The Enhancing Energy Security and Mitigating Fossil Risk: The Role of Renewables

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Renewables Provide *Micro* and *Macro* Economic Benefits

- ***Micro*: Renewables *reduce* generating cost by mitigating financial risk**
  - e.g.: Risk of future fossil volatility
  - Individual investors can hedge, but not society
- ***Macro* Benefits- Energy Security: Oil/Gas volatility hurts GDP growth**
  - Cannot be effectively hedged
  - Renewables can *reduce* this risk

Macroeconomic Consequences of Fossil Price Risk: A major cost

- **Fossil volatility hurts employment & GDP growth in oil consuming *&* producing nations**
- **Macroeconomic cost of 2000-04 oil spikes in EU: €400 Billion +/-**
- **Exceeds total estimated renewables investment needed to meet 2020 / 20% EU targets**

Market Risk Affects KWH Cost Estimates

- **Risk affects *value* and economic *expectations***

- **Engineering kWh cost estimates ignore risk**
  - Have no economic interpretation
  - Should carry no weight in policy making

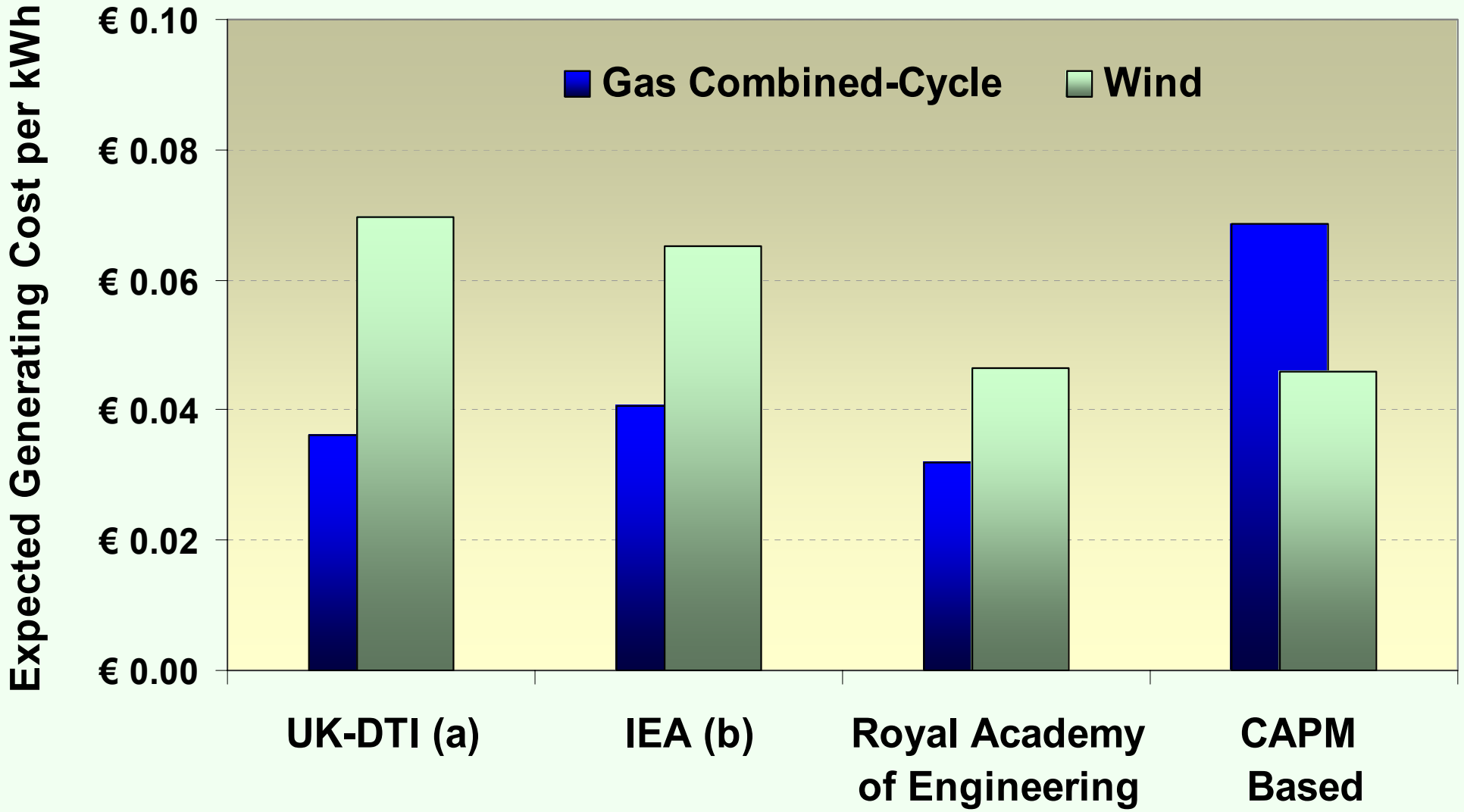
How to Estimate Meaningful Risk-Adjusted kWh Generating Costs for Gas and Wind Over the Generating Asset's Life

