Is Nuclear Power a Good Alternative Source of Energy (for the U.S.)?

Is Nuclear Power a Good Alternative Source of Energy (for the U.S.)?

It **IS** a good source of energy!

Is Nuclear Power a Good Alternative Source of Energy (for the U.S.)?

It **IS NOT** a good alternative source of energy for the U.S. (yet)!

Is Nuclear Power a Good Alternative Source of Energy?

Cost?

Safety?

Proliferation risk?

Waste management?

Nuclear Power In the USA:
Energy of broken promises!

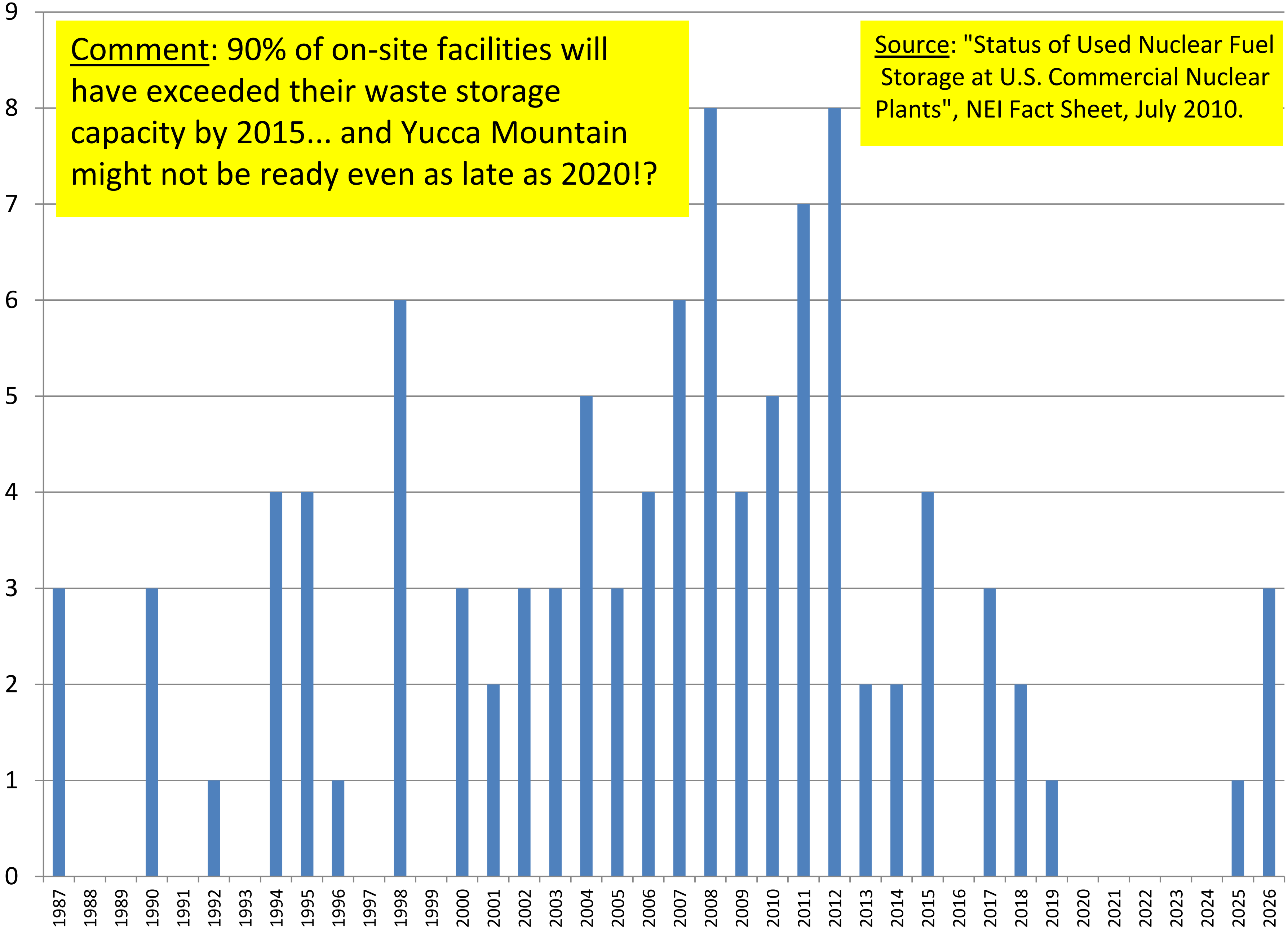
1950s:

