The Effects of Inflation in Engineering Economic Studies

February 18, 2004

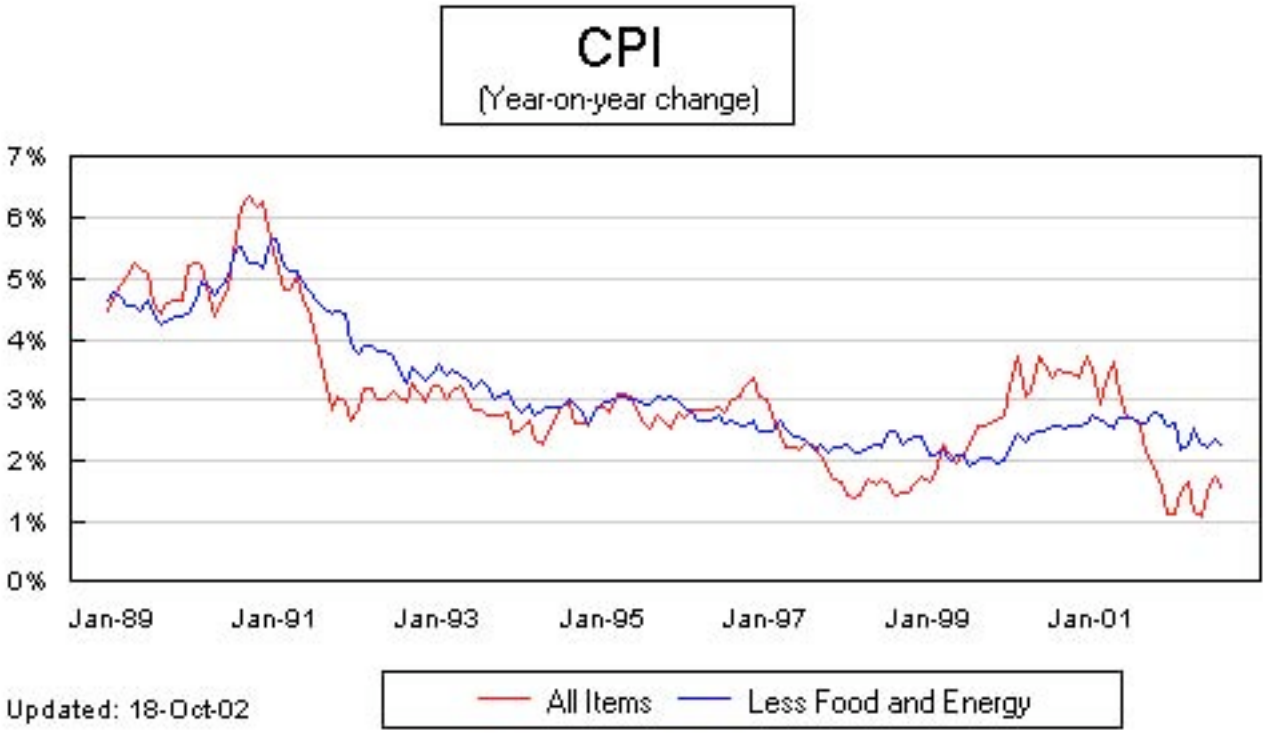
Source: Bradford DeLong, http://www.j-bradford-delong.net/Econ_Articles/woodstock/woodstock4.html

Consumer Price Index - All Urban Consumers

12 Months Percent Change

Series Id: CUUR0000SA0
Not Seasonally Adjusted
Area: U.S. city average
Item: All items
Base Period: 1982-84=100

