

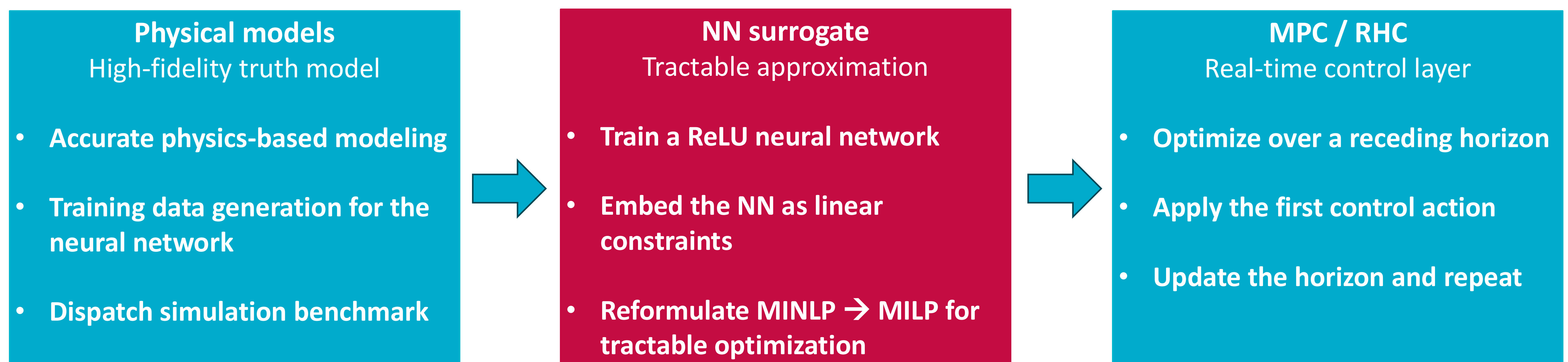
Context of the project

EFES (Enhanced Flexibility in Energy Systems) is a project funded by Europe and Wallonia which addresses the major challenges posed by the growing electrification of energy systems, particularly regarding storage, conversion, and flexibility management. Bringing together four francophone universities, research partners, and Walloon industrial stakeholders across 13 doctoral theses, EFES is structured around two topics: the first focuses on **energy storage and conversion technologies** (thermal storage, e-fuels, geothermal storage, metal fuels, heat pumps), while the second addresses **energy flow management within energy communities**, covering market design, control and sizing models for multi-sector communities.

Context & Problem of the thesis

Hybrid renewable energy communities (RECs) combining photovoltaics, battery storage, and hydrogen systems (electrolyzer and fuel cell) are a promising solution for local, low-carbon energy autonomy. However, their real-time optimal control is challenging due to strong nonlinearities in key components, such as fuel cell (FC) performance, leading to non-convex constraints and MINLP formulations that are computationally intractable for real-time applications. This work addresses this challenge by developing neural network-based surrogate models of nonlinear components tailored for Model Predictive Control, enabling MILP reformulation that ensures real-time feasibility while maintaining high solution quality and accurate system dynamics.

Proposed approach : Three-layer framework



Contributions

- FC surrogate** → **MILP**: ReLU NN embedding PEM-FC efficiency for real-time optimization
- MPC dispatch**: Receding horizon control with battery + H₂ dynamics
- Benchmarking**: MILP vs MINLP vs MILP-NN vs rule-based (quality, time, constraints)

Preliminary Results

Strategy	Solution Quality	Computation Time	Objective Cost
Rule-Based	+++	+++	--
MILP	+++	-	++
MINLP	++	---	+++
MILP-NN	+++	--	+++

Status and next steps