[(over?)confident in the wake of the Manhattan Project]

"Electricity will soon be too cheap to meter…"

We have plenty of time to figure out
how and where to store the (high-level) waste…

Run-away fission accidents simply cannot happen…


Comment: 90% of on-site facilities will have exceeded their waste storage capacity by 2015... and Yucca Mountain might not be ready even as late as 2020!?
Source: "Status of Used Nuclear Fuel Storage at U.S. Commercial Nuclear Plants", NEI Fact Sheet, July 2010.
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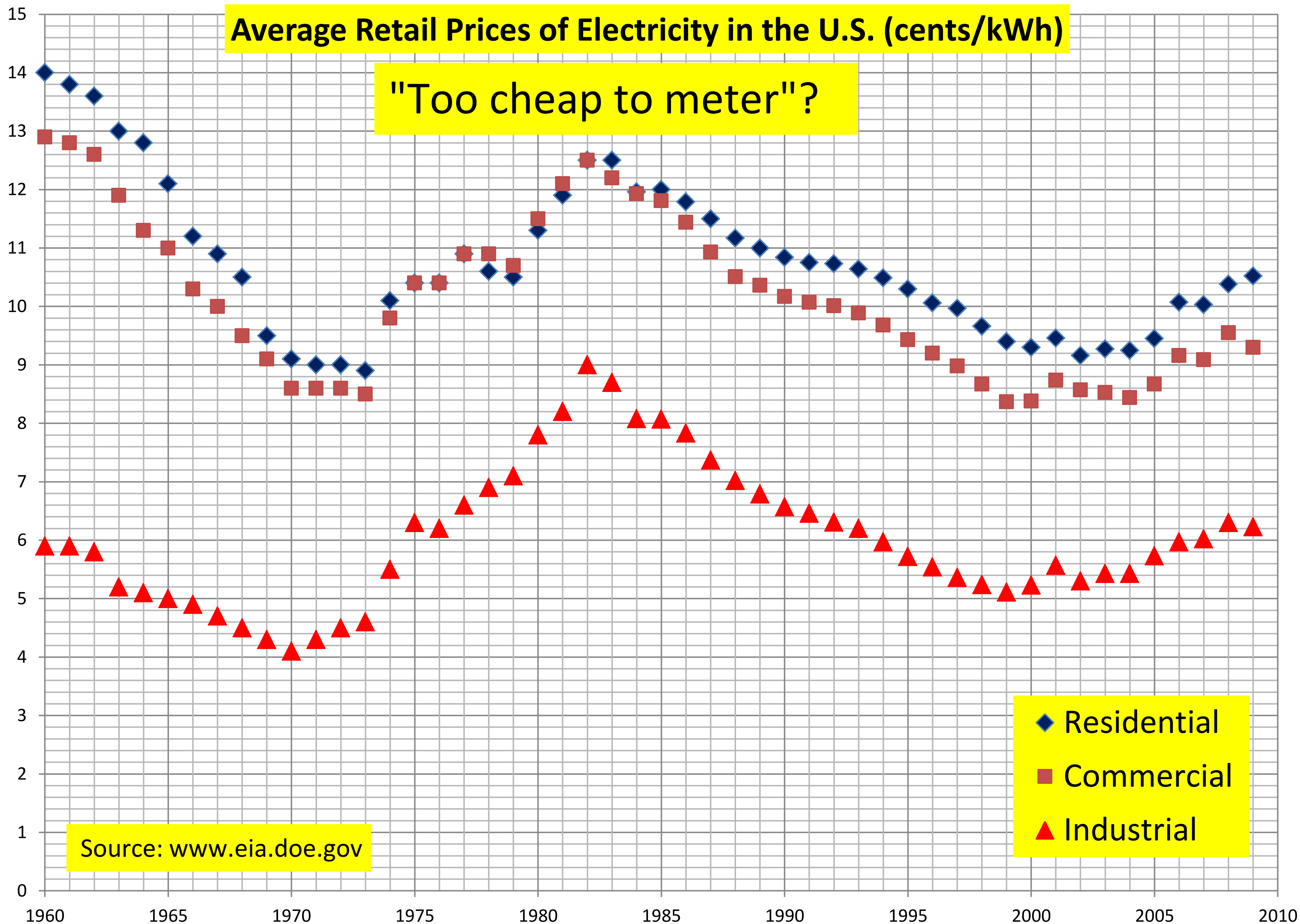


