Hedging Wind Risk through a Power-to-Gas enabled Integrated Energy System
Junkai Liang, Wenyuan Tang, NC State University, NC

Overview

Most generation capacity will be natural gas and renewables
• Result of low natural gas prices
• Result of declining renewables technology costs
• Result of supportive policies

Renewable generation curtailment happens on an involuntary basis
• Transmission congestion
• Excess generation
• Voltage, or interconnection issues

Problem Formulation

Modeling the energy hub
• A key element in future energy networks
• An interface between different energy systems

Security constrained unit commitment for integrated system
• The goal is to minimize the total cost over the scheduling horizon
• Subject to the security constraints of power networks, natural gas networks, and energy hubs equipped with P2G
• Uncertainty is modeled as interval numbers

Technical Approach

Interval quadratic optimization
• A special scenario reduction method
• The object value and solution are intervals
• Solving two deterministic optimization problems instead of solving a large-scale stochastic optimization problem

Benders Decomposition
• Computational intractability of the interval quadratic optimization due to binary variables
• Decomposing the stochastic mixed-integer quadratic programming problem into one deterministic mixed-integer quadratic problem, and one stochastic quadratic programming problem that is solved by interval quadratic optimization

Case Study

An integrated energy system comprised of a 6-bus power network and a 6-node gas network

• Evaluate the value of energy hub
• Investigate the impact of transmission constraints: adjust the transmission capacity of line 1-4 from 100 MW to 50 MW

Accomplishments

• An interval optimization based stochastic SCUC model for an electric-gas integrated energy system is proposed to optimally coordinate the operation of integrated system
• Energy hubs equipped with P2G technology are modeled in detail
• Interval optimization and Benders Decomposition are used to reduce computational burden without loss of optimality
• A case study verifies the applicability of the proposed method
• A case study demonstrates that P2G can be a promising method to reduce the wind curtailment
• A case study indicates that P2G can reduce the total operational cost and the total gas supply, especially when the curtailment is serious

Next Step

System level
• The economic viability of P2G
• The siting and the sizing of energy hubs
• Other uncertainties such as gas prices
• Dynamic model of the natural gas networks

Energy hub level
• Bidding strategy with the emergence of P2G
• Other ancillary services provided by P2G such as demand response
• Expansion planning of energy hub equipped with P2G

P2G is a new technology, many questions remain unknown!