FlexCHESS

Digital twins: a living mirror of the energy system

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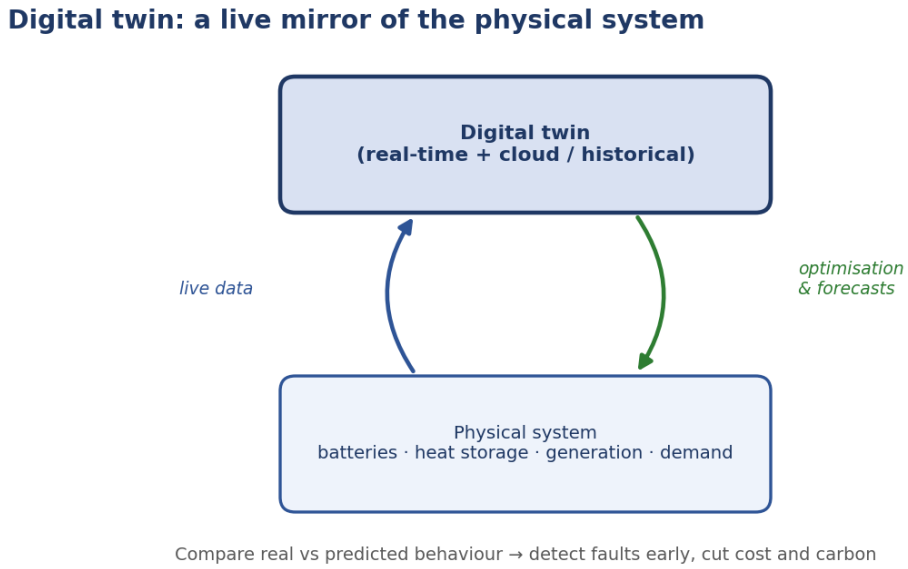

Imagine being able to test a decision about your energy system before making it in the real world — to see, in advance, how a battery would behave, how much solar power you might generate tomorrow, or how to balance competing goals such as saving money and extending equipment life. This is the promise of the digital twin, one of the cornerstone technologies of the FlexCHESS project.

A digital twin is a virtual replica of a physical system that runs alongside the real thing, continually updated with live data. In FlexCHESS, digital twins are created for the components of the energy system — batteries, heat storage, renewable generation and demand — and used to optimise how those resources are managed.

The project draws on three kinds of information to make its twins useful. Historical data helps the system understand the past behaviour of each resource and learn from experience. Near-real-time data allows it to monitor and optimise decisions as they happen. And forecast data, generated using artificial intelligence and machine learning, helps anticipate what is coming — from weather to demand — so the system can plan ahead.

FlexCHESS uses two complementary types of digital twin. Real-time twins operate close to the equipment, making rapid decisions within very short timeframes. Non-real-time twins run in the cloud, drawing on large volumes of historical data to set longer-term strategies and constraints. The two work together: short-term actions feed back into long-term planning, and vice versa. This allows the system to balance objectives that often pull in different directions — for example, getting the most out of renewable energy while protecting the lifespan of a battery.

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Digital twins are also a digitalisation story. The European Union sees digital technologies — from artificial intelligence to the Internet of Things — as critical enablers of the energy transition, and FlexCHESS puts them to work in the service of cleaner, more flexible storage. By running physics-based and machine-learning models side by side, the project's twins aim for both accuracy and the speed needed to act in real time.

The practical value is considerable. By comparing how a system actually behaves with how its digital twin predicts it should behave, operators can spot deviations, detect potential faults early and identify opportunities to improve performance — reducing both costs and carbon emissions. The twin becomes a safe space to explore "what if" scenarios before committing real resources.

In FlexCHESS, digital twins are not a stand-alone curiosity but a working part of the platform, feeding the decision-support system and helping turn a complex mix of distributed resources into a coordinated, optimised whole.

References and further reading

- FlexCHESS project — CORDIS, European Commission
- International Energy Agency (IEA)
- EU initiatives for smart energy systems — European Commission

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