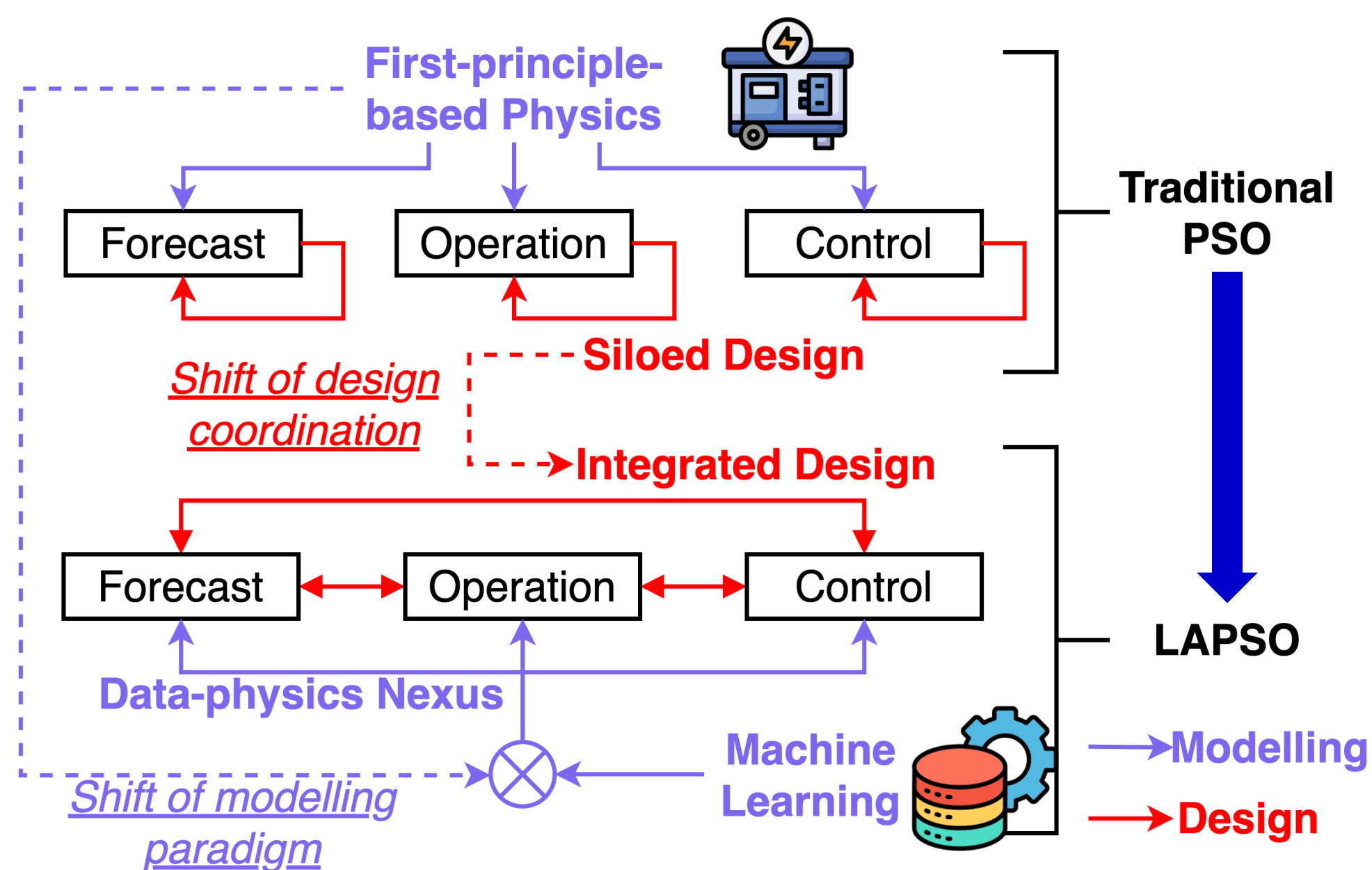


## Both DATA and PHYSICS Matter, But How to Integrate Is a Problem! We build Learning-augmented Power System Operations (LAPSO): A Unified Framework

