INSTITUTE FOR ENERGY AND ENVIRONMENT

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Distributed Generation Access and Power Flow Management

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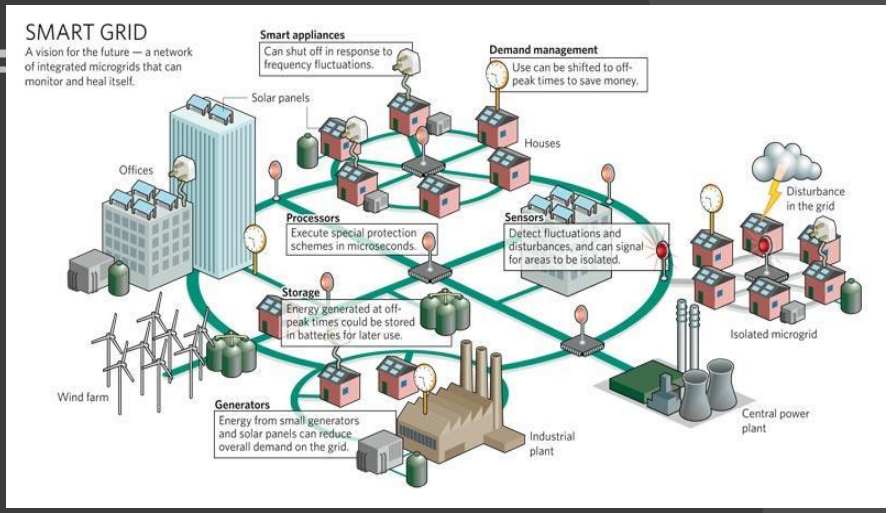
Overview

- 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

$$\min_{\mathbf{P}_g, \mathbf{Q}_g \mathbf{V}, \delta} \sum C_i(P_{gi})$$

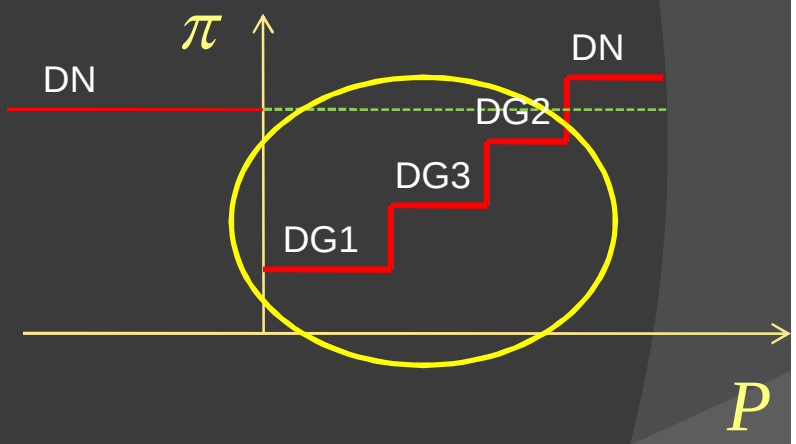
$$s.t.$$

$$(\mathbf{P}_g, \mathbf{Q}_g, \mathbf{V}, \boldsymbol{\delta}) \in S$$

- 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



$$\min_{\mathbf{P}_g, \mathbf{Q}_g \mathbf{V}, \delta} \sum C_i(P_{gi})$$

Access based on OPF

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

$$\min_{\mathbf{P}_g, \mathbf{Q}_g \mathbf{V}, \delta} \sum (P_{gi}^{\max} - P_{gi})$$

  - The value of maximum output is dynamic

Access based on OPF

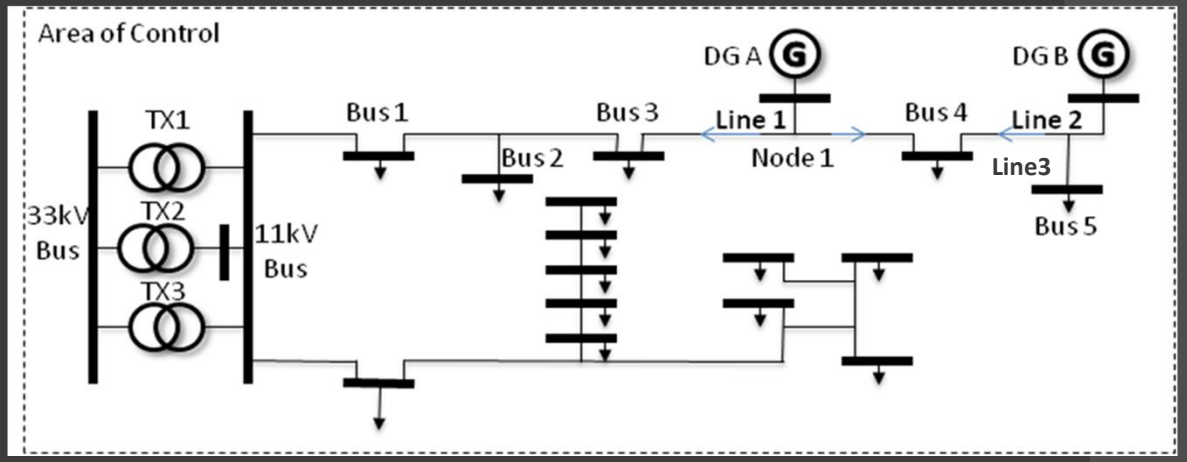
- Willingness to pay for access
  - The objective function is based on minimizing a deviation from the maximum DG output
  - cost of deviation is different for each generator and based on its bid

