DISTRIBUTED GENERATION ACCESS AND POWER FLOW MANAGEMENT

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Overview

- Role of Active Network Management
- Access rights for DG
  - Types
  - Arrangements
  - Possible improvements
- Comparisons of different approaches
Some Key Challenges

- Integrating intermittent generation
  - finding the best ways of integrating intermittent generation including residential microgeneration;

- Developing decentralized architectures
  - enabling smaller scale electricity supply systems to operate harmoniously with the total system;

- Capturing the benefits of DG and storage.
Active Network Management

- Connection of DG units on a distribution network affect power flows
- Why does it matter?
  - Most distribution networks are originally designed for unidirectional power flow
  - With DG connections power flow become bidirectional
    - Change in flow directions and magnitude
    - May affect network security
- Need to control flows – i.e control DG operation via access arrangements
DG Access Rights in the UK

- Two types of network access rights
  - Firm
  - Non-firm

- Why managing no-firm access rights is important?
  - Increase DG penetration with less infrastructure investments
    - Low carbon networks
  - Facilitate DG connections and investments

- How to manage non-firm access?
  - Different access rules..
Access Rules

- **Last-in-first-out (LIFO) rule**
  - Last connected DG unit will be curtailed first
  - Currently implemented in the UK
  - Pros: Transparent and simple
  - Cons: Curtails even generators that do not contribute to the network operation problem and thus reduces amount of overall DG outputs
  - Calculations are based on power flow analysis
Access rules based on OPF

\[
\min_{P_g, Q_g, V, \delta} \sum C_i(P_{gi})
\]

s.t.

\[(P_g, Q_g, V, \delta) \in S\]

- OPF-LIFO
- Least Curtailment Access
- Willingness to pay
Access based on OPF

- **OPF-LIFO**
  - Assign costs to generators according to connection order
  - This mimics the LIFO approach but has additional flexibility not to curtail generators that are not contributing to the problem
  - Increases of the utilization of DG resources

\[
\min_{P_g, Q_g, V, \delta} \sum_i C_i (P_{gi})
\]
Access based on OPF

- Least curtailment access
  - The objective function is based on minimizing a deviation from the maximum DG output

\[
\min_{P_g, Q_g, V, \delta} \sum (P_{gi}^{\text{max}} - P_{gi})
\]

- The value of maximum output is dynamic
Access based on OPF

- Willingness to pay for access
  - The objective function is based on minimizing a deviation from the maximum DG output
  - cost of deviation is different for each generator and based on its bid

\[
\min_{P_g, Q_g, V, \delta} \sum_i C_i (P^\text{max}_{gi} - P_{gi})
\]

- The value of maximum output is dynamic

[Image with mathematical formulas]
Case studies

- Distribution network with two DG units
  - DG A constant output of 1.6MW
  - DG B variable output
  - Variable load at bus 5

- Load profile
LIFO vs OPF-LIFO

- Constraint on line 3
- DG B is “first on”
- LIFO: both A & B would be curtailed
- OPF-LIFO only B is curtailed
Case study for 5bus network

<table>
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<tr>
<th>bus</th>
<th>connection order</th>
<th>installed Pgmax</th>
<th>LIFO</th>
<th>OPF-LIFO</th>
<th>LAC</th>
<th>LAC-W</th>
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<td>inf</td>
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</tbody>
</table>
Access based on OPF

- **Pros**
  - less unnecessary curtailments
    - better utilization of DG units and network infrastructure
    - lower emissions

- **Cons**
  - more complex to implement
    - Solving OPF
    - Possibility to control DG units
Conclusions

- Improving DG access and network utilization is important
  - Lower infrastructure investment costs
  - Increase of DG connections
  - Lower emissions

- Access rules can help

- But...
  - necessary to evaluate technical requirements and cost analysis for their implementation
Remark …

Consumers’ opinions on smart grids…

  - “While the Americans and Chinese are positive about smart grids, Europeans and Australians remain more skeptical despite the environmental benefits of the new technology”
  - 88% of American consumers trust the smart grid 😊
  - 41% of Chinese are positive
  - 70% of British households would ignore any information provided by smart meters 😞
GE Survey

- GE survey
  - 88% of Americans said they would be willing to use a smart device such as a meter, thermostat or appliance if it would help to better manage their energy.
  - 82% of those willing to use these devices believe smart meters and smart appliances are the future.
Some of the primary motivators for consumers’ smart grid support include:

- Desire to save money (95%)
- Increased control over my energy bill (90%)
- Desire to make a difference for my children or grandchildren (88%)
- Helping reduce the number of power outages (86%)
- Environmental concerns (85%)
Thank you!