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	[illegible]	Annual	[illegible]F1	HALF2
1980	13.9	14.2	14.8	14.7	14.4	14.4	13.1	12.9	12.6	12.8	12.6	[illegible]5	13.5		
1981	11.8	11.4	10.5	10.0	9.8	9.6	10.8	10.8	11.0	10.1	9.6	[illegible]	10.3		
1982	8.4	7.6	6.8	6.5	6.7	7.1	6.4	5.9	5.0	5.1	4.6	[illegible]	6.2		
1983	3.7	3.5	3.6	3.9	3.5	2.6	2.5	2.6	2.9	2.9	3.3	[illegible]3	3.2		
1984	4.2	4.6	4.8	4.6	4.2	4.2	4.2	4.3	4.3	4.3	4.1	[illegible].9	4.3		
1985	3.5	3.5	3.7	3.7	3.8	3.8	3.6	3.3	3.1	3.2	3.5	[illegible].8	3.6	3	3.4
1986	3.9	3.1	2.3	1.6	1.5	1.8	1.6	1.6	1.8	1.5	1.[illegible]	[illegible].1	1.9	2	1.5
1987	1.5	2.1	3.0	3.8	3.9	3.7	3.9	4.3	4.4	4.5	4.[illegible]	[illegible].4	3.6	3	4.4
1988	4.0	3.9	3.9	3.9	3.9	4.0	4.1	4.0	4.2	4.2	4[illegible]	[illegible].4	4.1	3	4.2
1989	4.7	4.8	5.0	5.1	5.4	5.2	5.0	4.7	4.3	4.5	4[illegible]	4.6	4.8	[illegible]	4.7
1990	5.2	5.3	5.2	4.7	4.4	4.7	4.8	5.6	6.2	6.3	6[illegible]	6.1	5.4		5.8
1991	5.7	5.3	4.9	4.9	5.0	4.7	4.4	3.8	3.4	2.9	3[illegible]	3.1	4.2		3.5
1992	2.6	2.8	3.2	3.2	3.0	3.1	3.2	3.1	3.0	3.2	3[illegible]	2.9	3.0	[illegible]0	3.1
1993	3.3	3.2	3.1	3.2	3.2	3.0	2.8	2.8	2.7	2.8	[illegible]	2.7	3.0	[illegible]2	2.8
1994	2.5	2.5	2.5	2.4	2.3	2.5	2.8	2.9	3.0	2.6	[illegible]	2.7	2.6	[illegible]	2.8
1995	2.8	2.9	2.9	3.1	3.2	3.0	2.8	2.6	2.5	2.8	[illegible]6	2.5	2.8	[illegible]9	2.6
1996	2.7	2.7	2.8	2.9	2.9	2.8	3.0	2.9	3.0	3.0	[illegible]3	3.3	3.0	[illegible]4	3.1
1997	3.0	3.0	2.8	2.5	2.2	2.3	2.2	2.2	2.2	2.1	[illegible]8	1.7	2.3	[illegible]6	2.1
1998	1.6	1.4	1.4	1.4	1.7	1.7	1.7	1.6	1.5	1.5	[illegible]5	1.6	1.6	[illegible]5	1.6
1999	1.7	1.6	1.7	2.3	2.1	2.0	2.1	2.3	2.6	2.6	[illegible]6	2.7	2.2	[illegible]9	2.5
2000	2.7	3.2	3.8	3.1	3.2	3.7	3.7	3.4	3.5	3.4	[illegible]	3.4	3.4	[illegible]3	3.5
2001	3.7	3.5	2.9	3.3	3.6	3.2	2.7	2.7	2.6	2.1	1.[illegible]	[illegible]6	2.8	[illegible].4	2.2
2002	1.1														



Source: briefing.com

Producer Price Index -- All Manufacturing (1992-2002)

Producer Price Index Revision-Current Series

12 Months Percent Change

Series Id: PCUONFG
Industry: Total manufacturing industries
Product: Total manufacturing industries
Base Date: 8412

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1992	-0.9	0.1	1.0	1.3	1.7	2.0	2.1	1.6	1.6	1.6	1.5	1.6	1.3
1993	2.2	2.2	2.5	2.4	1.9	1.4	1.3	0.9	0.7	0.9	0.9	0.8	1.4
1994	0.8	0.8	0.5	0.3	0.5	0.8	1.3	2.4	2.3	1.8	2.2	2.4	1.3
1995	2.8	2.8	2.9	3.3	3.4	3.3	2.9	2.4	2.6	3.0	2.6	3.0	2.9
1996	2.6	2.1	2.1	2.2	2.3	2.2	2.2	2.4	2.6	2.5	2.3	2.2	2.3
1997	1.8	1.8	1.4	0.7	0.2	0.1	-0.2	0.0	-0.2	-0.5	-0.4	-0.8	0.3
1998	-1.3	-1.4	-1.5	-1.2	-0.9	-0.8	-0.6	-1.1	-1.1	-0.9	-1.0	-0.9	-1.0
1999	-0.2	-0.2	0.3	1.0	1.0	1.3	1.7	2.4	3.0	3.0	3.2	3.7	1.7
2000	3.6	5.0	5.2	4.1	4.2	5.0	4.4	3.5	3.9	3.6	3.5	2.9	4.1
2001	3.1	2.0	1.2	2.3	2.6	1.2	0.4	0.8	0.7	-1.0(P)	-1.6(P)	-2.2(P)	0.7(P)
2002	-2.3(P)												

P : Preliminary. All indexes are subject to revision four months after original publication.

