U.S. capacity factors: Can older reactors keep up the pace?

BY E. MICHAEL BLAKE

While the median three-year capacity factor has continued to edge upward, most of the reactors that will soon enter their license renewal periods have been a little less productive.

THIS YEAR, NUCLEAR power in the United States officially enters the license renewal era, as both Oyster Creek and Nine Mile Point-1 pass the 40-year mark and continue to operate. As the nation's 104 power reactors continue to maintain their three-year capacity factors at the level of recent years, with small (and perhaps statistically insignificant) gains, this year's survey seeks to infer performance expectations for power reactors entering their fifth decades by looking at how they have done so far in their fourth decades. The result appears to be that the oldest reactors lag behind the rest of the fleet, but not by much.

The median design electrical rating (DER) net capacity factor of the 104 operable power reactors in 2006–2008 was 90.60, exactly one point higher than the median in 2003–2005. In effect, the last three three-year periods have had nearly equivalent performances, given the rise of only 0.02 percentage points from 2000–2002 to 2003–2005. The rise appears slightly larger when one looks at averages, rather than medians, partly because of resumed operation at Browns Ferry-1 and Davis-Besse after multiyear outages. The 2006–2008 average capacity factor was 89.46, up from 88.04 in 2003–2005 and 87.88 in 2000–2002.

The top quartile rose nearly as much as the median, with a value of 93.12 in 2006–2008 after the 92.18 in 2003–2005. The bottom quartile rose even more, at 87.82 in 2006–2008, fully two points higher than the 85.82 in 2003–2005. To the extent that there might still exist an improvement trend in the industry as a whole, it may be most apparent here, with even the comparatively less impressive performers approaching 90 percent capacity.

For the third straight three-year period, the median capacity factor for boiling water reactors was slightly higher than that for pressurized water reactors. The BWR median in 2006–2008 was 91.16, up about a point from the 90.14 median in 2003–2005. The PWR medians in the same periods were 90.06 and 89.55. This survey considers medians to be more significant than averages, but it can be interpreted that with both averages and medians considered, the slight apparent difference between the performances of the two reactor types might vanish altogether. The PWRs had a higher average capacity factor in 2006–2008 than the BWRs had, 89.72 to 88.95 (they were 88.94 and 86.27, respectively, in 2003–2005). Browns Ferry-1's 22-year outage extended through almost half of 2006–2008, continuing to bring down the BWR average.

Sixty-one reactors had higher capacity factors in 2006–2008 than in 2003–2005, and 43 had lower factors. As was seen in greater detail last year (*NN,* May 2008, p. 28), shifts of a few points either way are influenced greatly by how many refueling outages a reactor has had in the three-year period. While most PWRs are on an 18-month cycle, which generally means two refuelings in a three-year period, most BWRs are on a 24-month cycle. It would be typical, therefore, for a BWR to have two refuelings in one period and one in the next, and a long-term trend of higher factors alternating with lower factors in consecutive three-year periods. As a result, a difference between gainers and losers may not mean much because the number of outages in the next three-year period could shift the balance the other way. It should be noted that only 42 reactors had better capacity factors in 2003–2005 than they had in 2000–2002, and 61 had poorer factors—almost an exact mirror image of the 61 to 43 gainers-over-losers result in 2006–2008 versus 2003–2005.

This time, however, the gainers-to-losers situation may be more than an outage differential, and not just imbalanced by the restarts of Davis-Besse and Browns Ferry-1. Gainers outweighed losers in every category. Even with Davis-Besse and Browns Ferry-1 omitted, there were four gainers and two losers of more than 10 points each (as noted on page 31, Hope Creek's figure may be too high, but even when adjusted it would yield a gain of more than 10 points), 16 gainers and nine losers between five and 10 points each, and 39 gainers and 32 losers of less than five points each.

Continued

What this is and where we got it

Every year, *NN* presents an analysis of U.S. power reactor capacity factors. The raw data—each reactor's annual electricity output and its design electrical rating (DER)—come from the quarterly compilation of monthly operating reports on the Nuclear Regulatory Commission's Web site, at <www.nrc.gov>.

The author then computes three-year capacity factors for each reactor in the belief that this time frame shows sustained performance and helps even out fueling cycles of different lengths. The historical material shown in the figures includes only reactors that were in service in those earlier time periods and are still in service today. The potential for discrepancies between three-year periods is declining because no reactors have started up since 1996, and none have closed since 1998.

