Improving the Reactive Power Balance between a German MV and HV Grid through Coordinated Reactive Power Provision by WPPs

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Motivation

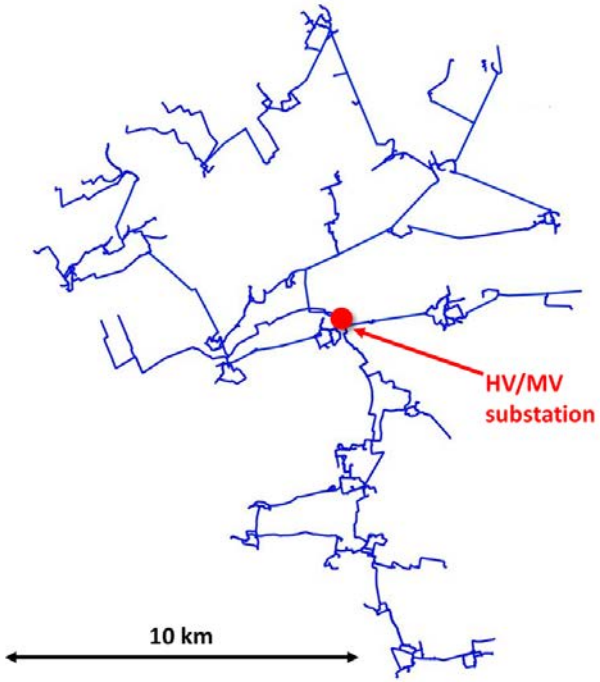
Decommissioning of large, synchronous generation

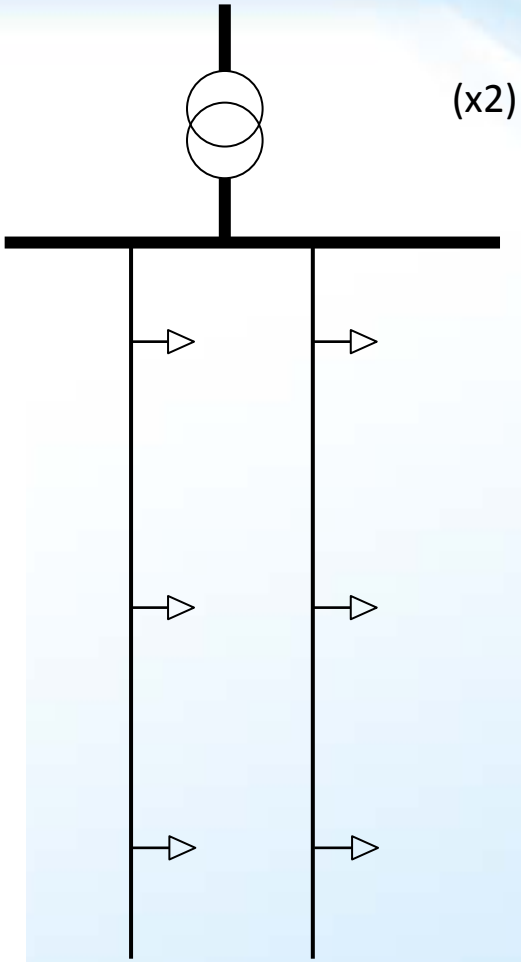
Reactive power control for voltage rise mitigation

1st goal: Compensate reactive power in the distribution grid
2nd goal: Providing reactive power with VRE for the transmission grid

MODEL SETUP

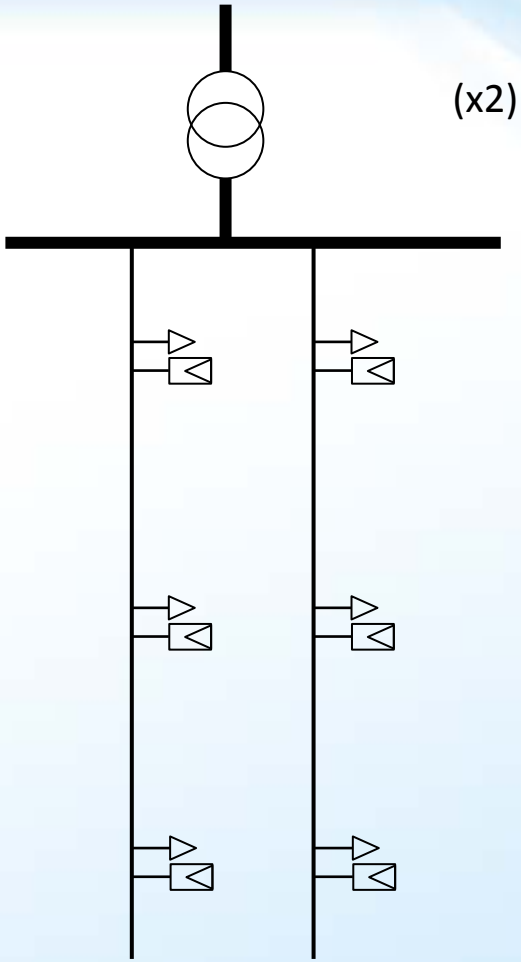
- 20 kV network
- 2 transformers (combined 90 MVA)
- Maximum load (2015): 16.7 MW





MODEL SETUP

- 20 kV network
- 2 transformers (combined 90 MVA)
- Maximum load (2015): 16.7 MW
- 15 MW LV-connected PV



MODEL SETUP

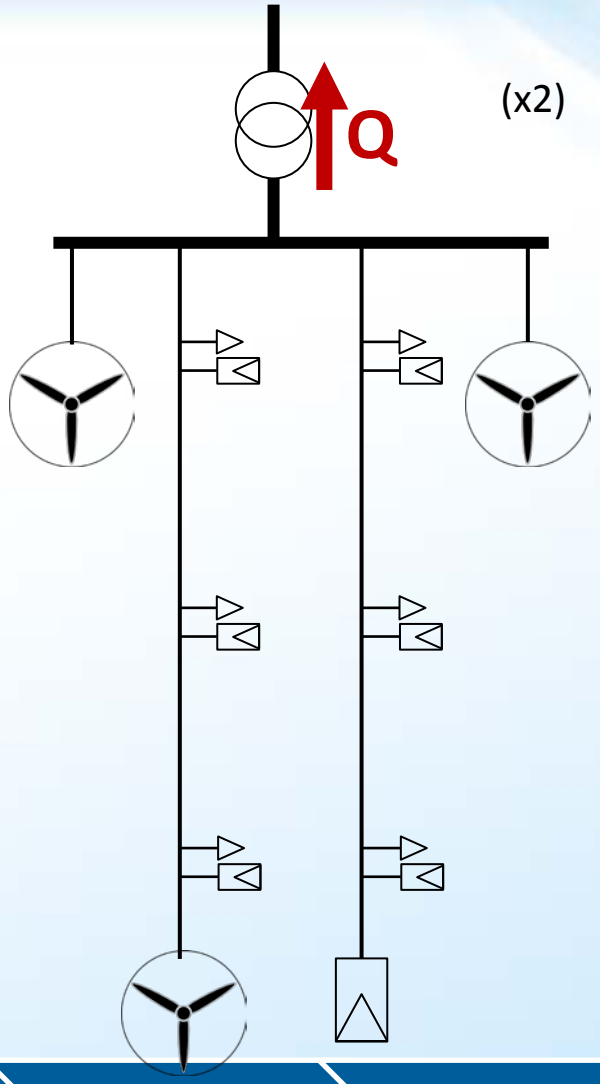
- 20 kV network
- 2 transformers (combined 90 MVA)
- Maximum load (2015): 16.7 MW
- 15 MW LV-connected PV

