

Risk Analysis using PRISM (Power Risk System Model)

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Presentation Outline

- ❑ Reasons for Developing PRISM
- ❑ Purpose of PRISM
- ❑ Key Inputs
- ❑ Representation of MH System in PRISM
- ❑ The Simulation
- ❑ Sample Risk Analyses



Reasons for Developing PRISM

- ❑ To analyze the financial impact of variations in:
 - Water conditions (volume risk)
 - Manitoba load
 - Gas and electricity prices
 - Forward contracting risk (export sales)
 - Transmission access (intertie connections)
 - Wind energy (variability in generation)
- ❑ Recommended and initial development by RiskAdvisory



Purpose of PRISM

- Provide Monte Carlo Simulation
 - Probabilistic analysis
- In-house model
 - Therefore functional, easily modified
- To provide an overview, not a precise analysis
- Used to identify range of outcomes associated with defined scenarios



Limitations

- ❑ Limited resolution
- ❑ Limited capacity consideration
- ❑ 5 year analysis period set in long-term planning horizon
 - Fiscal Years 2010 – 2014
- ❑ Price volatility data is not readily available
 - Annual price forecast used
 - No intra year correlation

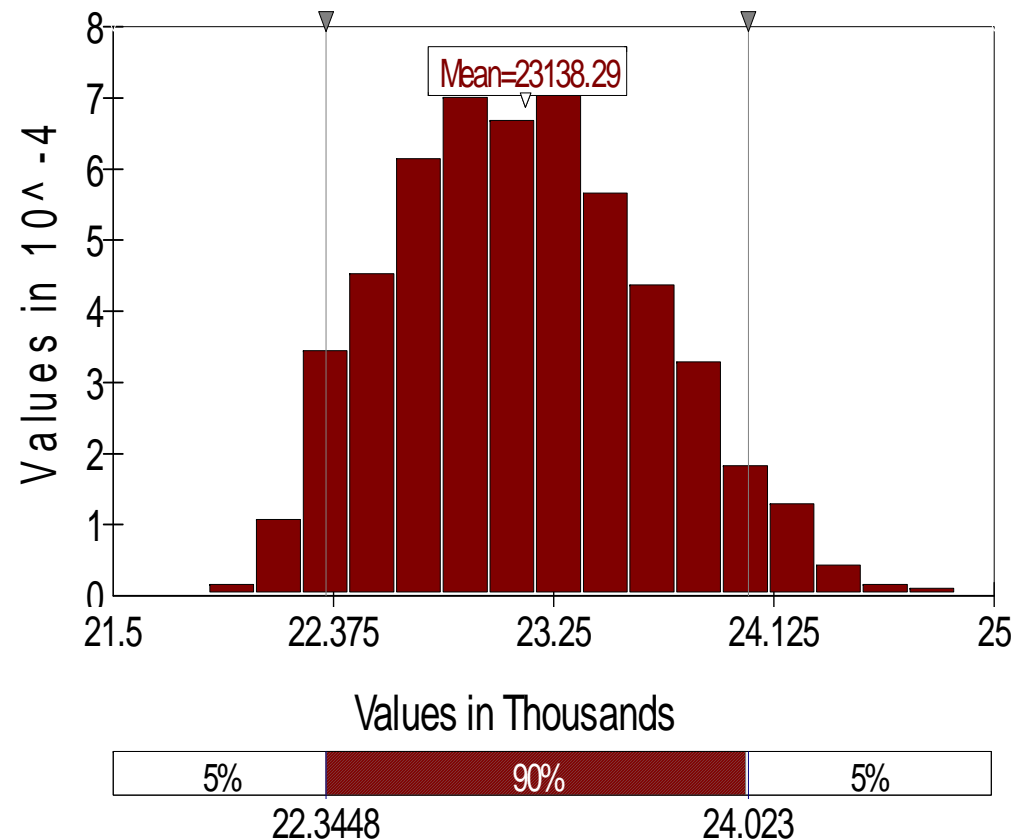


Key Inputs

- ❑ Manitoba Load
- ❑ Hydro Generation
- ❑ Gas and Electricity Prices
- ❑ Sourced from Approved MH resources
 - Electric Load Forecast
 - Electricity Export Price Forecast
 - Energy Price Outlook Report
 - HERMES (Hydraulic Operations)
 - SPLASH (Resource Planning & Market Analysis)

Key Input: Manitoba Load

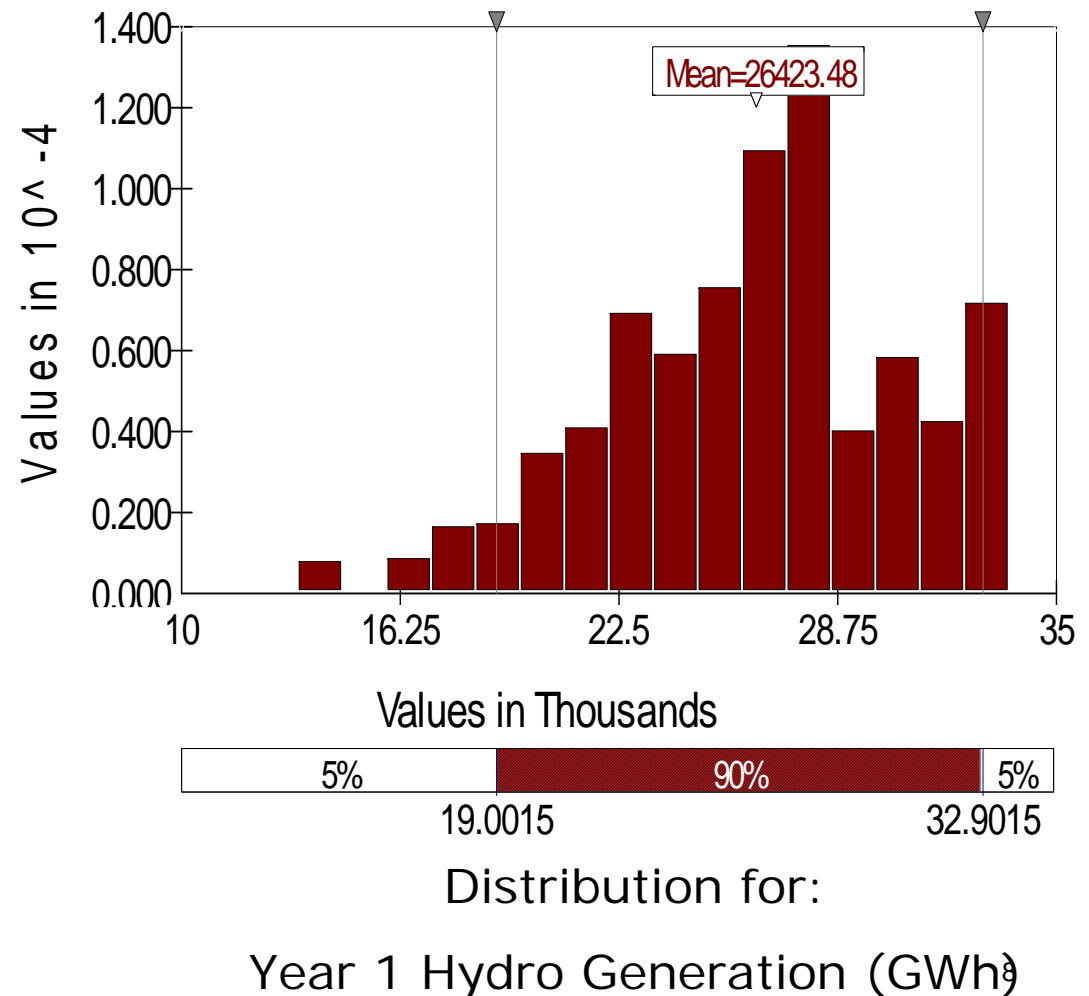
- Load distribution from HERMES
 - 50 discrete load values per season
 - Year 1 Load
- Load for years 2, 3, 4, and 5 is scaled from year 1 based on annual load growth rate
- Load growth rate = average growth rate from 2008/09 to 2014/15 in Electric Load Forecast



