



University of
Strathclyde
Engineering

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

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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



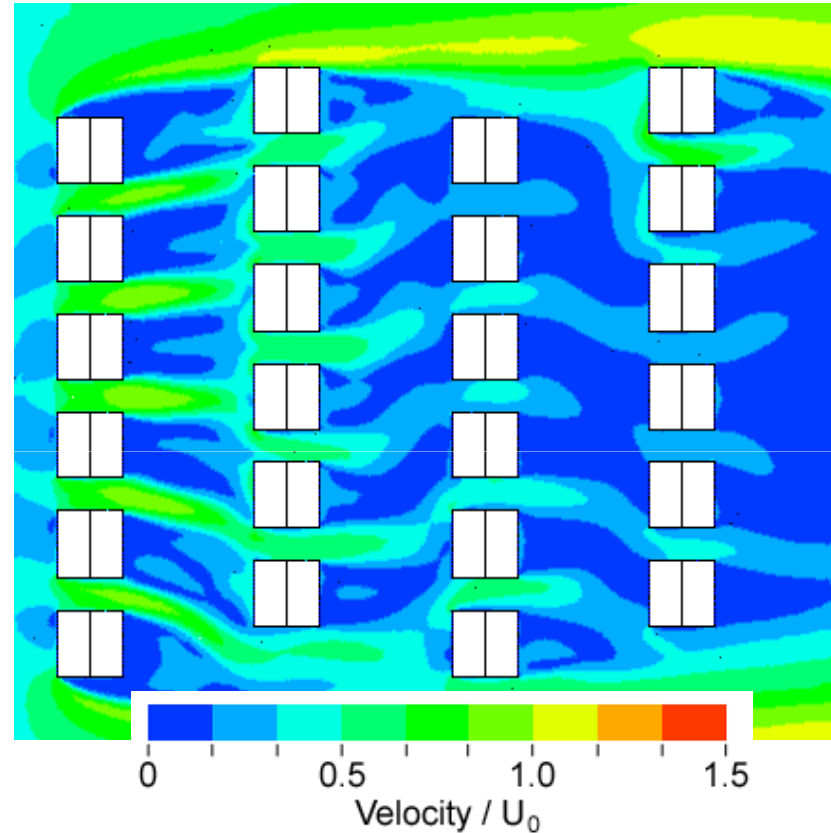
Mataro Public Library, near Barcelona Spain

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



Vallant/Plug Power PEM fuel cell prototype



5kWe Ecopower IC Unit

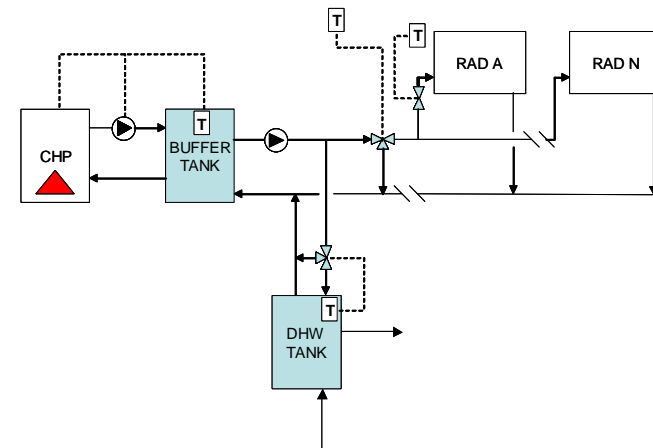
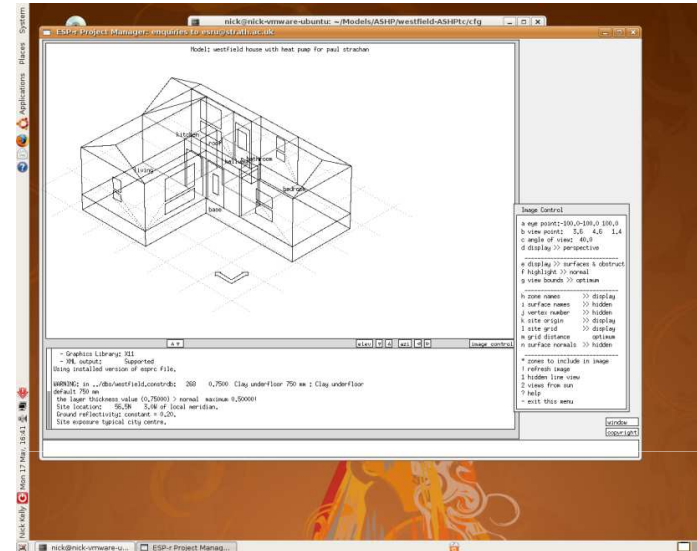
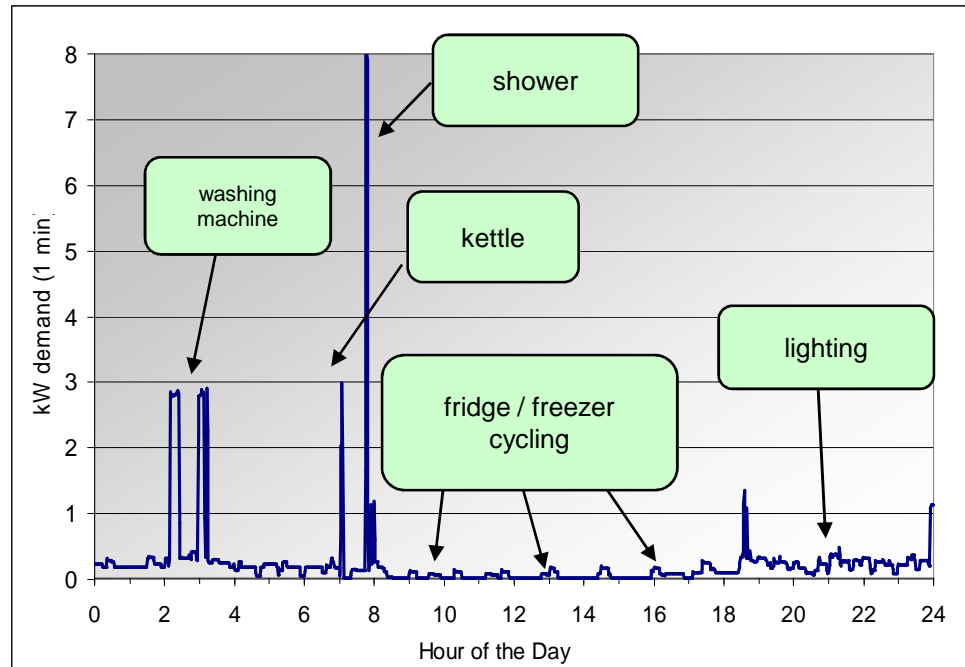
Various micro-chp technologies are under development including: fuel cells and engine based systems, but they may not result in net CO2 savings

