Post-Doctoral Position on “Storage Optimization in Model-Free Settings”

Francis Bach Olivier Féron Xavier Warin

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1 Context

Storage assets are used to store energy when prices are low and to withdraw this energy to sell it on the market when prices are high. Three types of storage are used at EDF:

- **Gas storage:** Depending on the characteristics of the storage facility (withdrawal and injection rates), gas storages are used differently. Very large storages (such as depleted gas fields or hydraulic caverns) are managed on an annual cycle: they are generally filled from April to the end of October, and then emptied during the winter from November to March. Salt caverns are much smaller and much more reactive assets, typically used for arbitrage over a few weeks.
- **Hydraulic storage:** Pumped-storage plants allow water to be pumped to an upper reservoir when prices are low, and turbined when prices are high. The associated management periodicity is at most a few days. The electricity generated can be sold on the spot market, the intraday market, or on reserve markets.
- **Batteries:** Batteries directly store electricity that can be sold on different markets. As batteries are expensive, the stored energy volume is relatively small and the operating frequency is high. Batteries also have an additional constraint: the number of cycles (total number of charges and discharges) is limited per year for warranty reasons.

Asset managers typically optimize these assets to maximize the expected profit generated by buying and selling energy. They also seek to minimize risk by buying and selling futures to hedge their positions.

To optimize profit, asset managers rely on a stochastic price model calibrated using maximum likelihood methods, and then use dynamic programming to optimize the control policies associated with asset management [2]. Recently, it has been shown that when the control is not restricted to be discrete, machine learning methods can be used to optimize storage problems using a Markovian price model, yielding even better results than dynamic programming [3].

2 Subject

In practice, using a model for price evolution is problematic. Due to calibration issues, the number of factors in the price model must remain low. Uncertainties are not Gaussian, and prices may be affected by jumps (as observed during the Covid period or the Gulf tensions during the Trump administration). Managers generally recalibrate the model using recently observed prices.

At a given frequency, an optimization is performed using updated market prices, and the resulting control for the storage is applied for one or several time steps until the next re-optimization. Although the objective function depends only on the realized spot price, at each time a full forward curve—giving the prices of the underlying for different maturities—is available and can be used.

The goal of this work is to develop a framework using a model-free approach, learning from data a control policy for injection and withdrawal to be applied at a given frequency. The problem should likely be optimized online using reinforcement learning techniques. The periodicity of the storage could also be incorporated into the learning framework.

3 Conditions

The post-doctoral researcher will be based at INRIA, 48 Rue Barrault, 75013 Paris, under the supervision of Francis Bach. Supervision at EDF will be shared between Olivier Féron and Xavier Warin.
The selected candidate will hold a PhD and have a very good knowledge of stochastic optimization theory and machine learning. PhD candidates who are about to defend their thesis are strongly encouraged to apply.

Applications should include:

- a CV,
- a concise description of research activities,
- a motivation letter indicating a possible starting date,
- the name and email address of one or two referees.

Applications should be sent to the supervisors at the following addresses:
`francis.bach@inria.fr`
`olivier-2.feron@edf.fr`
`xavier.warin@inria.fr`

Applications will be reviewed on a rolling basis. For any questions, please feel free to contact Olivier Feron or Xavier Warin.

References

[1] R. Machlev, N. Zargari, N.R. Chowdhury, J. Belikov, and Y. Levron. A review of optimal control methods for energy storage systems - energy trading, energy balancing and electric vehicles. *Journal of Energy Storage*, 32:101787, 2020.

[2] Xavier Warin. Gas storage hedging. In *Numerical methods in finance: Bordeaux, June 2010*, pages 421–445. Springer, 2012.

[3] Xavier Warin. Reservoir optimization and machine learning methods. *EURO Journal on Computational Optimization*, 11:100068, 2023.