Thesis Project Portfolio

Adapting Hydropower Operations to Support Renewable Energy Transitions and Freshwater Sustainability in the Columbia River Basin

(Technical Report)

The Social Construction of Nuclear Energy in the United States and its Prospects in Net-Zero Emissions Pathways

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring 2023

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Sociotechnical Synthesis

Human activities, principally through emissions of greenhouse gasses (GHGs), have unequivocally caused global warming, with global surface temperature reaching 1.1 °C above pre-industrial (1850–1900) levels in 2011–2020, precipitating widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere. To mitigate escalating climate change effects, the Paris Agreement calls for limiting global warming to no more than 1.5 °C; IPCC global modeled pathways which achieve this goal reach net-zero CO_2 emissions by 2050. Deep decarbonization efforts in pursuit of net-zero emissions should be especially prioritized within the energy sector which is responsible for approximately two-thirds of global CO_2 emissions. However, increased deployment of weather-dependent renewable energy sources like wind and solar will make the energy supply more variable and out of phase with demand.

This research pertains to two load-balancing energy sources capable of increasing grid stability and enabling the transition to renewable energy: hydropower and nuclear energy. My capstone research examines the Columbia River Basin—which provides more than 40% of total U.S. hydroelectric generation—and considers the effects adapting hydropower operations for greater load balancing on the region's ability to sustain environmental flows for wildlife and ensure sufficient water supply and flood protection. The study uses the Borg multi-objective optimization algorithm in combination with the California and West Coast Power Systems model and a reservoir simulation model to design alternative reservoir operating rules that balance these conflicting objectives. This optimization additionally considers the human and social dimensions of dam operation, as changes in streamflow temperatures from re-designed operating policies can significantly affect salmon and steelhead populations and by extension the local Native American groups who rely on them.

My STS research applies the social construction of technology framework to examine the historical adoption of nuclear energy in the United States as well as assess the potential of nuclear energy to facilitate the transition to a carbon-neutral energy sector. I analyze current U.S. energy and climate initiatives to find discrepancies between renewable and nuclear energy policies and compare the projected low and decreasing adoption of nuclear energy which results from these policies with the levels modeled in net-zero emissions studies by Breakthrough Institute, Princeton University, Vibrant Clean Energy, and Williams et al. (2021). Ultimately, I explain the dichotomy between projected and net-zero nuclear deployment with poor project management and a lack of enabling legislative policies which create a reinforcing loop that makes nuclear energy prohibitively expensive as an investment. These two areas of research in conjunction aim to improve the feasibility of cost-efficient net-zero emissions pathways.