Electricity system impact

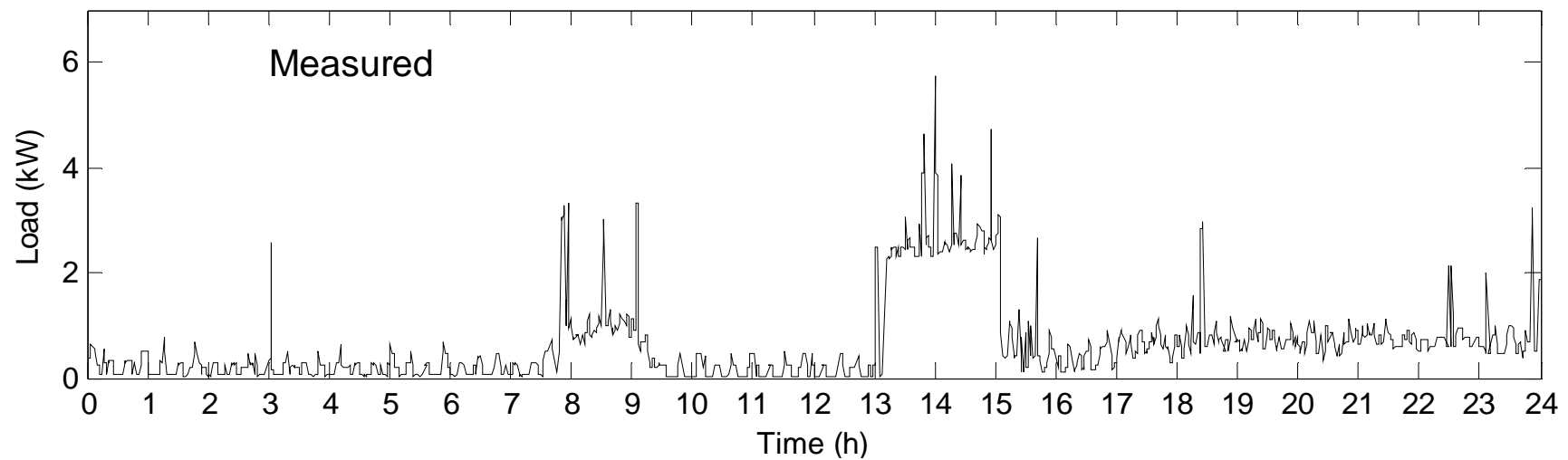
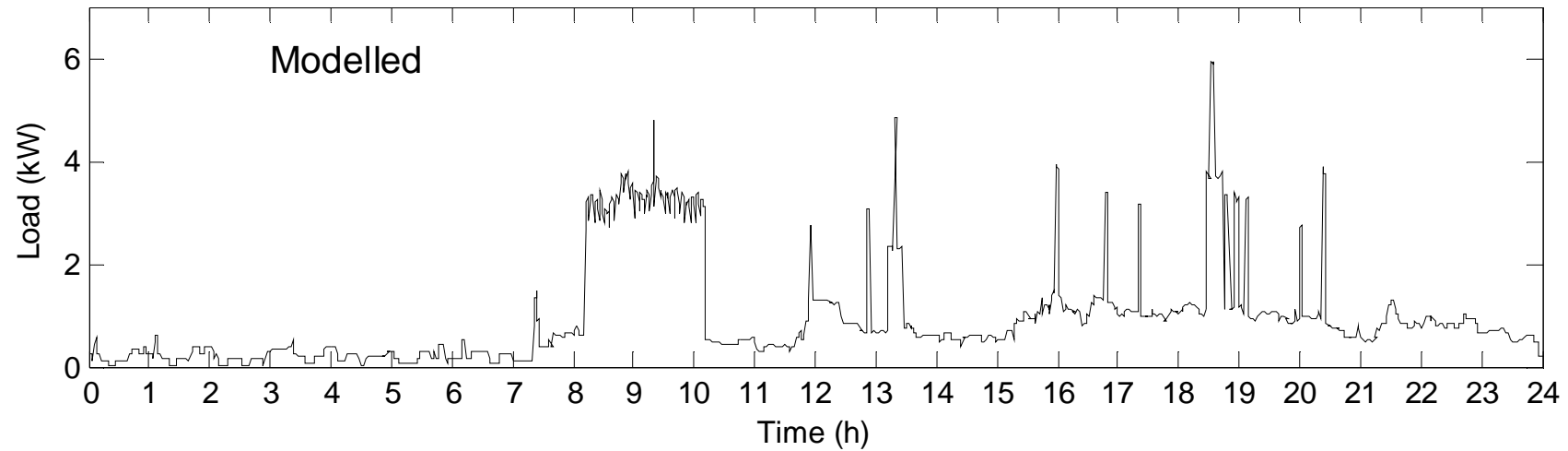
- Potential to reduce distribution system losses
- Possibility of excessive voltages
- Possible reduction in safety
- Possible reduction in system reliability

