

Optimisation for Energy Systems

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Australian Government

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Decisions everywhere



Decision-support = Optimisation



Decision-support = Optimisation



Decision-support = Optimisation



The Future Smart Grid

Cost Efficiency

Stability Guarantees

Self-Healing

According to The International Energy Agency: the world will need to invest \$13.6 trillion between now and 2030 in transmission, distribution and generation of electricity



The Future Smart Grid

Optimal Power Flow

Cost Efficiency

Voltage Control

Stability Guarantees

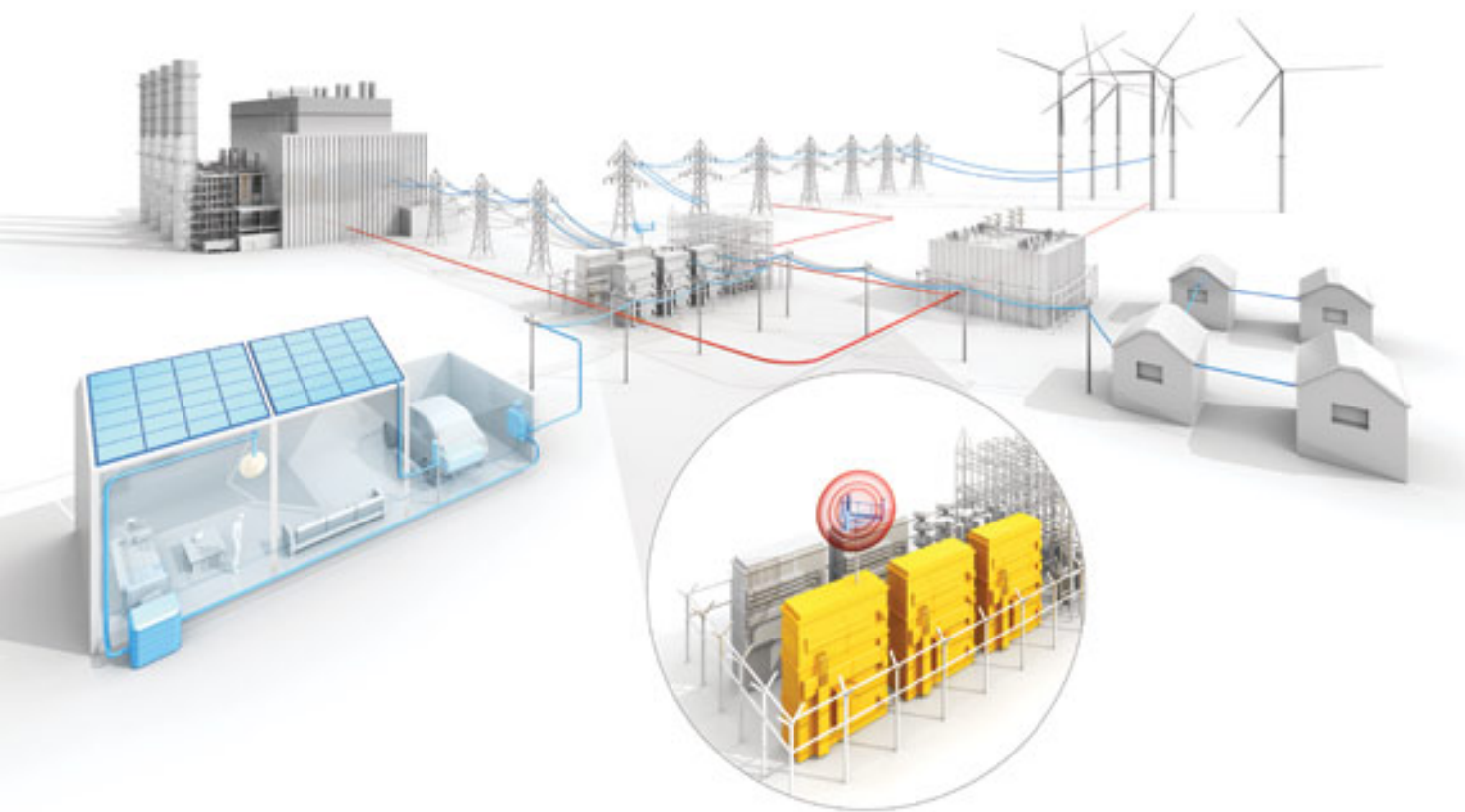
Power Supply Restoration

Self-Healing

Optimisation everywhere!



