GREENFIELD ECONOMICS

USING SIPMATH MODELING

Brian Putt

#RISKAWARENESSWEEK2019

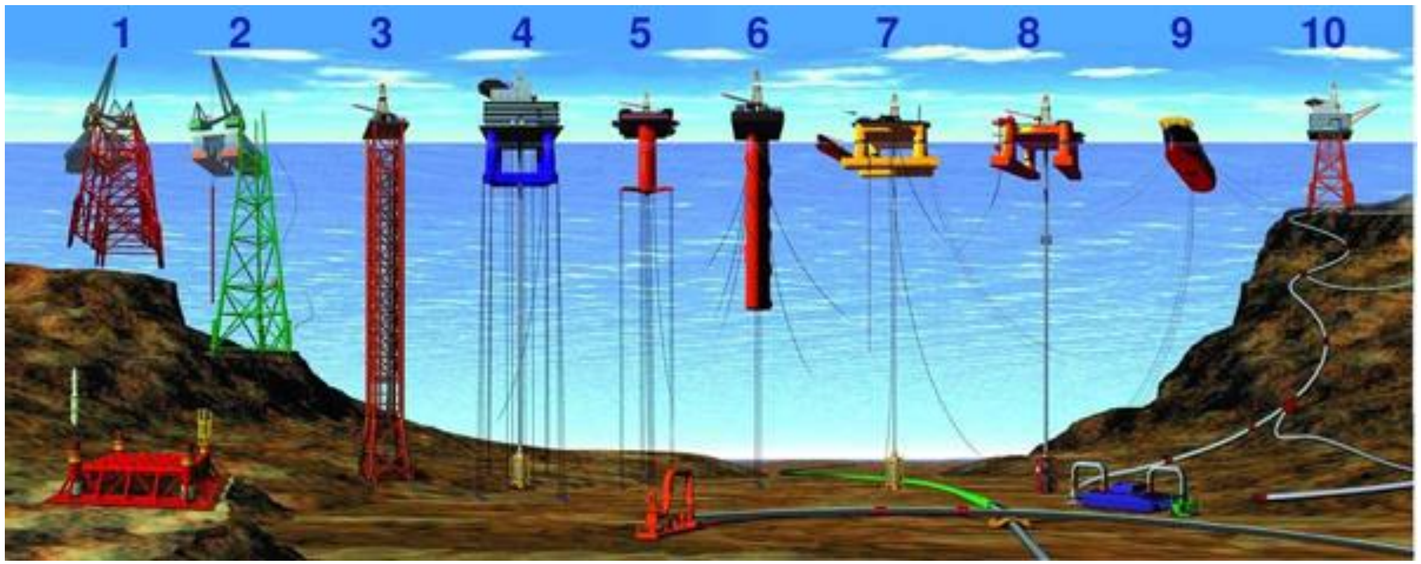
RISK AWARENESS WEEK 2019

Objectives of this session

- Have a discussion around greenfield economics
  - Principles to consider
  - Sensitivities that impact results
  - Impact of value measures
- Explain the SIPmath model used in the discussion
- Understand how SIPmath can be used to evaluate the Value of Information

Greenfield Development

Objective: Determine the optimum development plan for an offshore oil & gas development



Issues

- Should we develop?
- What type of facility?
- What size facility should be built
- Resource size
- Deliverability
- Cost to develop
- Operating costs
- Contractor to build the facility
- Oil Price
- Where to market the oil and gas
- Fiscal and tax uncertainty

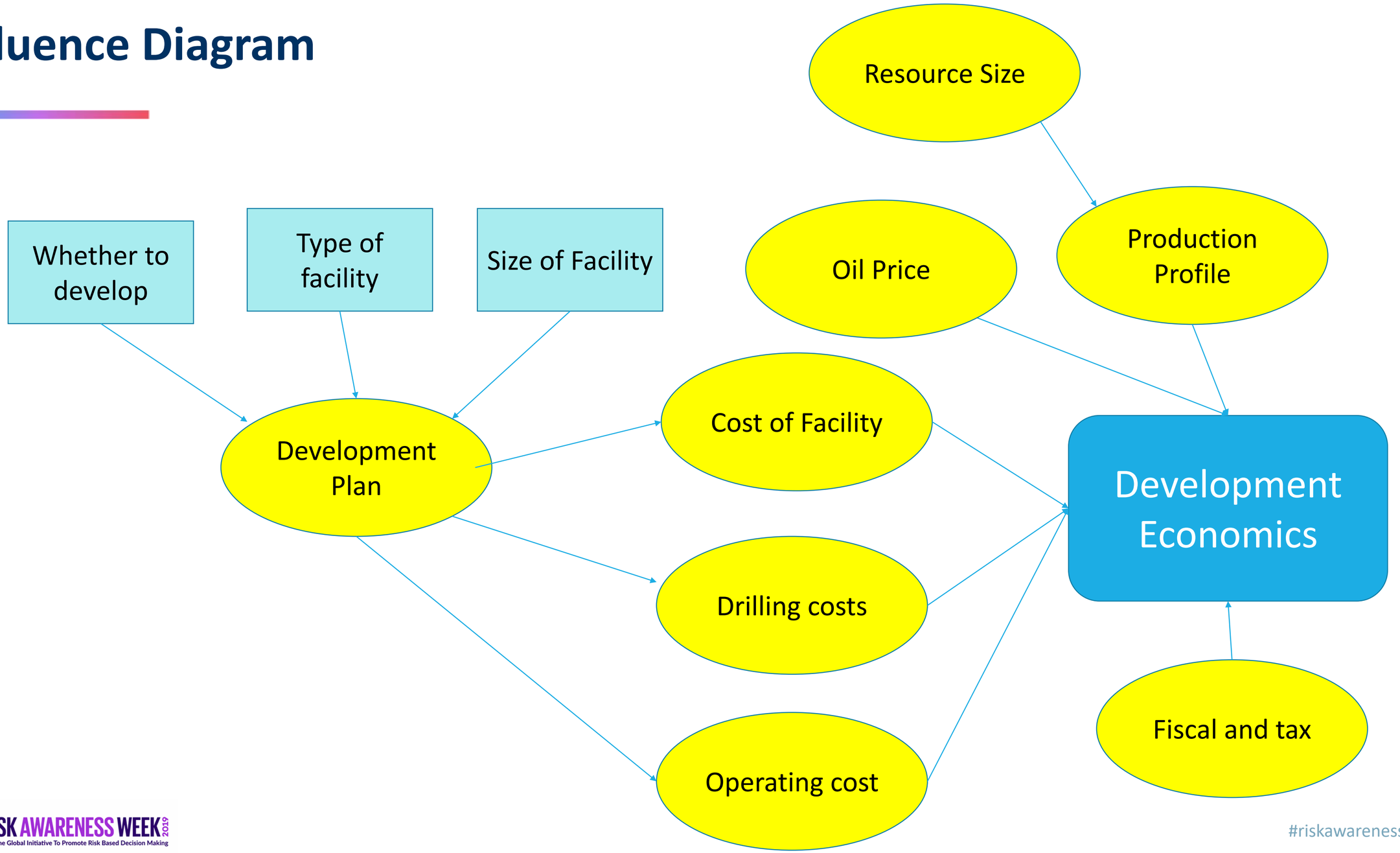
Decision Hierarchy

Givens:
- Fiscal and tax stability

Focus Decisions:
- Should we develop
- What type of facility
- What size of facility should be built

Tactical Decisions:
- Contractor to build the facility
- Where to market the oil and gas

Influence Diagram

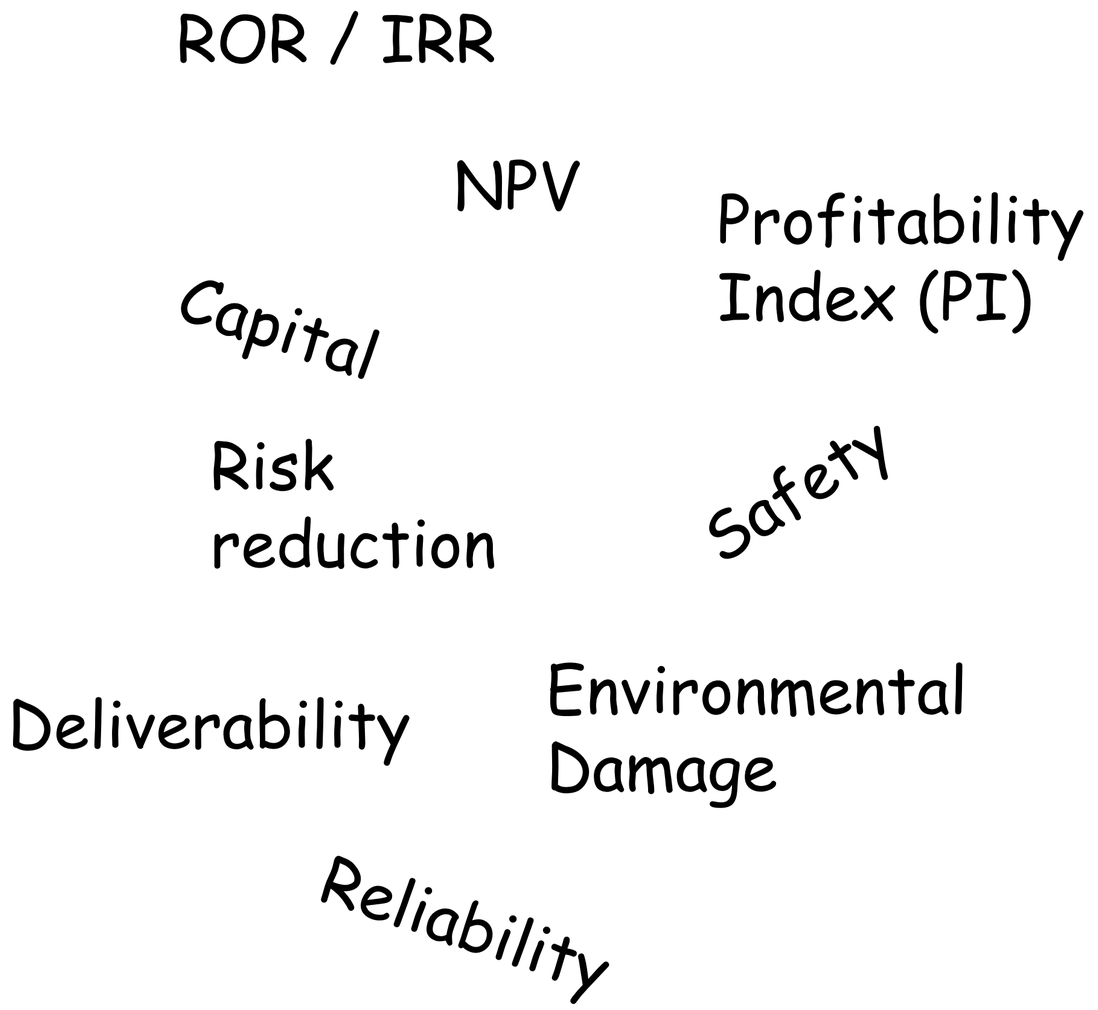


Strategy Table

Decision	Alternatives →		
Should we develop	Yes	No	
What type of facility	FPSO	Platform	Connect to existing infrastructure
Size of processing facility	30 MBD	50 MBD	80 MBD

Value Measures are very important

- What are your value measures?
- Do they change with decisions?
- How do they impact your decision?