House and load modelling

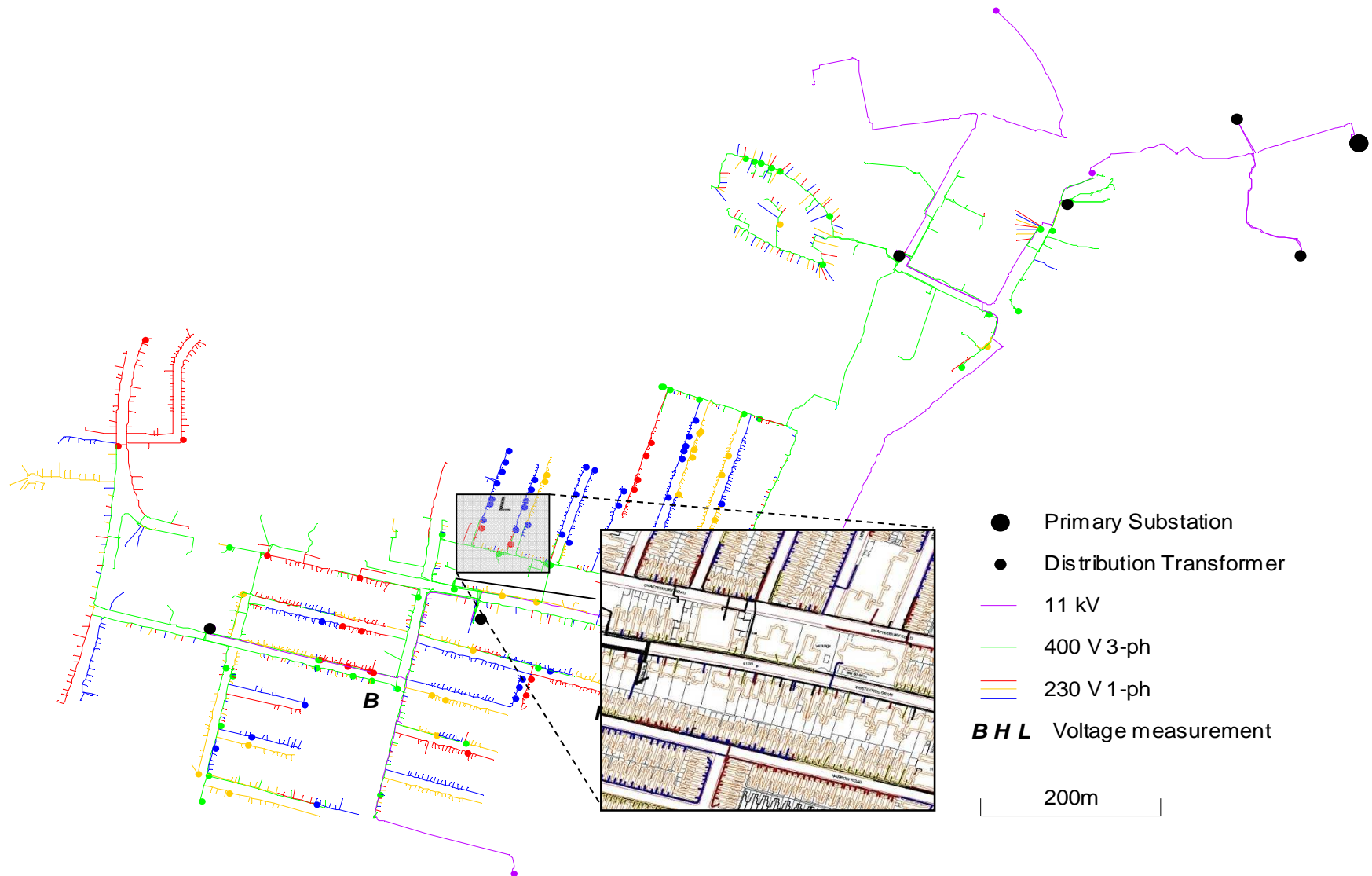
- Detailed stochastic house by house load modelling
- House model output can be used to quantify: device efficiency, fuel consumption, energy costs, start-up times, on/off cycling, temperatures, thermal comfort, etc.



