PROBABILISTIC RESOURCE ANALYSIS

presented by Letha Lencioni

Society of Petroleum Evaluation Engineers 56th Annual Conference

Lake Louise, Alberta, Canada

June 11, 2019

GUSTAVSON ASSOCIATES

GEOLOGISTS • ENGINEERS • ECONOMISTS • APPRAISERS

Outline

- What are resources?
  - Definitions
  - Reasons for estimating
- Probabilistic analysis
  - Basic concepts
  - History in industry
  - Software
- Estimation of resources
  - Input data and distributions
  - Running the software
  - Evaluating results
- Examples

WHAT ARE RESOURCES?

What are resources?

- PRMS
  "Petroleum resources are the quantities of hydrocarbons naturally occurring on or within the Earth's crust."
  The term "resources" encompasses all petroleum quantities, including discovered and undiscovered (recoverable and unrecoverable) plus quantities already produced, or Petroleum Initially in Place (PIIP).
- COGEH – same definitions

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Classification of Resources

- Resources are classified into
  - Discovered
    - Reserves
    - Contingent Resources
    - Unrecoverable
  - Undiscovered
    - Prospective Resources
    - Unrecoverable

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Classification of Resources

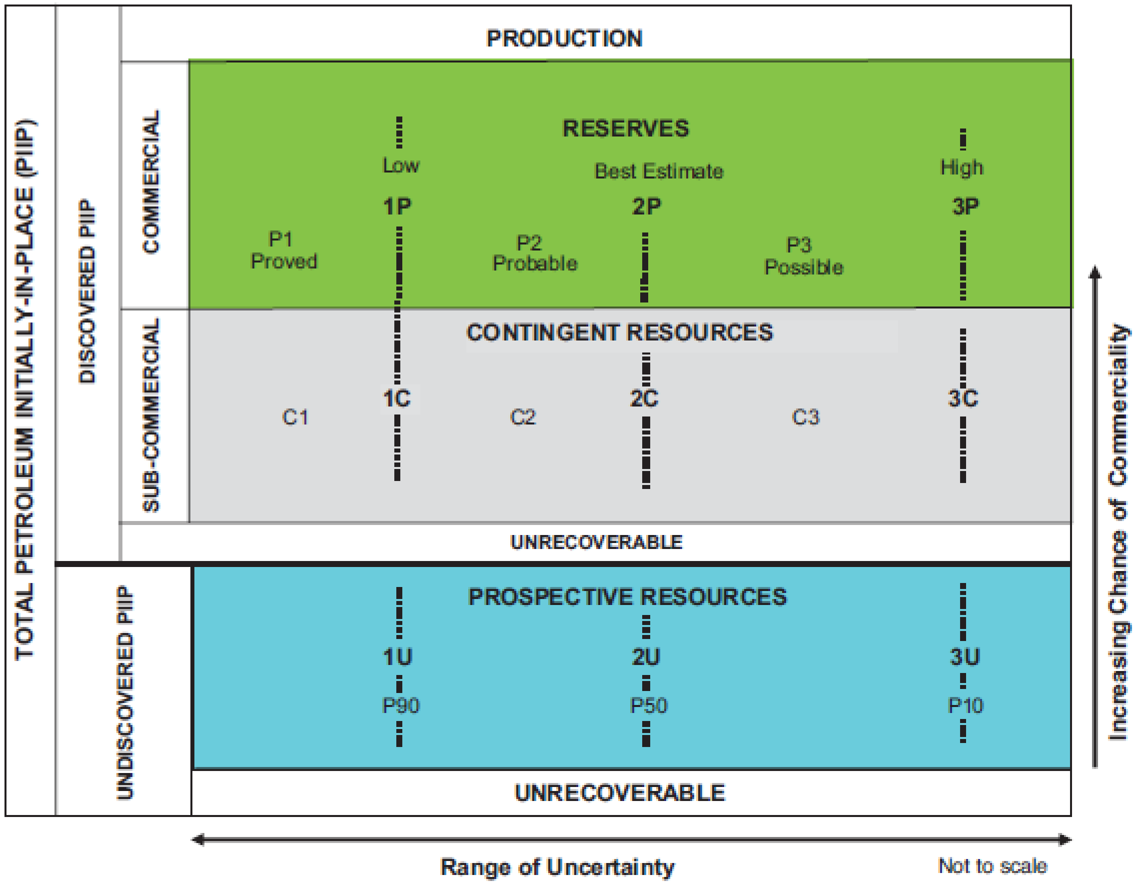


Figure 1.1—Resources classification framework

Definitions

- Reserves
  - "those quantities of petroleum anticipated to be commercially recoverable by application of development projects to known accumulations from a given date forward under defined conditions."
- Contingent Resources
  - "those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations, by the application of development project(s) not currently considered to be commercial owing to one or more contingencies."

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Definitions

- Prospective Resources
  - "those quantities of petroleum estimated, as of a given date, to be potentially recoverable from undiscovered accumulations by application of future development projects."
- This presentation focuses on Contingent and Prospective Resources

Reasons for Estimating

- Evaluation of exploration targets
  - Ranking of prospects
  - Make development plans that can cover the range of possible outcomes
  - Provide a range of production forecasts to evaluate the expected outcome of their ventures
  - Measure exploration, appraisal, and commercial risks
  - Ensure that they can handle an unfavorable outcome (i.e., that they have an economic project, even if the low case materializes)
  - Understand and communicate the confidence level of their reserves estimate
  - Appraisal of market value of undeveloped acreage
    - Could be considered too hypothetical
    - May be appropriate for some times and places, i.e. Alaska in mid-70s

Reasons for Estimating

- Regulatory reporting
  - The following exchanges allow reporting of Contingent and Prospective Resources
    - Canada (TSX Venture)
    - Australia (ASX)
    - London (AIM)
    - Hong Kong (HKEx)

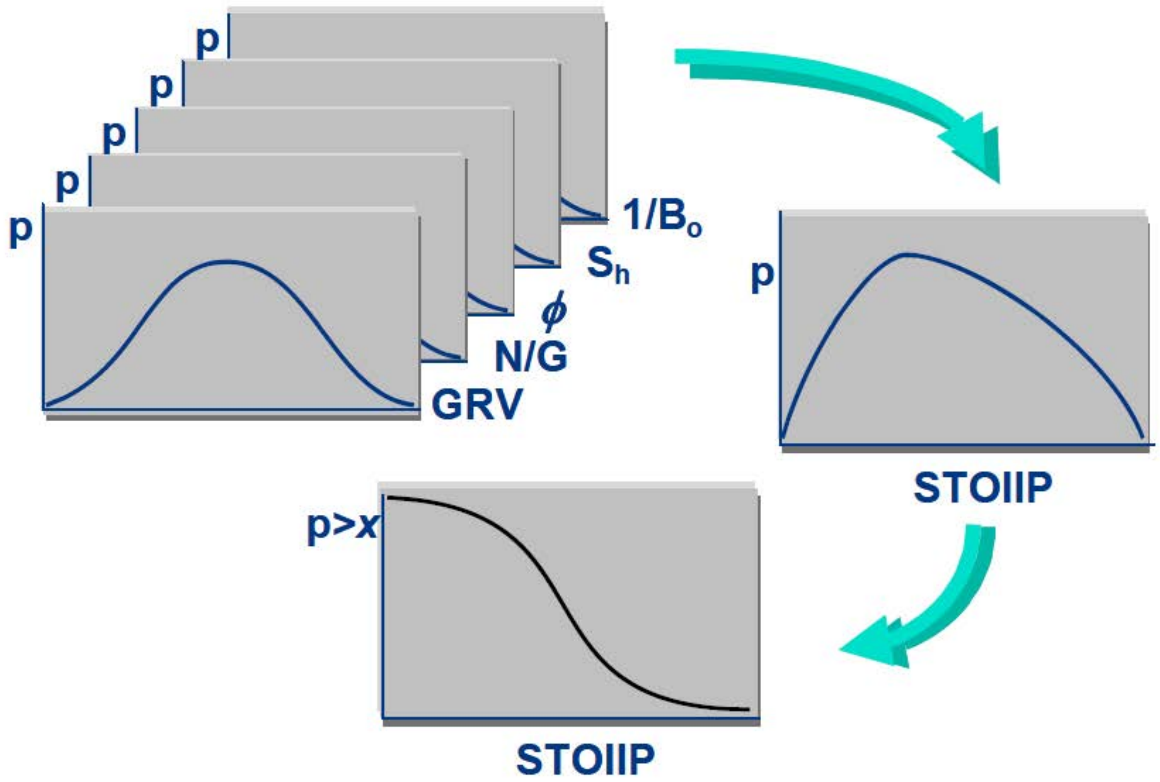
GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

PROBABILISTIC ANALYSIS

Basic Concepts

- PRMS Definition:
  "The method of estimation of resources is called probabilistic when the known geoscience, engineering, and economic data are used to generate a continuous range of estimates and their associated probabilities."
- May also be called stochastic, or Monte Carlo analysis
- User defines the uncertainty distributions of the input parameters (input distributions) and the relationship (correlations) between them
- Method involves repeated random sampling of input distributions to generate a resulting distribution (such as recoverable petroleum quantities)

Probabilistic Approach to Volumetrics



From PRMS Guidelines, Nov. 2011

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

History in Petroleum Industry

- Probabilistic analysis has long been used in the industry

  Technical papers
  - From 1961 discusses "operations research" and stochastic analysis
  - From 1962 mentions Monte Carlo analysis applied to decision making
  - From 1965 on fundamentals and applications of Monte Carlo method

  Books
  - Newendorp, 1975
  - Megill, 1977?

  1984 WPC classification system including probabilistic definitions.

  First included in SPE definitions in 1997.

