

Mitigation Options for Exposure Reduction

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WHO Workshop on developing and
implementing protective measures for ELF EMF
Geneva, 20th June 2007

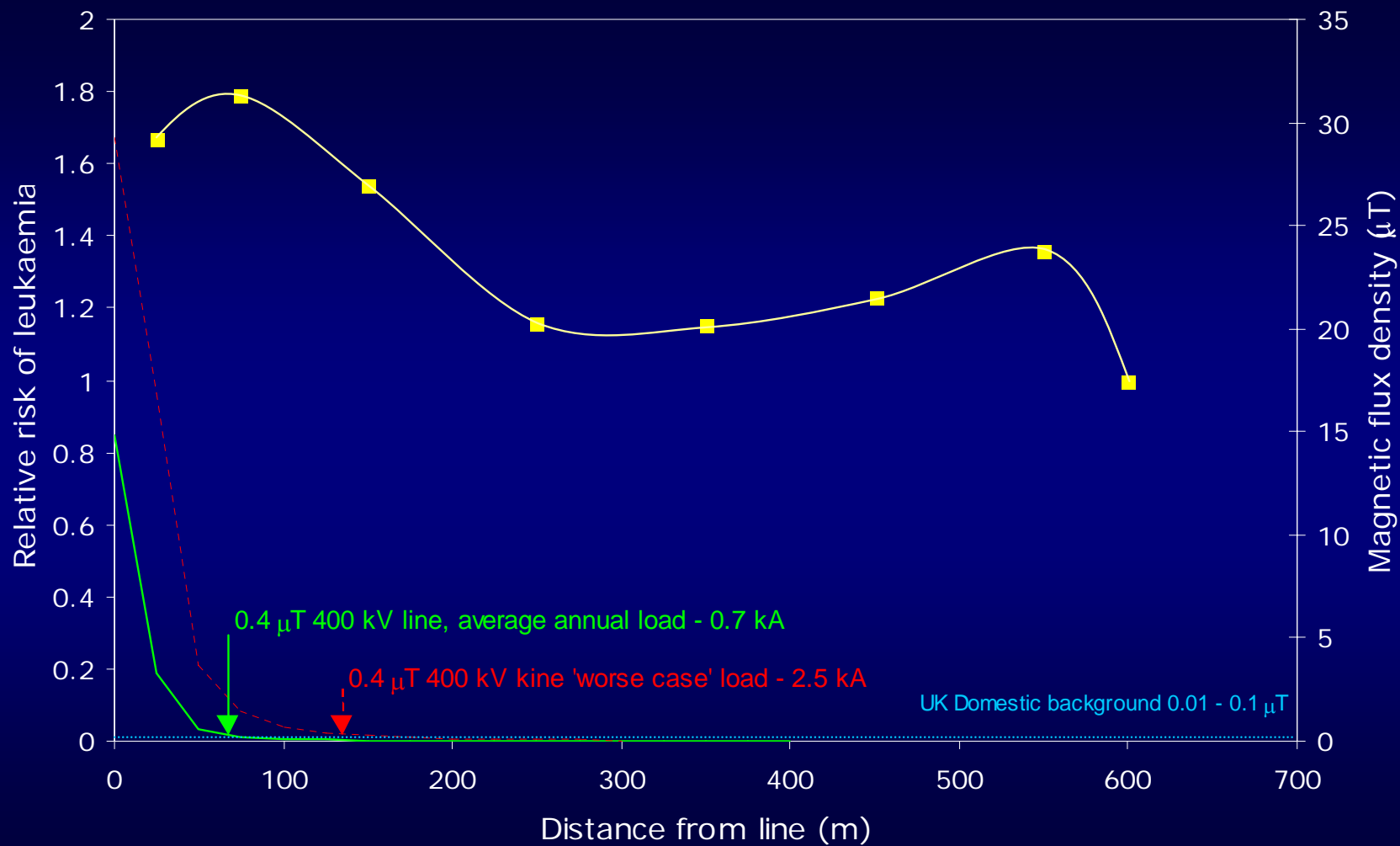


- **Managing the risk**
 - The situation so far
 - Issues to address
- **Options for mitigation**
 - Source management
 - Region management
- **Recent evidence from the UK**
 - The UK Childhood Cancer Study
 - The Residential Sources Study

What is the risk agent we dealing with?

- TWA average magnetic fields?
- Other field parameters?
- Electric fields?
- Other risk factor?

Draper et al study (2005)





Engineering controls

- Modification of electricity supply
- Shielding
- Modification of appliances

Minimum cost measures

- Public information
- Voluntary measures

High voltage power lines

- Decrease separation between conductors
- Increase distance from the source
- Transpose phases on double circuit lines
- Remove any imbalance of phase currents



Photo courtesy of RTE France

HV cables (three phase)

- Decrease separation between conductors
- Increase distance from the source
- Transpose phases on double circuits
- Remove any imbalance of phase currents
- Cable shielding

HV substations

- Design efficient transformers
- Increase distance from the low voltage feeders
- Control incoming / outgoing lines and cables



Low voltage cables (single phase) and home wiring

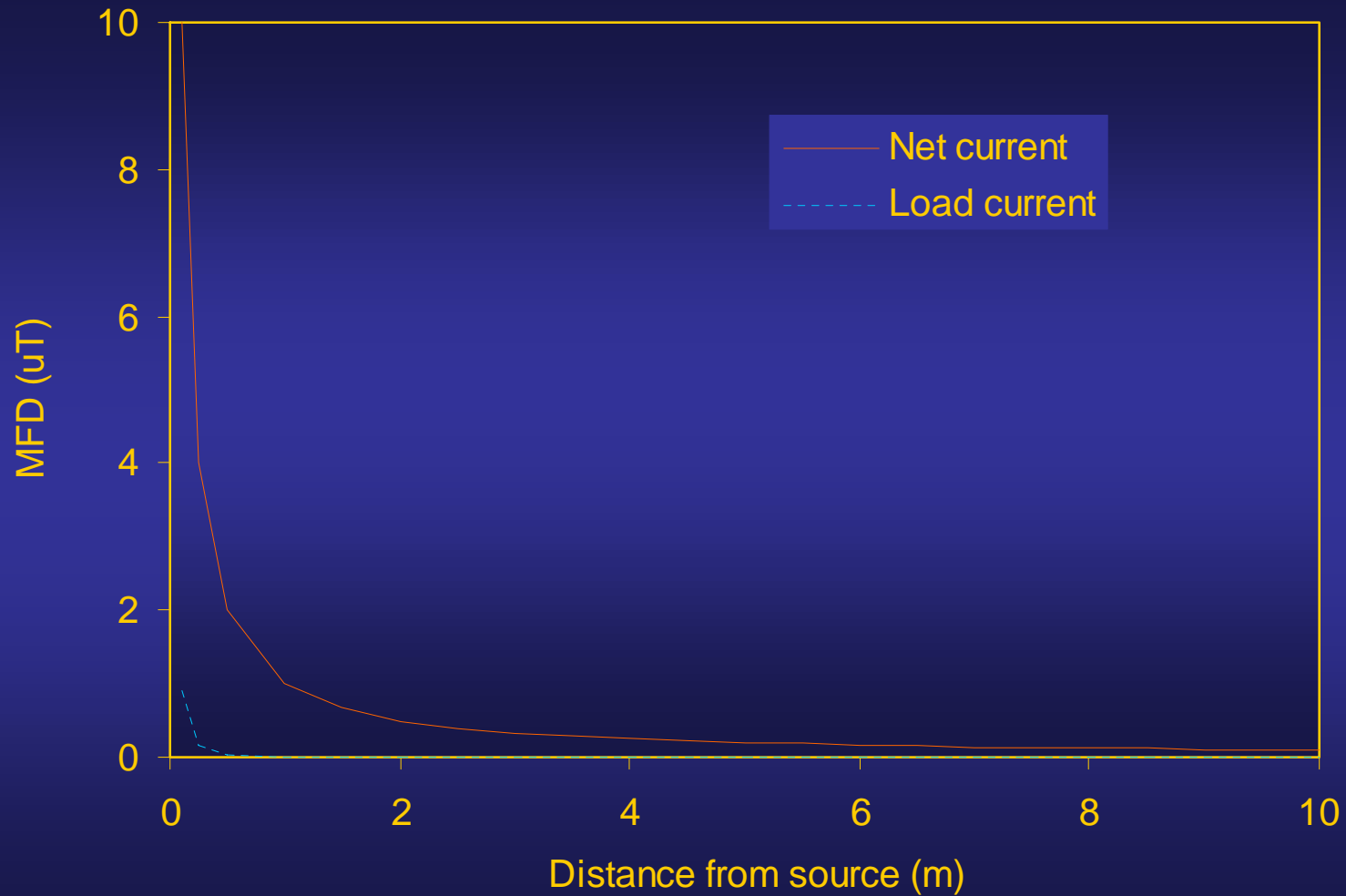
- Decrease spacing between conductors
- Increase distance from the source
- Remove any imbalance in phase and neutral currents
- Ensure return currents flow in the neutral conductor
- Cable shielding