Modelling & Solving Challenges



Computational
Efficiency

Accuracy

Scalability

Optimality
Guarantees

Feasibility
Guarantees

Modelling & Solving Challenges

Power Supply Restoration

Modelling & Solving Challenges

Power Supply Restoration



Annual business losses in the U.S. from electrical failures average about \$100 billion

Modelling & Solving Challenges



$$p_{ij} = \mathbf{g}_i v_i^2 - \mathbf{g}_i v_i v_j \cos(\theta_{ij}) - \mathbf{b}_i v_i v_j \sin(\theta_{ij})$$

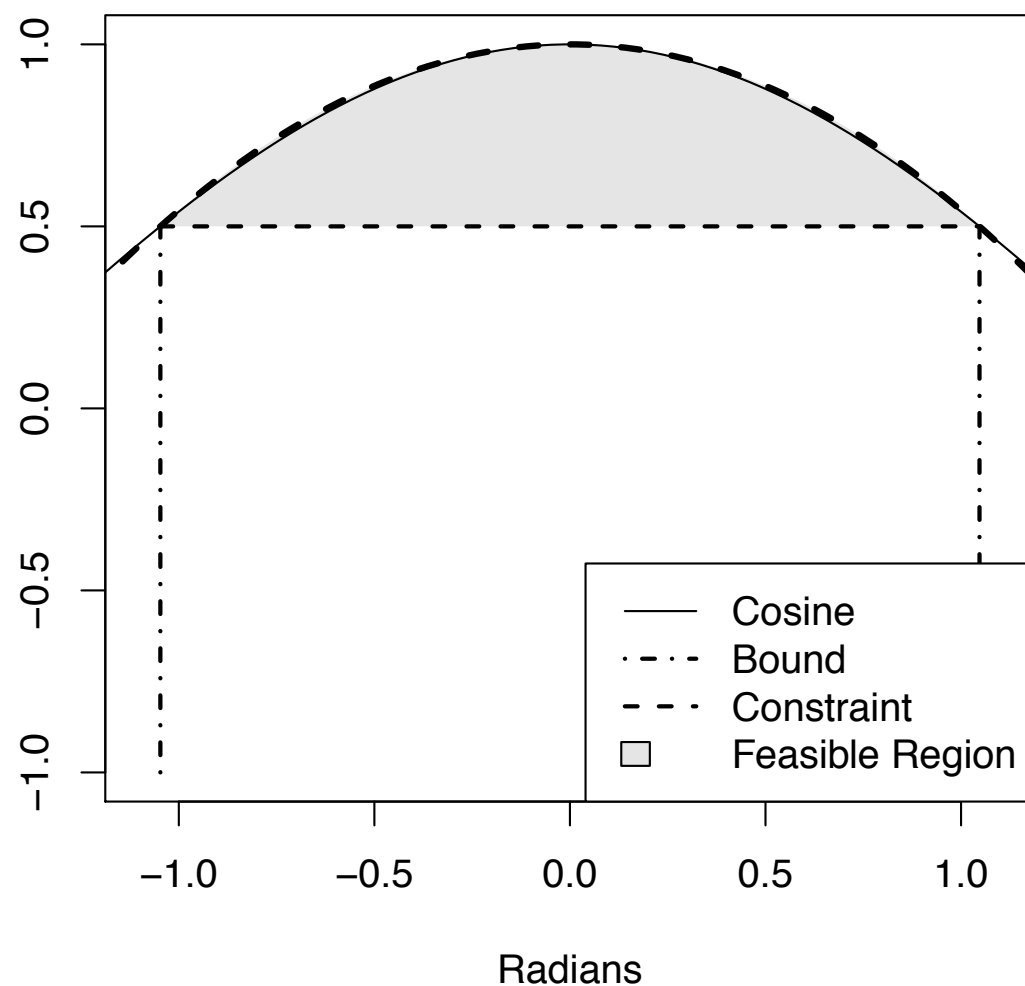
$$q_{ij} = -\mathbf{b}_i v_i^2 + \mathbf{b}_i v_i v_j \cos(\theta_{ij}) - \mathbf{g}_i v_i v_j \sin(\theta_{ij})$$

Accurate!