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Software for Monte Carlo Analysis

- Most common in the industry
  - @Risk by Palisade
  - Crystal Ball by Oracle
- Others
  - Quantum XL by SigmaZone
  - DiscoverSim by Sigma XL
  - Premium Solver V7.0 + Risk Solver V7.0 by Frontline Systems
  - GoldSim by GoldSim
  - Analytica by Lumina
  - Excel
- Most are add-ins to Excel except Analytica

Estimation of Resources

- Volumetric
  - Seismic-based prospects
  - Gravity / aero-mag leads
  - Surface expressions
- Analog performance based
- Statistical/Other

Input Data and Distributions

Volumetric analysis of identified prospect

- Area
- Net pay

OR

- Bulk reservoir volume

- Porosity
- Water / hydrocarbon saturation
- Formation volume factors
- Recovery factor
- Ratios of secondary product

Data Considerations

- Type of distribution
  - Triangular
    - most commonly used when little data available
    - minimum, most likely, maximum or
    - P90, most likely, P10
  - can greatly over/underestimate parameter if distribution is highly skewed
- Others
  - fit a larger group of data
  - select better representation of skewed data

Data Considerations

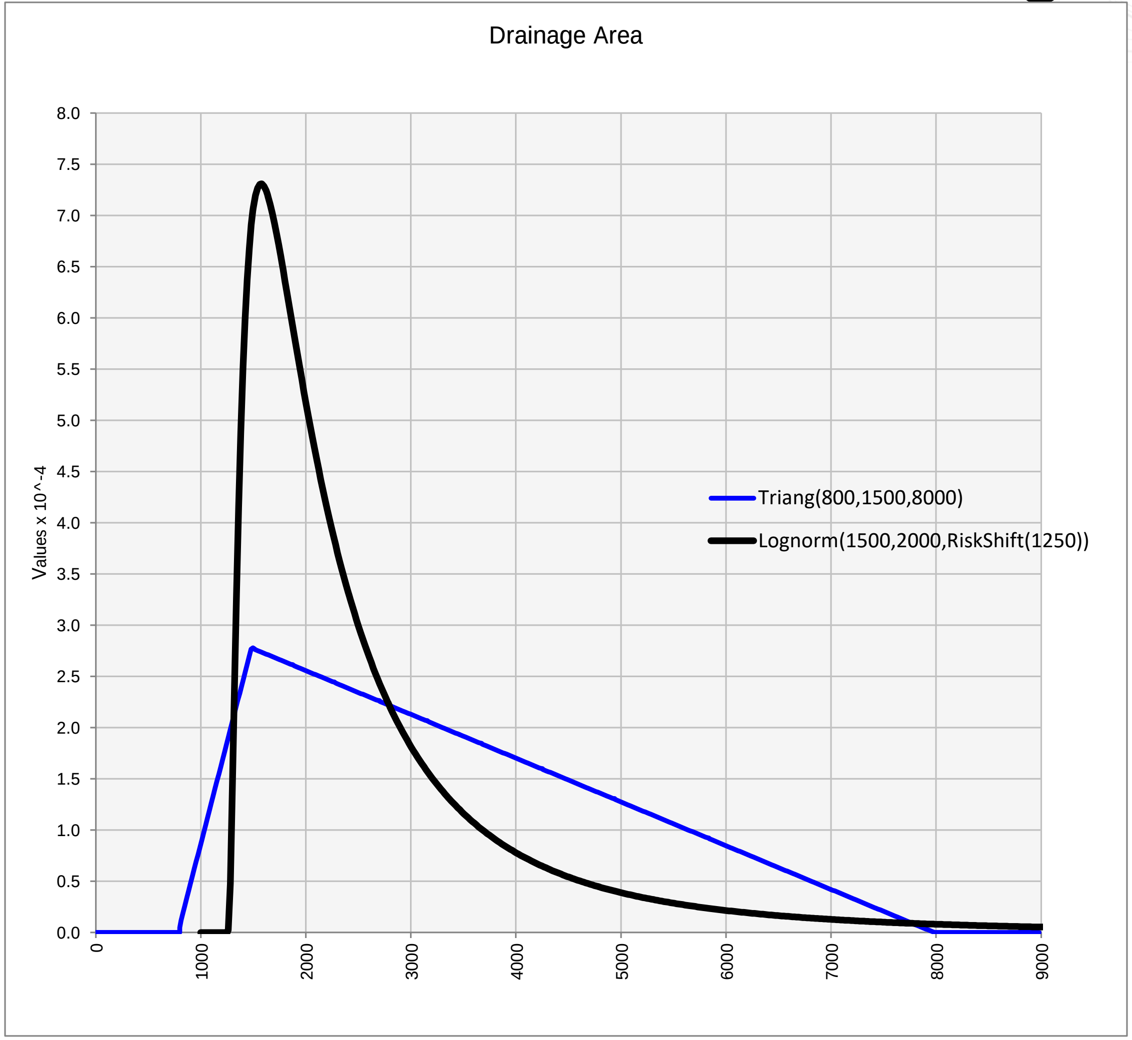
- Risk of failure is incorporated in another way
  - Separate POS applied for economic analysis
  - Do not include porosity, area, or hydrocarbon saturation of zero
  - We are calculating prospective resources if a successful discovery is made
- Remember, input range represents range of average reservoir properties, not range seen in any well or any specific point in reservoir

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Data Considerations

- Risk of failure is incorporated in another way
  - Separate POS applied for economic analysis
  - Do not include porosity, area, or hydrocarbon saturation of zero
  - We are calculating prospective resources if a successful discovery is made
- Remember, input range represents range of average reservoir properties, not range seen in any well or any specific point in reservoir

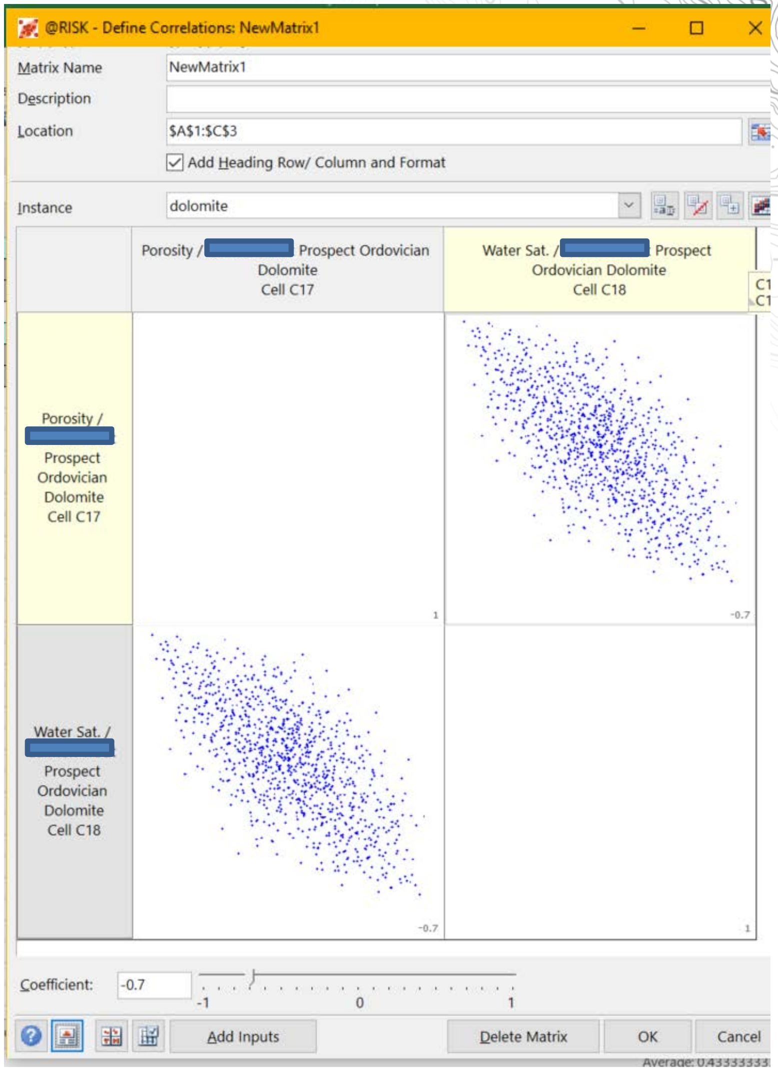
Comparison of Triangular and Lognormal Distributions with Similar Ranges



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Correlation of Input Parameters

- Positive Correlation
  - Net pay and productive area
- Negative Correlation
  - Porosity and water saturation



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Running the Program

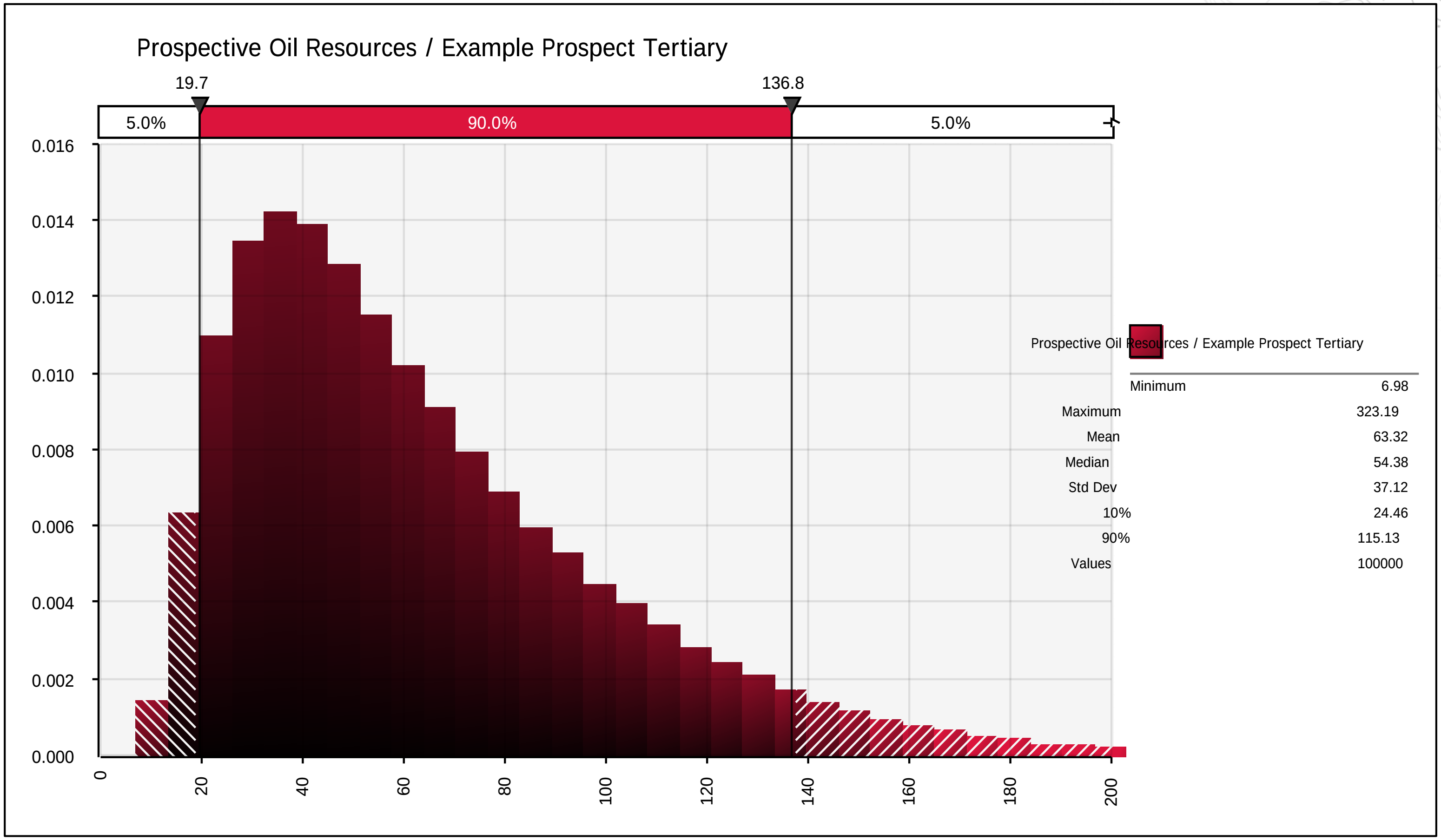
- 5,000 iterations usually sufficient for simple models
- Large, complex models may require 40,000

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Output

- Built-in graphical output
  - Output distributions
  - Tornado plots
  - Summary trend plots
- Excel output of inputs and results
- Plots made with Excel output

