How Wind and Other Renewables *Really* Affect Generating Cost: A Portfolio Risk Approach

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'Shifting the Grounds for Debate'

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6th Inter-Parliamentary Meeting
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SPRU Energy Group
University of Sussex, UK

- **SPRU: One of the oldest & largest institutes for the study of science and technology policy**
  - 50 faculty, 70 Ph.D. / 50 MSc students
  - Science & Technology Policy, Technology and Sustainability

- **Energy Group Focus**
  - Transition to a low carbon, sustainable energy economy in the UK, including governance and appraisal issues

REFLECTING MARKET RISK

Valuing Energy Technologies Necessarily Involves an Assessment of Financial Risk

Market Risk Affects kWh Cost Estimates

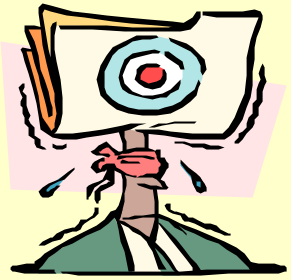
- **Risk affects *value* and economic *expectations***
  - Gas→ variable rate mortgage
- **Engineering kWh cost estimates ignore risk--have no economic interpretation**
  - Cost models developed around the time of the Model-T FORD
  - Should carry no weight in policy making

Talking about kWh cost without also talking about risk is like watching a movie…….. With the sound turned off!

How to Estimate Meaningful Levelized Risk-Adjusted kWh Costs for Gas, Wind, etc.

? **Invite large number of investors to submit *firm, binding* 20-year price bids, non-dischargeable in bankruptcy**

GAS = 3*p*/kWh?

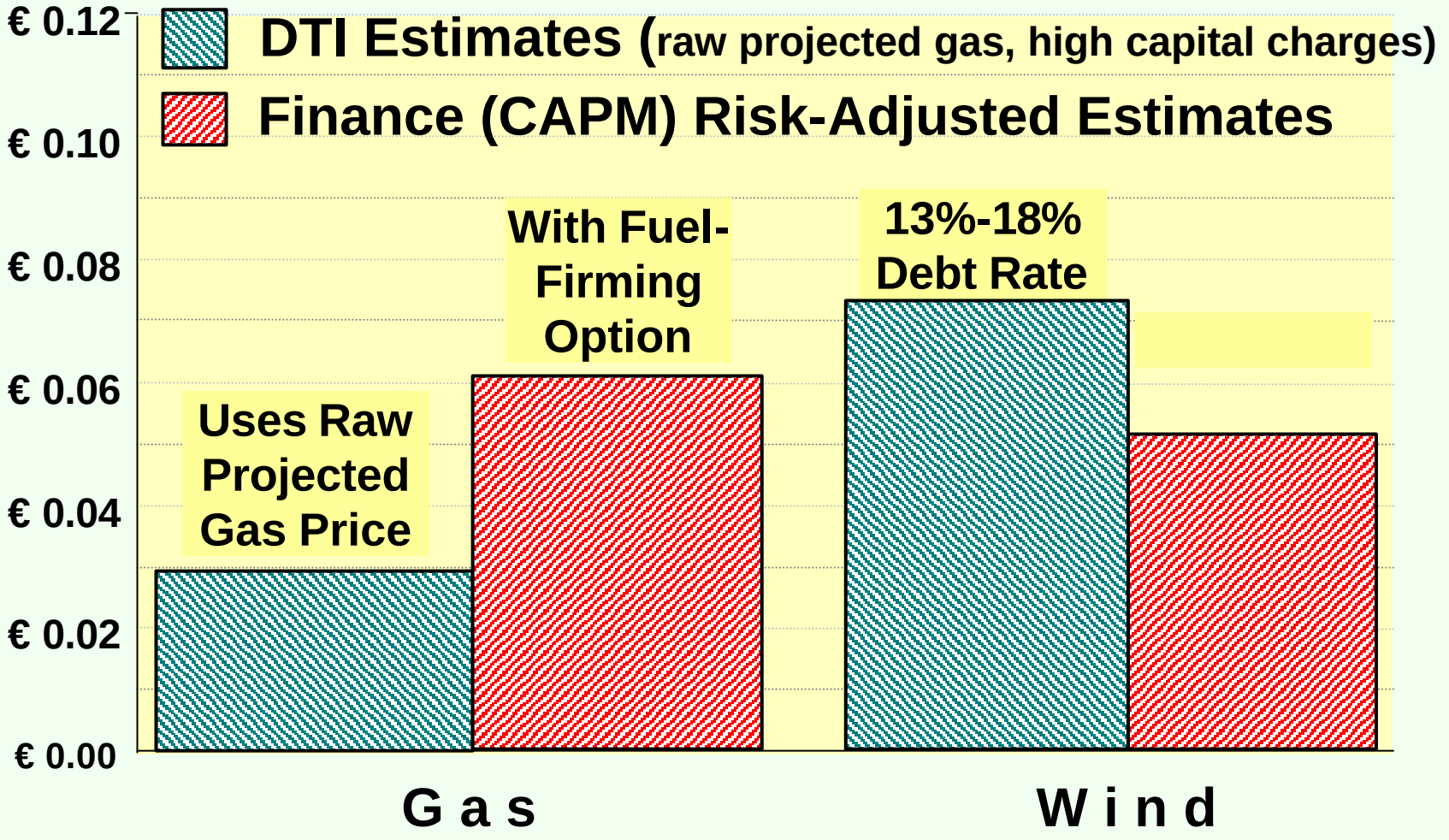


Wind = 5*p*?… 6*p*…?

? **Assuming no collusion, these bids represent a reasonably unbiased estimate of true kWh cost over each technology's life**

? **Differs radically from engineering estimates**

Ignoring Risk Distorts Wind-Gas Comparisons: DTI and Finance-Theory Estimates



Portfolio Effect:

The Only Free Lunch in Economics!