Modelling & Solving Challenges

$$p_{ij} = \mathbf{g}_i v_i^2 - \mathbf{g}_i v_i v_j \cos(\theta_{ij}) - \mathbf{b}_i v_i v_j \sin(\theta_{ij})$$

$$q_{ij} = -\mathbf{b}_i v_i^2 + \mathbf{b}_i v_i v_j \cos(\theta_{ij}) - \mathbf{g}_i v_i v_j \sin(\theta_{ij})$$

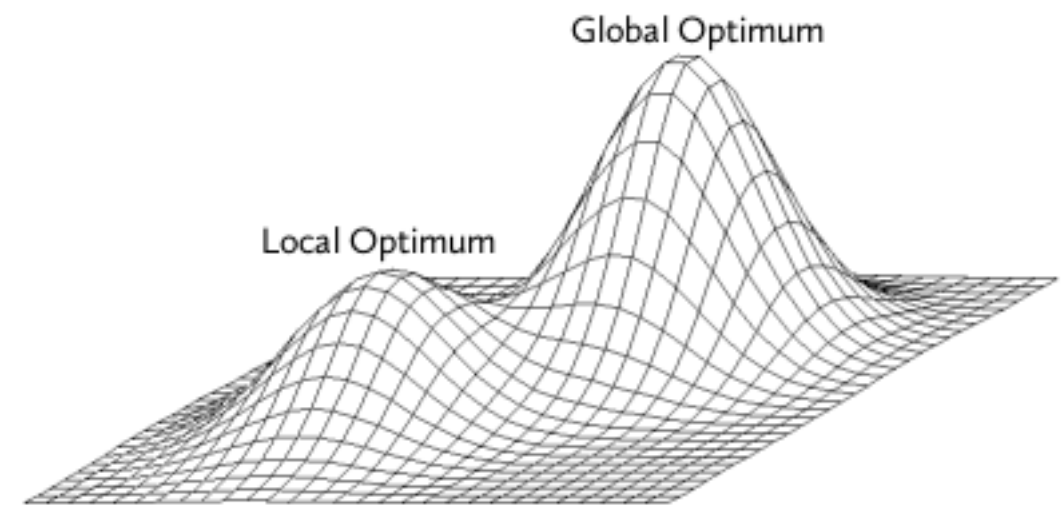
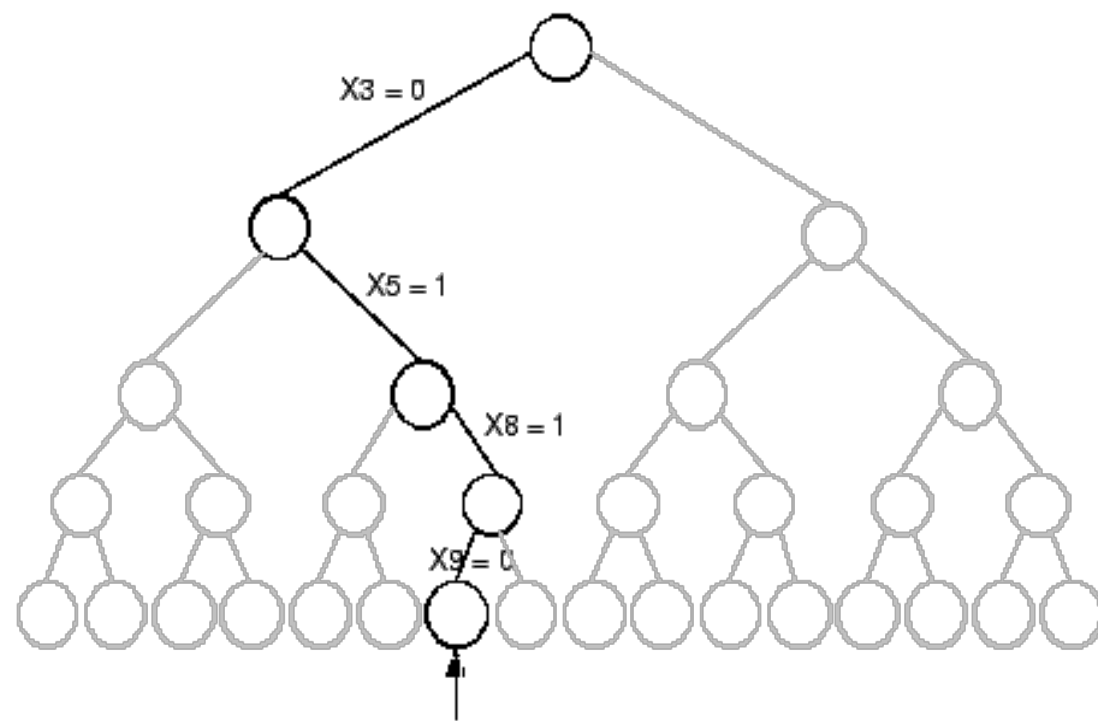


