Strategic Investment Model for Future Distribution Network Planning

Session 2
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The challenge...

- **Validate** that **extra capacity** was created in the FPP trial area using the **right interventions** at the **right places** of the network.

- **Design, develop and leave** a tool behind that can help UKPN and other DNOs **identify** other **areas** of the network **to optimise using the appropriate interventions**.

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**Strategic Investment Model**

Successful completion of the FPP Strategic Investment Model including validation and testing of the model using data captured within the FPP trials.
DG growth and network constraints 2014 / 2015

*Excludes all firm generators connected, only few selected FPP generators are shown.

Legend
- Normally Open Point
- FPP Generator
- 132/33 kV Transformer
- 33/11 kV Transformer
- Overload
- Partly Overload

Installed capacity of DG (MW)

- CHP
- PV
- Wind
- Total

DG growth and network constraints 2016 / 2017

*Excludes all firm generators connected, only few selected FPP generators are shown.

RPF limit assumes total connected + accepted generation. Constraint at 132kV side of the network.

Legend

- 132kV
- 33kV
- 11kV
- Normally Open Point
- FPP Generator
- 132/33 kV Transformer
- 33/11 kV Transformer
- Overload
- Partly Overload
- Installed DG capacity

- CHP
- PV
- Wind
- Total

Graph showing network connections and installed DG capacity for years 2014/15 to 2016/17.
DG growth and network constraints
2018 / 2019

RPF limit assumes total connected + accepted generation. Constraint at 132kV side of the network.

*Excludes all firm generators connected, only few selected FPP generators are shown.

Legend
- Normally Open Point
- FPP Generator
- 132/33 kV Transformer
- 33/11 kV Transformer
- Overload
- Partly Overload
- Installed DG capacity

![Diagram showing network connections and DG capacity](image-url)
DG growth and network constraints 2020 / 2021

RPF limit assumes total connected + accepted generation. Constraint at 132kV side of the network.

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- 132/33 kV Transformer
- 33/11 kV Transformer
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- Partly Overload

*Excludes all firm generators connected, only few selected FPP generators are shown.
DG growth and network constraints
2022 / 2023

RPF limit assumes total connected + accepted generation. Constraint at 132kV side of the network

Legend
- Normally Open Point
- FPP Generator
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- Partly Overload

*Excludes all firm generators connected, only few selected FPP generators are shown.
The challenge required a multitude of problems to be solved

• High DG penetration triggers network reinforcements
  – Thermal overloads
  – Voltage rise
  – New protection

• A shift to more active network requires strong coordination between operation and network planning:
  – Interactions are complex and need to be supported by appropriate modelling tools

• Multi year optimisation of investment and operation
  – Incremental planning, currently based on load growth may not be very efficient in systems with rapid changes (e.g. with high DG). Strategic planning with generation growth uncertainties should be considered
Problem formulation to be solved by the Strategic Investment Model

Minimise total operating and investment cost across multi-year time horizon by:

- **Investment cost:**
  - Traditional network reinforcement
  - Quadrature-boosters;
  - Dynamic line rating capability;
  - Reactive compensation;
  - Advanced protection to improve reverse power capability in a substation.

- **Operating cost:**
  - Cost of DG curtailment
  - Network Losses

- **Commercial arrangement:**
  - Firm connection
  - LIFO, pro-rata

The SIM uses a multi-year security constrained AC Optimal Power Flow algorithm to solve AC power flow problems and to model ANM.
Strategic Investment Model inputs and outputs

**Inputs**
- Generation & load growth scenarios
- Generation, network, load data
- Models of:
  - Smart grid technologies devices
  - Smart commercial arrangements
  - Other smart solutions (other LNCF projects)
- Costs
- Timescales of traditional and smart solutions
- CO₂ emissions of DG
- Electricity prices and carbon intensity of national generation mix
- Set of alternative solutions

**Strategic Investment Model with an Excel-based interface**

**Outputs**
- Identify triggers for network reinforcement
- Impacts on network and DG operation
- Prioritisation of different technical and commercial solutions
- Curtailment estimation

Outputs presented in tabular forms
- Investment decisions
- Operating decisions
- State variables (V, power flows)
An example of a traditional network reinforcement solution costing £5.1m

- Network based solution
- Passive operation

CAPEX: £5.1m

- Firm network access
- Low utilisation

New line/reinforcement
The solution proposed by FPP’s SIM reduces costs to £1.75m

SIM deploys minimum investment at the right location taking into account both traditional and smart solutions. CAPEX: £1.75m
Learning outcome 1:
The value of FPP's smart solutions

The FPP solutions are cost-effective
Comparison of emissions and cost performance indicates a trade-off

Emissions of the FPP approach is slightly higher than the traditional solution due to increased losses and curtailment of DG output but this is achieved at significantly lower costs.
Learning outcome 2: Strategic versus incremental planning (1 of 2)

### Strategic Approach

- **Benefits from economies of scale**
- **Avoid reinforcing a network section twice in the short-term** → brings forward network investment rather postponing with smart solutions
Learning outcome 2: Strategic versus incremental planning (2 of 2)

Strategic investment approach ensures the least cost development of the system in the long term while the incremental investment approach minimises the short-term cost by using aggressive “smart” solutions but may lead to higher long-term cost as the short-term decisions may be sub-optimal.
Learning outcome 3: Least-Worst Regret development strategy

Traditional short-term strategy is to connect the new DG to Glassmoor. SIM chooses to connect to Farcet (Least-Worst Regret solution) as the future cost of reinforcing Peterborough Central (PETC) – Glassmoor (GLAS) is high.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Growth Wind</th>
<th>Commercial Solar PV</th>
<th>Capacity (MW) Wind</th>
<th>Commercial Solar PV</th>
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<td>Zero</td>
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<tr>
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<td>Medium</td>
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<td>173%</td>
<td>152</td>
<td>127</td>
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<tr>
<td>High</td>
<td>65%</td>
<td>251%</td>
<td>170</td>
<td>163</td>
</tr>
</tbody>
</table>
Due to high DG growth, Peterborough Central to Farcet will need to be reinforced and therefore the connection of new DG will have smaller effect.
Recommendation 1: From incremental to long-term strategic planning

- More cost effective than the current traditional incremental investment approach
- Optimal portfolio of smart and traditional network solutions
- Long-term strategic planning involves anticipatory investment
- Understand risks associated with uncertainty in future development
Recommendation 2: Further development in commercial frameworks

• Facilitate investment that provide flexibility to deal with uncertainty
  – Balance the cost to existing and future network users and enable least cost evolution to lower carbon future

• Develop mechanism/process to facilitate pro-active roll-out of FPP concepts and solutions
Key achievements of Flexible Plug and Play

Engaged with 50+ DG developers → Interviewed 20

Trialled two DG access principles: LIFO and Pro-rata capacity quota

Made 40 connection offers:
- 15 accepted, 54.4MW enabled, £44m savings

Developed analysis tool for investment options in DG dominated networks

Commissioned RF mesh wireless network for wide area comms

Integrated and commissioned smart devices across 12 sites

Installed and commissioned first quad-booster at 33kV

Deployed IEC 61850 for interoperability between solution components

Successful deployment of new commercial arrangements and interoperable smart grid components to deliver faster and cheaper DG connections

For more information visit ukpowernetworks.co.uk/innovation