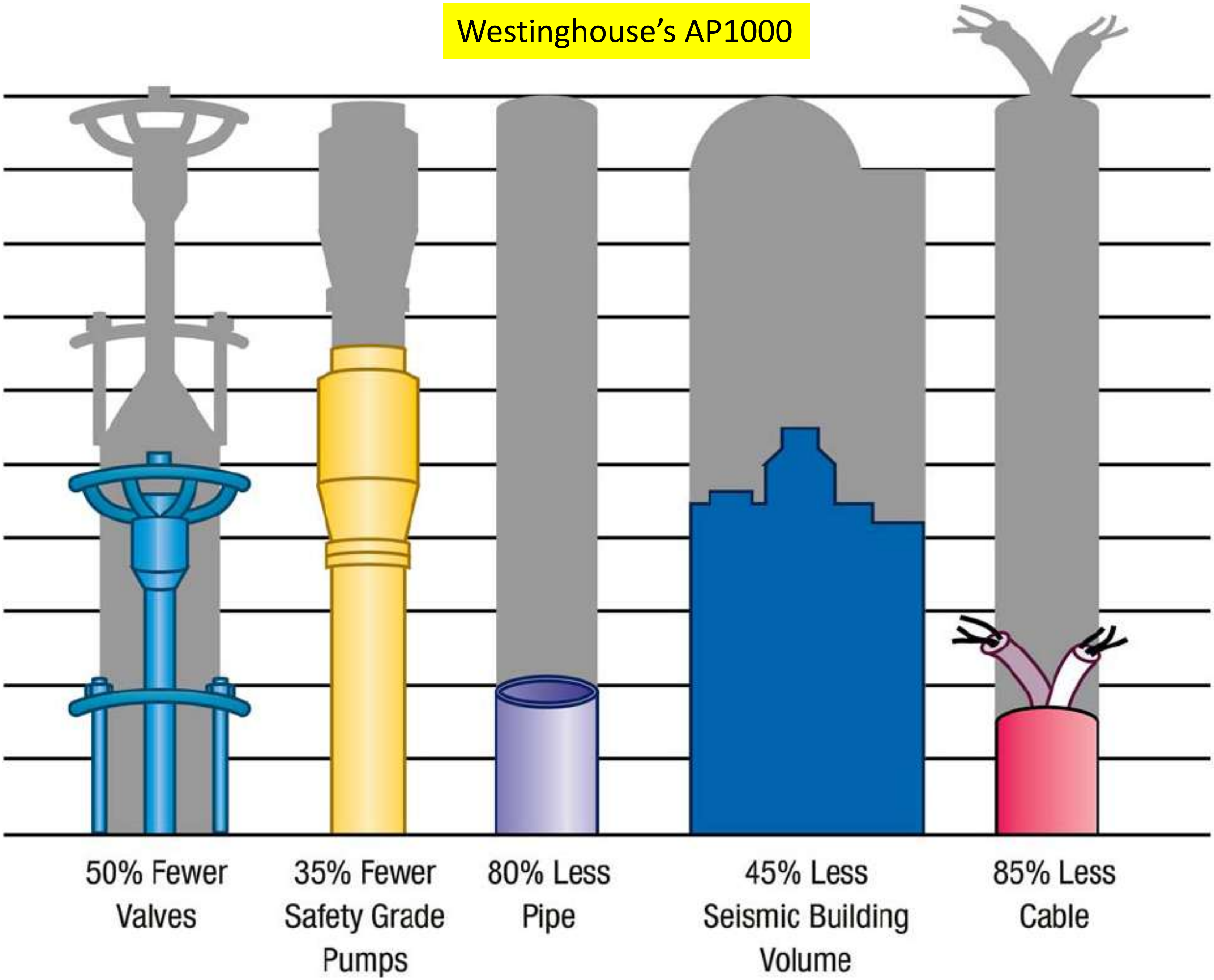
Average Retail Prices of Electricity in the U.S. (cents/kWh)
"Too cheap to meter"?
Residential
Commercial
Industrial
Source: www.eia.doe.gov
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010

