The potential for re-powering wind turbines: reducing turbines, increasing output

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Introduction

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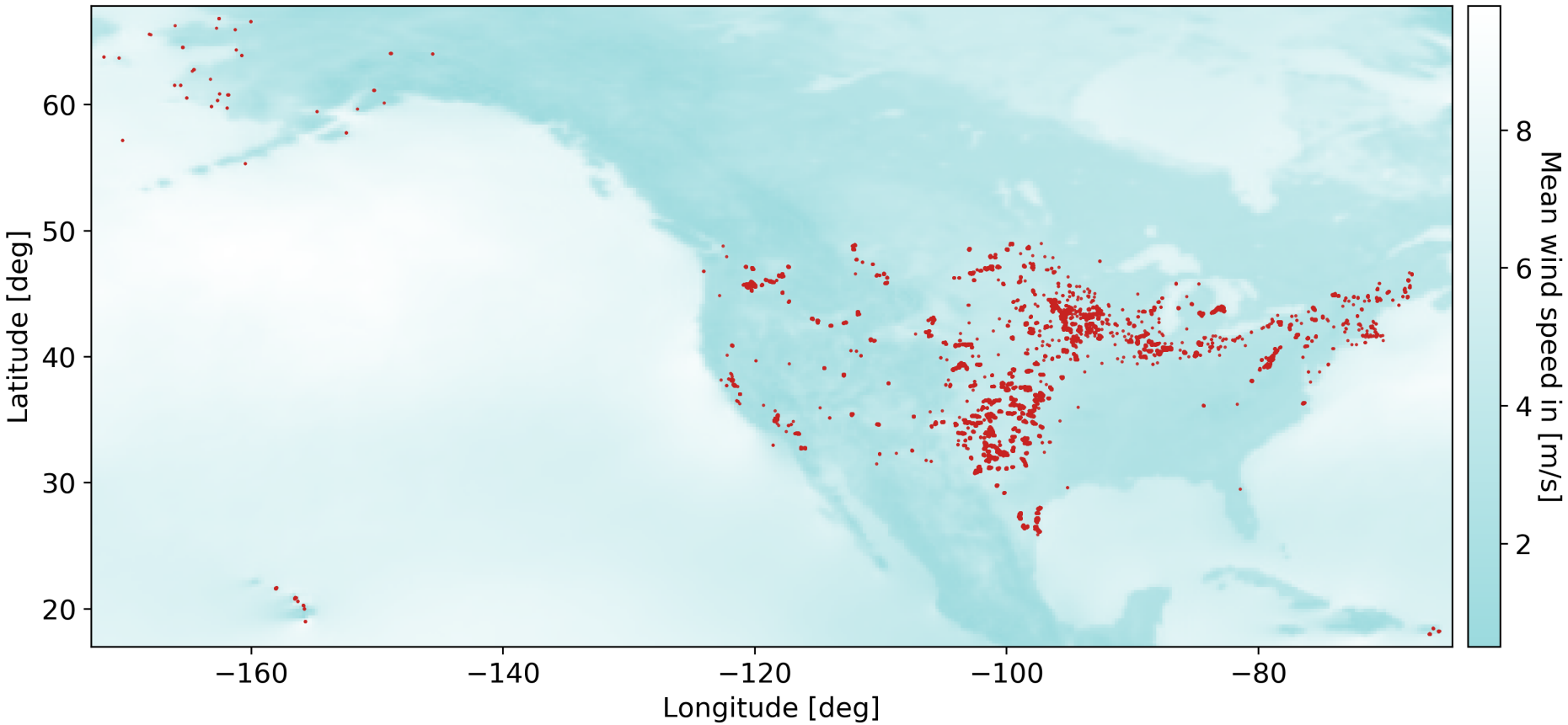
- Low carbon energy systems: land usage is a critical factor
- **repowering** = replacing power plants with newer ones, which have a higher rated **capacity** or more **efficiency**
- How much power generation gain can be expected in the US with newer wind turbine models? How many wind turbines will be installed?

Data


60
50
40
30
20
Latitude [deg]
−160
−140
−120
−100
−80
Longitude [deg]
8
6
4
2
Mean wind speed in [m/s]

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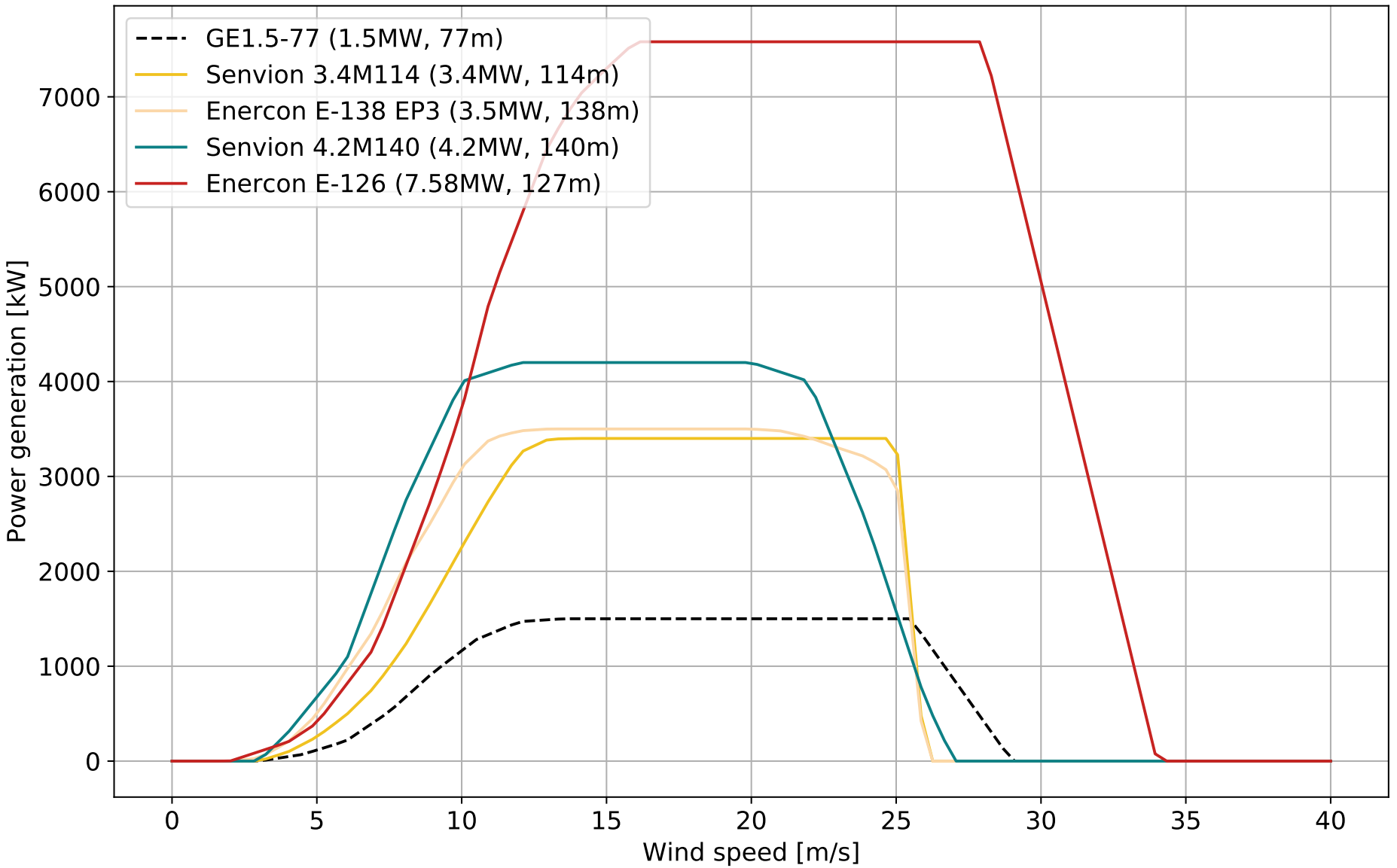
- Data sheets and NREL SAM: **rotor diameter**, **power curve** for some selected turbine models