Why Greenfield development analysis is important

Forces For Large Facilities

- Revenue now is worth more than the future
- Meet our production targets
- Brings more oil into the concession life
- Bigger is better

Forces Against Large Facilities

- Requires greater capital expenditures
- Reserves may be less than anticipated
- Reservoir may not sustain the higher production rate
- Oil prices could increase in the future

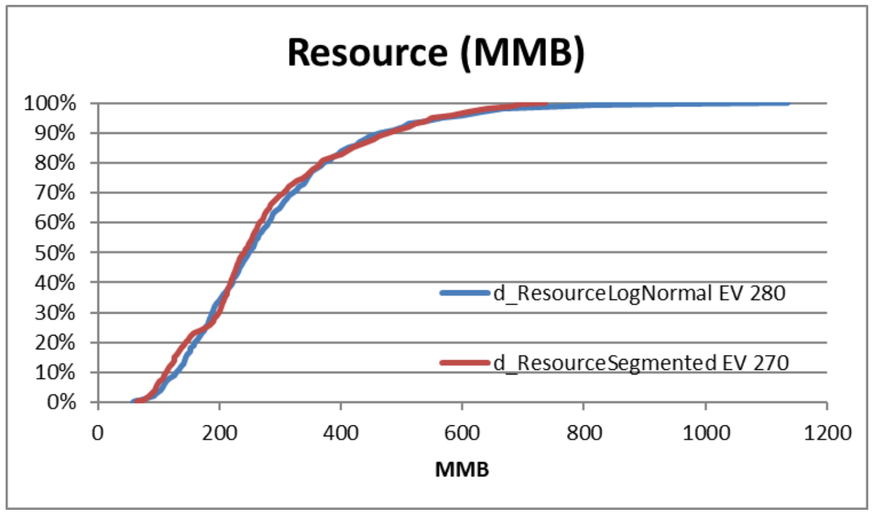
Resource Characterization is critical

- Three segments with traditional 25/50/25% probabilities
- Segments defined as percentiles of the original lognormal distribution with overlap

  Seg 1 goes from P0 to P30 while Seg 2 starts at P25 → Overlap of segments
- Multiple ways to characterize the resource distribution in preparation for a VOI analysis

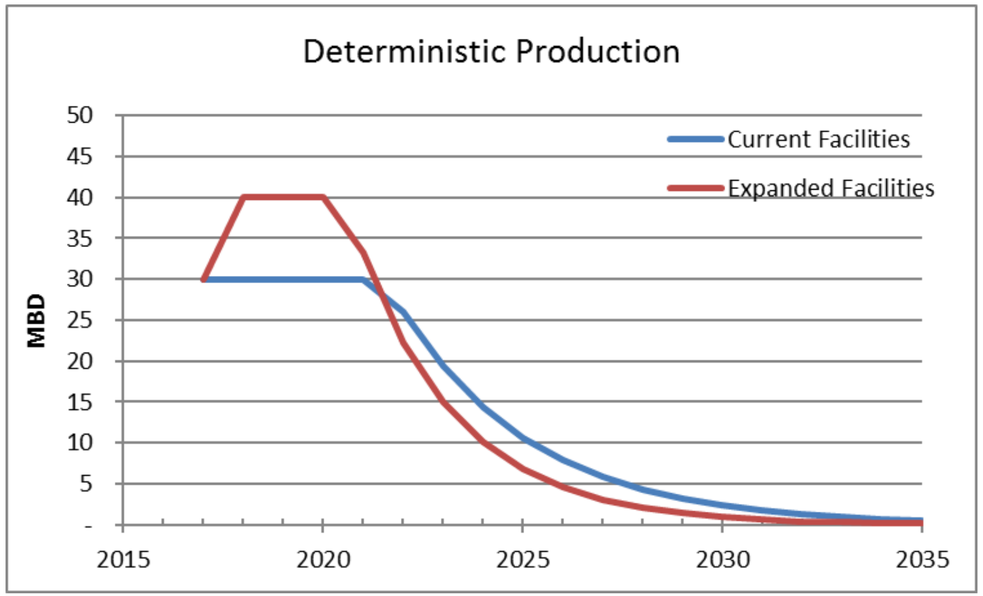
- Characterization must reasonably represent original assessment

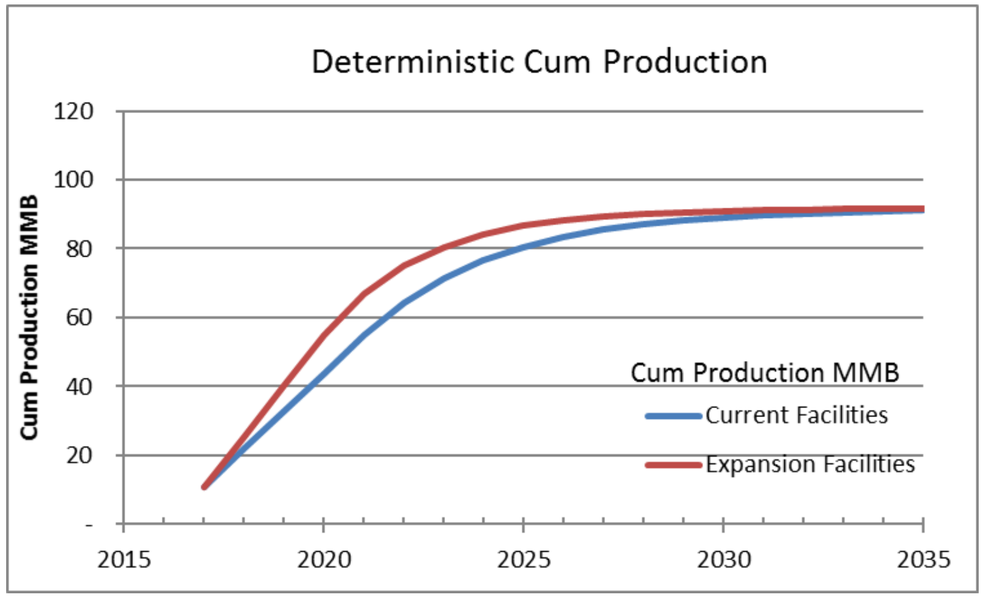
Three Triangular distributions					
Segment 1			0%	25%	75%
			0%	10%	30%
	25%	156.27	53.03	129.78	188.46
Segment 2					
			25%	35%	80%
	50%	276.49	177.79	203.30	372.30
Segment 3					
			75%	75%	99%
	25%	464.83	345.13	345.13	767.45



What is impact of larger facilities?

- Oil is produced soon but reduces the production in later years
- Cumulative production, given sufficient concession life, is unchanged
- Near term cash flows are higher but then lower when production declines





Dashboard

- Models typically have a “dashboard” that enables the analyst and management to focus on what is important.
- Multiple value measures are calculated for each deterministic / trial.
- Profitability Index (PI) defined as:

  NPV10/ Investments discounted at 10% (PVI)

