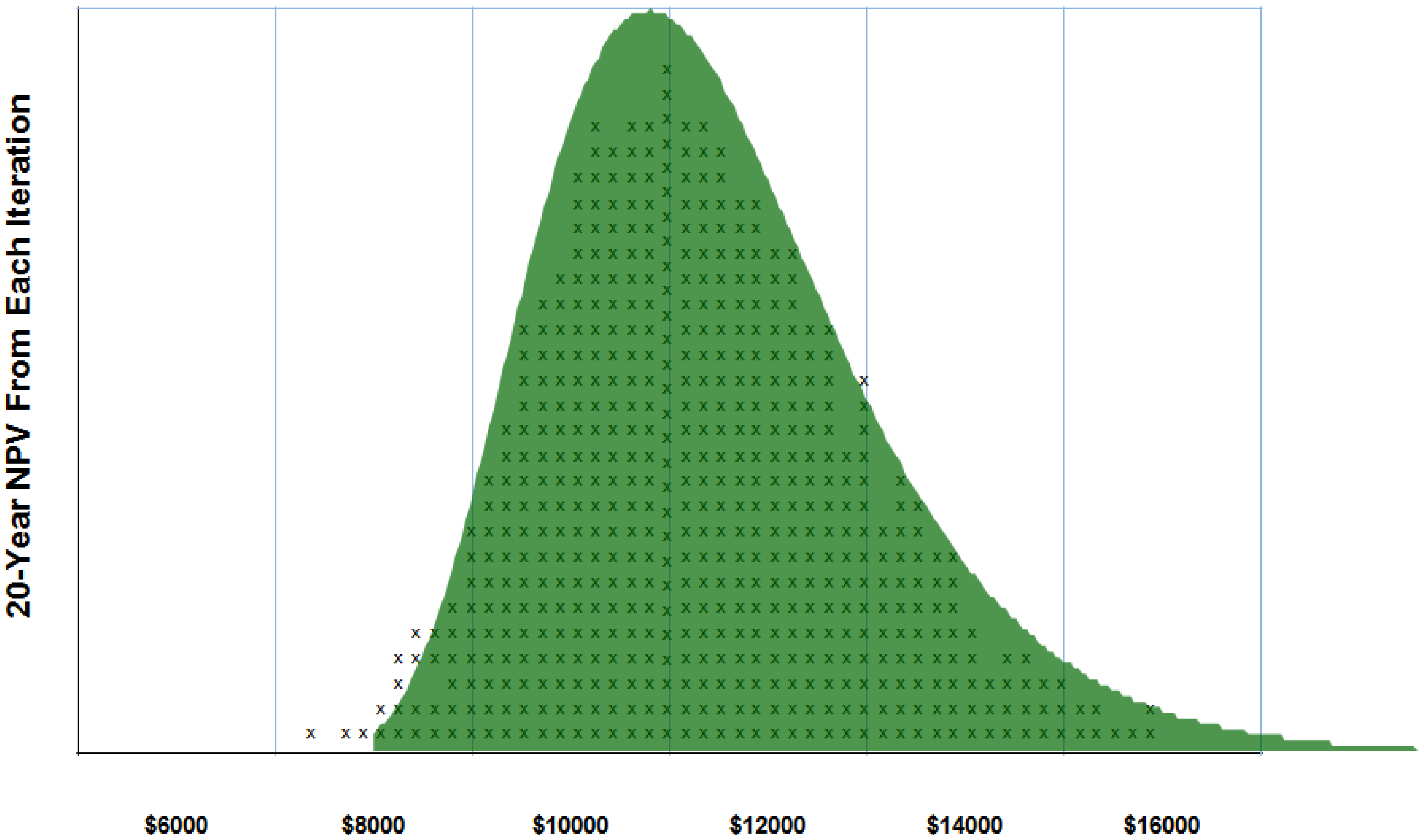
Focusing on a specific quantified outcome such as the 20 year NPV, provides additional insight