Turbine models

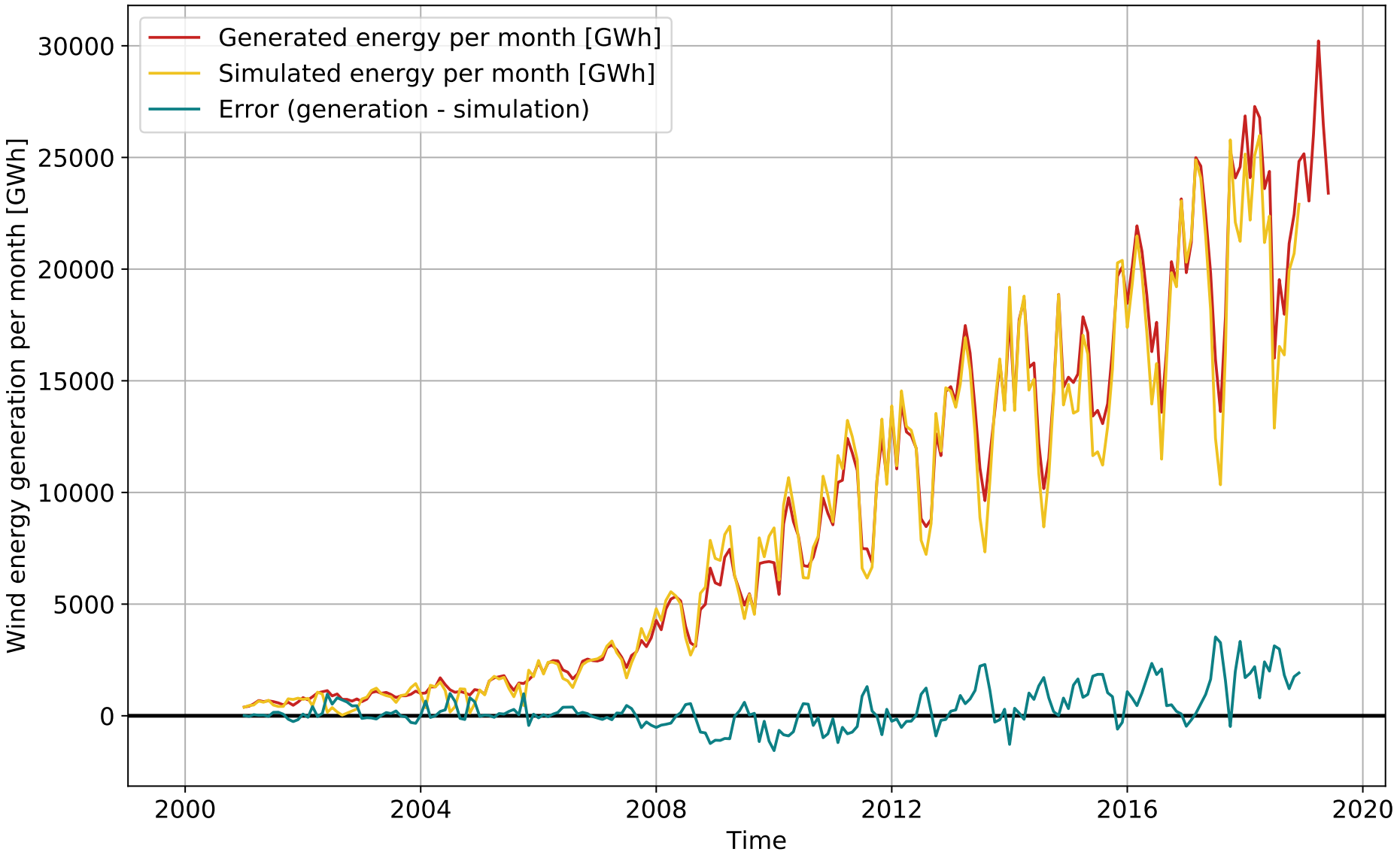
Model name	**Rated capacity**	**Rotor diameter**
GE-1.5 77	1.5 MW	77 m
Senvion 3.4M114	3.4 MW	114 m
Enercon E-138 EP3	3.5 MW	138 m
Senvion 4.2M140	4.2 MW	140 m
Enercon E-126	7.58MW	127 m

GE-1.5 77 is the most frequent model in the U.S. (14.7% of all turbines).