Price trends in turbines and turbine generator sets

Producer Price Index Revision-Current Series

Original Data Value

Series Id: PCU35111
Industry: Turbines and turbine generator sets
Product: Turbines and turbine generator sets
Base Date: 8206

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1992	141.4	141.4	141.5	141.5	141.5	141.5	141.5	142.3	142.3	142.3	142.4	142.5	141.8
1993	143.7	143.6	143.7	143.7	143.7	143.7	143.7	143.7	144.5	144.5	144.5	144.5	143.9
1994	145.0	146.0	146.0	146.0	145.6	146.2	146.2	146.2	148.2	148.3	148.2	148.3	146.7
1995	148.5	148.6	148.6	149.4	149.4	149.4	149.6	148.5	146.3	146.4	146.4	146.4	148.1
1996	146.4	146.4	146.4	146.4	146.4	144.4	145.0	145.0	145.0	145.0	145.0	146.9	145.7
1997	146.9	146.9	147.4	147.4	147.4	146.0	147.0	147.0	146.5	146.7	146.7	146.6	146.9
1998	146.8	146.9	146.7	146.7	146.8	146.9	146.9	147.0	147.1	147.1	147.2	147.2	146.9
1999	148.3	148.4	148.5	148.5	148.6	148.6	148.7	148.8	148.8	148.9	149.0	149.0	148.7
2000	149.1	149.0	149.1	149.2	149.2	149.3	149.9	149.9	150.0	149.9	150.0	150.1	149.6
2001	150.1	150.2	150.3	150.3	150.4	150.5	151.2	151.3	151.4	151.4(P)	151.6(P)	151.6(P)	150.9(P)
2002	151.7(P)												

P : Preliminary. All indexes are subject to revision four months after original publication.

Source: US Bureau of Labor Statistics

Producer price index for computers and work stations

Producer Price Index Revision-Current Series

Original Data Value

Series Id: PCU3571#14
Industry: Electronic computers
Product: Personal computers and workstations (excluding portable computers)
Base Date: 9812

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1992												751.9	
1993	741.3	738.4	692.2	686.5	685.3	656.6	659.2	636.2	636.1	615.4	613.5	613.4	664.5
1994	609.0	608.6	605.3	604.7	600.3	596.9	594.7	587.7	577.7	570.3	551.0	551.0	588.1
1995	536.0	522.2	510.9	509.8	501.1	477.9	476.9	453.6	438.9	425.5	415.8	412.3	473.4
1996	399.1	378.7	362.6	343.0	335.4	324.7	313.3	309.8	308.6	298.7	286.9	269.4	327.5
1997	262.1	255.1	246.6	243.0	230.2	221.5	215.0	205.0	200.5	194.6	189.2	186.2	220.8
1998	171.4	160.4	157.4	146.2	141.8	136.6	131.8	114.1	111.9	107.6	103.1	100.0	131.9
1999	95.6	93.6	92.8	89.7	88.5	85.9	85.1	83.7	82.7	78.0	77.0	77.2	85.8
2000	77.2	75.9	74.7	73.6	72.5	70.2	70.1	64.9	63.9	63.3	62.9	62.0	69.3
2001	56.3	54.8	52.3	51.7	50.6	50.4	48.3	45.4	45.3	44.8(P)	44.0(P)	41.1(P)	48.7(P)
2002	42.5(P)												

P : Preliminary. All indexes are subject to revision four months after original publication.

Source: BLS

Treatment of inflation in investment analysis

- Two alternatives:
  - Estimate cash flows in actual ('nominal' or 'current') dollars, and use 'market' ('nominal') interest rates
  - Estimate cash flows in terms of the purchasing power of the dollars of some base year (i.e., in 'constant dollars') and use real interest rates

Relationship between future worth of construction project at time of completion and 'overnight cost' in dollars of construction start year:

1) Uniform rate of expenditure (in constant dollars)