DER has been chosen as a measure of each reactor's generating capacity in the belief that it provides the best indication of what a reactor was intended to accomplish. Other surveys may use measures such as maximum dependable capacity, summer peak, or gross electricity generation. This survey draws most of its conclusions from medians within each group, but also computes averages in some cases.—*E.M.B.*

It appears that the same upward trend among the reactors around the bottom quartile has shown up in these gains. Again omitting the outliers Browns Ferry-1 and Davis-Besse, of the 50 other reactors that were below the median capacity factor in 2003–2005, 38 have improved since then, with higher factors in 2006–2008. Just because reactors with lower factors have more room for improvement does not guarantee that improvement will take place. The fact that it has taken place—and starting from performance levels that would have been considered excellent 20 years ago but are now seen as substandard—speaks well of power reactor personnel nationwide.

Uprates and DERs

Speaking of room for improvement, it has been noted in past years' capacity factors articles that there really isn't much in a fleet of light-water reactors that must go off line every once in a while for refueling. It might be reasonable to look at all of these tables and charts more generally as indicating a high level of overall performance for about the past decade, a long enough time to suggest that it might be possible to sustain the same level for the next decade or more.

At first glance, it seems that nuclear electricity production in 2008 (806 665 GWh, by our count) was only a shade below the record amount produced in 2007 (807 185 GWh, again by our count). In fact, three pieces of data make the 2008 performance of the fleet in general a bit less impressive.