http://www.nrc.gov/reactors/new-reactors/col/new-reactor-map.html

* cancelled

Expected New Nuclear Power Plant Applications Updated June 21, 2010								
Company (Project or Docket Numbers)	**Date of Application**	**Design**	**Date Accepted**	**Site Under Consideration**	**Number of Units**	**State**	**Existing Operating Plant**	**Status**
Calendar Year (CY) 2007 Applications								
NRG Energy (52-012/013)	09/20/07	ABWR	11/29/07	South Texas Project	2	TX	Y	Accepted/Docketed
NuStart Energy (52-014/015)	10/30/07	AP1000	01/18/08	Bellefonte	2	AL	N	Accepted/Docketed
UNISTAR (52-016)	07/13/07 (Envir.) 03/13/08 (Safety)	EPR	01/25/08 06/03/08	Calvert Cliffs	1	MD	Y	Accepted/Docketed Accepted/Docketed
Dominion (52-017)	11/27/07	ESBWR	01/28/08	North Anna	1	VA	Y	Accepted/Docketed
Duke (52-018/019)	12/13/07	AP1000	02/25/08	William Lee Nuclear Station	2	SC	N	Accepted/Docketed
2007 Total Number of Applications = 5 **Total Number of Units = 8**								
Calendar Year (CY) 2008 Applications								
Progress Energy (52-022/023)	02/19/08	AP1000	04/17/08	Harris	2	NC	Y	Accepted/Docketed
NuStart Energy (52-024)	02/27/08	ESBWR	04/17/08	Grand Gulf	1	MS	Y	Accepted/Docketed
Southern Nuclear Operating Co. (52-025/026)	03/31/08	AP1000	05/30/08	Vogtle	2	GA	Y	Accepted/Docketed
South Carolina Electric & Gas (52-027/028)	03/31/08	AP1000	07/31/08	Summer	2	SC	Y	Accepted/Docketed
Progress Energy (52-029/030)	07/30/08	AP1000	10/06/08	Levy County	2	FL	N	Accepted/Docketed
Detroit Edison (52-033)	09/18/08	ESBWR	11/25/08	Fermi	1	MI	Y	Accepted/Docketed
Luminant Power (52-034/035)	09/19/08	USAPWR	12/02/08	Comanche Peak	2	TX	Y	Accepted/Docketed
Entergy (52-036)	09/25/08	ESBWR	12/04/08	River Bend	1	LA	Y	Accepted/Docketed
AmerenUE (52-037)	07/24/08	EPR	12/12/08	Callaway	1	MO	Y	Accepted/Docketed
UNISTAR (52-038)	09/29/08	EPR	12/11/08	Nine Mile Point	1	NY	Y	Accepted/Docketed
PPL Generation (52-039)	10/10/08	EPR	12/19/08	Bell Bend	1	PA	Y	Accepted/Docketed
2008 Total Number of Applications = 11 **Total Number of Units = 16**								
Calendar Year (CY) 2009 Applications								
Florida Power and Light (763)	06/30/09	AP1000	09/04/09	Turkey Point	2	FL	Y	Accepted/Docketed
2009 Total Number of Applications = 1 **Total Number of Units = 2**								
Calendar Year (CY) 2010 Applications								
No Letters of Intent have been received from applicants expressing their plans to submit new COL applications in CY 2010								
2010 Total Number of Applications = 0 **Total Number of Units = 0**								
Calendar Year (CY) 2011 Applications								
Blue Castle Project		TBD		Utah	1	UT	N	
Southern		TBD		TBD	1		TBD	
AEHI		TBD		Payette, ID	1	ID	N	
Unnamed		TBD		TBD	1		TBD	
Unnamed		TBD		TBD	1		TBD	
2011 Total Number of Applications = 5 **Total Number of Units = 5**								
2007 - 2011 Total Number of Applications = 22 **Total Number of Units = 31**								

Westinghouse's AP1000



The Economist

Nuclear power in America

Constellation's cancellation

America's nuclear renaissance is mighty slow in coming

Oct 14th 2010 | NEW YORK

NUCLEAR power should be hot. It emits virtually no carbon dioxide. It requires no costly imports of oil from countries that breed terrorists. Even greens don't hate it as much as they used to. What's for a politician not to like?