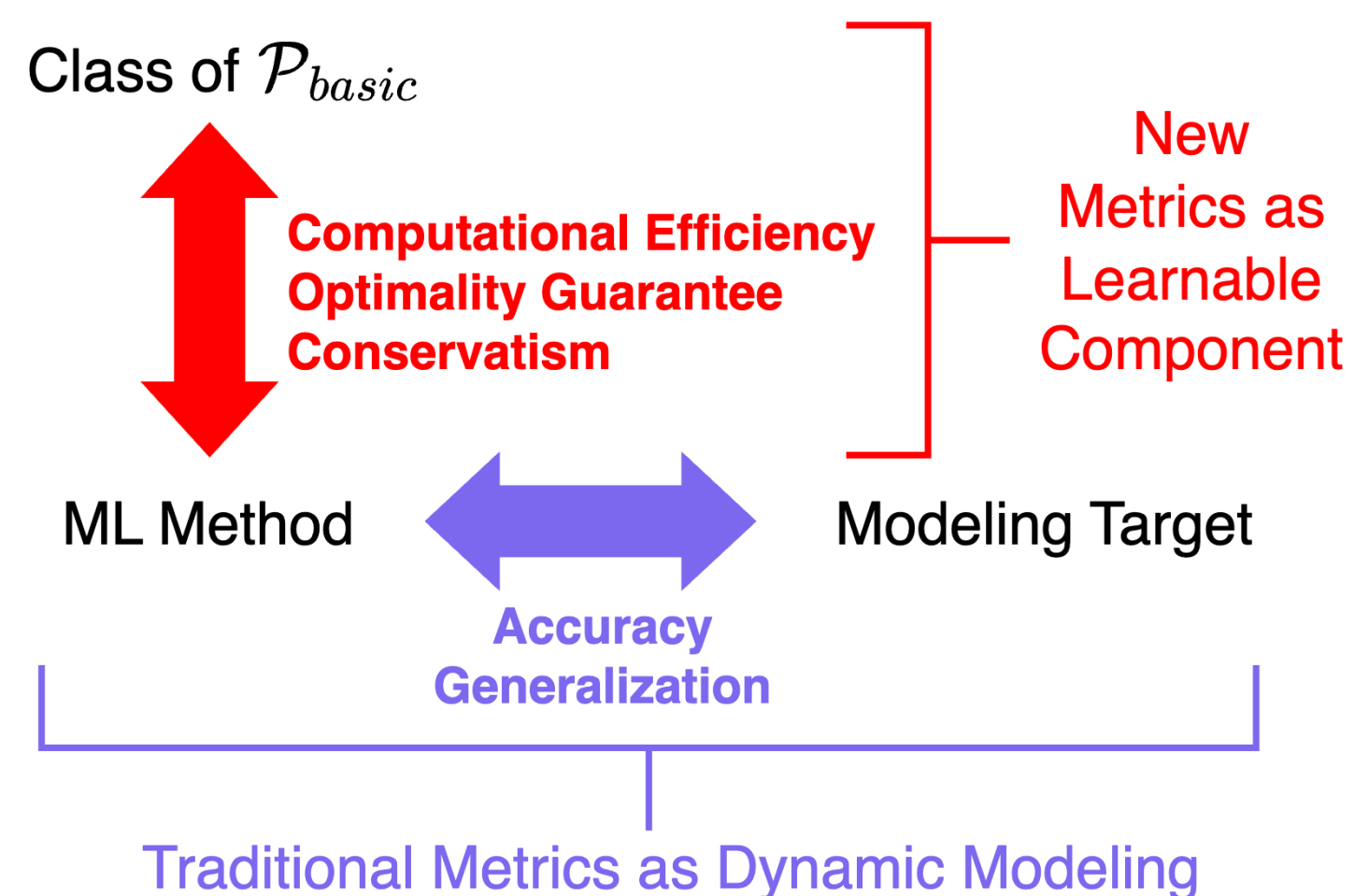
Dr. Wangkun Xu (EPICS-UK, Imperial),  
Dr. Zhongda Chu (Tianjin U, China),  
Dr. Fei Teng (EPICS-UK, Imperial)

