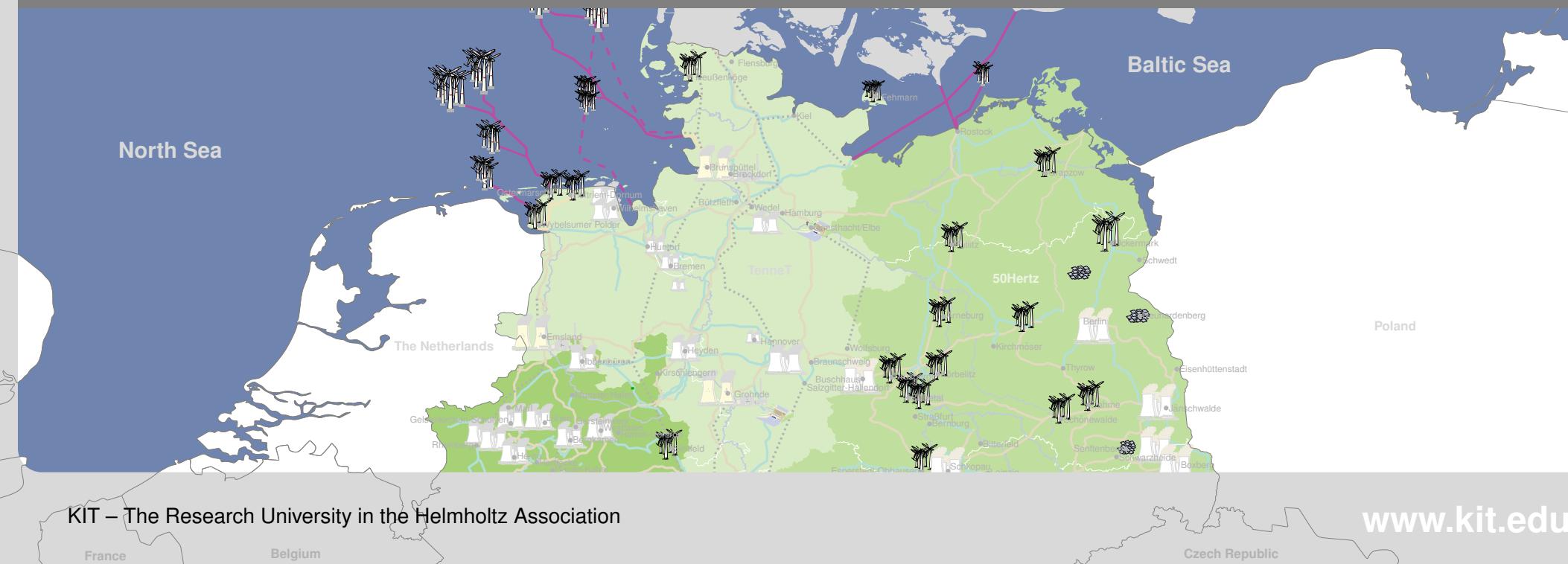


A Simulated-Annealing-Based Approach for Wind Farm Cabling

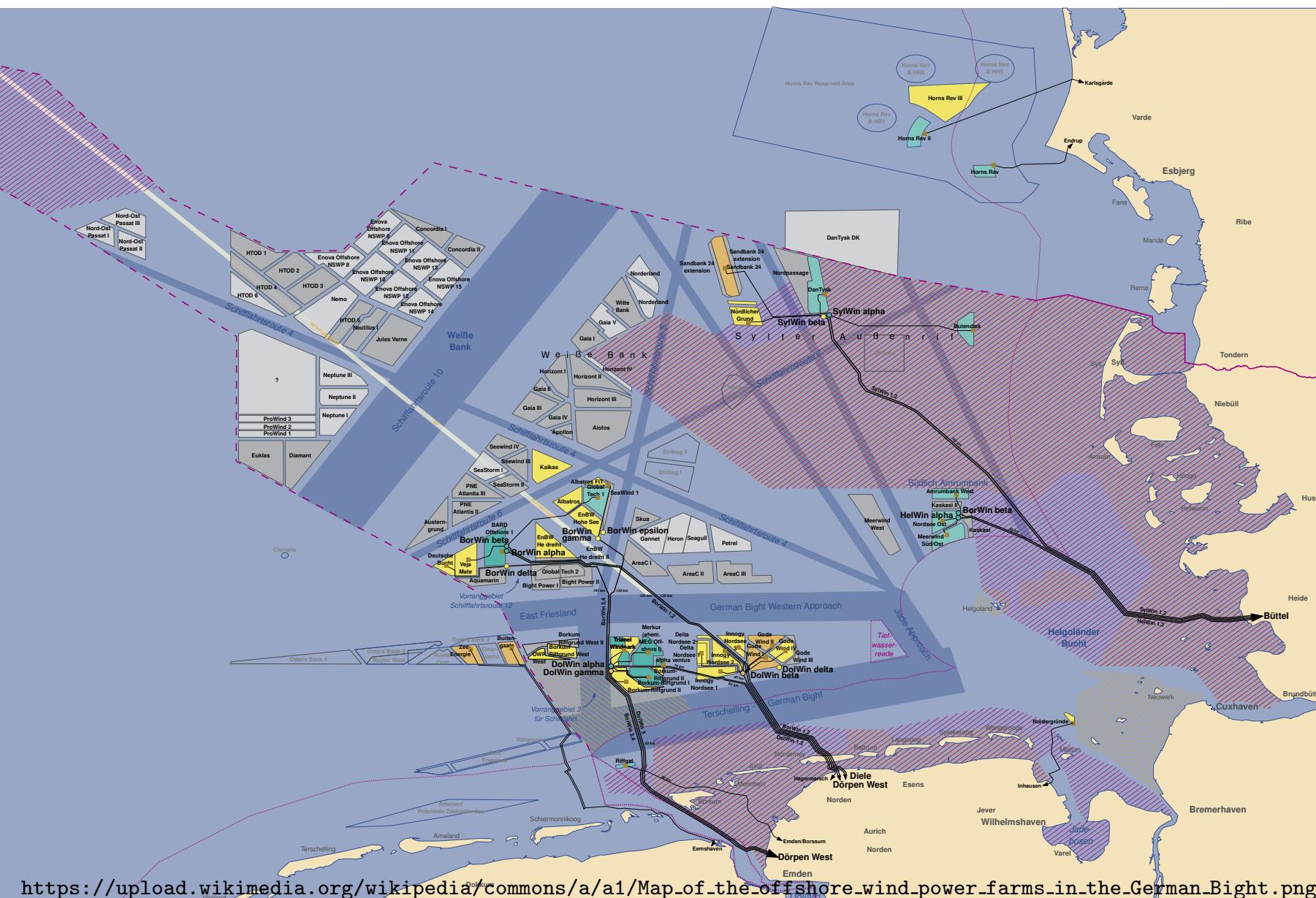
ACM e-Energy 2017 · May 19, 2017

Sebastian Lehmann, Ignaz Rutter, Dorothea Wagner and Franziska Wegner

INSTITUTE OF THEORETICAL INFORMATICS · ALGORITHMIC GROUP



Motivation



https://upload.wikimedia.org/wikipedia/commons/a/a1/Map_of_the_offshore_wind_power_farms_in_the_German_Bight.png