Astute Asset Combinations Reduce Cost at any Given Level of Risk

Even with risk-adjustment, "*Least-cost*" make little sense in today's uncertain environment

? **Energy planners need to follow financial investors who routinely deal with risk**
  – No one can predict stock markets or fossil prices

? **Investors hold efficient, diversified, balanced portfolios -** Best hedge against uncertain future

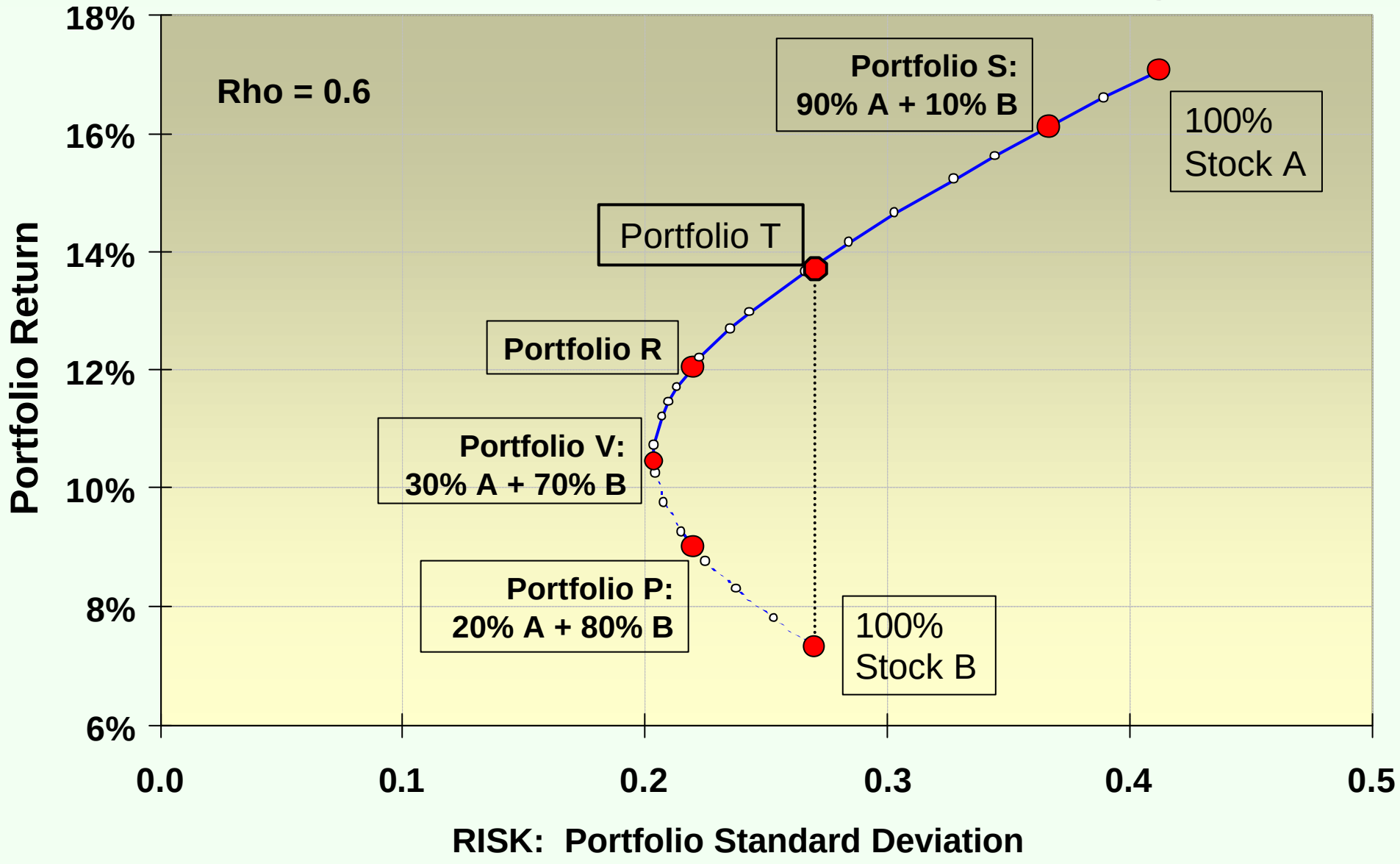
? **Is gas cheaper than renewables?….. it matters little**
  – Even if true today, picture could change dramatically

? **Renewables question not *if* – but only *how much***
  → Every optimal portfolio requires *some* fixed-cost technology

Nobel Laureate Harry Markowitz Taught the World About Portfolios

- **Portfolio of risky equity stocks expected yield = 10%**
- **Add risk-free government bonds with expected yield = 3%**
- **Resulting Overall Yield? ??**
- **Resulting yield will be >10% at the same level of portfolio risk**

