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

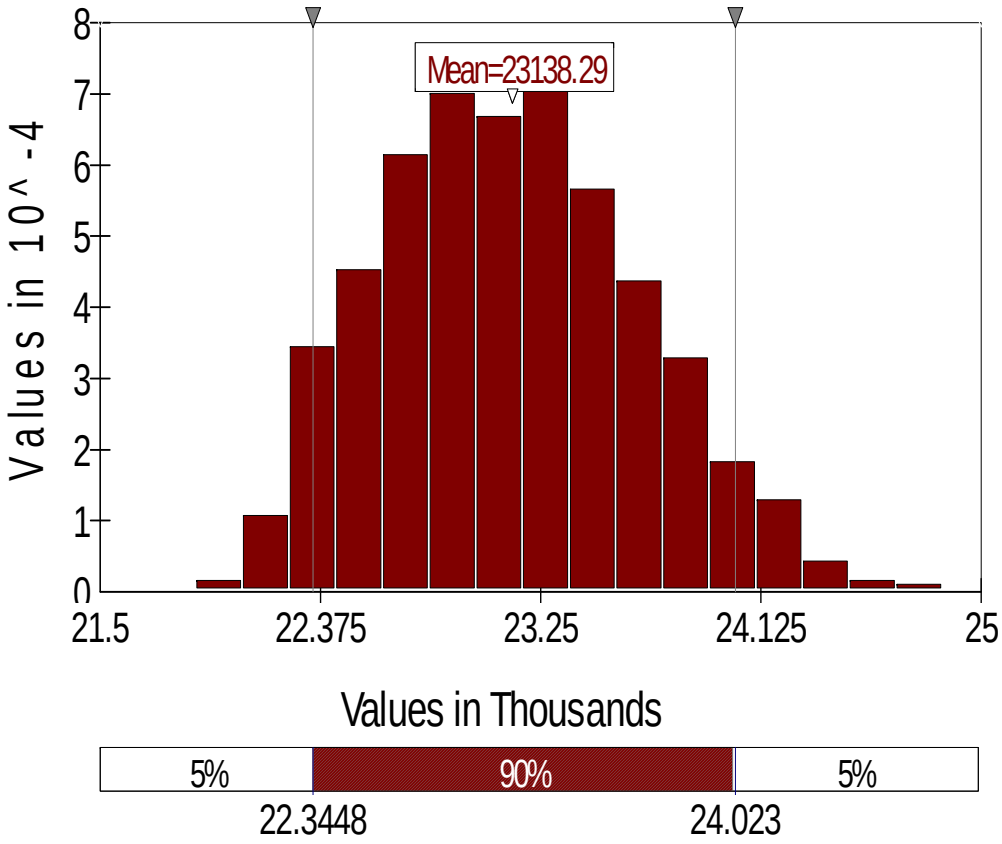
Key Inputs

- 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)