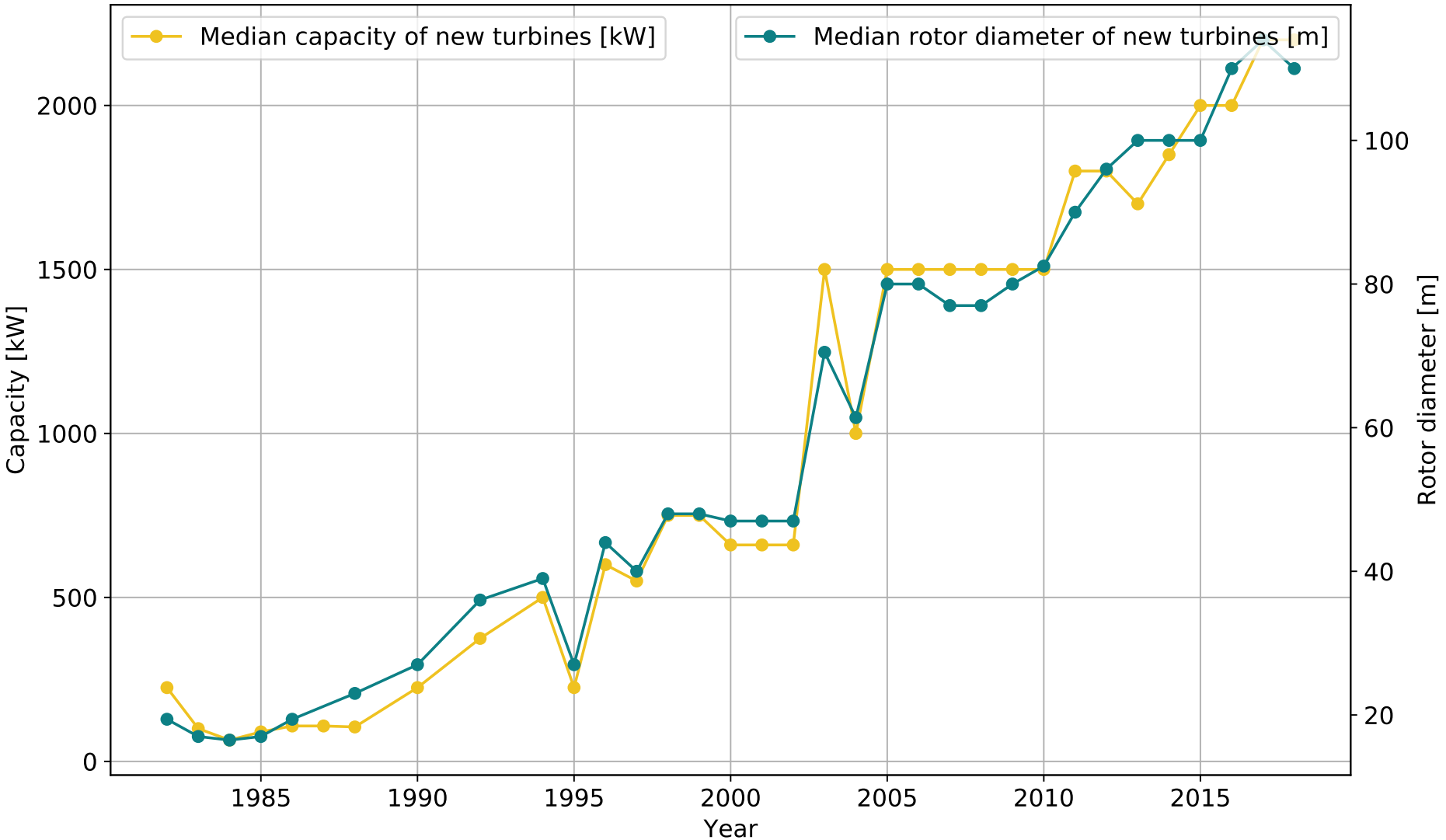
Power curves



Simulation of power generation



Historical development of wind turbine characteristics



Maximum power generation with different turbines

Optimization problem:

Existing turbines are replaced by newer ones at the location of the old turbines, such that:

- objective function: total power generation is maximized
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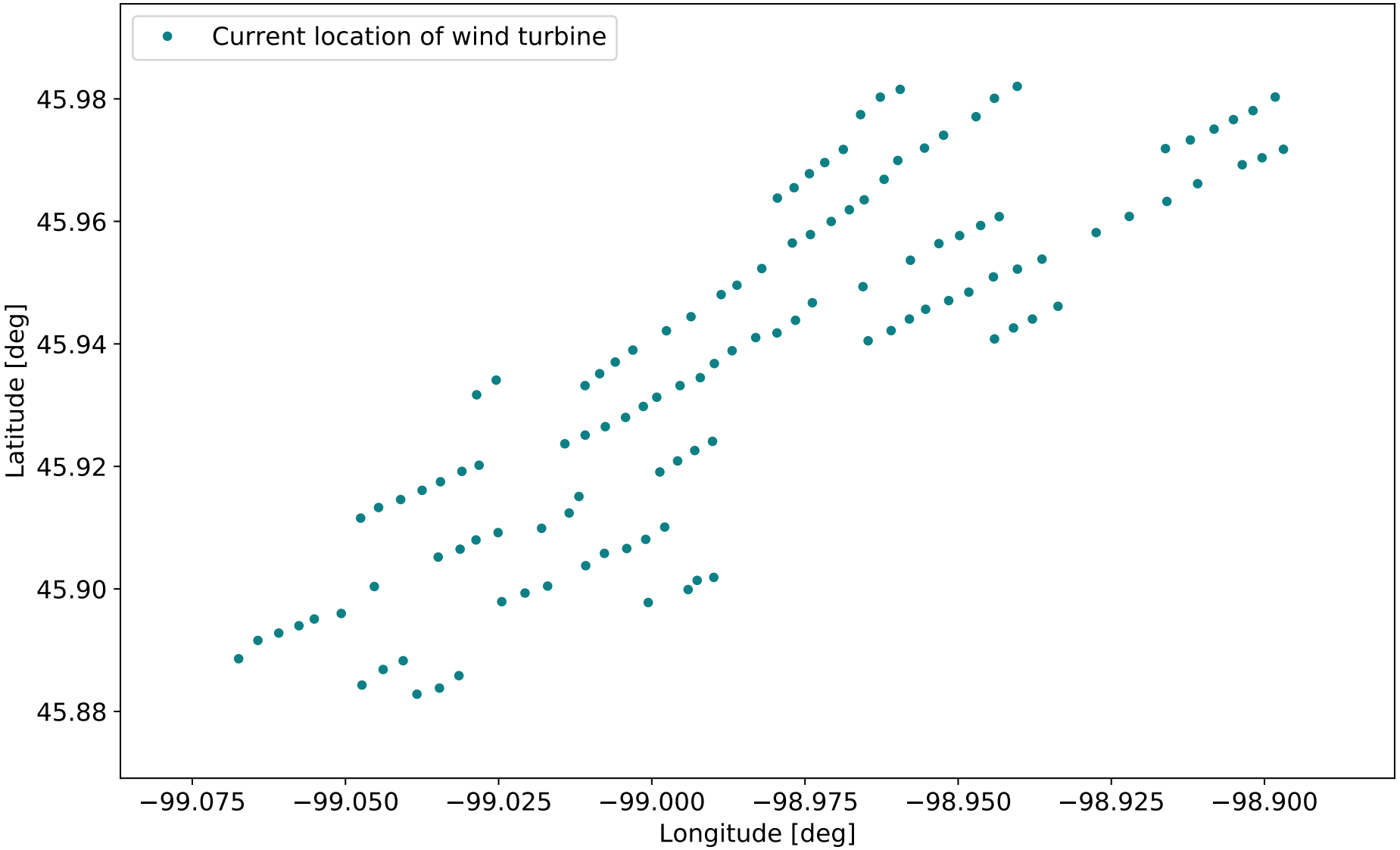
Optimal locations for new wind turbines