- MV-connected generation:

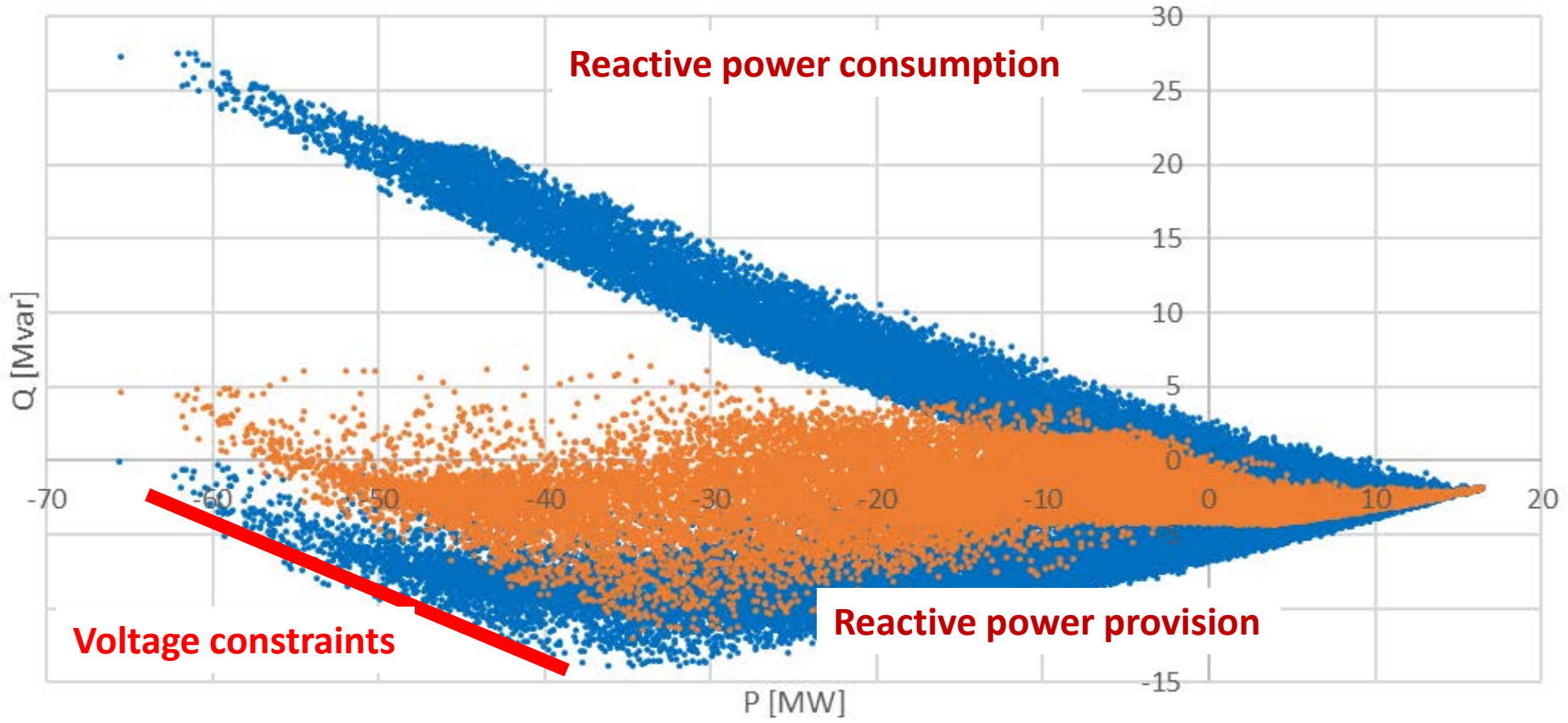
WPPs (connected to MV busbars)	35 MW
WPPs (connected to MV feeders)	19 MW
PVPP (connected to MV feeders)	7 MW

- Goal:

Control Q exchange with HV network



MODEL SETUP


Reactive power consumption
Voltage constraints
Reactive power provision
Q [Mvar]
P [MW]
30
25
20
15
10
5
0
-15
-70
-60
-50
-40
-30
-20
-10
0
10
20

CONTROL APPROACH

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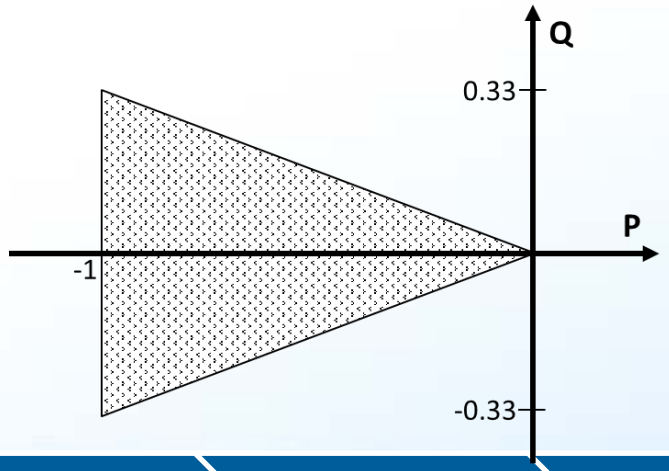
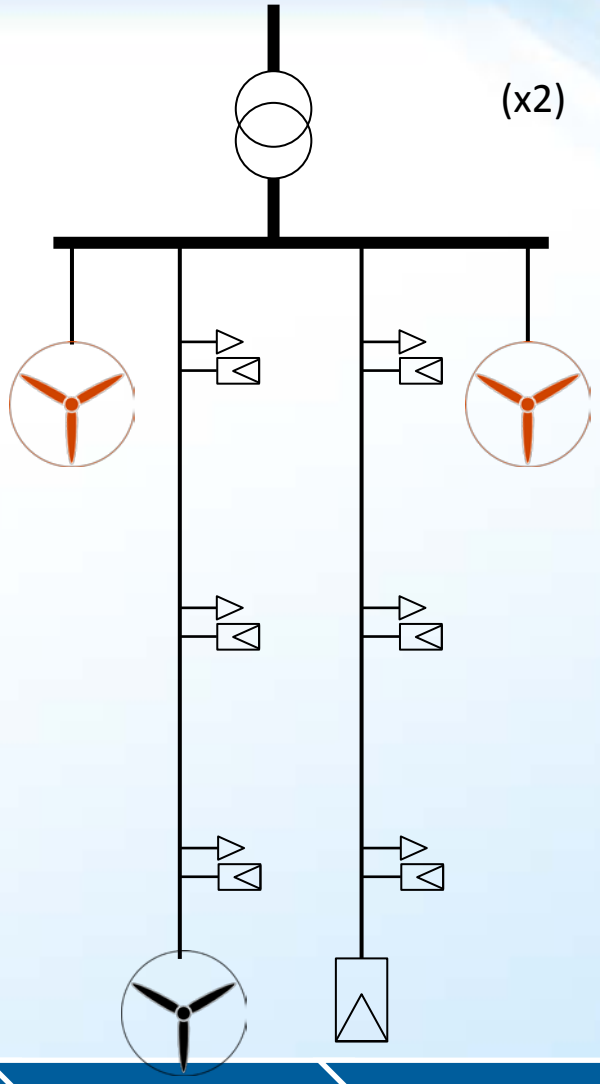
3 strategies:

I. Control busbar-connected PV/wind

+ Easy implementation / few plants





CONTROL APPROACH

3 strategies:

I. Control busbar-connected PV/wind

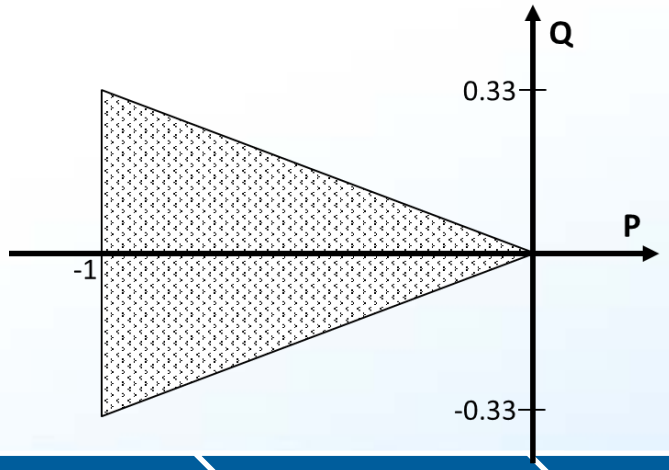
+ Easy implementation / few plants

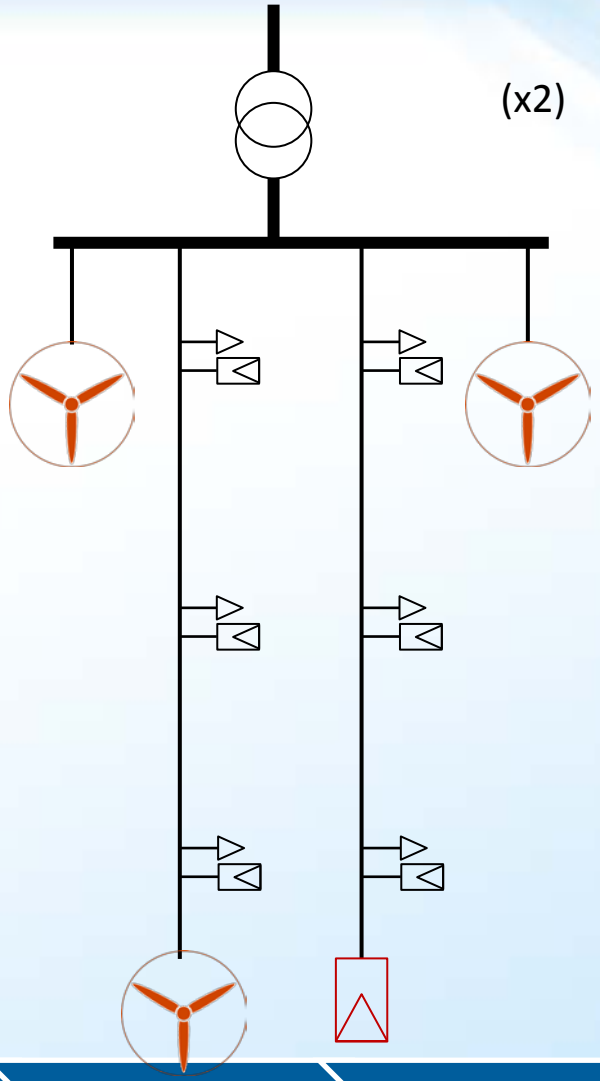
II. Control all PPs (in MV grid)

+ More Q flexibility

- Higher complexity

- Limited contribution due to voltage/overload limits





CONTROL APPROACH

3 strategies:

I. Control busbar-connected PV/wind

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II. Control all PPs (in MV grid)

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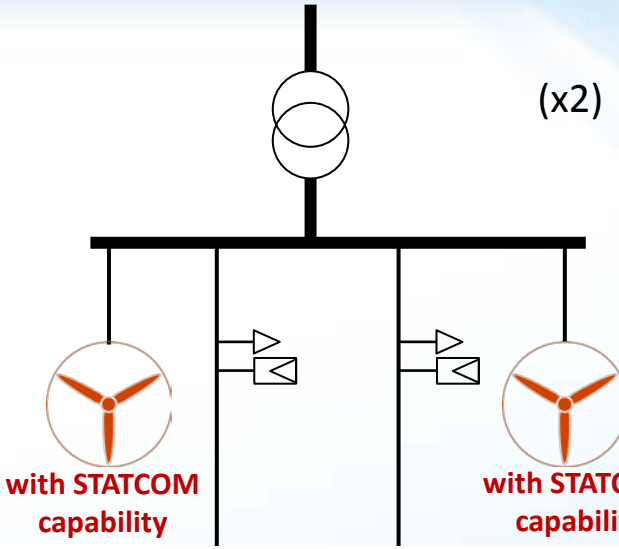
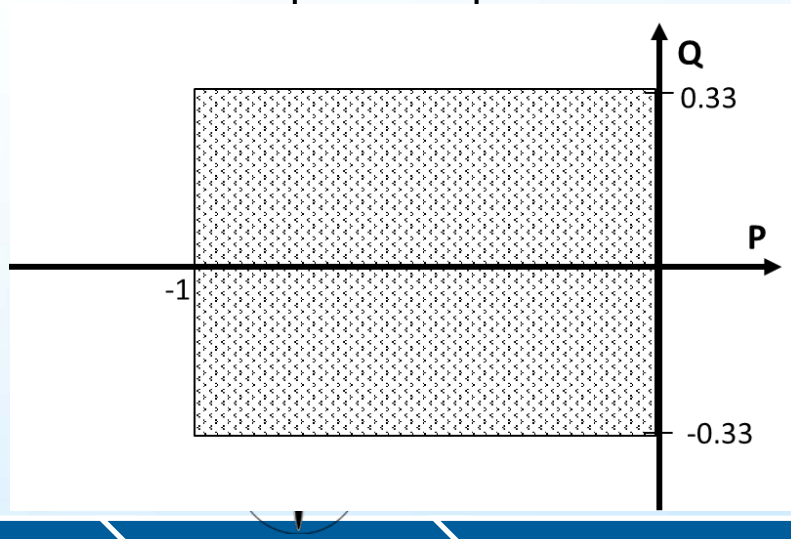
III. Control busbar-connected PV/wind with STATCOM capability

