

Towards Real World Co-optimization of a Storage System

ISGT 2023 Grenoble

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SATIE - ENS Rennes

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école
normale
supérieure



Co-optimization approach

Optimal management

- depends on sizing

Optimal sizing

- depends on management

Co-optimization problem for a storage

$$\max_{\text{design}} \sum_{\text{lifetime}} (\text{utility value}) - \text{building cost}$$

Obstacles : methodology and information

- Complexity : bilevel problem
- Anticipation of the future
- Modeling of components and time series

Motivation

Coupling with expert knowledge of the industrial situation

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Outline

Introduction

Test case

Optimal Control

Stochastic Control

Life Time and Ageing

Conclusion

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Optimal Control

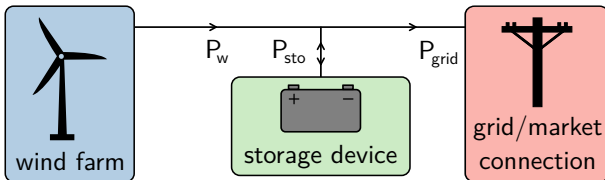
Stochastic Control

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Illustrative Test Case

Representative and as simple as possible



- Virtual Power Plant : wind farm and storage
- Selling to market with fluctuating price
-

$$\text{Utility}(P_{sto}(t)) = \text{price}(t) \cdot (P_w(t) - P_{sto}(t))$$

Illustrative Test Case

Co-optimization problem

$$\max_{\text{design}} \sum_{\text{lifetime}} (\text{utility value}) - \text{building cost}$$

- E_{sto}, P_{sto} : storage capacity and instantaneous power
- T_{life} : storage lifetime
- price : selling price to the market
- CAPEX : capital expenditure

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Co-optimization problem

$$\max_{E_{sto}} \sum_{t=0}^{T_{life}} \text{price}(t) \cdot (P_w(t) - P_{sto}(t)) - \text{CAPEX} \cdot E_{sto}$$

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Co-optimization problem

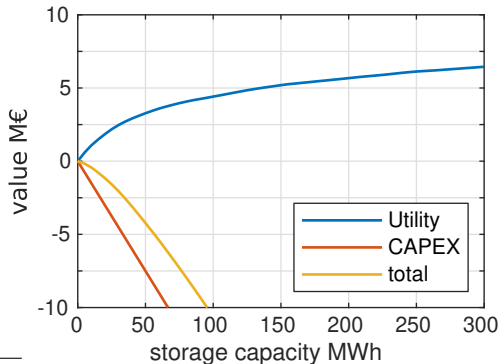
$$\max_{E_{sto}} \sum_{t=0}^{T_{life}} \text{price}(t) \cdot (P_w(t) - P_{sto}(t)) - CAPEX \cdot E_{sto}$$

Parameters values

- Questionable¹

Simple management

- Price threshold
- Loss-making decision



1. It is the purpose of this talk.

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Optimal Management

For each time step of the lifetime simulation

$$\max_{P_{sto}} \sum_{\tau=0}^{horizon} price(\tau) \cdot (P_w(\tau) - P_{sto}(\tau))$$

- Optimisation of the control
- Anticipation of future events → *Model Predictive Control*

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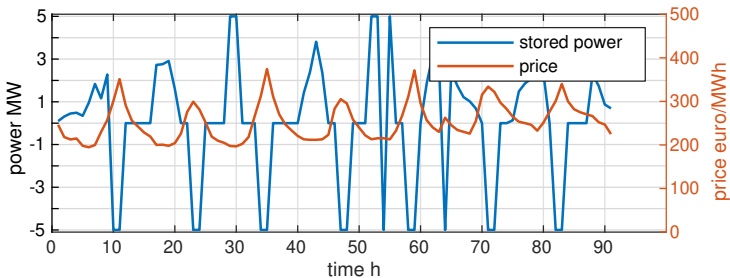
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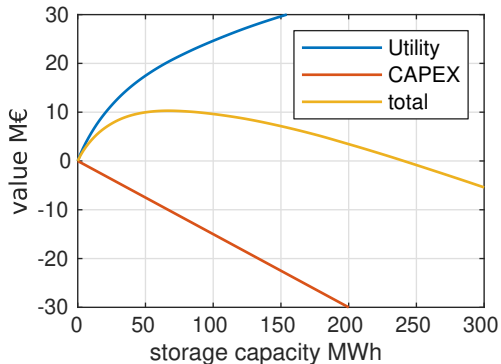
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Optimal Management

Impact on sizing

- Anticipation of price and production
- Earnings from storage operation
- Co-optimization design-management
- 2022 prices
- 2019 prices



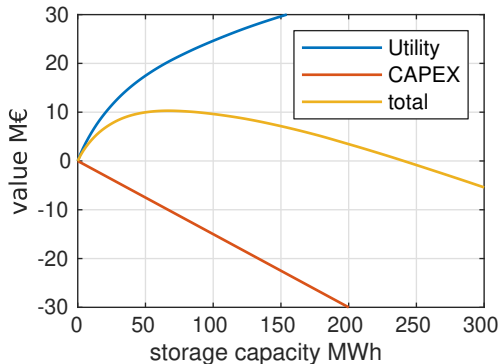
Reliant on the data used for simulation

- Depends on the time series
- Requires a representative sample of temporal data.

