TCS Quantum Challenge

Mock Presentation

Challenge #2 *Power Grid Optimization using Quantum Algorithms*

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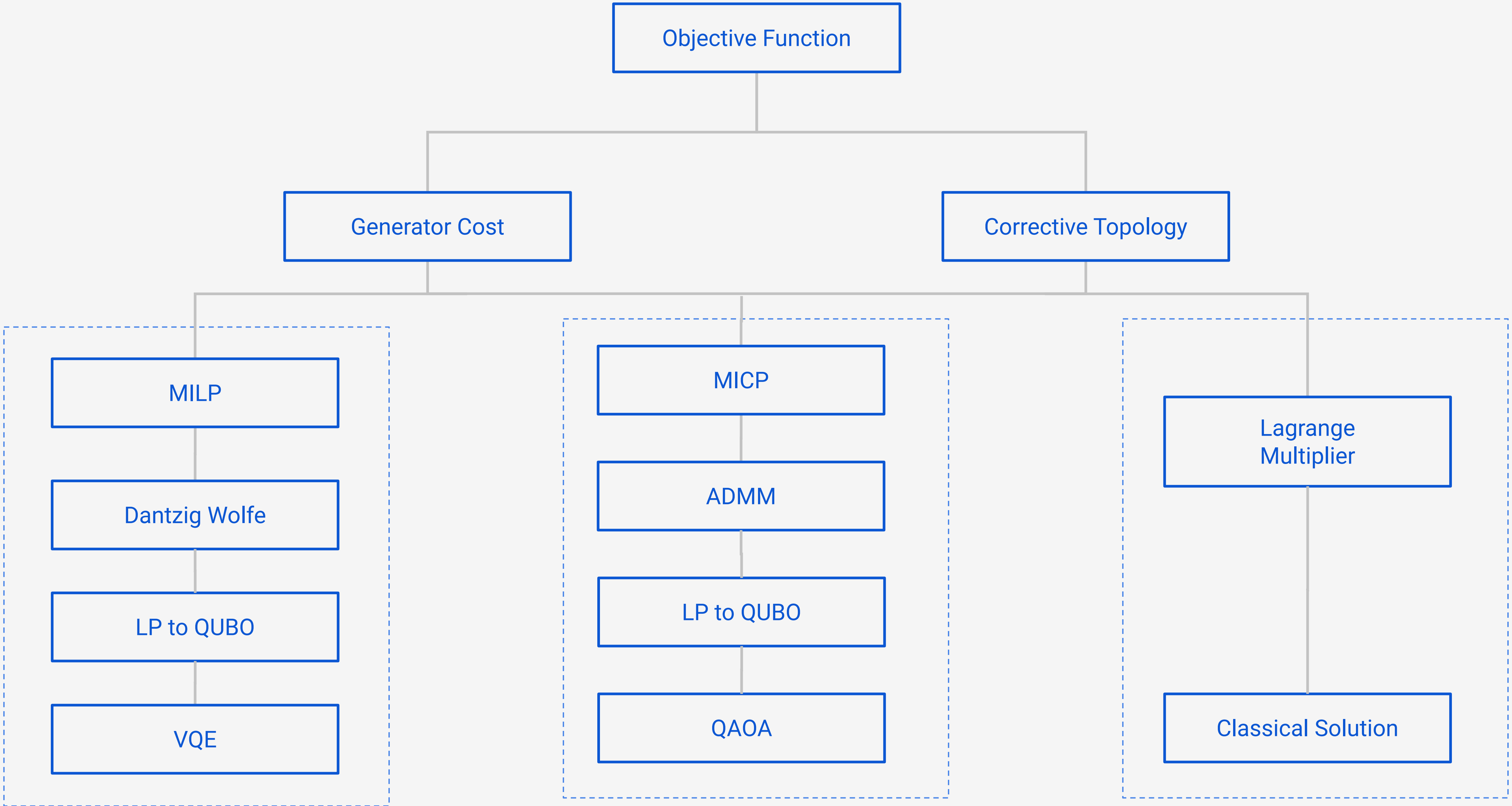
Challenge

