International Seabed Authority

Financial Payment System Working Group Meeting

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Decision Analysis Framework & Review of Cash Flow Approach

Underlying philosophy of the analysis

Identify payment systems that **maximize** the return to the common heritage of mankind while providing **sufficient** revenue to motivate the construction and operation of a mine

Some Key ISA Decisions about the Financial Payment System

Framing Questions

- What should be the basis of payment?
  - Ad-valorem (metal value)
  - Profit share (contractor profit)
  - Combination of the two
  - Others
- What should be the rate of payment?
- Should the basis of payment be in reference to only on the operation at sea (collector)?
- Should we assume that other administrative fees and/or an environmental / liability fund will be assessed?

Analytical Questions

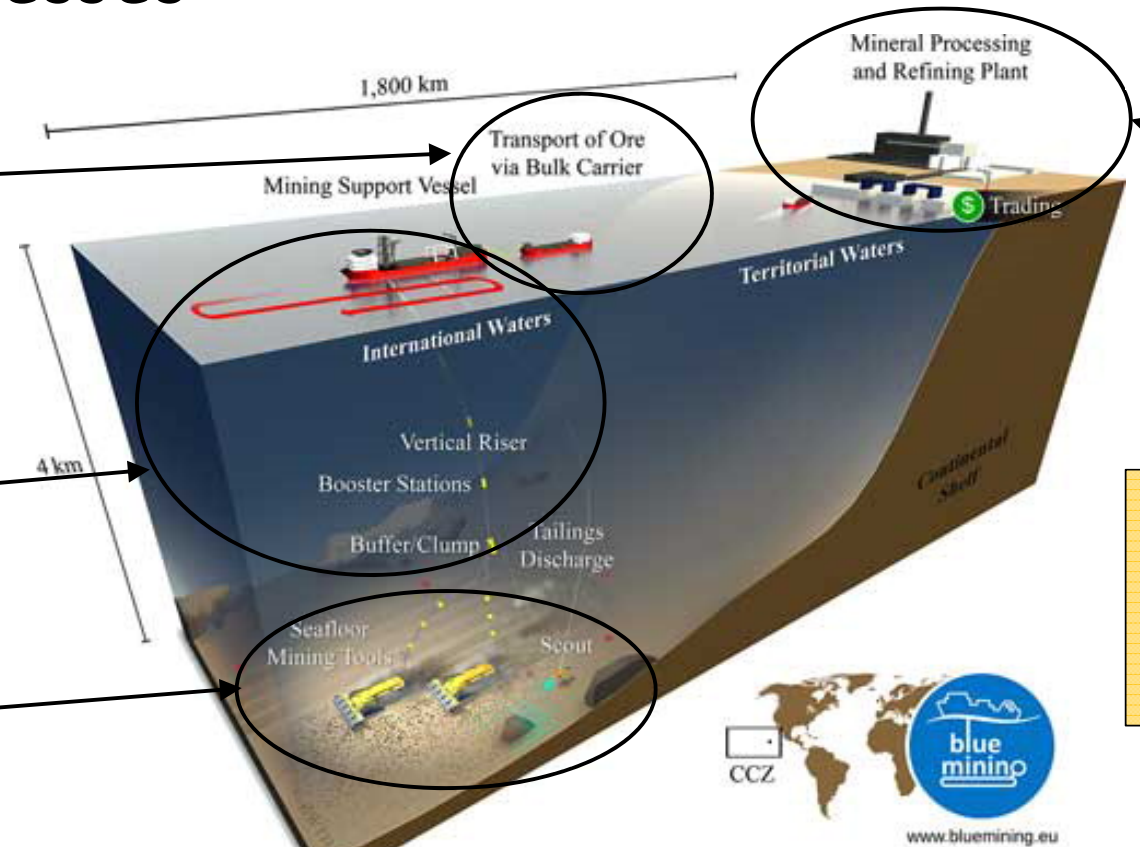
- What metrics should we use to evaluate systems? Currently we report
  - NPV of ISA Revenues
  - Undiscounted cumulative revenues to ISA
  - Contractor IRR
  - Undiscounted shares to
    - ISA
    - Sponsoring state
    - Environmental fund
    - Contractor
- What is a reasonable return to the contractor as a basis of analysis?
- What is the minimum acceptable return to the ISA for the CHM?

Assessment requires understanding the mining & refining processes

Transport

Lift/Platform/ Process Water

Nodule Collection



Metallurgical Processor
Separate the four metals

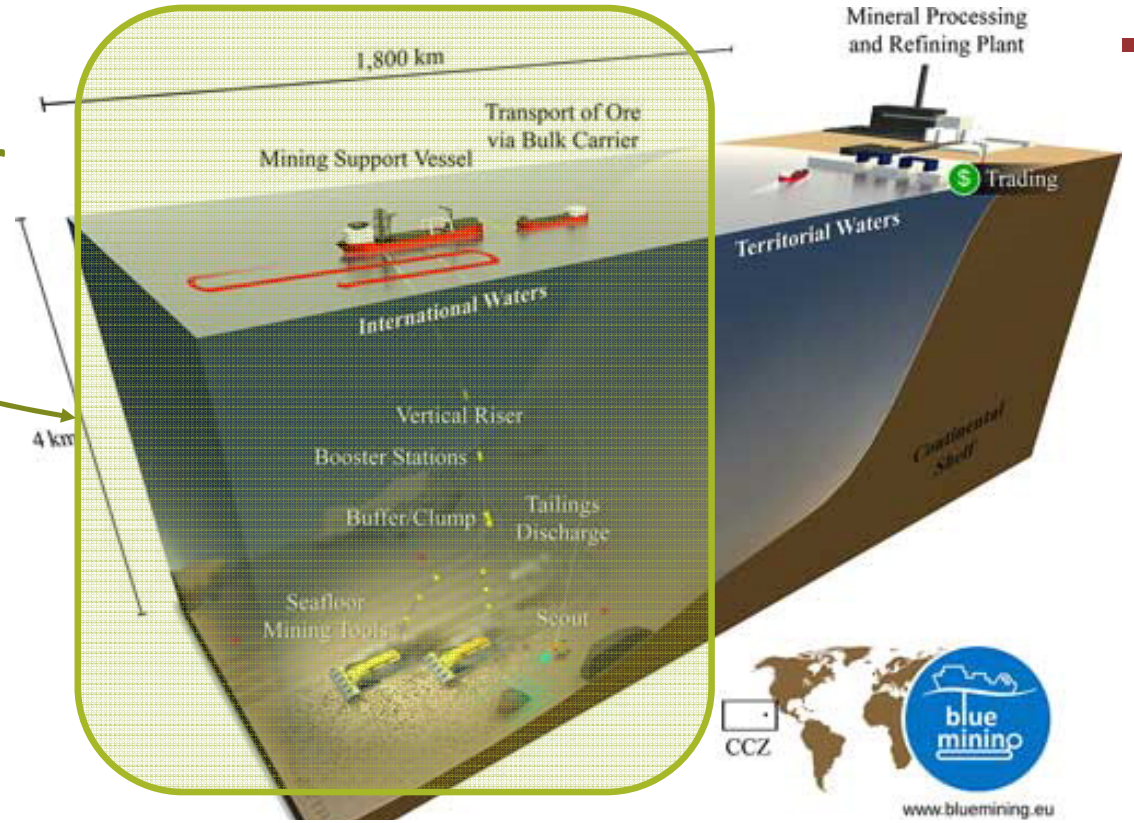
Each of these activities require:
-upfront investments
-ongoing operating
…expenditures

Image from: Marvasti, A. Env. and Resource Econ (2000) 17: 395. https://doi.org/10.1023/A:1026566931709

ISA Oversight Only Related to Collector Activities

Modelled Collector

Modelling assumes that ISA royalties are only based on activities at the collector



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Revenue Sharing

- Why is it necessary?
  - Formally collectors will receive the money from sale of nodules
  - ISA should receive as much of these funds as possible to compensate for the transfer of ownership of the nodules
  - May want some funds set aside for environmental contingencies
- How much money should go to each?
  - ISA will want to maximize its revenue
    - Cover expenses
    - Distribute to member states
  - Sufficient revenues need to go to collectors to incentivize risky investment
  - How much should be set aside for environmental contingencies?

How large should the contractors share be? What rate of return will be needed to attract investment?

Higher Risk

Greater Rate of Return Required

Nearly Guaranteed Investment
(for example: Gov't bonds)

Very low returns required
(0% - 3%)

Land based mining

Moderately high returns required
due to price & geological risk
(typically above 15%)

Seabed mining

Higher returns than land based mining
Same risks, plus technological risk
Never been done at scale before
Banks may be unwilling to provide loans

Highly Speculative Venture Capital
(Angel investments in new tech)

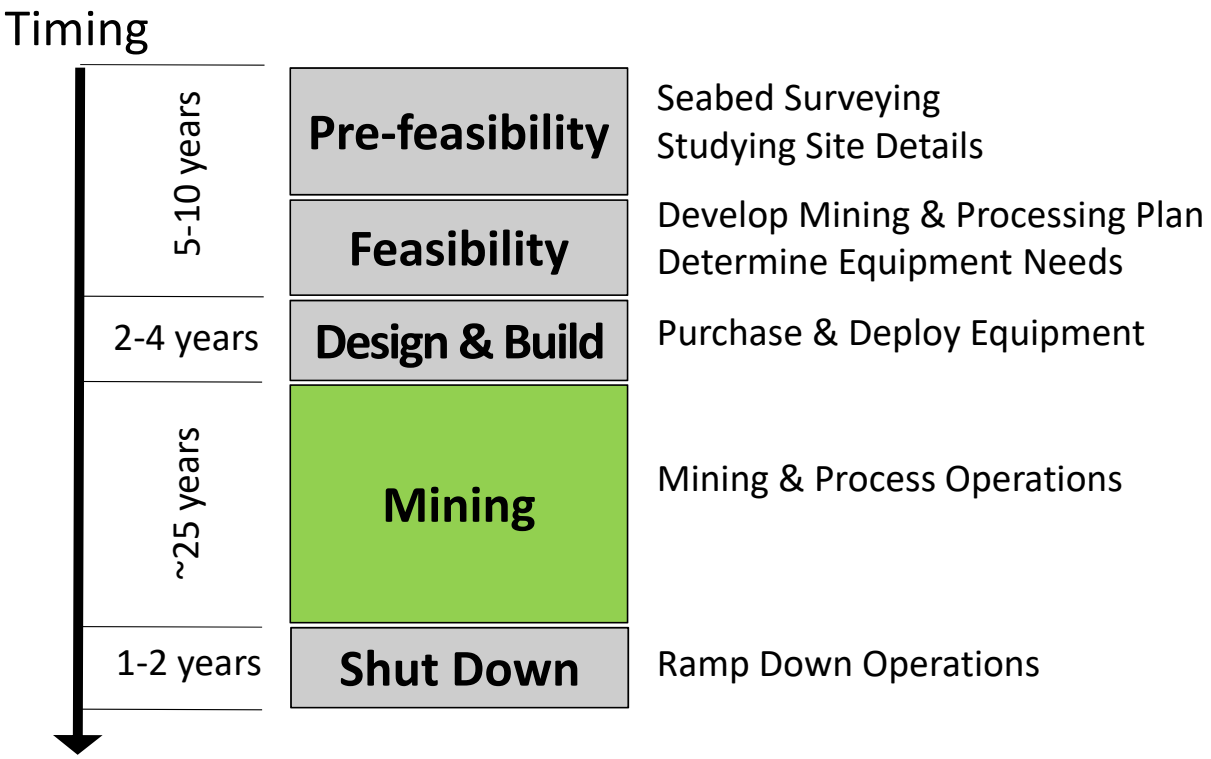
Very high returns required
(sometimes well in excess of 100%)

Analytical Approach

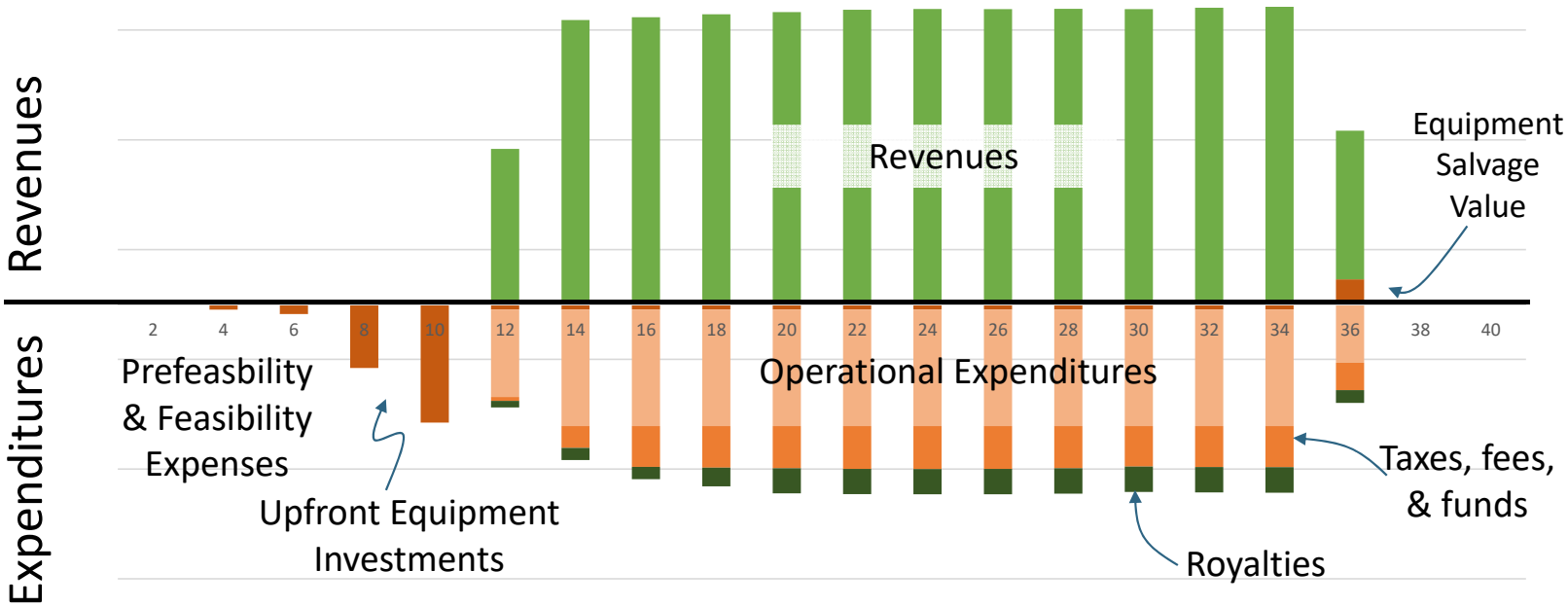
- Cash Flow Models
  - Understand all of the costs and revenues for each stakeholder
  - Explicit consideration of the timing of those cash flows
    - Dollars in early years are not equal to dollars in later years
  - Ability to calculate key metrics to be used for ISA decision making in setting up the financial payment system with rates
    - NPV of revenues to the ISA
    - Return on investment (IRR) to the various stakeholders (nodule collectors & metals processors)
    - Share of net revenues to each stakeholder
  - Model can demonstrate the impact of ISA decisions on these key metrics
    - Structure of financial payment system
    - Payment rate and timing
    - Administrative fees, environmental funds, monitoring plans, etc.

How would a seabed mining project develop?

Modeling is based on progression through 5 activities



Let's look at the different types of cash flows throughout the project



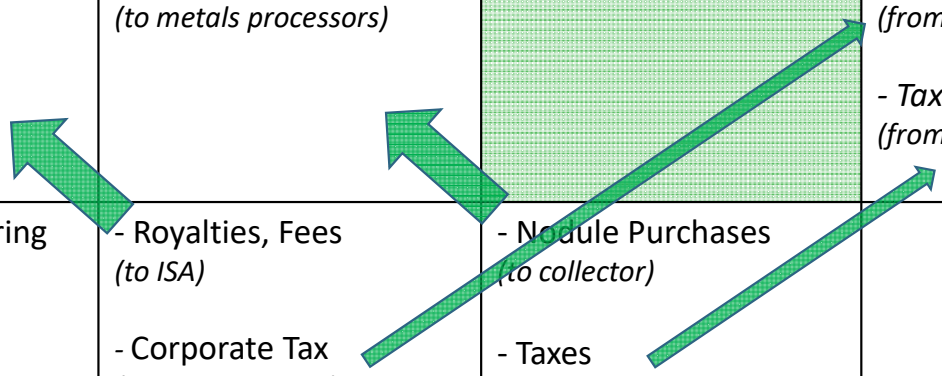
Values are representative, not intended to be exact.

Multiple Cash Flow Analysis Should Be Considered. Why?

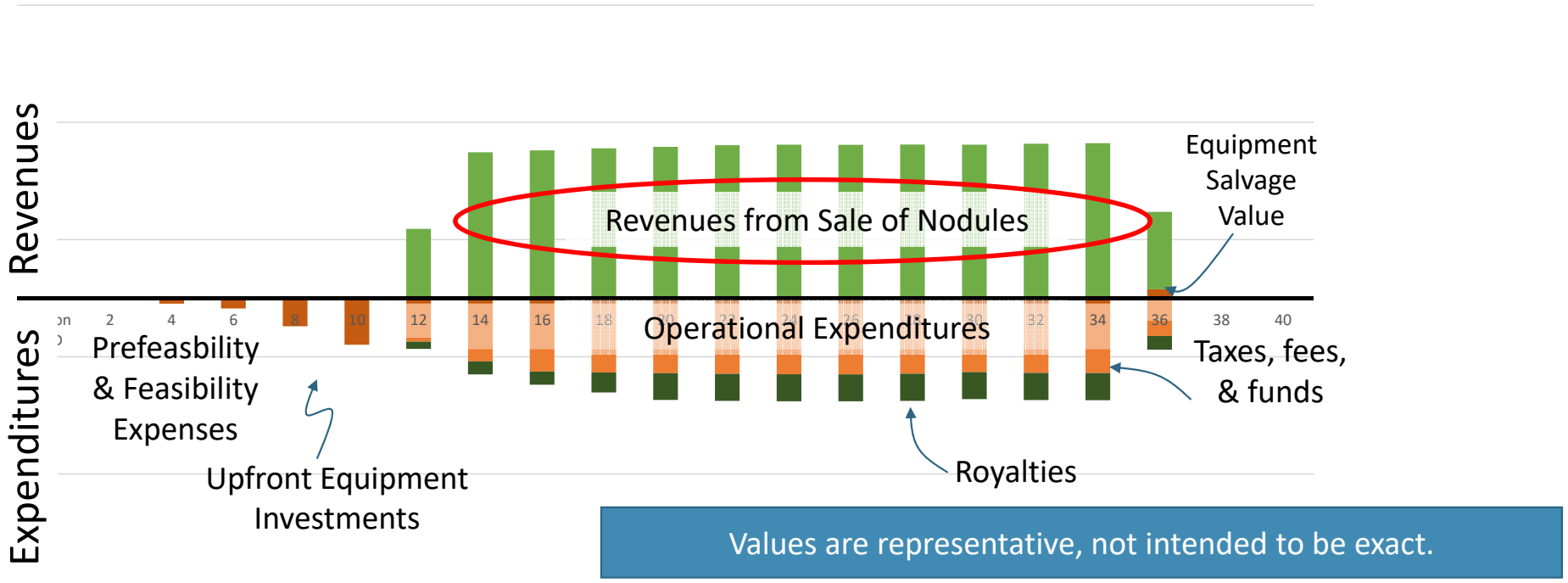
- Multiple Financial Participants:
  - ISA
  - Nodule Collectors
  - Metals Processors
  - Host and Sponsor States
- ISA jurisdiction only pertains to nodule collector activities
  - This is particularly important for any system that is based on profits
- How to think about the split of cash flows
  - Analyze funds that will flow from one stakeholder to another, not just flows into and out of the complete system

Flows of funds between major particpants

	ISA	Nodule Collector	Metals Processor	Sponsor State & Host Nation
Costs	- Administration - Oversight	- Prefeasibility Studies - Feasibility Studies - Upfront Investments - Operating Expenses	- Prefeasibility Studies - Feasibility Studies - Upfront Investments - Operating Expenses	
Revenues *(including inbound transfers)*	- Fees - Royalties *(from collector)*	- Sale of Nodules *(to metals processors)*	- Sale of Metals	- Taxes to Sponsor State *(from collector)* *- Taxes to Host Nation* *(from metals processor)*
Transfers *(outbound)*	- Revenue sharing	- Royalties, Fees *(to ISA)* - Corporate Tax *(to Sponsor State)*	- Nodule Purchases *(to collector)* - Taxes *(to host nation)*	



Nodule Collector Cash Flows



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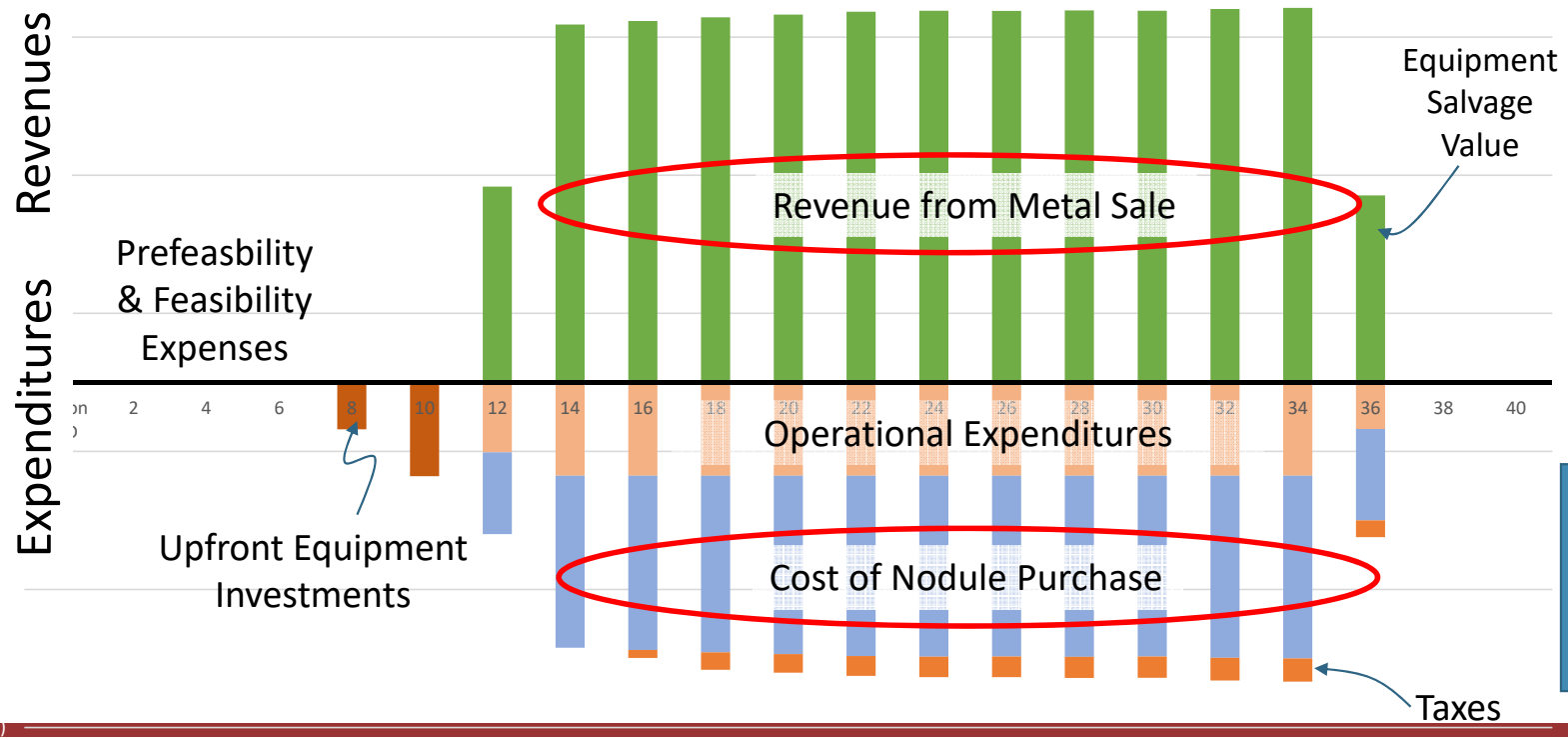
Metals Processor Cash Flows



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Why Analyze Metals Processor Cash Flows?

