Portfolios & Systematic Risk

Expected Return and Variance of a Portfolio

$$E(R)=\Sigma w_i E(r_i)$$
$$V(R)=\Sigma\Sigma w_i w_j Cov(r_i,r_j)$$

The Variance Contributed by Stock i

$$\Sigma w_j Cov(r_i,r_j) = Cov(r_i,\Sigma w_j r)$$
$$= Cov(r_i,r_m)$$

Portfolios & Systematic Risk

Stocks with *small* or *negative* covariances with the market:

1. **will reduce portfolio risk**
2. **will be demanded by investors.**

<u>*Systematic* risk determines value</u>

Residual Risk: Why it Does Not Affect Value

Return Model for Securities

Return on security i: $r_i=\alpha_i+\beta_i r_m+\varepsilon_i$

Return on security j: $r_j=\alpha_j+\beta_j r_m+\varepsilon_j$

$E(\varepsilon_i)=E(\varepsilon_j)=0,\ Cov(\varepsilon_i,\varepsilon_j)=0$

Expected Returns, Variances & Covariances

$$E(r_i)=\alpha_i+\beta_i E(r_m)$$

$$Var(r_i)=\beta_i^2 Var(r_m)+Var(\varepsilon_i)$$

$$Cov(r_i,r_j)=\beta_i\beta_j V(r_m)$$

Mean & Variance of Portfolio Returns

Form a Equally Weighted Portfolio of n Stocks

$$R=(1/n)\Sigma r_i=(1/n)\Sigma(\alpha_i+\beta_i r_m)+(1/n)\Sigma\varepsilon_i$$
$$Var(R)=(1/n)^2\Sigma\Sigma\beta_i\beta_j Var(r_m)+(1/n)^2\Sigma Var(\varepsilon_i)$$

Residual risk is "diversified away" in a portfolio. Therefore it has no effect on the cost of capital.

Calculating the Cost of Equity

Cost of equity=risk free rate+Risk premium

$$r_e = r_f + \beta\,(E(r_m) - r_f)$$

where r_f is the risk free rate, and $E(r_m)$ is the return on the market portfolio.

