



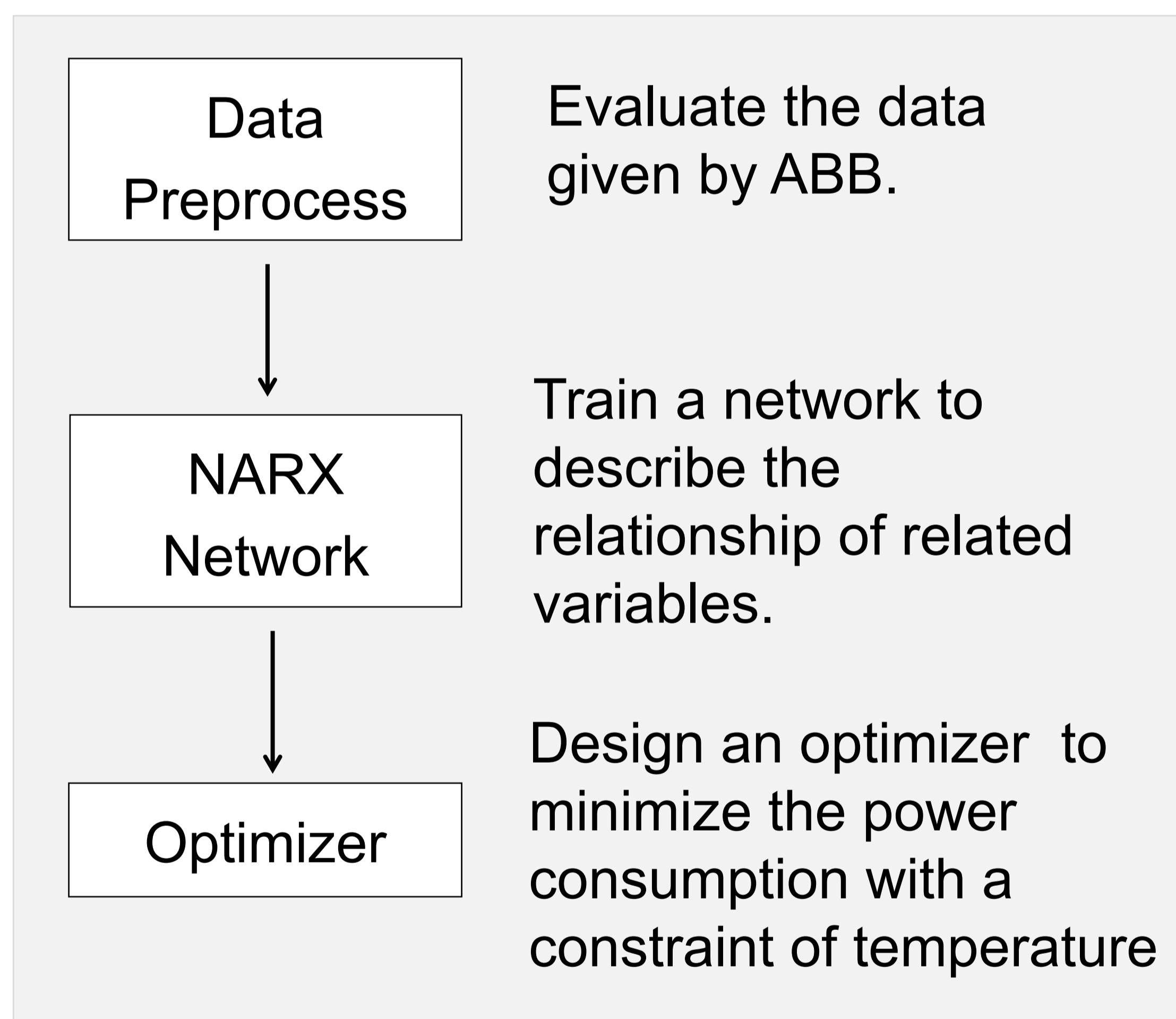
It's so cold... We didn't dust off the servers, we defrosted them. Data Based Optimization for Optimal Energy Consumption at Data Centers



