Machine Learning in Economic Dispatch Problem - Deep Q Network based Reinforcement Learning Approach

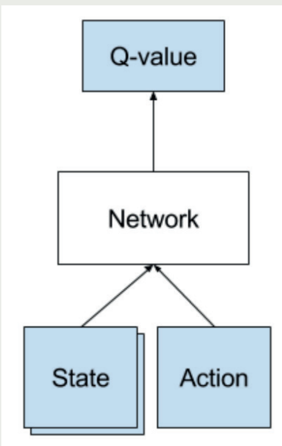
THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學

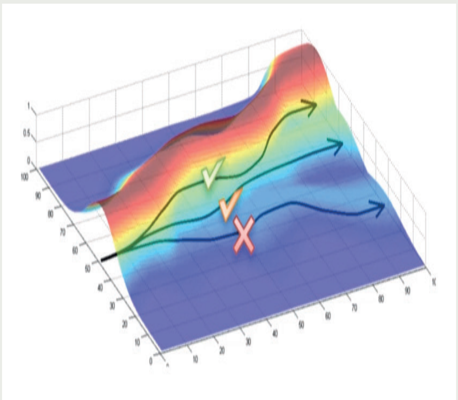
Department of Electrical Engineering 電機工程學系

Fung Chun Yin 13027548D Supervisor: Dr. C.W. Yu

Deep Q Network (DQN) has achieved gameplay learning sucessfully. If our engineering problem can be treated as a game, can machine also solve it? In the traditional approach, we have found that for many situations in practice we cannot easily find the optimal maginal cost λ of power generation. In this project, machine learned by itself to solve economic dispatch problems!

Engineering Problem -> Machine Gaming -> Learning -> Playing -> Engineering Solution





DQN

Actor

Critic

Policy

Reinforcement Learning Theory

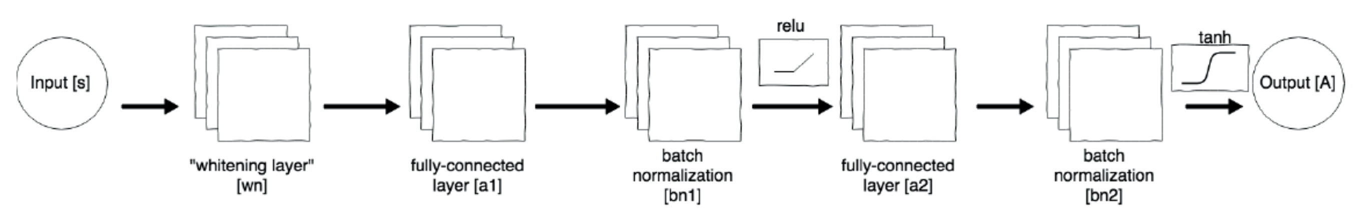


Figure 14: Neural Network for Actor: $A(s) = a; s \in \mathbb{R}^{n_s}, a \in (-1,1)^{n_a}$

