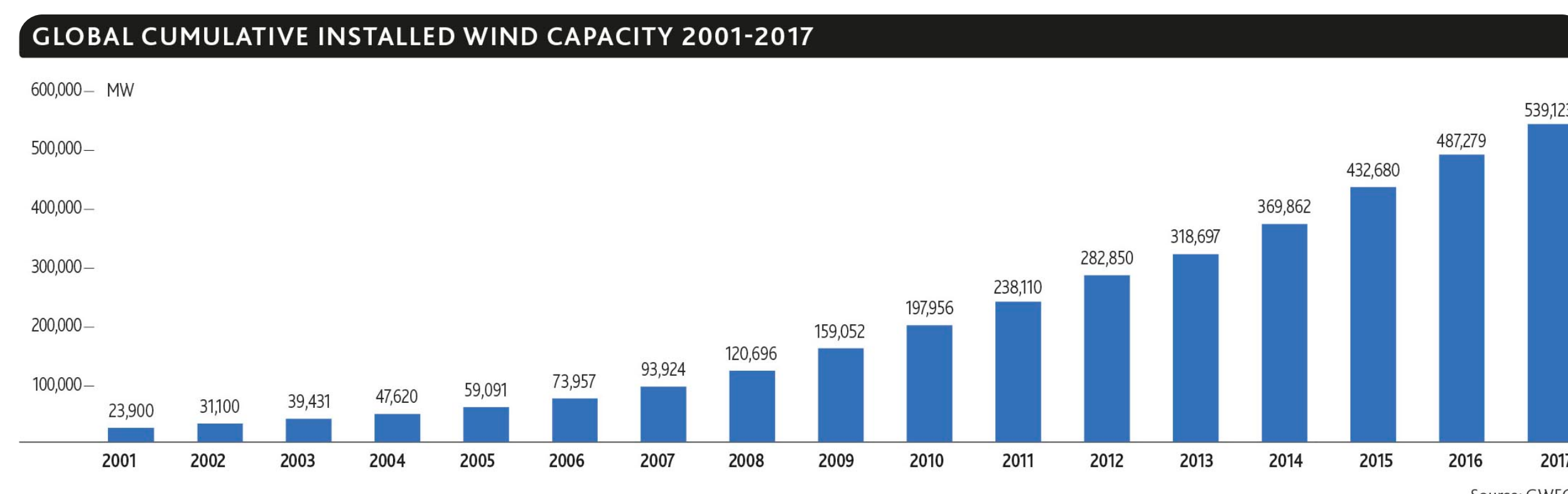


## A look into the future of energy generation

- Renewable energies have the potential to meet the global energy demand
- They are ideal candidates to tackle problems such as air pollution and global warming
- Wind energy is the fastest growing renewable technology
- Wind energy is mostly supplied by wind farms



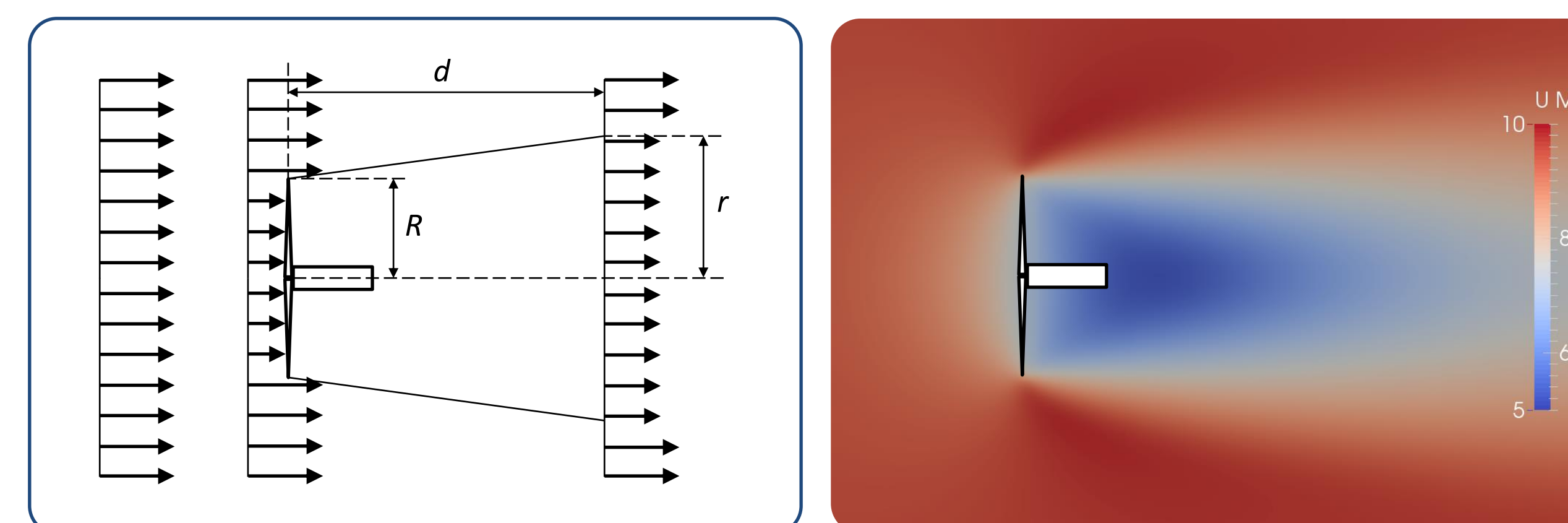
## How are we going to design the next generation of wind farms?