- Outside of the jurisdiction of ISA and no direct impact on funds coming to the ISA
- Major “indirect” impact on ISA through the price they will be willing to the Nodule Collectors for nodules
  - Revenues from end users of metals will come to the metals processor
  - If a market existed for nodules, we could forecast their price from historical and other supply/demand info.
  - However, no nodule market currently exists, so prices can only be forecasted by understanding metals processors economics

Estimating Key Elements of Metal Processor Cash Flows

	ISA	Nodule Collector	Metals Processor	Sponsor State & Host Nation
Costs	- Administration - Oversight	- Prefeasibility Studies - Feasibility Studies - Upfront Investments - Operating Expenses	- **Prefeasibility Studies** - **Feasibility Studies** - **Upfront Investments** - **Operating Expenses**	
Revenues *(including inbound transfers)*	- Fees - Royalties *(from collector)*	- Sale of Nodules *(to metals processors)*	- **Sale of Metals**	- Taxes to Sponsor State *(from collector)* *- Taxes to Host Nation* *(from metals processor)*
Transfers *(outbound)*	- Revenue sharing	- Royalties, Fees *(to ISA)* - Corporate Tax *(to Sponsor State)*	- **Nodule Purchases** ***(to collector)*** - **Taxes** ***(to host nation)***	

Estimating Future Metals Revenues

Metals Revenues = Σ_{metal} **Quantity of Metals Recovered** x **Metals Prices**

Quantity of Metals Recovered

	Composition	Recovery Rate
Cobalt	0.2%	85%
Nickel	1.3%	95%
Copper	1.1%	90%
Manganese	28.4%	90%

Amount Recovered
5,100 tons
37,050 tons
29,700 tons
766,800 tons

Metal Price Forecasting

	Initial Price	Long Term Price	Uncertainty Parameter
Cobalt	$38,000/ton	$55,000/ton	$3,000/ton
Nickel	$10,800/ton	$24,717/ton	$800/ton
Copper	$5,600/ton	$7,000/ton	$500/ton

	Initial Price	Long Term Price	Uncertainty Parameter
Mn ore	$450/ton	$450/ton	$50/ton
Metal Mn	varies	Varies	varies

Substitution Theory Approach to Mn Metal

- Processors will want to sell Mn into the high value EMM market
- EMM market is of limited size and is not expected to be able to handle all of the additional Mn coming from nodules
- This will cause EMM prices to drop until it is no longer the most valuable market, at which point processors will want to sell into the next highest value market, Low Carbon Ferromanganese
- The combined EMM & Low Carbon Mn price will then drop until it reaches the price of the next lowest market and so on, until all Mn is sold.

Mn Metal Substitution Model Variables

2015 Electrolytic Manganese Metal (EMM) Supply Curve	
90th Percentile Cost	$2,150/ton
10th Percentile Cost	$800/ton
Total Market Size	1400 kt

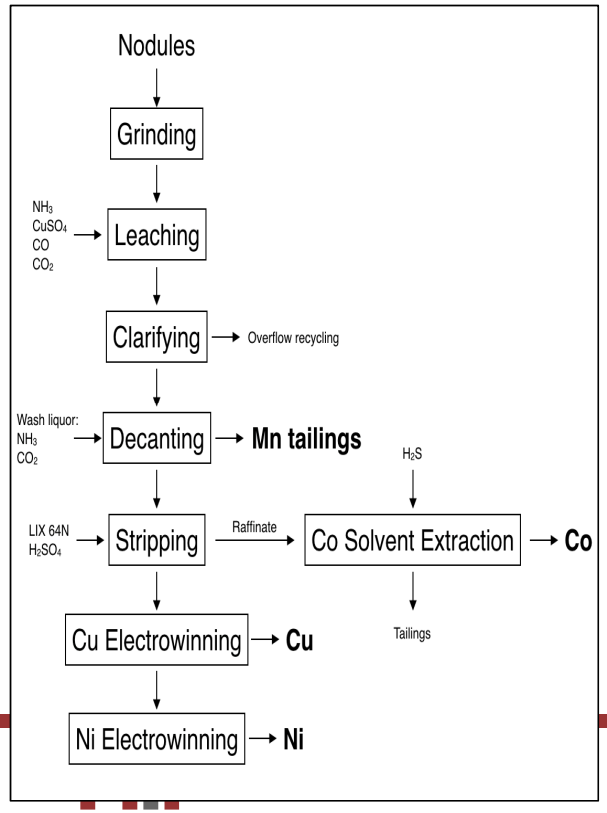
2015 Ferro-Manganese (Fe-Mn) Markets		
	Market Size (kt)	Price ($/ton)
High Carbon Fe-Mn	4,200	$875
Medium Carbon Fe-Mn	1,450	$1,507
Low Carbon Fe-Mn	120	$1,641

Future (2025) EMM Supply & Demand Assumptions	
Mine Sites	2
EMM Supply per Mine Site	767 kt
EMM Annual Demand Growth Rate	2.4%/year

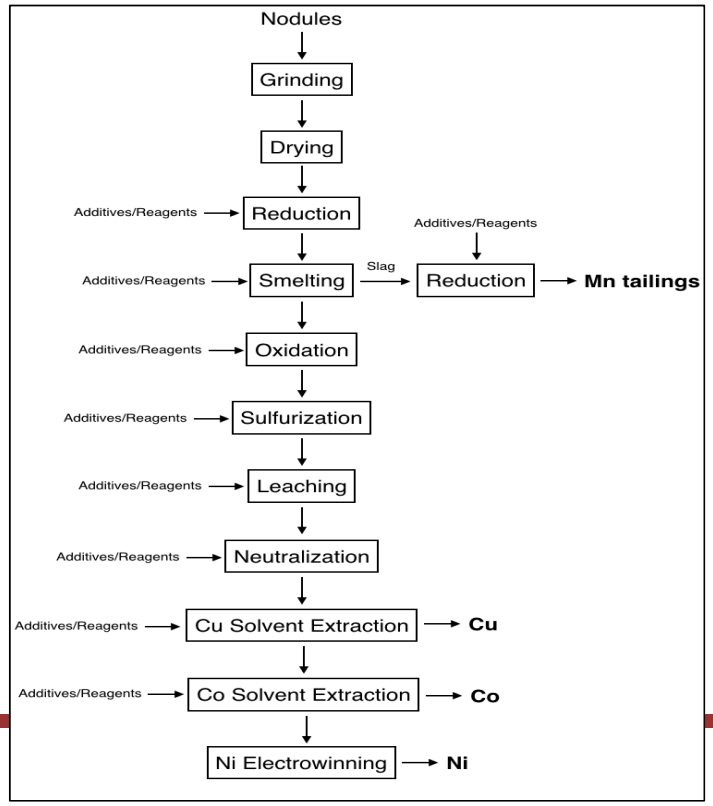
Long Term Average Manganese Metal Price = $1561/ton

Estimating Metals Processor Costs

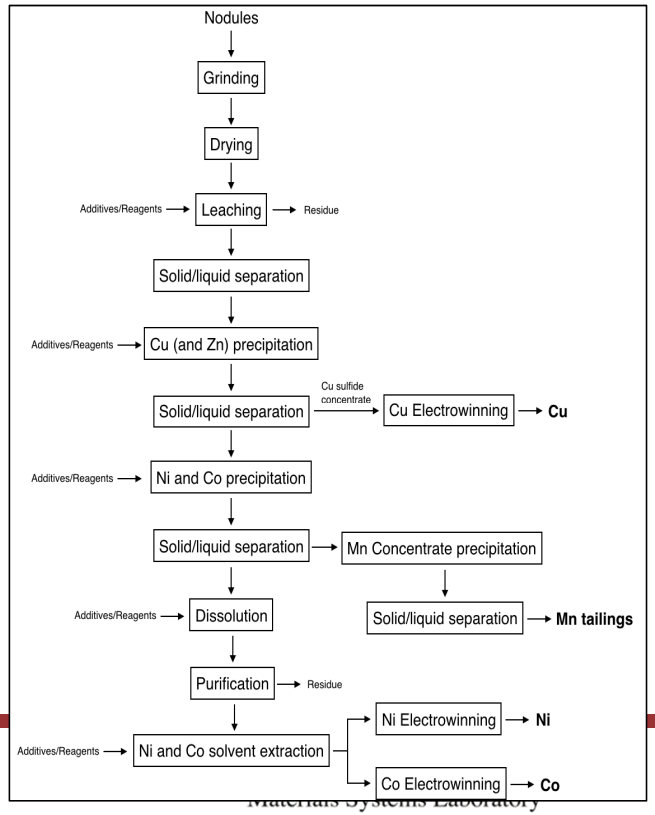
Ammonaical Leach/Cuprion



Pyrometallurgy



Hydrometallurgy



Detailed Cuprion Model Inputs

- Detailed Cost Model for Each Process Step
- Tracked All Consumables, Energy, Labor & Other Operating Costs
- Assigned Investment Required for Each Process Step to Estimate CAPEX
- Analysis at 3 million dry tons processed, but model will automatically scale

Wage	$18/hr
Electricity Price	$0.15/kWhr
Land Cost	$27/m2
Infrastructure Costs	50% additional investment
Power Plant Costs	67% additional investment

Feedstock	Price	Quantity (per ton dry nodules)	Process Step
NH_3	$300/ton	0.095 tons	Leaching
Fuel (LNG)	$4.5/mmbtu	2.16 mmbtu	Power & Steam
Limestone ($CaCO_3$)	$15/ton	0.0078 tons	CO & CO_2 Generation
Lime (CaO)	$7/ton	0.012 tons	Ammonia Recovery
LIX 64N	$8500/m3	1.90E-05 m3	Stripping
Kerosene	$570/m3	7.67E-05 m3	Stripping
Sulfuric Acid (H_2SO_4)	$100/ton	0.24 tons	Stripping
Hydrogen Sulfide (H_2S)	$450/ton	0.00163 tons	CO Recovery
Na_2SO_4	$150/ton	4,50E-04 tons	Ni Electrowinning
H_3BO_3	$710/ton	6.70E-05 tons	Ni Electrowinning
NaCl	$50/ton	7.70E-05 tons	Water Treatment
Chlorine Gas (Cl_2)	$350/ton	0.00033 tons	Water Treatment
Coal	$40/ton	0.23 tons	CO Generation
Water	$0.50/m3	2 m3	

	Yield	Equipment Cost	Land Required	Power Required	Workers Required
Grinding	100%	$31.1 M	20,235 m2	4.24 kW	2.5
Leaching	100%	$75.4 M	121,406 m2	12.88 kW	20.0
Stripping	100%	$65.9 M	80,937 m2	2.25 kW	15.0
Co Extraction	80%	$15.6 M	40,469 m2	2.25 kW	10.0
Cu Electrowinning	90%	$74.2 M	40,469 m2	23.75 kW	10.0
Ni Electrowinning	95%	$74.2 M	40,469 m2	39.50 kW	10.0
Other	---	$288.1 M	445,165 m2	8.26 kW	80.0

Cuprion & EMM Cost Model Results

Ammoniacal Leach/Cuprion Process Capital Requirements (CAPEX)	
Baseline Production Volume (tons/year)	3,000,000
Primary Extraction Process Investment	$969 million
Refining Investment	$1,050 million
Dock Cost	$52.5 million
Production Volume Scaling Factor	0.6

Ammoniacal Leach/Cuprion Operating Expenses (OPEX) including Dock Operating Costs	
Energy	$130 /ton
Consumables	$77 /ton
Labor	$10 /ton
Other	$1 /ton

Metallurgical Recovery Rates	
Cobalt	85%
Nickel	95%
Copper	90%
Manganese	90%

Pyrometallurgy & Hydrometallurgy Analysis

- Simplified approach to pyrometallurgy & hydrometallurgy options
- Used benchmarking study of recent nickel plants to estimate CAPEX
  - Study made estimates of CAPEX for additional activities beyond Nickel recovery
  - Build scaling function into overall model
- OPEX derived by looking at "middle" of current Nickel cost curve
  - Additions for activities beyond Nickel recovery
- Model assumes Mn rich slag as final product, not EMM

Process Capital Requirements (CAPEX)		
	Pyrometallurgy	Hydrometallurgy
Baseline Production Volume (tons/year)	2,400,000	4,880,000
Primary Extraction Process Investment	$1,855 million	$5,136 million
Refining Investment	$529 million	$1,840 million
Dock Costs	$52.5 million	$52.5 million
Production Volume Scaling Factor	0.6	0.6

Operating Expenses (OPEX)		
	Pyrometallurgy	Hydrometallurgy
Energy	$28 /ton	$14 /ton
Consumables	$90 /ton	$104 /ton
Labor	$7 /ton	$7 /ton
Other	$14 /ton	$14 /ton

Metallurgical Recovery Rates		
	Pyrometallurgy	Hydrometallurgy
Cobalt	92%	89%
Nickel	94%	97%
Copper	95%	92%
Manganese	95%	96%

Summary of Cost Results for Metals Processors and Discussion of Nodule Prices

	Cuprion	Pyrometallurgy	Hydrometallurgy
OPEX	$218/ton	$139/ton	$139/ton
CAPEX	$2,072 million	$1,750 million	$2,742 million
Prefeasibility Cost	$20.7 million	$17.5 million	$27.4 million
Feasibility Cost	$95.1 million	$87.5 million	$137.2 million

Does not include payments to acquire nodules

Nodule Transfer Price Calculation Methodology

- Nodule prices will be a negotiation between collectors & processors
  - *Bounded by the costs and potential profits of each stakeholder*
- For now, assume that each stakeholder will get the same IRR
  - *Nodule price can only be known after exploring Nodule Collector cash flows*

Estimating Key Elements of Nodule Collector Cash Flows

	ISA	Nodule Collector	Metals Processor	Sponsor State & Host Nation
Costs	- Administration - Oversight	**- Prefeasibility Studies** **- Feasibility Studies** **- Upfront Investments** **- Operating Expenses**	- Prefeasibility Studies - Feasibility Studies - Upfront Investments - Operating Expenses	
Revenues *(including inbound transfers)*	- Fees - Royalties *(from collector)*	**- Sale of Nodules** ***(to metals processors)***	- Sale of Metals	- Taxes to Sponsor State *(from collector)* *- Taxes to Host Nation* *(from metals processor)*
Transfers *(outbound)*	- Revenue sharing	**- Royalties, Fees** ***(to ISA)*** **- Corporate Tax** ***(to Sponsor State)***	- Nodule Purchases *(to collector)* - Taxes *(to host nation)*	

Detailed Nodule Collection Cost Model Inputs

- Detailed Cost Model for Each Activity
- Data from a variety of sources
  - Published seabed mining studies
  - Singapore workshop 2016
  - Discussions with contractors/workshop
  - Generally available data
- Calibrated against contractor surveys

General Inputs

Production Target	3,000,000 dry tons/year
Dry as a % of Wet Nodules	30%
Average Nodule Coverage	10 kg/m2
Topology Factor	75% of recoverable area
Average Seabed Depth	5000 m

Collection Inputs

Collector Width	15 m
Collector Speed	0.7 m/sec
Power Required per Collector	1700 kW
Sweep Efficiency	90%
Dredge Efficiency	90%
Collector Maintenance Interval	24 days
Time Needed for Collector Maintenance	6 days
Other Collection Downtimes	20 days/year
Investment per Collector	$20 million
Collector Life	2 years
# of Collectors Held in Reserve	1 reserve/active collector

Lift System Inputs

Average Pump Rate of 2-Phase Mixture	4.0 m/sec
Two Phase Mixture Density	1200 kg/m3
Width of Riser	35.56 cm
Riser Height per Pump	1500 m
# of Risers Held in Reserve	1 per active riser
Investment per Lift System	$60,000,000
Investment per Pump	$6,875,000
Investment per Buffer	$8,250,000
Investment per Flexible Hose	$6,000,000
Investment per Cabling	$5,500,000
Riser Life	5 years
Pump Power Requirement	1900 kW/pump

Mining Vessel & Process Water System Inputs

Investment per Mining Vessel	$450 million
Holding Capacity of the Mining Vessel	55,000 tons
Maximum Allowable Fill	95%
# of Crews Needed	2
# of Replacement Crews	1 per active crew

Mining Vessel Labor Requirements:	# of Workers	Monthly Wage
General Crew	16	$10,938
Mining System Crew	40	$16,250
Support Staff	56	$7,798

Mining Vessel Power Requirements:	
Propulsion, Positioning & Compensation Systems	2250 kW
Cranes & Handling Systems	3600 kW
Crew Quarters	1200 kW

Process Water System Requirements:	
Average Pumping Rate	1.9 m/sec
Investment per Pump System with Sensors	$15.5 million/system
Investment per Process Water System	$23 million/system
Process Water System Power Requirement	650 kW/system
# of Systems in Reserve	1 per active system

Nodule Transport Cost Model Inputs

Distance to Port	1000 nautical miles
Fuel Consumption at Port	3 ton/day
Fuel Cost	$400/ton
Crew Replacements	2
Monthly Crew Salary	$10,938/worker/month

	VLCC	Capesize	Supramax
Baseline Ship Cost	$90 million	$53 million	$30 million
Additional Systems Cost	$10 million	$5 million	$5 million
Ship Speed	12 knots	12 knots	12 knots
Capacity	250,000 tons	100,000 tons	50,000 tons
Unload Time	2 days	2 days	2 days
% of Time at Berth	50%	50%	50%
Load Time	3 days	2.5 days	2 days
Crew Required	25 workers	20 workers	15 workers
Fuel Consumption	45 tons/day	25 tons/day	15 tons/day

Environmental Parameters of Interest

Physical Oceanography	Geology	Chemistry and Geochemistry	Biological Communities	Sediment properties	Bioturbation	Sedimentation
- Currents - Temperature - Conductivity - Sediment in water column (Turbidity, TSS, PSD) - Satellite data analysis - Underwater noise level - Underwater lighting level (Measurements adapted to geomorphology and regional processes of ocean)	-Seabed geomorphology -Heavy metals and trace elements concentration in seabed.	-Background water column chemistry (phosphate, nitrate, nitrite, silicate, carbonate alkalinity, oxygen, zinc, cadmium, lead, copper, mercury and total organic carbon) -Information on heavy metals, trace elements, other chemicals released in the plume discharge	-Representative fauna samples for seabed (photos and samples) -Data on benthic megafauna, macrofaunal, meiofauna, microfauna, demersal scavengers and others associated with nodules. -Pelagic communities assessment. -Baseline metal levels in dominant species. -Marine mammals and birds sightings -Regional distribution of species and genetic connectivity.	-Seabed sediment physical properties (specific gravity, bulk density, shear strength, grain size, depth of change from oxic to suboxic or vice versa) -Organic, inorganic carbon, metals, nutrients, carbonate and redox in pore waters (as far down as 20cm).	- Profiles of excess Pb-210 from cores, at least five levels per core.	-Sedimentation rate -Sediment transport -Sediment loading

Average Depth	4500 m
Annual mined area	370 km^2
Active mining area (3 months)	90 km^2
Next active mining area	90 km^2
Preservation Reference Zone	250 km^2
Impact Reference Zone	100 km^2

*Table based on ISA recommendations (ISBA/19/LTC/8, 2013), which have recently been reviewed as part of recent Mining & Pelagic Workshop in August 2018.

