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WindEnergy Hamburg
The global on- & offshore expo

Integration of Wind Power in Medium Voltage Grid by Smart Transformer

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Hamburg Sep. 28, 2016

Outline

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- ✓ Voltage rise of power grid due to the growth of wind penetration
- ✓ Smart transformer concept
- ✓ Test feeder description
- ✓ Case study
- ✓ Conclusions

Voltage rise of power grid due to the growth of wind penetration

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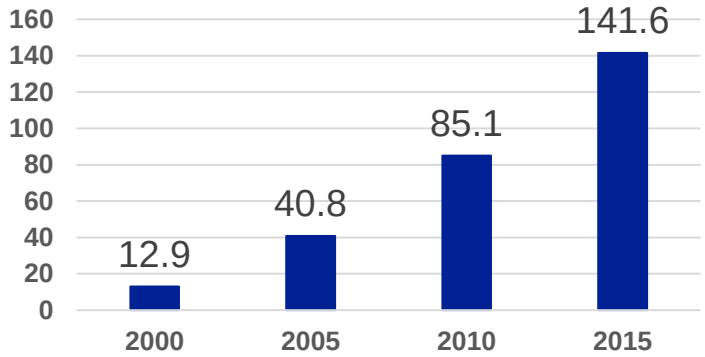
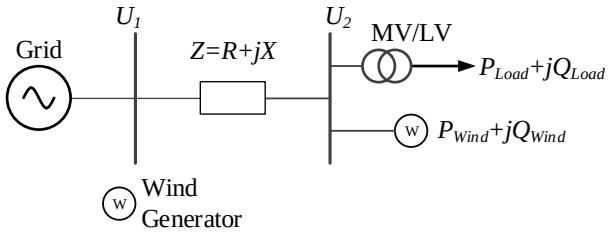
Growth of installation of wind power generation



Cumulative wind power installation in EU (*GW*)

Voltage rise with wind power penetration



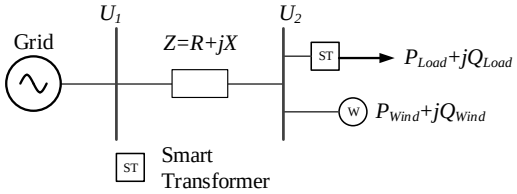
$$\Delta U_2 \approx \frac{R(P_{Wind}-P_{Load})+X(Q_{Wind}-Q_{Load})}{U_2}^{(*)}$$

Traditional counter measures against voltage rise

- Tap-changer of transformer
- FACTS devices

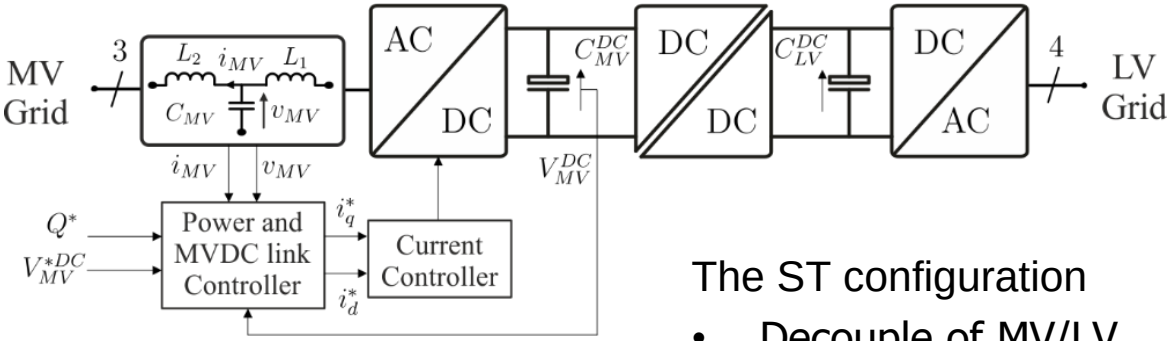
(*) N. Dinic, B. Fox, D. Flynn, L. Xu, A. Kennedy, Increasing wind farm capacity, IEE Proceedings - Generation, Transmission and Distribution, Vol. 153, Issue 4, pp. 493-498, July 2006

Smart transformer (ST) concept



Services provided by ST in MV grid:

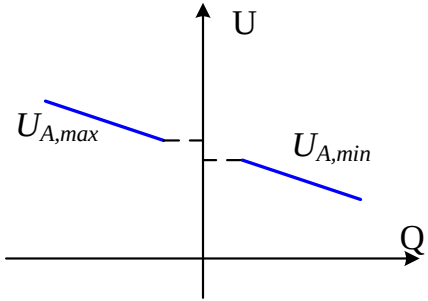
- Power quality improvement
- Power factor correction
- Voltage support



The ST configuration

- Decouple of MV/LV grids
- Individual MV/LV converter and controller

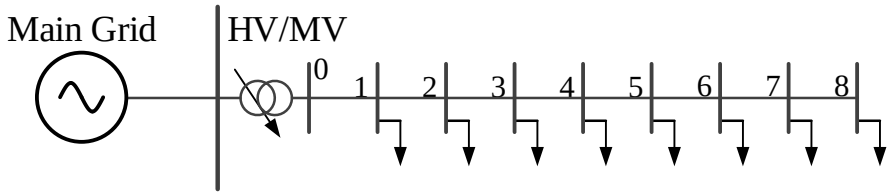
ST voltage support by means of reactive power compensation



$$Q_{\max} = \pm\sqrt{S_{ST}^{\ 2} - P_{Load}^{\ 2}}$$

Test feeder description

- Main grid: 135kV, 1400MVA short-circuit capacity(SCC)
- HV/MV transformer 132/20kV X_T=8% tap-changer fixed
- Light load case: 25% of full load amount