+ Maximum Q flexibility with few plants

- Additional CAPEX (plant upgrade)

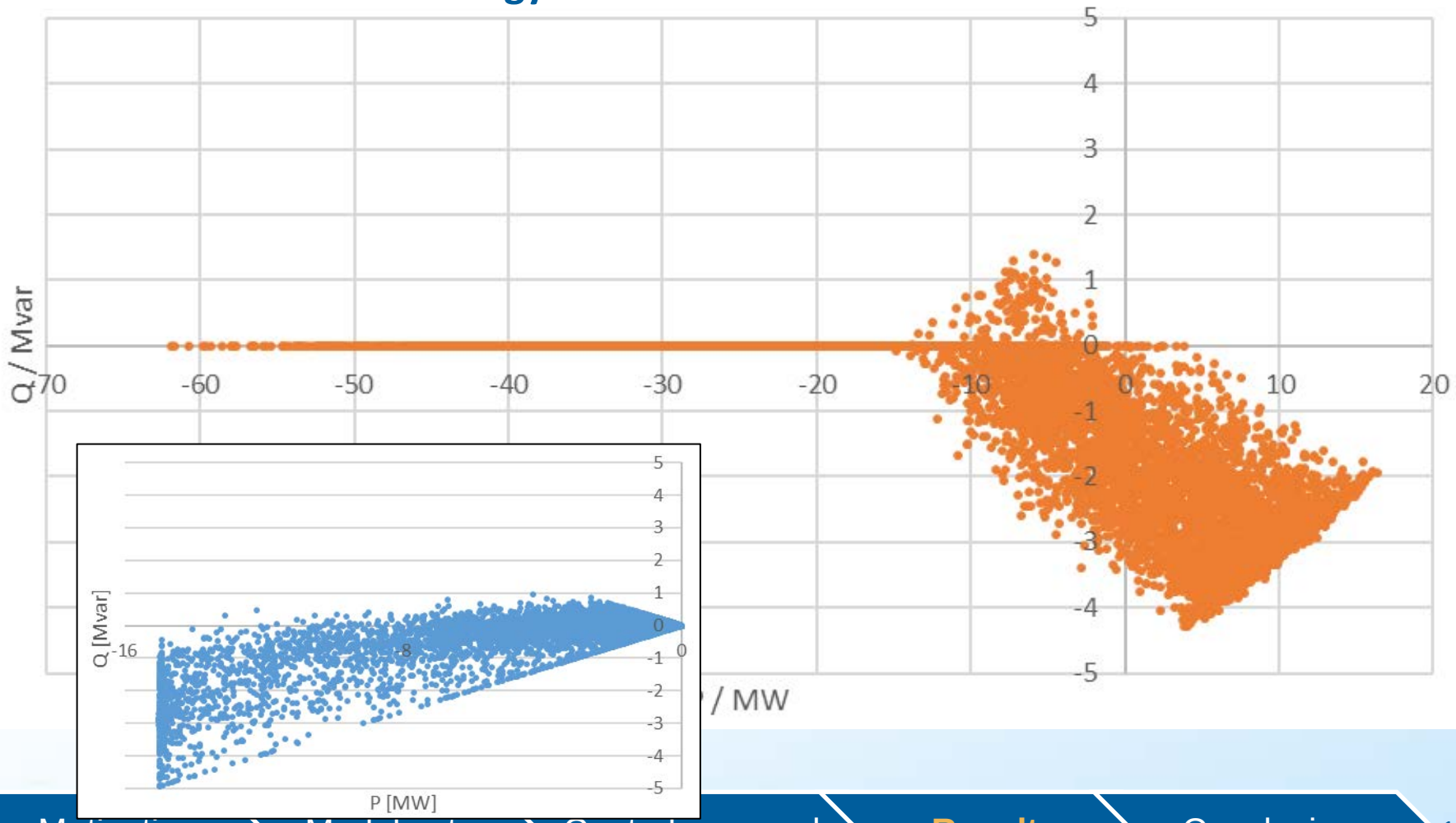
- Additional OPEX (losses, aging)