- Wind farms consist of hundreds of turbines and take advantage of economies of scale
- Wind farm performance is however affected by the wakes generated by the turbines
- Accurate wake effect predictions and reliable wind farm layout design are critical aspects to the economic success of a wind farm project



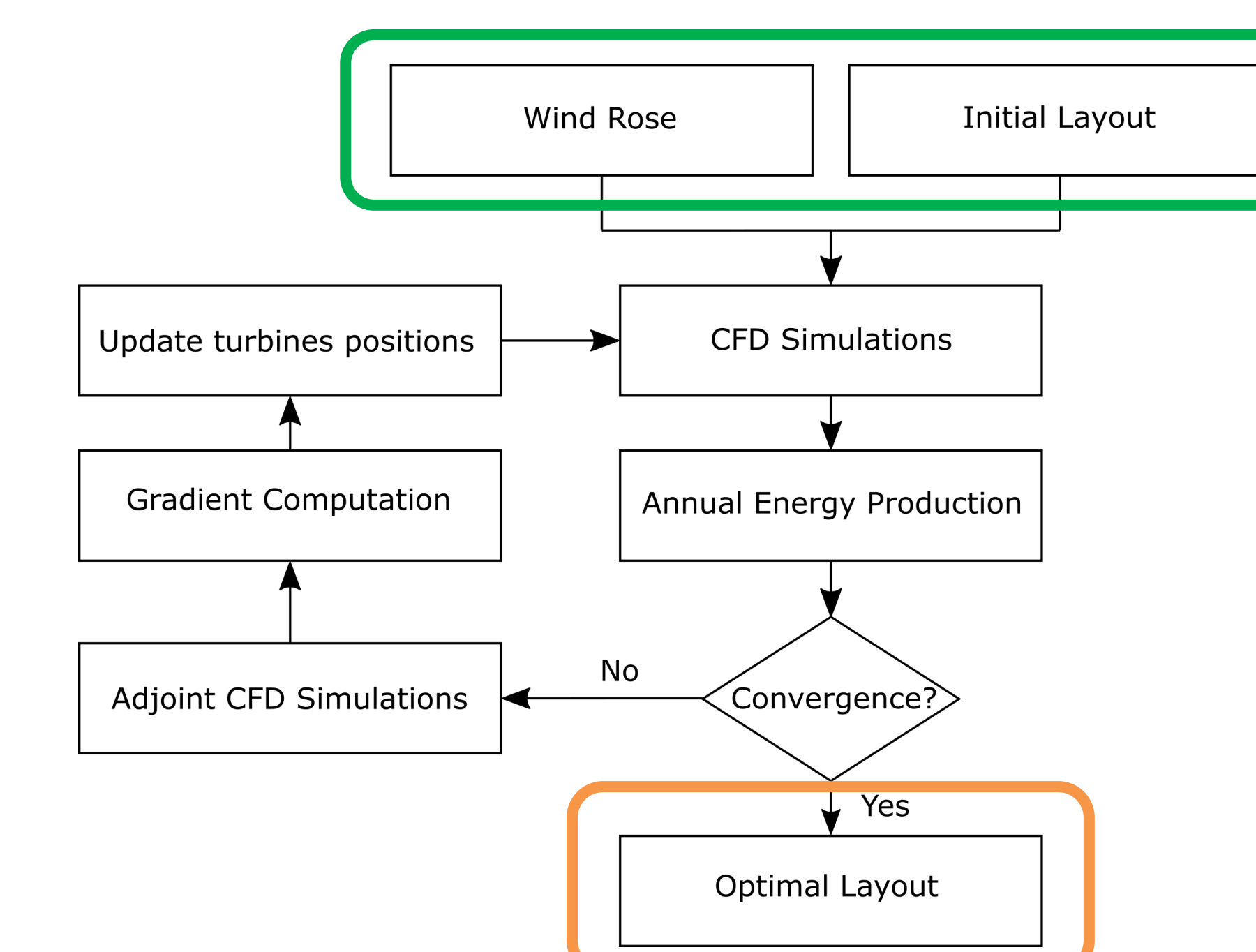
## From low- to high-fidelity wake modeling

