ASSESSMENT OF ACTIVE POWER CURTAILMENT METHODS IN LOW VOLTAGE GRIDS WITH REGARD TO THE GERMAN REGULATORY CONTEXT

Solar Integration Workshop, October 25th, 2017

Friederike Meier

Fraunhofer IWES

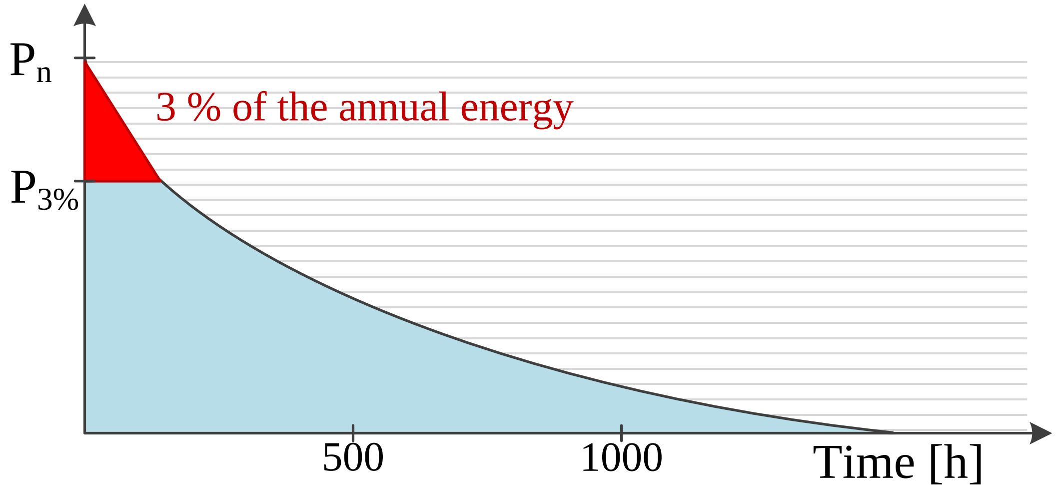
UNIKASSEL VERSITÄT

AGENDA

- German regulation 2017: Active Power Curtailment
- Active power curtailment methods
  - Static active power curtailment
  - Dynamic active power curtailment
  - P(V) droop control
- Assessment
  - Hosting capacity
  - Time series simulation
  - Comparison
- Conclusion & Recommendations

German regulation 2017: Active Power Curtailment

- German Energy Act 2017: Strategic curtailment of 3% of the annual energy of renewables in order to increase the efficiency of future grid extension
  - → Dimensioning the grid not for the full installed PV capacity P_n but for $P_{3\%}$



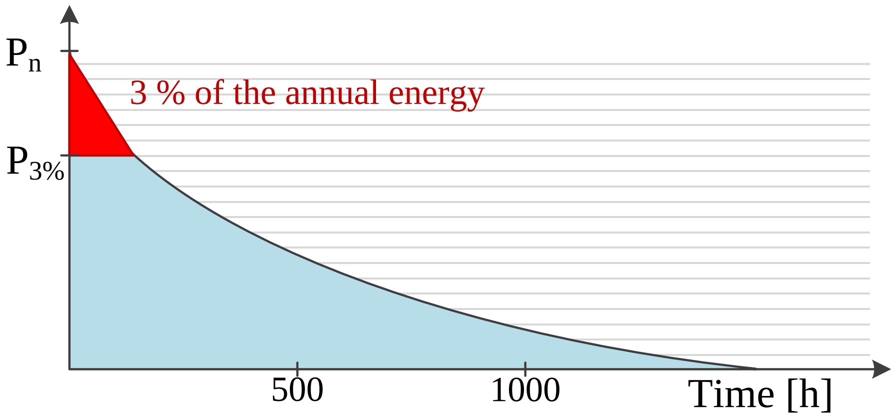
Schematic duration curve of a PV plant

ACTIVE POWER CURTAILMENT METHODS

- German regulation 2017: Active Power Curtailment
- Active power curtailment methods
  - Static active power curtailment
  - Dynamic active power curtailment
  - P(V) droop control
- Assessment
  - Hosting capacity
  - Time series simulation
  - Comparison
- Conclusion & Recommendation s

