Example with 8 EVs and 8 hours Horizon

EV	Energy Demand (KWh)	Elapsed Time of charging (h)
1	50	6
2	50	6
3	50	6
4	50	6
5	50	6
6	50	6
7	10	1
8	10	1

Optimization Variables

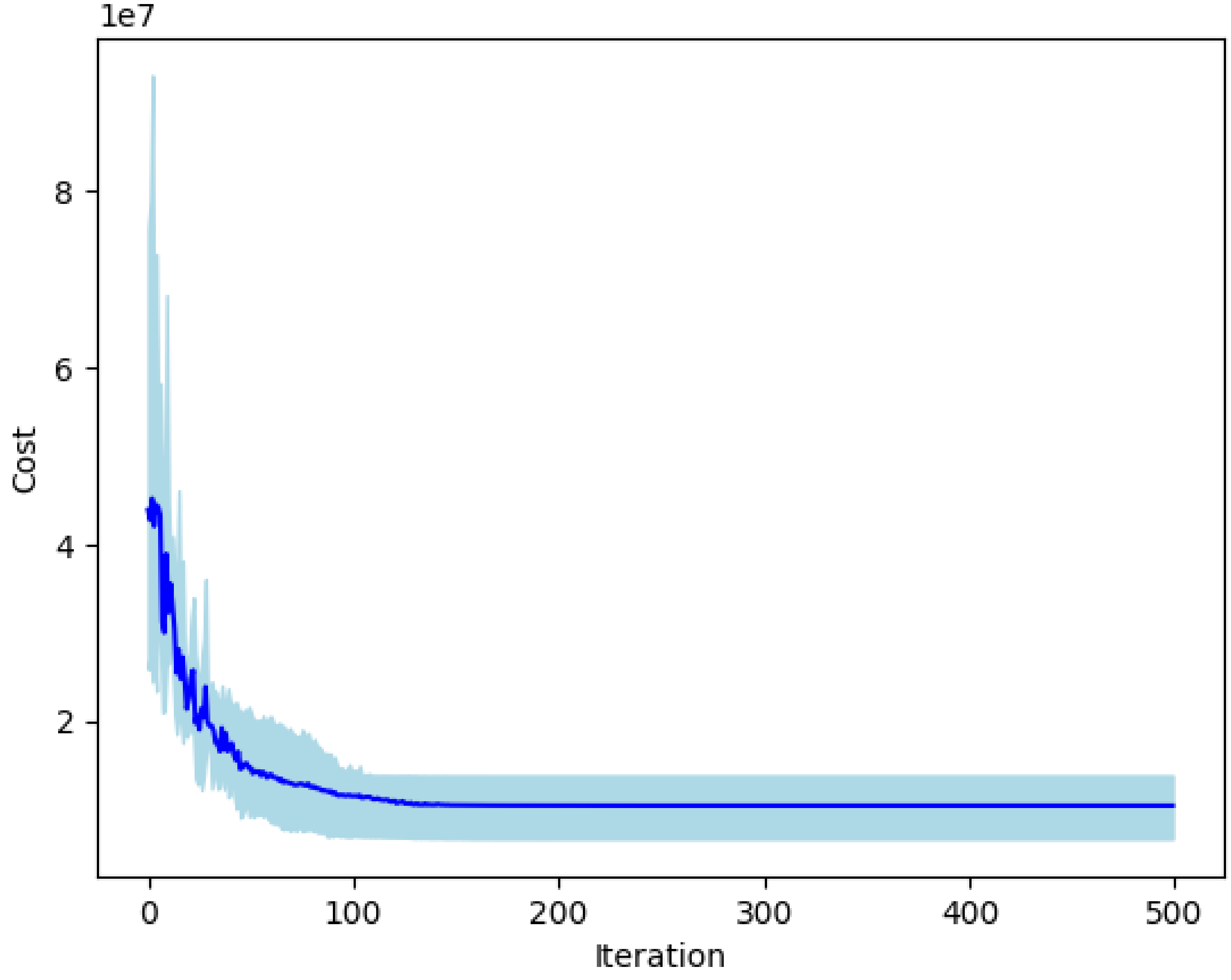
$$\boldsymbol{r} = \overbrace{\begin{bmatrix}
r_1(1) & r_1(2) & r_1(3) & r_1(4) & r_1(5) & r_1(6) & r_1(7) & r_1(8) \\
r_2(1) & r_2(2) & r_2(3) & r_2(4) & r_2(5) & r_2(6) & r_2(7) & r_2(8) \\
r_3(1) & r_3(2) & r_3(3) & r_3(4) & r_3(5) & r_3(6) & r_3(7) & r_3(8) \\
r_4(1) & r_4(2) & r_4(3) & r_4(4) & r_4(5) & r_4(6) & r_4(7) & r_4(8) \\
r_5(1) & r_5(2) & r_5(3) & r_5(4) & r_5(5) & r_5(6) & r_5(7) & r_5(8) \\
r_6(1) & r_6(2) & r_6(3) & r_6(4) & r_6(5) & r_6(6) & r_6(7) & r_6(8) \\
r_7(1) & r_7(2) & r_7(3) & r_7(4) & r_7(5) & r_7(6) & r_7(7) & r_7(8) \\
r_8(1) & r_8(2) & r_8(3) & r_8(4) & r_8(5) & r_8(6) & r_8(7) & r_8(8)
\end{bmatrix}}^{\text{Horizon}} \left.\vphantom{\begin{matrix} 1\\1\\1\\1\\1\\1\\1\\1 \end{matrix}}\right\} \text{Num of EVs}$$

