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Network Hosting Capacity and Distributed Generation

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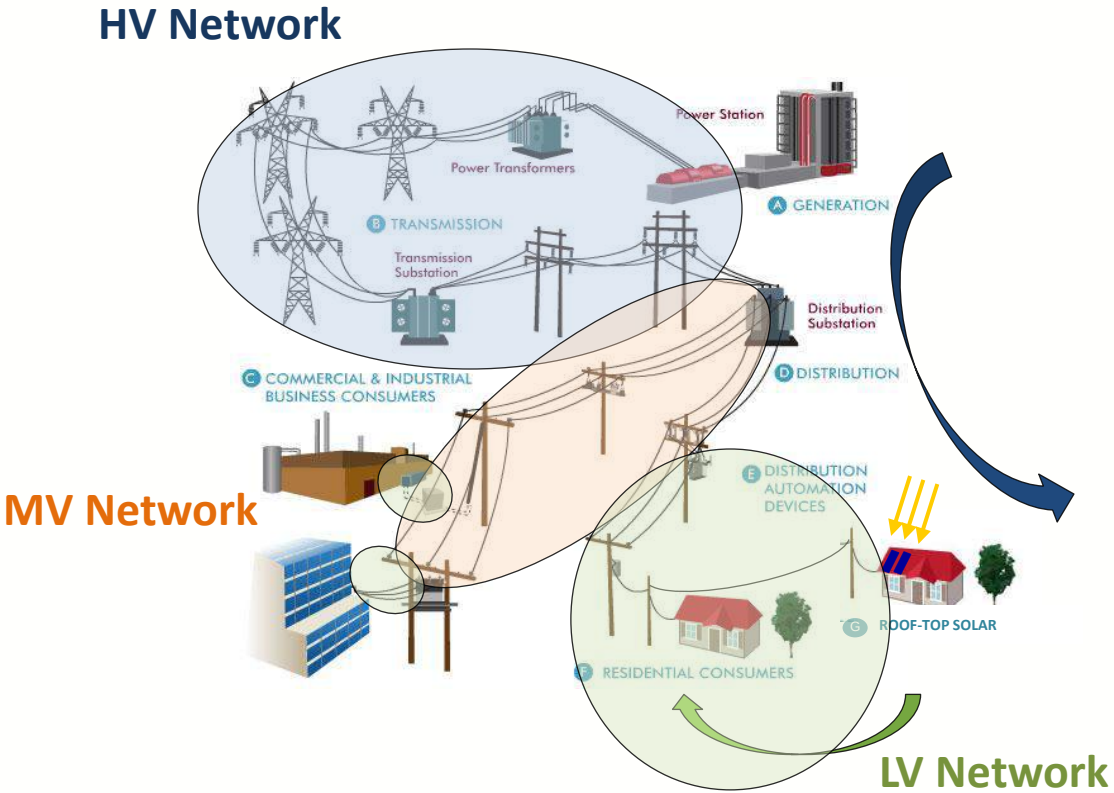
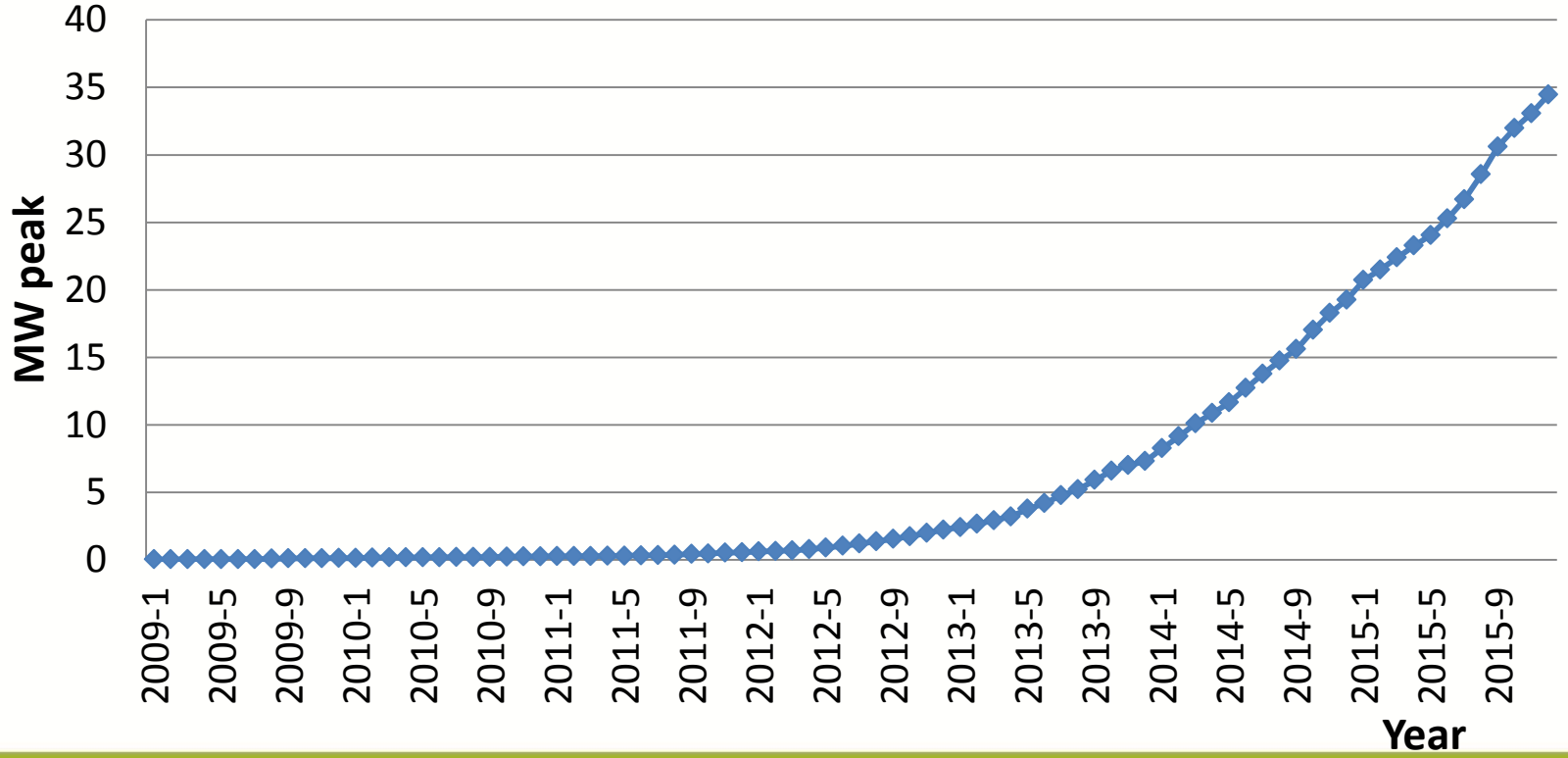
Outline

