Valuing Renewable Generation and Other Technology:

A Finance-Accounting Oriented Survey

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OVERVIEW: TRADITIONAL ELECTRICITY COST MODELS IN NO LONGER WORK

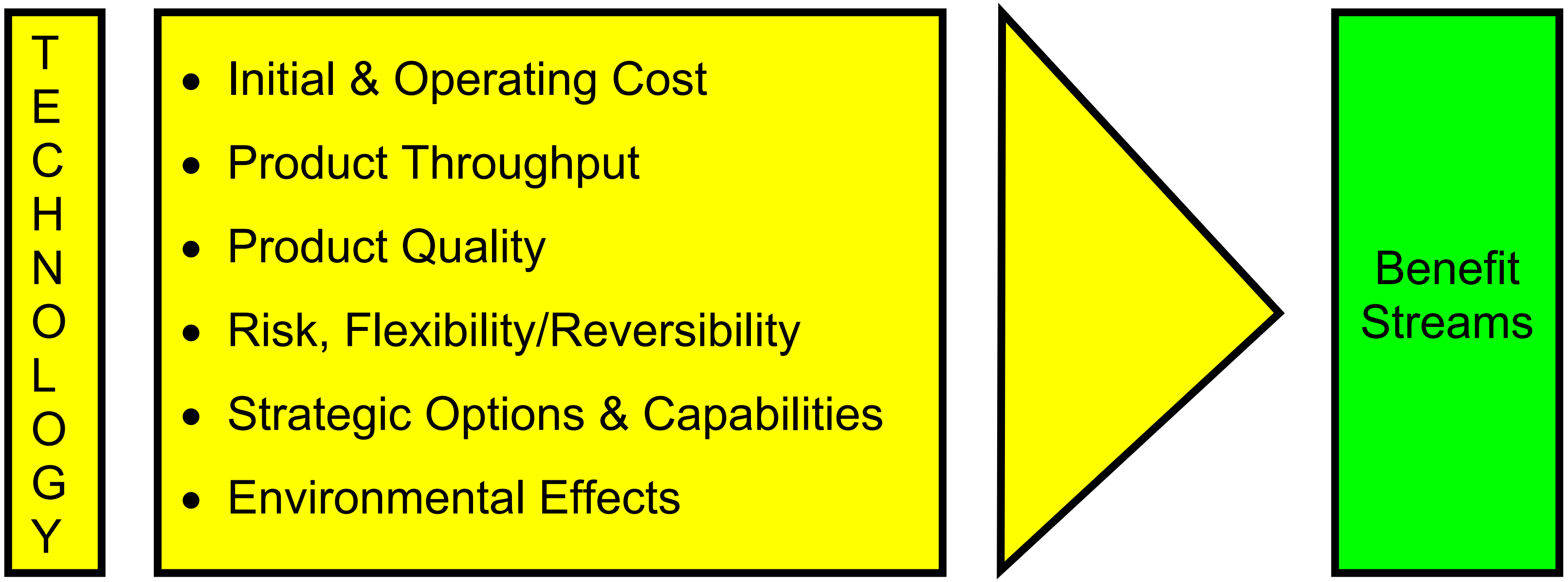
	Just as Investors Understand That….	Energy Planners/Policy Makers Must Also Recognize That….
Risk	**Expected returns (profits) cannot be separated from expected investment risks**	**A technology's cost, unadjusted for its market risk, is meaningless**
Portfolios	**A diversified portfolio is the only effective risk-hedging strategy**	**"Least-cost" analysis is no substitute for energy portfolio diversification**
Measurement	**Accounting profits are not a good predictor of a firm's future potential, strategic options and market share**	**"Least-cost" analysis does not capture all dimensions of a technology's cost and value**

PRINCIPAL ANALYTIC RESULTS– TWELVE YEARS OF RESEARCH IN THREE MINUTES:

- **Standard, finance-oriented valuation models show that the kWh-cost for most renewables is less than gas-fired electricity**
  - Reflects market risk and the effect of taxes
  - Excludes environmental externality, flexibility and other additional values
- **Adding renewables to a fossil generating portfolio *reduces* overall generating cost as well as risk**
  - This result derives from basic portfolio theory
  - Most renewables are *zero-beta* or "systematically riskless" assets
- **Experience in other industries suggests that exploitation of *broadly-applicable* technologies requires changes in organizations, supporting systems and infra-structure and can produce benefits not easily conceived in advance**
  - Renewables/DG: changes in network organization, regulation & pricing
  - Modernization focus: "Informated" networks
    - Basis for re-conceptualized electricity production/delivery system

Valuation in the Presence of Technological Change

EVALUATING NEW TECHNOLOGY
Technologies Provide a Bundle of Benefit-Cost Attributes



Most Attributes Have No Direct Accounting Measure

TRADITIONAL COST MODELS NO LONGER WORK:

Difficulty Conceptualizing/Quantifying Benefits and Reflecting Market Risk

- **Traditional Cost Models often fail to identify promising innovations**
  - Legacy of American Manufacturing:
    - Steel mini-mills, CAD, CIM, robotics…
- **They Were conceived in a different technological era**
  - Do not work well for DG/renewables and other passive, capital-intensive technologies– e.g. fax machines
- **They produce "rule-of-thumb" valuations that ignore taxes and risk differentials…**
  - But, fossil prices vary *systematically* – non-diversifiable risk
  - Costs of passive/capital-intensive renewables are systematically riskless
    - Financial properties mimic US Treasury obligations

Today's Cost & Value Measures Conceived in Context of 19th Century Organizations and Technology

- **Discounted Cash Flow (DCF) Formalized in the 1940's**
  - — Values Technologies/Processes Using Attributed Direct Cash Flows Only
    - – Ignores Overheads - Assumed Small, Not-Controllable
    - – Cannot Express *Quality*, *Strategic/Capability* Attributes
- **Cash-Flow Based Valuation (e.g. DCF) Conceived in an Era of *Active, Expense-Intensive* Technology**
  - — Machines 'Wear Out' With Use
    - – Costs Readily 'Matched' to Outputs by Accountants
    - – Low Capital/High Operating Costs
  - — Low Rates of Technological Progress
    - – Replace Machine When: Running $\text{Costs}_{\textbf{old}}$ > Total $\text{Costs}_{\textbf{new}}$
    - – Accounting Reasonably Serves This Purpose

Yesterday's Project Evaluation Techniques No Longer Work

- **Today's Technology Is Passive / Capital-Intensive / Infinitely-Durable**

  — Low Expense/High Capital Costs

  – Asset Replacement Not Driven by 'Wear & Tear'

  — Costs Not Readily 'Metered' -- 'Matching' Cost & Output Difficult

  — "Cost Saving" Largely Affects Overheads

  – Traditional Accounting Does Not 'See' Resulting Cost Reductions

How Do You Value A Fax Machine Using the Standard Accounting Model?

True Cost Drivers: The Limits of Our Accounting Vocabulary

- **Accounting Costs Differ from True Cost Drivers**
  - $/mile and FedEx
  - Is volume (kWh's) the only cost driver for electricity?

- **$/Unit Masks the True Cost of Activities**
  - Manufacturing— Activity-Based-Costing (ABC) demonstrated the cost of producing waste material and defective products
    - Identify waste and defectives as separate "outputs"
    - Showed that dirty processes which require subsequent cleanup are often more costly

$/kWh is an incomplete, Fordist Era measure that often ignores quality (including overhead reductions) and other attributes of renewables and other new technologies

TRADITIONAL COST APPROACHES NO LONGER WORK: THE LEGACY OF MANUFACTURING

- **Traditional accounting-based benefit-cost techniques fail to identify promising innovations**

- **These techniques have a dismal record for picking winners:**

1960's:	*Computers*	"Armies of Clerks are Cheaper"
1980's:	*Robotics*	"Human Workers are Cheaper"
1980's:	*CAD*	"Engineers Are Cheaper"

In each case, cash-flow based valuations failed to consider *Risk*, *Complementarities,* *New Capabilities* and *Strategic Options*

These same Techniques say Renewables are "Not Yet Cost-Effective"

TRADITIONAL COST APPROACHES NO LONGER WORK
EXAMPLE: VALUING COMPUTER-AIDED-DESIGN (CAD)

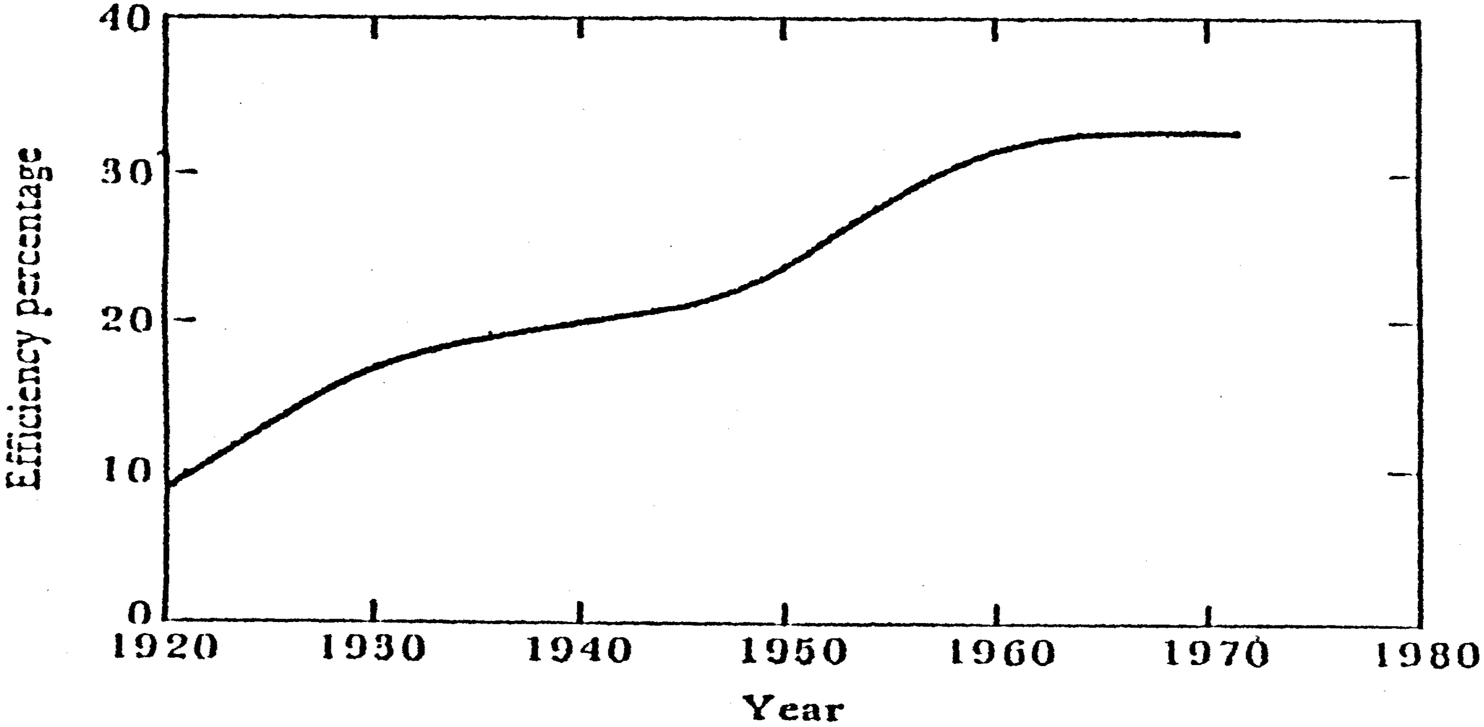
- **Analyses Based on Naive Benefit-Cost:**
  - Engineering Salaries Saved Vs. CAD-Station Outlays
  - Did Not Value CAD's "Intangible" Benefits: Complementarities (Milgrom/Roberts, AER, 1990) and Capability Attributes

Frequent product redesign	→	No obsolete product/inventory
Rapid response/throughput	→	More varied product line
Complementary benefits	→	Reduce set-up costs in computer-integrated manufacturing (CIM)

CAD helps firm retain customers— Not save engineering salaries

Fixed-cost renewables reduce financial risk and provide the basis for reconceptualizing the electricity production/delivery process

TECHNOLOGIES MATURE BECAUSE THEY EXHAUST EFFICIENCY GAINS….



U.S. Average Efficiency for Base-load Steam–Electric Utility Plants

………YET NEW TECHNOLOGY OFTEN DIFFICULT TO JUSTIFY

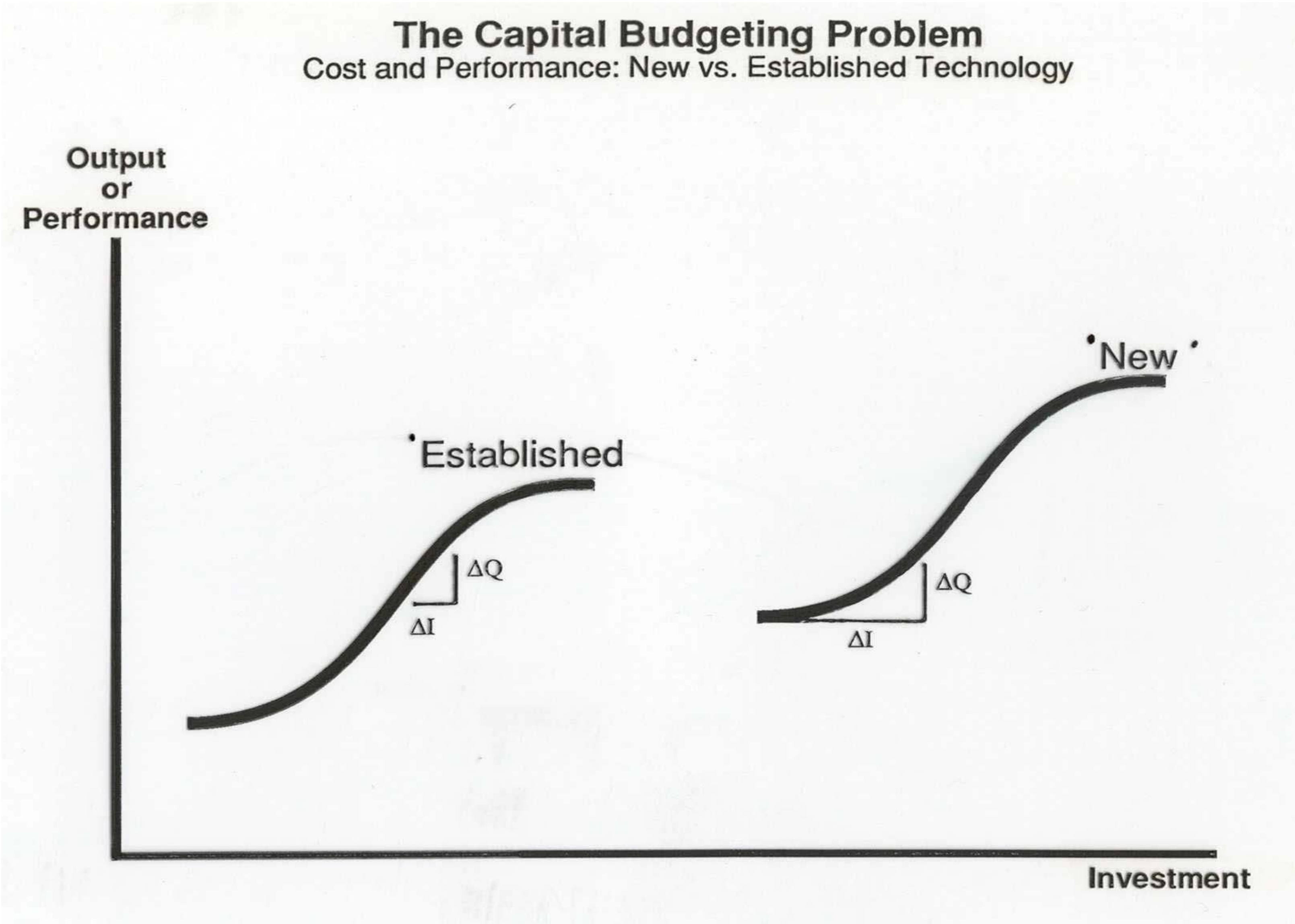
TRADITIONAL COST APPROACHES NO LONGER WORK: THE CASE OF YAMAZAKI MACHINE

YMAZAKI – FMS Investment: $18 million (circa 1970's)

- **Number of Machines:** → **68 Reduced to 18**
- **Order processing time (days):** → **35 Reduced to 1.5**
- **Floor Space (sq. ft. × 10^3):** → **103 Reduced to 30**
- **Employees (number):** → **215 Reduced to 12**

Project's Accounting Return → **Under 10%**

Source: Robert Kaplan, "Must CIM be Justified on Faith Alone," HBR



See: R. Kaplan: “Must CIM be Justified on Faith Alone?” *HBR* / R. Foster, Innovation: Attacker's Advantage

ARE INCREMENTAL PROCESS IMPROVEMENTS IN ELECTRICITY GENERATION & DELIVERY LESS RISKY THAN RADICAL ARCHITECTURAL INNOVATIONS?