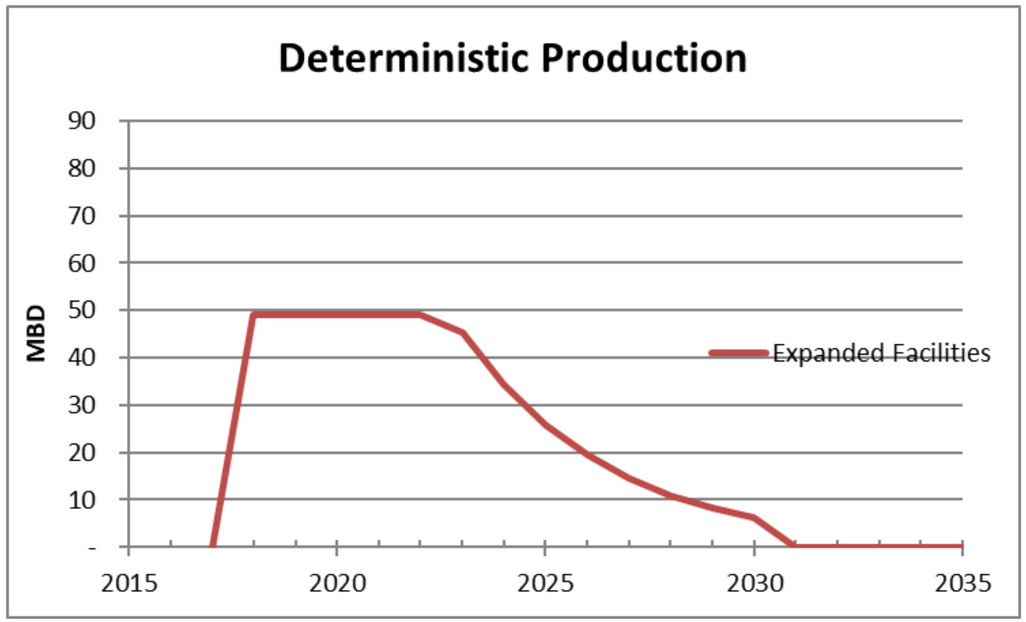
- Value Creation is NPV – PVI *PI

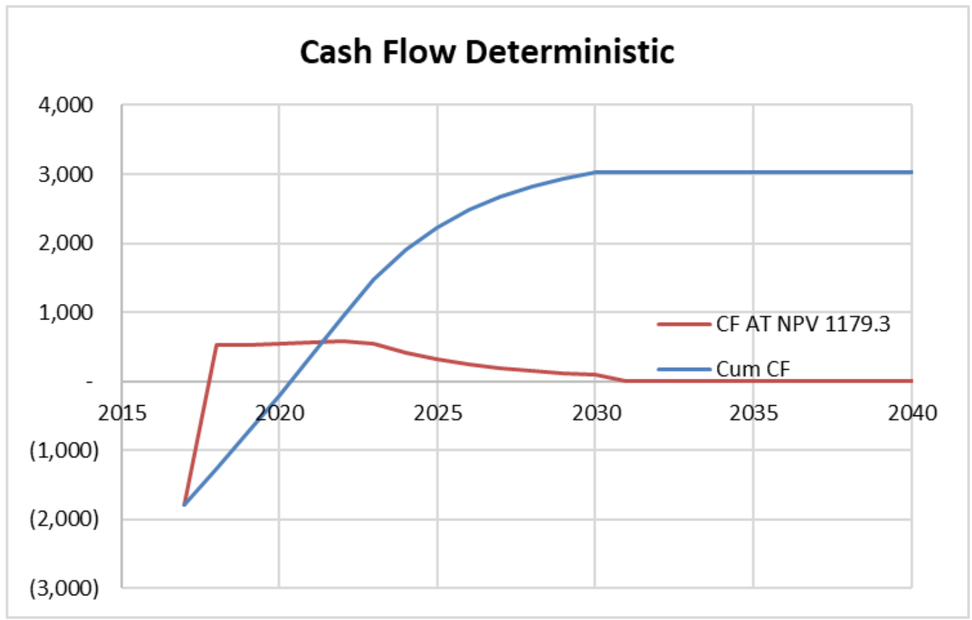
  PVI = Capital discounted

Simulation	1	**Greenfield Economics**			
Decision Policy		Objective			NPV10
		Probabilistic			Yes
		Concession Ends			2030
		PI Hurdle			0.3
		Test			No
	Incr Capacity with No Info			82.43	**82.43**
					Probabilistic
	Optimized Variable				(103.8)
	NPV10 of Project				1,079.1
w/VOI	NPV @10%				1,078.3
w/VOI	NPV @15%				433.0
w/VOI	P10 NPV10				(905.9)
	Value Creation				**(103.8)**
	Cost $MM (Undiscounted)				4,132.92
	Cost Discounted @10%				3,940.59
	Profitability Index (PI)				0.26
	Total Resource MMB				192.92
	Years on Plateau				3.12

Sensitivity of Capacity

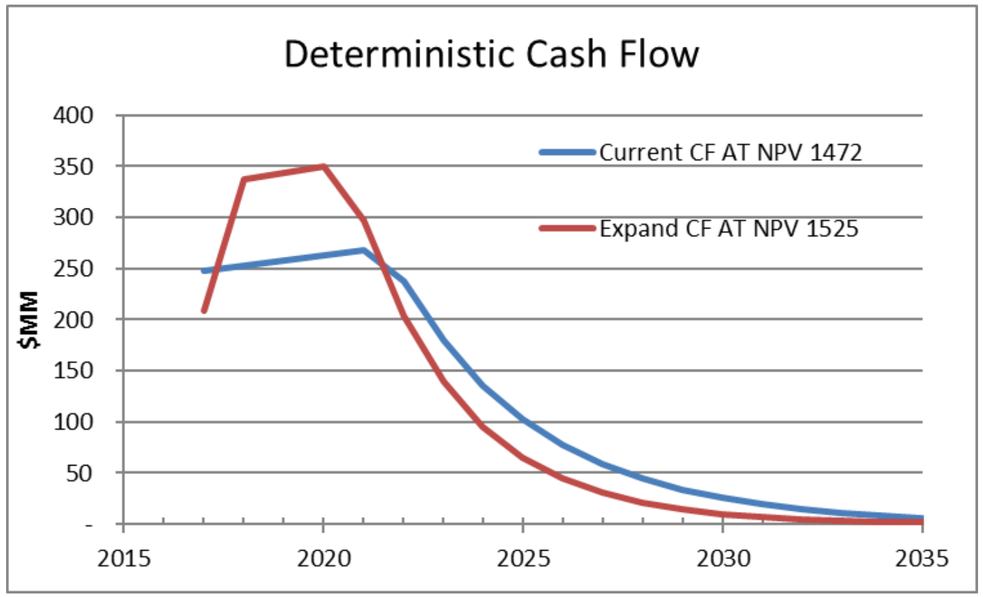
- Let’s look at some different capacities deterministically.
- Then we will add uncertainty and compare results.

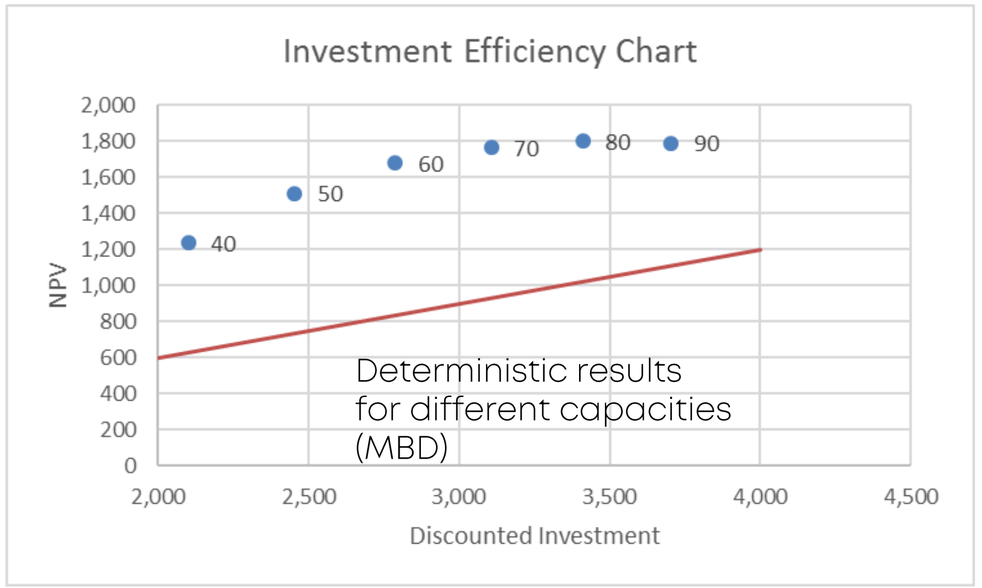




Deterministic Analysis Provides Insights but also can be miss leading

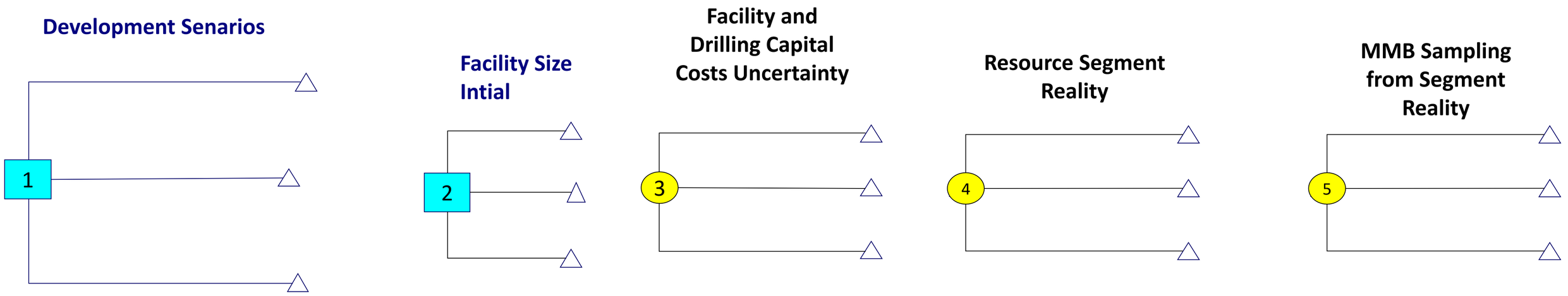
- After Initial Investment, Cash Flow is Higher for a Few Years
- The sign changes in the incremental cash flow makes calculation of IRR meaningless.
- Value creation is optimized around 60 MBD facility size deterministically.





Adding uncertainty
Conceptual No Information Decision Tree

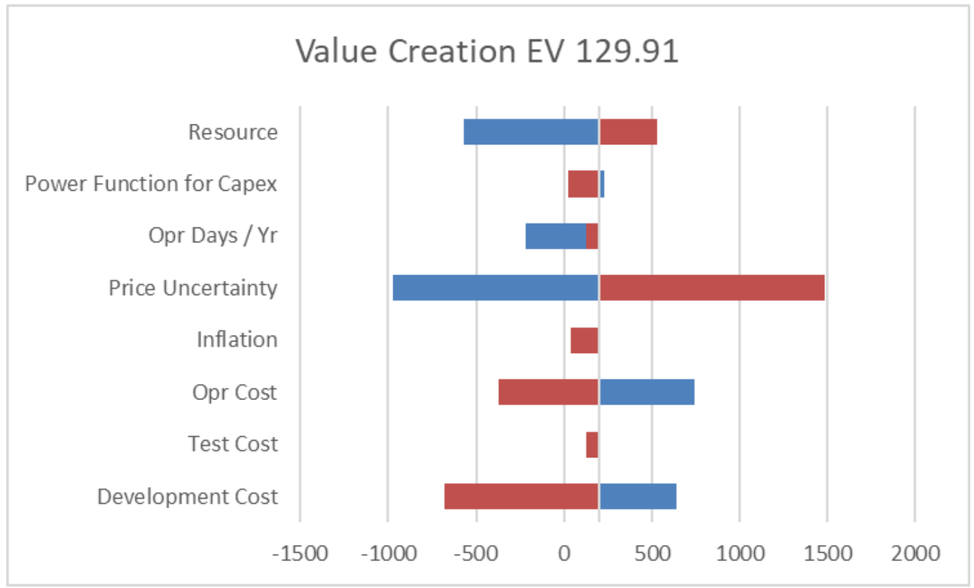
- All decisions are up front. Choice of facility size based on Development Plan
- While shown here as discrete capacity decision and uncertainties, but we will treat both as continuous in the analysis.



Sensitivity Analysis with Tornado Diagrams

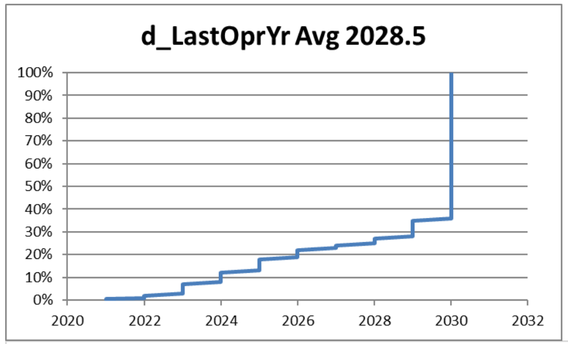
- Most tornado diagrams are **“deterministic”.** The center line reflects the Most Likely deterministic value for all the variables. The end point reflect the change in the deterministic result.
- The **EV Tornado** diagram changes one variable at a time while all the other variables are uncertainty. The x-axis reflects the change in the mean value of the value measure.