- **Invite a large number of investors to submit *firm* 20-year price bids**
  - Binding- no adjustments, no re-openers, no discharge in bankruptcy
- **Assuming no collusion, these bids will represent a reasonably unbiased estimate of true kWh generating cost for each technology**

Such an Experiment Would be Extremely Valuable

- **Meaningful KWH cost estimates must mimic bids investors would submit when facing future cost risk**
- **Differs from engineering KWH cost estimates**
  - **--** Produce "rule-of-thumb" valuations that ignore risk differentials (and taxes)
- **Fossil prices vary *systematically* – non-diversifiable risk**
  - Costs of passive/capital-intensive renewables are systematically riskless
  - Mimic Financial properties of US Treasury obligations

Engineering Versus Finance (CAPM) Based Generating Cost Estimates - 2005



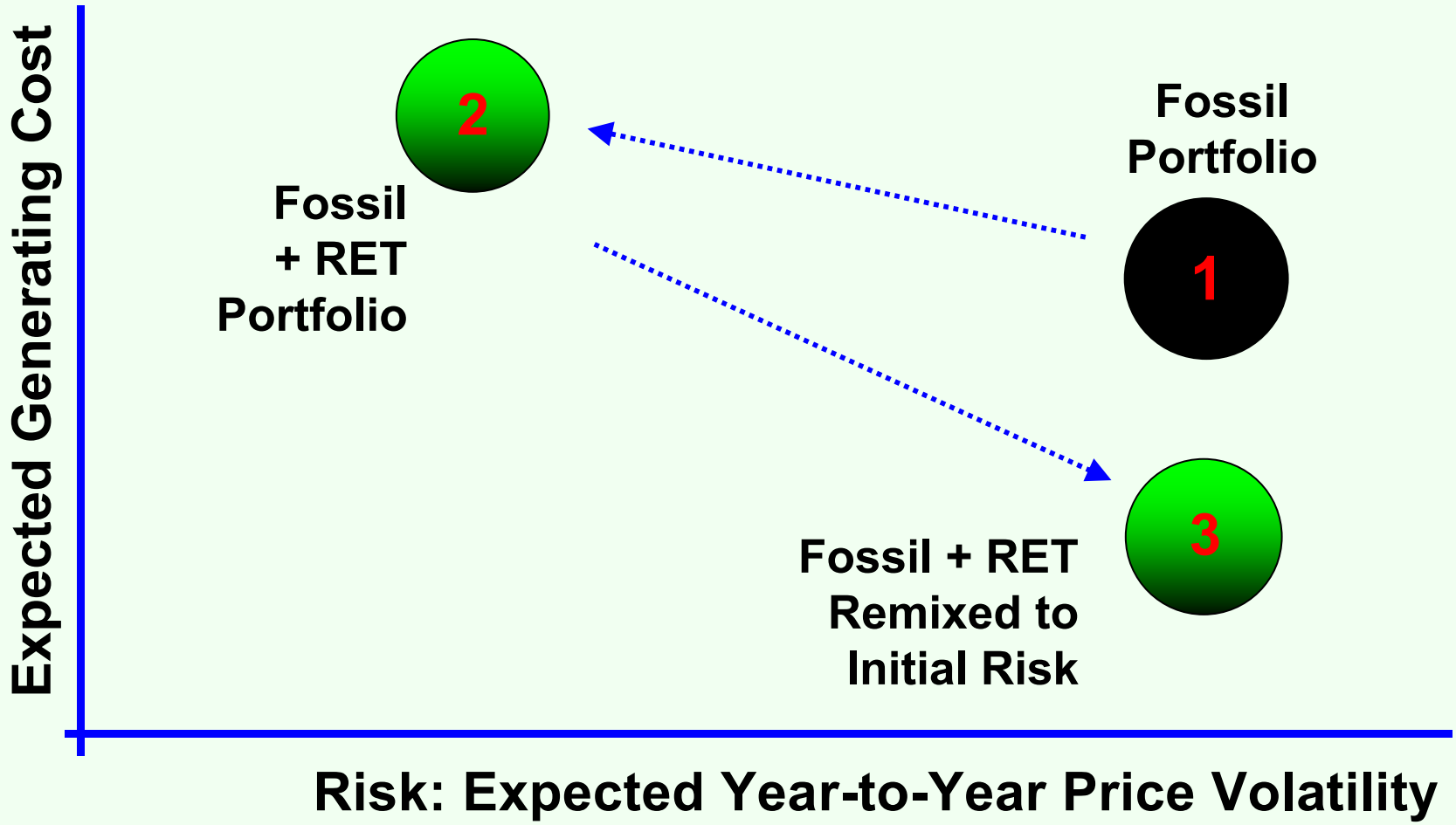
(a) Adjusted for inflation
(b) Average of 23 planned gas and 19 planned wind projects

