Department of Wind and Energy Systems

Can renewable energy sources support future active distribution networks?

Challenges and opportunities

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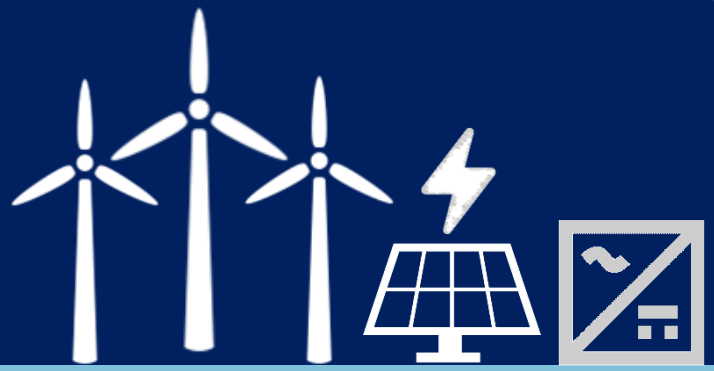

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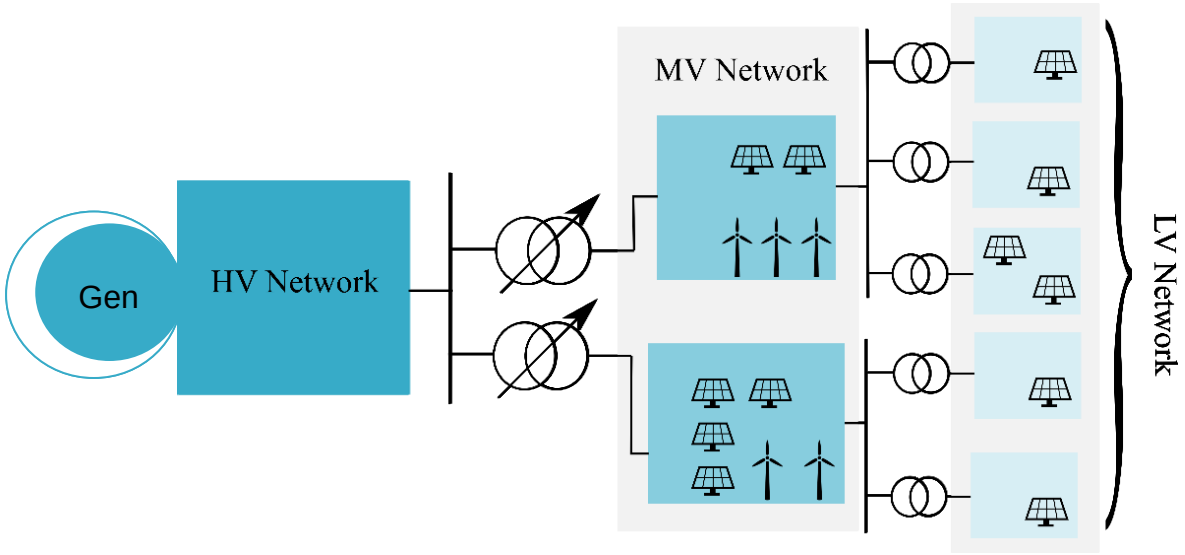
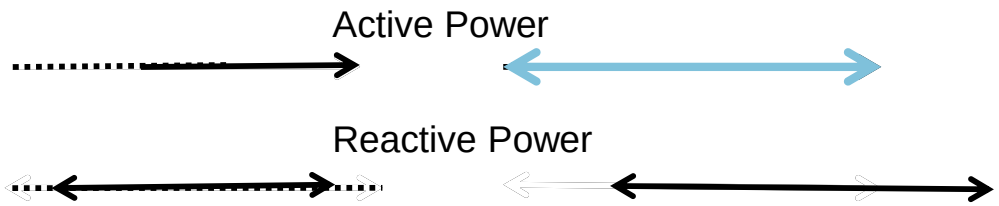
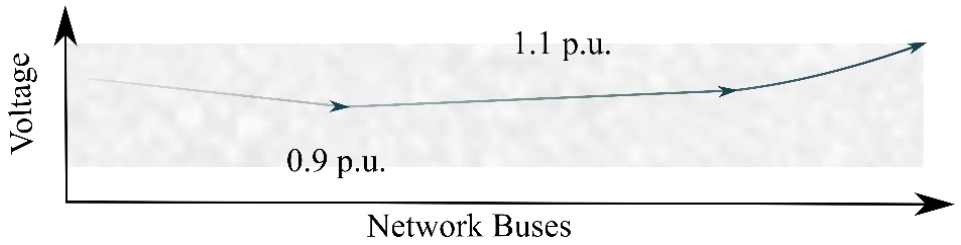
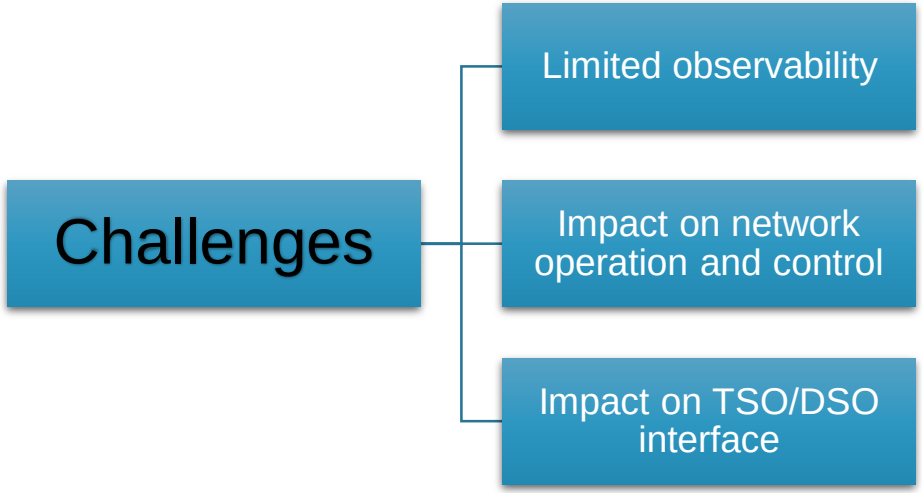
Challenges in a future active distribution grid !!









