

## INTRODUCTION

- Integration of electric vehicles (EVs) poses some potential issues for low voltage (LV) distribution networks
- Controlled charging may reduce or defer the need for costly network upgrades
- Need to forecast individual customer behaviour, possibility of large forecast errors

### Objective:

- Rolling optimisation to control charge rates and times of EVs while taking account of uncertainties

## METHODOLOGY

- Unbalanced load flow and optimisation implemented in MATLAB
- Load flow generates network sensitivities
- Minimum cost objective subject to network constraints
- Initial 24-hour load flow and optimisation followed by 12-hour load flow and optimisation every 30 minutes using updated inputs

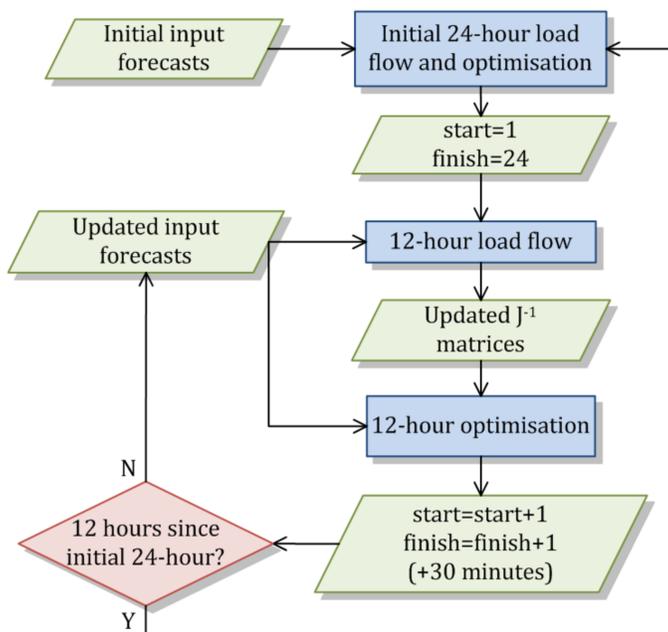


Fig. 1 Flowchart of rolling optimisation process

## TEST CASE

- Test network: representative of typical suburban feeder in Ireland

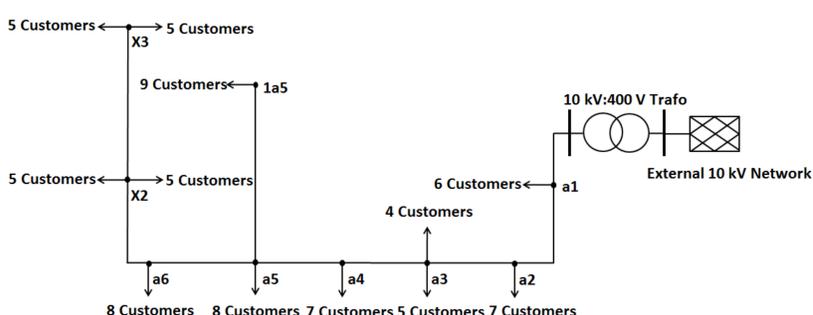


Fig. 2 Simplified single line diagram of test network

- Rolling method tested for 50% EV penetration level on high load winter day

- Uncertainties considered

- Residential base load
- Customer/EV availability
- EV battery requirements
- Electricity price

## RESULTS

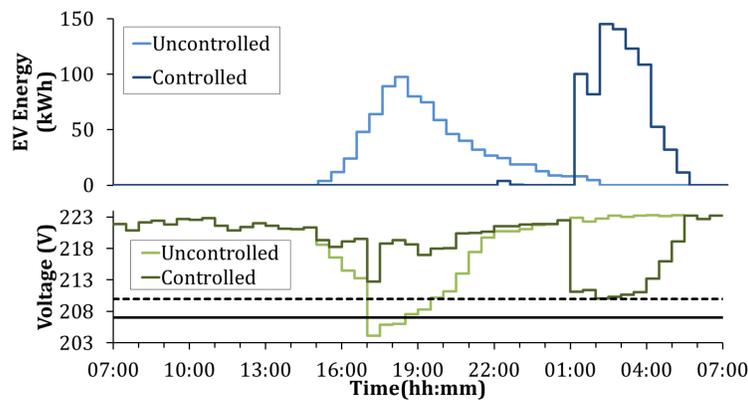


Fig. 3 Aggregate EV energy and resulting voltage for individual customer for controlled and uncontrolled charging

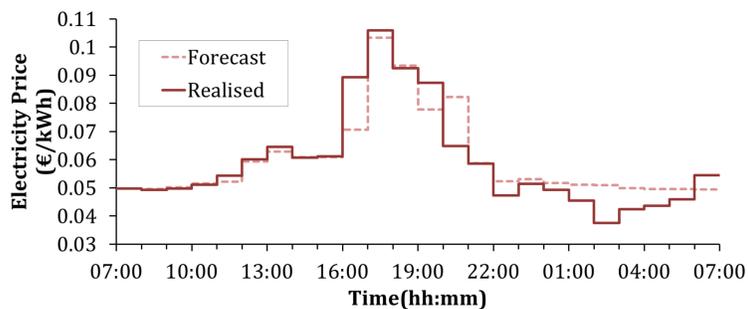


Fig. 4 Forecast and realised electricity price for test day

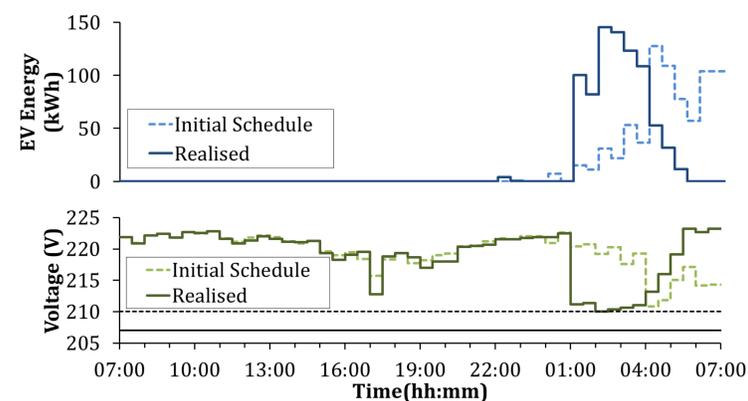


Fig. 5 Aggregate EV energy and resulting voltage for individual customer for initial forecasts and realised inputs

	Normalised Cost (€/kWh)	% Required Energy Delivered
<b>Uncontrolled</b>	0.0822	100
<b>Controlled no Rolling</b>	0.0466	80.02
<b>Controlled Rolling</b>	0.0416	100

Table 1 Comparison of cost and energy metrics for uncontrolled charging, controlled charging without rolling, and controlled charging with rolling

## CONCLUSIONS AND FURTHER WORK

- Controlling charging of EVs can reduce large voltage drops that may be incurred if charging is left uncontrolled
- Minimum cost objective can reduce charging costs for both the system operator and the customer
- Rolling gives least cost solution while taking account of uncertainties and maintaining customer satisfaction

### ACKNOWLEDGEMENT

This work was conducted in the Electricity Research Centre, University College Dublin, Ireland, which is supported by Bord Gáis Energy, Bord na Móna Energy, the Commission for Energy Regulation, Cylon Controls, EirGrid, Electric Ireland, the Electric Power Research Institute (EPRI) (US), Energia, ESB International, ESB Networks, Gaielectric, Intel, SSE Renewables, and United Technologies Research Centre, Ireland (UTRCI).