# Decentralised electricity generation and demand side management opportunities in the urban environment

David Infield, Institute of Energy and Environment
Department of Electronic & Electrical Engineering
University of Strathclyde

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# Why consider urban DER?

- Generating electricity near to loads is a good thing
- It's potentially more sustainable
- Renewable energy generation can be located in the urban environment
- Urban (indeed all) electricity loads will need to become more flexible to accommodate large scale RE

# Urban PV

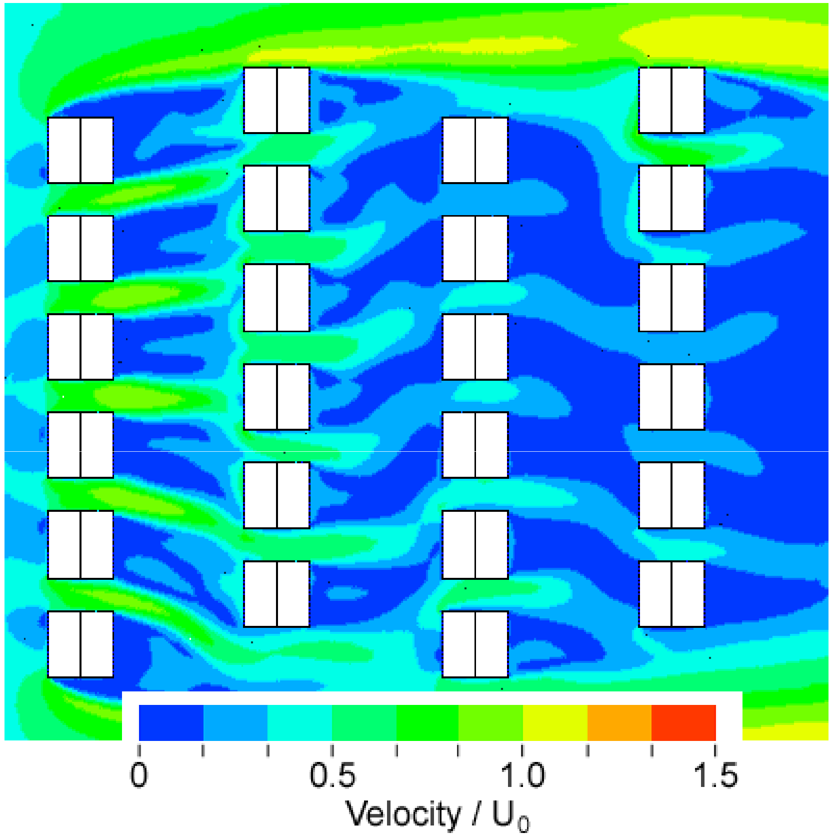
West Oxfordshire Council Offices, UK

Mataro Public Library, near Barcelona Spain

PV is ideal in the (sub)urban environment due to the availability of good places to put it, like on buildings (BAPV of better still BIPV)

# Urban wind

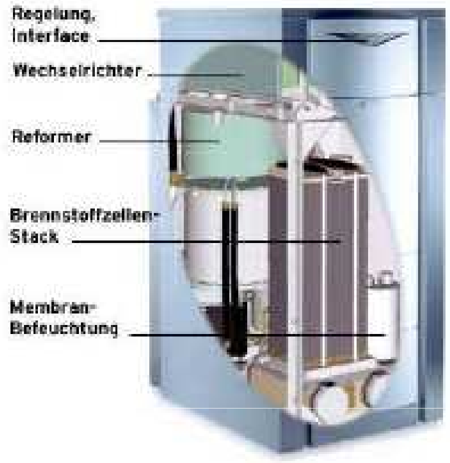
An urban wind turbine in the UK




Wind turbines can be placed in the urban environment and can be integrated on/into buildings (BIW) but performance may be poor

# Domestic micro-chp

WhisperTech Stirling Engine unit




*Vaillant/Plug Power PEM fuel cell prototype*


5kWe Ecopower IC Unit

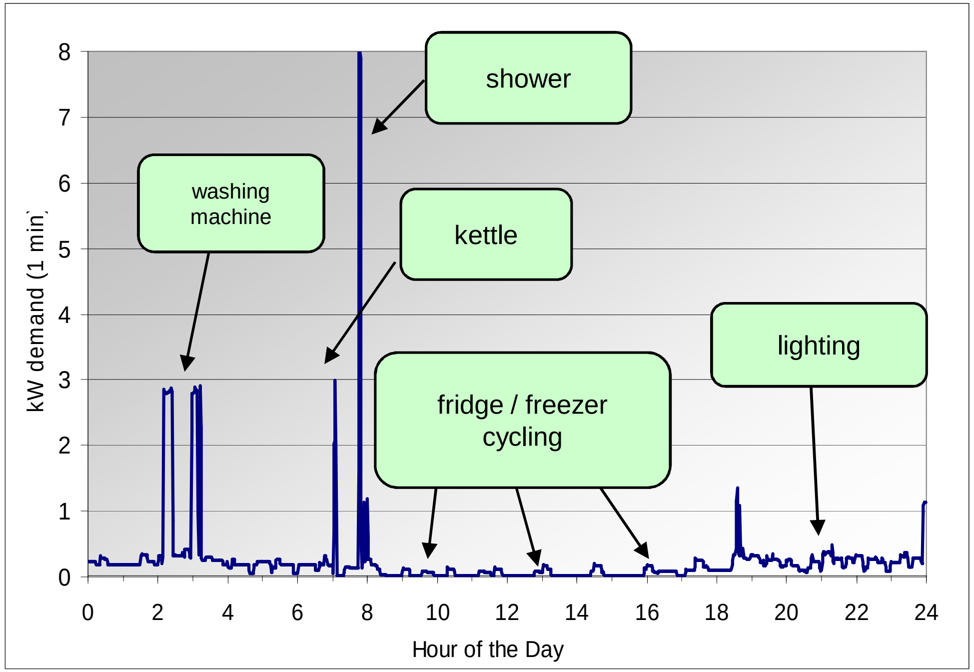
Various micro-chp technologies are under development including: fuel cells and engine based systems, but they may not result in net $CO_2$ savings