Electrical appliances

- Design efficient transformers
- Increase distance from source

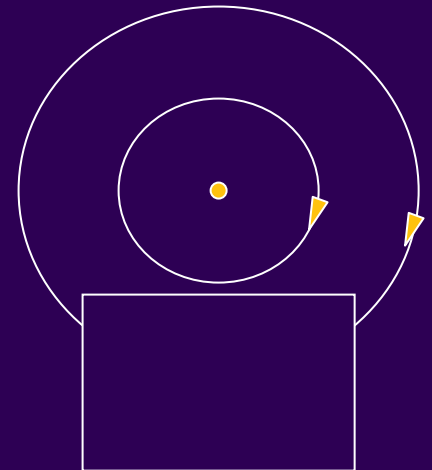


Net and load currents



Region management

- passive (magnetic or electromagnetic) shielding
 - large permeability and / or
 - high electrical conductivity material
- active shielding
 - cancellation current through coils



NRPB 2004 review of the scientific evidence for limiting exposure to electromagnetic fields (0-300 Ghz)

‘The data concerning childhood leukaemia cannot be used to derive quantitative guidance on restricting exposure’

‘..Such studies taken together with people’s concerns provide a basis for considering the possible need for further precautionary measures’

[Http://www.Hpa.Org.Uk/radiation/publications/documents_of_nrpb/abstracts/absd15-2.Htm](http://www.Hpa.Org.Uk/radiation/publications/documents_of_nrpb/abstracts/absd15-2.Htm)

- UK Childhood Cancer Study (UKCCS)
- EMF part of study
 - 2226 children with cancer and equal number of matched controls
- Designed specifically to assess exposures $< 0.2 \mu\text{T}$
- Sophisticated TWA exposure assessment
- Results published in 1999
 - 1073 leukaemia case-control pairs
 - No evidence of association for exposure $< 0.2 \mu\text{T}$

Residential Sources Study



- Investigation of sources of residential magnetic field exposures within the UKCCS
- The study was carried out by HPA-RPD on behalf of the Leukaemia Research Fund
- Supported by the UK Department of Trade and Industry and the Electricity Industry



Residential Sources Study



- Stage 1 - verification of original UKCCS data and non-intervention site visits for 196 homes of which 105 were at or above $0.2 \mu\text{T}$
- Stage 2 - consent obtained from homeowners to make inspections inside the home



Stage 1 process



- Checking of original UKCCS data
- Site procedures according to agreed protocol
- Magnetic flux density measurements outside properties
- Description of local electricity supply



Stage 2 process



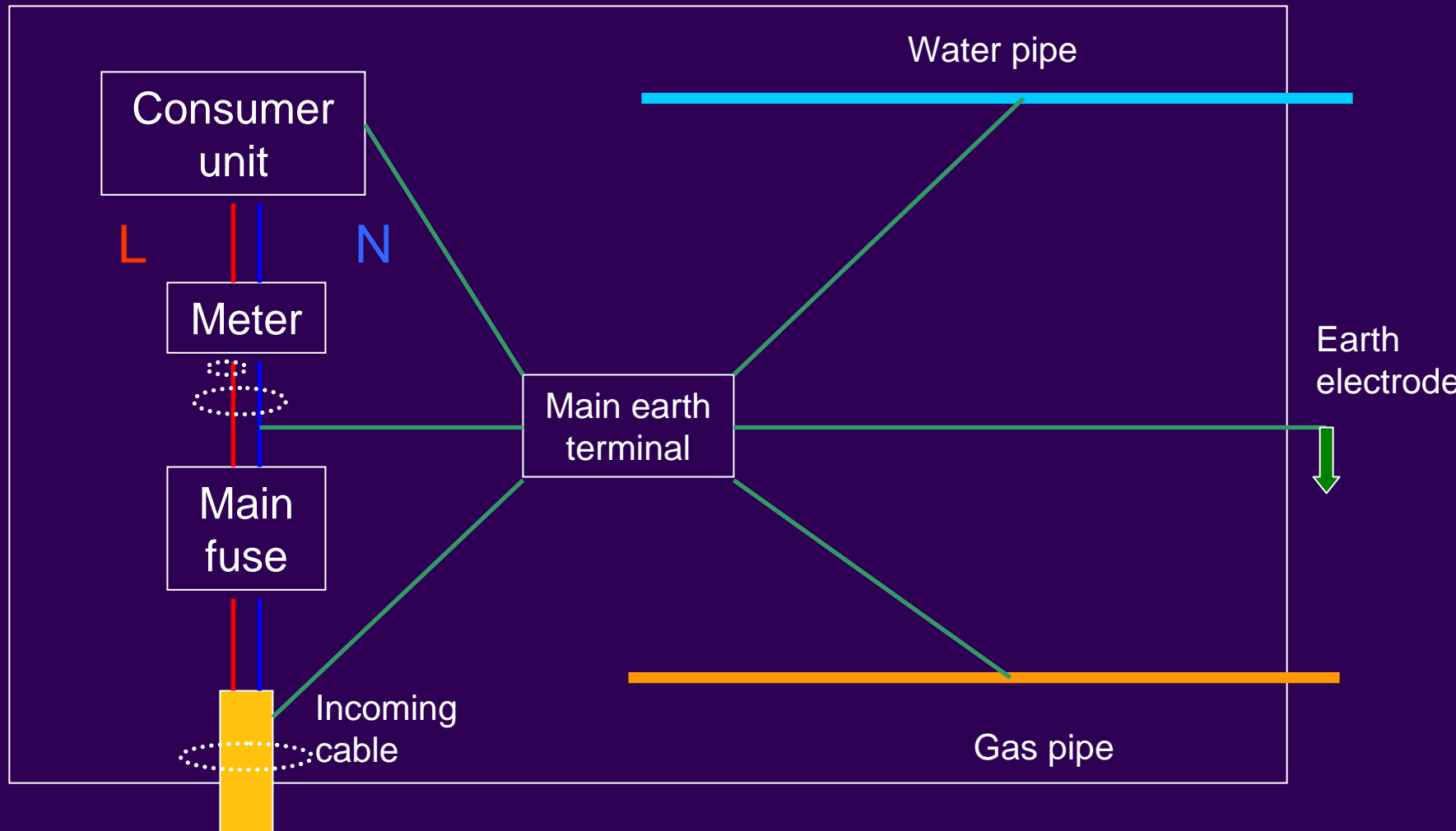
- Agreed procedures
- Magnetic field measurements inside and outside the home
- Internal electrical wiring inspection
- Net currents measured in house wiring



