Impact of load shifting and inverter control on the quality of electricity supply with high penetration of photovoltaic generation

William MARTIN – Christophe BALLIF
Swiss Center for Electronics and Microtechnology (CSEM)
william.martin@epfl.ch

The SEMIAH project

This project contributed to the SEMIAH project, where the goals were to implement a demand response scheme based on direct load control in order to shift loads to renewable production. An investigation on power quality issues is performed, namely voltage variation. Furthermore, taking advantage of the reactive power capabilities of inverters as a novel solution of voltage control was implemented and compared in terms of performances. All this is focused on low-voltage (< 1 kV) distribution networks with a high penetration of PV generation.

Power quality and control

Power quality

Issues related to PV systems:
• voltage rise - over-voltages reduce the lifetime of appliances
• reverse power flow - faults may not be detected
• power factor degradation - low power system efficiency

European standards limit voltage supply to ± 2.0% of nominal voltage. If limits are not met: output restriction of PV.

The SEMIAH project

Power quality and control

Power quality

Based on a mixed integer linear programming problem (MILP) MILP, meets power constraints (1), smooths the consumption profile (Aa-b) and shifts loads to production while minimizing cost (3).

Inverter control

Proportional control following a droop characteristic subject to:

- absorb q when voltage is high (PV generation)
- inject q when voltage is low (load)

Tuning parameters:
1. voltage deadband
2. reactive power capabilities Qmin/Qmax
3. droop characteristic (slope)

References


Conclusion

DLC naturally outperforms Volt/Var control in terms of load shifting, using more solar energy and reducing electricity costs and line losses, Inverter control on the other hand is the most efficient method for regulating the voltage rise due to PV generation but increases the maximum loading of the line. In terms of practicability, DLC needs an ICT infrastructure which may come with high fixed costs whereas inverters are already installed with PV systems (virtually no additional costs).

Acknowledgments

A special thank you to the following for making this research possible:
Pierre-Jean ALET, CSEM
Christophe BALLIF, EPFL