$$\min_{\mathbf{P}_g, \mathbf{Q}_g \mathbf{V}, \delta} \sum C_i (P_{gi}^{\max} - P_{gi})$$

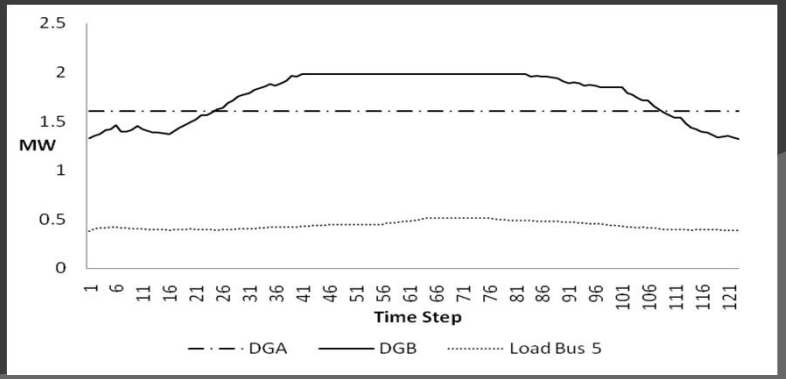
  - The value of maximum output is dynamic

Case studies

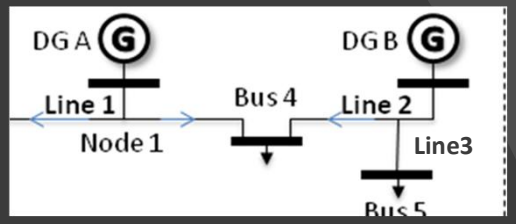
- Distribution network with two DG units
  - DG A constant output of 1.6MW
  - DG B variable output
  - Variable load at bus 5