Environmental Monitoring Overview

Main Element	**Moorings (submerged and full depth)**	**Research Vessel**	**Mining Vessel (Underwater Autonomous Vehicles)**
Frequency of operation	Active 24/7 (except during maintenance ops)	Active 24/7 throughout visits during exploration or exploitation.	Depend on exploration or exploitation
Area of operation	- Throughout of active area. - Previously mined areas - IRZs and PRZs	- Throughout active area. - Previously mined areas - IRZs and PRZs	- -Throughout active area. - Previously mined areas - IRZs and PRZs
Exploration Phase	- 1 full-depth mooring - 3 short moorings	- 1 R/V for 1 x 5 weeks per year + 1 AUV + 1 ROV	
Exploitation Phase	- 8 full-depth mooring - 16 short moorings	- 1 R/V for 4 x 4 weeks per year	- 5 AUVs (24/5) - 1 Glider - 1 ROV
Tasks	- CTD (Hydrography) - ADCP (currents) - Turbidity sensors - Sediment traps - Noise measurement - Light measurement	- CTD (Hydrography) - ADCP (currents) - Turbidity - Water samples (biology, chemistry and sediment content) - Seabed samples (biology, chemistry and sediment)	- CTD - ADCP - Turbidity - Video (biology observations)

This environmental monitoring system is based on existing technologies. However, it is expected that the development of new technologies will increase the presence of autonomous systems in the future.

Environmental Modeling

- Environmental model:
  - Main inputs:
  - Seabed geomorphology
  - Physical oceanography parameters: currents, temperature, conductivity.
  - Sediment properties
  - Operational parameters: nodule collector characteristics, mined area, resuspended sediment, characteristics of the returned water and sediment from the mining vessel.
- Main outputs:
  - Plumes: affected area, sediment concentration, sedimentation rate, sediment transport
  - Biological effects
  - Chemical effects
  - Noise
  - Light

Environmental Monitoring Costs

Main Element	**Moorings**	**Research Vessel**	**Underwater Unmanned/manned Vehicles**
Capital Cost	- Average cost per mooring: 250,000 USD - Operating life: 5 years	- Chartered (No CAPEX)	- Subcontracted (No CAPEX)
Operating Cost	- 10% Maintenance	- Charter: 50,000 USD/day	- 20,000 USD/day per vehicle (exploration) - 5,000 USD/day per vehicle (exploitation)
Others	- Labor cost associated to data processing and analysis: 25,000 USD per mooring per year	- Data and lab analysis 500,000 USD per trip.	- Data analysis costs: 25,000 USD per vehicle per year

- **Environmental modeling** cost: 200,000 USD per year (operating cost)
- **EIA, EIS and EMMP** cost: 150,000 USD per year each (during exploitation)

Exploration	Total Environmental Monitoring CAPEX	1,000,000 USD (every 5 years)
	Total Environmental Monitoring and Modeling OPEX	3,250,000 USD per year
Exploitation	Total Environmental Monitoring CAPEX	6,000,000 USD (every 5 years)
	Total Environmental Monitoring and Modeling OPEX	20,050,000 USD per year

*All the costs are considered from the perspective of the nodule collector for a one-mining vessel operation with two nodule collectors and an annual production of 3 million metric tons of dry nodules, using currently available technologies.

Supply and Crew Transport

Main Element	**1 Supply Vessel**	**1 Crew Transport Vessel**
Operation	- 2 weeks per month	- 1 week per month
Capital Cost	- Chartered (no CAPEX)	- Chartered (no CAPEX)
Operating Cost	- Charter: 25,000 USD/day	- Charter: 15,000 USD/day

Total Supply Vessel OPEX	4,200,000 USD / year
Total Crew Transport Vessel OPEX	1,260,000 USD / year

*All the costs are considered from the perspective of the nodule collector. This corresponds to a one-mining vessel operation with an annual production of 3 million metric tons of dry nodules.

Nodule Collector Cost Model Results

Nodule Collector CAPEX & OPEX

	CAPEX	Annual OPEX	OPEX/ton
Collection	$80 million	$15.6 million	$5.21
Lift	$429 million	$78.8 million	$26.27
Mining Vessel	$900 million	$193.7 million	$64.22
Process Water	$123 million	$17.5 million	$5.84
Environmental Monitoring	$6 million	$20.0 million	$6.68
Transport	$105 million	$57.9 million	$19.31
TOTAL	**$1,643 million**	**$382.5 million**	**$127.53**

Nodule Collector Recurring CAPEX

	Investments	Period	Annual Equivalent
Collectors	$40,000,000	2	$30,000,000
Risers, Pumps, Hoses	$42,250,000	5	$12,675,000
Moorings	$6,000,000	5	$1,450,000

Additional Payments to ISA and Sponsoring State

- We assume that the ISA collects administrative fees
- Assume 1% of GMV to environmental liability / sustainability fund to max of $500 million per contract
- Assumed sponsoring state corporate income tax rate
  - 25%

Fee	Amount	
EXPLORATION		
Exploration contract application fee	0.5	million USD
Annual administrative fee during exploration	0.047	million USD/annum
EXPLOITATION		
Exploitation contract application fee	1	million USD
Annual admin fee during exploitation contract	0.1	million USD/annum
Minimum fixed fee during exploitation contract (waived if royalty or profit-based payments exceed this amount)	1	million USD/annum

These values have recently been updated in 2019

Assumed Operational Timing

	Phase Start year	Phase Duration years
Pre Feasibility	1	6
Feasibility	4	4
Design and Build	8	3
Operation Phase		
Ramp Up	11	2
Full Operation	13	24
Shutdown	37	1
Total Exploitation Period		30

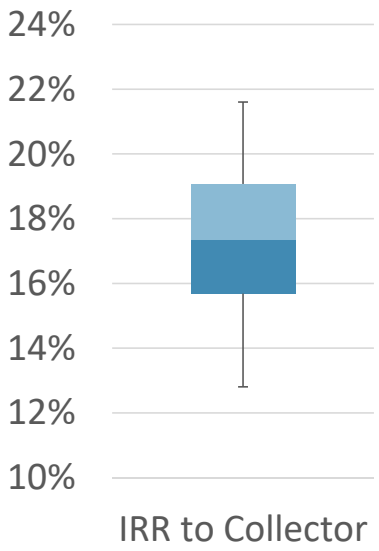
Once we have estimated all cash flows, what do we do with that?

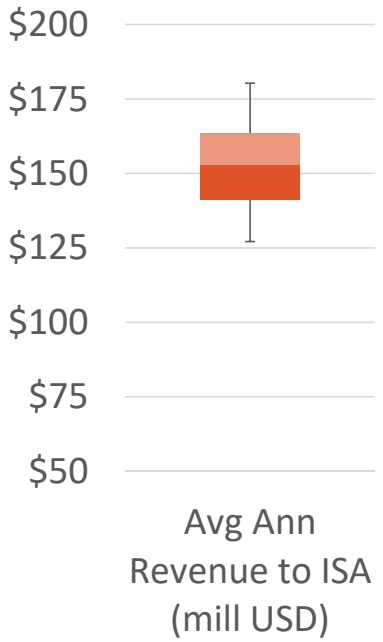
Evaluation Metrics

Financial Payment System should be Evaluated From Several Perspectives: Previously relied on two metrics

- Previously, we presented
  - Contractor: Internal Rate of Return
  - ISA: Average annual payment
- For example, a 2% / 6% ad-valorem system* generates
  - Average IRR = 17.5%
  - Average annual payment = 153 million USD /year

2% / 6% ad-valorem means: 2% of gross metal value (GMV) collected shifting to 6% of GMV at year five (5)



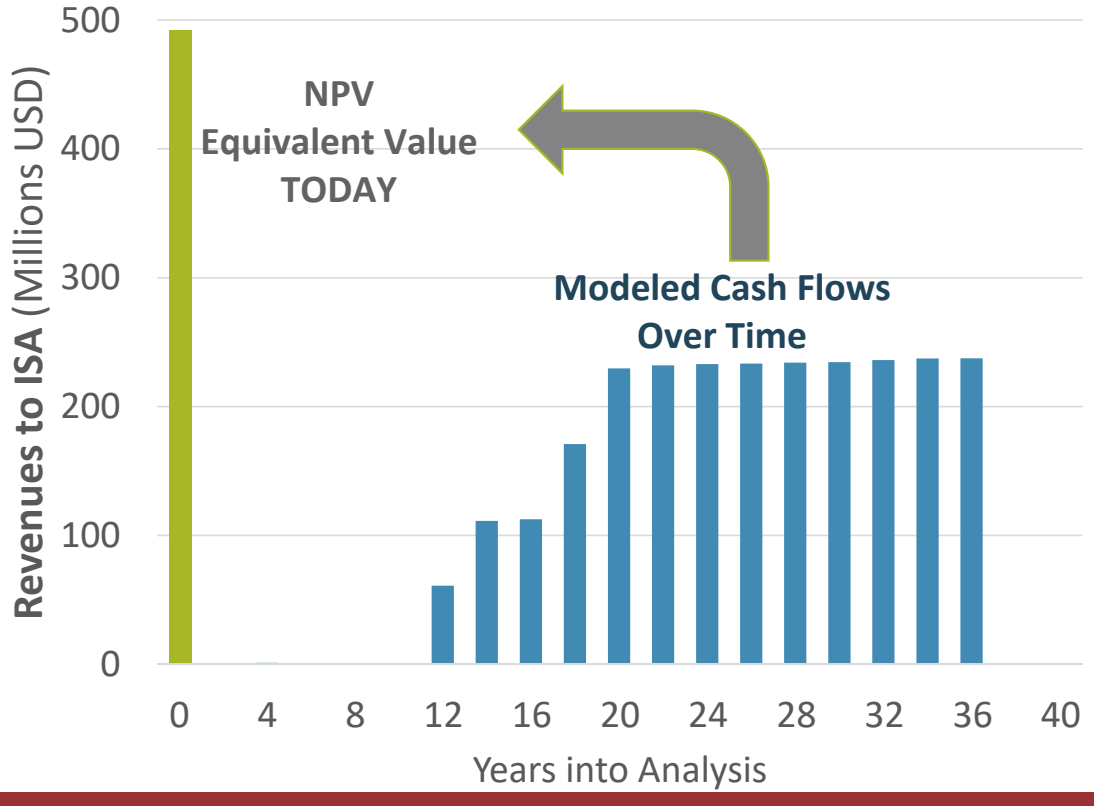


Financial Payment System Evaluation: Shifting to More Metrics to Quantify Tradeoffs Among Stakeholders (1)

- We are shifting from

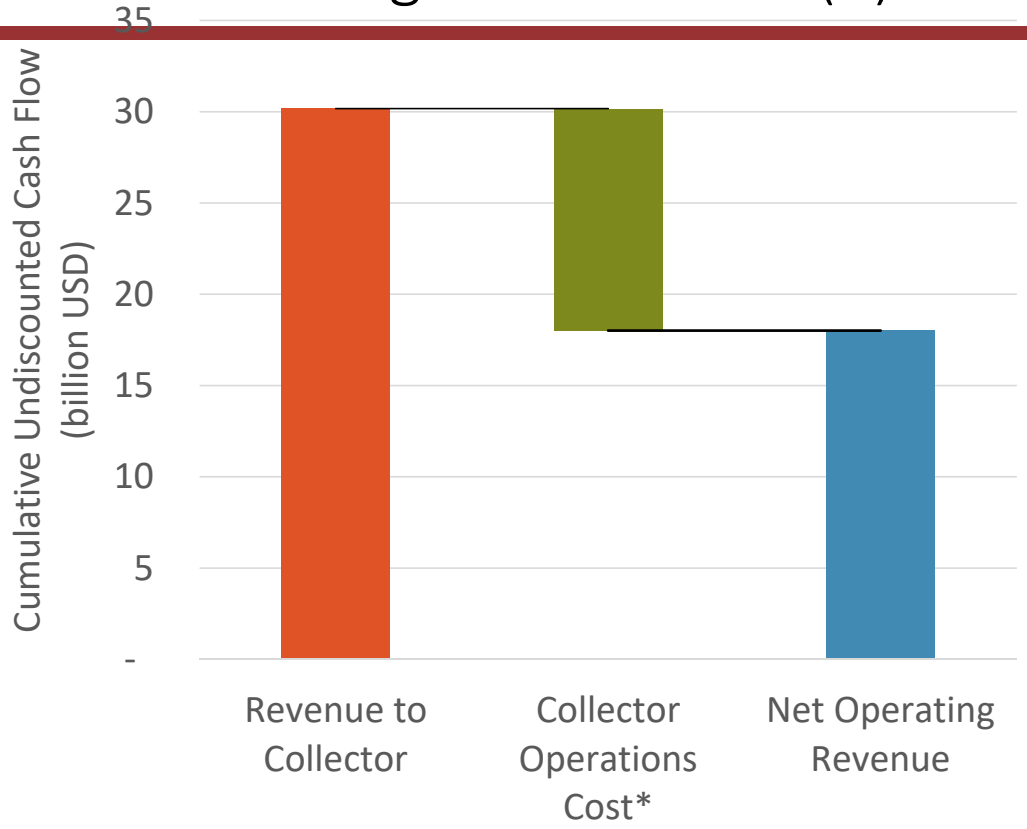
  Average annual revenue to ISA → Net present value (NPV) of revenue to ISA

- NPV is the equivalent value TODAY of all revenues received over time
  - better captures the time value of money
  - Discounted sum of all cash flows
  - We have generally assumed an ISA discount rate of 10%
- Contractor IRR is discount rate where contractor NPV = 0
  - Standard metric to evaluate investments



Financial Payment System Evaluation: Shifting to More Metrics to Quantify Tradeoffs Among Stakeholders (2)

- Metrics suggested by the LTC
  - Share of Net Operating Revenues to
    - ISA
    - Sponsoring state
    - Other
    - Contractor
- We define
  Net Operating Revenue = Revenue – Operating Cost*
- This represents all of the available cash flow that can be divided among the stakeholders
  - Cashflows are cumulative over analysis period and NOT discounted

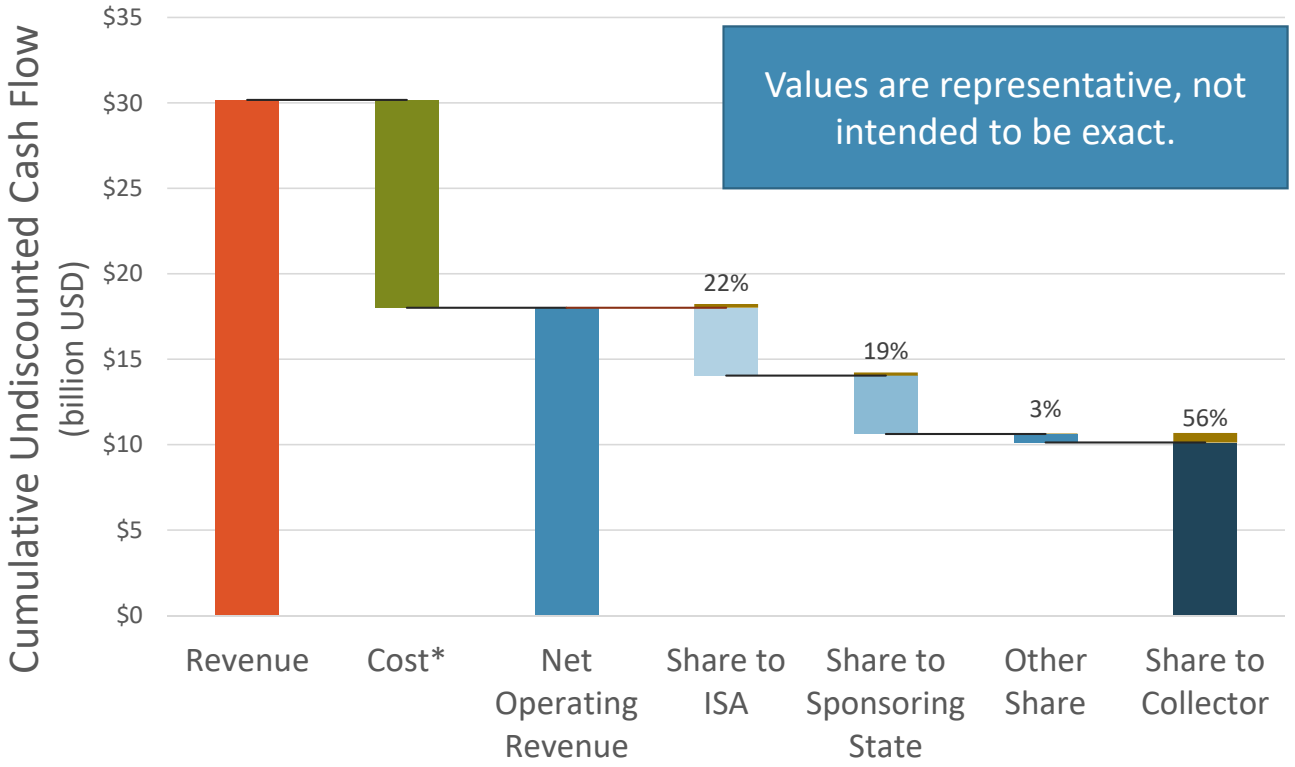


* Costs exclude payments for fees, levies, royalties, or taxes

Financial Payment System Evaluation: Shifting to More Metrics to Quantify Tradeoffs Among Stakeholders (2)

New metrics suggested by the LTC

- Share of Net Operating Revenues to
  - ISA
  - Sponsoring state
  - Other
  - Contractor



Financial Payment System Evaluation: Shifting to More Metrics to Quantify Tradeoffs Among Stakeholders (2)

New metrics suggested by the LTC

- Share of Net Operating Revenues to
  - ISA
  - Sponsoring state
  - Other
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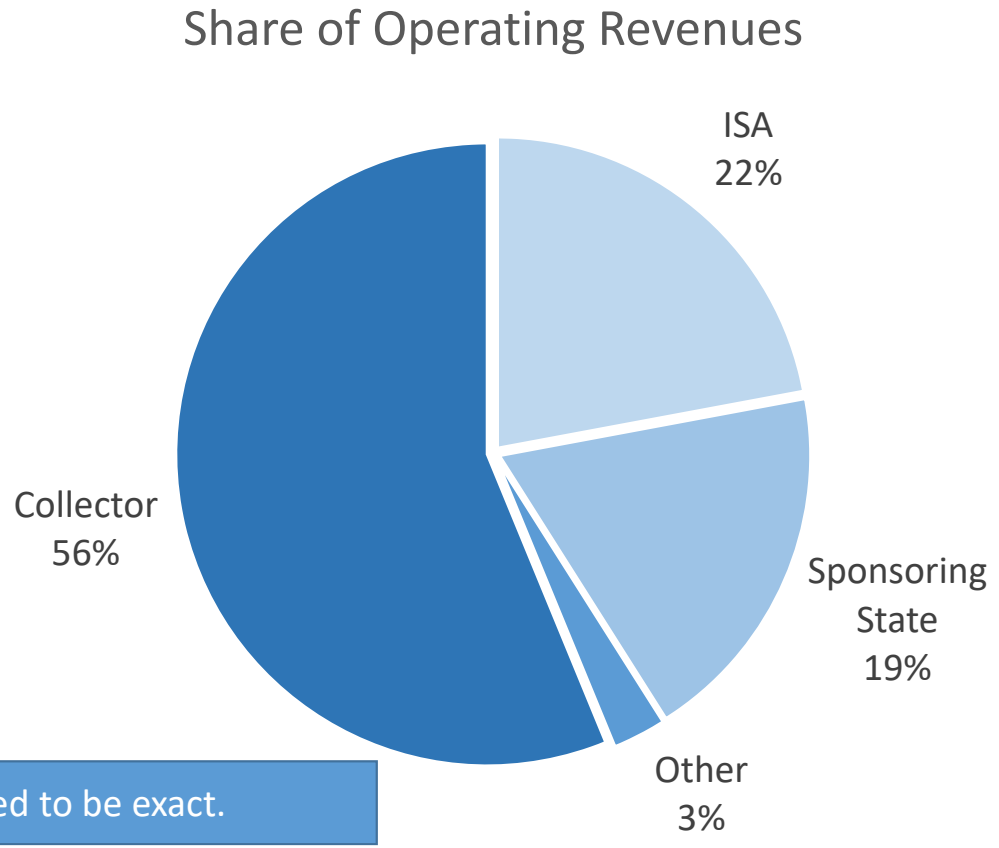
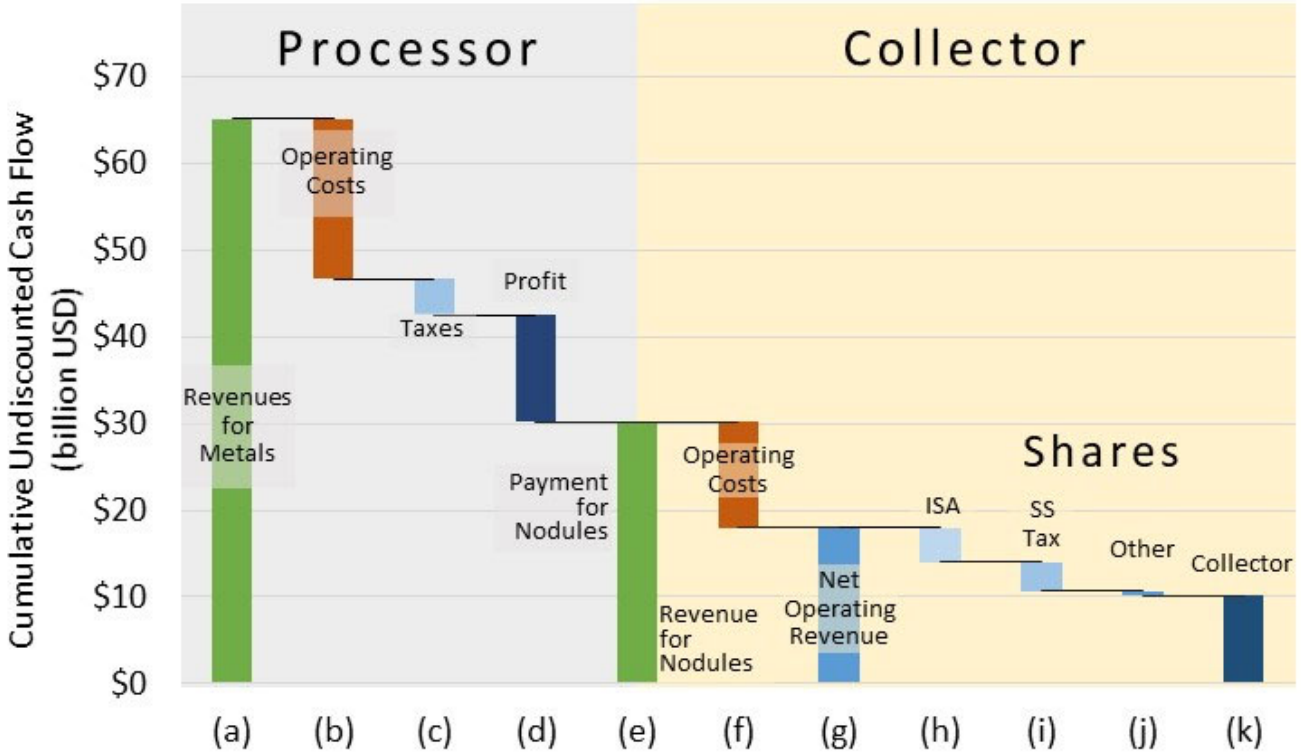


Values are representative, not intended to be exact.