β is the measure of systematic risk

$$\beta = Cov(r_e, r_m)/Var(r_m)$$

Value of a Stock

large covariance with the market

implies

large Beta

implies

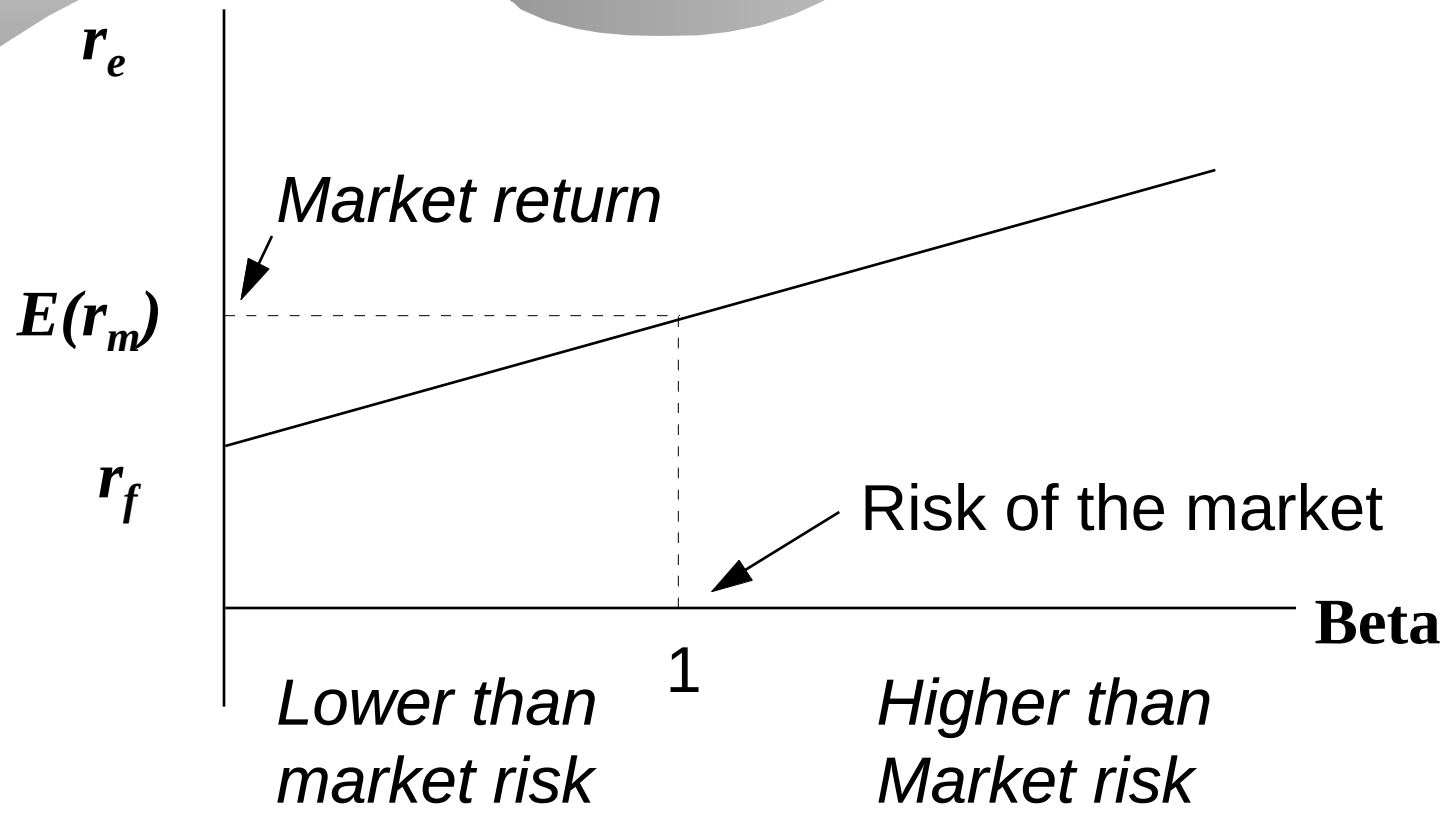
high cost of capital

implies

low stock price

Stock price= $\Sigma E(Cash\ Flow)/(1+r_i)^t$

Calculating the Cost of Equity



Some Betas

Company	***Beta***	***COC***
Grumman	0.617	<Market
Honeywell	1.045	=Market
Scientific-Atlanta	1.541	>Market
Cyprus Minerals	1.200	>Market
Ashland Coal	0.650	<Market
Intel Corp	1.435	>Market
Wisc Energy	0.565	<Market

Source ***Value Line, QuoteCom***

Application to lunar mining of Helium-3

How would a market for ^{3}He be organized?

What would be the cost of capital to a lunar mining company?

How much financing would be required?

Could the capital be raised?

Can D^{3}He fusion generated power compete?

Cost of Capital for a Lunar Mining Company

Residual Risk

Related to lunar mining operations

May be substantial

Can be diversified away in investor portfolios

Systematic Risk

Related to the sales of electricity

Should be comparable to fuel suppliers to electric utilities and aerospace companies

Cannot be diversified away in investor portfolios

Cost of Capital

Should be comparable to fuel suppliers and aerospace companies

D^3He Penetration in US Electricity Market

Year	Predicted % of US Energy Generated by DHe3 Fusion
2015	0.03%
2020	0.41%
2025	1.80%
2030	7.19%
2050	60.27%

From Thompson, Ott, Kulcinski "*Economic Analysis of the Use of Lunar Helium-3 as a Fuel in U.S. Energy Policy," Wisconsin Working Paper 3-90-5, 1990*

