U.S. nuclear capacity factors: Buoyed by record generation

Incremental increases in nuclear generation and capacity factors have set a new record as more reactors pass the 40-year mark.

By Susan Gallier

Nuclear power generated more electricity in 2018 than ever before from a U.S. fleet that is excelling even as it ages. Over half of the power reactors in the United States have been operating for more than 40 years. Those reactors contributed to the steadily increasing capacity factors of the 1980s and 1990s and to the very high performance of the past two decades. Now they have helped edge fleet-wide capacity factors still higher.

A record 807.1 TWh of electricity was generated by nuclear power in 2018, according to the U.S. Energy Information Administration (EIA), besting a previous record of 807.0 TWh set in 2010, when 104 reactors were in operation. By making operational improvements and shaving more time off already tight refueling outage schedules, the fleet has produced more electricity from fewer reactors.

For most of the three-year period of 2016–2018, 99 reactors were in operation. Oyster Creek's closure in September 2018 reduced the fleet to 98. The 2016–2018 median design electrical rating net capacity factor of the 98 reactors in this survey was 91.01, up by 0.6 percentage points from the median of 90.41 in 2013–2015 (see Fig. 1).

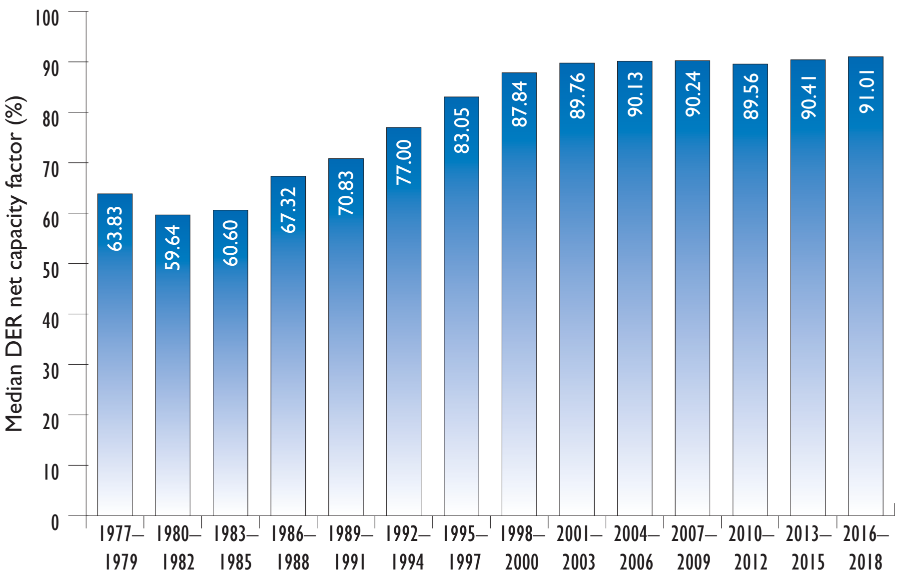

Fig. 1: All reactors. The median DER net capacity factor of the 98 reactors included in this survey for the three-year period of 2016–2018 is 91.01 percent, the highest ever reported in a *Nuclear News* capacity factors survey. For the five three-year periods between 1998 and 2012, 104 reactors were in operation. The 2013–2015 capacity factor is that of the 99 reactors remaining in service following the closure of Crystal River-3, Kewaunee, San Onofre-2 and -3, and Vermont Yankee. Fort Calhoun, which closed in October 2016, is not included in the database for 2016–2018, while Oyster Creek, which closed in September 2018, is included. There were 43 reactors in the database in 1977–1979, and in the six subsequent periods there were 53, 60, 77, 97, 102, and 103.

Even as U.S. power reactors continue to perform at a high level, plant owners have repeatedly sounded alarms on the economic viability of plants that sell their electricity to markets with unfavorable pricing conditions. Dominion Energy, Entergy, Exelon, FirstEnergy Nuclear, and PSEG Nuclear have hinted in terms of varying urgency that reactors may close early if they are not sufficiently compensated for their unique contribution to grid resiliency and their ability to produce large amounts of carbon-free electricity.

The EIA published a nuclear capacity factor for 2018 of 92.6 percent—the highest yet—in its *Electric Power Monthly* in March. There are different ways to calculate capacity factor, and we will not repeat the EIA's calculations in this survey. Simply put, capacity factor is a measure of how well a reactor is performing up to its potential, represented as a percentage and using a ratio of actual output to maximum possible output over a defined period of time. Select different criteria for maximum possible output and for time, and your mileage *will* vary. Yet all calculations based on recent generation totals show that the economically challenged U.S. nuclear industry has, on the whole, continued and improved on its excellent performance of recent years.