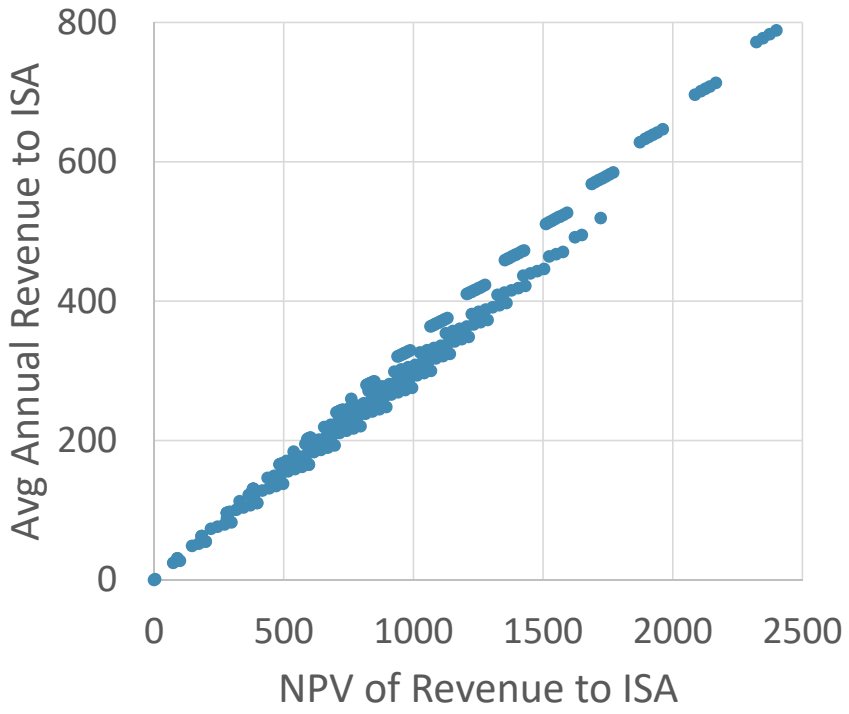
NOTE: Share is Computed Based on Net Operating Revenue at the **Collector**



Values are representative, not intended to be exact.

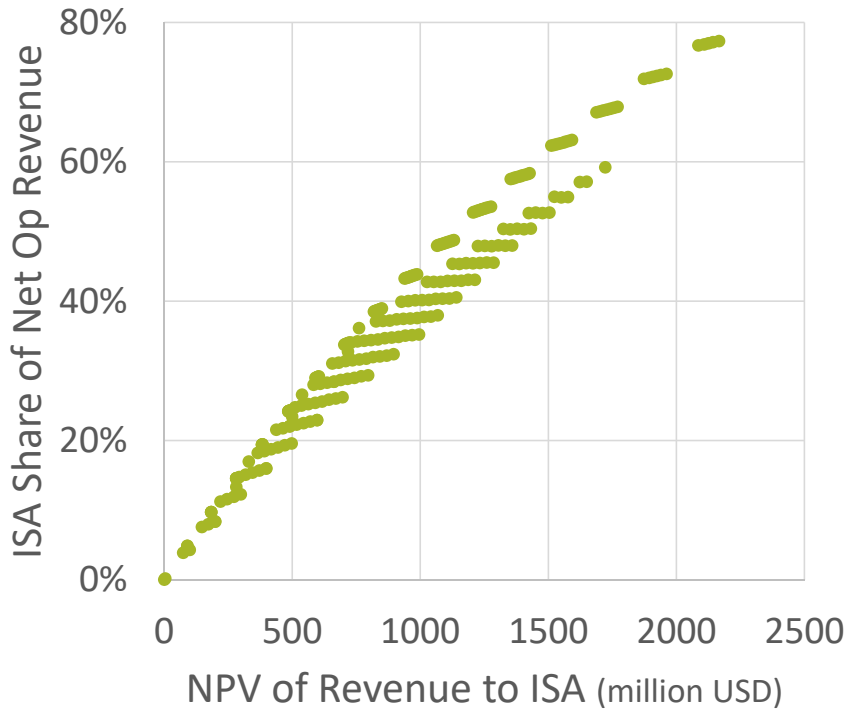
All Three Metrics of ISA Revenues lead to Similar Conclusions

- Generally, the three ISA metrics provide equivalent information
- When NPV is large, Average annual revenue is large



All Three Metrics of ISA Revenues lead to Similar Conclusions

- Generally, the three ISA metrics provide equivalent information
- When NPV is large,
  ISA Share is large



General Evaluation Approach: A broad range of payment systems were explored, selected ones in detail

Method

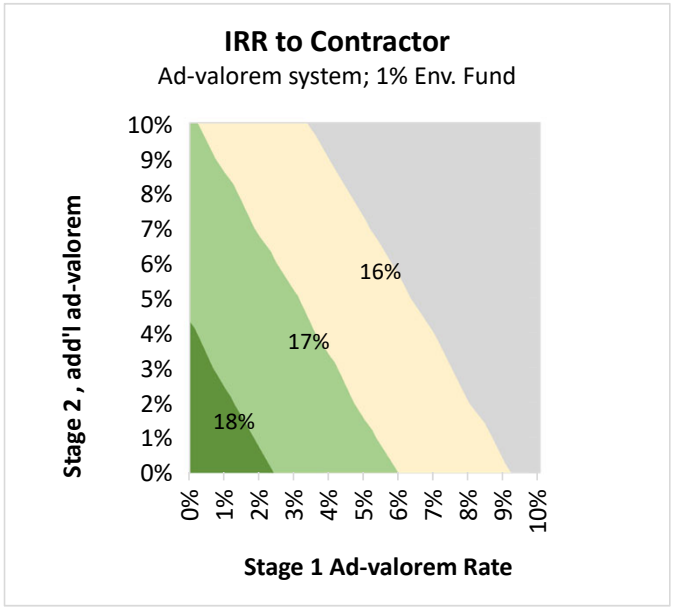
- Screening
  - Analyze broad set of payment systems
  - Baseline conditions only
- Select promising alternatives
  - Identify diverse set of systems that provide minimum levels of return to contractors
  - Three minimum levels explored: 18%, 17.5%, and 17%
- Promising alternatives explored in more detail
  - Monte Carlo analysis
  - More metrics

Scope of screening

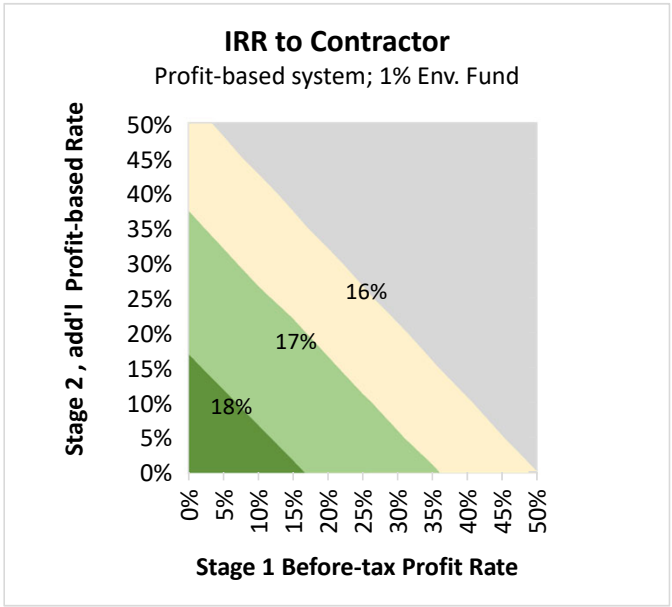
- Ad-valorem Rate
  - Stage 1: 0% to 10% of GMV
  - Stage 2: + additional 0% to 10% of GMV (Stage 2 rate = Stage 1 + Stage 2 add'l)
- Profit-based Rate
  - Stage 1: 0% to 50% of Net Operating Revenue (NOR)
  - Stage 2: + additional 0% to 50% of NOR (Stage 2 rate = Stage 1 + Stage 2 add'l)
- Combination / blended
  - Stage 1&2: 0% to 10% gross metal value collected
  - Stage 2 only: plus an additional 0% to 50% of NOR

There are many ways to design a scheme that provides similar return to the contractor

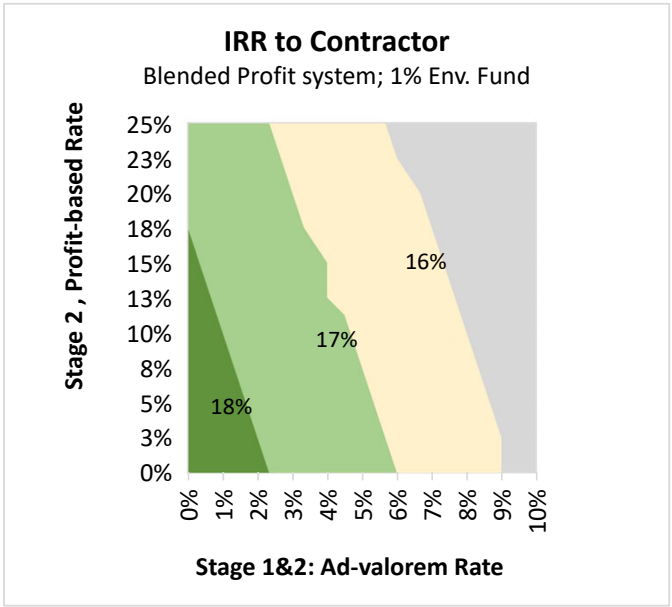
Ad-valorem Only System



Profit-based Only System

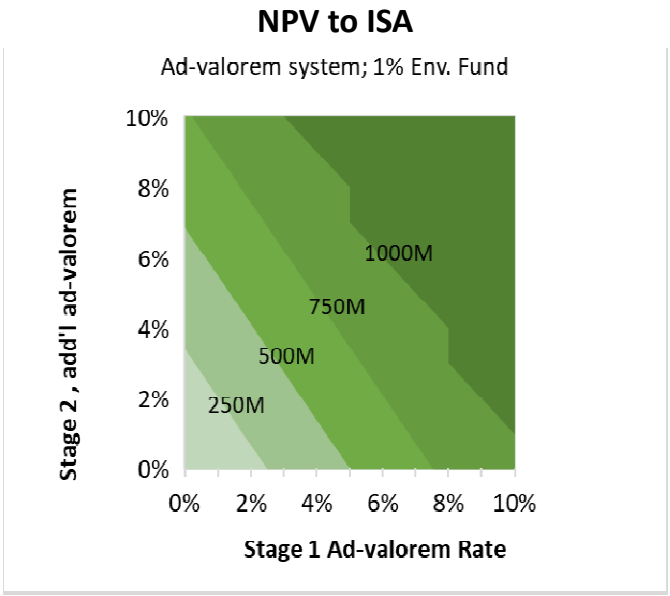


Blended System

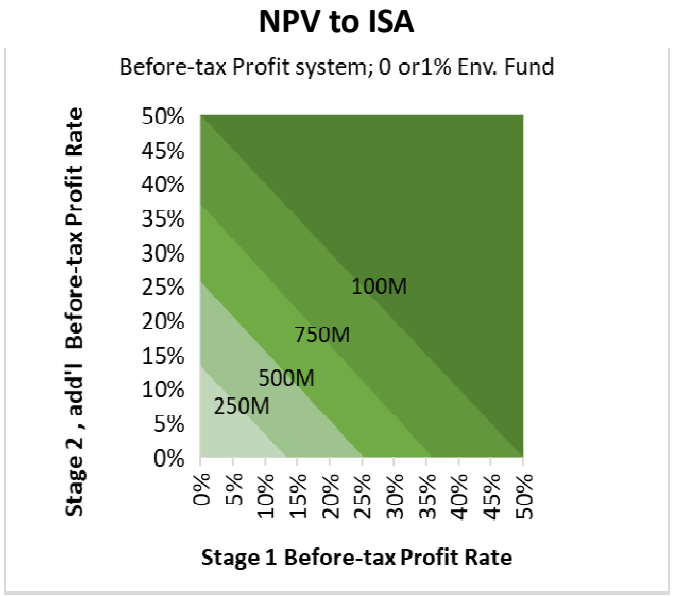


And many different systems to generate a certain level of revenue to the ISA

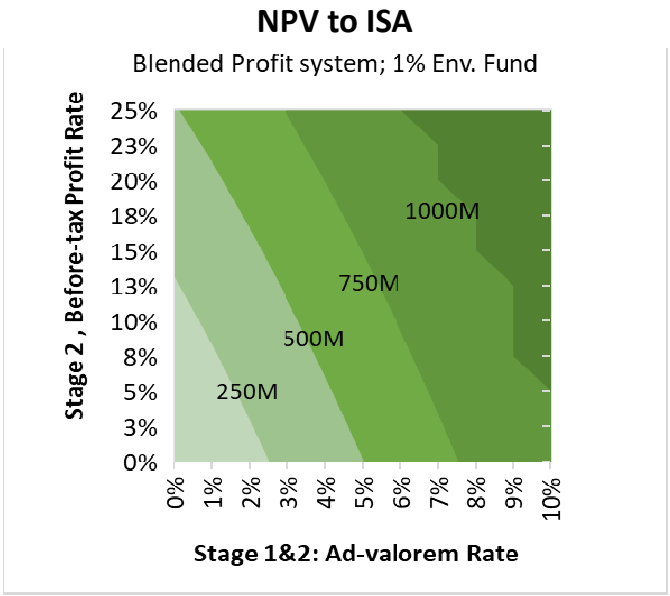
Ad-valorem Only System



Profit-based Only System



Blended System

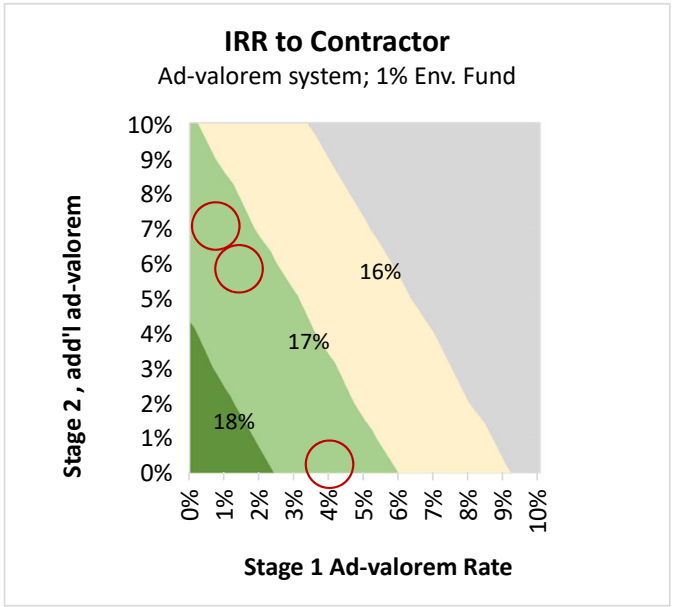


We explored a few alternative systems in detail

- Selected systems that were
  - Able to provide some threshold return value
    - 18%, 17.5% or 17%
  - Distributed across the rate space
  - Roughly integer percent values (some 0.5% options were allowed)
- Each selected system was evaluated using Monte Carlo analysis
- Metrics evaluated
  - Collector IRR
  - ISA NPV
  - Undiscounted share in dollars & in percent
    - ISA
    - Sponsoring State
    - Other
    - Collector

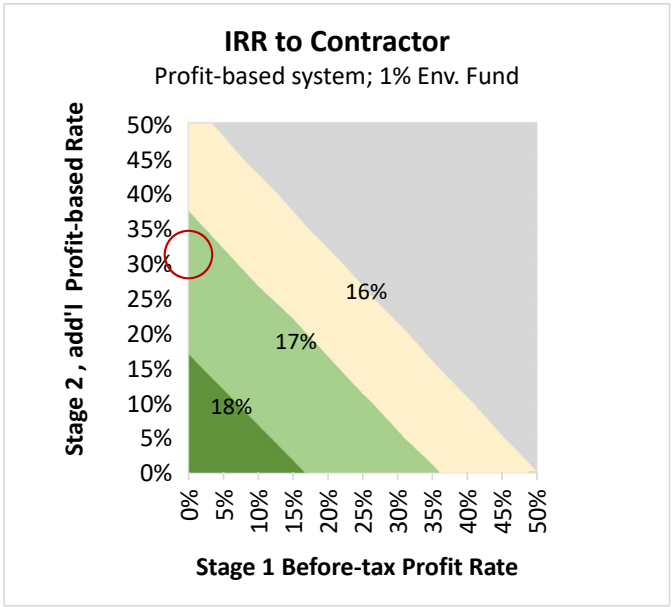
Example: We selected several promising alternatives that should provide 17.5% return