- **Underestimating the Risks of No-Action or Piecemeal Enhancement (*a la* R. Kaplan)**

The countryside is littered with remains of firms who chose "safe" incremental improvements over what appeared at the time to be "radical" innovations:

Pickett/K&E; Victor Comptometer,
U.S. Steel Industry

Moral: i) Calculators seemed radical;

ii) Mini-mills and continuous casting did not seem cost-effective

THE ROLE OF MARKET RISK IN TECHNOLOGY VALUATION

RISK ADJUSTED

COST-OF-ELECTRICITY ESTIMATES

VALUING ENERGY TECHNOLOGIES NECESSARILY INVOLVES AN ASSESSMENT OF FINANCIAL RISK

- **Traditional cost-of-electricity estimates, approaches, yield “rule of thumb” valuations**
  - Ignores risk differentials among technologies and processes xx
  - Probably sufficed until very recently xx
  - Ignores the effects of corporate taxes and depreciation tax shelters xx

- **Fossil Fuel Prices Vary Systematically**

- **The costs of Passive/Capital-Intensive Technologies (e.g.: PV, wind) are Essentially Systematically Riskless (beta ≈ 0)**

Valuation: Arbitrary Discounting Can Produce Conflicting Results

Valuing Two Bond Investments Using a Single Arbitrary Discount Rate

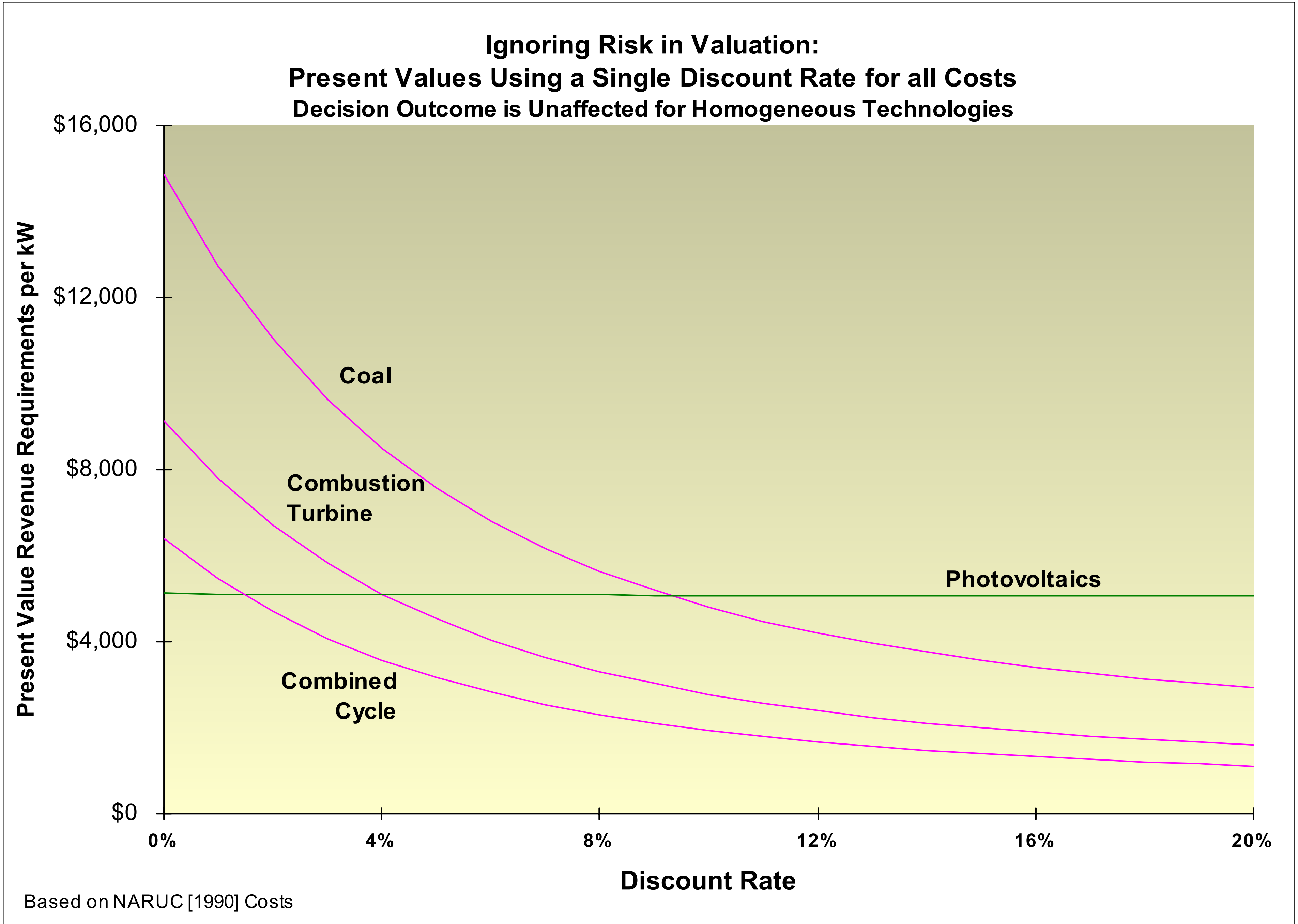
Assumed Discount = 6%

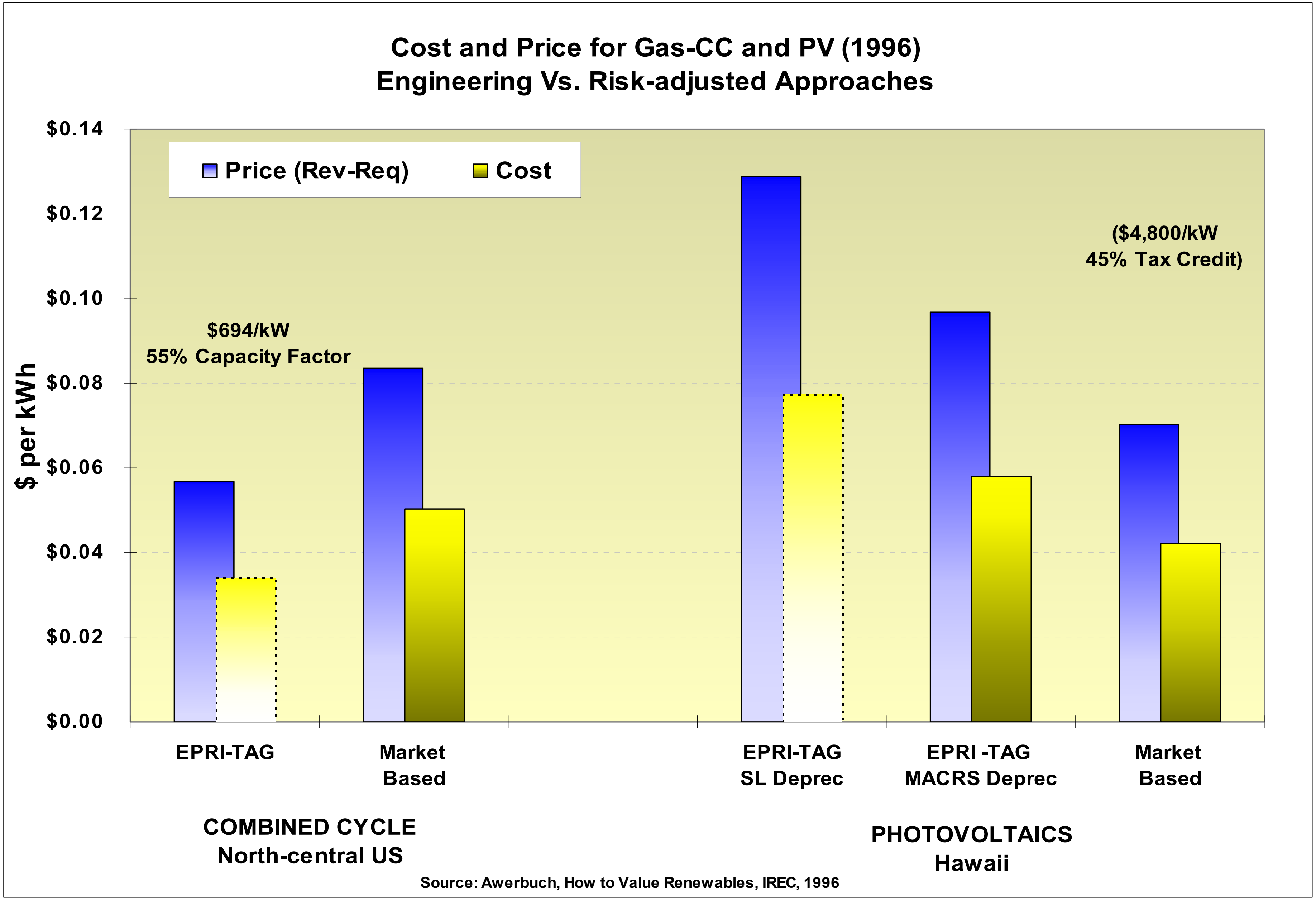
YEAR	10% Junk Bond	4% Government Bond
	Yearly Proceeds	
1	$100	$40
2	$100	$40
3	$100	$40
5	$100	$40
Present Value of Proceeds	$347	$139

Sensitivity Analysis for Bond Investments With a Single Arbitrary Discount

Assumed Discount = 6%

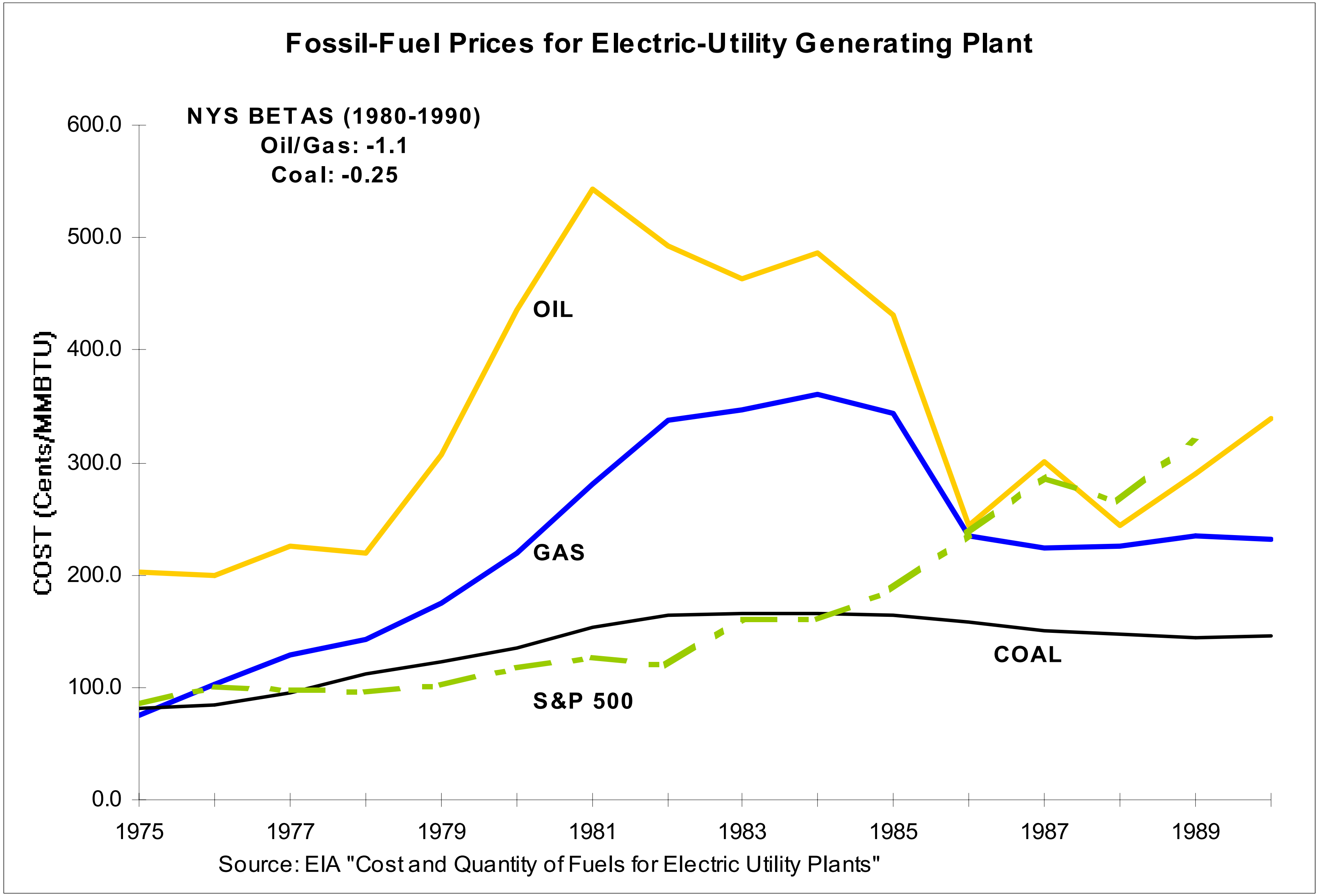
	10% Junk Bond		4% Government Bond	
Sensitivity Range	1.0	0.9	1.0	0.9
Year	**Yearly Proceeds**		**Yearly Proceeds**	
0	($1,000)	($1,000)	($1,000)	($1,000)
1	$100	$100	$40	$40
2	$100	$100	$40	$40
3	$100	$100	$40	$40
4	$1,100	$990	$1,040	$936
Net Present Value	**$131**	**$49**	**($65)**	**($143)**
Percent Change	**0%**	**-62.9%**	**0%**	**-118.9%**


Ignoring Risk in Valuation:
Present Values Using a Single Discount Rate for all Costs
Decision Outcome is Unaffected for Homogeneous Technologies
Present Value Revenue Requirements per kW
$16,000
$12,000
$8,000
$4,000
$0
Coal
Combustion Turbine
Photovoltaics
Combined Cycle
0%
4%
8%
12%
16%
20%
Discount Rate
Based on NARUC [1990] Costs


Cost and Price for Gas-CC and PV (1996)
Engineering Vs. Risk-adjusted Approaches
$0.14
$0.12
$0.10
$0.08
$0.06
$0.04
$0.02
$0.00
$ per kWh
Price (Rev-Req)
Cost
$694/kW
55% Capacity Factor
($4,800/kW
45% Tax Credit)
EPRI-TAG
Market
Based
EPRI-TAG
SL Deprec
EPRI -TAG
MACRS Deprec
Market
Based
COMBINED CYCLE
North-central US
PHOTOVOLTAICS
Hawaii
Source: Awerbuch, How to Value Renewables, IREC, 1996

VALUING ENERGY TECHNOLOGIES NECESSARILY INVOLVES AN ASSESSMENT OF FINANCIAL RISK (CONTINUED)

- **Fossil Fuel Prices Vary Systematically**
  - Negative covariance with economic activity ($\beta < 0$)
  - First observed by Lind and Arrow (Johns Hopkins Press 1986)
  - Important implications for EU energy diversity/security goals
    - Fossil price increases seem to depress economic activity
    - More profound implications than traditional "energy security" view
  - Important portfolio Implications:
    - Non-fossil generating assets produce counter-cyclical returns
    - Their value is high when the rest of portfolio is low


Fossil-Fuel Prices for Electric-Utility Generating Plant
NYS BETAS (1980-1990)
Oil/Gas: -1.1
Coal: -0.25
600.0
500.0
400.0
300.0
200.0
100.0
0.0
COST (Cents/MMBTU)
OIL
GAS
COAL
S&P 500
1975
1977
1979
1981
1983
1985
1987
1989
Source: EIA "Cost and Quantity of Fuels for Electric Utility Plants"

A Primer On Risk:

- **Modern Finance Theory Based on Risk Research in 1950's**

  -- Capital Asset Pricing Model for Estimating Market Price of Risk ⇒ Cost of Capital

  -- Equivalent to Determining Cost of Any Other Resource

- **Total Risk Is the Year-to-Year Variability (σ^2) in Financial Returns**

  -- Returns on "safe" assets cluster closely around the mean or *expected* rate of return

- **Two Components of Risk:**

Total Risk = Diversifiable Risk + Systematic Risk = σ^2 {annual returns}
(Random) (Non-Diversifiable)

- **Random Risk Does Not Affect the Discount Rate**

  - Investors can readily diversify it away
  - Markets do not compensate investors for assuming random risk
    - weather adjustment clauses?

