# Effects of Climate Change on US Federal Hydropower Generation

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**Background/Objectives.** Understanding the future changes in projected water supplies is a vital objective for federal hydropower facilities tasked with providing low-cost, reliable electricity across a large regional footprint that encompasses a growing customer base, alternative market structures for marketing the electricity, and a more diverse generation asset mix. This study evaluates the effects of climate change on hydroelectric energy generated from 132 US federal hydropower plants across the nation. This study is the result of extensive consultation with four Department of Energy (DOE) Power Marketing Administrations (PMAs), as well as other agencies, including federal hydropower owners/operators (US Army Corps of Engineers, Bureau of Reclamation), and US Geological Survey. The main findings of this assessment will support a subsequent DOE SECURE Water Act Section 9505 Report to Congress.

**Approach/Activities.** This assessment leverages the latest global climate model (GCM) projections from the Coupled Model Intercomparison Project Phase 6 (CMIP6). Six CMIP6 GCMs under the SSP585 emission scenario are selected through an objective GCM selection process that factors in relative model skills, uniqueness, and data availability. To understand how the choice of modeling and analytical approaches may affect the projections of future hydroclimate conditions and hydropower generation, a multimodel assessment framework is introduced. This multimodel assessment framework includes two downscaling methods, two reference meteorological observations, two hydrologic models, and two hydropower models to simulate the ensemble meteorological, hydrologic, and hydropower projections in the near-term (2020–2039) and mid-term (2040–2059) future periods with respect to the historical baseline period (1980–2019). An analysis of variance technique is used to quantify the relative contribution of variance in ensemble projections arising from different modeling choices and their interactions. The key controlling factors in each of the key variables and PMA study areas are identified, demonstrating the sensitivity from these modeling and analytical approaches. Additionally, the effect of climate change on the direct reservoir evaporation is analyzed to understand its potential long-term impacts on water availability for hydropower generation. A customer energy demand analysis in each PMA region is further conducted to evaluate how climate change may impact the energy demand in different regions.

**Results/Lessons Learned.** Maintaining the operational flexibility is found to be the key challenge for federal hydropower reservoirs that are projected to experience seasonal supply and demand changes. Early snowmelt and change of runoff seasonality are important climate change drivers affecting federal hydropower generation. In general, winter and spring runoff is projected to increase in most PMA regions, and summer runoff is projected to decrease across much of the US. Hydrologic extremes, conflicting timing of change, and other indirect climate change effects are also identified as potential risks that may impact the resilience of future federal hydropower generation. Further site-specific studies using operational models, forced by up-to-date hydroclimate projections, can be one most rigorous way to reliably evaluate the risks and identify required mitigation actions for a specific system.