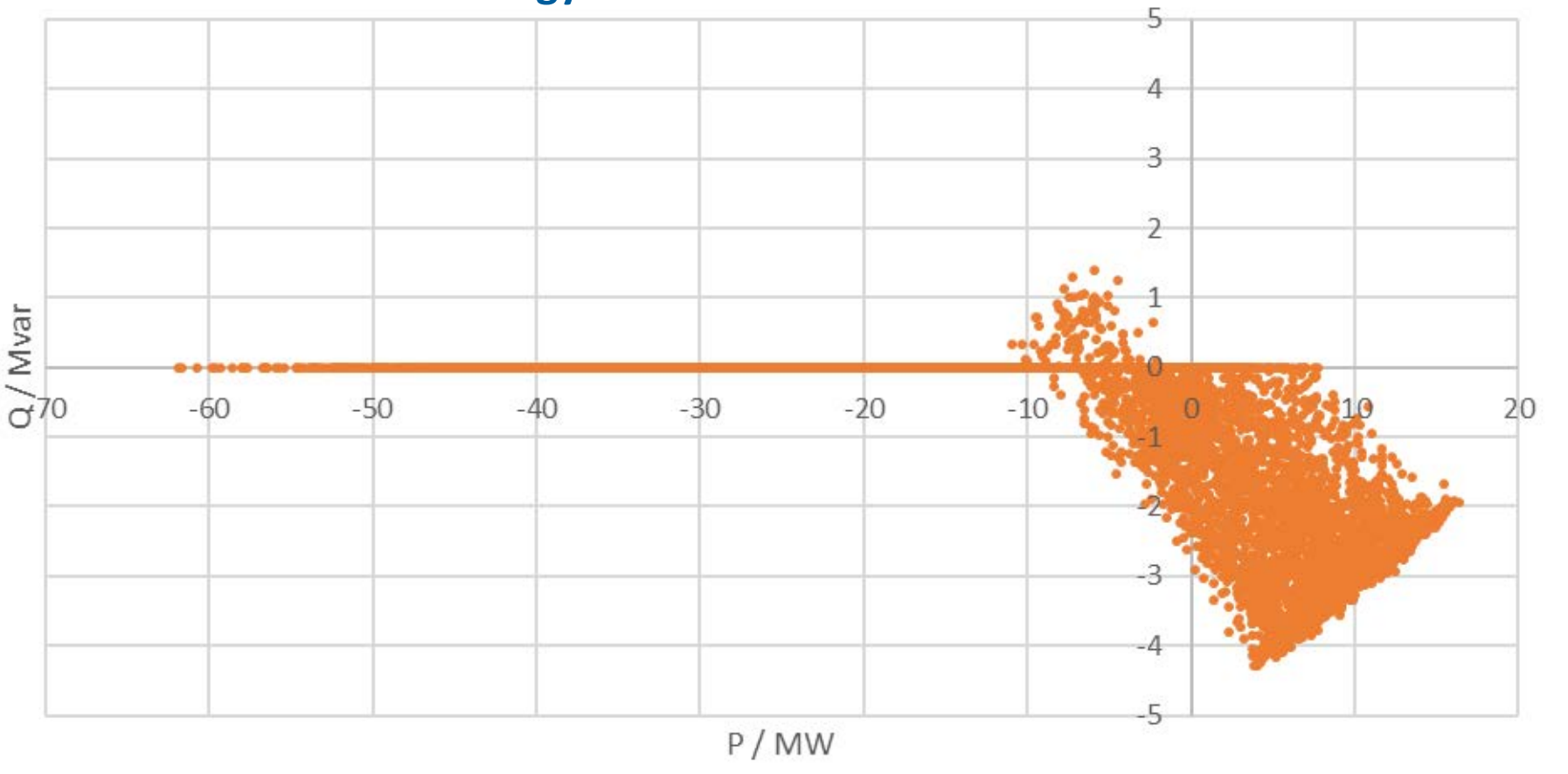
RESULTS

Strategy 1: busbar-connected PPs



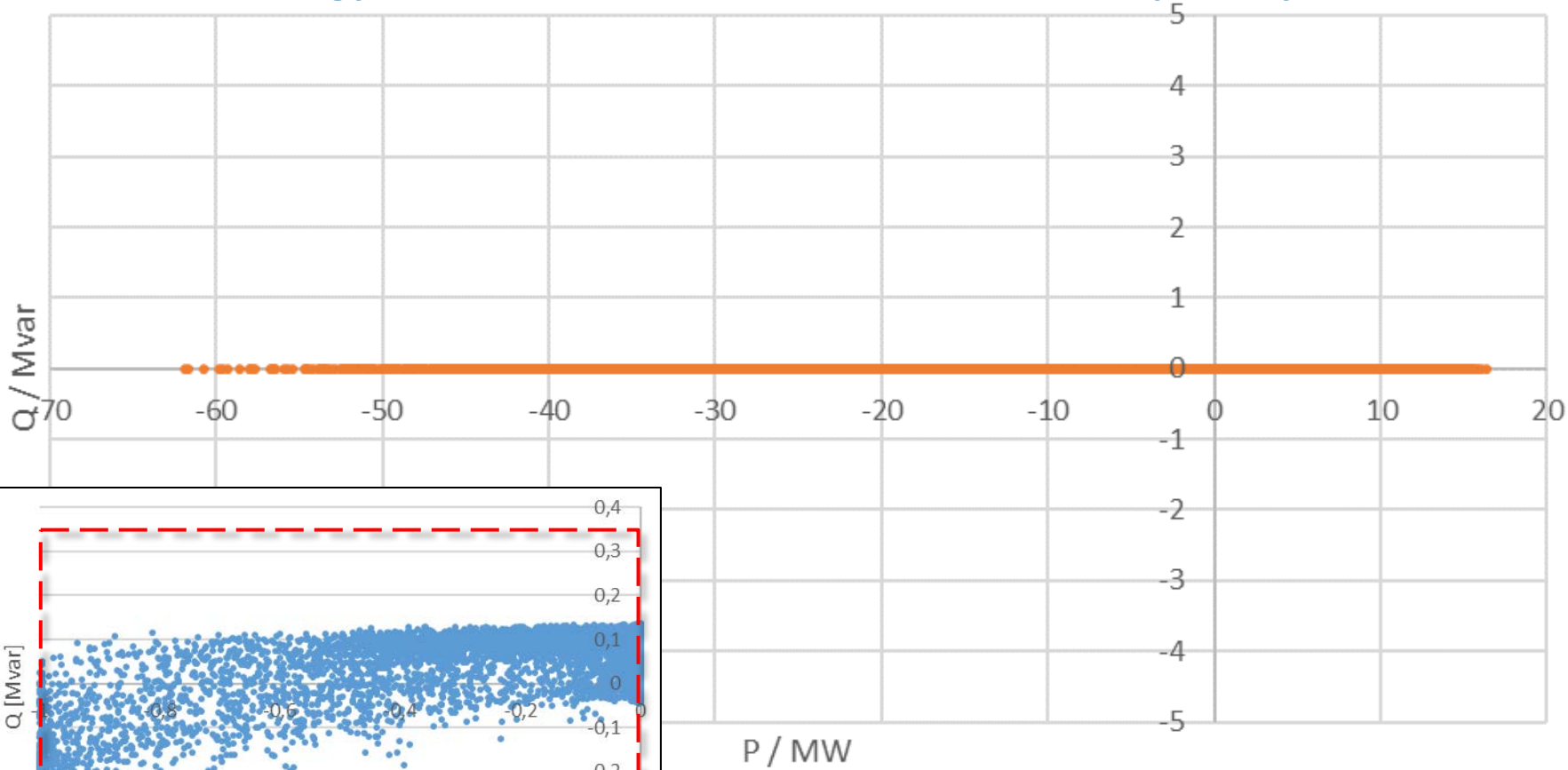
RESULTS

Strategy 2: all MV-connected PPs



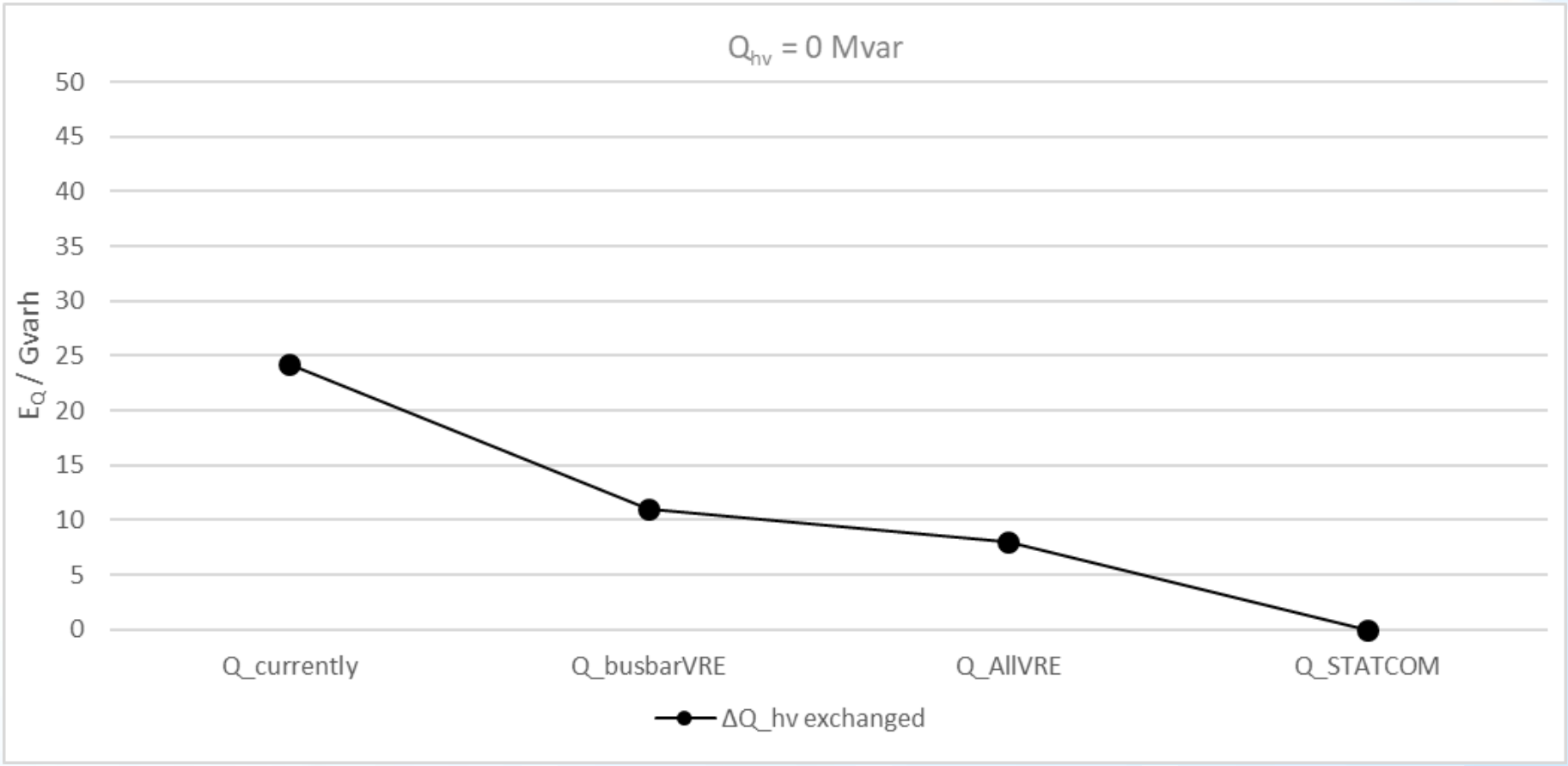
RESULTS

Strategy 3: busbar-connected PPs + STATCOM capability