- **Markets Compensate Investors for *Systematic* Risk Only**

  - The extent to which the investment's returns co-vary with returns on a diversified portfolio of assets

    Q. Is oil exploration "risky"?
    Q. Is owning a roulette wheel risky? Many wheels?

A PRIMER ON RISK-- CONTINUED

- **Systematic Risk (β): The Co-Variance of Project Costs (or Returns) with Returns to a Diversified Market Portfolio**

$$\beta_{cost,mkt} = \frac{Cov(K_{cost}, K_{mkt})}{\sigma^2_{mkt}} = \frac{\rho_{(cost,mkt)} \bullet \sigma_{cost} \bullet \sigma_{mkt}}{\sigma^2_{mkt}}$$

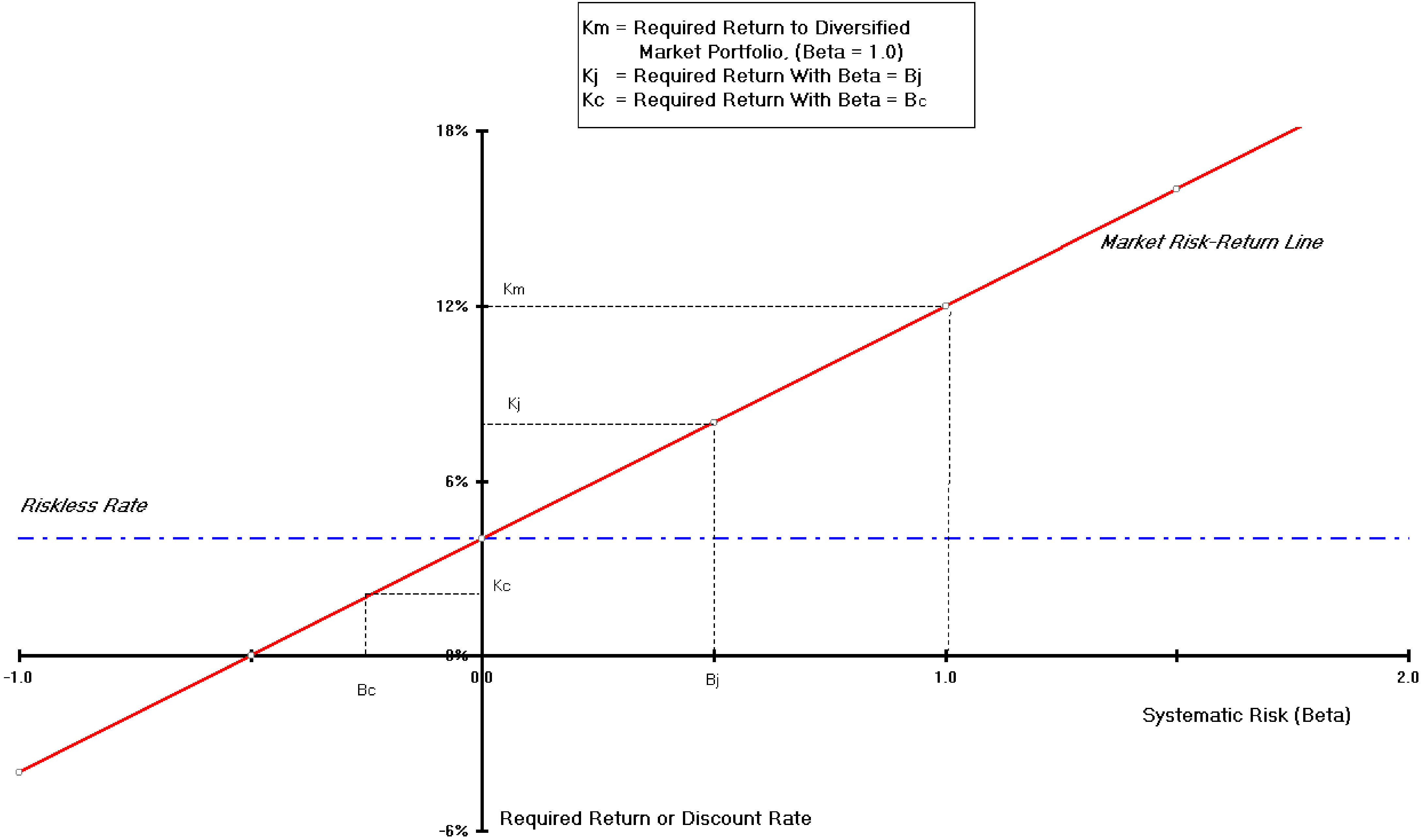
-- Beta = "Riskiness of the cost (or benefit) stream relative to the market portfolio"

-- Beta for the market as a whole = 1.0 by definition

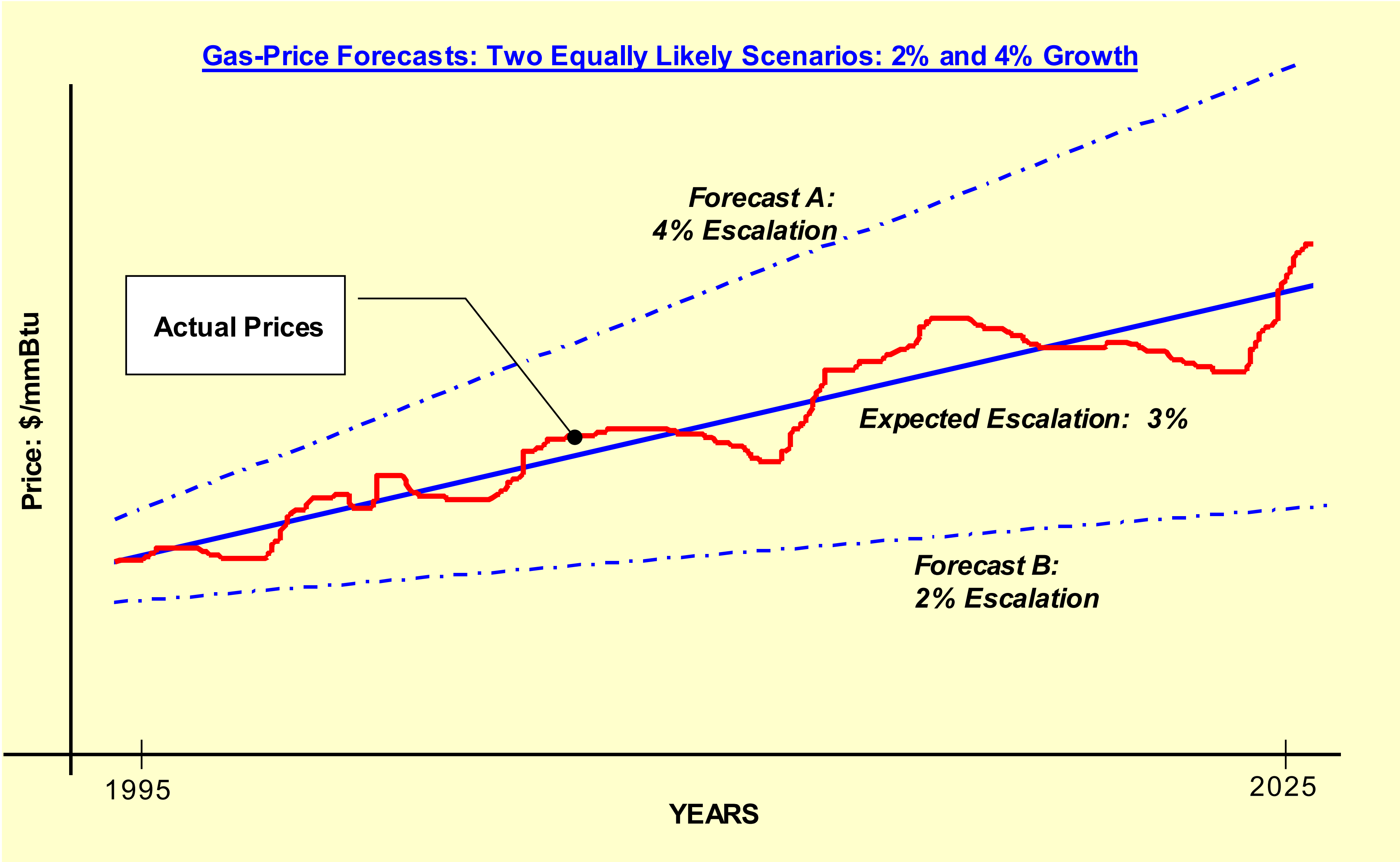
- **Estimating the Appropriate Discount Rate for a Cost (or Benefit) Stream:**

1. Empirically: $K_{cost} = K_{rf} + \beta \times (K_{mkt} - K_{rf})$
2. By Convention:
   - *Debt-Equivalent* Costs -- Discounted at K_{debt}
   - *Riskless Costs* -- Discounted at $K_{risk\text{-}free}$

Using the CAPM to Estimate Discount Rates for Projects and Cost Streams



A PRIMER ON RISK-- WHAT MAKES FUEL PRICES RISKY?



Risky Cash Flows

Figure 1: Risky Revenues and Costs -- Riskless Profits

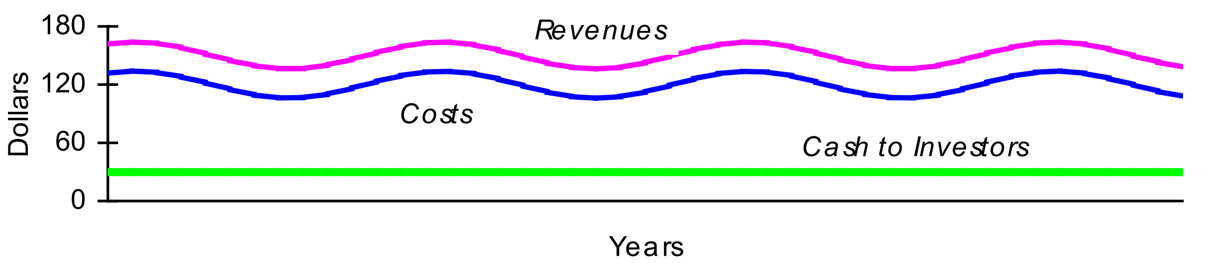


Figure 2: Risky Revenues, Riskless Costs -- Risky Profits

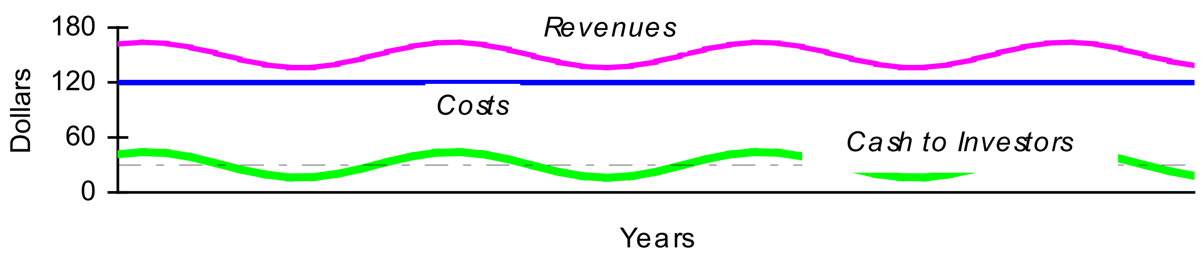
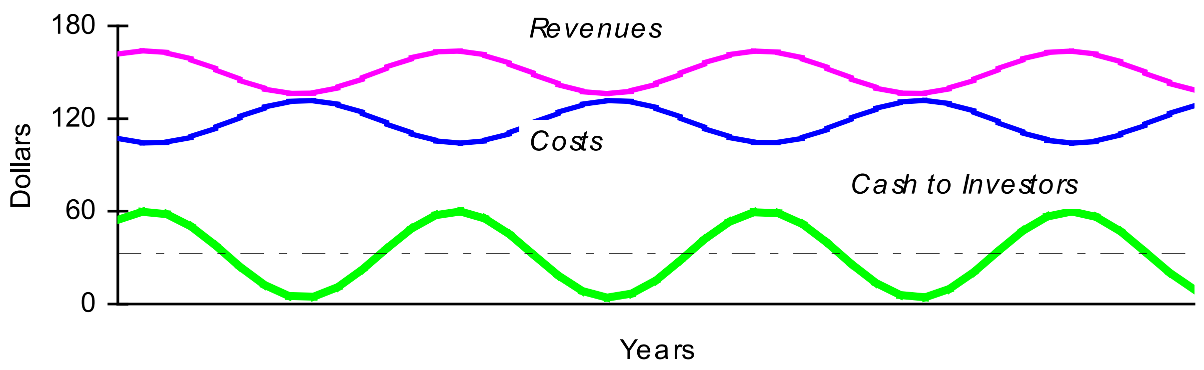


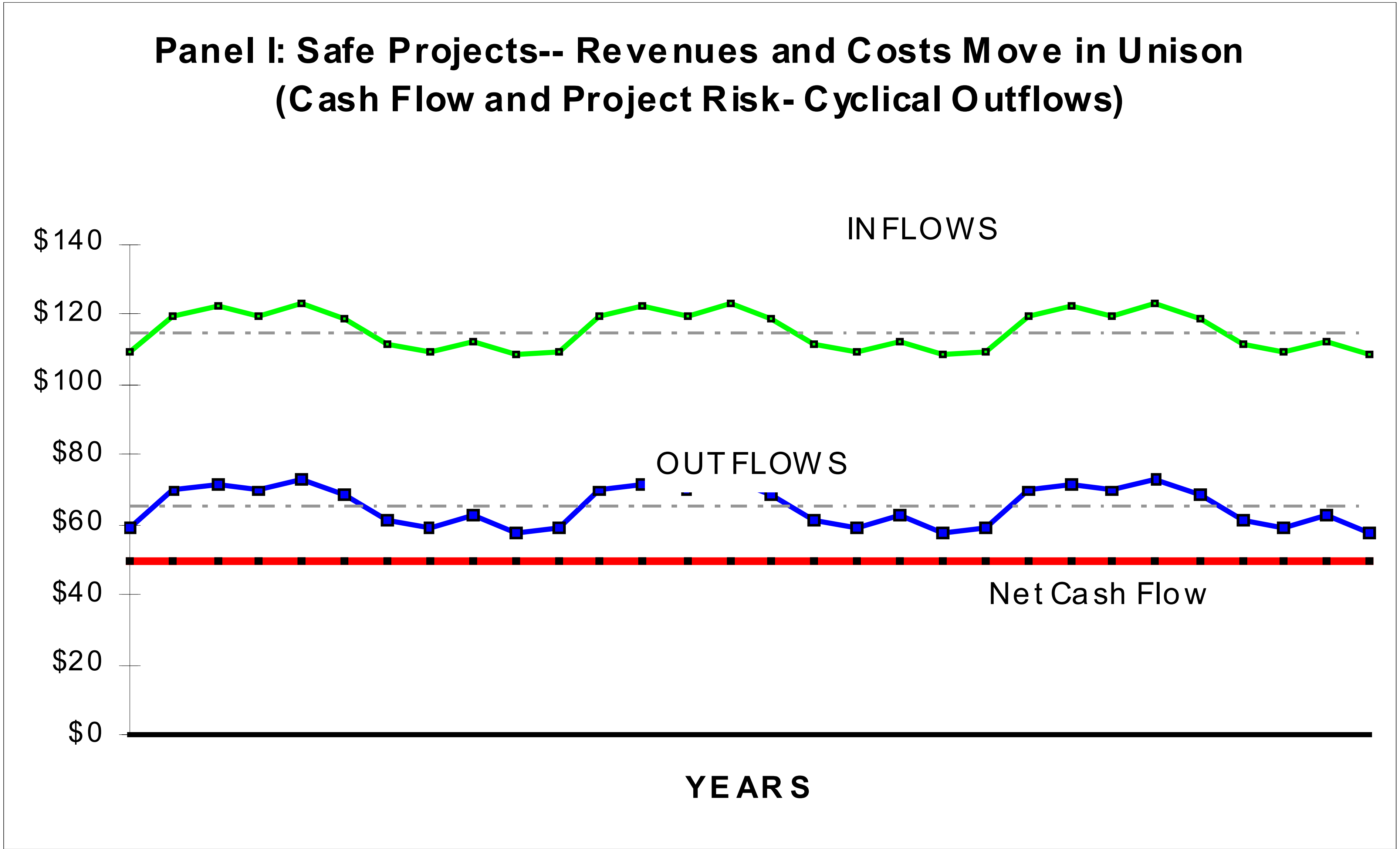
Figure 3: Risky Revenues With Countercyclical Costs

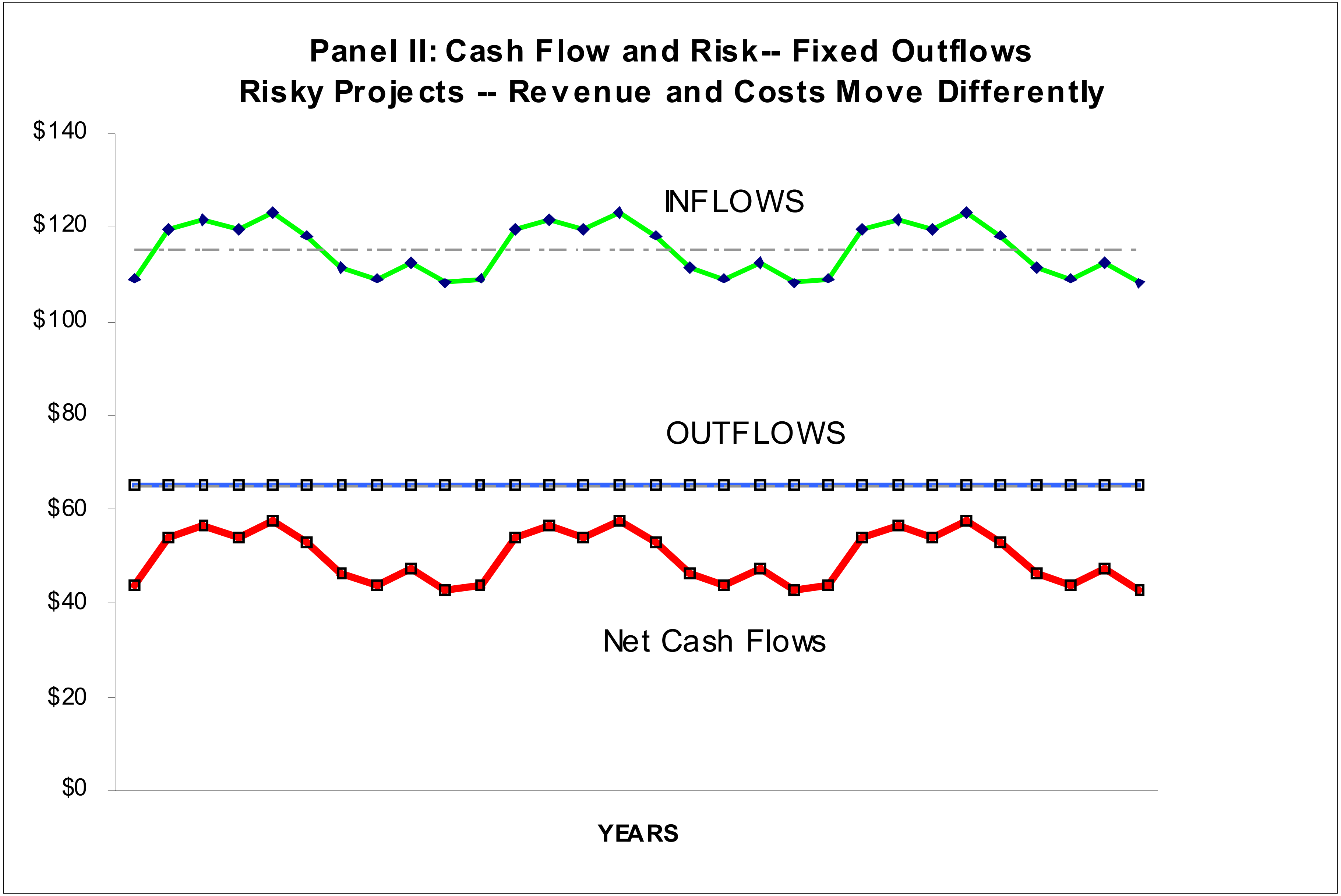


CASH FLOW AND PROJECT RISK ××

EXPECTED ANNUAL COSTS FOR TWO ALTERNATIVE GENERATING TECHNOLOGIES Sponsor's Rate of Return (WACC): 10%	
***Technology A:* Costs Vary With Output**	***Technology B:* Fixed Costs**
Initial Outlay $0 Project Life 30years	Initial Outlay $ 0 Project Life 30years
Expected Revenue: $115 E(Variable Maint.) */ 65 E(Fixed Maint.) */ 0 ------- E(Net Cash Flow) $ 50	Expected Revenue: $115 E(Variable Maint.) */ 0 E(Fixed Maint.) */ 65 ------- E(Net Cash Flow) $ 50
*/ Revenues and Variable Maintenance Costs Vary Directly With Output	

- Under Traditional Methods:
  PVRR (Project A) = PVRR (Project B) and NPV(A) = NPV(B)
- But…. Are These Projects Valued Equally By Investors?