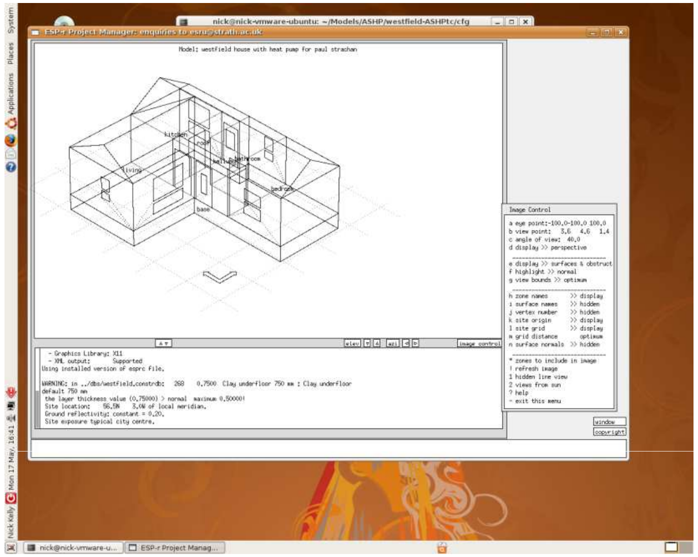
# Electricity system impact

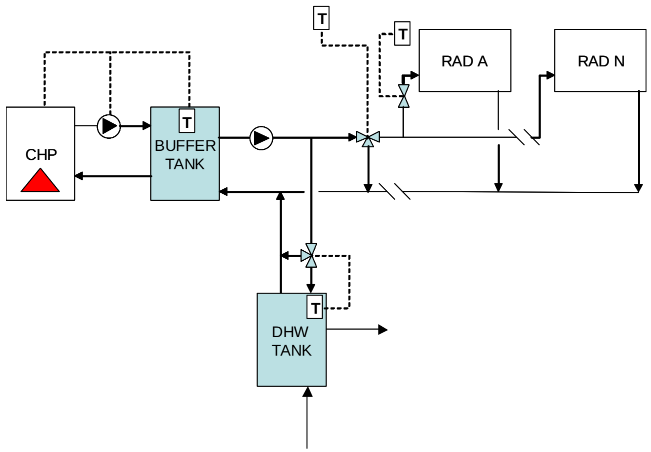
- Potential to reduce distribution system losses
- Possibility of excessive voltages
- Possible reduction is safety
- Possible reduction in system reliability

# House and load modelling

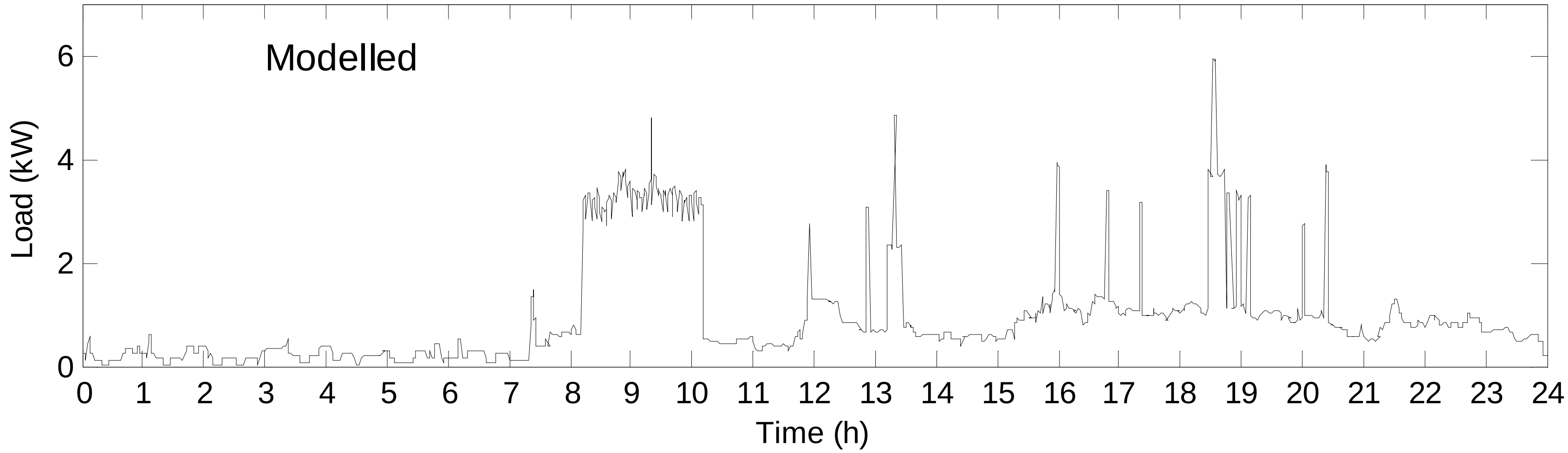
- Detailed stochastic house by house load modelling
- House model output can be used to quantify: device efficiency, fuel consumption, energy costs, start-up times. on/off cycling, temperatures, thermal comfort, etc.

