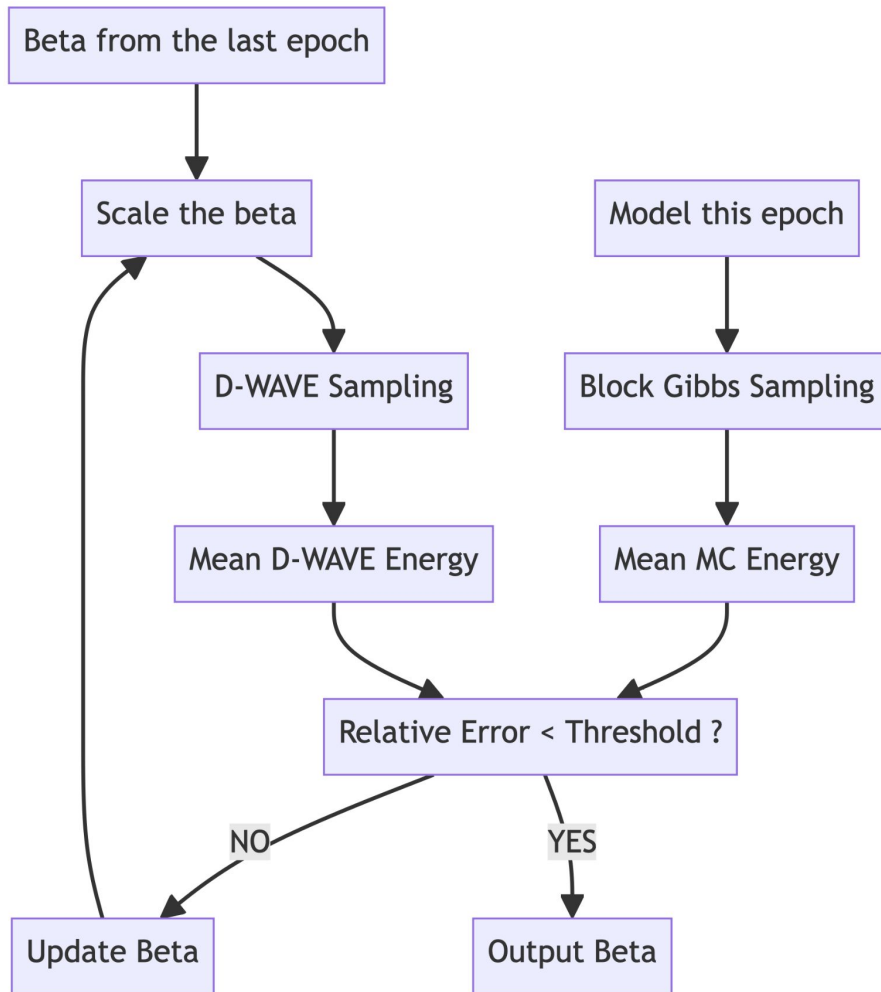
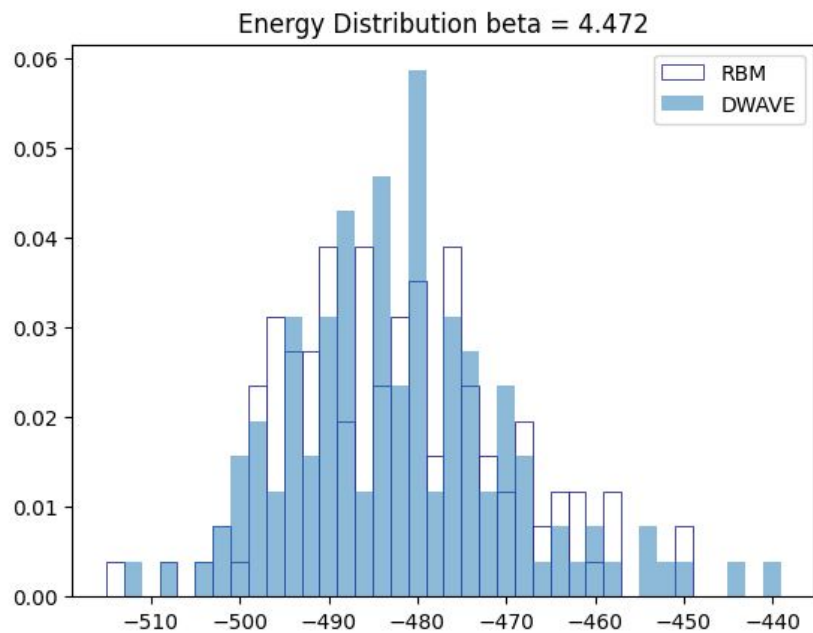