Distribution for:
Year 1 Manitoba Load (GWh)

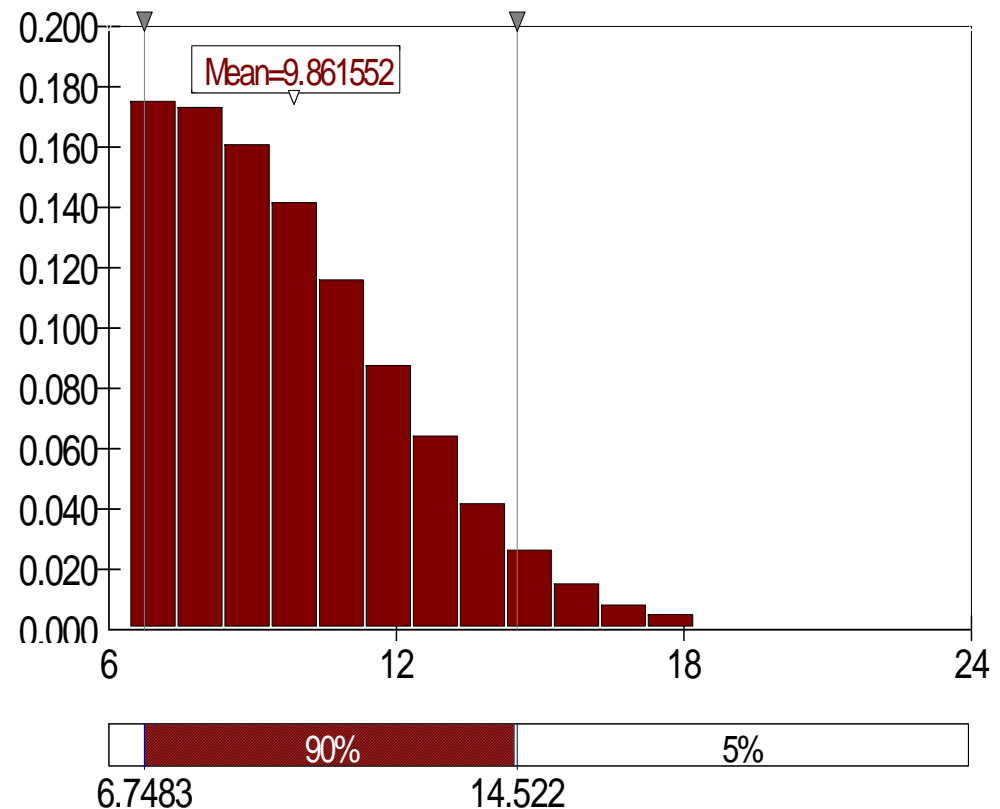
Key Input: Hydro Generation

- SPLASH provided total hydro energy generation
- 94 discrete flow cases represent historic flow years 1912 – 2005



Key Input: Gas Prices

- Normal distribution with truncated lower tail
- Based on Natural Gas price from Energy Price Outlook Report (reference, medium-low, medium-high)



Distribution for:

Year 1 Gas Price (2008 US \$ / MMBtu)



Key Input: Electricity Prices

- Normal distribution
- Data source:
Electricity Export
Price Forecast
- Correlation
between gas and
electricity prices

Representation of MH System in PRISM

- Model is Seasonal
 - Summer = April – October (7 months)
 - Winter = November – March (5 months)

Representation of MH System in PRISM

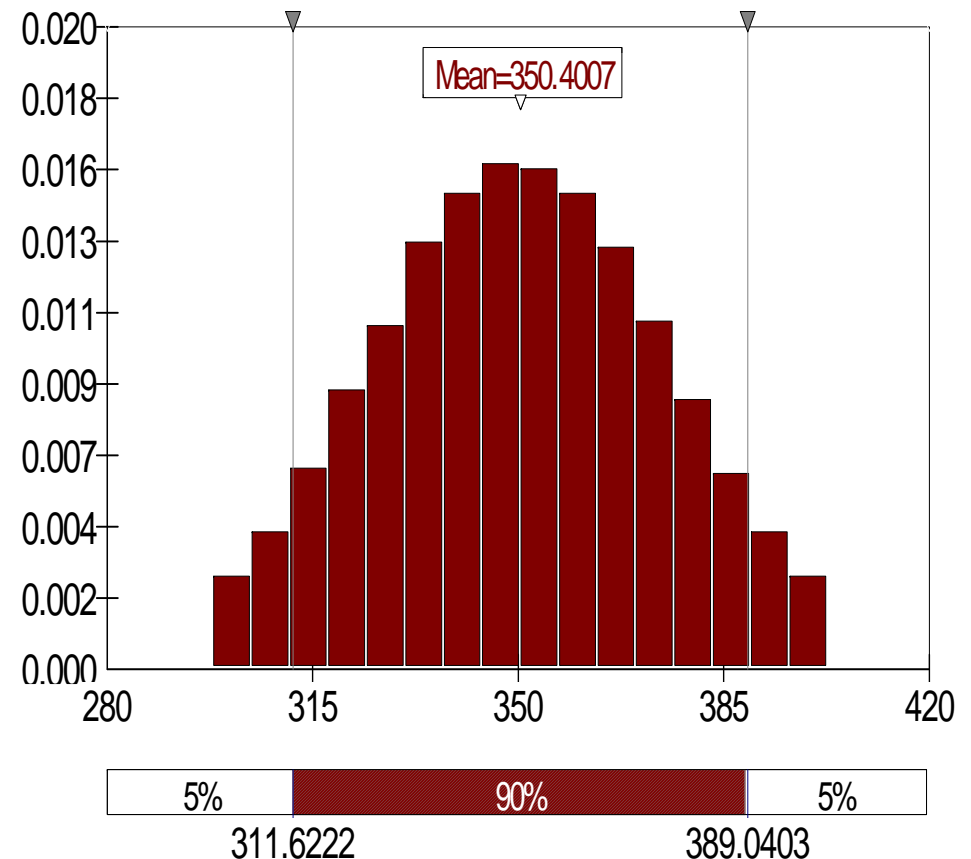
- ❑ Model is Seasonal
- ❑ Chronologic Flow
 - 5 flow years for 5 year analysis
 - Each of the 94 historic flow years has an equal chance of being selected for year 1
 - Flow cases for years 2, 3, 4, and 5 are sequential based on year 1 flow year
 - If Year 1 = 1956, then Year 2 = 1957, Year 3 = 1958, etc.

