Autonomous reactive power control for increased utilization of the hydropower generator

Project leader	Thomas Øyvang
Project period	2021 – 2025, KPN (or KSP) project,
Key-persons	Partners; USN (Thomas Øyvang), US DoE (Mark Christian or Sam), NTNU (Kjetil Uhlen and Arne Nysveen)
Potential Research partners:	Skagerak Kraft AS, v/ Jane Solvi, Seksjonssjef prosjekt og teknologi. Statkraft AS, v/Jan Petter Haugli, Vice President Electro & Mechanical Discipline, Hymatek Controls AS, v/Mathias Gallefos, Produktansvarlig magnetisering, Statnett

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Background:
The aim of this work is to refurbish (prepare) the hydropower generator for the next generation operating pattern and to provide increased value creation in the interface between the generator and the grid. Greater reactive power exchange from generator to grid will contribute to reduced grid losses and provide the necessary reliability for the grid where varying power (solar and wind) is dominant. These make short-term reactive power capacity a scarce resource.

The concept of voltage regulation and monitoring of the hydroelectric generator should be based on an autonomous and predictive regulator that makes decisions based on a digital twin of the unit. To achieve this, real-time measurement data must be made available through cloud solutions with communication / integration to the power system, and necessary models must be developed. The system should also adapt to the continuously varying external condition and topology of the power grid. This will ensure optimal use of hydropower resources in interaction with the power grid. The concept will primarily focus on a local and central optimal reactive power exchange to the grid. Furthermore, available real-time power reserves in the machine will be made visible and used as part of the concept.

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The main objective is to develop hybrid models and algorithms (digital twins) for real-time control of the generator based on the actual state of relevant components during flexible operation.

The project will contain the following main elements:

- Develop simple models (physical and data-driven) with sufficient predictive quality for real-time feedback (digital twin). The models must identify dynamic (thermal, mechanical, etc.) phenomena in the machine and associated equipment (cables, transformers, etc.) and be able to identify any sources of error.

- Develop a new, autonomous control system that can utilize the hydroelectric generator optimally in a planned reactive power market. The control system must be robust and handle a considerable degree of model uncertainty. The system will not change today's primary control loop (AVR, turbine regulator), but will be an additional equipment that safeguards the machine when delivering system services to the grid.

- Implement extended instrumentation (also soft sensors) and measurement methods on relevant machines, and make real-time data available for the project. AI and machine learning algorithms will be used, and an interaction with the power grid will be included using PMU measurements.

Testing should be carried out in the Hydropower Laboratory at NTNU and Smartgridlab at SINTEF (and at US partner) and will be done to examine the system's functionality and stability. If possible, the system will be tested on a research unit for full scale tests. A prototype will be developed and a possible patent considered. A collaboration on relevant ongoing work mainly in WP2 but also WP3 are desired.