TABLE I.
2006–2008 DER NET CAPACITY FACTORS OF INDIVIDUAL REACTORS

Rank	Reactor	Factor[1]	Design Electrical Rating (DER), MWe[2]	Type	Operator[3]	Rank	Reactor	Factor	Design Electrical Rating (DER), MWe	Type	Operator
1.	South Texas-1	99.53	1250.6	PWR	STPNOC	53.	Summer-1	90.59	972.7	PWR	SCE&G
2.	Three Mile Island-1	98.58	819	PWR	Exelon	54.	Seabrook	90.52	1246	PWR	FPL
3.	South Texas-2	98.22	1250.6	PWR	STPNOC	55.	Cooper	90.26	815	BWR	NPPD/Entergy
4.	Calvert Cliffs-2	97.43	845	PWR	Constellation	56.	Farley-1	90.06	854	PWR	Southern
5.	Comanche Peak-2	97.27	1150	PWR	Luminant	57.	Vogtle-1	90.02	1169	PWR	Southern
6.	Diablo Canyon-1	96.97	1138	PWR	PG&E	58.	ANO-2	90.00	1032	PWR	Entergy
7.	LaSalle-2	96.51	1154	BWR	Exelon	59.	Harris-1	89.84	941.7	PWR	Progress
8.	Peach Bottom-3	96.17	1138	BWR	Exelon	60.	Millstone-2	89.69	883.5	PWR	Dominion
9.	Surry-2	95.92	788	PWR	Dominion	61.	Monticello	89.61	600	BWR	NSP
10.	Braidwood-1	95.88	1187	PWR	Exelon	62.	Salem-2	89.59	1181	PWR	PSEG
11.	Nine Mile Point-1	95.74	613	BWR	Constellation	63.	Catawba-1	89.51	1145	PWR	Duke
12.	Braidwood-2	95.71	1155	PWR	Exelon	64.	Callaway-1	89.31	1228	PWR	Ameren
13.	Calvert Cliffs-1	95.64	845	PWR	Constellation	65.	Prairie Island-1	89.28	536	PWR	NSP
14.	Dresden-2	95.22	867	BWR	Exelon	66.	Browns Ferry-2	89.17	1120	BWR	TVA
15.	Dresden-3	94.93	867	BWR	Exelon	67.	Turkey Point-3	89.08	720	PWR	FPL
16.	Indian Point-3	94.92	1048	PWR	Entergy	68.	Oconee-3	89.05	886	PWR	Duke
17.	FitzPatrick	94.91	816	BWR	Entergy	69.	Cook-2	88.98	1107	PWR	IMP
18.	Ginna	94.90	585	PWR	Constellation	70.	Prairie Island-2	88.91	536	PWR	NSP
19.	Comanche Peak-1	94.39	1150	PWR	Luminant	71.	North Anna-2	88.53	913	PWR	Dominion
20.	Byron-2	94.18	1155	PWR	Exelon	72.	Davis-Besse	88.41	893	PWR	FENOC
21.	Hope Creek	93.95	1083	BWR	PSEG	73.	Oconee-2	88.19	886	PWR	Duke
22.	Salem-1	93.83	1169	PWR	PSEG	74.	Turkey Point-4	88.16	720	PWR	FPL
23.	Surry-1	93.58	788	PWR	Dominion	75.	Grand Gulf-1	88.15	1279	BWR	Entergy
24.	North Anna-1	93.45	913	PWR	Dominion	76.	Columbia	88.06	1153	BWR	Northwest
25.	Farley-2	93.32	855	PWR	Southern	77.	Perry	87.88	1273	BWR	FENOC
26.	Arnold	93.14	613.5	BWR	FPL	78.	Point Beach-1	87.88	522	PWR	FPL
27.	Byron-1	93.12	1187	PWR	Exelon	79.	Palisades	87.77	805	PWR	Entergy
28.	Vermont Yankee	92.97	617	BWR	Entergy	80.	Robinson-2	87.51	765	PWR	Progress
29.	Clinton	92.97	1062	BWR	Exelon	81.	Hatch-1	87.42	885	BWR	Southern
30.	Quad Cities-1	92.96	866	BWR	Exelon	82.	McGuire-2	87.35	1180	PWR	Duke
31.	Peach Bottom-2	92.70	1138	BWR	Exelon	83.	Brunswick-2	86.72	980	BWR	Progress
32.	Pilgrim	92.66	690	BWR	Entergy	84.	Susquehanna-1	86.58	1235	BWR	PPL
33.	Point Beach-2	92.52	522	PWR	FPL	85.	Vogtle-2	85.69	1169	PWR	Southern
34.	Limerick-2	91.98	1191	BWR	Exelon	86.	Brunswick-1	85.48	983	BWR	Progress
35.	Indian Point-2	91.93	1035	PWR	Entergy	87.	Fort Calhoun	85.31	502	PWR	OPPD
36.	St. Lucie-1	91.79	856	PWR	FPL	88.	San Onofre-2	85.02	1070	PWR	SCE
37.	Wolf Creek	91.71	1170	PWR	WCNOC	89.	Browns Ferry-3	84.95	1120	BWR	TVA
38.	Limerick-1	91.68	1191	BWR	Exelon	90.	Diablo Canyon-2	84.83	1151	PWR	PG&E
39.	ANO-1	91.65	850	PWR	Entergy	91.	Oyster Creek	84.14	650	BWR	Exelon
40.	Hatch-2	91.57	908	BWR	Southern	92.	Fermi-2	84.08	1150	BWR	Detroit
41.	Beaver Valley-2	91.54	868	PWR	FENOC	93.	Kewaunee	84.02	574	PWR	Dominion
42.	Waterford-3	91.51	1173	PWR	Entergy	94.	McGuire-1	83.69	1180	PWR	Duke
43.	Quad Cities-2	91.22	871	BWR	Exelon	95.	Palo Verde-2	83.63	1336	PWR	APS
44.	Crystal River-3	91.18	860	PWR	Progress	96.	Oconee-1	83.15	886	PWR	Duke
45.	Nine Mile Point-2	91.16	1143.3	BWR	Constellation	97.	River Bend-1	82.77	967	BWR	Entergy
46.	Beaver Valley-1	91.14	911	PWR	FENOC	98.	St. Lucie-2	82.48	856	PWR	FPL
47.	LaSalle-1	91.06	1154	BWR	Exelon	99.	Watts Bar-1	81.92	1155	PWR	TVA
48.	Sequoyah-2	91.03	1151	PWR	TVA	100.	Palo Verde-3	79.40	1339	PWR	APS
49.	Millstone-3	91.00	1156.5	PWR	Dominion	101.	Cook-1	78.98	1084	PWR	IMP
50.	Sequoyah-1	90.78	1173	PWR	TVA	102.	San Onofre-3	78.41	1080	PWR	SCE
51.	Catawba-2	90.74	1145	PWR	Duke	103.	Palo Verde-1	67.43	1333	PWR	APS
52.	Susquehanna-2	90.61	1182	BWR	PPL	104.	Browns Ferry-1	44.07	1120	BWR	TVA

[1]These figures are rounded off. There are no ties. For example, Vermont Yankee is in 28th, with 92.9724, and Clinton is in 29th, with 92.9679.

[2]The rating shown is effective as of December 31, 2008. If the reactor's rating has changed during the three-year period, the capacity factor is computed with appropriate weighting.

[3]As of December 31, 2008. In most cases this also means the reactor's owner, but Entergy is the contracted operator of Cooper.