[C1] Baviskar A, Hansen AD, Das K, Koivisto M. Challenges of Future Distribution Systems with a Large Share of Variable Renewable Energy Sources – Review. In Proceedings of the 19th Wind Integration Workshop. Energynautics GmbH. 2020

Line losses and power fluctuations

- Line losses are proportional to the current squared through the line → line losses increase with reverse power flow.
- At a certain penetration level, the losses can reduce significantly. But will increase as the amount of distributed generation increases in the MV/LV network.
- Due to weather-dependent nature of VREs, higher variance in the expected distribution network losses is expected.

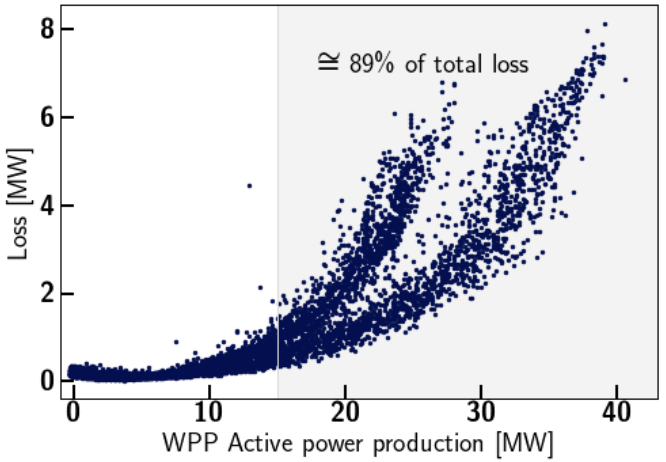


Fig. Wind power plant active power production Vs. Losses in the network

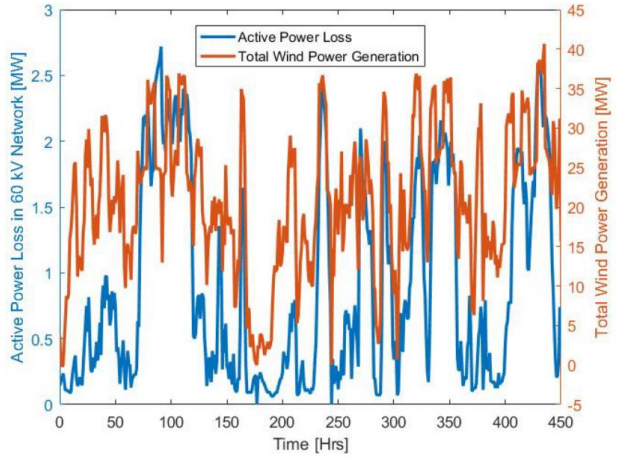
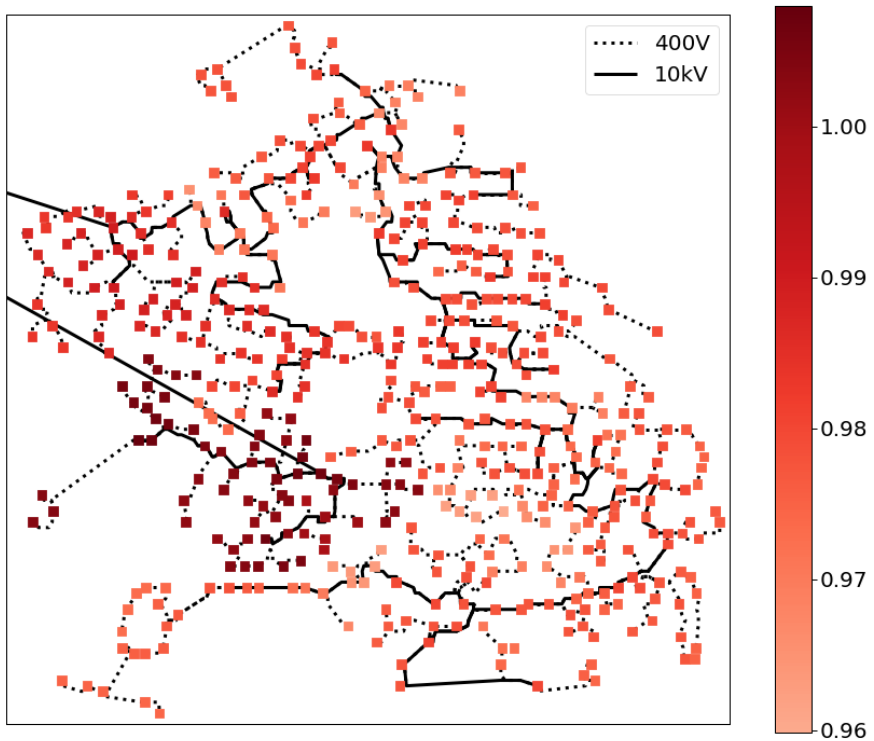


Fig. Time series of active power loss and total wind power generation with 1 hour resolution [6]