Representation of MH System in PRISM

- Model is Seasonal
- Chronologic Flow
- Intertie Capabilities
 - Imports will be limited during high water conditions

Representation of MH System in PRISM

- Model is Seasonal
- Chronologic Flow
- Intertie Capabilities
- Wind Generation
 - Capacity = 100 MW
 - Capacity Factor = 40%
 - Normal distribution
 - Truncated outliers



Sample Distribution:
1 Year Wind Generation (GWh)¹⁴

Representation of MH System in PRISM

- Model is Seasonal
- Chronologic Flow
- Intertie Capabilities
- Wind Generation
- Storage
 - 5 storage draws available
 - Storage draws are priced very high
 - Therefore, storage is rarely used

Representation of MH System in PRISM

- ❑ Model is Seasonal
- ❑ Chronologic Flow
- ❑ Intertie Capabilities
- ❑ Wind Generation
- ❑ Storage
- ❑ Thermal Generation
 - Includes Brandon 5, Brandon CT, Selkirk GS
 - Available energy is determined from:
 - ❑ Capacity
 - ❑ Annual maintenance (6 weeks/year)
 - ❑ Forced outage rates (HERMES)

Representation of MH System in PRISM

- ❑ Model is Seasonal
- ❑ Chronologic Flow
- ❑ Intertie Capabilities
- ❑ Wind Generation
- ❑ Storage
- ❑ Thermal Generation
- ❑ Forward Contracts
 - Source: Power Resource Plan

Representation of MH System in PRISM

- ❑ Model is Seasonal
- ❑ Chronologic Flow
- ❑ Intertie Capabilities
- ❑ Wind Generation
- ❑ Storage
- ❑ Thermal Generation
- ❑ Forward Contracts
- ❑ Opportunity Export
 - Based on surplus energy, on and off peak prices, and intertie capabilities

The Simulation

- ❑ One simulation requires 1000 iterations
- ❑ For each iteration
 - Inputs with distributions are determined
 - Energy is stacked (resources are selected)
 - Net Revenue is determined
 - ❑ Annually (1 year) and cumulatively (5 years)
 - Repeat
- ❑ Output: Model produces plots (histograms) of distributions of inputs and outputs

Key Output: Net Revenue

Year 1: Flow Yr 1939, Fiscal Yr 2010/11

Supply

	Energy (GWh) (@ load)	Revenue (CDN\$)
Y1 Hydro Generation	19001	(\$72,625,535)
Y1 Wind	350	(\$19,832,065)
Y1 Coal (Brandon 5)	717	(\$29,853,820)
Y1 Imports	6475	(\$424,593,789)
Y1 Gas (Selkrik GS + Brandon CT)	0	\$0
Y1 Bookouts	0	\$0
Y1 Storage Draws	0	\$0
<i>Total Supply</i>	26544	(\$546,905,211)

Demand

Y1 Manitoba Load	23140	
Y1 Forward Contracts	3404	\$200,998,578
Y1 Incremental Load		\$539,366
Y1 Opportunity Export	0	\$0
<i>Total Demand</i>	26544	\$201,537,944

Total Energy (GWh)

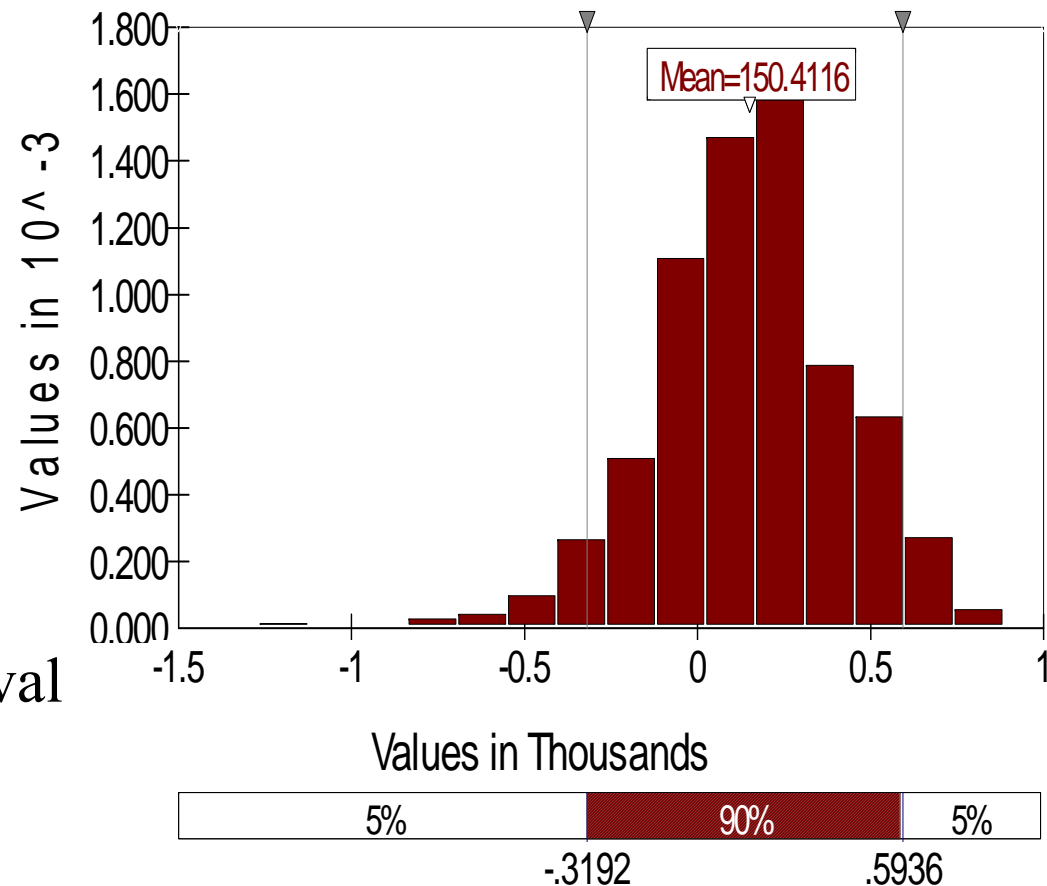
Y1 Total Supply	26544
Y1 Total Demand	26544
Y1 Net Energy	0

Net Revenue (Millions of Dollars)

Y1 Total Revenue (\$M)	\$202
Y1 Total Costs (\$M)	(\$547)
Y1 Net Revenue (\$M)	(\$345)