### Background: The New Transformation within Power System Decision-makings

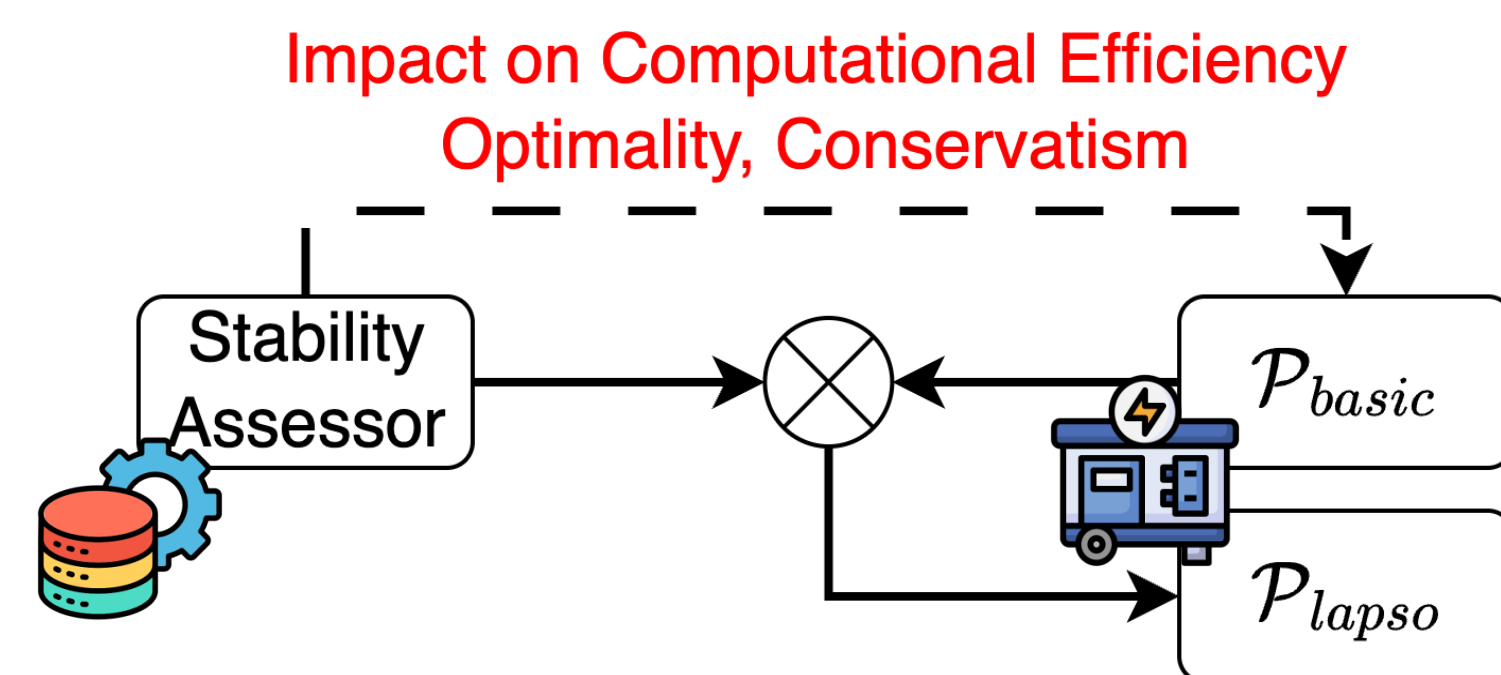
With the increasing renewable energy, physics-based power system operation (PSO) faces new challenges for economic efficiency and stability. Machine learning (ML) is a powerful tool for modeling system dynamics to address these challenges.