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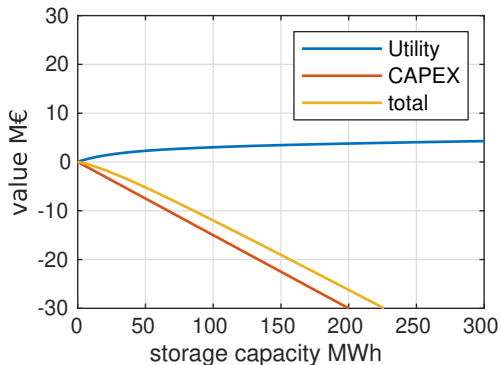
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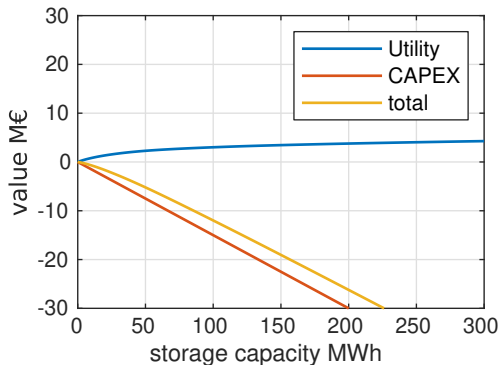
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- Anticipation of future events → future is unknown.
- Requires forecast

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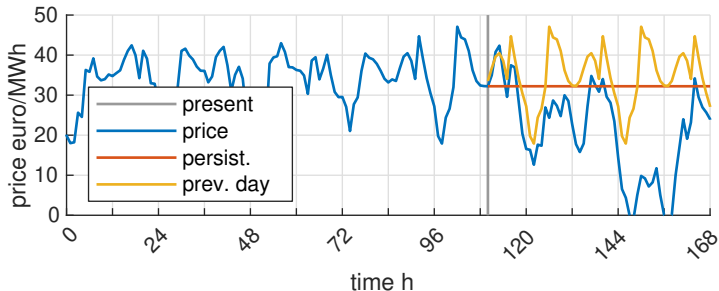
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Many possible forecasts

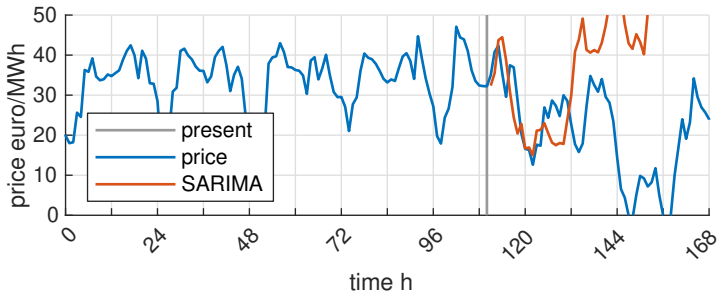
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- Time series modeling : *SARIMA*, Neural Networks
- Exogeneous forecast : meteorologist
 - Modeling of forecast errors



Stochastic Management

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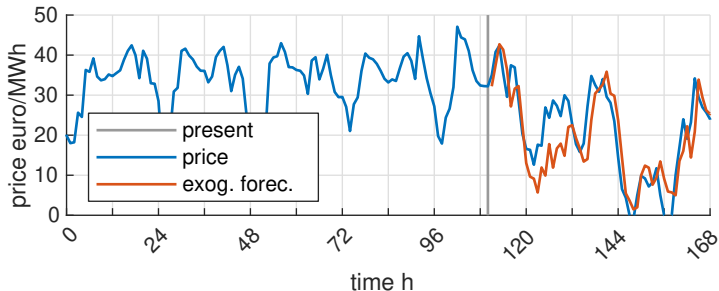
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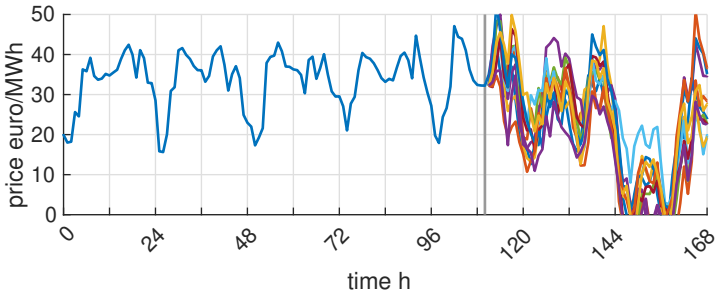