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Wind Farm Cabling



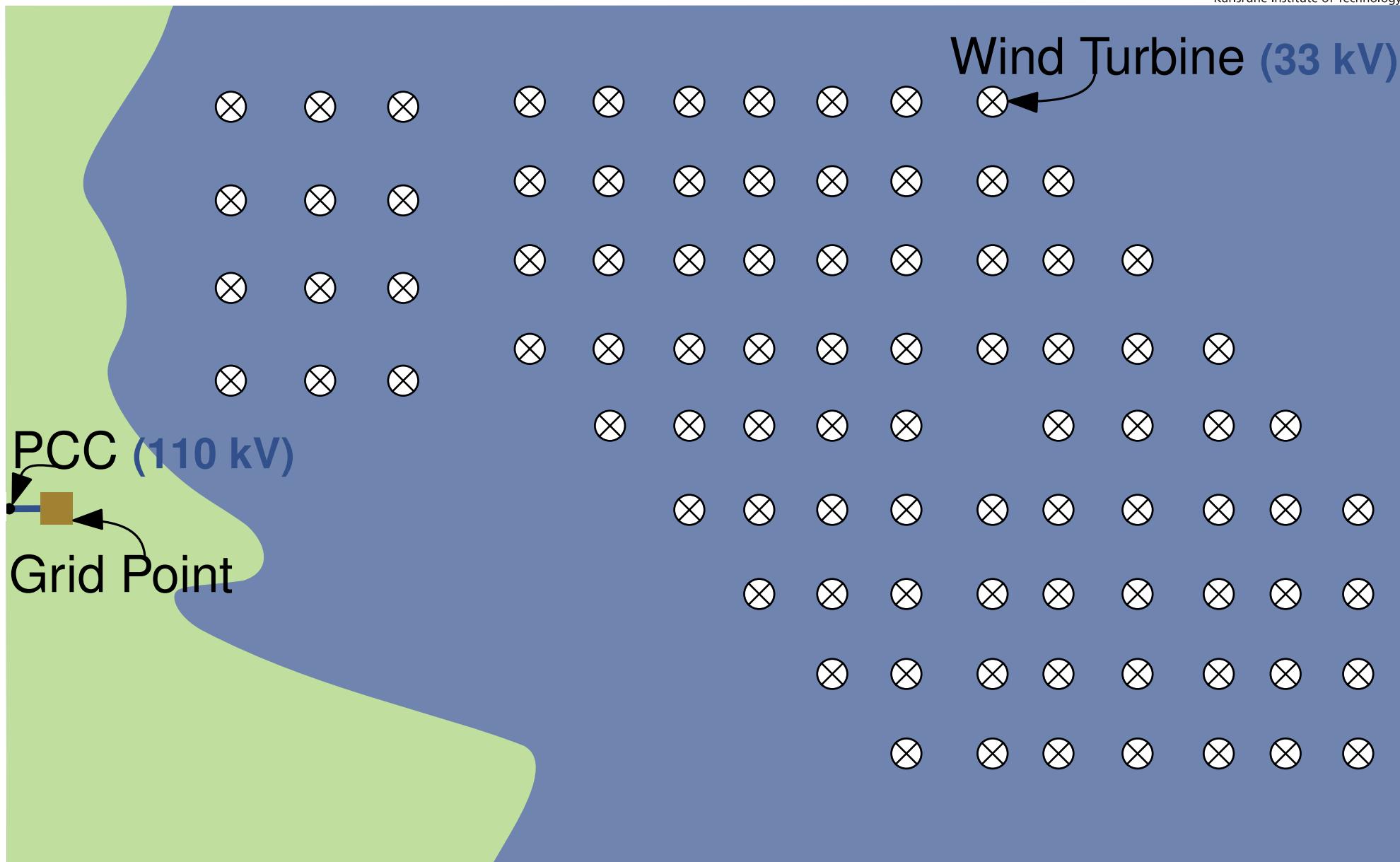
Wind Farm Cabling



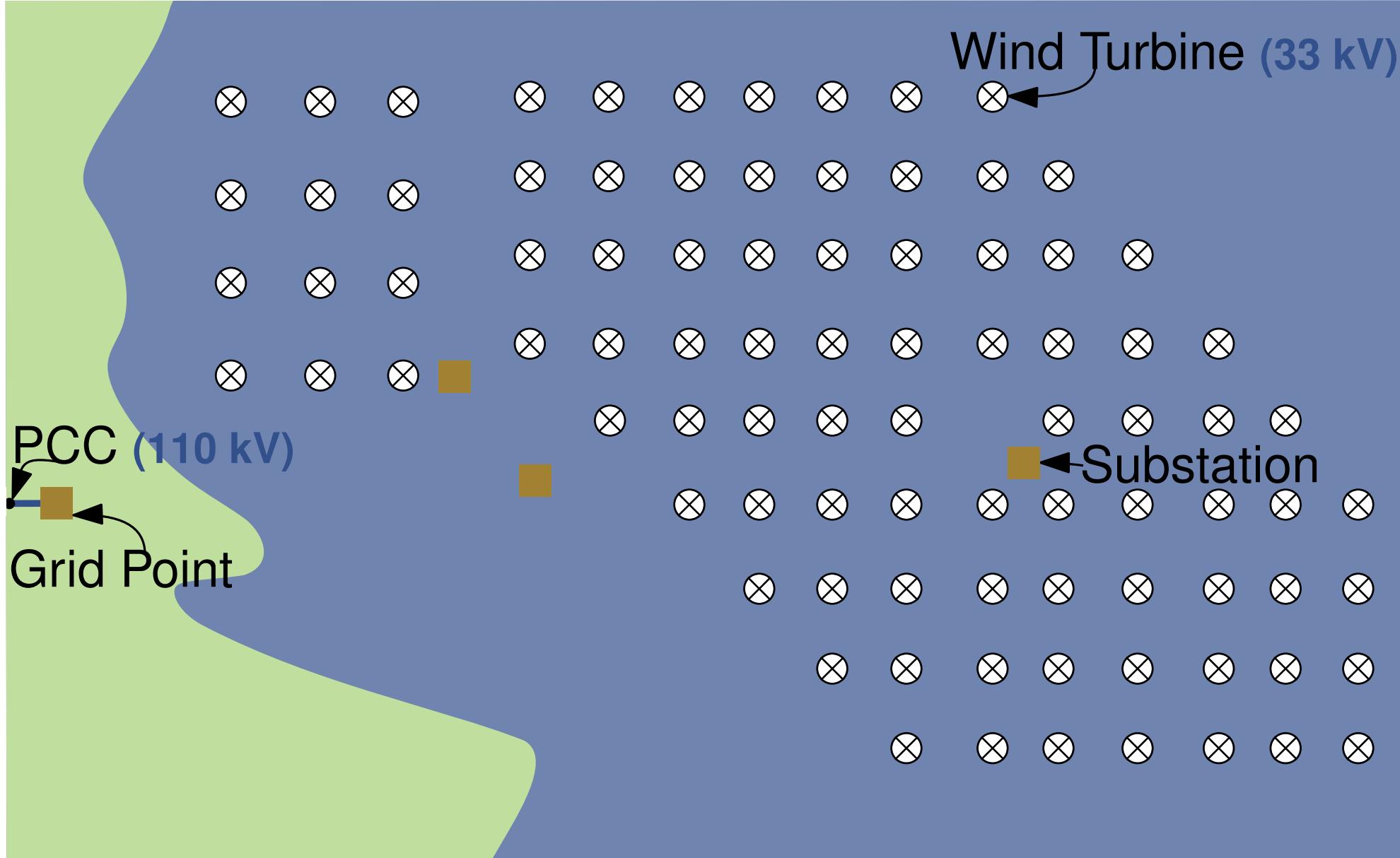
Wind Farm Cabling



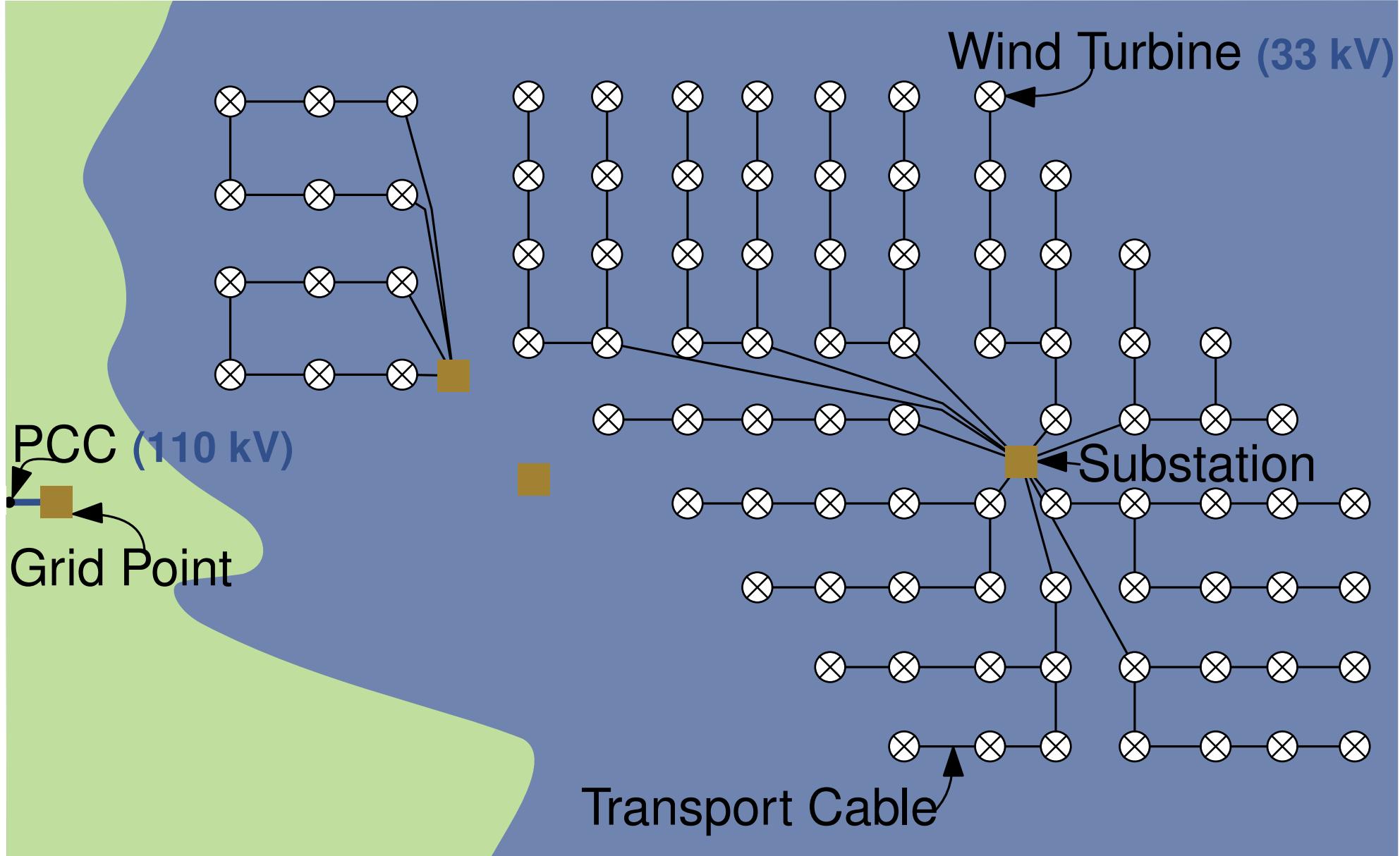
Wind Farm Cabling



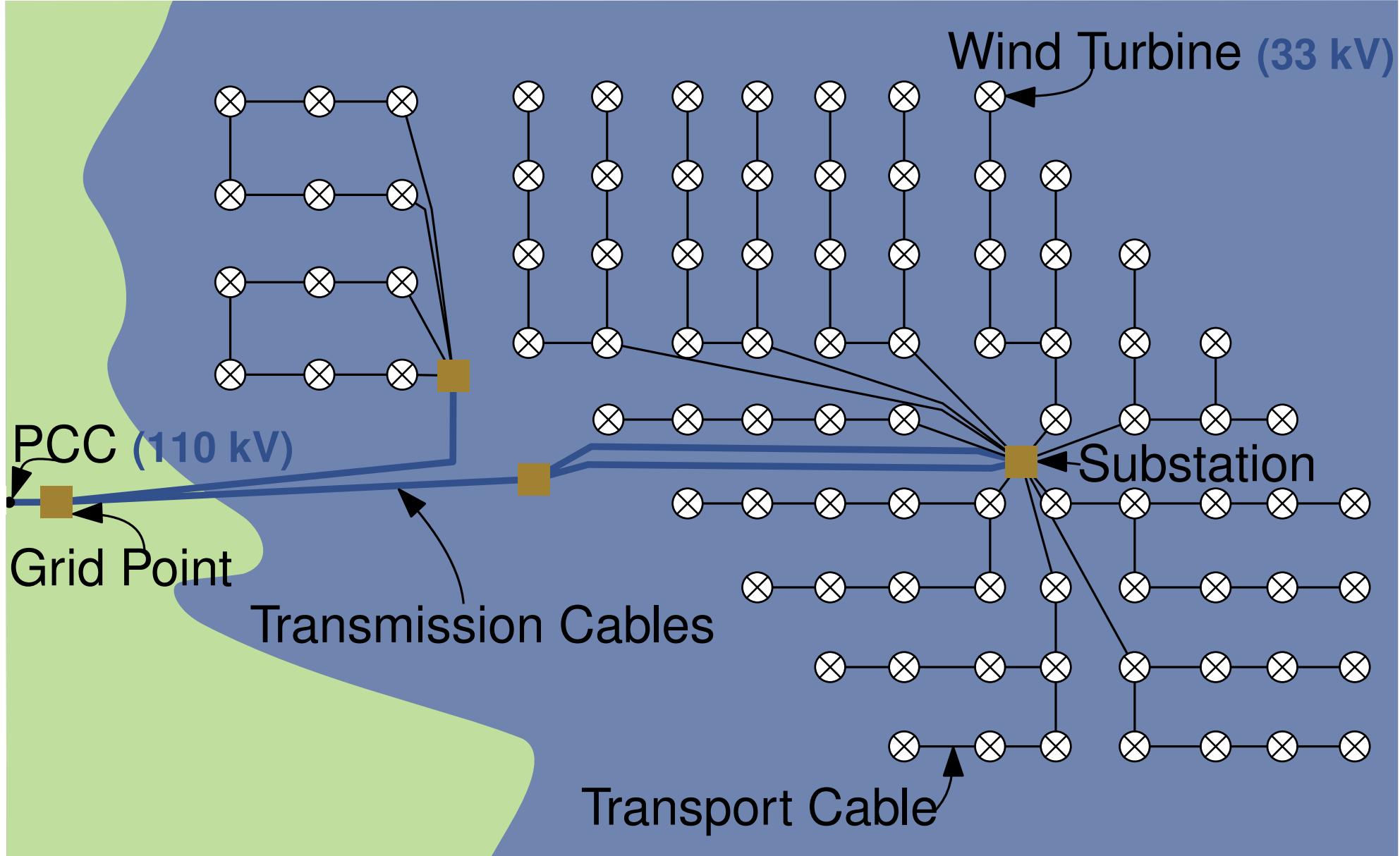
Wind Farm Cabling



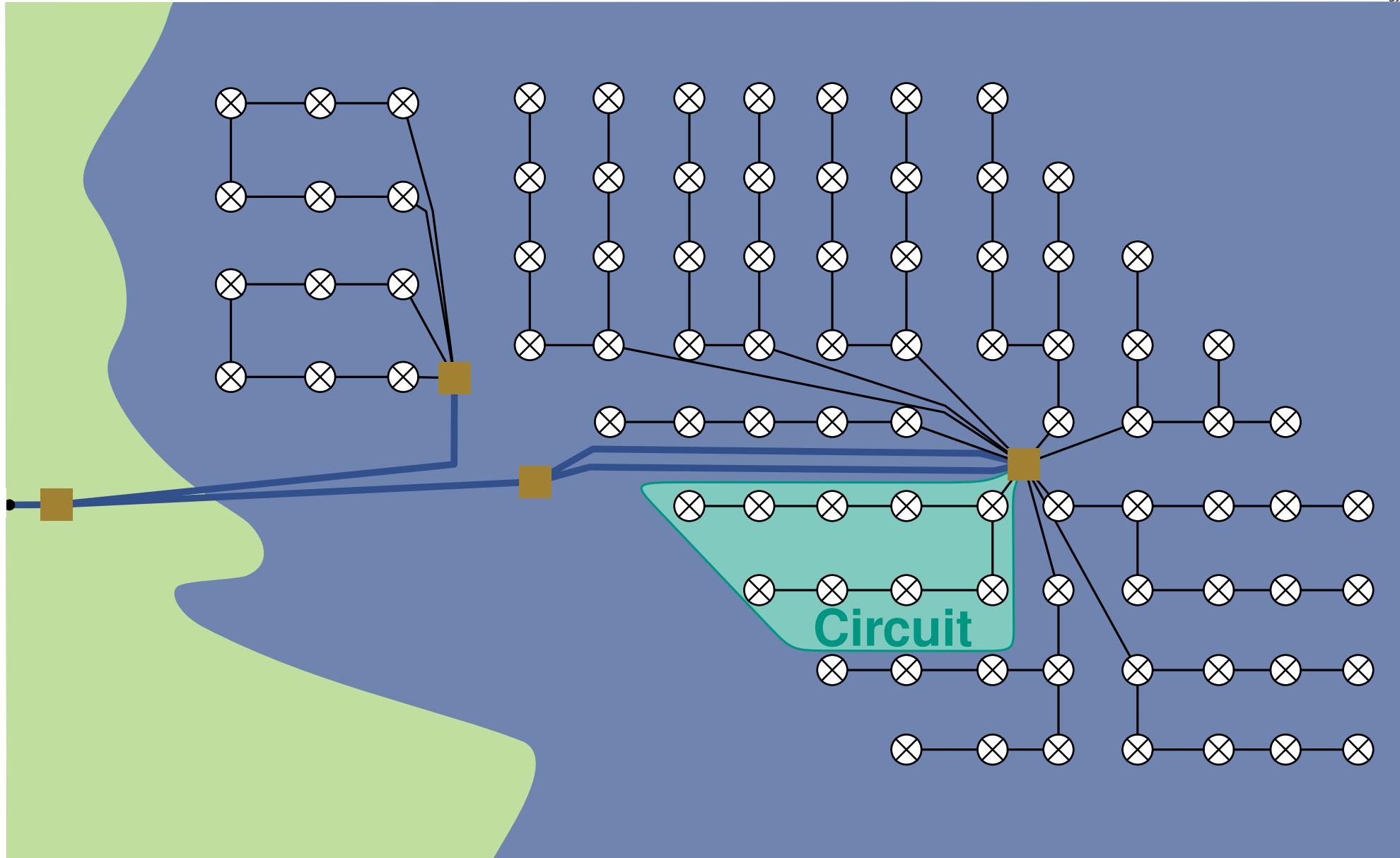
Wind Farm Cabling



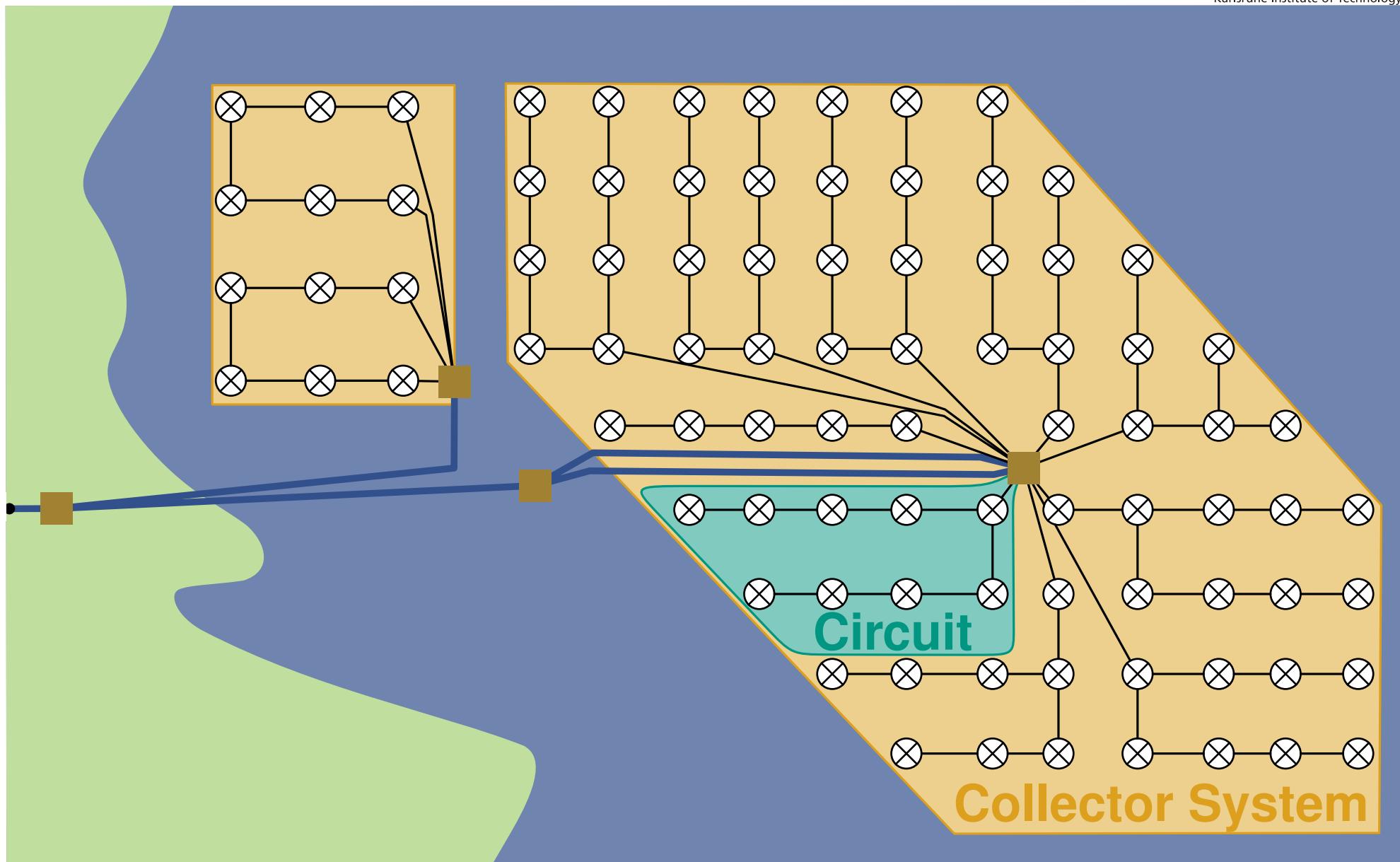
Wind Farm Cabling



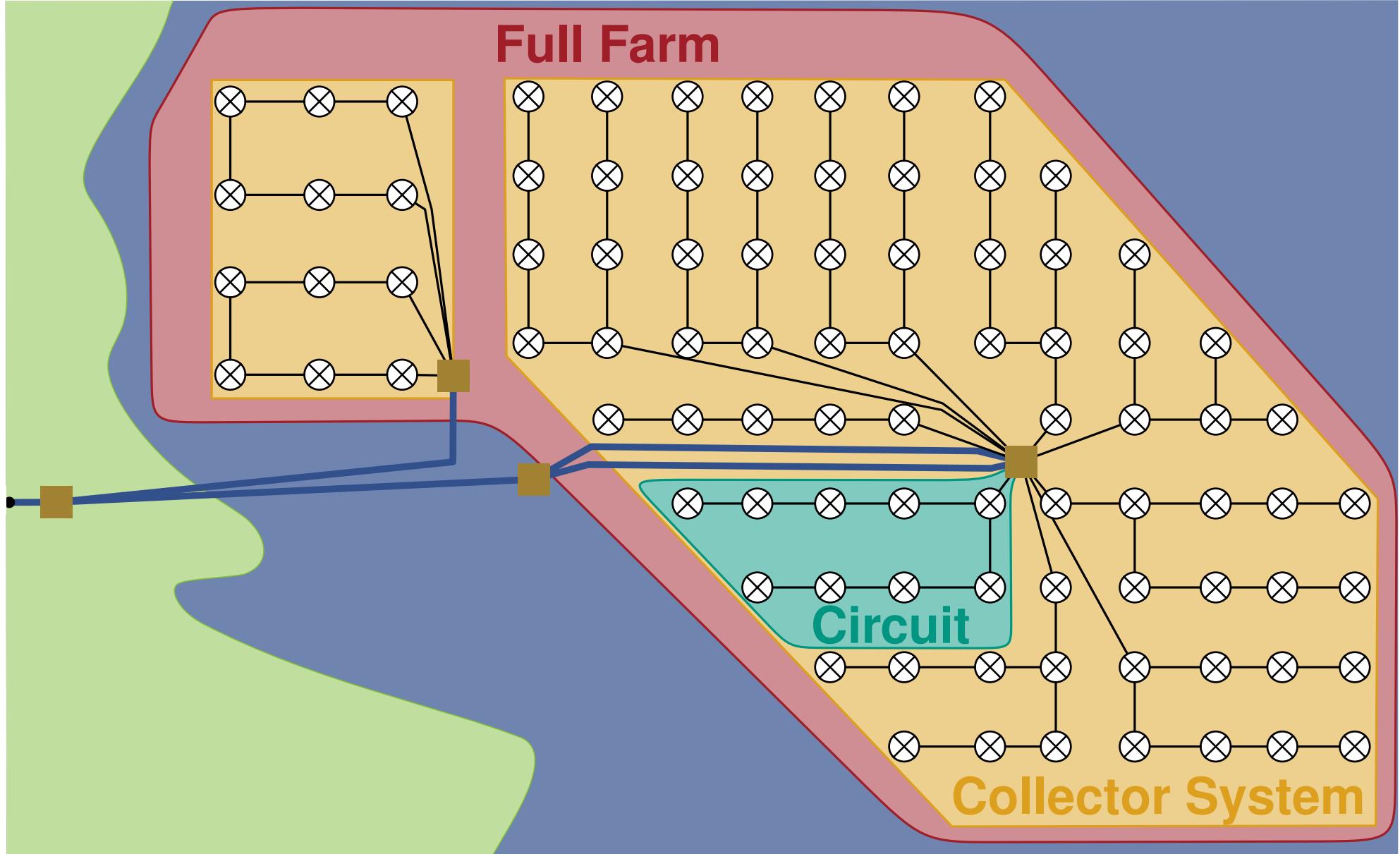
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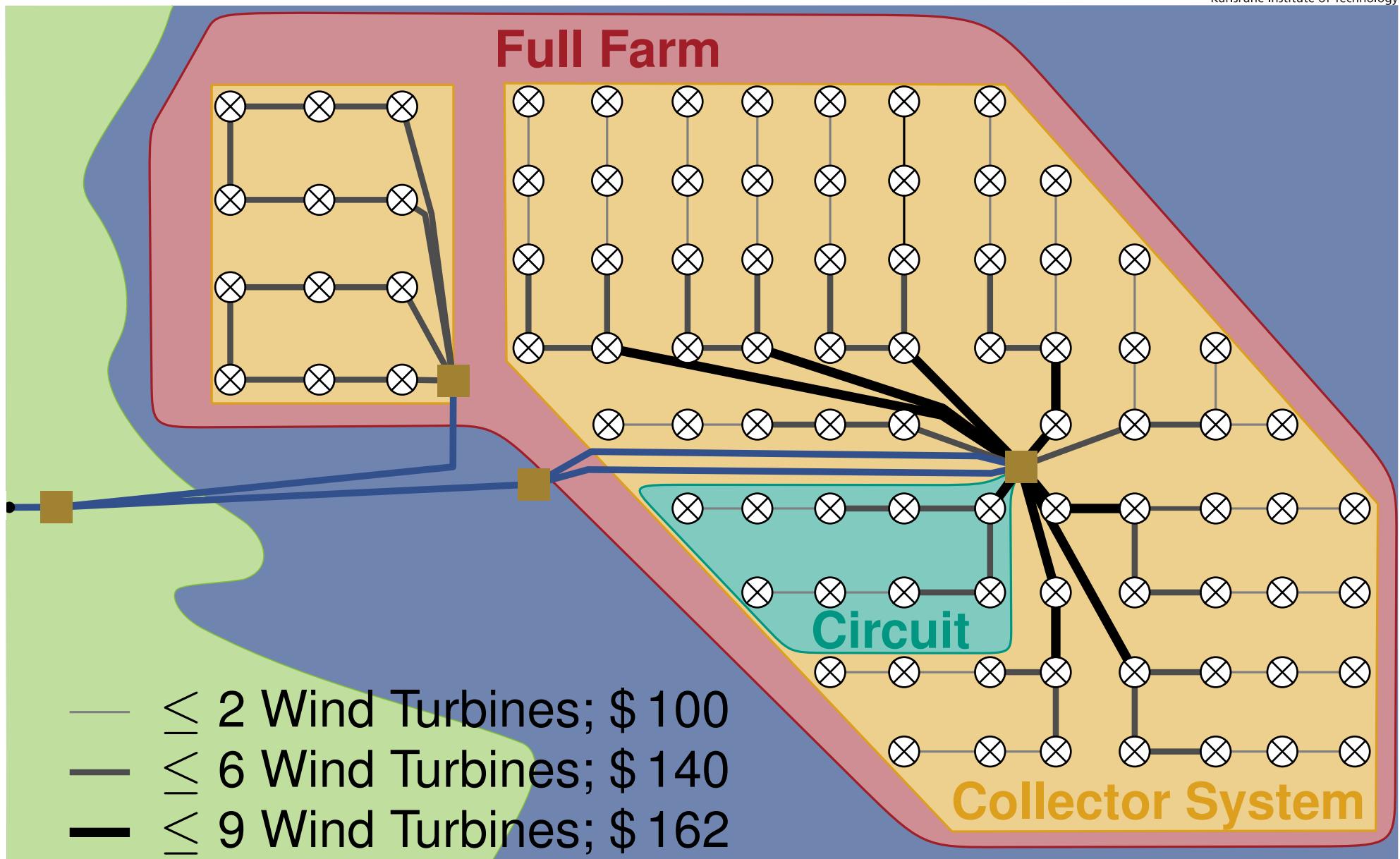
Wind Farm Cabling