Static active power curtailment

- Static active power curtailment (SAPC): Curtailment of all active power above $P_{3\%}$
- Ex post determination of threshold value $P_{3\%}$ → uncertainty for future years



Advantages	Disadvantages
Easy implementation directly in the inverter	Curtailment even without present violations
Predictable Behavior	

- Compliant to German regulatory for plants smaller than 30 kWp

Dynamic active power curtailment

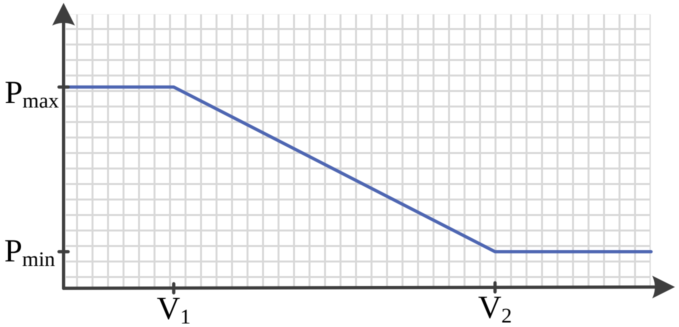
- Using an optimal power flow to find the optimal curtailment
  - Minimizing the curtailed energy
  - Connection to control center

- Compliant to German regulatory in terms of the feed in management

Advantages	Disadvantages
No curtailment without present violations	High need for Information and Communication Infrastructure (ICT)
Lowest energy losses	

P(V) droop control

- P(V) droop control configuration with $P_{max} = P_n$ and $P_{min} = P_{3\%}$
- Here:
  - $V_1 = 1.05$ p.u.
  - $V_2 = 1.06$ p.u.



P(V) droop characteristc curve

Advantages	Disadvantages
Easy implementation directly in the inverter	Curtailment without present violations

- Compliance to German regulatory depending on parametrization
- Billing of curtailed energy not regulated in Germany