State-of-the-art Modelling

Convex Relaxations

Modelling & Solving Challenges

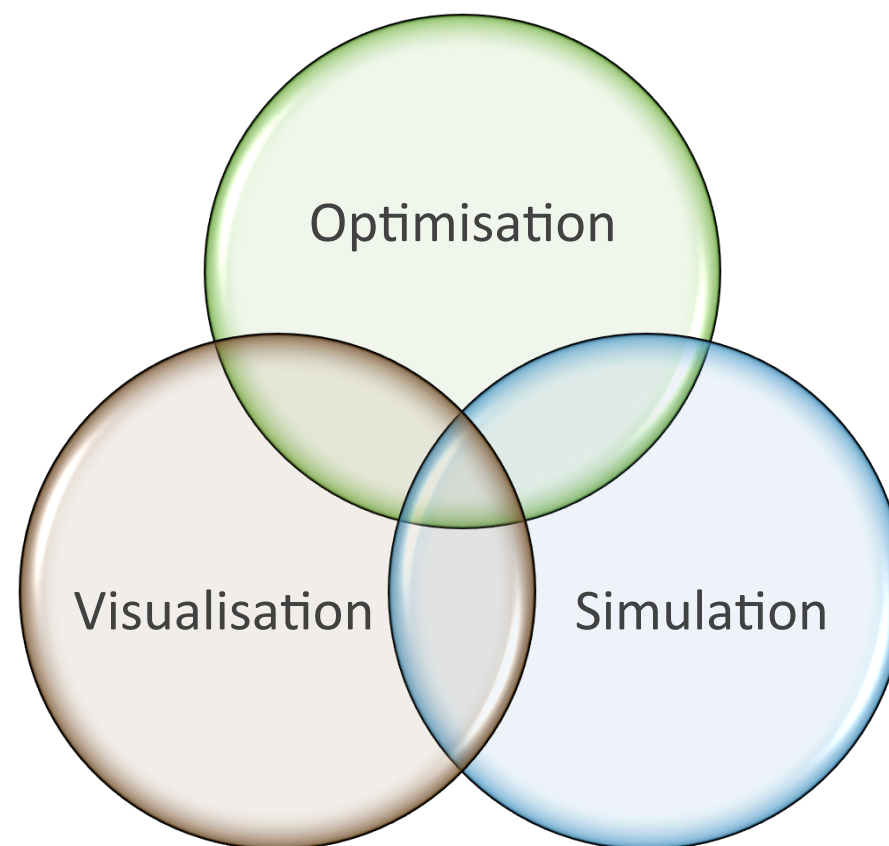
State-of-the-art Algorithms



2^{400} solutions $>$ number of atoms in the observable universe

NICTA-ANU PowerTools

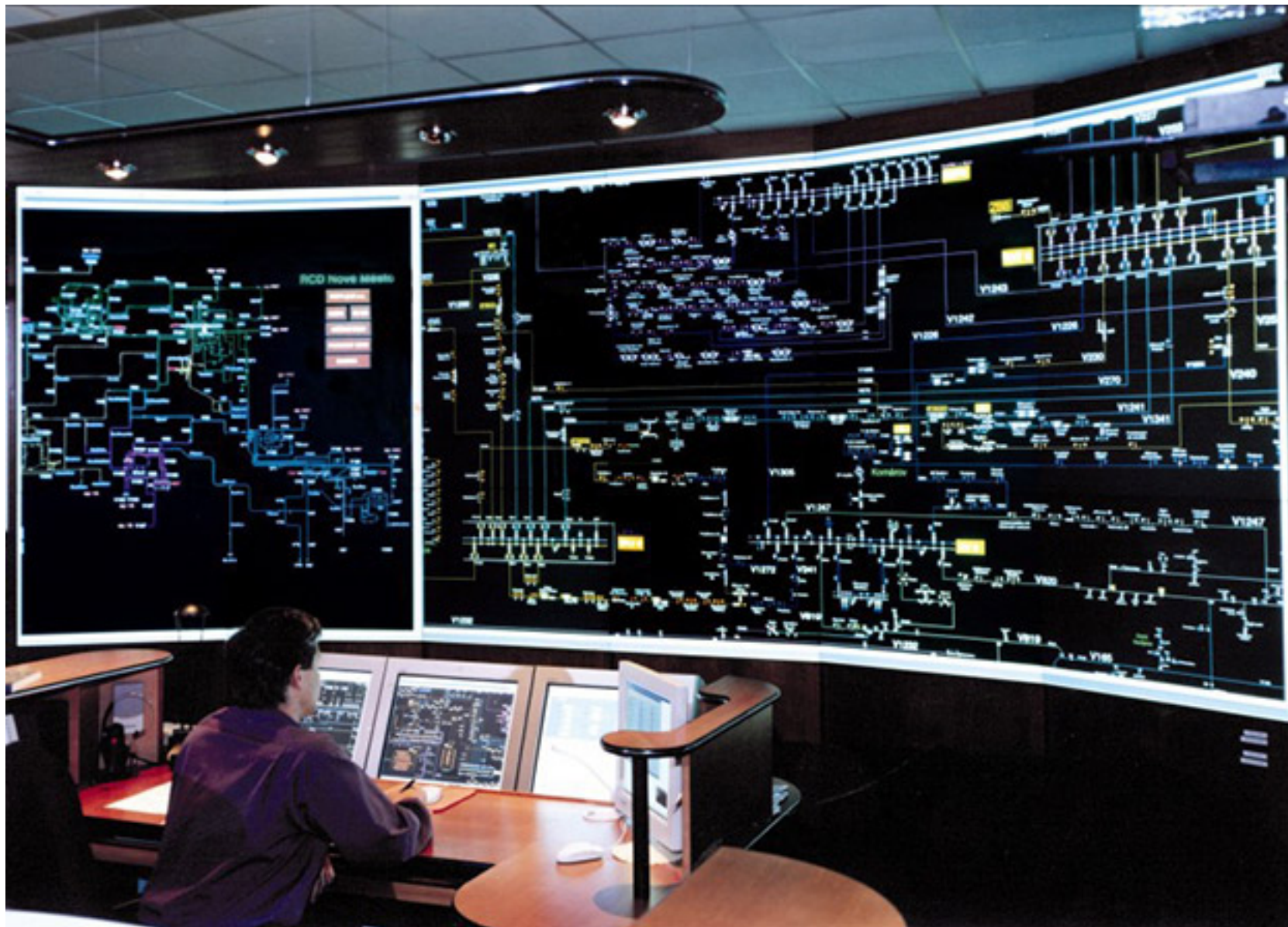