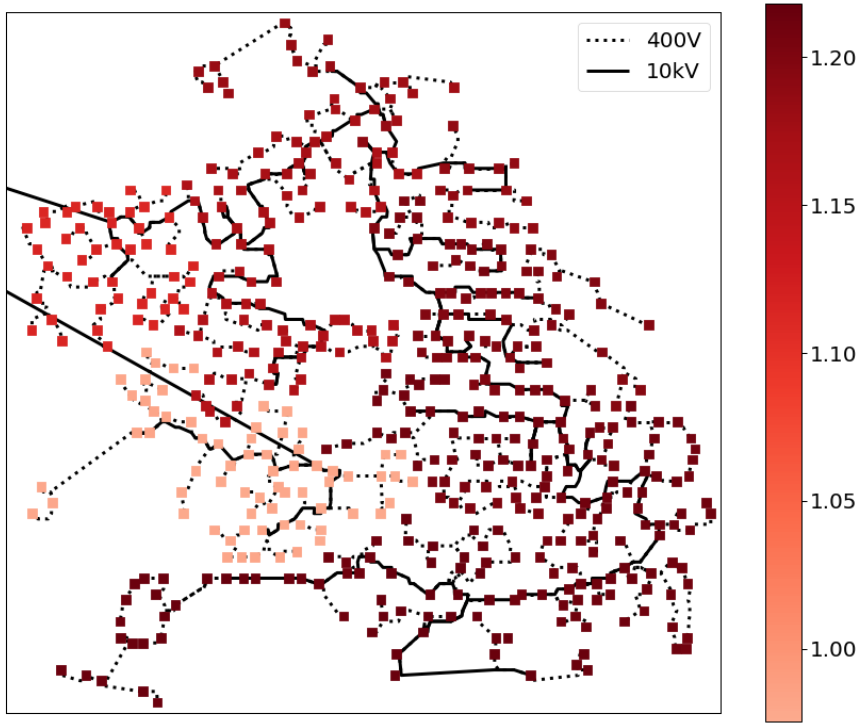
[C2] Das, K., Martinez, E.N., Altin, M., Hansen, A.D., ES, P., Thybo, G.W. and Rangård, M., 2017, June. Facing the challenges of distribution systems operation with high wind power penetration. In 2017 IEEE Manchester PowerTech (pp. 1-6). IEEE.

Load flow result: Voltage profile in the network



1st Jan 2015 02:00

- Line Losses: 0.26 MW
- Demand at 60kV/10kV substation: 1.84 MW
- Generation: 0.042

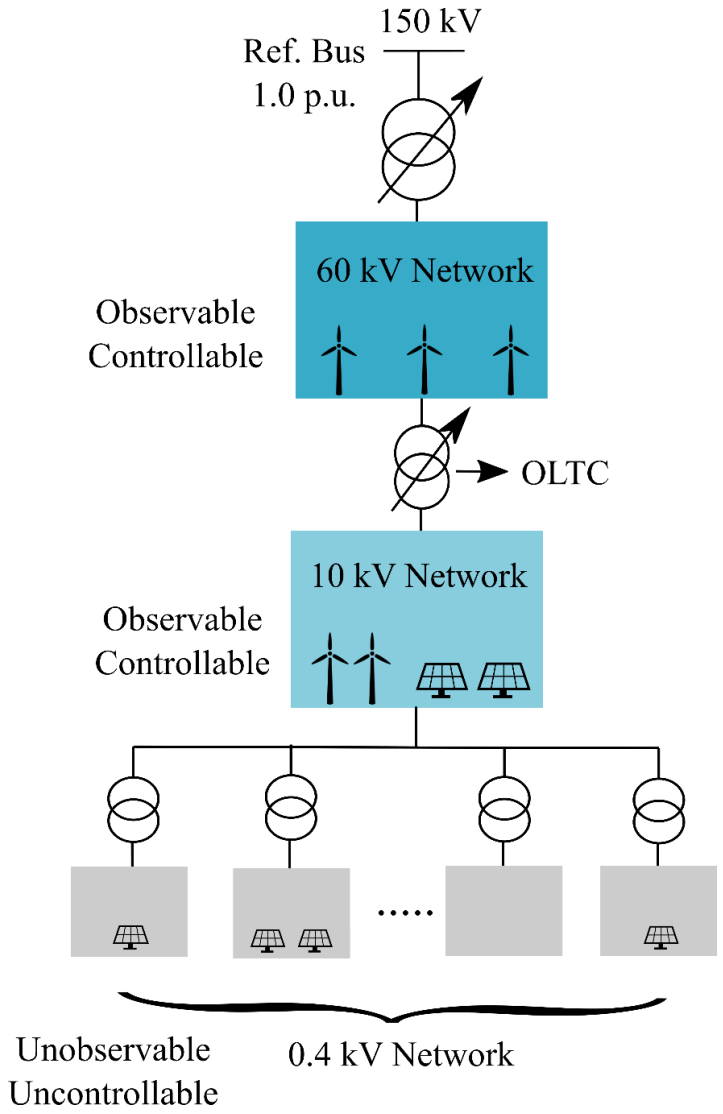


20th Dec 2014, 22:00

- Line Losses: 11.06 MW
- Demand at 60kV/10kV substation: -31 MW
- Generation: 32.62

