Supergen Energy Networks Hub Risk Day

Wed 4th March 2020

Three-phase low voltage flexibility dispatch forecasting for aggregators and DSOs

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Introduction

Background

- Distribution level flexibility markets are here…..

Kaluza and WPD deliver first domestic battery flex service *Network Online , 21 January 2020*

UKPN launches 'biggest ever' 170MW competition for flexibility on Piclo Flex *Current News, 14 Nov 2019*

Scottish Power Energy Networks seeks 95MW flex, signs with Piclo *The energyst , 4 October 2019*

Introduction

Motivation

- Increasing use of low voltage (LV) flexible assets (e.g. electric vehicles (EVs) and home batteries)
  - Increasing risk of LV network constraints

- Need to know probability of network constraints
  - Which will limit flexibility available to aggregators

Introduction
Objectives

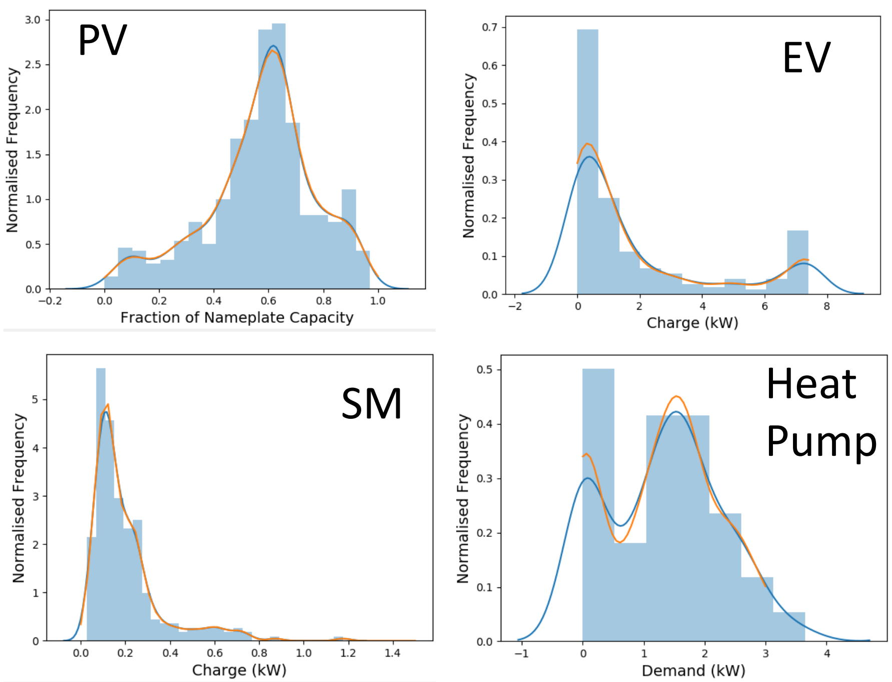
1. To determine the probability of network constraints
   I. and probability of flexibility dispatch or 'agent adjustments' to relieve these constraints

2. To estimate constraint and agent adjustment probability.
   I. On each of the 3-phases
   II. For a given day. e.g. Summer weekend
   III. For a given forecast (e.g. Intraday)

3. To provide this 'probability' for a range of:
   I. Feeders, and networks (including secondary substations)
   II. PV,EV, heat pump and 'Agent' penetrations/clusters