Power reactor performance is determined by the amount of electricity produced. A reactor's license and the physical limits of how much fuel the reactor can hold and what can be done with the energy released dictate the maximum thermal output. The plant's other equipment

Table I. 2016–2018 DER Net Capacity Factors of Individual Reactors

Rank	Reactor[1]	Factor[2]	Rating[3]	Type	Owner[4]
1.	Calvert Cliffs-2	101.46	845	PWR	Exelon
2.	Calvert Cliffs-1	100.39	845	PWR	Exelon
3.	Dresden-2	99.97	894	BWR	Exelon
4.	Dresden-3	99.25	879	BWR	Exelon
5.	Three Mile Island-1	98.78	819	PWR	Exelon
6.	South Texas-2	98.46	1250.6	PWR	STPNOC
7.	Farley-2	96.59	855	PWR	Southern
8.	Vogtle-2	96.54	1169	PWR	Southern
9.	Nine Mile Point-1	96.39	613	BWR	Exelon
10.	South Texas-1	96.38	1250.6	PWR	STPNOC
11.	Oconee-2	96.18	872	PWR	Duke
12.	Peach Bottom-3	96.13	1331	BWR	Exelon
13.	Vogtle-1	95.32	1169	PWR	Southern
14.	Monticello	94.86	656.3	BWR	Xcel
15.	Comanche Peak-1	94.73	1218	PWR	Luminant
16.	LaSalle-2	94.22	1178	BWR	Exelon
17.	Peach Bottom-2	94.19	1330	BWR	Exelon
18.	Catawba-1	93.97	1190	PWR	Duke
19.	Seabrook	93.86	1248	PWR	NextEra
20.	Ginna	93.83	585	PWR	Exelon
21.	McGuire-1	93.60	1199	PWR	Duke
22.	Byron-1	93.46	1213	PWR	Exelon
23.	Oconee-3	93.36	881	PWR	Duke
24.	Waterford-3	93.33	1173	PWR	Entergy
25.	Quad Cities-1	93.29	963.99	BWR	Exelon
26.	Diablo Canyon-1	93.25	1138	PWR	PG&E
27.	Hatch-2	93.21	908	BWR	Southern
28.	Point Beach-2	92.98	615	PWR	NextEra
29.	McGuire-2	92.95	1187	PWR	Duke
30.	Browns Ferry-2	92.94	1120	BWR	TVA
31.	Byron-2	92.88	1186.4	PWR	Exelon
32.	Perry	92.80	1268	BWR	FirstEnergy
33.	Farley-1	92.79	854	PWR	Southern
34.	Susquehanna-2	92.76	1287	BWR	Susquehanna
35.	Catawba-2	92.67	1180	PWR	Duke
36.	North Anna-1	92.56	973	PWR	Dominion
37.	Turkey Point-4	92.35	840	PWR	NextEra
38.	Surry-1	92.16	874	PWR	Dominion
39.	Hope Creek	92.15	1237	BWR	PSEG
40.	Point Beach-1	92.10	615	PWR	NextEra
41.	North Anna-2	92.03	973	PWR	Dominion
42.	Clinton	91.90	1062	BWR	Exelon
43.	Palo Verde-3	91.70	1334	PWR	APS
44.	Millstone-3	91.68	1229	PWR	Dominion