ASSESSMENT

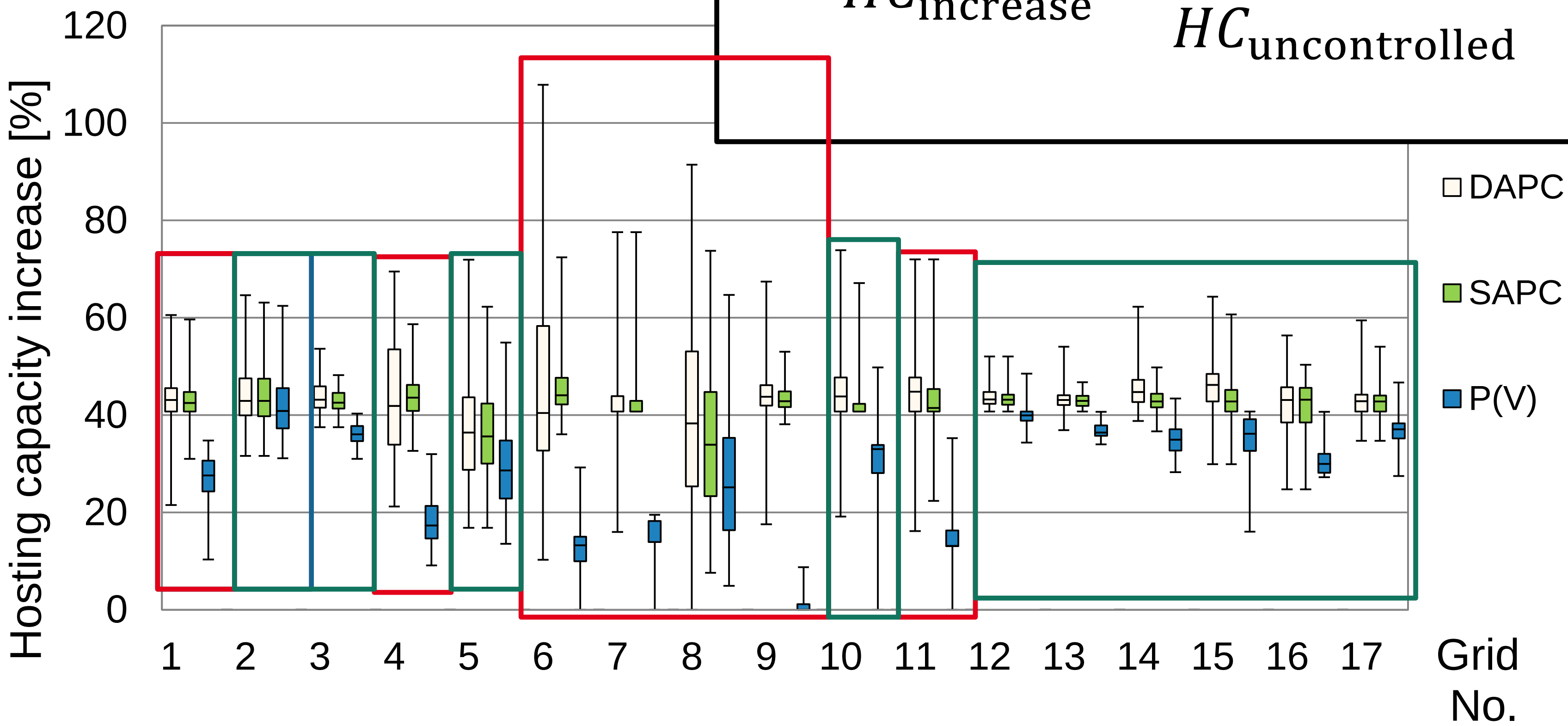
- German regulation 2017: Active Power Curtailment
- Active power curtailment methods
  - Static active power curtailment
  - Dynamic active power curtailment
  - P(V) droop control
- Assessment
  - Hosting capacity
  - Time series simulation
  - Comparison
- Conclusion & Recommendations

Hosting capacity

- Amount of maximum installable PV capacity in a grid before operational limits are violated.
- Probabilistic determination using varying generator positions and sizes
- Indicator for the impact of an operation method on the grid extension costs
- Classification into voltage constrained grids and loading constrained grids

Hosting capacity

$$HC_{\text{increase}} = \frac{HC_{\text{controlled}}}{HC_{\text{uncontrolled}}}$$