Ad-valorem Only System



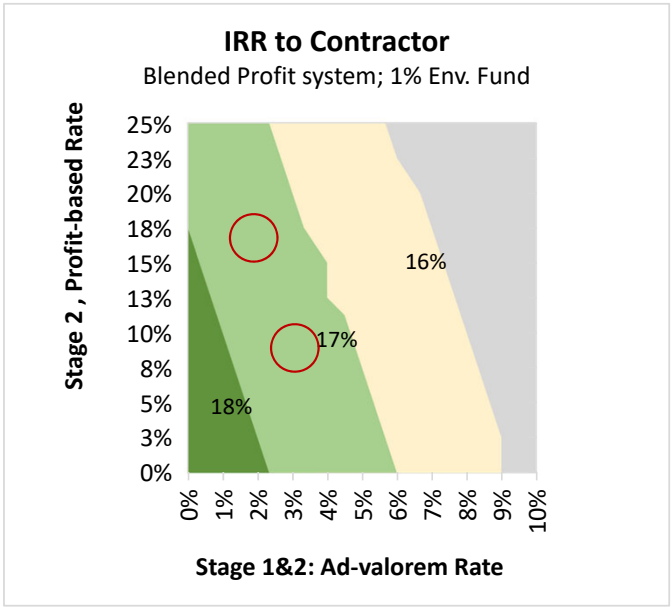
AV 4% → 4% AV 2% → 6%
AV 1% → 6.5%

Profit-based Only System



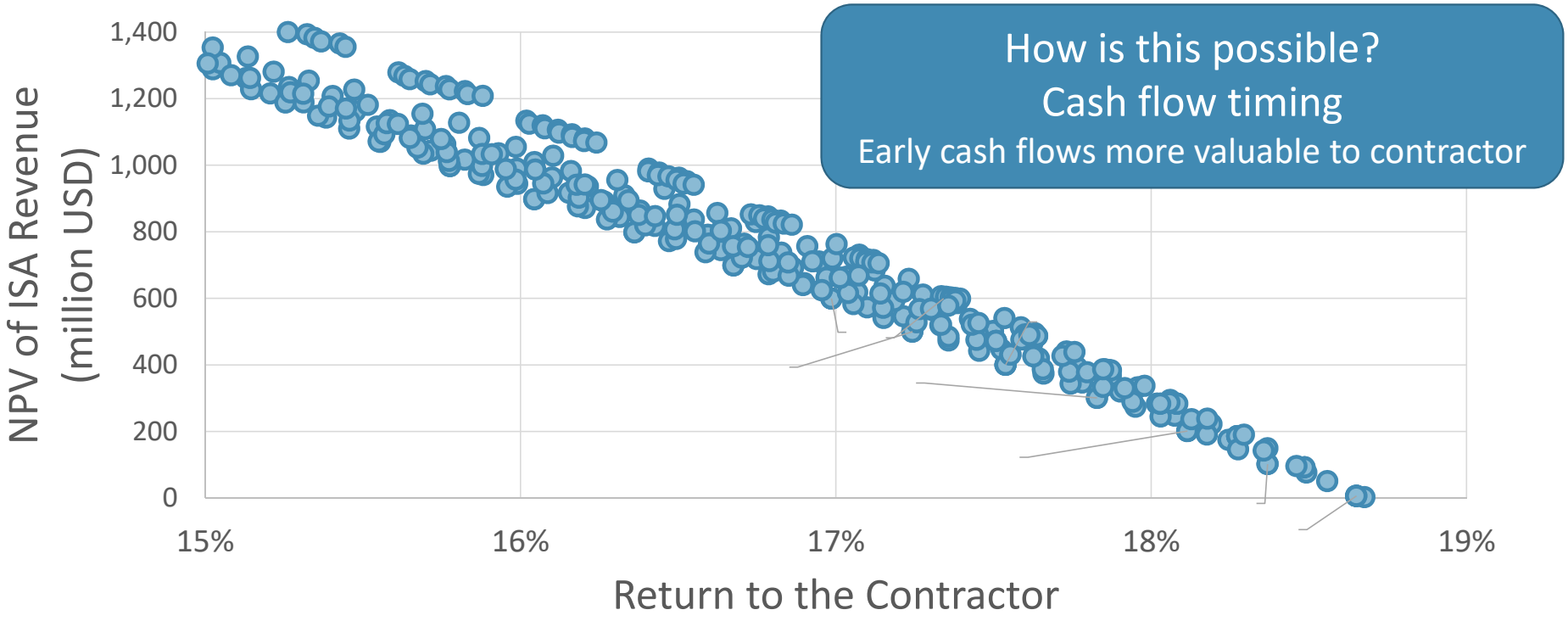
PB 0% → 27.5%

Blended System

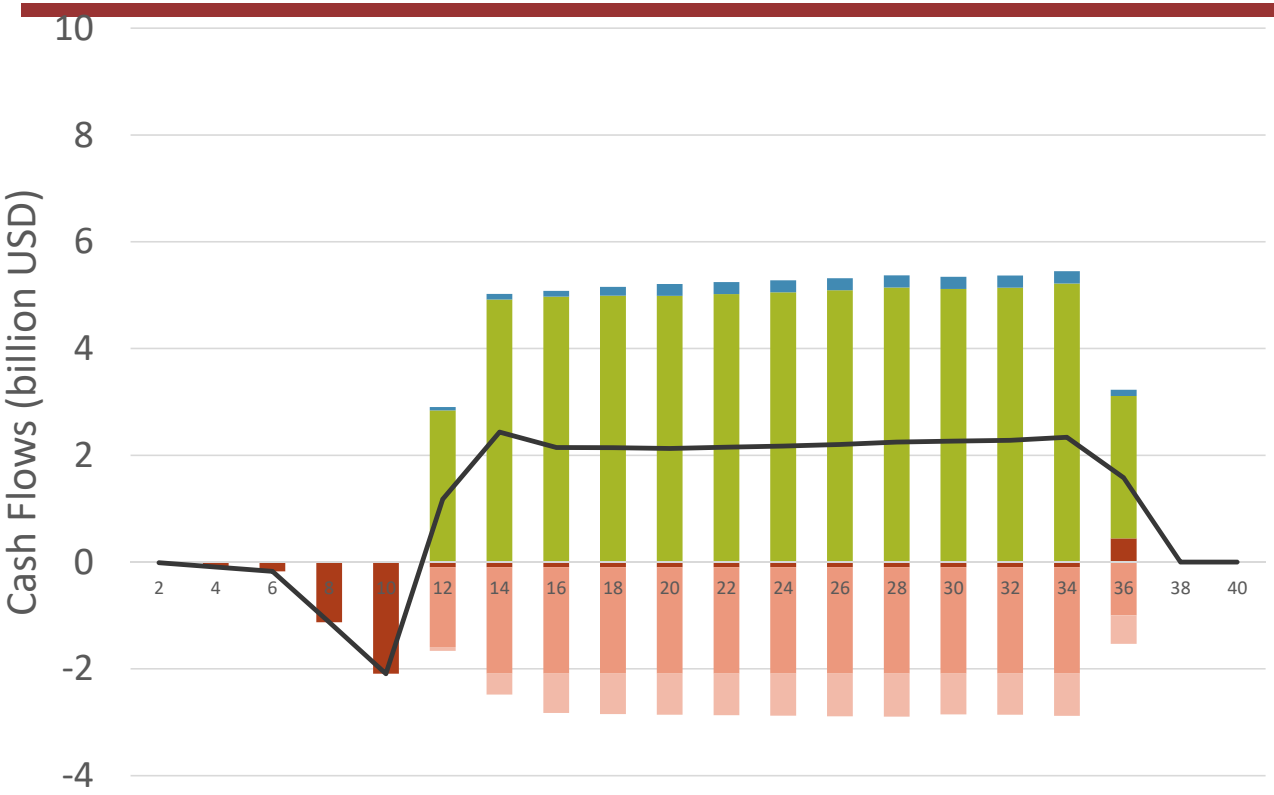


AV 2% + PB 15% AV 3% + PB 7.5%

Even though systems provide similar return, they can yield more than 25% differences in ISA NPV

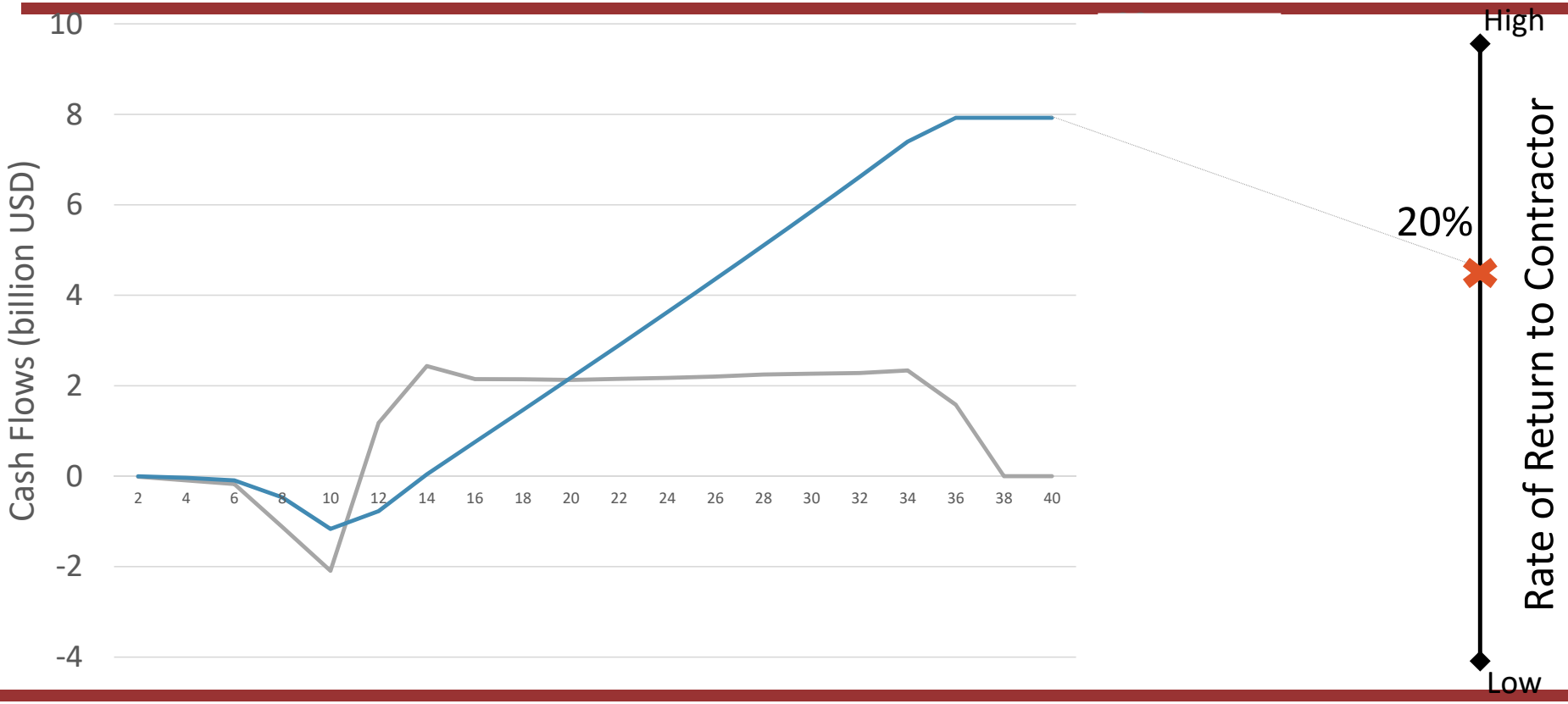


We will look at each type of system individually: First estimate cash flows



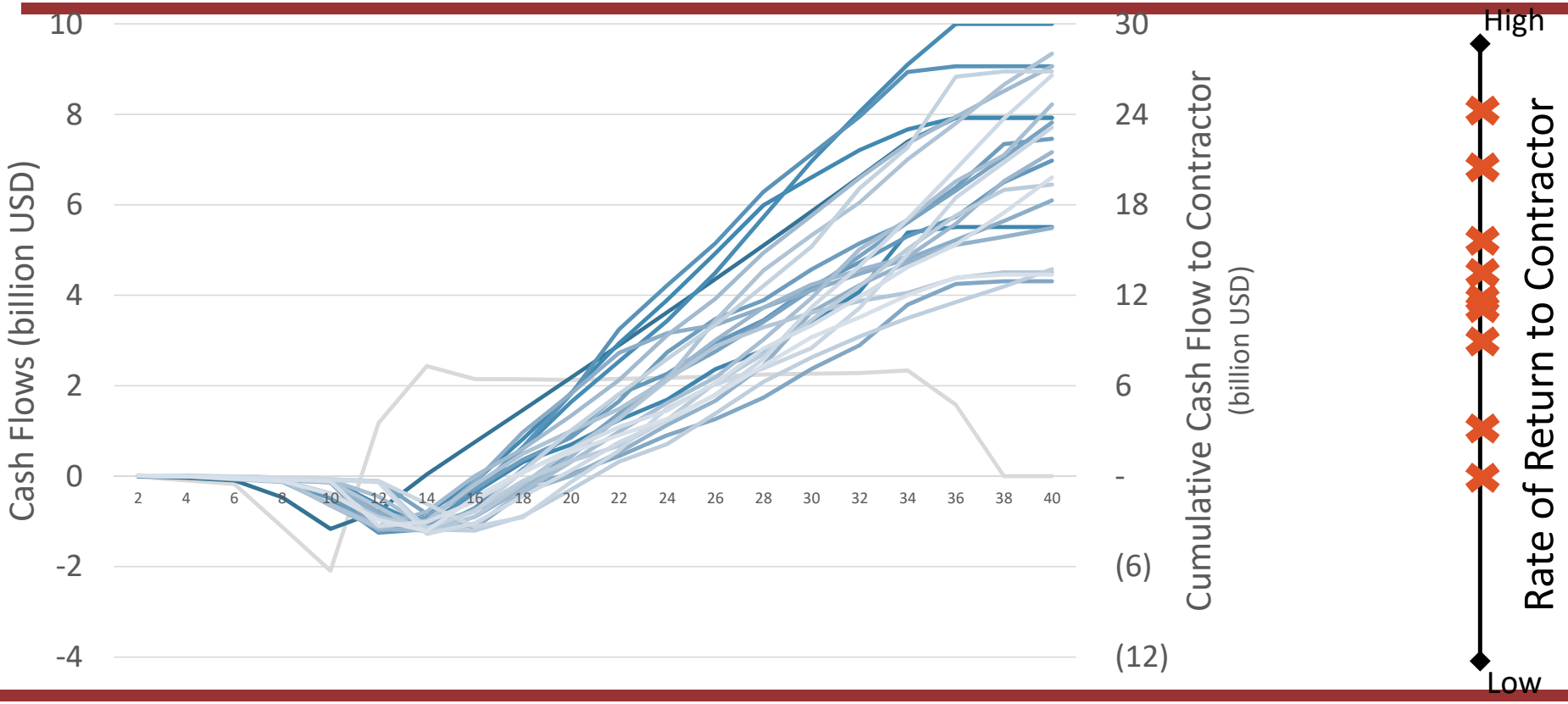
Values are representative, not intended to be exact.

We will look at each type of system individually: Then estimate metrics (e.g., rate of return)



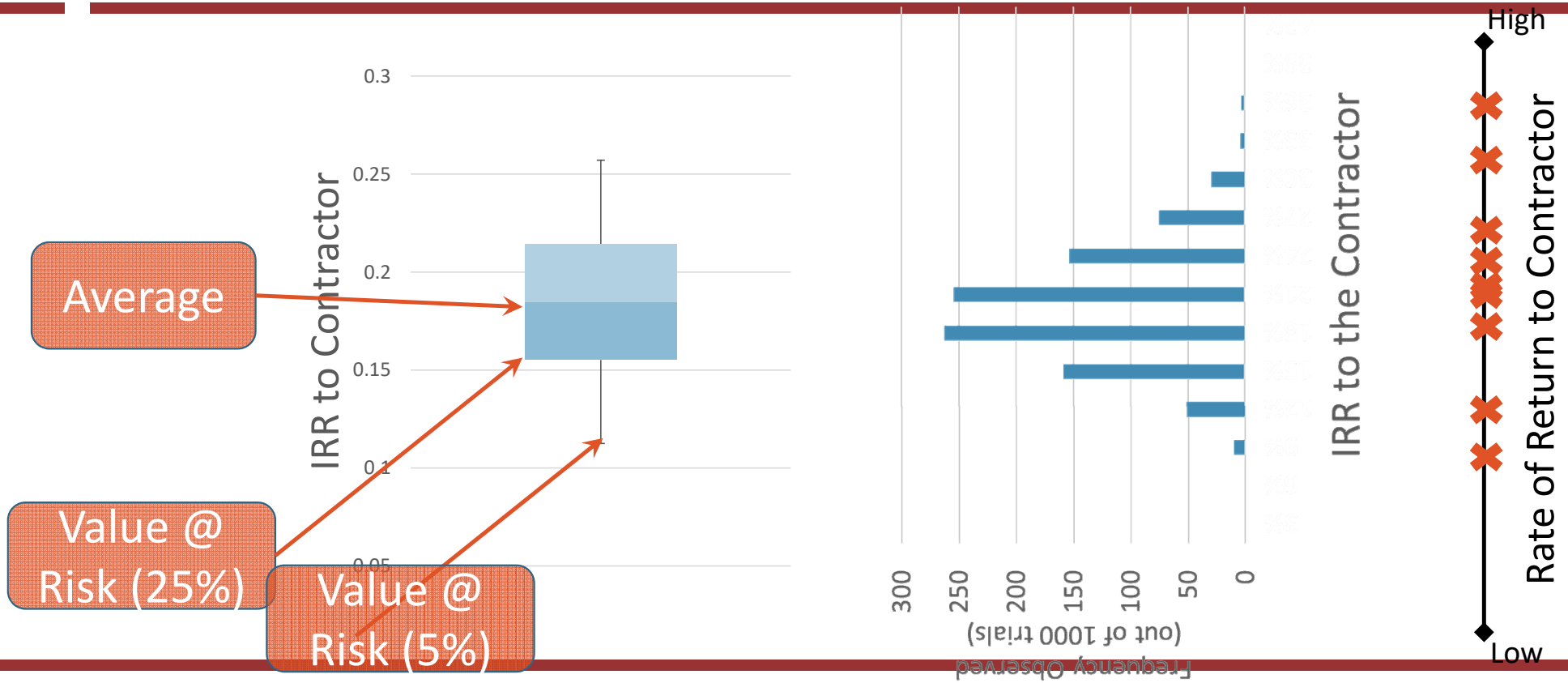
Values are representative, not intended to be exact.

Because of Uncertainty, Simulate Many Futures to Estimate Distribution of Performance Metrics



Values are representative, not intended to be exact.

Distribution of Metrics Can Be Represented Several Ways

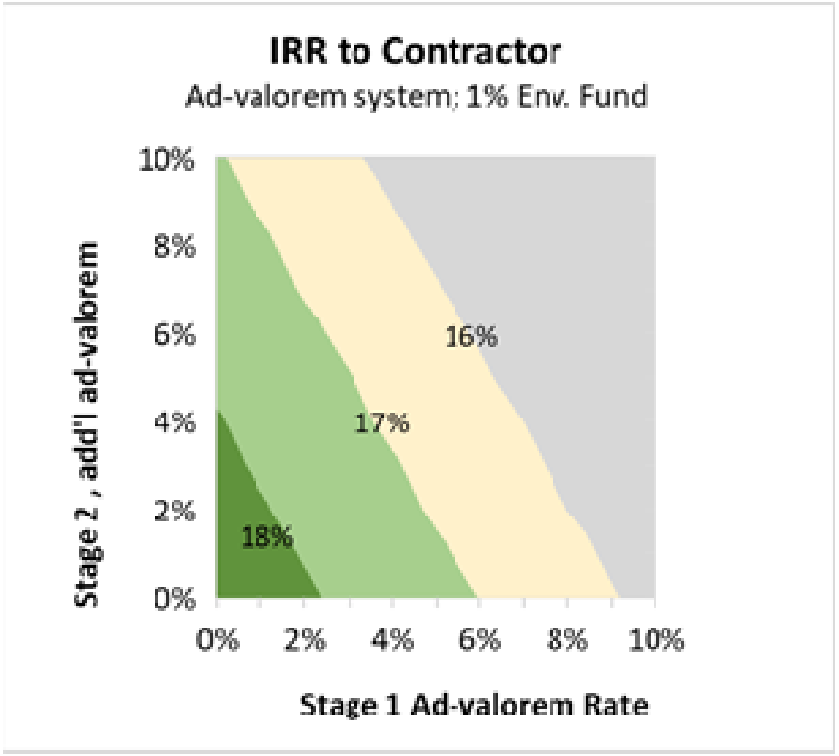


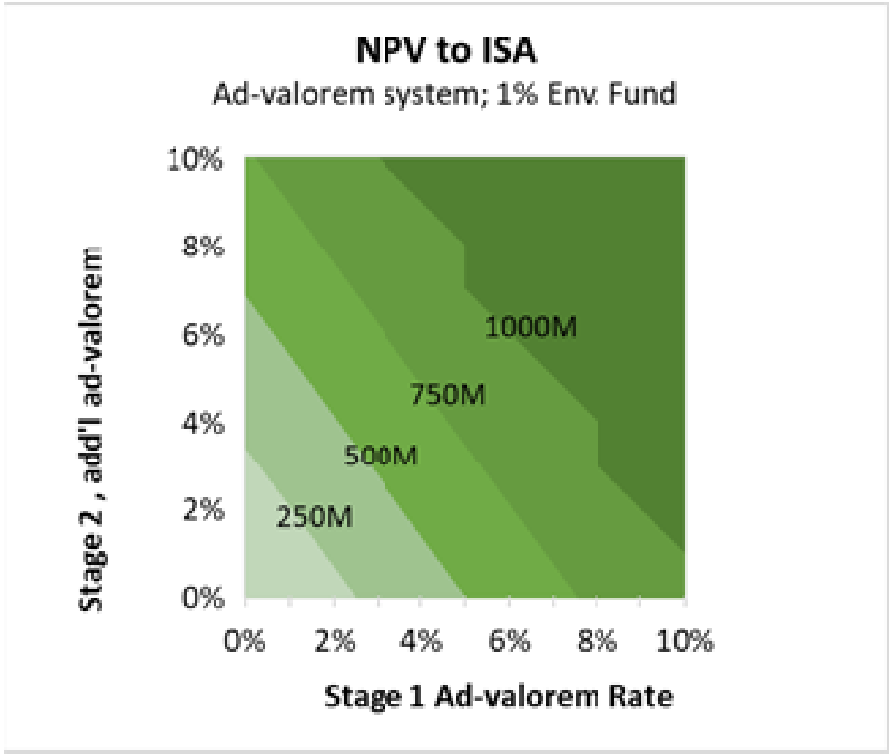
Values are representative, not intended to be exact.

