CONGESTION MANAGEMENT IN DISTRIBUTION GRIDS WITH PHOTOVOLTAICS

new assets, reactive power, intelligent curtailment and batteries
Outline

• Congestion in distribution grids
• The MetaPV project
• Recommendations from real-world testing
• Questions for discussion
Bottlenecks are Local

CONGESTION IN DISTRIBUTION GRIDS
Overvoltage in Distribution Grids

grid voltage

maximum

nominal

minimum

transformer
distribution line

... with PV
In Many Distribution Grids Congestion Occurs Rarely
The MetaPV Project
GRID SUPPORT FROM DISTRIBUTED PHOTOVOLTAICS
MetaPV at a Glance

• FP7 grant agreement 239511 with DG Energy
• October 2009 - March 2015
• Large-scale demonstration
  • Residential (LV): 85 plants with 430 kW
  • Industrial (MV): 9 plants with 2.4 MW
• Results at www.metapv.eu
Strategic Objectives

- Distribution grid hosting capacity: + 50%
- For ~10% of the costs of grid reinforcements
- Maintaining quality, safety & security of supply

Large-scale demonstration in the real world!

(a) Province of Limburg (red) in Belgium
(b) Municipalities in Limburg
The Citizen as Guinea Pig

A distribution grid in Opglabbeek

Source: Infrax
Three Solutions for Smart Control of Inverters

1. Reactive power

2. Limit active power

3. Battery storage
Alternating Tests with Different Control Methods
Real-life Testing and Evaluation

RESULTS & RECOMMENDATIONS
It Works

- Inverter-based voltage control works in practice
- By controlling reactive and active power, the voltage is kept within the limits
- … hence more PV can be connected to the existing grid.
Pro’s and Con’s of Different Solutions

Criteria

• effectiveness
• efficiency
• fairness
• simplicity
<table>
<thead>
<tr>
<th>Q(V) with small/no deadband</th>
<th>Effectiveness</th>
<th>Efficiency</th>
<th>Fairness</th>
<th>Simplicity</th>
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<tr>
<td>++</td>
<td>-</td>
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<td>+</td>
<td>++</td>
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<tr>
<td>Q(V) with medium deadband</td>
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<td>Q(V) with large deadband</td>
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<tr>
<td>Q(V) with location-based deadband</td>
<td>+</td>
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<tr>
<td>PF(P) without deadband</td>
<td>+</td>
<td>+</td>
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<tr>
<td>PF(P) with deadband</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
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<td>Coordinated control with uniform Q</td>
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<td>Coordinated control with uniform PF</td>
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<tr>
<td>Coordinated control (hierarchical)</td>
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Costs and Benefits

Cost Comparison for LV Feeder

- ▲▲ + Real time control over private SCADA network
- •• + Standard control over private SCADA network
- ■■ + Standard control over the internet
- ▼▼▼ + Standard control over the internet (inverter integrated communication)

Grid Reinforcement
- Grey
- Yellow: Reactive Power and Storage (Central)
- Green: Reactive Power and Storage (Local)
- Red: Reactive Power and Curtailment (Central)
- Blue: Reactive Power and Curtailment (Local)

Net Present Value of Costs (& Benefits) (kEUR)

Increase in Hosting Capacity

EC RES Integration Conference 2015
Combining Reactive and Active Power

Small limitations do not significantly affect the annual energy yield. However, this requires a clear legal and regulatory framework.

Political questions:
• Should power from renewables be wasted?
• How much is acceptable?
• Who decides to control?
• Should there be financial compensation?
Active Power Curtailment and Storage

- Curtailment is not the preferred option
- Combination of reactive power with curtailment is very effective

- Small amounts of curtailment do not alter the yearly energy yield

- Larger amounts of energy can be buffered with storage
- Most expensive option
- Consider combining different objectives
Overall Conclusion

- Inverter control can increase hosting capacity significantly
- Allows to deploy grid reinforcement more strategically
- Keeps grid fees affordable
  - Requires voltage control capabilities as a standardized feature for all plants, even though these may never be activated in many grids

We encourage all stakeholders to build further on the results for improving, replicating and upscaling the solutions presented here.
Broader Context of RES Integration

STATEMENTS FOR DISCUSSION
Differentiation in the Smart Grid Context

Local congestion management:

- MetaPV solutions
- **Reactive & active power** control for local congestion management
- **Optimizing** the use of infrastructure **locally**
- More strategic grid reinforcement
- Probably regulated

System level challenges:

- Require **active power** control towards a **global optimum**
- Possible with energy management or storage
- With distributed or centralized resources
- With **central control** or **adequate aggregation** & disaggregation
- Probably market-based

*Source: EPIA 2012*
Thank you

Brussels
Toulouse
Gent
Beijing
Istanbul
Cape Town

www.3E.eu