Source: S. Awerbuch, *Renewable Energy World*, 2006

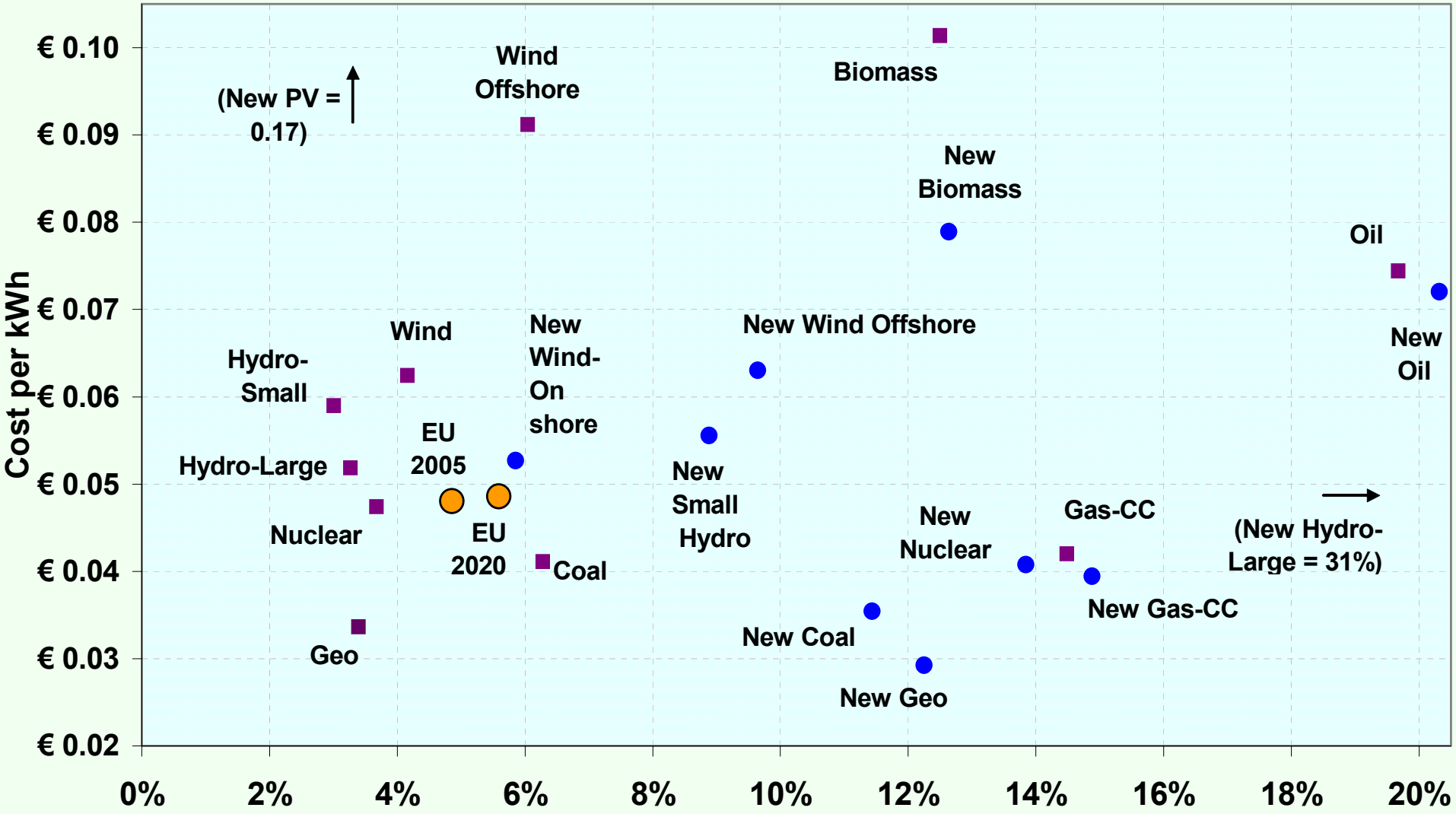
Policymakers: Take a Cue From Financial Investors

- **Are used to dealing with risk**
- **Hold efficient, diversified, balanced portfolios**
- **Is gas cheaper than RE?….. it matters little**
  - Even if true, picture could change dramatically
  - RE *reduces* portfolio cost-risk– even if it costs more
- **RE question not *if* – but only *how much***
  - Relative cost dictates make-up of optimized mix

