

# Algorithmic Development for Solving Large-Scale SCACOPF with UC and Line Switching

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**GO Outreach Meeting**



# GMI-GO Team

## GMI-GO Team Members

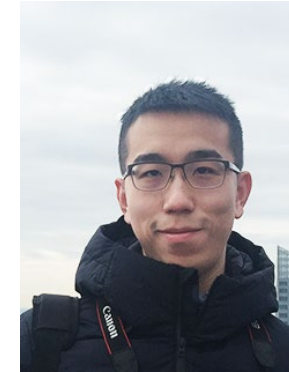
PhD Students:  
(Real Drivers)



Amin Gholami



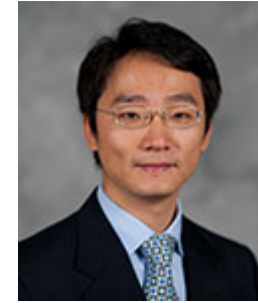
Kaizhao Sun



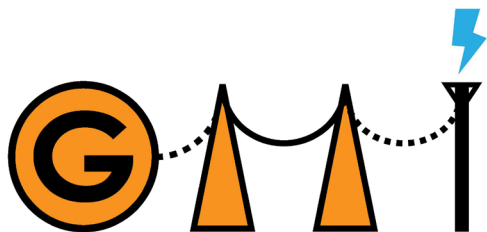
Shixuan Zhang



Prof. Santanu Dey  
Discrete Optimization



Prof. Andy Sun (PI)  
Grid Optimization  
Robust/Stochastic  
Optimization



# Optimization Models

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- ▶ SC-ACOPF in Challenge 1
  - Minimize base-case cost + average ctg penalty cost
  - AC PF
  - Contingency corrective action
  - Disjunctive constraints linking base-case and ctg
  
- ▶ SC-ACOPF in Challenge 2
  - Flexible load with piecewise linear market surplus
  - (Gen cost – demand surplus) and penalty in both stages
  - UC decision
  - Line switching/transformer/adjustable shunts decision

# Computational Challenges

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- ▶ Two-stage MINLP
  - 1<sup>st</sup>-stage: base case ACOPF+UC+LS
  - 2<sup>nd</sup>-stage: a large number of contingencies
  - Each stage is a difficult MINLP
  
- ▶ Stringent time requirement
  - Base case: 5 min or 60 min for obtaining solution
  - Contingency ACOPF can be much harder to solve than base case
  
- ▶ Very large scale instances
  - Parallel computation

# Solution Strategy

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- ▶ Code 1 Strategy:
  - Decouple two stages
    - Solution time 5min
  - Handle integer decisions and nonlinear constraints
    - Heuristics for UC and Line Switching to fix integer var
    - IPOPT for solving ACOPF
- ▶ Code 2 Strategy:
  - Solve ctgs ranked by contingency ranking

# Decoupled Method

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- ▶ Decoupled method:
  - Solve base case alone in code 1
  - Use MA57, MA86, MA97 solvers for IPOPT
  - Modifications of base case model
  - Various US heuristics
  - Parallel codes