Lines data

Bus No.	Bus No.	R (Ohm)	X (Ohm)
0	1	0.34125	0.4806
1	2	0.34125	0.4806
2	3	0.34125	0.4806
3	4	0.34125	0.4806
4	5	0.2281	0.3204
5	6	0.2281	0.3204
6	7	0.2281	0.3204
7	8	0.2281	0.3204

Full Load

Bus No.	P (kW)	Q (kVar)
1	313	153
2	313	153
3	272.5	133.35
4	272.5	133.35
5	1368.5	669
6	1368.5	669
7	2458	1201.85
8	2458	1201.85

- Short-circuit capacity:
  - Bus 4: 88.56MVA
  - Bus 7: 60.85MVA
- Wind generator: Doubly-fed asynchrnous generator, unity power factor
- Smart transformer: *1MVA* capacity of the MV converter

Case study

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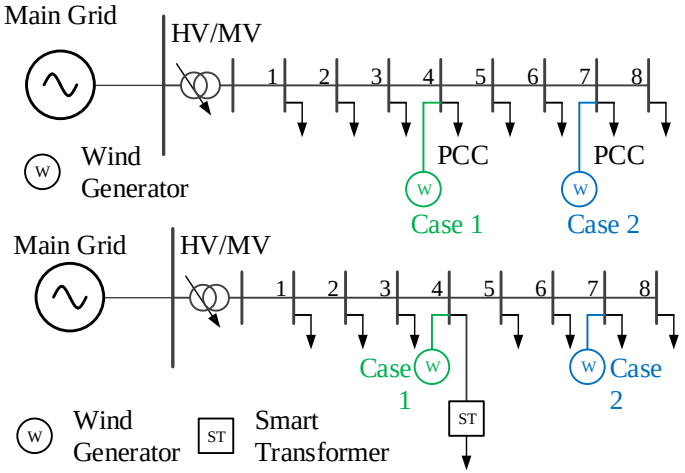
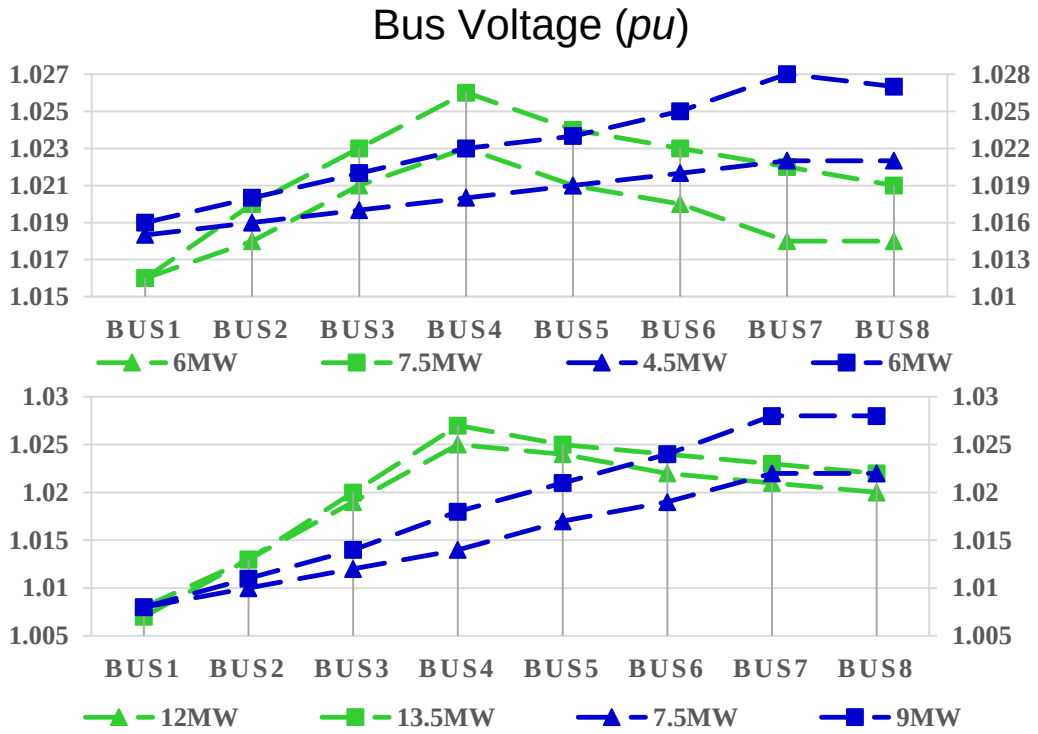
Aim of voltage control: all bus voltage of the feeder within (0.975, 1.025)



	Without ST	With ST
Case 1	6MW	12MW
Case 2	4.5MW	7.5MW

Maximal wind installed size



Installed size of wind generator

Conclusions

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- ✓ The Smart Transformer (ST) can provide ancillary services to the MV grid: power quality improvement, power factor correction, voltage support
- ✓ Controlling the voltage, the ST can increase the hosting capacity of wind energy in the MV grid.
- ✓ In this work, the hosting capacity of wind energy in MV grid increases by 67%-100% by ST with respect the base case.

Thanks for your attention!