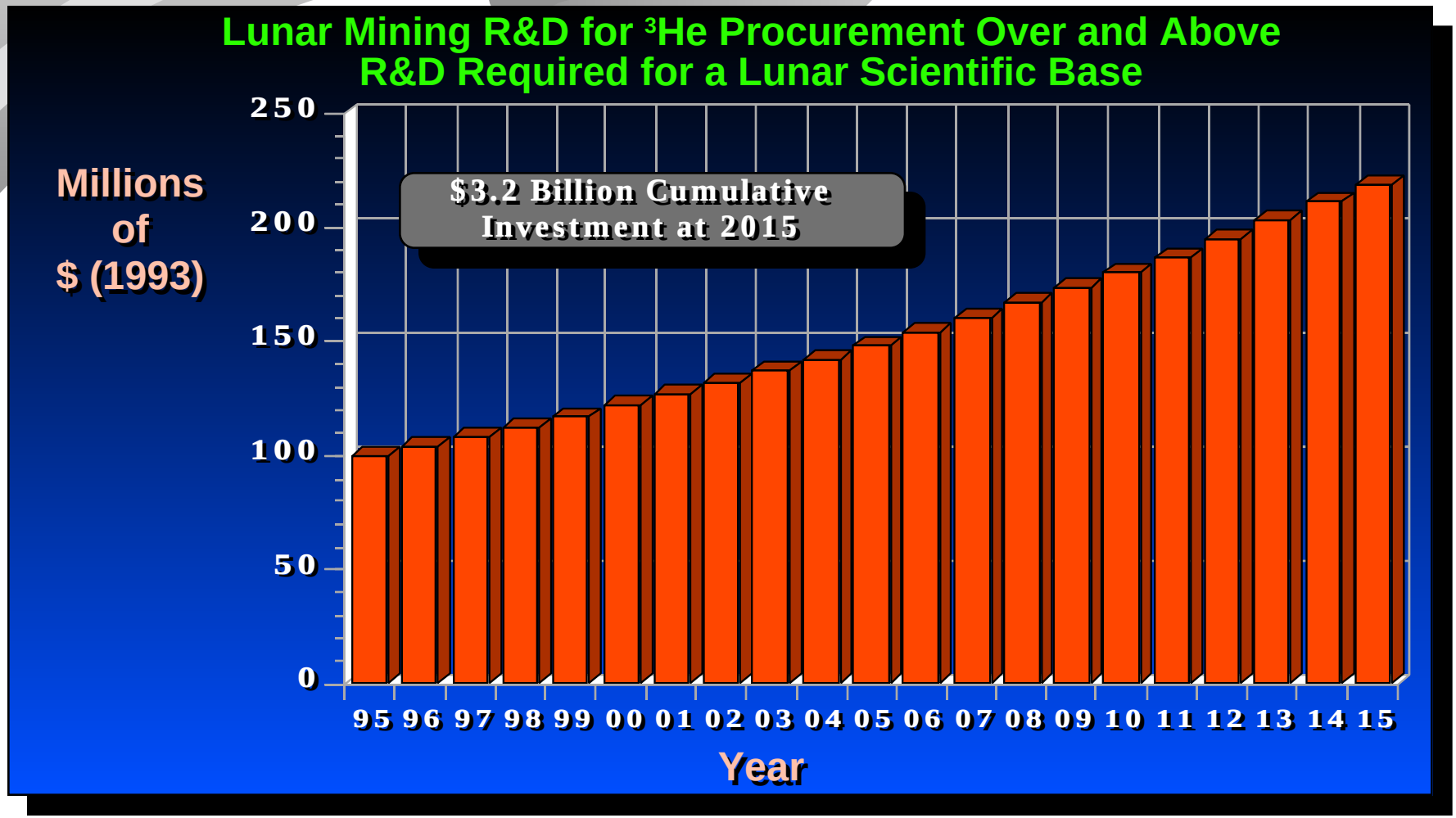
Financing the Lunar Mining Company: Production of ^3He

Projected Investment in Mining Machines

Year	*Mach.*	*Mach Invest*	*Launch Invest*	*Total Invest*
2015	**1**	**$ 10M**	**$ 50M**	**$ 60M**
2020	**10**	**$ 100M**	**$ 500M**	**$ 600M**
2025	**57**	**$ 570M**	**$ 2.,850M**	**$ 3,420M**
2030	**230**	**$ 2,300M**	**$11,500M**	**$13,800M**
2050	**2050**	**$20,500M**	**$102,500M**	**$123,000M**

Investment per miner-$10,000,000
Launch cost per miner $50,000,000

Financing the Lunar Mining Company: R&D



Private Financing of Large Projects Is Possible...

Some Large Projects

Investor (Year, Project)	***Size***
Globalstar (1996)	**$ 2.00B**
(Satellite Communications)	
General Electric (1986)	**$ 6.14B**
(Acquisition of RCA)	
KKR (1989)	**$26.4B**
(Takeover of RJR Nabisco)	

...But Large Losses Can be Devastating

<u>Orange County, CA (1994)</u>

~$1.7B loss on municipal investment pool

~Filed for reorganization under Chapter 9, Federal Bankruptcy Reform Act of 1978

<u>Barings Bank (1995)</u>

~Nicholas Leeson lost $1.3B on a derivative gamble

~Barings bank ceased to exist as an independent unit

Two Financing Plans

1. *Government finances R&D; private enterprise finances production*

2. *Private enterprise finances R&D and production*

--

Are they feasible?

❶ *Government-Private*

- ✓ ***Government*** *pays R&D 1996-2015 in return for the by-products of lunar mining after 2015.*
- ✓ ***Lunar mining Company*** *finances miner purchases, launches, and mining operations starting in 2015 and recovers ^{3}He. Supplies by-products to the government after 2015.*

❶ *Government-Private*

- ***Government***
  - *$3.2B spent between 1996 and 2015*
  - *Return on investment delayed until after 2015*
  - *Taxing power used to raise funds*
  - ***Maximum losses to taxpayers are small***
- ***Lunar Mining Co***
  - *No investment required until 2015*
  - *Return on investment begins in 2015 when ^{3}He is recovered and sold to electric utilities*
  - ***Minimum risks to investors***

❷ *Private Only*

- ✓ ***Lunar Mining Company***
  - *– finances R&D 1996-2015*
  - *– finances miners, launches, and production after 2015*
  - *– recovers and sells both ^{3}He and by-products*
- ✓ ***Government***
  - *– buys by-products from Lunar Mining Company after 2015*