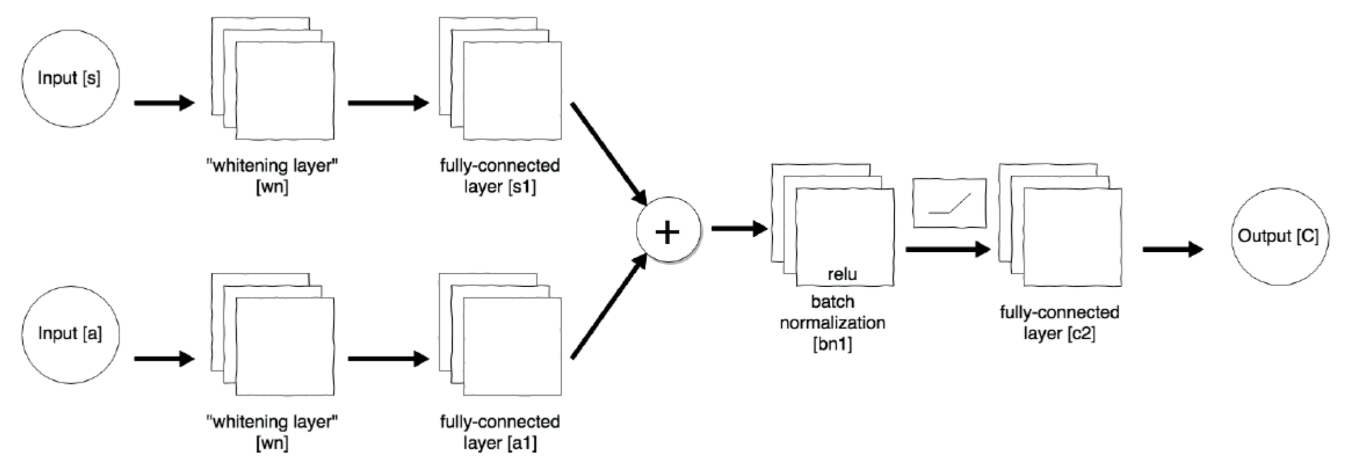
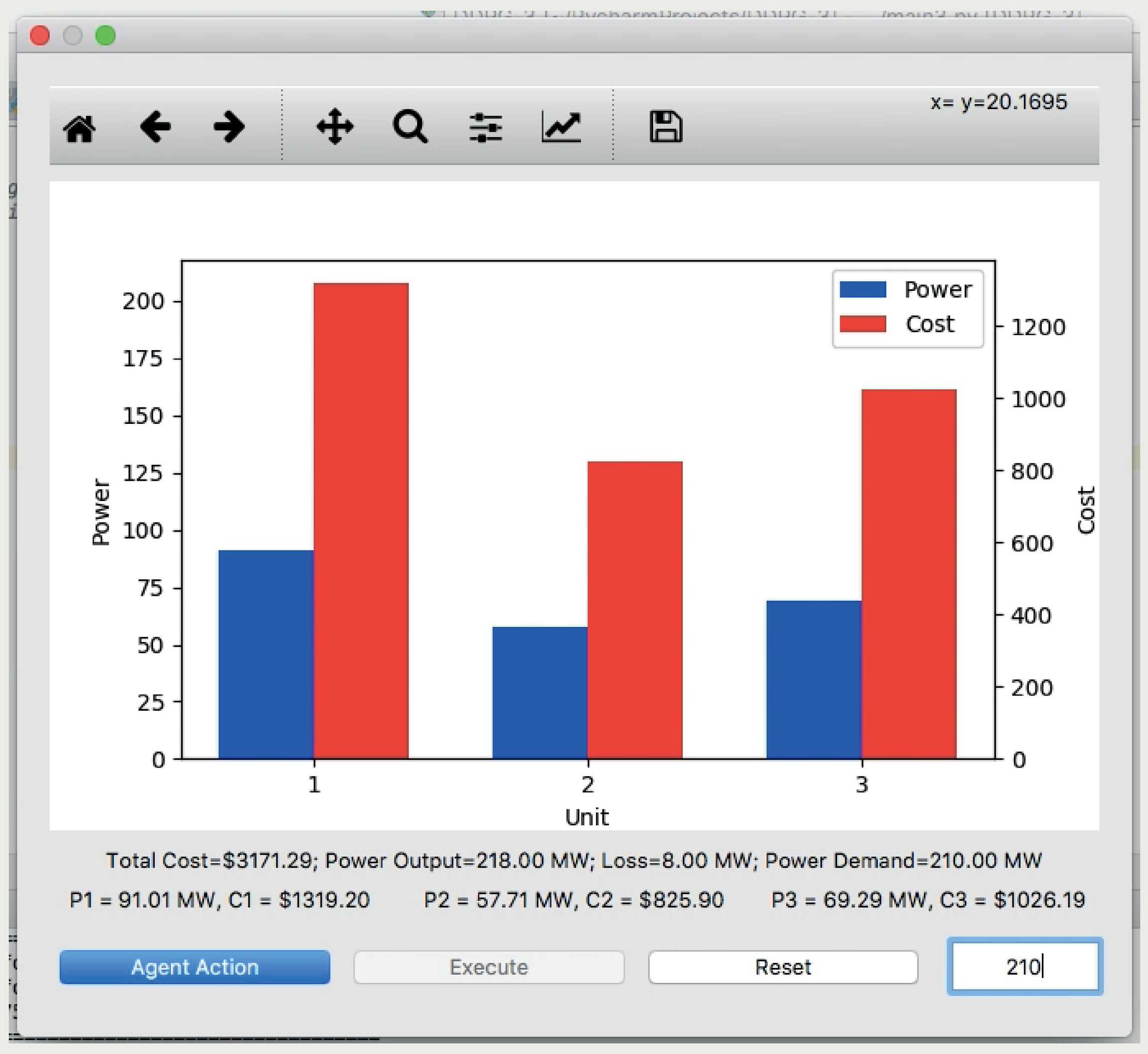


Figure 15: Neural Network for Critic: $C(s,a) = Q; s \in \mathbb{R}^{n_s}, a \in (-1,1)^{n_a}, Q \in \mathbb{R}^1$