The Economist, October 14, 2010

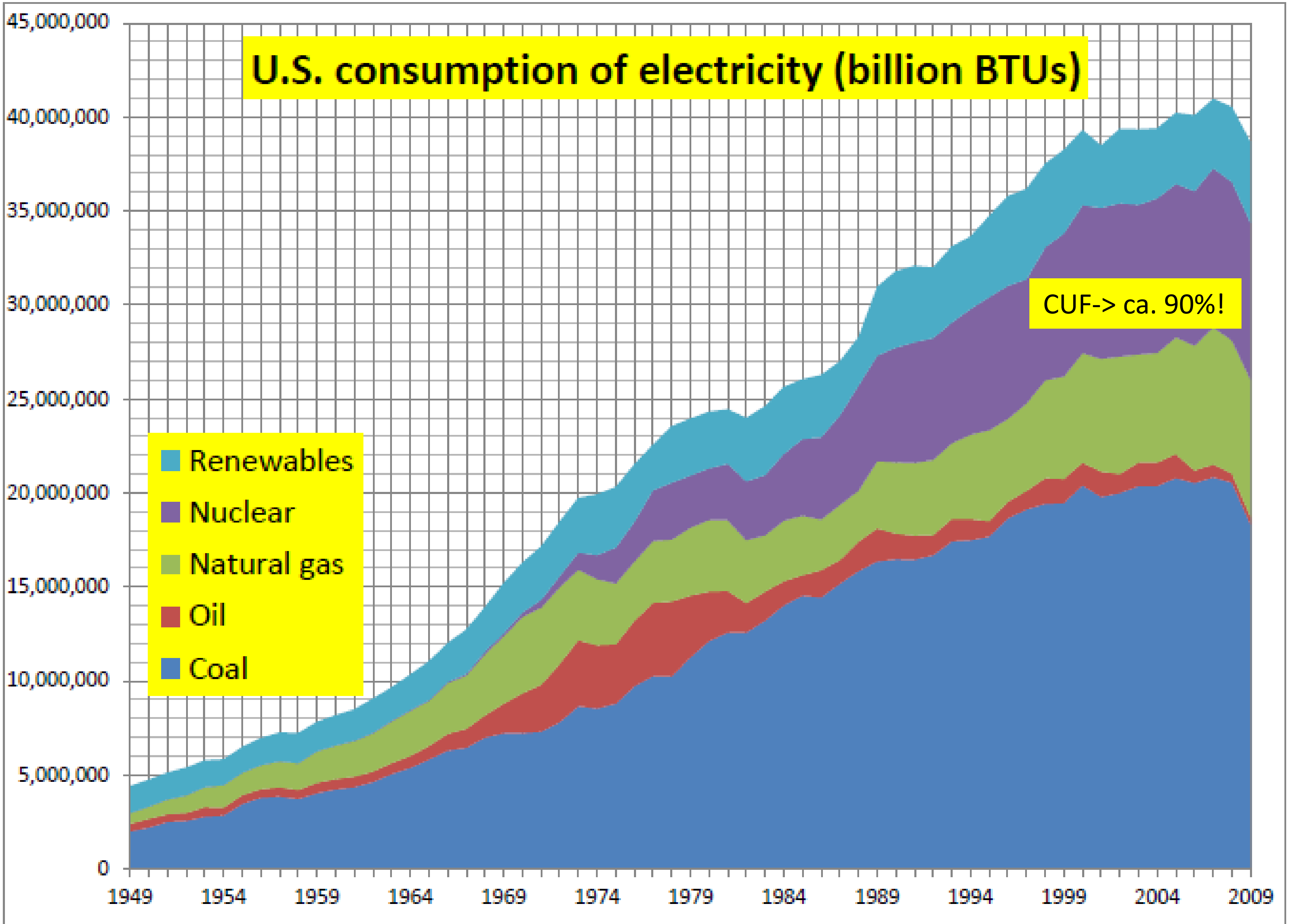
Nuclear power in America

Constellation's cancellation

Constellation's decision is the latest in a series of blows to the industry. After Congress agreed in 2007 to fund loan guarantees, some 28 applications were filed to build new nuclear plants. America is the world's largest producer of nuclear energy, but has not approved a single new plant since a scary (but non-lethal) nuclear accident at Three Mile Island in 1979. (The 50 or so plants that have opened since then already had regulatory approval; plans for dozens more were cancelled.)