Portfolio Effect Illustration
Risk and Return for A Portfolio of Risky Assets



S. Awerbuch, "Getting It Right: The Real Cost Impacts of a Renewables Portfolio Standard," PUF, 2-15-2000.

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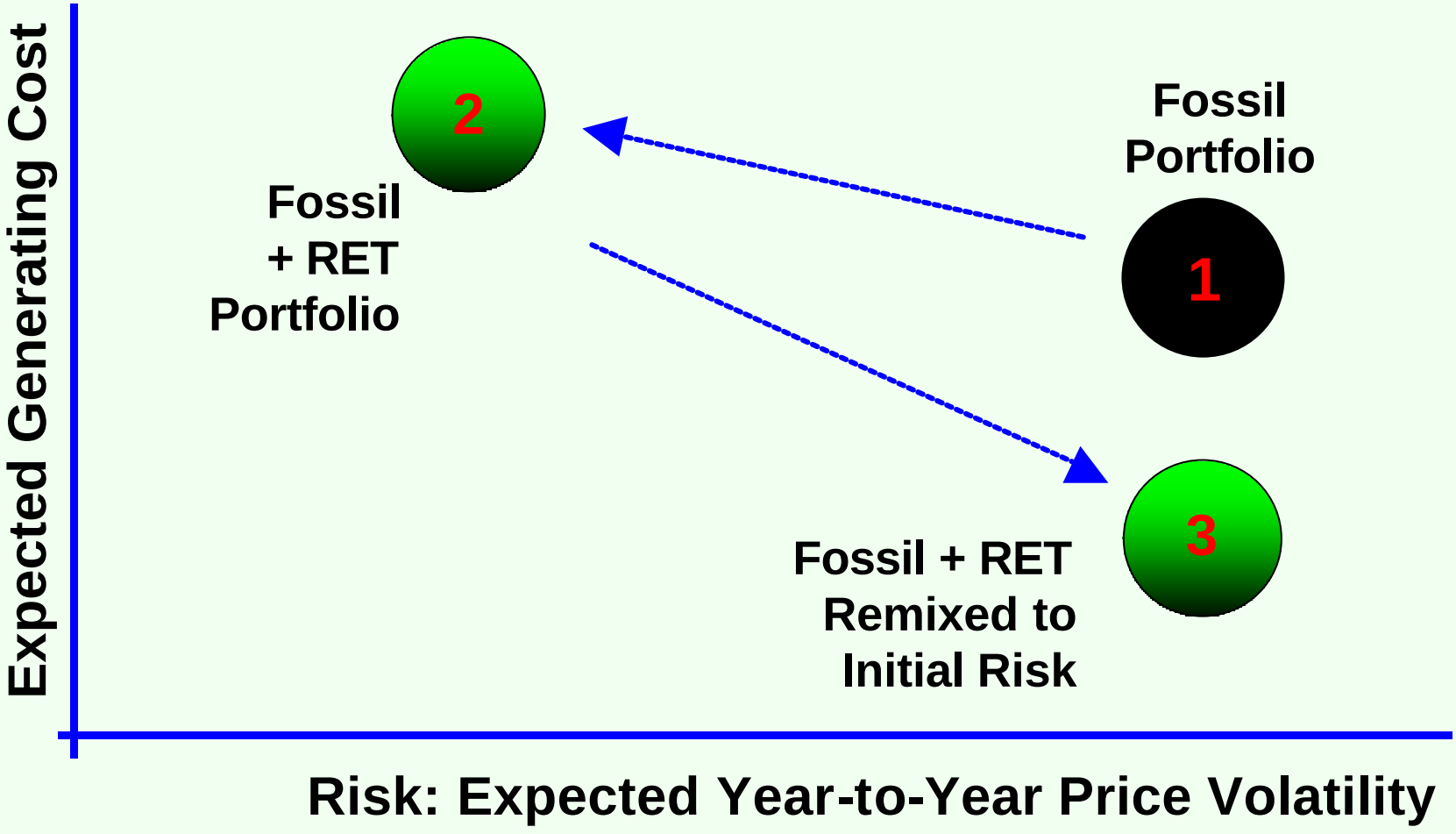
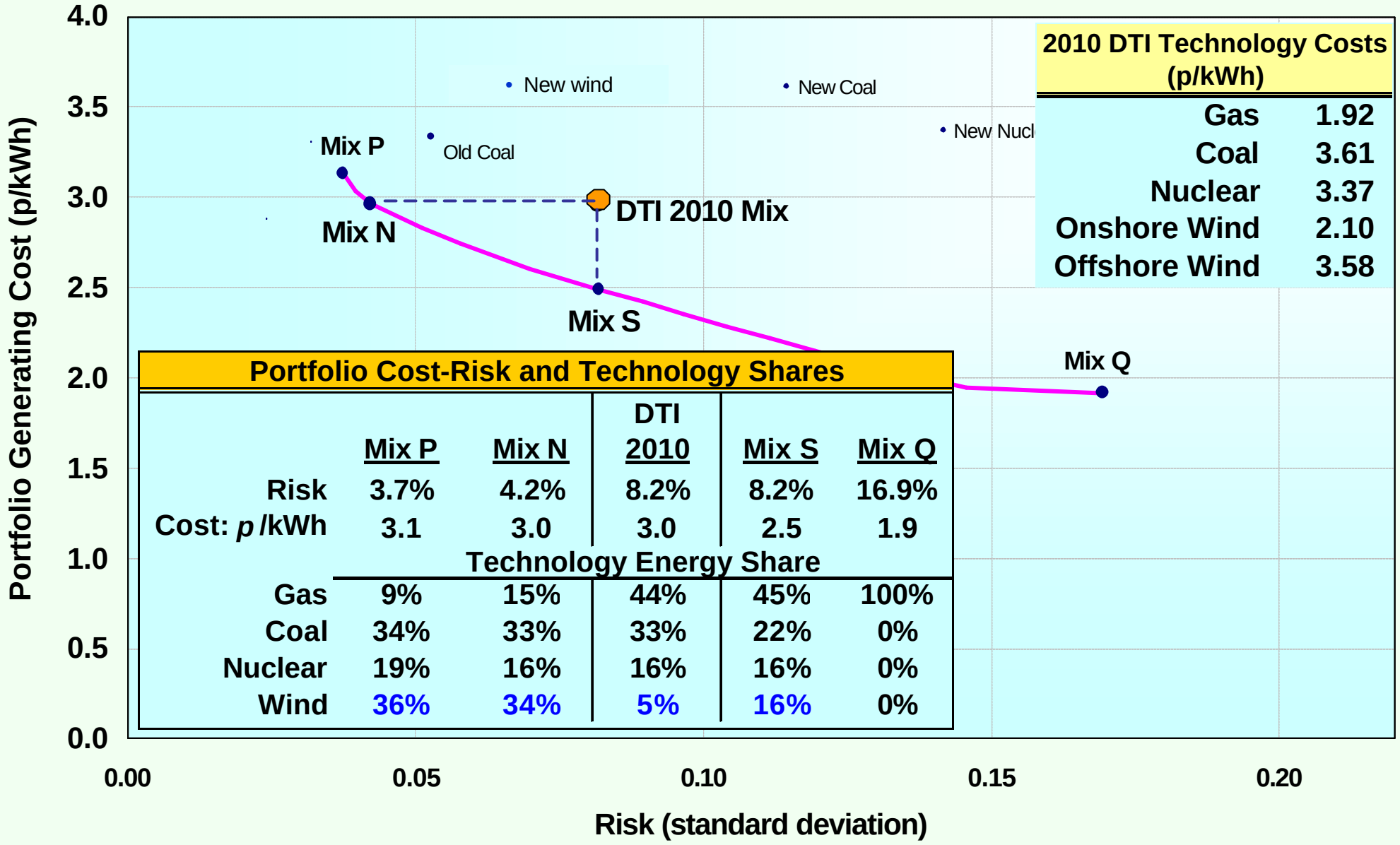
Renewables Help the Generating Mix
They Affect Portfolio Cost *and* Risk