45.	Nine Mile Point-2	91.66	1299.9	BWR	Exelon
46.	Surry-2	91.65	874	PWR	Dominion
47.	Hatch-1	91.58	885	BWR	Southern
48.	LaSalle-1	91.19	1178	BWR	Exelon
49.	Limerick-2	91.16	1205	BWR	Exelon
50.	Harris	90.87	979.5	PWR	Duke
51.	Quad Cities-2	90.86	957.3	BWR	Exelon
52.	Davis-Besse	90.65	908	PWR	FirstEnergy
53.	Palo Verde-1	90.60	1333	PWR	APS
54.	Arnold	90.54	621.9	BWR	NextEra
55.	Turkey Point-3	90.51	844	PWR	NextEra
56.	Oconee-1	90.43	865	PWR	Duke
57.	Palo Verde-2	90.33	1336	PWR	APS
58.	Diablo Canyon-2	90.14	1151	PWR	PG&E
59.	Limerick-1	90.06	1205	BWR	Exelon
60.	Braidwood-1	89.96	1268	PWR	Exelon
61.	Beaver Valley-1	89.93	963	PWR	FirstEnergy
62.	Columbia	89.73	1174	BWR	Energy Northwest
63.	Summer	89.65	972.7	PWR	Dominion
64.	Browns Ferry-1	89.27	1120	BWR	TVA
65.	Braidwood-2	89.18	1241	PWR	Exelon
66.	Prairie Island-2	88.99	557	PWR	Xcel
67.	Wolf Creek	88.95	1200	PWR	Wolf Creek
68.	Beaver Valley-2	88.72	960	PWR	FirstEnergy
69.	Millstone-2	88.55	877.2	PWR	Dominion
70.	Prairie Island-1	88.48	557	PWR	Xcel
71.	Browns Ferry-3	88.45	1120	BWR	TVA
72.	Brunswick-2	88.44	980	BWR	Duke
73.	Indian Point-3	88.26	1048	PWR	Entergy
74.	Watts Bar-1	88.24	1160	PWR	TVA
75.	Callaway	88.05	1228	PWR	Ameren
76.	Sequoyah-2	87.92	1177.46	PWR	TVA
77.	Palisades	87.82	805	PWR	Entergy
78.	Comanche Peak-2	87.45	1207	PWR	Luminant
79.	Brunswick-1	87.35	983	BWR	Duke
80.	Cook-1	87.23	1084	PWR	AEP
81.	Susquehanna-1	86.72	1287	BWR	Susquehanna
82.	FitzPatrick	86.51	816	BWR	Exelon
83.	Cooper	86.14	815	BWR	NPPD
84.	Salem-1	86.12	1169	PWR	PSEG
85.	St. Lucie-2	85.80	1074	PWR	NextEra
86.	Salem-2	84.69	1181	PWR	PSEG
87.	Robinson-2	84.36	795	PWR	Duke
88.	Cook-2	83.84	1194	PWR	AEP
89.	Fermi-2	83.61	1150	BWR	DTE
90.	St. Lucie-1	83.57	1062	PWR	NextEra
91.	Sequoyah-1	83.36	1184.37	PWR	TVA
92.	River Bend	83.36	967	BWR	Entergy
93.	Pilgrim	82.10	690	BWR	Entergy
94.	Indian Point-2	82.07	1035	PWR	Entergy
95.	ANO-1	81.45	850	PWR	Entergy
96.	Oyster Creek	79.28	650	BWR	Exelon
97.	ANO-2	76.33	1032	PWR	Entergy
98.	Grand Gulf	52.17	1485	BWR	Entergy