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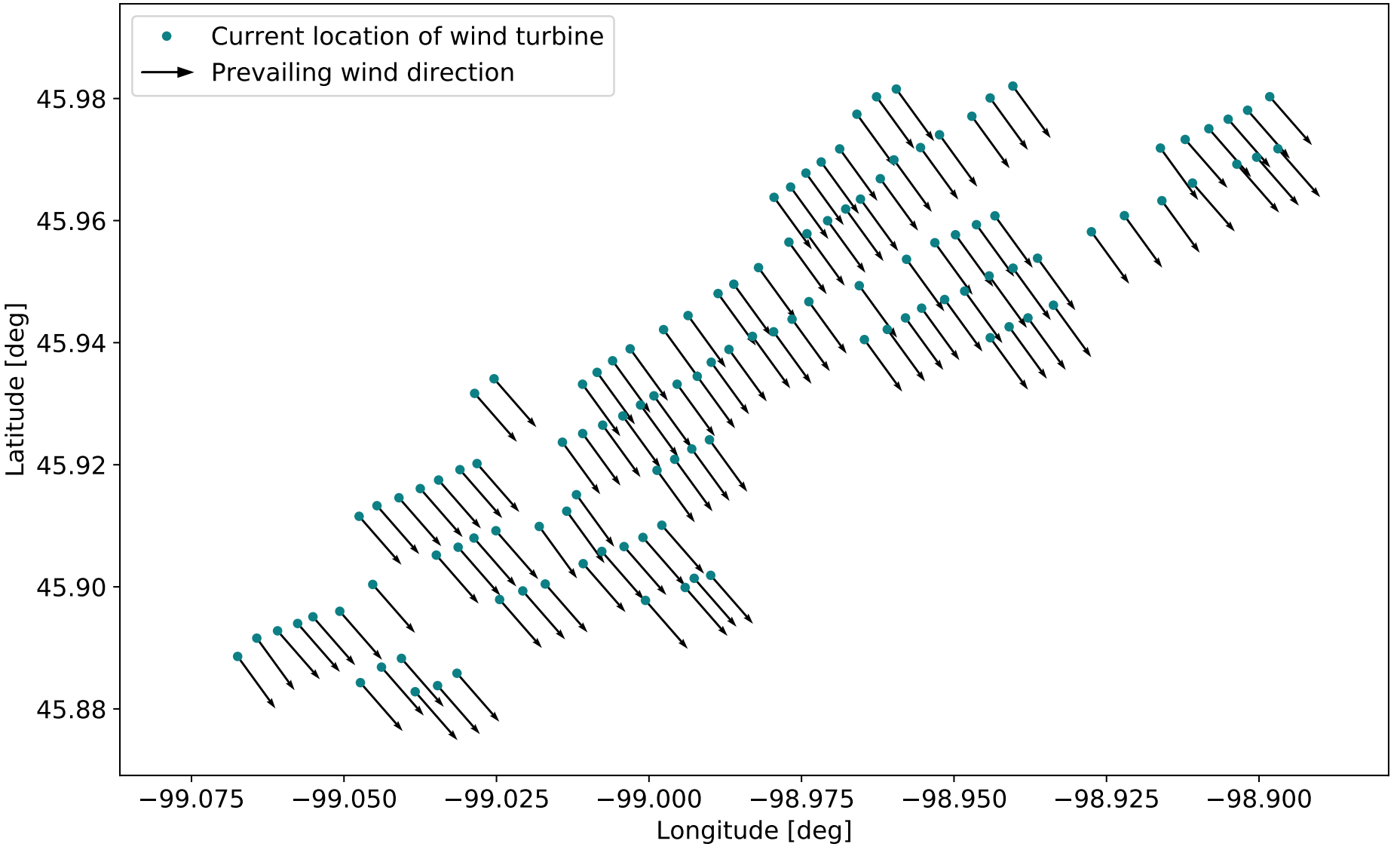