2010 UK Portfolio Optimization
Adding Wind Does Not Raise Cost



2010 DTI Technology Costs (p/kWh)

Gas	1.92
Coal	3.61
Nuclear	3.37
Onshore Wind	2.10
Offshore Wind	3.58

Portfolio Cost-Risk and Technology Shares

	Mix P	Mix N	DTI 2010	Mix S	Mix Q
Risk	3.7%	4.2%	8.2%	8.2%	16.9%
Cost: *p*/kWh	3.1	3.0	3.0	2.5	1.9
Technology Energy Share					
Gas	9%	15%	44%	45%	100%
Coal	34%	33%	33%	22%	0%
Nuclear	19%	16%	16%	16%	0%
Wind	36%	34%	5%	16%	0%

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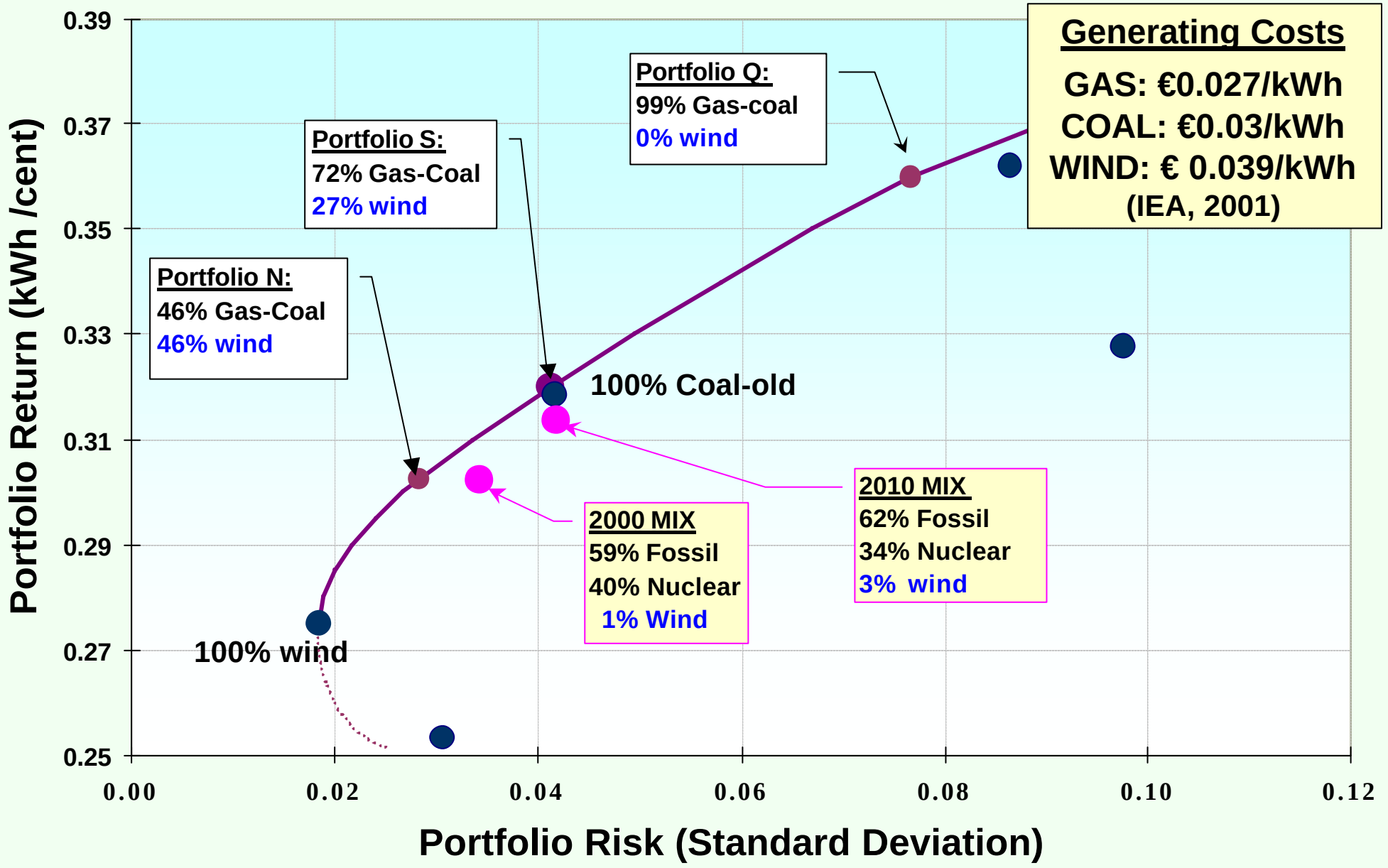
Scotland Projected 2010 Generating Mix and Optimized Portfolios

Technology Generating Costs (p/kWh - includes system costs)

Coal: 5.0 - Gas: 3.5 - Nuclear: 4.0 - Wind: 4.9 / 7.6 on/off shore

	2010 NGC Target Mix	Optimized Portfolios	
		'Equal Cost'	'Equal Risk'
Portfolio Cost	4.5 *p*/kWh	4.5 *p*/kWh	4.2 *p*/kWh
Portfolio Risk	4.0%	3.3%	4.0%
Gas-Coal Share	45%	36%	38%
Nuclear Share	26%	26%	26%
Wind Share	23%	34%	31%

Adding Wind to the EU Generating Mix *Lowers* Cost and Risk



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Renewable Energy and the Power Grid:

RE Can Help Re-conceptualize Electricity Production & Delivery Paradigms

Issues Surrounding the Integration of Wind and Other 'Intermittent' Renewables Are Not New

- **Exploiting new technology always requires changes in Organizations, Support Systems & Infra-structures**
  - Bessemer, Word Processing
- **Current debate on wind integration is misdirected**
  - Focuses on shoehorning wind into inappropriate electricity production and delivery systems
- **Allows wind to ride …… but only side-saddle**

Networks of the Future: *Informated, Decentralized* and *Market-Driven*

- **_Facilitate_ Markets - Deliver Market-driven products**
  - Not just transporting commodity electrons
- **_Exploit_ technology attributes**
  - Match to load's need
  - Do not force all sources to resemble gas turbines
- ***Promote diversity:* create opportunities for *all* new resources**