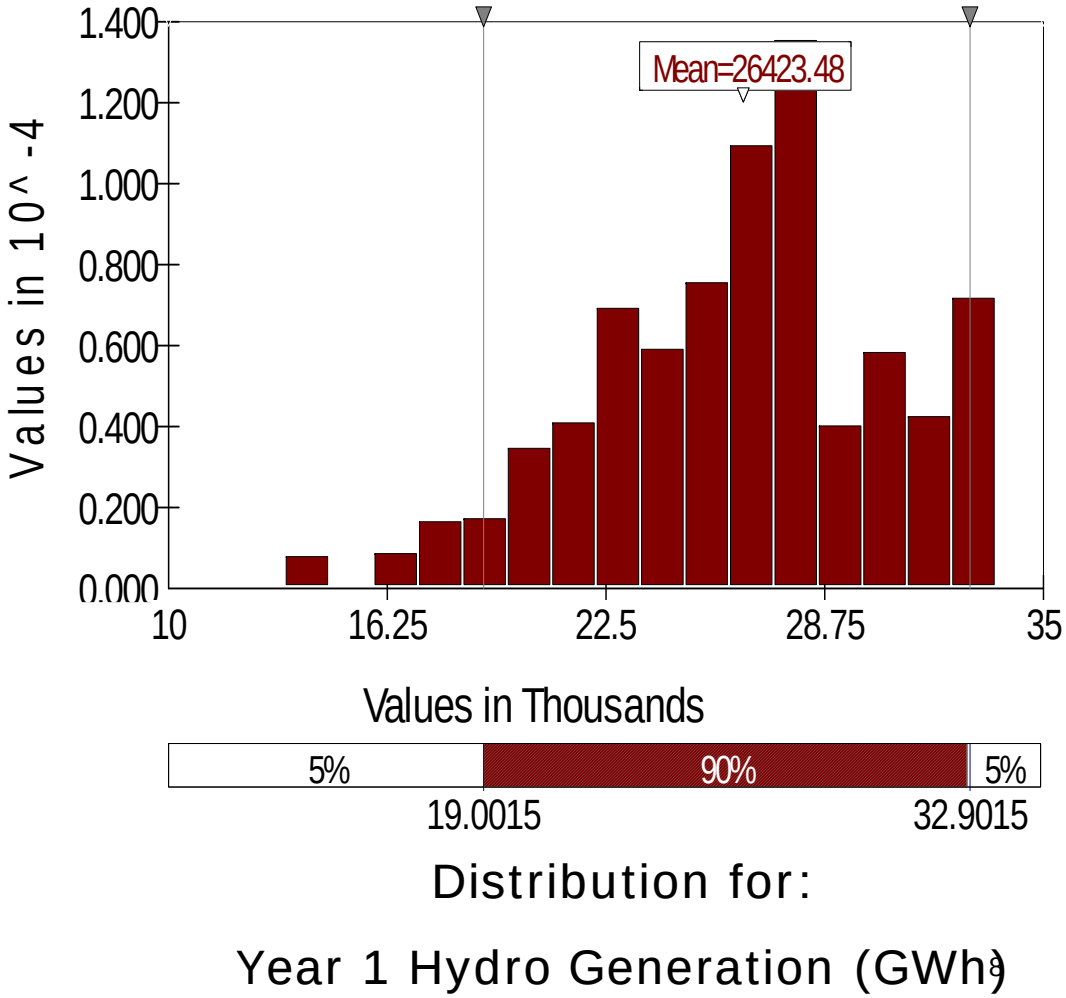
Key Input: Manitoba Load

- 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



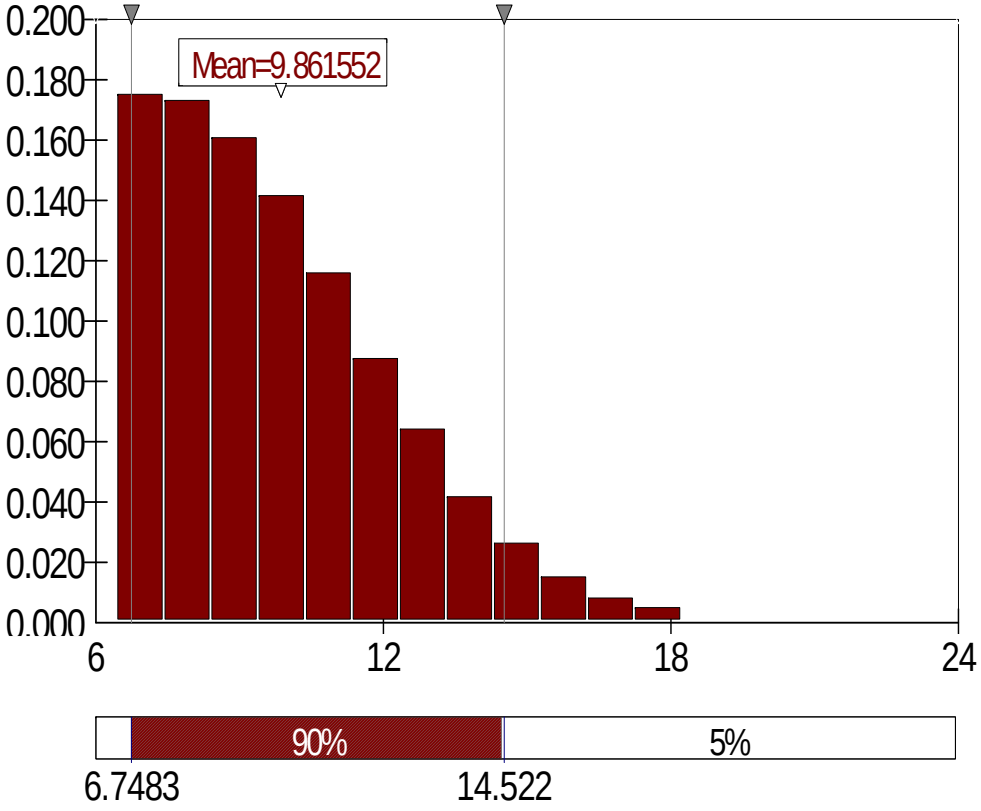
Key Input: Hydro Generation

- 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)



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

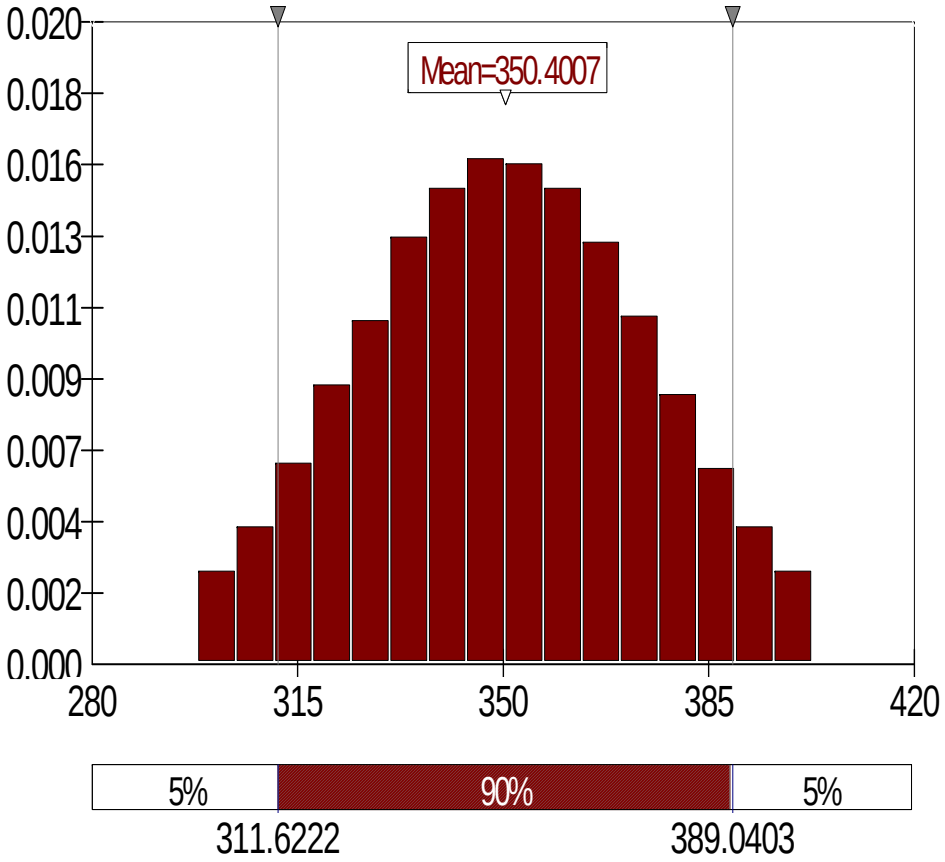
- Model is Seasonal
- Chronologic Flow
  - 5 flow years for 5 year analysis
  - Each of the 94 historic flow years has an equal chance of being selected for year 1
  - Flow cases for years 2, 3, 4, and 5 are sequential based on year 1 flow year
  - If Year 1 = 1956, then Year 2 = 1957, Year 3 = 1958,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

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

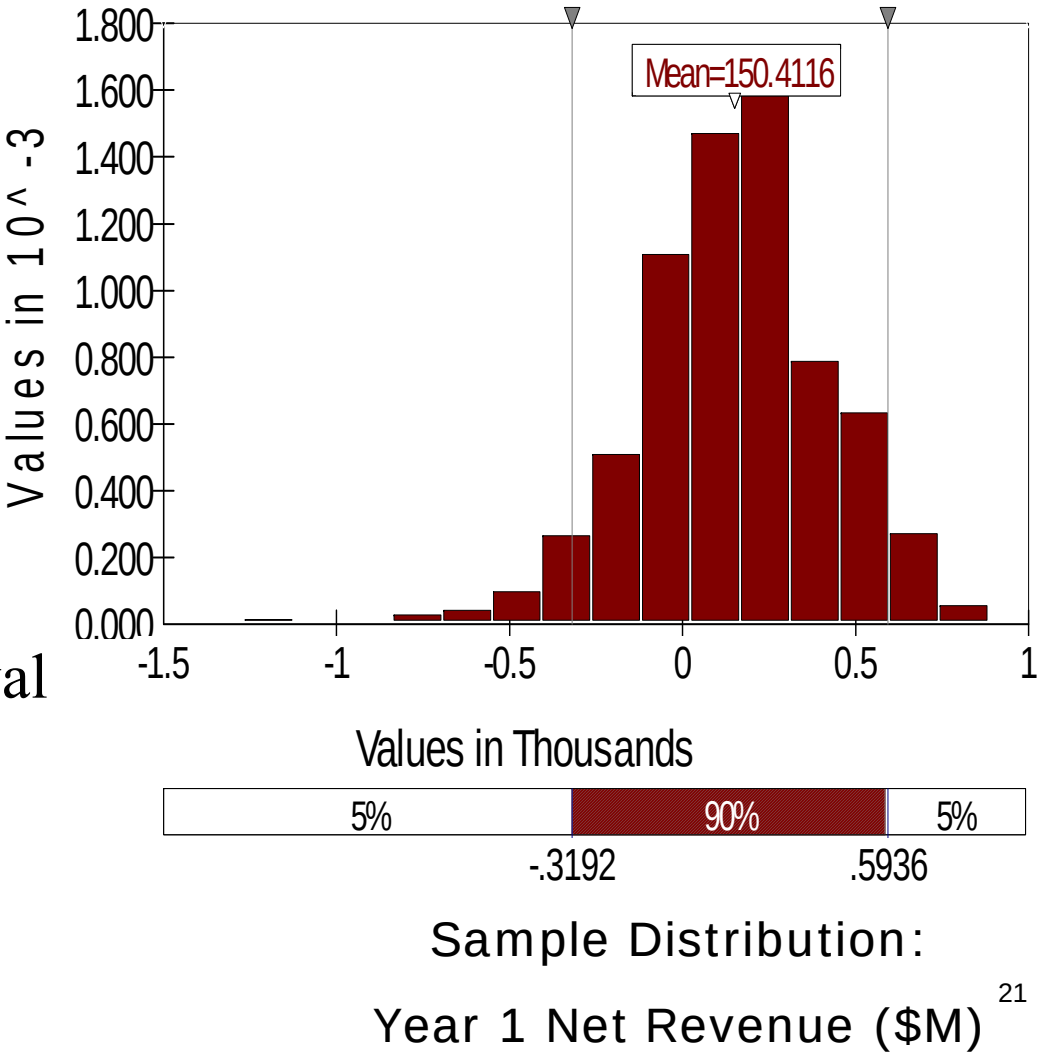
- One simulation requires 1000 iterations
- For each iteration
  - Inputs with distributions are determined
  - Energy is stacked (resources are selected)
  - Net Revenue is determined
    - Annually (1 year) and cumulatively (5 years)
  - Repeat
- Output: Model produces plots (histograms) of distributions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

