Benefits of Energy Management Systems

on local energy efficiency: an agricultural case study

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Context: microgrid

Electricity and energy are critical aspect of industries.

Targeting: companies, industries, farmers, with renewable energy sources.

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Improving energy efficiency means trade-offs between:

- local production: type, size,
- energy storage: technology, inverter power (C rating), capacity,
- efforts on demand response.

Need for a **global approach** to these energy related analysis.

Objectives

What we are trying to do:

- equipment sizing:
  - solar panels,
  - wind turbine,
  - battery capacity
- activity optimization (demand response) to:
  - reduce energy production excess,
  - optimize battery usage (cycle),
  - reduce energy costs.

Proposition: model based approach

Model Driven Engineering (MDE) to capture energy and activities variability and scheduler optimization algorithms for **simulation** and **control** using the same model.

Features: extension, variable granularity, ...

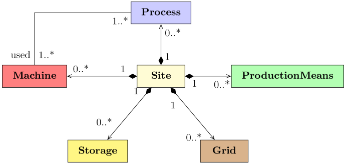

Figure: simplified metamodel

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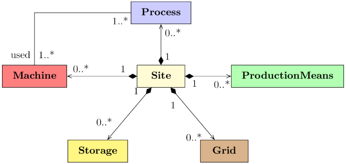


Figure: simplified metamodel

```
process Cleaning(WaterPump, Lights) {
    after (Milking) // Dependency
    frequency Periodic
        at 10:00
        for 1 h
        on days {MONDAY, TUESDAY}
    shift between 0 h and 2 h // Flexibility
}
```

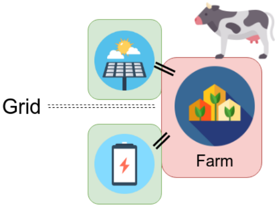
Figure: Domain Specific Language: example to express process variability

Rio *et al.* Efficient use of local energy: An activity oriented modeling to guide Demand Side Management. ACM/IEEE International Conference on Model Driven Engineering Languages and Systems

Case study: description

Farmers are:

- Collaborative
- Big energy consumers
  (1 appliance ~ 60% of the daily
  consumption $\Longrightarrow$ easier for impact)
- at the edge of the infrastructure
  (blackouts)



We want to explore the **variability** in:

- solar production,
- storage capacity,
- activity shift impact.

Inputs

Using our model and simulator.

Two years of **logged data**:

- 18kWp on site solar PV,
- consumption

We selected commonly used lithium and vanadium redox battery specifications.

Process variability with help of an expert

In this context we focus on: **self-consumption**, **autonomy** and global **economy** of the system.

Implementation

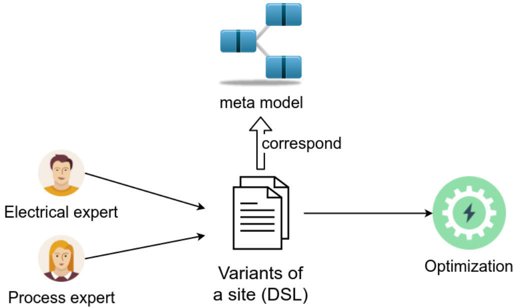
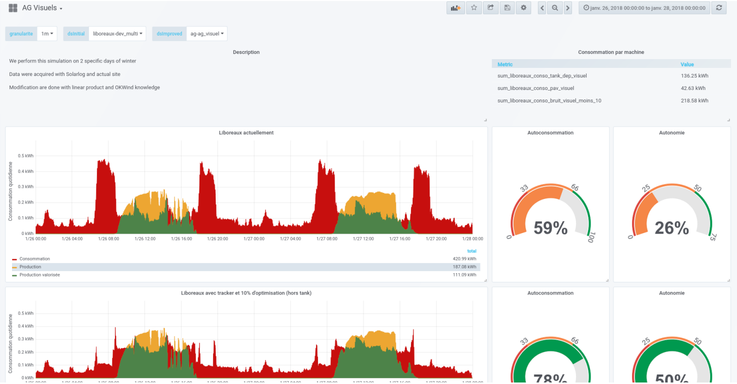


Figure: Typical workflow

Detailed results are pushed into a Time Series database (Influxdb) and visualised in Grafana for further analysis.



Figure

Results: production variability

Production sizing

Considering equipment costs, electricity bill reduction and Feedin Tariff:

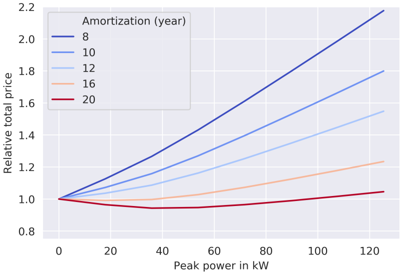


Figure: From 0kWp to 120kWp 2-axis solar system. Shorter amortization period is better

Predictable results:

- from 0 to 50kWp: relatively profitable
- beyond: 50kWp: not enough consumption, feedin tariff is not enough

Common scenario: adding lithium or vanadium redox batteries.

Simulations from 5 to 60kW power inverter and from 15 to 90kWh capacity.
Red line is level without battery and 50kWp solar panels

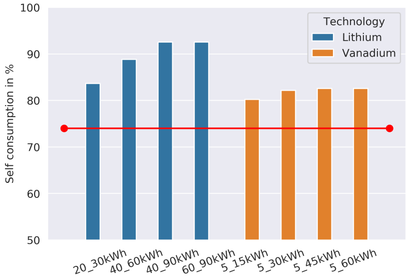


Figure: Self consumption is greatly improved

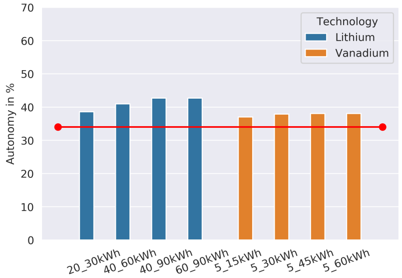


Figure: Autonomy is slightly improved in all scenarios

Inverter power quickly cap the autonomy if set too low.

Results: demand response

Measure the impact of activity shifting and compare it to adding batteries.

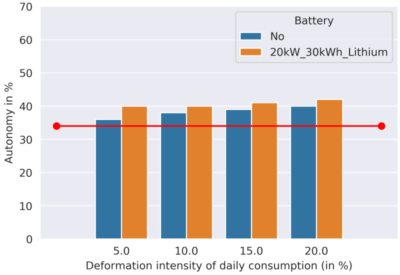


Figure: Batteries improve the autonomy

The more efficient the shifts, the less the batteries are.
The two reduce the production excess, **energy cost** should be used to set priorities

Lessons learned and future work

Lessons learned from this case study:

- no perfect solution can maximize self consumption and minimize costs,
- these simulations took from 3–6 minutes to perform on a laptop for 2 years of data,
- **Model based** approach makes it easy to define different activities variability and devices heterogeneity.

Future work will consider extending the metamodel beyond electricity and capture global incentives to guide optimization.

Questions?