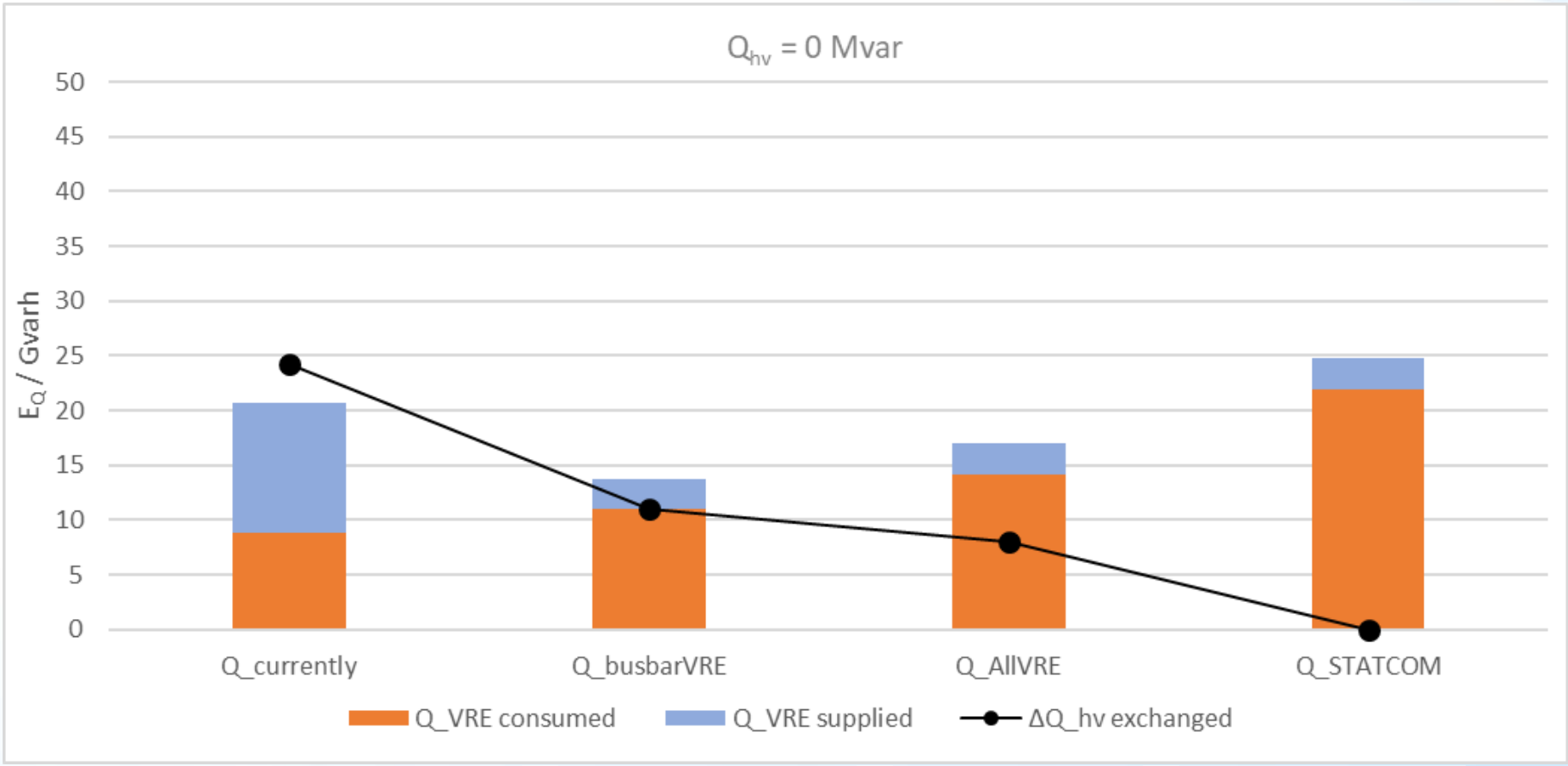
RESULTS

- Q import/export over a year is significantly reduced



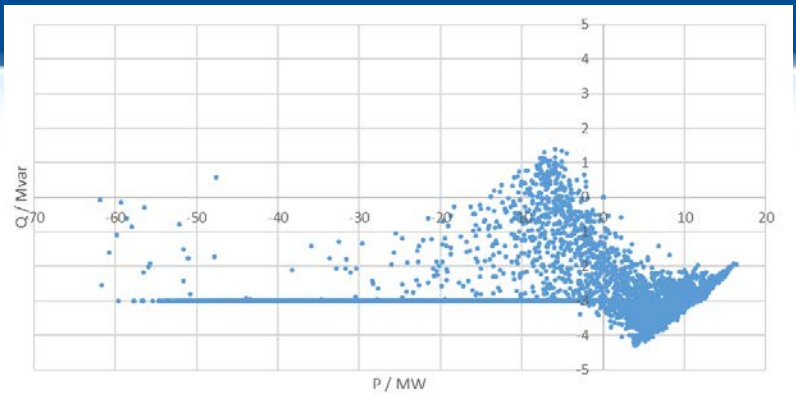
RESULTS

- Q from VRE can also be reduced (strategy 1)
- however, more Q controllability leads to increase of Q from VRE (strategy 3)