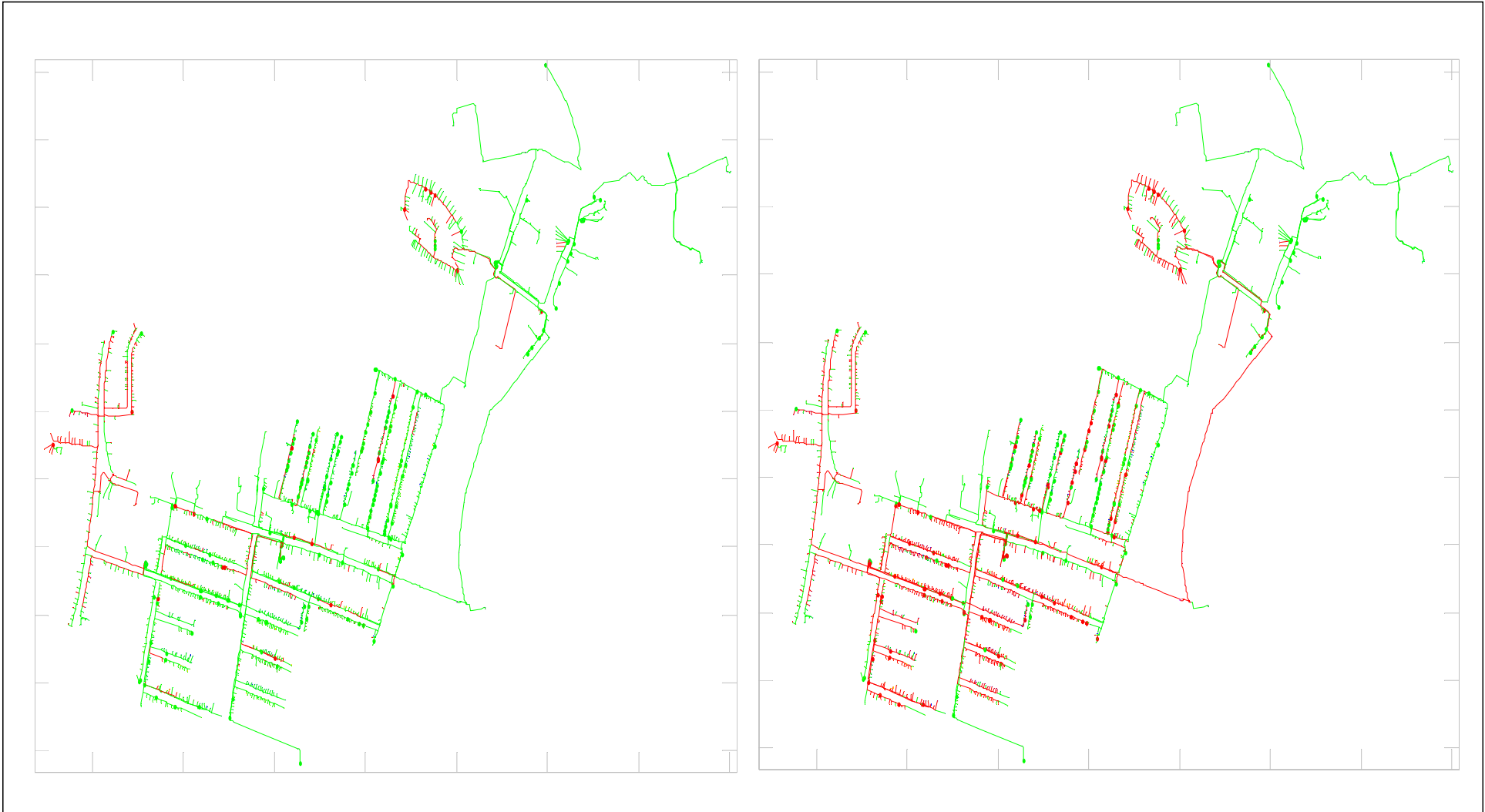
House load model validation



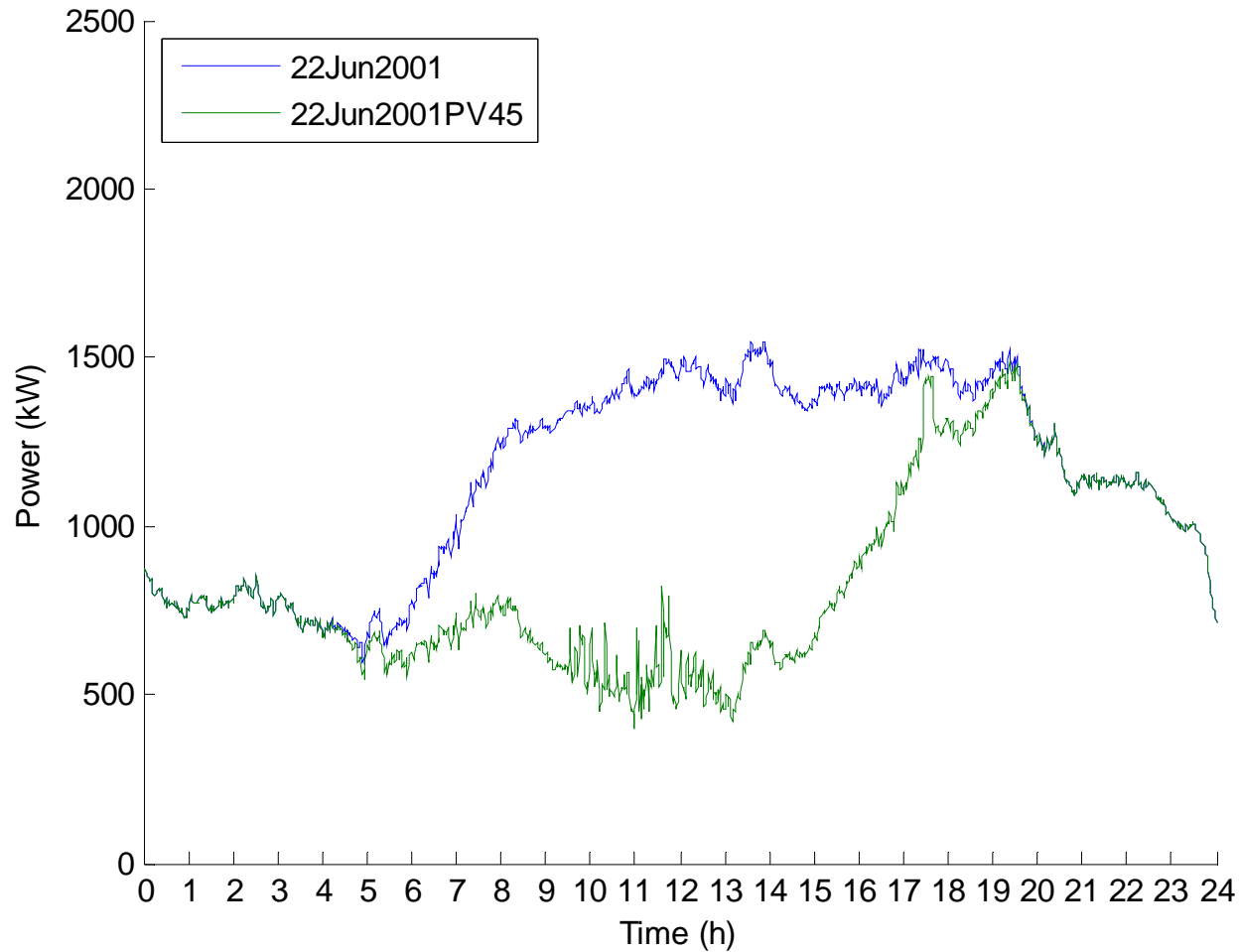