Exposure assessment



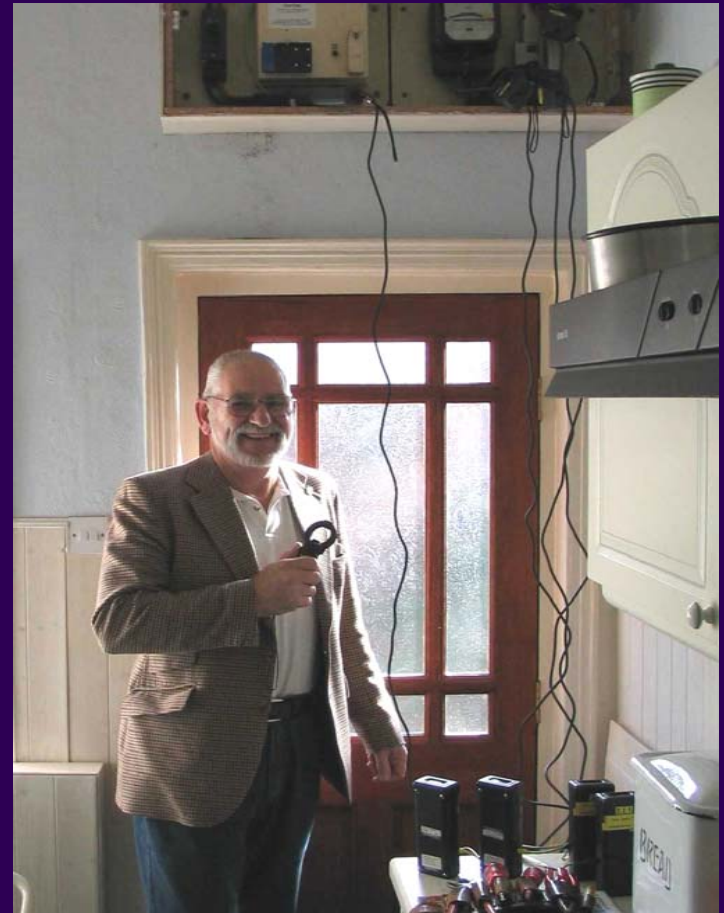
Electric currents



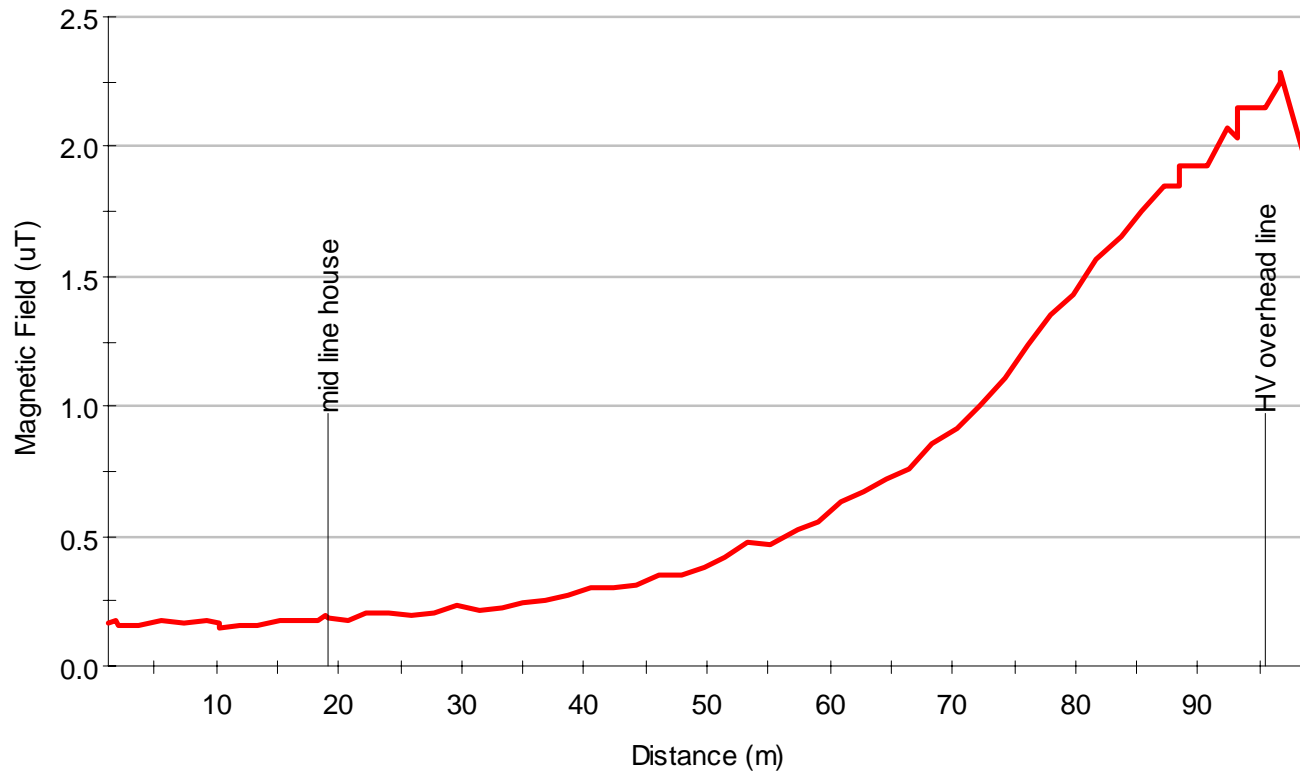
Wiring inspection



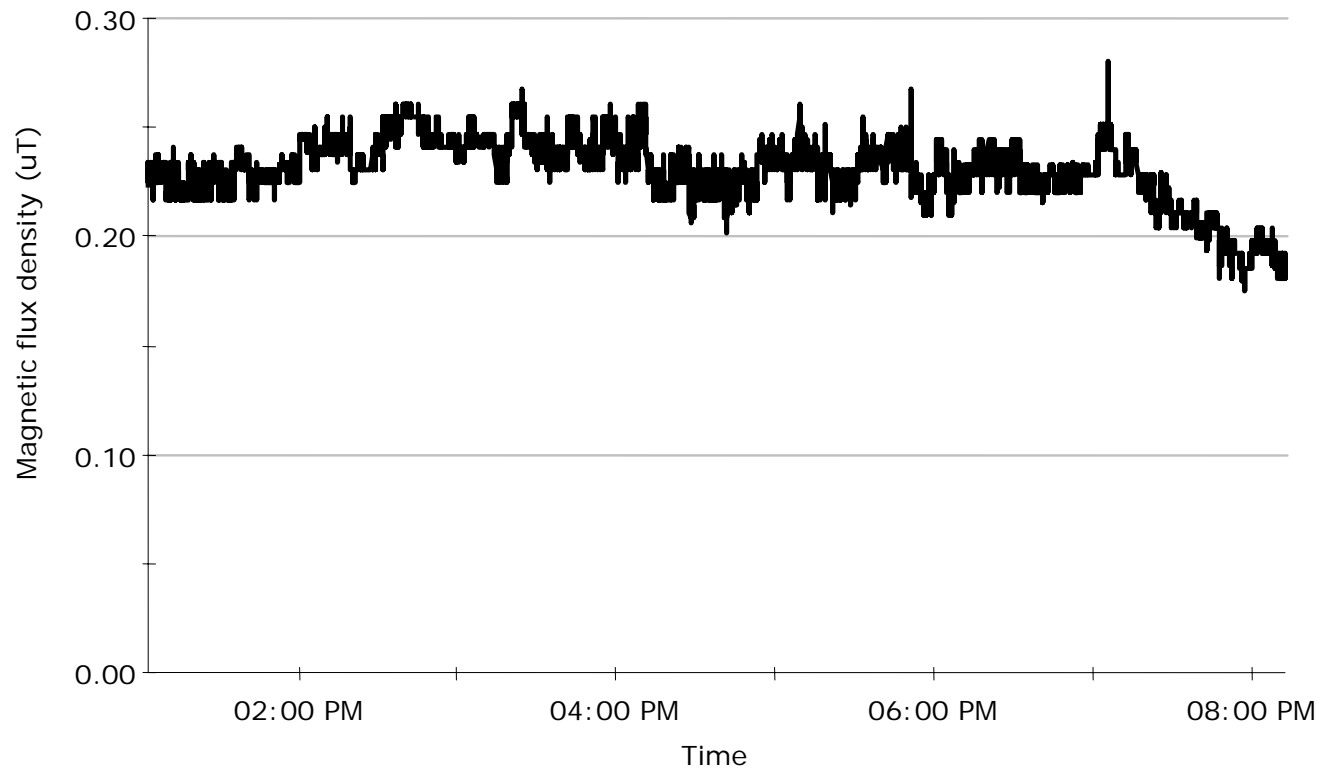
- Description of service connection and earth arrangements inside the home
- Logging of load and net currents under test load conditions
- Spot measurements of net currents
- Measurement of contact voltages