- Background
- Modelling DG in the LV network
- Hosting Capacity
- DGHost tool
  - Streamlining DG Connections
  - Congestion Mapping

Changing Power Flows Within Distribution Networks



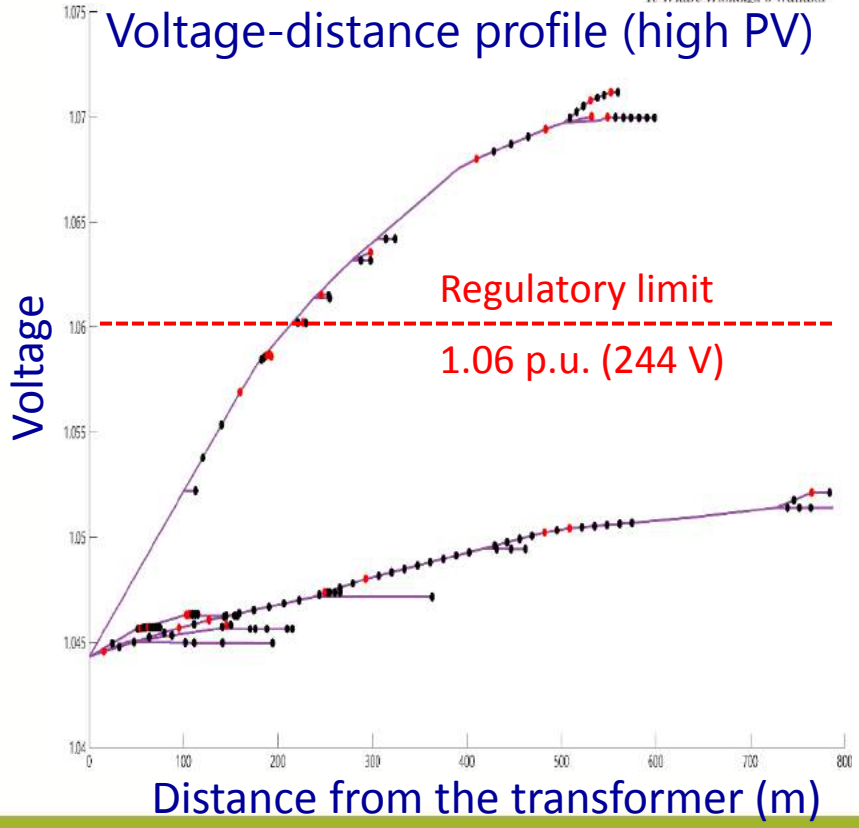
Photovoltaic (PV) Uptake Cumulative Capacity NZ 2009 - 2015



Impact of DG on Distribution Networks

- Congestion
  - Network voltage limits exceeded
  - Equipment current ratings are exceeded

- Identify congestion issues (EIPC clause 6.3)



How to Model DG in the Network?