Method 1: Use one circuit for the entire matrix

VQE Circuit

$$\text{VQE Circuit} \longrightarrow |a\rangle = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_{64} \end{bmatrix} \longrightarrow \boldsymbol{r} = c * \begin{bmatrix} |a_1|^2 \\ |a_2|^2 \\ \vdots \\ |a_{64}|^2 \end{bmatrix} \longrightarrow \lceil \log_2 64 \rceil = 6\ qubits$$

Method 1: Result



Method 2: Use a circuit for every column of the matrix

$\lceil \log_2 8 \rceil = 3\ qubits$

$\boldsymbol{\theta}_1$ VQE Circuit $\rightarrow |a_1\rangle = \begin{bmatrix} a_{1,1} \\ \vdots \\ a_{1,8} \end{bmatrix} \rightarrow \boldsymbol{r}(1) = c * \begin{bmatrix} |a_{1,1}|^2 \\ \vdots \\ |a_{1,8}|^2 \end{bmatrix}$

$\vdots$

$\lceil \log_2 8 \rceil = 3\ qubits$

$\boldsymbol{\theta}_8$ VQE Circuit $\rightarrow |a_8\rangle = \begin{bmatrix} a_{8,1} \\ \vdots \\ a_{8,8} \end{bmatrix} \rightarrow \boldsymbol{r}(8) = c * \begin{bmatrix} |a_{8,1}|^2 \\ \vdots \\ |a_{8,8}|^2 \end{bmatrix}$