Sample Risk Analysis: Base Case

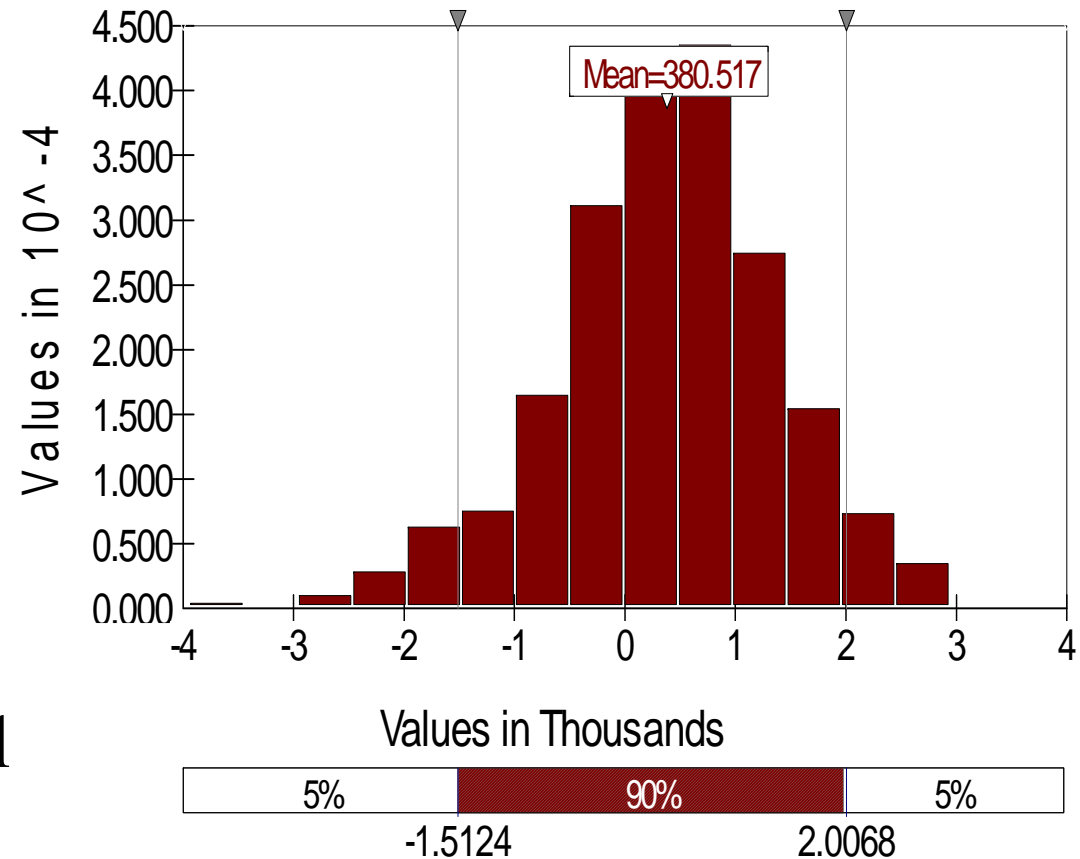
- All distributions as presented. Includes:
 - Year 1 flow year
 - Load
 - Gas price
 - Electricity price
 - Wind
- Mean Net Revenue = \$150 M
- 90% Confidence Interval (C.I.):
 - 5%: -\$319 M
 - 95%: \$593 M
- Base case is used to benchmark scenarios



Sample Distribution:
Year 1 Net Revenue (\$M)²¹

Sample Risk Analysis: Base Case

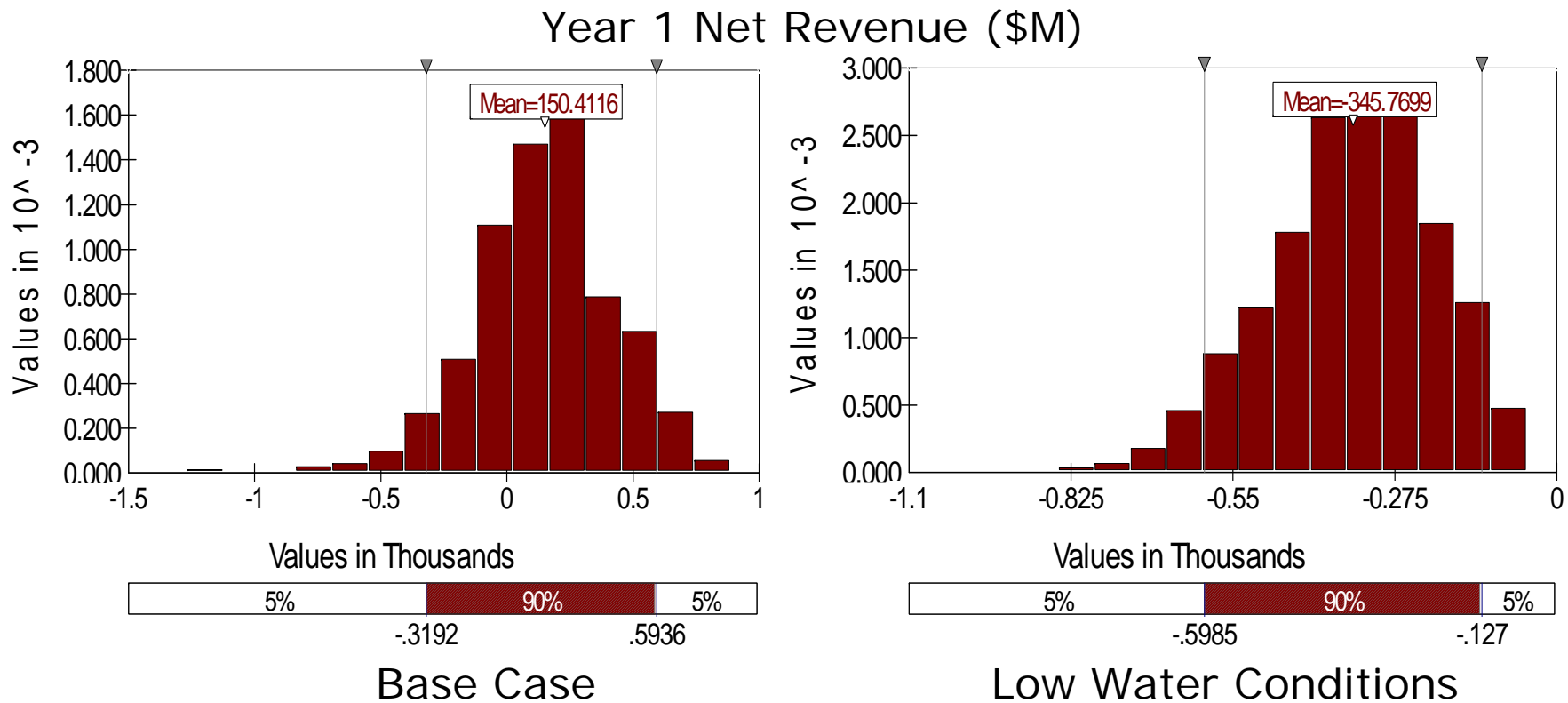
- 5 Year Cumulative
- Mean = \$380 M
- 5 Year Mean is not equal to Year 1 Mean x 5
 - i.e. \$150 M x 5 = \$750 M
 - ≠ \$380 M
- Confidence Interval (C.I.):
 - 5%: -\$1,512 M
 - 95%: \$2,006 M



Sample Distribution:

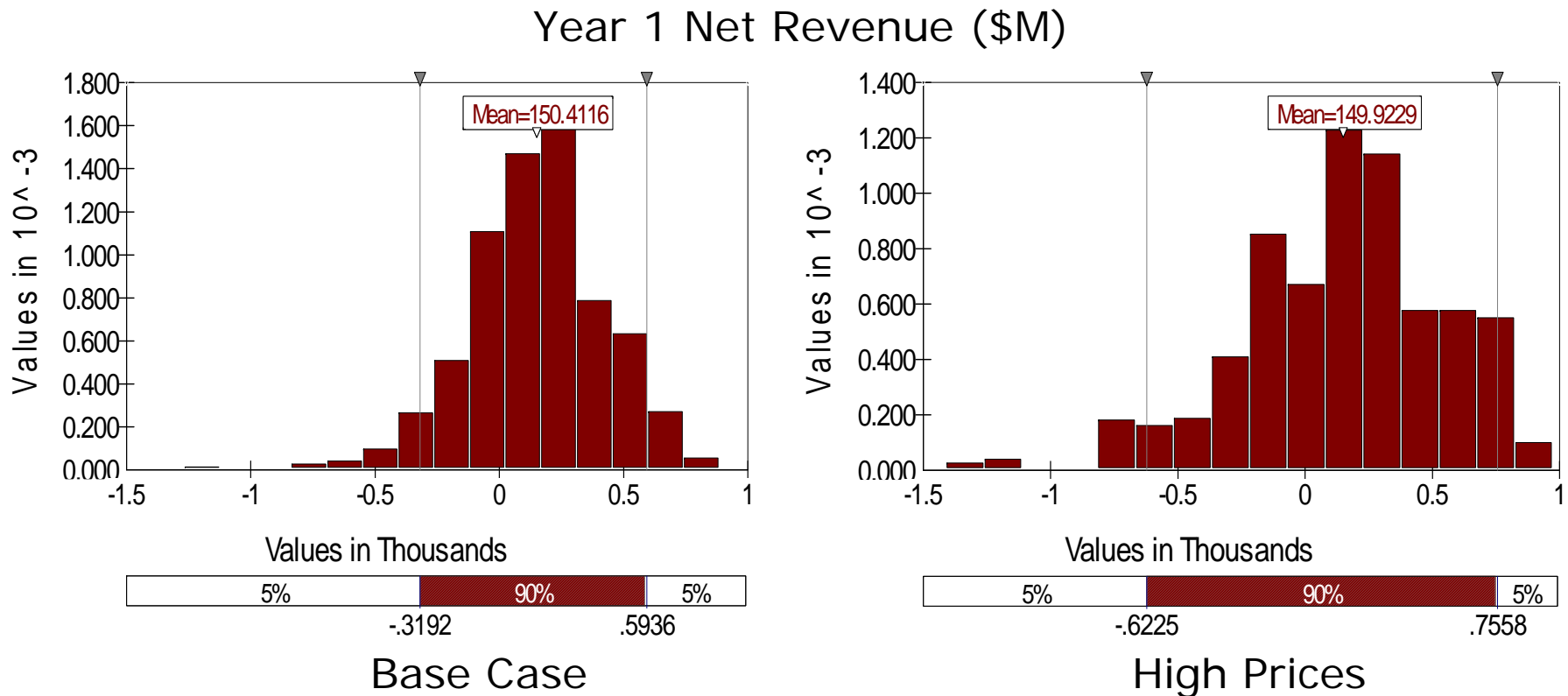
5 Year Cumulative Net Revenue (\$M) ²²

Sample Risk Analysis: Low Water Conditions (FY 1939)



- Set Year 1 Flow Year = Low Flow Year = 1939
- Base Case Mean = \$150 M (C.I. -\$319 M to \$593 M)
- Scenario Mean = -\$345 M (C.I. -\$598 M to -\$127 M)

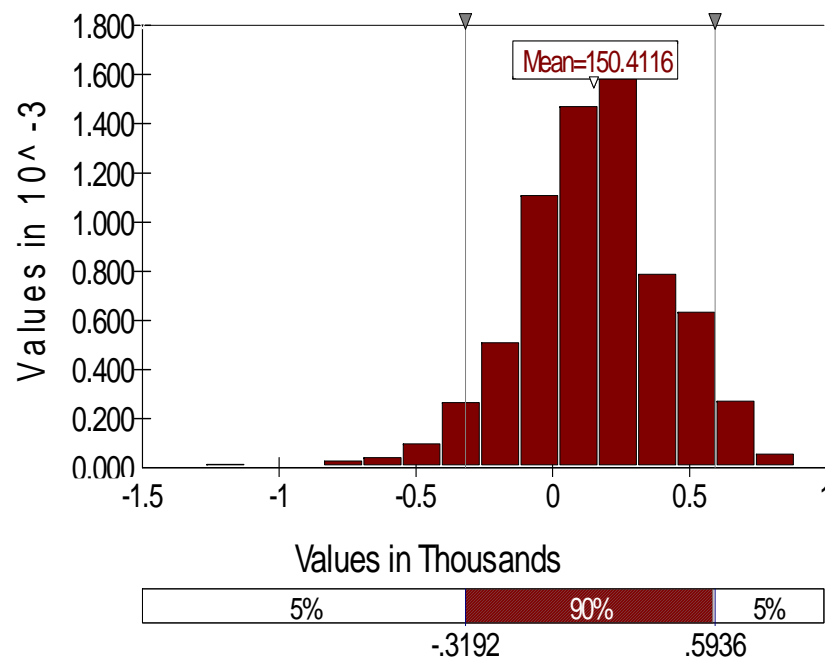
Sample Risk Analysis: High Gas and Electricity Prices



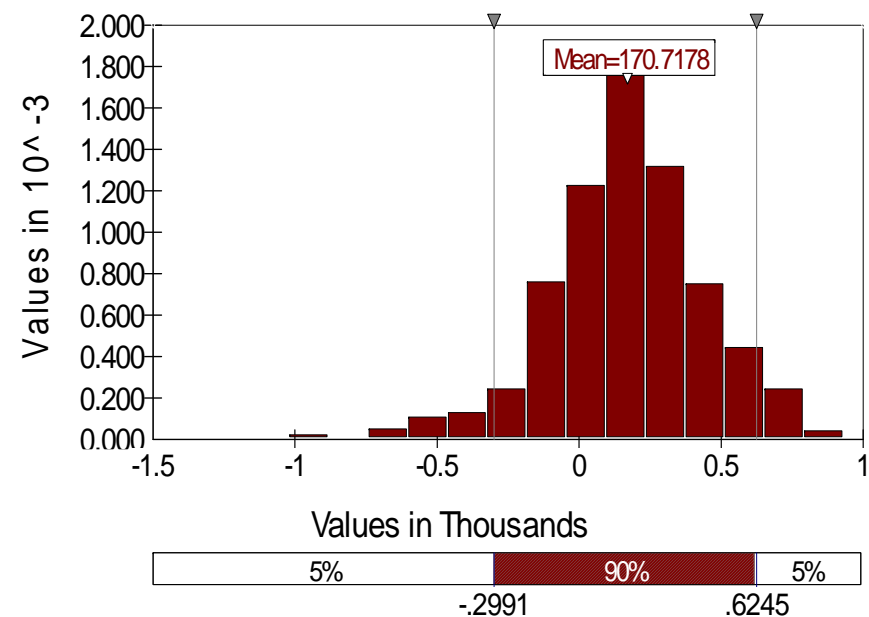
- Set Gas & Electricity Prices = 95th percentile
- Base Case Mean = \$150 M (C.I. -\$319 M to \$593 M)
- Scenario Mean = \$149 M (C.I. -\$622 M to \$755 M)

Sample Risk Analysis: Forward Contracts = 50% of Current Commitments

Year 1 Net Revenue (\$M)



