Digital Twin for microgrid energy optimization

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Context

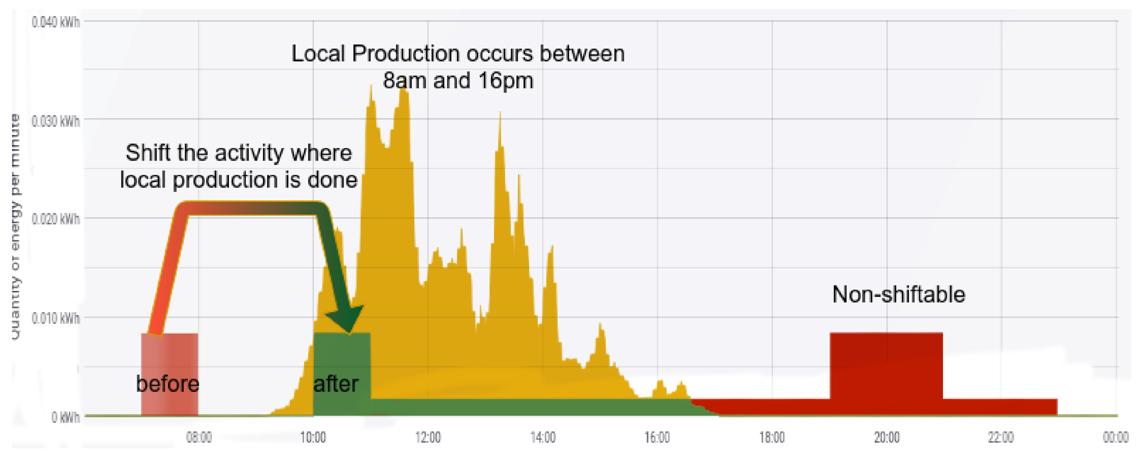
Energy efficiency is a concern impacting both ecology and economy.
Decentralization of production is an approach to improve this efficiency through the use of renewable energies creating **microgrids**.
Most approaches focus on only **one aspects** of the ecosystem: appliances, local generation or energy storage.
Digital Twin are traditionally used to monitor: sites behavior, health or energy consumption.
We propose to extend Digital Twin concepts to address energy efficiency issues regarding local production.

Challenges

RQ1 How to properly **size** production means and energy storage systems?

RQ2 How to perform this **Demand Response**? Consumption must be aligned with the varying production of renewable energies.

1. Proper equipment sizing impacts all the aspects of the site
2. Demand Response includes load shifting considering human constraints but can also impact charge and discharge strategy of batteries.