[1]Oyster Creek, which closed in September 2018, is included in the 2016–2018 database, while Fort Calhoun, which closed in October 2016, is not. Watts Bar-2 is not included because it has yet to complete three full calendar years of operation.
[2]These figures have been rounded. There are no ties. Sequoyah-1 is in 91st place, with 83.3589, and River Bend is in 92nd place, with 83.3558.
[3]This is the design electrical rating (DER) in megawatts (electric), effective as of December 31, 2018. If a reactor's rating has changed during the three-year period, the capacity factor is computed with appropriate weighting.
[4]This is also the reactor's operator, except in the case of Cooper, which is operated by Entergy.

Table II. Capacity Factor Change, 2013–2015 to 2016–2018

Rank	Reactor	% Change
1.	Monticello	+24.09
2.	Prairie Island-2	+13.66
3.	Fermi-2	+11.59
4.	Wolf Creek	+11.58
5.	Turkey Point-4	+11.43
6.	South Texas-2	+10.74
7.	Susquehanna-2	+8.49
8.	Calvert Cliffs-2	+7.85
9.	Perry	+7.61
10.	Turkey Point-3	+7.43
11.	LaSalle-2	+7.00
12.	South Texas-1	+6.84
13.	McGuire-1	+6.54
14.	Peach Bottom-3	+6.09
15.	Waterford-3	+5.87
16.	Oconee-2	+5.52
17.	Brunswick-2	+5.07
18.	Surry-1	+4.75
19.	Vogtle-2	+4.49
20.	Browns Ferry-2	+4.36
21.	Dresden-2	+4.23
22.	Harris	+4.02
23.	Hatch-2	+3.58
24.	Columbia	+3.53
25.	Prairie Island-1	+3.37
26.	Vogtle-1	+3.33
27.	Three Mile Island-1	+3.13
28.	Cook-1	+3.09
29.	St. Lucie-2	+3.00
30.	Diablo Canyon-1	+2.95
31.	Surry-2	+2.62
32.	Catawba-1	+2.45
33.	Hope Creek	+2.39
34.	Nine Mile Point-1	+2.21
35.	Summer	+2.02
36.	Diablo Canyon-2	+1.95
37.	Comanche Peak-1	+1.91
38.	Palisades	+1.83
39.	Point Beach-1	+1.69
40.	Limerick-2	+1.56
41.	Point Beach-2	+1.41
42.	Farley-2	+1.30
43.	Palo Verde-3	+1.01
44.	Beaver Valley-1	+0.89
45.	Callaway	+0.82
46.	Peach Bottom-2	+0.68
47.	Catawba-2	+0.63
48.	Seabrook	+0.63
49.	Clinton	+0.51
50.	Arnold	+0.50
51.	North Anna-2	+0.43
52.	Davis-Besse	+0.36
53.	Robinson-2	+0.21
54.	ANO-1	+0.17
55.	Byron-2	+0.17
56.	Millstone-3	+0.10
57.	Ginna	0.00
58.	Byron-1	-0.13
59.	North Anna-1	-0.29
60.	Sequoyah-2	-0.44
61.	McGuire-2	-0.54
62.	Hatch-1	-0.62
63.	St. Lucie-1	-0.75
64.	Palo Verde-2	-0.93
65.	Calvert Cliffs-1	-1.01
66.	Watts Bar-1	-1.01
67.	Pilgrim	-1.11
68.	Salem-2	-1.16
69.	Dresden-3	-1.41
70.	Nine Mile Point-2	-1.54
71.	Oconee-3	-1.66
72.	Quad Cities-2	-1.82
73.	Susquehanna-1	-1.85
74.	Indian Point-3	-1.96
75.	Palo Verde-1	-1.98
76.	Millstone-2	-1.99
77.	Oconee-1	-2.22
78.	Sequoyah-1	-2.33
79.	Limerick-1	-2.45
80.	Braidwood-2	-2.75
81.	Farley-1	-2.92
82.	Braidwood-1	-3.09
83.	LaSalle-1	-3.11
84.	Beaver Valley-2	-3.47
85.	Brunswick-1	-4.06
86.	Salem-1	-4.35
87.	Browns Ferry-1	-4.61
88.	Browns Ferry-3	-4.71
89.	Cooper	-4.97
90.	ANO-2	-5.41
91.	River Bend	-6.10
92.	Comanche Peak-2	-6.39
93.	FitzPatrick	-6.99
94.	Cook-2	-7.11
95.	Quad Cities-1	-7.99
96.	Oyster Creek	-9.85
97.	Indian Point-2	-13.04
98.	Grand Gulf	-35.91

determines how much electricity can leave the plant. When now-retired *NN* Senior Editor E. Michael Blake began this survey in the 1980s, he selected design electrical rating (DER) as the closest measure of what a reactor is intended to do. A reactor's DER usually changes only for the better, through heat rate improvements or power uprates. The EIA uses net summer capacity—the steady output a reactor's equipment can supply to the grid (excluding auxiliary power) as demonstrated by testing during summer peak demand.

Annual industry capacity factors, such as those calculated by the EIA, are ideal for comparing nuclear power to other types of generation, and by any measure, nuclear will shine. Take the 92.6 percent nuclear capacity factor for 2018 mentioned above. Compare it to the 2018 capacity factors for some other fuel sources published in the same EIA report: natural gas combined cycle, 57.6 percent; coal, 54.0 percent; hydro, 42.8 percent; wind, 37.4 percent; and solar photovoltaic, 26.1 percent.

Once we have given nuclear its due, however, we can zoom in for a detailed look at the capacity factors of individual reactors. To do that, we need to broaden the data set beyond 12 months and get a view of sustained reactor performance by including three calendar years of total generation. This survey has been presented in *Nuclear News* annually (with a few hiatuses—most recently in 2018), and the three-year span changes each time. The 2016–2018 data overlap the 2014–2016 data that were analyzed in May 2017, but are compared to 2013–2015 data and those of earlier three-year periods, without overlaps. *Nuclear News* has been calculating capacity factors in this way since the 1980s, and we intend to continue as we began.