Ad-valorem Systems

- Basis of rate:
  - Value of metal contained in the collected nodules
  - Referred to as Gross Metal Value (GMV)
- Two stages of rates
  - Allows ISA to maximize revenue while providing a target return to the contractor
    - Early revenues are more valuable to contractors than the ISA
  - Set at five (5) years, approximately when contractors begin to make a net annual profit (3-6 years)
- Scope of screening rate
  - Stage 1: 0% to 10% of GMV
  - Stage 2: Plus additional 0% to 10% of GMV
    (Stage 2 rate = Stage 1 + Stage 2 add'l)

Ad-valorem Systems: Screening of a Range of Rates

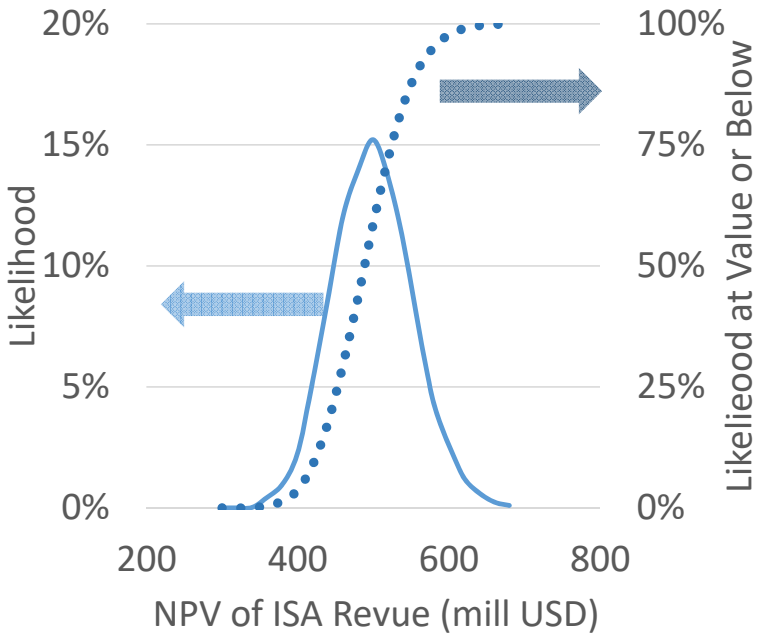


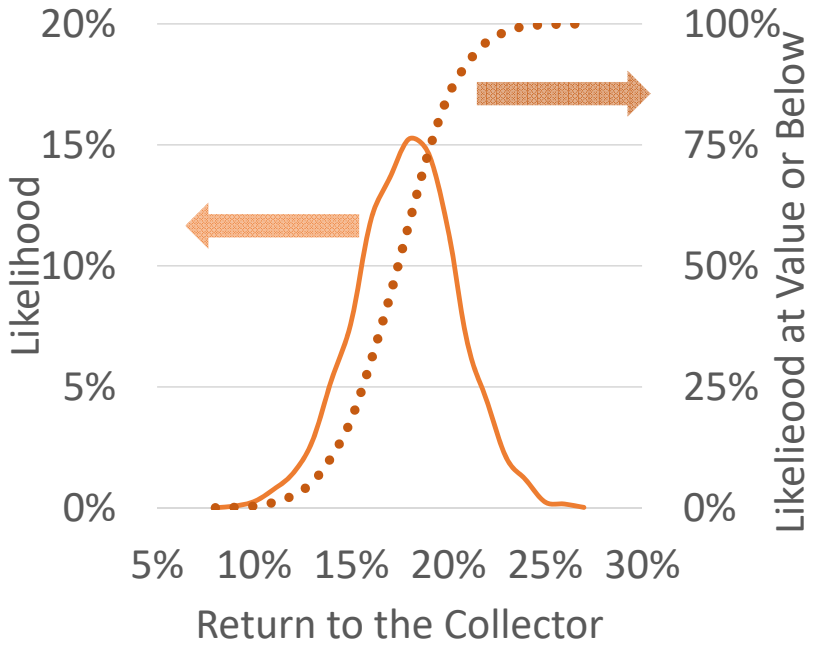


Ad-valorem Systems:
Several alternatives chosen for detailed analysis

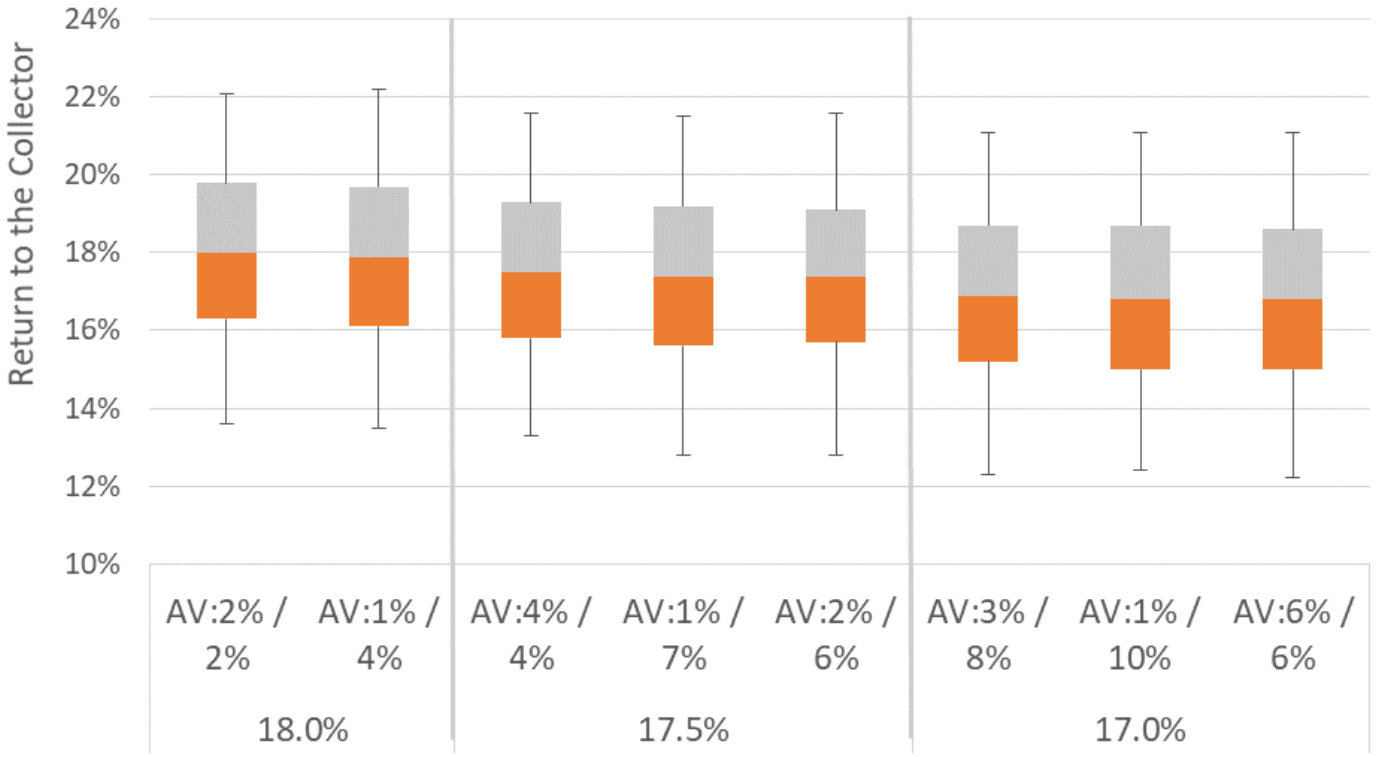
System	Initial Rate	Stage 2 Rate	Collector IRR	ISA NPV	ISA Share	Sponsoring State Share	Other Share	Collector Share	ISA Share (%)	Sponsoring State Share (%)	Other Share (%)	Collector Share (%)
AV6% / AV6%	6%	6%	17%	598	4,309	3,603	500	10,414	23%	19%	3%	55%
AV1% / AV9.5%	1%	9.5%	17%	716	6,095	3,029	500	9,009	32%	16%	3%	48%
AV3% / AV8%	3%	8%	17%	663	5,331	3,286	500	9,656	28%	17%	3%	51%
AV2% / AV6%	2%	6%	17.4%	490	3,976	3,441	500	10,180	21%	18%	3%	54%
AV1% / AV6.5%	1%	6.5%	17.4%	499	4,207	3,348	500	9,966	22%	18%	3%	53%
AV4% / AV4%	4%	4%	17.4%	398	2,875	3,735	500	10,932	15%	20%	3%	58%
AV1% / AV3.5%	1%	3.5%	18%	280	2,299	3,627	500	10,804	12%	19%	3%	57%
AV2% / AV2%	2%	2%	18%	199	1,441	3,867	500	11,460	8%	21%	3%	61%

Each **selected** alternative stem was analyzed using Monte Carlo simulation: Example Ad-valorem 2%→ 6%

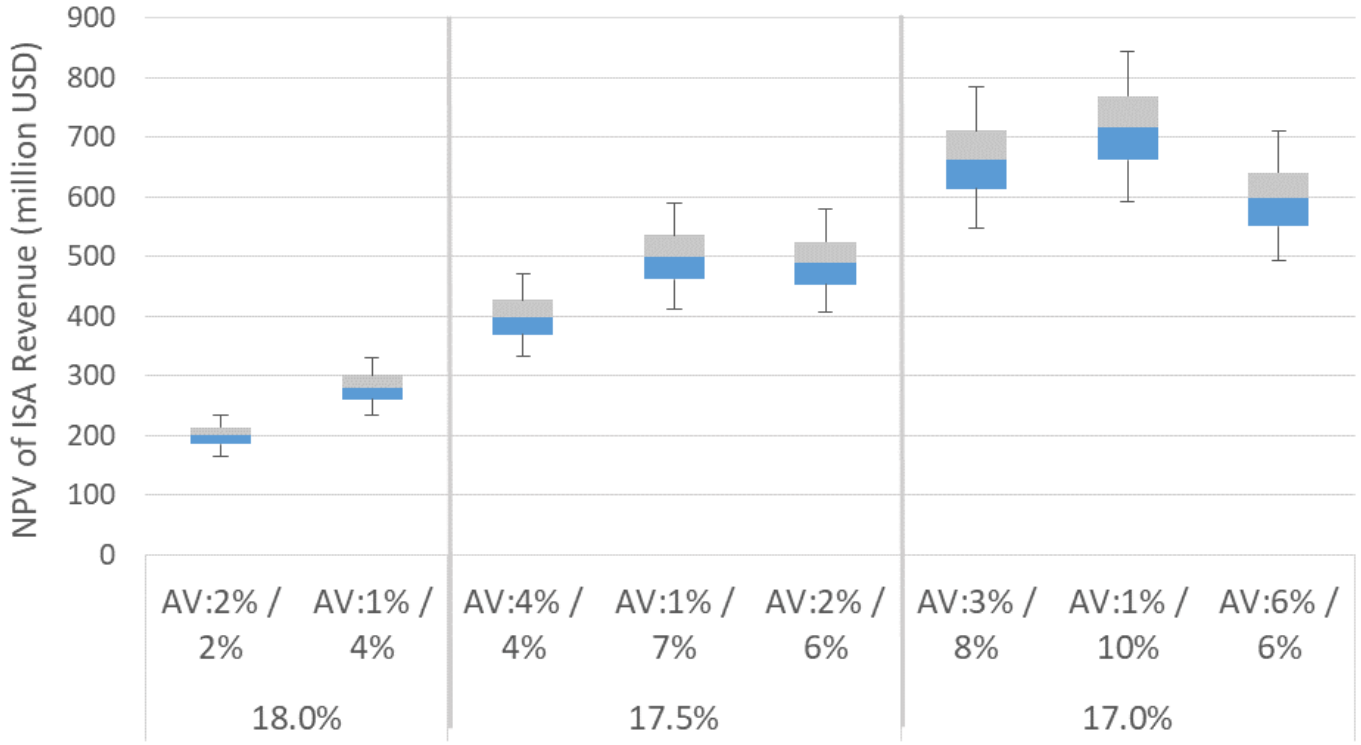




Ad-valorem: Options within a group provide similar returns, but…



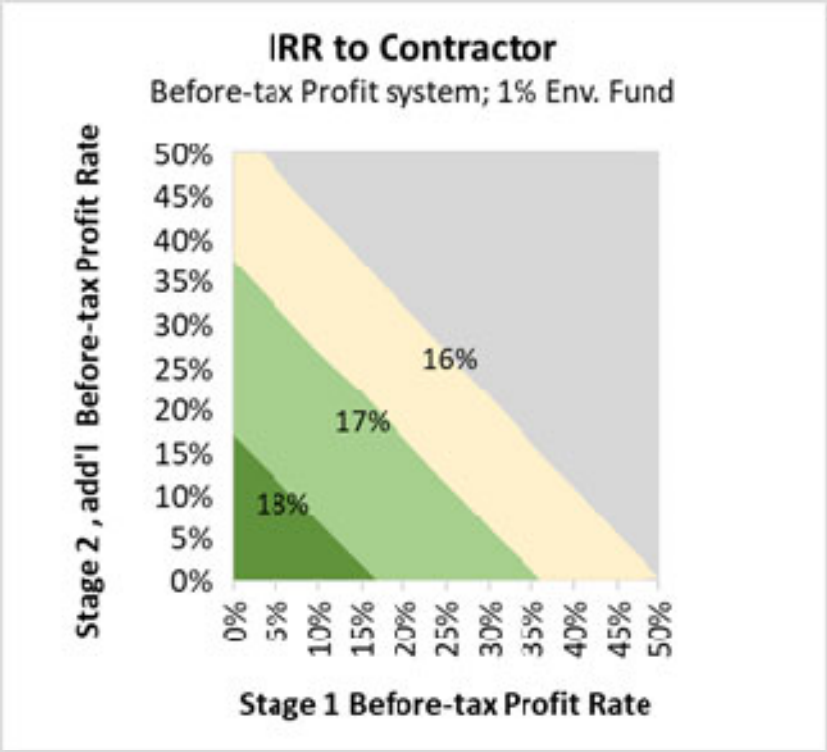
Ad-valorem: Options within a group provide similar returns, but not the same revenue to the ISA

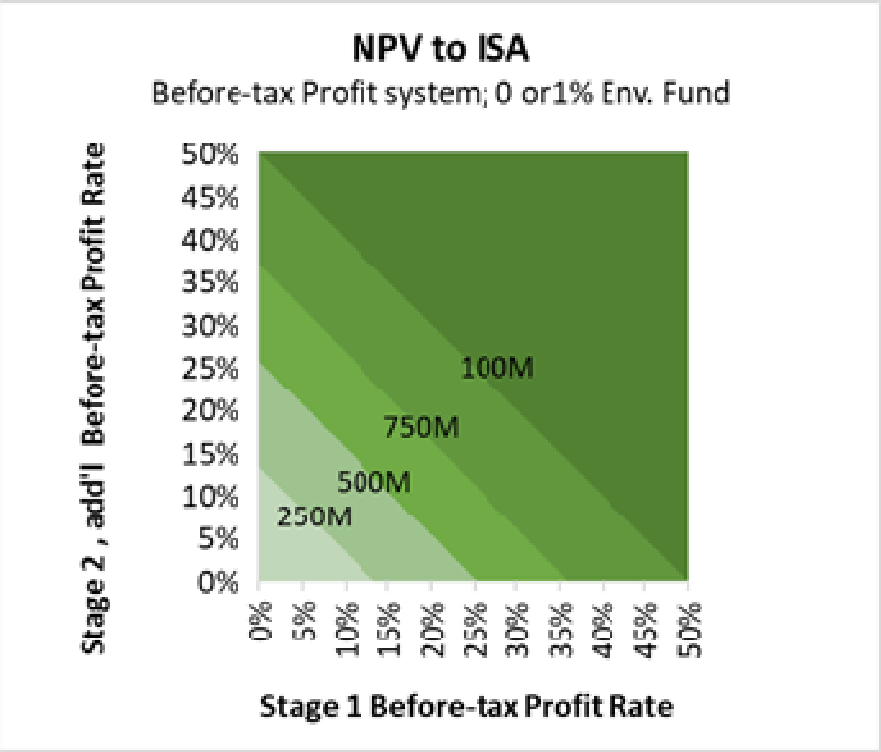


Profit-based Systems

- Basis of rate:
  - Net operating revenue including any fees paid to ISA
    - Collector's revenue minus operating costs (including capital carryover charges) and fees paid to the ISA
    - Capital carryover is a deduction for investments made in years prior to revenue
  - Referred to as Net Operating Revenue (including fees) for the collector ($NORif_c$)
- Two stages of rates
  - Allows ISA to maximize revenue while providing a target return to the contractor
    - Early revenues are more valuable to contractors than to ISA
  - Set at five (5) years, approximately when contractors begin to make a net annual profit (3-6 years)
- We only explore in detail profit based systems when Stage 1 rate = 0
  - All profit-based systems provide little revenue to ISA in the first five years of mine operation
- Scope of screening rate
  - Stage 1: 0% to 10% of GMV
  - Stage 2: Plus additional 0% to 10% of GMV (Stage 2 rate = Stage 1 + Stage 2 add'l)

Profit-based Systems: Screening of a Range of Rates



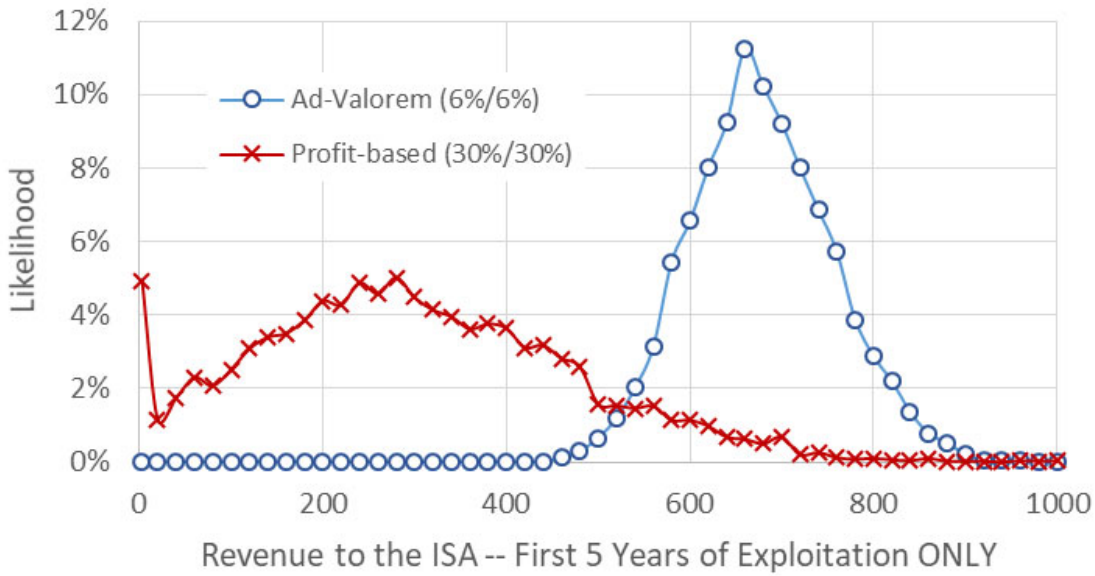


Profit-based Systems:
Several alternatives chosen for detailed analysis

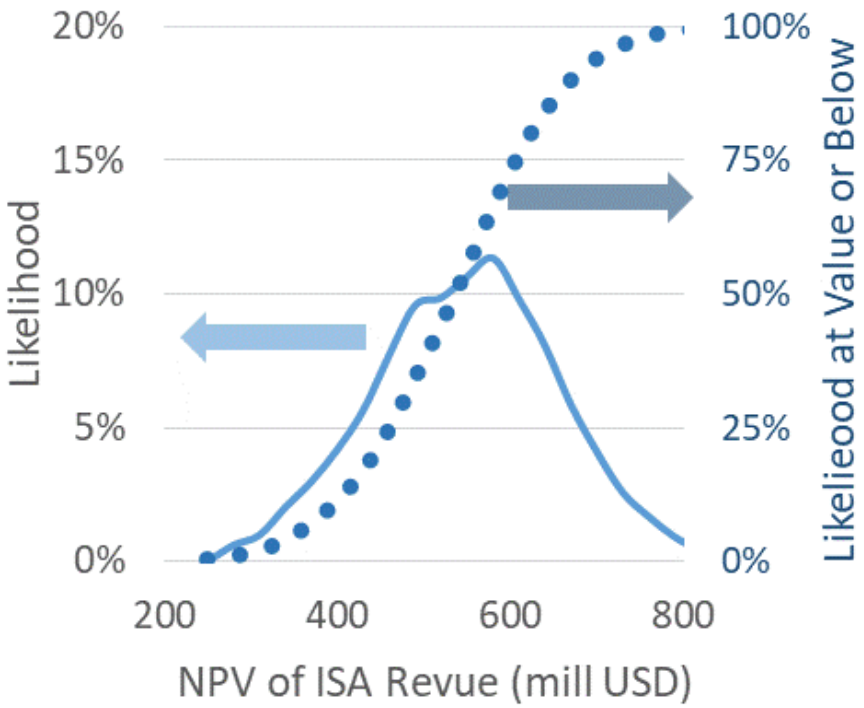
System	Initial Rate	Stage 2 Rate	Collector IRR	ISA NPV	ISA Share	Sponsoring State Share	Other Share	Collector Share	ISA Share (%)	Sponsoring State Share (%)	Other Share (%)	Collector Share (%)
PB0% / PB17.5%	0%	17.5%	18%	337	3,028	3,620	500	10,861	17%	20%	3%	60%
PB0% / PB25%	0%	25%	17.7%	483	4,338	3,308	500	9,923	24%	18%	3%	55%
PB0% / PB27.5%	0%	27.5%	17.6%	535	4,802	3,223	500	9,668	27%	18%	3%	54%
PB0% / PB37.5%	0%	37.5%	17%	726	6,517	2,773	500	8,319	36%	15%	3%	46%