Introduction

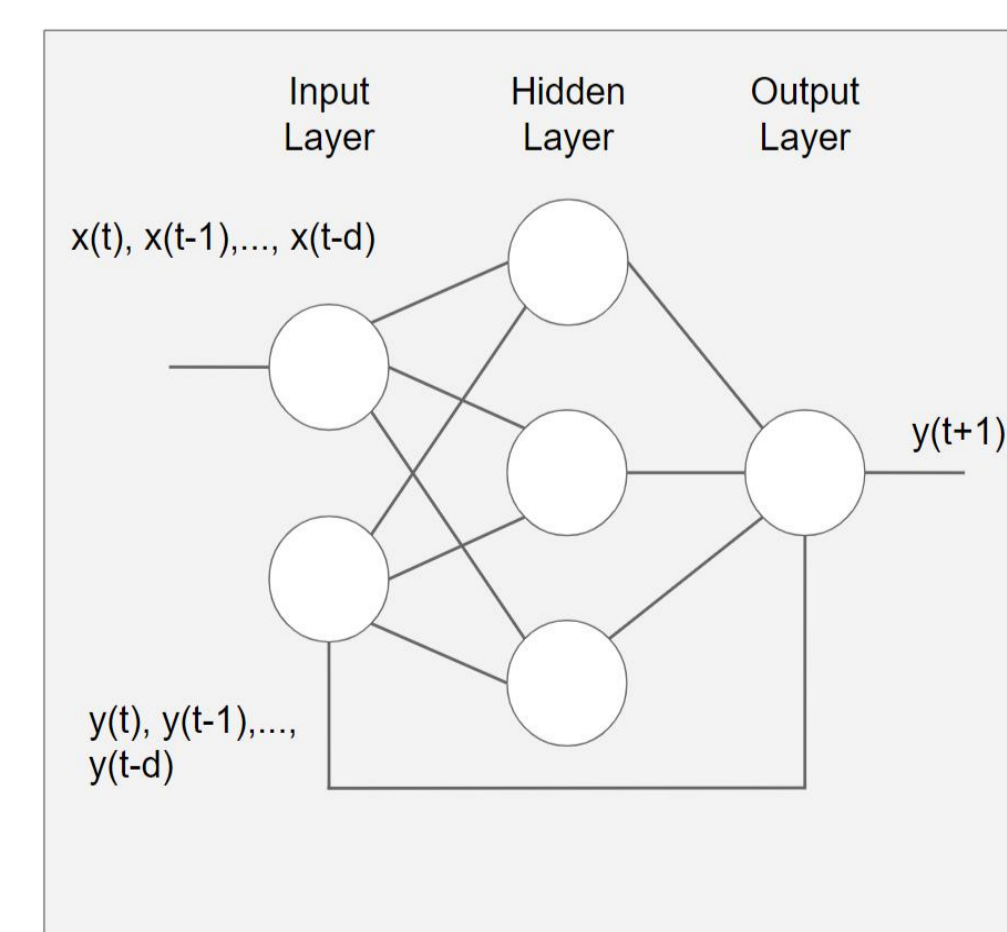
In recent years the demand for data centers have increased rapidly, which brings an interesting topic of optimizing their power consumption. One way is designing an automatic controller to avoid under or over cooling by adjusting the fan speed of cooling units.