Wind Farm Cabling

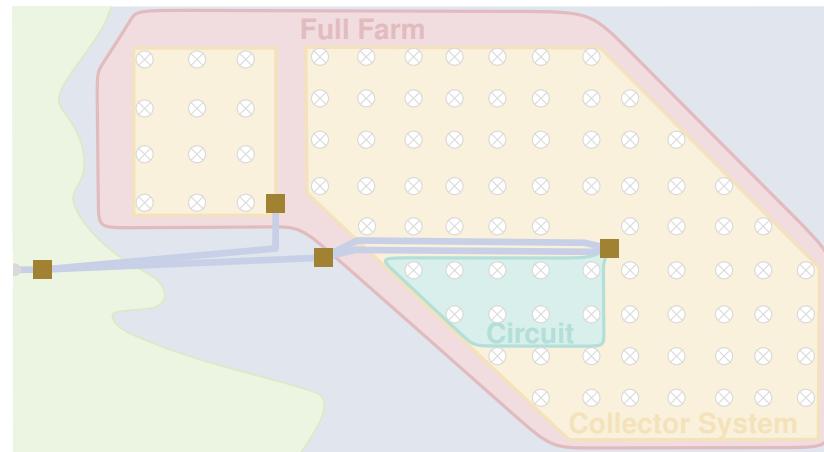


Wind Farm Cabling



Wind Farm Cable Layout Problem

Given V_S set of substations, V_T set of turbines (each with **capacity**),
for each edge: cable types (each with **cost** and **capacity**)



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Wind Farm Cable Layout Problem

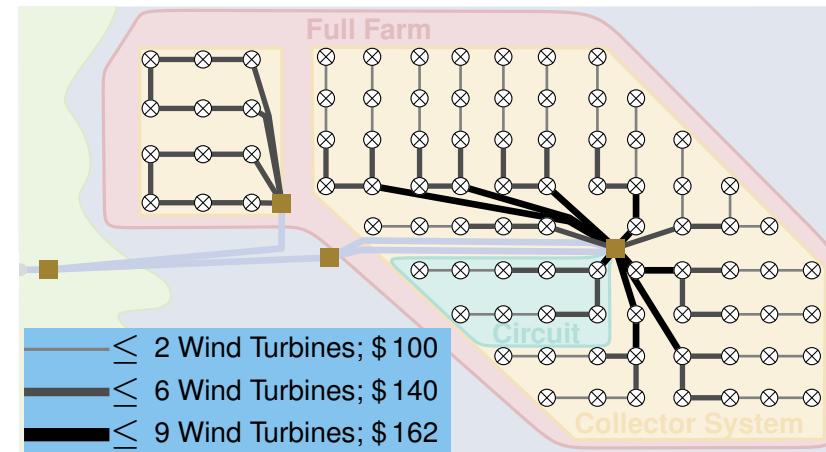
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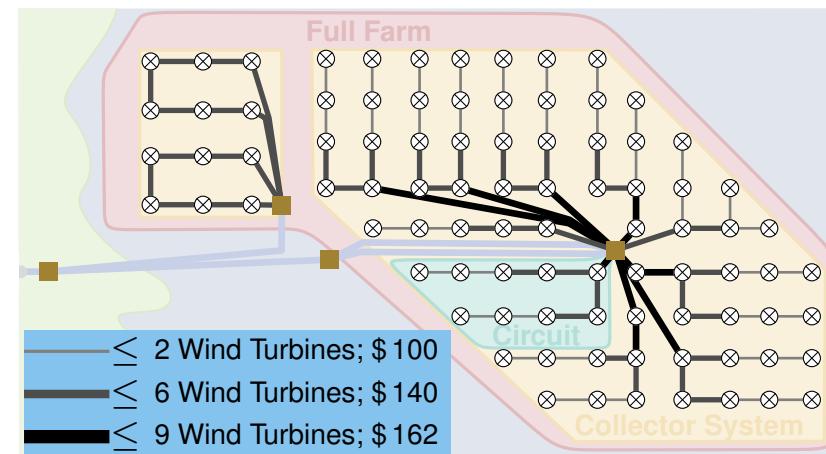


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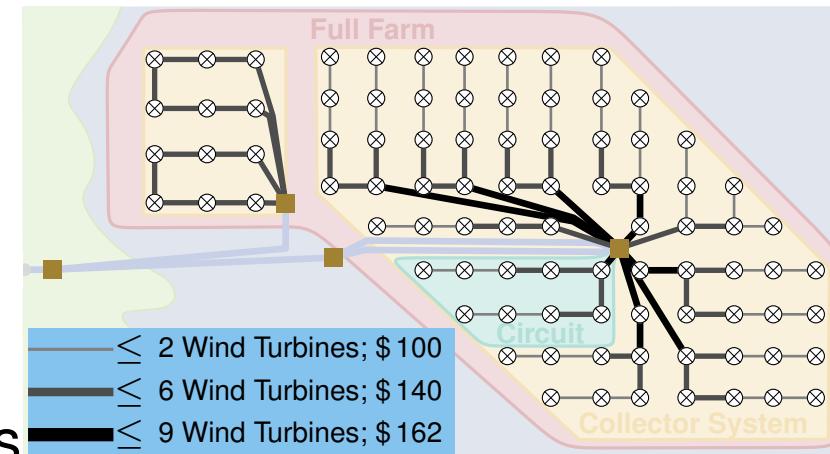
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subject to cable capacity constraints
substation capacity constraints
flow conservation constraints



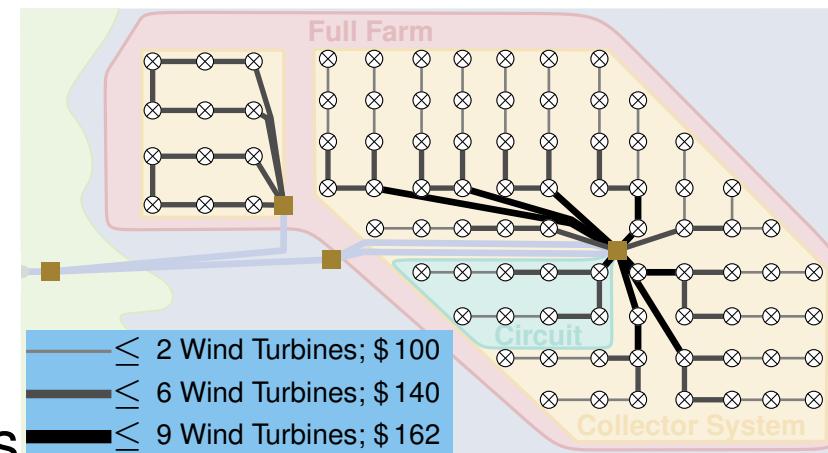
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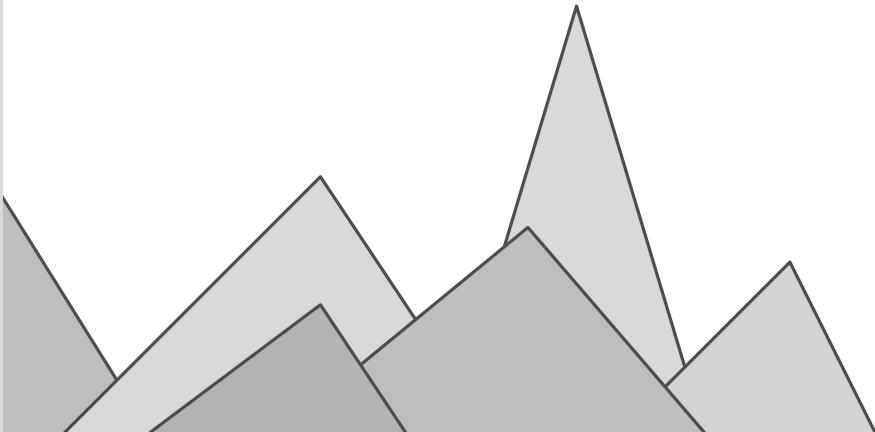
Wind farm planning problem \Leftrightarrow Minimum cost flow problem

using [Leibfried et al., 2015]

$$\text{OPT}(\mathcal{N}_{\text{FFP}}) \leq \sum_{j \in V_s} \text{OPT}(\mathcal{N}_{\text{SP}}(j)) \leq \sum_{j \in V_s} \sum_{i \in \mathbb{N}} \text{OPT}(\mathcal{N}_{\text{CP}}(j, i))$$