TABLE II.
CAPACITY FACTOR CHANGE, 2003–2005 TO 2006–2008

Rank	Reactor	Change (percentage points)	Rank	Reactor	Change (percentage points)	Rank	Reactor	Change (percentage points)	Rank	Reactor	Change (percentage points)
1.	Browns Ferry-1	+44.07	27.	Surry-1	+3.73	53.	Millstone-2	+0.77	79.	Byron-1	-2.42
2.	Davis-Besse	+34.04	28.	Cook-2	+3.65	54.	Oconee-1	+0.62	80.	Nine Mile Point-2	-2.51
3.	Hope Creek	+20.26	29.	Sequoyah-2	+3.55	55.	St. Lucie-1	+0.56	81.	Limerick-1	-2.56
4.	South Texas-1	+14.82	30.	Surry-2	+3.52	56.	Summer-1	+0.44	82.	Byron-2	-2.74
5.	Dresden-2	+11.02	31.	Sequoyah-1	+3.23	57.	Harris-1	+0.31	83.	Catawba-2	-3.07
6.	Diablo Canyon-1	+10.31	32.	Point Beach-1	+3.21	58.	Beaver Valley-1	+0.29	84.	LaSalle-1	-3.17
7.	Point Beach-2	+9.96	33.	Peach Bottom-3	+2.99	59.	Fermi-2	+0.29	85.	North Anna-2	-3.45
8.	South Texas-2	+9.57	34.	Salem-2	+2.93	60.	Monticello	+0.26	86.	Ginna	-3.57
9.	Cooper	+9.36	35.	Oconee-2	+2.73	61.	Peach Bottom-2	+0.04	87.	Vogtle-1	-3.62
10.	Nine Mile Point-1	+9.29	36.	Quad Cities-2	+2.68	62.	Catawba-1	-0.36	88.	Hatch-1	-3.64
11.	Kewaunee	+8.81	37.	Vermont Yankee	+2.60	63.	Millstone-3	-0.39	89.	McGuire-1	-3.68
12.	Salem-1	+8.77	38.	Farley-2	+2.43	64.	FitzPatrick	-0.48	90.	Vogtle-2	-3.73
13.	Perry	+8.08	39.	Hatch-2	+2.38	65.	Diablo Canyon-2	-0.74	91.	Seabrook	-3.87
14.	Quad Cities-1	+7.04	40.	Comanche Peak-1	+2.29	66.	Braidwood-1	-0.78	92.	Calvert Cliffs-1	-3.94
15.	Comanche Peak-2	+6.73	41.	Pilgrim	+2.23	67.	Farley-1	-0.91	93.	St. Lucie-2	-4.33
16.	Callaway-1	+6.54	42.	Clinton	+2.08	68.	Prairie Island-1	-0.91	94.	Brunswick-1	-5.72
17.	Oconee-3	+6.24	43.	Palisades	+2.05	69.	Palo Verde-3	-1.31	95.	Oyster Creek	-6.39
18.	Columbia	+6.16	44.	Fort Calhoun	+1.80	70.	McGuire-2	-1.47	96.	Grand Gulf-1	-6.78
19.	LaSalle-2	+5.75	45.	Waterford-3	+1.73	71.	Brunswick-2	-1.50	97.	Browns Ferry-3	-7.32
20.	Dresden-3	+5.33	46.	Crystal River-3	+1.63	72.	Prairie Island-2	-1.52	98.	River Bend-1	-7.36
21.	Arnold	+5.20	47.	Susquehanna-2	+1.27	73.	Robinson-2	-1.70	99.	Watts Bar-1	-7.68
22.	ANO-1	+5.04	48.	Wolf Creek	+1.20	74.	Indian Point-2	-1.71	100.	Cook-1	-8.45
23.	Turkey Point-3	+4.71	49.	Limerick-2	+1.12	75.	Braidwood-2	-1.89	101.	San Onofre-3	-9.77
24.	Three Mile Island-1	+4.66	50.	North Anna-1	+1.11	76.	Susquehanna-1	-2.15	102.	San Onofre-2	-9.88
25.	Turkey Point-4	+4.29	51.	Indian Point-3	+1.09	77.	Beaver Valley-2	-2.28	103.	ANO-2	-12.18
26.	Calvert Cliffs-2	+3.74	52.	Palo Verde-2	+1.01	78.	Browns Ferry-2	-2.34	104.	Palo Verde-1	-13.81

The leap year gave 2008 an extra day, which itself accounts for about 2700 GWh more than could have been produced in 2007. Browns Ferry-1 was in service for all of 2008, and only seven-plus months in 2007, giving 2008 another 3600 GWh. Also, Hope Creek put a 15 percent power uprate into effect in mid-2008 without yet raising its DER, adding about 1000 to 2000 GWh to its output while claiming the same capability in 2008 as it had earlier. On the whole, this means that if the overall performance level of 2007 had been in effect in 2008, the total output for 2008 would have been about 8000 GWh greater than it was.