Work Process

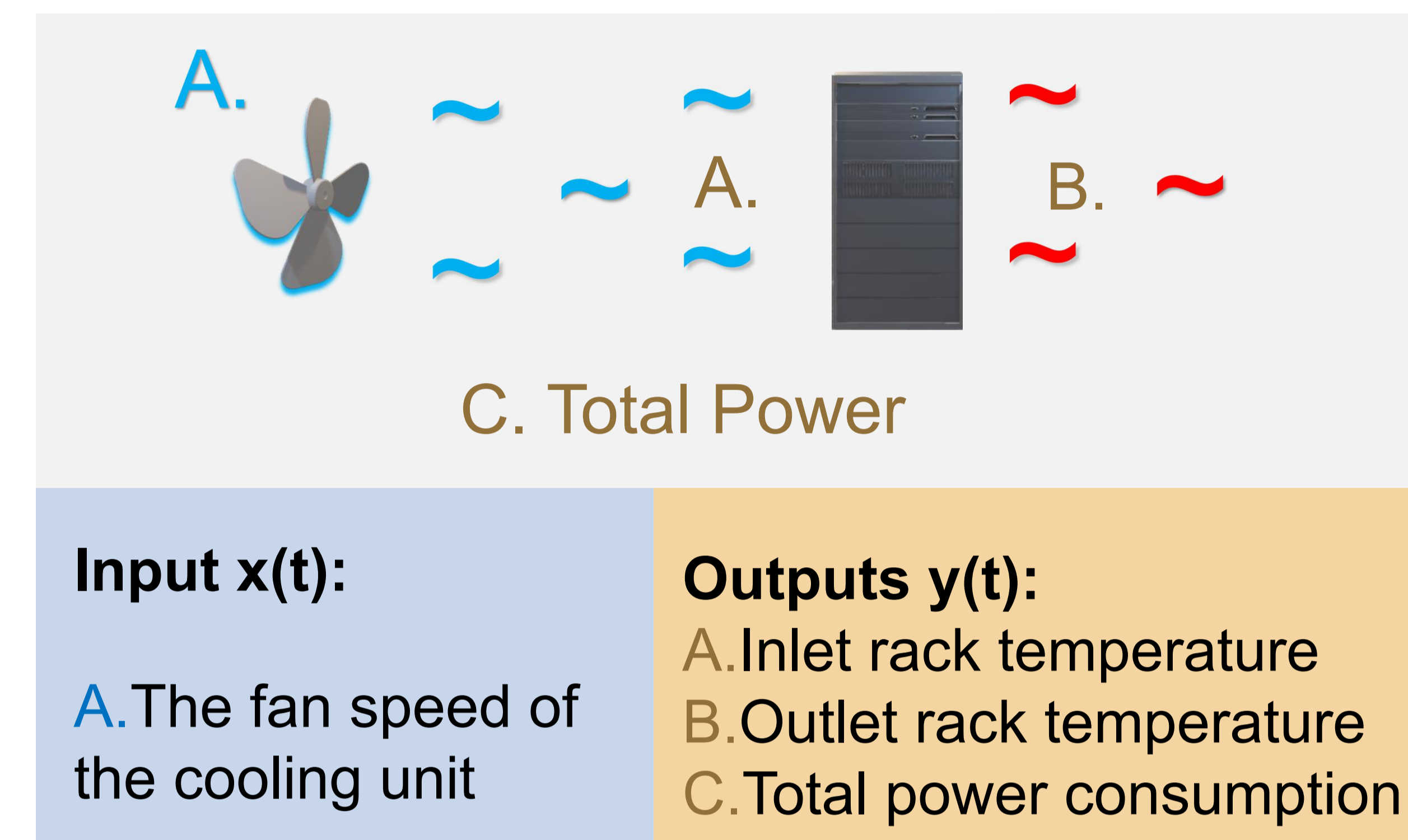


NARX Network

A NARX network is a nonlinear autoregressive network with exogenous inputs which uses data from previous time steps to predict the next one.