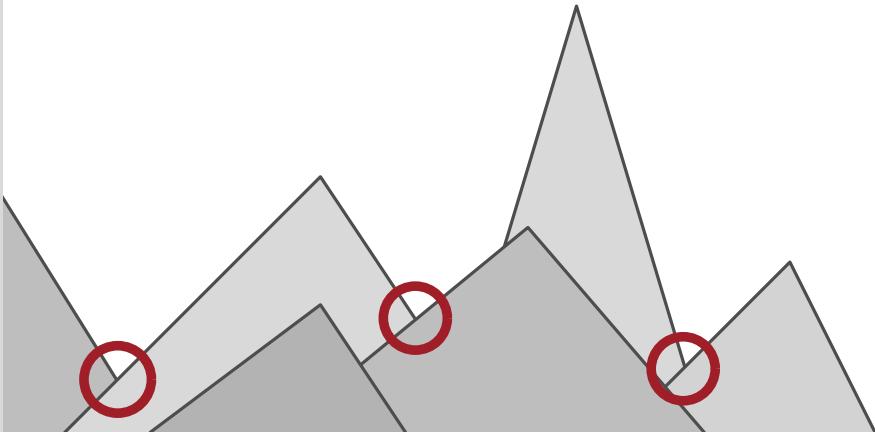
Metropolis Algorithm

Cooling Schedule



Metropolis Algorithm

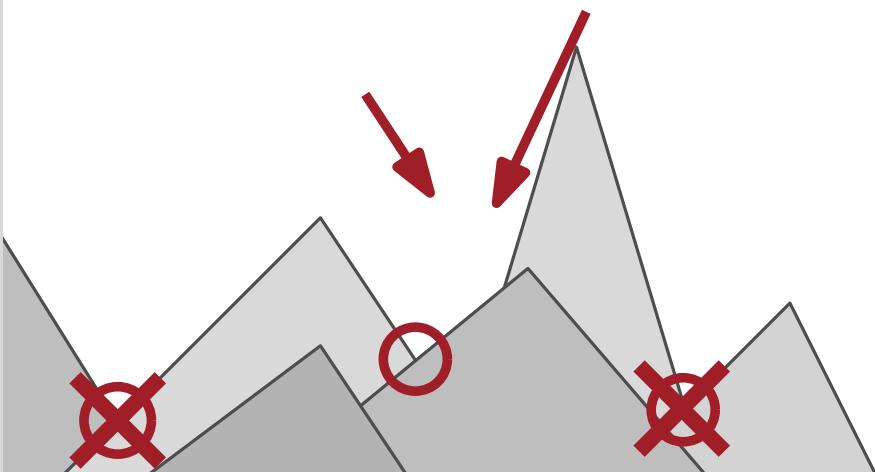
Cooling Schedule



many local optima

Metropolis Algorithm

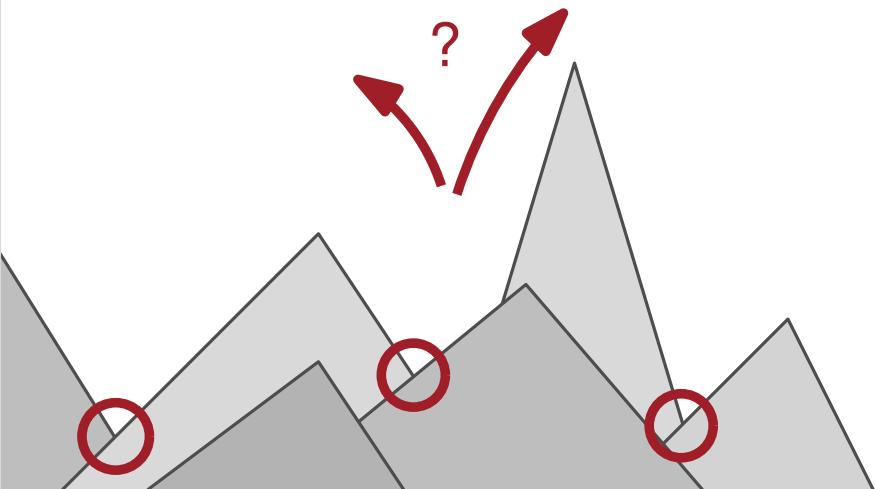
local search



many local optima

Cooling Schedule

Metropolis Algorithm escape local optimum



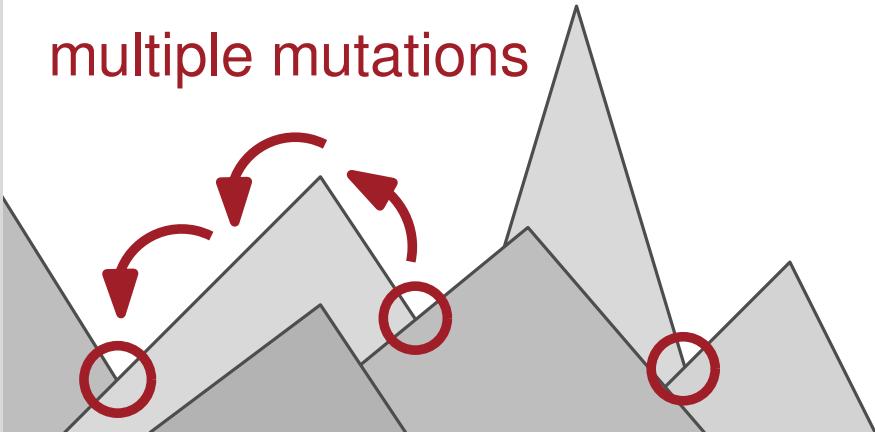
many local optima

Cooling Schedule

Metropolis Algorithm

Cooling Schedule

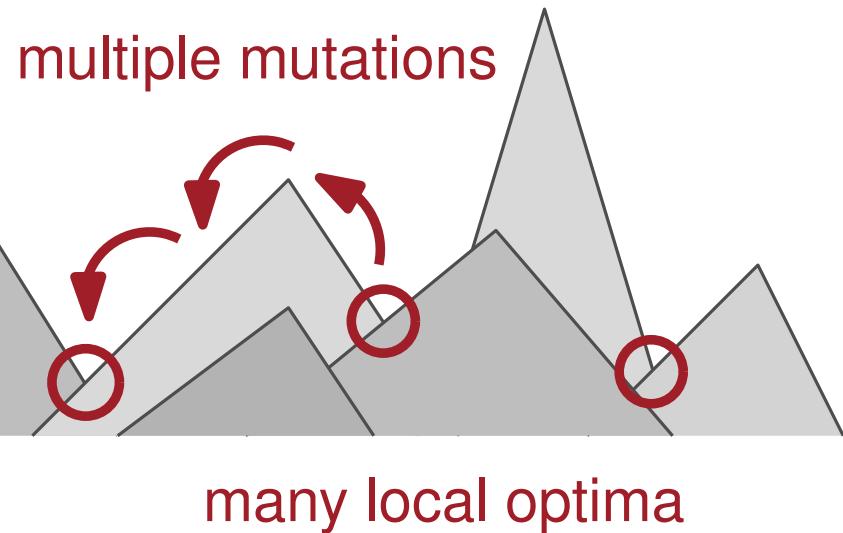
multiple mutations



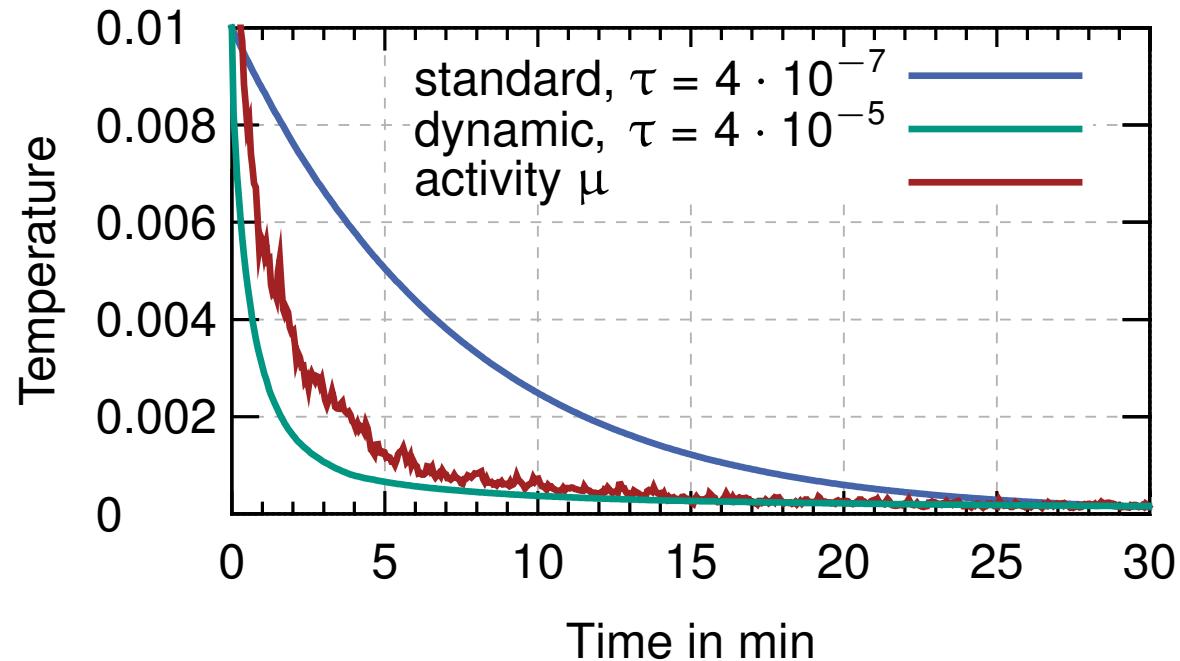
many local optima

Simulated Annealing

Metropolis Algorithm