Panel I: Safe Projects-- Revenues and Costs Move in Unison
(Cash Flow and Project Risk- Cyclical Outflows)
INFLOWS
$140
$120
$100
$80
$60
$40
$20
$0
OUTFLOWS
Net Cash Flow
YEARS


Panel II: Cash Flow and Risk-- Fixed Outflows
Risky Projects -- Revenue and Costs Move Differently
$140
$120
$100
$80
$60
$40
$20
$0
INFLOWS
OUTFLOWS
Net Cash Flows
YEARS

The Relationship of Revenues, Costs and Net Cash Flows

- **WACC is the Discount Rate for the Net Cash Flows to Investors**
  (Earnings + Depreciation + Interest Payments + Tax Deferrals)

- **Technology Valuation— Choosing among two Process Technologies —**
  Involves Estimating the Present Value of Revenue Requirements or *Costs*

- **What is the Discount rate for Costs? -- K_{COST}**

VALUING PROJECT CASH-FLOW COMPONENTS

- The (risky) revenue streams are unaffected by the choice of generating technology
  - Average or expected value = $115

- Standard capital-market theory
  - Investors prefer *A* over *B* since: E(return)$_{\mathbf{A}}$ = E(return)$_{\mathbf{B}}$, but risk is lower.

- Now: PV(NCF) = PV(REVENUES) – PV(OUTFLOWS)

  If: PV(REVENUES) of A = PV(REVENUES) of B

  and: PV(NCF) of A > PV(NCF) OF B

  Then: PV(OUTFLOWS) of A < PV(OUTFLOWS) of B

- Can hold only if the "safer" outflows of B are discounted at a lower rate
  - Intuitively appealing: makes their PV's larger, which reduces PV(ncf)$_{\mathbf{B}}$, as it should, since B is less desirable than A. (Proof : Copeland /Weston [1988, 416]

VALUING PROJECT CASH-FLOW COMPONENTS – NUMERIC SOLUTION

- **Assume: Krf = 6.0% = the appropriate discount for riskless costs of Project B and the riskless NCF of Project A.**

- **The risk of the revenues is the same as the risk of a broadly diversified market portfolio (i.e. β = 1.0), whose return or discount rate is K_{rev} = 12%.**

Relationship for Three Discount Rates

K_{COST}, K_{NET} (WACC) and K_{REV} [Booth 1982, JFQA] (two-period model)

$$K_{COST} = K_{REV} \times \frac{PV_{REV}}{PV_{COSTS}} - K_{NET} \times \frac{PV_{NET}}{PV_{COSTS}}$$

Rearranging: $Kcost_{\mathbf{A}}$:

$$Kcost = .12 \times (\$934 / \$246) - .06 \times (\$688 / \$246) = \mathbf{27\%}$$

Table 4- ____

Estimating The Discount Rate for Outflows (Kout) and Project Value

Krev = Kmkt = 12%; Krf = 6%.

	PROJECT A Cyclical Outflows			*PROJECT B* Fixed Outflows		
YEAR	Inflows	Outflows	Net Flow	Inflows	Outflows	Net Flow
1	$109	$59	$50	$109	$65	$44
2	$120	$70	$50	$120	$65	$54
3	$122	$72	$50	$122	$65	$56
4	$120	$70	$50	$120	$65	$54
5	$123	$73	$50	$123	$65	$58
6	$118	$68	$50	$118	$65	$53
7	$112	$62	$50	$112	$65	$46
8	$109	$59	$50	$109	$65	$44
9	$113	$63	$50	$113	$65	$47
10	$108	$58	$50	$108	$65	$43
11	$109	$59	$50	$109	$65	$44
12	$120	$70	$50	$120	$65	$54
13	$122	$72	$50	$122	$65	$56
14	$120	$70	$50	$120	$65	$54
15	$123	$73	$50	$123	$65	$58
16	$118	$68	$50	$118	$65	$53
17	$112	$62	$50	$112	$65	$46
18	$109	$59	$50	$109	$65	$44
19	$113	$63	$50	$113	$65	$47
20	$108	$58	$50	$108	$65	$43
21	$109	$59	$50	$109	$65	$44
22	$120	$70	$50	$120	$65	$54
23	$122	$72	$50	$122	$65	$56
24	$120	$70	$50	$120	$65	$54
25	$123	$73	$50	$123	$65	$58
26	$118	$68	$50	$118	$65	$53
27	$112	$62	$50	$112	$65	$46
28	$109	$59	$50	$109	$65	$44
29	$113	$63	$50	$113	$65	$47
30	$108	$58	$50	$108	$65	$43
Discuont Rate	12.0%		6.0%	12.0%	6.0%	
Present Values	**$934**		**$688**	**$934**	**$899**	

PVout = PVrev - PVncf = **$246**
IMPLIED k = ***26.9%***

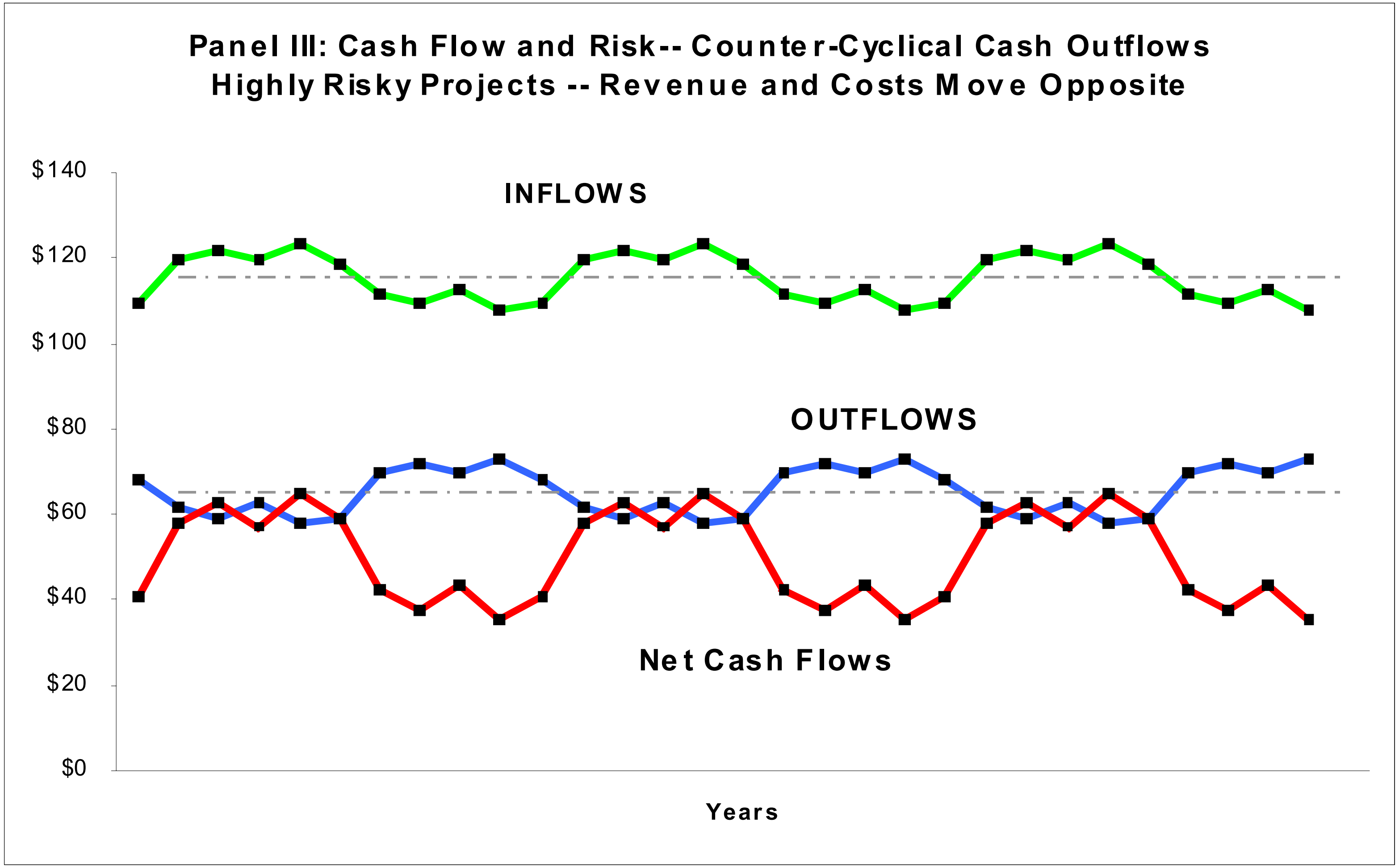
PVncf = PVrev - PVout = **$35**
139%

Kin = 12.0%
PV in = **$934**

Knet = 246.0%
PV net = **$19**

PV out = **$916**
Kout = 5.7%

30%



Market Based Cost-of-Electricity Estimates for IEA Europe

- **Extends Previous US-DOE Funded Research**
- **Provides Risk-Adjusted, (Market-Based) C-O-E Estimates**
- **These Differ from Engineering Estimates**
  - — Reflect market risk and the effects of taxation
  - — Results have an economic interpretation:
    - The cost at which a 30-year contract for future electricity delivery would trade in efficient markets

POST-TAX RISK-ADJUSTED COST-OF-ELECTRICITY ESTIMATES

- **Riskier Costs ⇒ Lower Discount Rates ⇒ Higher Present Values**

- **Reflects the Effect of Taxes and Depreciation Tax Shelters**

  -- Effects not uniform across technologies

- **Enables "Apples-to-Apples" Comparison**

  – Important in today's environment of heterogeneous technological alternatives ××

- **C-O-E Estimates Can be Interpreted as the cost at which a 30-year contract for electricity delivery would trade in efficient markets**

  -- Differs from Engineering COE Estimates

RISK-ADJUSTED VALUATION (DISCOUNTING) PROCEDURES

STEP I. USE *EXPECTED* COSTS

- **Probability-weighted average of all outcomes**

- **Reflect diversifiable risks (“technology” risks) and contingencies**
  - e.g.: turbine or inverter failures, etc.
  - future environmental retrofits
  - These do not affect discount rates

- **Diversifiable risks largely included to the extent that WEO cost inputs are based on actual field observations**
  - Otherwise – estimate for each technology using: $\sum p_j \times c_j$

STEP II. DISCOUNT EACH EXPECTED COST AT ITS (POST-TAX) RISK-ADJUSTED RATE TO PRODUCE PRESENT VALUE COST PER KW

- **Four risk-homogeneous cost categories– four discount rates**
- **Discount rates pertain to the cost stream – not the technology**
  - e.g.: The discount for fixed O&M is independent of technology

	Cost Group	Risk Category	Estimation Procedure	Nominal Pre-Tax Discount Rate
1.	Depreciation tax-shelter	Riskless	Convention	4.3%
2.	Fixed O&M	Debt-Equivalent	Convention	7.4%
3.	Variable O&M	Pro-Cyclical	Judgment	9%
4.	Fuels			
	Fossil	Counter-cyclical	Empirical	0.5% – 4%
	Nuclear	Debt-equivalent	Empirical	7.4%
	Bio	Riskless	Literature	4.3%

STEP III. LEVELIZE PRESENT-VALUE COSTS TO DERIVE LEVELIZED ANNUAL COST PER KWH

- **Levelized costs represent an imaginary time-weighted average**
  - Cannot be compared to observed market prices xx
- **Widely used, but creates significant problems**
  - In the case of arbitrary discounting, levelization can produce conflicting valuation criteria
- **Theoretically, the levelization rate will differ for each technology and each year of the project life** **(J. Read, EPRI, 1991)**
  - Represents the rate of return at which investors are indifferent between the lump-sum present value cost and the levelized annual cost
    - Generally the after-tax WACC (given the right assumptions)
    - Presents enormous computational hurdles

RISK-ADJUSTED DISCOUNTING – LEVELIZATION - CONTINUED

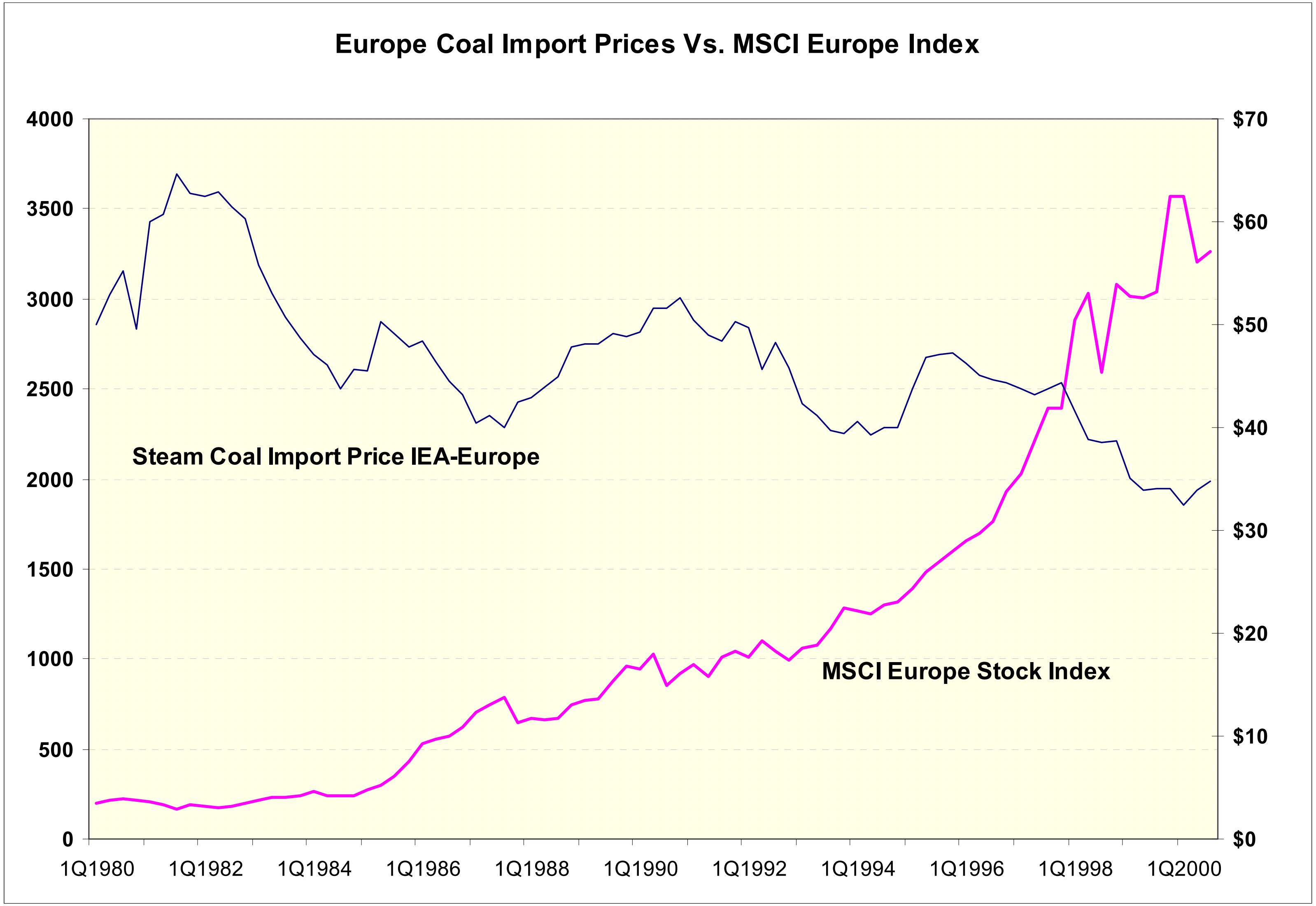
- **A defensible compromise levelization procedure:**
  - Two levelization rates, one for fossil projects, one for fixed-cost projects
    - Fossil estimate based on Value-Line power producer sample
  - Estimate for fixed-cost technologies based on asset beta = 0.1
    - 10 – 20 times as risky as investment grade corporate bonds