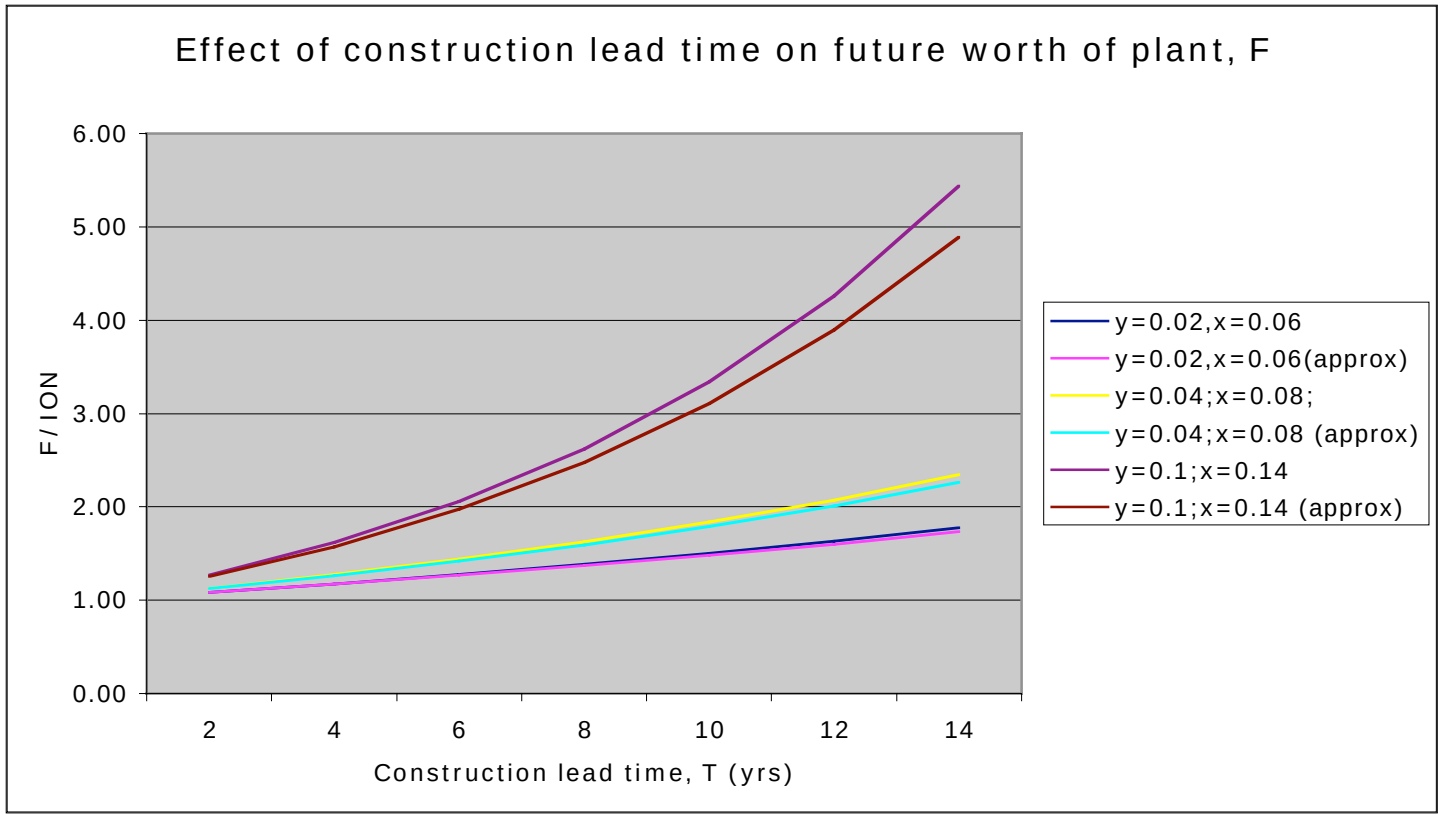
Exact expression : $F = I_{ON} e^{xT} \left[\frac{1 - e^{yT} e^{-xT}}{(x - y)T} \right]$

Approximate expression : $F = I_{ON} \left[1 + \frac{x + y}{2} T \right]$

2. Sine - wave construction expenditure profile (constant dollars) :

Exact expression : $F = I_{on} \left[\frac{e^{yt} + e^{xT}}{2 \left[1 + \frac{(x - y)^2}{\left(\pi / T \right)^2} \right]} \right]$

Approximate expression : $F \approx I_{on} \left[1 + \left[\frac{x + y}{2} \right] T \right]$



Uniform rate of expenditure assumed (in constant dollars)