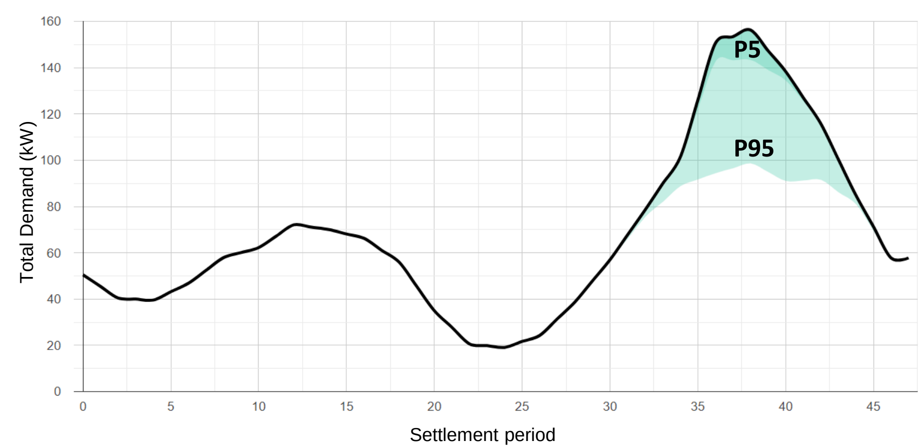
Methodology
Overview

Sample Distributions



Network Heuristic

Flexibility dispatch probability



Methodology

Heuristic & probabilities

- **Heuristic model**
  - Estimates agent adjustments (Using OpenDSS 3-phase power flow software) to relieve voltage and thermal constraints
    - Sensitivities of agent adjustments to constraints
    - Agents adjusted to relieve constraints based on most effective agents
- **Timeseries probability modelling**
  - Seasonal probability calculated from sampling data for ~90 days of each season (i.e. summer/winter)
  - EV/ Smart Meter/ PV distributions:
    - KDE (kernel density estimation) used to represent probability distributions
    - One for each hour, and for each season (summer, winter etc)
    - Datasets: London Datastore (PV,EV, Smart Meter and Heat pump)
    - EV travel diaries used to simulate 7.4 kW EVs and different battery sizes

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LV Network

Example feeder

University of Strathclyde Engineering

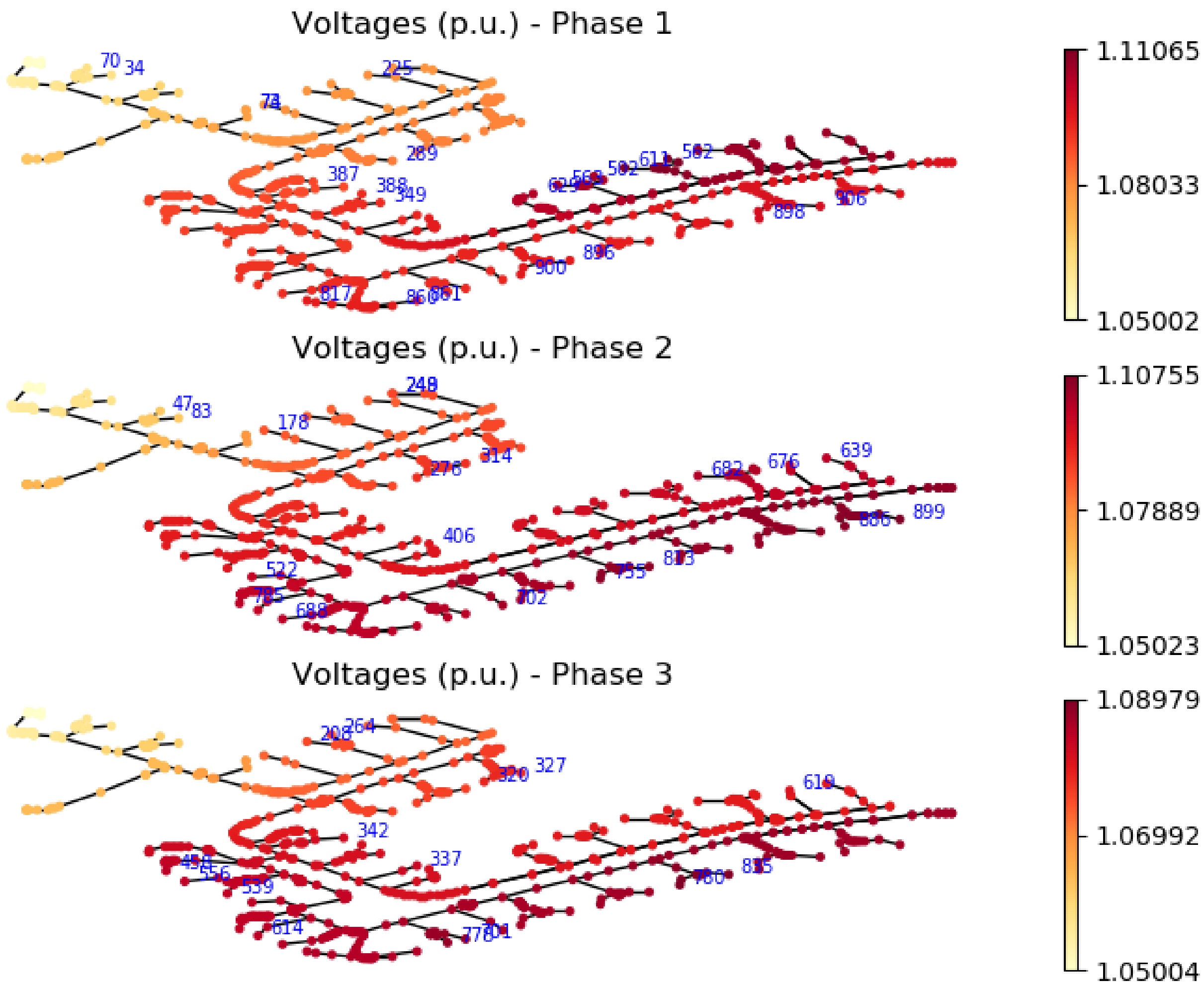


Figure 1: LV feeder 1 (from Network 1) from UKPN/University of Manchester Low Voltage Network Solutions (LVNS) project