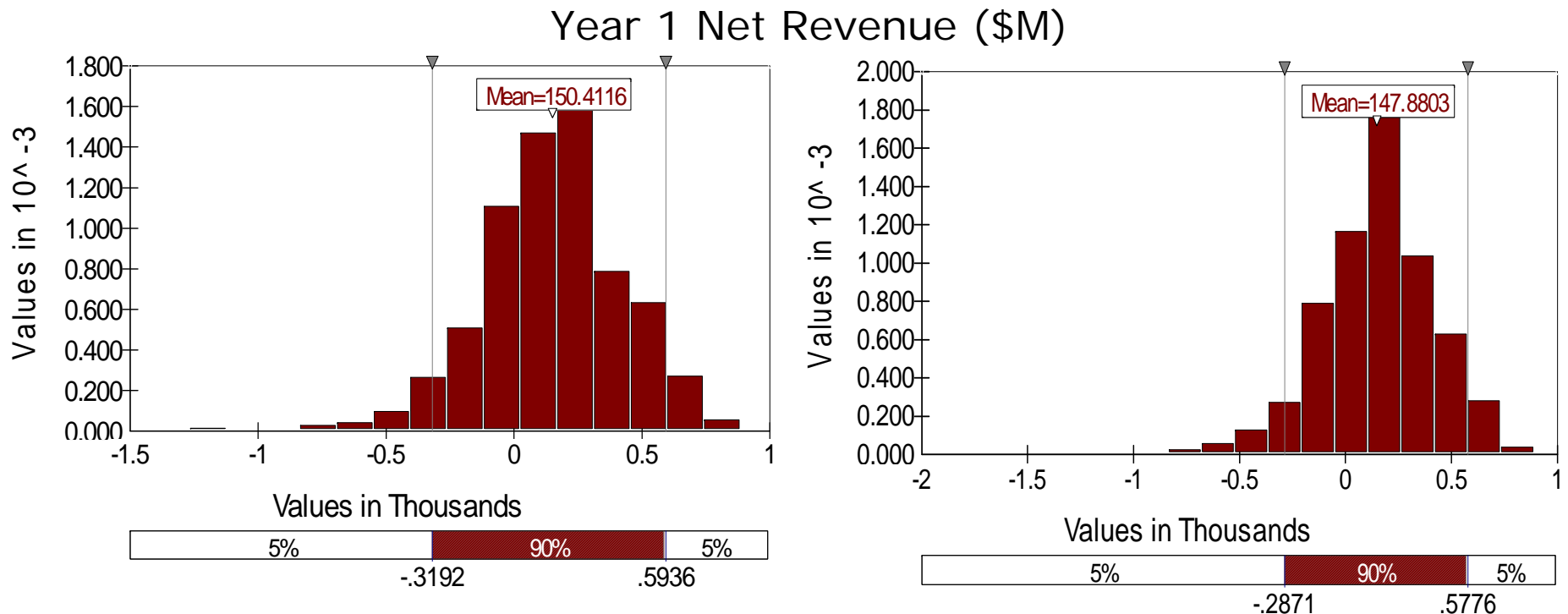
Base Case



Reduced Forward Contracts

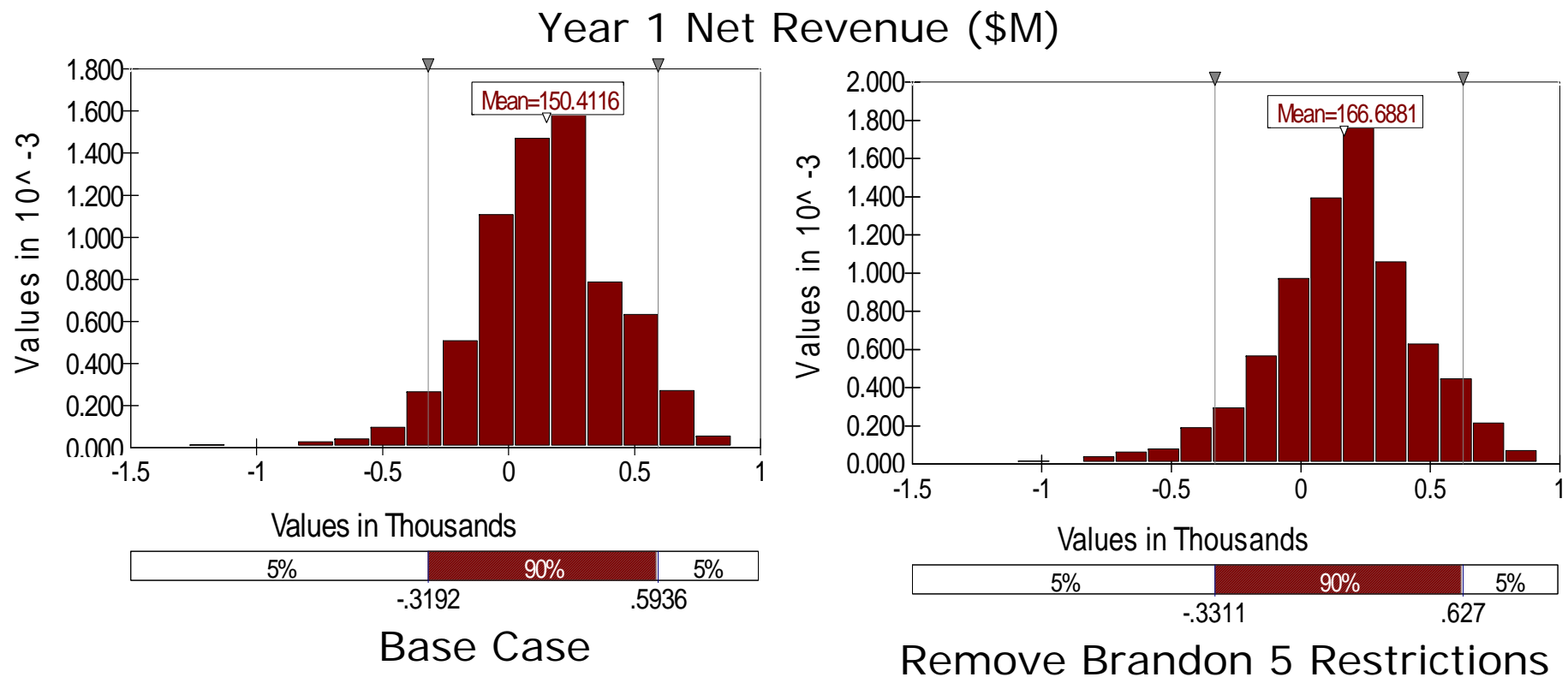
- Set Forward Contracts = 50% of current commitments
- Base Case Mean = \$150 M (C.I. -\$319 M to \$593 M)
- Scenario Mean = \$170 M (C.I. -\$299 M to \$624 M)