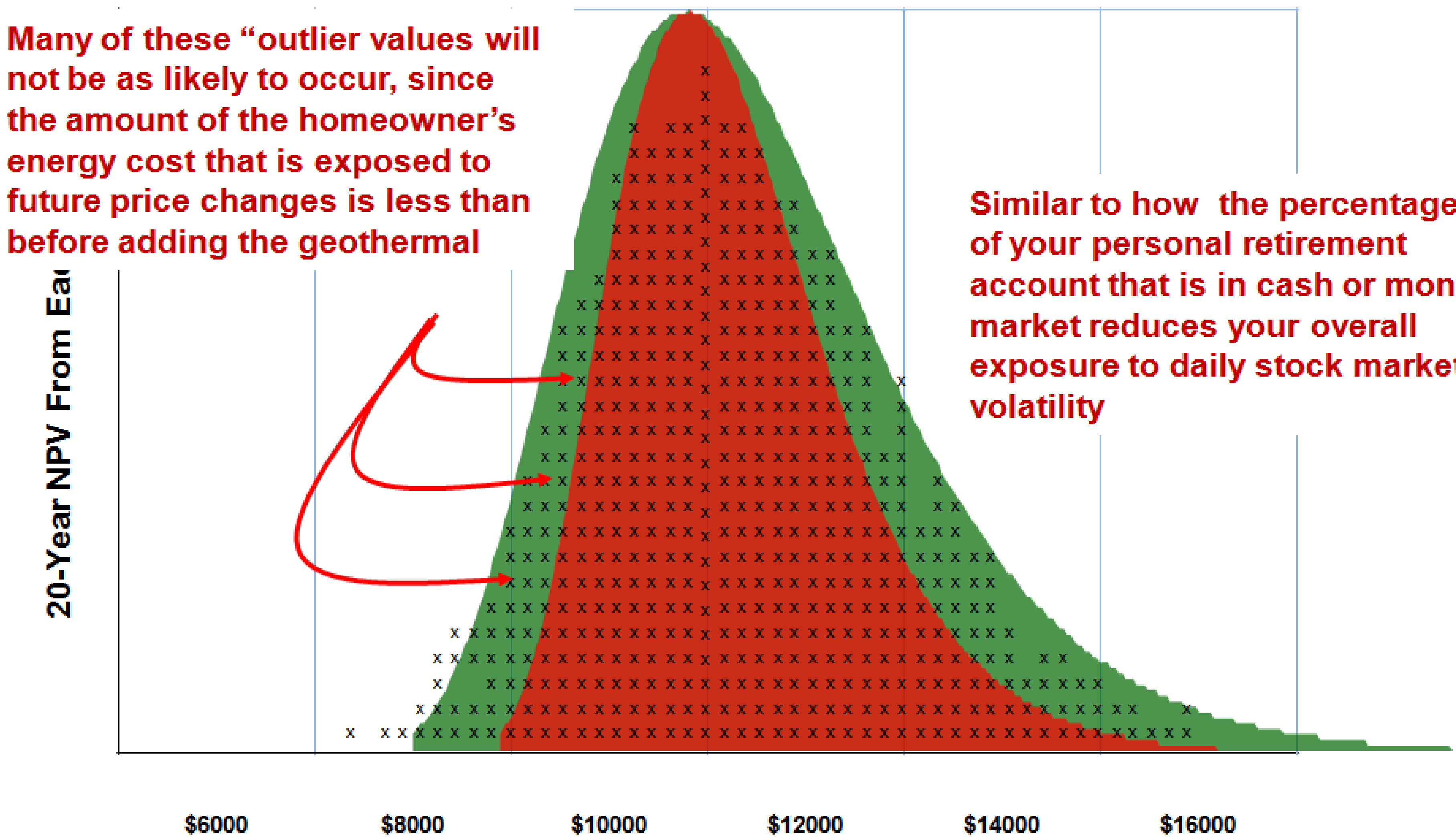
Focusing on a specific quantified outcome such as the 20 year NPV, provides additional insight



A distribution of power portfolio cost is more likely to be a "log-normal" than a "normal" shape due to the greater potential for costs to increase, while many costs cannot fall below a certain point



Because of its flat variable costs (fuel), most renewables such as geothermal or solar, will dampen cost volatility and as a result reduce total portfolio risk



Summary of what each party learns

Developer Learns

- Developer is able to provide something that customers value with the help of the utility
  - Tangible economic value (lower dollars paid for energy)
  - Higher efficiency home creates environmental benefits
- Quantifies the homeowner's exposure to future energy price volatility
  - Homeowner can evaluate the cost to install GHP versus the risk of increasing energy prices
- This same analysis and approach could also be expanded to other technologies
  - Solar PV, energy efficiency programs

Utility Learns

- Insight to a lower risk alternative to meeting load growth requirements
  - Owning a generating asset or signing a fixed price PPA is an obvious other risk mitigation strategy they could also consider
  - Most IRPs recently are concluding to do all the energy efficiency and peak load management programs they can manage
- Utility will still need to look more fully at all cost factors to optimize a GHP program
  - Tariffs
  - Rebates
  - Impact to other customers

Questions


ION
CONSULTING
BRIAN WALSHE
MANAGING PARTNER
3773 Cherry Creek North Dr.
Suite 575
Denver, CO 80209
Main: 303 355 1030
Cell: 303 949 4646
bfw@ionconsulting.com