Deep Deterministic Policy Gradient Neural Network Model



Engineering Problem as a Game

Evaluate on 3-generator system with demands 140/240/340/440MW

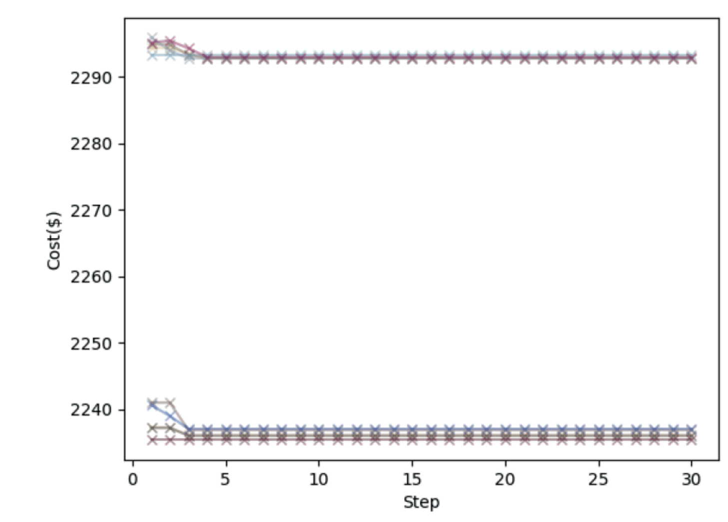


Figure 26: Optimizing the cost for $P_d = 140$ MW (lossy/lossess)

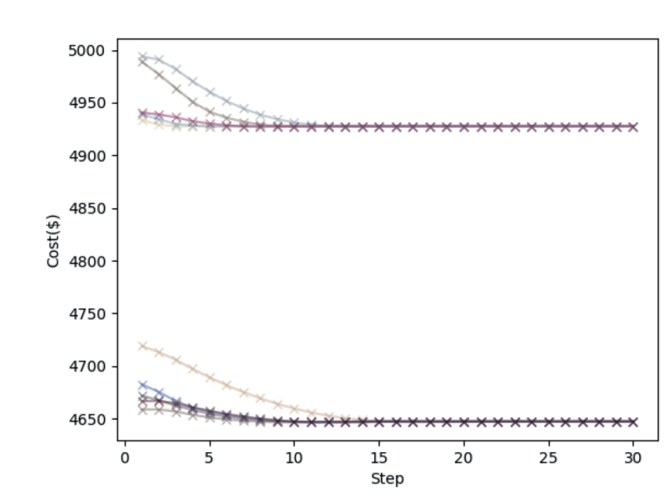


Figure 28: Optimizing the cost for $P_d = 340$ MW (lossy/lossess)

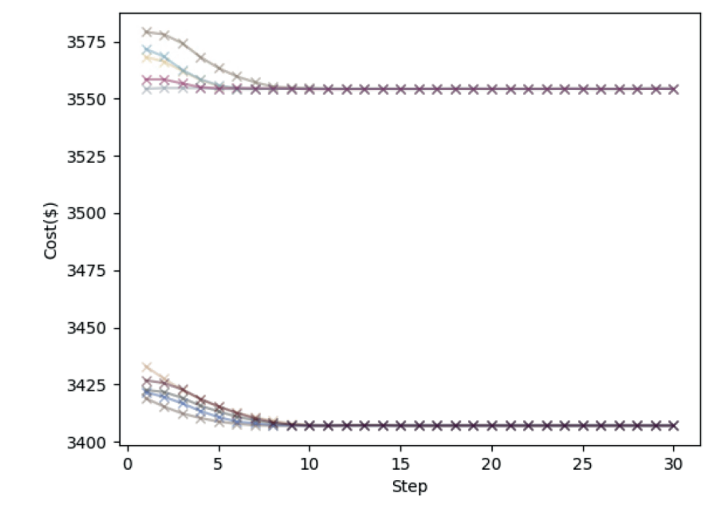


Figure 27: Optimizing the cost for $P_d = 240$ MW (lossy/lossess)