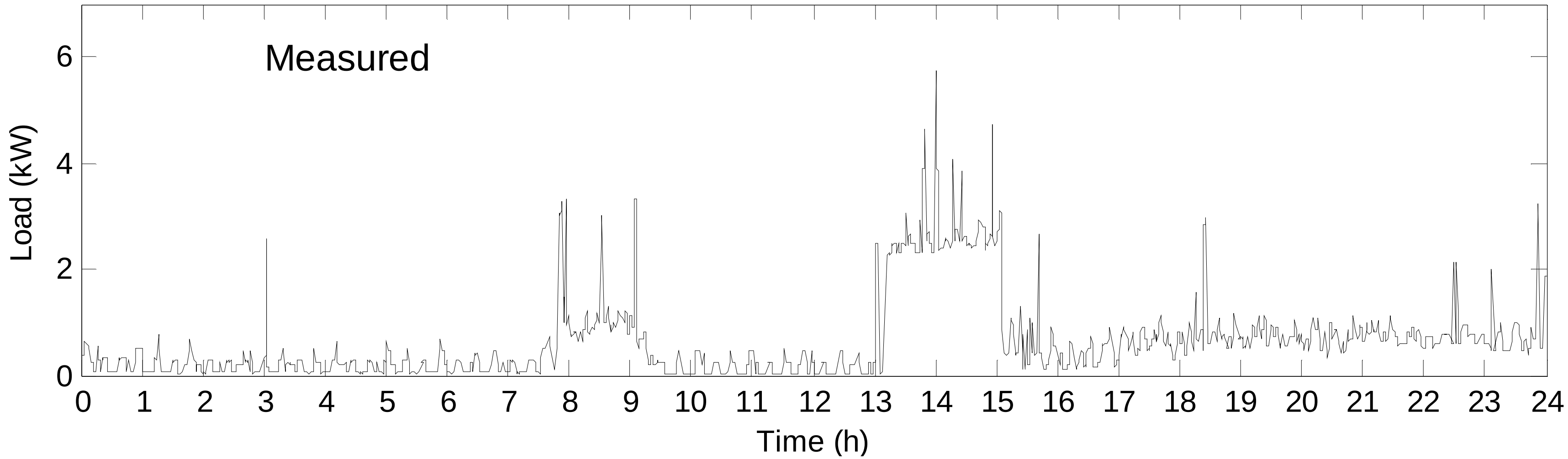


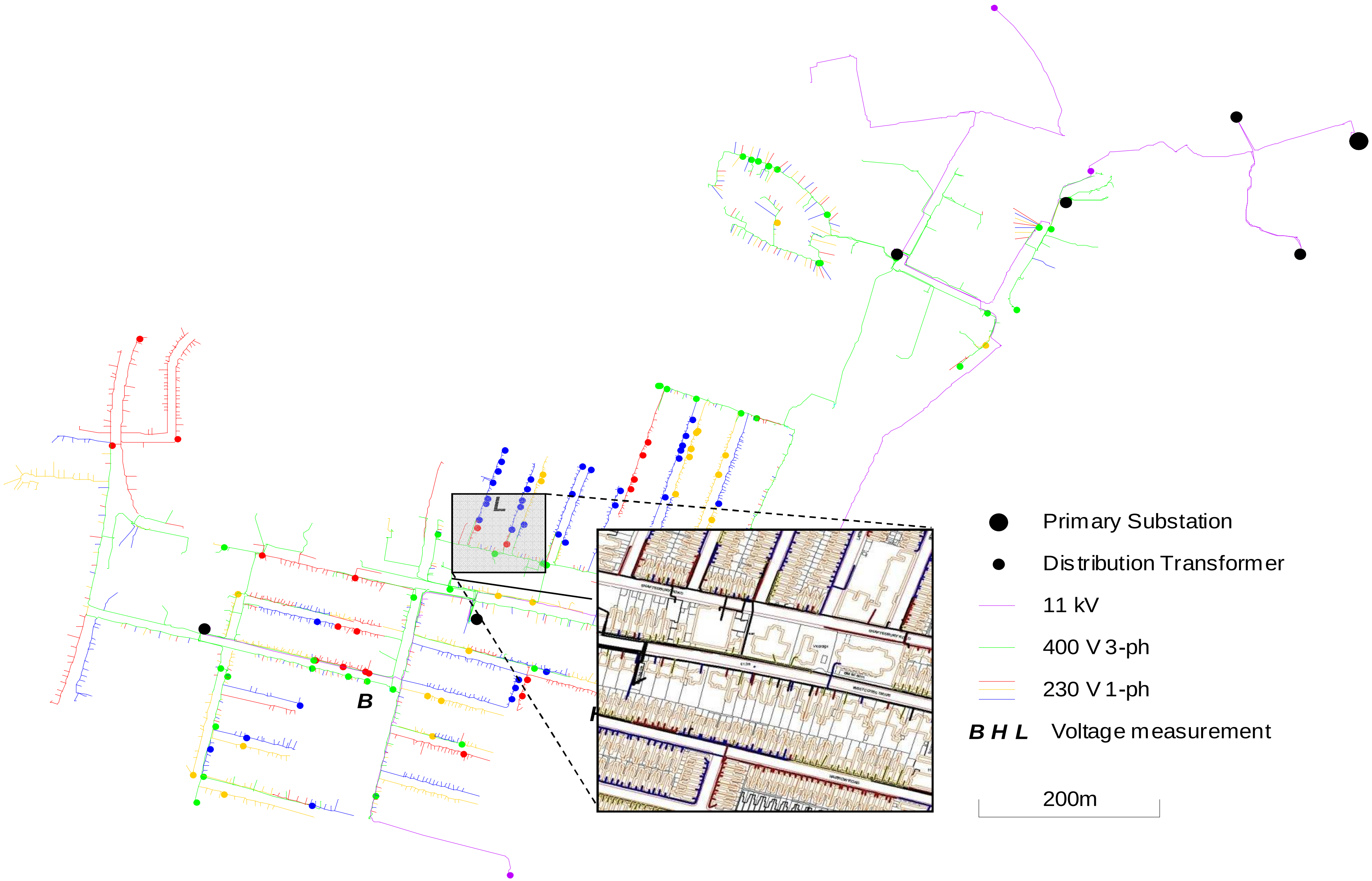


# House load model validation



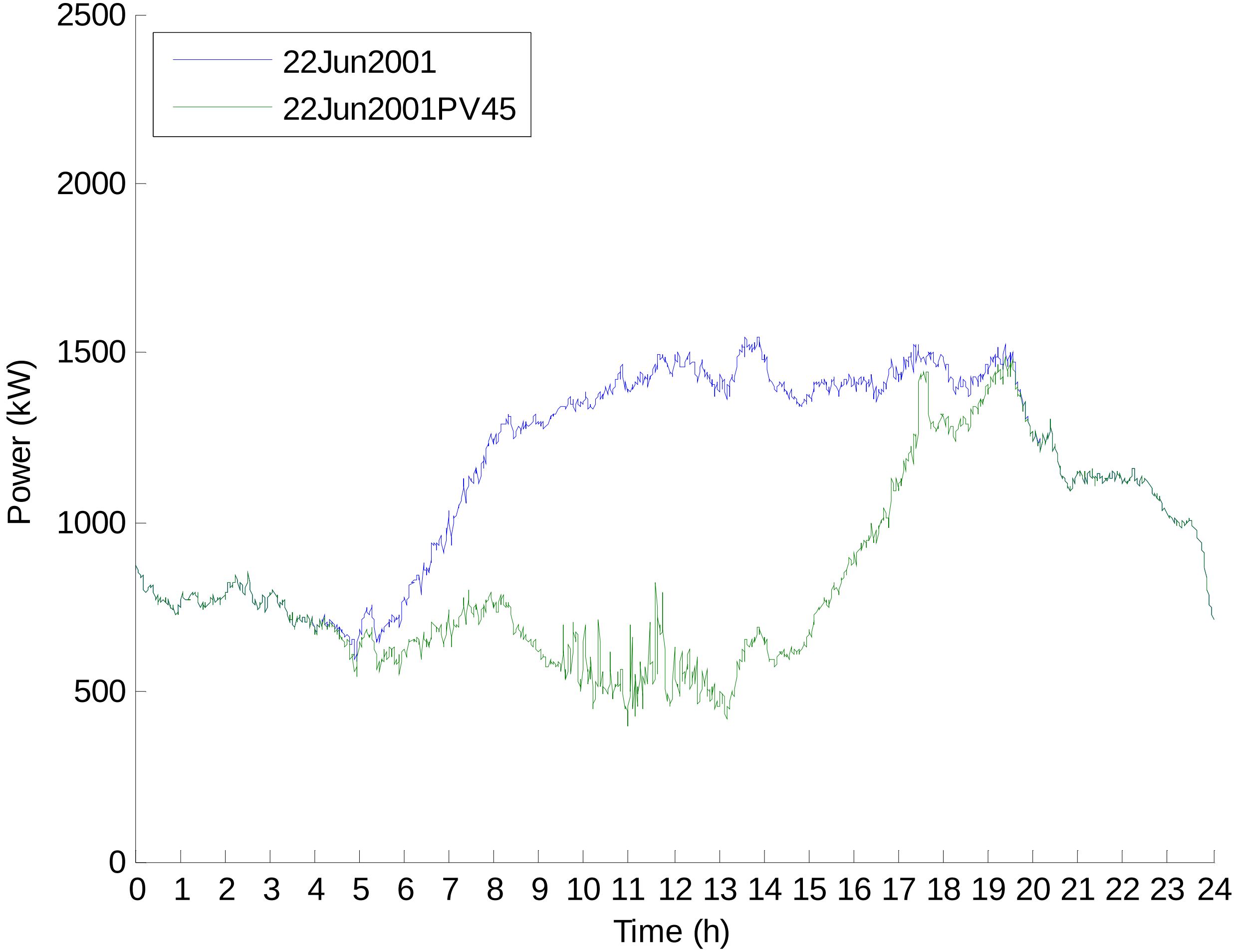



# Detailed distribution system modelling

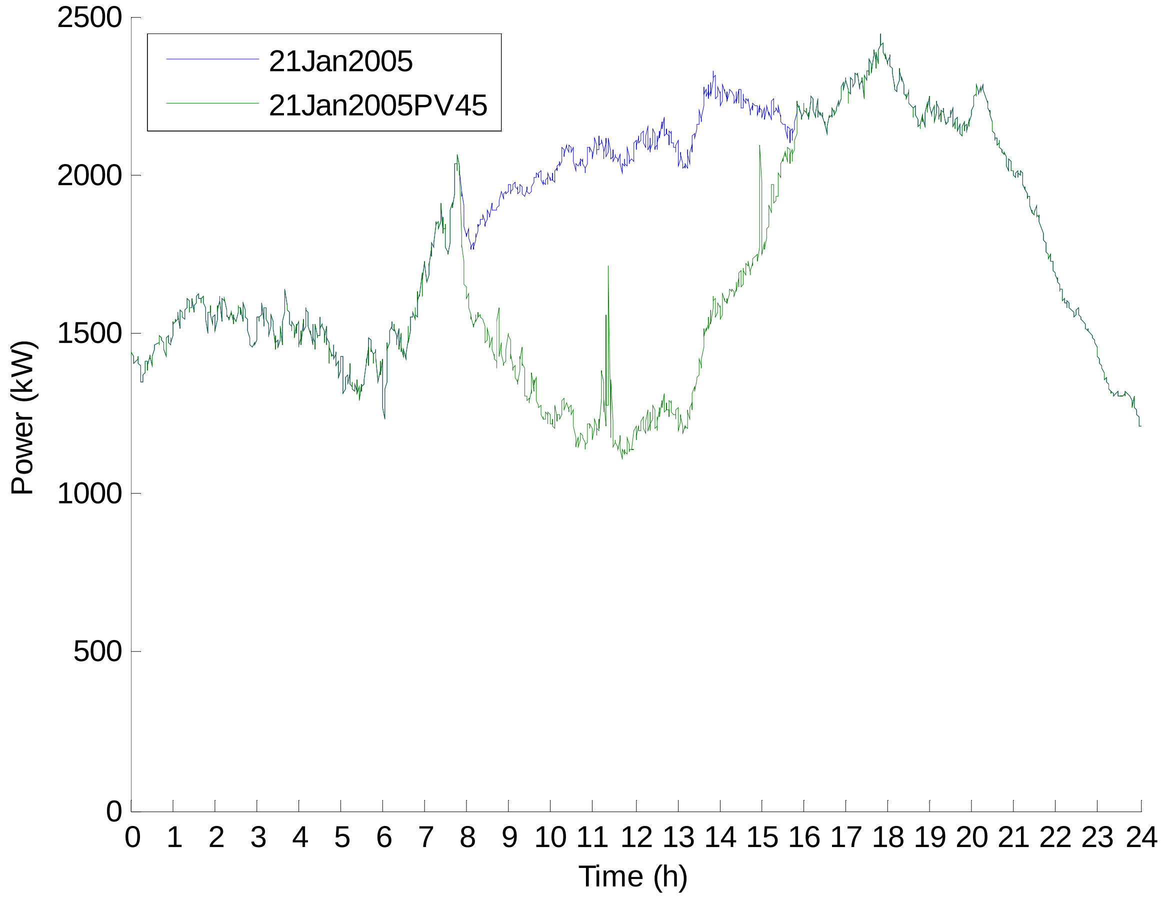