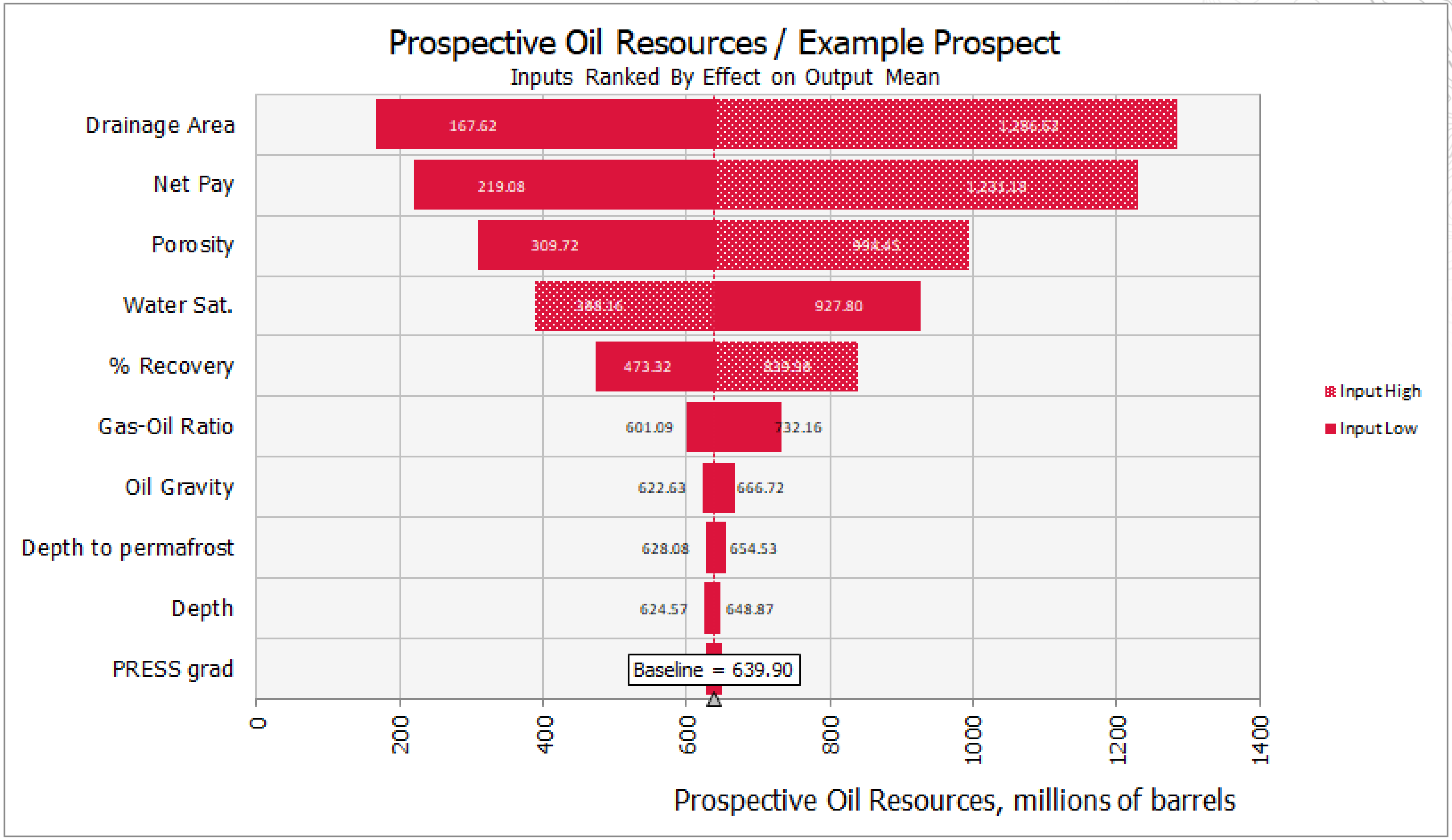
Output Distributions



Million barrels

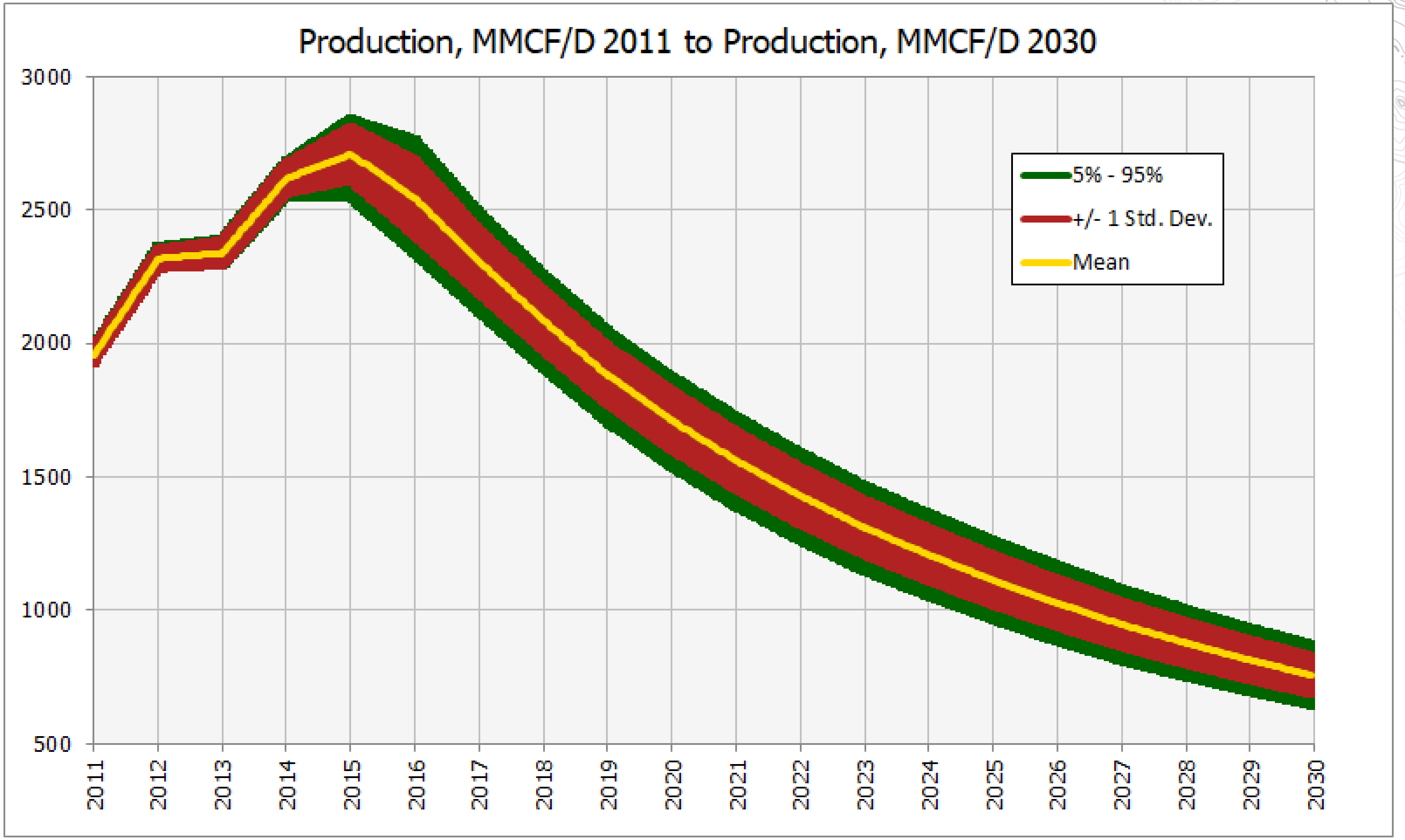
GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Tornado Plot



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Summary Trend Plot



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Output to Excel

@RISK Detailed Statistics

Performed By: Chen, Ting T.
Date: Friday, September 7, 2018 11:45:37 AM

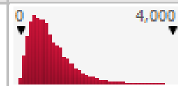
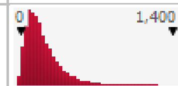
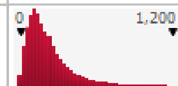
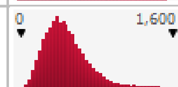
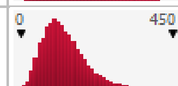
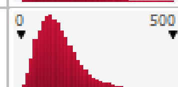
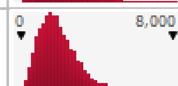
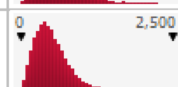
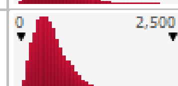
Name	Prospective Resources - Oil in Place / KB (Tert)	Prospective Oil Resources / KB (Tert)	Prospective Assoc. Gas Resources / KB (Tert)	Prospective Resources - Oil in Place / DJ (U Cret)	Prospective Oil Resources / DJ (U Cret)	Prospective Assoc. Gas Resources / DJ (U Cret)	Prospective Resources - Oil in Place / KG	Prospective Oil Resources / KG	Prospective Assoc. Gas Resources / KG	Prospective Resources - Oil in Place / KD (U Cret)
Description	Output	Output	Output	Output	Output	Output	Output	Output	Output	Output
Cell	KB (Tert)!C22	KB (Tert)!C23	KB (Tert)!C24	DJ (U Cret)!C22	DJ (U Cret)!C23	DJ (U Cret)!C24	KG!C22	KG!C23	KG!C24	KD (U Cret)!C22
Minimum	119.2	29.3	30.4	105.4	23.6	24.9	348.6	84.4	65.8	364.7
Maximum	3,721.1	1,229.3	1118.7	1,430.7	441.9	498.6	7,102.8	2,227.9	2358.1	8,244.8
Mean	877.2	239.6	237.0	499.7	136.5	134.9	2,113.5	577.8	571.0	2,319.0
Std Deviation	475.6	133.6	137.5	187.0	53.8	56.8	847.4	243.3	254.6	1,097.8
Variance	226197.6	17838.99	18901.14	34971.57	2891.9	3231.673	718130.9	59194.8	64810.54	1205264
Skewness	1.248811	1.327508	1.348992	0.672334	0.7685375	0.8933885	0.7447173	0.8522304	0.950909	1.033043
Kurtosis	5.062639	5.477387	5.304563	3.469089	3.710736	4.085405	3.65677	4.050351	4.398961	4.406108
Errors	0	0	0	0	0	0	0	0	0	0
Mode	596.7	138.0	149.5	420.4	116.9	107.2	1,811.2	547.2	429.9	1,757.5
5% Perc	304.7	81.0	77.0	233.2	62.0	58.2	929.9	245.3	230.6	899.1
10% Perc	373.4	100.2	94.8	276.2	73.0	69.3	1,108.9	295.0	277.6	1,101.3
15% Perc	431.9	115.7	110.6	307.3	82.0	77.9	1,247.8	331.9	317.1	1,256.2
20% Perc	480.1	129.4	124.8	335.7	90.0	86.1	1,369.1	366.7	354.5	1,383.6
25% Perc	524.9	141.8	138.1	362.4	96.8	93.1	1,489.5	398.9	386.2	1,516.9
30% Perc	573.2	154.7	150.5	387.0	103.4	99.8	1,594.7	429.1	415.3	1,626.6
35% Perc	620.3	167.8	163.1	409.6	110.1	106.7	1,700.2	458.0	444.2	1,747.9
40% Perc	670.1	181.5	176.0	431.3	116.4	113.0	1,802.4	486.0	473.4	1,866.8
45% Perc	719.8	195.1	189.2	453.9	122.7	119.4	1,899.4	513.2	500.8	1,979.9
50% Perc	772.5	209.3	204.0	478.7	129.1	126.2	2,008.4	545.0	532.3	2,113.2
55% Perc	825.2	224.3	220.2	501.3	136.1	133.5	2,112.0	573.6	564.9	2,253.0
60% Perc	891.1	240.7	237.5	526.3	143.2	140.8	2,215.2	604.7	593.6	2,401.2
65% Perc	959.2	261.0	256.0	552.7	150.9	148.5	2,337.4	638.8	629.1	2,551.2
70% Perc	1,038.0	282.7	276.7	580.8	159.0	157.7	2,469.3	678.7	669.7	2,722.2
75% Perc	1,124.1	306.5	301.5	612.6	168.4	167.3	2,619.6	720.3	713.6	2,925.4
80% Perc	1,221.9	334.4	332.9	650.2	179.1	178.6	2,795.6	767.1	764.4	3,150.6
85% Perc	1,348.0	369.7	370.2	695.0	192.0	192.6	3,003.8	825.1	833.0	3,449.3
90% Perc	1,520.8	419.0	424.9	752.5	209.7	211.2	3,259.7	904.9	913.6	3,812.2
95% Perc	1,799.7	502.2	511.5	842.5	237.0	241.5	3,666.4	1,030.3	1042.5	4,389.6

