Nuclear Power in the US: Still Not Viable Without Subsidy

Nuclear Power and Global Warming Symposium

Nuclear Policy Research Institute

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High Cost of Nuclear Power Widely Recognized

- **MIT Study Team**: "In countries that rely on state owned enterprises that are willing and able to shift cost risks to consumers to reduce the cost of capital, or to subsidize financing costs directly, and which face high gas and coal costs, it is possible that nuclear power could be perceived to be an economical choice." (MIT, p. 41).
- **Scully Capital**: "Without government participation, some risks and costs of new plants may remain at unmanageable levels…" (Scully Capital did cost work for DOE).
- **Dominion CEO Thomas Capps**: "We aren't going to build a nuclear plant anytime soon. Standard & Poor's and Moody's would have a heart attack. And my chief financial officer would to." (NYT, 5/2/05).
- **Economist Magazine**: "The upshot of all this is that even today's cheaper, safer nuclear designs are still more expensive than coal or gas." (7/9/05).
- **Paul Joskow, MIT**: "[The] nuclear industry has put forward very optimistic construction cost estimates but there is no experience to verify them. Nobody has ever underestimated the construction cost of a nuclear power plant at the pre-construction stage." (4/12/05).
- **NETF**: "..follow-on plants should be able to obtain conventional financing without the support necessary for the first few projects." (1/10/05, p. 2).

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Nuclear Levelized Cost, "No Policy" Baseline: Range and Assumptions

	Low Estimate	High Estimate	Range, other nuclear estimates	Other Relevant Benchmarks	
Levelized cost, "No Policy" Baseline					
Levelized cost, 2004 cents/kWh	3.1	8.2	na		
Study	NEA Low	MIT High			
Important Assumptions Driving Results					
Overnight capital cost (excludes financing), 2004$/kWe	$ 1,935	$ 2,080	$1,226-$2,080	$1,074-$2,510 $1,796-$2,827	Projected costs. Completed past 11 years.
Real discount rate	5.0%	8.3%	5-12%	35-50%	VC discount rates; early stage financing can be even higher.
Assumed debt fraction	not specified	50%	50-60%	46% 35% <10%	Average, Electric Utility Sector Exelon, Entergy Drug manufacturing (SIC 213)
Capacity factor	85%	75%	75-95%	83.70%	Peak average world availability factor for nuclear plants, 1990-2003.
Construction period (years)	6	5	4-7	5.3-9.3	Low: average for plants beginning construction after 1993. High: US historical average
Life of investment (years)	40	25	25-60		