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



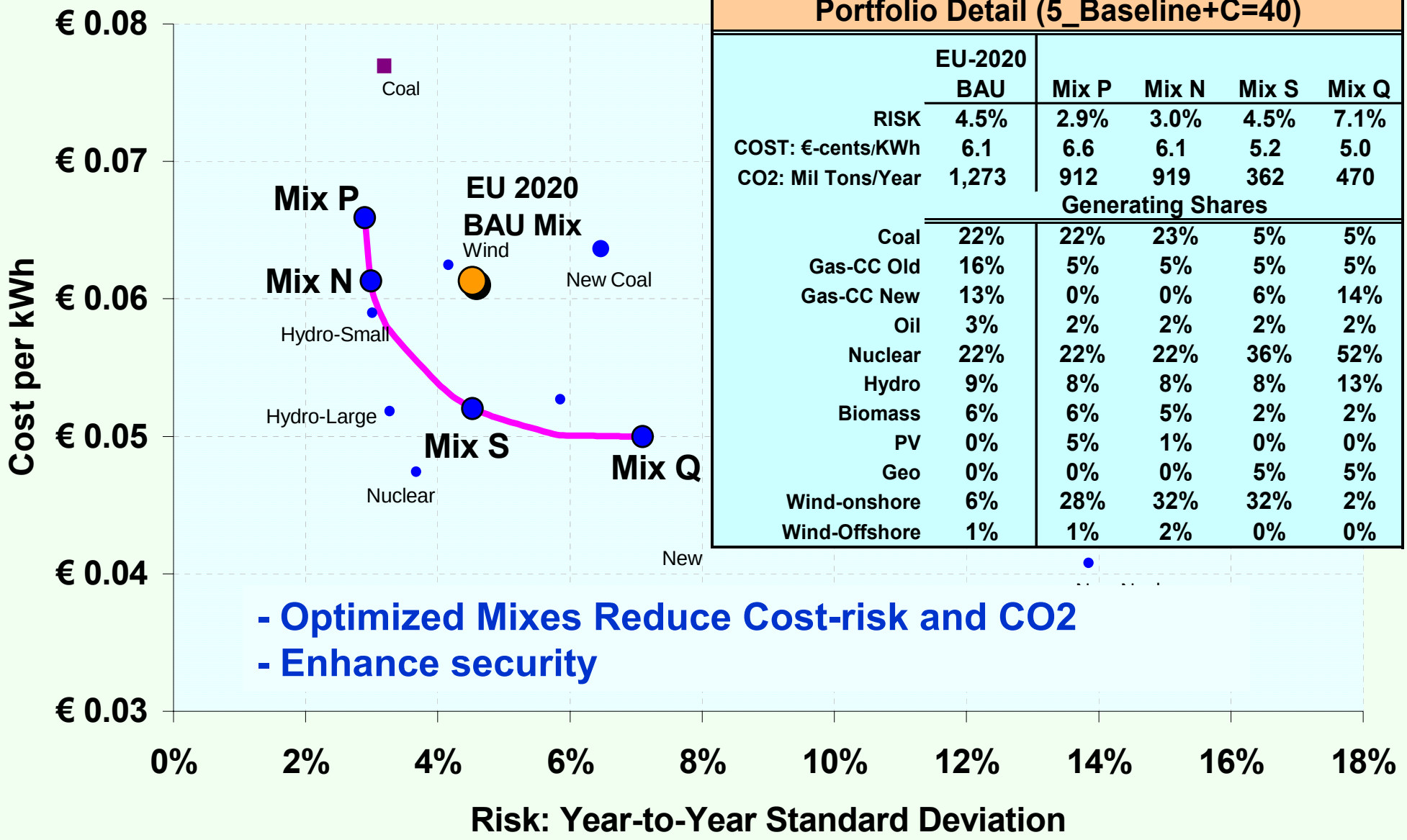
2020 EU Technology Cost-Risk (includes wind system integration charge)



5_baseline_noC_Oct_05

Cost estimates from TECHPOL database, courtesy Philippe Menanteau, University of Grenoble, CNRS (LEPII), 2006

Minimally Constrained EU 'Baseline' Optimized Results



Portfolio Detail (5_Baseline+C=40)