- Distribution grid inefficient with significant energy loss
- By optimising the routing , it is possible to minimise energy loss
- This can lead to cost savings and also ensure a reliable supply of energy
- This is a complex problem that requires the consideration of many factors
- Quantum computing suited for solving combinatorial optimisation problems
- It has the potential to significantly outperform

Approach


Objective Function
Generator Cost
Corrective Topology
MILP
Dantzig Wolfe
LP to QUBO
VQE
MICP
ADMM
LP to QUBO
QAOA
Lagrange Multiplier
Classical Solution

Reduction of generation cost and Improvisation

- The objective function typically aims to minimize the total operating cost of the power system

  Constraints :

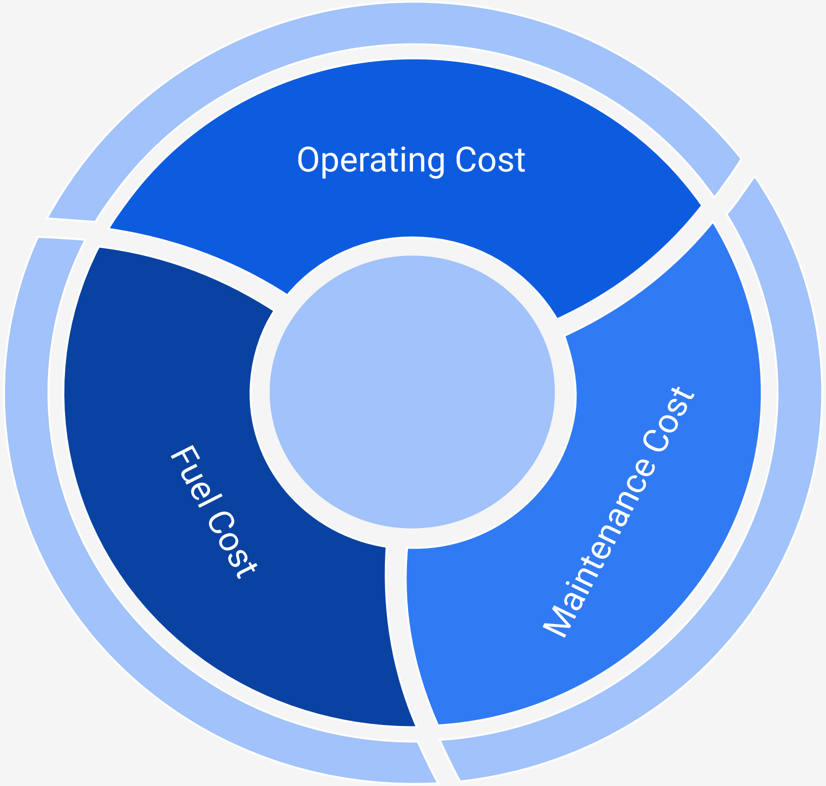
  1) Total Demand
  2) Individual Generator Limit

Total Demand =

Σ Cost Coefficients x Optimal generator output

- The objective function is quadratic hence linearization is done for conversion into MILP

- Using Convex Relaxation :
  This created a linear equation with additional 3 auxiliary constraints.



