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Microgrid Design Under Optimal Control With Batch Reinforcement Learning

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Abstract : Microgrids offer potential solutions to meet the need for local grid stability and increase isolated networks autonomy with the integration of intermittent renewable energy production and storage facilities. In such a context, sizing production and storage for a given network is a complex task, highly depending on input data such as power load profile and renewable resource availability. This work aims at developing an operating cost computation methodology for different microgrid designs based on the use of deep reinforcement learning (RL) algorithms to tackle the optimal operation problem in stochastic environments. RL is a data-based sequential decision control method based on Markov decision processes that enable the consideration of random variables for control at a chosen time scale. Agents trained via RL constitute a promising class of Energy Management Systems (EMS) for the operation of microgrids with energy storage. Microgrid sizing (or design) is generally performed by minimizing investment costs and operational costs arising from the EMS behavior. The latter might include economic aspects (power purchase, facilities aging), social aspects (load curtailment), and ecological aspects (carbon emissions). Sizing variables are related to major constraints on the optimal operation of the network by the EMS. In this work, an islanded mode microgrid is considered. Renewable generation is done with photovoltaic panels; an electrochemical battery ensures short-term electricity storage. The controllable unit is a hydrogen tank that is used as a long-term storage unit. The proposed approach focus on the transfer of agent learning for the near-optimal operating cost approximation with deep RL for each microgrid size. Like most data-based algorithms, the training step in RL leads to important computer time. The objective of this work is thus to study the potential of Batch-Constrained Q-learning (BCQ) for the optimal sizing of microgrids and especially to reduce the computation time of operating cost estimation in several microgrid configurations. BCQ is an off-line RL algorithm that is known to be data efficient and can learn better policies than on-line RL algorithms on the same buffer. The general idea is to use the learned policy of agents trained in similar environments to constitute a buffer. The latter is used to train BCQ, and thus the agent learning can be performed without update during interaction sampling. A comparison between online RL and the presented method is performed based on the score by environment and on the computation time.

Keywords : batch-constrained reinforcement learning, control, design, optimal
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