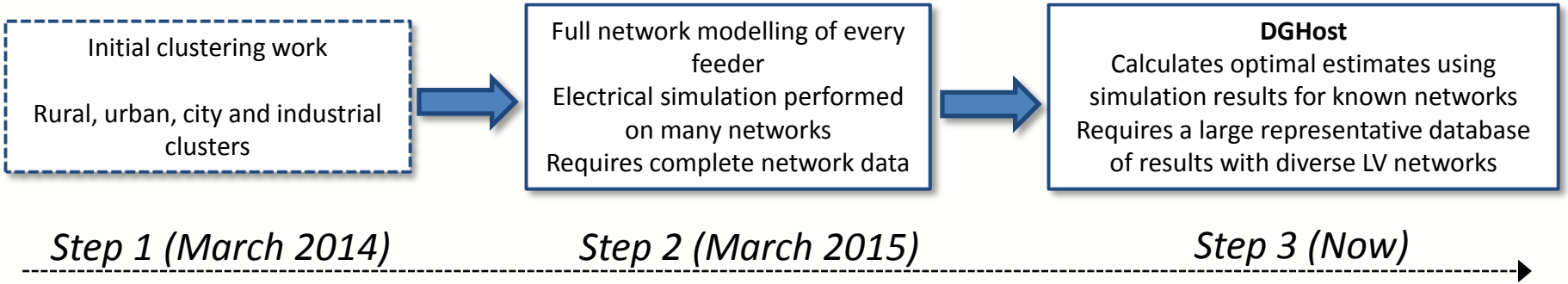
- How do we model the impact of DG in networks given?
  - Computationally difficult problem to solve
  - Large numbers of diverse networks
  - Large scenario set
  - Typically incomplete network information

How to Model DG in Distribution Networks?

- GREEN Grid Network Analysis Group
  - Collaborative Industry / Research partnership (Canterbury and Auckland Uni.)
- NAG Industry Members:

Approximation Method Evolution

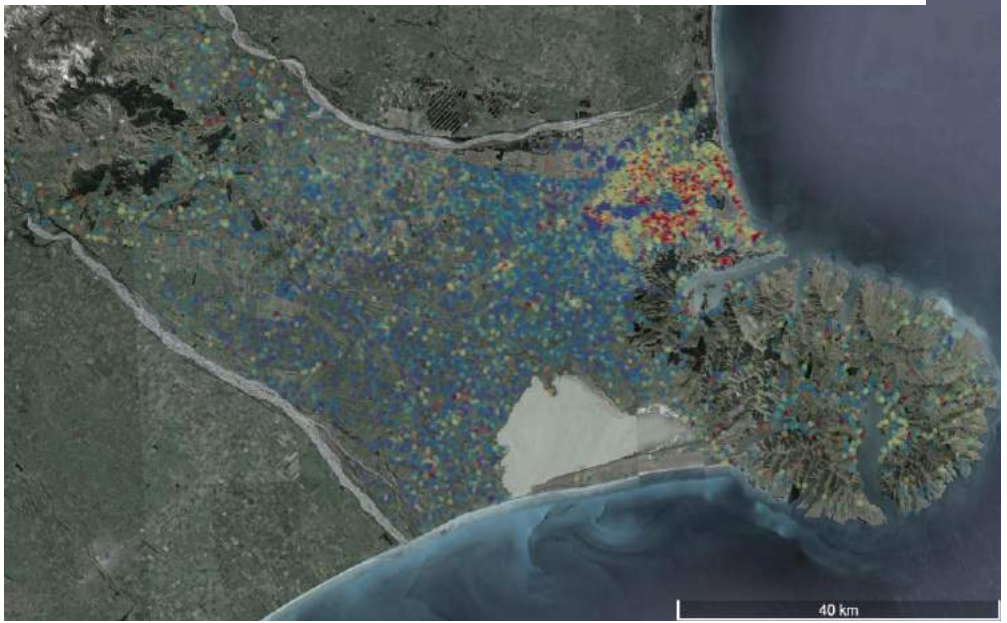
- Acquiring large set of real world network data
- Initial work was based on clustering of networks
- Full power flow simulations to simulate all low-voltage networks for select Electricity Distribution Businesses (EDBs)
- Full simulation results -> populate a **reference data set**, from which we can approximate the hosting capacity of other networks via a proprietary algorithm called **DGHost**