❷ *Private Only*

- ***Lunar Mining Co***
  - *$3.2B investment 1996-2015 produces no return until 2015*
  - *^{3}He sales price must include R&D costs*
  - *Risks relating to by-product sales*
  - ***High risk venture with questionable profitability***
- ***Government***
  - *Smaller tax revenues needed 1996-2015*
  - *Moon bases must be supplied from earth with high cost launches*
  - ***Increased cost of space programs***

Government-Private

General Assumptions

- Scientific Base on the Moon Established by Government
- An Investor Owned Lunar Mining Company Exists
  - Holds a U.S. Franchise for Mining ^{3}He on the Moon
  - Responsible for Transport of Equipment to and ^{3}He from the Moon
  - Markets ^{3}He Fuel to Utilities
  - Is Financed Entirely with Equity Capital
  - Seeks to Earn a Return Commensurate with Risks
- Government Agencies Fund Lunar Mining R&D in Return for Free Volatile By-Products
- First ^{3}He Mining in 2015

Government-Private

Expenditure Categories Used to Analyze the Cost of ^{3}He

Operating Cost Categories

- Mining Equipment, Labor, and Habitat Costs
- Launch Costs
- Required Profits
- Income Taxes

Development Cost and Cost Offset Categories

- Research and Development Costs
- Cost Offsets from Volatiles

Government-Private

Assumptions Regarding Mining Operating Starting in 2015 (cost in 1993$)

Launch Costs	$1000/kg
Miner Mass	50 tonnes
Miner Economic Life	20 years
Miner Capacity	33 kg of ^{3}He/year/miner
Miner Purchase Price	$10,000,000
Labor Force on the Moon	3 persons/miner
Salary and Fringe Benefits	$500,000/person/year
Habitat and Consumables	820 kg/person/year
Miner Depreciation	Straight Line, 20 years
Miner Launch Cost Amortization	Straight Line, 20 years
Income Tax Rate	36%