Corrective topology

= Σ Switching line cost x Decision variable

\+

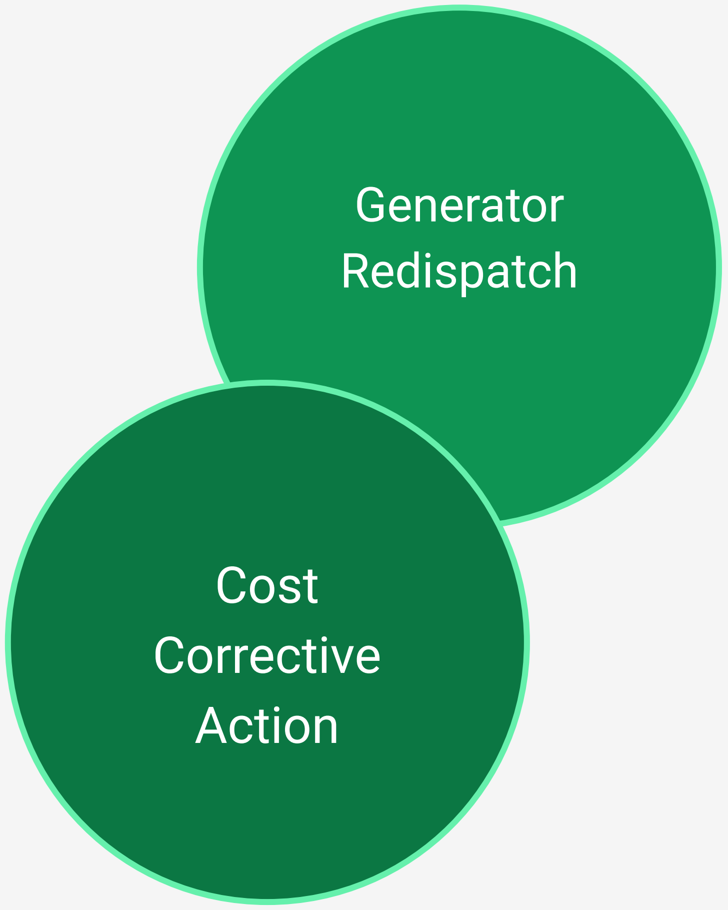
Σ Redispatch cost x Redispatch variable

Minimizing the cost of corrective actions, including line switching, and generation redispatching.

Parameter :

- L is the set of transmission lines.
- S is the binary decision variable.
- C is the cost associated with switching line
- R is representing whether generator i is redispatched (1 if redispatched, 0 otherwise).
- C_r redispatch, is the cost associated with redispatching generator

