Challenges and Opportunities for Distributed Wind Integration

...from the perspective of distribution networks

IEA Task 41-Distributed Wind Workshop

Date: 20th Jan 2023

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Background

- **Growing number of variable renewable energy installations**
  - Cumulative wind installed capacity in Europe 205 GW [1]
  - Solar installations in the EU grew by 104% in 2019 [2]

- **Large volume of variable renewable sources at MV/LV**
  - Total amount of distributed wind in Denmark ≈ 3.1GW [3]
  - 50% of the total energy consumption in Denmark comes from variable renewable sources (47% Wind and 3% Solar)(2019) [3]
  - 49% of EU's cumulative photovoltaic capacity consists of rooftop solar (19% residential and 30% commercial) [2]

- **Onshore wind is one of the cheapest form of new electricity around the world!**

Country	Wind in the energy mix [%]
Denmark	48%
Ireland	33%
Portugal	27%
Germany	26%
UK	22%

+470 GW centralized renewable

+40 GW self-consumption

~70%

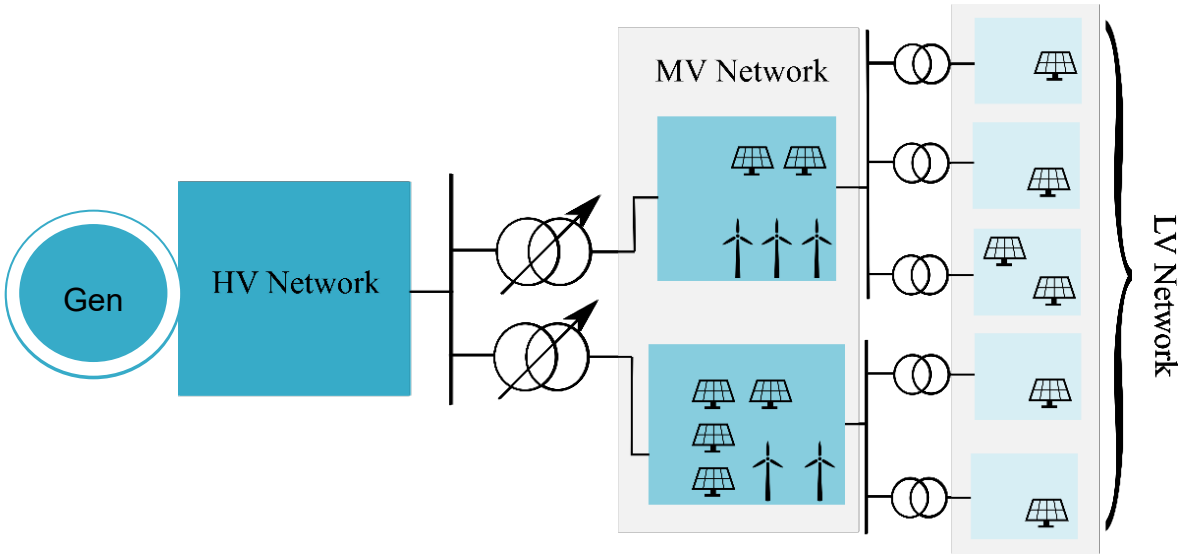
renewable capacity **connected to distribution grids**

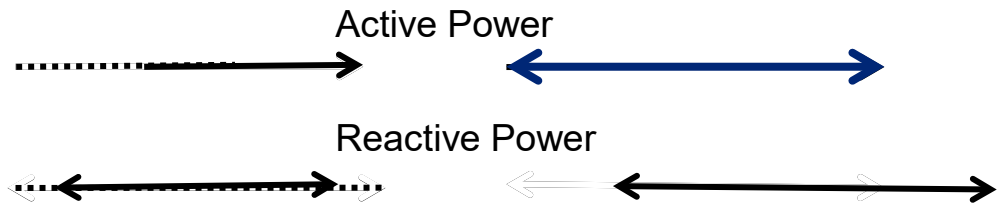
[1] Colin Walsh, "Wind energy in Europe in 2019," Tech. Rep., 2019.

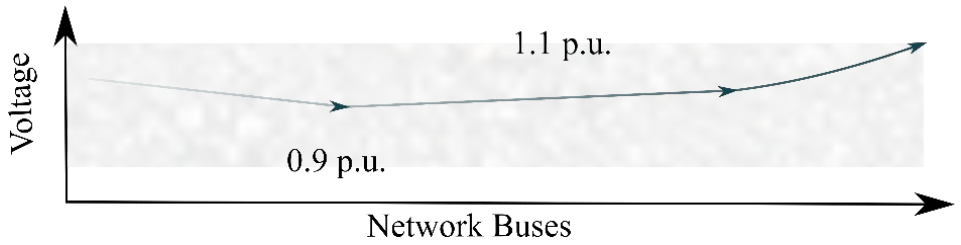
[2] M. . Schmela, B. Aurelie, C. Naomi, G. P. Mariano, H. Mate, and R. Raffaele, "Global market outlook," Tech. Rep., 2018. [Online]. Available: www.africa-eu-renewables.org