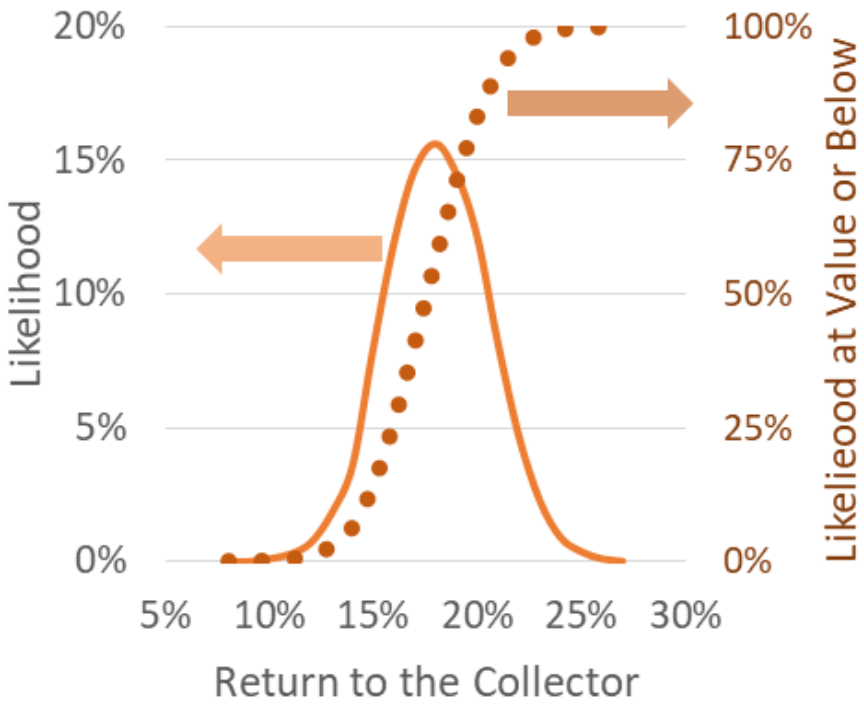
Note: Profit-based only systems provide little revenue to the ISA in early years

- Model assumes that contractors can deduct the cost of upfront investments against early year profits.
- Therefore, early year profits are small or zero

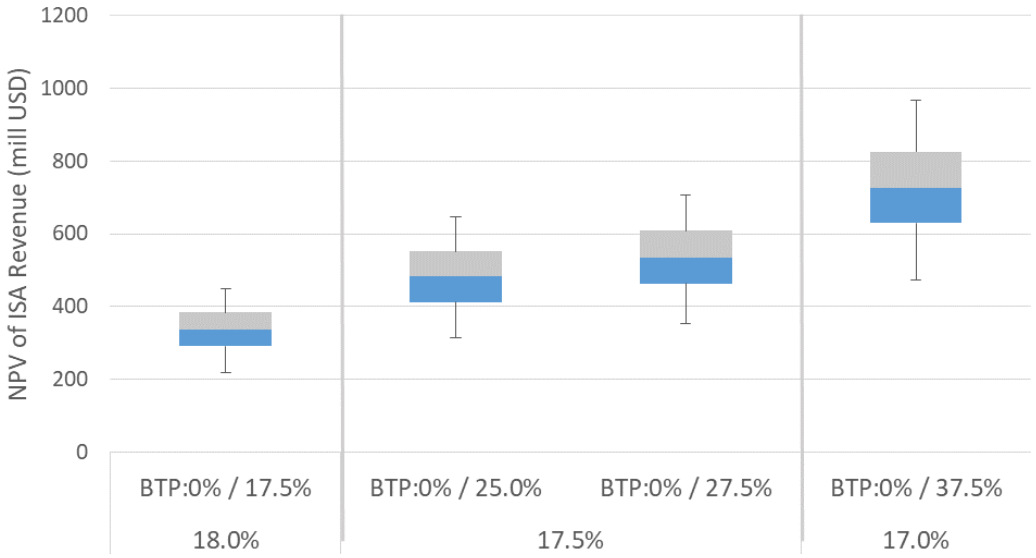


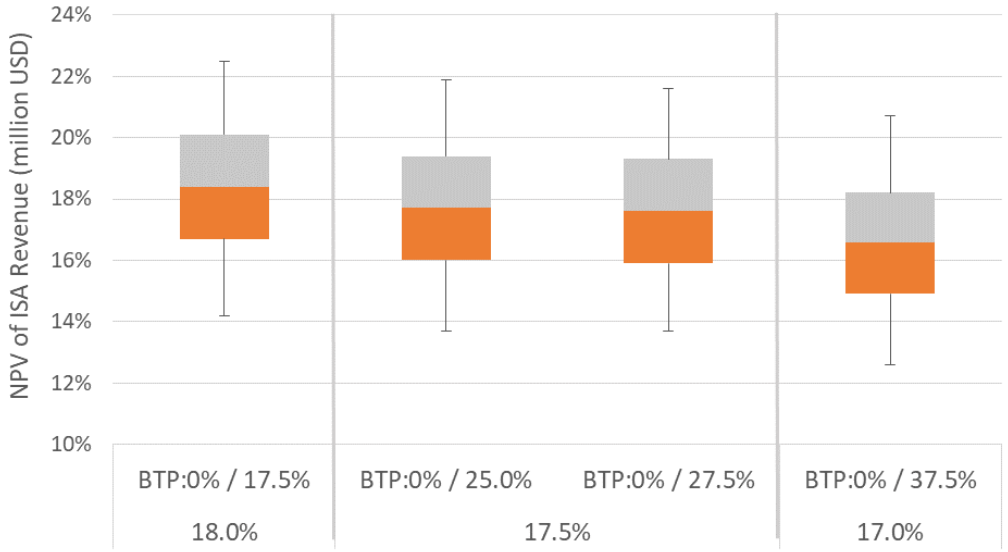
Each **selected** alternative stem was analyzed using Monte Carlo simulation: Example Profit-based 0%→ 27.5%





Profit-based Systems: Alternatives straightforward, higher rate, higher ISA NPV, lower contractor IRR



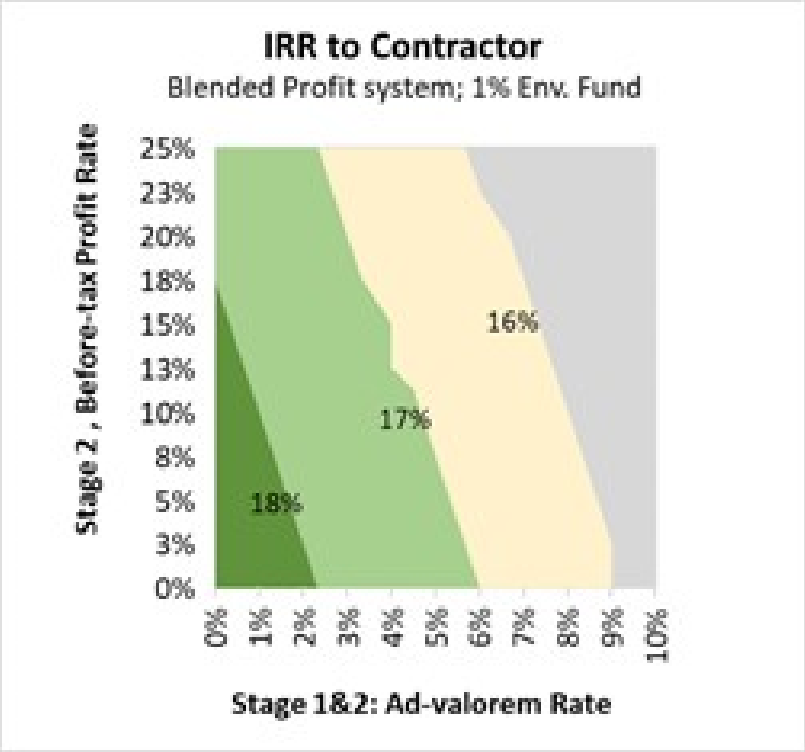


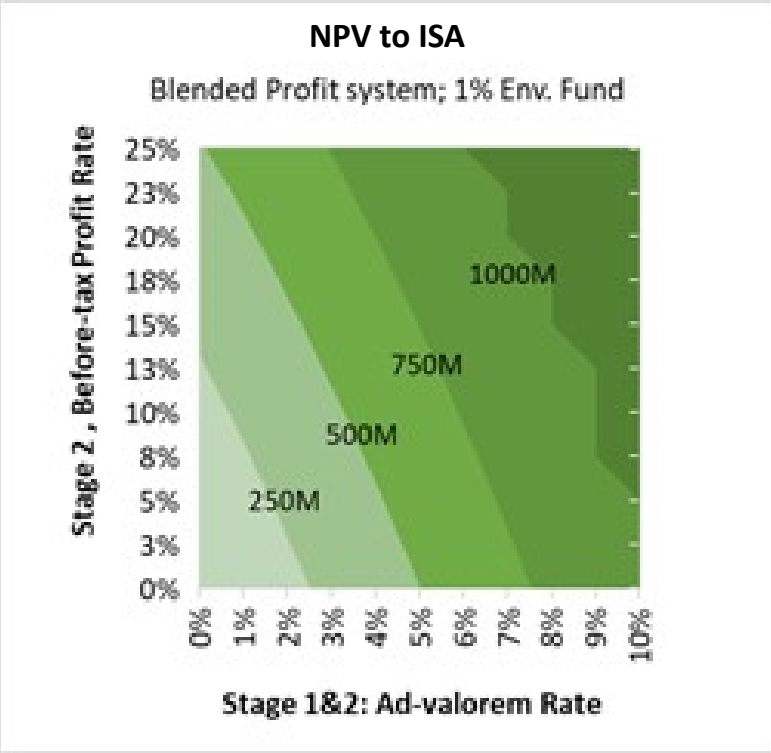
Blended systems

- Combine
  - Ad-valorem rate that begins in Stage 1 and continues in Stage 2
  - Profit-based rate that begins in Stage 2
- Stage 2 begins after 5 years of mine operation

- Scope of screening rates
  - Stage 1&2: 0% to 10% gross metal value collected
  - Stage 2 only: plus an additional 0% to 50% of NOR

Blended Systems:
Screening of a Range of Rates

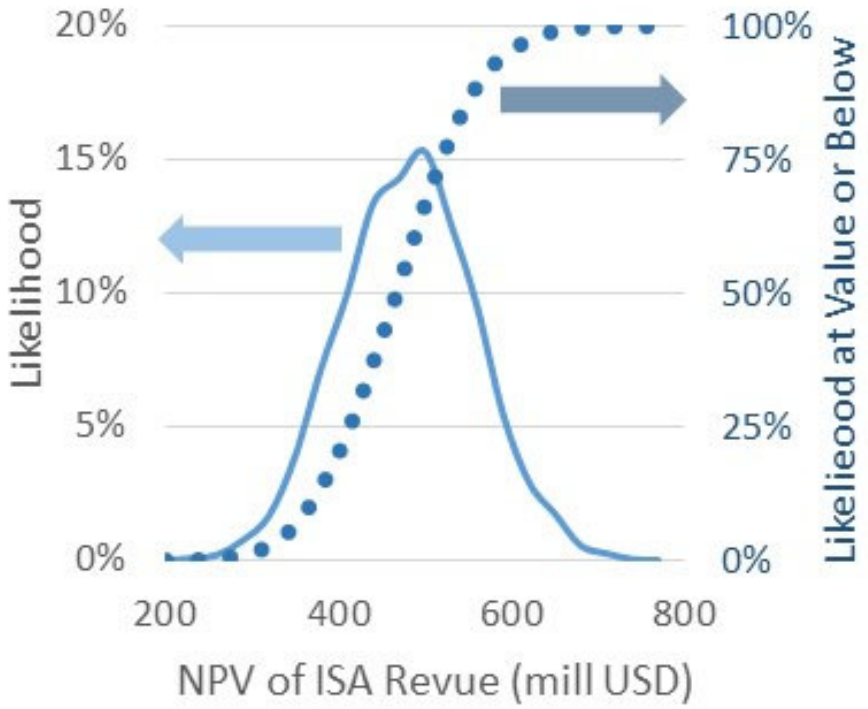




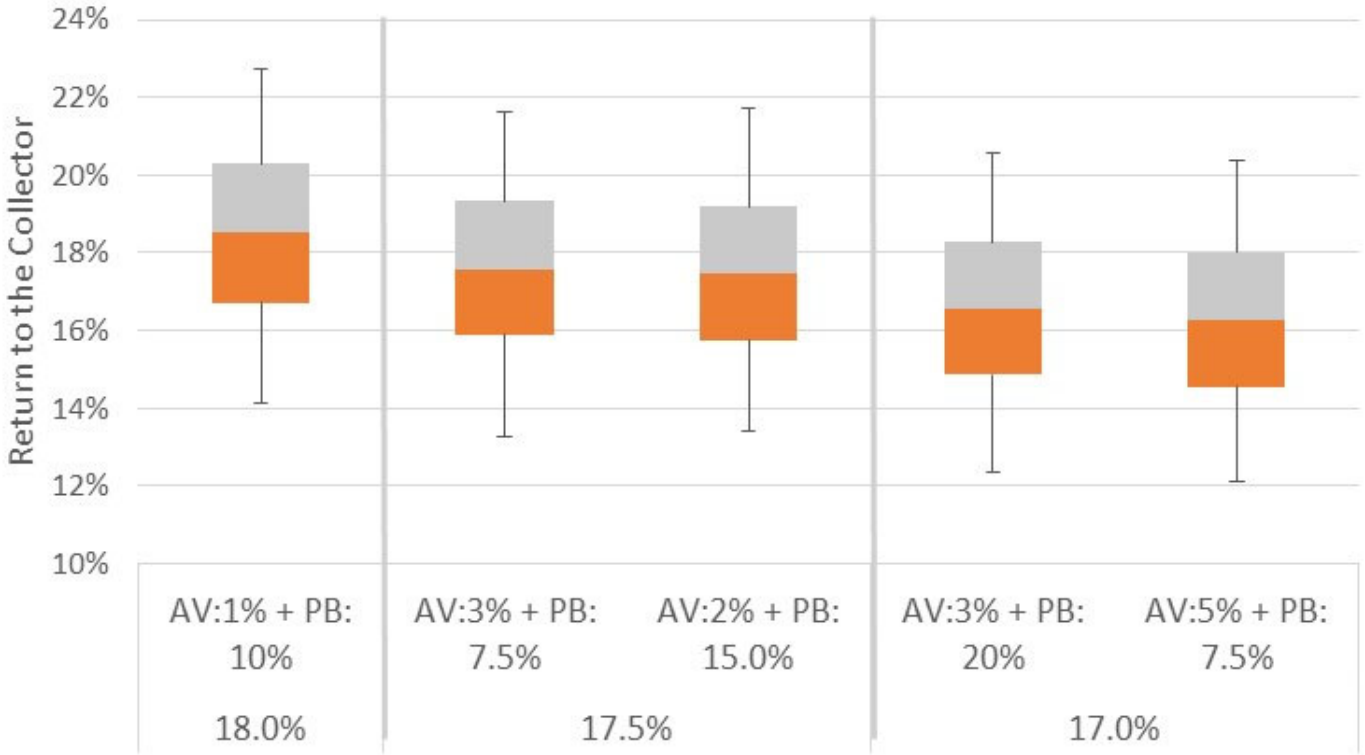
Blended Systems:
Several alternatives chosen for detailed analysis

System	Initial Rate	Stage 2 Rate	Collector IRR	ISA NPV	ISA Share	Sponsoring State Share	Other Share	Collector Share	ISA Share (%)	Sponsoring State Share (%)	Other Share (%)	Collector Share (%)
AV1% + PB10%	1%	10%	18.5%	286	2,393	3,815	500	11,379	13%	21%	3%	63%
AV2% + PB15%	2%	15%	17.5%	467	3,847	3,464	500	10,258	21%	19%	3%	57%
AV3% + PB7.5%	3%	7.5%	17.5%	427	3,312	3,620	500	10,659	18%	20%	3%	59%
AV3% + PB20%	3%	20%	16.5%	644	5,259	3,146	500	9,237	29%	17%	3%	51%
AV5% + PB7.5%	5%	7.5%	16.3%	615	4,652	3,321	500	9,621	26%	18%	3%	53%

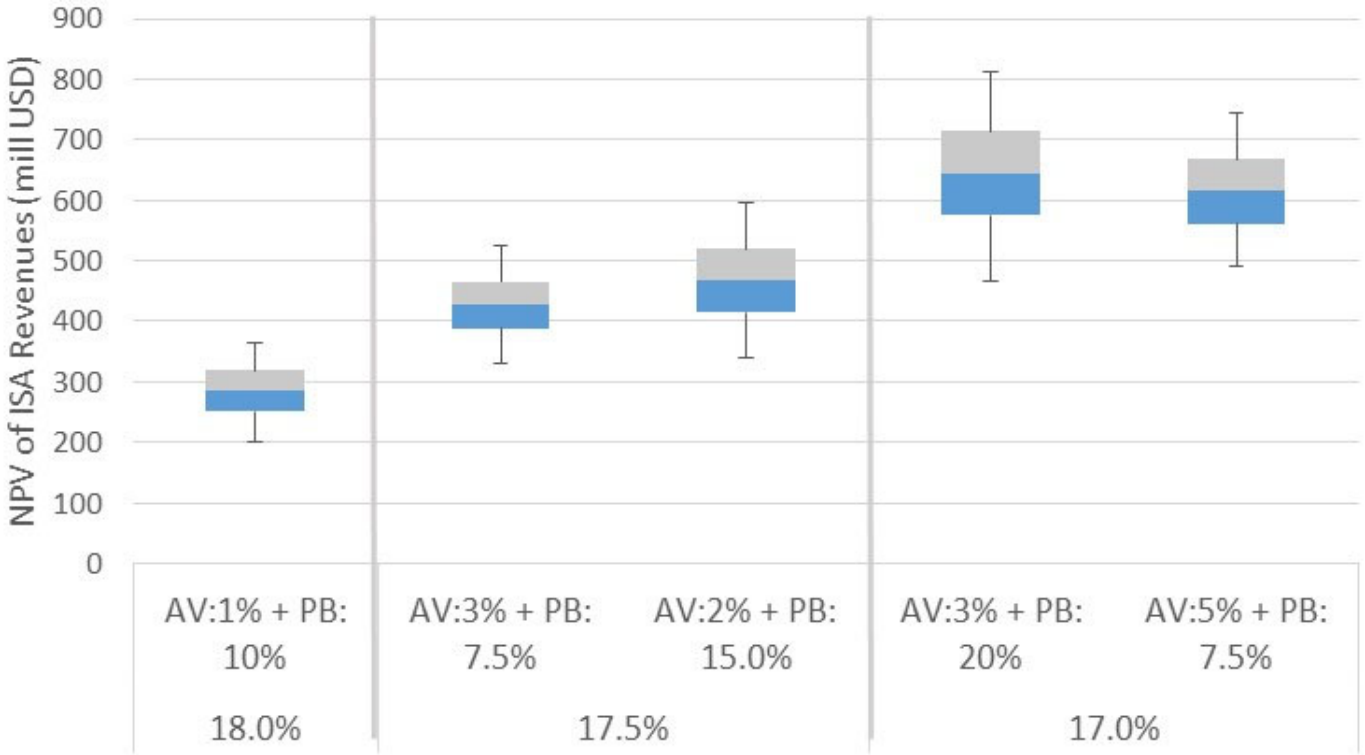
Each **selected** alternative stem was analyzed using Monte Carlo simulation: Example Blend AV2% + Profit15%



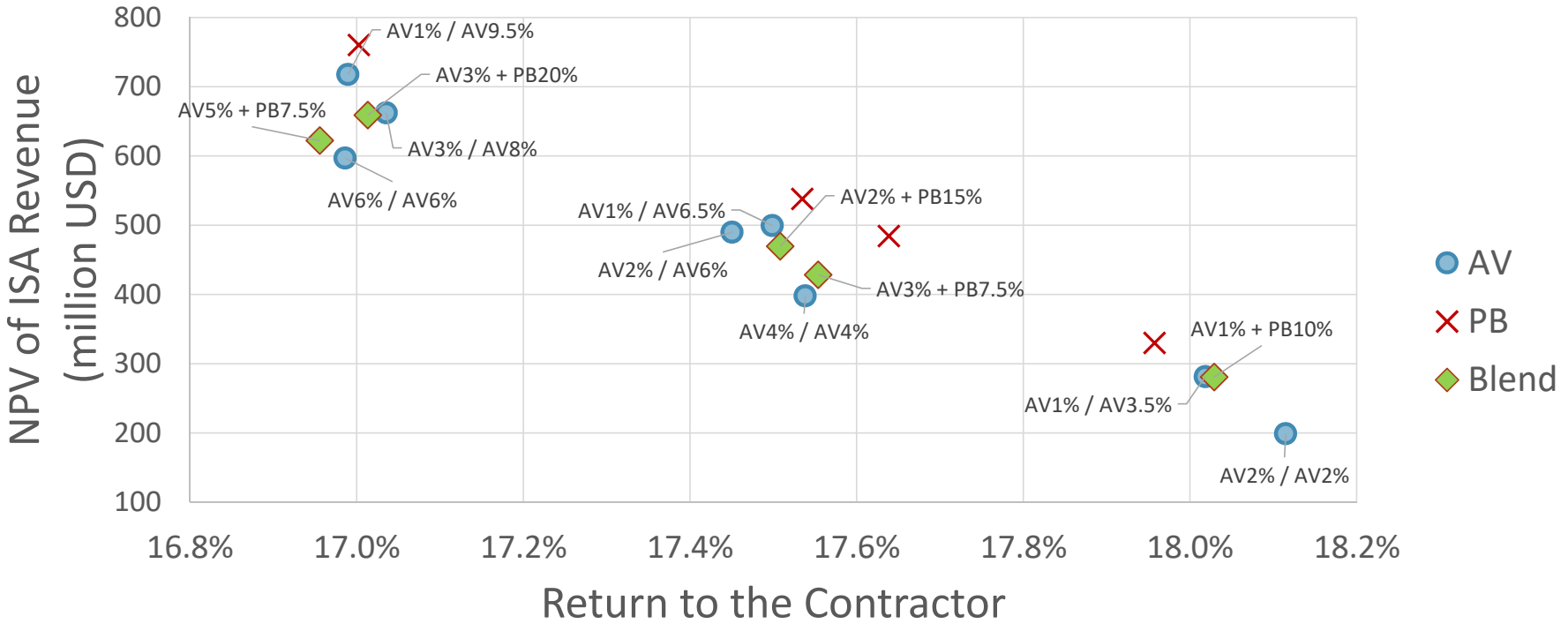
Blended Systems: Options within a group provide similar returns, but…



