Supplementary Material for "Generation Expansion Planning Considering Discrete Storage Model and Renewable Energy Uncertainty: A Bi-Interval Optimization Approach"

Choice of the Inner Interval Based Uncertainty Set in Case Study

A. Choice of the Inner Interval Based Uncertainty Set for IEEE Reliability Test System

The choice of the inner interval based uncertainty set affects the system investment and operation costs. Based on the assumed distributions, the inner set in IEEE RTS is decided from the idea of confidence level. It is designed to cover a probability of ξ for each renewable energy source. The bounds for the inner interval can be calculated by (S-1), wherein $\mathrm{qf}_i(\cdot)$ denotes the quantile function, i.e., the inverse of the cumulative distribution function.

$$wc^{\mathrm{U}}_{i,s,t} = \mathrm{qf}_i\left(\frac{1+\xi}{2}\right),\ wc^{\mathrm{L}}_{i,s,t} = \mathrm{qf}_i\left(\frac{1-\xi}{2}\right) \qquad \forall i \in \Omega_{\mathrm{w}} \cup \Omega_{\mathrm{nw}}, s, t \qquad \text{(S-1)}$$

The results under different confidence level coefficients are shown in Fig. S-1. As indicated, the cost increases dramatically when the confidence level coefficient ξ is close to 1. Thus, $\xi = 0.995$ is selected as an appropriate confidence level for this case.

B. Choice of the Inner Interval Based Uncertainty Set for Gansu Power Grid

As the unavailability of accurate distribution for renewable generation in this practical system, the bounds for the inner interval based uncertainty set are calculated by (S-2). It follows a scalar separation with a coefficient ρ.

$$\begin{aligned} wc^{\mathrm{U}}_{i,s,t} &= wc_{i,s,t} + \rho \cdot \left(wc^{\mathrm{EU}}_{i,s,t} - wc_{i,s,t}\right), \\ wc^{\mathrm{L}}_{i,s,t} &= wc_{i,s,t} + \rho \cdot \left(wc^{\mathrm{EL}}_{i,s,t} - wc_{i,s,t}\right) \end{aligned} \qquad \forall i \in \Omega_{\mathrm{w}} \cup \Omega_{\mathrm{nw}}, s, t \qquad \text{(S-2)}$$

As indicated in Fig. S-2, the overall cost increases sharply when the coefficient ρ is large. Note that cumulative distribution functions usually saturate on both ends, i.e., the probability near wc^{EU} or wc^{EL} is relatively low. However, the scalar ρ moves linearly over the interval in (S-2), thus the slope in Fig. S-2 is not as sharp as that in Fig. S-1. We choose $\rho = 0.5$ as an appropriate coefficient for this case.

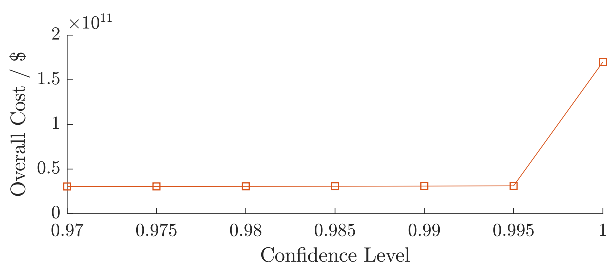

Fig. S-1. Choice of the inner interval for IEEE RTS.

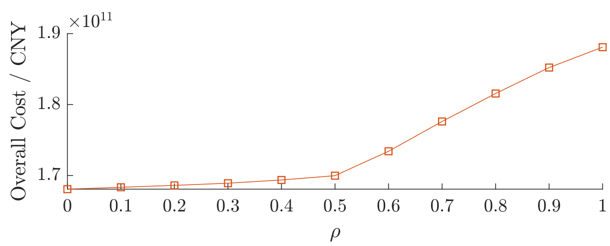

Fig. S-2. Choice of the inner interval for Gansu power grid.