y= escalation rate

x= interest rate

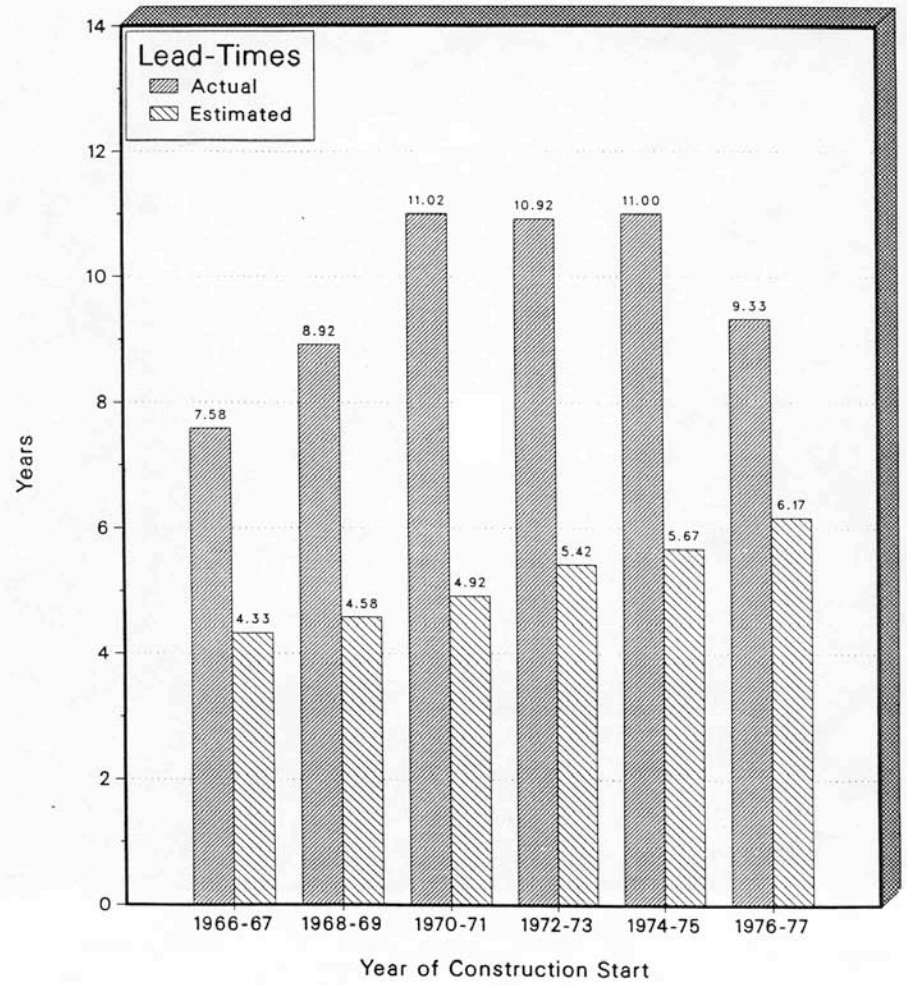
Interpretation of alternative capital cost measures

I_{on}: The 'overnight cost' of the project, expressed in dollars of the year of construction start. This is what the plant would cost if there were no inflation and no interest charges on capital, i.e., if the plant were built 'overnight'. It consists of the direct costs of labor, materials, equipment, engineering and design, etc.

F: The future worth of the project at the construction completion date. This is the amount of money that, if paid to the constructor at the completion of the project, would be just sufficient to cover all costs incurred during construction, i.e., both the direct costs and the interest accruing on funds borrowed (or equity invested) during construction. In the days when power plants were constructed by regulated electric utilities, this was also often referred to as the ratebase cost.

$F-I_{on}$: The 'time-related' costs of the project.

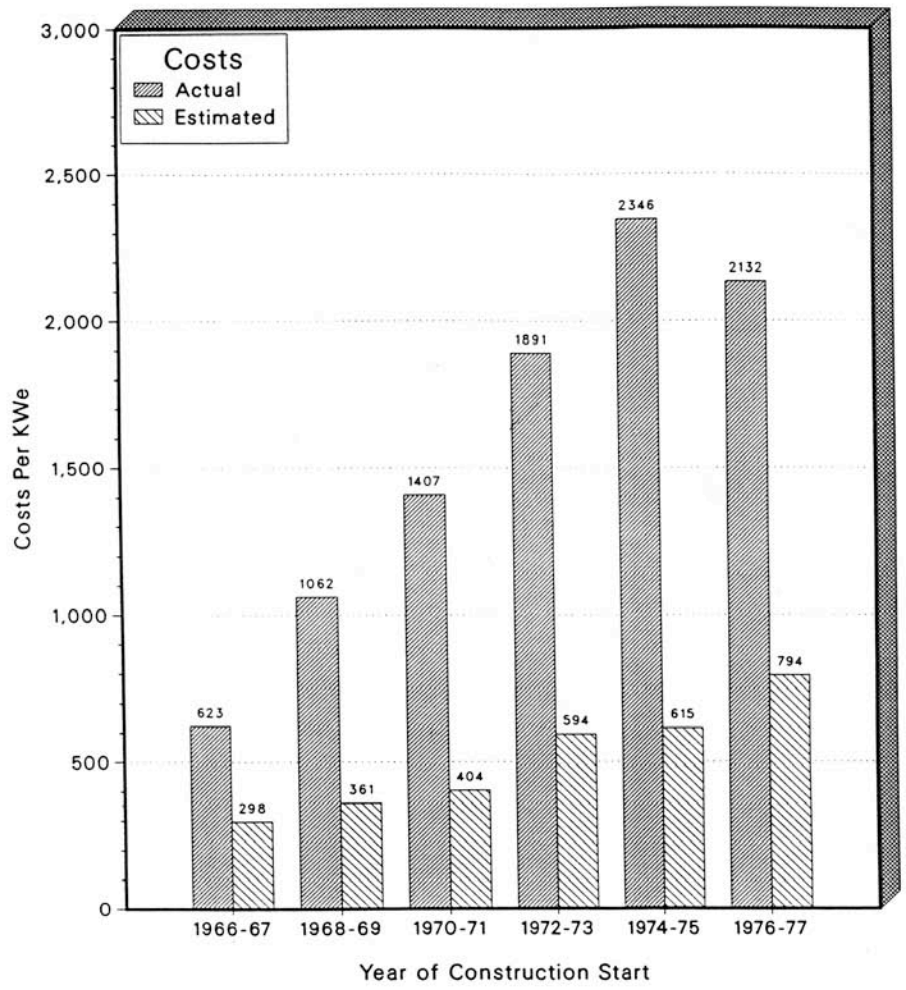
Figure 2. Actual and Estimated Lead-Times of Nuclear Power Plants In Operation by the End of 1986