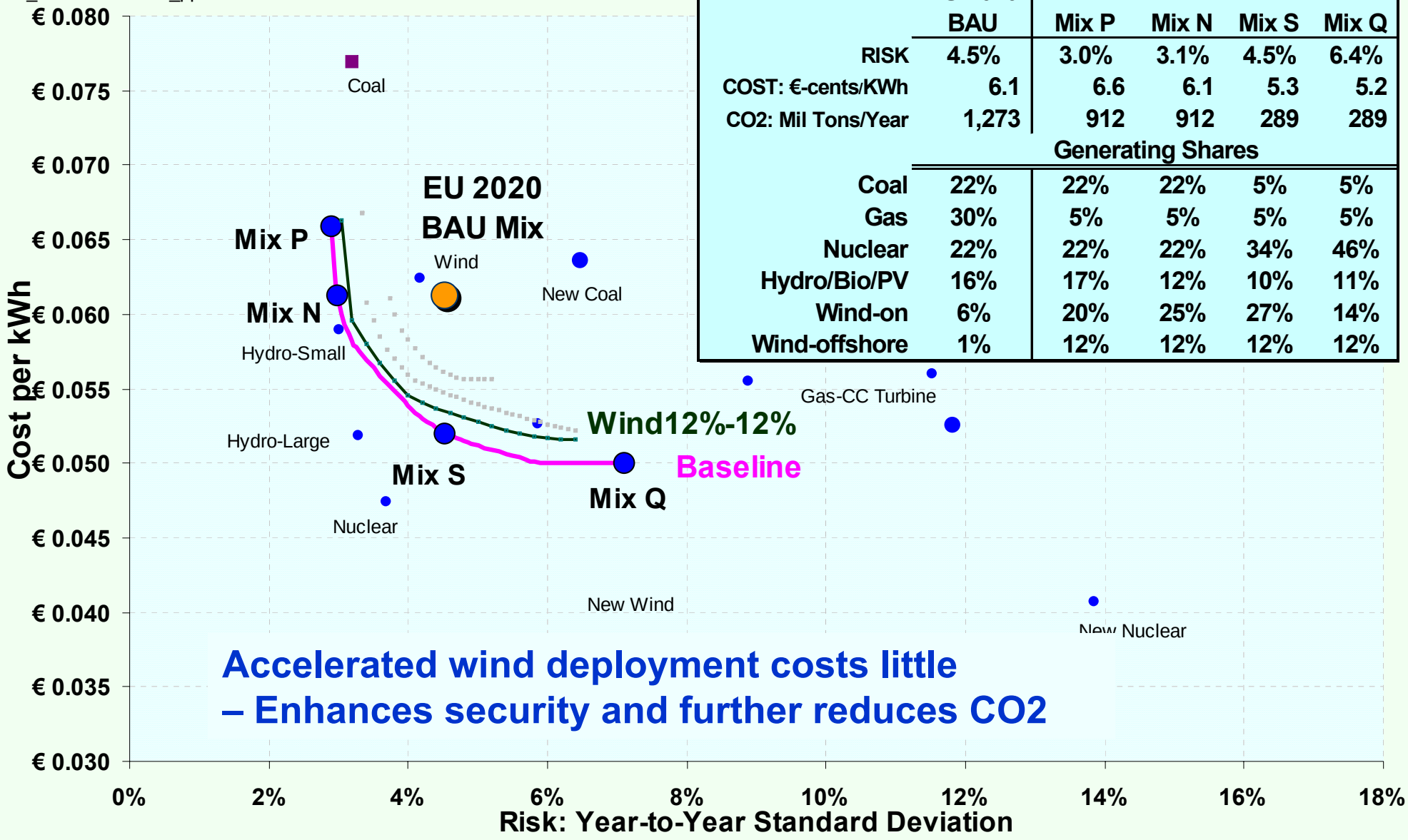
	EU-2020 BAU	Mix P	Mix N	Mix S	Mix Q
RISK	4.5%	2.9%	3.0%	4.5%	7.1%
COST: €-cents/KWh	6.1	6.6	6.1	5.2	5.0
CO2: Mil Tons/Year	1,273	912	919	362	470
	Generating Shares				
Coal	22%	22%	23%	5%	5%
Gas-CC Old	16%	5%	5%	5%	5%
Gas-CC New	13%	0%	0%	6%	14%
Oil	3%	2%	2%	2%	2%
Nuclear	22%	22%	22%	36%	52%
Hydro	9%	8%	8%	8%	13%
Biomass	6%	6%	5%	2%	2%
PV	0%	5%	1%	0%	0%
Geo	0%	0%	0%	5%	5%
Wind-onshore	6%	28%	32%	32%	2%
Wind-Offshore	1%	1%	2%	0%	0%