This is not to suggest that 2008 was an off year, because it was not, and power uprates, at Hope Creek and elsewhere, are proving their worth by adding to the amount of nuclear-generated electricity available to the grid. It's just a reminder that total output isn't the only performance criterion, and that each year's output need not break records.

The 504-MWt boost at Hope Creek is the second largest single uprate ever granted by the Nuclear Regulatory Commission, topped only by the 579 MWt approved for Clinton in 2002 (a 20 percent hike from its originally licensed level). There have been performance gains recently at both Hope Creek and the collocated Salem-1 and -2, credited in part to Exelon's involvement as contracted operator, which has now ended because the planned merger of Exelon and Public Service Enterprise Group was called off. Even if Hope Creek's DER had been revised immediately to reflect the uprate—perhaps to the neighborhood of 1235 MWe—it would still show a gain of at least 10 percentage points in its 2006–2008 factor compared with its 2003–2005 factor.

During 2008, ratings were changed as follows: Beaver Valley-1, 911 MWe (from 868 MWe); Beaver Valley-2, 868 MWe (from 854 MWe); Cooper, 815 MWe (from 778 MWe); Davis-Besse, 893 MWe (from 898 MWe); Indian Point-3, 1048 MWe (from 1034 MWe); North Anna-1 and -2, 913 MWe each (from 907 MWe each); Palo Verde-3, 1339 MWe (from 1269 MWe); Perry, 1273 MWe (from 1258 MWe); Salem-1, 1181 MWe (from 1155 MWe); and Susquehanna-1, 1235 MWe (from 1177 MWe). A change that we failed to catch last year was Diablo Canyon-1, now 1138 MWe, up from 1103 MWe, effective at the start of 2007. This is a total increase of 319 MWe of nuclear generating capacity, in addition to whatever the extra from Hope Creek is.

Keeping track of official DERs, and noting when they change, is a key to obtaining reasonable capacity factor figures for this survey. The numbers in the tables reflect

TABLE III.
DER NET CAPACITY FACTOR OF MULTIREACTOR SITES[1]

Rank	Site	Factor	Operator	Rank	Site	Factor	Operator
1.	South Texas	98.87	STPNOC	19.	Diablo Canyon	90.85	PG&E
2.	Calvert Cliffs	96.53	Constellation	20.	ANO	90.75	Entergy
3.	Comanche Peak	95.83	Luminant	21.	Millstone	90.43	Dominion
4.	Braidwood	95.80	Exelon	22.	Point Beach	90.20	FPL
5.	Dresden	95.07	Exelon	23.	Catawba	90.13	Duke
6.	Surry	94.75	Dominion	24.	Hatch	89.52	Southern
7.	Peach Bottom	94.43	Exelon	25.	Prairie Island	89.10	NSP
8.	LaSalle	93.78	Exelon	26.	Turkey Point	88.62	FPL
9.	Byron	93.64	Exelon	27.	Susquehanna	88.59	PPL
10.	Indian Point	93.43	Entergy	28.	Vogtle	87.86	Southern
11.	Nine Mile Point	92.76	Constellation	29.	St. Lucie	87.14	FPL
12.	Hope Creek/Salem	92.44	PSEG	30.	Oconee	86.80	Duke
13.	Quad Cities	92.09	Exelon	31.	Brunswick	86.10	Progress
14.	Limerick	91.83	Exelon	32.	McGuire	85.52	Duke
15.	Farley	91.69	Southern	33.	Cook	84.07	IMP
16.	Beaver Valley	91.34	FENOC	34.	San Onofre	81.70	SCE
17.	North Anna	90.99	Dominion	35.	Palo Verde	76.80	APS
18.	Sequoyah	90.90	TVA	36.	Browns Ferry	72.94	TVA

[1]Because Nine Mile Point and FitzPatrick have different owners, Nine Mile Point is listed here as a multireactor site, but FitzPatrick is not included, even though the plants are on adjacent properties; combined, Nine Mile Point and FitzPatrick would have a 2006–2008 factor of 93.44. Hope Creek and Salem are treated as a single site because they are adjacent and have the same owner; the two-reactor Salem had a 2006–2008 factor of 91.73. The figure given for Browns Ferry is for all three reactors, although Unit 1 returned to service in May 2007; the 2006–2008 factor for Units 2 and 3 only is 87.06.

TABLE IV.
DER NET CAPACITY FACTORS
OF OWNERS OR OPERATORS
OF MORE THAN ONE SITE[1]

Rank	Owner/Operator	Factor
1.	Constellation Energy	94.65
2.	Exelon	93.63
3.	Dominion Energy	91.12
4.	Entergy Nuclear	90.91
5.	FirstEnergy Nuclear Operating Co.	89.54
6.	Southern Nuclear Operating Co.	89.49
7.	Northern States Power–Minnesota	89.28
8.	FPL Energy	88.59
9.	Progress Energy	88.08
10.	Duke Power	87.43
11.	Tennessee Valley Authority	80.59

[1]TVA without Browns Ferry-1 is 89.02. Entergy is the contract operator of Cooper, but not its owner; Entergy with Cooper is 90.86.