Detailed distribution system modelling



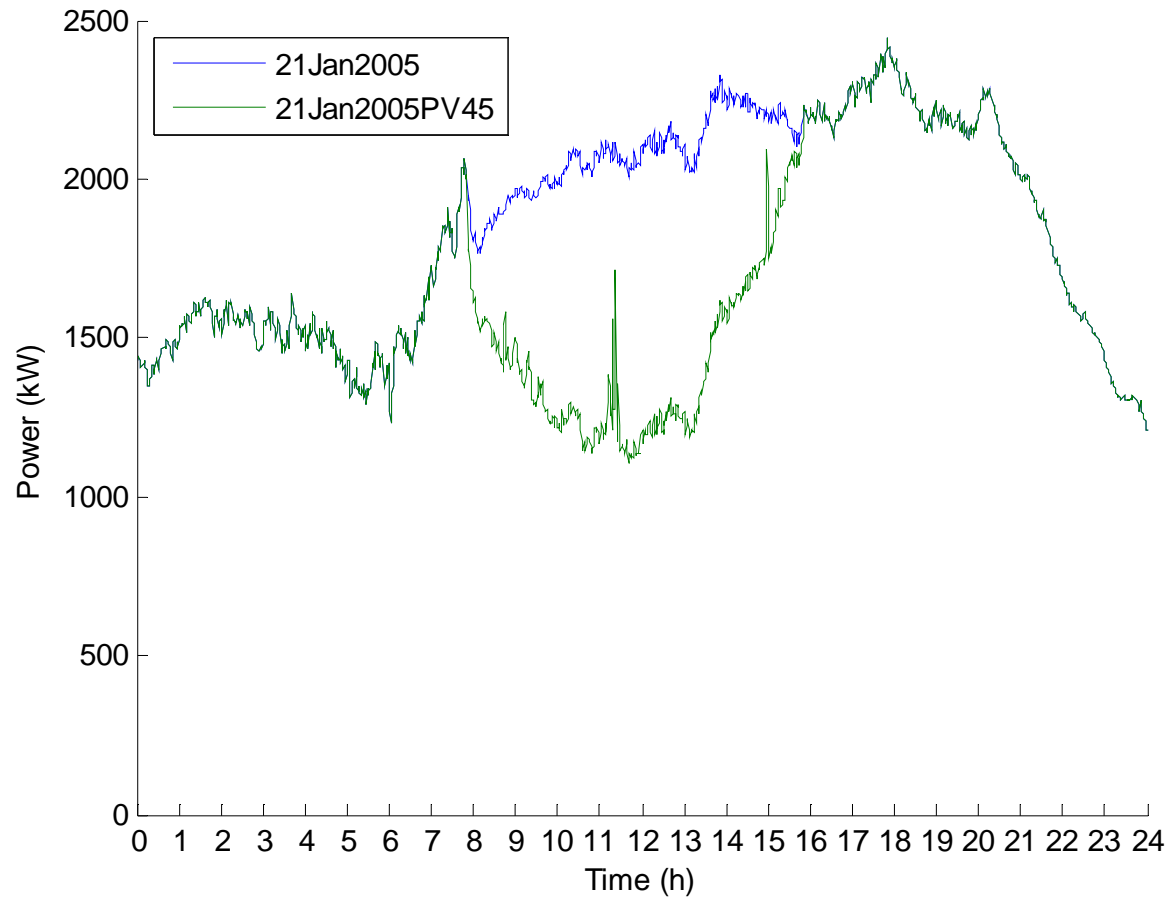
Reverse power flow from PV



Effect of PV on summer load