Key Output: Net Revenue

Year 1: Flow Yr 1939, Fiscal Yr 2010/11	Energy (GWh) (@ load)	Revenue (CDN$)
Supply		
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
Total Supply	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
Total Demand	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



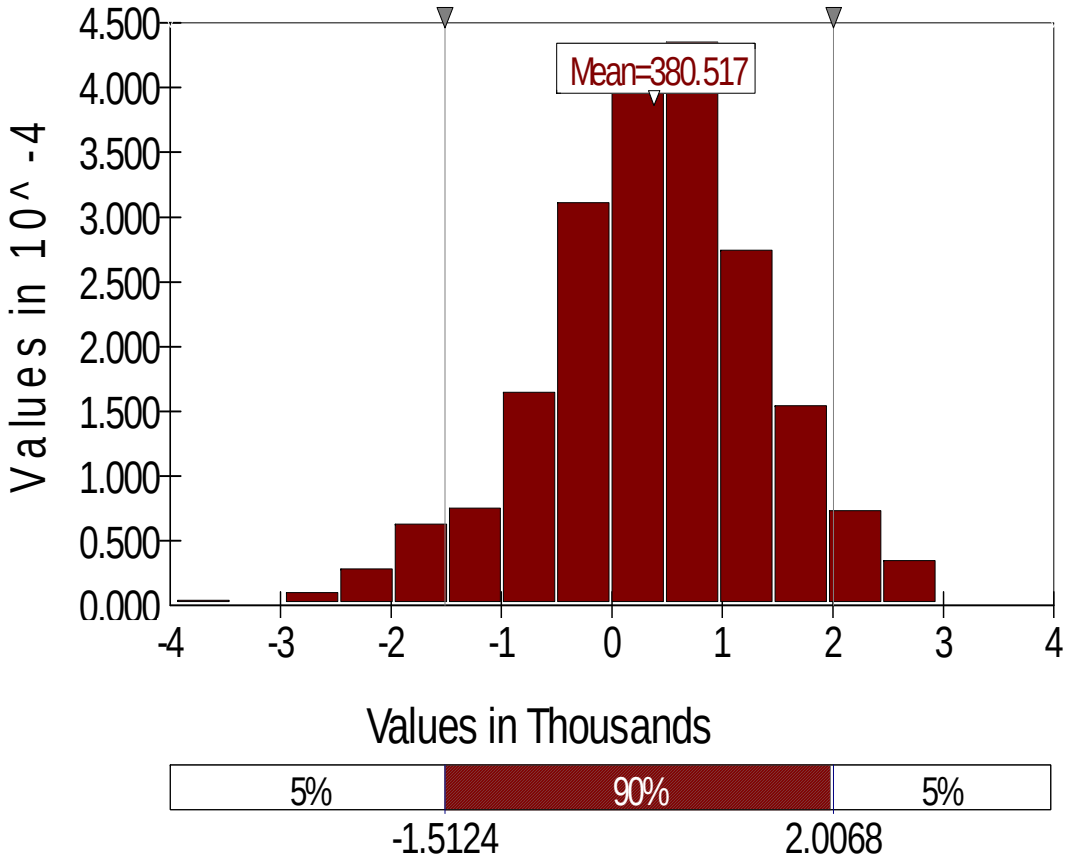
Sample Distribution: Year 1 Net Revenue ($M)

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

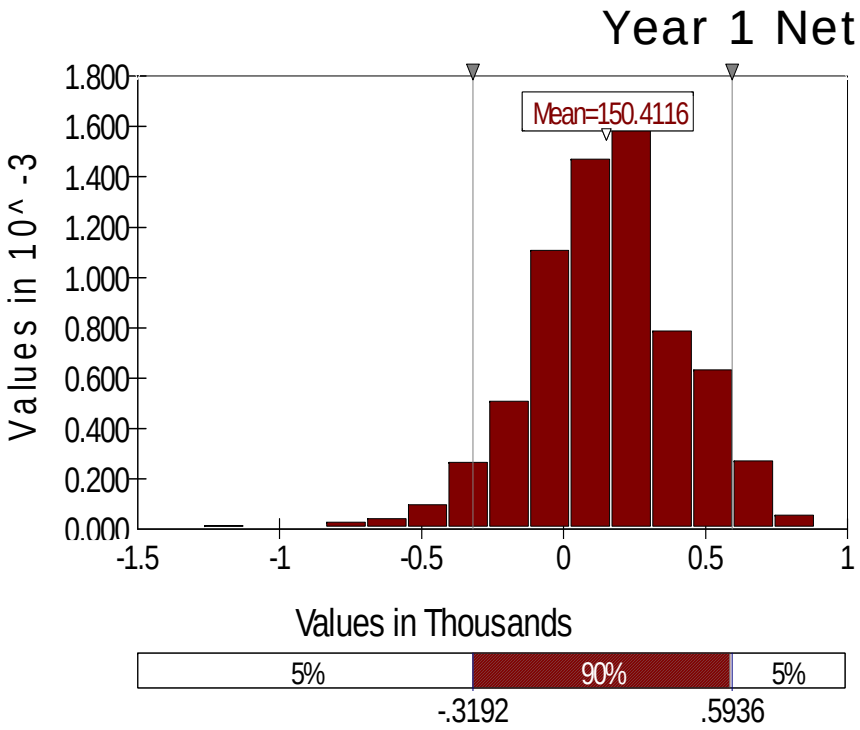
  ≠ $380 M
- Confidence Interval (C.I.):
  - 5%: -$1,512 M
  - 95%: $2,006 M

