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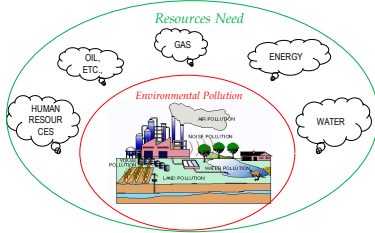
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Energy modeling and simulation for industrial systems designed for integration into digital twin framework

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1. Context and research objective

Industry impacted by resources such as energy, water and gas are under ever-increasing pressure, and have received a limited attention from industry, while it directly affects their performance.



MISSING MATURITY IN DES!

The challenge is that Discrete event simulation (DES) tools today focus on economic factors and are not yet mature enough to account for energy, water, or human resources.

This research aims to answer the following key question:

- How can we effectively model and integrate energy resources in DES by creating scenarios ranging from simple analysis to optimization?

2. Research methodology

To integrate critical resources into the discrete-event simulation, we propose a three-level CSR (Corporate Social Responsibility) framework that defines objectives, KPIs, attributes, methods, and required inputs at each level (that could be applicable to multiple resource types—not only energy, which will be explained in more detail later).

Inst.	No	Name	Requirements			
			Need	KPIs	Attributs/ Methods	Inputs
Levels	0	No Integration	?	?	?	?
	1a	+ Accounting & Production Flows	?	?	?	?
	1b	+ Building	?	?	?	?
	2	+ Critical Resources	?	?	?	?
	3a	Internal Generator Resource Modeling	?	?	?	?
	3b	External Generator Resource Modeling	?	?	?	?

Table1. CSR Framework in the context of Discrete Event Simulation

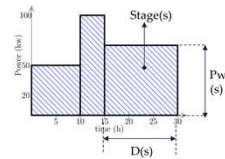
3. Research framework

- Objective: Modeling energy aspects as critical resources through discrete event simulation

For modeling energy, we have proposed new artifacts that are:

Power Profile

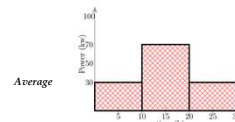
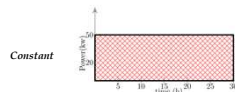
- is used to model the energy behavior of both consumers and producers, in order to provide an analysis of power generation vs. demand.



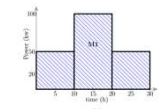
- nb stage (s): the number of stages in the process.
- D(s): the duration of stage s.
- Pw(s): the power during stage s.

Energy Behaviours: Producers, Consumers, Prosumers

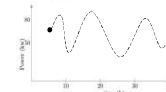
Producers Profile



Consumers Profile



Prosumer Profile



The different energy KPIs

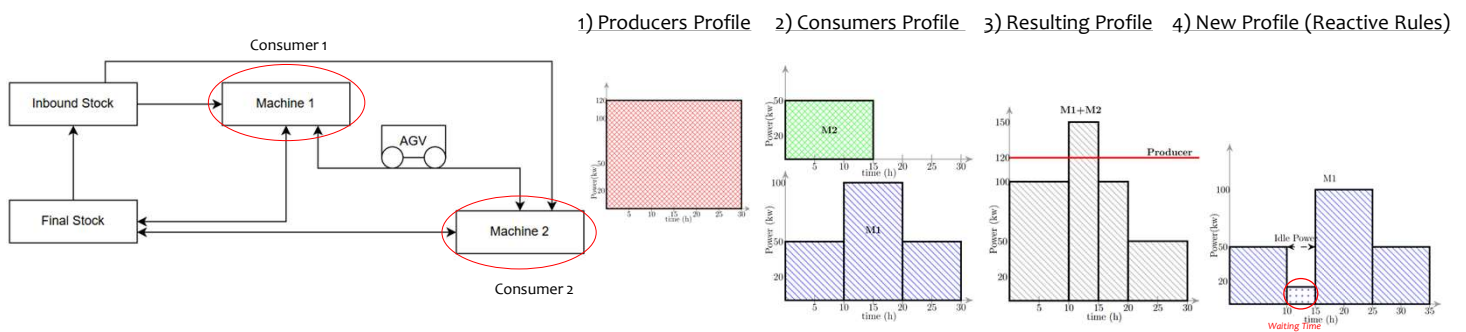
- Instantaneous power profile;
- Total energy consumption;
- CO₂ Emissions,
- Mean Wait Time,
- Energy Loss
- Energy Cost, etc.,

New Operational Rules

- Lev 1: Diagnosis Level
- Lev 2: Proactive et Reactive Rules
- Level 3: Centralized Energy Management

4. Partial results: "Energy Modeling" case study

- Example of a simple manufacturing system
- Energy diagnosis Artifacts



5. Conclusions & Perspectives

I. **Novel modeling technique for DES** energy analysis and management in industrial systems, starting with the construction of power profiles for all industrial activities.

II. **DES Models can be embedded in a digital twin framework**, allowing real-time data collection on the status of energy sources (upstream information flow).

References

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