We make those comparisons while acknowledging the obvious: The number of operating reactors is shrinking. There have been seven reactor closures since 2013: Crystal River-3, Kewaunee, San Onofre-2 and -3, Vermont Yankee, Fort Calhoun, and, most recently, Oyster Creek. Pilgrim is operating at this writing, but is scheduled to close by June 1. This survey's 98 reactors are being compared to 99 in 2013–2015 and 104 in 2010–2012. Yet we will continue to compare, because, as Blake would say, "that is what we do here."

By the numbers

The raw data (each reactor's electricity production and DERs, with the latter's change dates) are recorded as monthly operating reports through the Institute of Nuclear Power Operations, which shares the data with the Nuclear Regulatory Commission, which then makes the reports public on a quarterly basis. The results of this survey are based on the compilation and grouping of that data.

As stated above, the median factor for 2016–2018 is 91.01, up by 0.6 percentage points from the median of 90.41 in 2013–2015. The average factor is up by a similar amount, at 90.31 for 2016–2018, compared to 89.52 in 2013–2015 (including data on 99 reactors) and 87.17 in 2010–2012 (including data on 104 reactors). This survey uses the median of a data set to assess performance, but sometimes an average can provide another useful perspective, although that may be open to question because the differences are so small.

Fifty-six reactors—a clear majority of the 98 reactors listed—had capacity factors in 2016–2018 that were better than those in 2013–2015 (see Table II). (Ginna's capacity

Table III. DER Net Capacity Factor of Multireactor Sites

Rank	Site	Factor	Owner
1.	Calvert Cliffs	100.92	Exelon
2.	Dresden	99.62	Exelon
3.	South Texas	97.42	STPNOC
4.	Vogtle	95.93	Southern
5.	Peach Bottom	95.16	Exelon
6.	Farley	94.69	Southern
7.	Oconee	93.33	Duke
8.	Catawba	93.32	Duke
9.	McGuire	93.28	Duke
10.	Byron	93.17	Exelon
11.	LaSalle	92.71	Exelon
12.	Point Beach	92.54	NextEra
13.	Hatch	92.41	Southern
14.	North Anna	92.30	Dominion
15.	Quad Cities	92.08	Exelon
16.	Surry	91.90	Dominion
17.	Diablo Canyon	91.69	PG&E
18.	Turkey Point	91.44	NextEra
19.	FitzPatrick/Nine Mile Point	91.18	Exelon
20.	Comanche Peak	91.11	Luminant
21.	Palo Verde	90.88	APS
22.	Limerick	90.61	Exelon
23.	Millstone	90.38	Dominion
24.	Browns Ferry	90.22	TVA
25.	Susquehanna	89.74	Susquehanna
26.	Braidwood	89.58	Exelon
27.	Beaver Valley	89.33	FirstEnergy
28.	Prairie Island	88.74	Xcel
29.	Brunswick	87.90	Duke
30.	Hope Creek/Salem	87.72	PSEG
31.	Sequoyah	85.63	TVA
32.	Cook	85.47	AEP
33.	Indian Point	85.18	Entergy
34.	St. Lucie	84.69	NextEra
35.	ANO	78.64	Entergy

Hope Creek and Salem are treated as a single site because they are adjacent and have the same owner; the two-unit Salem plant had a capacity factor of 85.40. FitzPatrick, which is adjacent to Nine Mile Point, was purchased by Exelon in March 2017, and the factors of the two plants have been combined in this table, since they now have the same owner; the two-unit Nine Mile Point plant had a capacity factor of 93.17.

factor decreased by just 0.0013 percentage points, which rounds to the 0.00 shown in Table II.) The top and bottom quartiles of the 98 reactors included in this year's survey were also slightly higher in the most recent three-year period than in the one before, at 93.30 and 88.19 (see Fig. 2). The 2013–2015 top and bottom quartiles were 92.82 and 87.23, respectively.

Insofar as a factor of 90 percent is a benchmark for solid performance, 59 of the 98 reactors exceeded it. The median factor of the 35 multireactor sites was 91.44 for 2016–2018, up from 91.06 in 2013–2015 (see Table III). The nine fleet owners in 2016–2018 have a median factor of 91.00 (see Table IV), and while the median of nine data points may be of dubious significance, it is higher than in 2013–2015, when the same owners had a median factor of 89.77.

