Attachment 1: Evaluation of depletion reactivity decrement bias and uncertainty values using linear versus quadratic weighted least squares regression models

Per the agreement during the December 20, 2018 NRC public meeting, EPRI performed uncertainty and bias analyses using linear regression analysis, instead of quadratic regression analysis as reported in EPRI Benchmark report.

The results of the analyses are presented in Table A-1. As discussed during the meeting, the linear versus quadratic analysis does not yield any difference in decrement bias uncertainty values. Since the EPRI benchmark report's decrement values are based on quadratic regression analysis, the difference between linear and quadratic bias values will be used to account for differences from the NRC's requested linear regression model.

Table A-1. Bias and uncertainty values for the EPRI original (quadratic) versus revised (linear) regression analysis

Burnup (GWd/MTU)	**Linear** Regression **Bias (pcm)**	**Quadratic** Regression **Bias (pcm)**	**Linear** Regression **Bias (%)**	**Quadratic** Regression **Bias (%)**	**Delta Bias** (Linear minus Quadratic) **(%)**	**Uncertainty*** **(%)**
10	34	66	0.30	0.58	-0.28	3.05
20	68	101	0.34	0.50	-0.16	2.66
30	102	106	0.36	0.38	-0.02	2.33
40	135	80	0.38	0.23	0.15	2.12
50	169	22	0.40	0.05	0.35	1.95
60	203	-64	0.41	-0.13	0.54	1.81

*As presented[1] by Prof. Kord Smith during the December 20, 2018 public meeting, **there is no change in uncertainty values** whether the analysis is done using **linear** or **quadratic regression**

As is clear from the data in draft SER Table 1, there are differences in bias and uncertainty values between the EPRI analysis and the NRC/PNNL confirmatory analysis. The reasons behind these differences were discussed during the meeting. To summarize:

1) EPRI's approach is constrained to 0.0 bias at 0.0 burnup, as dictated by physics, whereas the confirmatory analysis was unconstrained.
2) EPRI's regression analysis allows for possible decrement bias saturation at high burnups, as illustrated in Slide 13 of Prof. Smith's presentation, whereas the NRC/PNNL approach forces linear decrement bias vs. burnup.
3) Finally, the impact of intra-cycle correlation and the use of variance versus sensitivity contributes to the differences.

[1] Reference for presentation materials: ML18360A449

Based on these results and the agreement from the December 20, 2018 meeting, Table 1 on page 18 of Draft SER, Revision 2 should reflect the agreement and be replaced with the following bias and uncertainty values. In this table, negative bias values for burnups below 30 GWD/T are set to zero. Applicants are expected to add additional bias values, as shown in Table 1, above 30 GWD/T as additional NRC safety margins in their analysis. Note that linear interpolation between the burnup values, listed in Table 1, is acceptable to calculate the corresponding EPRI uncertainty and additional NRC bias for specific fuel assembly burnups.

Table 1: Bias and Uncertainty (% Reactivity Decrement) Versus Burnup (GWd/MTU) to be applied by Applicants when using the EPRI Depletion Reactivity Benchmarks

Burnup (GWd/MTU)	**EPRI Uncertainty (%)**	**Additional NRC Bias (%)**
10	3.05	0.0
20	2.66	0.0
30	2.33	0.0
40	2.12	0.15
50	1.95	0.35
60	1.81	0.54