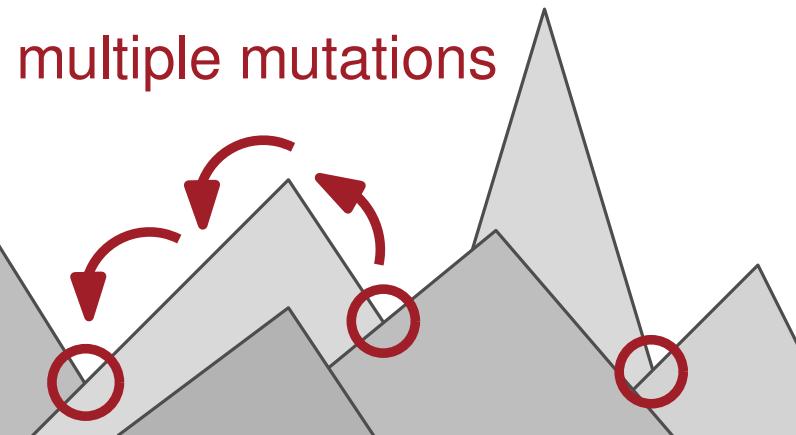


Cooling Schedule



Simulated Annealing

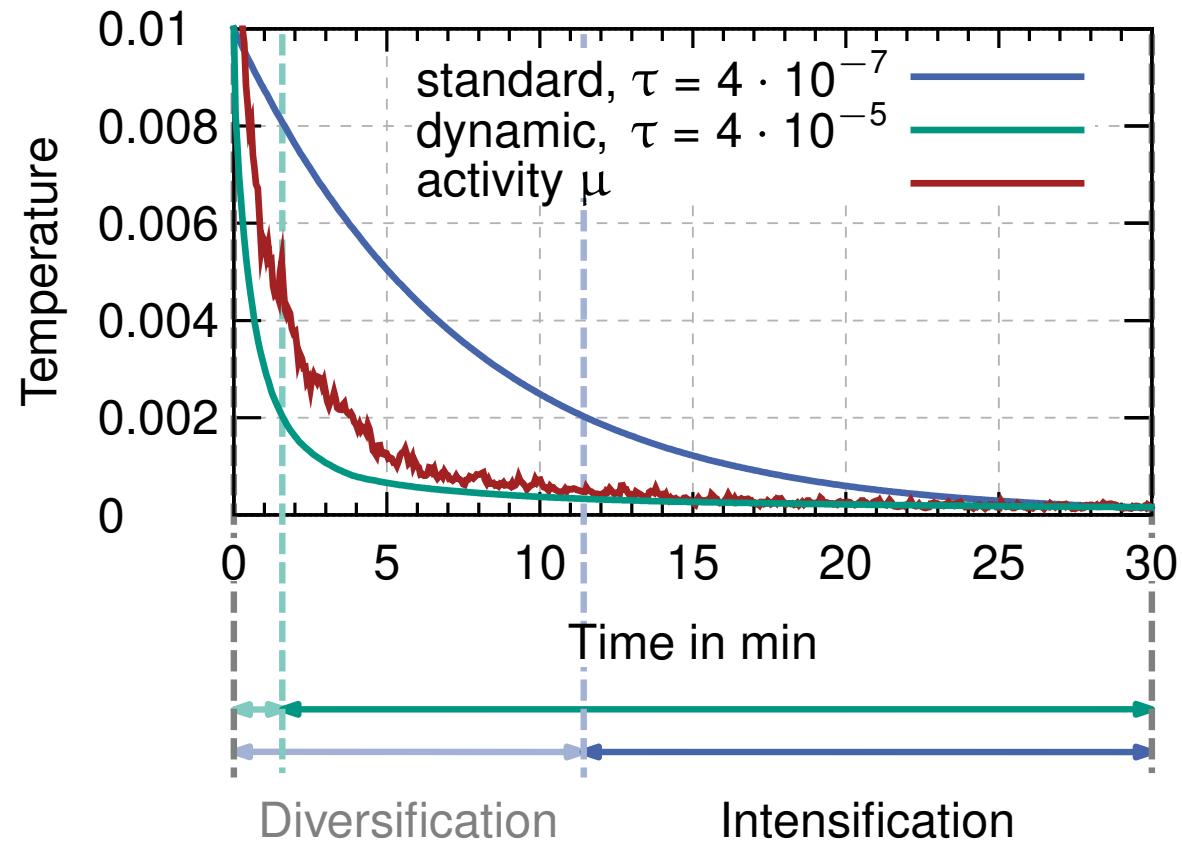
Metropolis Algorithm



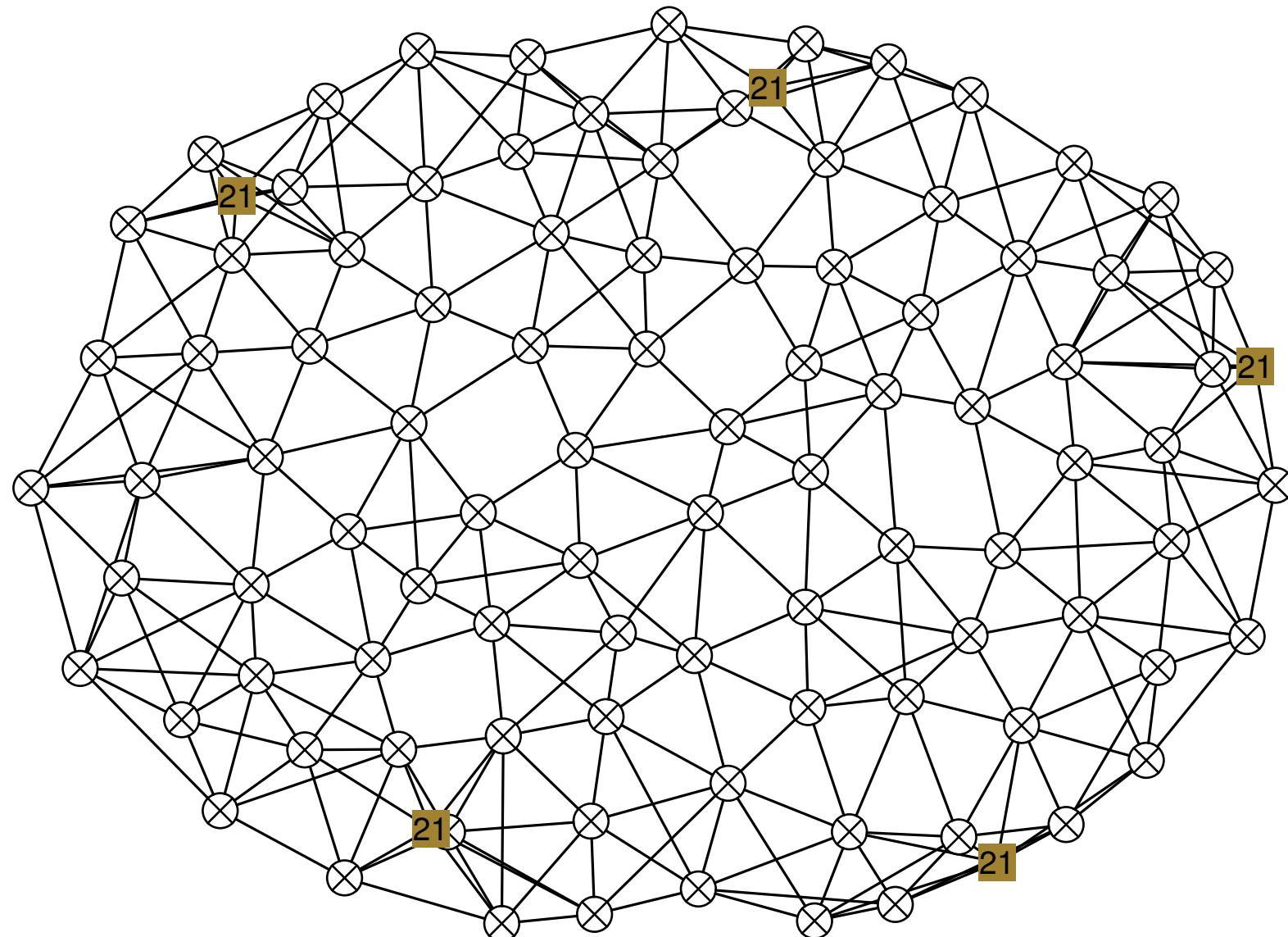
many local optima

Diversification

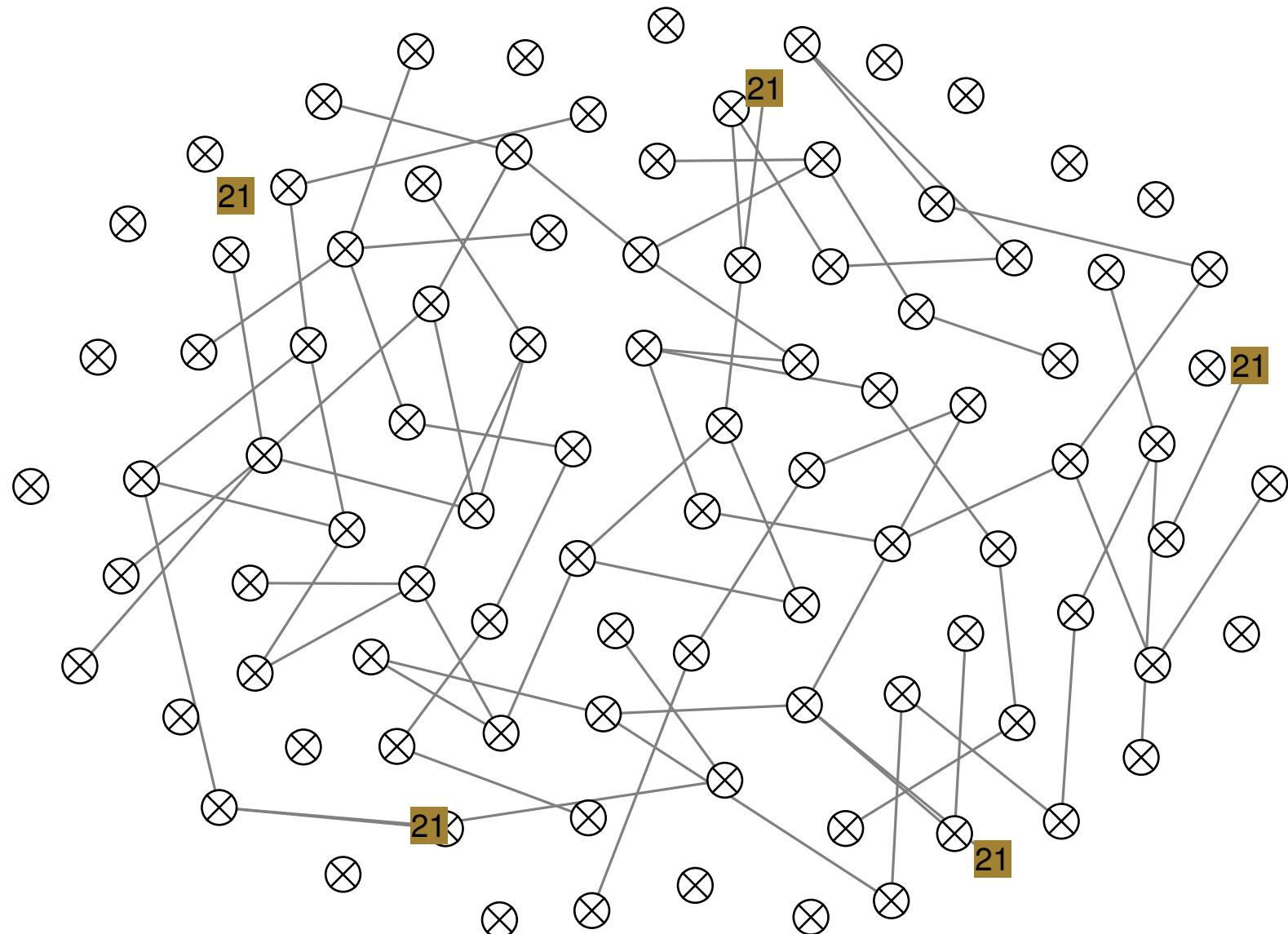
Cooling Schedule



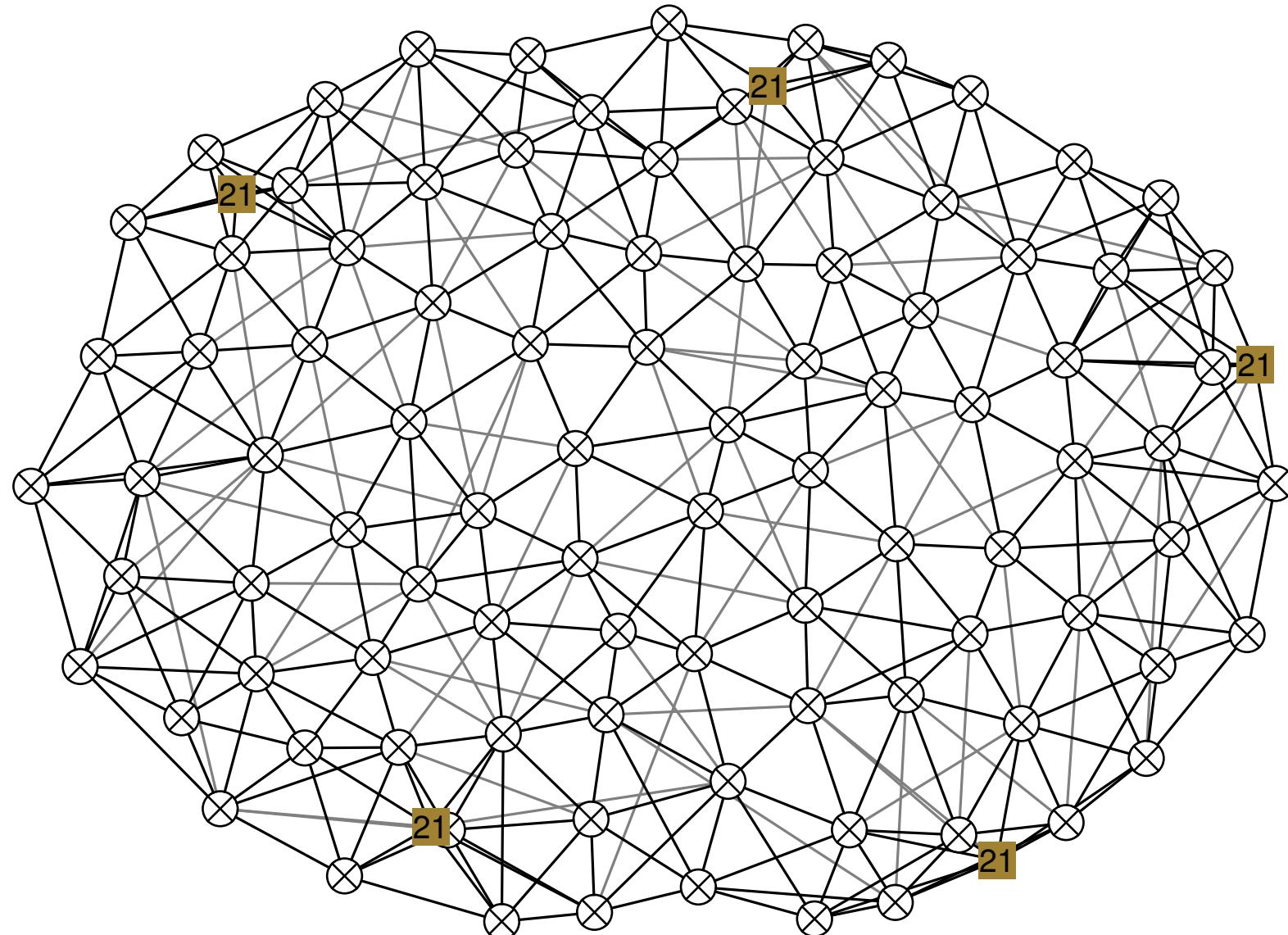
Benchmark Sets



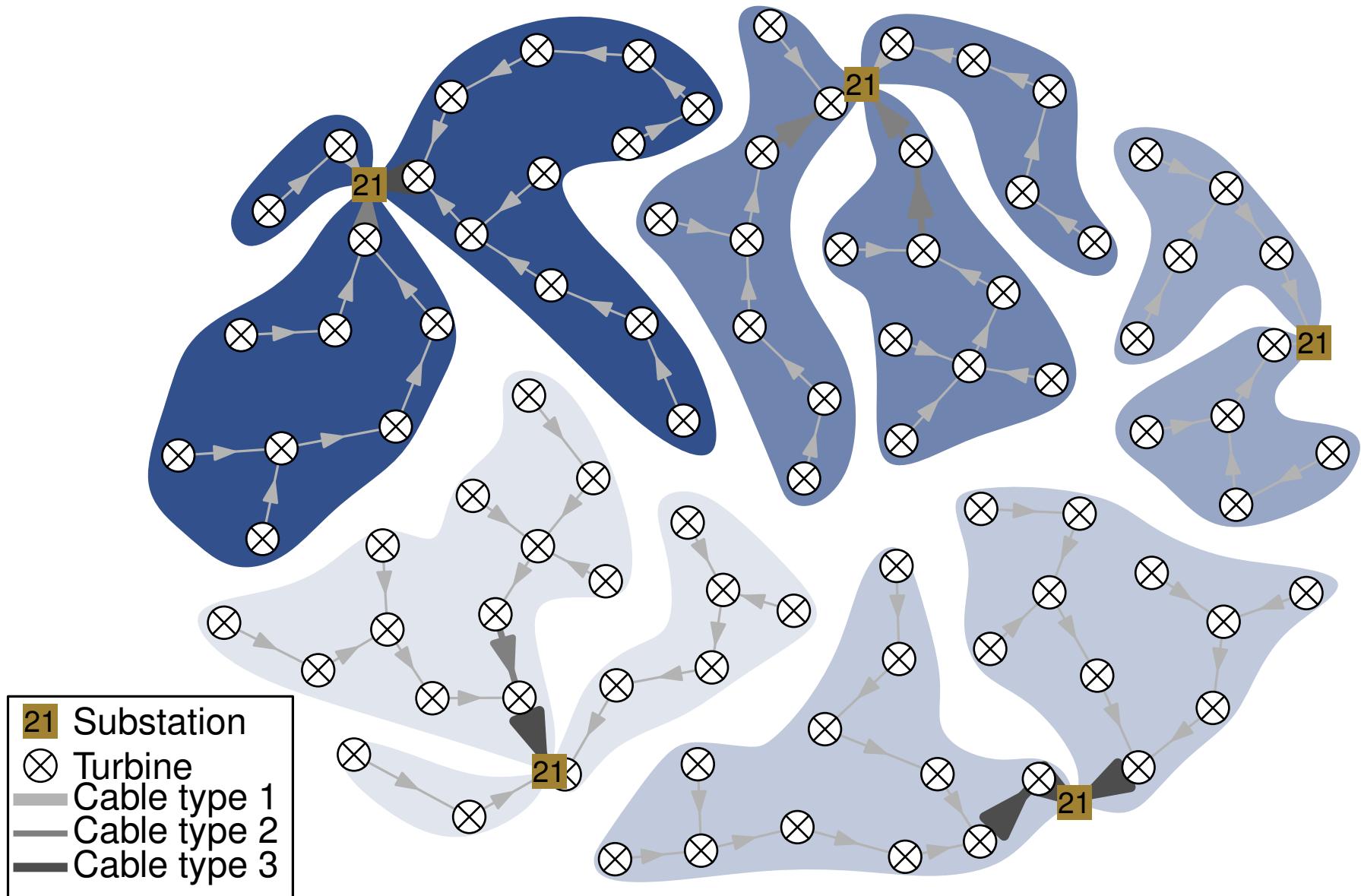
Benchmark Sets



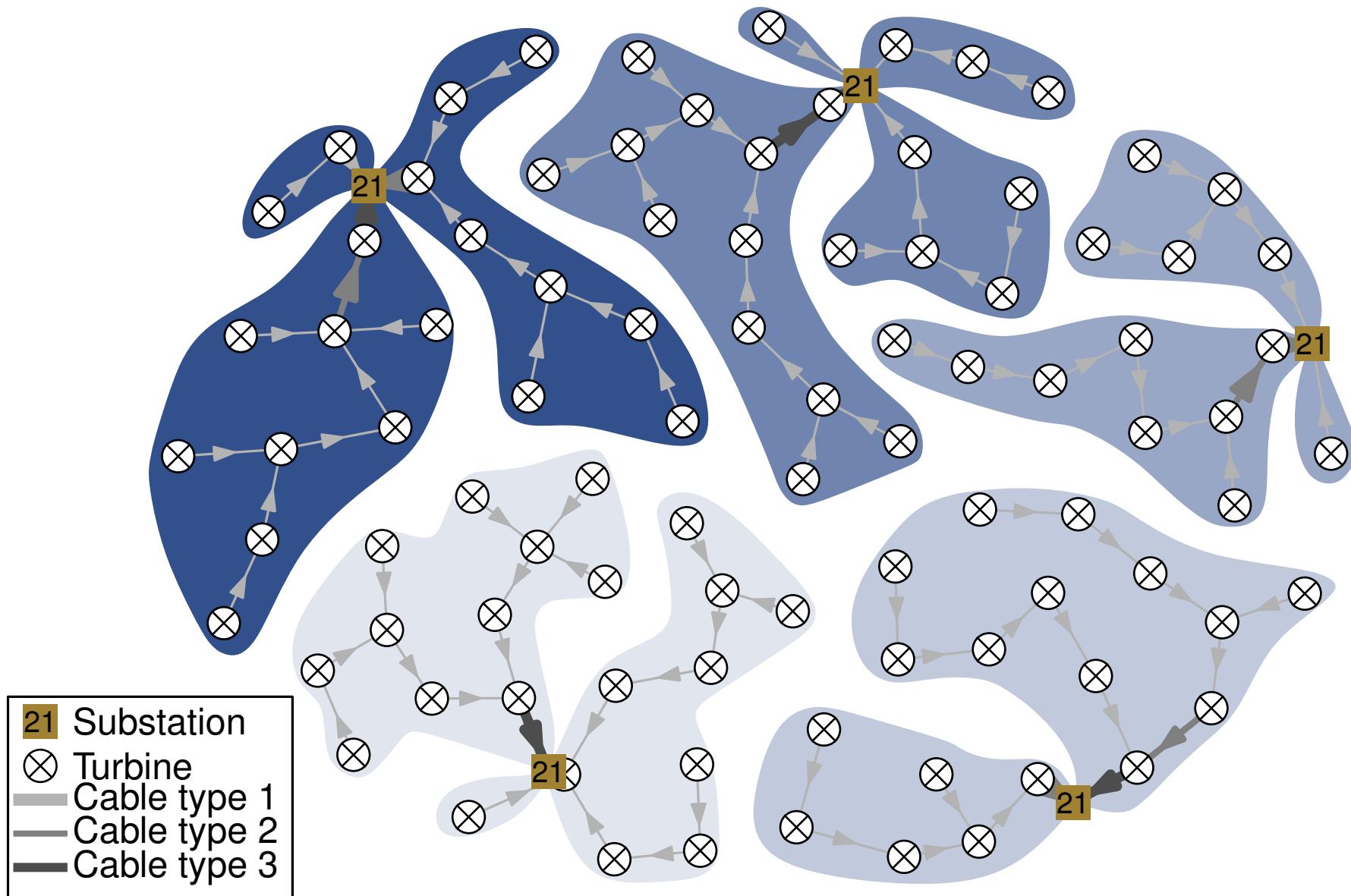
Benchmark Sets



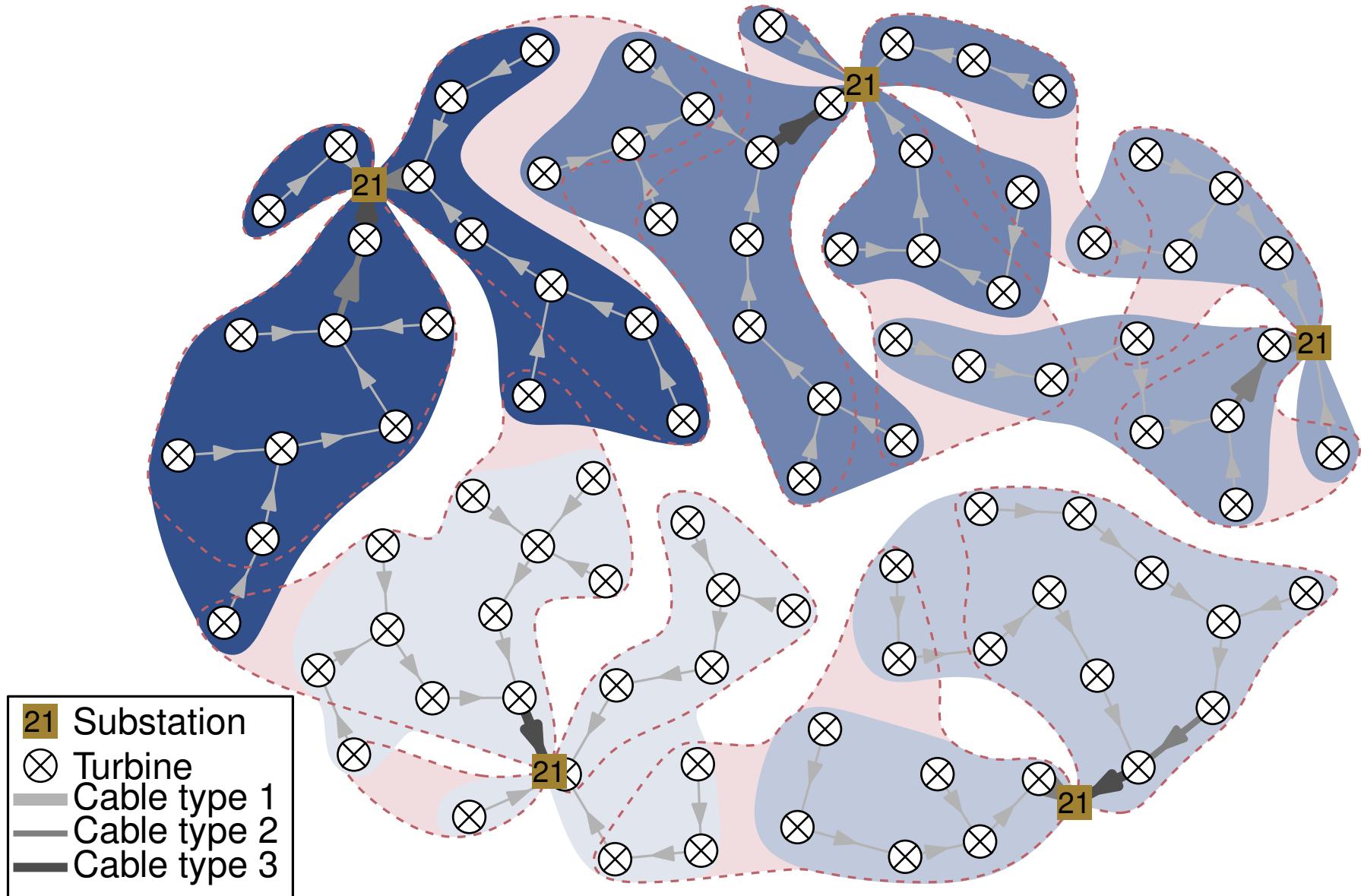
Benchmark Sets



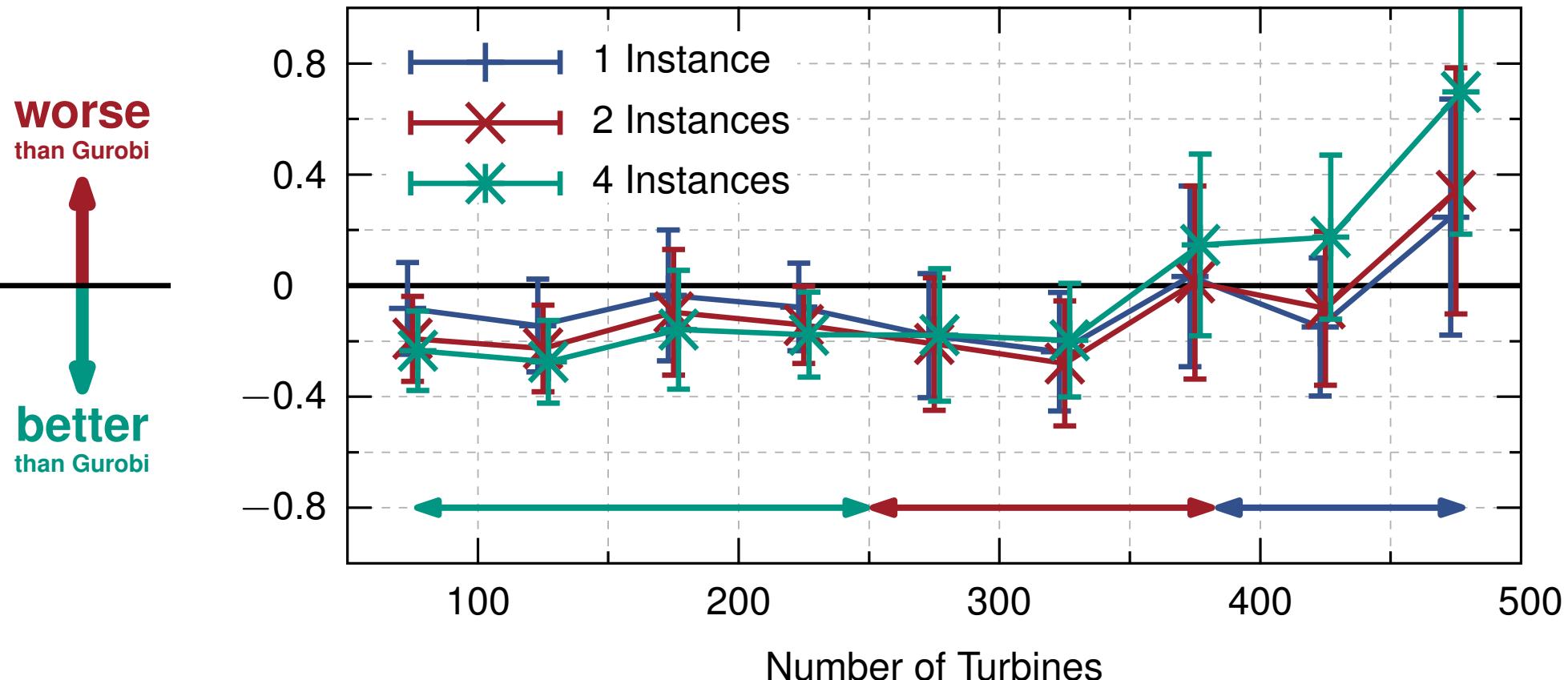
Benchmark Sets



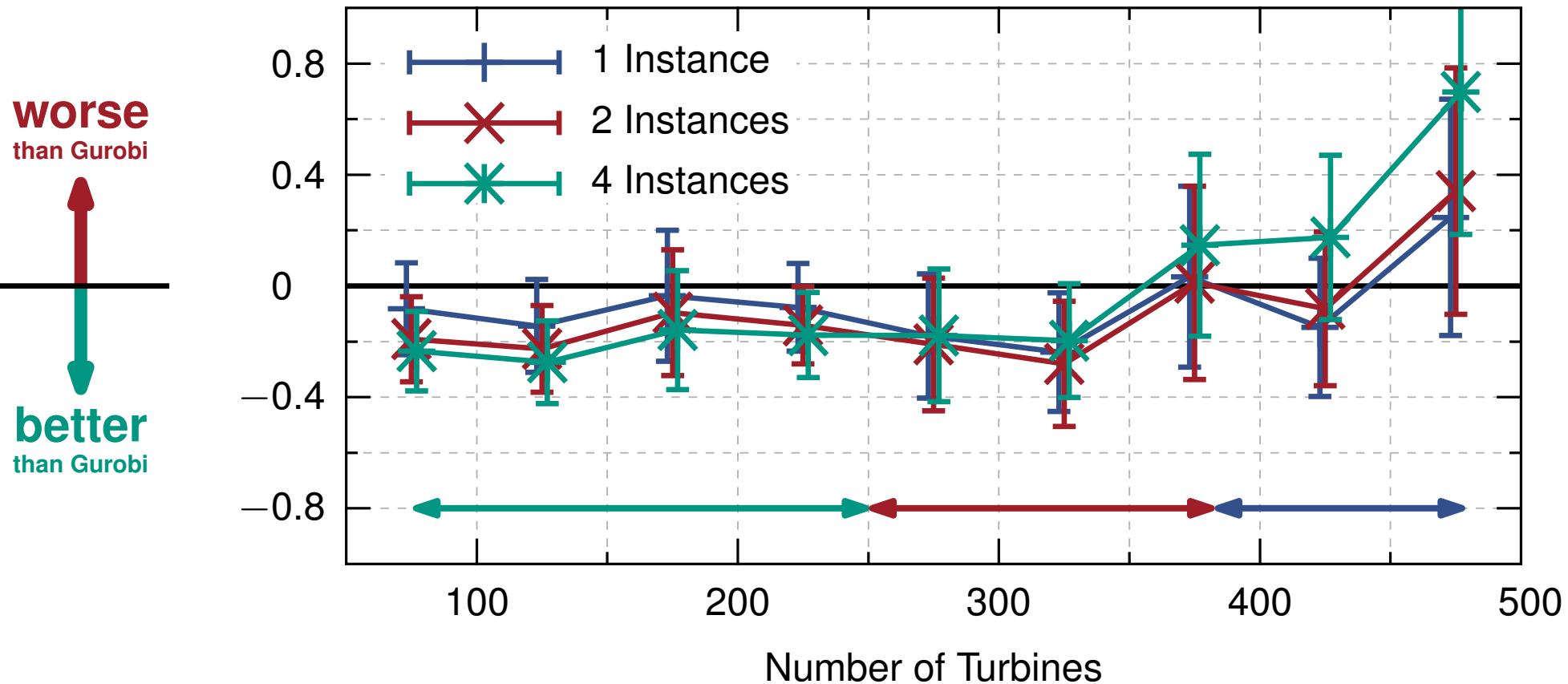
