PHD THESIS

Igor Iliev

**Department of Energy and Process Engineering**

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## Design of a high-head Francis turbine for variable speed configurations

**Supervisor:**
Ole Gunnar Dahlhaug
**Co-supervisor:**
Chirag Trivedi

NTNU HydroCen

## Background

Traditionally speaking, the runners of hydraulic turbines have always been designed to operate at synchronous speed. This is governed by the fact that the generator has a certain number of poles and it has to rotate at a certain synchronous speed to produce the required grid frequency. This is crucial for uninterrupted electricity production.

On the other hand, synchronous speed turbines have certain challenges when they are operated at off-design load. Nowadays, turbines are indeed required to operate at either part-load or full-load much more frequently than before. Despite the decreased efficiency at these operating points, there is a higher dynamical load present on the runner as well, which can lead to severe material cracks, expensive repairs and decreased power plant reliability in general. Therefore, it's considered that variable speed operation can improve efficiency and stability of the turbine.

The idea of using variable speed generators is relatively old but opens future prospects only because the price of such generators are getting lower nowadays. But, as reported in previous research, not all turbine runners can gain benefit from operating at variable speeds.

Both the idea and objective of this research is to develop new tools and methodology for designing a turbine that will operate at variable speeds almost exclusively. A better understanding of the design philosophy is then required in order to sustain the parametric study needed. Finally, a model runner will be produced and tested in order to compare the performance against the existing Francis-99 runner.