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Output to Excel

@RISK Output Results

Performed By: Chen, Ting T.
Date: Friday, September 7, 2018 11:45:33 AM

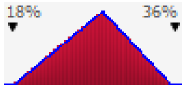
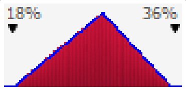
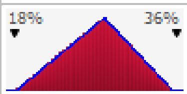
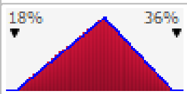
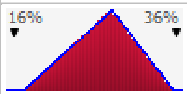
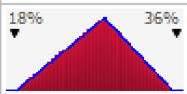
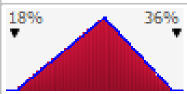
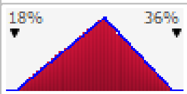
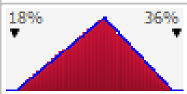
Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
Prospective Resources - Oil in Place / KB (Tert)	KB (Tert)	C22		119.2	877.2	3,721.1	304.7	1,799.7	0
Prospective Oil Resources / KB (Tert)	KB (Tert)	C23		29.3	239.6	1,229.3	81.0	502.2	0
Prospective Assoc. Gas Resources / KB (Tert)	KB (Tert)	C24		30.4	237.0	1118.7	77.0	511.5	0
Prospective Resources - Oil in Place / DJ (U Cret)	DJ (U Cret)	C22		105.4	499.7	1,430.7	233.2	842.5	0
Prospective Oil Resources / DJ (U Cret)	DJ (U Cret)	C23		23.6	136.5	441.9	62.0	237.0	0
Prospective Assoc. Gas Resources / DJ (U Cret)	DJ (U Cret)	C24		24.9	134.9	498.6	58.2	241.5	0
Prospective Resources - Oil in Place / KG	KG	C22		348.6	2,113.5	7,102.8	929.9	3,666.4	0
Prospective Oil Resources / KG	KG	C23		84.4	577.8	2,227.9	245.3	1,030.3	0
Prospective Assoc. Gas Resources / KG	KG	C24		65.8	571.0	2358.1	230.6	1042.5	0

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Output to Excel

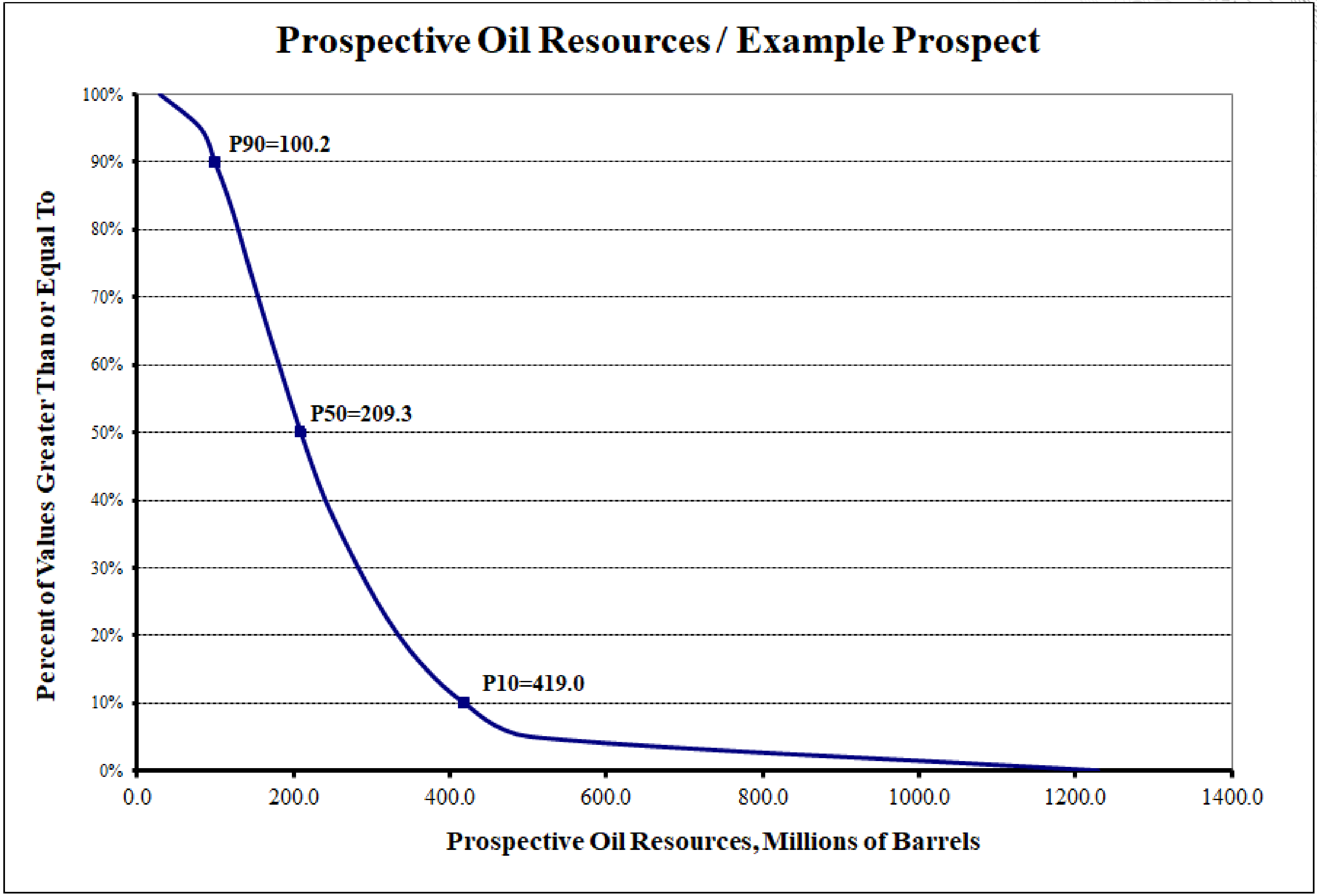
@RISK Input Results

Performed By: Chen, Ting T.
Date: Friday, September 7, 2018 11:45:19 AM

Name	Worksheet	Cell	Graph	Min	Mean	Max	5%	95%	Errors
Category: % Recovery									
% Recovery / KB (Tert)	KB (Tert)	C20		19.0%	27.3%	34.9%	21.7%	32.6%	0
% Recovery / DJ (U Cret)	DJ (U Cret)	C20		19.1%	27.3%	34.9%	21.7%	32.6%	0
% Recovery / KG	KG	C20		19.0%	27.3%	34.9%	21.7%	32.6%	0
% Recovery / KD (U Cret)	KD (U Cret)	C20		19.1%	27.3%	34.9%	21.7%	32.6%	0
% Recovery / Iatuk-D (U Cret)	Iatuk-D (U Cret)	C20		18.1%	27.0%	35.0%	20.9%	32.6%	0
% Recovery / KC (U Cret)	KC (U Cret)	C20		19.1%	27.3%	34.9%	21.7%	32.6%	0
% Recovery / Amatuk (U Cret)	Amatuk (U Cret)	C20		19.1%	27.3%	35.0%	21.7%	32.6%	0
% Recovery / MJ-3 (U Cret)	MJ-3 (U Cret)	C20		19.1%	27.3%	34.9%	21.7%	32.6%	0
% Recovery / MJ-4 (U Cret)	MJ-4 (U Cret)	C20		19.1%	27.3%	34.9%	21.7%	32.6%	0

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Output Distributions from Excel



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Aggregation

- If we sum of P_{90} values for several prospects, we assume full dependence -- that all prospects will experience their low case simultaneously
- This results in a value with greater certainty than P_{90}
- Addition of P_{10} values results in a value with lower probability than 10%
- Statistical aggregation can avoid this
- Sometimes dependencies should be incorporated, which can be accounted for in the Monte Carlo software

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Aggregation

- 2018 PRMS recommends:
  - For reporting purposes, assessment results should not incorporate statistical aggregation beyond the field, property, or project level.
  - Results reported beyond this level should use arithmetic summation by category but should caution that the aggregate P_{90} may be a very conservative estimate and aggregate P_{10} may be very optimistic, depending on the number of items in the aggregate.
- COGEH (2005)
  - When a probabilistic approach is used, Reported Reserves are derived by arithmetic summation of discrete property reserves estimates for each reserves category resulting from separate probabilistic analyses.