QC Relaxation



SmartGridToolbox

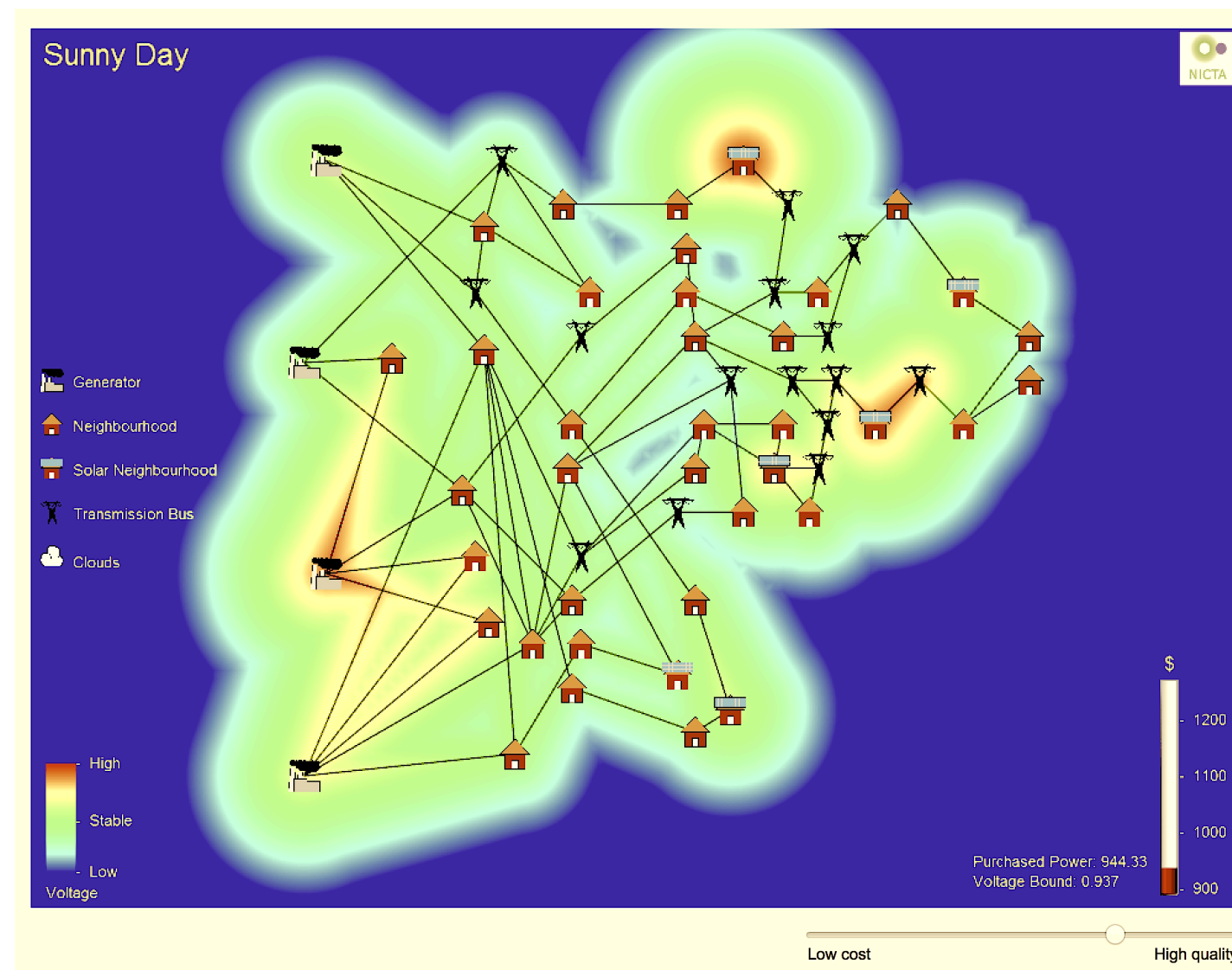
Modelling & Solving Challenges

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Modelling & Solving Challenges

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What's next

- Improve the scalability of our algorithms
 - from 2^{400} to 2^{10000}
- Improve uncertainty modelling (e.g., renewable generation)
 - Robust Optimisation
- Produce a first decision-support prototype
 - Interact with utilities

Thanks!

Team

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