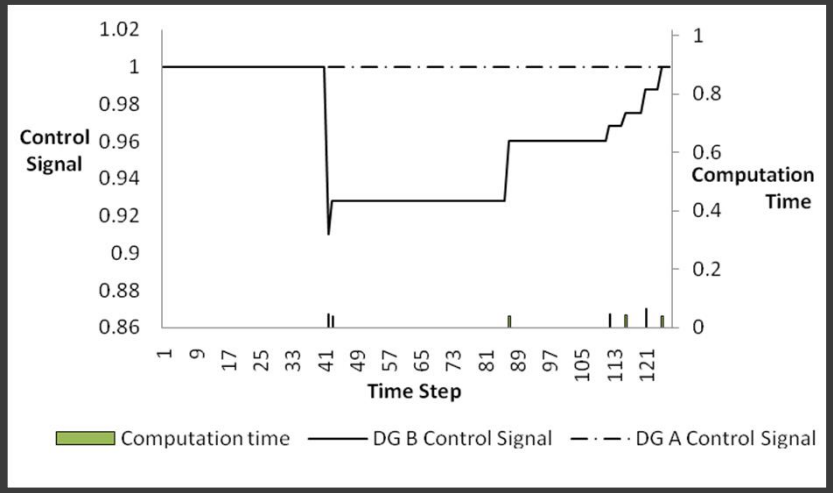


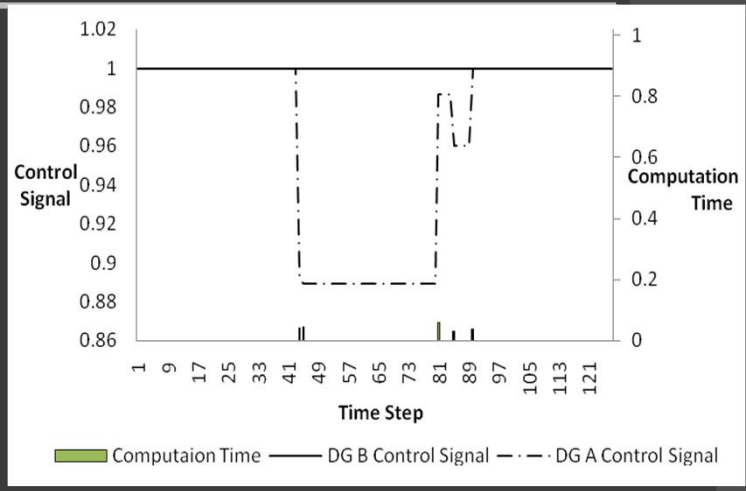
- Load profile



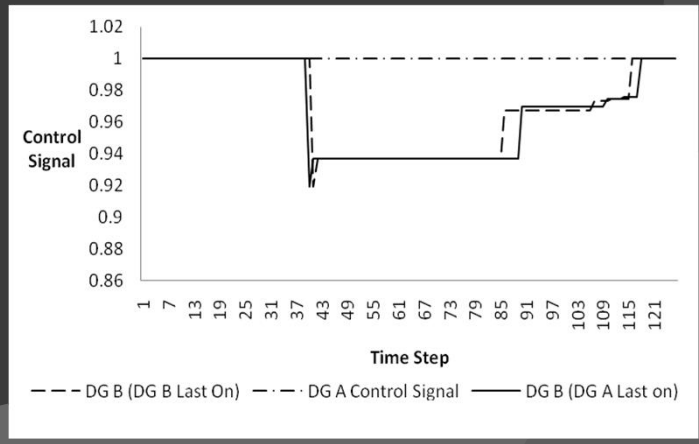
LIFO vs OPF-LIFO



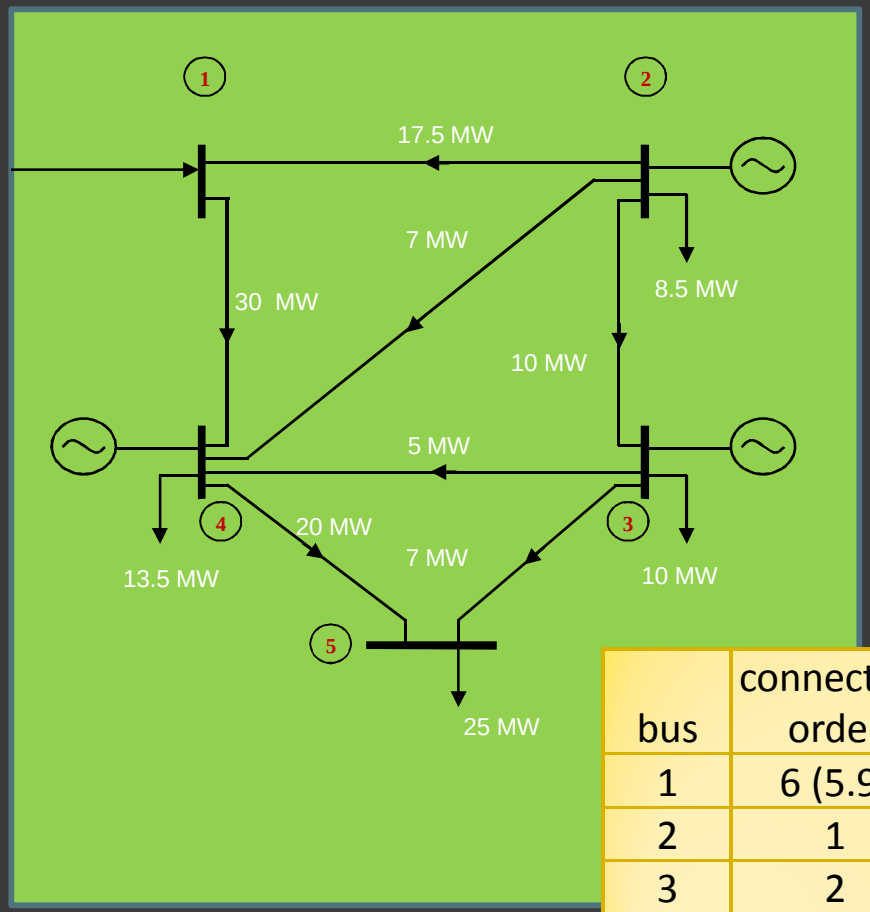




- Constraint on line 3
- DG B is “first on”
- LIFO: both A & B would be curtailed
- OPF-LIFO only B is curtailed



Case study for 5bus network



bus	connection order	instalalled Pgmax	LIFO	OPF-LIFO	LAC	LAC-W
1	6 (5.9)	inf	46.5	34.9	35.2	35.3
2	1	10	7	10.0	9.6	10.0
3	2	7	0	5.6	5.7	5.2
4	3	3	0	3.0	3.0	3.0

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 girds…

- Independent, "Consumer opinion divided on smart grid technology", 26 July 2010.
  - "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.

GE Survey

- 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!