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Offshore Guyana Example

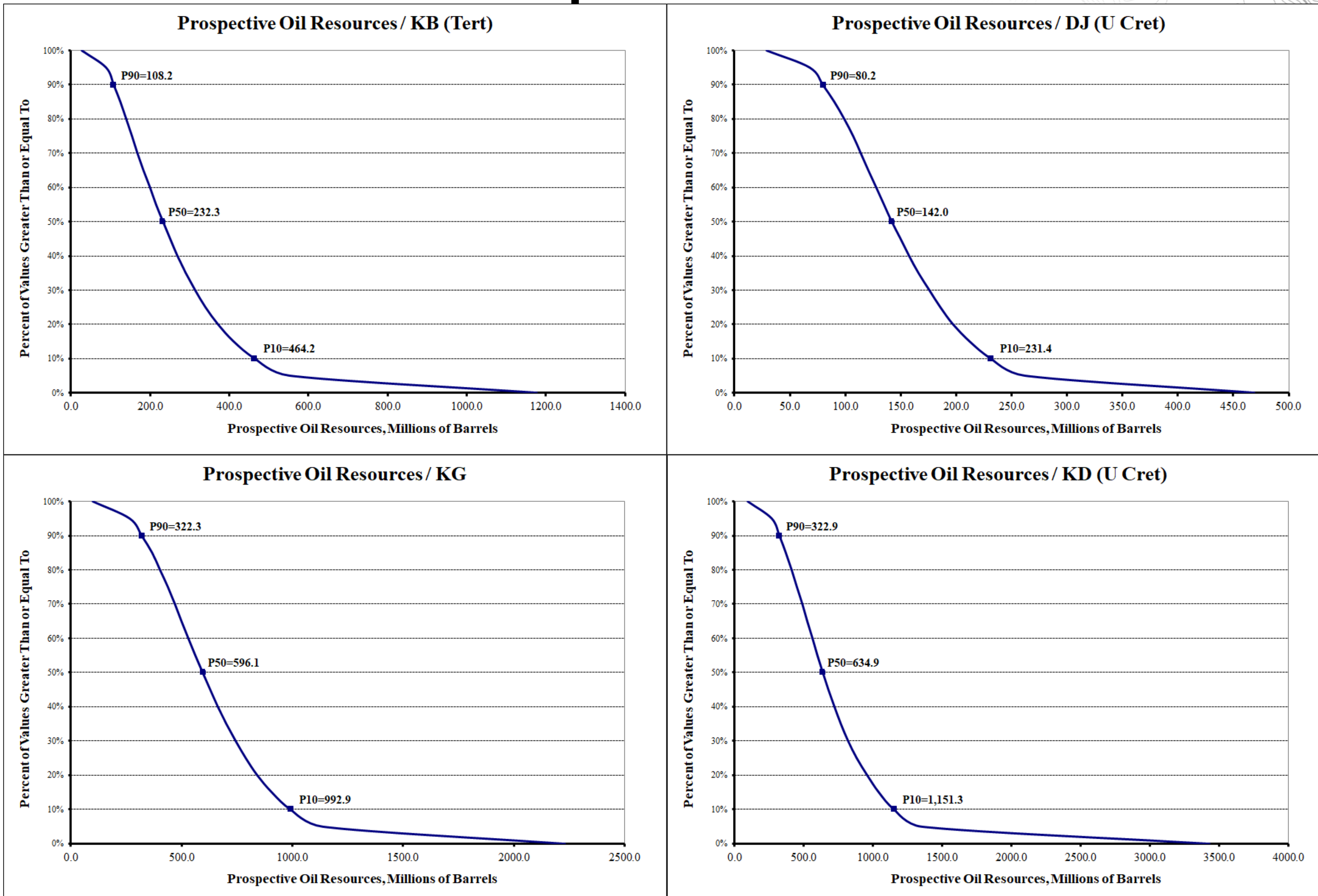
- Conventional prospects delineated by seismic
- Numerous prospects, varying target horizons
- Volumetrics calculated probabilistically to estimate Prospective Resources

Input Data (partial)

LEAD	KB (Tert)			DJ (U Cret)			KG (U Cret)		
	Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum
Oil Gravity	30	35	40	30	35	40	30	35	40
Gas-Oil Ratio	100	500	1,000	500	1,000	1,500	500	1,000	1,500
Gas Gravity	0.65	0.70	0.75	0.65	0.70	0.75	0.65	0.70	0.75
Pgr, psi	0.44	0.45	0.48	0.44	0.45	0.48	0.44	0.45	0.48
Depth, m	3,660	3,700	3,740	4,060	4,160	4,230	3,400	3,900	4,050
Porosity	15	25	30	15	22	30	15	22	30
Water Sat.	20	30	40	20	30	40	20	30	40
Drainage area, km^2	17	27	43	14	24	30	17	30	34
Gross Thickness, m	60	70	125	40	50	60	200	275	325
Net/Gross, fraction	0.45	0.55	0.75	0.50	0.70	0.80	0.25	0.45	0.65
% Recovery	19.00	28.00	35.00	19.00	28.00	35.00	19.00	28.00	35.00
LEAD	**Kumaka (U Cret)**			**Iatuk-D (U Cret)**			**KC (U Cret)**		
	Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum	Minimum	Most Likely	Maximum
Oil Gravity	30	35	40	30	35	40	30	35	40
Gas-Oil Ratio	500	1,000	1,500	500	1,000	1,500	500	1,000	1,500
Gas Gravity	0.65	0.70	0.75	0.65	0.70	0.75	0.65	0.70	0.75
Pgr, psi	0.44	0.45	0.48	0.44	0.45	0.48	0.44	0.45	0.48
Depth, m	4,000	4,250	4,550	4,625	4,850	5,150	2,360	2,460	2,560
Porosity	15	22	30	15	22	30	15	22	30
Water Sat.	20	30	40	20	30	40	20	30	40
Drainage area, km^2	32	51	77	37	50	73	6	11	15
Gross Thickness, m	100	140	180	100	125	175	30	40	50
Net/Gross, fraction	0.25	0.45	0.65	0.25	0.45	0.65	0.25	0.45	0.65
% Recovery	19.00	28.00	35.00	18.00	28.00	35.00	19.00	28.00	35.00

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Example Results



Example Results

	Prospective Oil Equivalent Resource, $MMBOE_6$		
Lead	Low Estimate	Best Estimate	High Estimate
Joe (Tert)	62.7	148.3	280.7
Jimmy (Tert)	12.6	35.5	81.0
Amatuk (U Cret)	100.6	228.3	428.2
KC (U Cret)	20.3	41.1	73.3
KC-A (U Cret)	35.5	63.5	109.5
Hammerhead (Tert)	6.2	11.0	19.0
MJ-3 (U Cret)	124.1	230.1	402.3
KB (Tert)	167.6	349.5	689.1
KG (U Cret)	339.7	633.5	1,058.3
Jethro Ext (Tert)	15.6	46.1	91.7
Rappu (U Cret)	247.1	535.6	1,002.9
DJ (U Cret)	85.6	150.0	244.9
Kumaka (U Cret)	335.0	667.5	1,236.7
Jethro (Tert)	114.9	214.5	372.0
Iatuk-D (U Cret)	348.2	627.2	1,125.4
Total	**2,015.8**	**3,981.9**	**7,215.0**

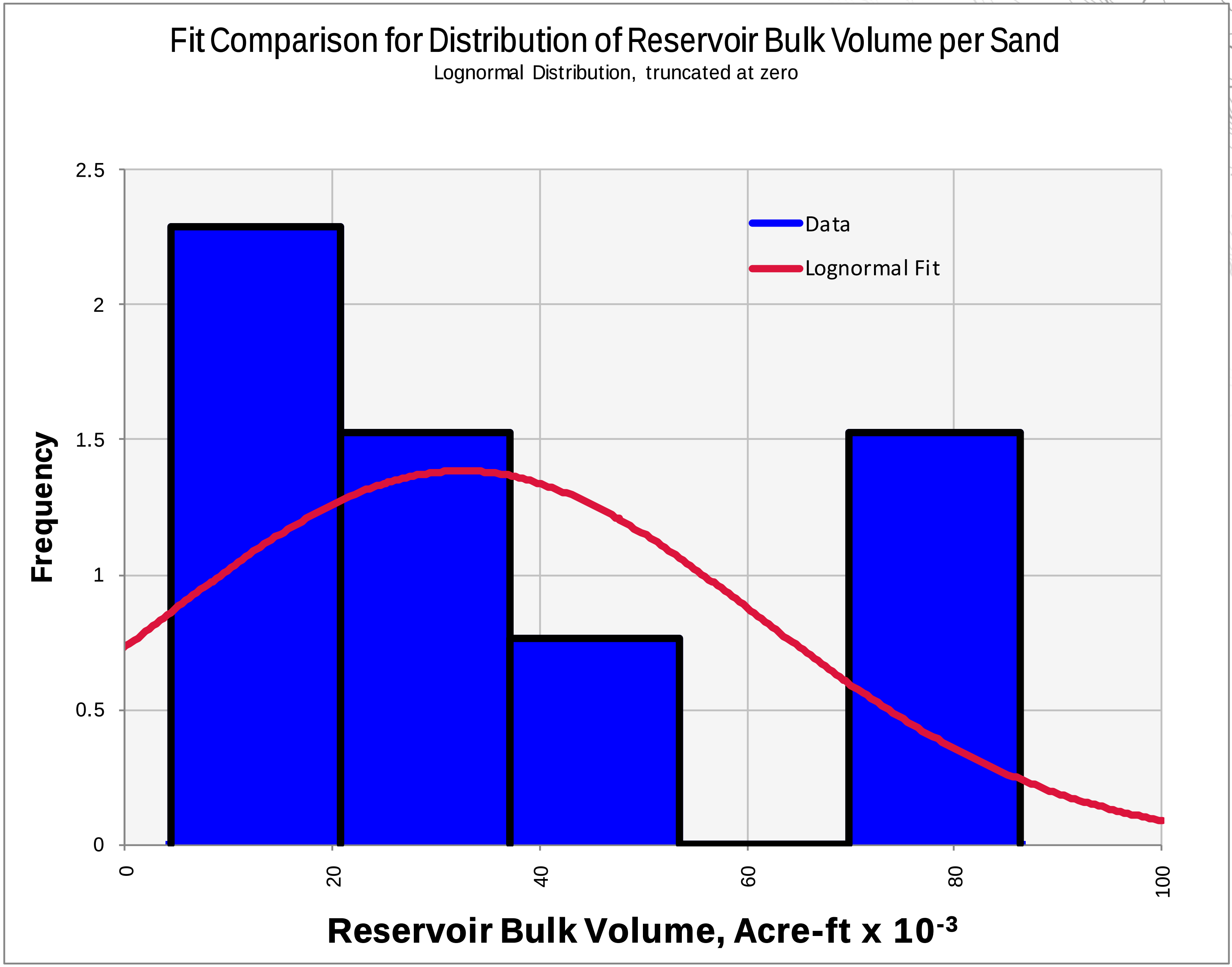
GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Mongolia Example

- Conventional exploration targets
- Data limited to extensive gravity surveys and sparse 2D seismic coverage
- Methodology used is a statistical approach based on the analogy of the currently producing fields in nearby blocks