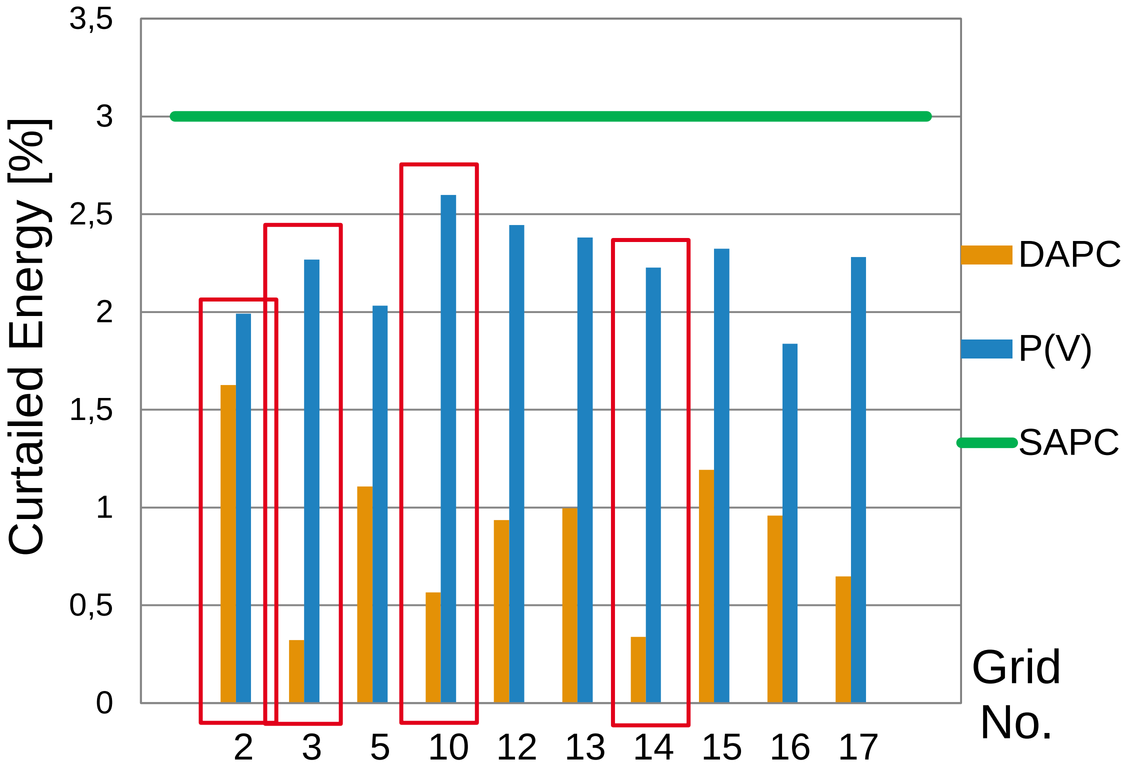
Hosting capacity for real low voltage grids for three active power curtailment methods

Time series simulation

- Determination of annual curtailed energy of the curtailment methods
- Operational expenses of the curtailment methods
  - Reimbursement of curtailed energy to the PV plant owner (DAPC)
  - Loss in revenue for the PV plant owner (SAPC)
- Benchmark loadcase derived from maximum hosting capacity using SAPC → Grids with significant lower hosting capacity with P(V) not considered

Time series simulation

- Curtailed energy with P(V) droop control is lower than with SAPC
- Grids 3,10,14: significantly less curtailment with DAPC than with P(V)



Curtailed annual energy of the low voltage grids for the respective curtailment method

Comparison

	Static active power curtailment	Dynamic active power curtailment	P(V) droop control
Hosting capacity increase	++	++	+
Low curtailed energy	0	++	+
Low Installation costs	+	--	+
Compliance	(+)	+	(+)

- Compliance of P(V) depending on parametrization,
  - Billing/reimbursement not regulated
- SAPC currently only allowed for PV plants smaller than 30 kWp
  - No reimbursement

CONCLUSION & RECOMMENDATIONS

- German regulation 2017: Active Power Curtailment
- Active power curtailment methods
  - Static active power curtailment
  - Dynamic active power curtailment
  - P(V) droop control
- Assessment
  - Hosting capacity
  - Time series simulation
  - Comparison
- Conclusion & Recommendations

Conclusion: Options for P(V) droop control

- Loading constrained grids: P(V) droop control is not suitable. A curtailment could only be conducted using SAPC and DAPC
- Voltage constrained low voltage grids: P(V) droop control is activated in case of violations in the grid and successfully avoids overvoltage and overloading.
- P(V): Trade-off between low curtailed energy and low installation expense
- Further investigations necessary on the combination of active power curtailment and reactive power control (At the moment, reactive power provision by distributed generators is not reimbursed) and transformer tap control

RECOMMENDATIONS

- **P(V) droop control needs to be considered in future case studies on active power curtailment and its impact on grid expansion costs.**
- **SAPC and P(V) droop control should be respected in the revision and modification of future technical regulation.**

Thank you very much for your attention!

Contact: Friederike Meier, friederike.meier@iwes.fraunhofer.de