### New ML Design Metrics with Optimization Integration

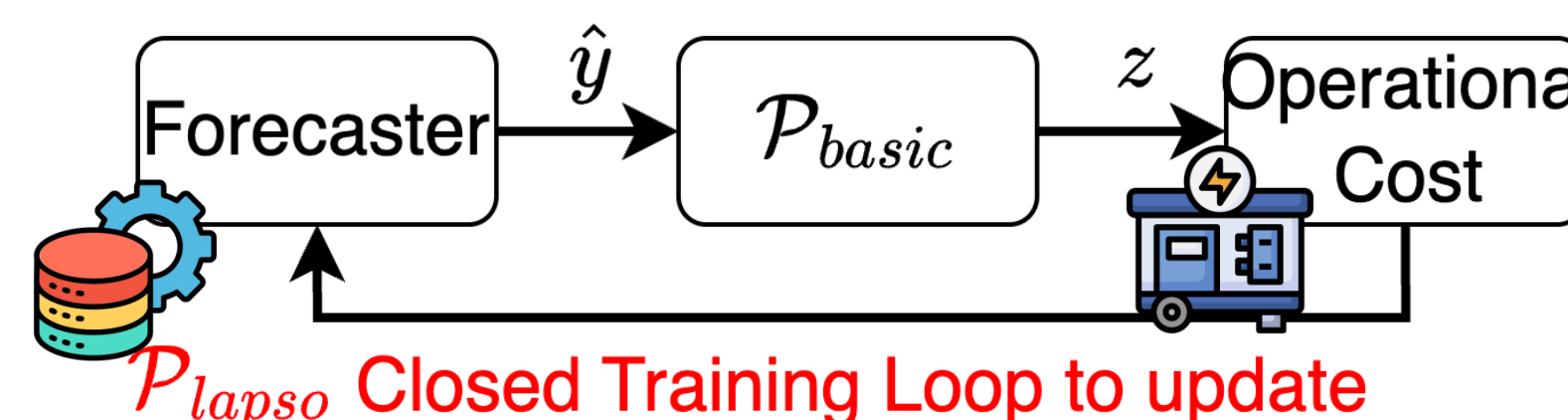


#### Application One: Stability-Constrained Optimization (SCO)



#### Application Two: Objective-based Forecasting (OBF)

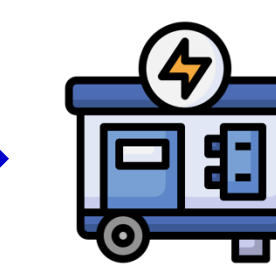
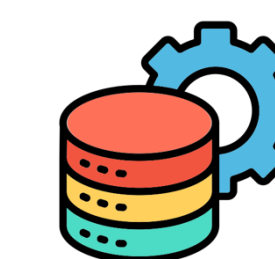
Train forecaster to minimize operational cost



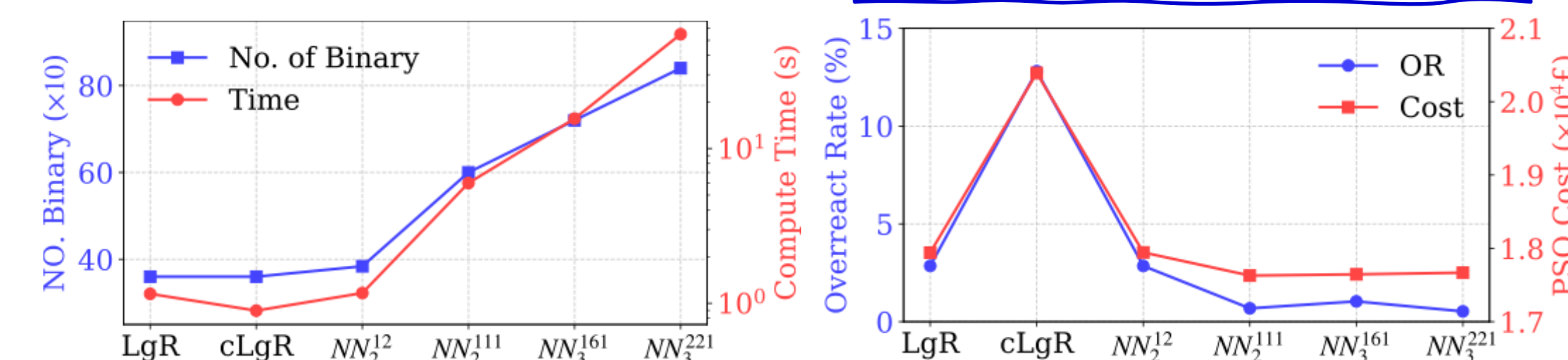
### Open-source Software: LAPSO Efficient linking data and optimization



Wangkun Xu  
github.com/xuwkk  
Research Associate at EEE, Imperial College London.  
Working on ML for power system.  
75 followers · 26 following  
Imperial College London · London, UK

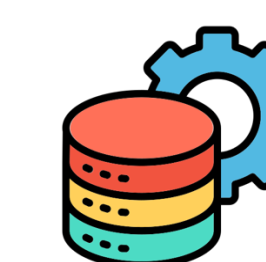


Data-driven modeling into physics-based optimization. E.g., SCO



Left: The complexity of NN determines the No. of binary variables in  $\mathcal{P}_{lapso}$ , which is related to the computational time;  
Right: Conservative stability assessor results in extra operational cost.