Note: Lead-time estimates made at construction start were used.
Source: Computations based on data from Energy Information Administration, Form EIA-254, "Semiannual Progress Report on Status of Reactor Construction," and predecessor survey forms.

Energy Information Administration. "An Analysis of Nuclear Power Plant Operating Costs." DOE/EIA-0511 (Washington,DC,1988).

Figure 4. Actual and Estimated Real Overnight Costs of Nuclear Power Plants In Operation by the End of 1986



Note: Cost estimates made at construction start were used. Estimated costs were computed from data reported by the utility.
Source: Computations based on data from Energy Information Administration, Form EIA-254, "Semiannual Progress Report on Status of Reactor Construction," and predecessor survey forms.

An Analysis of Nuclear Power Plant Construction Costs
Energy Information Administration

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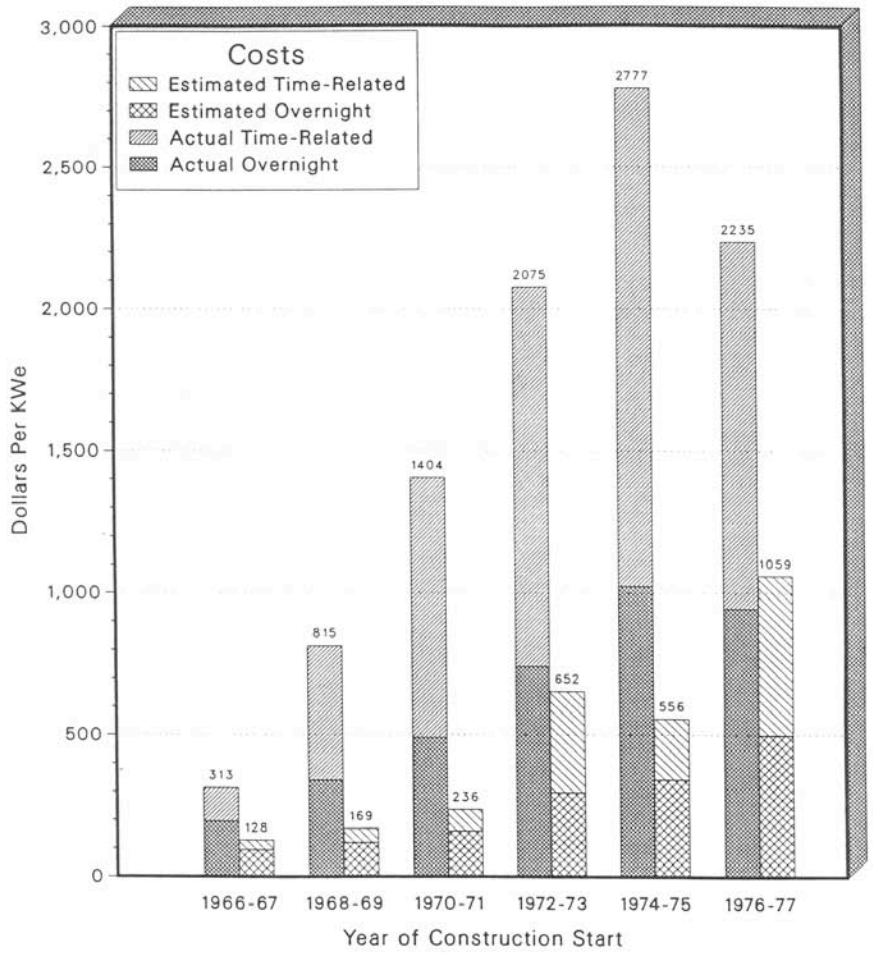
Costs in 1982 constant dollars

Energy Information Administration. "An Analysis of Nuclear Power Plant Operating Costs." DOE/EIA-0511 (Washington,DC,1988).

Figure 1. Actual and Estimated Total Costs in Mixed Current Dollars for Nuclear Power Plants in Operation by the End of 1986



Note: Cost estimates made at construction start were used. Estimated time-related and overnight costs were computed from data reported by the utility.
Source: Computations based on data from Energy Information Administration, Form EIA-254, "Semiannual Progress Report on Status of Reactor Construction," and predecessor survey forms.