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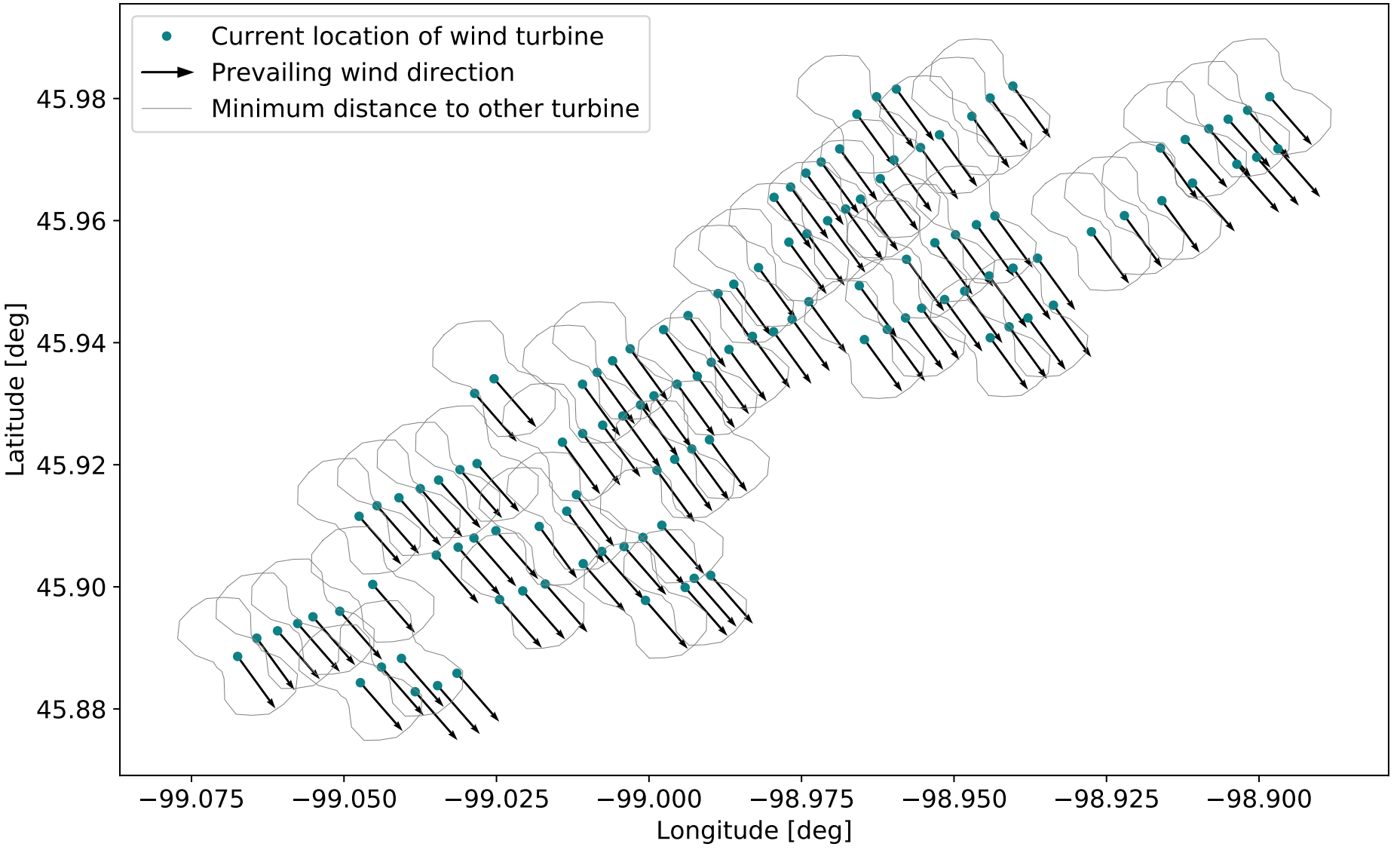

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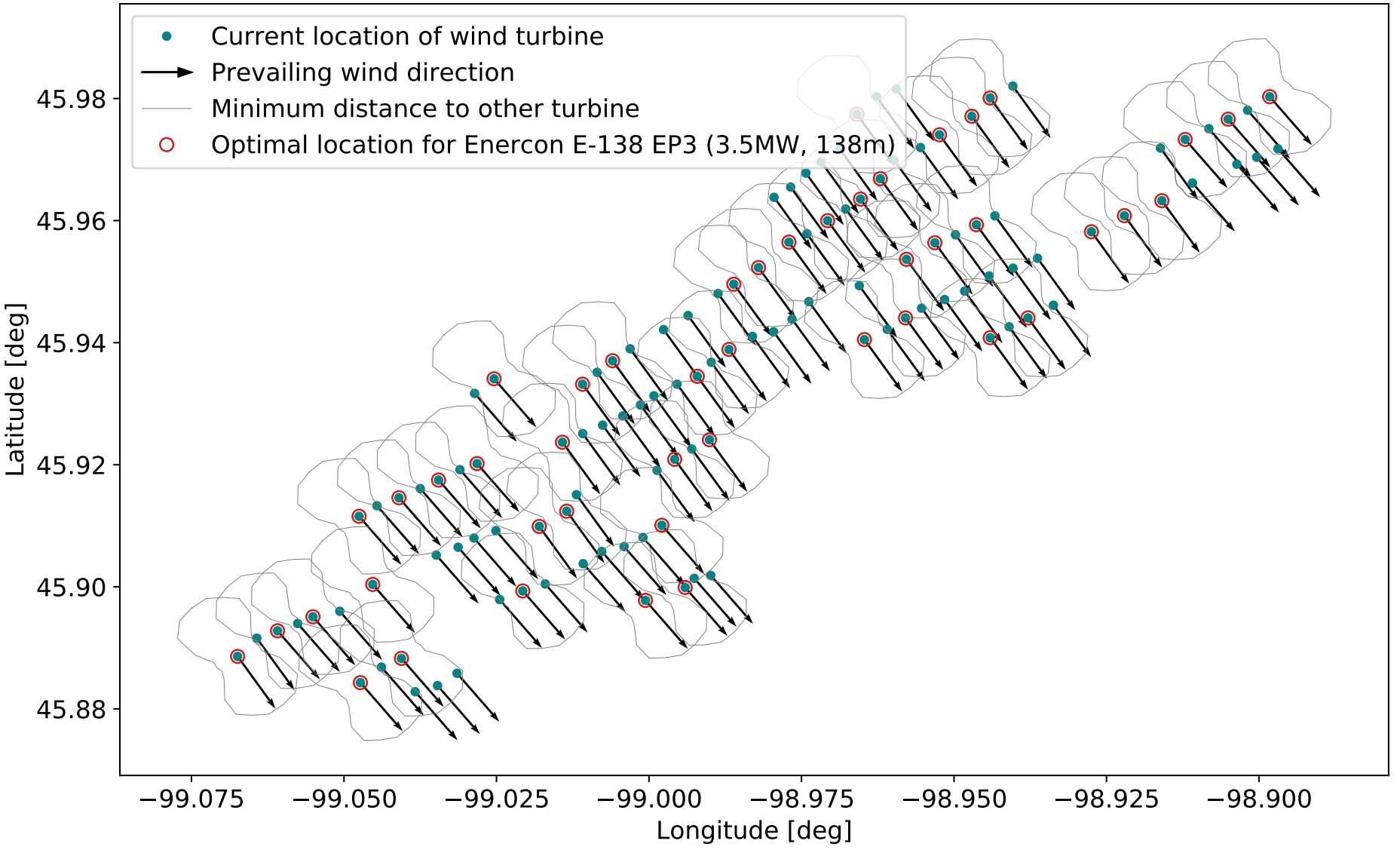