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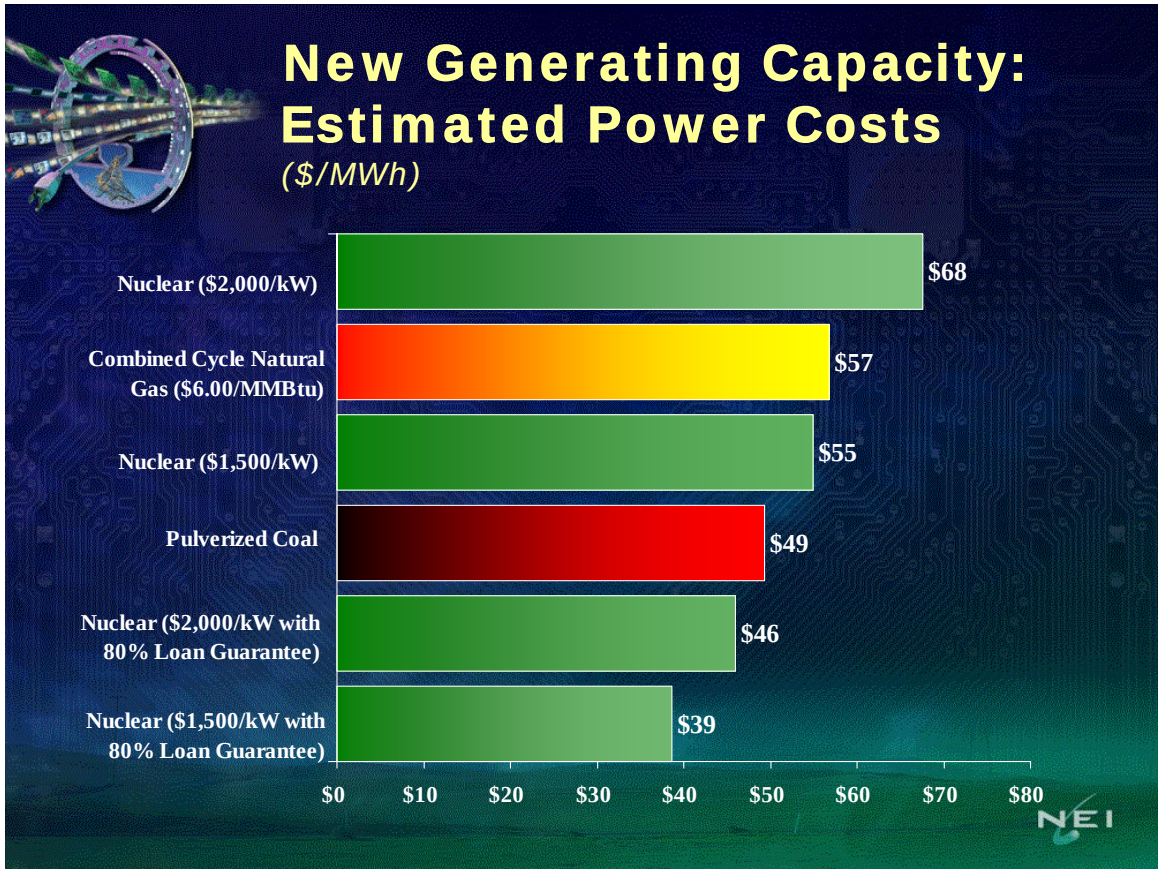
Nuclear Levelized Cost: Industry Estimates Also Dispersed



Source: Frank Bowman, NEI, Briefing for the Wall Street Utility Group, September 22, 2005.

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Large Market Risks Underlie Range of Cost Estimates; Suggest High Cost of Capital

Characteristic	Rating	Implications
Unit size	Large	-Economies of scale. -Transmission pricing would affect economics. -Lumpy capital with potential for market disruptions, especially if overbuilt due to subsidies and prices fall to variable costs. -Higher risk to investors than smaller scale, shorter-lead time incremental units.
Lead time	Long	-Increased market risk. -Greater sensitivity to interest rate environment and capital structure. -Short construction periods are important.
Cap cost/kw	High	-Same as above.
Operating cost	Medium	-Assumed attractive as compared to alternative energy sources. -Terror risk and insurance requirements are important variables here.
Fuel prices	Low	-Assumed benefit relative to other energy sources. -Some concerns about uranium shortages or environmental damage from extraction if large scale ramp-up. -Improved economies in enrichment or reprocessing may create problems in terms of proliferation.
CO2 emissions	Low	-Sensitive to carbon control regime: auction vs. grandfathering. -Pushing for windfall carbon allocations.
Regulatory risk	High	-Emphasis in energy bill on streamlining permitting. -Public input minimized; will concerns emerge in surprising ways? -Who bears risks for waste management costs/overruns important as well. Considered a small financial cost (0.1 c/kWh), but quite important from liability standpoint.

Source: Adapted from NEA (2005), p. 180.

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Historic Subsidies to Nuclear: Subsidy Dependency an Old Problem

Subsidizing Plant Construction and Operation (2004$)

Period of Analysis	Federal Subsidy, $Billions		Subsidy, cents/kWh		Avg Subsidy as % of Industrial Price	Analysis	Notes
	Low	*High*	*Low*	*High*			
1947-99	160.87	-	1.33	-	NA	Goldberg/Renewable Energy Porfolio Project (2000)	P-A not estimated.
1968-90	110.52	-	2.06	-	32.8%	Komanoff/Greenpeace (1992)	P-A not estimated.
1950-90	128.69	-	2.35	-	NA	Komanoff/Greenpeace (1992)	
1989	6.89	14.61	1.31	2.76	31.2%	Koplow/Alliance to Save Energy (1993)	
1985	24.23	-	6.31	-	81.8%	Heede, Morgan, Ridley/Center for Renewable Resources (1985)	P-A not estimated.
1981	-	-	5.29	11.16	104.0%	Chapman et al./US EPA (1981)	Tax expenditures only.
1950-79	-	-	3.71	5.46	NA	Bowring/Energy Information Administration (1980)	Tax and credit subsidies not estimated.