Stochastic Management

Many possible forecasts

Risk policy

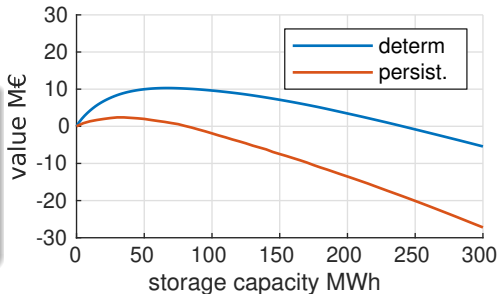
- Stochastic forecast
- Choice : neutral, risk averse, ...



Stochastic Management

Impact on sizing

- Optimal design : slightly affected
- Anticipated profitability : highly sensitive



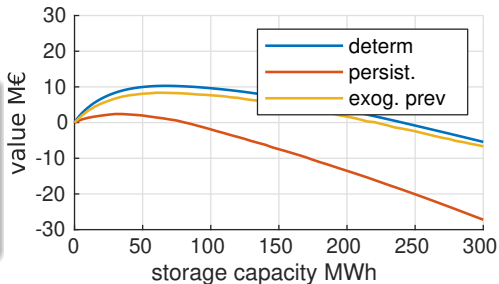
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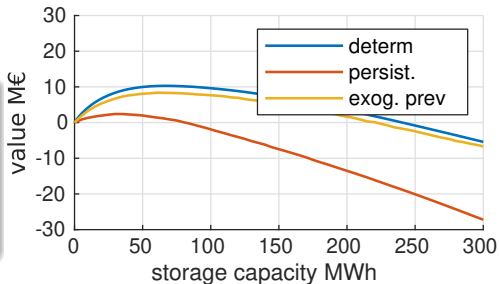
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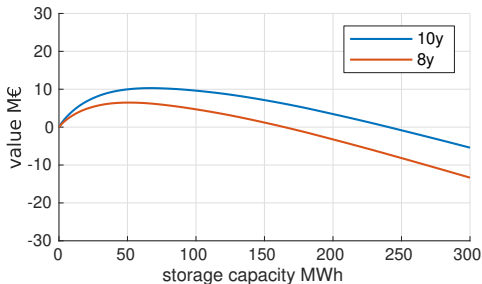
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Ageing and Lifetime

- Optimal design depends on lifetime
- Simplest : exchanged energy
- Ageing models may get quite complex



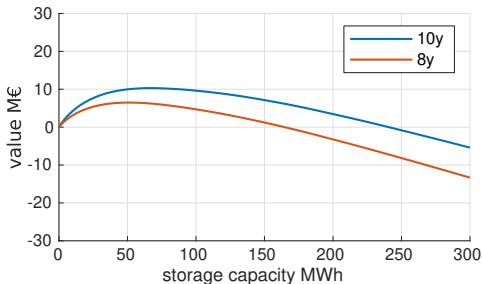
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Mandatory modeling choices during design phase

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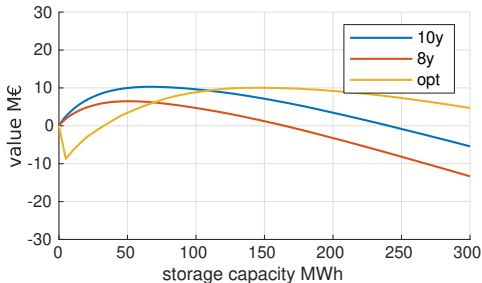
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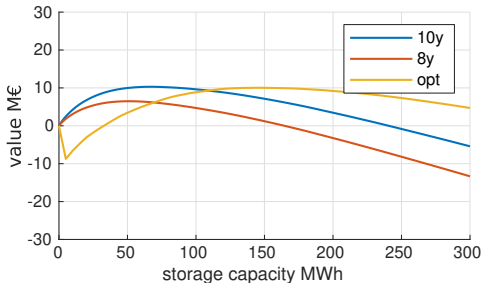
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Conclusion and Take Home Messages

Co-optimization

- Powerfull and mature methodology
- Assess best design over the lifetime

Highly dependent on input data

- Optimal management → time series
- Stochastic management → forecast quality
- Lifetime → ageing models

Requires expert knowledge and communication

- What is known : take it into account
- What is not measured : robust approach and sensitivity analysis
- What is unknown : measures transfer, explainable assumptions

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