Benchmark Sets



Multiple Instances of Simulated Annealing



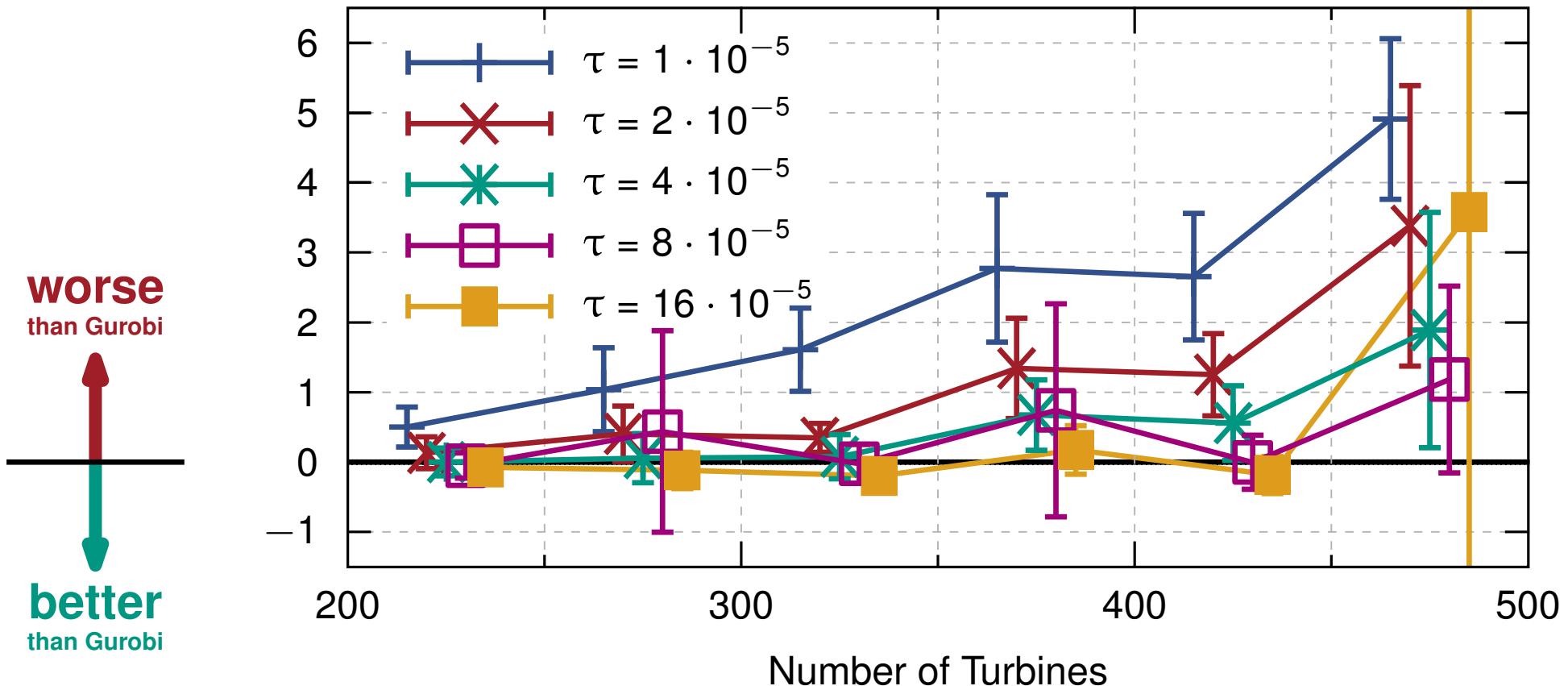
Multiple Instances of Simulated Annealing



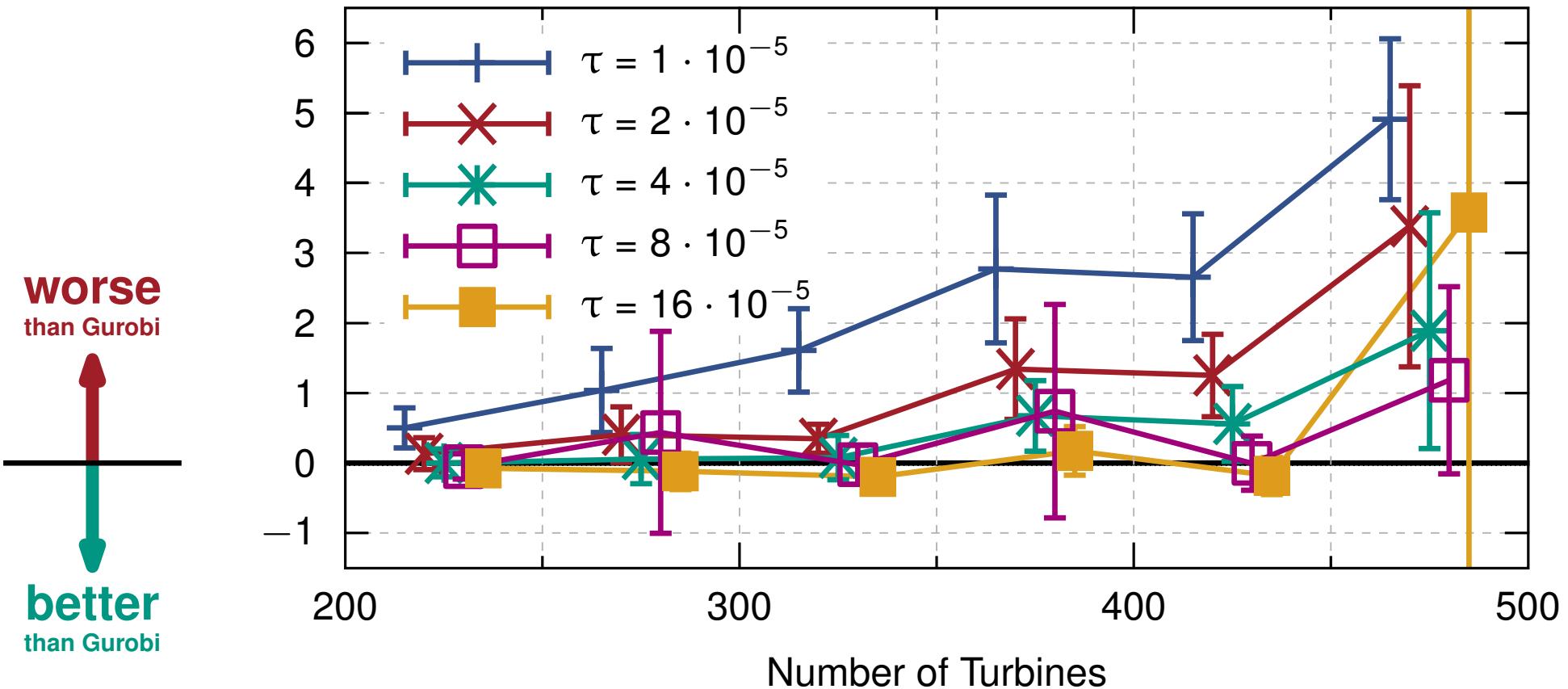
Results depend on a **random seed**.

Multiple instances reduce the overall computation time. This causes a reduced time spend for the intensification phase.

Performance Influence of the Thermal Conductivity and Capacity τ

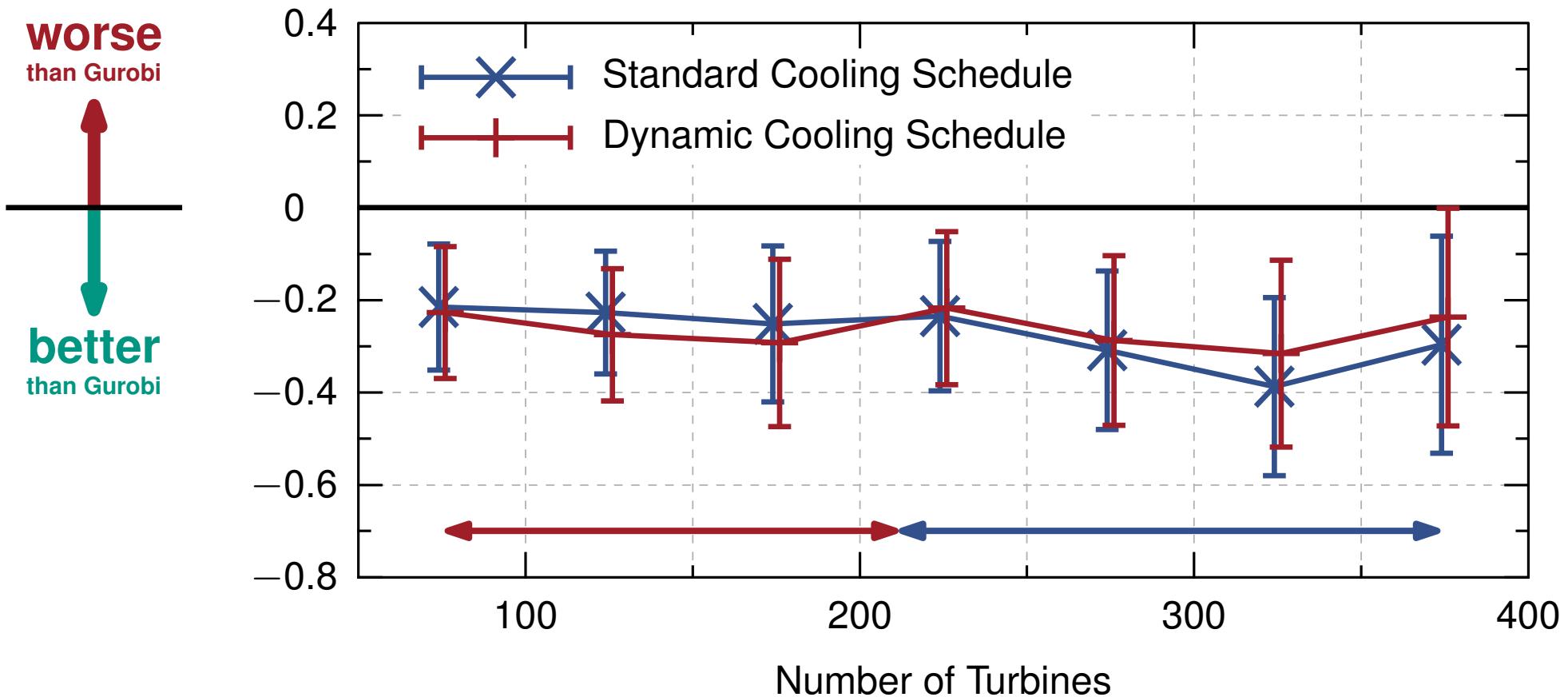


Performance Influence of the Thermal Conductivity and Capacity τ

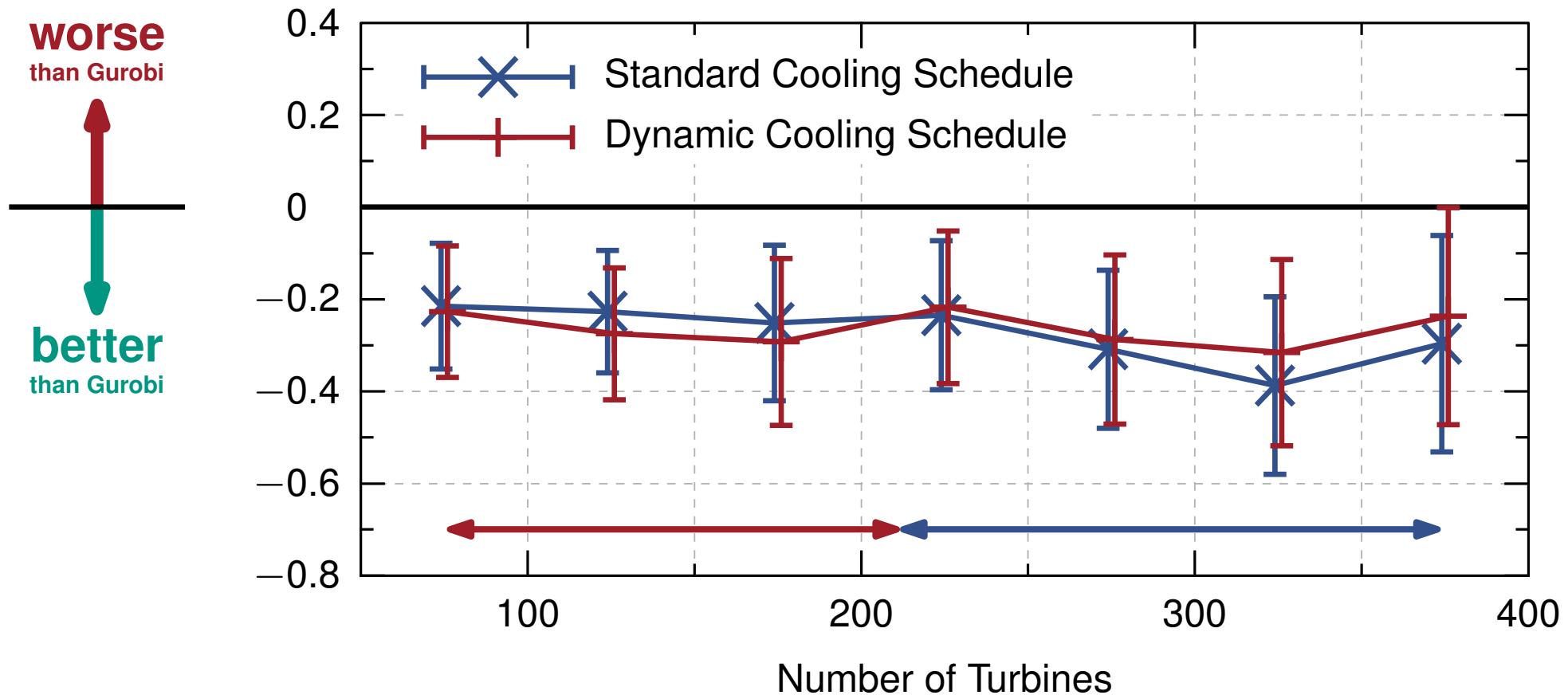


Parameter tuning is difficult for the cooling schedule.