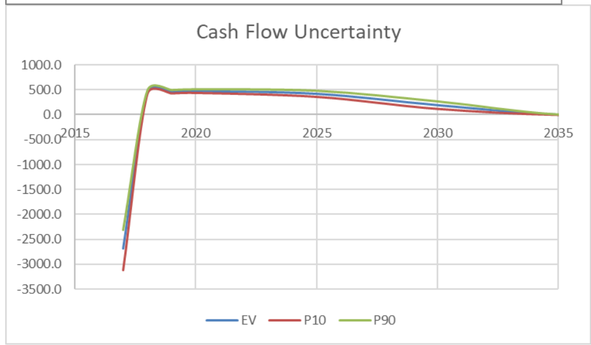
EV Tornado



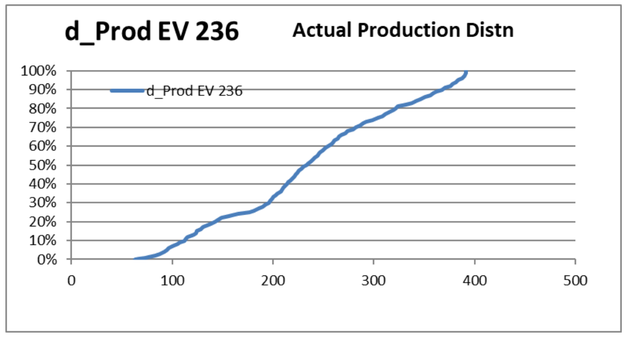
Probabilistic Results

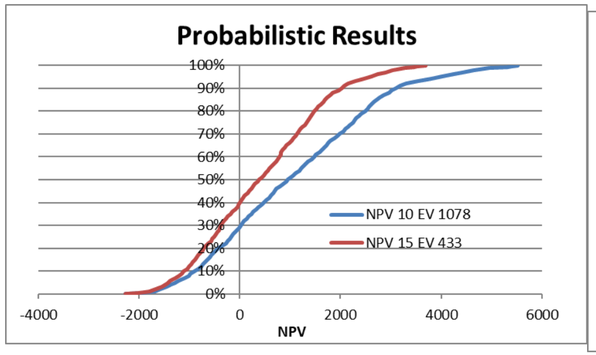
- There are many graphics we can display for a probabilistic results that provide the decision maker insight into the possible result.
- Looking at different scenarios will often lead to a hybrid solution that is better than any of the initial scenarios.

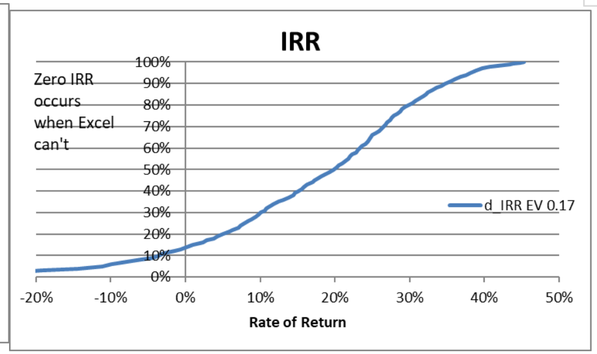


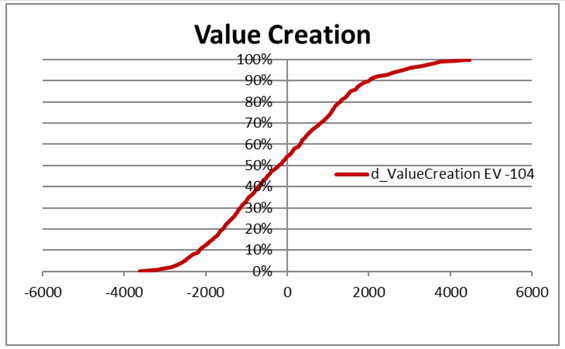


Assumes capacity of 82.42 MBD



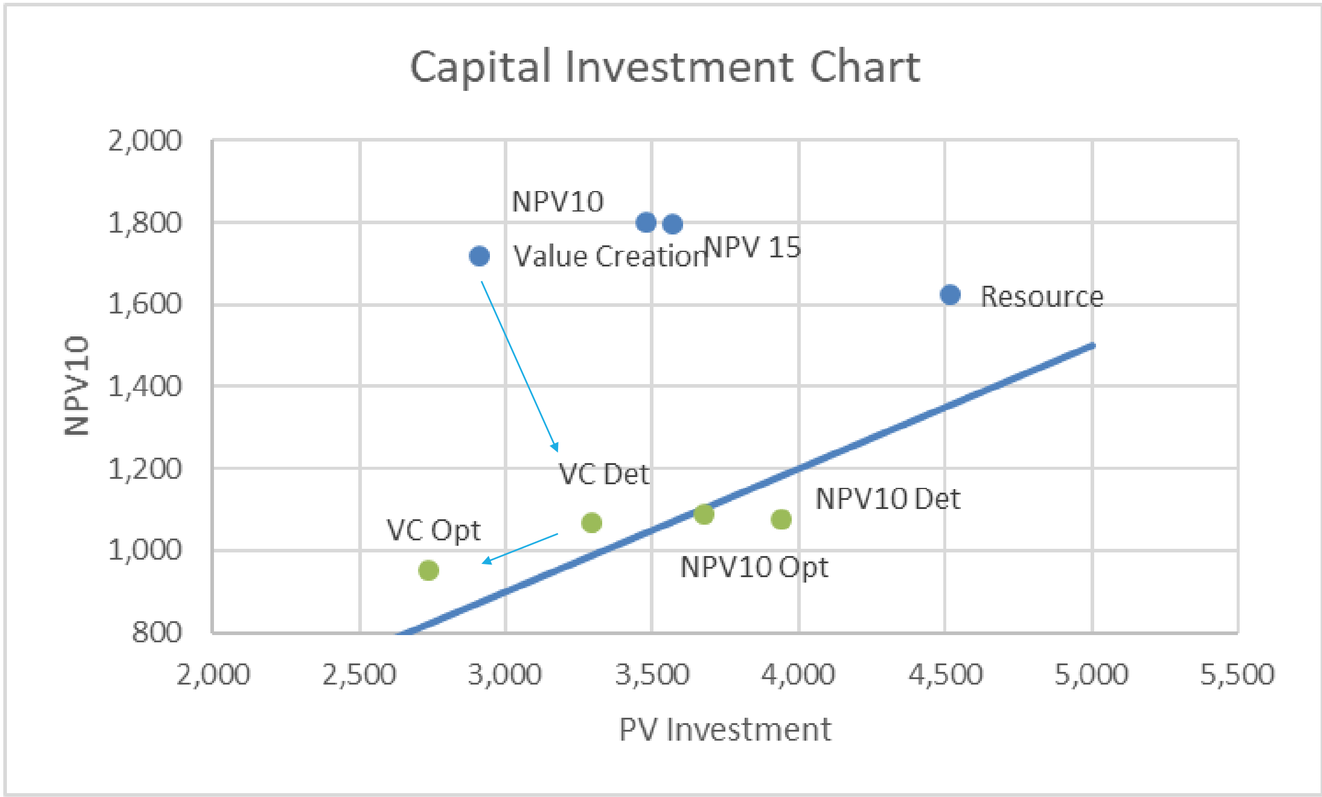






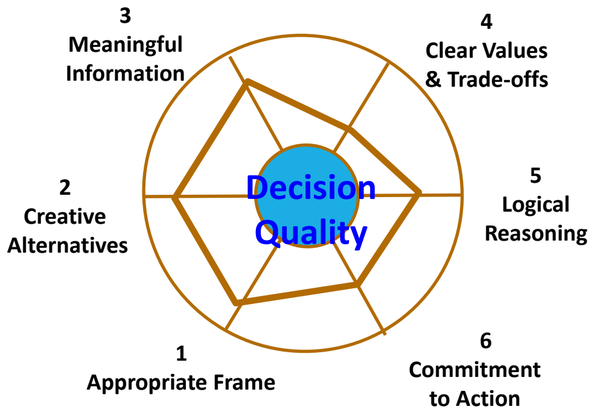
Greenfield Economics without VOI

- The dark blue dots reflect the optimized deterministic results using different decision criteria (NPV10,NPV 15, Value Creation and Resource)
- However when uncertainty is considered the results are much lower using the same development plan. (light green)
- The line represents a PI of 0.3
- Optimized development for NPV10 and $VC_{0.3}$ are also shown.
- We could also optimize on other (or different) metrics if desires



What have we learned?

- Framing the opportunity is important
  - Decision Hierarchy defined our focus decisions
  - Strategy Table identified alternatives.
  - Forcefield diagram to characterize large vs small capacity
  - Influence diagram to show relationships of decisions, uncertainties and value measures
- Deterministic results can provide misleading results.
- Uncertainty needs to be considered when making a decision
- Value measures matter. Need to determine upfront what is important.
- EV Tornado diagrams tell us what is important to EV of the results.
- Capital Investment Chart is a good way to characterize results