Integrate physical knowledge into machine learning. E.g., OBF

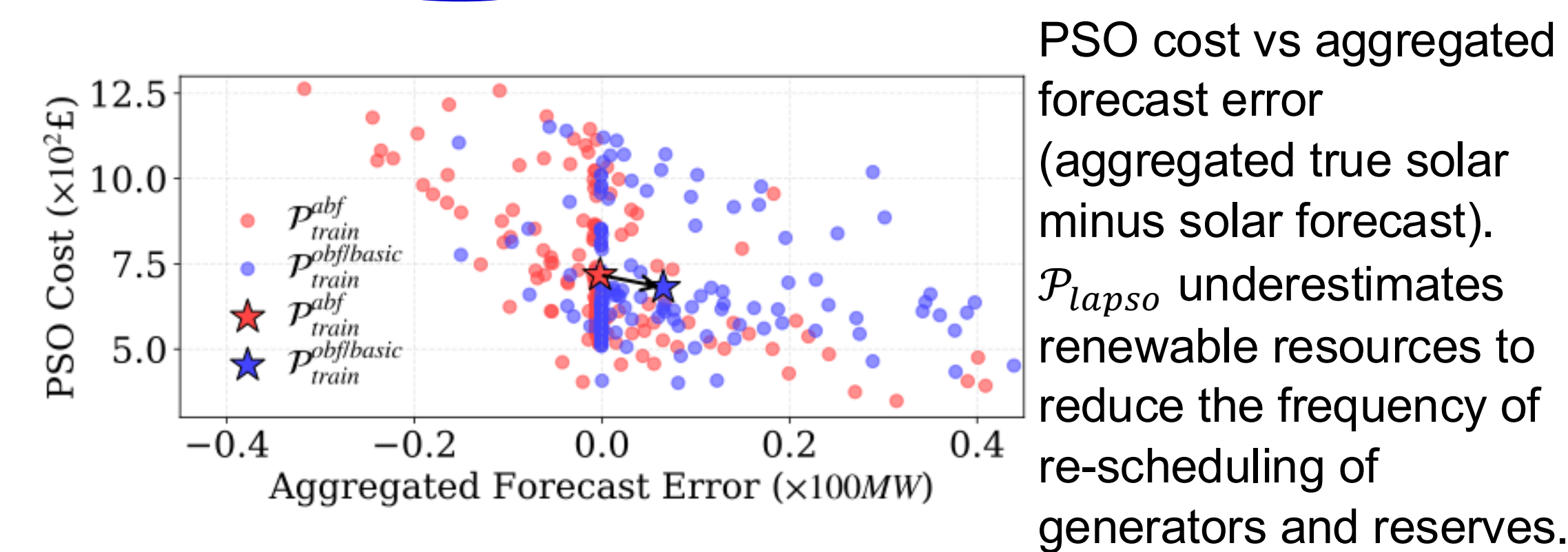


### Mathematics of Data-Physics Nexus

Traditional PSO  $\mathcal{P}_{basic} : \min_z f(z; y) \quad \text{s.t. } g(z; y) \leq 0$

LAPSO  $\mathcal{P}_{lapso} : \min_z f(z; \hat{y})$   
s.t.  $g(z; \hat{y}) \leq 0, \quad g_v(z; \hat{y}) \leq \tau$   
 $\hat{y} = v(z, x; \theta^*)$

(ML becomes a learnable parameters of optimization)



PSO cost vs aggregated forecast error (aggregated true solar minus solar forecast).  $\mathcal{P}_{lapso}$  underestimates renewable resources to reduce the frequency of re-scheduling of generators and reserves.