Watts Bar-2 has yet to earn a berth in this annual capacity factor survey because it has not completed three full years of commercial operation, having started up in October 2016. However, a quick calculation of two full calendar years of operation (2017 and 2018) yields a capacity factor of 72.19. Watts Bar-2 will make its debut in next year's capacity factor survey, but a more accurate gauge of its performance may have to wait for the survey of 2018–2020 data, once data from 2017—which included a five-month outage because of a steam condenser failure—is no longer part of the three-year period of study.

Boiling water reactors overtook pressurized water reactors in 2016–2018 by a slight margin: 34 BWRs had a median capacity factor of 91.18, while 64 PWRs had a median capacity factor of 90.76. In 2013–2015, the 34-BWR median was 90.05, and the 65-PWR median was 90.47. The median capacity factors of the two types have been within 1 percentage point since 2001–2003.

Oyster Creek's closure will leave the U.S. fleet with just 33 BWRs going forward. Oyster Creek's 2016–2018 capacity factor of 79.28 in this survey was calculated based on a full three years of capacity. If Oyster Creek's 105.5 post-shutdown days at the end of 2018 are excluded from the capacity calculation, its factor improves to 87.72.

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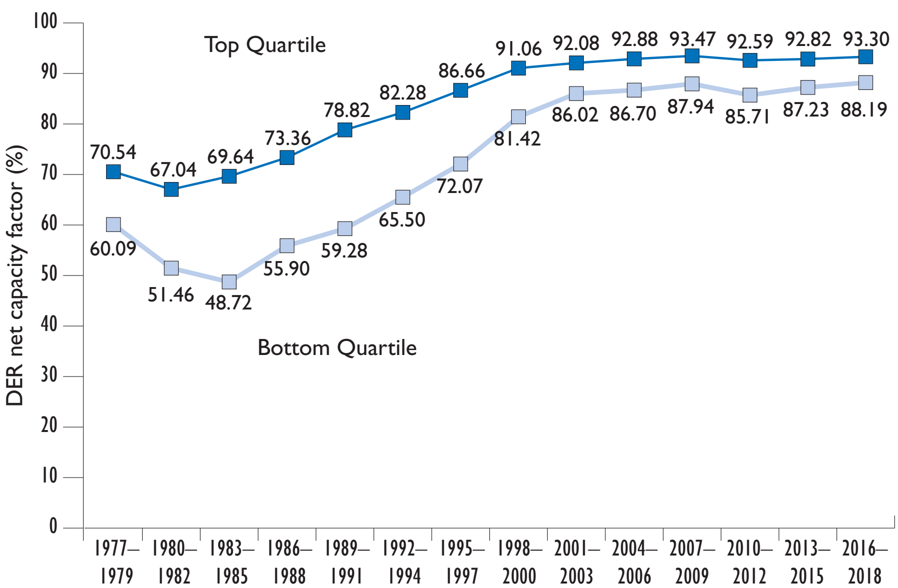

Fig. 2: All reactors, top and bottom quartiles

Table IV. DER Net Capacity Factors of Owners of More Than One Site

Rank	Owner/Operator	Factor
1.	Southern	94.49
2.	Exelon	93.19
3.	Duke	91.50
4.	Dominion	91.48
5.	Xcel	91.00
6.	FirstEnergy	90.70
7.	NextEra	89.90
8.	TVA	88.31
9.	Entergy	79.29

Entergy is the contracted operator of Cooper. With Cooper included, Entergy's factor would be 79.85. Dominion's factor does not include Summer, which was owned by SCANA Corporation/South Carolina Electric & Gas Company until January 1, 2019. With Summer included, Dominion's factor would be 91.22.

Small but capable

No other form of electricity generation in use today has a capacity factor that can approach that of nuclear power, and similar high factors over the past two decades have built confidence in nuclear's ability to sustain that level of performance. As has been stated before in these pages, many of the large light-water reactors that came on line in the 1970s and 1980s were planned with rate-base expectations of 65 percent capacity, but a selling point for the small modular reactor and microreactor designs in the pipeline is their assumed capacity factors at or above 92 percent. Such claims for what are still "paper" reactors would have no credibility without the high capacity factors of existing LWRs.

A report about the use of incentives for SMR development was prepared for the Department of Energy and released in November 2018. "When viewed in terms of spending per unit of power produced, the proposed support for SMRs compares favorably against the historic support for solar or wind," the report said. "This is because SMRs are expected to realize capacity factors of 92.1 percent or above and have very long operating lives."