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Historic Subsidies to Nuclear: Capital Write-offs

Massive Capital Write-offs, Despite Subsidies

	Total (Bilions 2004$)	**Subsidy/kWh in year of write-off**		**Analysis**	**Notes**
		Low	*High*		
Write-offs during period 1968-90	59.0	0.0	7.0	Komanoff/ Greenpeace (1992)	Write-offs/kWh generation varied by year.
	Total (Bilions 2004$)	**Subsidy/kWe capacity in 1997**			
Nuclear stranded assets as of 1997	97.6	978.7		Seiple/Resource Data International (1997)	

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Levelized Costs: Adjusting for Existing Subsidies

	Levelized Cost		Overall Valuation	Discussion
	Low Estimate	***High Estimate***		
	(2004 cents/kWh)			
"No Policy" Baseline Cost of Nuclear	3.1	8.2		
Subsidies Embedded in Baseline				
Generation				
Accelerated depreciation	0.168	0.338	PV ~ $210m/plant	15 yr (150 DB) vs. 40 yr straight line.
Price-Anderson liability cap	0.500	2.500	Values based on Heyes (2002).	Estimates need updating, expansion.
Decomm. Trusts - Pref. Tax Rates	0.0002	0.0002	$160m/year	Subsidy rises with fund compounding.
Decomm. Trusts - Special Transfers	0.017	0.017	$1.3-$1.7b; PV of $1.0 $1.3 billion	PV sensitive to timing of transfers.
Uranium Fuel cycle				
Uranium % depletion	Neglible based on current data		40m/yr.	Old values need updating.
Fines to DOE for Yucca Delays	0.027	0.733	$215m - >$5b/yr.	Low-end: extrapolated Exelon settlement; high-end based on liability claims of $60b.
Waste Fund: LT funding shortfall	0.000	0.200	>$30 billion shortfall	Large uncertainty, rising real costs.
Enrichment D&D: LT funding shortfall	0.014	0.014	$1.1 - $1.5 billion shortfall	Commercial share of GAO-estimated shortfalls.
P-A cap: fuel cycle, transport, contractors	Never estimated			
Research and Development	0.065	0.420	$510m in CY05.	Low: 2005 budget (expected to rise under EPA05); High: historical average.
Total Subsidies not reflected in Baseline	0.791	4.222		
Adjusted baseline cost of plants	3.86	12.44		
Existing subsidies as % of baseline	26%	51%		

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Levelized Costs: Adjusting for New Subsidies

********PRELIMINARY ESTIMATES********

	Levelized Cost		Overall Valuation	Discussion
	Low Estimate *(2004 cents/kWh)*	***High Estimate***		
Enacted in the Energy Policy Act of 2005				
Production tax credit, new plants	0.854	1.366	$1.35b/plant; value to sector $8.1b	Outlay-equivalent value, not cost to gov't. If DOE can redeploy tax credit eligibility, costs will be much higher.
Exclusion of Homeland Security costs from NRC fee base	0.008	0.008	~$60m/year	Visible spending has doubled in recent years.
Delay insurance (contingent)				Creates financial conflict of interest for NRC.
Reactors 1 & 2	0.740	0.815	Up to $500m per reactor	
Reactors 3 - 6	0.370	0.407	Up to $250m per reactor	
Increased nuclear RD&D	not estimated			Assume R&D support will rise in future years.
Subsidies not yet funded				
Loan guarantees for new plant construction	1.793	1.793	$130m/reactor-yr	Intermediation benefits cut WACC from 10 to ~4% even w/out default. Costs w/ defaults would be even higher.
Licensing/Design Cost-Share	Small	Small	$220-$260m/design	
Total New Subsidies	3.394	3.981		Assumes 1st tier reactor for delay insurance.

