Artelys
optimization solutions

Decision-helping tools for long term investment in energy storage systems

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Euro 2010, Lisbon

Why electric energy storage?

- Main applications of electricity energy storage, according to DoE report[1]:
  - « Electric Energy Time-Shift »
    - Purchase during off-peak hours, use or sell during peak hours.
  - « Renewables Capacity Firming »
    - Combine intermittent energy source with storage to get a constant output.
  - « Load Following »
    - Storage used as a marginal generator to follow the load variation at the minute scale.
  - « Transmission Congestion Relief »

1- Eyer J., Corey G, "Energy Storage for the Electricity Grid: Benefits and Market Potential Assessment Guide", 2010, Sandia report.

Which kind of energy storage?

- Main technologies (DoE report):
  - Electrochemical Batteries
    - Flow batteries (fuel cells)
  - Compressed Air Energy Storage
  - Pumped Hydroelectric
  - Thermal Energy Storage

Long term investment

- Question asked:
  - What are the financial risks and benefits of a system including an electrical energy storage?
- The difficulty comes from uncertainties:
  - Long term:
    - Trends of energy prices and of demand.
  - Short term :
    - Meteorogical variables (wind, sun, water fall, temperature) and their impact on production, demand and prices
- Answer through simulations:
  - How would the system have been run if a given scenario has happened?

Simulations

- How to generate the scenarios
  - Either linear, from now to the investment horizon.
  - Or tree-like, with branches representing alternatives.
- How to simulate the system over the scenarios
  - Not a « physical » simulation: decisions have to be taken (When to charge, when to discharge).
  - Optimization is needed.
    - For each (linear) scenario, compute the optimal schedule.

Optimization : Anticipativity

- When the decision to charge or discharge is taken, the future is still uncertain.
  - Tactical horizon << Investment horizon
- Need to define what is known on the future at the time of the decision:
  - Surely, the future is not perfectly know.
  - But it is somehow predictable.
    - for example, inside a one-year scenario, assume that a decision depending on the temperature of the 13th is taken on July 12th: a reasonnably good forecast already exists.

Optimization: Algorithms

- Anticipative:
  - Assuming that the future is known, the problem for one scenario can be formulated as a standard optimization problem of reasonable size.
- Non anticipative:
  - Stochastic algorithms: “Best decision” under uncertainty (expectation, risk aversion...)

Stochastic algorithms: standard methods

- Stochastic programming:
  - The problem quickly becomes untractable because of its size.
- Dynamic programming:
  - The problem quickly becomes untractable when the number of « state variables » increase.
  - 1 storage is OK, 5 is difficult *(cf Maceira et al., PSCC 2008, Glasgow)*

Stochastic algorithms: other methods

- Evolutionnary methods (genetic algorithms…)
- Bandit based Monte Carlo Tree Search
  - Used to create the best computer go-player in the world.
  - Idea:
    - Try many strategies drawn randomly (sequences of decision) and evaluate them.
    - Trade-off between "exploring" new strategies and "exploiting" the reasonably good one found.

Artelys Risk Manager

- A platform dedicated to energy assets simulation.
- Allows the high-level representation of energy systems
- Optimization engines compute schedules
- Artelys Risk Manager reports results to the user.

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