Planning the production and energy supply minimizing the costs of a factory.

Zoe Fornier[1], Bernardo Da Costa[4], Dorian Grosso[3], and Vincent Leclere[2]

[1] *METRON - CERMICS, France,* zoe.fornier@enpc.fr
[2] *Universidade Federal do Rio de Janeiro, Brazil,* bernardofpc@im.ufrj.br
[3] *METRON, France,* dorian.grosso@metronlab.com
[4] *CERMICS, France,* vincent.leclere@enpc.fr

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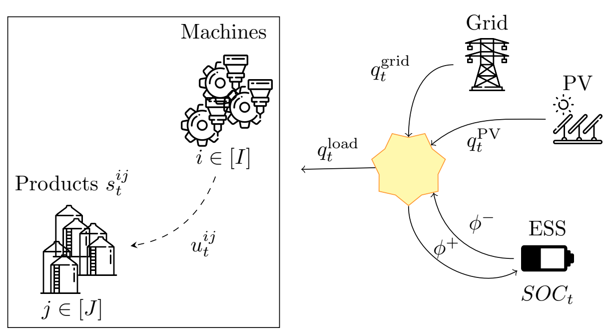
Industrial processes can be highly energy consuming. Industrial actors are increasingly trying to integrate renewable energies to their energy supply for economic and environmental reasons. Recent reviews on related research can be found in [2] and [3].

In this work, we present a mixed-integer multistage stochastic problem optimizing both the production planning and the energy supply management of an industrial complex. The goal is to minimize the expected energy supply costs of the factory on a discrete horizon $t \in [T]$. More specifically, we consider a facility with I machines that manufactures up to J types of products that can be stored (see fig. 1a). The production is bounded and there are set-up costs. In addition, we consider shared resources constraints such that some products cannot be produced simultaneously. Factory energy needs, proportional to production, are met with electricity from a main grid or produced onsite by a micro-grid consisting in solar panels coupled with an energy system storage (ESS) see fig. 1b.



(a) Factory Structure

(b) Energy exchanges

Figure 1: Industrial Management Problem

Electricity from the main grid can be purchased through two different contracts, usually cumulated: Intra-day contract where prices are fixed annually, the factory pays the energy extracted from the main grid at a given time t; In-advance contract where the factory buys energy blocks in advance (*e.g.,* a day ahead of production) at a preferential rate. Decisions are made adjusting energy purchases based on intra-day rates in real time.

The mathematical problem is difficult to address first due to the stochasticity of renewable energy, coupled with a large number of time-step and the presence of (a few) binary variables.

We consider two classic methods to solve our problem: dynamic programming and model predictive control (MPC). The first one consists in reducing a $T-$stage problem to $1-$stage consecutive sub-problems by exploiting the problem structure (under stage-wise independence of the noise); the second one (MPC) consists in solving deterministic sub-problems at each stage, with updated information, to adjust the solution trajectory accordingly.

Those methods are computationally time-consuming, leading us to explore two heuristics based on stochastic dual dynamic programming (SDDP, [4, 5]), an algorithm solving the continuous relaxation of the problem fast. The heuristic uses the cost-to-go approximation of the continuous relaxation (obtained through SDDP) and computes a policy (satisfying integer constraints) with dynamic programming. The second heuristic extends this idea by computing a policy over two time-step instead of one.

Exactly solving the mixed integer multistage stochastic linear program would require to use an extension of SDDP known as SDDiP ([1]). Unfortunately this algorithm approximates all continuous variables with binary ones, which in our problem with few binary variables doesn't seem reasonable. Instead we develop an alternative approach based on branch & cut methodology.

We run the proposed method on two different case studies modeling a real-case factory. In one of them we consider only time-of-use electricity prices, in the other it is also possible to buy electricity a day-ahead (at preferential rates). We compare and analyze the MPC results to the heuristics exploiting SDDP's cuts on both study case.

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