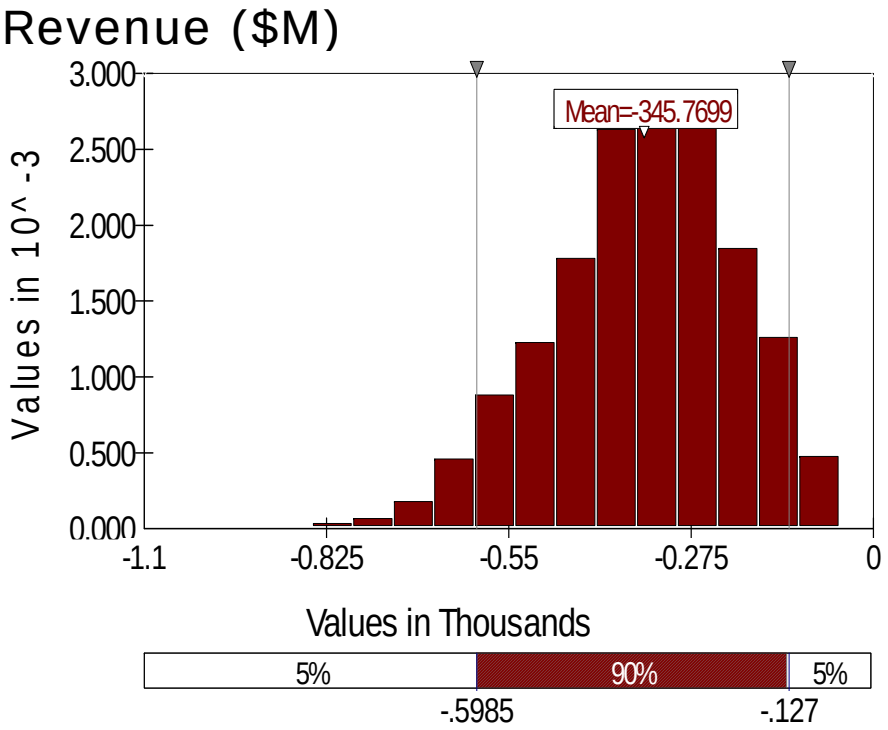


Sample Distribution:

5 Year Cumulative Net Revenue ($M)

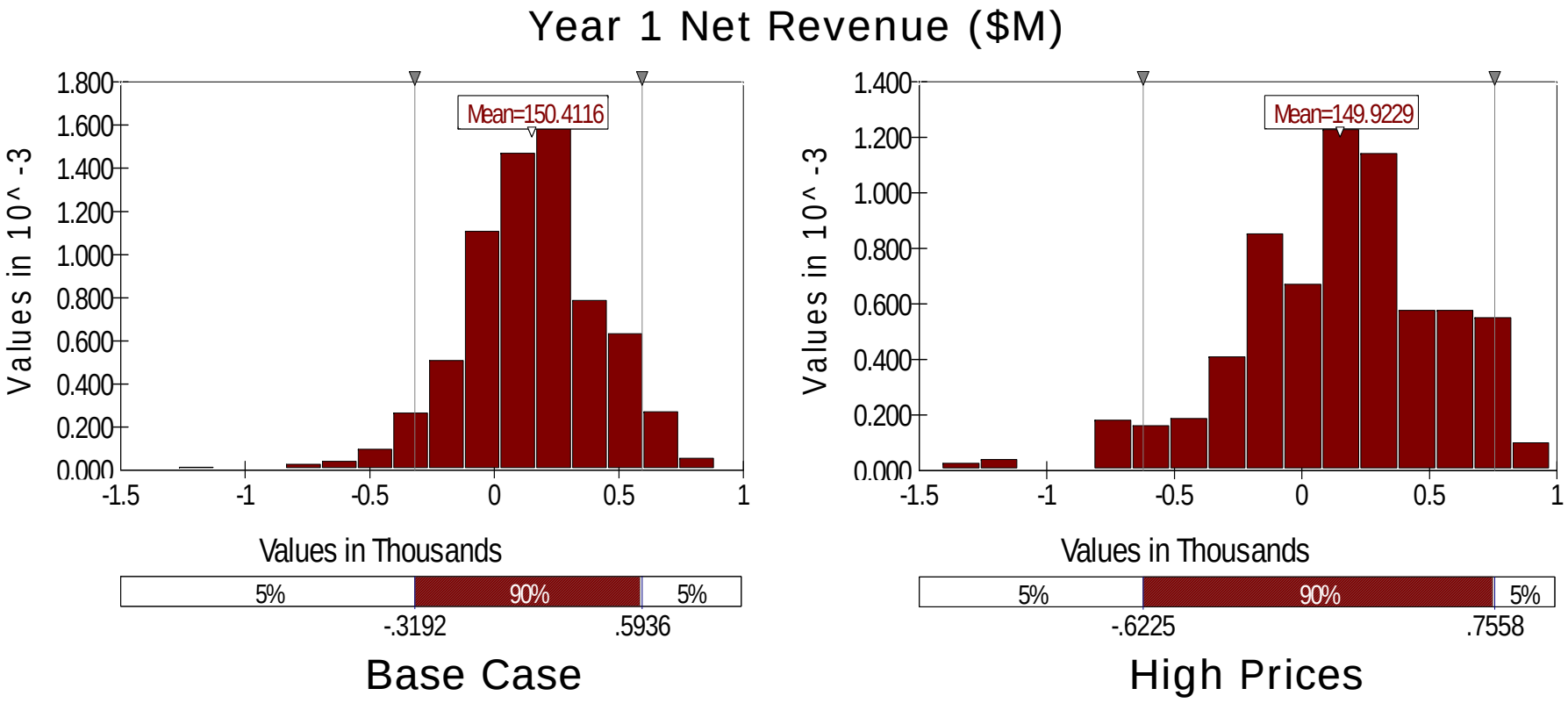
Sample Risk Analysis: Low Water Conditions (FY 1939)