- **Produces an empirically reassuring risk premium for fossil projects:**

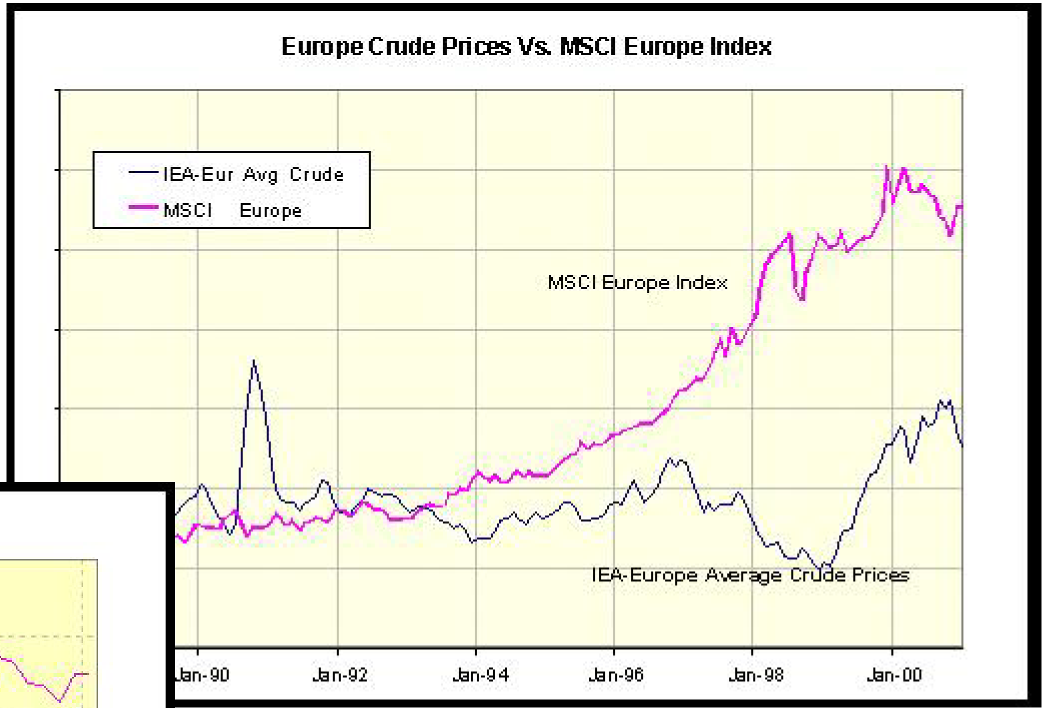
WACC for Fossil Projects:	7.0%	
WACC for Fixed Cost Projects:	5.7%	(should be 5.4)
Implied Fossil Risk Premium	1.3%	

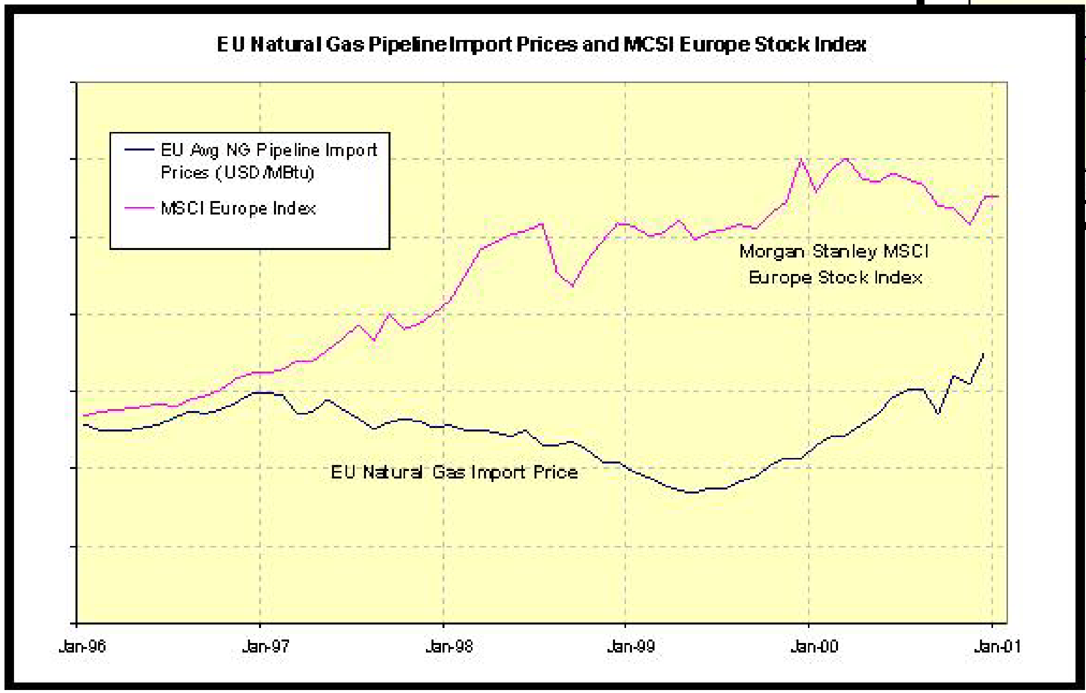
  - Fossil fuel risk alone produces a CAPM risk premium of 0.7% - 2.0%
    - Δ Beta = 10%-25%, Litzenberger, Clarke, Bower, et. al., *J. of Finance*, Special Symposium, May 1980)

Estimating Discount Rates:
Systematic Fossil Price Risk Measured Against the Morgan-Stanley MCSI Europe Stock Index (Based on French & Fama)

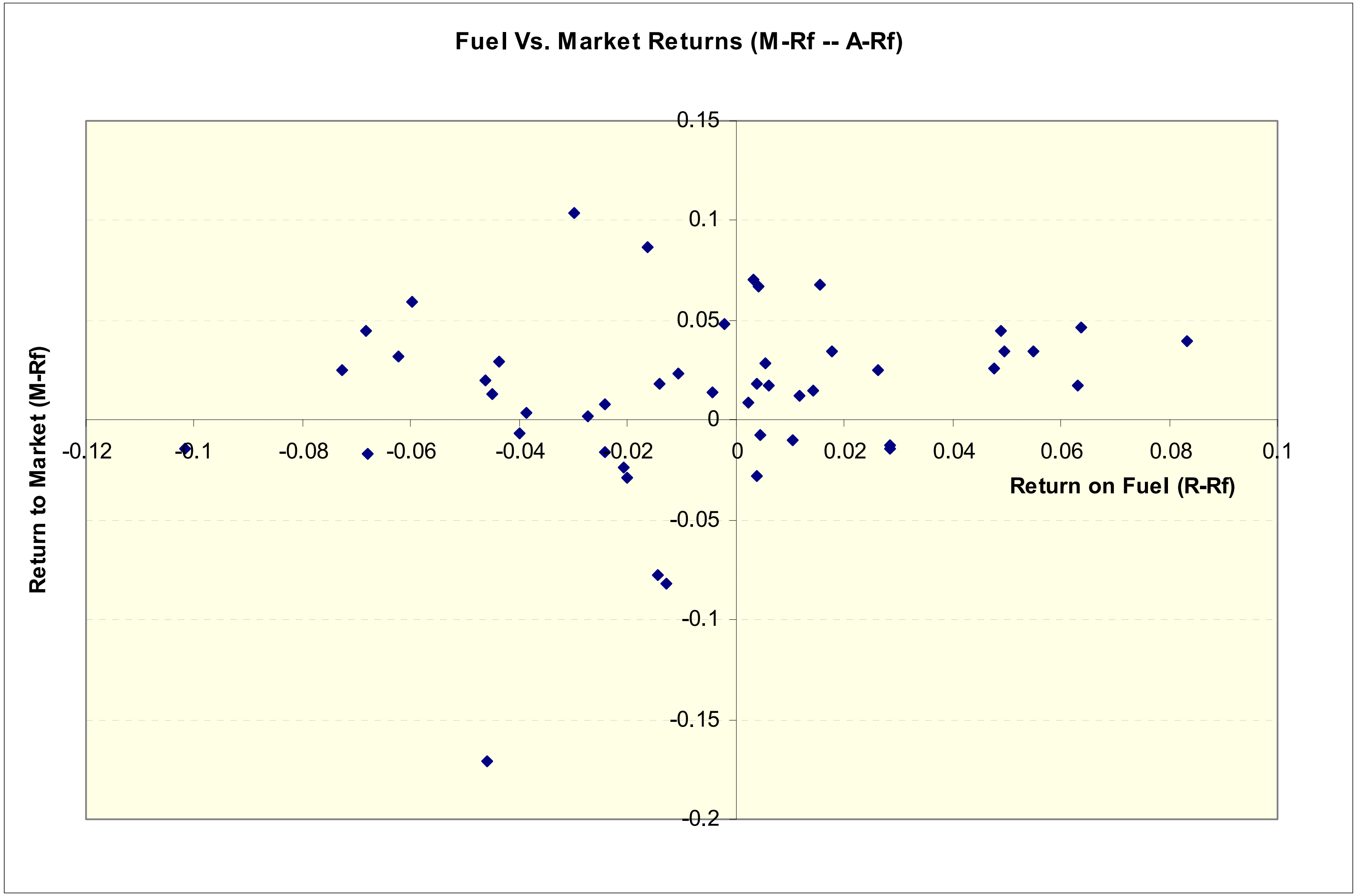


FOSSIL PRICES VS. *MCSI EUROPE STOCK INDEX* (CONTINUED)



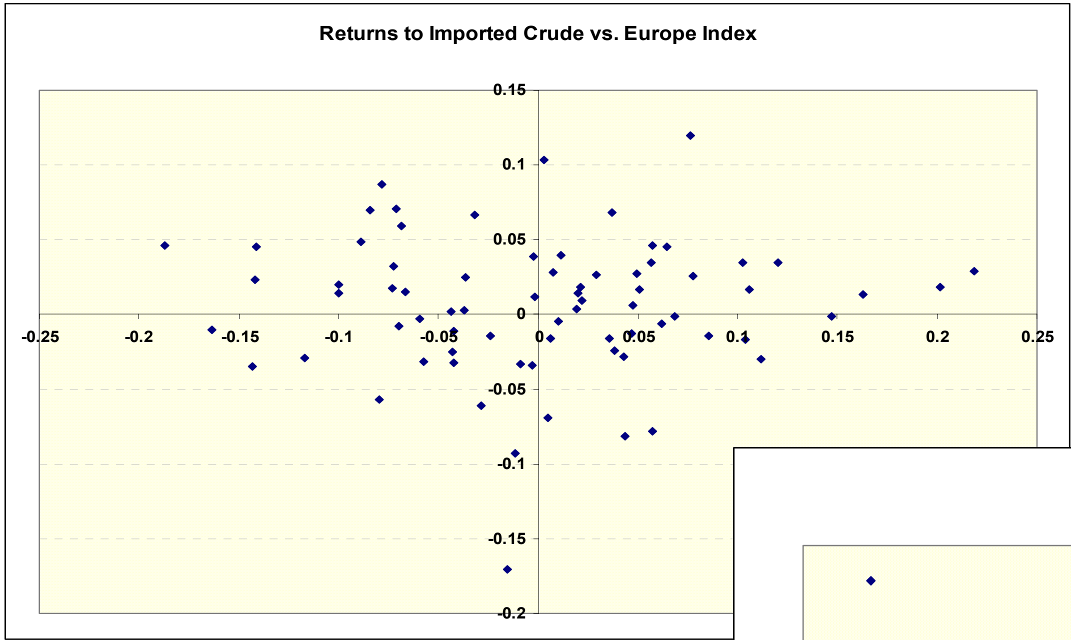


Returns to Europe Import Gas Vs. Returns to *MSCI* Europe Stock Index (48-Month Beta = -0.15)

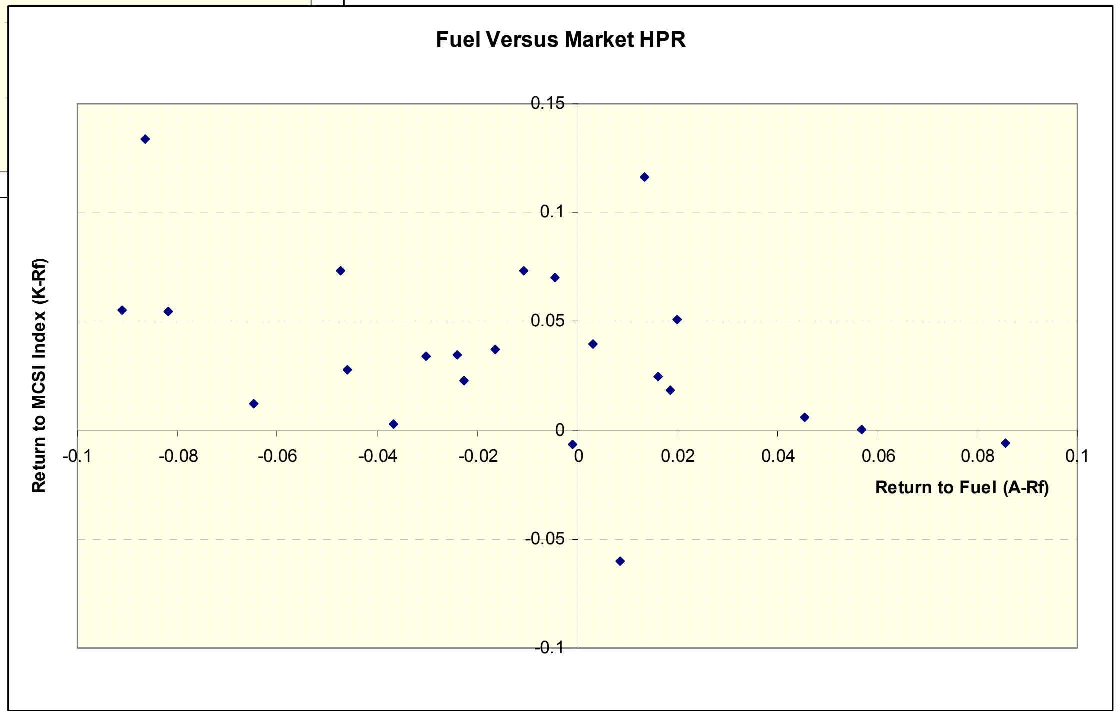


60-MONTH RETURNS TO EUROPE OIL & COAL VS. *MSCI* INDEX

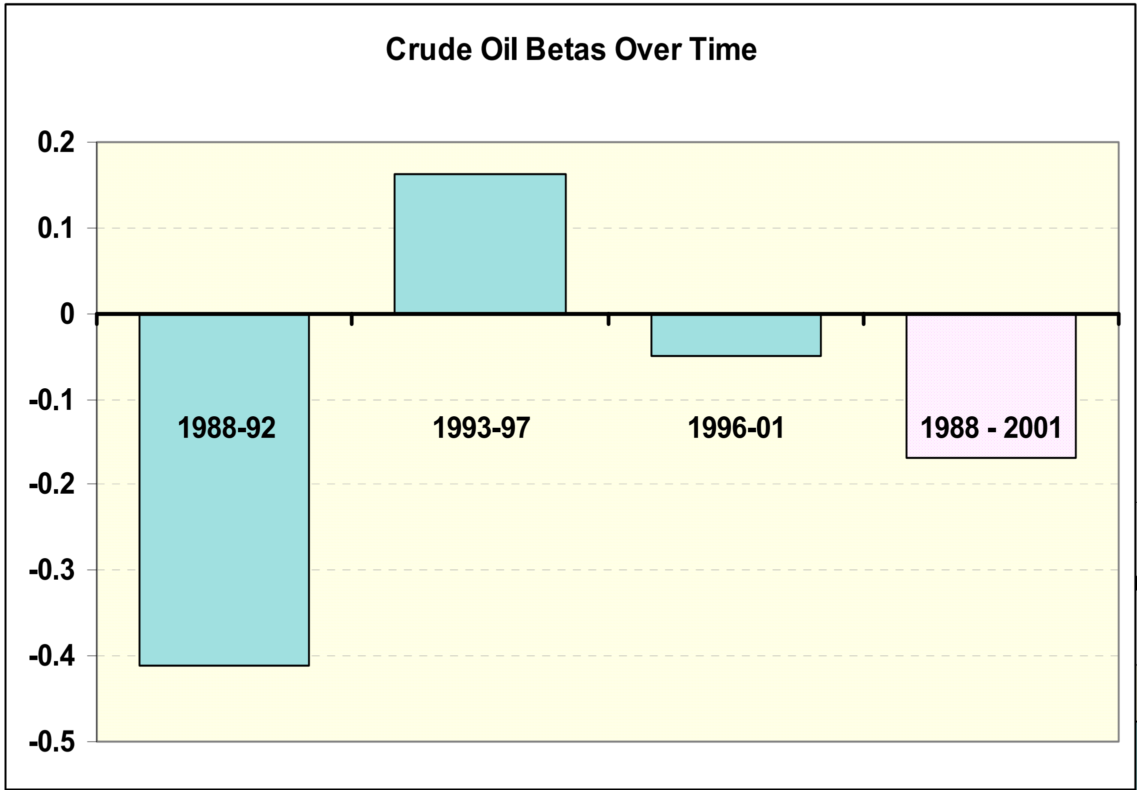
Crude Oil Imports (Beta = -0.05)