❶ Government-Private

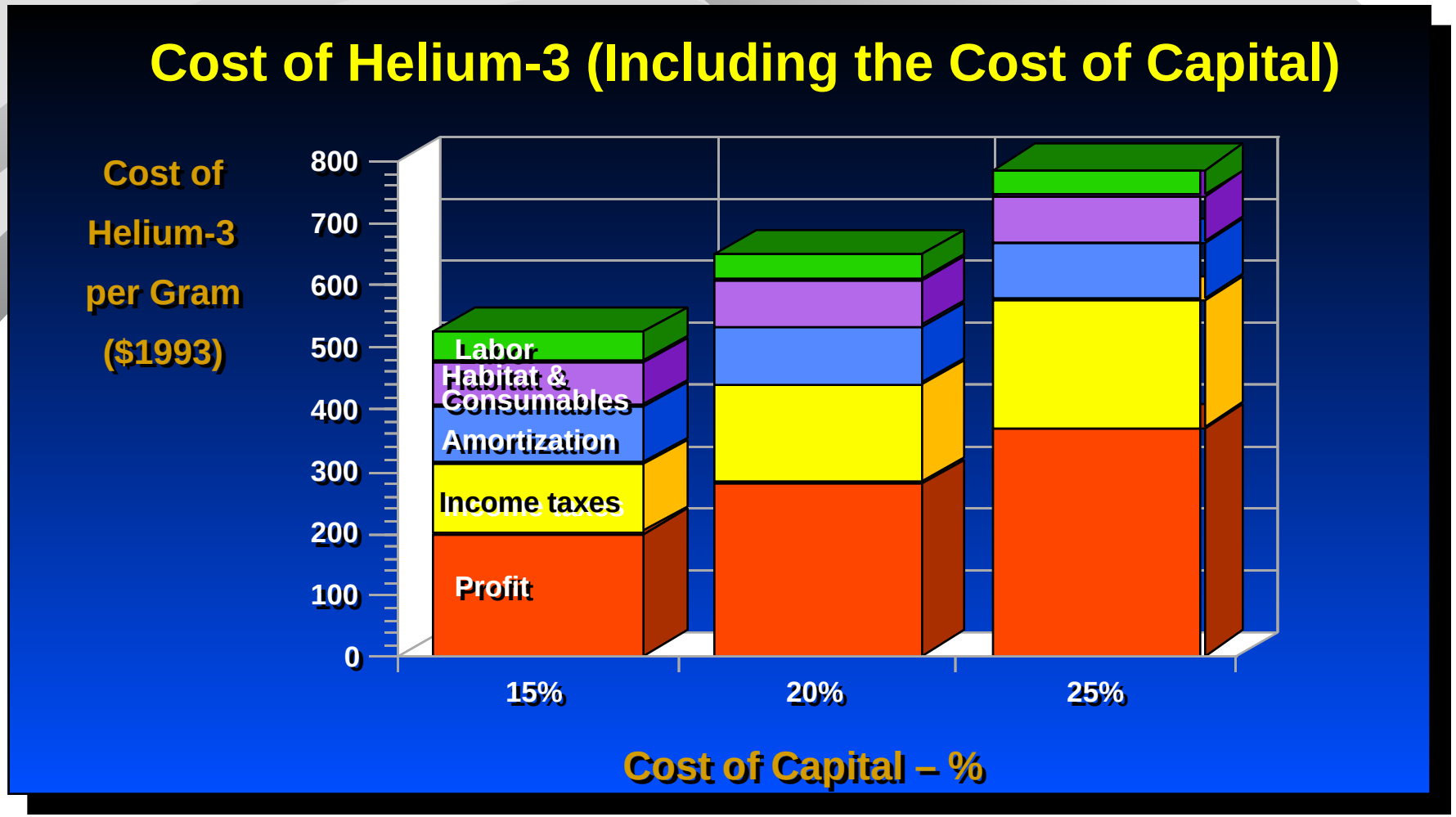
Yearly Required Revenue Per Miner

(Habitat+Labor+Profit+Taxes+Depreciation)

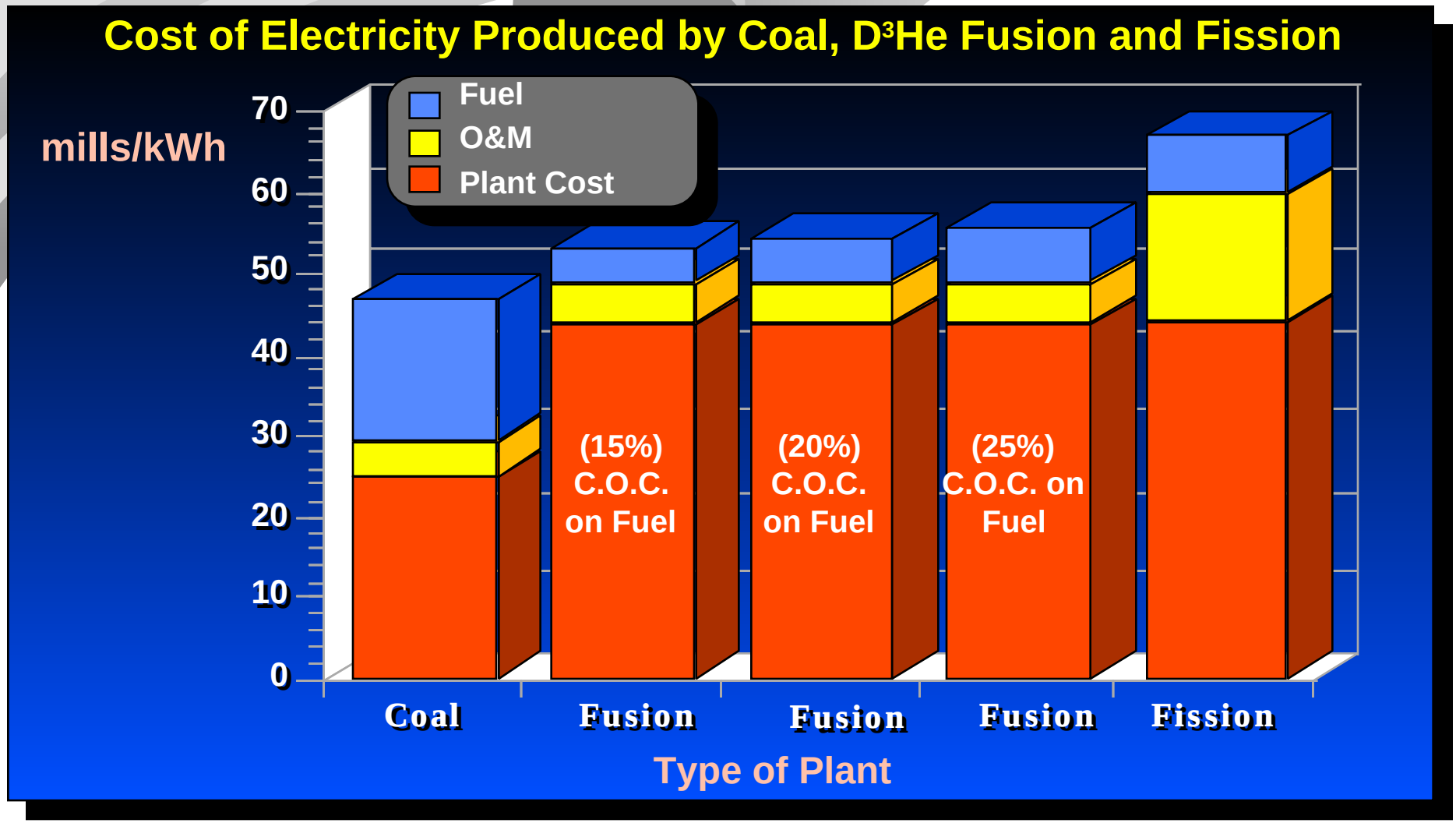
$$R = aH + aL + \left[\frac{L_m + M}{pvf} - D\right] + \frac{\tau}{1-\tau}\left[\frac{L_m + M}{pvf} - D\right] + D$$