Effect of PV on winter load

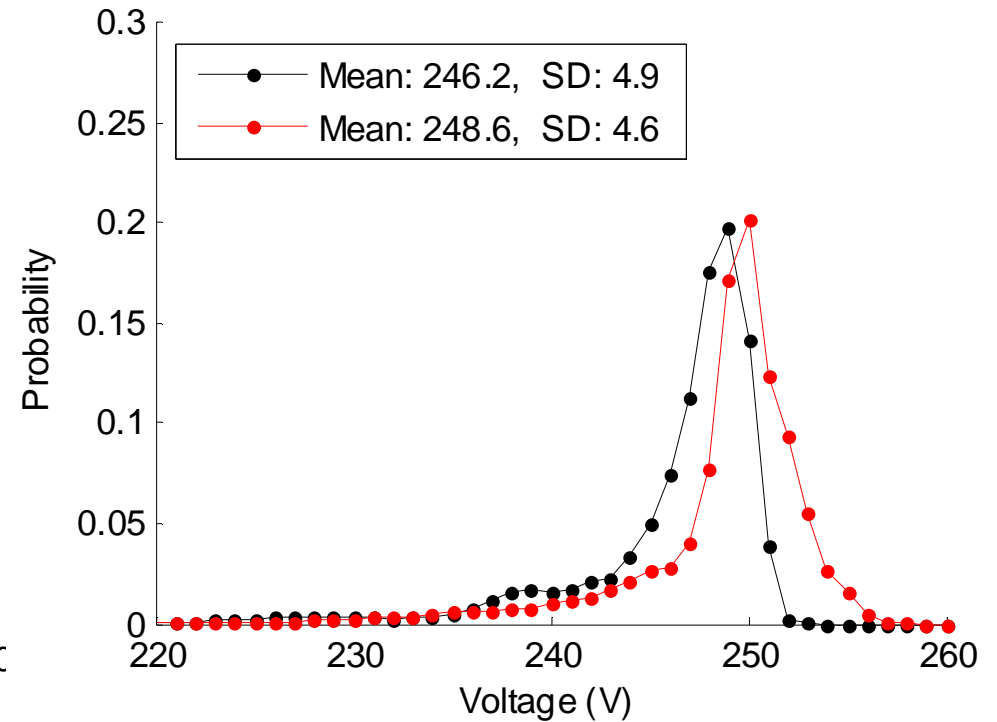
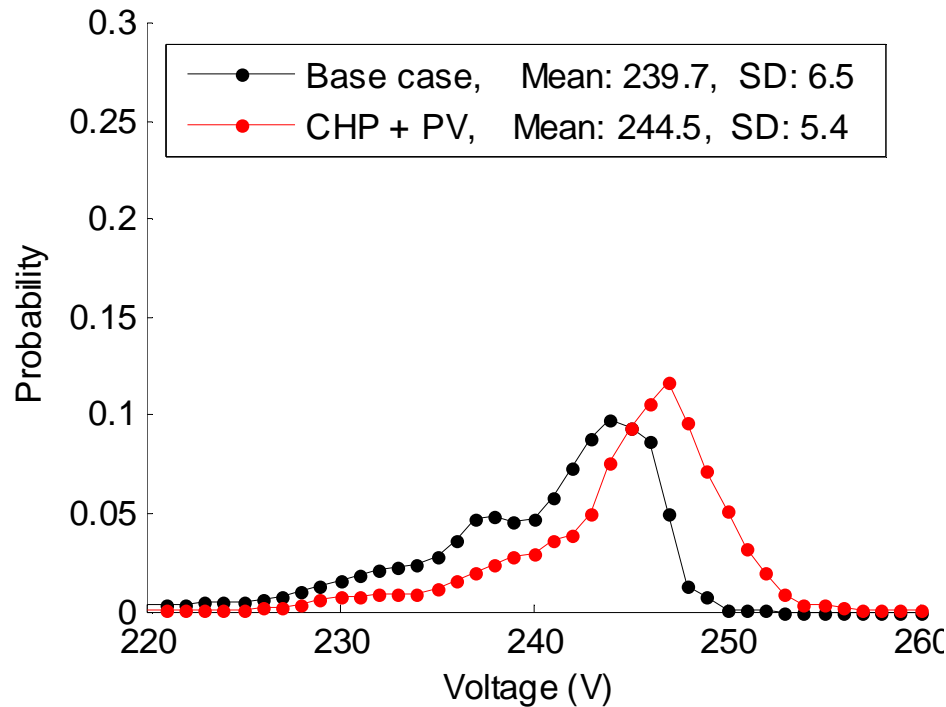