Source: Spider Diagram attributed to Strategic Decision Group

GREENFIELD ECONOMICS

VALUE OF INFORMATION USING SIPMATH MODELING

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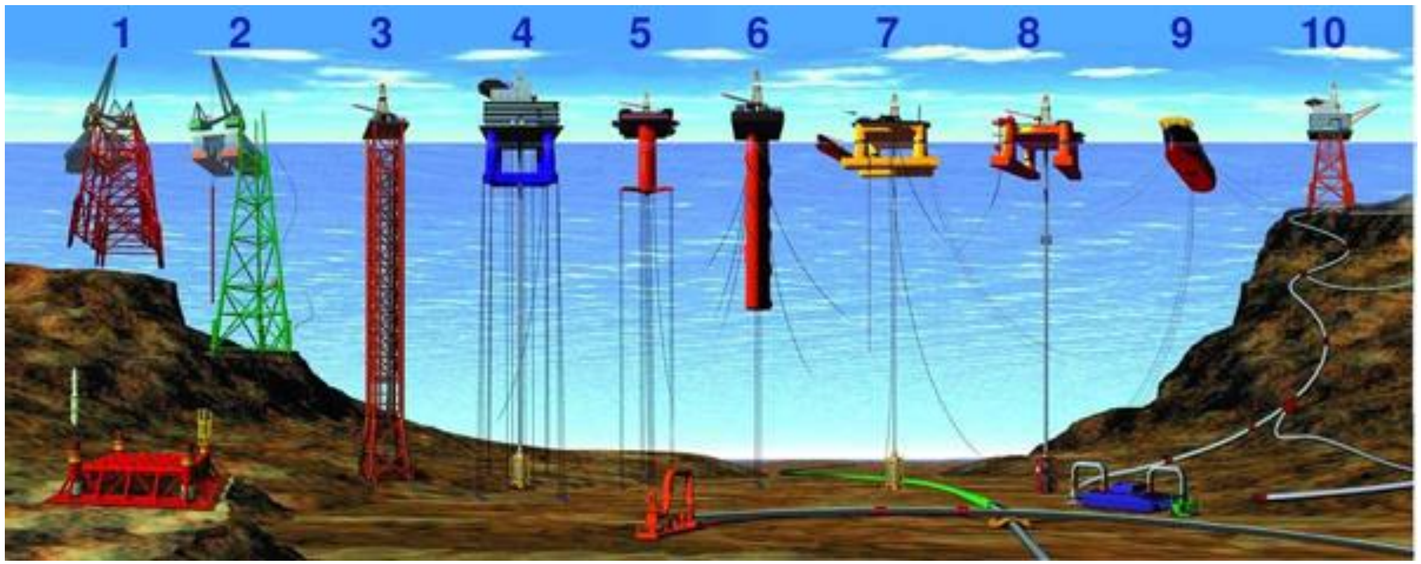


Issues

- Should we develop?
- What type of facility?
- What size facility should be built
- Resource size
- Deliverability
- Cost to develop
- Operating costs
- Contractor to build the facility
- Oil Price
- Where to market the oil and gas
- Fiscal and tax uncertainty

Decision Hierarchy

Givens:
- Fiscal and tax stability
- What type of facility

Focus Decisions:
- Should we develop
- What size of facility should be built
- Should we drill an appraisal well to understand size of resource

Tactical Decisions:
- Contractor to build the facility
- Where to market the oil and gas

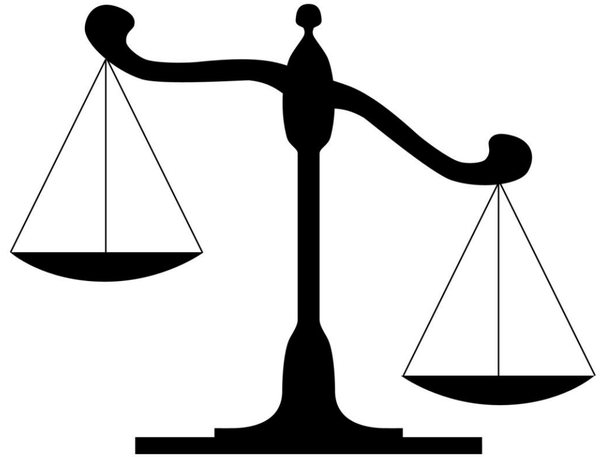
Strategy Table

Decision	Alternatives →		
Should we obtain information	Yes	No	
Should we Develop	Yes	No	
Size of processing facility for each outcome of indicator	30 MBD	50 MBD	80 MBD

Value of Information compares the value without and with information

- There can only be Value of Information (VOI) if there is a change in decision policy
- Information can be perfect or imperfect information
- If we have information on the resource, how would the decision policy change?

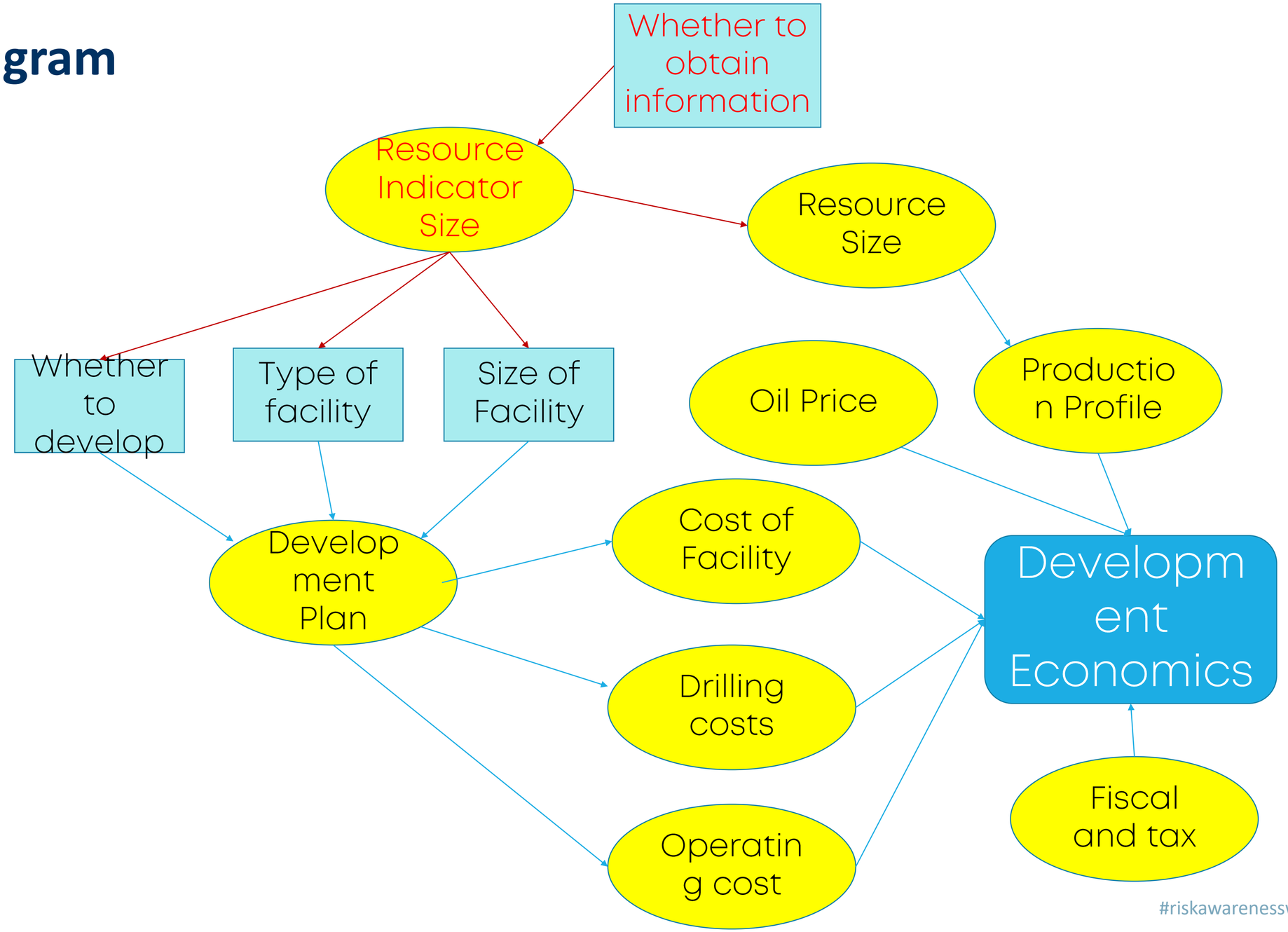
Incr Capacity with Info		Develop	
	Indicate Seg 1	No	0.00
	Indicate Seg 2	Yes	56.24
	Indicate Seg 3	Yes	77.57



With Information

Without Information

Influence Diagram



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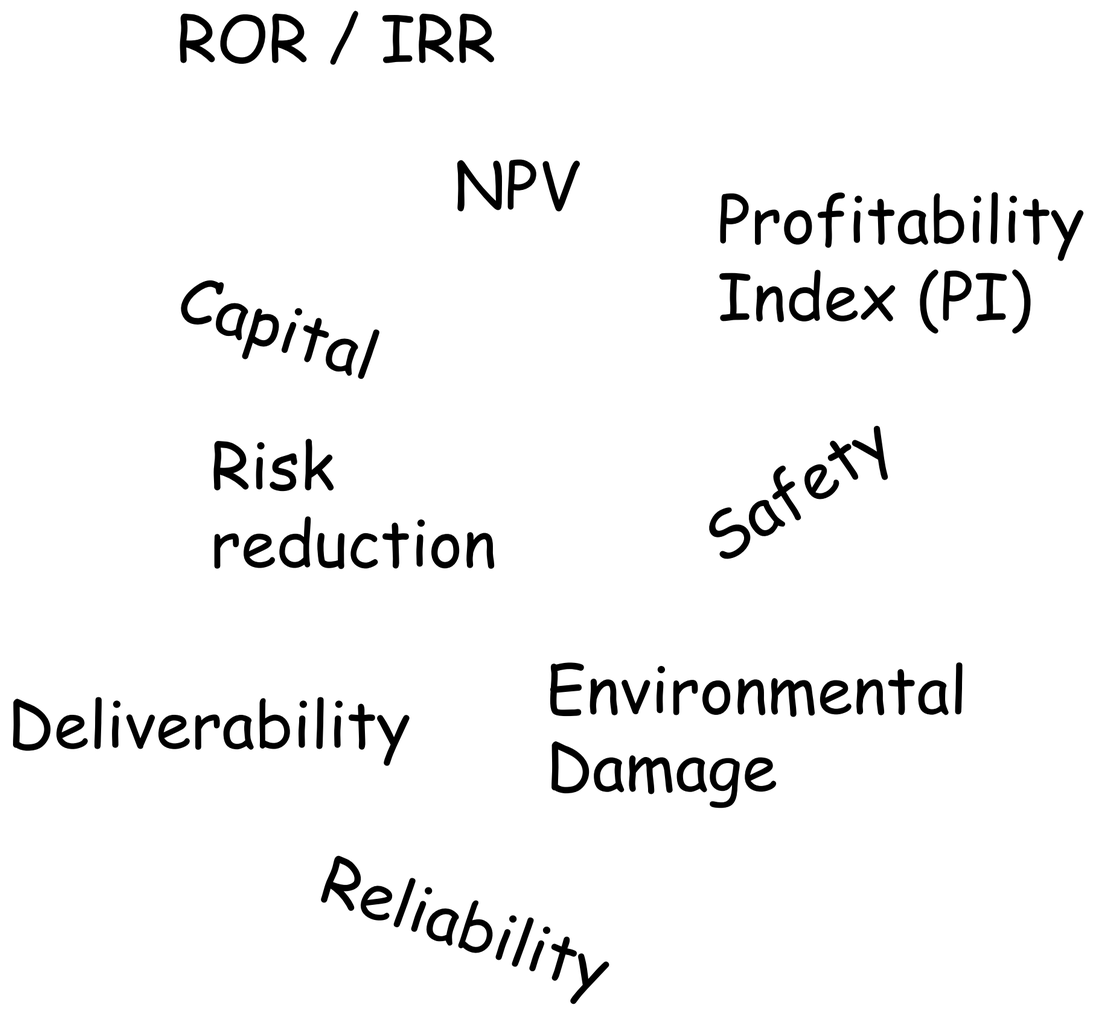