Hosting Capacity of Distributed Generation on LV Networks

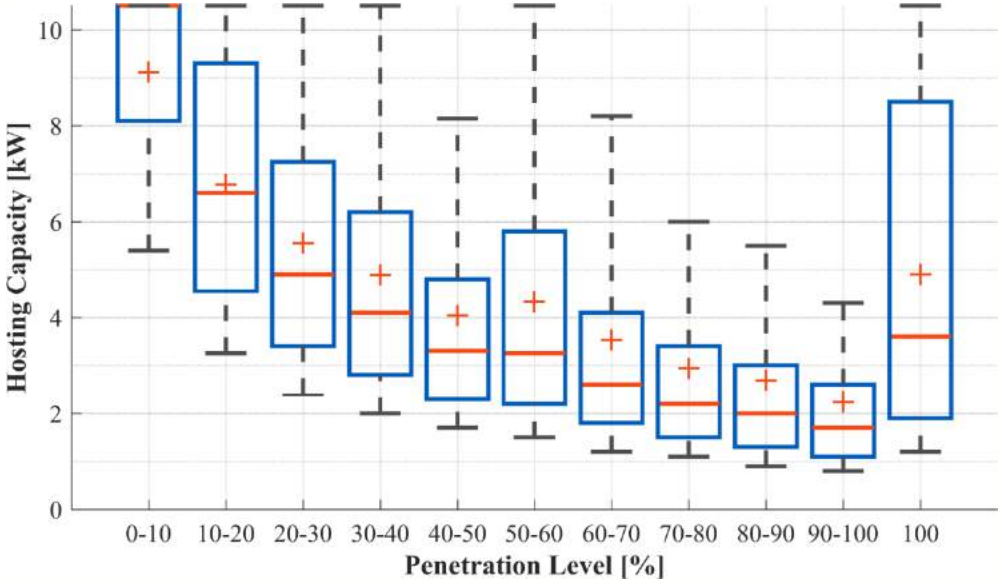
- Hosting Capacity:
  - The ability of low-voltage networks to host distributed generation (DG) before congestion (kW)
- What influences HC?
  - Physical nature of the network
  - Number of ICPs (customers)
  - Size of distribution transformer
  - Network minimum load profiles
  - Penetration of DG