Sample Risk Analysis: Add 400 MW Gas CCCT



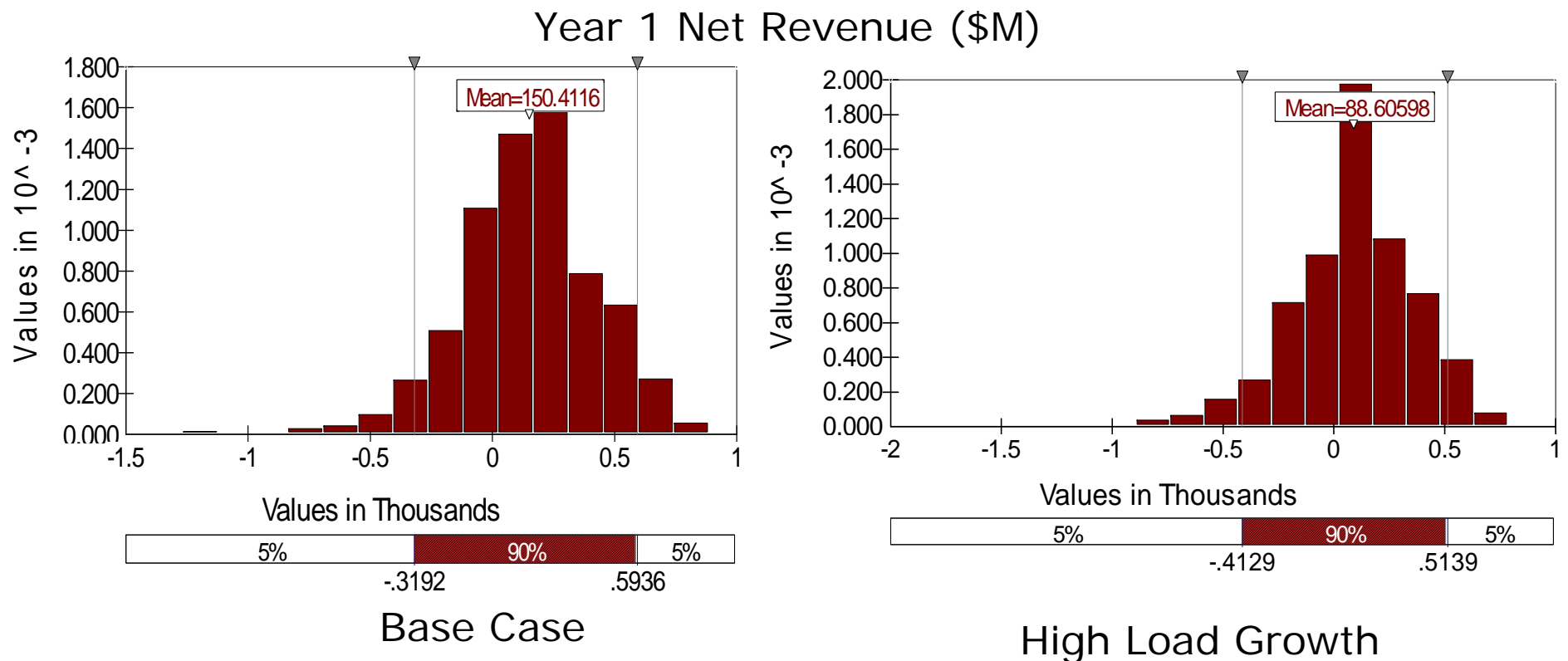
- Add 400 MW Gas CCCT to Manitoba Hydro generation system
 - Heat Rate = 8 MMBTU/MWh
- Base Case Mean = \$150 M (C.I. -\$319 M to \$593 M)
- Scenario Mean = \$147 M (C.I. -\$287 M to \$577 M)

Sample Risk Analysis: Remove Brandon 5 Restrictions



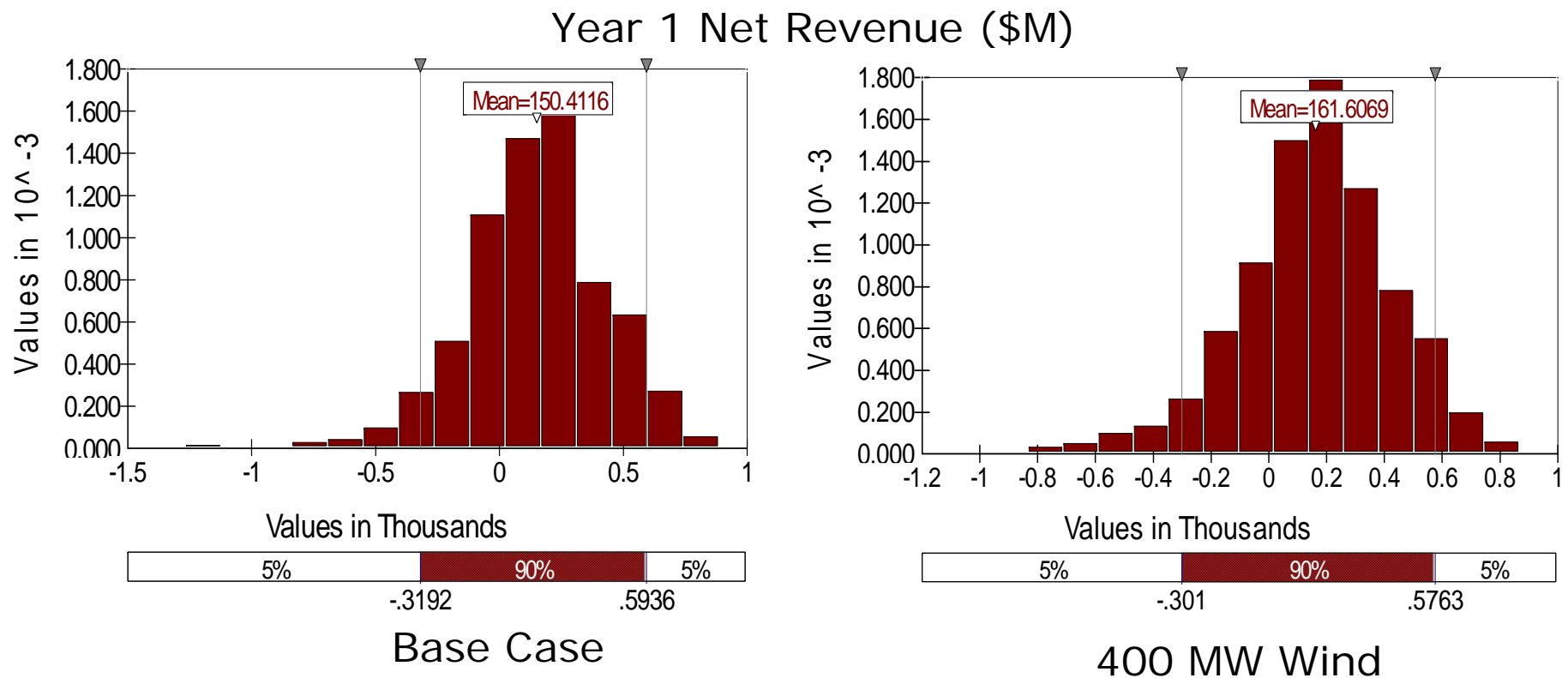
- Allow Brandon 5 to operate economically
- Base Case Mean = \$150 M (C.I. -\$319 M to \$593 M)
- Scenario Mean = \$166 M (C.I. -\$331 M to \$627 M)