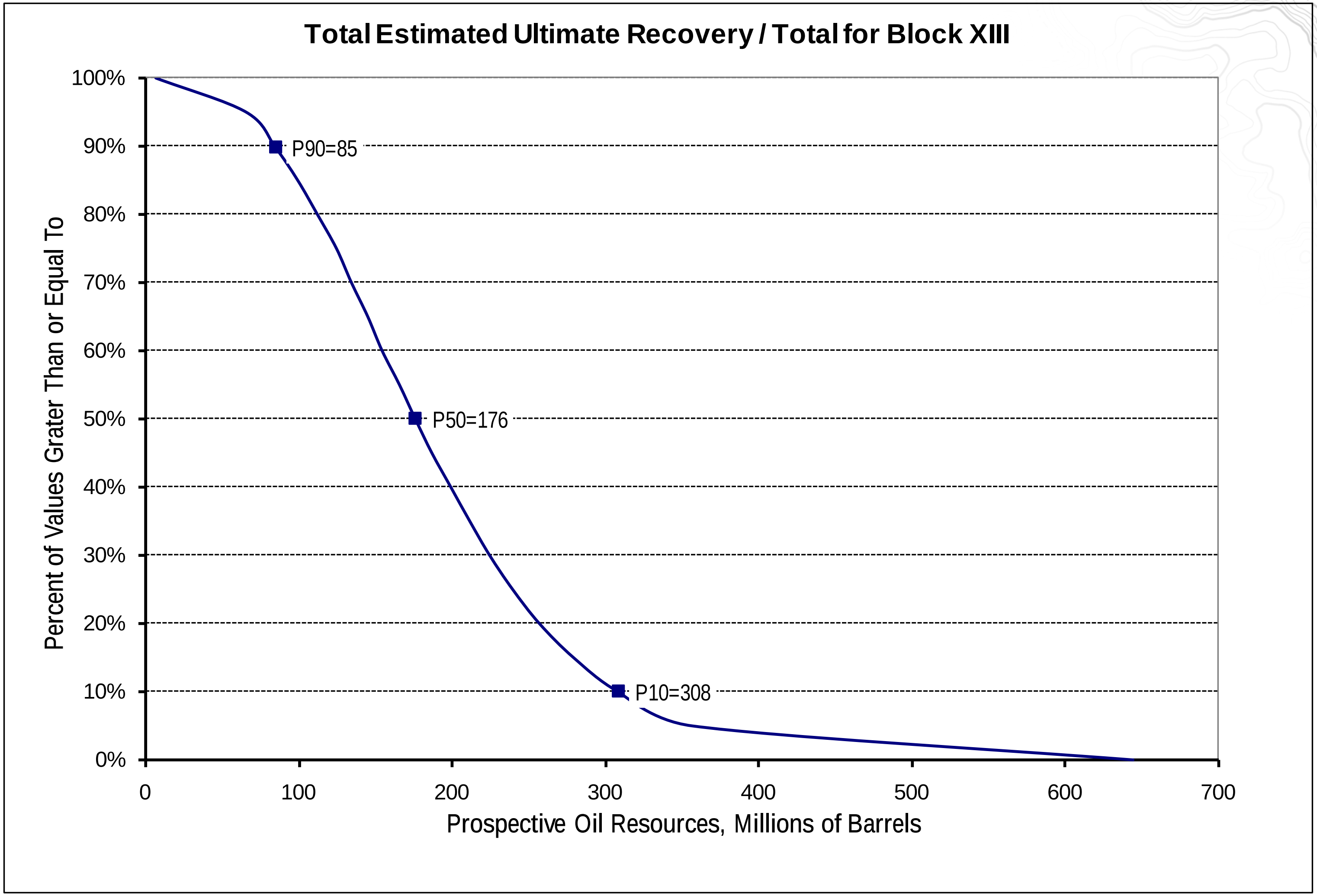
Input Data

Parameter	Units	Minimum	Most Likely	Maximum
Oil Gravity	°API	22	27.9	33.5
Solution Gas-Oil Ratio	cuft/bbl	97	124	169
Gas Gravity	Relative to air	0.60	0.65	0.70
Temperature gradient	°F/ft	0.0164	0.0169	0.0174
Pressure gradient	psi/ft	0.43	0.44	0.45
Depth	ft	1,394	4,265	8,203
Porosity	%	11	13	15
Water Sat.	%	30	35	40
% Recovery		12%	17%	30%
# Prospects Block XIII		5	12	18
# Prospects Block XIV		4	11	18



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Example Output



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

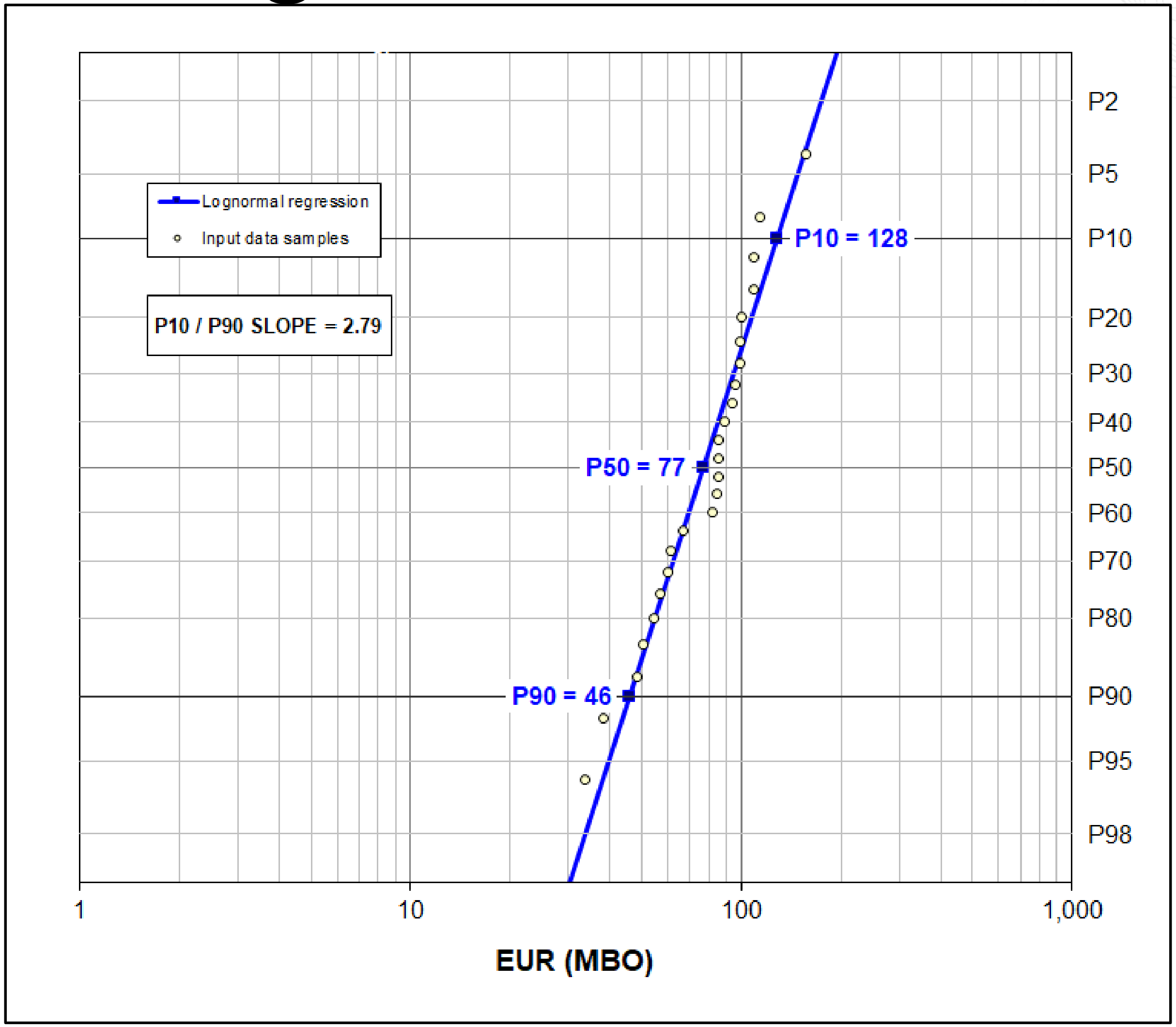
Summary of Estimates

	Prospective Oil Resources, Millions of Barrels		
Block	**Low Estimate**	**Best Estimate**	**High Estimate**
XIII	85	176	308
XIV	78	165	293
Sum of Prospects	**163**	**341**	**602**

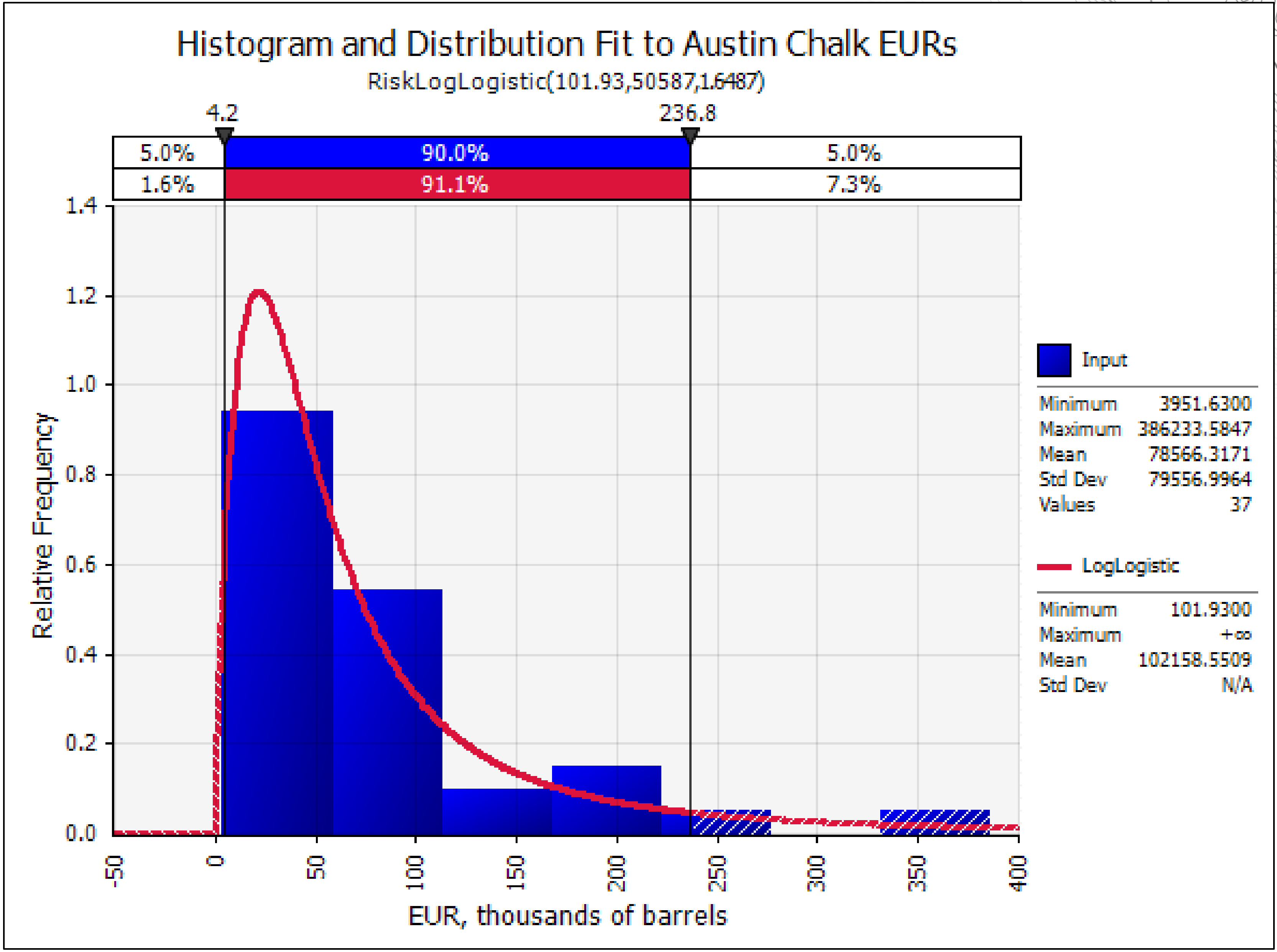
Austin Chalk Example

- Resource Play
- Known reservoir – penetrated and produced from numerous vertical wells
- No horizontal wells nearby
- Designated Contingent Resources
  - Estimated based on statistics of nearest horizontal wells' EURs
  - Input distribution for number of wells to be drilled
  - Multiple samplings of EUR distribution for each iteration