$$\boldsymbol{r} = [\boldsymbol{r}(1), \dots, \boldsymbol{r}(8)]$$

Method 2

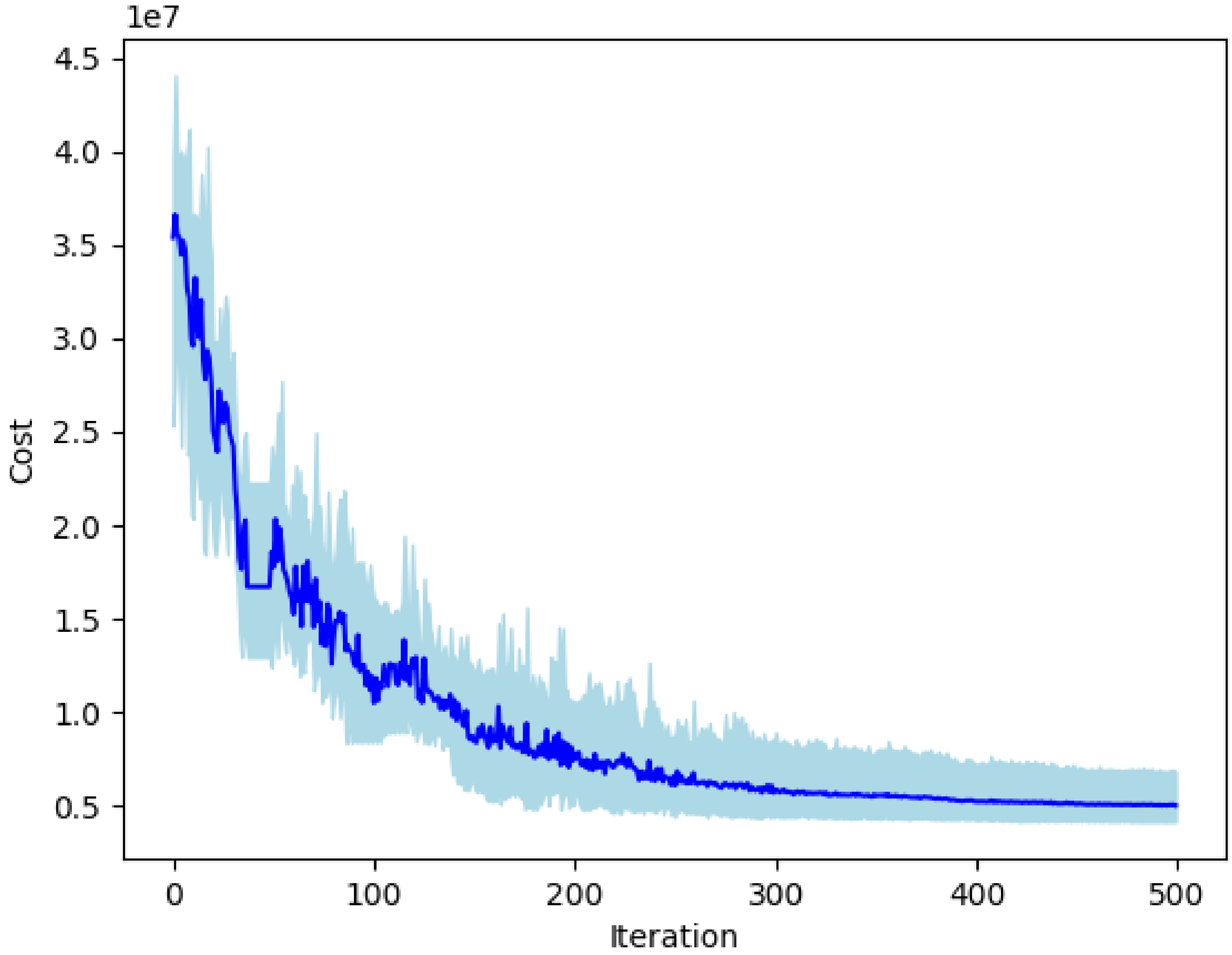
$$\boldsymbol{r} = \begin{bmatrix} r_1(1) & r_1(2) & r_1(3) & r_1(4) & r_1(5) & r_1(6) & r_1(7) & r_1(8) \\ r_2(1) & r_2(2) & r_2(3) & r_2(4) & r_2(5) & r_2(6) & r_2(7) & r_2(8) \\ r_3(1) & r_3(2) & r_3(3) & r_3(4) & r_3(5) & r_3(6) & r_3(7) & r_3(8) \\ r_4(1) & r_4(2) & r_4(3) & r_4(4) & r_4(5) & r_4(6) & r_4(7) & r_4(8) \\ r_5(1) & r_5(2) & r_5(3) & r_5(4) & r_5(5) & r_5(6) & r_5(7) & r_5(8) \\ r_6(1) & r_6(2) & r_6(3) & r_6(4) & r_6(5) & r_6(6) & r_6(7) & r_6(8) \\ r_7(1) & r_7(2) & r_7(3) & r_7(4) & r_7(5) & r_7(6) & r_7(7) & r_7(8) \\ r_8(1) & r_8(2) & r_8(3) & r_8(4) & r_8(5) & r_8(6) & r_8(7) & r_8(8) \end{bmatrix}$$