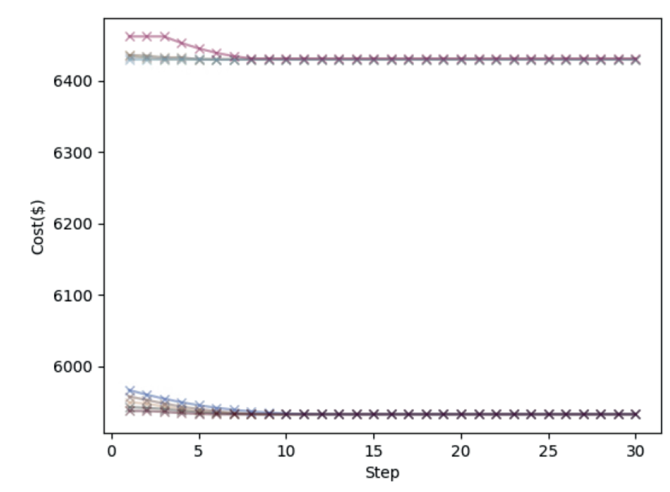
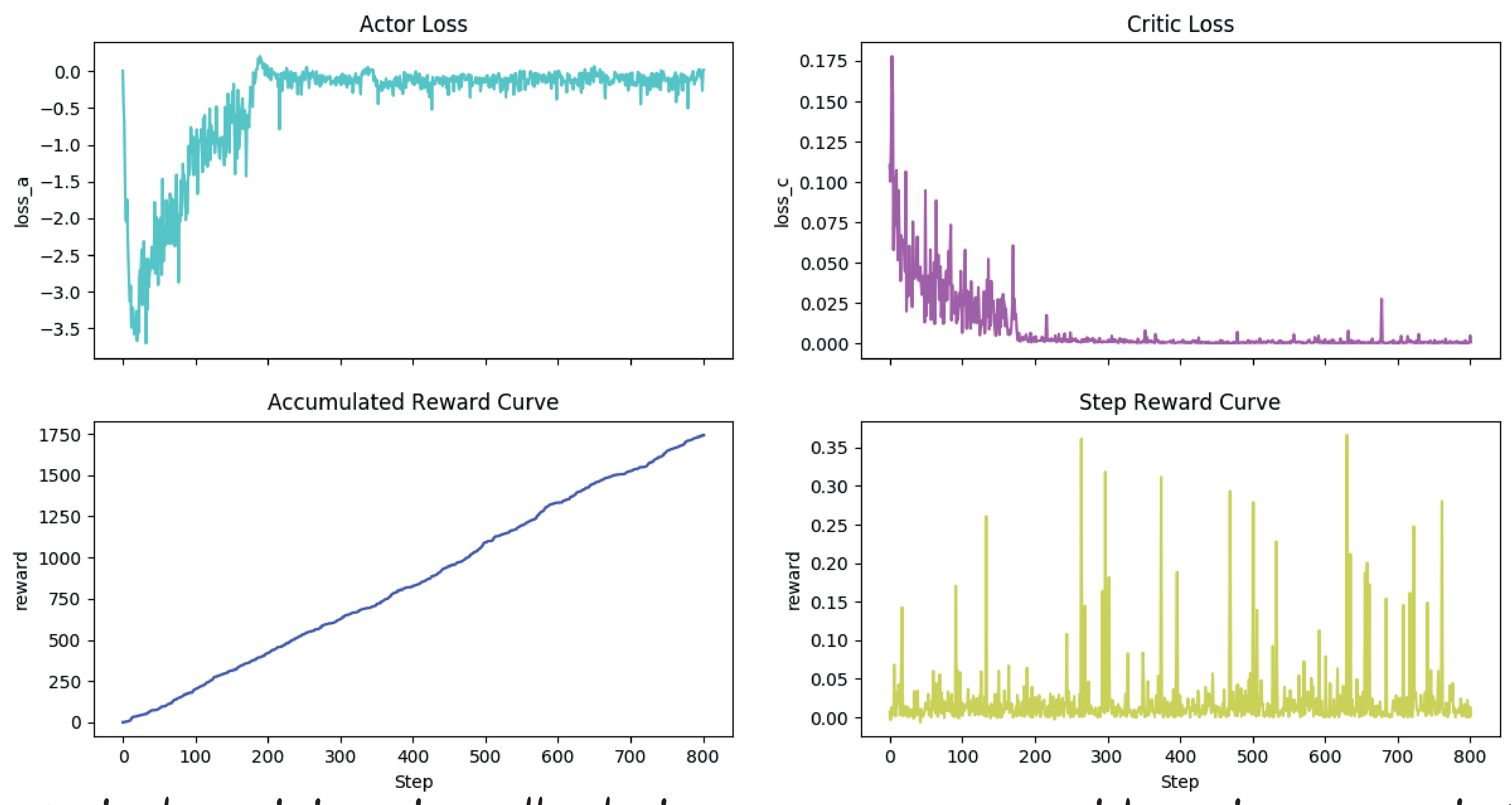