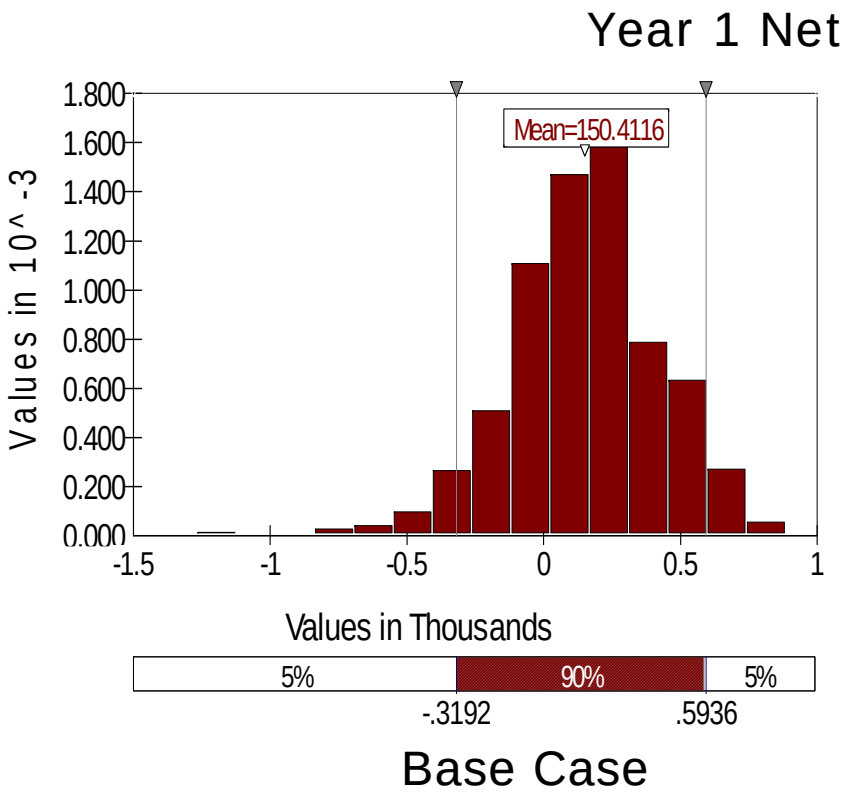
- Set Year 1 Flow Year = Low Flow Year = 1939
- Base Case Mean = $150 M (C.I. -$319 M to $593 M)
- Scenario Mean = -$345 M (C.I. -$598 M to -$127 M)

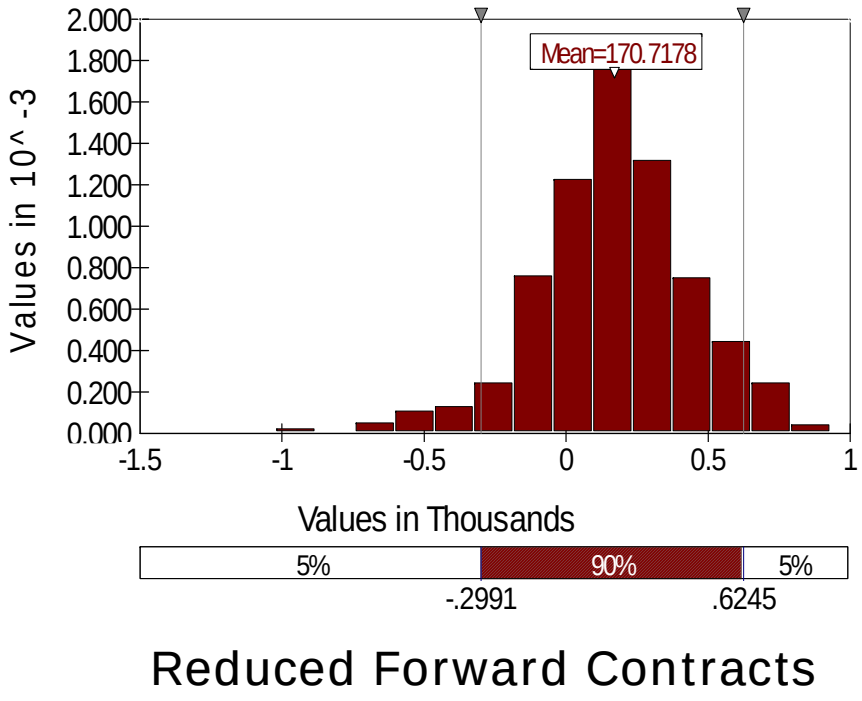
Sample Risk Analysis: High Gas and Electricity Prices



- 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)

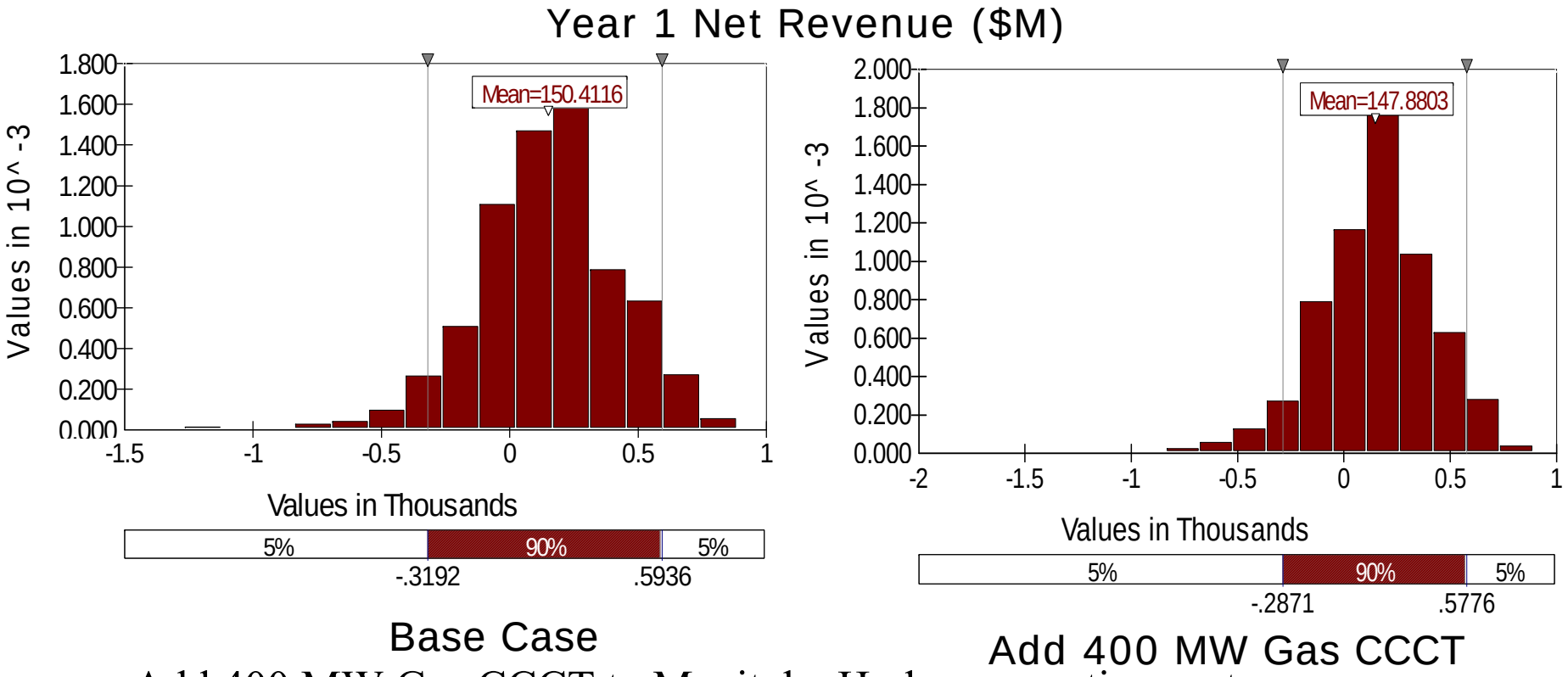
Sample Risk Analysis: Forward Contracts = 50% of Current Commitments