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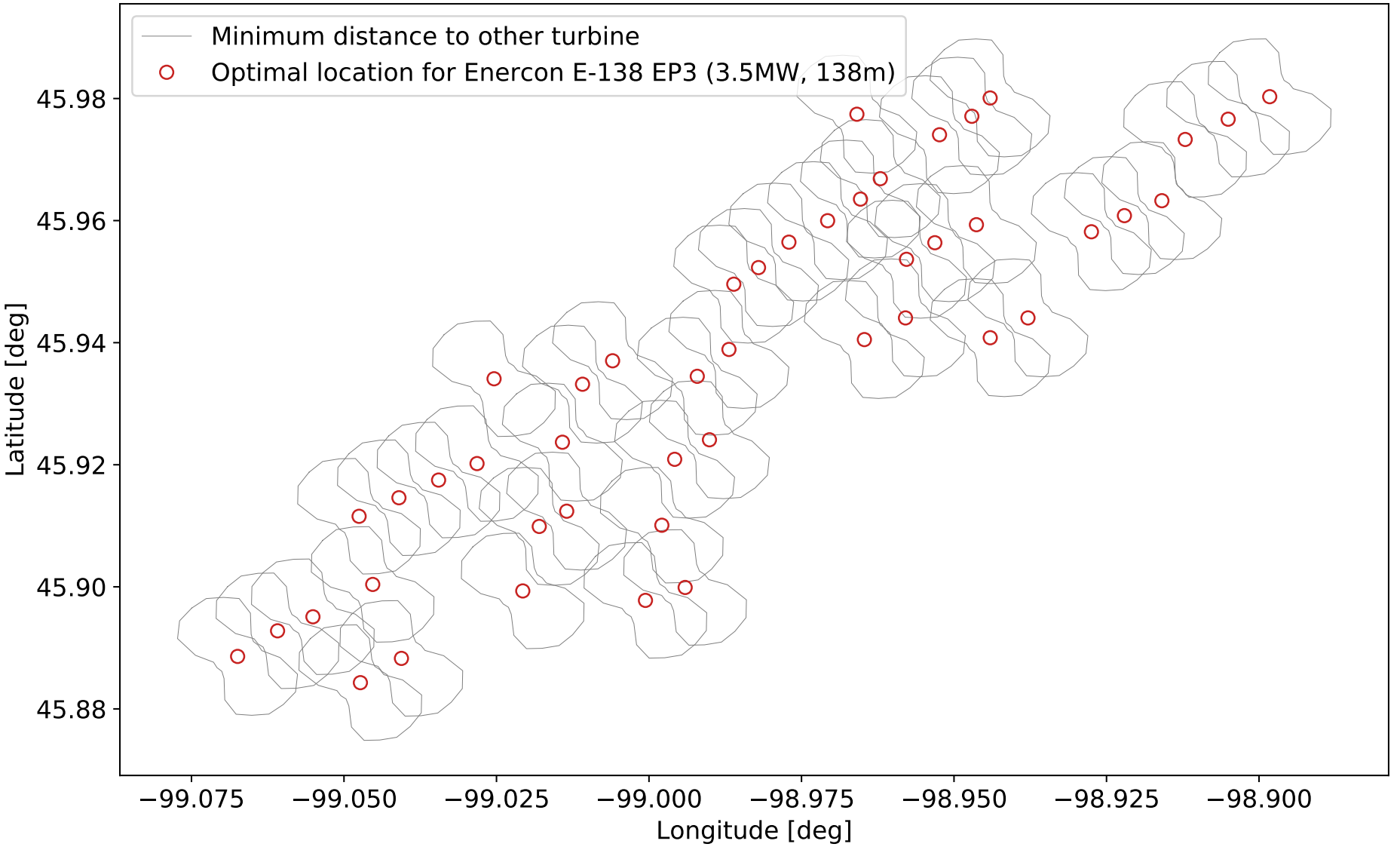
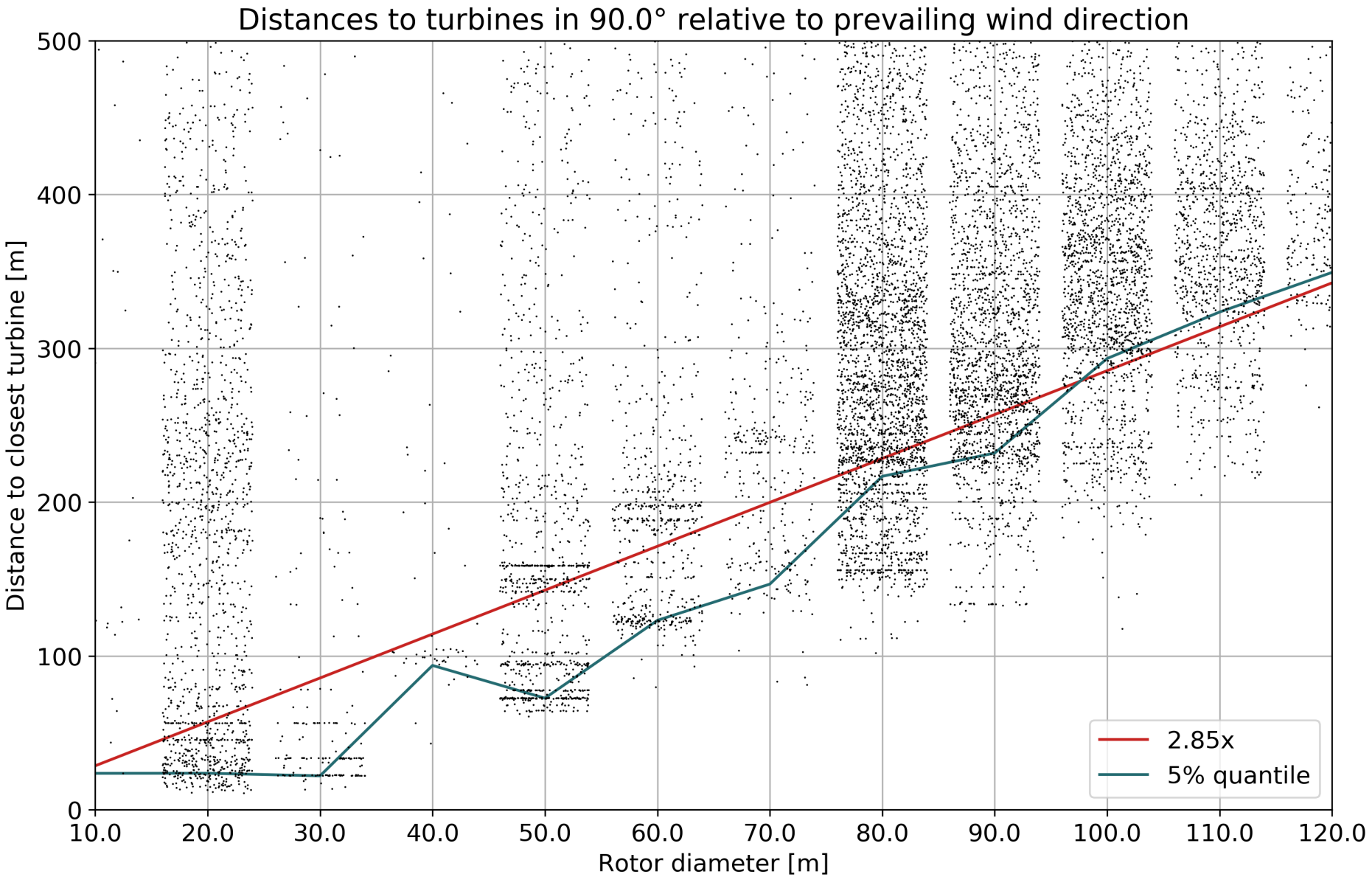
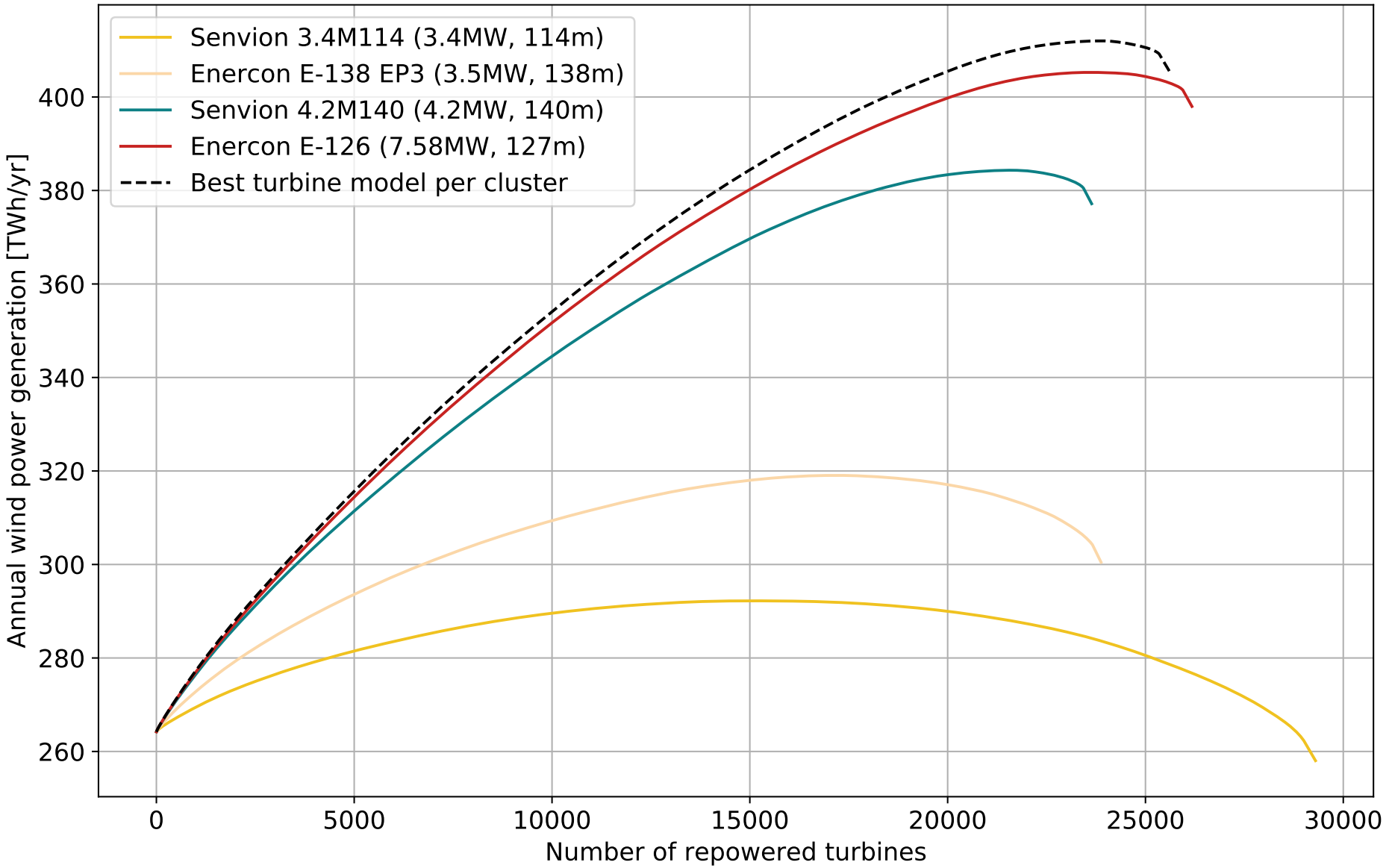