Hypothetical High PV Penetration Scenario



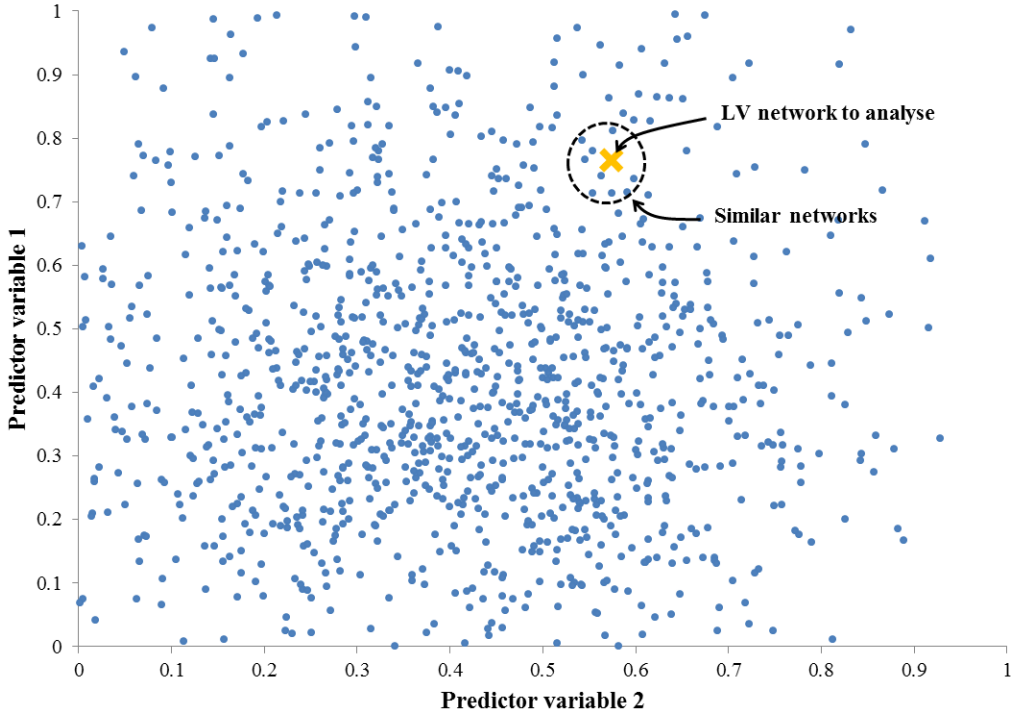
Determining Hosting Capacity

- Full power-flow simulations
  - Requires complete and accurate network model data
  - Iterate over a range of DG allocations
  - Time consuming to compile and simulate
- Full network model data not readily available
- How about approximate methods?



Approximation of Hosting Capacity via DGHost (Step 3)

- Estimate hosting capacity of each LV network using the reference data set
  - 20 million HC results
- Simplified Inputs
  - number of ICPs (customers)
  - max feeder impedance
  - transformer rating
  - Penetration level
- *k*-Nearest Neighbour Regression
- 6 dimensional optimization problem
- Map network congestion



Hosting Capacity -> Congestion Mapping

Potential for congestion when:

$$\sum_{i=1}^{n} P_i \geq N \cdot \gamma \cdot HC$$

- P – Net DG Power approved
- n – Number of DG's approved
- N – Number of ICPs/households
- γ – Forecast penetration level
- HC – Hosting Capacity

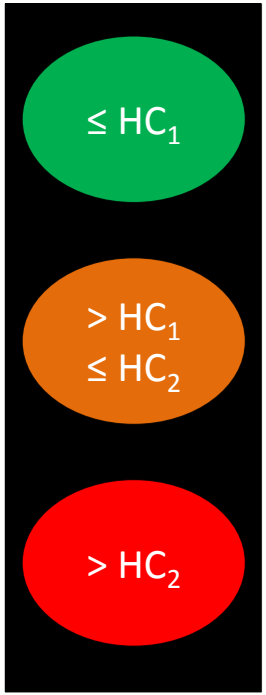
Future congestion:

- Include 12 month forecast of PV uptake

SSDG Connection Guidelines and Use of Hosting Capacity

Customer applies to connect PV (they specify Max Net Injection)

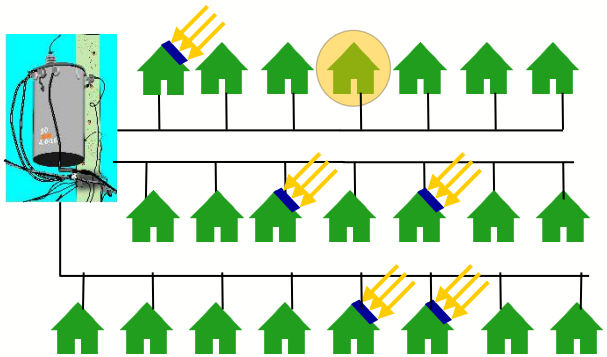
EDB assesses application based on network hosting capacity for customer's location



- Application approved
- Approved subject to DG installing an inverter with volt-response modes activated
- Requires a manual assessment

Example DG Connection Scenario

1. Customer applies to connect PV



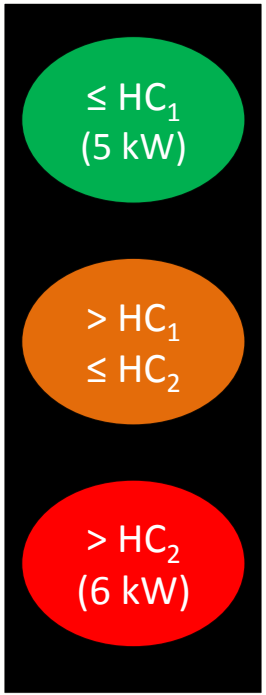
Example LV Network

- 22 ICPs
- 100kVA transformer
- Max Feeder Impedance |Z| = 0.2Ω
- Forecast Penetration level 36%

(predicted 8 /22 eventually have PV)

2. EDB compares applicants "Max Net Injection" compared to Hosting Capacity thresholds HC_1, HC_2determined for their LV network

- DGHost (approx.)
- Full power flows



Summary

- Developed modelling tools to aid understanding around the impact of an increasing amount of DG in distribution networks
- Tools to inform EDBs how much DG can be hosted, with only limited network information is available
- Draft DG Connection Guidelines have been developed to standardise and streamline DG application processes across NZ
- Ability to provide congestion information as required by the recent EIPC regulations

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