Future networks must enable

re-conceptualized *just-in-time, mass-customized*

electricity production/delivery paradigms

Intermittency– Capacity *Credit (ELCC)*

- **Capacity-credit: conventional generation capacity that can be replaced with wind**
  - Function of capacity-factor and coincidence with system peak
- **Every grid asset requires backup**
  - e.g. 500-MW fossil generator with 15% forced outage rate (.85 capacity-factor)
    - → Capacity-credit might be 78% (Milligan, NREL, 2002)
- **Backup issue is complex**
- **Research sugests wind resources are sufficiently reliable or diversified**
  - 20% Wind Integration < 0.5*p* or 0.4 Euro-cents/kWh

Capacity Credit

- **Some argue wind unreliable, intermittent and "non-dispatchable"**
- **Recent studies suggest wind deployment imposes only small additional system costs**
  - Dale, Milborrow, et. al., National Grid Transco and UMIST (2004), and German *DENA Grid Study* (2005):
  - Cost of 20% wind penetration = 0.5p/kWh in the UK (5% of average domestic prices) and 0.4 Euro-cent in Germany

"There does not appear to be any technical reason why a substantial proportion of the (UK's) electricity requirements could not be delivered by wind."
(Dale, Milborrow, et. al., 2004)

Conclusion: Shifting The Grounds for Debate:

? **Standard risk-adjusted finance cost models show kWh-cost for most renewables is *less* than gas-fired electricity**

? ***Modern Portfolio Theory Says***

– Even if you believe RETs cost more…… Adding them to a fossil generating mix *reduces* overall kWh cost

? **Exploiting new 'broadly-applicable' technology**

- Requires changes in accounting, organizations & supporting systems/infra-structures

THANK YOU

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Exploiting the Oil-GDP Effect to Promote Renewables and Energy Security

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RETs Provide Important Portfolio Benefits Without Increasing Cost.... But Lenders/Investors Cannot Capture These

Benefit	Policymaker Awareness
? **Environmental Benefits** - Widely understood– undervalued by regulators	**HIGH**
? **Help Mitigate Market Power** - Help *Unlock* Benefits of Liberalization by Enhancing Competition along Power Network - Requires NO restructuring & incentives	**MOD-LOW**
? **Security: *Mitigate/Diversify* Fossil Risk** - *Reduce* overall electricity generating costs - *Minimize* exposure to macroeconomic fossil risk	**LOW**

Most significant aspect of energy security today

Valuing Renewable Energy Technologies

Macroeconomic Fossil Risk

The Oil-GDP Externality

The Macroeconomic Consequences of Fossil Price Risk: A Major External Cost

- **Fossil volatility hurts employment & GDP growth in oil consuming and producing nations**
  - Widely accepted in academic literature and the press
- **Macroeconomic cost of 2000-04 oil spikes in EU: Approximately €400- €700 Billion**
  - Offsets *entire* 2020/20% RET investment needs estimated by EWEA/EREC
- **Policy makers *seem* aware– but apparently do not see connection to renewables** Rodrigo Rato IMF

Where/What is the Policy Disconnect?

Oil-GDP Effect:
% GDP Change for Oil-Price Doubling

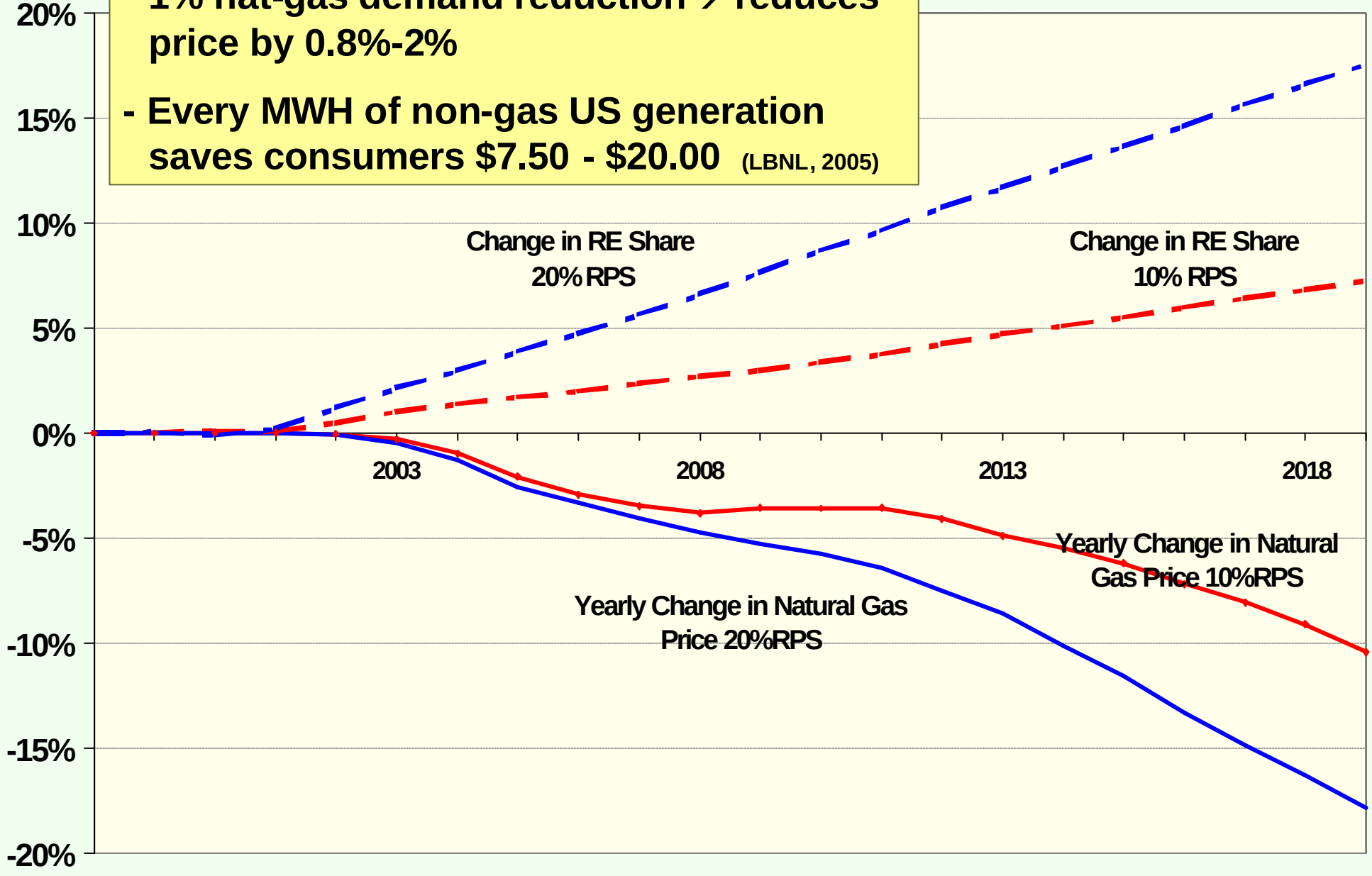
Importers			Exporters	
Country	GDP Elasticity		Country	GDP Elasticity
Taiwan	-8.4%		Indonesia	-4.3%
Hong Kong	-6.5%		Malaysia	-5.6%
Japan	-5.8%		Norway	5.1%
South Korea	-8.7%			
Philippines	-3.6%	a/		
Singapore	-4.2%			
Thailand	-8.4%			
France	-9.8%			
Germany	-8.1%			
Greece	-2.4%			
U.K.	-3.8%			
Average	**6.3%**		**Average**	**-1.6%**

