

# RECLAMATION

*Managing Water in the West*

## Non-dispatchable Renewable Integration

Research and Development Office  
Science and Technology Program  
(Final Report) ST-2018-2533-00



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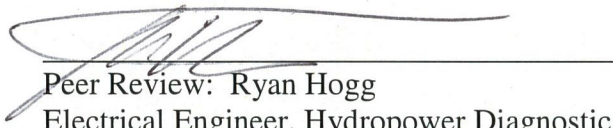
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## Non-dispatchable Renewable Integration




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# Executive Summary

There is growing concern in the hydro industry that hydro generation costs associated with the integration of non-dispatchable renewable energies is not well understood, but the costs are significant and there is justification to provide budgetary compensation to hydropower facilities for providing these services. Reclamation, along with the hydropower industry, has a significant role in the successful integration of non-dispatchable generation such as wind and solar energy. Hydropower's operational characteristics make it a valuable resource to support non-dispatchable renewable energy. But providing these services comes with a cost. This research effort continues ongoing research work in identifying and quantifying these costs.

As the hydro industry in whole is interested in this topic, there is a benefit to Reclamation to work with our hydro generation partners on this research project. This helps leverage Reclamation's efforts and costs. Reclamation's participation in CEATI International, Inc. The Hydraulic Plant Life Interest Group (HPLIG) provides the access and structure needed for Reclamation to work collaboratively with other utilities and industry experts. Reclamation is able to participate and help direct HPLIG projects related to renewable integration to insure the results are applicable. Non-dispatchable renewable integration research work over the last 3 years has focused on two main efforts with HPLIG: (1) effects of starts/stops and load cycling on hydro generators, particularly concerning unit fatigue issues such as rotor pole attachment cracking, and (2) developing a standard methodology to evaluate start/stop and cycling costs and impacts.

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# Introduction

There is growing concern in the hydro industry that hydro generation cost associated with the integration of non-dispatchable renewable energies is not well understood but the costs are significant and there is justification to provide budgetary compensation for these costs. Reclamation, along with the hydropower industry, has a significant role in the successful integration of non-dispatchable generation such as wind and solar energy. Wind and solar generation differs from tradition generation in that they are an energy resource that provides very little power system capacity or reserves. Hydropower's operational characteristics make it a valuable resource to support non-dispatchable renewable energy by providing the power system reserves needed to maintain system dependability, stability, and reliability. Non-dispatchable renewable integration research proposal identified three separate tasks to be pursued to help Reclamation and the hydro industry meet the current and future power system needs: 1) Effects of Starts/Stops and Load Cycling on Hydro Generators, 2) Ancillary Service Costs, and 3) Improved Hydro Models for Renewable Integration Studies.

## Effects of Starts/Stops and Load Cycling on Hydro Generators

Providing power system reserves results in more generator starts/stops and increased load cycling. These impacts may result in increased wear and tear and maintenance on both the generator and associated equipment. It is important to focus on the hydro generator impact as it represents about 70% of the cost of maintaining a hydro plant. Past Reclamation work on this topic resulted in a report written for CEATI HPLIG entitled "Stator Winding Insulation Life Expectancy and Start/Stop Related Aging". Its conclusion is that start/stop cycles seem to have minimal effect of the life of generator insulation system. However; the impact on other generator components may be significant.

One of the latest developments in the hydro industry is the costs associated with fatigue. Equipment damage due to fatigue of various generator components is directly impacted by start/stops and unit cycling. Examples of unit fatigue damage include rotor pole attachment cracking, head cover failures, and rotor spider/hub cracking. Through this research effort, Reclamation has participated in CEATI workshops and reviews that have helped identify components susceptible to fatigue and quantify the impact and expected life-time cost loss of life as it relates to unit starts/stops and unit cycling. These workshop presentations are not publicly available but are available to all CEATI HPLIG members, including all Reclamation personnel, via CEATI's website - [www.CEATI.com](http://www.CEATI.com).

## Ancillary Service Costs

There is little hydro industry consensus on the costs associated with starts/stops and unit cycling at hydroelectric facilities (the generators and associated equipment). Various utilities including Reclamation have attempted to identify these costs on a very limited basis using a variety of methodologies. This research effort looked at the patch work of studies and results and found little cohesion among these studies that could be utilized for future work. One of the major problems is that the data each hydro utility collects on maintenance costs, failure types, and replacements varies greatly. This makes it very difficult to replicate the results of one utility/powerplant at another location. During this literature review it became obvious that what was needed is a standardized methodology that can be used by the hydro industry as a whole. The methodology would identify the minimum data requirements for such a study. The development of this methodology requires working with external organizations.

For this research project we worked with the CEATI HPLIG. Organizing this effort with the various utilities proved harder than anticipated. Participating utilities have their own unique needs and outlook on how to proceed. As a result, the CEATI study was delayed several years. The non-dispatchable renewable integration research proposal originally anticipated that a HPLIG study would start in 2016, but delays pushed back the start date. As a result, progress on the non-dispatchable renewable integration research effort also has been delayed and most of the anticipated funding was returned to the Science & Technology office. However, consensus within CEATI HPLIG has been reached and a study has now been initiated. This HPLIG study will be a multiple phase study on the cost associated with generator starts/stops and unit cycling. The first phase, which was initiated this year, focuses on establishing a "standard methodology to evaluate start/stop and cycling costs and impacts". The study involves major collaboration and participation of the member utilities, including Reclamation. A new research proposal entitled "Determining Hydro Generation Start/Stop and Cycling Cost" [6] will fund Reclamation involvement. A team of experts from across Reclamation has been formed to help in reviewing the studies progress and to provide feedback and suggestions of the starts/stops and cycling cost methodology. The final report is scheduled to be completed by 2020. Project materials are not publicly available but are available to all CEATI HPLIG members, including all Reclamation personnel, via CEATI's website - [www.CEATI.com](http://www.CEATI.com).

## Improved Hydro Models for Renewable Integration Studies

Models for past industry studies regarding the impact of wind and solar energy on the power system used very simplified models of a hydroelectric plant and associated reservoir and river systems. Hydro models need to account for water and energy constraints at the plant. The current models need to be updated to properly represent the impact on the hydro industry. This work was funded via separate research proposals and is not included in this report.

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