Temperature Estimation During Training

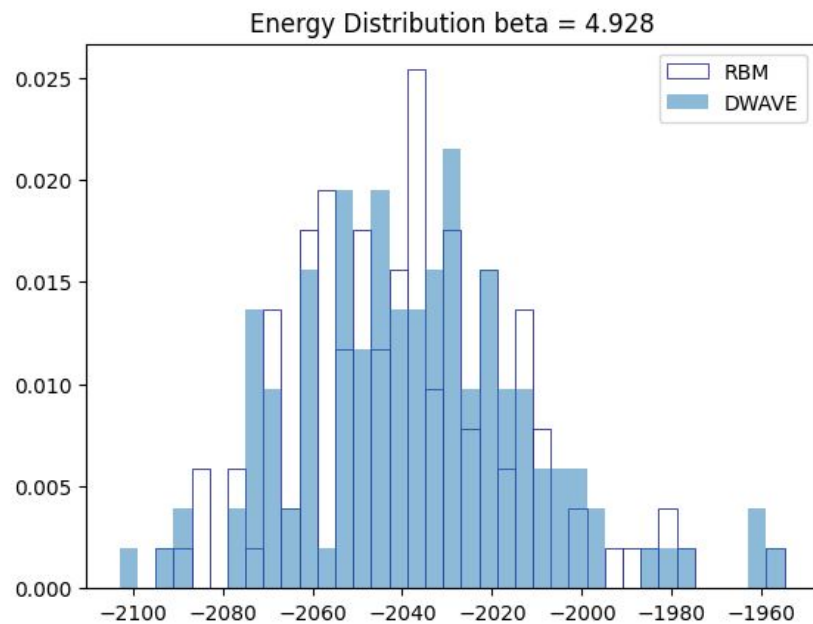
- When is the beta well trained?
- How to make the standard independent from?
 - Learning Rate
 - Number of Nodes (Mean Energy, energy scale)
- How to train the beta effectively (safely)?
- How to prevent reaching D-WAVE limit during training/beta training?



n of nodes per layer = 128



n of nodes per layer = 512



Loss Limit

```
energy_loss = abs(mean_dwave_energy - mean_rbm_energy)
```

```
loss_limit = np.var(rbm_energies) * error_limit_ratio
```

- Independent with number of nodes
- Independent with the size of mean energy.

Beta Limit

- Min beta = 2 during the beta training
- Won't need to care about higher beta

`n of nodes per layer = 512`

`beta = max(beta - lr * (mean_dwave_energy - mean_rbm_energy), 2.0) , lr=0.1`

Method 1

```
beta, error_list, rbm_energies, dwave_energies = beta_training(model, beta_init = 100.0)
⊗ 43.0s
The error_limit is: 4.999545288085938
The number of epoch is: 1      The beta is: 2.0      The energy loss is: 1856.0181958675385
The number of epoch is: 2      The beta is: 30.483887505531314      The energy loss is: 284.8388750553131
The number of epoch is: 3      The beta is: 2.0      The energy loss is: 1417.5135419368744
The number of epoch is: 4      The beta is: 30.023780083656312      The energy loss is: 280.2378008365631
The number of epoch is: 5      The beta is: 2.0      The energy loss is: 1418.334464788437
The number of epoch is: 6      The beta is: 30.452881646156314      The energy loss is: 284.5288164615631
The number of epoch is: 7      The beta is: 2.0      The energy loss is: 1433.2275922298431
The number of epoch is: 8      The beta is: 30.230835747718814      The energy loss is: 282.3083574771881
```