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Full Costing for New Nukes: Who is Bearing the Risk?

******PRELIMINARY ESTIMATES******

	Levelized Cost		Discussion
	Low Estimate	***High Estimate***	
	(2004 cents/kWh)		
Initial estimate, "no policy" plant cost	3.064	8.218	
Add subsidies existing in baseline	0.791	4.222	
Add increased security costs	0.008	0.008	
Estimated real "no policy" cost	3.863	12.447	
Subsidies as share of total levelized cost			
Baseline subsidies	0.791	4.222	
Production tax credit, accredited reactor	0.854	1.366	
Delay Insurance, accredited first two plants	0.740	0.815	Technically would offset price rises rather than baseline cost.
Loan guarantee, recipient reactor	1.793	1.793	Intermediation value only; assuming no defaults.
Total subsidy value	4.177	8.195	
Subsidy share/total levelized cost	108%	66%	
Share, excluding delay insurance	89%	59%	

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Subsidized Firms: Combined Revenues Exceed all but 12 Largest Global Economies

- Nuclear-involved firms comprise very large organizations.
  - FY04 snapshot of financial strength: firms that own, operate or build reactors; involved in fuel cycle.
    - Revenues: $569 billion; $32 billion in net income; $19.5 billion dividends paid.
    - Market capitalization of $694 billion; enterprise value (market cap plus debt) of $1.25 trillion.
    - Capital expenditures $41 billion.
  - A number of firms excluded due to lack of public data.
- Revenues on par with *combined* GDP of bottom 60% of world's countries (112 of 183 nations tracked by World Bank).
  - Combined revenues exceed GDP for all but the world's 12 largest economies.
  - Nations with lower GDP include Australia, Brazil, Netherlands, Russia, Switzerland.

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A Fuel Cycle of Subsidies

- Mining (percentage depletion, legacy costs)
- Enrichment (legacy costs, HEU, waste, liability)
- Technology development (reactors, waste management)
- Generation
  - Capital (PTC, Accelerated Depreciation, Construction Risk Mitigation, Loan Guarantees; Export subsidies up-and-coming?)
  - Operating (Insurance, Security, Waste Disposal, Regulatory Oversight, Phantom carbon credits)
- Transmission (cross-subsidies?)
- Security and proliferation
- Post-closure (Decommissioning, Insurance)

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The Rightful Role of Nuclear Power

- Some pros; many cons.
- Should compete based on market characteristics, not political gifts.
- Negative offsets to low-carbon attributes -- cost, security, waste, proliferation – must be weighed objectively rather than suppressed.
- Huge opportunity costs for multi-billion dollar political bets. These are being ignored.

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Additional Details on Specific Subsidies

- Liability caps and the Price-Anderson Act.
- Patterns in federal energy R&D.
- Uranium Enrichment.
- Nuclear Production Tax Credit.
- Nuclear security.
- Waste disposal.
- Carbon credit windfall profits.
- The mystery of competitive foreign plants.

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Price-Anderson Act
Liability Caps: Overview

- Caps accident liability for entire nuclear industry at a present value of less than $7 billion (~$10b nominal).
- Two tiered system: regular premiums, industry-wide retrospective charges.
  - Retrospective charges occur over 7 years.
  - Government has latitude to delay collections further if fear too much financial stress on industry.
- Subsidy estimates done long ago
  - Original researchers (Rothwell, Heyes) believe they should be updated.
  - Estimates should be extended to fuel cycle, transport, contractors; not just reactors.

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Price-Anderson: Subsidy Estimates Too Low or Too High?

Factors Suggesting Estimate is Too High	Factors Suggesting Estimate is Too Low
-Better management, efficiency from plant consolidation. -Higher capacity factors reduce subsidy per kWh. -Newer technologies may be safer.	-Excludes non-reactor beneficiaries. -Coverages for own property purchased by single firm exceed P-A cap for entire country. -Real increase in coverage/reactor only 10% in 30 years. -Huge increase in density and value of offsite assets (RE, people). -Risk of T2 non-payment rising from single-asset LLC structure and multiple premiums due from single owner. -Increased risk of attack post 9/11.