[3] "Energinet." [Online]. Available: https://energinet.dk/

Challenges for integration of Distributed Wind







Challenges

- Limited observability
- Impact on network operation and control
- Impact on TSO/DSO interface

Challenges for integration of Distributed Wind

- Generating source at low voltage nodes increases the voltage at the end of the lines
- High voltages at the end of the line affect the operating characteristics of network assets such as voltage regulators

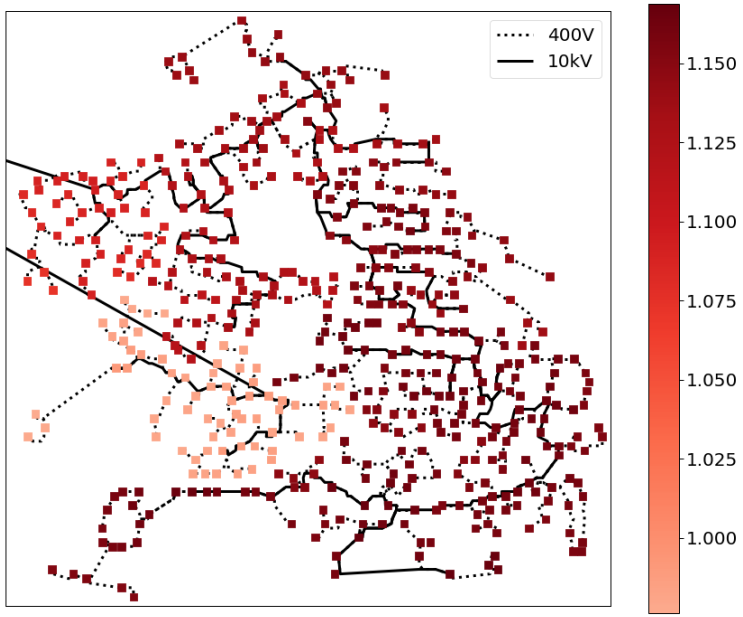


Fig. Voltage profile for 10kV-0.4kV network at Bus 46 at one time instance
Load Demand: 1.62 MW | Generation: 32.6 MW

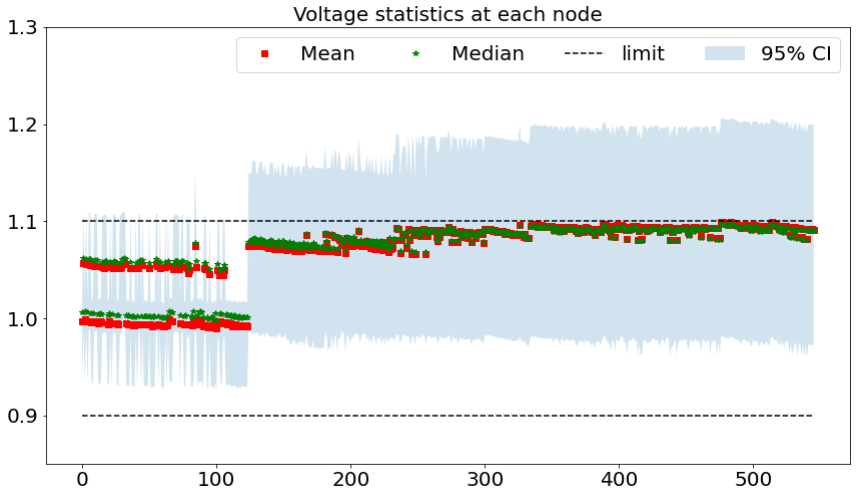


Fig. Distribution of voltage at all nodes in the 10kV-0.4kV network at Bus 46 for load and generation profile over a year