Sample Risk Analysis: High Load Growth



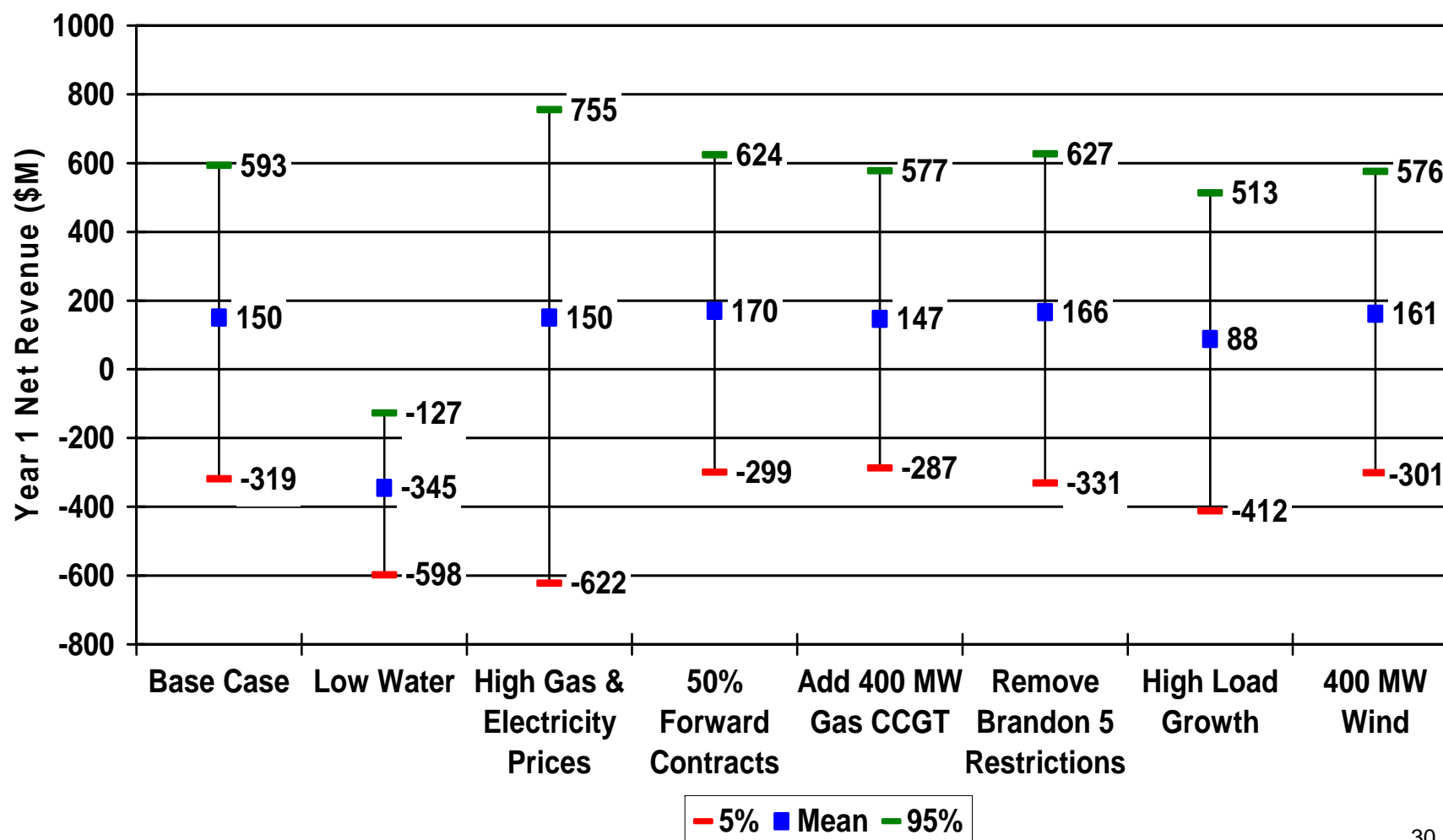
- Set Average Annual Load Growth Rate = 4%
- Base Case Mean = \$150 M (C.I. -\$319 M to \$593 M)
- Scenario Mean = \$88 M (C.I. -\$412 M to \$513 M)

Sample Risk Analysis: 400 MW Wind

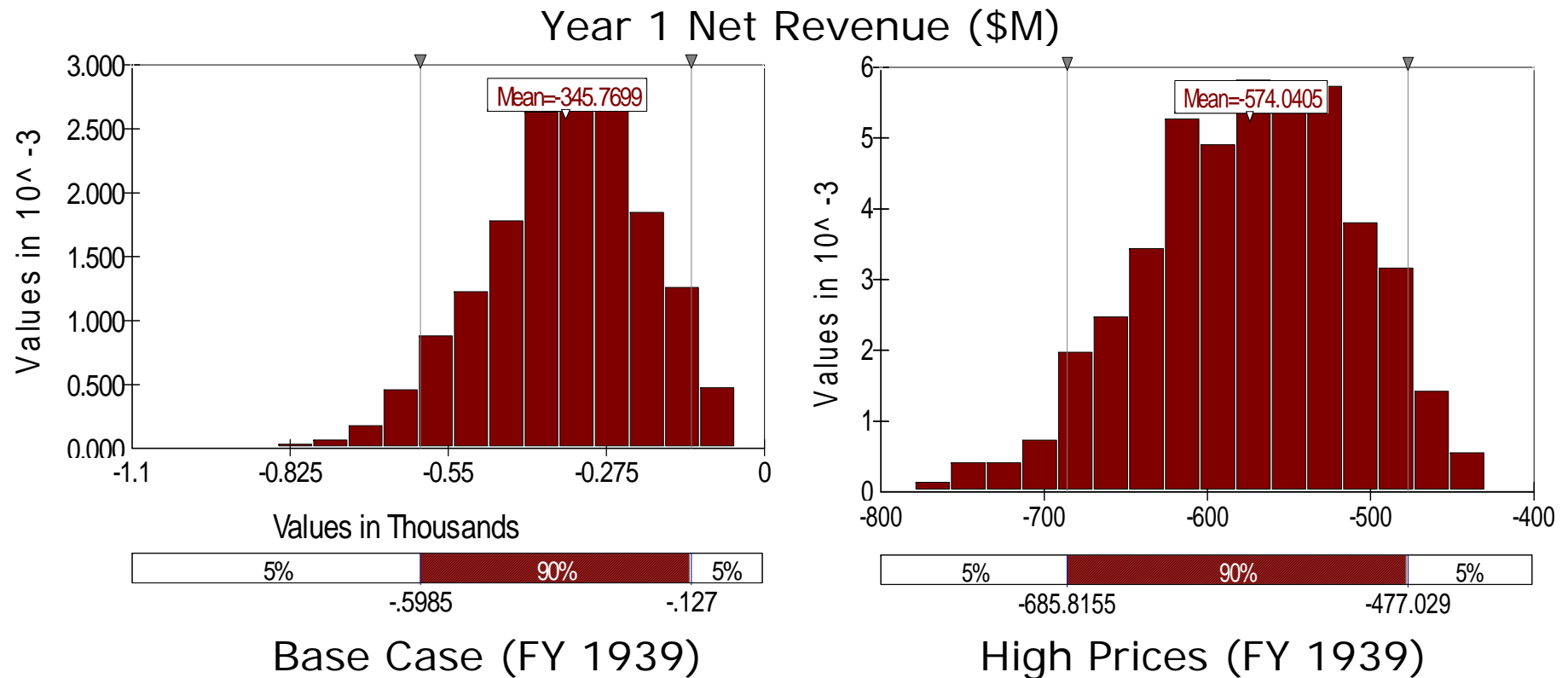


- Add 300 MW of Wind Generation (Total = 400 MW)
- Base Case Mean = \$150 M (C.I. -\$319 M to \$593 M)
- Scenario Mean = \$161 M (C.I. -\$301 M to \$576 M)

Sample Risk Analysis: Summary



Sample Risk Analysis with Low Flow: High Gas and Electricity Prices



- Year 1 Flow = 1939 and Gas & Electricity Prices = 95th Percentile
- Base Case Mean = -\$343 M (C.I. -\$611 M to -\$164 M)
- Scenario Mean = -\$574 M (C.I. -\$685 M to -\$477 M)



PRISM Modifications for V2008-1

- Updated Forecasts (data and application of data):
 - Load Forecast
 - Electricity Export Price Forecast
 - Hydro Generation (from SPLASH)
 - Exchange Rate
 - Gas Price Forecast
- Implementation of:
 - Foreign Exchange Volatility
 - Load Growth Volatility
 - Annual Energy for Forward Contracts
 - Brandon 5 Operating Restrictions



Impact of 2008 Assumptions & Data

- Year 1 Net Revenue decreased by approximately \$45 M
- Reasons:
 - Brandon 5 Restrictions
 - Increased Load
 - Higher Electricity Export Price Forecast
 - Less Favorable Exchange Rate

PRISM Conclusions

- ❑ PRISM provides a coarse overview of the MH system
- ❑ PRISM considers uncertainty in:
 - Water conditions
 - Load
 - Prices
 - Wind
- ❑ All data and key inputs come from within MH
- ❑ The model is a Monte Carlo analysis where one simulation consists of 1000 iterations
- ❑ PRISM can analyze various scenarios
- ❑ Discussion? Suggestions?