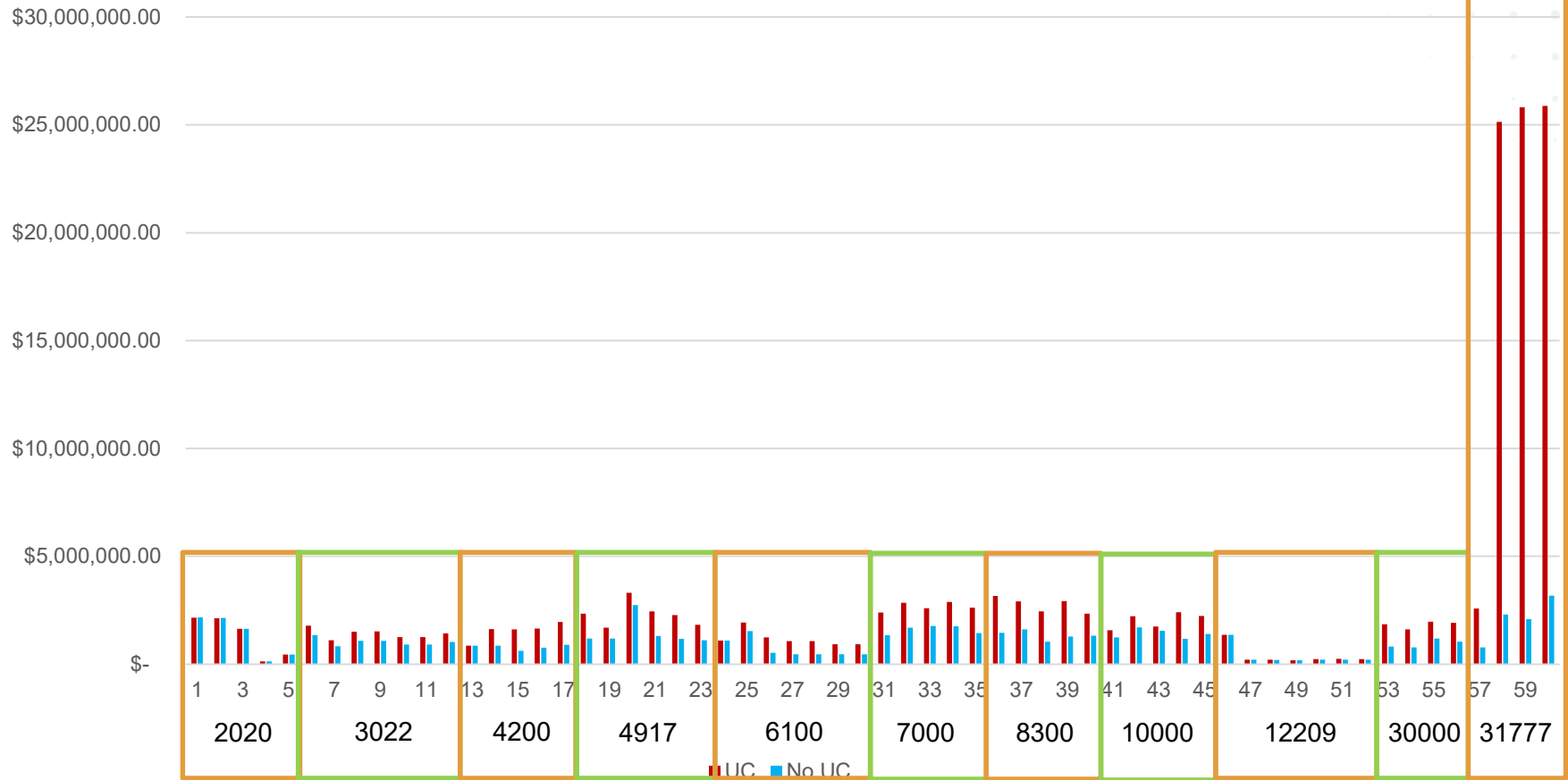
# UC and Line Switching Heuristics

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- ▶ Observation:
  - When load is flexible, too much load may lead to very high gen cost and low load benefit
  - Need to meet gen and load
  - Solving full UC is time consuming
- ▶ UC Heuristics:
  - Heuristic strategy to find a proper level of gen for a given level of load by ranking generators according to average generation; give a marginal cost
  - LP-based matching
- ▶ Line Switching Heuristics:
  - Determine which lines to turn on based on UC heuristics (marginal gen cost)