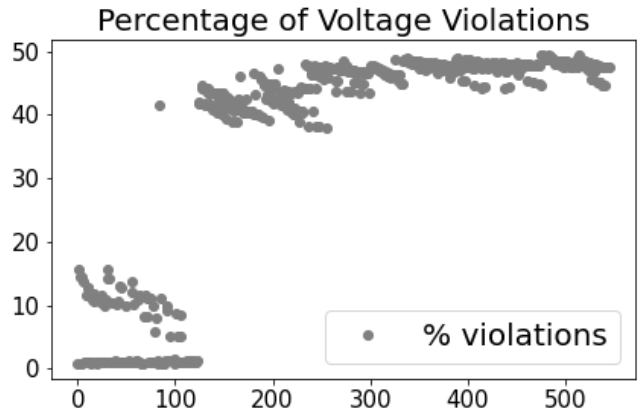


Fig. Percentage voltage violations at all nodes in network at Bus 46

Challenges for integration of Distributed Wind

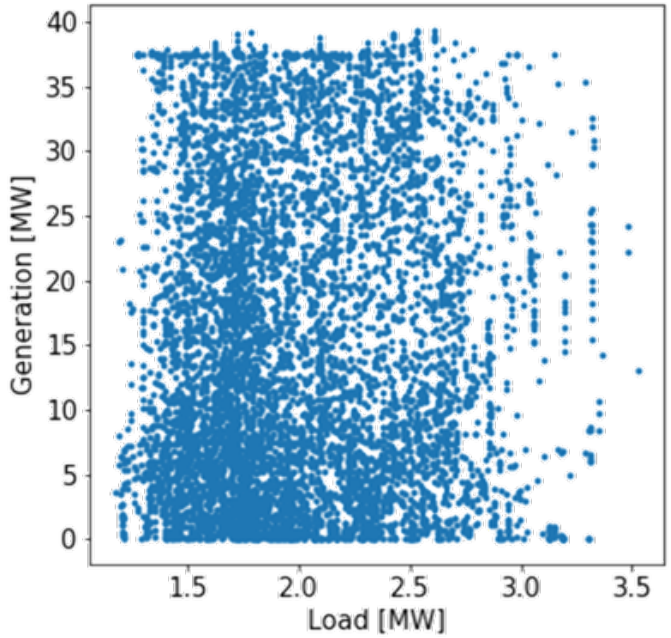


Fig. Scatter plot showing the lack of correlation between load demand and renewable generation

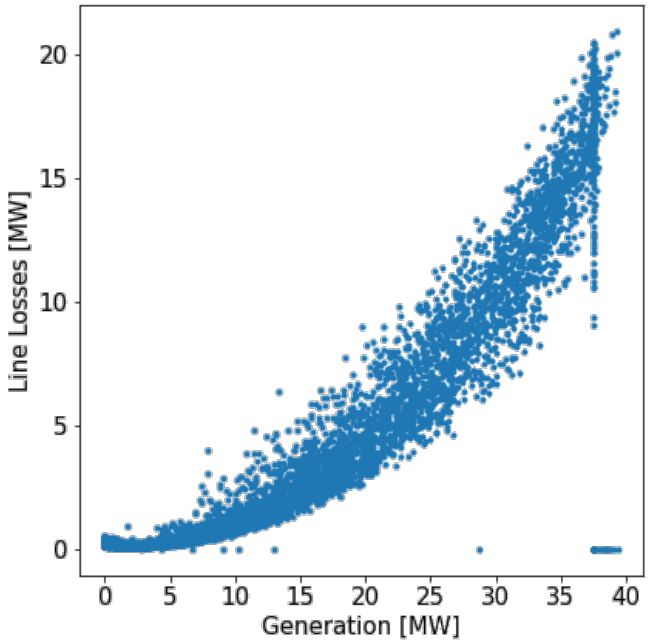


Fig. Scatter plot showing correlation of line losses and renewable generation in the network

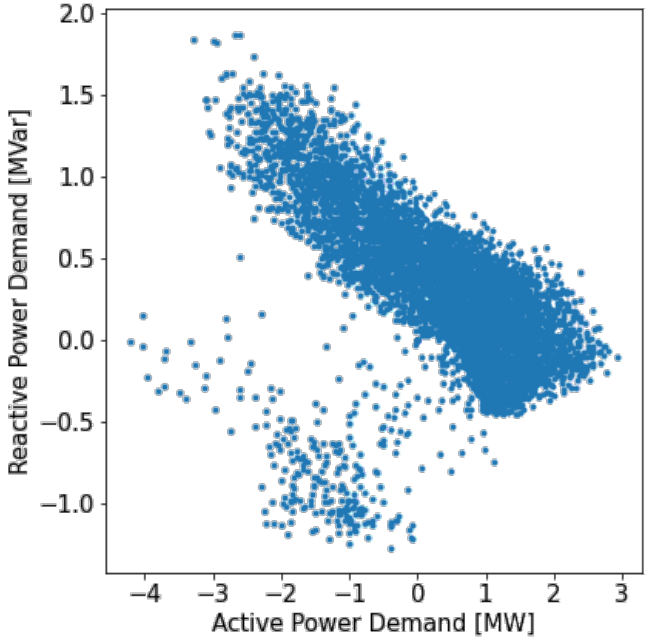


Fig. Scatter plot showing the active and reactive power flow at the 60kV-10kV substation

- Load demand and renewable generation in the network do not correlate at most time-stamps
- However, the active power losses in the distribution network proportionally increase with the renewable generation
- Reverse active and reactive power flow from the distribution network to the transmission network also increases.

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

Thank you!

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