Sum = c

Since $sum([|a_{i,1}|^2, \ldots, |a_{i,1}|^2]) = 1 \quad if\ r(i) = c * [|a_{i,1}|^2, \ldots, |a_{i,1}|^2] \longrightarrow \quad sum(r(i)) = c$

We set c= max aggregate current rate

Method 2: Result



Method 3: Use a circuit for every row of the matrix

$\lceil \log_2 8 \rceil = 3\ qubits$

$\boldsymbol{\theta}_1$ VQE Circuit $\rightarrow |a_1\rangle = \begin{bmatrix} a_{1,1} \\ \vdots \\ a_{1,8} \end{bmatrix} \rightarrow \boldsymbol{r}_1 = c * \begin{bmatrix} |a_{1,1}|^2 \\ \vdots \\ |a_{1,8}|^2 \end{bmatrix}$

$\vdots$

$\lceil \log_2 8 \rceil = 3\ qubits$

$\boldsymbol{\theta}_8$ VQE Circuit $\rightarrow |a_8\rangle = \begin{bmatrix} a_{8,1} \\ \vdots \\ a_{8,8} \end{bmatrix} \rightarrow \boldsymbol{r}_8 = c * \begin{bmatrix} |a_{8,1}|^2 \\ \vdots \\ |a_{8,8}|^2 \end{bmatrix}$

$$\boldsymbol{r} = \begin{bmatrix} r_1 \\ \vdots \\ r_8 \end{bmatrix}$$

Method 2

$$\boldsymbol{r} = \begin{bmatrix} r_1(1) & r_1(2) & r_1(3) & r_1(4) & r_1(5) & r_1(6) & r_1(7) & r_1(8) \\ r_2(1) & r_2(2) & r_2(3) & r_2(4) & r_2(5) & r_2(6) & r_2(7) & r_2(8) \\ r_3(1) & r_3(2) & r_3(3) & r_3(4) & r_3(5) & r_3(6) & r_3(7) & r_3(8) \\ r_4(1) & r_4(2) & r_4(3) & r_4(4) & r_4(5) & r_4(6) & r_4(7) & r_4(8) \\ r_5(1) & r_5(2) & r_5(3) & r_5(4) & r_5(5) & r_5(6) & r_5(7) & r_5(8) \\ r_6(1) & r_6(2) & r_6(3) & r_6(4) & r_6(5) & r_6(6) & r_6(7) & r_6(8) \\ r_7(1) & r_7(2) & r_7(3) & r_7(4) & r_7(5) & r_7(6) & r_7(7) & r_7(8) \\ r_8(1) & r_8(2) & r_8(3) & r_8(4) & r_8(5) & r_8(6) & r_8(7) & r_8(8) \end{bmatrix}$$