a. Statistically Insignificant.

Source: Paul Leibey, IEA/ASEAN Workshop, April 2004

Addtional Renwables Share and Change in Gas Wellhead Price

- 1% nat-gas demand reduction→ reduces price by 0.8%-2%
- Every MWH of non-gas US generation saves consumers $7.50 - $20.00 (LBNL, 2005)



Avoided GDP Losses for 10% RE Addition

GDP Elasticity Measure	Loss Estimation: GDP Elasticty	Oil Price Reduction	GDP Loss %
PANEL I: Long Term Oil-Gas Correlation (? = .75)			
Pre-1986 Average	-9.8%	-6.2%	0.61%
1986 Inclusive Average	-7.3%	-6.2%	0.45%
Leiby (2004) Average	-6.4%	-6.2%	0.40%
PANEL II: Using Gas-Only GDP Elasticity (? = .40)			
	Gas-only Elasticity	Gas Price Reduction	GDP Loss %
Pre-1986 Average	-3.9%	-8.4%	0.33%
1986 Inclusive Average	-2.9%	-8.4%	0.24%
Leiby (2004) Average	-2.6%	-8.4%	0.21%

a. Based on US-EIA RES-E targets

	Avoided GDP Losses (USD $Billions) US	EU-25	OECD	World
	$66	$67	$113	$221
	$49	$49	$84	$164
	$43	$43	$74	$144
Averages	**$53**	**$53**	**$90**	**$176**
	$36	$36	$61	$119
	$27	$27	$45	$89
	$23	$23	$40	$78
Averages	**$29**	**$29**	**$49**	**$95**
GDP	**$10,882**	**$10,970**	**$18,659**	**$36,356**

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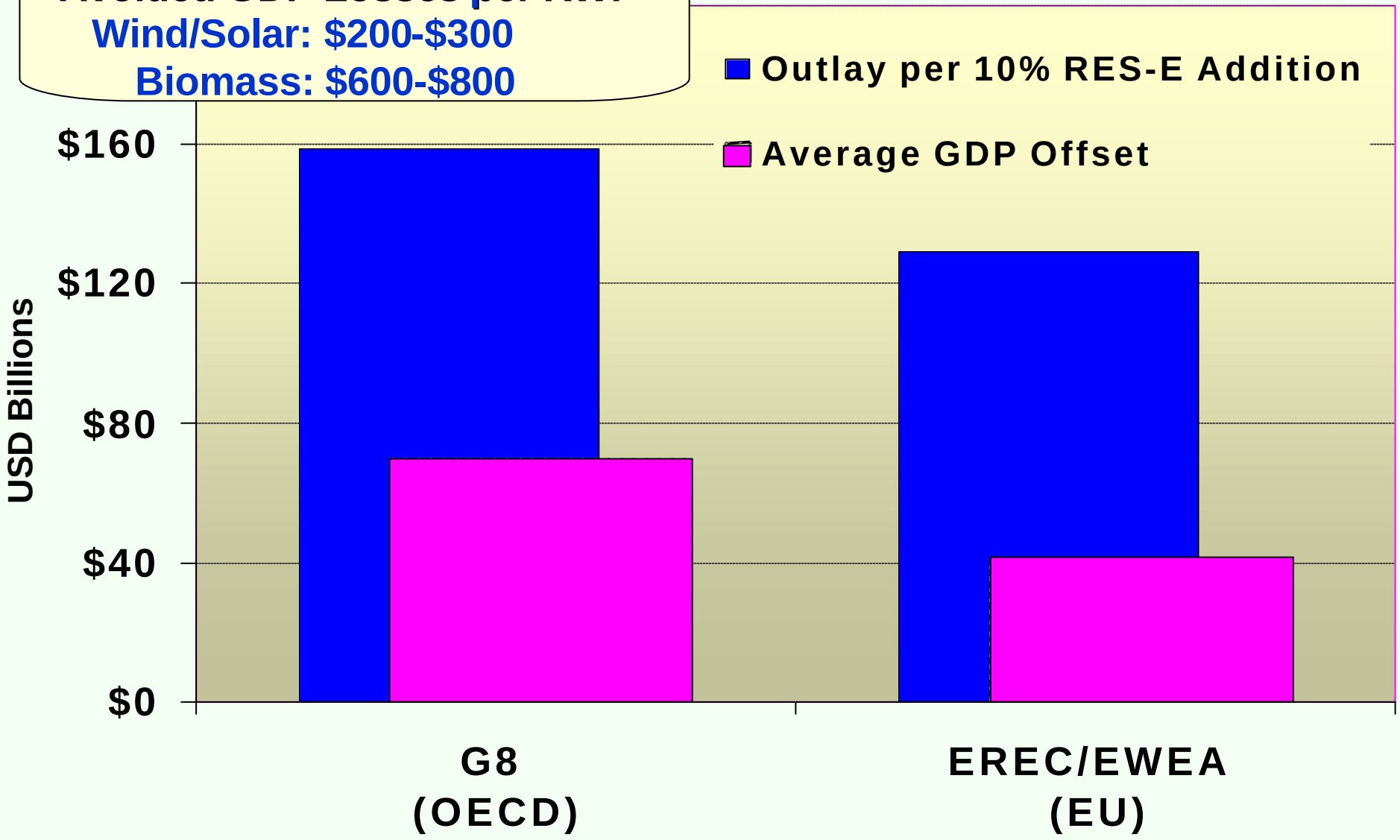
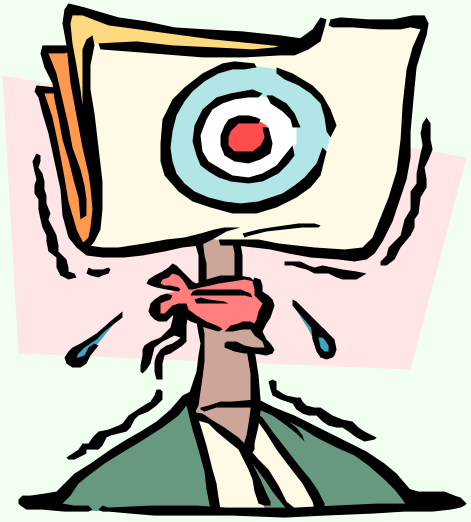
Required RES-E Investment for OECD/EU and Resulting GDP Offset