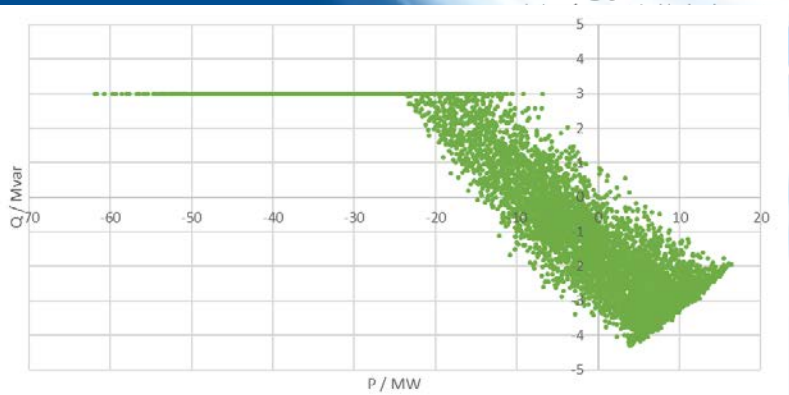


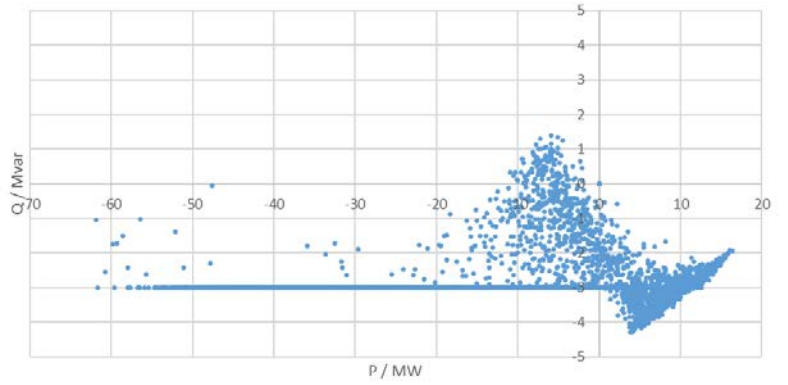
Q-setpoint: -3 Mvar

3 Mvar

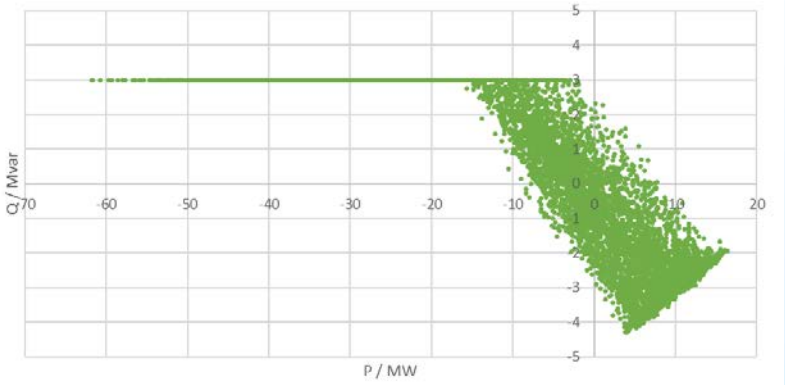


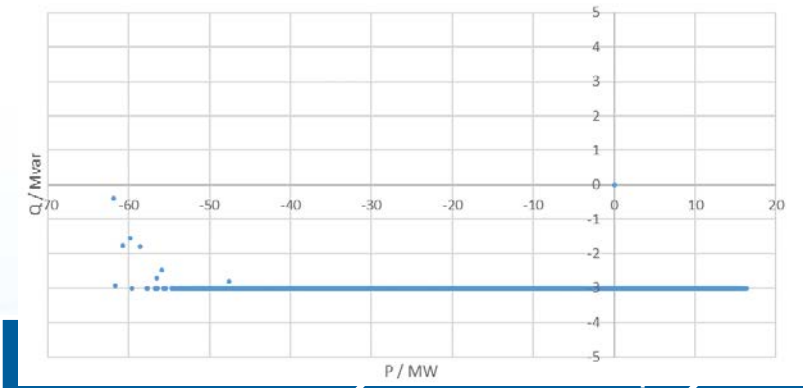
Strategy 1



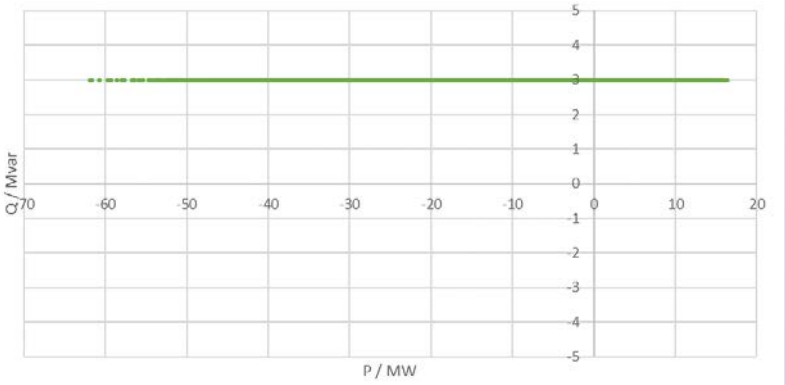


Strategy 2



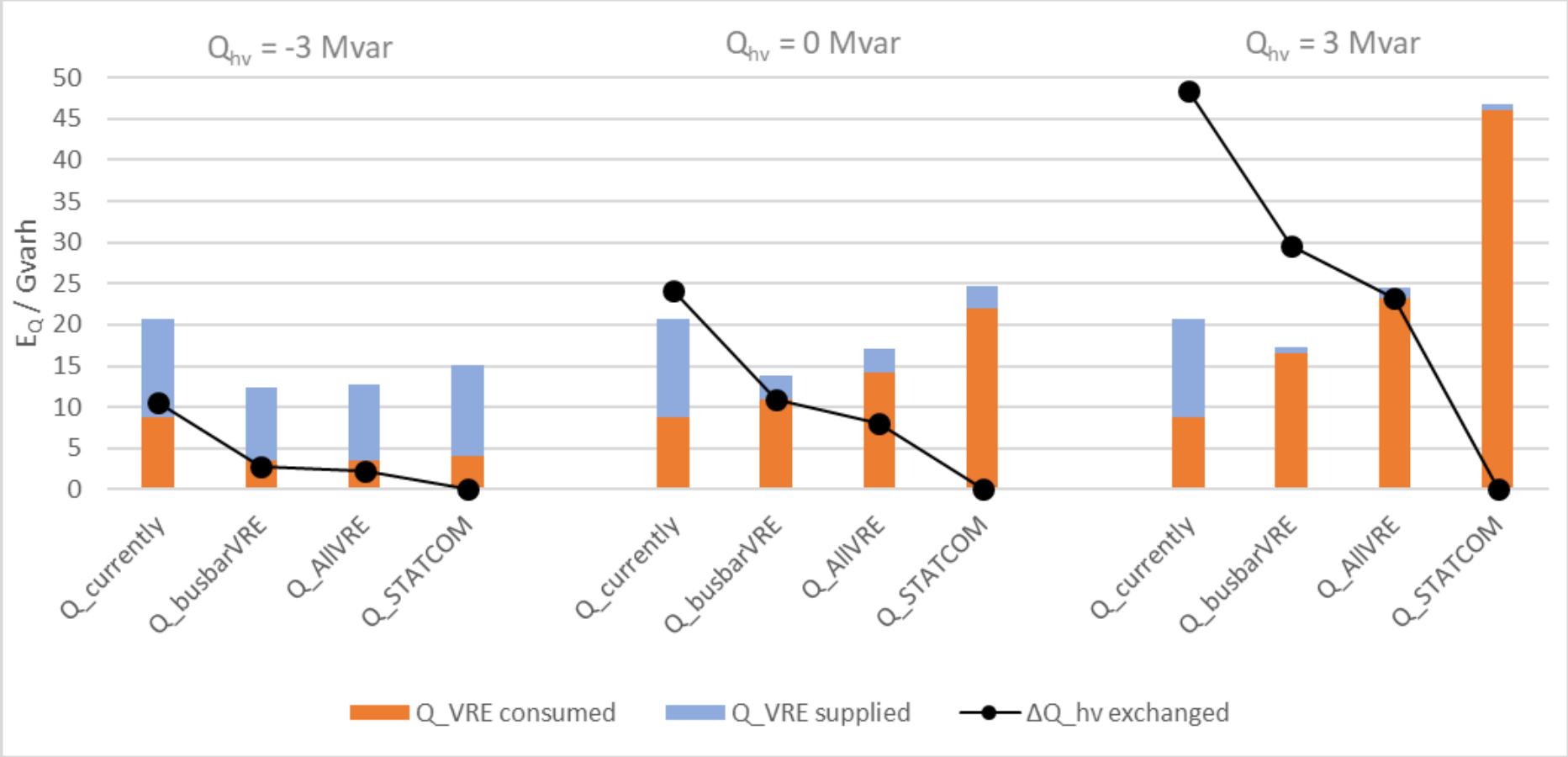


Strategy 3



ntrol approach

RESULTS


Q_{hv} = -3 Mvar
Q_{hv} = 0 Mvar
Q_{hv} = 3 Mvar
E_Q / Gvarh
50
45
40
35
30
25
20
15
10
5
0
Q_currently
Q_busbarVRE
Q_AllVRE
Q_STATCOM
Q_VRE consumed
Q_VRE supplied
ΔQ_hv exchanged

Conclusion

- Reactive power control of VRE in the distribution grid can both reduce Q import/export and reduce Q from VRE
- Only controllability of few plants is required => Simple and easy to implement

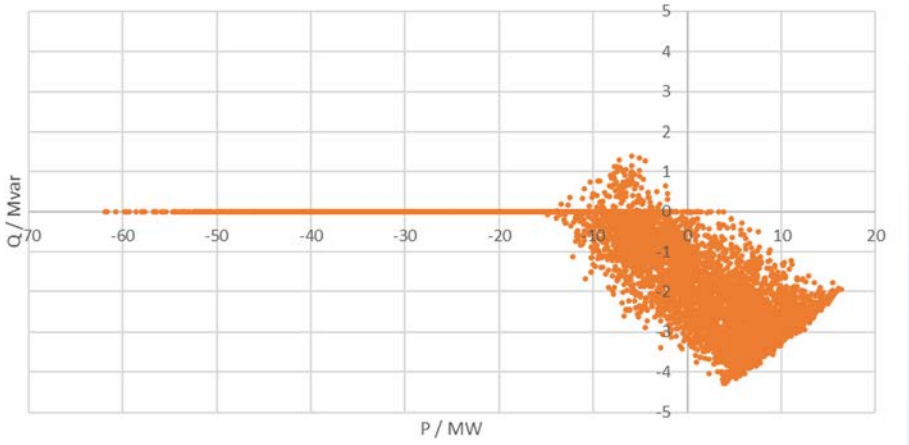
- MV-feeder connected VRE are inhibited by voltage constraints and cannot contribute significantly

- STATCOM capability can keep distribution within strict reactive power limits or provide reactive power as an ancillary service

Recommendations

- **Reduction in Q import/export works best with a mix of PV/wind**
- **With STATCOM capability: Only use PPs with maximum flexibility (close to busbar)**

- **Control Q during load situations with batteries/electric vehicles?**



- **Use VRE for reactive power supply instead of STATCOM/SVCs/etc.**

Barth, Heike, et al. "Technical and economical assessment of reactive power provision from distributed generators: Case study area of East Denmark." PowerTech (POWERTECH), 2013 IEEE Grenoble. IEEE, 2013.

Questions?

My question to you:

Could VRE with STATCOM capability be widely adopted?

- reactive power market?
- Inverter losses and aging too high?
- …

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