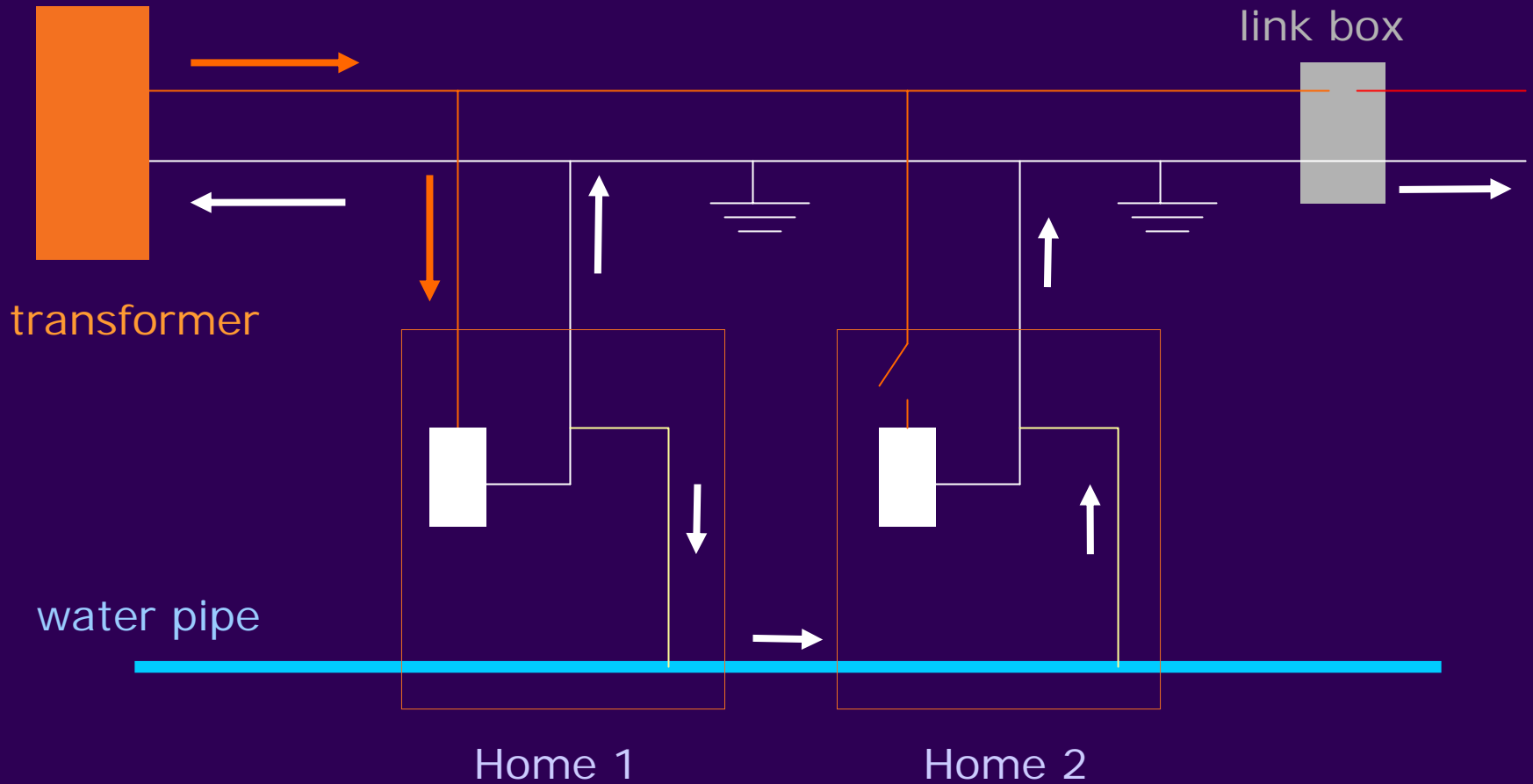
HV power lines



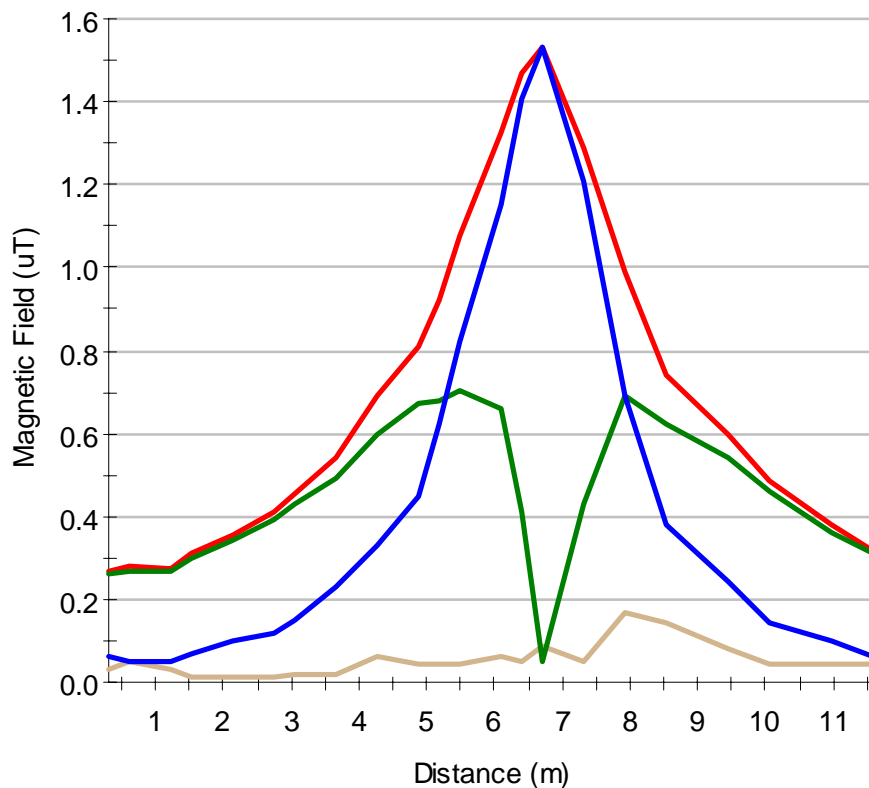
HV power lines



Net currents



Distribution mains cable



Ampère's Law
 $B = \mu_0 I / 2\pi a$

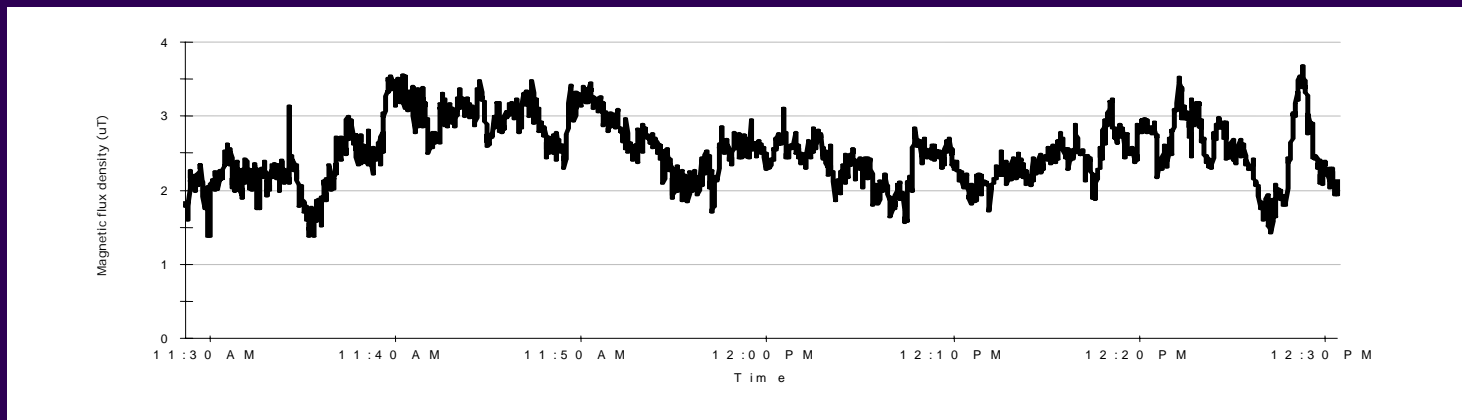
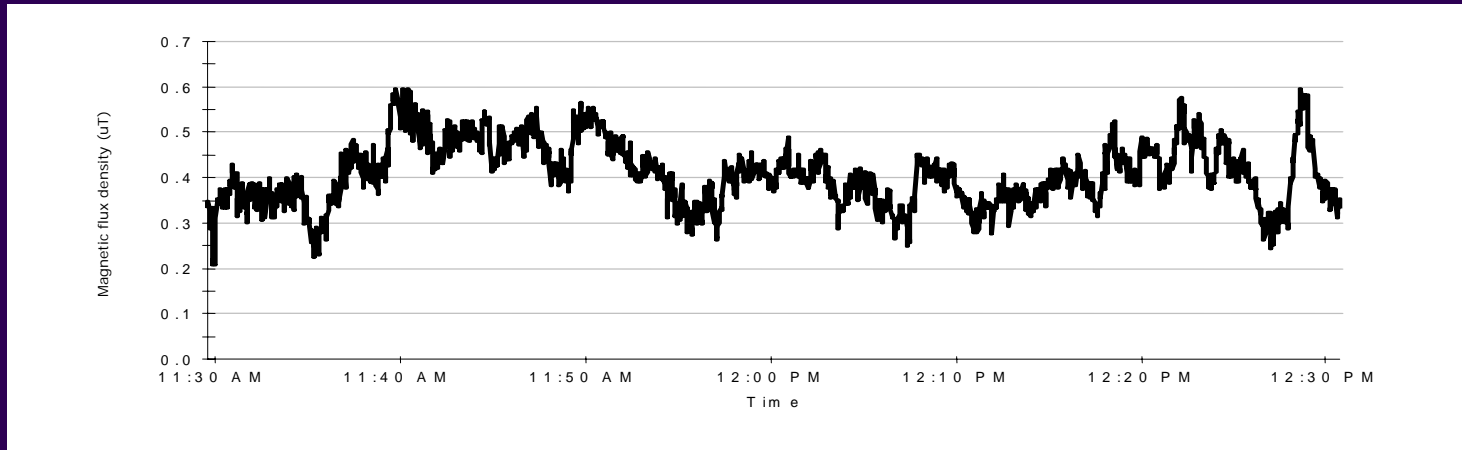
- Broadband Resultant
- Broadband X - Component
- Broadband Y - Component
- Broadband Z - Component