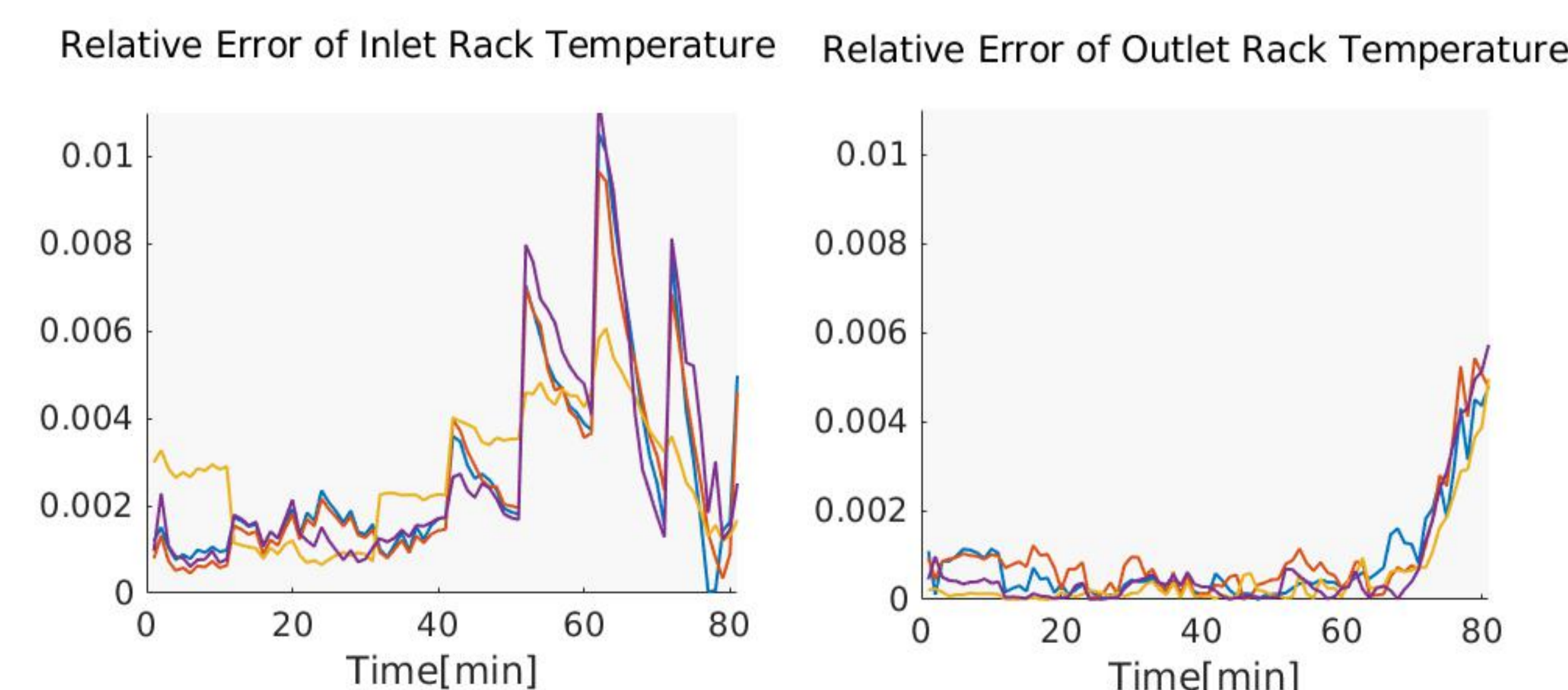
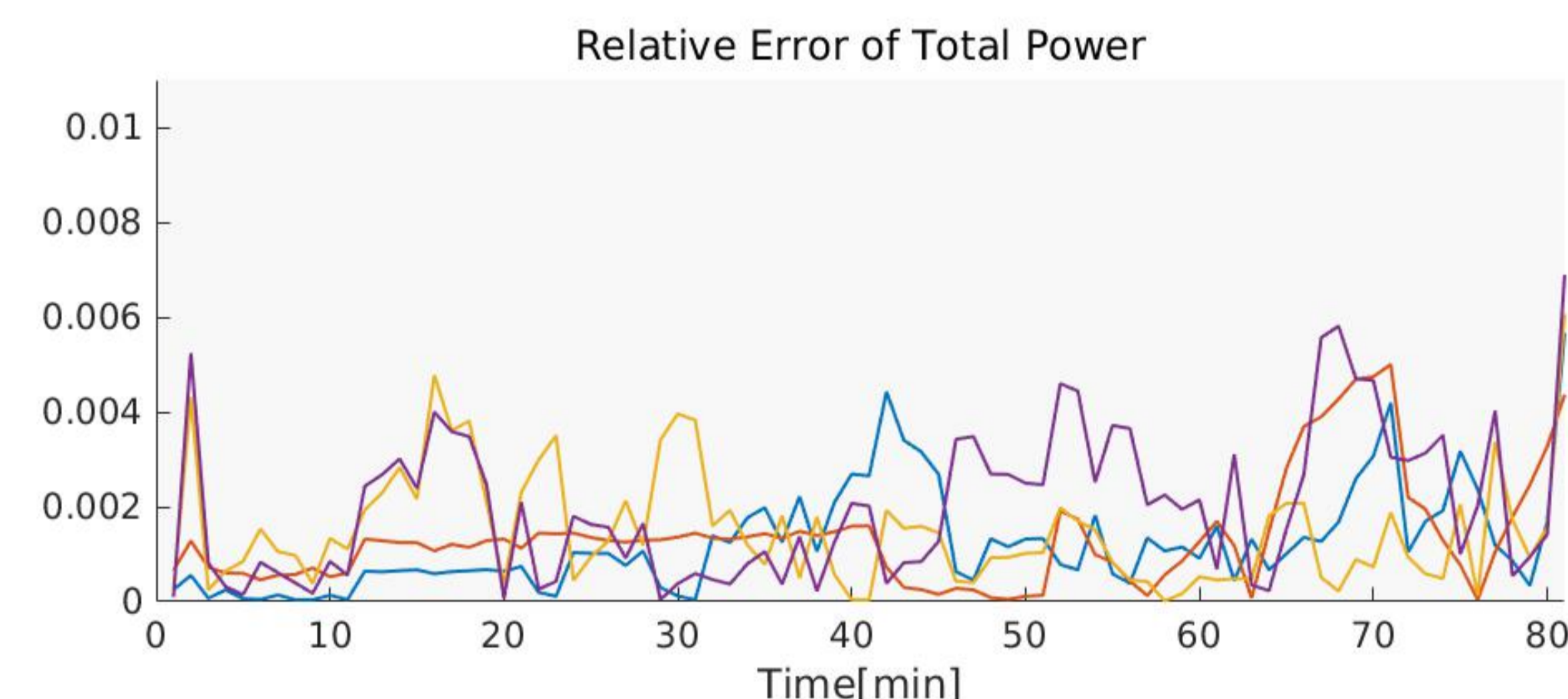