An Analysis of Nuclear Power Plant Construction Costs
Energy Information Administration

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Overnight costs given in dollars of year of construction start.

Energy Information Administration. "An Analysis of Nuclear Power Plant Operating Costs." DOE/EIA-0511 (Washington,DC,1988).

Table 4. Ranking of Plants in the Sample According to Real Overnight Construction Costs and Reported Construction Costs

Plant Name	Ranking Based on Real Overnight Costs	Ranking Based on Reported Costs	Real Overnight Construction Costs (1982 dollars per kWe)	Reported Construction Costs (mixed current dollars per kWe)
Palisades	1	1	393.94	170.22
Peach Bottom 3	2	3	395.39	206.20
Surry 2	3	2	416.74	187.37
Browns Ferry 2	4	4	463.29	244.73
Browns Ferry 3	5	5	463.29	244.73
Zion 2	6	7	543.38	266.90
Arkansas Nuclear 1	7	8	551.64	281.05
Zion 1	8	6	554.84	254.45
Browns Ferry 1	9	11	617.72	326.31
Brunswick 1	10	16	657.31	384.80
Indian Point 3	11	18	668.85	396.89
Calvert Cliffs 2	12	13	680.46	366.86
Rancho Seco	13	14	716.67	367.55
Surry 1	14	10	725.59	313.91
Trojan	15	17	761.10	392.09
North Anna 2	16	29	772.35	596.38
Kewaunee	17	15	785.56	376.11
McGuire 2	18	42	808.08	866.10
Millstone 2	19	21	808.35	475.50
Fort Calhoun 1	20	12	817.56	364.69
McGuire 1	21	36	826.78	778.81
Sequoyah 2	22	30	835.29	650.42
Brunswick 2	23	19	853.41	461.42
Crystal River 3	24	24	863.16	502.00
LaSalle 2	25	44	874.39	954.48
Edwin I. Hatch 2	26	31	884.00	651.79
Arkansas Nuclear 2	27	34	890.67	694.08
Edwin I. Hatch 1	28	20	919.36	469.93
Three Mile Island 1	29	23	924.61	490.86
Donald C. Cook 1	30	26	928.46	508.54
Duane Arnold	31	27	999.80	533.72
Peach Bottom 2	32	22	1,000.35	488.26
Salem 2	33	33	1,008.51	686.50
Calvert Cliffs 1	34	25	1,015.50	507.69
Cooper	35	9	1,017.33	298.53
Sequoyah 1	36	38	1,020.91	794.96
St. Lucie 1	37	28	1,023.26	557.83
Beaver Valley 1	38	32	1,037.22	684.74
Three Mile Island 2	39	37	1,067.15	789.04
Joseph M. Farley 2	40	43	1,112.96	941.95

See footnote at end of table.

Energy Information Administration. "An Analysis of Nuclear Power Plant Operating Costs." DOE/EIA-0511 (Washington,DC,1988).

Table 4. Ranking of Plants in the Sample According to Real Overnight Construction Costs and Reported Construction Costs (Continued)

Plant Name	Ranking Based on Real Overnight Costs	Ranking Based on Reported Costs	Real Overnight Construction Costs (1982 dollars per kWe)	Reported Construction Costs (mixed current dollars per kWe)
Davis-Besse 1	41	35	1,126.59	701.66
Salem 1	42	40	1,260.90	858.30
North Anna 1	43	41	1,288.44	859.35
Joseph M. Farley 1	44	39	1,325.60	827.97
LaSalle 1	45	46	1,337.04	1,245.72
Palo Verde 2	46	45	1,355.22	1,197.64
Catawba 1	47	50	1,360.79	1,690.83
Byron 2	48	48	1,389.77	1,585.71
San Onofre 3	49	49	1,419.03	1,590.10
Virgil Summer 1	50	47	1,425.31	1,425.59
Diablo Canyon 2	51	52	1,584.78	1,911.03
Susquehanna 2	52	53	1,627.20	2,056.19
Byron 1	53	54	1,688.94	2,119.64
St. Lucie 2	54	51	1,740.13	1,767.00
Braidwood 1	55	56	1,826.30	2,187.50
Wolf Creek 1	56	60	1,852.25	2,490.43
Susquehanna 1	57	55	1,898.83	2,149.28
Callaway	58	62	2,011.69	2,741.07
Grand Gulf 1	59	61	2,087.20	2,511.96
Waterford 3	60	59	2,132.18	2,345.36
San Onofre 2	61	58	2,283.48	2,335.48
Perry 1	62	66	2,324.97	3,273.86
Palo Verde 1	63	57	2,475.98	2,200.00
Millstone 3	64	67	2,598.41	3,308.82
Diablo Canyon 1	65	64	2,598.88	2,976.01
Fermi 2	66	65	2,600.23	3,084.17
WPPSS 2	67	63	2,737.76	2,909.09
Limerick 1	68	71	2,834.16	3,655.92
Hope Creek 1	69	69	3,237.37	3,520.15
Clinton 1	70	68	3,267.94	3,370.85
River Bend 1	71	70	3,290.52	3,574.82
Shearon Harris 1	72	72	3,338.68	3,790.30
Nine Mile Point 2	73	74	3,610.08	4,640.58
Beaver Valley 2	74	73	3,697.10	4,160.86
Shoreham	75	75	3,792.10	5,159.76