# Reverse power flow from PV

# Effect of PV on summer load



# Effect of PV on winter load

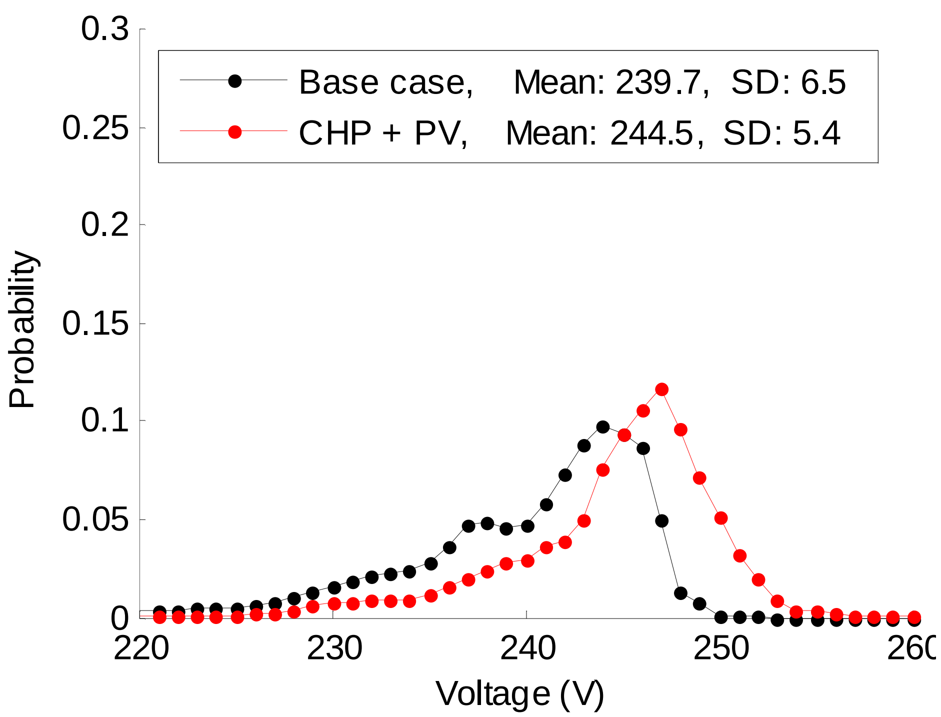


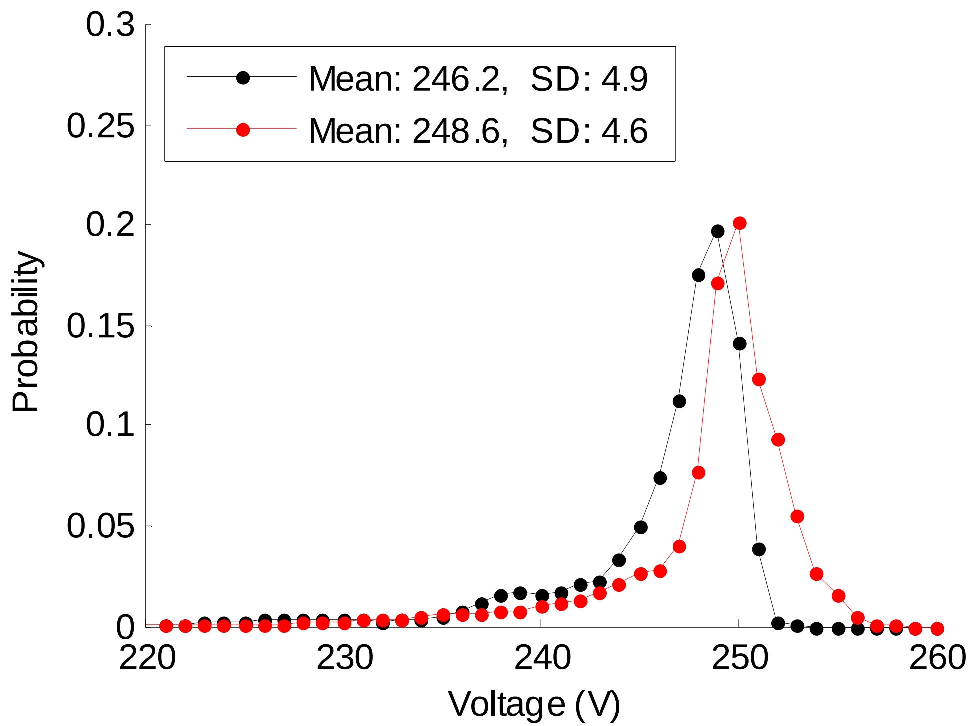
# EU voltage Standards

EN 50160 requires:

- During each week 95% of the 10 minute mean rms supply voltages must lie between nominal ± 10% (ie for UK between 207 and 253 Volts)
- All voltages must lie between nominal + 10% and nominal – 15% (ie between 195.5 and 253Volts)