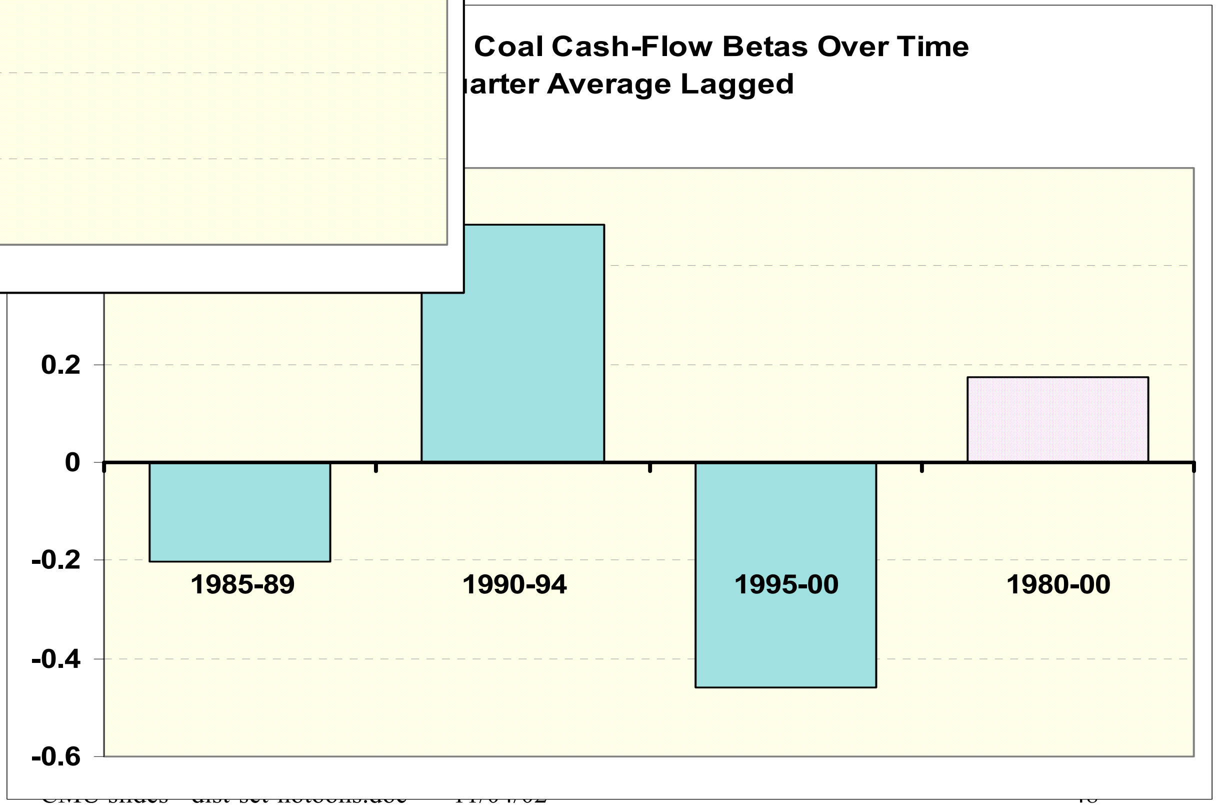


European Steam Coal Imports (Beta = -0.45)

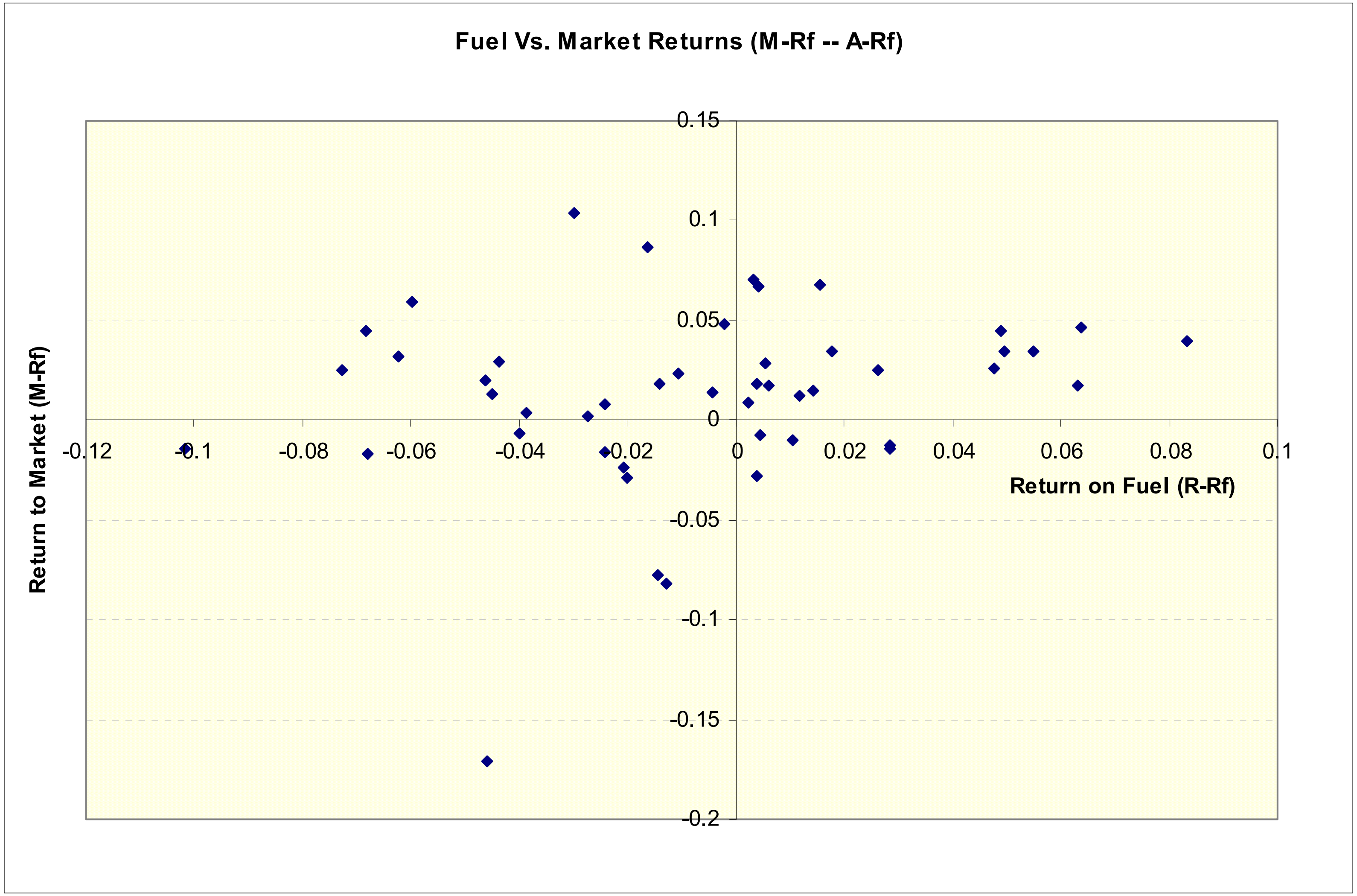


SYSTEMATIC RISK OVER TIME -- COAL AND CRUDE

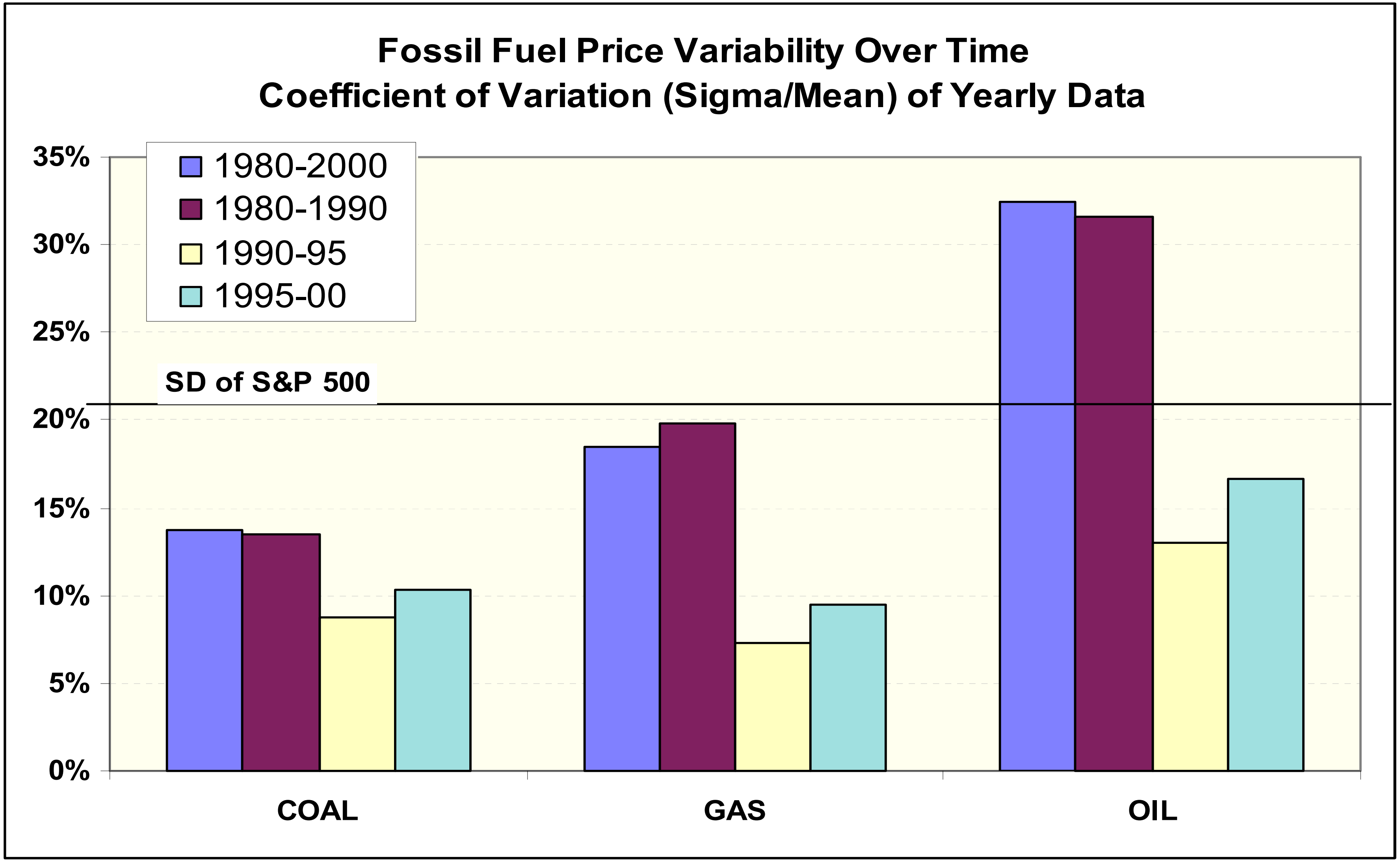




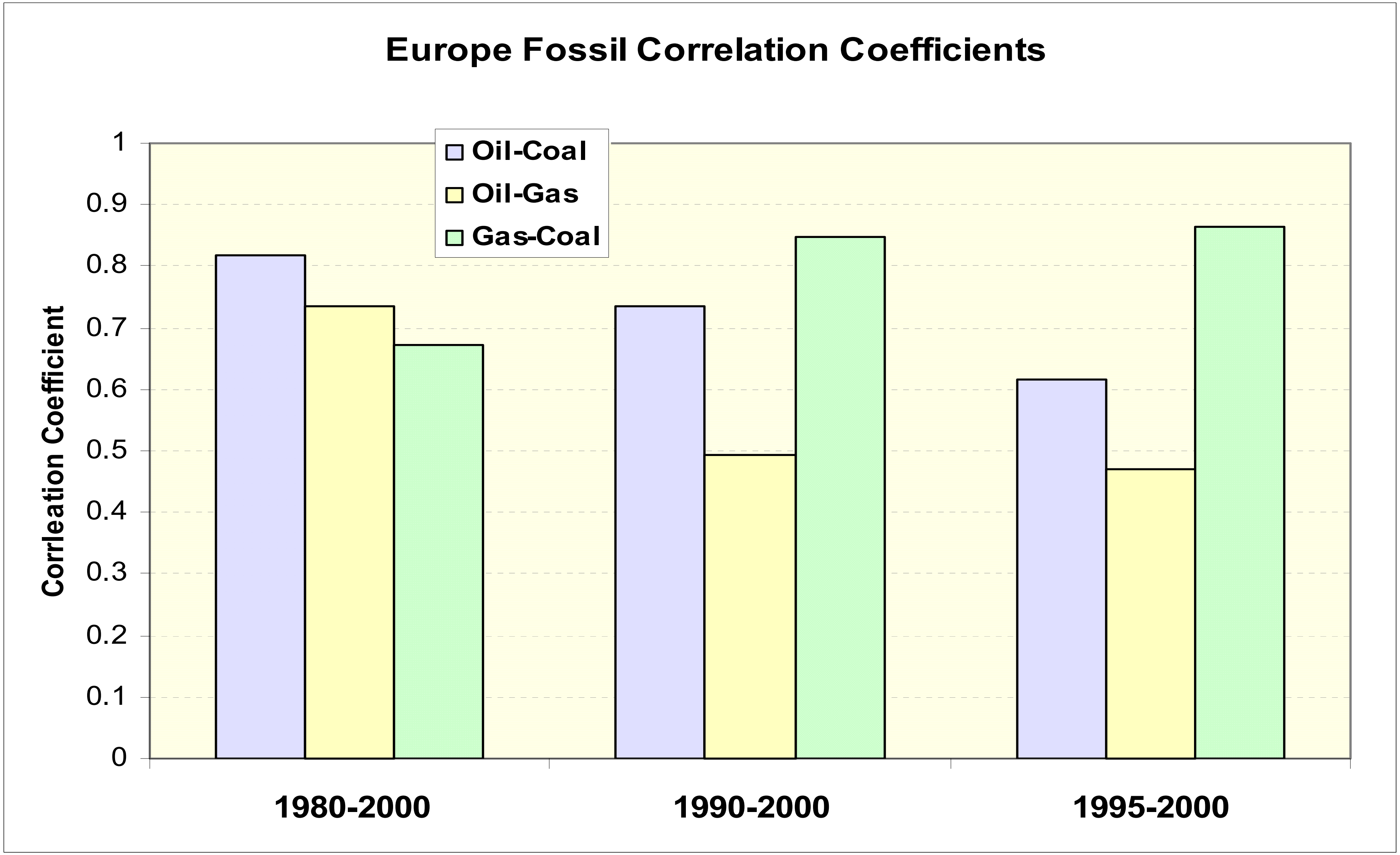
Returns to Europe Import Gas Vs. Returns to *MSCI* Europe Stock Index(48-Month Beta = -0.15)