LVNS project (Manchester)

Network 1
Feeder 1

55 Customers

Phase	Customers
1	21
2	19
3	15

Preliminary results

Summer dispatch probability

- Feeder 1: Summer dispatch probability (total of all agents): with 100% PV, EV (uncoordinated charging) and heat pump penetration
  - Midday (10am-3pm): PV needing turned down due to thermal and voltage constraints
  - Evening (5-10pm): Demand turn-down needed

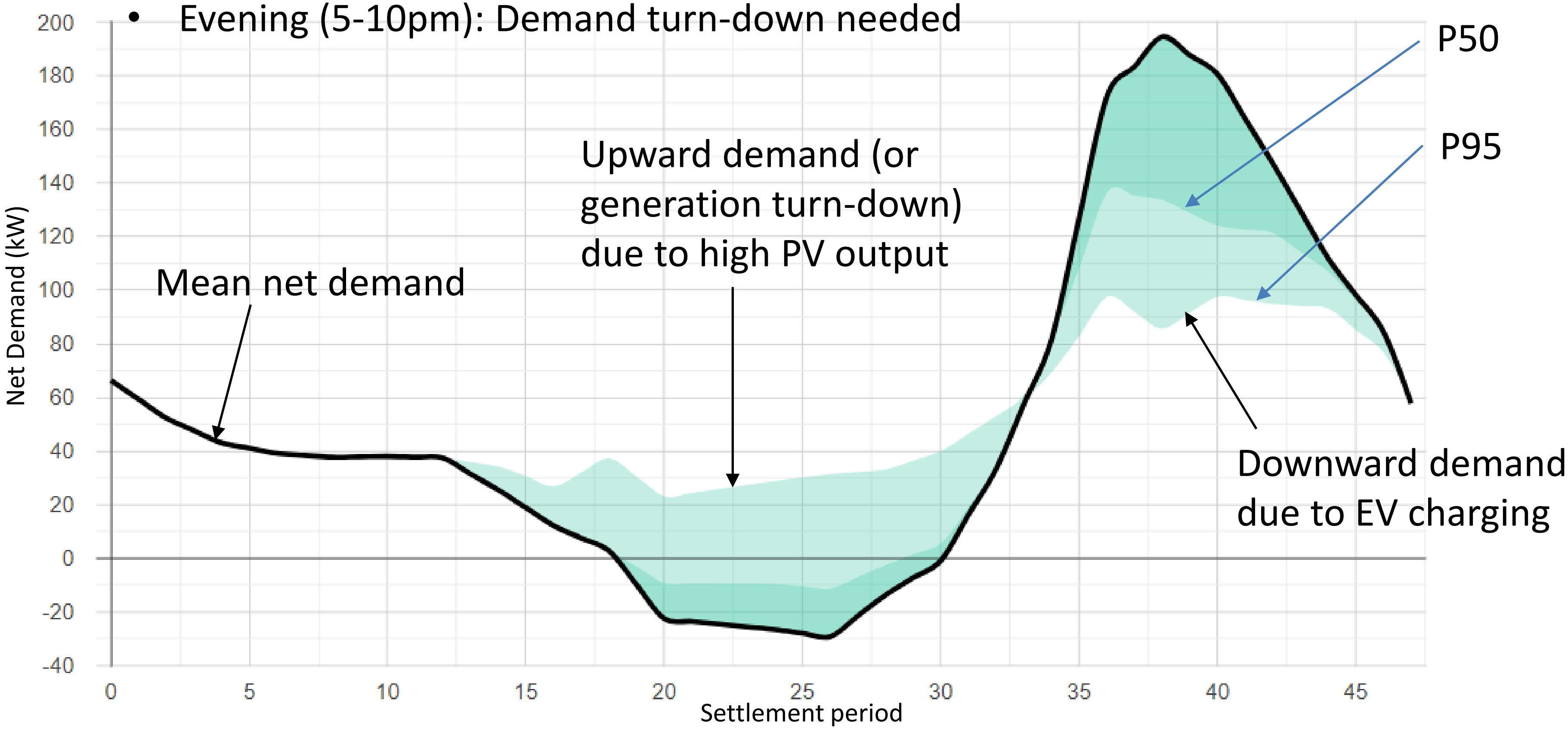
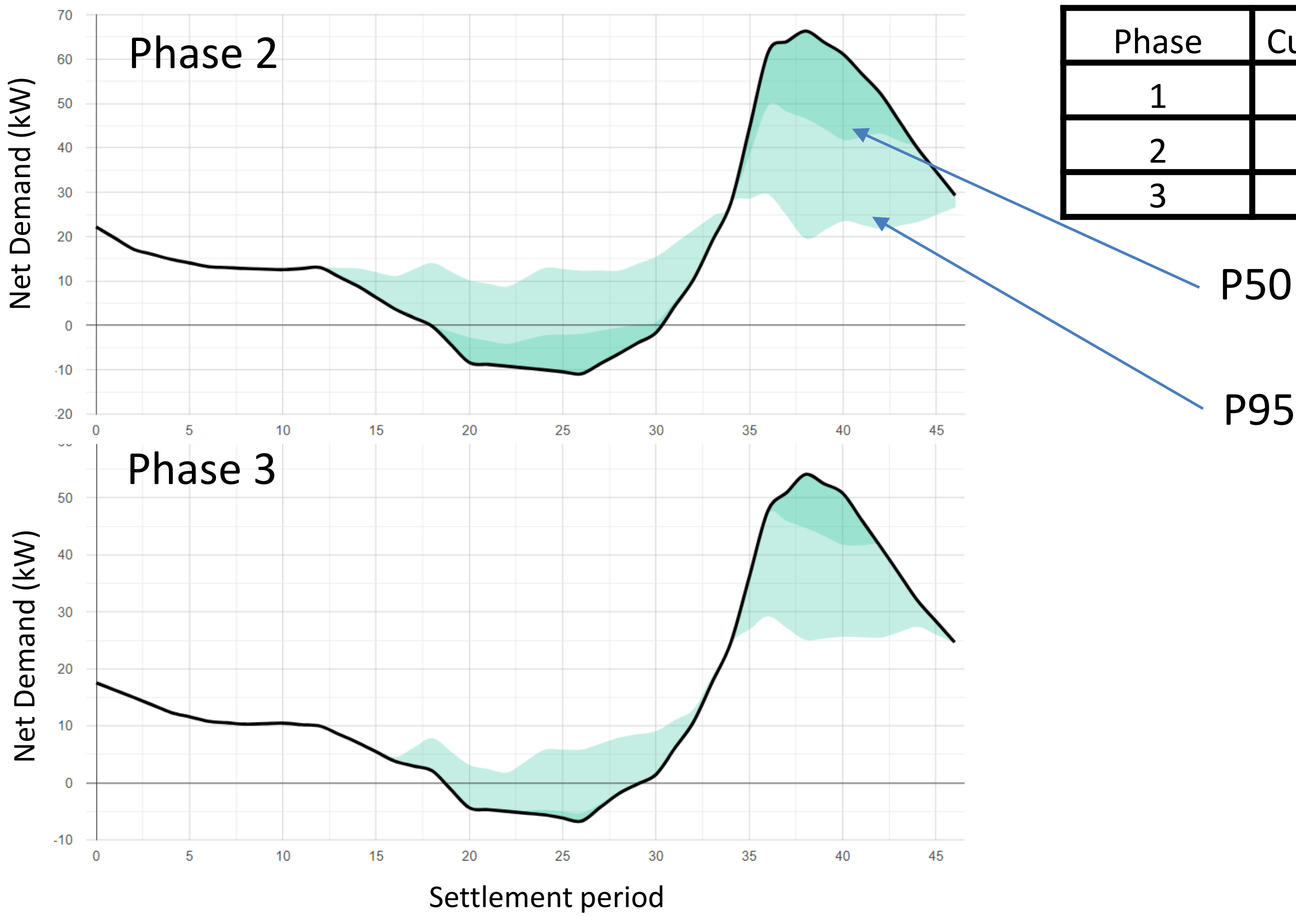


Figure 2: Summer Dispatch Probability from Network Heuristic, for Feeder 1 with 100% penetration of PV,EV,and heat pump

Preliminary Results
Dispatch probability

- Probability varies by phase: due to different number of customers on each phase