# Winter and summer voltage pdfs

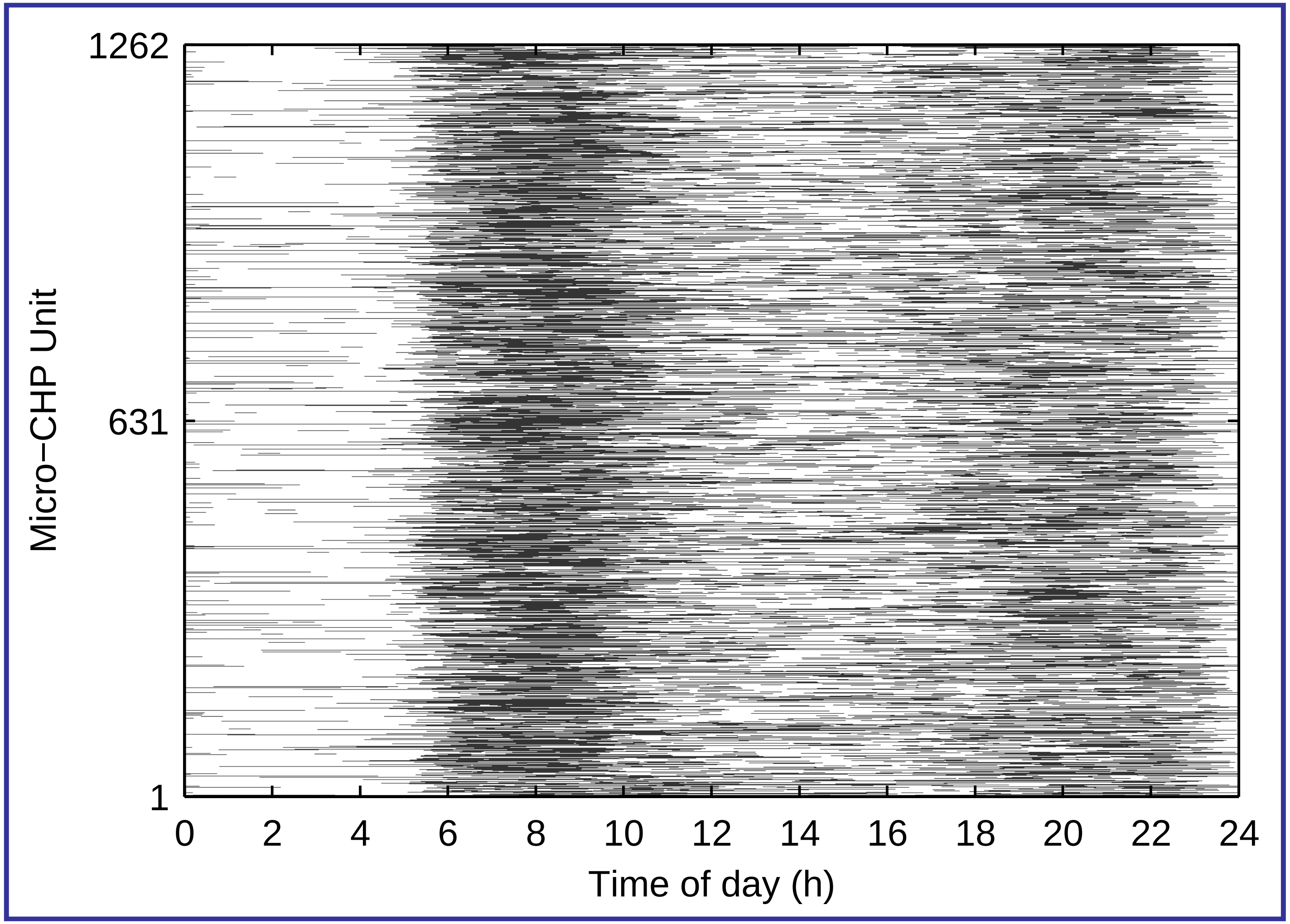


# Impact on system losses

| PV penetration, % | Average network losses, kW | |
|---|---|---|
| | Winter | Summer |
| 0 | 67 | 34 |
| 30 | 60 | 29 |
| 50 | 58 | 27 |