Vestibulum congue



Objective function conversion

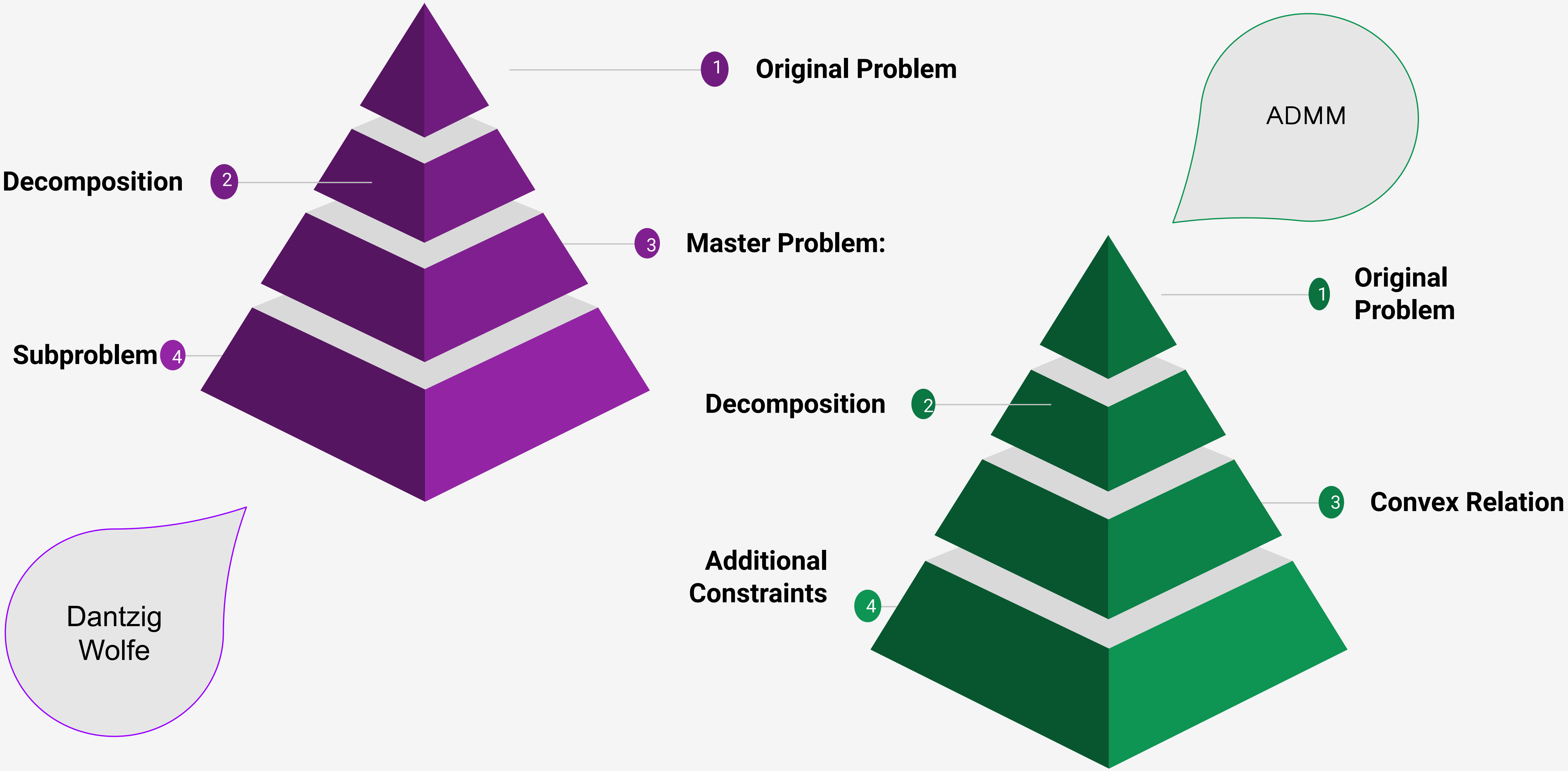
MILP

- linearizing the quadratic cost function
- Auxiliary variable z representing quadratic coefficient
- Adding additional constraints subject to new variable

- utilizing convex relaxation technique
- Adding auxiliary variable