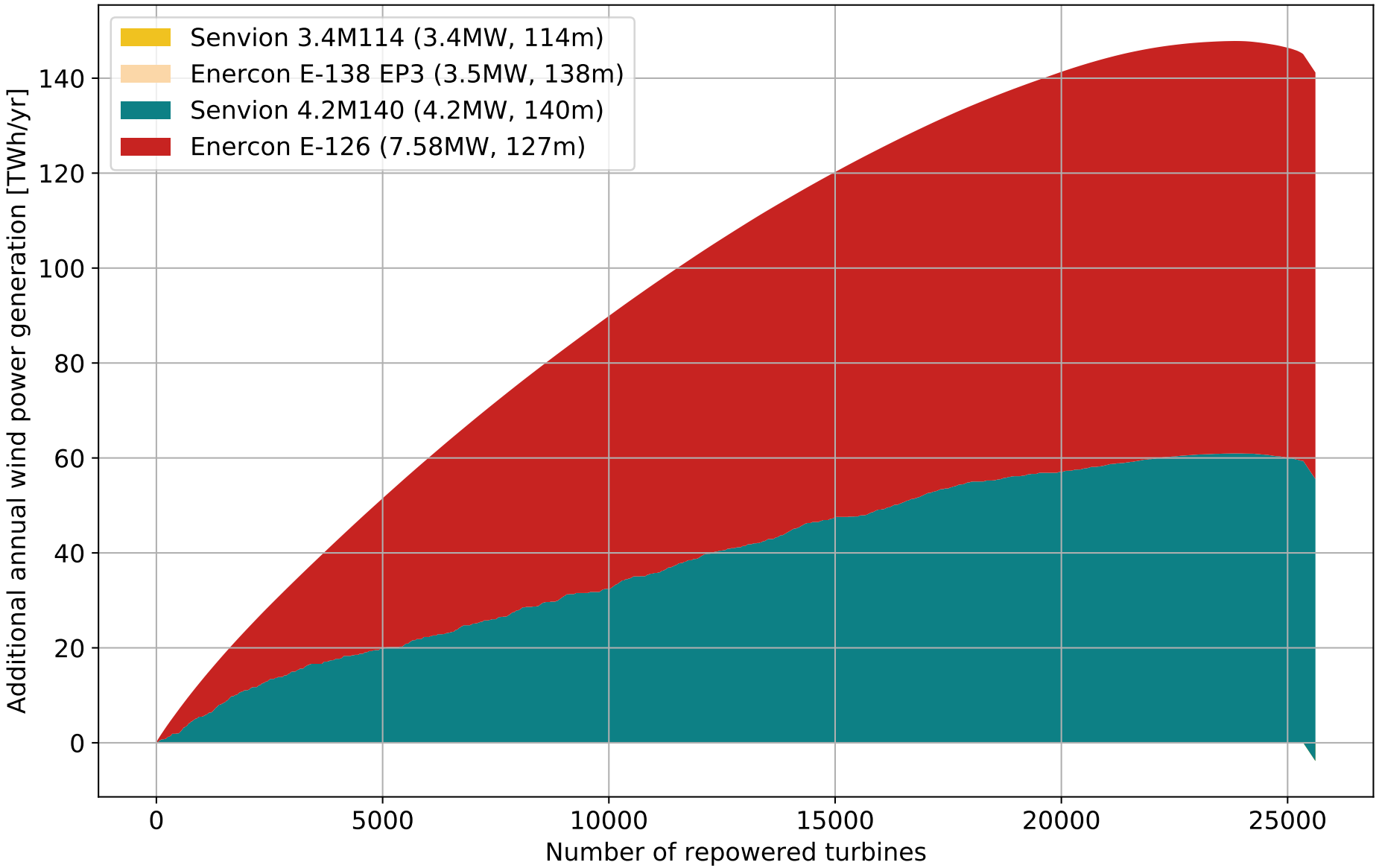
Minimum distances between turbine locations