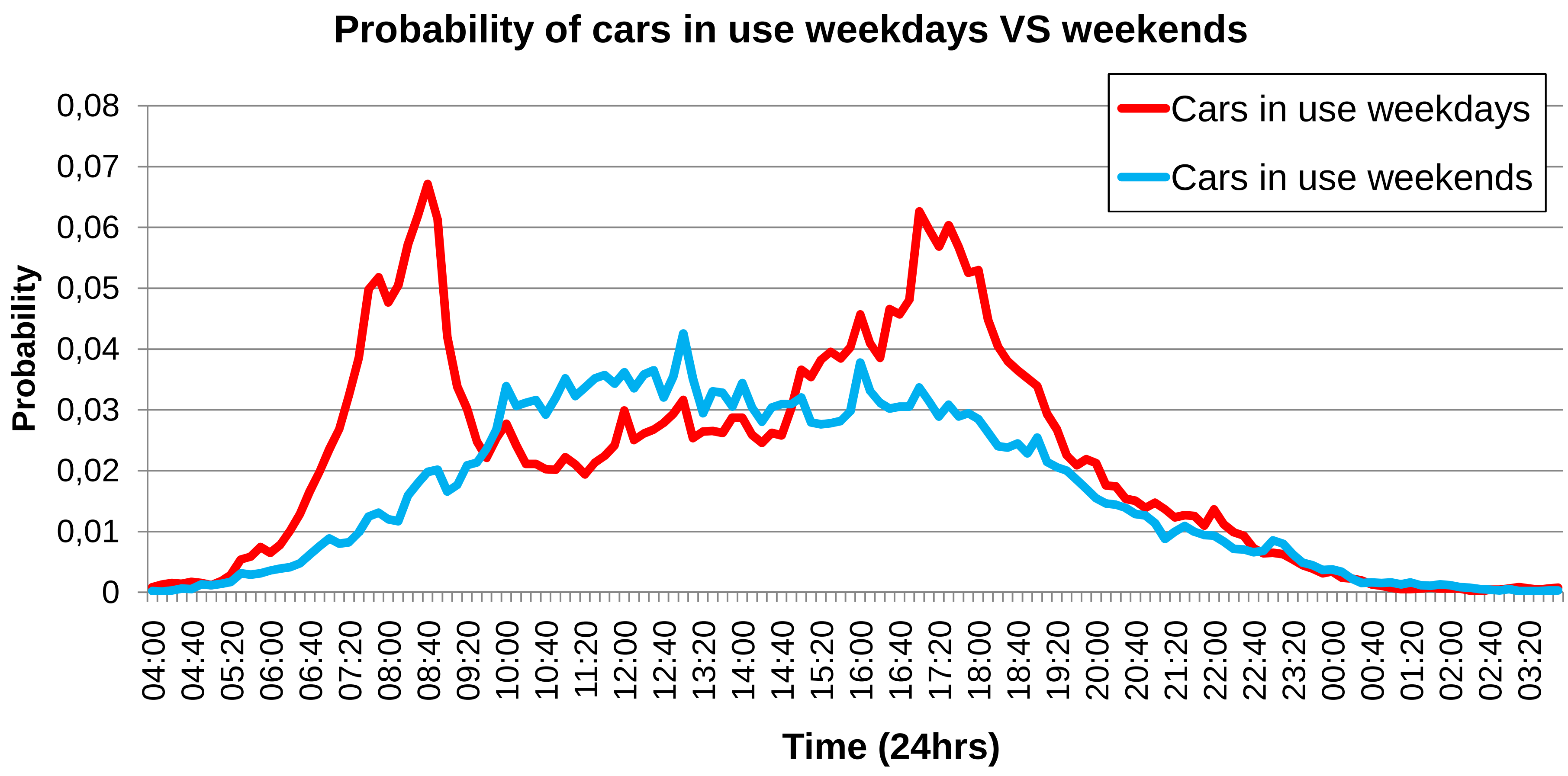
# chp modelling



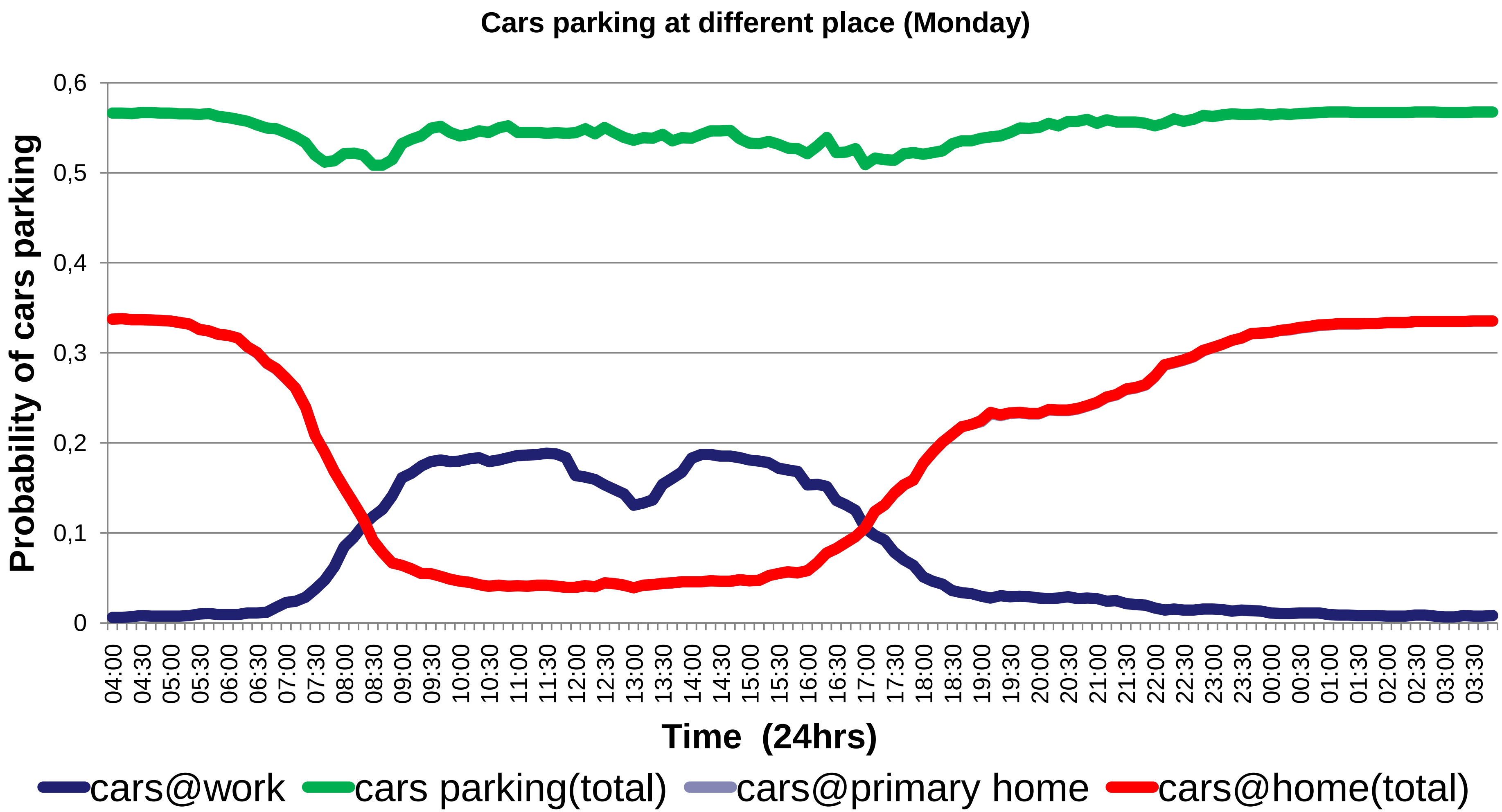
# Summary of chp impact

| Input parameters | | | Results | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Micro-CHP unit ratings | | Installed penetration (%) | Energy penetration (%) | | Voltages (V) | | | | | | | | Average losses (kW) | |
| | | | | | Summer | | | | Winter | | | | | |
| $kW_{th}$ | $kW_e$ | | Summer | Winter | Min | Mean | Max | >253 (%) | Min | Mean | Max | >253 (%) | Summer | Winter |
| | | 0 (base case) | 0 | 0 | 214.9 | 246.2 | 251.8 | 0 | 206.5 | 239.7 | 250.7 | 0 | 34 | 67 |
| 9 | 1 | 100 | 11 | 25 | 216.4 | 246.8 | 252.9 | 0 | 208.6 | 242.1 | 256.1 | 0.17 | 30 | 44 |
| 3 | 1 | 100 | 31 | 57 | 217.9 | 247.9 | 255.7 | 0.87 | 214.1 | 244.9 | 258.5 | 1.5 | 25 | 28 |
| 1 | 1 | 100 | 81 | 70 | 222.4 | 250.5 | 260.9 | 20 | 216.3 | 246.1 | 259.9 | 4.3 | 20 | 25 |
| 9 | 3 | 100 | 33 | 74 | 218.1 | 248.0 | 259.1 | 1.9 | 212.6 | 246.3 | 269.4 | 7.9 | 25 | 34 |
| 3 | 3 | 100 | 93 | 171 | 222.0 | 251.1 | 270.2 | 27 | 227.3 | 254.0 | 280.6 | 51 | 25 | 77 |
| 9 | 9 | 100 | 100 | 223 | 219.4 | 251.4 | 278.2 | 30 | 223.1 | 257.0 | 315.4 | 58 | 33 | 220 |