Cooling Schedule Performance

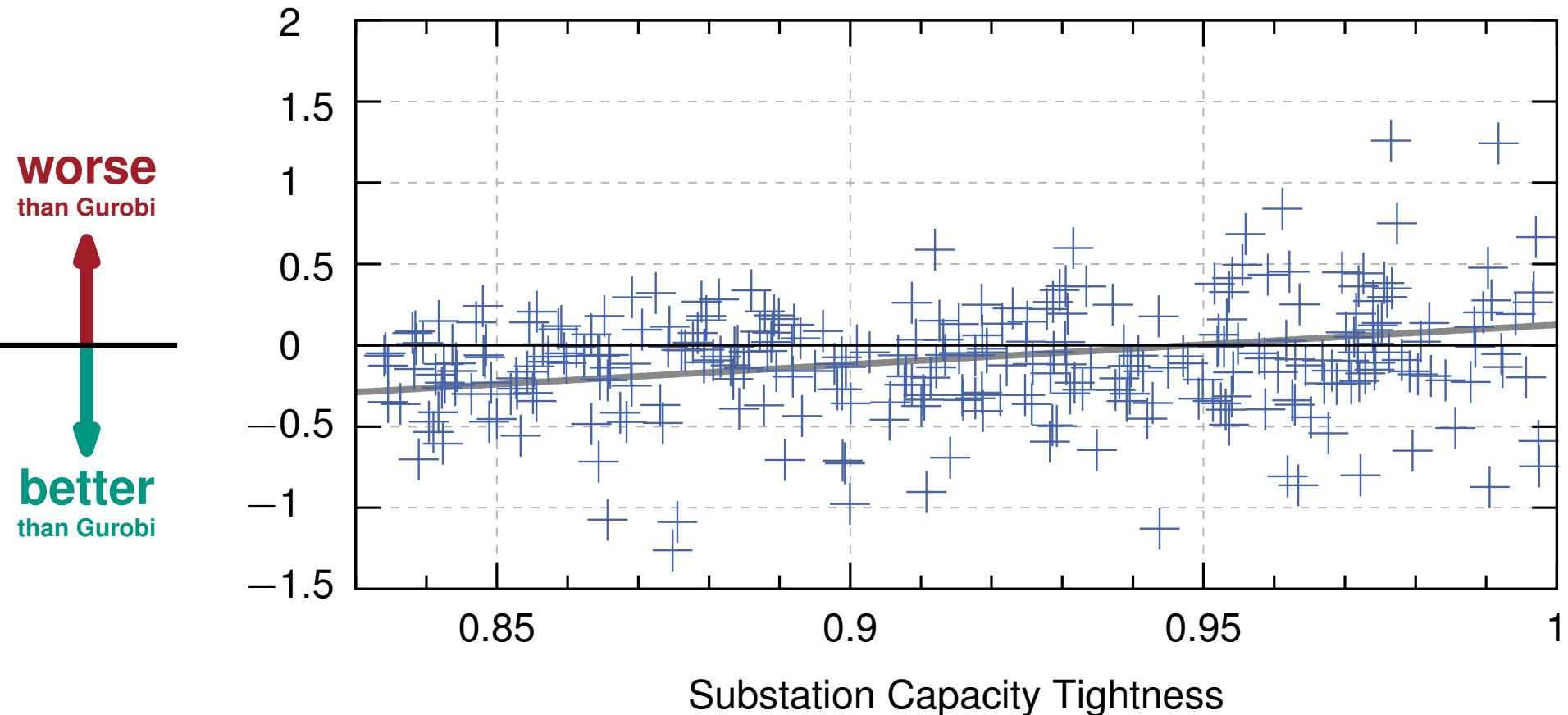


Cooling Schedule Performance

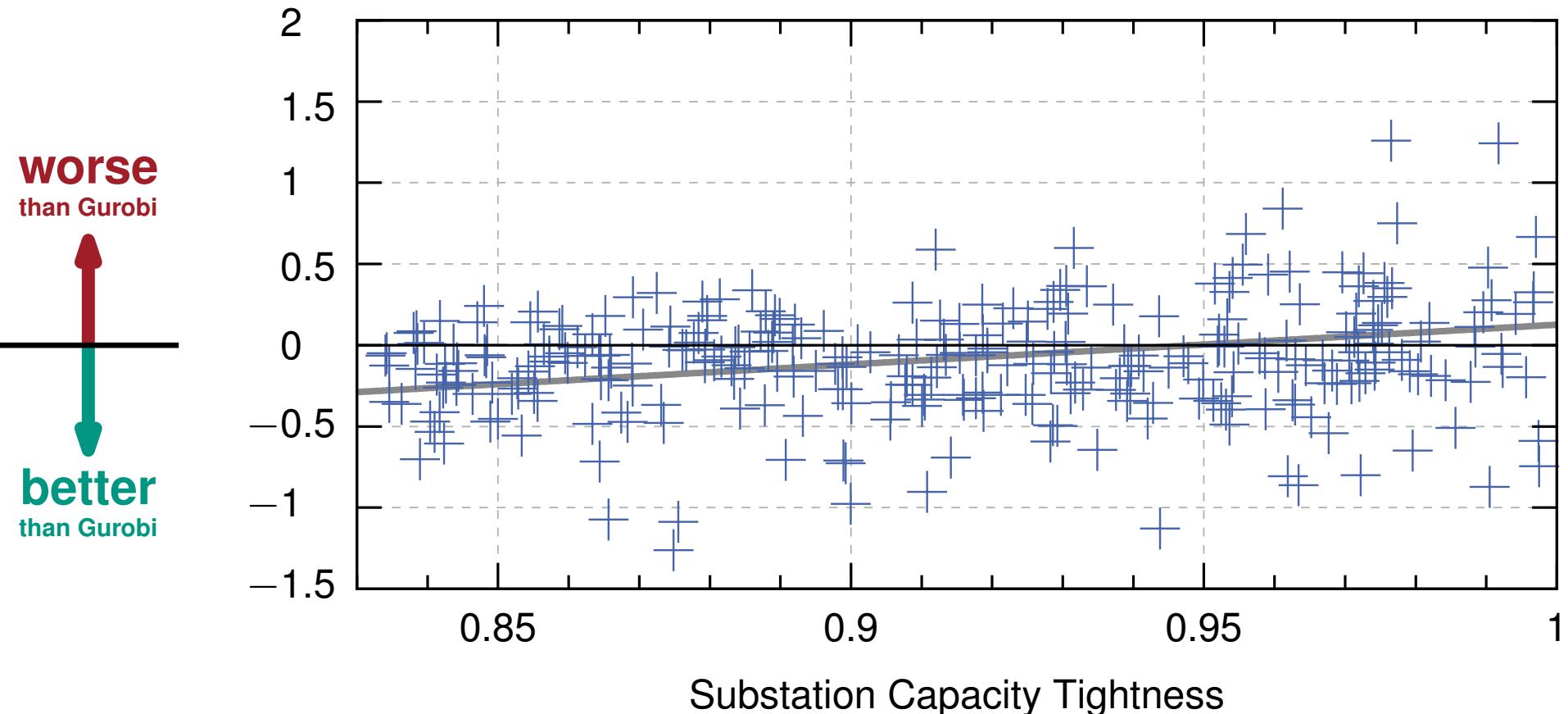


The **dynamic** outperforms the **standard** one without parameter tuning.
Parameter tuning improve the standard one for larger instances.

Performance Influence of the Substation Capacity Tightness



Performance Influence of the Substation Capacity Tightness

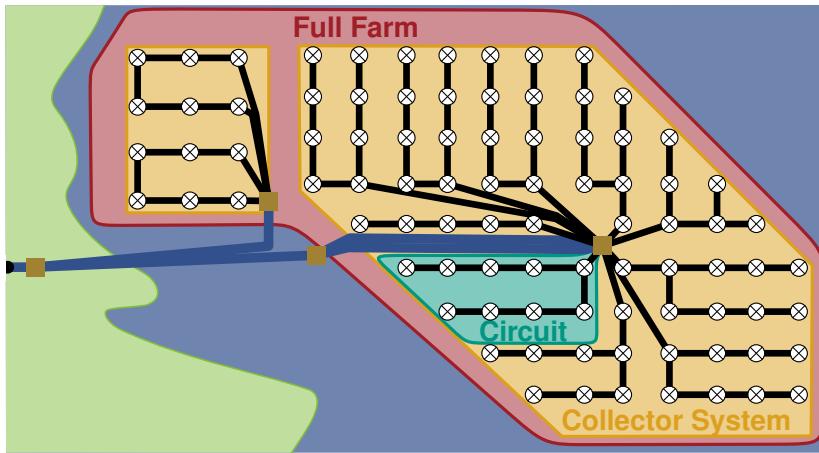


The **tighter** the substation capacity or the **more** substations the harder the instance is to solve. Thus, the solution quality reduces with same duration.

Conclusion & Future Work

Circuit Problem
Substation Problem
Full Farm Problem

Conclusion & Future Work

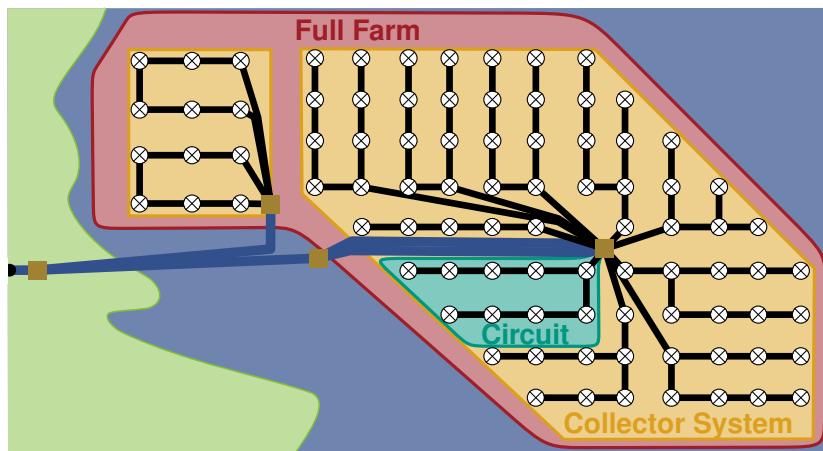


Circuit Problem

Substation Problem

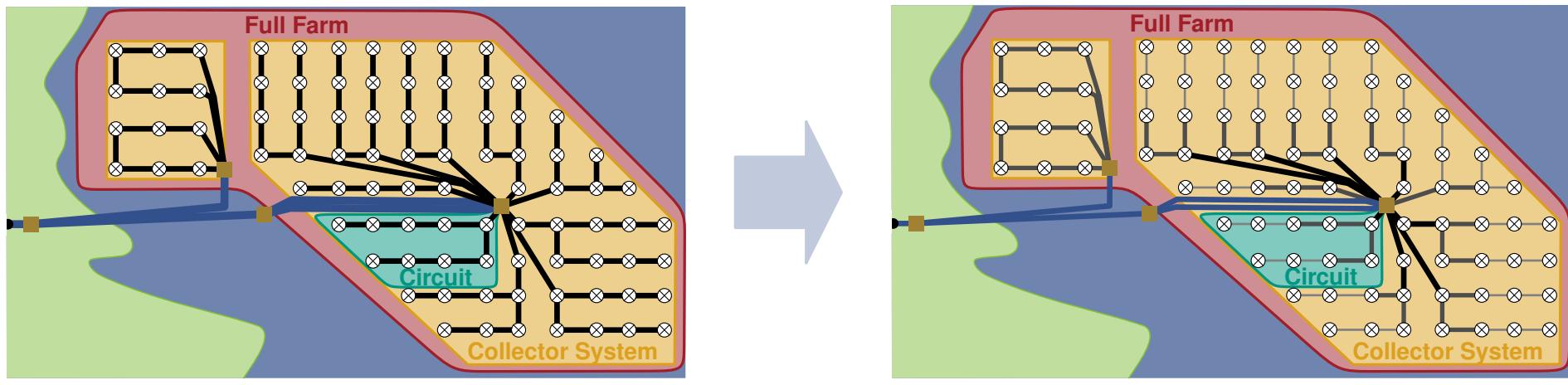
Full Farm Problem

Conclusion & Future Work



P (MST)	Circuit Problem
NP-hard (CMST)	Substation Problem
NP-hard (Heuristics)	Full Farm Problem

Conclusion & Future Work



P (MST)

Circuit Problem

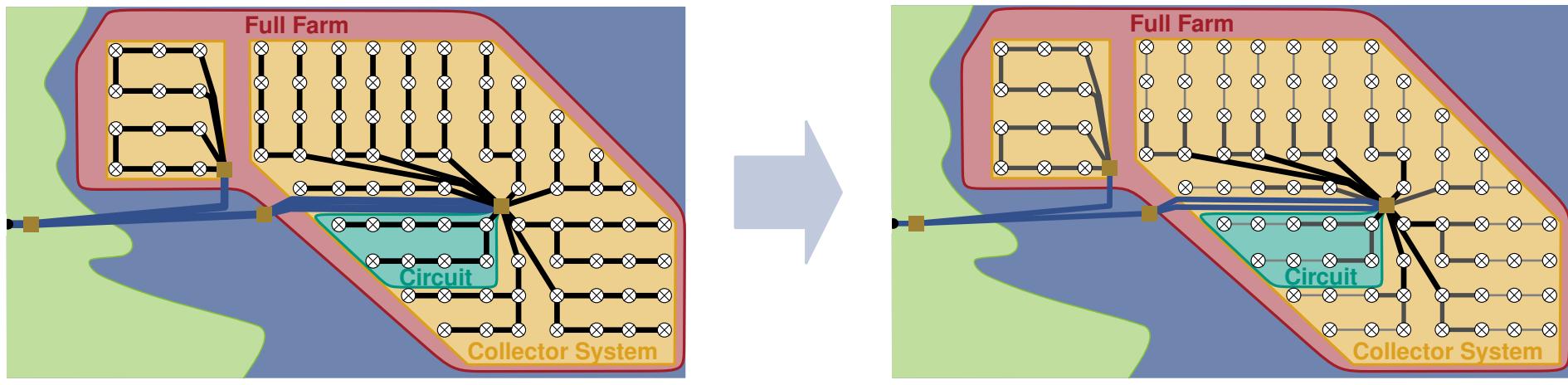
NP-hard (CMST)

Substation Problem

NP-hard (Heuristics)