- The new constraint is bound to the product of the minimum and maximum power output

MICP

Dantzig Wolfe and ADMM Decomposition



QUBO conversion and solution using VQE

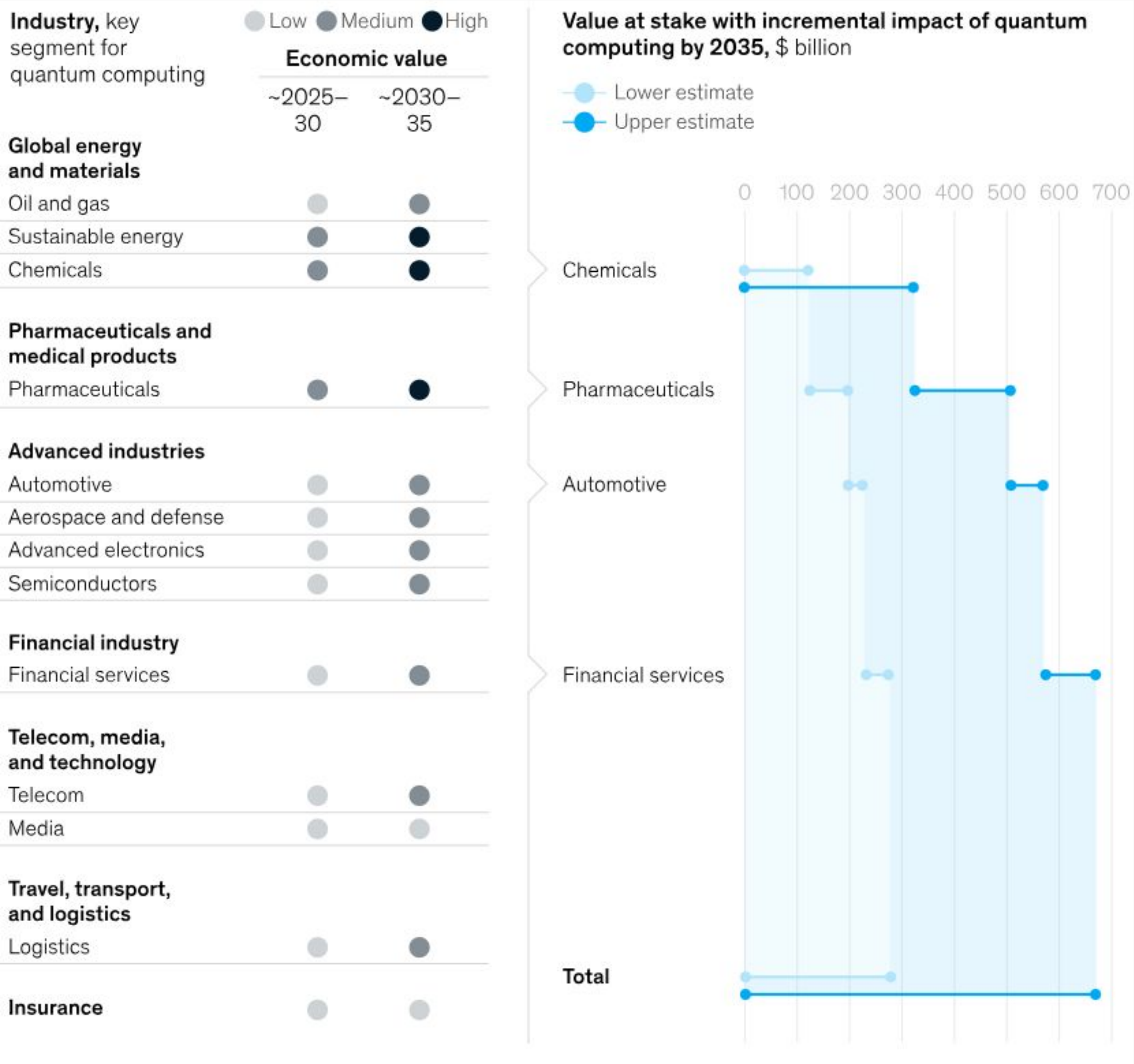
1. Function Conversion
2. Constraint Conversion
3. Binary Variable
4. QUBO Formulation