| | | 50 | 50 | 110 | 217.6 | 248.9 | 271.1 | 8.9 | 214.6 | 249.1 | 285.7 | 21 | 25 | 58 |
| | | 20 | 21 | 45 | 214.9 | 247.3 | 256.4 | 0.76 | 211.9 | 243.8 | 261.3 | 2.2 | 28 | 38 |

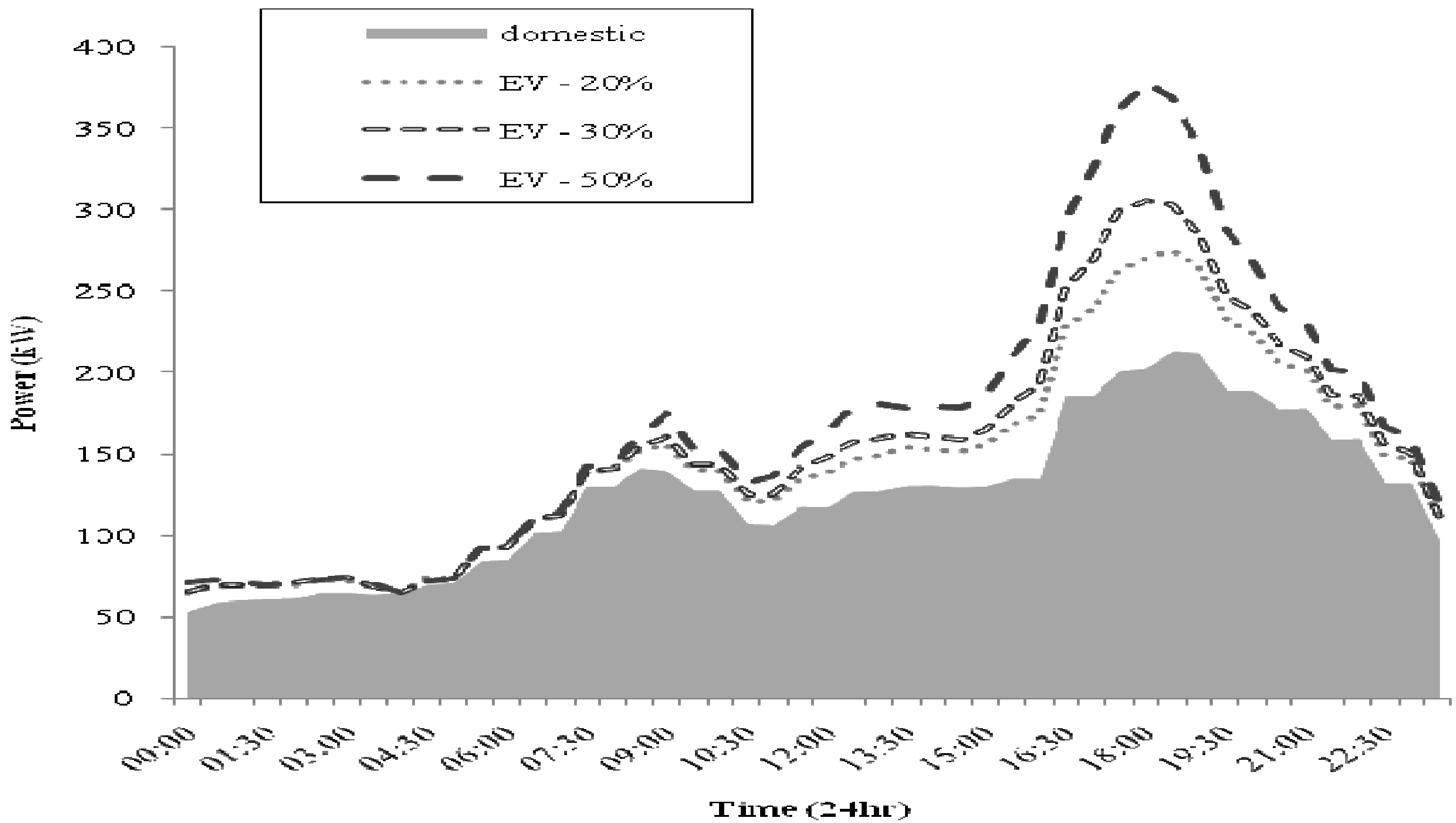
# Domestic vehicle use



# Vehicle parking



# EV charging loads



# Future loads

- new loads (EV charging and also heat pumps) seen as a problem
- but actually they can be part of the solution
- the key problem is to understand occupant behaviour (and manipulate it ?)

# Market challenges of DER

- marginal impact of a device
- uncertainty in device availability
- vast numbers of market entities
- management, access and utilisation of network assets
- pricing structures
    - locational pricing
    - real-time pricing
    - time of use tariffs

# Conclusions

- PV is the most appropriate technology for distributed generation in the longer term
- micro-chp may have a useful (transitional) role to play
- DER in the form of demand side management will become increasingly important but much more research needs to be done to establish how it should be used