- Optimized Mixes Reduce Cost-risk and CO2
- Enhance security

Accelerated Wind '12-12' Deployment

EF_Combined-older_ppt.xls Carbon = 40

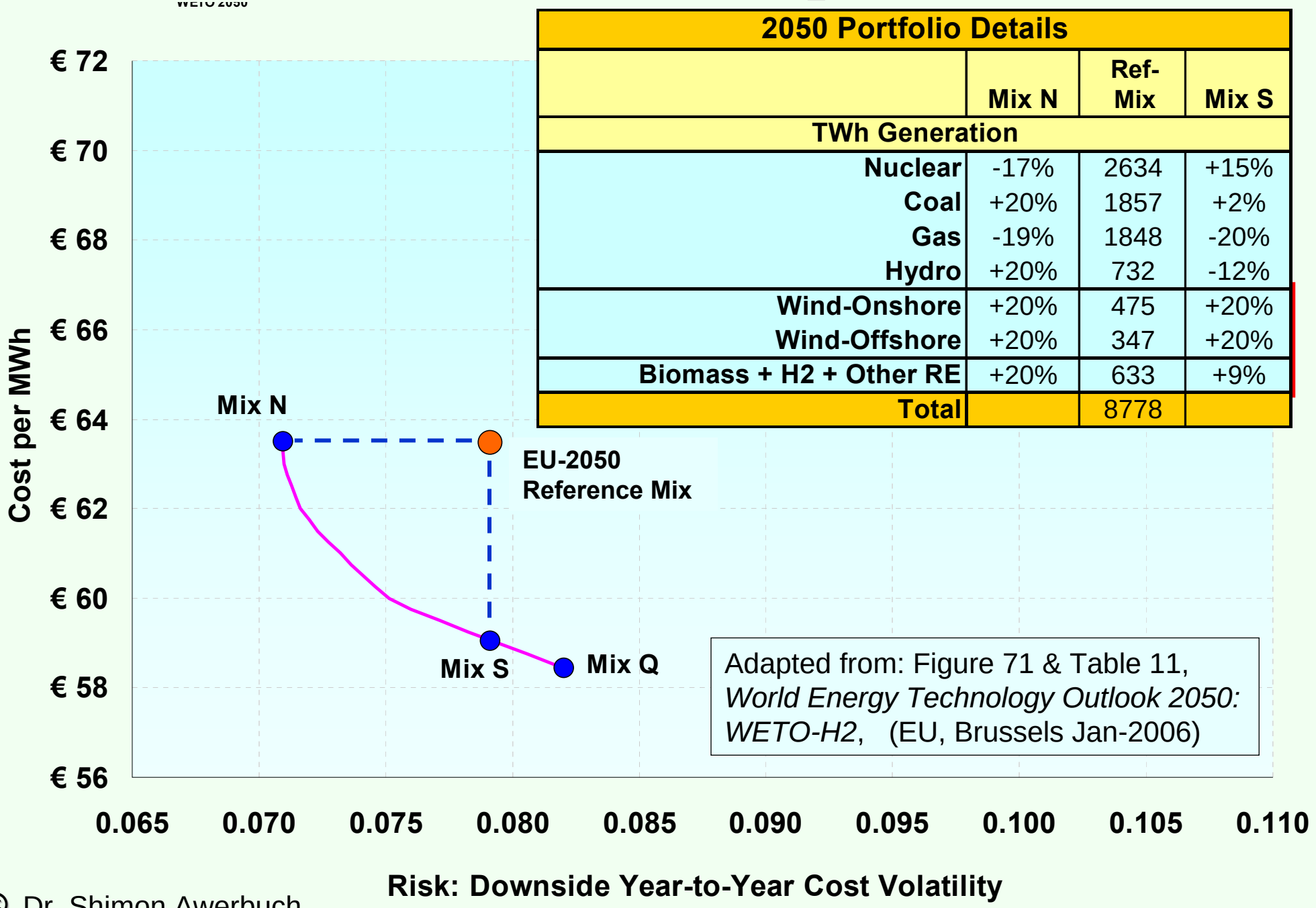
Portfolio Details - Wind 12-12	EU-2020 BAU	Mix P	Mix N	Mix S	Mix Q
RISK	4.5%	3.0%	3.1%	4.5%	6.4%
COST: €-cents/KWh	6.1	6.6	6.1	5.3	5.2
CO2: Mil Tons/Year	1,273	912	912	289	289
	Generating Shares				
Coal	22%	22%	22%	5%	5%
Gas	30%	5%	5%	5%	5%
Nuclear	22%	22%	22%	34%	46%
Hydro/Bio/PV	16%	17%	12%	10%	11%
Wind-on	6%	20%	25%	27%	14%
Wind-offshore	1%	12%	12%	12%	12%



Accelerated wind deployment costs little
– Enhances security and further reduces CO2