[J1] Baviskar A, Das K, Koivisto MJ, Hansen AD. Multi-Voltage Level Active Distribution Network with Large Share of Weather-Dependent Generation. IEEE Transactions on Power Systems. 2022. https://doi.org/10.1109/TPWRS.2022.3154613

Opportunities in distribution networks with large share of RES



1

Availability of large amount of data and detailed models (weather, technology, etc.)

2

Control of already available network assets together with RES to mitigate the adverse impact on network operation

3

Co-ordination between TSO/DSO for flexibility provision, optimal operation and grid support

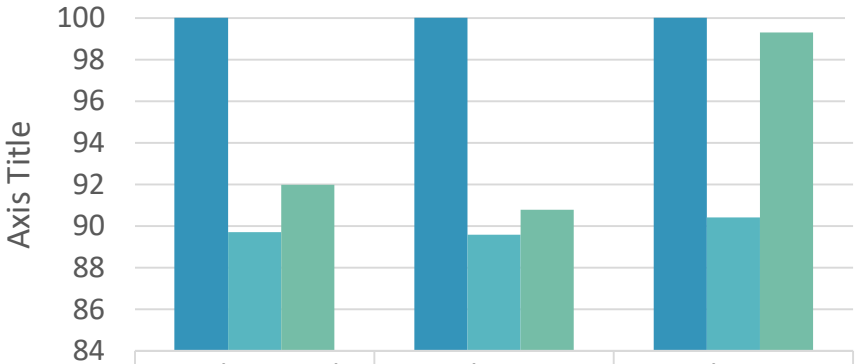
Does it improve the distribution grid operating condition?

This article is more than **6 years old**

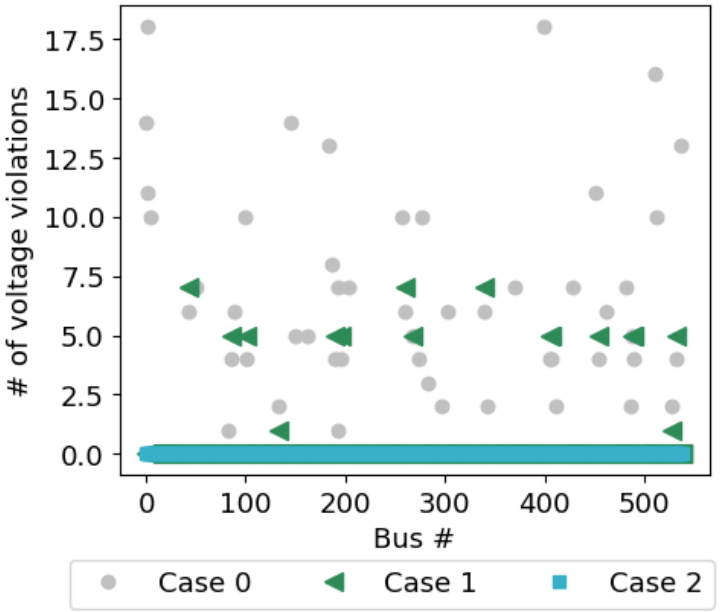
Wind power generates 140% of Denmark's electricity demand