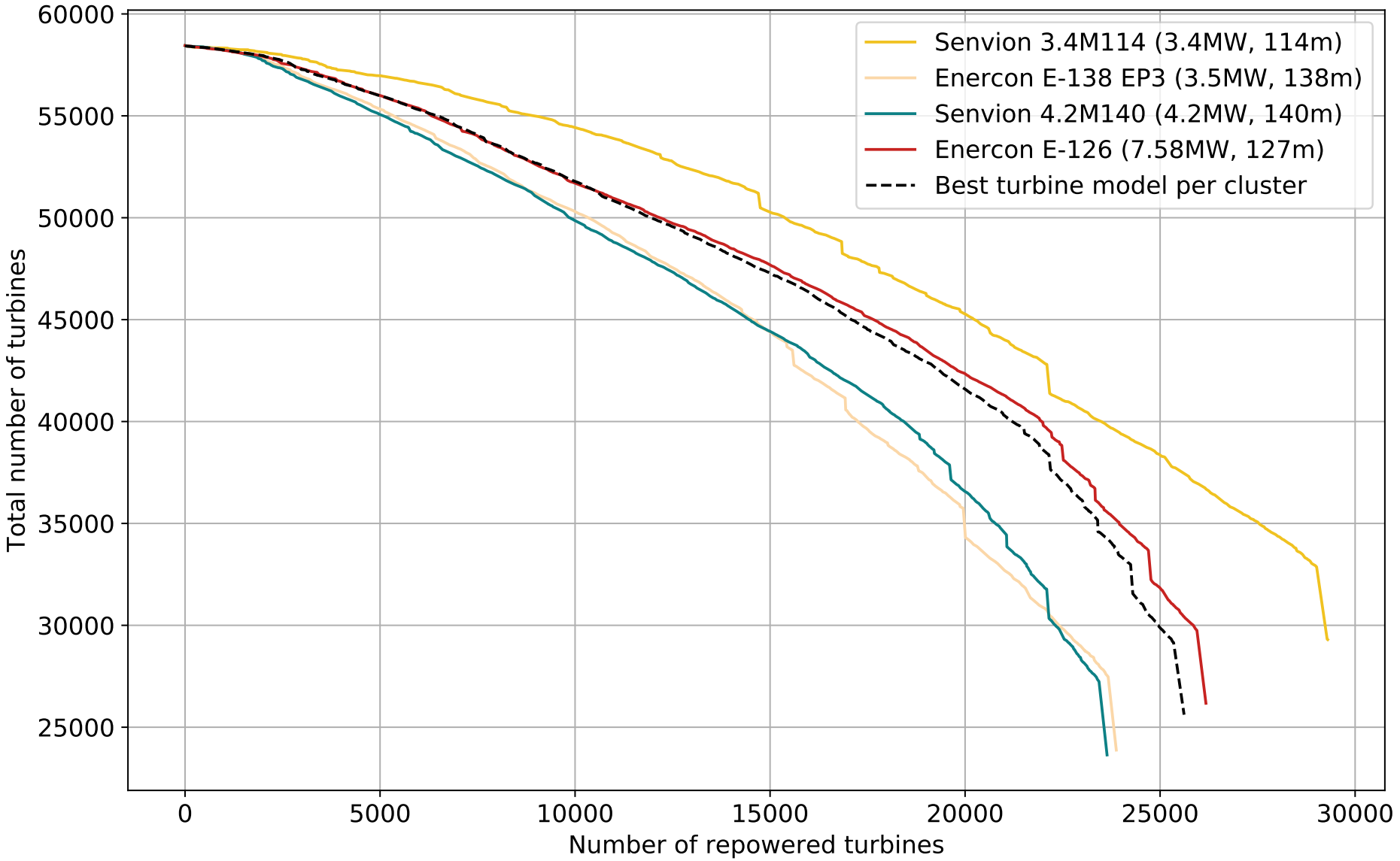
Repowering potential: power generation



Repowering potential: best turbine models



Repowering potential: number of turbines



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Open Code & Data

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- **Code:** MIT-licensed (partially CC-BY), see http://bit.ly/wind-repower-us

Thank you!

https://refuel.world/
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http://bit.ly/wind-repower-us

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