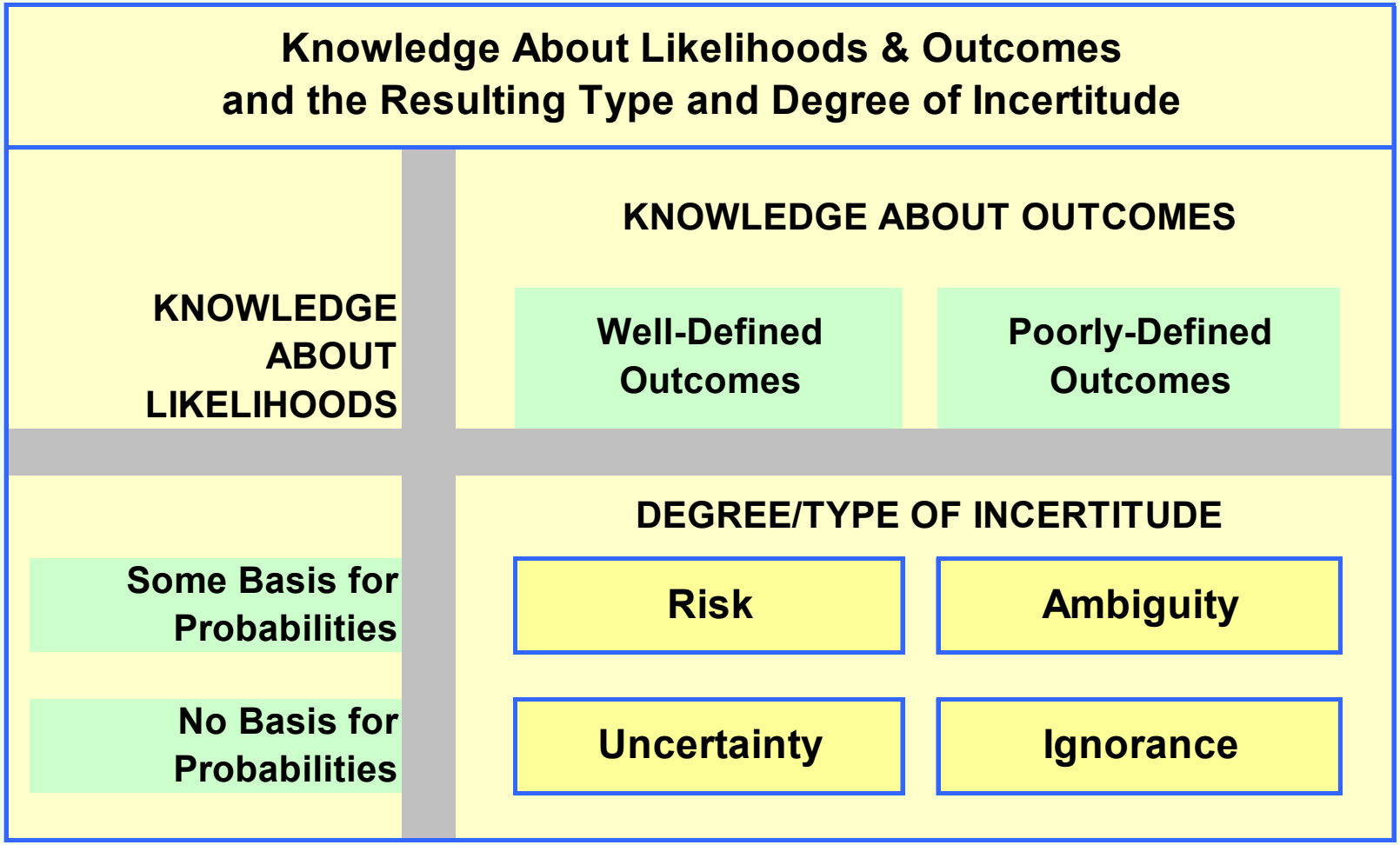
EU-2050 Reference and Optimized Mixes

2050 Portfolio Details			
	Mix N	Ref-Mix	Mix S
TWh Generation			
Nuclear	-17%	2634	+15%
Coal	+20%	1857	+2%
Gas	-19%	1848	-20%
Hydro	+20%	732	-12%
Wind-Onshore	+20%	475	+20%
Wind-Offshore	+20%	347	+20%
Biomass + H2 + Other RE	+20%	633	+9%
Total		8778	



Adapted from: Figure 71 & Table 11, *World Energy Technology Outlook 2050: WETO-H2*, (EU, Brussels Jan-2006)