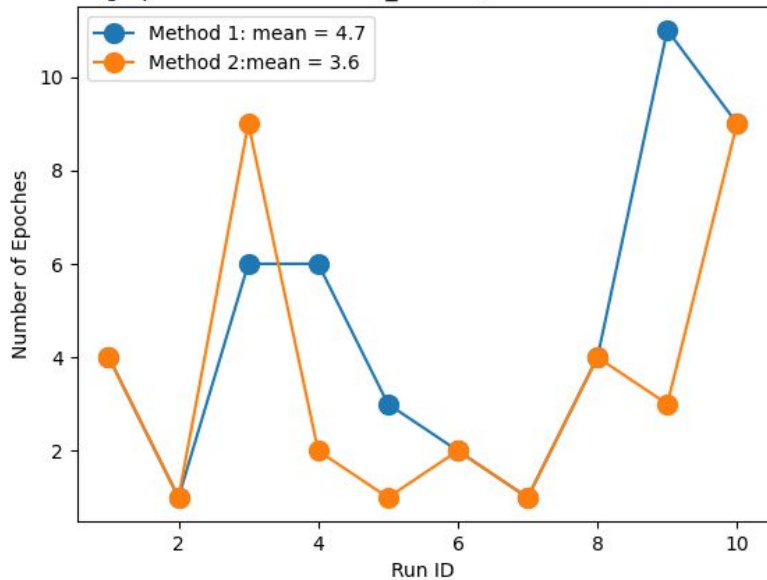
Method 2

`beta = max(beta * (mean_dwave_energy / mean_rbm_energy)**power, 2.0) power = 4`

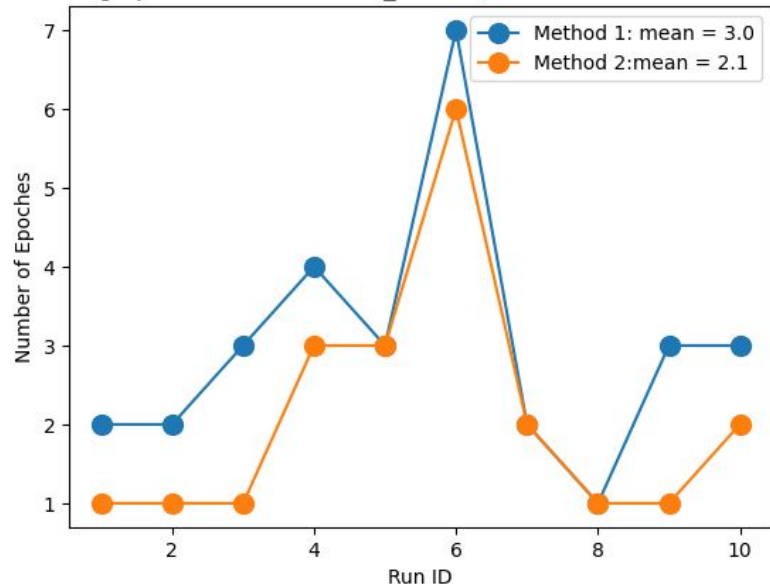
```
The error_limit is: 4.883040771484375
The number of epoch is: 1      The beta is: 2.0      The energy loss is: 1842.6183339357376
The number of epoch is: 2      The beta is: 3.3803340567305784      The energy loss is: 285.8223398923874
The number of epoch is: 3      The beta is: 4.732109431334821      The energy loss is: 178.8621348142624
The number of epoch is: 4      The beta is: 5.07920413696327      The energy loss is: 36.39631450176239
The number of epoch is: 5      The beta is: 5.149997790701203      The energy loss is: 7.06672465801239
The number of epoch is: 6      The beta is: 5.065853906822259      The energy loss is: 8.37858784198761
The number of epoch is: 7      The beta is: 5.117269493574827      The energy loss is: 5.15315043926239
The number of epoch is: 8      The beta is: 5.211023693651247      The energy loss is: 9.27400004863739
The number of epoch is: 9      The beta is: 5.070120653940952      The energy loss is: 13.92277729511261
The number of epoch is: 10     The beta is: 5.132352068205577      The energy loss is: 6.22700297832489
The number of epoch is: 11     The beta is: 5.135008568138234      The energy loss is: 0.26374614238739014
The trained beta is: 5.135008568138234
The number of epoch of the beta training is: 11
```

Lr = 0.01 vs Training power = 4, Error Limit Ratio = 0.01

Training Epochs needed: beta_init = 5, number of nodes = 4 x 128



Training Epochs needed: beta_init = 5, number of nodes = 4 x 512



Lr = 0.01 vs Training power = 4, Error Limit Ratio = 0.01