Not only do SMRs and microreactors have projected capacity factors that solar and wind can't hope to reach, they can also be sited where power is needed. Total capacity factors for solar and wind have improved over time, in part because operators have learned how to place solar panels and wind turbines to maximize exposure to sunshine and breezes. The siting of SMRs and microreactors may be complicated by other factors, but at least their capacity factors won't depend on getting on Mother Nature's good side.

Results during renewal

Blake's analysis of 2013–2015 capacity factors, published in the May 2016 issue of *Nuclear News*, included a look at the performance of 15 reactors that had been operating past their initial 40-year license terms for at least three years. That subset of U.S. reactors has now more than doubled to 38 reactors (including Oyster Creek, which, as already noted, is no longer operating). Table V shows the capacity factors of those 38 reactors in each of the last four three-year periods. It is possible to see how they have performed as they approached and surpassed 40 years of operation.

The 2016–2018 median factor of these 38 units is 91.22, which is just slightly higher than the 91.01 median factor for all 98 operating reactors, and 19 of the 38 were above the median. In the early years of license renewal, there does not appear to be a substantial drop-off in performance. In fact, many of these reactors seem to be in the prime of their operating lives. And while strong performance may not outweigh economic considerations, a high capacity factor could tip the scale in favor of continued operation for some plants.

The first applications for subsequent license renewal (SLR), which would permit a reactor to operate for 80 years by adding 20 more years to the 60 years permitted following initial license renewal, were submitted to the NRC in 2018. Perhaps not surprisingly, the six reactors at the three plants for which SLR applications have been submitted have typically ranked high in the capacity factor survey.

The application for NextEra Energy's Turkey Point-3 and -4 came first, in January 2018, and was followed by applications for Exelon's Peach Bottom-2 and -3 in July and Dominion Energy's Surry-1 and -2 in October. The 2016–2018 capacity factors of those reactors are 90.51, 92.35, 94.19, 96.13, 92.16, and 91.65, respectively. The average of the six is 92.83, nearly two points above the fleet-wide median capacity factor, and over two points higher than

Table V. DER Capacity Factors of Reactors With At Least Three Years of License Renewal

Reactor	2007–2009	2010–2012	2013–2015	2016–2018
ANO-1	90.90	91.45	81.29	**81.45**
Arnold	89.42	85.66	90.05	**90.54**
Browns Ferry-1	73.24	86.00	93.88	**89.27**
Browns Ferry-2	84.33	88.73	88.57	**92.94**
Brunswick-2	83.04	86.60	83.37	**88.44**
Calvert Cliffs-1	100.49	91.63	101.40	**100.39**
Cook-1	53.15	86.79	84.14	**87.23**
Cooper	88.02	85.75	91.12	**86.14**
Dresden-2	93.60	**100.07**	**95.74**	**99.97**
Dresden-3	95.77	93.36	**100.66**	**99.25**
FitzPatrick	97.89	91.67	93.50	**86.51**
Ginna	93.09	**90.08**	**93.83**	**93.83**
Hatch-1	90.74	89.53	92.20	**91.58**
Indian Point-2	94.95	88.06	95.11	**82.07**
Indian Point-3	89.86	94.94	90.23	**88.26**
Millstone-2	88.56	87.69	90.55	**88.55**
Monticello	83.73	82.02	**70.77**	**94.86**
Nine Mile Point-1	93.48	**91.00**	**94.18**	**96.39**
Oconee-1	85.28	85.87	92.64	**90.43**
Oconee-2	89.11	90.66	90.65	**96.18**
Oconee-3	90.16	89.22	95.02	**93.36**
Oyster Creek	86.10	**85.52**	**89.13**	**79.28**
Palisades	88.72	85.29	**85.99**	**87.82**
Peach Bottom-2	95.69	92.48	93.52	**94.19**
Peach Bottom-3	92.05	95.85	90.04	**96.13**
Pilgrim	90.28	93.00	**83.21**	**82.10**
Point Beach-1	85.04	86.76	**90.41**	**92.10**
Point Beach-2	90.58	82.72	91.57	**92.98**
Prairie Island-1	85.72	86.60	85.11	**88.48**
Prairie Island-2	93.46	82.93	75.33	**88.99**
Quad Cities-1	93.45	100.46	**101.27**	**93.29**
Quad Cities-2	95.90	92.60	**92.68**	**90.86**
Robinson-2	87.66	76.28	**84.14**	**84.36**
Surry-1	94.96	95.28	**87.41**	**92.16**
Surry-2	97.00	90.06	89.04	**91.65**
Three Mile Island-1	92.38	94.51	95.65	**98.78**
Turkey Point-3	87.32	72.12	**83.08**	**90.51**
Turkey Point-4	88.43	85.93	80.92	**92.35**

