Low Voltage Load Modelling for Network Impact Studies

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Introduction

- High level demand response schemes for residential load have potential impacts for distribution networks.
- Bottom-up load modelling provides the ability and flexibility of simulating low-voltage (LV) loads for demand response schemes with ability to aggregate for medium voltage (MV) analysis.
- These models allow for comprehensive assessments of potential impacts of demand response schemes on distribution networks.
- ***Objectives:***
  - **Build a comprehensive bottom-up low-voltage load model.**
  - **Investigate the effects of different pricing schemes on distribution networks.**

Methodology

- The load model, built in MATLAB, combines bottom-up energy demand modelling, with electrical load models and thermal load modelling.
- Markov Chain Monte Carlo modelling techniques are used to generate household load data based on available statistical data.
- Demand response is captured through novel modelling of elastic response of consumers and algorithms for optimal scheduling of wet appliances and control schemes for thermostatic devices.

Model:	Overview:
Occupancy	Occupancy profiles from Time Use Survey data.
Lighting	Global irradiance and bulb ownership is used to create high resolution lighting profiles based on bulb type.
General Appliance Model	Device ownership, duration of use and power rating are used along with associated activities to generate profiles.
Thermal Models	Thermostatically controlled devices are modelled through time different equations and device data.
Electrical Load Model	Polynomial ZIP models are used, categorizing appliances into a general library of load types.

Network Model

- Household load data is brought into a sample low-voltage distribution network in DigSilent for network analysis.

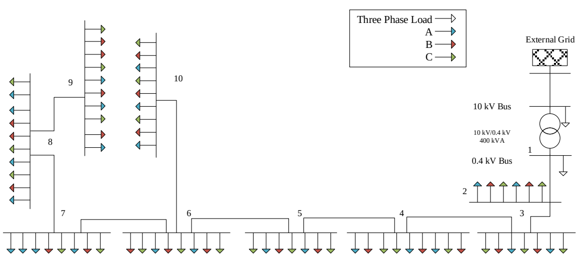

Fig. 1 Distribution Network Model

Results

- The load model can both simulate single customer electrical data for high resolution LV analysis, and can be aggregated for MV networks.

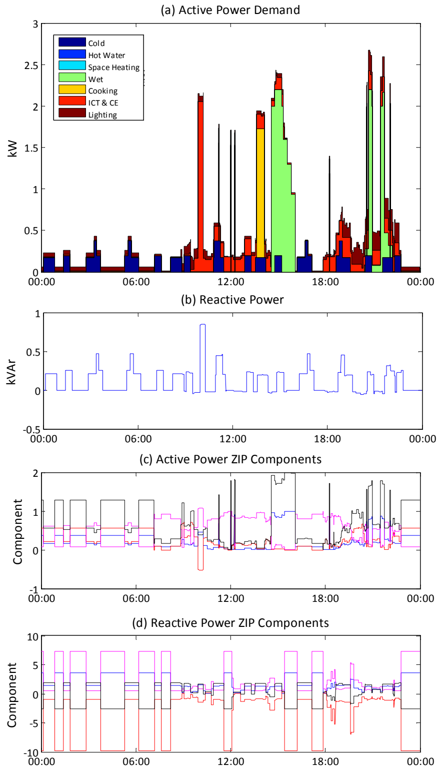

Fig. 2 Single Customer Profiles

Constant Impedance
Constant Current
Constant Power
Exponent

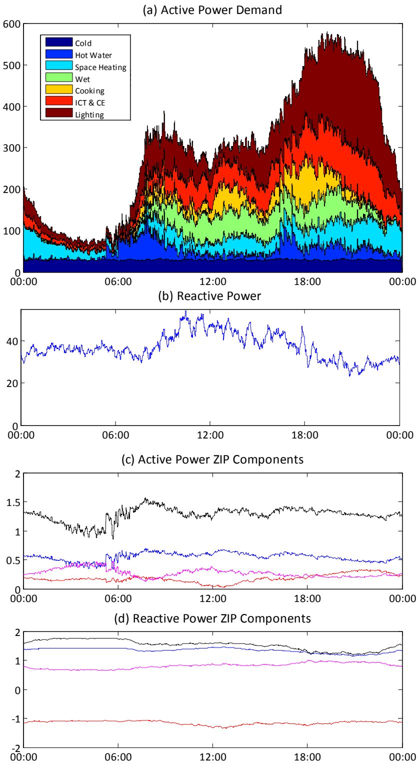

Fig. 3 Aggregate Profiles of 500 Customers

Constant Impedance
Constant Current
Constant Power
Exponent

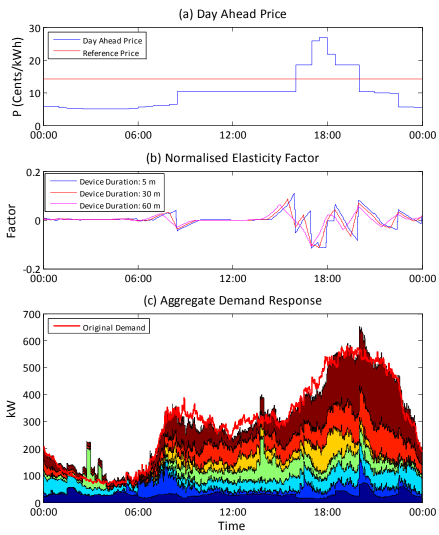

Fig. 4 Day ahead price response of 500 customers with 50% penetration of automated thermostatic and wet appliances

- Dynamic pricing schemes can be tested on residential customers, and network power flow analysis examined.
- Novel methodologies allow the capturing of the inherent elastic response of customers to pricing signals.
- Different penetrations of both the optimal scheduling of wet appliances and dynamic price control of thermostatic devices can be tested to check their effects on voltage deviation and line loading.

Conclusions & Future Work

- **Initial findings show dynamic pricing schemes reduce load diversification.**
- **Large variation in reactive power consumption due to co-incidental appliance operation has significant impacts on voltage profiles.**
- **Line loading increases over short intervals, with potential impacts for the MV network.**

Acknowledgement

This work was conducted in the Electricity Research Centre, University College Dublin, Ireland, which is supported by the Electricity Research Centre's Industry Affiliates Programme (http://erc.ucd.ie/industry/).

Killian McKenna is supported by Science Foundation Ireland under Grant Number SFI/09/SRC/E1780.