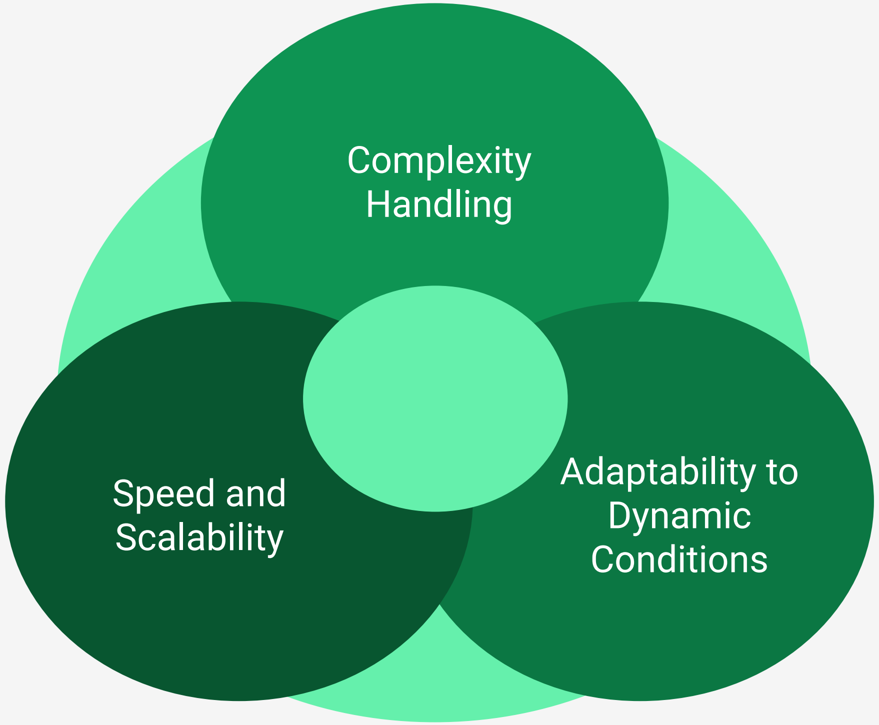
QUBO Conversion

VQE Implementation

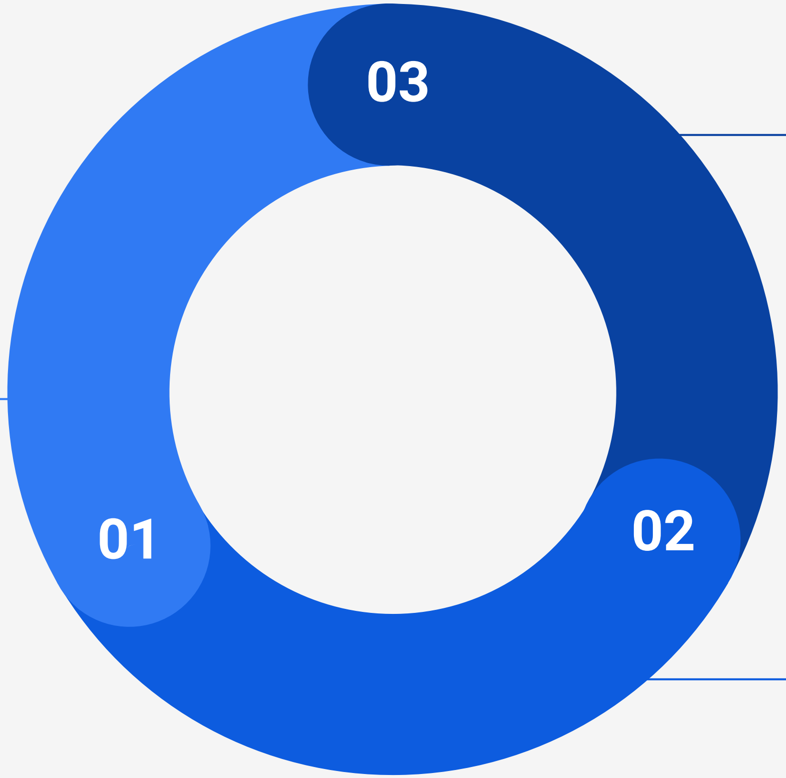
- Formulating the QUBO Problem
- Mapping to Quantum Circuit:
- Running VQE on AWS Braket
- Optimization Process
- Iterative Refinement