The reactors in this table have operated for at least three full years beyond their original license expiration dates. Green indicates a capacity factor that is greater than or equal to 91.01 (the median for all reactors in 2016–2018), while orange indicates a factor of less than 91.01. Nineteen of the 38 reactors had a factor at or above the median of 91.01 during 2016–2018. The 2016–2018 median factor of these 38 units is 91.22, which is just slightly higher than the median factor for all 98 reactors. The median for the same group of 38 reactors was 90.48 in 2013–2015, 88.98 in 2010–2012, and 90.22 in 2007–2009. **Bold type** allows for a rough comparison of the age of the reactors in this table. A factor is bold if the reactor was operating beyond its original license expiration date for the entirety of a three-year period; reactors with more bold factors are older. For example, Dresden-2, Ginna, Nine Mile Point-1, and Oyster Creek reached their original license expiration dates in 2009, and the type in the 2010–2012 column is bold.

the fleet-wide average of 90.31. Dominion Energy anticipates submitting an SLR application for North Anna-1 and -2 in late 2020, and those reactors also have capacity factors above the median, at 92.56 and 92.03, respectively.

Looking for some respect

Plant owners have warned that more reactor closures are inevitable if market reforms are not enacted, including for some high performers that have already been the beneficiaries of investments in new plant equipment and aging management programs. A power reactor is a resource with longtime added value, yet plant owners—and, in some cases, state officials—are fighting for that value to be recognized, with apparent hope that the proverbial squeaky wheel will get the subsidies.

Sometimes, a fleet owner must fight the same battle in multiple states with different market conditions. And no two reactors are identical—similar reactors may differ by age, component condition, performance, operator, colocation with other reactors, or any combination of the above. Strong performance is no guarantee of survival.

Four states—Connecticut, Illinois, New Jersey, and New York—have passed laws establishing zero-emissions credit (ZEC) programs. New York's FitzPatrick got a new lease on life when Exelon purchased the plant from Entergy in 2017. Dominion's Millstone recently inked a 10-year power purchase agreement, won after the Connecticut Department of Energy and Environmental Protection deemed it at risk of early retirement. Exelon's Quad Cities and Clinton were the winning bidders through the Illinois ZEC procurement program. PSEG got word on April 18 that the New Jersey Board of Public Utilities voted to approve ZECs for Hope Creek/Salem.

Negotiations on the future of other plants have seemed to lead inexorably to closure. Oyster Creek's shutdown will be followed soon by Pilgrim's. Indian Point-2 and -3 are scheduled to close in 2020 and 2021, respectively, Arnold in late 2020, Palisades in 2022, and Diablo Canyon-1 and -2 in 2024 and 2025.

Exelon filed a decommissioning report with the NRC on April 5 for Three Mile Island-1, a perennial strong performer in the *Nuclear News* capacity factor survey, but the company stated that it won't begin decommissioning in September if legislation is enacted by June 1 (see p. 8). Separately, in financial reports filed in February, Exelon stated that certain Illinois plants—namely Dresden, Byron, and Braidwood—are "showing increased signs of economic distress, which could lead to an early retirement." Meanwhile, FirstEnergy is calling for market reforms in Ohio and Pennsylvania to keep its Davis-Besse, Perry, and Beaver Valley plants operating.

Each time a nuclear plant gets a reprieve, it's a gain for the nuclear industry and for clean energy. But it's an incremental gain. So too are the gains from power uprates, the start of operation of Watts Bar-2, and the expected starts of Vogtle-3 and -4 in 2021 and 2022. Capacity factor gains in recent years—measured to the hundredth of a percentage point—have also been incremental.

Maybe it should come as no surprise then that incremental fixes are the only fixes available for plants that are struggling economically. In the absence of support at the federal level for operating power plants, a patchwork of ZECs may be the best we can do. Yet today's operating plants are licensed for decades of steady baseload generation, and there is nothing incremental about that.

Can SMRs and microreactors, offering up electricity in per-reactor increments of anywhere from 1 to 300 MWe, give the grid the nimble, load-following electricity it's looking to buy? Time will tell. But electricity is electricity, and reliable baseload generation still has value. We need only look at the number of large LWRs under construction overseas to be reminded of that. **NN**