$$y(t) = f(y(t-1), y(t-2), \dots, y(t-d), x(t-1), x(t-2), \dots, x(t-d))$$



Evaluation of NARX network

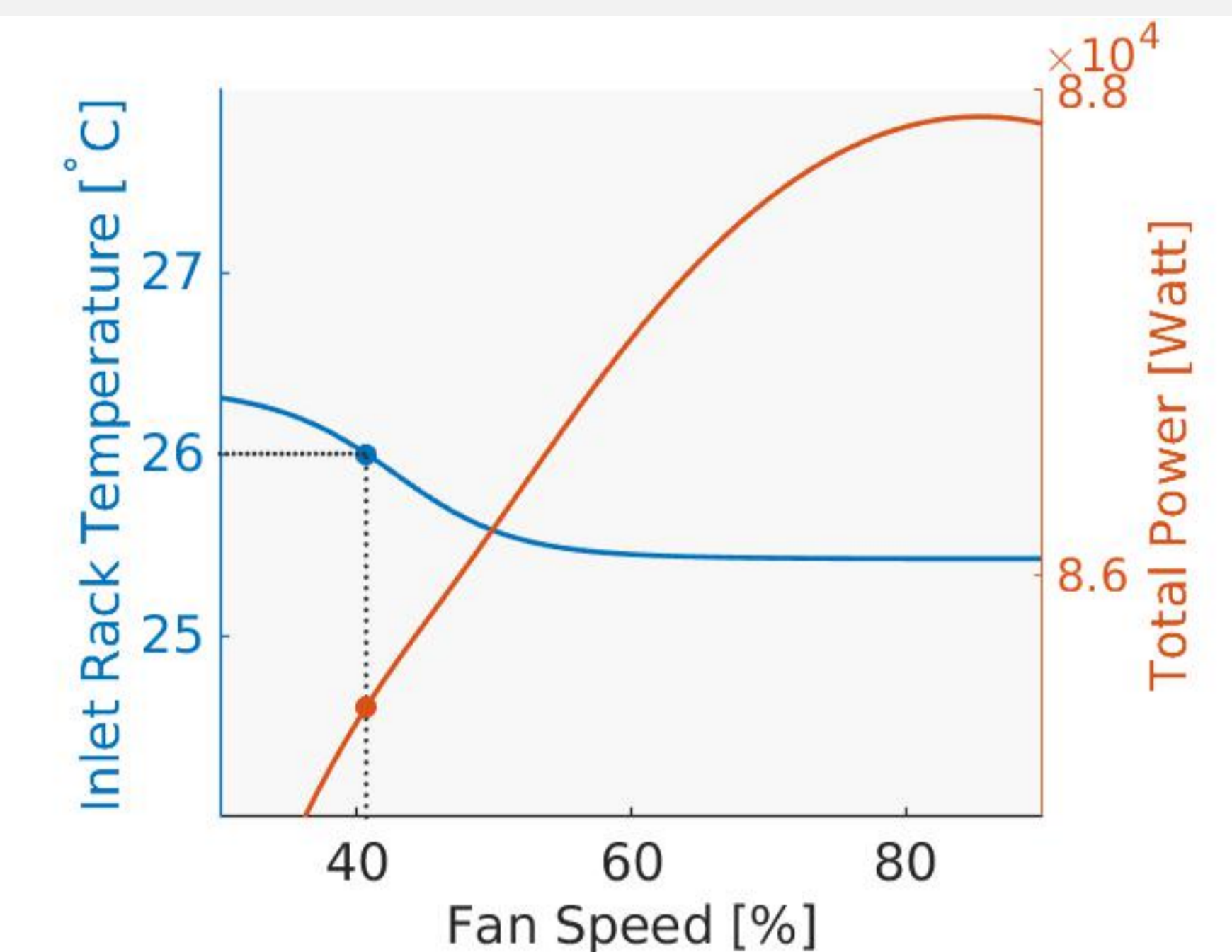
The relative error of the trained NARX network is less than 2% and it has a variance since the initial weights and bias of the network are chosen randomly.



Optimization

```

minimize Totalpower(FanSpeed)
subject to InletRackTemp ≤ TupperLimit
  
```



MATLAB has several built-in functions for solving this constrained optimization problem, among which *fmincon()* with sqp algorithm is the most efficient one.

Conclusions & Future Work

- NARX networks can be used to simulate the performance of cooling systems.
- Randomness in initial weight and bias of NARX network causes a variance which leads to different optimal fan speed.
- Performing real case trial is suggested, since the errors of the NARX network prediction will accumulate with time.
- It would be interesting to consider the IT-load of data center.

We want to give thanks to ABB for cooperating with UU and making this project possible.