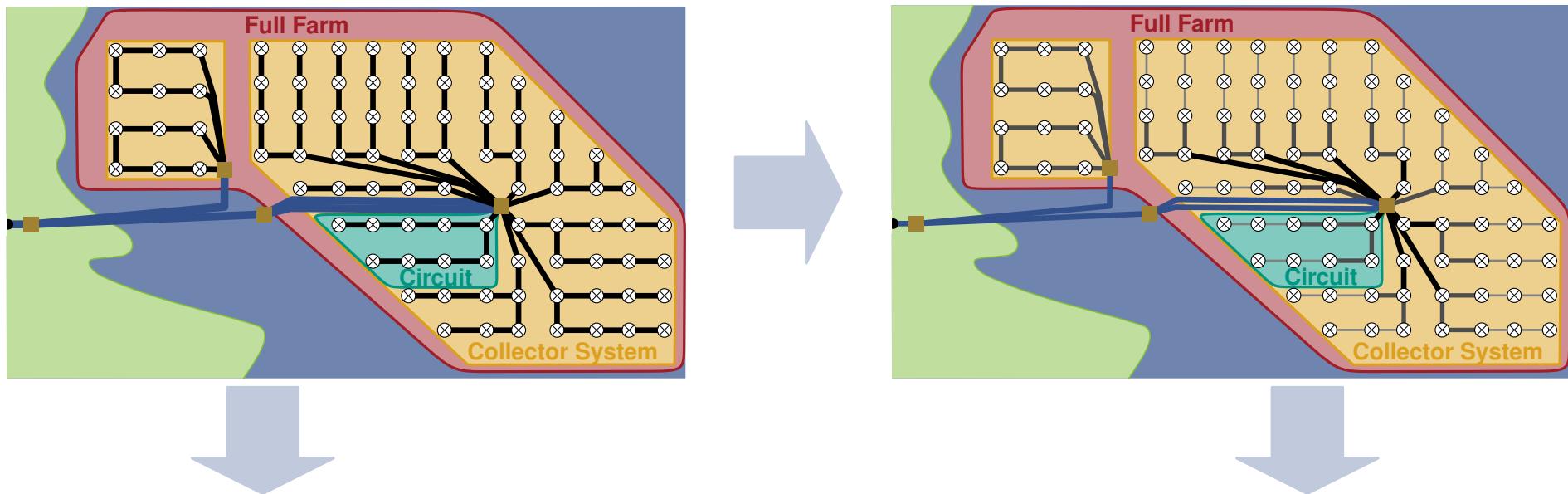
Full Farm Problem

Conclusion & Future Work



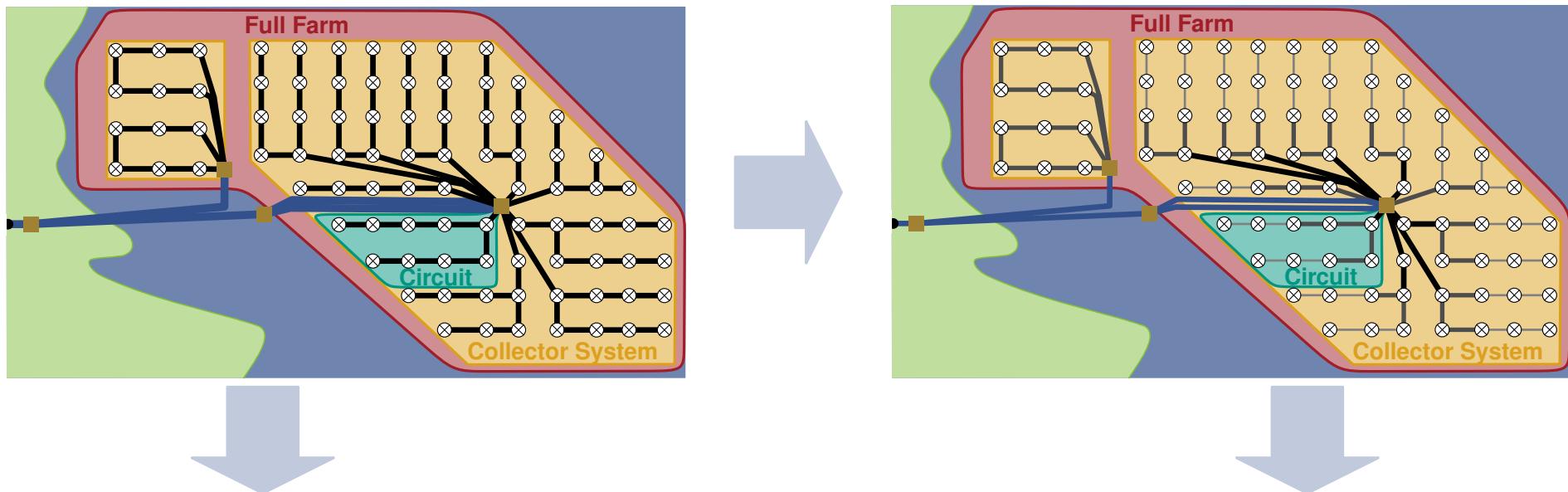
P (MST)	Circuit Problem	NP-hard
NP-hard (CMST)	Substation Problem	NP-hard
NP-hard (Heuristics)	Full Farm Problem	NP-hard

Conclusion & Future Work



P (MST)	Circuit Problem	NP-hard (Clustering)
NP-hard (CMST)	Substation Problem	NP-hard
NP-hard (Heuristics)	Full Farm Problem	NP-hard

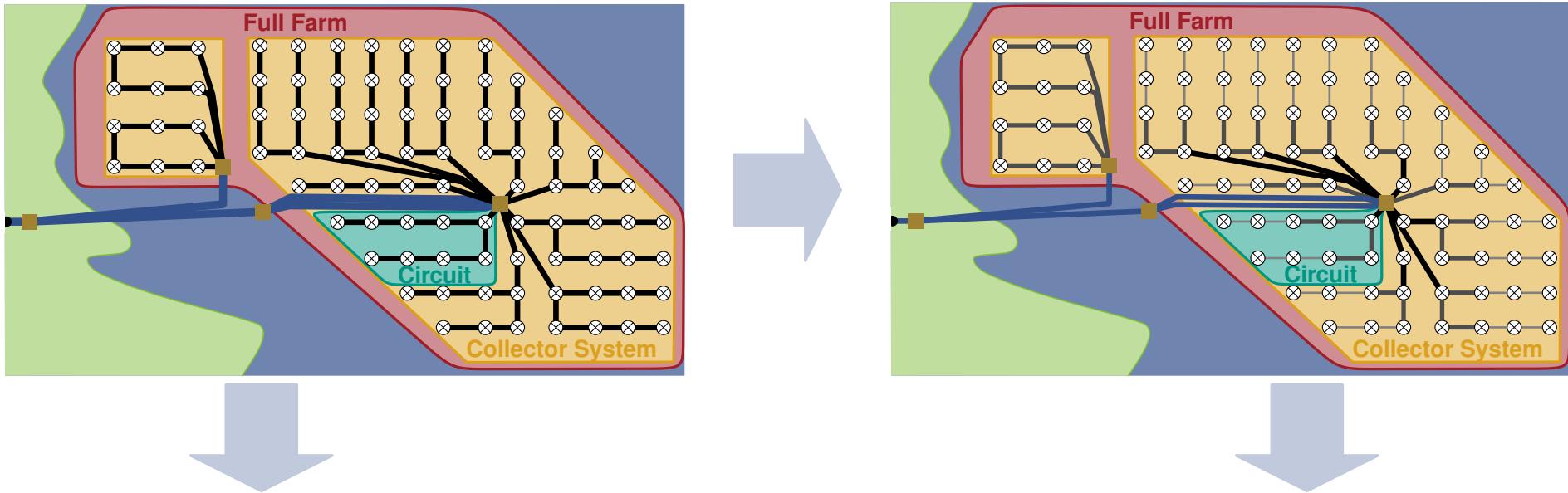
Conclusion & Future Work



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Simulated Annealing

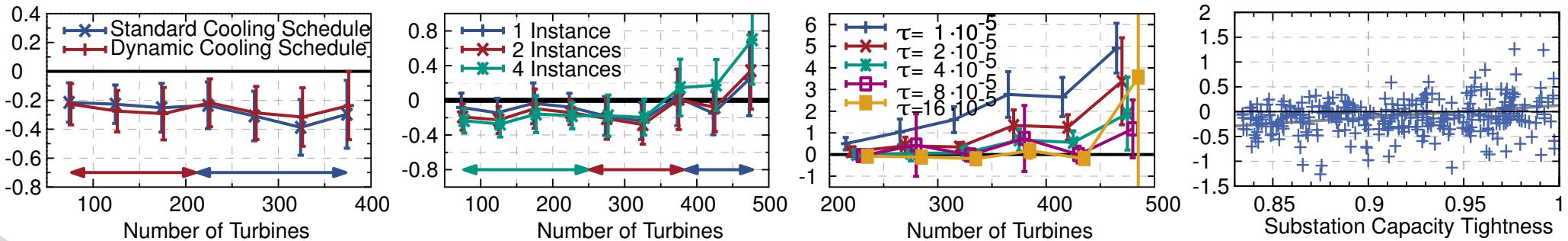
Conclusion & Future Work



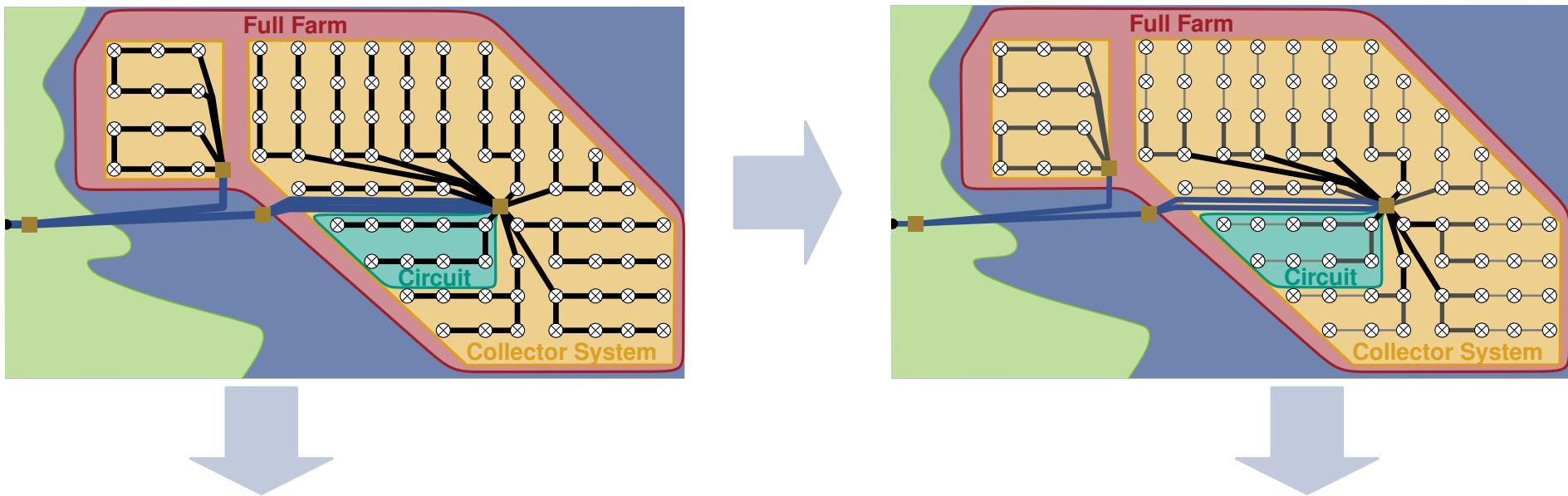
P (MST)	Circuit Problem	NP-hard (Clustering)
NP-hard (CMST)	Substation Problem	NP-hard
NP-hard (Heuristics)	Full Farm Problem	NP-hard

Simulated Annealing

RESULTS



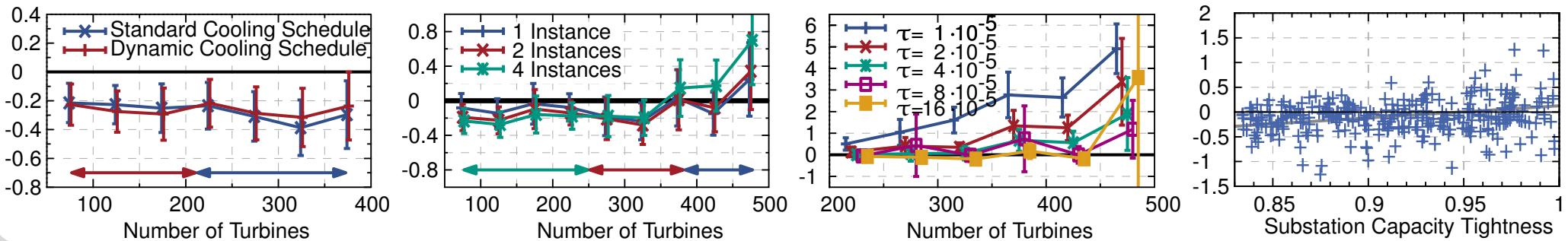
Conclusion & Future Work



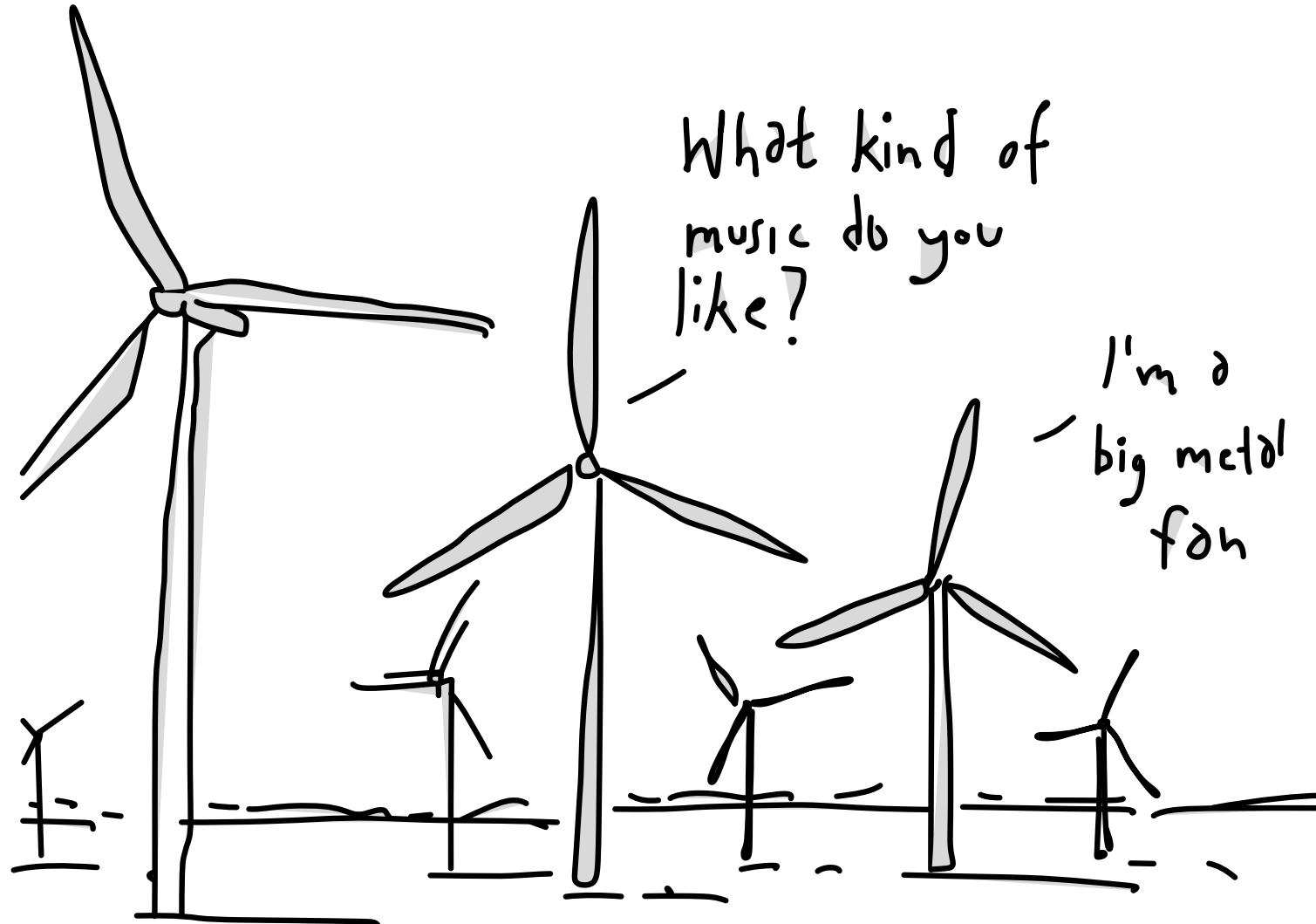
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NP-hard (CMST)	Substation Problem	NP-hard
NP-hard (Heuristics)	Full Farm Problem	NP-hard

Simulated Annealing

RESULTS & FUTURE WORK



Are you a metal fan, too?



<https://s-media-cache-ak0.pinimg.com/originals/8f/51/d3/8f51d30e4e60a97fc5b2fada2ecacd85.jpg>