# UC Heuristics vs No UC

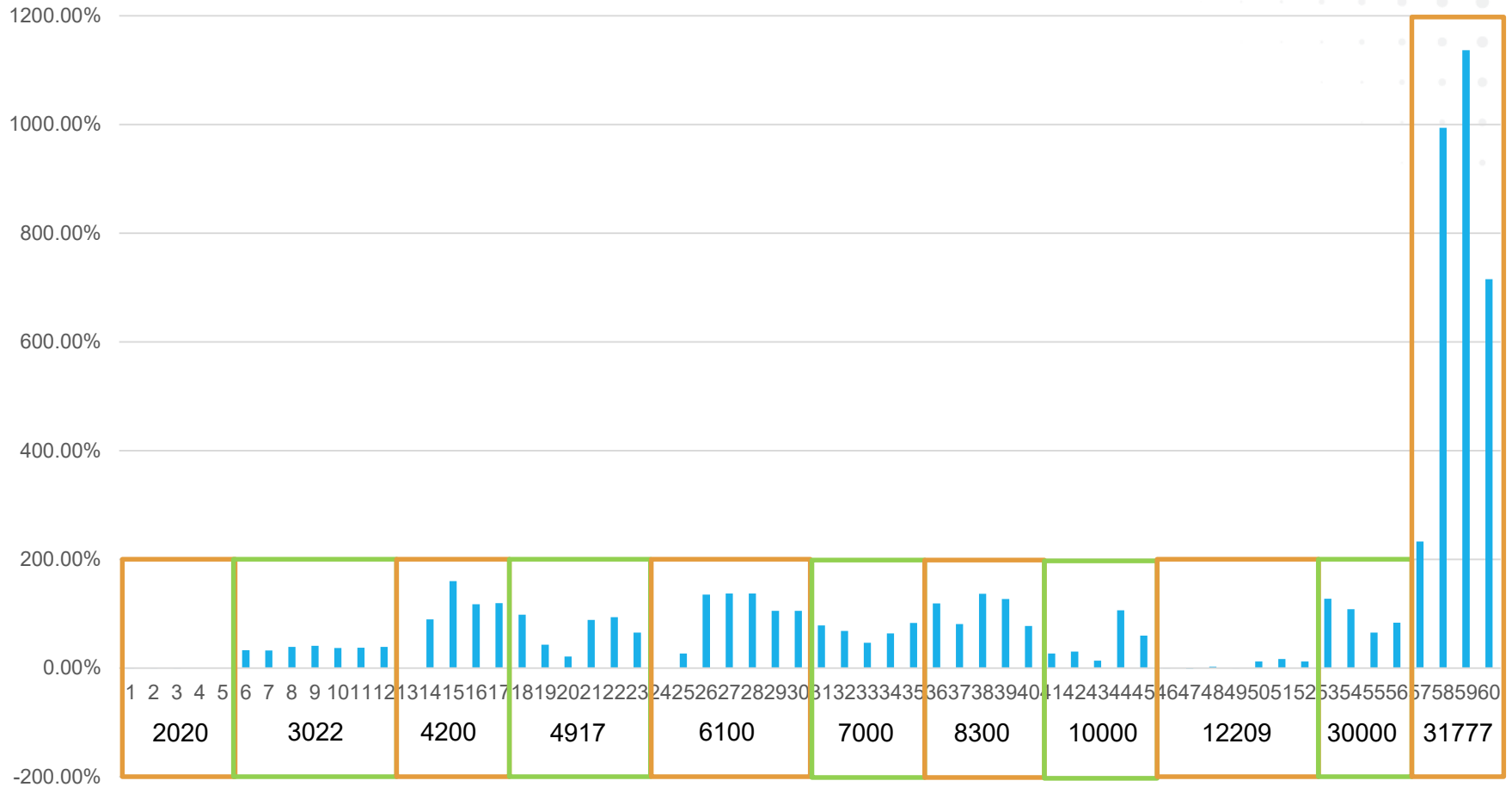
UC vs No-UC





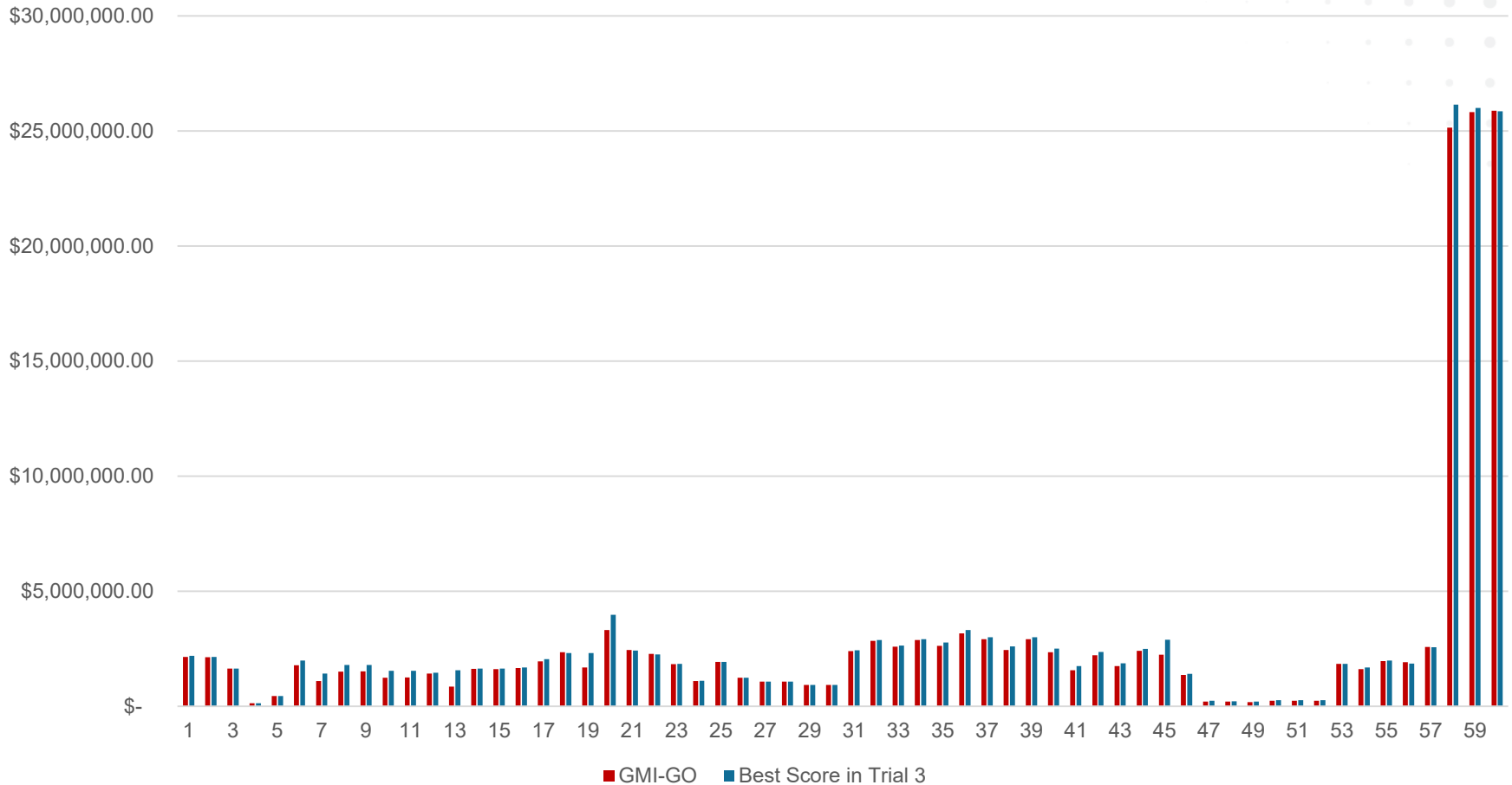
# UC Heuristics vs No UC

Percentage Improvement by UC Heuristics



# GMI-GO vs Best Score in T3

GMI-GO vs Best Score in Trial 3



GMI-GO Avg: **167,724,710.34**

Best Score Avg: **175,374,061.00**

Difference: 4.56%

# Future Path

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- ▶ Approximate two-stage SC-ACOPF and solve by distributed optimization
  - Solve 2-stage MINLP with a subset of 2<sup>nd</sup>-stage ctg
  - Contingency guarantees
- ▶ We plan to further develop the code in the direction of improved UC and LS heuristics, faster contingency solution time, better parallel implementation, and solution quality bounds.

# Contact Information

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