References

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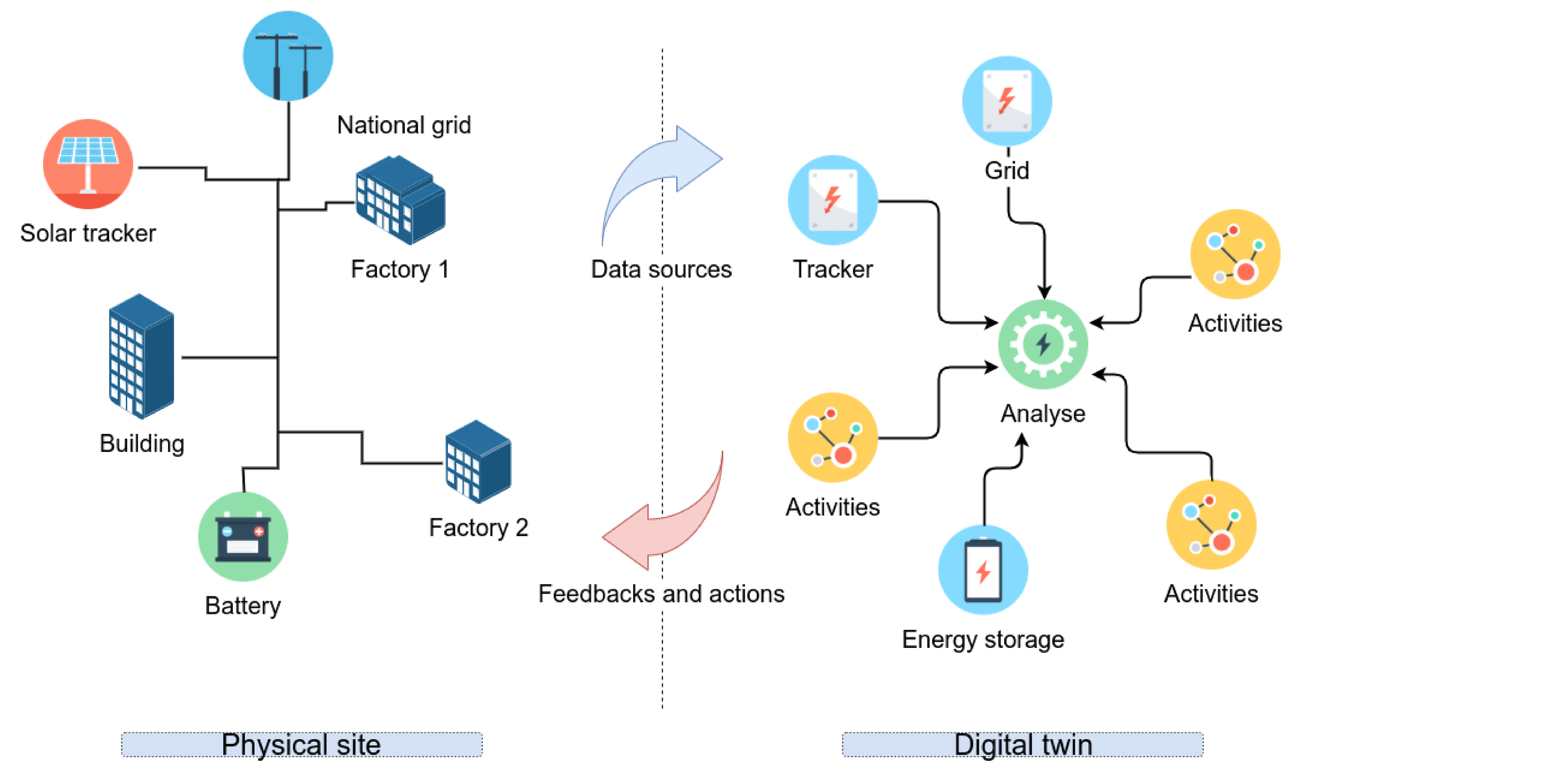
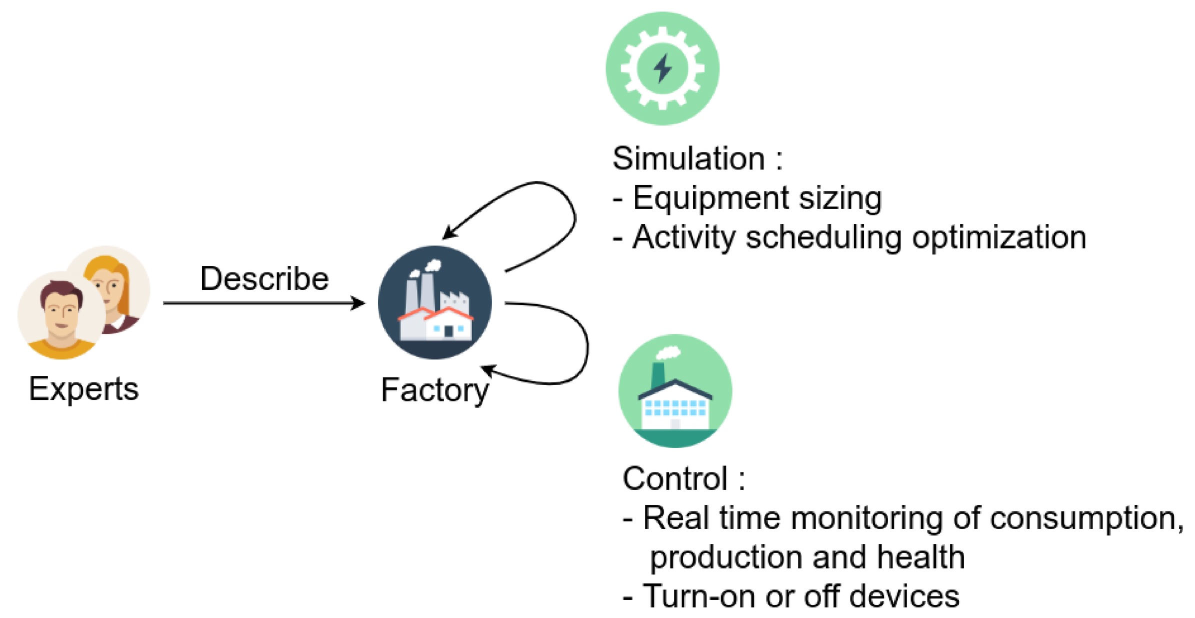
Proposal: an activity oriented Digital Twin



Activities variability is explored to find the best schedule minimizing the global **cost** of electricity. Constraints are provided to only consider sane activity shift for the final user.

Optimized scheduled are either:
1. sent to the user as feedbacks,
2. applied on devices controlled by the Digital Twin.

```
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
}
```



DSL use experts vocabulary to ease the description of their activities and the expression of their variability: time of start shift, intensity dimming

Results: agricultural case study

Inputs: 2 years of data from a real agricultural site (France), knowledge from an expert.
Benefits: Other approaches only consider: production only or battery only, we explore more solutions and improve further the energy efficiency.

Autonomy level shows how much we use renewable energies, and thus how green we can be, while the cost reflects the relative expected economy advantages compared to the current situation.

Solution		Prod. 50kWp Autonomy (%)	Prod. 50kWp Cost	Prod. 90kWp Autonomy (%)	Prod. 90kWp Cost
PV		34	0.92	40	1.03
PV +	B1	38.6	1.03	45.9	1.13
	B2	42.7	1.11	53.57	1.32
PV + O		39.9	0.86	48.7	0.94
PV + O +	B1	41.7	0.99	52.2	1.06
	B2	44.2	1.24	58.3	1.27

PV: photovoltaic panels, O: process optimization, B1: lithium battery,20kW inverter and 30kWh capacity, B2: lithium battery 40kW,inverter and 90kWh capacity.

Conclusion

We propose a Model Driven approach to model activities and energy related sources from any microgrids.
Our contribution falls into two parts:

1. a Domain Specific Language to **model**: producers, consumers and activities variability and their associated constraints,
2. a Digital Twin view to **optimize** the model and **control** the physical devices specified in the model (Serial, API, . . .).