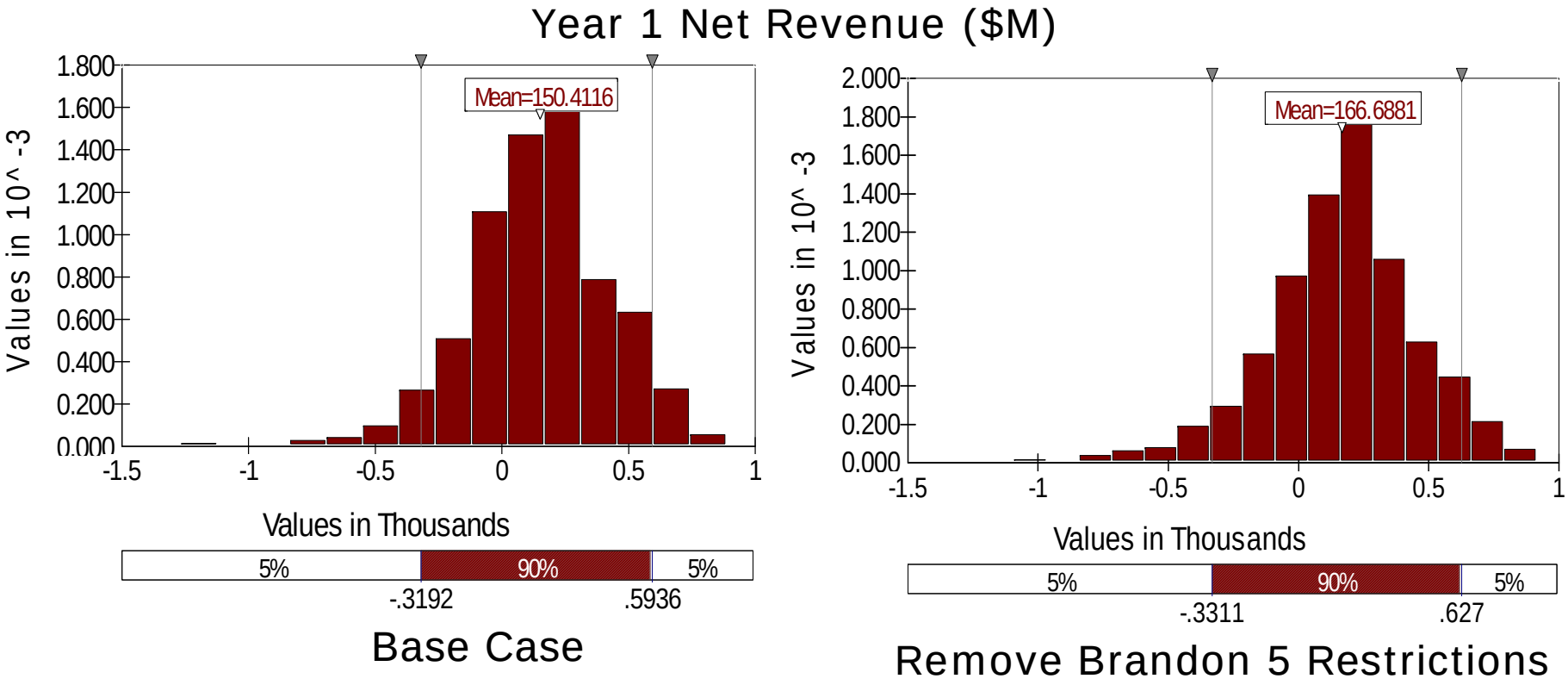
- Set Forward Contracts = 50% of current commitments
- Base Case Mean = $150 M (C.I. -$319 M to $593 M)
- Scenario Mean = $170 M (C.I. -$299 M to $624 M)

Sample Risk Analysis: Add 400 MW Gas CCCT



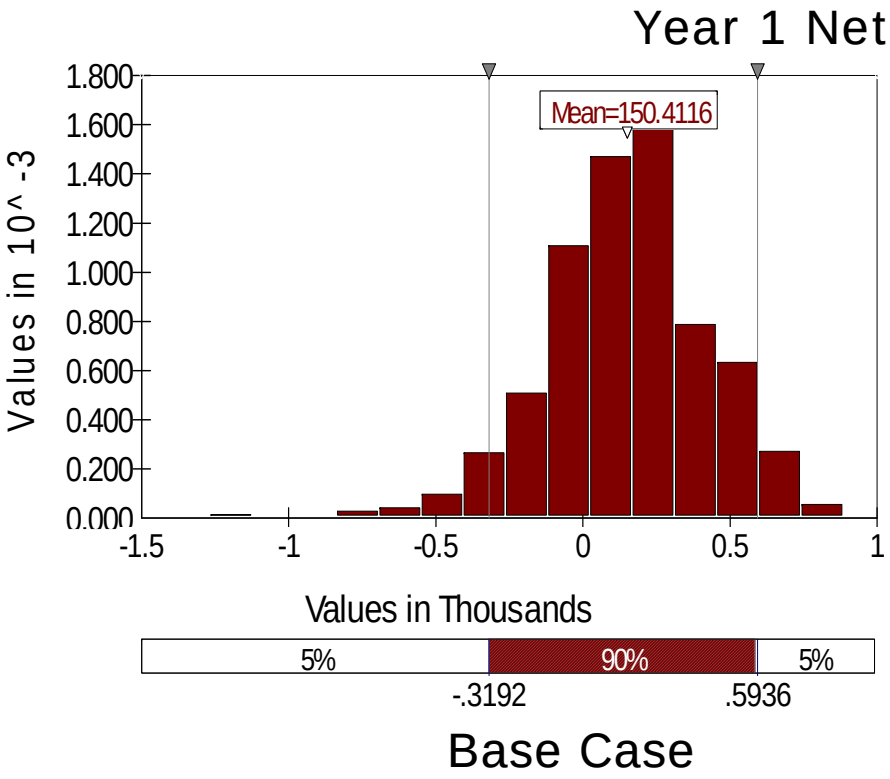
- Add 400 MW Gas CCCT to Manitoba Hydro generation system
  - Heat Rate = 8 MMBTU/MWh
- Base Case Mean = $150 M (C.I. -$319 M to $593 M)
- Scenario Mean = $147 M (C.I. -$287 M to $577 M)