To make matters worse, America has failed to adopt a coherent energy policy, let alone one that imposes a price on carbon. Everyone in the energy business believes that carbon-pricing will come, but when? It costs perhaps $9 billion to build a nuclear plant, and can take a decade (allowing maybe four years to get approval). With so much regulatory uncertainty, that is too big a bet for private investors—especially since projects of this kind often cost more than expected. Several plans to build nuclear plants have been shelved. Earlier this year Exelon, another power firm, suspended plans for a twin reactor in Texas (though it continues to seek regulatory approval, in case the economics improve).

Until the summer, the consensus was that four to eight new nuclear plants would come on stream in America between 2016 and 2018. Now, no one will be shocked if it is only two by 2020. After that, who knows? Meanwhile, other parts of the world are rushing to go nuclear. Some 55 plants are under construction. More than 20 are in China, which is forecast to surpass America and have the most nuclear reactors around 2030.



U.S. consumption of electricity (billion BTUs)
CUF-> ca. 90%!
Renewables
Nuclear
Natural gas
Oil
Coal
45,000,000
40,000,000
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
1949
1954
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009

Report #:DOE/EIA-0554(2010)
Release date: April 2010
Next release date: April 2011

Electricity Market Module

Table 8.12. Cost Characteristics for Advanced Nuclear Technology: Three Cases

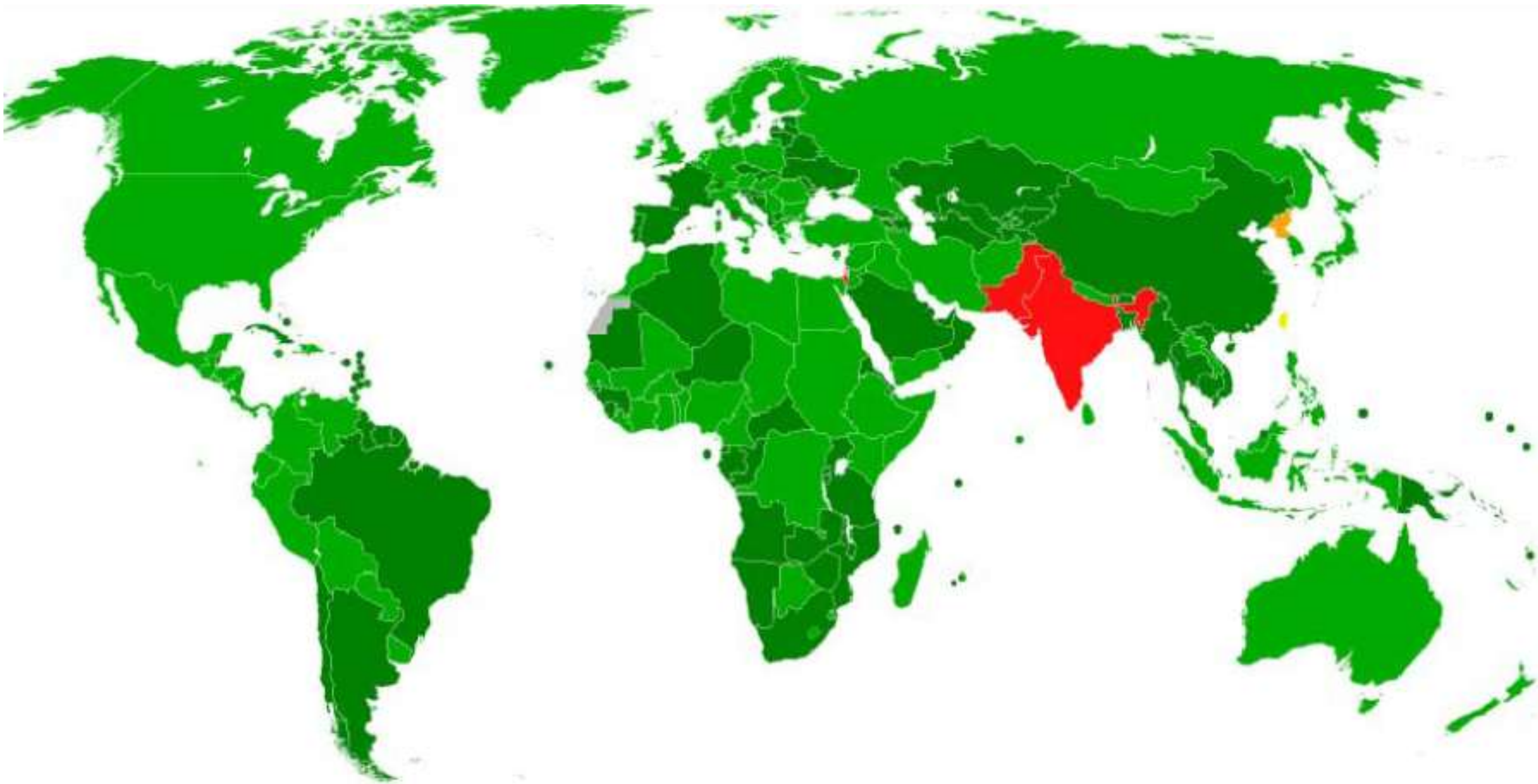
Advanced Nuclear Technology	Overnight Cost in 2009 (Reference) (2008$/kW)	Total Overnight Cost[1] Reference Case (2008$/kW)	High Nuclear Cost (2008$/KW)	Low Nuclear Cost (2008$/kW)
	3820			
2015		4089	4180	3470
2020		3670	3994	2943
2025		3203	3678	2514
2030		2835	3370	2141
2035		2496	3133	1872