EU voltage Standards

EN 50160 requires:

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

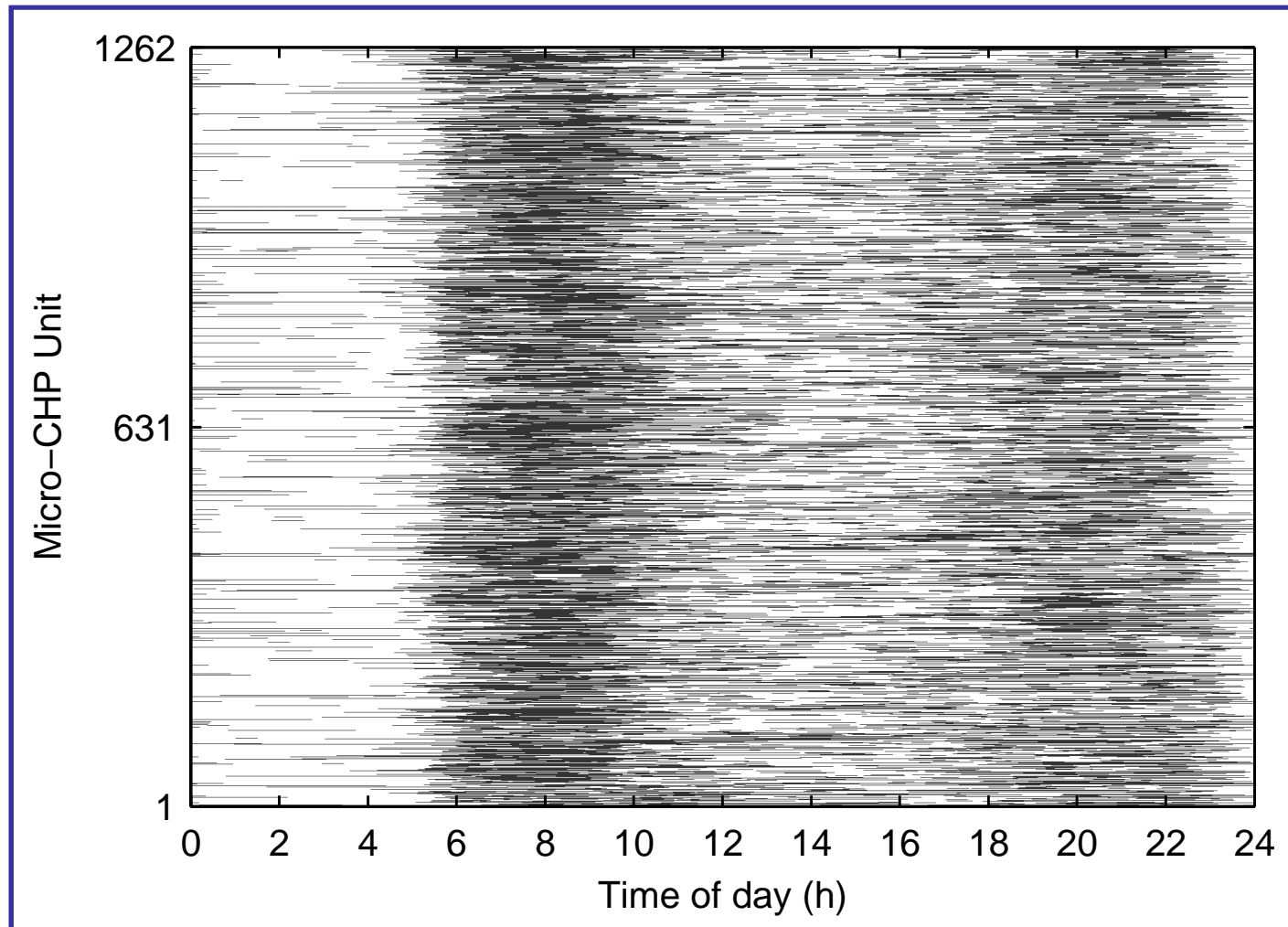
Winter and summer voltage pdfs



Impact on system losses

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

chp modelling

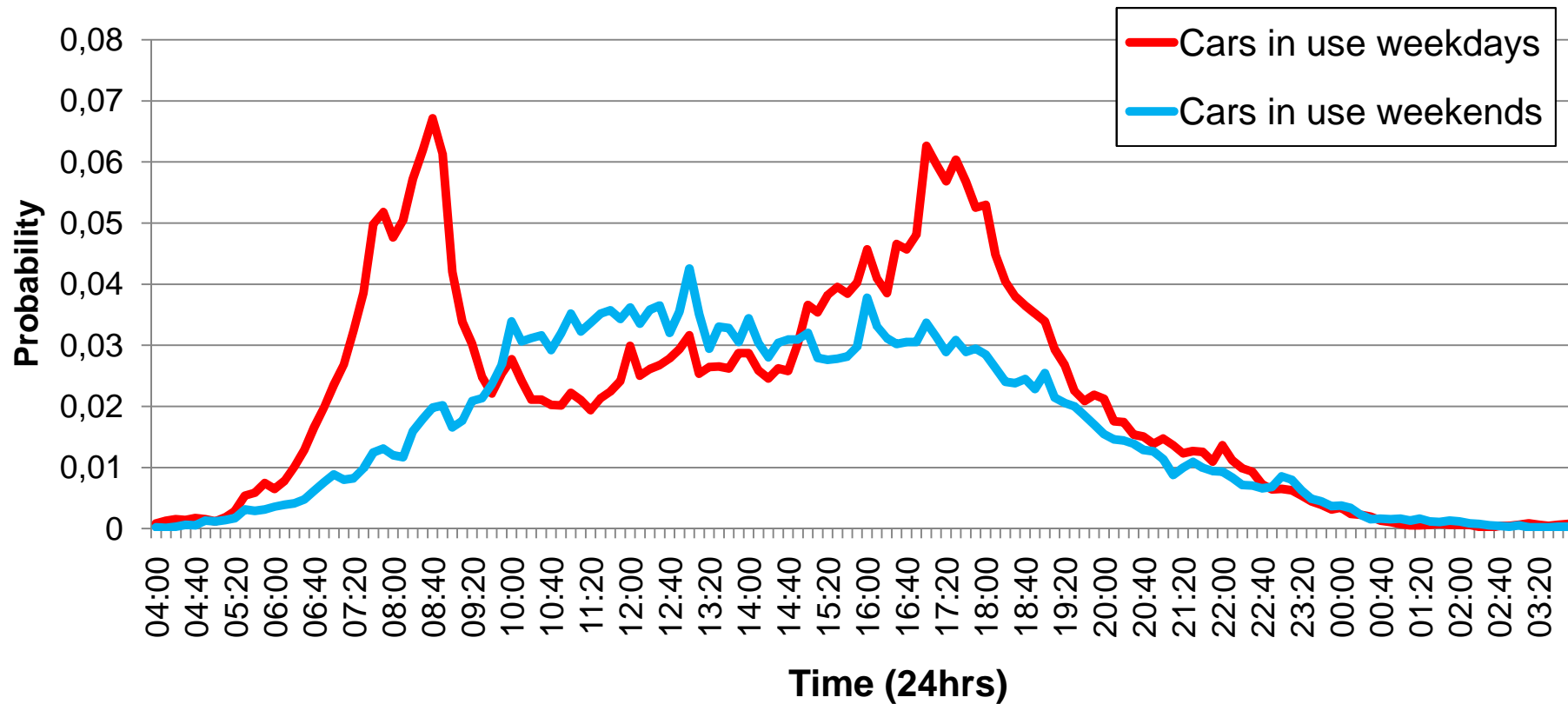


Summary of chp impact

Input parameters			Results											
Micro-CHP unit ratings		Installed penetration (%)	Energy penetration (%)		Voltages (V)								Average losses (kW)	
kW _{th}	kW _e		Summer	Winter	Summer				Winter				Summer	Winter
					Min	Mean	Max	>253 (%)	Min	Mean	Max	>253 (%)		
		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