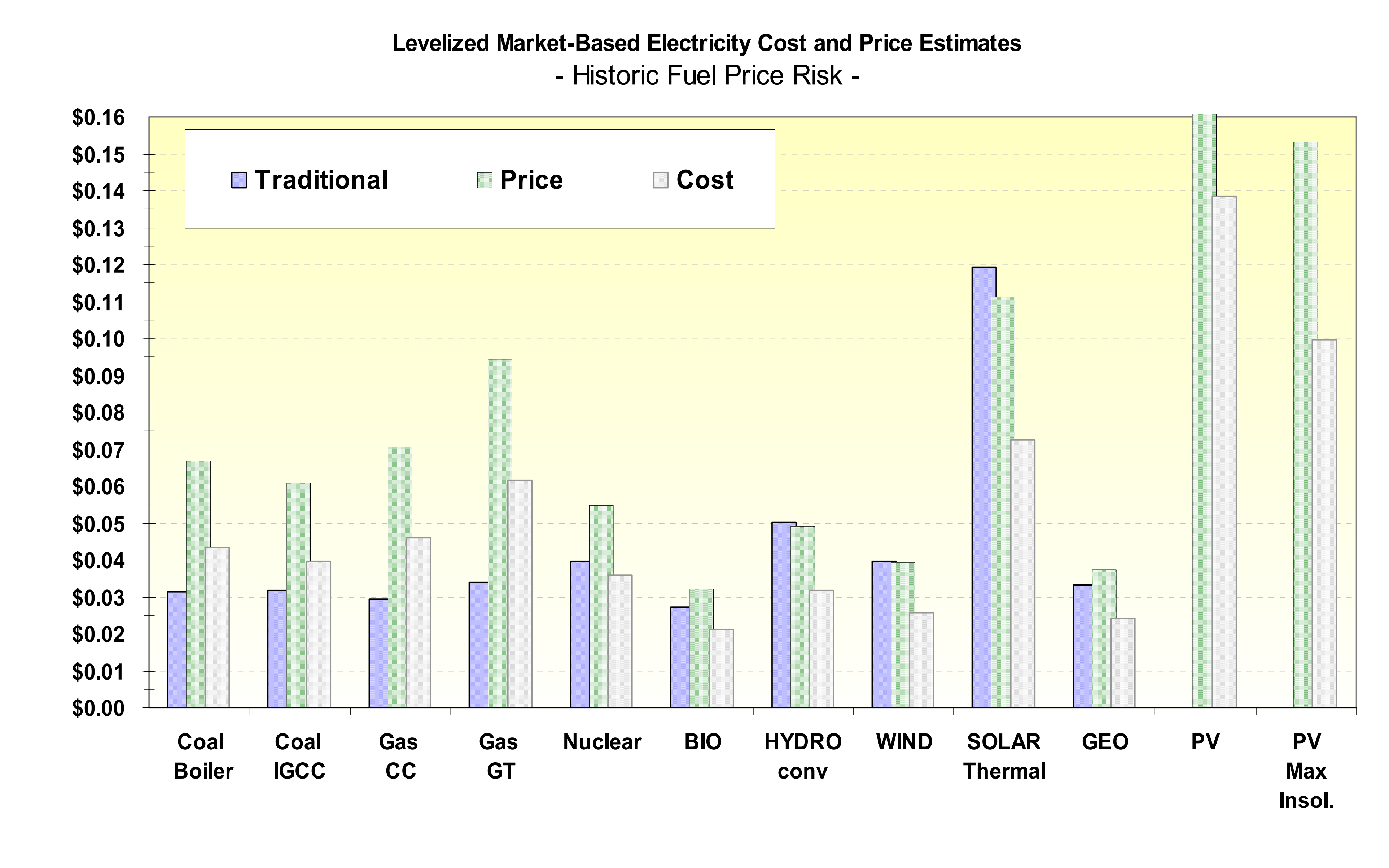
TOTAL FOSSIL FUEL RISK OVER TIME



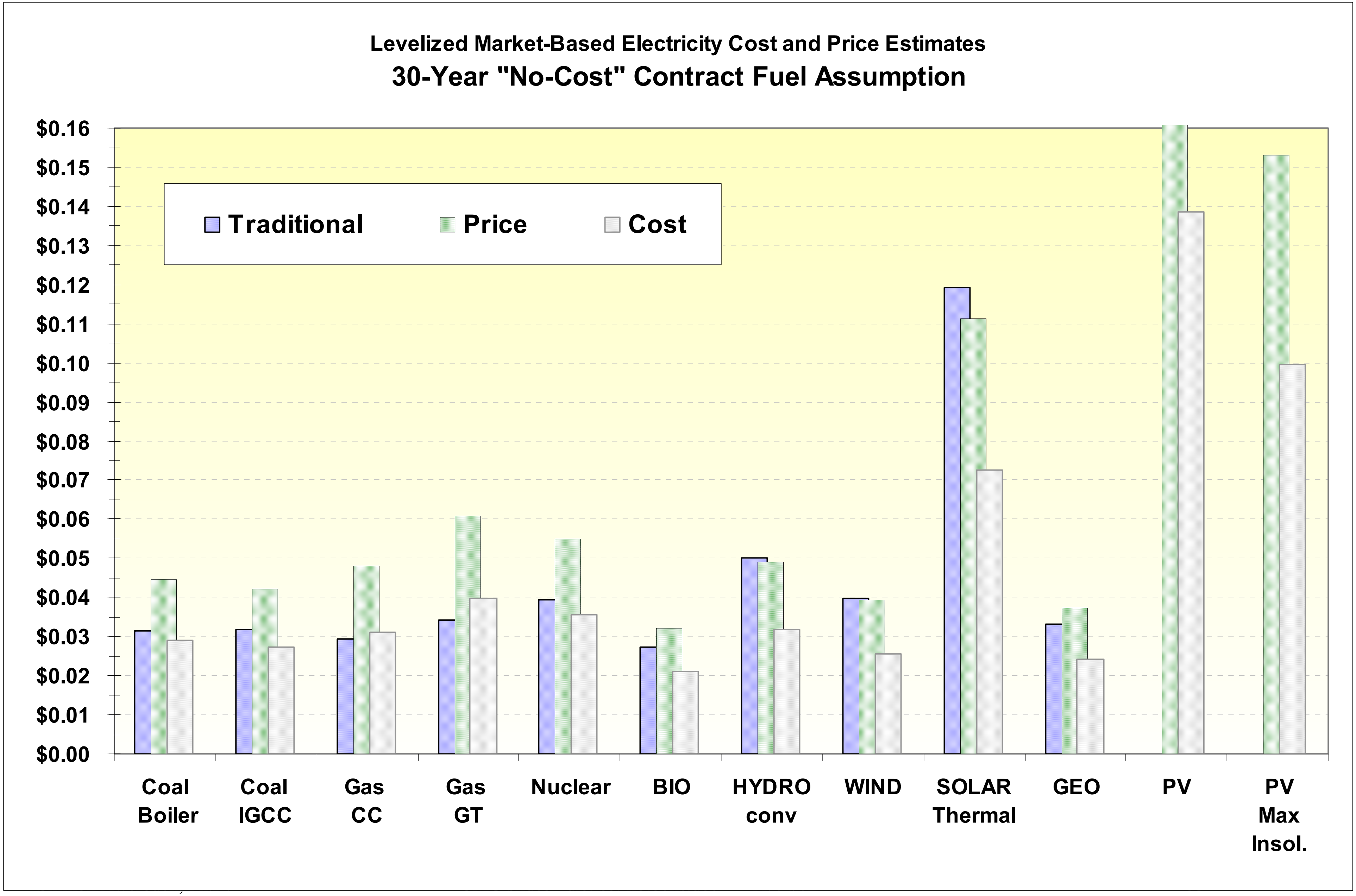
Fossil Correlations Over time:
The Gas-Coal Portfolio Offers Little Opportunity for Diversification



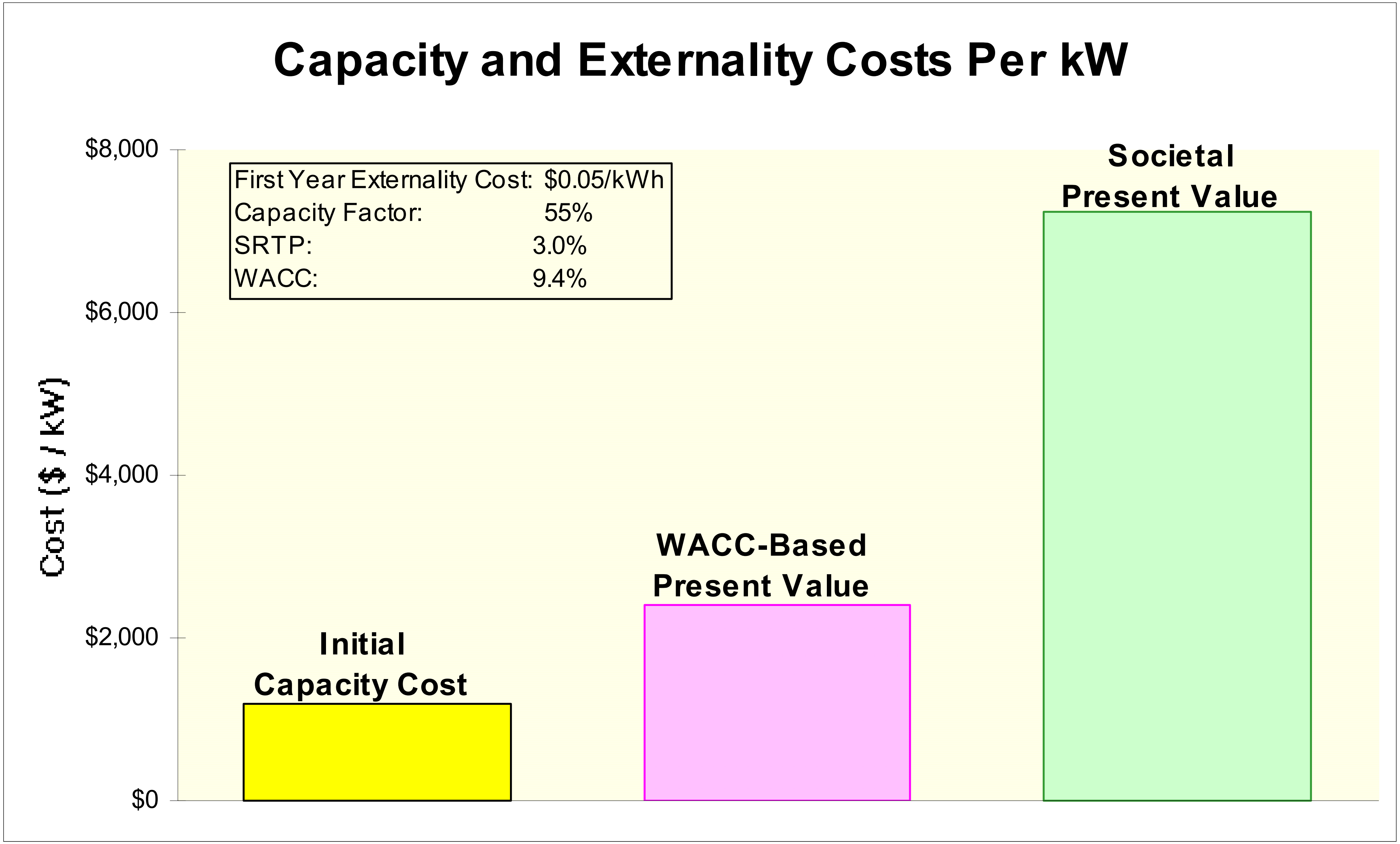
Risk-Adjusted Cost-of-Electricity Estimates: "Historic Fuel Price Risk"



Risk-Adjusted Cost-of-Electricity Estimates: "No-Cost " Contract Fuel



TRADITIONAL VALUATION ALSO DISTORTS ENVIRONMENTAL ISSUES



Valuing Externalities: Quasi-Perpetual Annual Emissions

g = Real Rate of Growth in the Economy (ΔPopulation$\bullet\Delta$Income)
= Rate of Growth in the Value of Environmental Damage Caused by Constant Emissions Level

k_s = g = Social Rate of Time Preference

E_1 = First Year Externality Cost;

$E_t = E_1(1+g)^t \quad t = 1,n$

Present Value of Environmental Costs =
PV[Perpetuity With Growth] $\Rightarrow$ Gordon Growth Model

Present Value of Environmental Cost $= E_1 / (k_s - g) = \infty$

Valuing Externalities:
Case II: Finite-Lived Project, Constant Annual Emissions

g = Real Rate of Growth in the Economy
= Rate of Growth in the Value of Environmental Damage
k_s = g = Social Rate of Time Preference

E_1 = First Year Externality Cost;
$E_t = E_1(1+g)^t \quad t = 1,n$

$$PV = \sum_{t=1}^{n} \frac{E_1(1+g)^t}{(1+k_s)^t} = n \bullet E_1$$

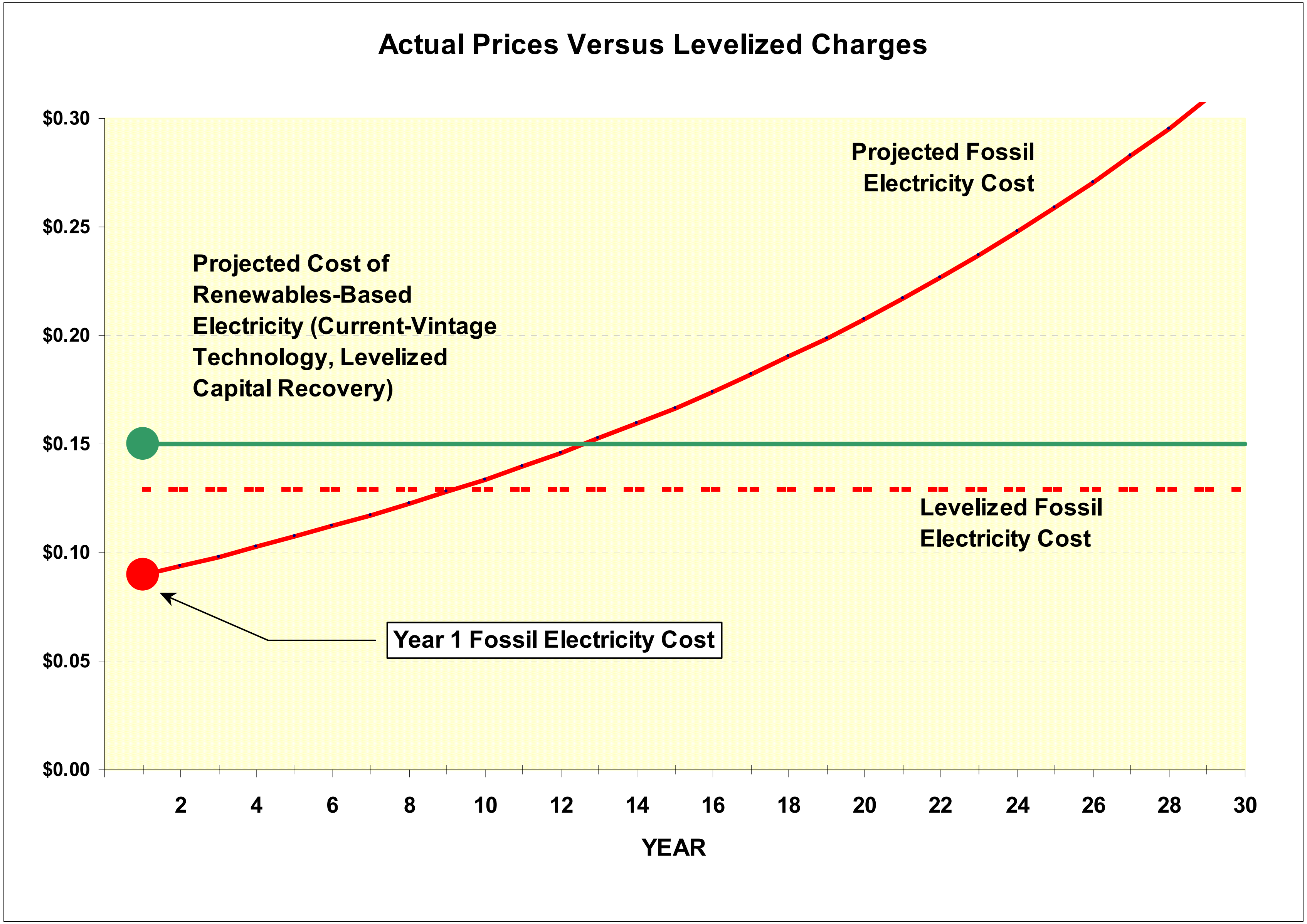
Present Value of Environmental Costs = First Year Cost × Project Life

FURTHER MEASUREMENT ISSUES:

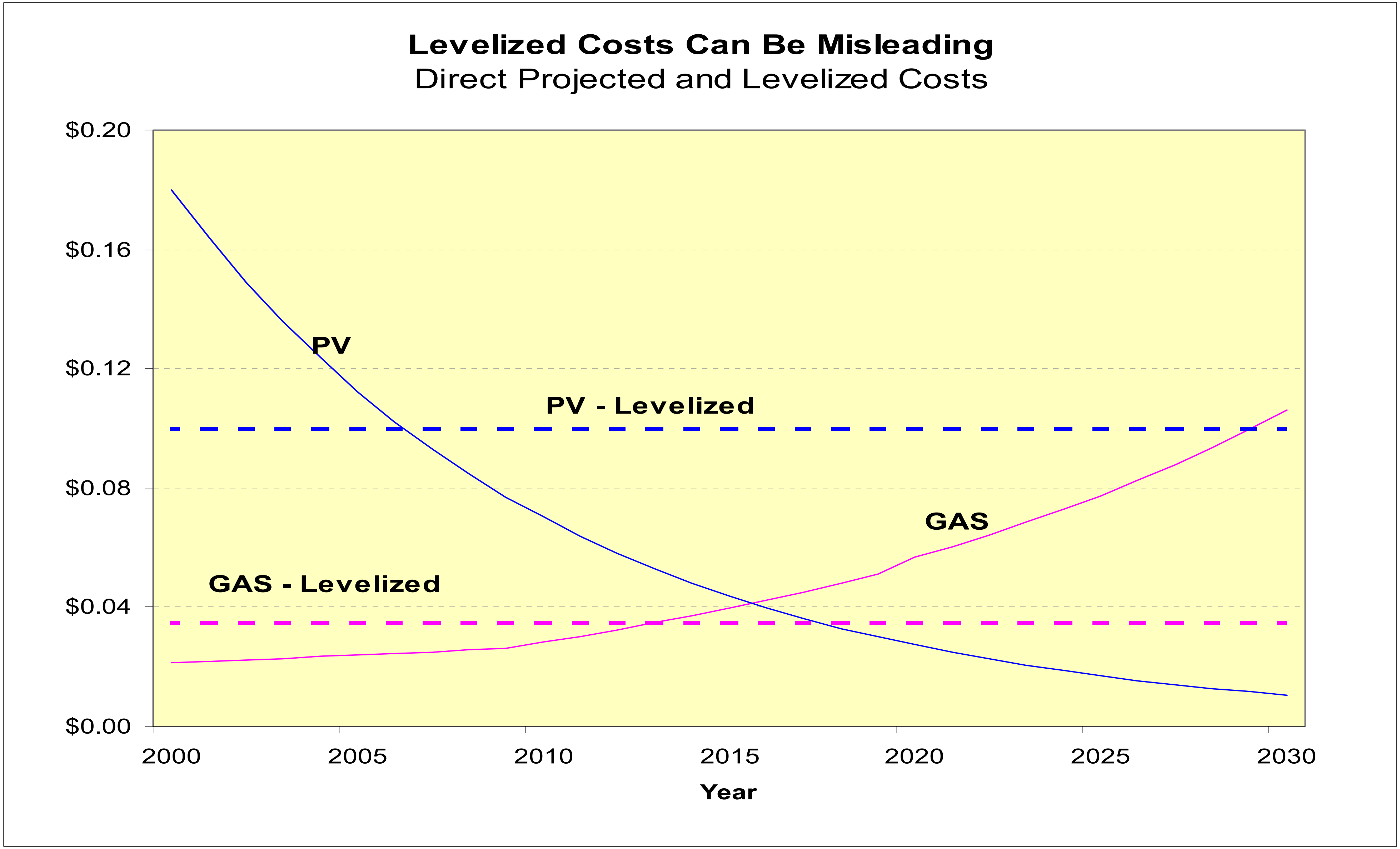
PROBLEMS OF ELECTRICITY COST LEVELIZATION

