Optimal Bidding Strategies on the Day-Ahead Electricity Market for a Hydro Power Producer: A Hybrid CPU-GPU Implementation

Martin Biel Mikael Johansson
KTH Royal Institute of Technology, Department of Automatic Control
Osquldas väg 10, 100 44 Stockholm, Sweden
{mbiel,mikaelj}@kth.se

In a day-ahead electricity market, energy producers submit sales bids for the following day in the form of energy volumes and corresponding ask prices per hour. Hydro power producers can delay energy production by storing water, which allows them to produce and sell when the electricity price is high. However, since the future market price is not known, intricate planning is required to make full use of this flexibility when submitting bids on the day-ahead market. Optimal bids are often generated by posing and solving multi-stage stochastic optimization problems. First stage decisions constitute the different bids submitted for the following day. Later stage decisions constitute planning the production of the contracted volumes when the next day market prices are known. An introduction to models of this type is given in [1].

The aim of this work is to explore an efficient solution method for the day-ahead problem. In [3], the authors present a scalable solution of a large-scale energy dispatch problem. Problems of up to 1.95 billion variables are solved efficiently on Cray supercomputers. However, this requires large hardware solutions. For a small hydro power producer, there is benefit in being able to quickly generate several sets of optimal bids and production plans as decision support. Therefore, we explore inexpensive alternatives, such as multi-core GPGPU, to accelerate computations when solving medium-scale problems.

We propose a hybrid CPU-GPU approach where Bender decomposition is applied to exploit the stochastic problem structure. Emerging subproblems are solved asynchronously on worker nodes. The master problem is updated and resolved on a master node as new cuts become available from the workers. The underlying linear algebra computations are accelerated on the GPU. Our work extends a similar approach, presented in [2], to make better use of modern accelerators.

The solution method is evaluated on a large-scale model of the hydroelectric sector in Sweden. The model is posed in the Julia programming language and contains up to 257 power stations. Historic price data from Nord Pool is used to generate market price scenarios.

References

[1] Stein-Erik Fleten and Trine Krogh Kristoffersen. Stochastic programming for optimizing bidding strategies of a Nordic hydropower producer. *European Journal of Operational Research*, 181(2):916–928, September 2007.

[2] Soren S. Nielsen and Stavros A. Zenios. Scalable parallel Benders decomposition for stochastic linear programming. *Parallel Computing*, 23(8):1069–1088, August 1997.

[3] C. G. Petra, O. Schenk, and M. Anitescu. Real-Time Stochastic Optimization of Complex Energy Systems on High-Performance Computers. *Computing in Science Engineering*, 16(5):32–42, September 2014.