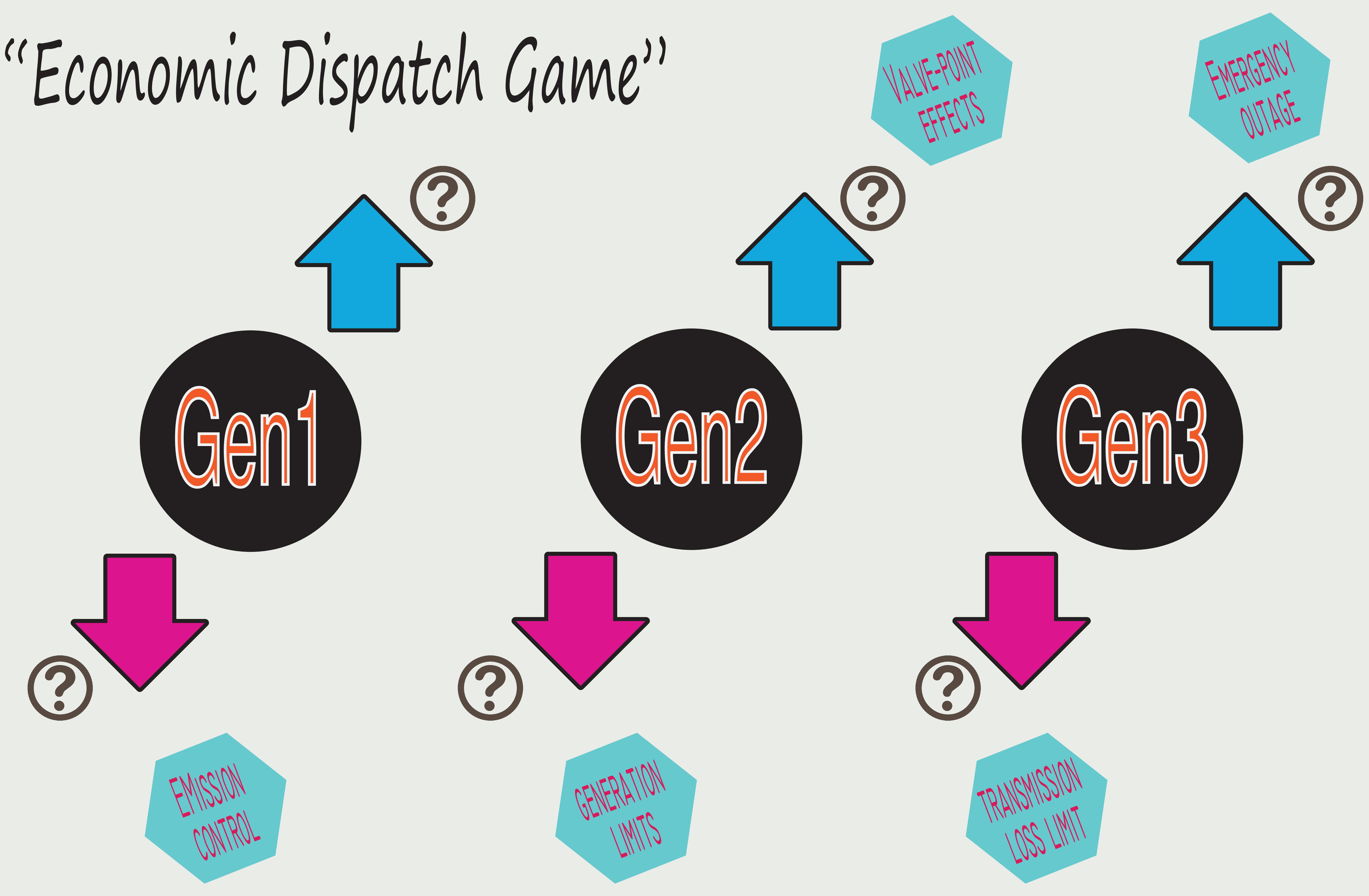
Figure 29: Optimizing the cost for $P_d = 440$ MW (lossy/lossess)

Train with full-connected hidden layers consisted of 300 neurous



A single training gives all solution on a same case with various scenarios!

"Economic Dispatch Game"



>> Objectives:

1) Well-trained network can give us a good solution much faster that the stochastic searching for repetitive usages

2) No re-learning is required for the change of designed conditions

>> How?

I made an imaginary game that allows the machine understand the relationship between dispatches and the change of total cost. Neural Network is applied to remember and learn the results.

>> How the game works?

The rewards is the cost reduction for a state transition.

positive -> good action negative -> bad action

Theoricality the agent can pass through all obstacles and find the best way to obtain highest cost reduction from any initial state!

>> It works? Any conclusion?

It works in a small system, which is a good start. However if the system gets complicated, much deeper network is required. For a large and practical environment, the agent may have to take days in learning with a very deep network.