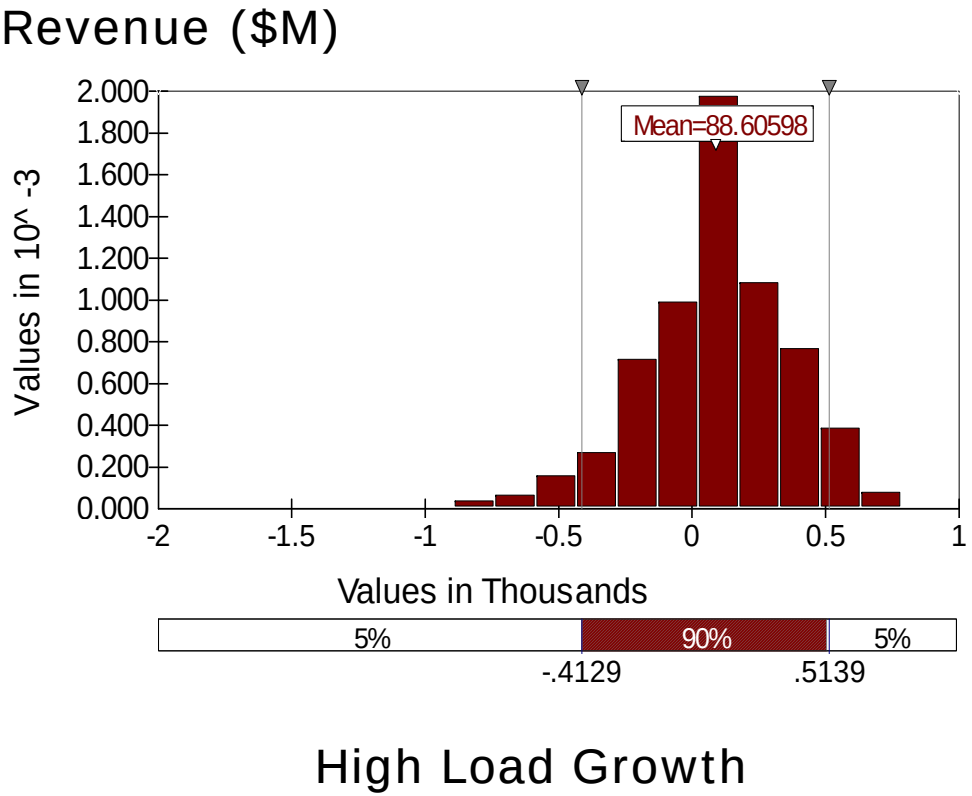
Sample Risk Analysis: Remove Brandon 5 Restrictions



- 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)

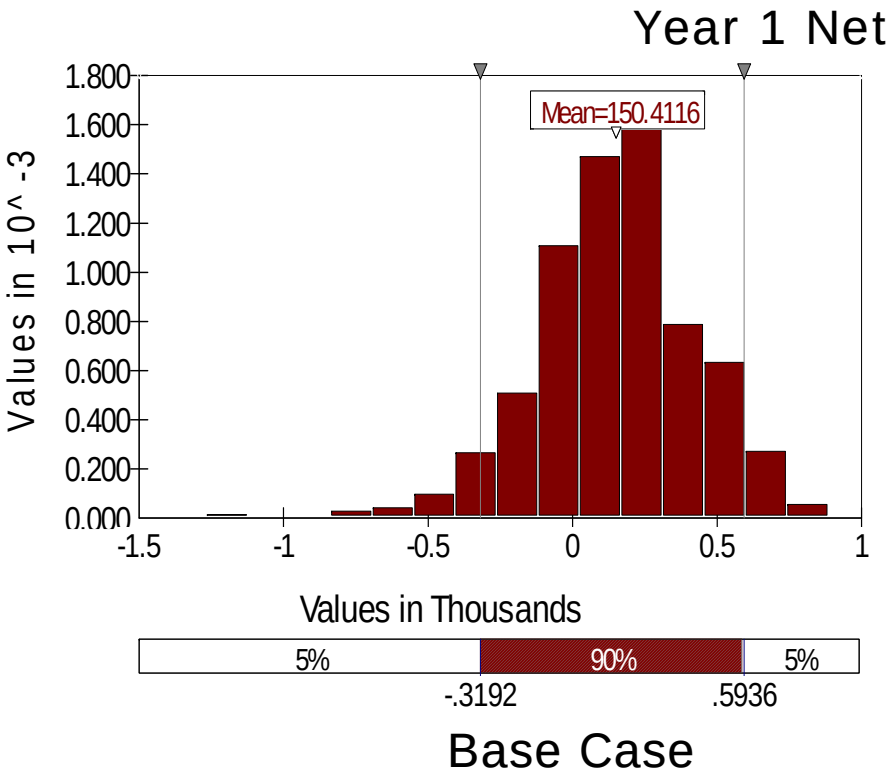
Sample Risk Analysis: High Load Growth



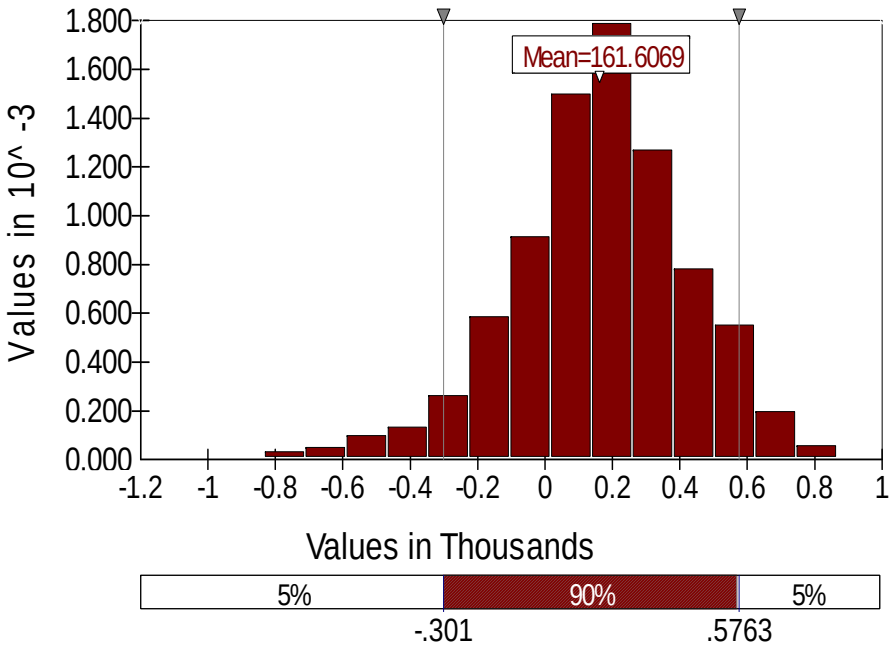


- Set Average Annual Load Growth Rate = 4%
- Base Case Mean = $150 M (C.I. -$319 M to $593 M)
- Scenario Mean = $88 M (C.I. -$412 M to $513 M)