Mean-Variance Risk vs. *Uncertainty* & *Ignorance*

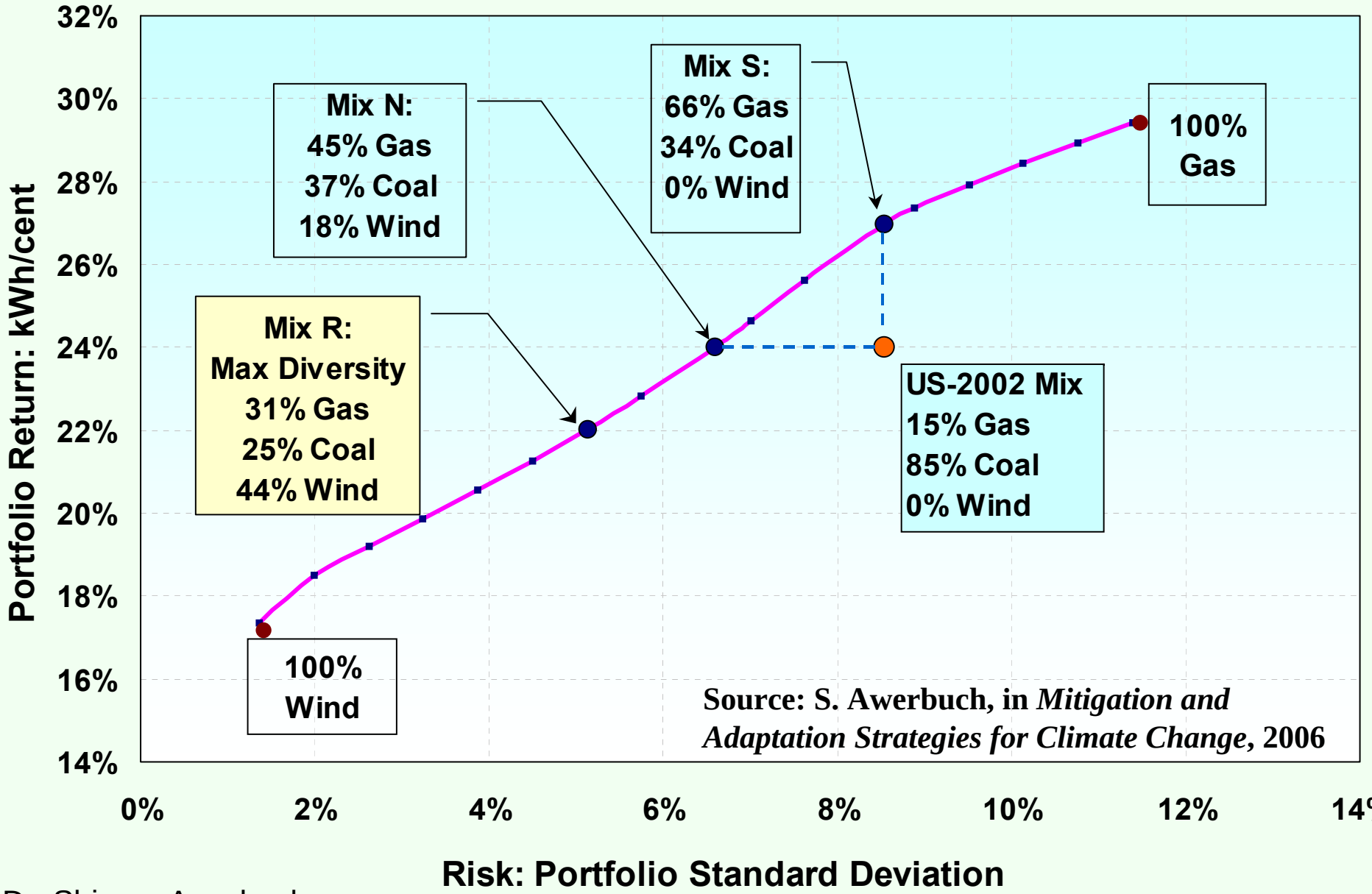


Source: S. Awerbuch, A.C. Stirling, *et. al.* "Portfolio and Diversity Analysis of Energy Technologies Using Full-Spectrum Risk Measures," in: D. Bodde, K. Leggio & M. Taylor (Eds.) ***Understanding and Managing Business Risk in the Electric Sector***, Elsevier, 2006; Based on: Stirling, 2003.

- **Mean-variance portfolio optimization manages *Risk***
- **Portfolio *Diversity* Hedges *Uncertainty* & *Surprise***
  - Diversity = Euclidean distance of disparity attributes

Diversity Vs. Mean-Variance

Risk-Return and *Diversity* for Illustrative US Generating Mix



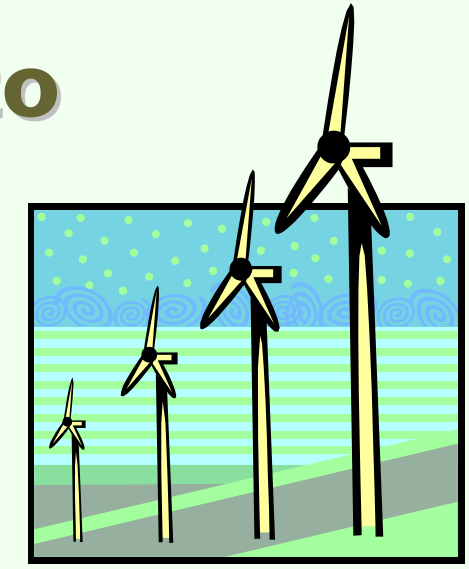
Energy Security: A Powerful Joint Benefit of Optimized Generating Mixes

- **Energy security concerns focus on catastrophic supply interruptions**
- **Exposure to fossil volatility: more powerful *market-based* security concept**
- ***Optimized* generating mixes:**
  - Minimize generating cost
  - Minimize exposure to Oil/Gas-GDP induced macro-economic losses
- **Energy Security costs *less***
  - Like *quality* in manufacturing

Where markets do not function

- **Renewables Investors cannot capture risk-mitigation benefits they provide for generating portfolio**
  - Leads to *under*-investment in RE relative to optimal societal levels
- **Gas investors in many countries have sufficient market power to externalize fuel risk to consumers**
  - Creates *over*-investment in gas relative to optimal societal levels
- **These imperfections arguably create economic basis for publicly supporting renewables**

Why Integrate Renewables into European Power Networks?



- **Promote EU energy security / diversity**
  - Mitigate Oil-GDP Losses
  - Provide *Counter-cyclical* Benefits
    - "National insurance" (R.C. Lind-J.K.Arrow, 1984)
- **Create Sizeable Portfolio Benefits**
  - *Reduce* overall generating cost and risk
- **Reduce Market Power**
  - Help open markets & unlock promised benefits of liberalization