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Price Anderson: 3rd Party Coverage Per Reactor Little Changed in 30 Years

	Original Liability Limits (Mils Nominal $)		Original Liability Limits (Mils 2004$)		Current Limits (Mils 2004$)	% Real Increase
Primary Insurance, 1957	$	60	$	313.0	$ 300.0	-4.2%
Retrospective Premiums, 1975						
Plant*	$	5	$	14.2	$ 95.8	572.5%
Industry	$	265	$	755.0	$ 9,963.2	1219.7%
*Cumulative coverage levels declined $725 million with passage of EPA'05						
Present value of coverage						
Plant	$	5	$	14.2	$ 62.4	338.3%
Industry	$	265	$	755.0	$ 6,502.2	761.2%
Total coverage, T1&T2 - Present Value						
Plant	$	65	$	327.3	$ 362.4	10.7%
Industry	$	325	$	1,068.0	$ 6,802.2	536.9%

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Price-Anderson: Firms Protect Own Property at 10x Coverage for Others

Example using Coverage Information from Duke Power

Liability under P-A for onsite accident	**Gross** (Mils 2004$)	**PV**
Tier 1	300.0	300.0
Tier 2	95.8	62.4
Total	395.8	362.4
Coverage for property loss in single incident (assumes 1 reactor hit)		
Primary property	500.0	500.0
Secondary property	2,500.0	2,500.0
Business interruption	490.0	394.7
Total	3,490.0	3,394.7
External liability as % of internal coverage	11.34%	10.68%

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Price Anderson: Single-Firm Self-Coverage Exceeds P-A Liability Caps for Entire Industry

	Gross coverage	PV
National total, T1 & 2, P-A	9,963	6,493
Duke Power business interruption, property	11,038	10,447
Public aggregate coverage as % of Duke coverage	90.3%	62.1%

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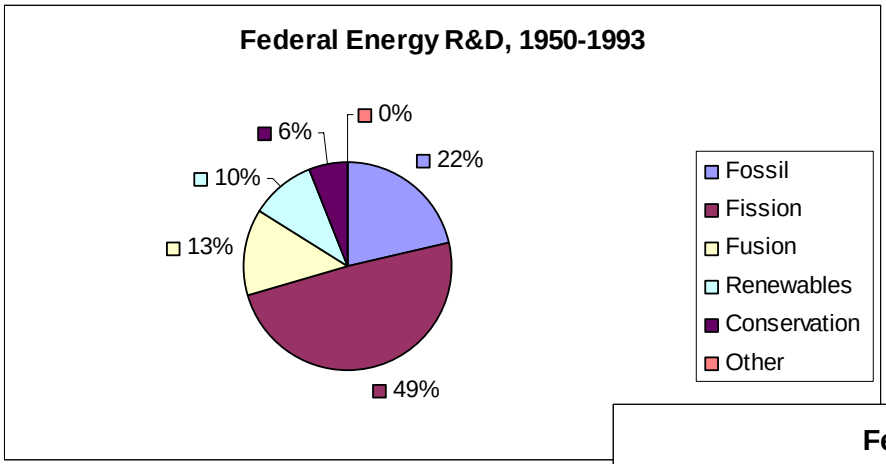
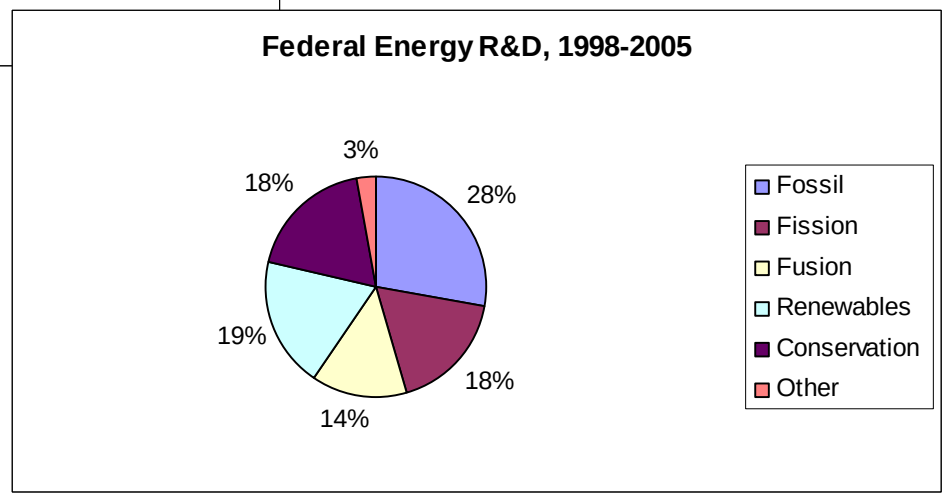
Nuclear Has Received Bulk of Federal R&D Support