Source: Computations based on data from Energy Information Administration, Form EIA-254, "Semiannual Progress Report on Status of Reactor Construction," and predecessor survey forms.

Energy Information Administration. "An Analysis of Nuclear Power Plant Operating Costs." DOE/EIA-0511 (Washington,DC,1988).

Predicted construction costs for future nuclear power plants

DOE-NE — 2010 Roadmap Study[5]

The economic analysis in the 2010 Roadmap study takes a parametric approach to nuclear capital costs, but states that engineering, procurement, and construction costs vary between $800 and $1,400 / kWe. Adding 20 percent for owner's costs and project contingency, the approximate range for overnight costs is $1,000–$1,600 / kWe in 2000 dollars. Construction is assumed to occur over 42 months, with six months between construction and commercial operation.

In addition to the parametric analysis, the 2010 Roadmap study evaluated eight advanced nuclear plant designs as candidates for near term deployment. The cost estimates for the new designs were provided by vendors with various levels of confidence and detail. A brief summary of relevant information for the eight designs is tabulated in Table A-5.B.1.

Deutsch, John, Ernest Moniz et al. "The Future of Nuclear Power: An Interdisciplinary MIT Study." Massachusetts Institute of Technology, 2003 (ISBN 0-615-12420-8). Available at http://web.mit.edu/nuclearpower/. p. 137.

Table A-5.B.1

DESIGN	OVERNIGHT COST	OTHER RELEVANT INFORMATION
GE ABWR	$1,400–$1,600/kWe	48 month construction (Japan) Real construction experience
GE ESBWR	Lower than ABWR	Availability goal of 92% Simplified design to reduce cost
Framatome SWR-1000	$1,150–$1,270/kWe FOAK[a] 15-20% reduction for NOAK[b]	Cost excludes cooling tower 48 month construction, 91% avail.
Westinghouse AP600	$2,175/kWe FOAK $1,657/kWe NOAK	5 years from order placement to commercial operation
Westinghouse AP1000	$1,365/kWe FOAK $1,040/kWe NOAK	Cost assumes twin units, includes owner's costs and contingency
Westinghouse IRIS	$687–$1,224/kWe FOAK $746–$1,343/kWe NOAK	100-300 MWe plant availability 85-99%
Pebble Bed Modular Reactor	$1,250/kWe NOAK	110 MW units
General Atomics GT-MHR	$1,122/kWe 25% reduction for NOAK	Cost includes contingency and owner's costs

a. FOAK - First-of-a-kind
b. NOAK - Nth-of-a-kind

Source: MIT Nuclear Study

Deutsch, John, Ernest Moniz et al. "The Future of Nuclear Power: An Interdisciplinary MIT Study." Massachusetts Institute of Technology, 2003 (ISBN 0-615-12420-8). Available at http://web.mit.edu/nuclearpower/. p. 138.

Predicted construction costs for future nuclear power plants (contd.)

EIA — Annual Energy Outlook 2003[4]

Cost and performance characteristics for nuclear plants in the Annual Energy Outlook are based on current estimates by government and industry analysis. Two cost cases are analyzed, the reference case and an advanced nuclear cost case, where overnight costs are reduced to be consistent with the goals endorsed by DOE's Office of Nuclear Energy.

In the reference case, overnight construction costs are predicted to be $2,044/kWe in 2010 and $1,906/kWe in 2025, specified in 2001 dollars. Construction costs are assumed to decline over time based on a representative learning curve. The overnight costs reported include a 10% project contingency factor and a 10% technological optimism factor, which is applied to the first four units to reflect the tendency to underestimate costs for a first-of-a-kind unit. The report indicates a five year lead time for construction. Predicted overnight costs for the advanced nuclear case are $1,535/kWe in 2010, dropping to $1,228/kWe by 2025, also reported in 2001 dollars. The advanced case does not include a technological optimism factor.

Deutsch, John, Ernest Moniz et al. "The Future of Nuclear Power: An Interdisciplinary MIT Study." Massachusetts Institute of Technology, 2003 (ISBN 0-615-12420-8). Available at http://web.mit.edu/nuclearpower/. p. 137.