H=habitat cost/person /yr, L=salary+fringe/person/yr, L_m=miner launch cost, M= miner initial cost, D= Yearly depreciation=$(L_m+M)/n$, n=miner life, τ= income tax rate, pvf=present value factor, a=Number of astronauts

❶ *Government-Private*



❶Government-Private



Sensitivity of Price of ^{3}He/g to Cost Elements

(15% Cost of Capital)

Launch Cost/kg	Price of ^{3}He/g
$1000	$523
$1500	$728
$2000	$933

Number of Astronauts	Price of ^{3}He/g
3	$523
6	$568
9	$613

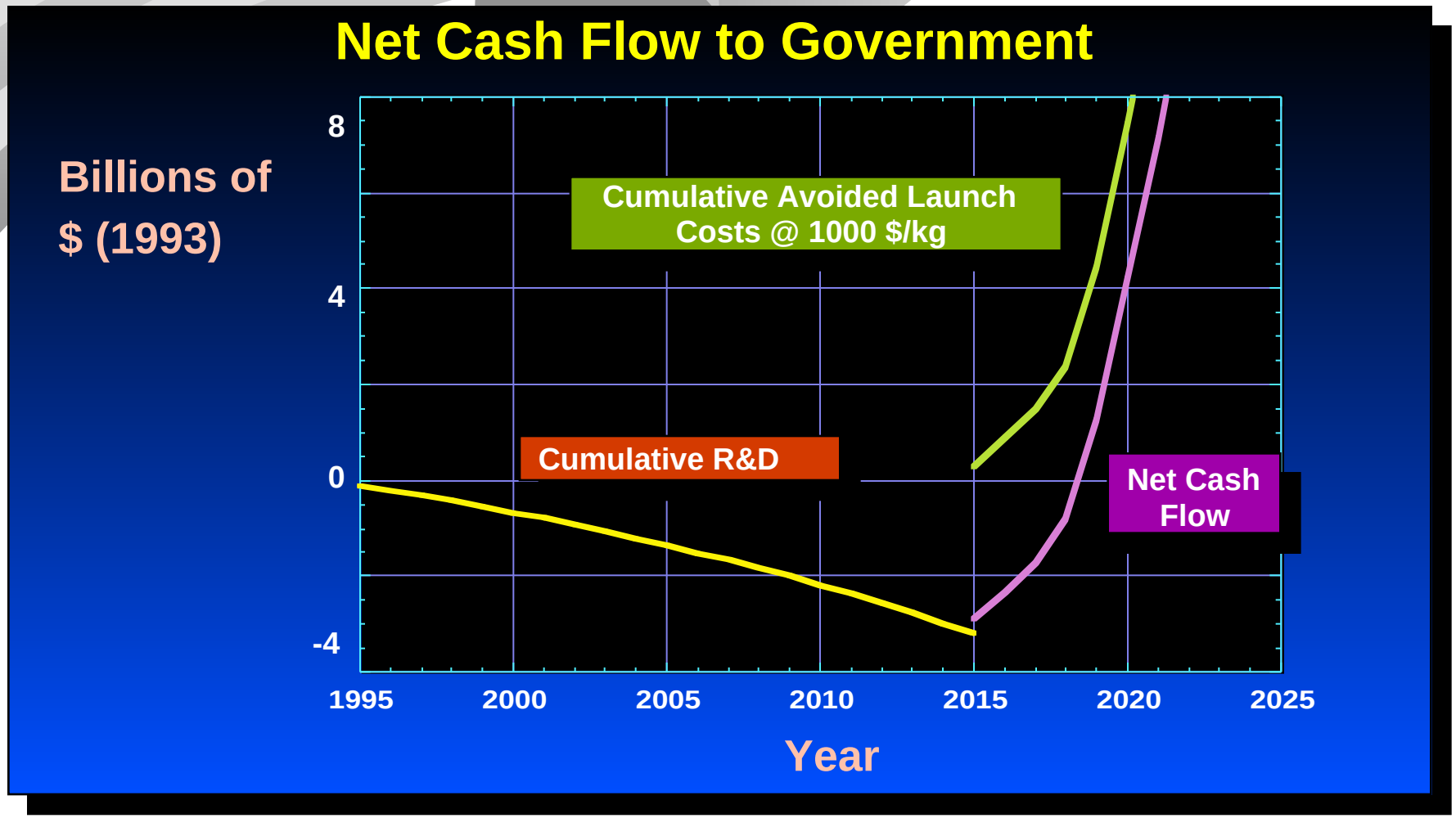
❶Government-Private

The Role of By-Products from ^{3}He Mining

- ✓ 18,200kg Volatile By-Products/kg ^{3}He
- ✓ 600,600kg of By-Products per miner per year
- ✓ Assume Government Uses 30% of the By-Products
- ✓ Launch Costs Saved per miner per year = $180,180,000