Avoided GDP Losses per KW:
Wind/Solar: $200-$300
Biomass: $600-$800



What's the "Catch?"



? **Adding Renewables Enhances Energy Security**
  – Helps avoid sizeable GDP losses

? **But Doesn't it Raise Generating Cost?**
  – Adjusted for market risk, *stand-alone* cost of many renewables is lower than gas
  – Renewables reduce overall portfolio generating costs-- even if their *stand-alone* costs are higher

Optimized Portfolios Enhance Energy Security by Reducing Exposure to Fossil Volatility

Energy Security: Powerful Benefit of Properly Optimized Generating Mixes

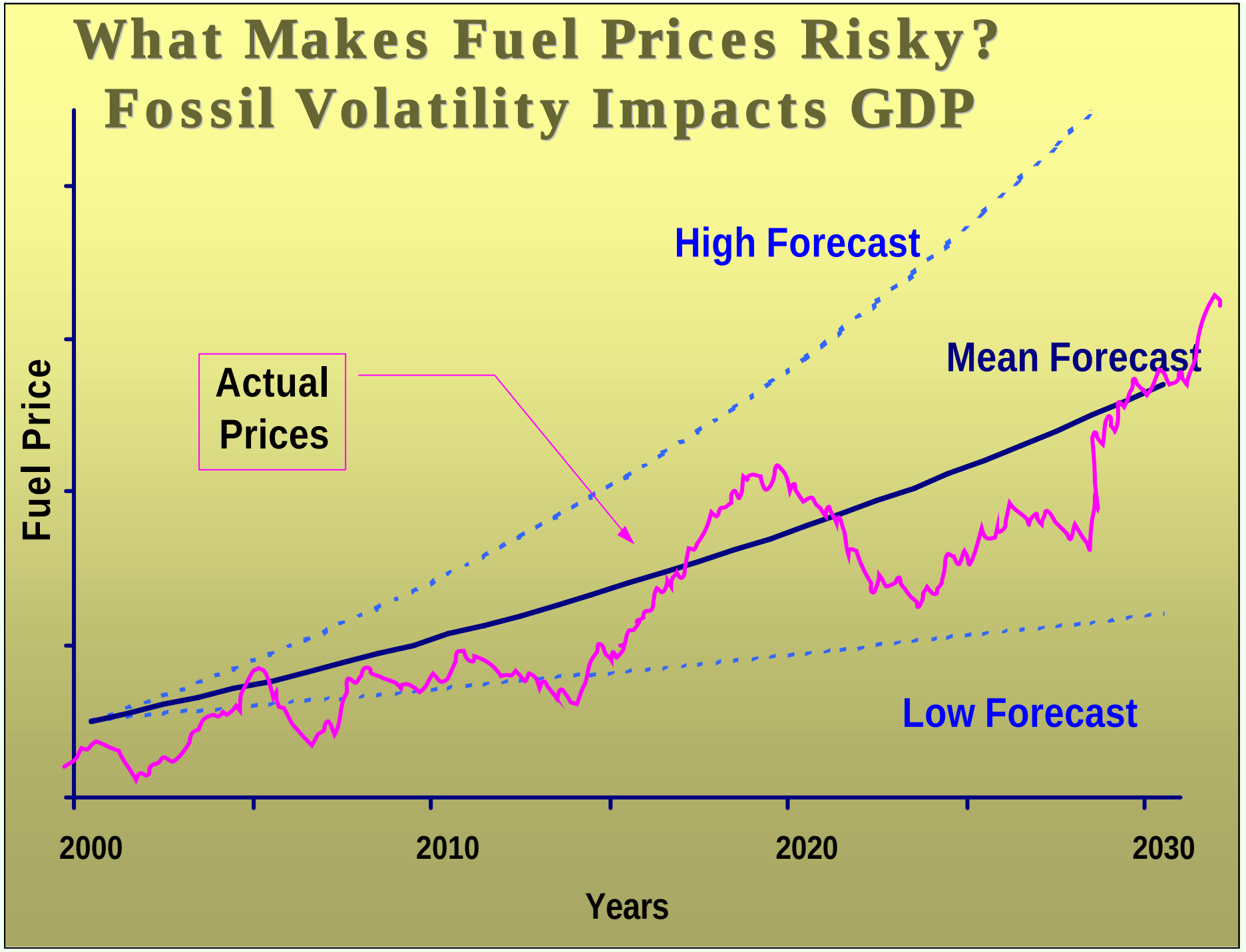
? **Everyone *talks* about energy diversity & security**
  – Little analytic work exists

? **Diversity poorly understood**
  – Not a "mix and match" concept
  – Diversity → uncorrelated assets