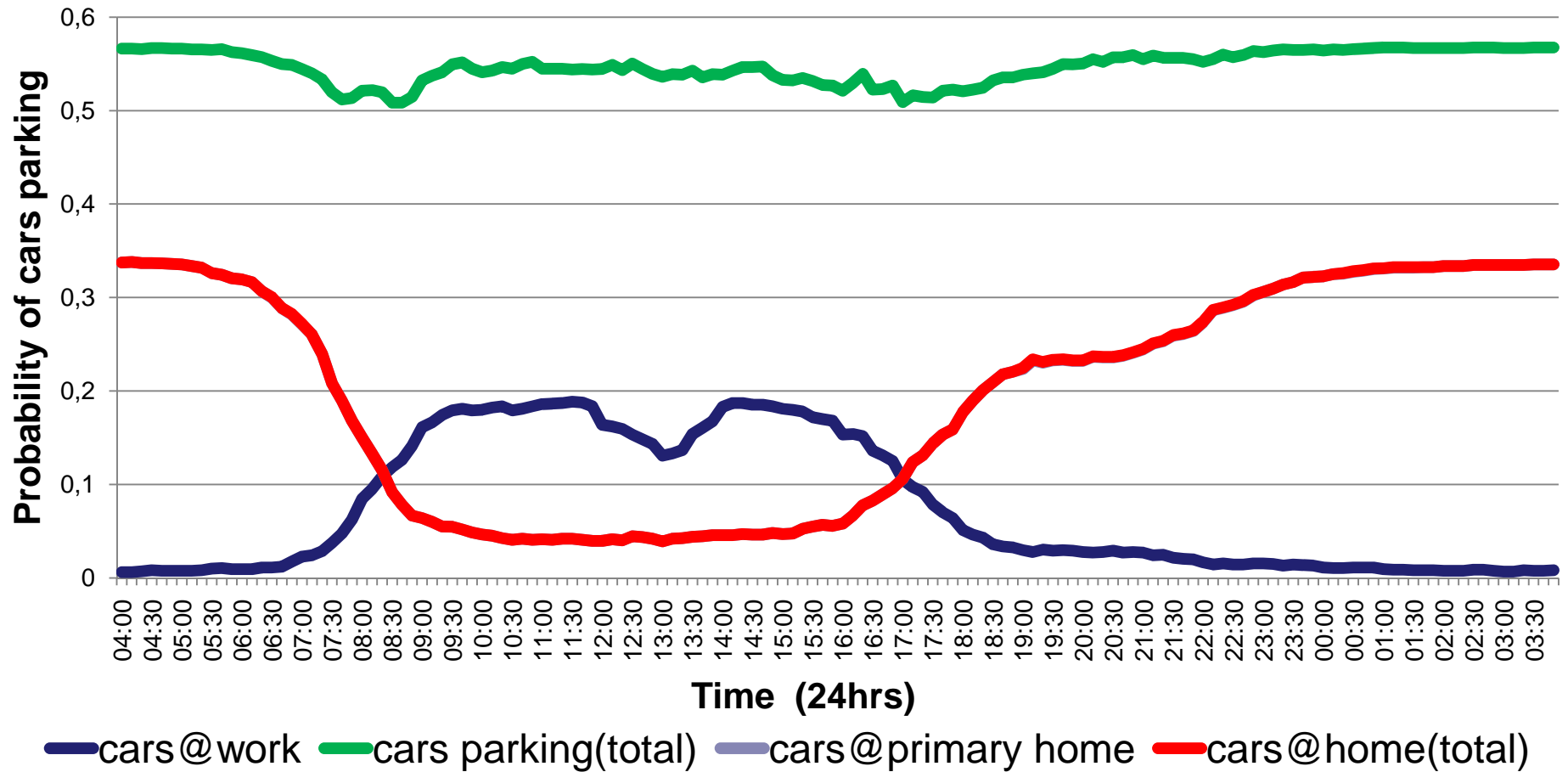
Domestic vehicle use

Probability of cars in use weekdays VS weekends



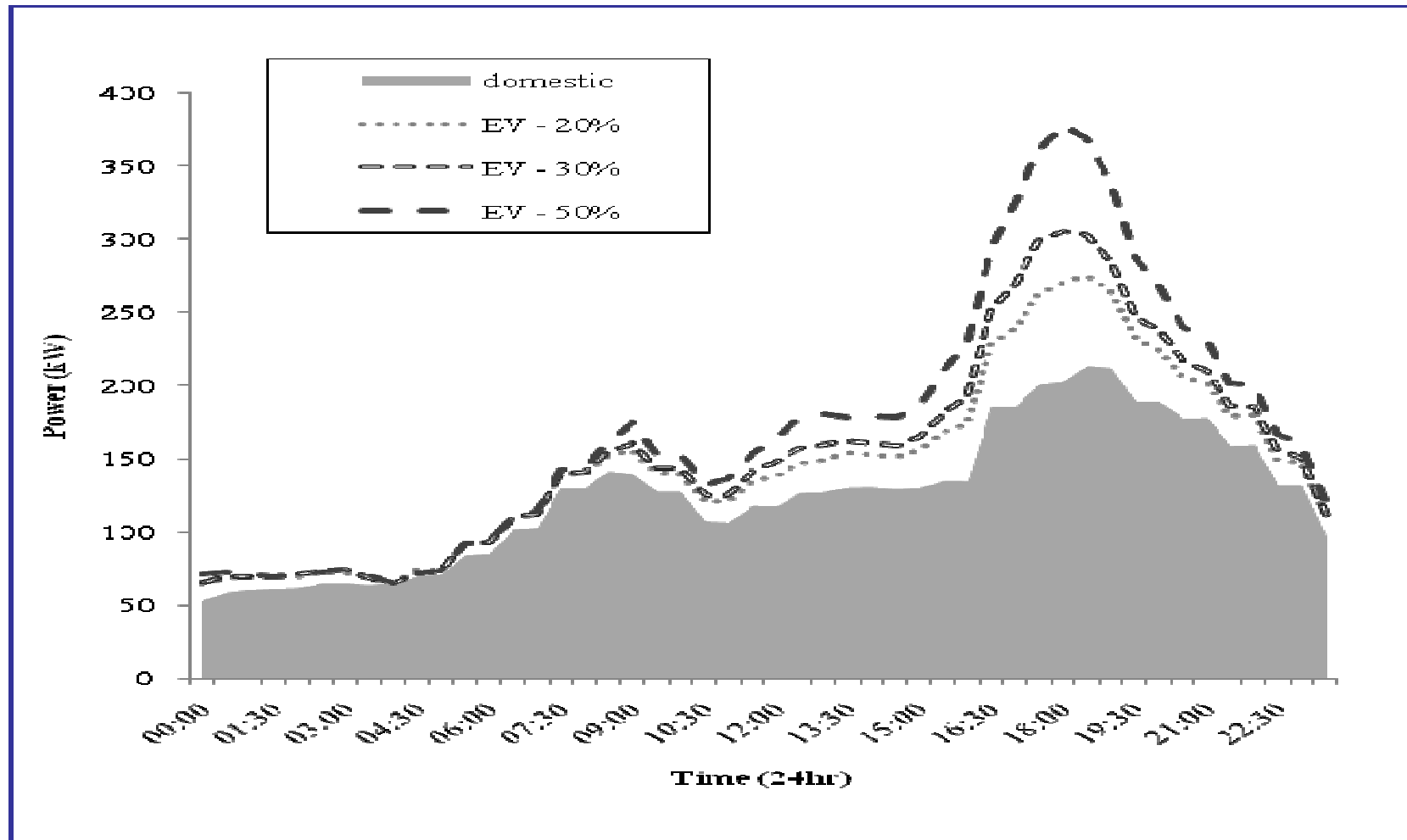
Vehicle parking

Cars parking at different place (Monday)





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