Year	Miners	Yearly Savings
2015	1	$ 180,000,000
2020	10	$ 1,180,000,000
2025	57	$10,270,260,000

❶*Government-Private*

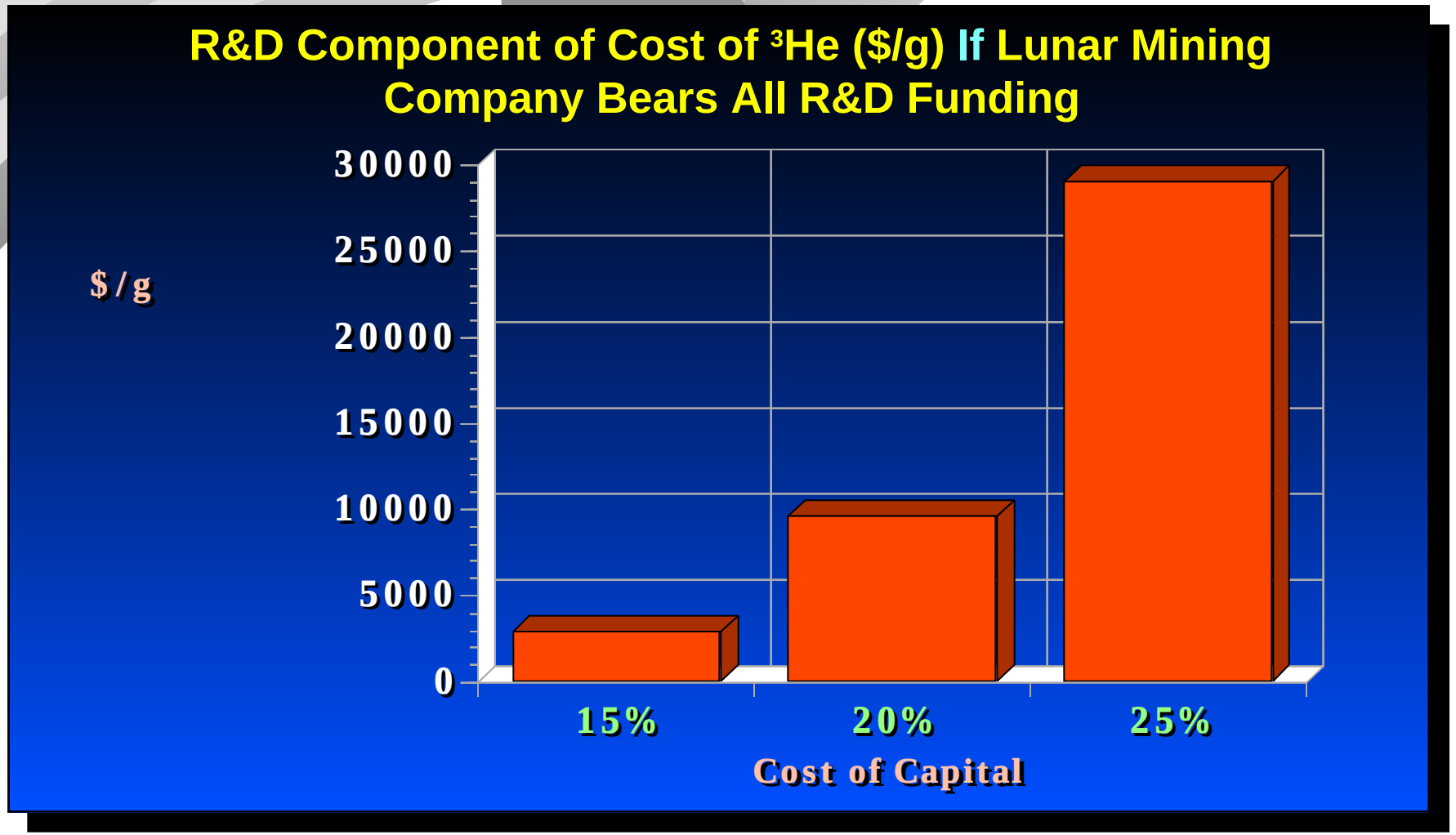


❶ *Government-Private*

Conclusions

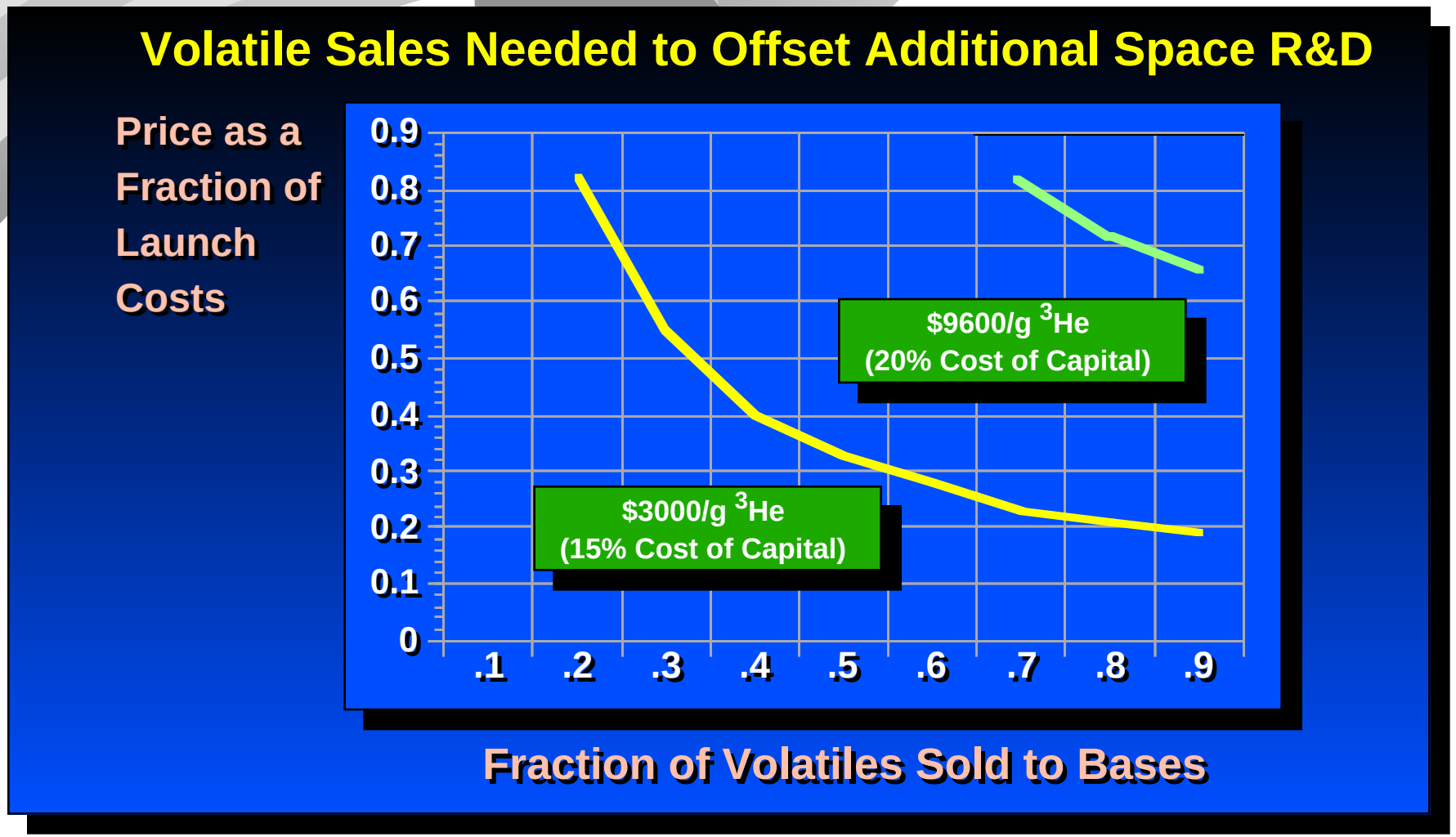
- **If the Government Funds all *Additional* Lunar Mining R&D**
  - **An adequate profit incentive for a Lunar Mining Company exists**
  - **The selling price to utilities will be between $500/gram and $800/gram**
  - **Electricity cost from ^{3}He fusion power plants will be competitive with coal and fission**
  - **The government will recover its R&D expenditures by 2020**
  - **The government will earn a substantial return (≈20%) on its investment**

❷ *Private Only*



❷Private Only

Volatile Sales Needed to Offset Additional Space R&D



Can the funds be raised for financing of the Lunar Mining Co., Inc.?

- *The key element is financing R&D*
  - *Funding amounts are large but manageable*
  - *Substantial risk for private investors*
    - *20 years of cash outlays beforea cash inflow*
    - *By-product sales needed to make ^{3}He competitive*
    - *Uncertainty of market for the by-products*
- *Government risks are minor in **government-private** undertaking*

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