Net currents

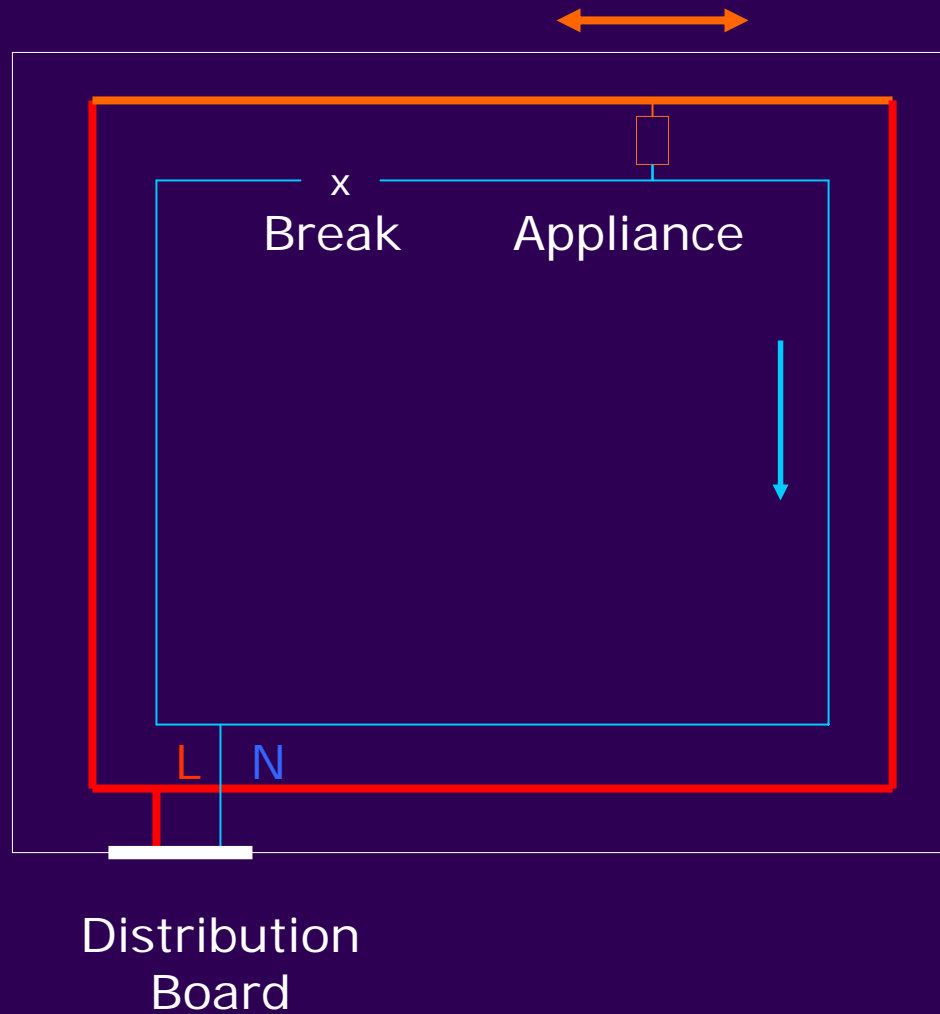


Magnetic flux density

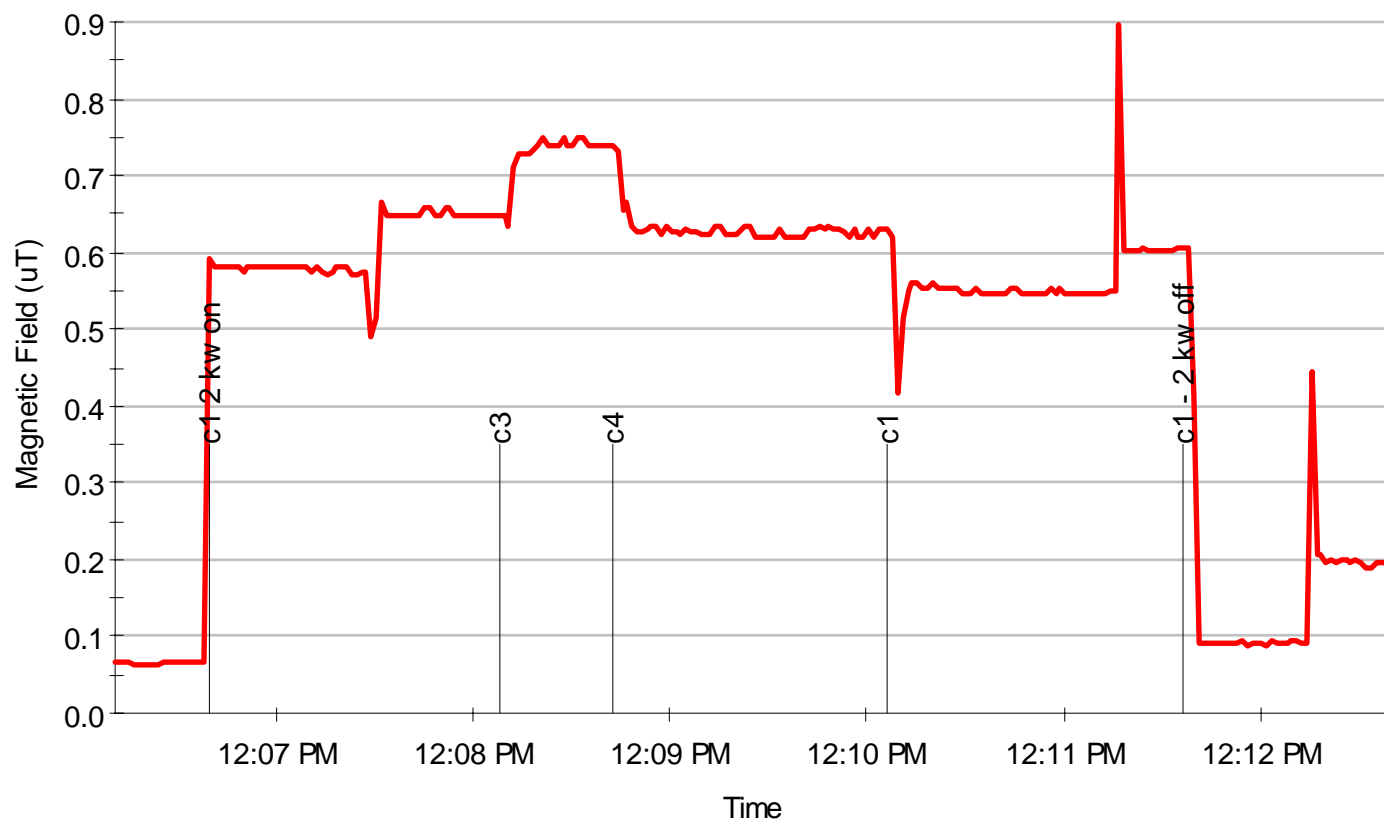


Time

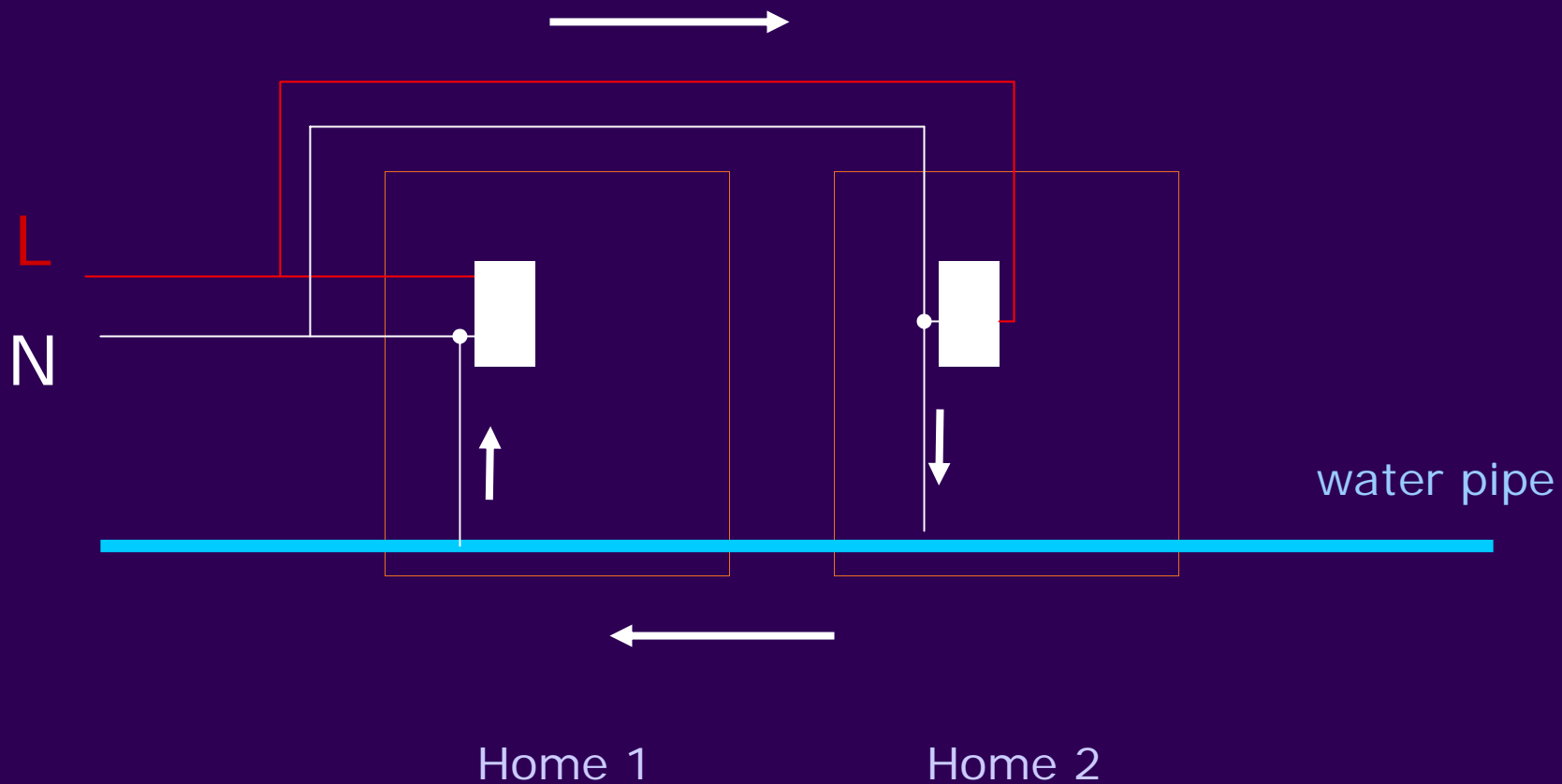
Ring main fault



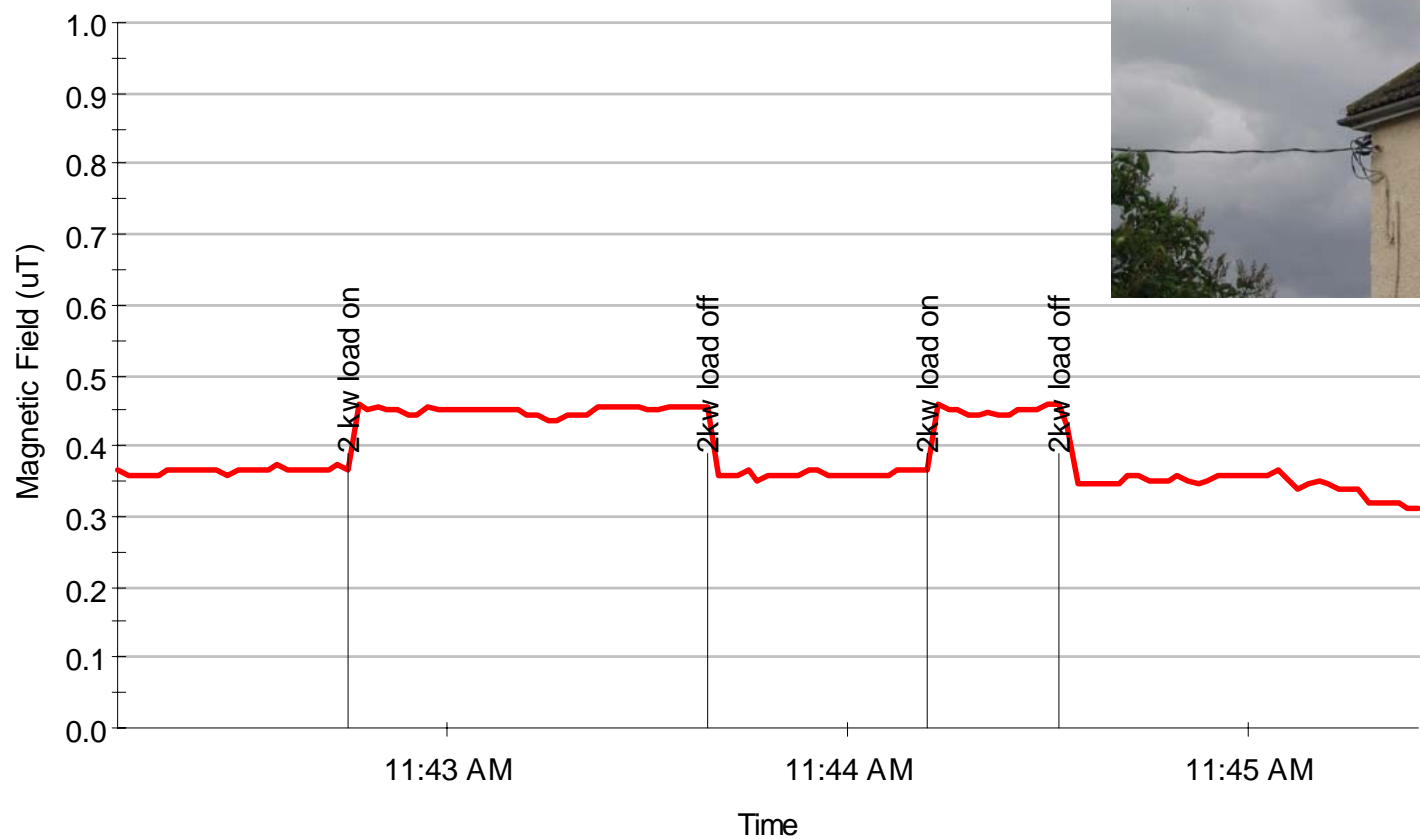
Ring main fault



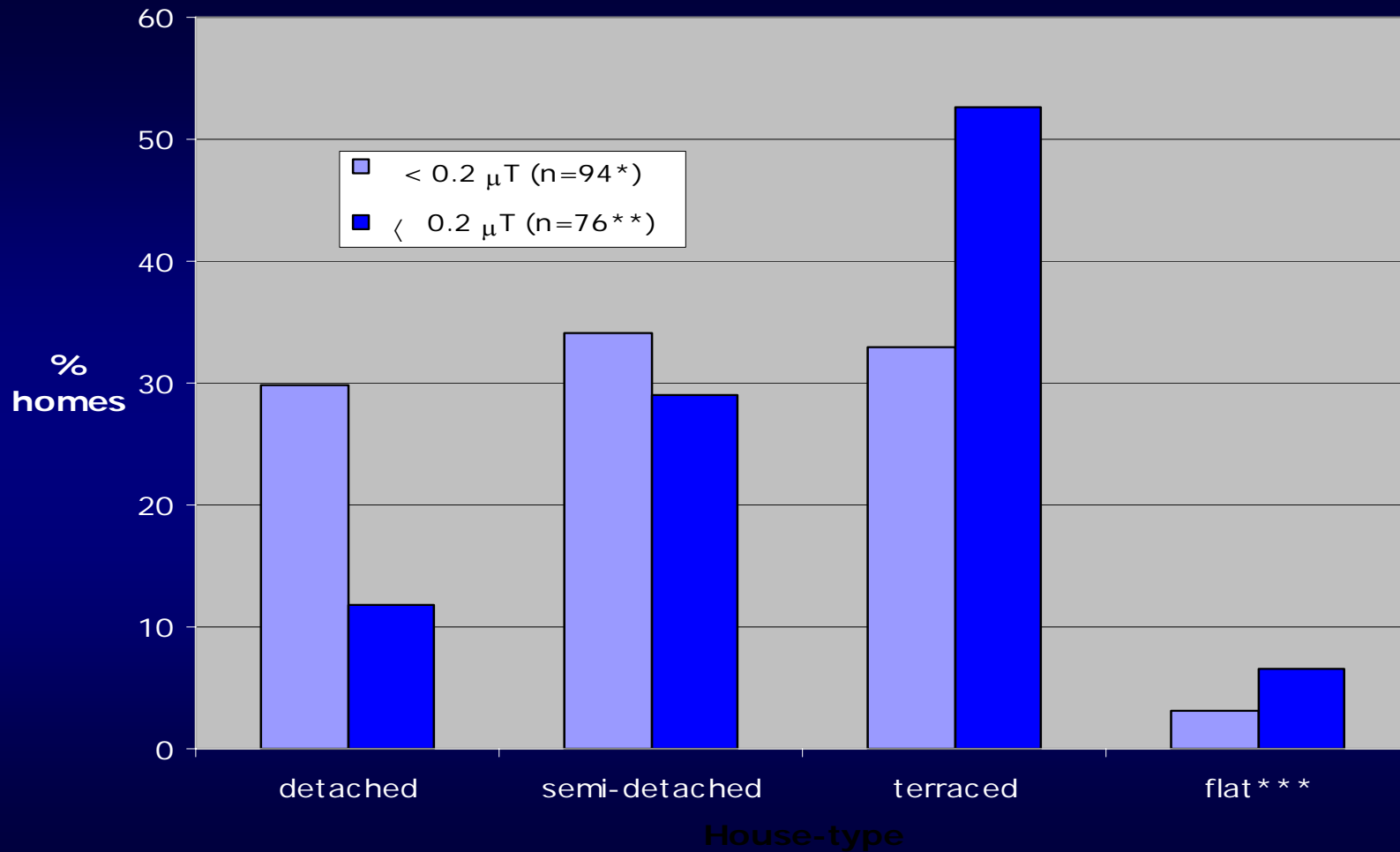
Shared service cable



Shared service cable



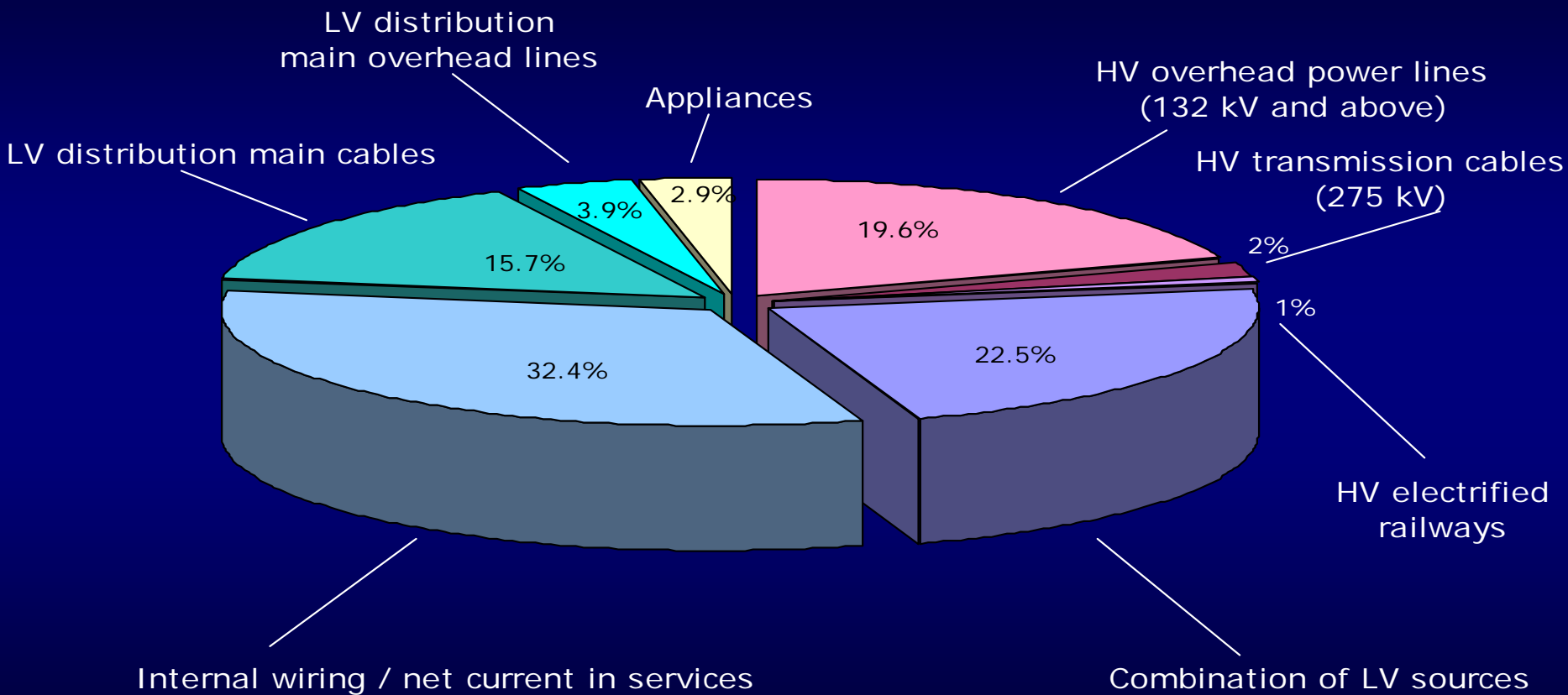
House type and exposure



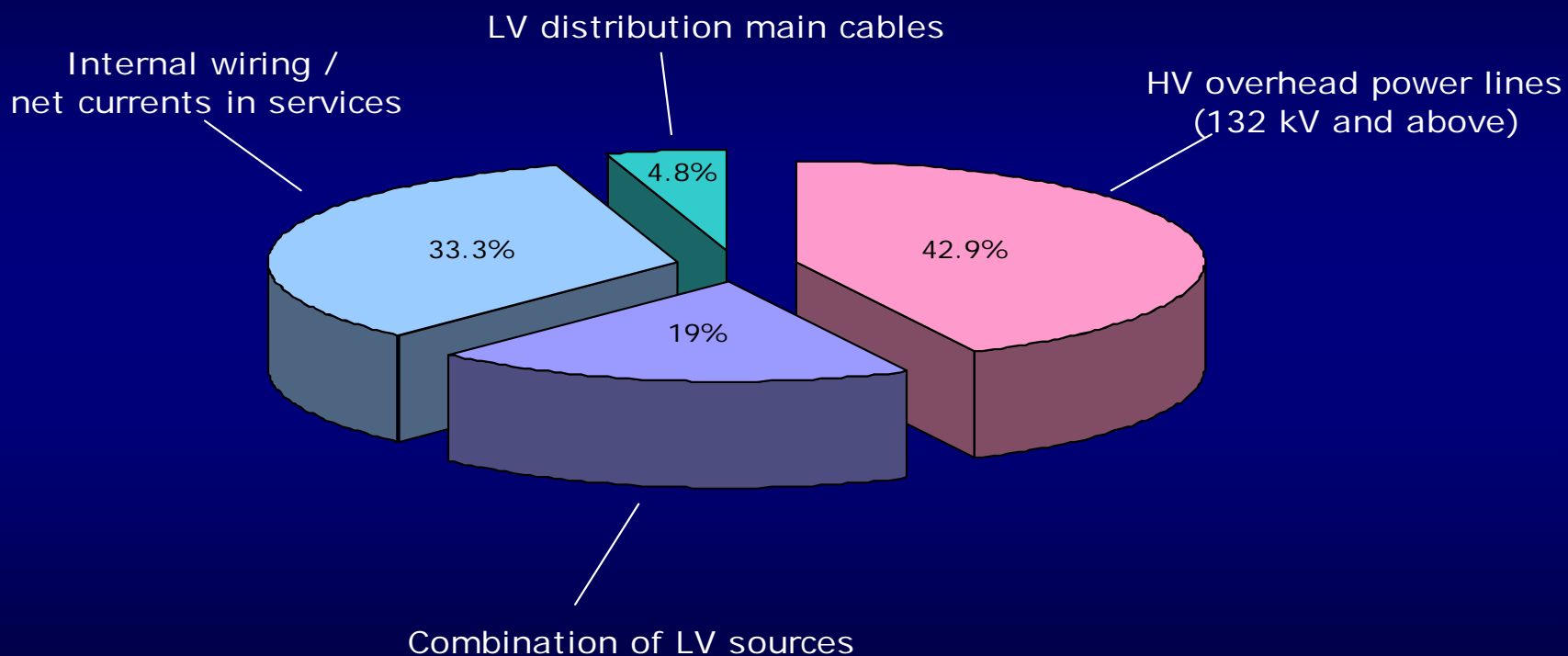
Source evaluation



