

Intelligent Systems Subcommittee
Working Group on Modern Heuristic Optimization
Task Force Optimization Test Bed on OPF

Competition on Application of Modern Heuristic Optimization Algorithms for Solving Optimal Power Flow Problems

Sebastian Wildenhues
Fraunhofer IWES Kassel
Germany

Optimization Test Bed on OPF

Targets

- Common benchmarks
- Objective assessments and comparisons
- Black box implementation
- Standard / open source software

Test systems / optimization problems

- IEEE 57, 118, 300
 - Problem 1: Optimal Reactive Power Dispatch
 - Problem 2: Optimal Active and Reactive Power Dispatch
- Offshore Wind Power Plant
 - Problem 1 : Modified Optimal Reactive Power Dispatch
96 times for 24hrs / 15mins scenarios

Optimization Test Bed on OPF

Problem overview

| | | Test system | | | |
|---|-----------|-------------|------------|-------------|-------------|
| | Problem # | WPP | IEEE 57 | IEEE 118 | IEEE 300 |
| Number of control variables | 1 | | 25 | 77 | 145 |
| | 2 | | 31 | 130 | 213 |
| | 1 | 22 | | | |
| Number of constraints | | 123 | 165 | 385 | 814 |
| Number of function evaluations / independent trials | | 10000 / 31 | 50000 / 31 | 100000 / 31 | 300000 / 31 |

Problem Formulations

IEEE 57, 118, 300

Problem 1:

Optimal Reactive Power Dispatch

$\min f = \text{Active power losses}$

s.t.

[Power balance, Slack generator active power,
Load bus voltages, Branch loadings,
Generator reactive powers]

$\mathbf{x} : [\text{Generator voltages, OLTC taps, Shunts on/off}]$

Problem Formulations

IEEE 57, 118, 300

Problem 2:

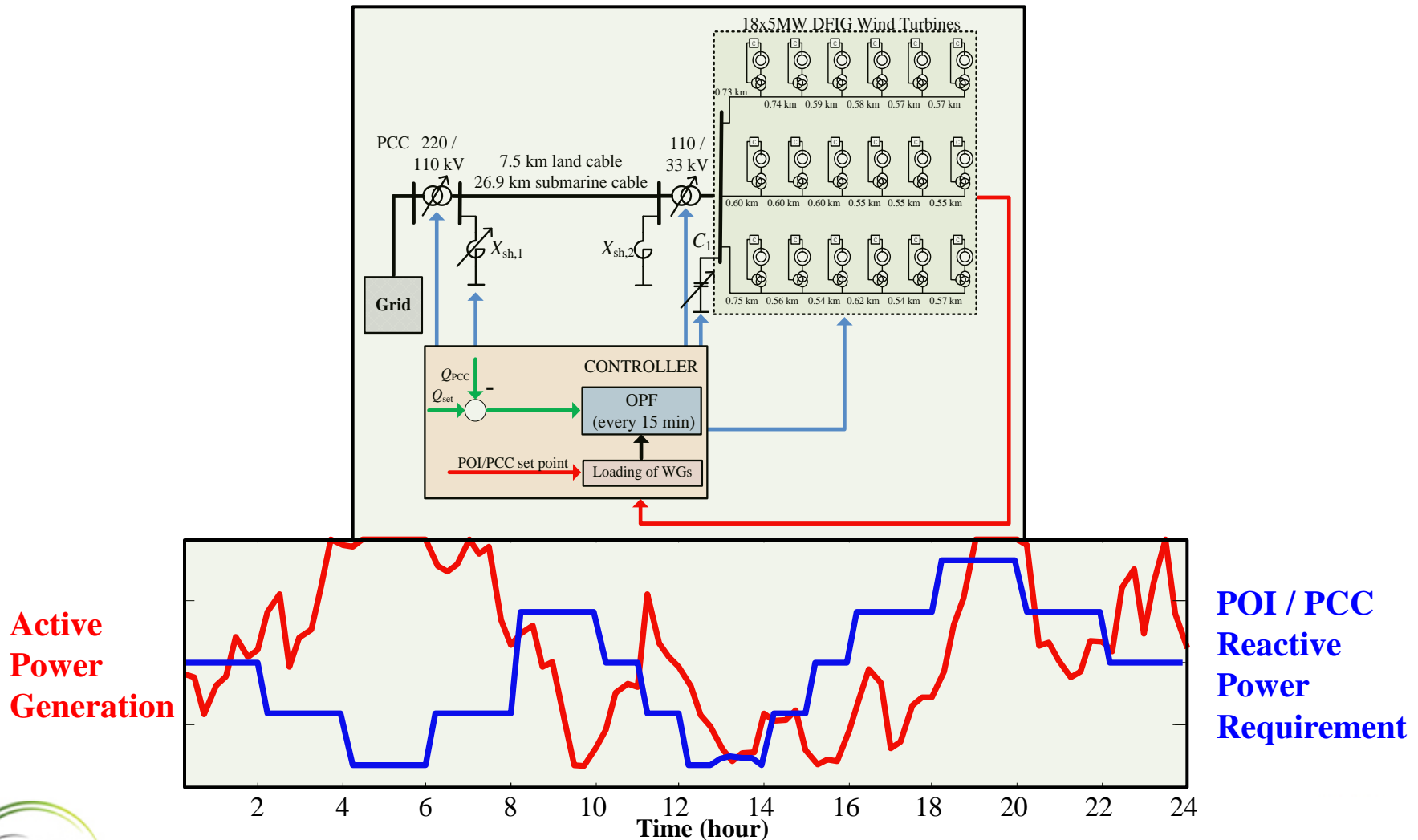
Optimal Active and Reactive Power Dispatch

$\min f =$ Dispatch costs using quadratic cost functions

s.t.

$$\mathbf{x} : \begin{bmatrix} \text{Power balance, Slack generator active power,} \\ \text{Load bus voltages, Branch loadings,} \\ \text{Generator reactive powers} \\ \text{Generator active powers,} \\ \text{Generator voltages, OLTC taps, Shunts on/off} \end{bmatrix}$$

Offshore Wind Power Plant



Active
Power
Generation

POI / PCC
Reactive
Power
Requirement

Problem Formulations

Offshore Wind Power Plant Problem 1: Modified Optimal Reactive Power Dispatch

$\min f = \text{Active power losses}$

s.t.

[Power balance, Slack generator active power,
Bus voltages, Branch loadings,
POI / PCC reactive power requirement]

\mathbf{x} : [Wind turbine reactive powers,
OLTC taps, Shunts susceptances / steps]

Conditions

Test bed procedure

- Packages: Matlab, Matpower, Parallel Computing Toolbox
Encrypted black box with automated evaluation for results submission
- Initialization of individuals
 $x^L + U(0,1)(x^U - x^L) \in \mathfrak{R}^n$
- Access only to
Constraint handling
Integer variable treatment
- Variable boundary checks
Continuous variables: no
Integer variables: yes

Algorithm tuning

- Allowed without restrictions

Evaluation criteria

- Statistics from internally calculated fitness
- Normalized variable boundary violations

$$f' = f + \rho \sum_{c=1}^n \max[0, g_i]^2, \quad \rho := 10^7$$