? ***Security* focuses on catastrophic supply interruptions – geo-political**

? **But– Oil (and gas) Traded in World Markets**
  – *Security* may be better conceived in *market* terms
  – Reflects costly exposure to fossil price volatility

What Makes Fuel Prices Risky?
Fossil Volatility Impacts GDP



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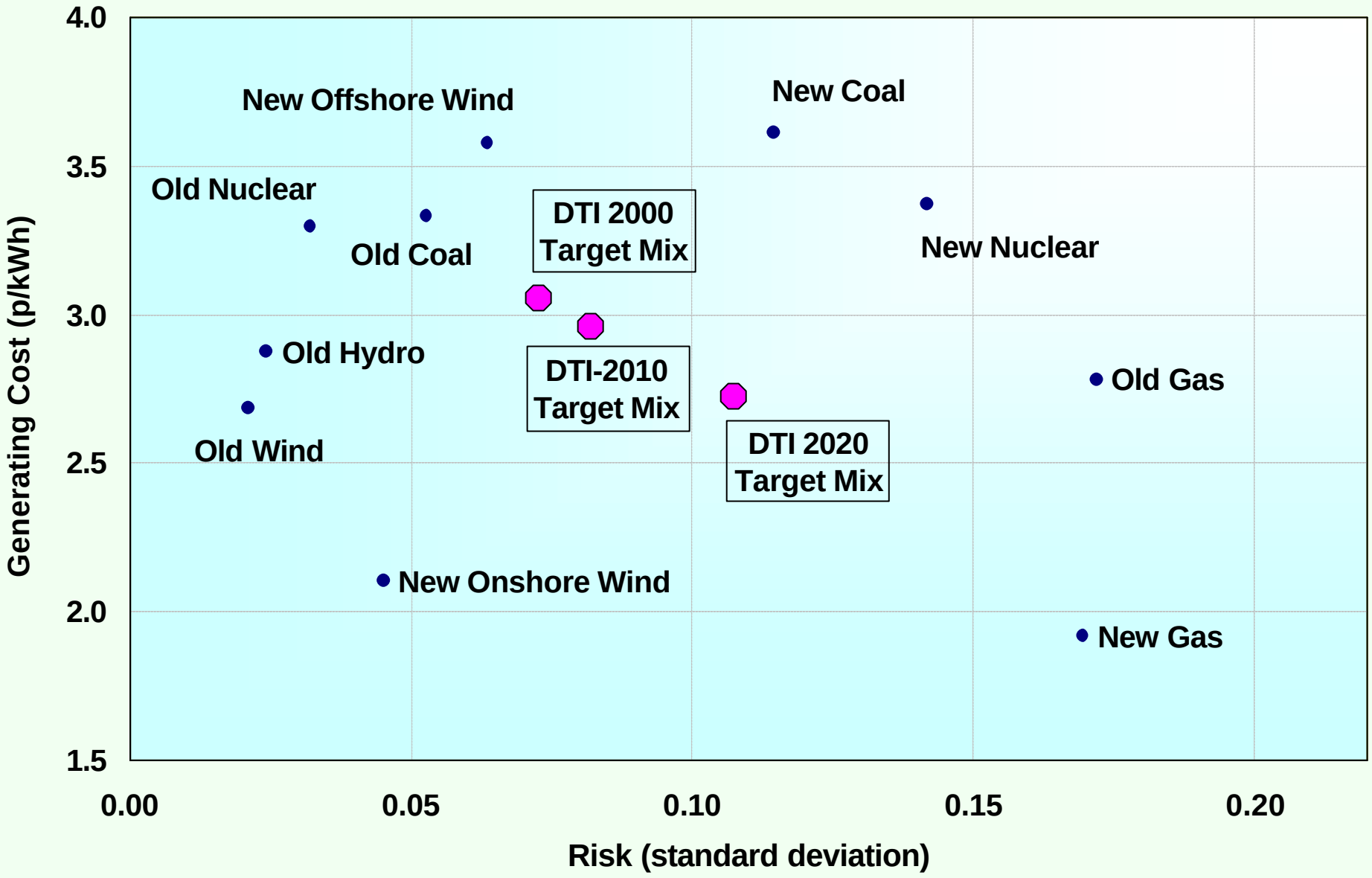
RETs Provide Another Important… but Poorly Recognized Energy Security Benefit

- **They Mitigate fossil price volatility - intuitive**
- **But they do so in a *Counter-cyclical* Manner: a form of "national insurance"**
  - **(R. C. Lind & Nobel Laureate J. Kenneth Arrow, 1984)**
- **Payoff occurs when economy is doing poorly**

Energy security is reduced when nations hold inefficient portfolios that are needlessly exposed to fossil risk

DTI 2010 Technology Cost and Estimated Risk

DTI Projected 2010 and 2020 Target Mixes



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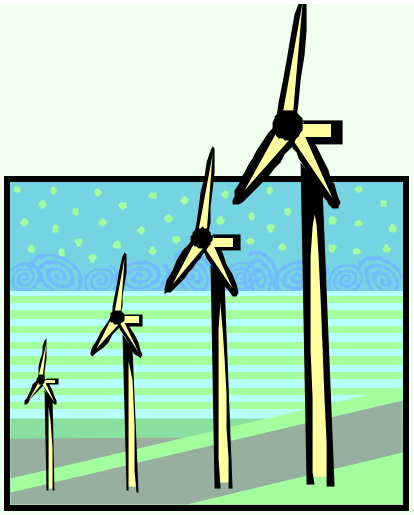
Enhanced Energy Security: Powerful Joint Benefit of Optimized Generating Mixes

? ***Efficient*** **generating mixes with optimized renewables shares:**

- Minimize generating cost
- Minimize needless exposure to Oil-GDP induced macroeconomic losses

Energy Security is Like Quality *Manufacturing*: It Costs *Less*

Why Integrate Renewables into the Power Network?



- **Create Sizeable Portfolio Benefits**
  - *Reduce* overall generating cost and risk
- **Enhance energy security/diversity**
- **Reduce Market Power:**
  - Help open markets & *unlock* the potential benefits of liberalization

The Power Grid Plays a Pivotal Role in Implementing These Crucial Objectives

THANK YOU

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