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Convex Relaxations of Probabilistic AC Optimal Power Flow for Interconnected AC and HVDC Grids

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Motivation

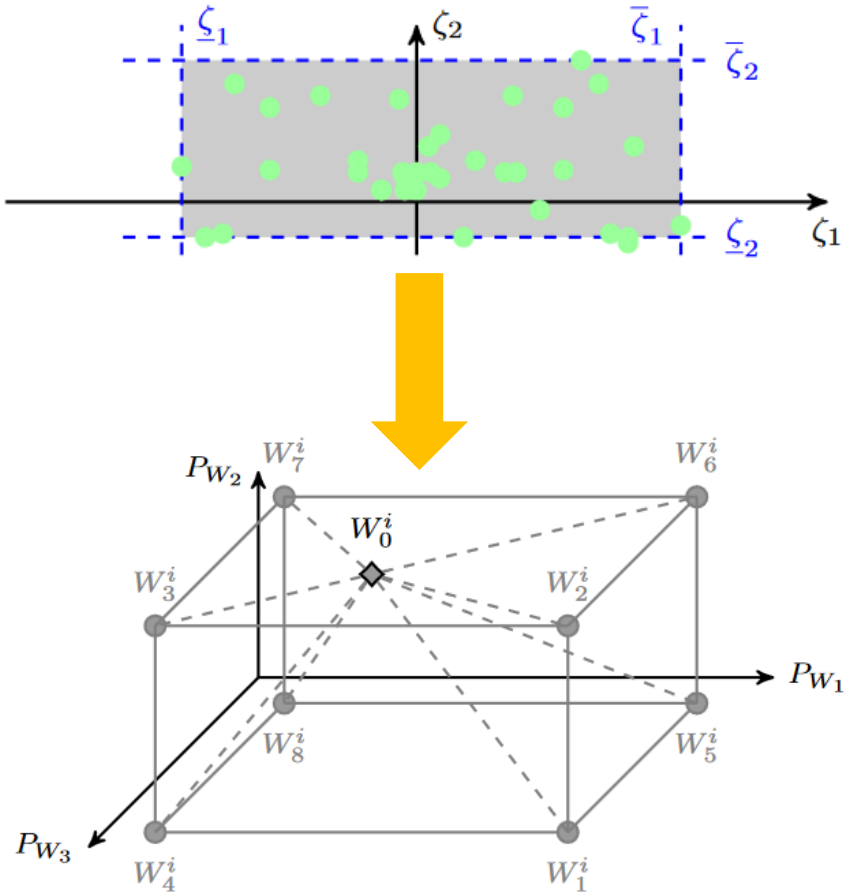
- High-Voltage Direct Current (**HVDC**) technology **increasingly** utilized to
  - connect **offshore** wind farms
  - interconnect **asynchronous** areas
- Novel operational tools which
  - account for **uncertainty**
  - utilize **full** available **controllability** (e.g. from HVDC converter)
  - ensure system **security**

North Sea Wind Power Hub

Source:www.tennet.etu

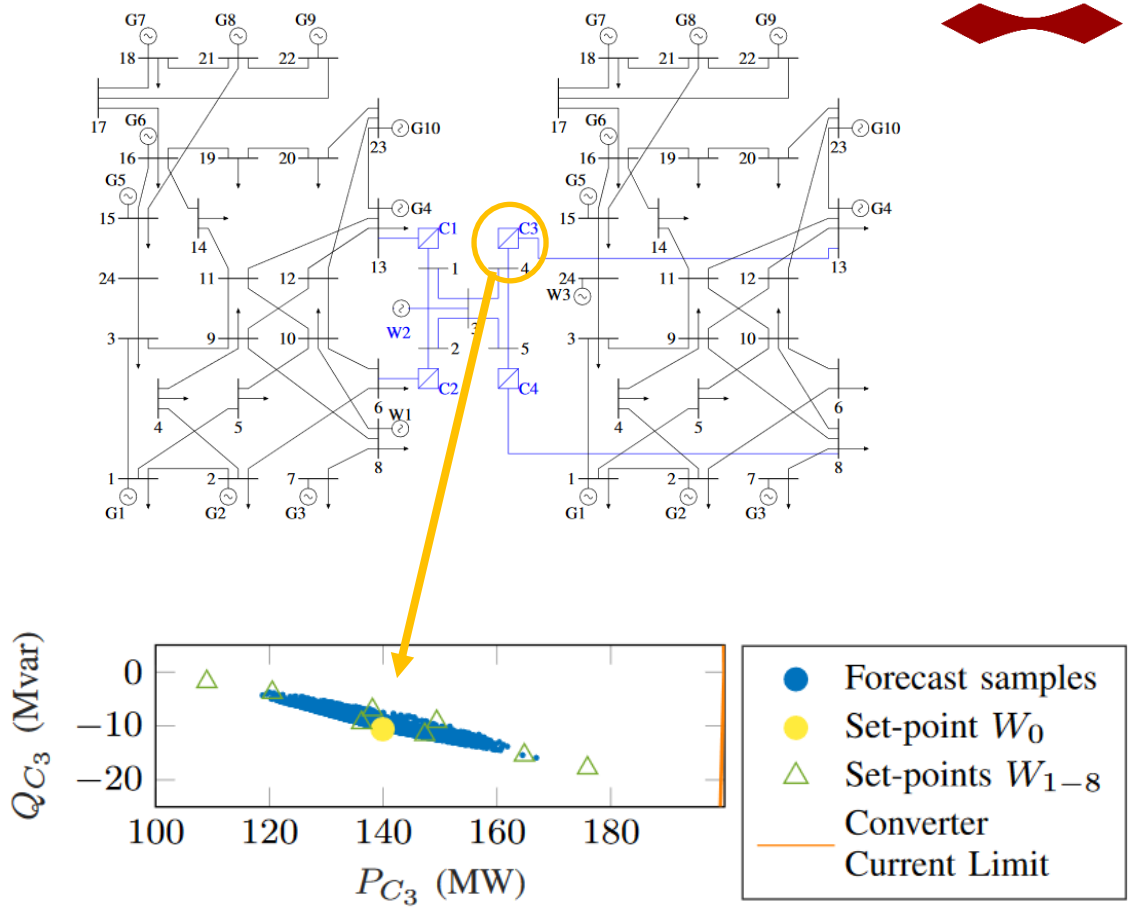
Methodology

- Use **full** AC-OPF formulation to model AC and HVDC grids, HVDC converter
- **Joint** chance constraint to account for uncertainty
- **Semidefinite** relaxation to address non-convexity of AC-OPF problems
- **Randomized** and **robust** optimization to achieve tractability
- **Penalization** methods to maintain AC-feasibility
- **Benders** decomposition for scalability



Simulation Results

- **Testcase**
  - 2 x IEEE 24 bus system
  - 5 bus multi-terminal HVDC grid
  - 2 onshore + 1 offshore wind farm
- Monte Carlo analysis with 10’000 scenarios from **realistic** forecast data
- Compared to **DC-OPF** approximation
  - Our approach **achieves compliance** with joint chance constraints
  - DC-OPF approximation **violates** constraints
  - Our approach allows to utilize both **active and reactive power** HVDC converter control capability



Conclusions

- Proposed **tractable** formulation of the **chance constrained** AC-OPF problem for interconnected AC and HVDC grids

- Using **realistic** wind forecast data, and a **53-bus AC-DC** system, our proposed formulation **complies** with the joint chance constraint, and utilizes **corrective** control capability of HVDC converter

- Future research towards utilizing **distributionally robust optimization** (DRO) and **alternative** penalization methods

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