VINTAGE –LEVELIZED COSTS

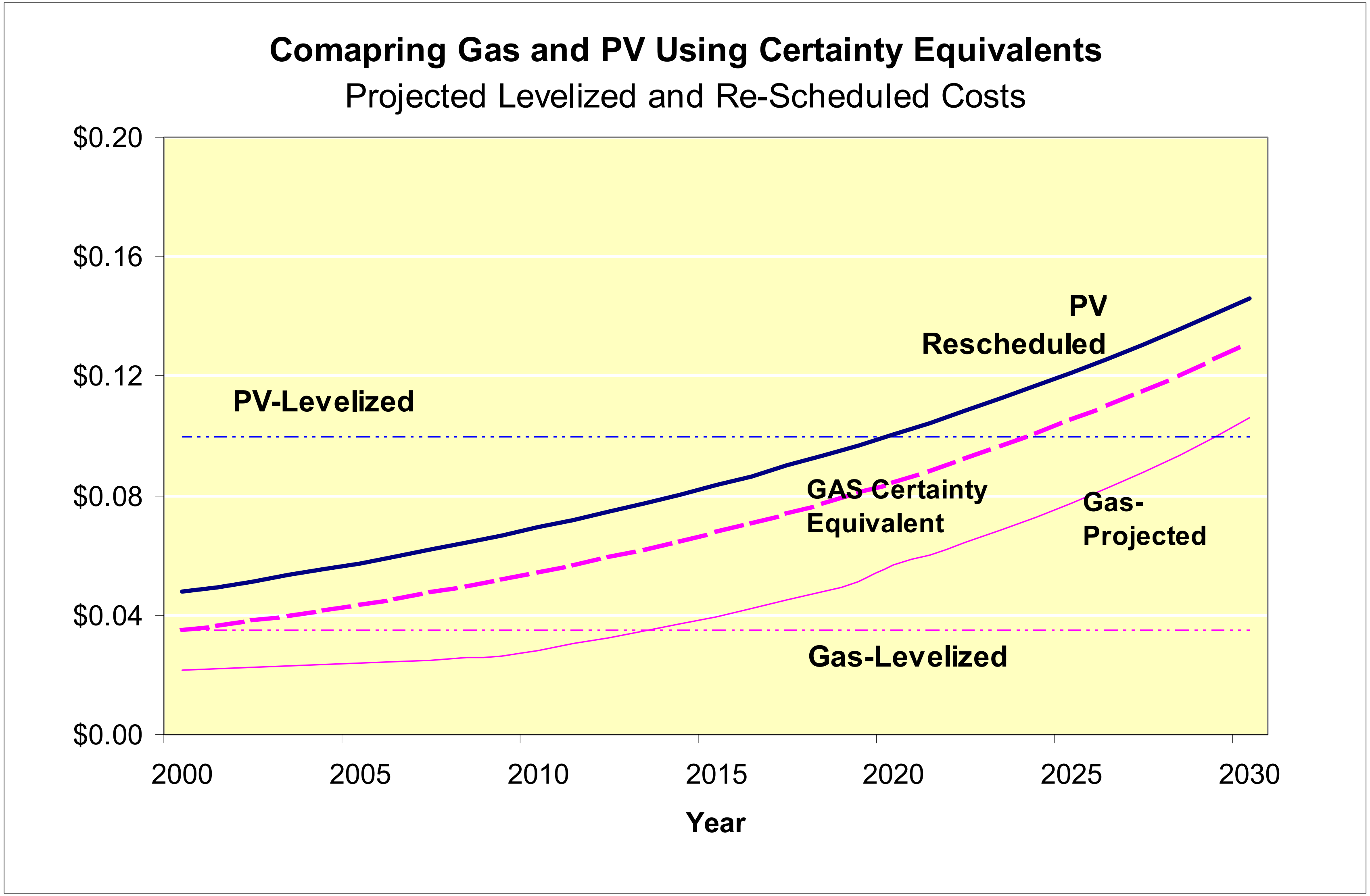
Levelized COE Estimates cannot be compared to actual market prices



LEVELIZED COSTS MASK IMPORTANT INTER-TEMPORAL INFORMATION



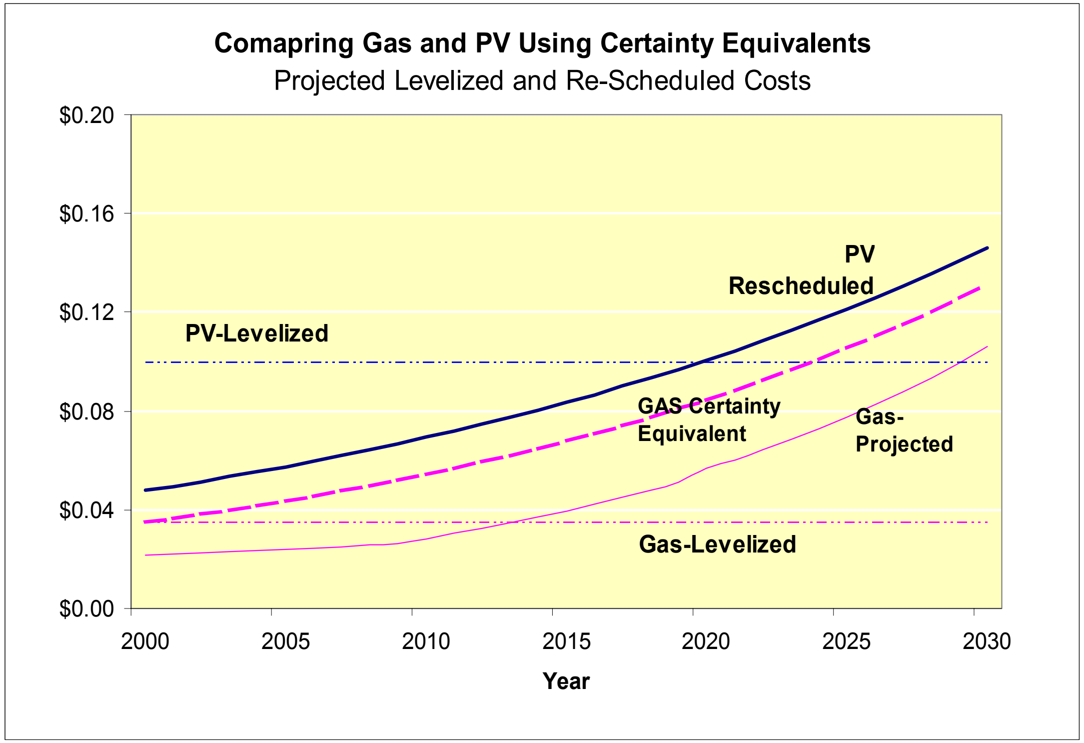
LEVELIZED COSTS MASK IMPORTANT INTER-TEMPORAL INFORMATION



CAN WE ALTER OUR COMPACT WITH FUTURE GENERATIONS? RENEWABLES CAN RESHAPE THE LEGACY WE LEAVE FOR THEM

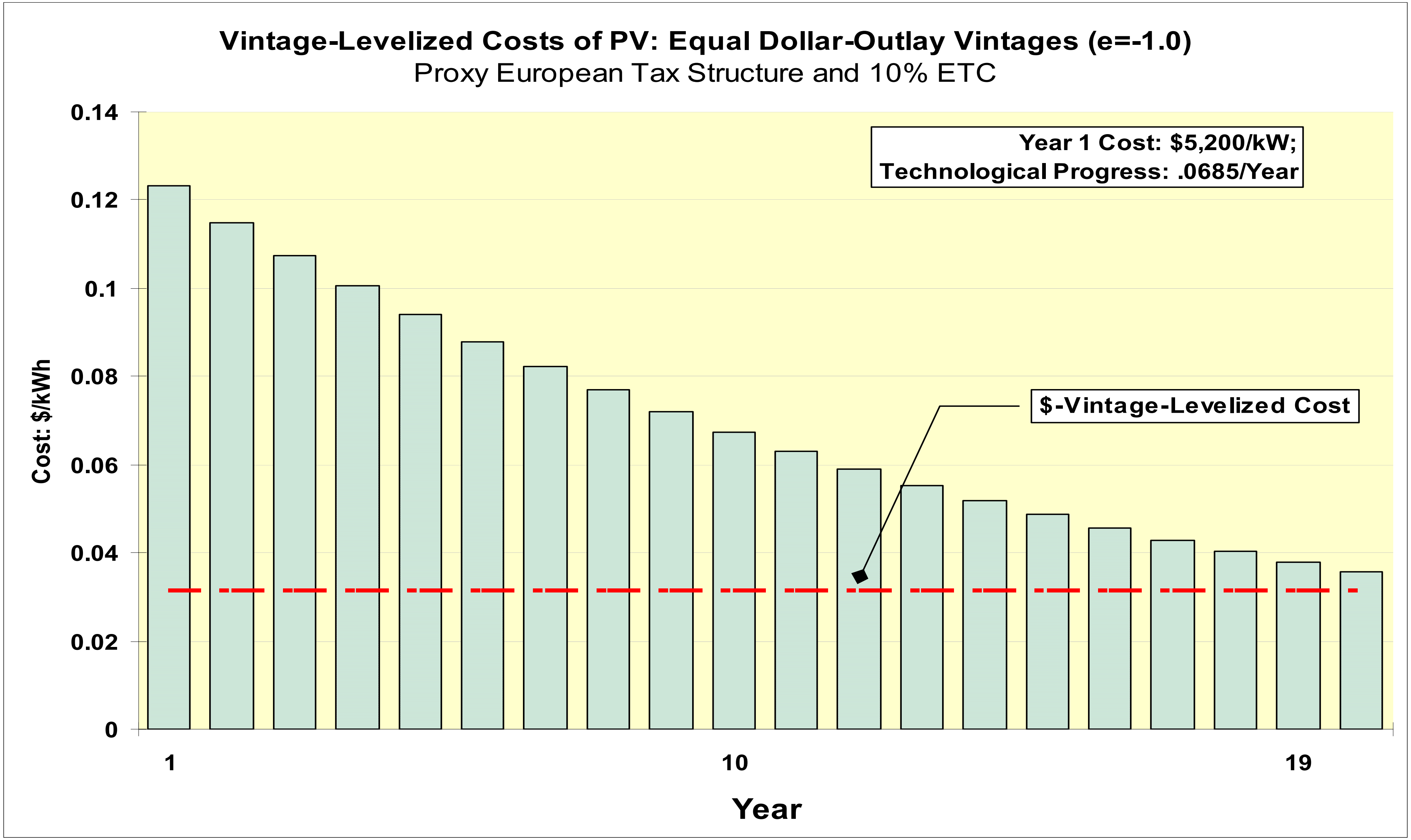
- **Fossil Fuel Usage Saddles Future Cohorts With Rising Fuel and Environmental Costs**

- **Should We Alter Our Compact With Future Generations?**



It may be no greater injustice to install renewables now and shift capital recovery to future generations!

WE MUST VALUE ENERGY *STRATEGIES* -- NOT TECHNOLOGIES



ACCOUNTING MEASUREMENT, INNOVATION, ORGANIZATIONAL CHANGE AND OTHER ISSUES

SHIMON AWERBUCH

Understanding and Valuing Distributed RETs: The Role of Organizational and Infra-structure Changes

- **RETs/DG: First Reorganization Around New Technology in 100 years**
  - — Cannot be understood in context of current (19th Century) utility Organizations
  - — Existing T&D Networks, PEx, ISO structures, AGC, etc. -- all developed in support of large-scale central generation
    - do not support RETs

- **Fully Exploiting RETs will require Infra-structure changes**
  - "Informated" T&D Networks
  - Smart Meters
  - Discreet Load Matching – intermittent resources and loads
  - Decentralized network operation – no centralized AGC

Understanding and Valuing Distributed RETs: The Role of Organizational and Infra-structure Changes

- **Example: Reorganization –Bessemer Steel and Word Processing Both Required Organizational and infra-structure changes**
  - Bessemer: US- Reorganization, floor-plan, upstream & downstream flow-control quadruples productivity (Clark)
  - Word Processor: just a new typewriter - give it to the typing pool
    - exploitation required major organizational, (disintermediation) and value changes
- **Learning How to Fully Exploit Renewables is Non-Trivial**

Renewables are as much a substitute for fossil plants as computers were a "substitute" for typewriters & calculators

The Role of Quality in Electricity Generation and Delivery

Manufactured Products	*Electricity*
- Lower energy & labor content - Higher information-content - More value to customer (P. Drucker)	Fewer kWh's with higher information content and greater value: *"Fewer, Smarter kWh's"*
From Mass-production to Flexible, just-in-time Manufacturing and Mass Customization	- Lower Overhead DG/RE - Virtual utilities - Decentralized networks to facilitate market-based transactions - Minimizing transactions costs, excess generation and reserve capacity

Adapted From: S. Awerbuch, L. Hyman and A. Vesey,
***Unlocking the Benefits of Restructuring: A Blueprint for Transmission*, Arlington VA: PUR, 1999; Chapter 4.**

Mechanical Vs. Cognitive Paradigms:
The New Information Economics

- **Mechanical Production Paradigm**:

Raw Materials → Production → Output

Efficiency (Mechanical) = Input/Output

— e.g.: Btu / kWh, $ / kWh, € / km driven

Mechanical Vs. Cognitive Paradigms:
The New Information Economics

- **Cognitive Production Paradigm— The Information Age:**

Data → Information/Decisions → Action

-- Mechanical-age measures & decision tools do not work

-- Information-age firm is a decision-factory

- Design for quality decisions

- Decision quality =

f (data availability, processing speed,

asset reconfiguration/deployment)

e.g.: steel mini mills, Williams/Cat mobile turbines

VALUING RENEWABLES AS A RADICAL ARCHITECTURAL INNOVATION – WHAT IT REQUIRES

- **Integration of Modern Valuation Theory & Development of New Accounting Concepts, Insights and Valuation Measures**
- **Beyond Direct Costs- A Search for Complementary Benefits**
  -- Overhead Reductions, Information-Based Capabilities
- **Avoiding Myopic "Shoehorn" Analyses**
  -- Full Exploitation Involves Organizational Learning and infra-structure changes

> " The amazing historic stability of key relationships depletes our capacity to imagine anything different... " Bernstein, *HBR*

"The New Religion of Risk Management"

Synopsis: A Richer Accounting Vocabulary: Beyond Direct Cost Reduction

- **Today's Cost & Value Measures Conceived in Context of 19th Century Organizations and Technology**

  -- New Cost & Value Concepts Were Needed to Understand "New Manufacturing" -- *Quality*, *Capability & Flexibility Options & ABC*

  -- RETs are conceptualized using cost ideas developed for steam plants

*"**$/kWh**" is About as Useful for Comparing PV to Gas-Fired Turbines as "**$/Mile**" is for Comparing Automobiles to Horse-Drawn Carriages;*

The Moral

1. Fully Understanding RE/DG and Other New Technologies Requires:

a) The integration of modern portfolio based financial valuation models

b) The development of new accounting concepts and valuation insights and measures;

2. Trying to understand passive RE/DG using today's accounting vocabulary is roughly equivalent to trying to appreciate Shakespeare by 'listening' to a Morse-code rendition of *Hamlet*.

Depreciation, Firm Reinvestment and Firm Growth

Initial Principal Outlay	$	1,000
Investment Life		5 Years
Annual Revenues	$	298.32
Operating Expenses		$0.00
Net Cash Flow	$	298.32
Rate of Return		15.0%

"Proof": Present Value of {$298.32 / 5 years / 15%} = $1000

Accounting and Economic Rates of Return

5-Year Asset With No Operating Expenses -- IRR = 15%

Yr	Revenue	Depreciation	Net Income	Opening Book Value	ARR (ROE)
Panel I: Straight Line Depreciation					
1	$298.32	$200.00	$98.32	$1,000.00	9.8%
2	298.32	200.00	98.32	800.00	12.3%
3	298.32	200.00	98.32	600.00	16.4%
4	298.32	200.00	98.32	400.00	24.6%
5	298.32	200.00	98.32	200.00	49.2%
		$1,000.00		Average:	22.4%
PV= $1,000.00					
Panel II: Economic (Annuity) Depreciation					
1	$298.32	$148.32	$150.00	$1,000.00	15%
2	298.32	170.56	127.75	851.68	15%
3	298.32	196.15	102.17	681.12	15%
4	298.32	225.57	72.75	484.97	15%
5	298.32	259.40	38.91	259.40	15%
		$1,000.00			
PV= $1,000.00					

Hick's Income and the Amont the Owners Can Safely Withdraw

YEAR	Cash Flow	Distributable (Hick's) Net Income	Resulting Retention (Depreciation)	Future Compounded Retention Value
0	($1,000.00)			
1	$298.32	$150.00	$148.32	$259.40
2	298.32	150.00	148.32	225.57
3	298.32	150.00	148.32	196.15
4	298.32	150.00	148.32	170.56
5	298.32	150.00	148.32	148.32
			$1,000.00 (Sinking Fund)	$1,000.00