



Challenges with high PV penetrations in distribution grids

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About me...

System Studies and Simulations of Distributed Photovoltaics in Sweden (2010)

- Development of models for electricity use in households.
- Modelling of PV systems.
- Studies of PV system utilisation in Swedish households.
- Consequences of solar power integration into the Swedish power system.



Built Environment Energy Systems, Uppsala University



The group is part of the Energy Systems Programme, a and Swedich research programme and research

our research and our collaborations within the Energy Systems Programme, please contact Professor Ewa Wäckelgård. You can find additional contact information under

interdisciplinary anthology on energy use in the built environment (in

Outline of the presentation

- System integration of renewables
- Relevant properties of distributed photovoltaics
- Hosting capacity of photovoltaics in distribution grids: Two studies on Swedish grids
- Increasing the hosting capacity of distributed photovoltaics



Integration characteristics of renewables (IPCC SRREN Report, 2011)

Technology	Plant size (MW)	Variability	Dispatchability	Geographical diversity potential
Bioenergy	0.1 - 100	Seasons	Full	Moderate
Hydropower	0.1 - 20 000	Hours to years	Full (excl. run of river)	Moderate
Ocean energy	0.1 - 300	Minutes to years	Low	Moderate
Wind energy	5 – 300	Minutes to years	Low	High
PV	0.004 - 100	Minutes to years	Low	High





System integration challenges

Two distinctly different challenges

Power distribution and transmission

- Capacity for increased power flows
- Voltage levels
- Correlation between demand and generation

Power system balancing

- Production variability and dispatchability
- Predictability
- Utilisation of operating reserves



On-site PV generation in distribution grids



Hosting capacity

How much distributed generation can be integrated in a specific distribution grid before deteriorating power quality



Demand and generation balance



Joakim Widén, Ewa Wäckelgård, Jukka Paatero, Peter Lund, Impacts of distributed photovoltaics on network voltages: stochastic simulations of three Swedish low-voltage distribution grids, Electric Power Systems Research 80 (2010) 1562-1571.

Altered voltage distribution with increasing PV penetrations



Joakim Widén, Ewa Wäckelgård, Jukka Paatero, Peter Lund, Impacts of distributed photovoltaics on network voltages: stochastic simulations of three Swedish low-voltage distribution grids, Electric Power Systems Research 80 (2010) 1562-1571.

Voltage as performance index



Tobias Walla, on-going M.Sc. project, Fortum / Uppsala University To be presented at the 27th EU-PVSEC, Frankfurt, Germany, 2012

Overloading / overheating as performance index



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Voltage profiles along feeders (30 % PV penetration)



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Increasing hosting capacity

- Voltage control (manual or automatic)
- Grid reinforcements
- Power curtailment
- Reactive power control in inverters
- Demand side management
- Local energy storage



Thanks for the attention!

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