Why Greenfield development analysis is important

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- Requires greater capital expenditures
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Value of information can possibly support both perspectives

Resource Characterization is critical

- Three segments with traditional 25/50/25% probabilities
- Segments defined as percentiles of the original lognormal distribution with overlap

  Seg 1 goes from P0 to P30 while Seg 2 starts at P25 → Overlap of segments
- Multiple ways to characterize the resource distribution in preparation for a VOI analysis
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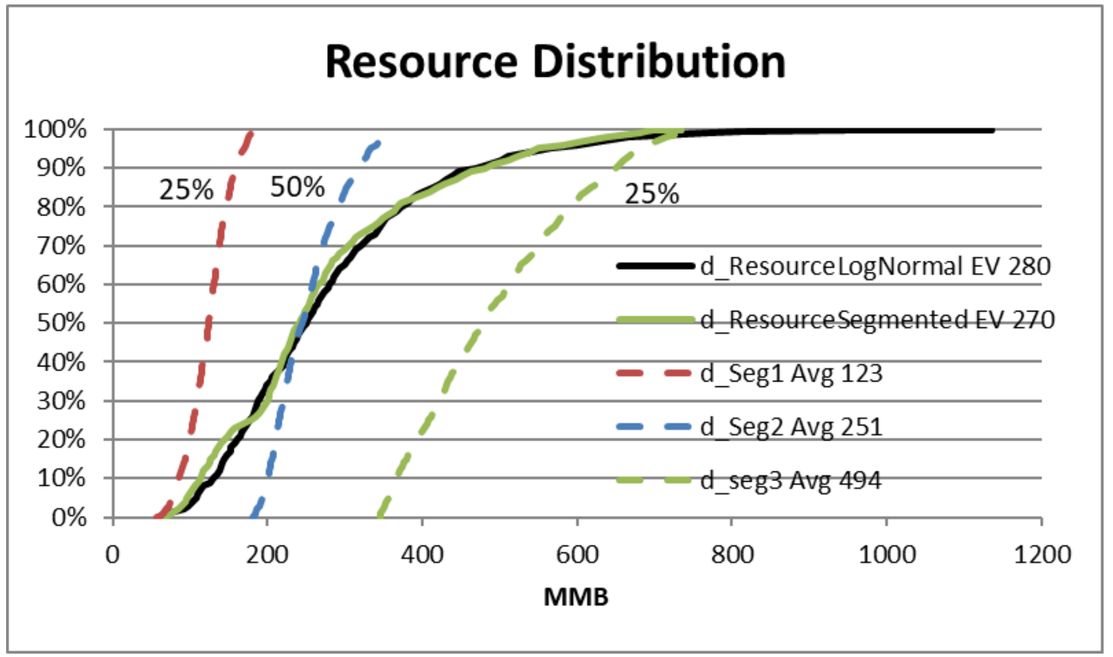
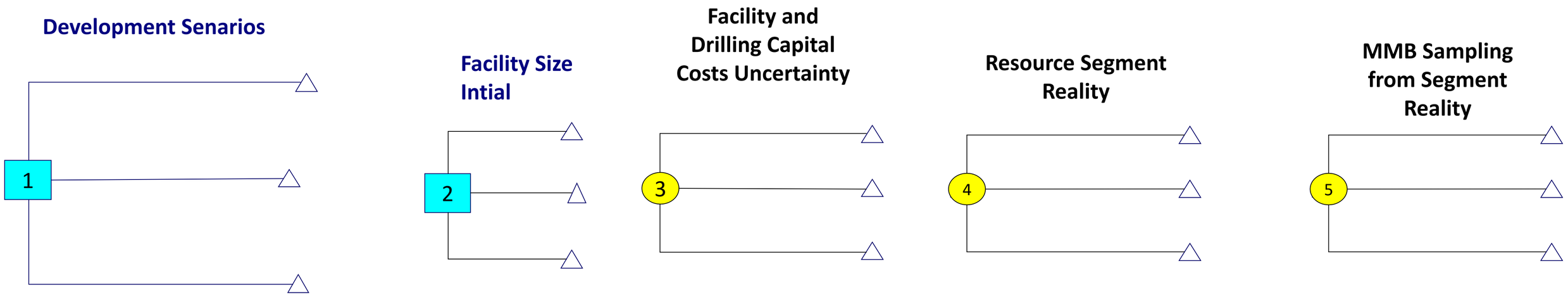


How might Information Impact the Optimal Decision Policy

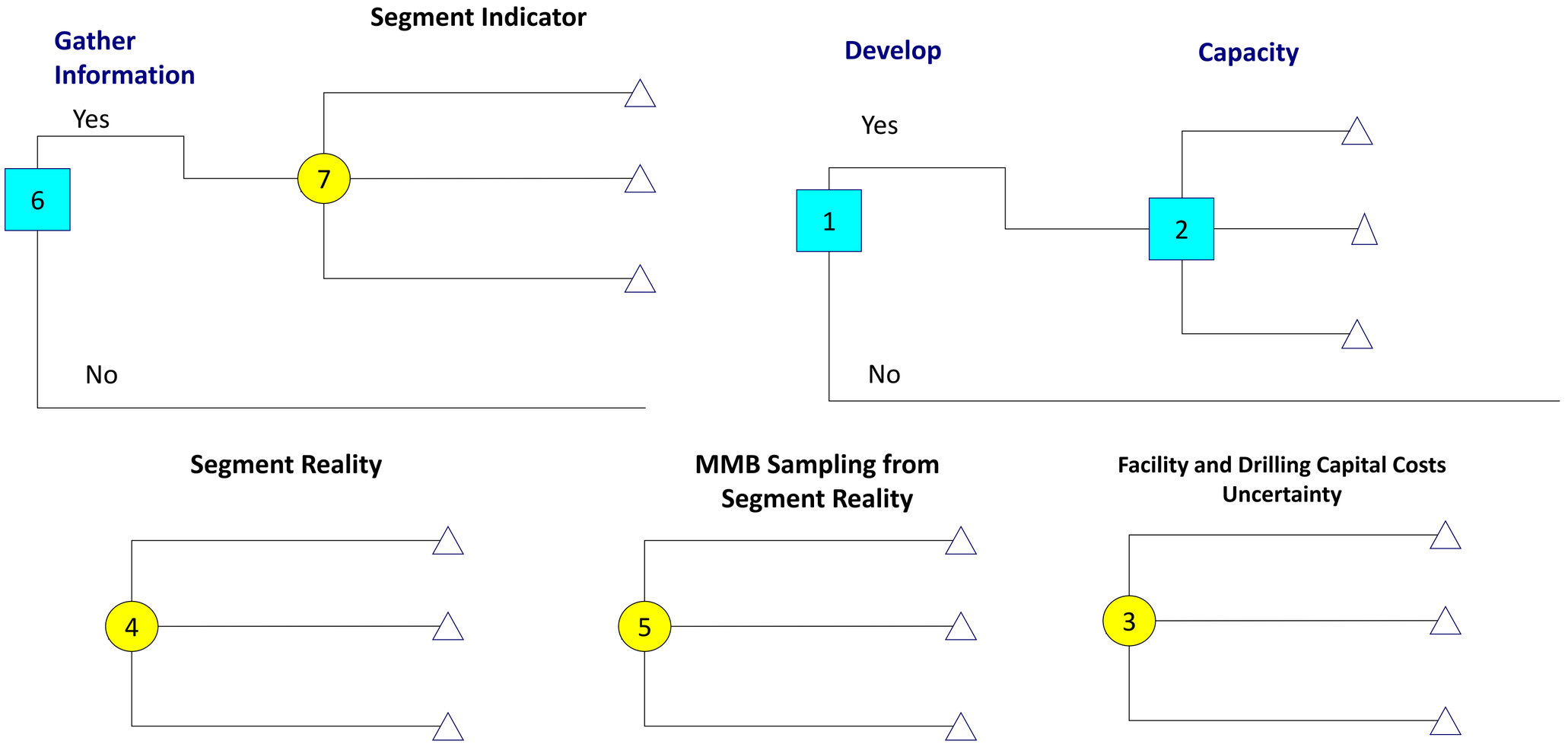
- What is the reference case for evaluating VOI?
- What is the optimal development plan with Perfect Information?
- What is the impact on the development plans if we used Discounted Resource?
- How does imperfect information impact us?
- How does the concession life impact the optimal development plan?

Adding uncertainty
Conceptual No Information Decision Tree

- All decisions are up front. Choice of facility size based on Development Plan
- While shown here as discrete, capacity decision and uncertainties, we will treat both as continuous in the analysis.



Conceptual Information Decision Tree



Expanded Dashboard

- Options to Test and specify type of information
- Decision Policy requires us to designate whether to develop and at what capacity for each of the resource indicators.
- We need to test / optimize these variables

Simulation	7	**Greenfield Economics**			
Decision Policy		Objective			NPV10
		Probabilistic			Yes
		Concession Ends			2030
		Test			Yes
		Information Type	InfoType		Imperfect
	Incr Capacity with No Info			49.01	49.01
	Incr Capacity with Info		Develop		
		Indicate Seg 1	No	0.00	0.0
		Indicate Seg 2	Yes	56.24	56.2
		Indicate Seg 3	Yes	77.57	77.6
					Probabilistic
	Optimized Variable				244.5
	NPV10 of Project				923.3
w/VOI	NPV @10%				923.3
w/VOI	#REF!				432.0
w/VOI	P10 NPV10				(109.2)
	Value Creation				**244.5**
	Cost $MM (Undiscounted)				2,373.11
	Cost Discounted @10%				2,262.68
	Profitability Index (PI)				0.39
	Total Resource MMB				-
	Years on Plateau				4.35
	VOI @using Value Creation				
	Number of Trials				1,000
	Date				8/13/2019

What is the difference between perfect and imperfect information

- With **perfect** information we know with certainty the segment of the resource curve
- With **imperfect** information, there is some uncertainty.