Report #:DOE/EIA-0554(2010)
Release date: April 2010
Next release date: April 2011

Electricity Market Module

Advanced Coal	2569			
2015		2769	2338	2408
2020		2590	2722	2176
2025		2329	2516	1887
2030		2065	2306	1610
2035		1829	2107	1372
Advanced Coal withSequestration	3776			
2015		4022	4172	3499
2020		3568	4002	2997
2025		3163	3697	2562
2030		2765	3391	2156
2035		2410	3098	1807
Conventional Combined Cycle	984			
2015		1070	1086	931
2020		1010	1042	849
2025		918	963	743
2030		823	884	647
2035		744	806	559
Advanced Gas	968			
2015		1048	1070	913
2020		985	1070	828
2025		889	949	719
2030		786	869	613
2035		698	795	524

Not even to mention (the unstoppable?) **nuclear weapons proliferation**!?



Source: Wikipedia (probably correct)… in red "non-signatories", in orange "withdrawn".

Table 1
Qualitative comparison of generic features of generation technologies.
Source: IEA/NEA (2005).

Technology	Unit size	Lead time	Capital cost (kW)
CCGT	Medium	Short	Low
Coal	Large	Long	High
Nuclear	Very large	Long	High
Hydro	Large	Long	Very high
Wind	Small	Short	High
Recip. engine	Small	Very short	Low
Fuel cells	Small	Very short	Very high
Photovoltaics	Very small	Very short	Very high

Note: CO_2 emissions refer to emissions at the power plant only.

Technology	Operating cost	Fuel prices	CO_2 emissions	Regulatory risk
CCGT	Low	High	Medium	Low
Coal	Medium	Medium	High	High
Nuclear	Medium	Low	Nil	High
Hydro	Very low	Nil	Nil	High
Wind	Very low	Nil	Nil	Medium
Recip. engine	Low	High	Medium	Medium
Fuel cells	Medium	High	Medium	Low
Photovoltaics	Very low	Nil	Nil	Low

Table 5.1 Costs of Electric Generation Alternatives
Real Levelized Cents/kWe-hr (85% capacity factor)

Base Case	25-YEAR	40-YEAR
Nuclear	7.0	6.7
Coal	4.4	4.2
Gas (low)	3.8	3.8
Gas (moderate)	4.1	4.1
Gas (high)	5.3	5.6
Gas (high) Advanced	4.9	5.1

Carbon Tax Cases (25/40 year)

	\$50/tC	\$100/tC	\$200/tC
Coal	5.6/5.4	6.8/6.6	9.2/9.0
Gas (low)	4.3/4.3	4.9/4.8	5.9/5.9
Gas (moderate)	4.6/4.7	5.1/5.2	6.2/6.2
Gas (high)	5.8/6.1	6.4/6.7	7.4/7.7
Gas (high) advanced	5.3/5.6	5.8/6.0	6.7/7.0