Sample Risk Analysis: 400 MW Wind



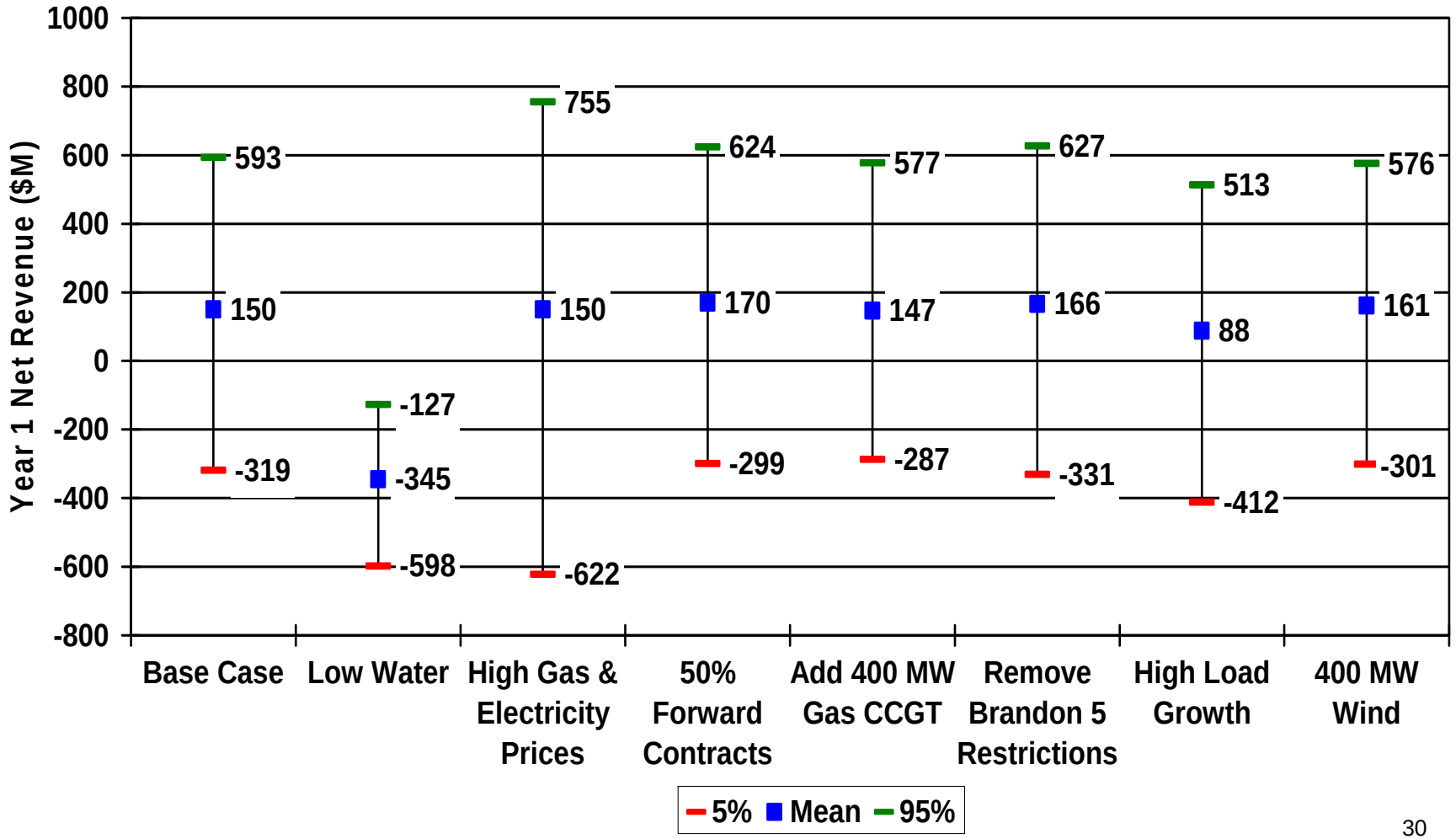
Base Case



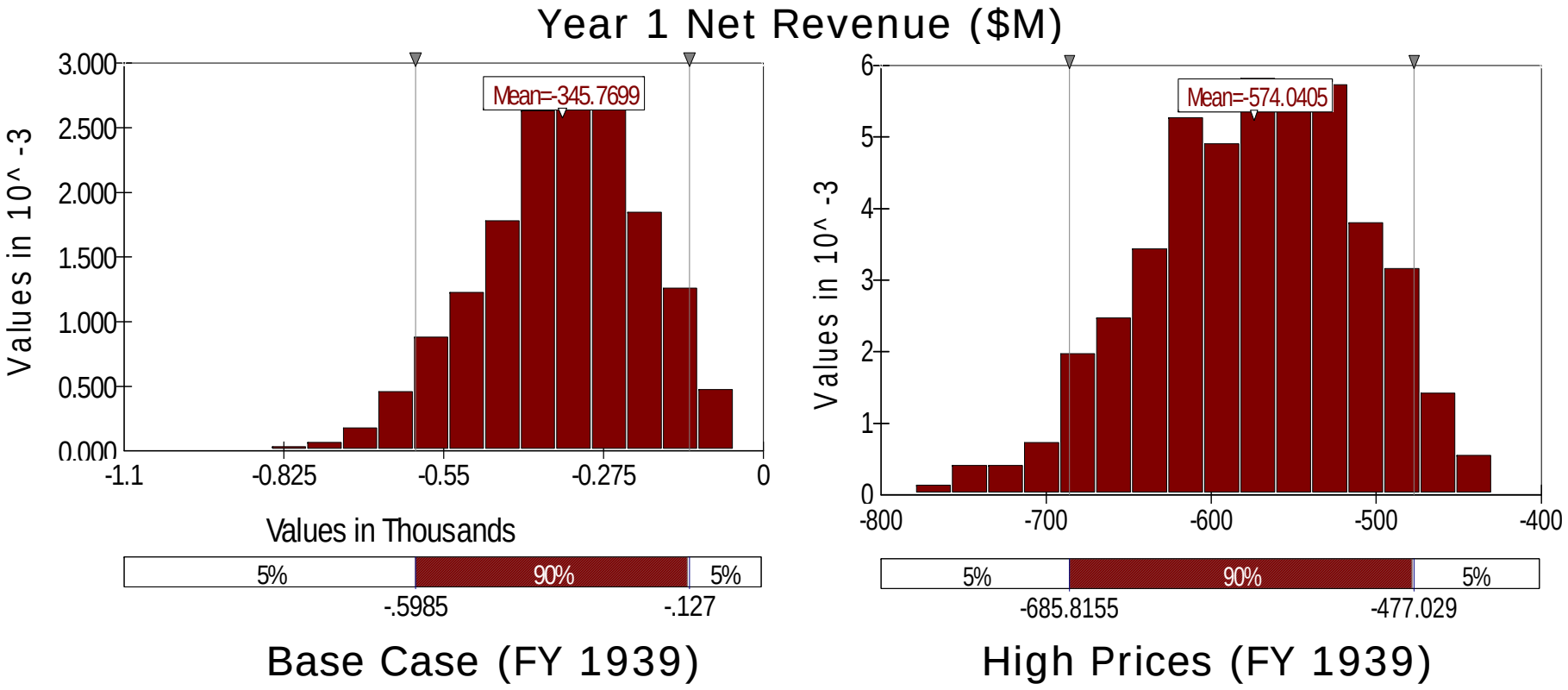
400 MW Wind

- 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?