Business Impact from Quantum





Novelty



Scalability

Compatible with any number of generators

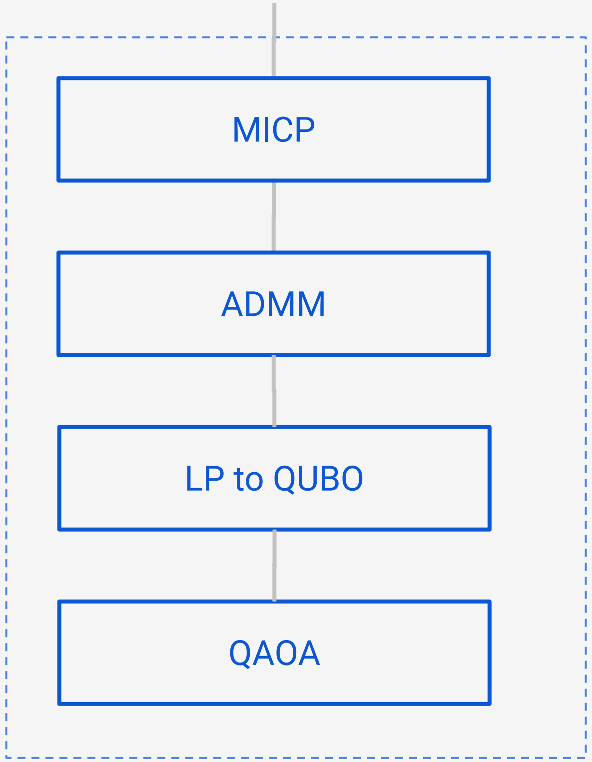
Decomposition Technique

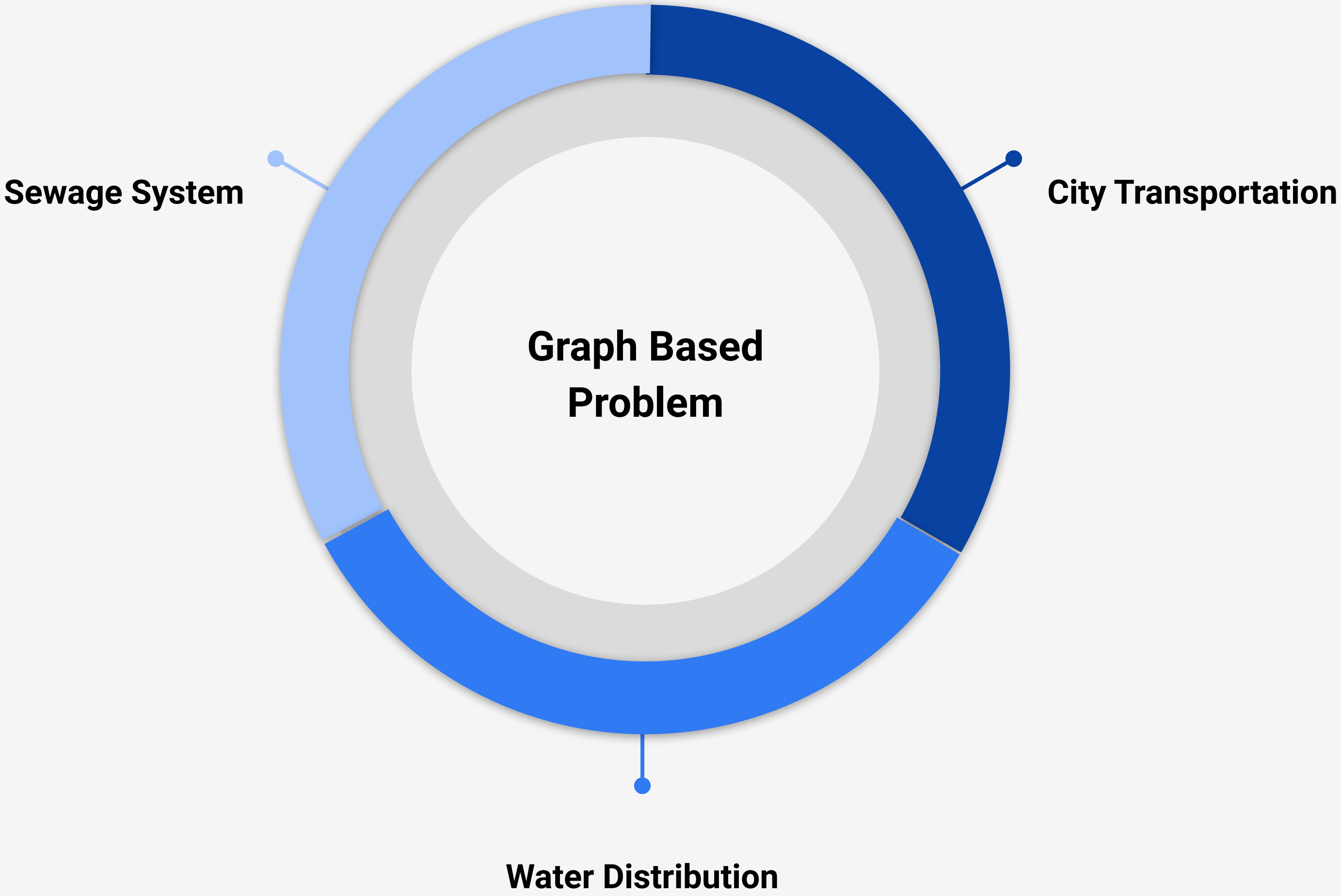
Dantzig Wolfe and ADMM

Compatibility

Compatible with QAOA and VQE

Future Development





Thank You

References

1) A SIMPLIFIED MODEL OF QUADRATIC COST FUNCTION FOR THERMAL GENERATORS ZIVIC DJUROVIC, M[arijana]; MILACIC, A[leksandar] & KRSULJA, M[arko]
2) Evaluate Quantum Combinatorial Optimization for Distribution Network Reconfiguration Phuong Ngo, Christan Thomas, Hieu Nguyen, and Abdullah Eroglu Dept. of Electrical & Computer Eng., North Carolina A&T State University fango1, cqthomasg@aggies.ncat.edu, fhtnguyen1, aeroglug@ncat.edu
3) Linear Programming Based Optimal Power Flow Optimization of DCOPF for an IEEE 5 and IEEE 14 Bus System M. Kamalakkannun, N. D. Sridhar
4) Quantum computing for smart grid applications Md Habib Ullah Rozhin Eskandarpour Honghao Zheng Amin Khodaei
5) https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/quantum-computing-use-cases-are-getting-real-what-you-need-to-know