TABLE V.
FOURTH-DECADE REACTORS, DIFFERENCE BETWEEN THREE-YEAR FACTOR AND MEDIAN FACTOR IN THE SAME PERIOD

First Three-Year Period

Reactor	Factor Difference
ANO-1*	-0.58
Arnold**	+2.54
Browns Ferry-2*	-1.43
Brunswick-2*	-3.88
Calvert Cliffs-1*	+5.04
Cook-1*	-11.62
Cooper**	-0.26
Dresden-2*	+1.92
Dresden-3*	+0.14
FitzPatrick*	+4.31
Fort Calhoun*	-8.52
Ginna*	+7.38
Hatch-1*	-3.18
Indian Point-2**	+3.98
Kewaunee**	-15.42
Millstone-2*	-0.91
Monticello*	+3.01
Nine Mile Point-1*	-2.98
Oconee-1*	-5.14
Oconee-2*	-1.14
Oconee-3*	-2.93
Oyster Creek**	-6.75
Palisades*	-5.56
Peach Bottom-2*	+5.07
Peach Bottom-3*	+2.37
Pilgrim**	+0.83
Point Beach-1*	-1.27
Point Beach-2*	-7.04
Prairie Island-1**	-3.43
Prairie Island-2**	-3.11
Quad Cities-1*	-4.49
Quad Cities-2*	-3.19
Robinson-2*	+1.20
Surry-1*	+0.25
Surry-2*	+5.06
Three Mile Island-1**	+5.23
Turkey Point-3*	-5.33
Turkey Point-4*	-7.21
Vermont Yankee**	+0.77

Second Three-Year Period

Reactor	Factor Difference
Dresden-2	-3.43
Dresden-3	+0.38
Ginna	+9.02
Monticello	-3.47
Nine Mile Point-1	-3.32
Oyster Creek	+0.93
Palisades	-3.67
Pilgrim	+2.06
Point Beach-1	-4.64
Point Beach-2	+1.92
Robinson-2	-1.32
Surry-1	+2.98
Turkey Point-3	-1.52
Vermont Yankee	+2.37

Third Three-Year Period

Reactor	Factor Difference
Nine Mile Point-1	+5.14
Oyster Creek	-6.46

* License already renewed
** License renewal application still under review

weighting for those reactors for which the DERs have changed. Many DERs have not changed, of course, and this survey would not be complete without a bit of throat-clearing directed at reactors for which the DERs haven't been changed, but probably should be. Uprates of 4 to 6 percent, effective for more than a decade, have not led to revised DERs for Calvert Cliffs-1 and -2, FitzPatrick, Surry-1 and -2, and Wolf Creek. This group has also included North Anna-1 and -2, for which the DERs have now been raised by about 0.7 percent each. Their uprates, approved in 1986, were 4.2 percent each.

Briefly, here are some housekeeping notes related to the tables. Effective in January, AmerGen Energy Company was officially absorbed into Exelon, so there are no longer any separate data here for AmerGen. What was left of Nuclear Management Company has now become the reactor operation organization of Northern States Power Company–Minnesota, owner of the last three reactors that NMC had been contracted to operate. The tables now refer to NSP and these three reactors, rather than to NMC.