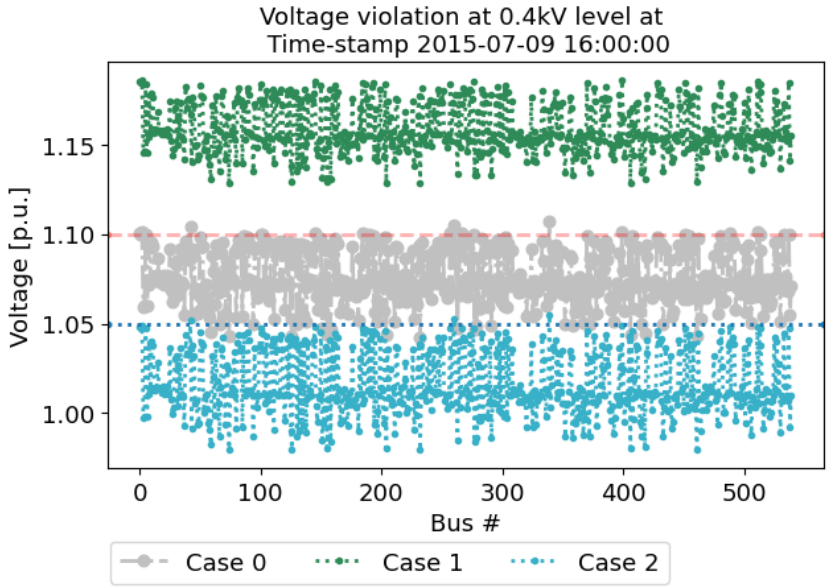
Unusually high winds allowed Denmark to meet all of its electricity needs – with plenty to spare for Germany, Norway and Sweden too

Active Power Loss Reduction on a very windy day as [%] of base case



	Total Network	60 kV Net	10 kV Net
Base	100	100	100
Case 1	89.71	89.6	90.42
Case 2	91.97	90.78	99.29





- Optimizing reactive power from WPPs and PVs in the distribution network has potential to decrease losses.
- Over-voltages are observed for the base case in the 10-0.4kV network
- The number of time-stamps with over-voltages decrease in Case 1, and are eliminated in Case 2

[C3] Baviskar A, Hansen AD., Das K. Reactive Power Support from Converter Connected Renewables in Active Distribution Network In Proceedings of 2022 13th IEEE International Symposium on Power Electronics for Distributed Generation Systems

What did we learn?

- Optimizing reactive power from the distribution network has multiple benefits
  - Active power loss reduction
  - Voltage profile regulation
  - Reducing Q from the transmission network
  - Transformer load reduction

How does the stochastic and uncertain nature of weather dependent renewables affect the distribution grid?

Journal Publications

[J1] Baviskar A, Das K, Koivisto MJ, Hansen AD. Multi-Voltage Level Active Distribution Network with Large Share of Weather-Dependent Generation. IEEE Transactions on Power Systems. 2022. https://doi.org/10.1109/TPWRS.2022.3154613

Conference Publications

[C1] Baviskar A, Hansen AD, Das K, Koivisto M. Challenges of Future Distribution Systems with a Large Share of Variable Renewable Energy Sources – Review. In Proceedings of the 19th Wind Integration Workshop. Energynautics GmbH. 2020

[C2] Baviskar AU, Hansen AD, Das K, Douglass PJ. Open-Source Active Distribution Grid Model with a large share of RES-features, and studies. In Proceedings of 2021 9th IEEE International Conference on Power Systems (ICPS). IEEE. 2022 https://doi.org/10.1109/ICPS52420.2021.9670223

[C3] Baviskar A, Das K, Hansen AD. MINIMIZE DISTRIBUTION NETWORK LOSSES USING WIND POWER. 2021. Paper presented at CIRED 2021 Conference, Virtual event.

[C4] Baviskar A, Hansen AD., Das K. Reactive Power Support from Converter Connected Renewables in Active Distribution Network In Proceedings of 2022 13th IEEE International Symposium on Power Electronics for Distributed Generation Systems [Preprint]

Dataset

[D1] Baviskar, Aeishwarya; Hansen, Anca Daniela; Das, Kaushik; Koivisto, Matti Juhani (2021): DTU 7k-Bus Active Distribution Network. Technical University of Denmark. Collection. https://doi.org/10.11583/DTU.c.5389910.v1

Thank you for your attention!

Q&A?

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