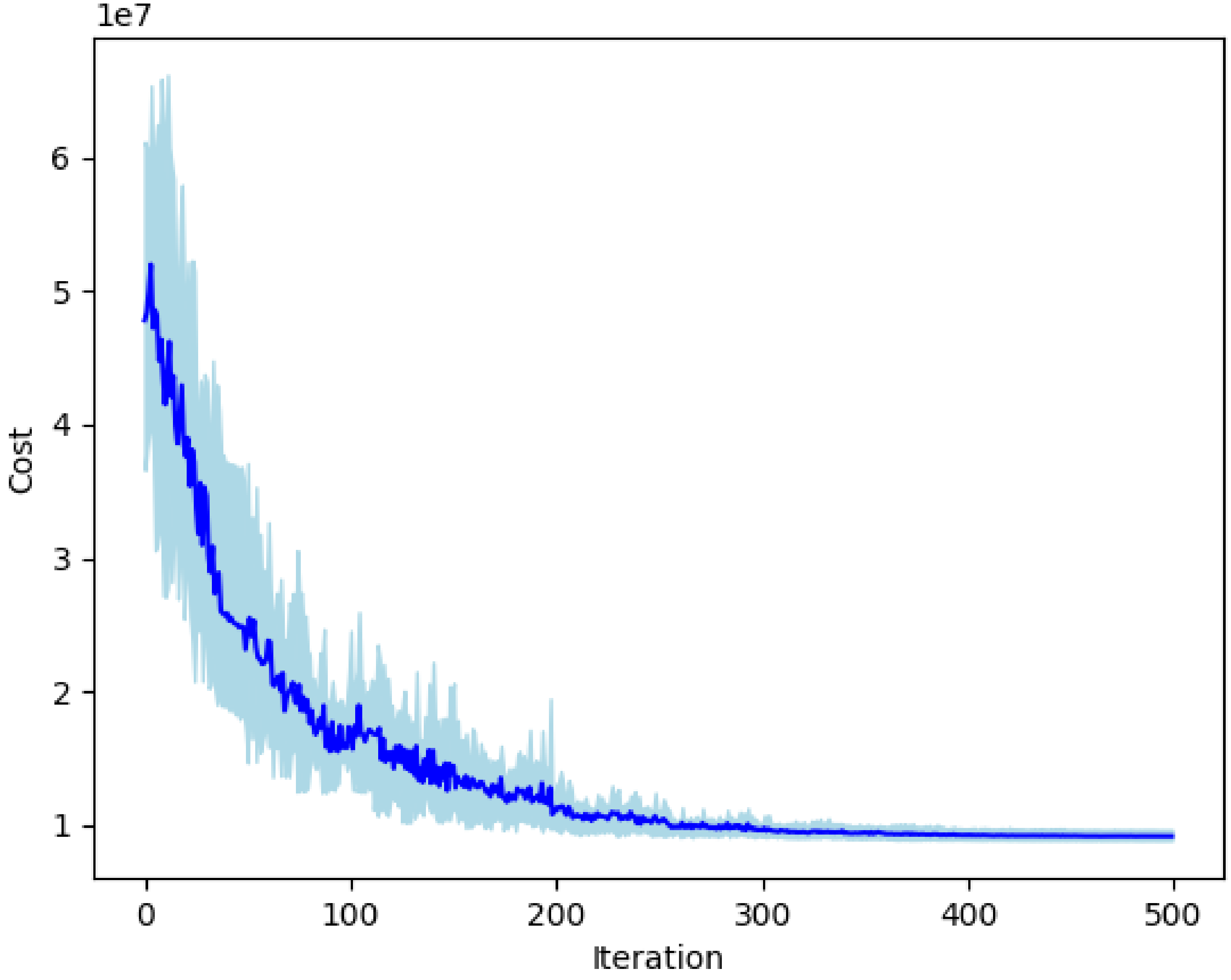
Sum = c

Sum = c

Since $sum([|a_{i,1}|^2, \dots, |a_{i,1}|^2]) = 1 \quad if\ r_i = c * [|a_{i,1}|^2, \dots, |a_{i,1}|^2]$ $\longrightarrow$ $sum(r_i) = c$

We set c= total rate needed for EV i

Method 3: Result



Comparison: % of Demand met w.r.t. power limit