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Uranium Enrichment: Large Historical Subsidies, Murky Present

- Overall picture murky: legacy issues, lots of government players in US and abroad.
- Legacy issues
  - Massive subsidies and write-offs related to legacy costs in both US and UK.
  - USEC received benefit and use rights for federal enrichment R&D ($3 billion in cumulative taxpayer investment).
  - Subsidized lease and electricity rates (through 2006) for their enrichment plants.
- International Trade:
  - Russian HEU: Large influx of new supply depressed prices; constitutes military cross-subsidy.
  - DOE controls on stockpile releases and import controls on other Russian supply work in opposite direction.

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Nuclear Production Tax Credit: High Value Could Rise Further

- 1.8 c/kWh, as tax credit, is worth 2.4 c/kWh.
  - Available only for 8 yrs; lifetime value is 0.85-1.4 c/kWh, depending on financing assumptions.
- Ambiguity in statutory language about annual vs. lifetime limits.
  - With no reassignment, value of tax break worth $8.1b, nominal, to industry.
  - With reassignment (after plant A uses credits for 8 years allowed), value could more than double.
- Precedent for renewing, extending, expanding PTCs.

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Nuclear Plant, Fuel Cycle Security: Industry Shifting at Least Some Costs

- Security profiles differ across energy sources; should be reflected in prices.
- Nuclear reactors widely recognized as high on targeting lists.
  - Mixed evidence as to their vulnerability: industry position is they are not.
  - Fuel cycle facilities and disposal sites also targets.
- Homeland Security spending through NRC:
  - $61m in 2005; double earlier years.
  - Exempted from charge-backs to licensees (commercial plants).
- State and local spending unknown; as is federal spending outside of transfers to NRC.

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Nuclear Waste: Long-tail Uncertainty Dumped on Taxpayers

- Huge problem, massive risk.
- Long time horizon mutes financial impact; however long-tailed liability for reactor owners would be huge detriment to investors.
- Fixed fee: how adequate are collections? Rothwell thinks they should be tripled.
- Litigation settlements w/ reactors:
  - Metric of cost of gov't risk bearing.
  - Exposure: $3.6 - $60 billion.
- Other countries: $90 billion deal in UK to deal with nuclear waste liabilities of British Nuclear Fuels. (Economist, 7/9/05).

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Phantom Carbon Credits

- Pollution taxes/permits: goal is to increase cost of polluting activities, encouraging substitution.
- Output-based allocation models would grant carbon credits to nuclear plants in proportion to share of generation.
- Potentially huge windfall profits to nuclear plants; value depends on specifics of regime.
- Further disadvantages smaller, less visible non-carbon resources.

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Foreign Nukes: Beware of What You Can't See

- Information scarce; large government involvement; special deals; risk shifting.
- Full costs often difficult or impossible to estimate.
  - Finland: financing assumptions – no income taxes, 100% debt at a cost of 5%. Allegations of low cost financing from banks, export credit agencies with government participation. (Bradford, 2005).
  - France: large government ownership and involvement with all stages of the market for decades; little transparency.
  - China: Nuclear development a state monopoly; government main source of debt and equity; guaranteed sales contract.

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