Improvement comes after solving to optimality models with rather small neighborhood search sizes $2 \leq K \leq 4$. The convenience of allowing large neighborhood search sizes as $K = 16$ or $K = 36$ is reflected from this moment. From point 30 to 33 (6 h) with $K = 16$ the incumbent is slowly boosted by nearly 1%. Again, after a three-hours-plateau, $N$ becomes equal to 1907, and in around 32 min for $2 \leq K \leq 4$, the AEP is augmented by 0.41%. Then, the large neighborhood search starts for $K = 16$ and $K = 36$, and after a total of 16 h, the final solution of 865 GWh (increment of 0.61%) is achieved (Fig. 8b).

The full model (i.e. without implementing the NSH algorithm) initially provides better solutions within the first 3 h, but then lags behind in solution quality compared to the NSH algorithm in the long run (lower 3.05%), as shown in in Fig. 7.

For this case, the proposed method reaches the best solution, as shown in the fifth column of Table 2. The SNOPT+WEC is again the closest contender. When uniquely comparing to GF methods, the proposed method matches the best solution from those algorithms in around 3 h, which is generally a reasonable computing time compared to methods where gradients are not explicitly utilized in the optimization process, especially to metaheuristics as genetic algorithm or swarm optimization.

![Initial wind farm layout provided to the heuristic.](image1)

![Final wind farm layout obtained by the heuristic.](image2)

**Figure 8.** Generated wind farm layouts for the benchmark Case II with 36 wind turbines.

### 5.4 Case III: 64 WTs

This case has a round shape of 3000 m radius and $n_T = 64$ WTs. The evolution of the proposed methods, and the initial and final WT layouts are displayed in Fig. 9 and Fig. 10, respectively. Table C1 displays the data linked to each point of Fig. 9. Main inputs are $C = \{625, 1017, 2741\}$, $T = \{1, 1.5, 2\}$ h, $V = \{2, 4, 8, 16, 32, 64\}$. Note that in comparison the number of elements of $V$ has been increased by one after each study case. This has been done taking into account the number of WTs. Likewise, the values of $N \in C$ are larger to cover for the wider project areas.

Comparing blue lines of Fig. 5, Fig. 7, and Fig. 9 is evident that for the last case the curve shows less sudden increases. The largest change occurs after 27 s where the initial solution (Fig. 10a) with AEP of 1395 GWh is improved by 3.18% for