- Currently used wake models for optimization are based on self-similar velocity profiles
- These engineering models are not capable of dealing with complex flow phenomena
- CFD models effectively handle different ambient conditions, turbulent flows and terrain topography



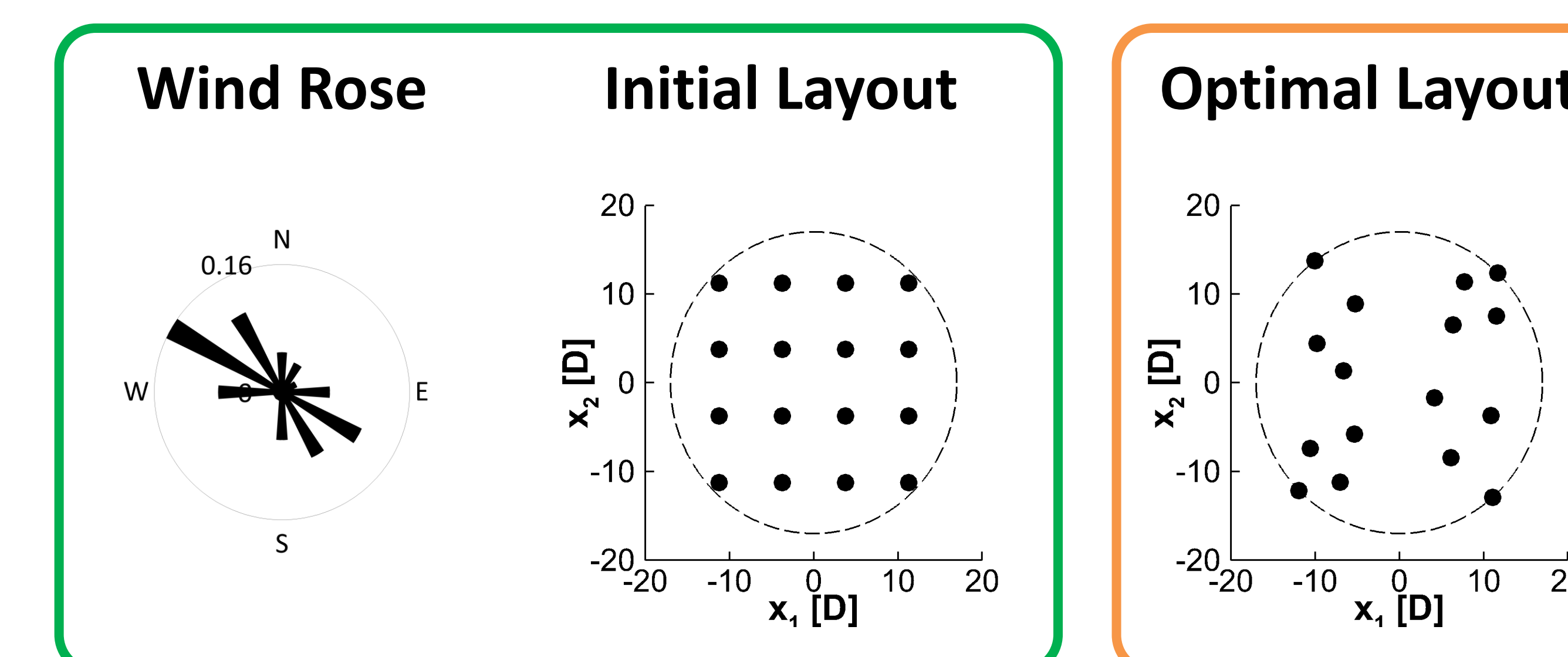
## High-fidelity automated optimization

- We developed a high-fidelity wind farm layout optimization framework using CFD models
- We enabled this high-fidelity optimization thanks to an innovative continuous adjoint formulation for gradient calculations



## Potential 5-10% improvement in annual energy production

- We aimed to optimize a 2D wind farm layout consisting of 16 wind turbines
- We tested our methodology for different initial layouts and wind resource distributions
- The annual energy production could be effectively improved within 300 to 500 simulations
- Improvements in energy production were found to be between 5-10%
- The computational resources were provided by the high performance computer at SciNet



Improvement of 7.1% in annual energy production