Phase	Customers
1	21
2	19
3	15

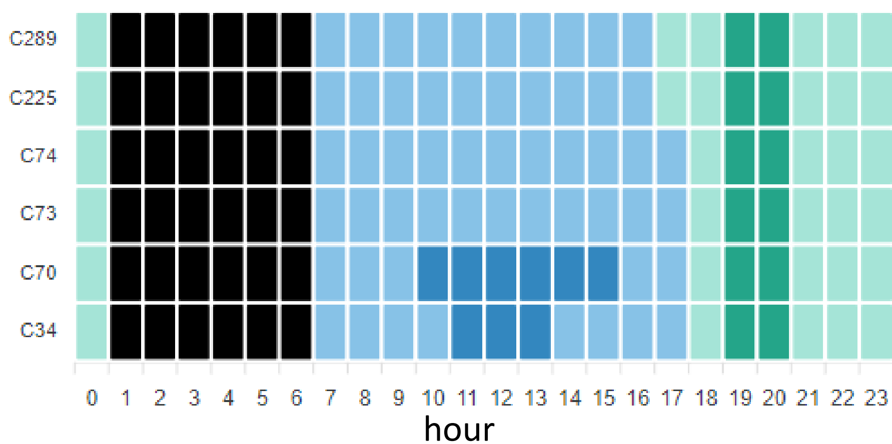
Figure 3: Summer Dispatch Probability from Network Heuristic, for Feeder 1: Phases 1 and 3

Preliminary Results

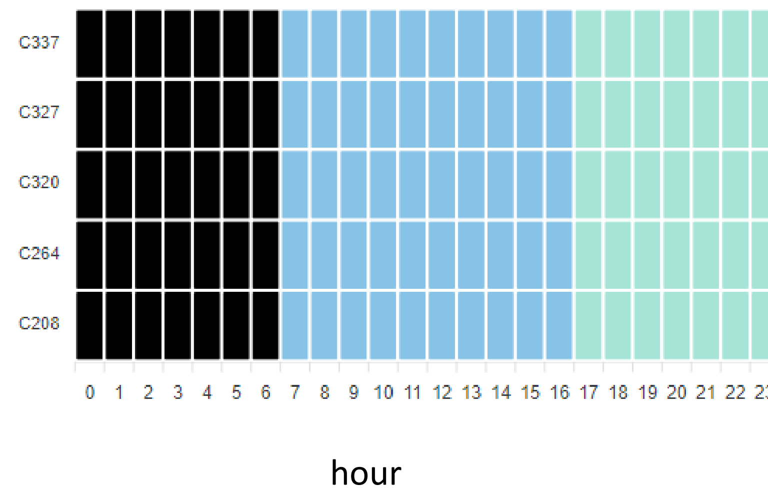
Adjustments per agent

Turn Down Level 2 · Turn Down Level 1 · No Action · Turn Up Level 1 · Turn Up Level 2

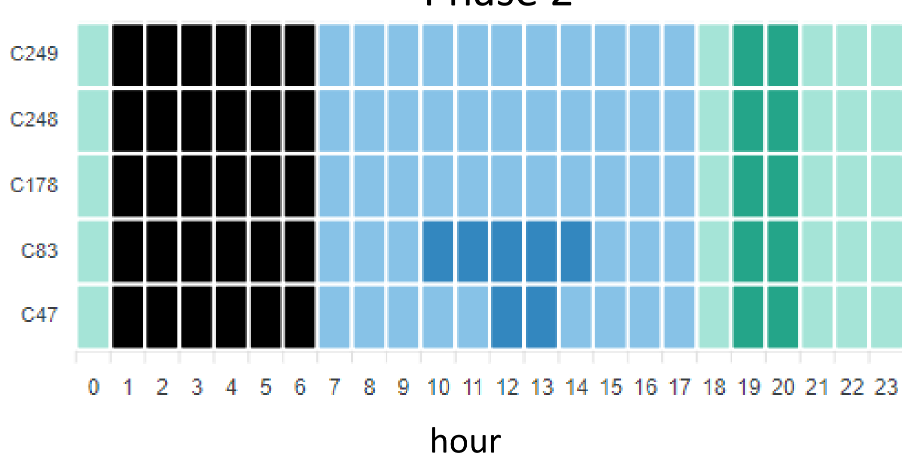
Phase 1



Phase 3



Phase 2



<u>In this Example</u>

- Agents on Phase 3 ‘flexed’ less than agents on phase 1 and 2

Conclusions & Future work

Conclusions

- In worst case of full penetrations of uncoordinated EV, PV and heat pumps: agent adjustments very likely to be required on test feeder 1.
- Adjustment probability varies between phases: depending on how many customers on each phase.

Future Work

- Move from general seasonal probability to forecasting (day-ahead and intraday)
- Probabilities for representative set of feeders
- Integrate congestion probability with aggregator optimisation
- Feedback loop of how aggregator optimisation will affect probabilities