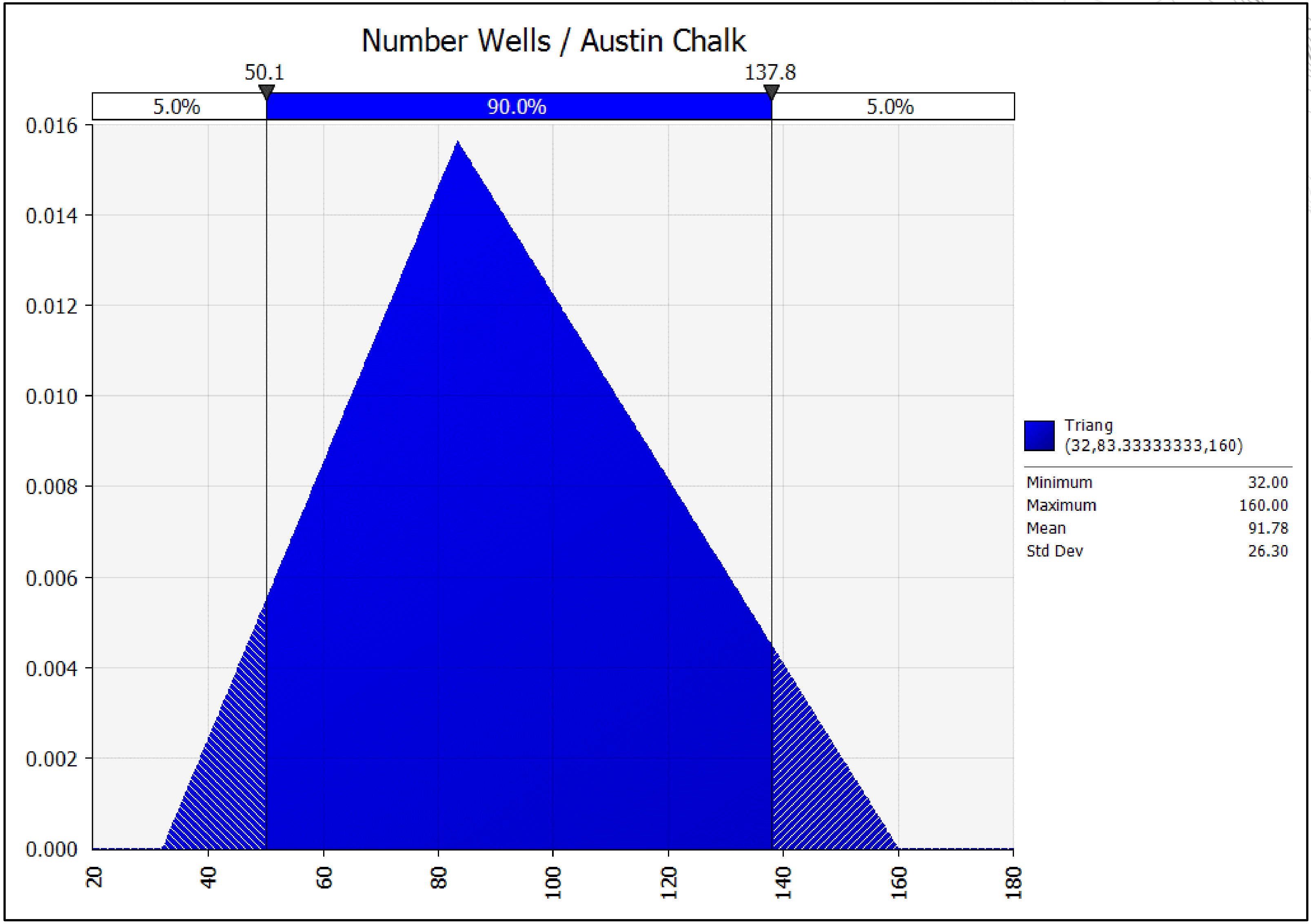
Log Cum Probit Plot



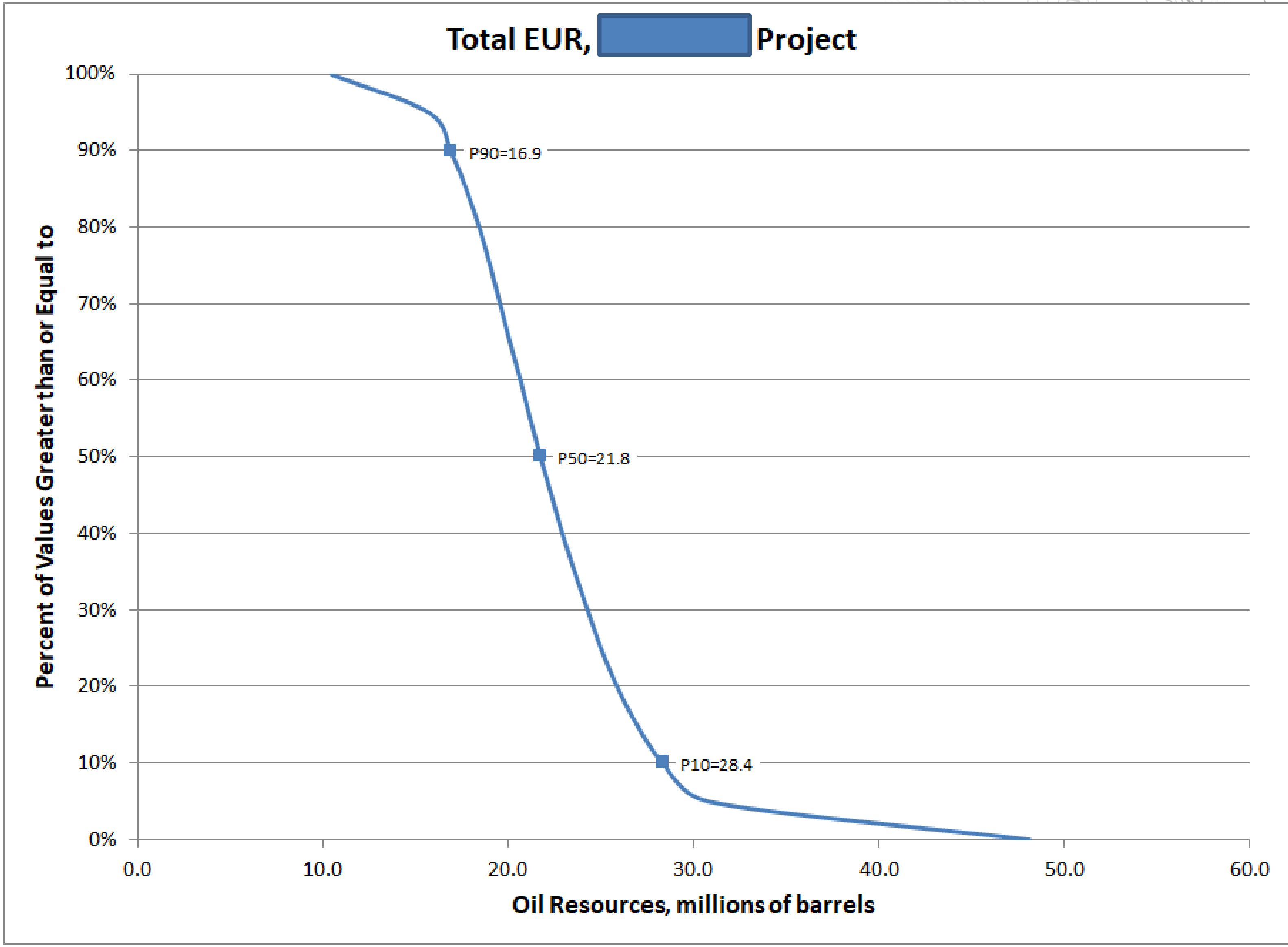
GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants



GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants

Bangladesh Example

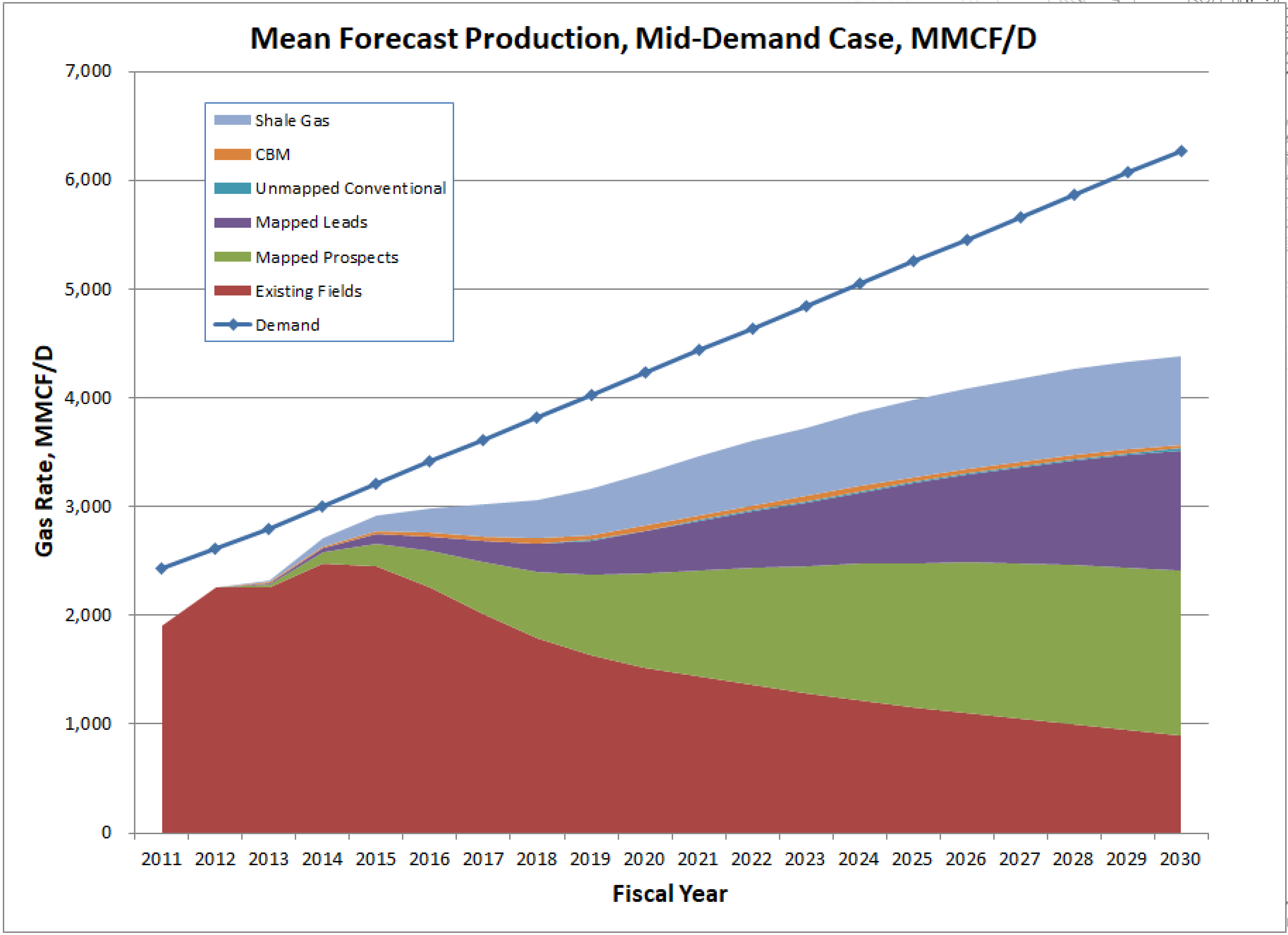
- Modeled identified exploratory prospects individually
- Modeled unmapped conventional resources based on a USGS study
  - Divided the country into six regions and did a probabilistic assessment of the number of fields within each region and the resource size for each field
  - Our model used the same regions and a simplified version of the USGS probabilistic modeling of success rates, discoveries, and field sizes.