Blended systems: Options within a group provide similar returns, but not the same revenue to the ISA

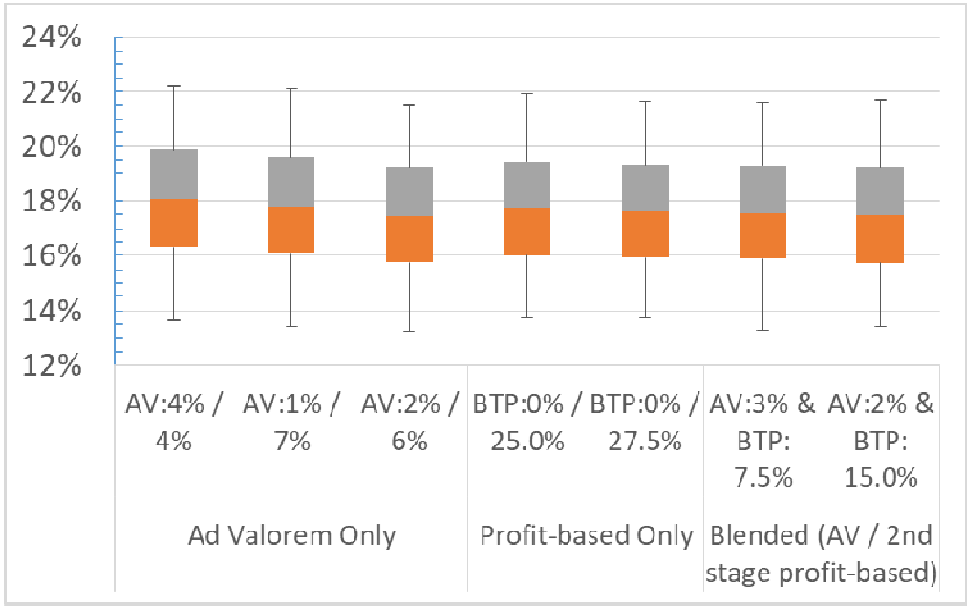


Even though systems provide similar return, they can yield 25% differences in ISA NPV

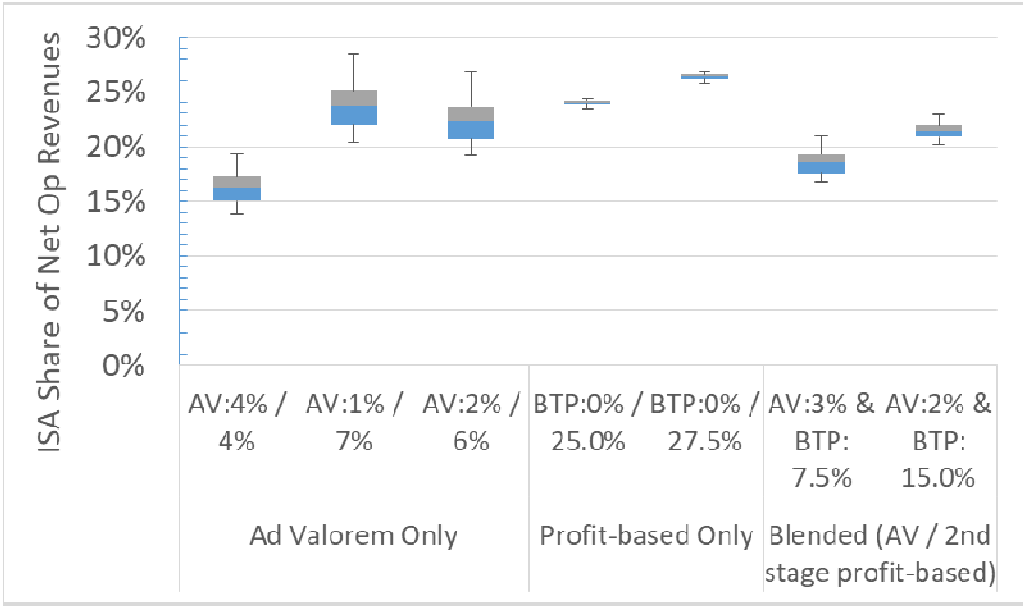


Consider these seven systems that provide a return of approximately 17.5%

- IRR Values are Similar for All Seven



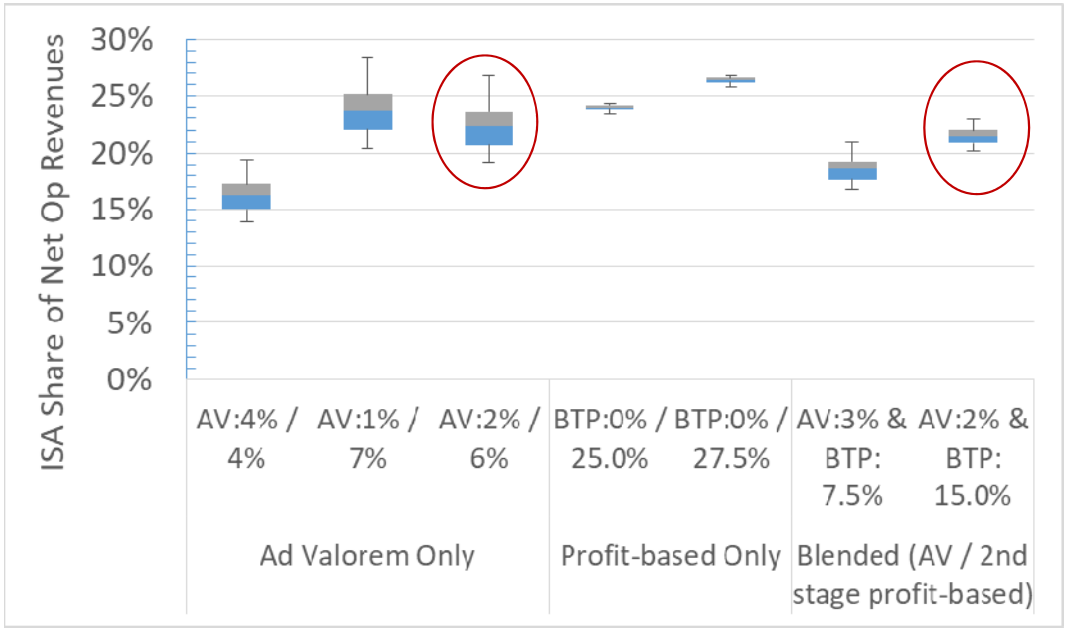
- HOWEVER …
  ISA Share of Revenues Varies



Profit-based Only Systems Can Provide Attractive ISA NPV, BUT They Generate 0 revenue for 5 years

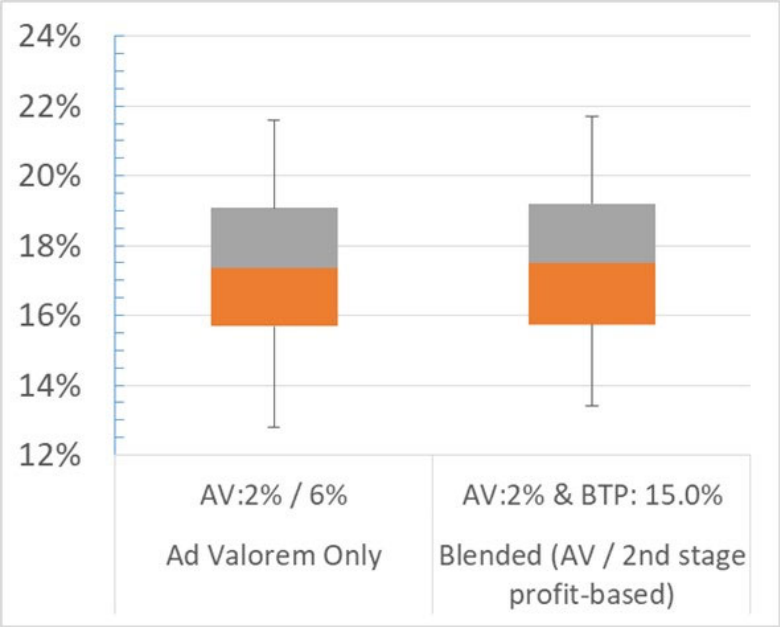
- Profit-based only systems can generate the highest revenues for the ISA at a given return to the contractor

  but…
- They generate NO revenue for ISA for the first five years
- So, we are not going to consider them further
- Let's look more closely at two systems
  - Ad-valorem only: 2% → 6% in yr 5
  - Blended:
    - Ad-valorem 2%
    - Profit-based levy of 15% beginning in yr 5

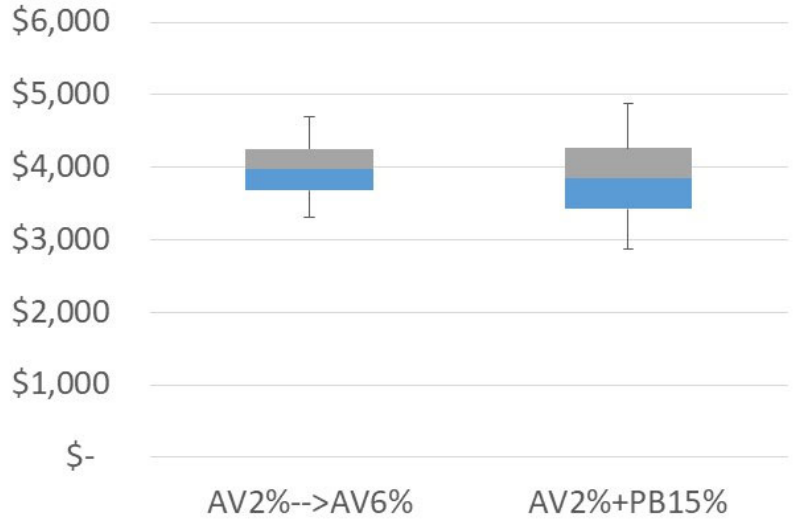


Comparing Two Systems that Yield 17.5% Return

Share of Operating Net Revenues
Ad-valorem: 2% → 6% in yr 5

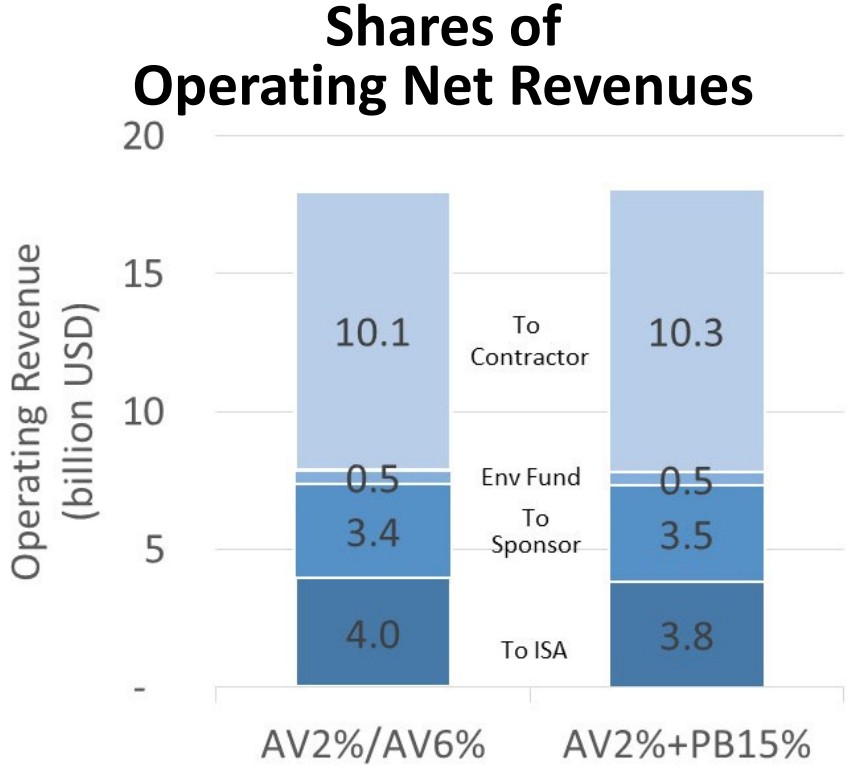


Share of Operating Net Revenues
Blended: AV2% + 15% profit-based in yr5



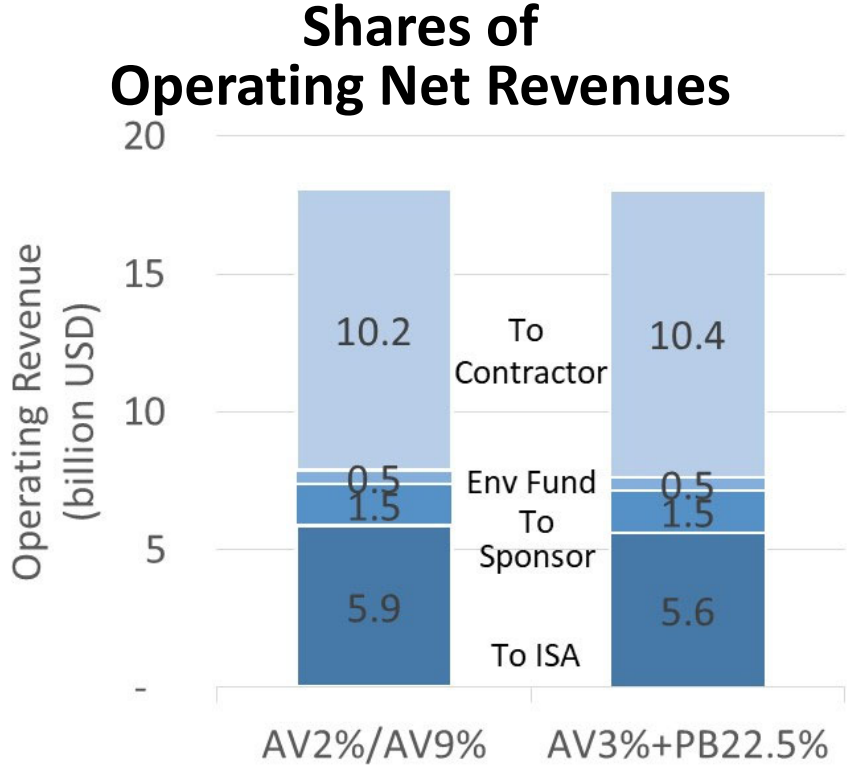
These Two Systems Yield Similar Distributions of Revenue Among Stakeholders

- Over the life of the license, both AV2%→AV6% and AV2%+PB15% yield approximately
  - $4 billion to ISA (22%)
  - $3.5 billion to sponsoring state (19%)
  - $10 billion to contractor (57%)
  - Also, $0.5 billion into environment/sustainability fund
- Note the role of the sponsoring state tax on revenue distribution

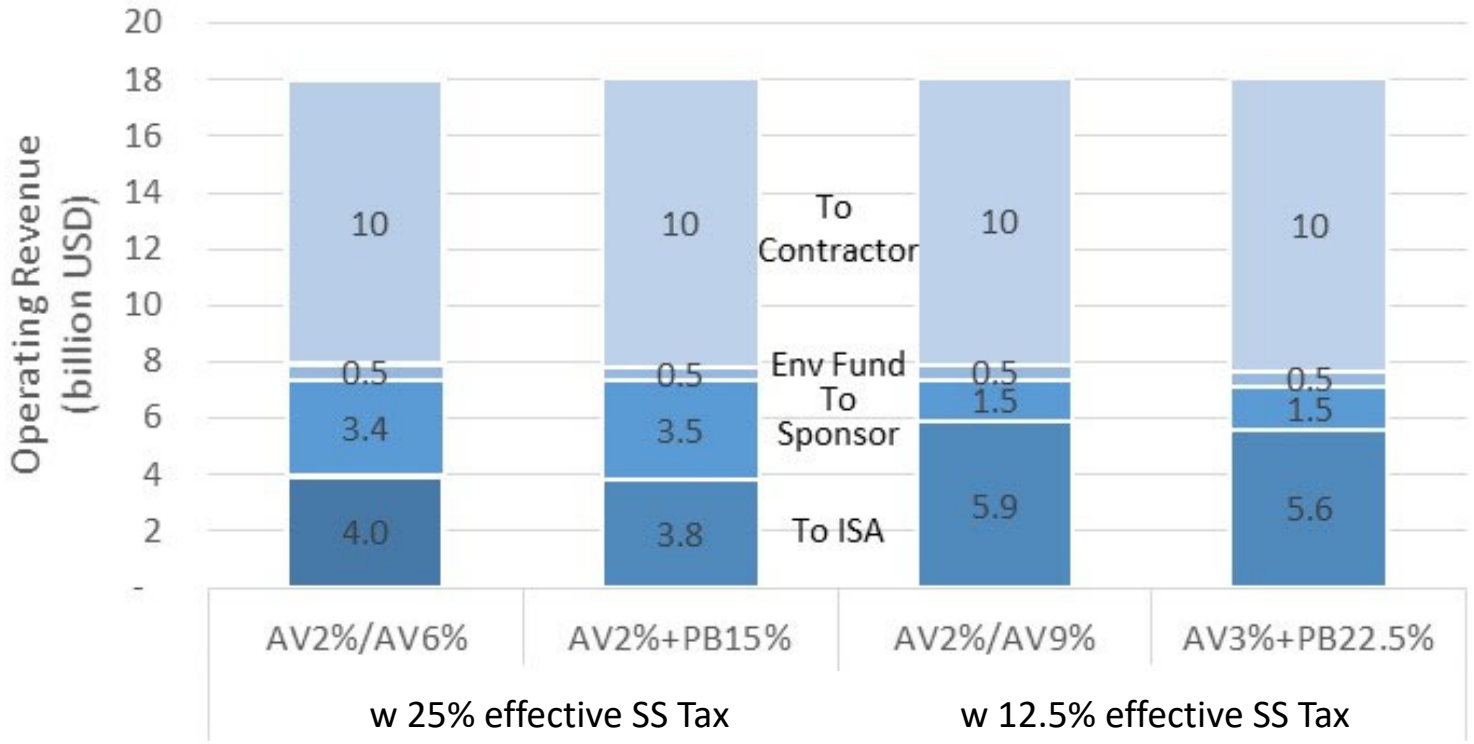


A Lower Sponsoring State Rate Translates to Higher Revenue Opportunity for ISA

- Over the life of the license, both AV2%→AV9% and AV3%+PB22.5% yield approximately
  - $5.5-6 billion to ISA (33%)
  - $1.5 billion to sponsoring state (8%)
  - $10 billion to contractor (57%)
  - Also, $0.5 billion into environment/sustainability fund
- If effective sponsoring state tax rate were reduced (perhaps if ISA royalties were creditable), the ISA could capture a larger share of revenue



A Lower Effective Sponsoring State Rate (perhaps through credits) Translates to Higher Revenue Opportunity for ISA



Balancing both total revenue and early stage revenue to the ISA, we recommend the LTC to consider the following options

- Generally, the ad-valorem only systems generate slightly higher revenues but they do not provide a guard against costs being lower than expected

Return to Contractor	System	ISA NPV	Cumulative ISA Revenue	Share to Contractor
17%	AV3%→ AV8%	$660	$5,300	51%
	AV3% + PB20%	$640	$5,300	51%
17.5%	AV2%→ AV6%	$490	$4,000	56%
	AV2% + PB15%	$470	$3,850	57%
18%	AV1%→ AV3.5%	$280	$2,300	63%
	AV1% + PB10%	$285	$2,400	63%

* All of these values assume 1% to Environmental Fund and 25% sponsoring state tax rate

Future work

- Additional
  - Payment mechanism forms
  - Sensitivities or scenarios
- Address Key Aspects of Revenue uncertainty
  - Dynamic of the Mn market
    - Will processing to metal significantly change the price of Mn metal?
    - At what premium / discount would outflows not processed to metal trade at relative to current Mn ore prices
  - Dynamic of the Ni market
    - Will the Ni market support two price levels: high-purity (in which nodule-derived metal would compete) and low purity
  - Dynamic of the Co market
    - Will the Co market support a price premium for non-conflict source material
- Impact of seabed mining on land-based mines particularly in developing nations
- Impact of tract abundance and variation on the economics of the contract
- Value of ecosystem services impacted by seabed mining
- Economics of other mineral resources (massive sulfides and cobalt-rich crusts)