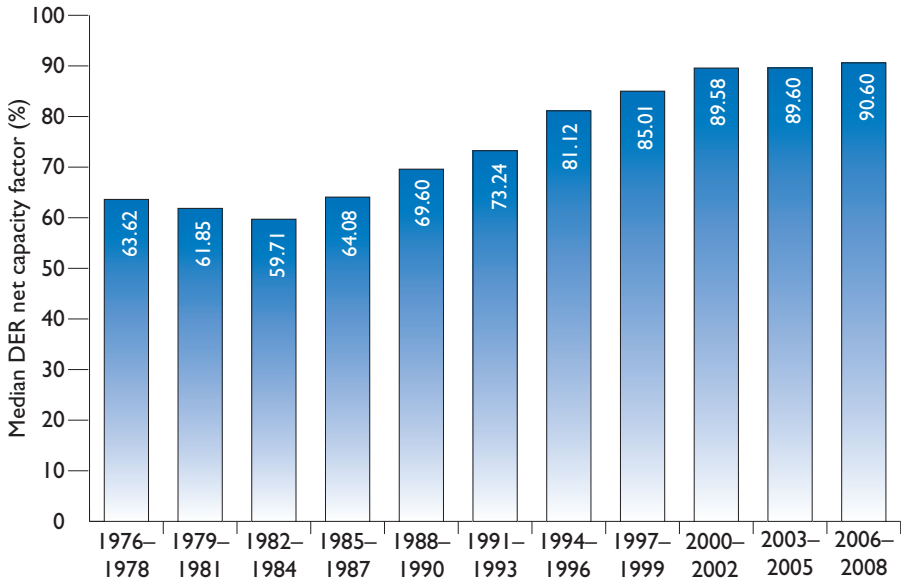

Fig. 1: All reactors. While there was little change from 2000–2002 to 2003–2005, there has been a slight gain in 2006–2008. The chart, like the others in this survey, shows only reactors that are still in operation. In 1976–1978 there were 40, and in each succeeding period there were 52, 59, 70, 91, 102, 103, and 104 in each of the last four. If closed reactors were included to show the median factor for the industry as it was at the time, the medians in the first seven periods would be 63.39 percent (51 reactors), 60.60 (63), 59.51 (71), 63.62 (81), 69.02 (100), 72.44 (108), and 80.64 (109).

Aging management

As has been stated in previous articles, the improvement in power reactor performance since 1980 has been achieved with much of the original equipment, fabricated as long ago as the 1960s. Some major components—turbines, steam generators, and so forth—have been changed out, and progress toward quicker and more reliable data acquisition is always ongoing, with digital instrumentation and controls replacing their analog counterparts to varying degrees. Still, every reactor continues to operate with a fair amount of hardware that has been there from the beginning.

While the concept of "aging management" is often associated with older reactors, in a sense, every reactor's aging management began when the reactor first went critical. Differences might arise in how effective, or intentional, the management is. Even neglect can be thought of as management by default, because a choice is made when no action is taken, as well as when it is. NRC regulations call for a formal aging-management program to be in place before a reactor can be approved for license renewal, but in practical terms, such programs already exist at newer reactors, which are either already compliant with the regulations or evolving in that direction.

This year's survey looks at performance

in a reactor's fourth decade of operation to see if it reveals trends that might be in effect for the fifth and sixth. Forty reactors have completed at least one three-year period after their 30th anniversaries of commercial operation. Browns Ferry-1 will be omitted, because its 22-year outage makes it largely irrelevant. For the remaining 39, each one's factor for every ensuing three-year period is compared with the median factor for all reactors in the same period.

Because different reactors turned 30 in different years, the periods are not necessarily 2006–2008, 2003–2005, and so on. Prairie Island-1 ended its 30th full calendar year in 2003, so its capacity factor for 2004–2006 is used. For Prairie Island-2, however, the 2005–2007 factor is used, because it is one year younger than Unit 1. This simply means that the Prairie Island-1 factor is compared with the median factor for 2004–2006, and the Prairie Island-2 factor is compared with the median for 2005–2007.

Table V shows the results, given by the number of percentage points above or below the median for each reactor. In addition to the 39 reactors that have completed one three-year period after 30 years of operation, the table shows the results for the second three-year periods of 14 reactors, and the third three-year periods of the oldest two. For the most part, the results are not especially dramatic, with most of the differences in the range of a few points. Even so, there may be an indication that performance has dropped off slightly in the fourth decade. Sixteen of the 39 reactors had factors above the median in the first three-year period, with 23 posting factors below the median. There were eight reactors three points or less above the median, and the same number below the median; seven reactors were three to six points above, and nine were in that range below; and one reactor was more than six points above the median, with six reactors more than six points below. This is a large enough sample to suggest that reactors in their fourth decades have not achieved results quite as impressive as those of newer reactors.

This does not, however, show up clearly as a trend in later three-year periods. The 14 reactors that have completed a second three-year period stayed roughly even with the rest of the fleet, with seven having factors above the median and the other seven coming in below. Of these reactors, eight had above-median factors in their first three-year periods, and the other six had below-median factors. Six of the seven above-median factors were by three points or less, and five of the seven below-median factors were by more than three points. This might be another sign of slippage, but it is so scant—and in a data set so small—that it does not seem conclusive.

Only Nine Mile Point-1 and Oyster Creek have completed a third three-year period after turning 30, with the former above the median and the latter below by similar amounts. This is much too small a data set for any conclusions, although the performance of Nine Mile Point-1—in 11th place on Table I—at least shows that lofty factors need not be the exclusive property of younger reactors.