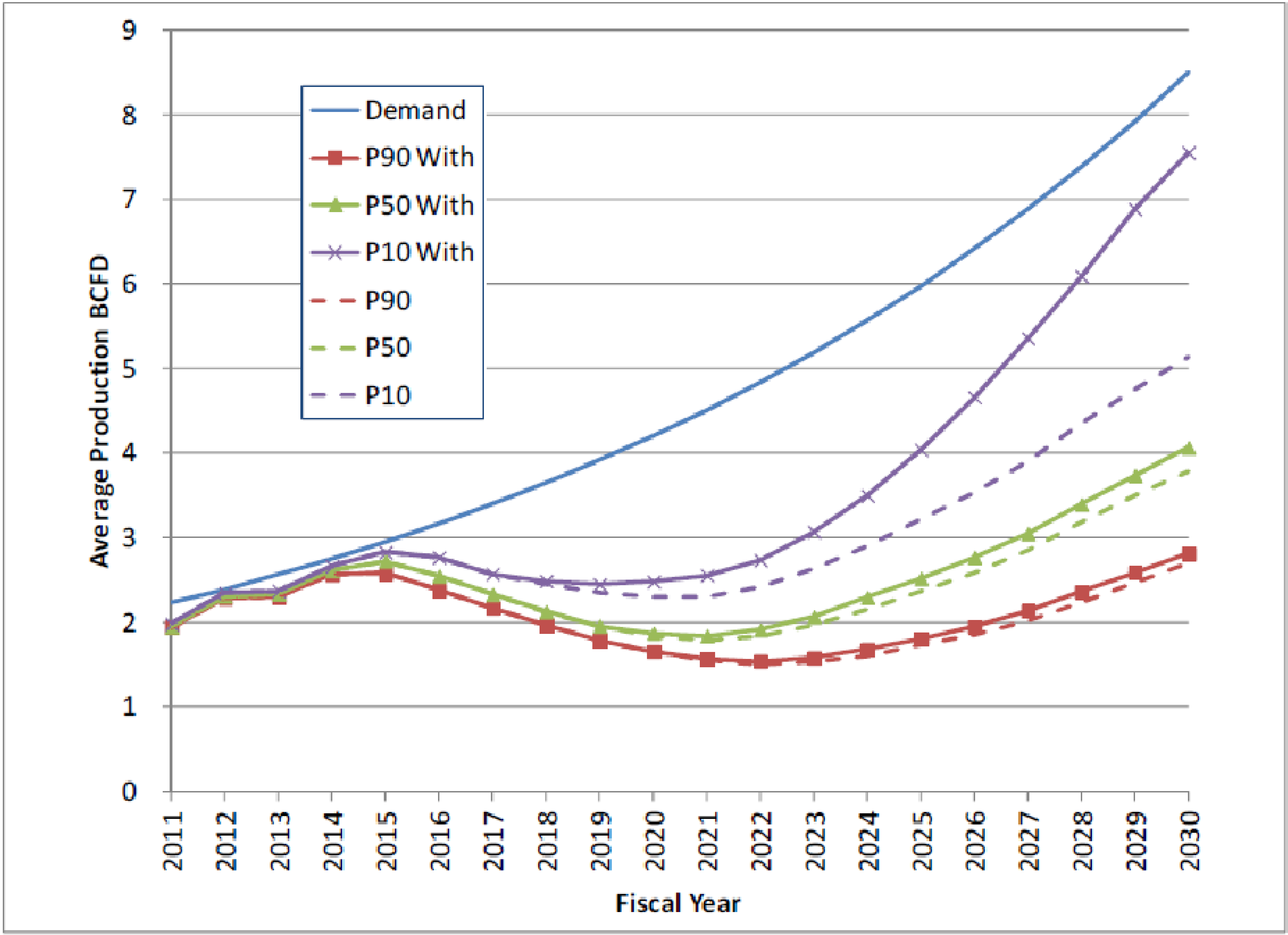
Bangladesh Example

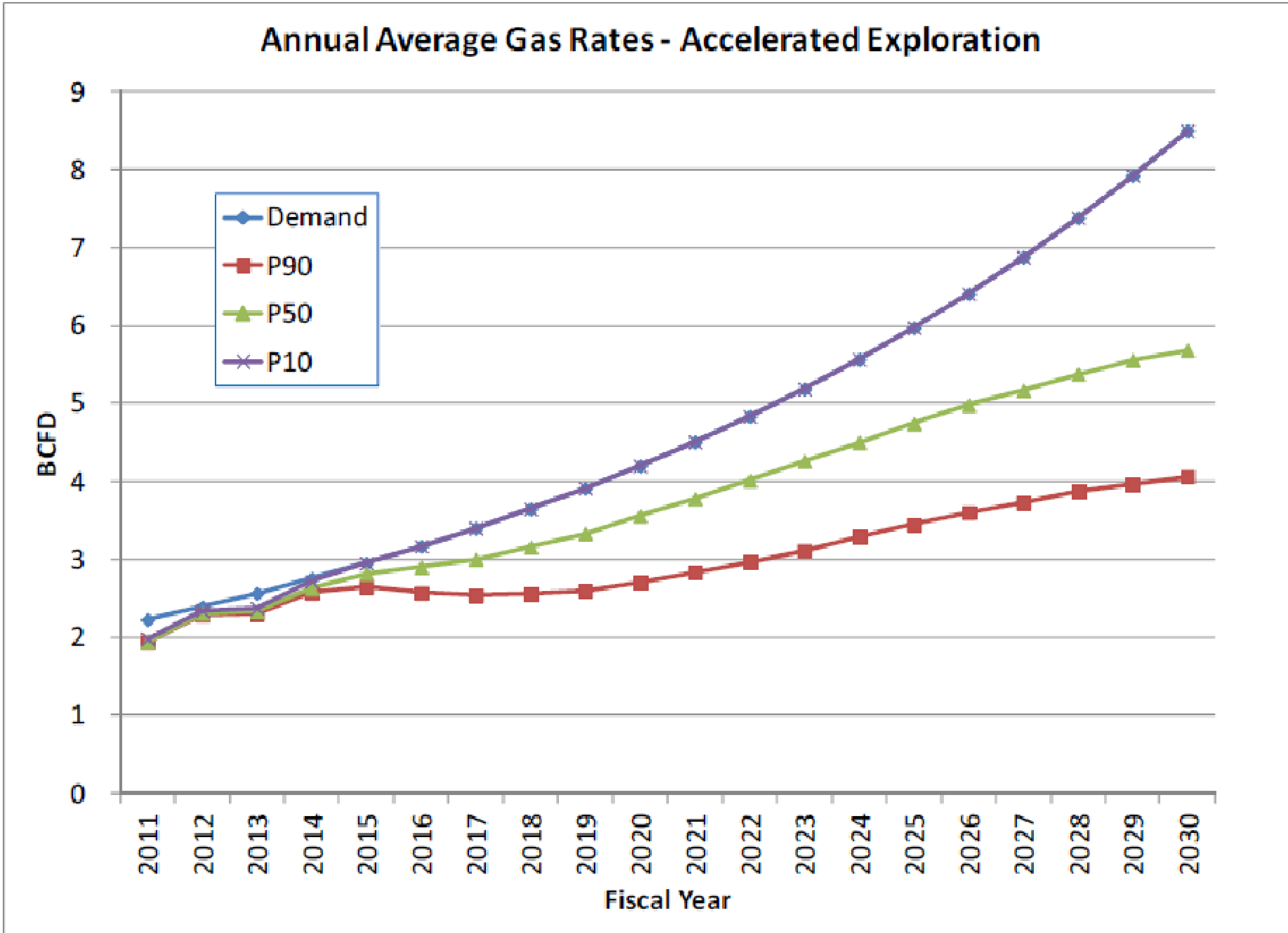
- Unconventionals
  - CBM
    - Estimated for each known coal deposit in Bangladesh
    - Resource estimates based on expected ranges of area, net coal thickness, density, gas content, and recovery factor
  - Shale gas
    - Four potential shale plays identified
    - Resource estimates based on expected ranges of area, thickness, and recoverable gas per acre-ft

Bangladesh Example

- Future gas supply and demand scenarios were also modeled
  - Three deterministic demand scenarios
  - Reserves forecast probabilistically
  - Each type of resource (prospects, unmapped conventional, CBM, and shale gas) modeled separately
  - POS considered, and assumptions about exploration schedule modeled


Mean Forecast Production, Mid-Demand Case, MMCF/D
Shale Gas
CBM
Unmapped Conventional
Mapped Leads
Mapped Prospects
Existing Fields
Demand
Gas Rate, MMCF/D
Fiscal Year
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030


Demand
P90 With
P50 With
P10 With
P90
P50
P10
Average Production BCFD
0
1
2
3
4
5
6
7
8
9
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Fiscal Year


Annual Average Gas Rates - Accelerated Exploration
BCFD
0
1
2
3
4
5
6
7
8
9
Demand
P90
P50
P10
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Fiscal Year

References

- Petroleum Resources Management System (PRMS): https://www.spe.org/industry/reserves.php
- Society of Petroleum Evaluation Engineers, (Calgary Chapter): Canadian Oil and Gas Evaluation Handbook (COGEH), Second Edition, Volume 1, 1st September 2007, and Volume 2, November 2005.
- SPE, et.al.: "Guidelines for Application of the Petroleum Resources Management System," November 2011, https://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf
- Allen, Fraser H. And Jones, Kevin R.: "Operations Research, A New Discipline of Interest to the Petroleum Engineer," Society of Petroleum Engineers, SPE-1658-G-PA, January 1961.
- Campbell, John M.: "Optimization of Capital Expenditures In Petroleum Investments," Society of Petroleum Engineers, SPE-188-PA, July 1962.
- Stoian, E.: "Fundamentals and Applications of the Monte Carlo Method," Petroleum Society of Canada, PETSOC-65-03-02, July 1965.
- *Quantification and Prediction of Petroleum Reserves,* edited by A.G. Doré, and R. Sinding-Larsen, Norwegian Petroleum Society (NPF) Special Publications 6, 1996, pp. 57-62
- Martinez, A.R., et al.: "Classification and Nomenclature Systems For Petroleum And Petroleum Reserves," *1983 Study Group Report*, 11th World Petroleum Congress, London (1984).

References

- U.S. Geologic Survey: “Petrobangla Cooperative Assessment of Undiscovered Resources of Bangladesh,” Bulletin 2208-A, June 2001.
- Bishop, M., Lencioni, L., et. al.: “Potential Unconventional Gas Supplies in Bangladesh,” presented at the SPE Middle East Unconventional Gas Conference and Exhibition held in Abu Dhabi, U.A.E., 23-25 January 2012.
- Cronshaw, M., and Lencioni, L.C.: ” A Stochastic Techno-Economic Model for Multi-Target Exploratory Prospects, Including Tax Implications of Purchase Price,” presented at the SPE Hydrocarbon Economics and Evaluation Symposium held in Houston, Texas, USA, 19-20 May 2014.

Thanks to Gustavson Associates, and our clients.

QUESTIONS?

GUSTAVSON ASSOCIATES
International oil, gas, & mining consultants