MIT STUDY ON THE FUTURE OF NUCLEAR POWER

YEAR	NUCLEAR	COAL	NGCC
Inflation rate	3%	3%	3%
Interest rate	8%	8%	8%
Expected return to equity investor	15%	12%	12%
Debt fraction	50%	60%	60%
Tax rate	38%	38%	38%
Debt term	10 years	10 years	10 years
Net capacity	1,000 MWe	1,000 MWe	1,000 Mwe
Capacity factor	85%	85%	85%
Plant life	40 years	40 years	40 years
Heat rate	10,400	9,300	7,200
Overnight cost	$2,000/kWe	$1,300/kWe	$500/kWe
Construction period	5 years	4 years	2 years
Post-construction period	—	—	—
Depreciation schedule	Accelerated, 15 years	Accelerated, 15 years	Accelerated, 15 years
Decommissioning cost	$350 million	—	—
Incremental capital costs	$20/kWe/yr	$15/kWe/yr	$6/kWe/yr
Fuel costs	$0.47/mmBTU	$1.20/mmBTU	$3.50/mmBTU
Real fuel escalation	0.5%	0.5%	1.5%
Nuclear waste fee	1 mill/kWh	—	—
Fixed O&M	$63/kWe/yr	$23/kWe/yr	$16/kWe/yr
Variable O&M	0.47 mills/kWh	3.38 mills/kWh	0.52 mills/kWh
O&M real escalation rate	1.0%	1.0%	1.0%
Carbon intensity	—	25.8 kg-C/mmBTU	14.5 kg-C/mmBTU
Carbon tax	—	—	—

Table 1: Costs of Electric Generation Alternatives

			LCOE		
	Overnight Cost	Fuel Cost	Base Case	w/ carbon charge \$25/ tCO_2	w/ same cost of capital
	\$/kW	\$/mmBtu	¢/kWh	¢/kWh	¢/kWh
	[A]	[B]	[C]	[D]	[E]
MIT (2003)					
\$2002					
[1] Nuclear	2,000	0.47	6.7		5.5
[2] Coal	1,300	1.20	4.3	6.4	
[3] Gas	500	3.50	4.1	5.1	
Update					
\$2007					
[4] Nuclear	4,000	0.67	8.4		6.6
[5] Coal	2,300	2.60	6.2	8.3	
[6] Gas	850	7.00	6.5	7.4	

Nuclear's Fall--and Rise; As some environmentalists begin to offer more support, the future of nuclear power in the U.S. still depends on whether it makes economic sense

Michael Totty. **Wall Street Journal (Online)**. New York, N.Y.: Apr 17, 2010.

Abstract (Summary)

In announcing the first guarantees for two new reactors planned in Georgia, President Obama made clear the connection he sees with global warming: "To meet our growing energy needs and prevent the worst consequences of climate change," he said, "we need to increase our supply of nuclear power."

WSJ, April 17, 2010

Placing Bets

Still, not all environmentalists are sold on nuclear, and most environmental groups remain opposed. For one thing, they warn that an ambitious nuclear-building program would squeeze out investments in other alternatives. Further, they say, the lengthy process of building and permitting a nuclear plant means the climate-change benefits aren't going to show up anytime soon, while efficiency programs, investments in solar and wind and even new natural-gas plants could meet low-carbon power needs much sooner.

For now, though, nuclear power's future isn't going to depend on how many environmentalists see the nuclear light. Instead, it's going to rise and fall on something more basic: economics. Loan guarantees may help a few new plants get built, but even if a tax or a cap-and-trade system puts a price on carbon emissions, nuclear power is still going to be hard-pressed to compete with coal or natural gas in today's power market without more government support.

This is leading some supporters of nuclear power to place their bets on the next generation of smaller, modular reactors being developed around the world. Some could be built in a factory and installed on site, significantly reducing the time and money involved in building a reactor from the ground up. They also are simpler, and therefore theoretically safer, because they don't require the complex cooling systems of bigger reactors. And while they aren't expected to come online anytime soon, these smaller reactors could eventually be used to power manufacturing plants and generate electricity.