Sources of exposure at $0.2\mu\text{T}$ and above (n= 102)



Sources of exposure at $0.4 \mu\text{T}$ and above (n= 21)



Low voltage sources

Inside the home

Relocation of appliances (voluntary measure)	5%
Changes to design of appliances	5%
Improving wiring / service installation	55%

Outside home

Using cables rather than overhead lines	9%
Laying cables further from homes	34%
Reduce net currents	34%

Maximum impact estimated as percentage of population removed from TWA fields at or above $0.2 \mu\text{T}$

High voltage sources

HV Distribution (11- 66 kV)

Bury power lines	Minimal impact
Routing lines away from homes	Minimal impact
Site substations away from homes	Minimal impact

HV Transmission (132 kV and above)

Routing cables away from homes	2%
Burying power lines	20%
Other overhead line options	20%

Maximum impact estimated as percentage of population removed from TWA fields at or above $0.2 \mu\text{T}$

- The most effective measure in reducing population exposure above $0.2 \mu\text{T}$ is improving the wiring and restricting net currents in the local LV supply to the home
- If magnetic field exposure is the relevant risk factor, then measurement-based approaches will be necessary to identify the exposed groups

Acknowledgements



- The UKCCS Management Committee
- Epidemiology and Genetics Unit at the University of York
- The HPA RPD staff volunteers
- National Grid Transco and UK Electricity Industry
- UK Department of Trade and Industry Steering Group