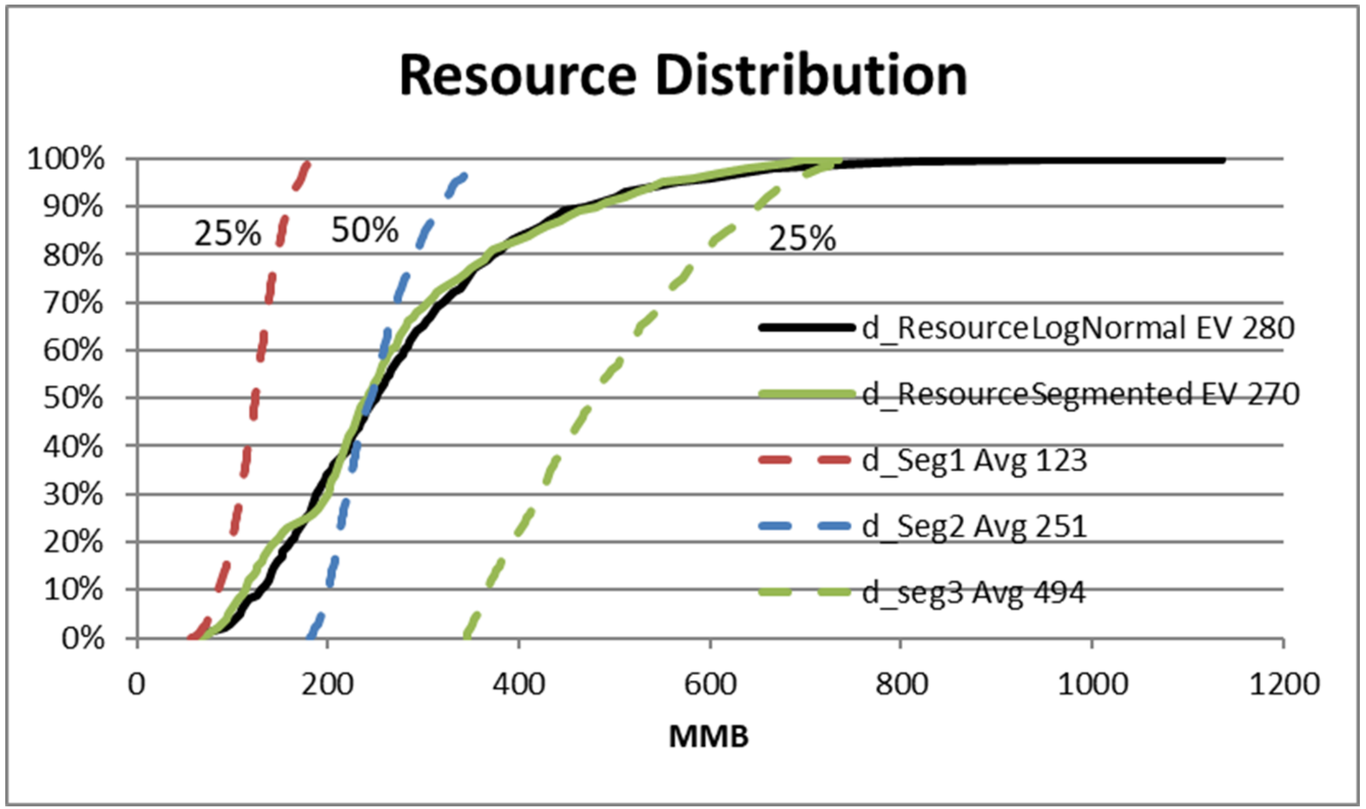
Given Reality, what is the probability that we will interpret Ind Seg 1, Ind Seg 2 or Ind Seg 3

Perfect Information					Imperfect Information			
	Ind Seg 1	Ind Seg 2	Ind Seg 3			Ind Seg 1	Ind Seg 2	Ind Seg 3
Seg 1	1	0	0		Seg 1	0.75	0.2	0.05
Seg 2	0	1	0		Seg 2	0.2	0.6	0.2
Seg 3	0	0	1		Seg 3	0.05	0.45	0.5

Understanding the definition of Imperfect Information

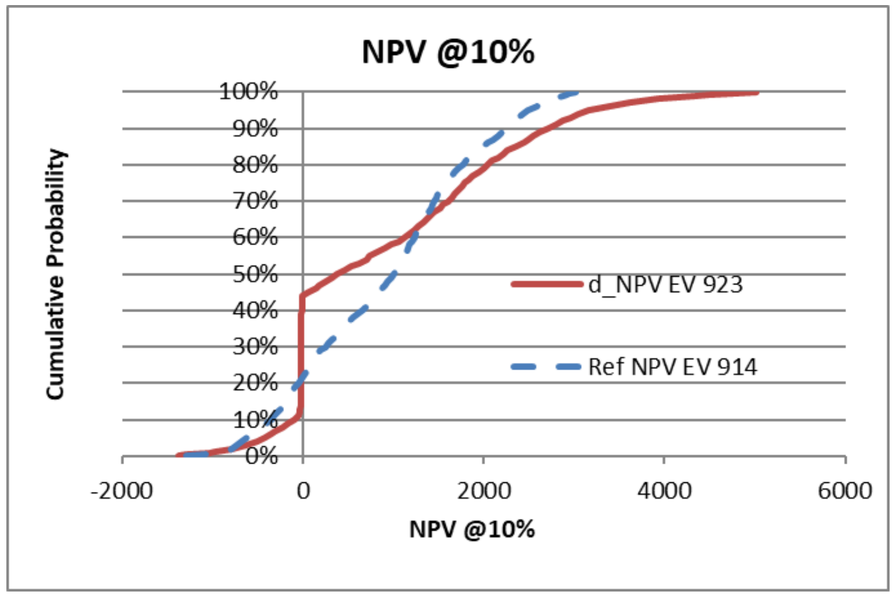
Given Reality, what is the probability that we will interpret Ind Seg 1, Ind Seg 2 or Ind Seg 3

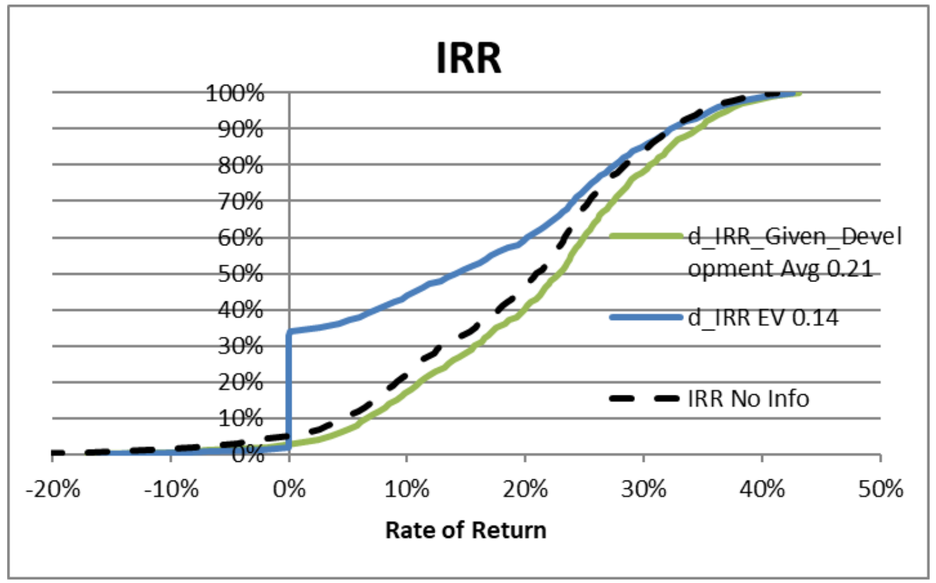
Imperfect Information			
	Ind Seg 1	Ind Seg 2	Ind Seg 3
Seg 1	0.75	0.2	0.05
Seg 2	0.2	0.6	0.2
Seg 3	0.05	0.45	0.5



Optimal Decision with Information

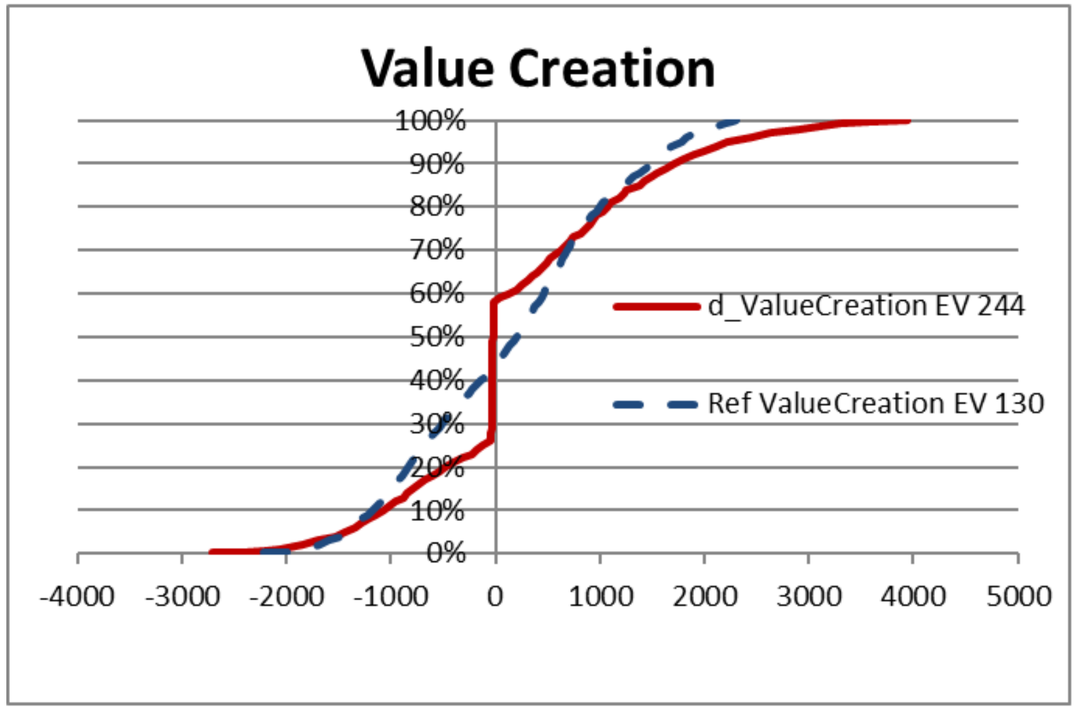
- Optimal decision is to not develop the low resource indicator
- NPV is higher than the reference case
- ROR distribution, given development is higher than the reference.