It has long been considered axiomatic that strong performance by the existing fleet of reactors is necessary if there is ever to be public support for the construction of new reactors. The performance is, and in recent years has been, undeniably strong. As more reactors move into their fourth decades and beyond, however, it may turn out to be increasingly difficult to maintain the 90-or-better trend in capacity factors.

This annual survey has stated repeatedly that the challenge now is not to reach even better capacity factors, but to continue to achieve factors at about the current level. To judge from Table V, that may become a daunting task. Then again, the nuclear industry has made use of the learning curve many times before, and perhaps if everyone studies closely what is being done at Nine Mile Point-1, Ginna, and other fourth-decade reactors that are turning in impressive factors, the fleet-wide performance of the past decade may indeed continue into the next. NN

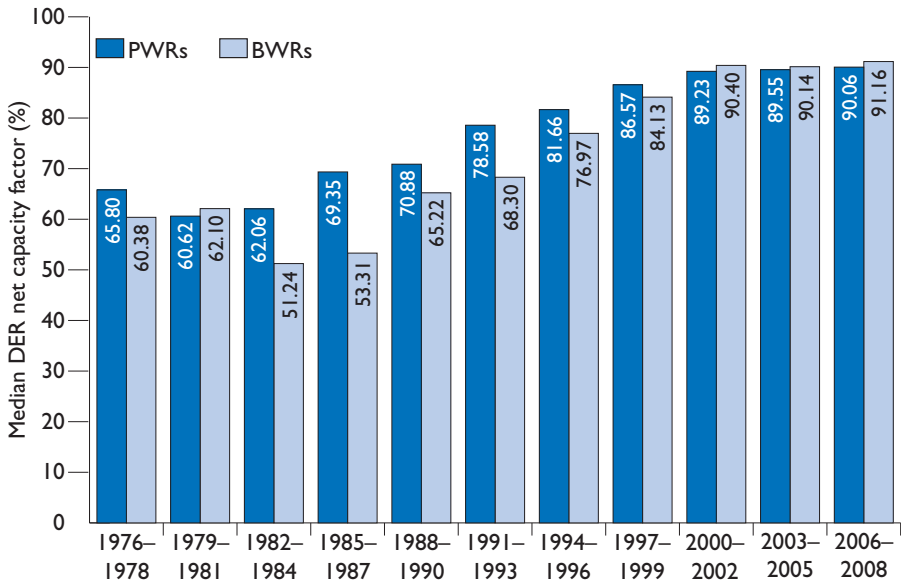

Fig. 2: Reactors by type. Boiling water reactors have managed to maintain a slight edge over pressurized water reactors for three straight periods. If closed plants were included, the trends would look about the same, with all medians within two percentage points of the medians shown above.

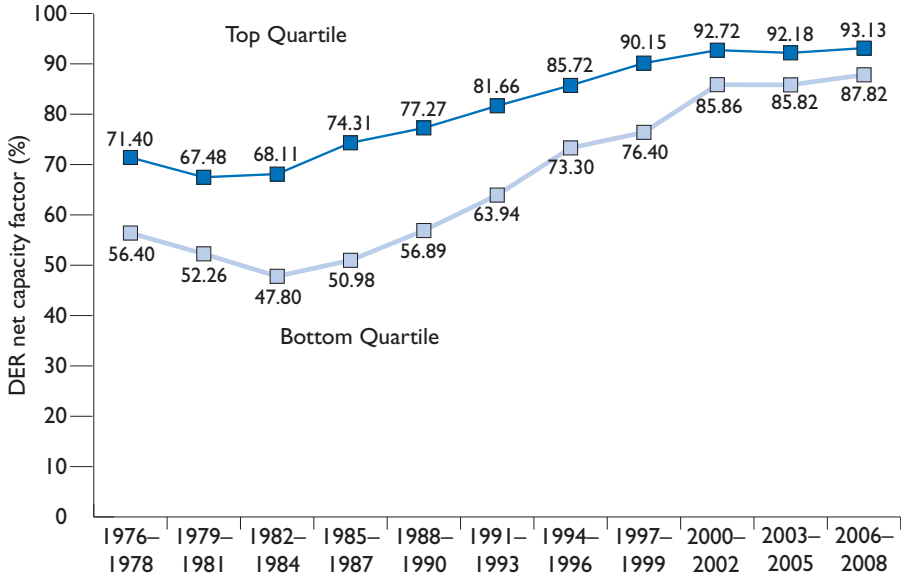

Fig. 3: All reactors, top and bottom quartiles. Both of the curves above have about the same shape as the progress of the median, indicating that the median represents fairly closely the industry as a whole. The latest two-point rise in the bottom quartile shows the extent to which performance has improved even at comparatively less impressive plants.