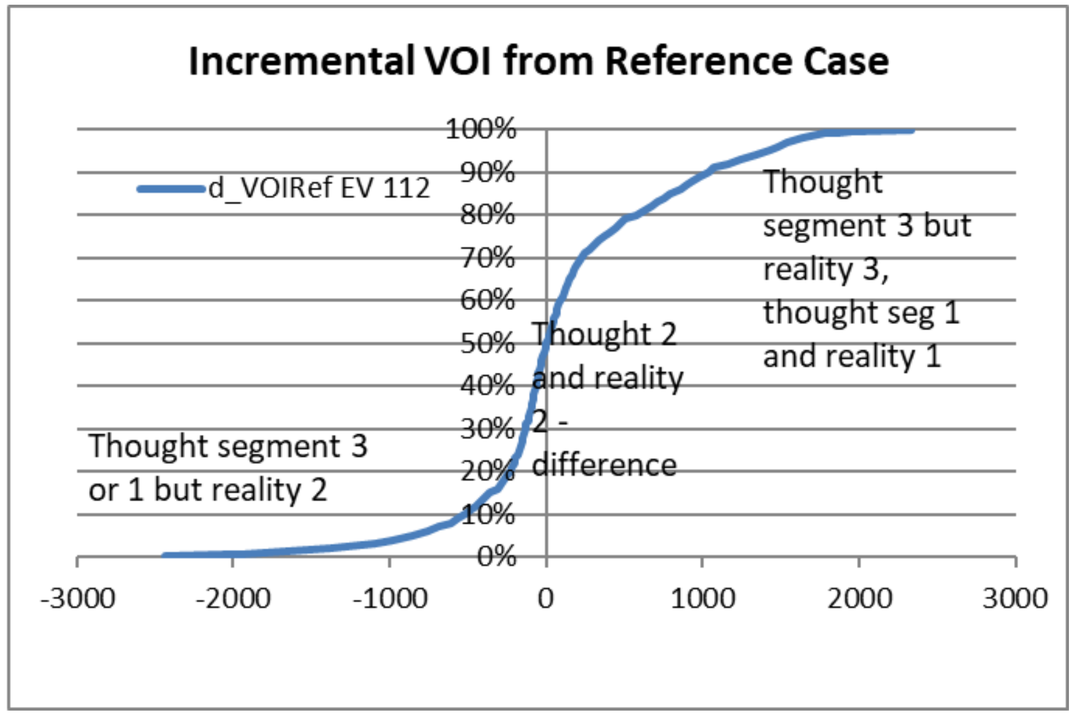




Understanding where the information adds value

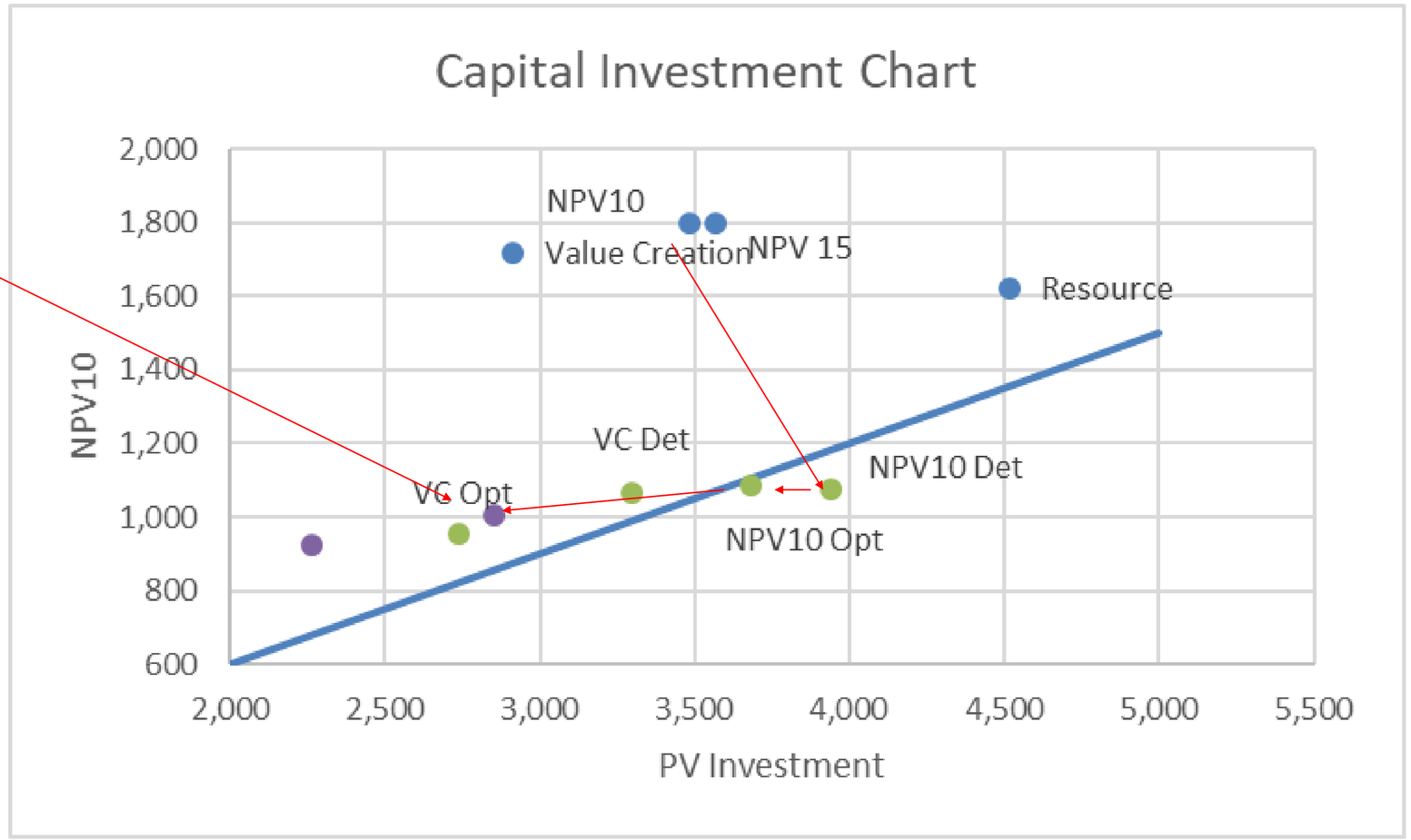
- Decision Maker can better understand the value of information by comparing the two distributions and the “difference” or incremental value of the distributions.





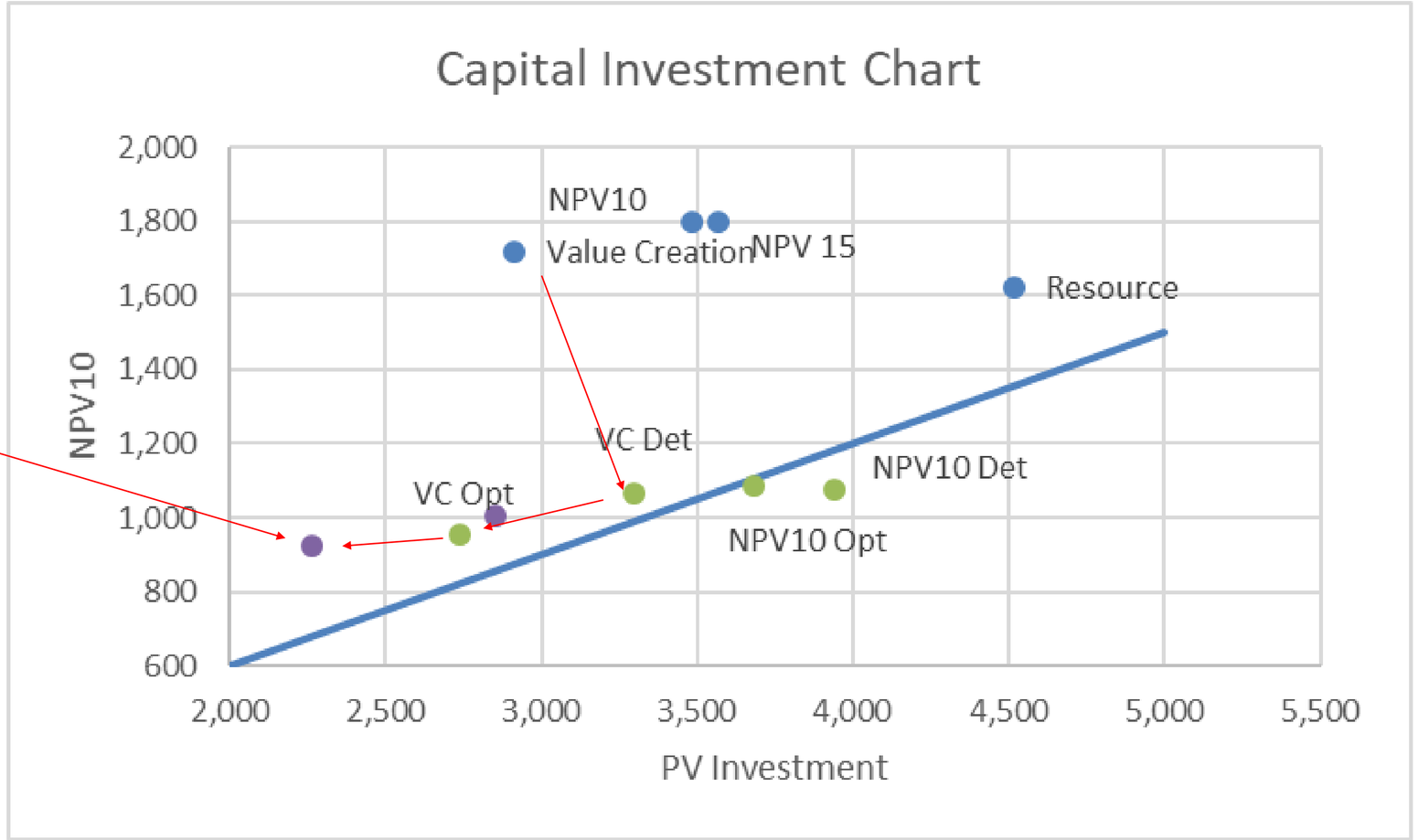
With information the Optimized NPV is lower

- Optimizing on NPV10, NPV given development is lower, but ROR is higher. Capital investments are lower.
- Sometimes we do not develop



With information the Optimized Value Creation is Higher

- Optimizing on NPV10, NPV given development is lower, but ROR is higher. Capital investments are lower.
- Value Creation is higher than without information



Final Thoughts

- What we have covered is not easy and I don’t have all the answers.
- This analysis could be conducted using discrete outcomes only and a traditional decision tree.
- Other Monte Carlo software could also be used but would not be as interactive and easy to generate presentation graphics.
- There are many miss conceptions about how to conduct greenfield economics. Hope this session has enlightened you.