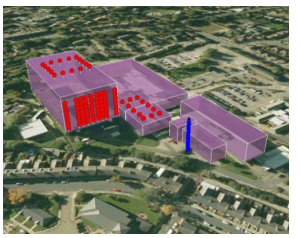
Dispersion modelling of small CHP and boilers in urban areas



Catheryn Price

APRIL Emissions Modelling and Measurements sub-group meeting

21st March 2013

GLA, London

CERC Cambridge Environmental Research Consultants
Environmental Software and Services

Contents

- Modelling biomass/CHPs/district heating - overview
- Issues for dispersion modelling
- Representing an urban area in ADMS
- Buildings effects in ADMS
- Example modelling studies

Overview

- Note: This talk is from the point of view of a consultant using ADMS (also training and helpdesk), not as a model developer

- Increasing installation of 'small' CHP/biomass/district heating in urban areas, including London
- Relatively large 'energy centres' built on large building complexes (schools, colleges, hospitals) in an urban situation
- Use of ADMS 5 in urban areas - previously unusual combination
  - Stack dispersion is key
    - Stack downwash effects
    - Building effects
  - Usually no modelling of roads required (it's the buildings module, not the street canyon module that's key)

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Some issues for dispersion modelling

- Tend to be amongst sensitive receptors, in built-up areas
  - Need to account for urban topography
  - Modelling of buildings always required
  - Receptors can be very close to the stack and are often elevated

- Development project team often unfamiliar with air quality issues
  - Potential to miss important details, e.g. building layouts, receptors

- Have high, very spatially-variable background concentrations

- Consultancies often have separate teams doing urban and industrial modelling – this type of modelling is a hybrid

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Representing an urban area in ADMS

- Account for city in several ways:
  - Inherently through use of local met data (e.g. Heathrow)
  - High surface roughness length (r_0)
  - Set a minimum Monin-Obukhov length (L_{MO})
  - For both r_0 and L_{MO},'dispersion site' values can be set to be different to met site values
- Then only have to consider immediate buildings for explicit modelling: common approach even for industrial sites
- Only tend to include:
  - buildings nearest/attached to sources
  - and/or buildings that will have greatest effect on dispersion (tallest/largest)

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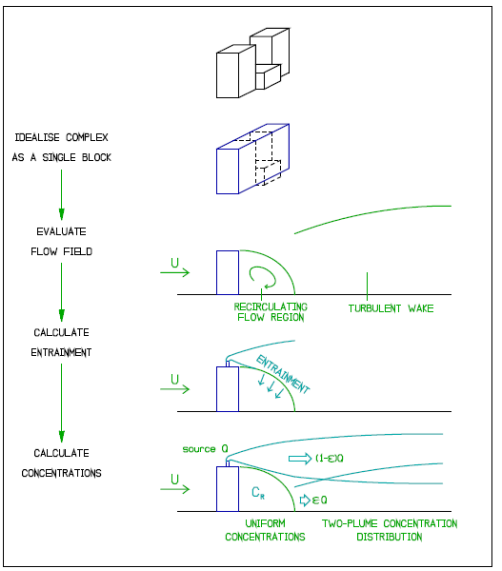
Buildings module in ADMS



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Buildings module in ADMS: Validation

- Buildings
  - CERC, 2011: *AGA experiment.* (.pdf, <1MB)
  - CERC, 2011: *Alaska North Slope tracer study.* (.pdf, <1MB)
  - CERC, 2011: *Bowline point site.* (.pdf, <1MB)
  - CERC, 2011: *EOCR study.* (.pdf, <1MB)
  - CERC, 2011: *Lee power plant wind tunnel study.* (.pdf, <1MB)
  - CERC, 2011: *Millstone nuclear power plant.* (.pdf, <1MB)
  - CERC, 2011: *Robins and Castro wind tunnel experiments.* (.pdf, <1MB)
  - CERC, 2011: *Snyder wind tunnel experiments.* (.pdf, <1MB)
  - CERC, 2011: *Warehouse fires wind tunnel experiments.* (.pdf, <1MB)
- Buildings & complex terrain
  - CERC, 2011: *Baldwin power plant.* (.pdf, <1MB)
  - CERC, 2011: *Martins Creek steam electric station.* (.pdf, <1MB)
- Complex terrain
  - CERC, 2011: *Clifty Creek power plant.* (.pdf, <1MB)
  - CERC, 2011: *Hogback Ridge tracer experiments.* (.pdf, <1MB)
  - CERC, 2011: *Lovett power plant.* (.pdf, <1MB)
  - CERC, 2011: *Tracy power plant.* (.pdf, <1MB)
  - CERC, 2011: *Westvaco corporation.* (.pdf, <1MB)
- Flat terrain
  - CERC, 2011: *Kincaid, Indianapolis and Prairie Grass experiments.* (.pdf, 1MB)

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Buildings module in ADMS: Extra information

- There are model output files that help in the understanding and checking of building effects assumptions and calculations (useful for sensititvity tests):
  - The dimensions of the effective building assumed for each wind direction
  - The region affected by the presence of the modelled buildings
  - The dimensions of the building recirculation region (cavity)
  - The residence times of the pollutants within the cavity
  - The fraction of pollutant entrained into the cavity
  - The concentration of the pollutants in the cavity
  - A description of the flow (e.g. whether the flow remains separated, or reattaches)

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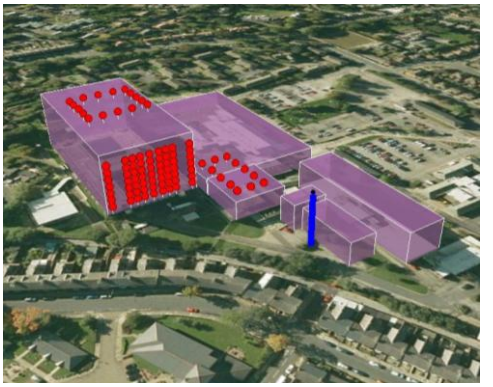
Example modelling study

- Modelling of emissions from a proposed energy centre on a hospital site, including CHP
- Sensitive receptors:
  - in nearby residential areas
  - within the hospital buildings
- Included a stack height assessment



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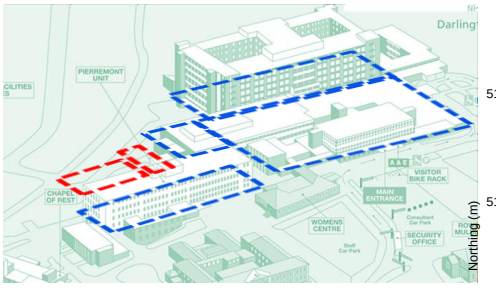
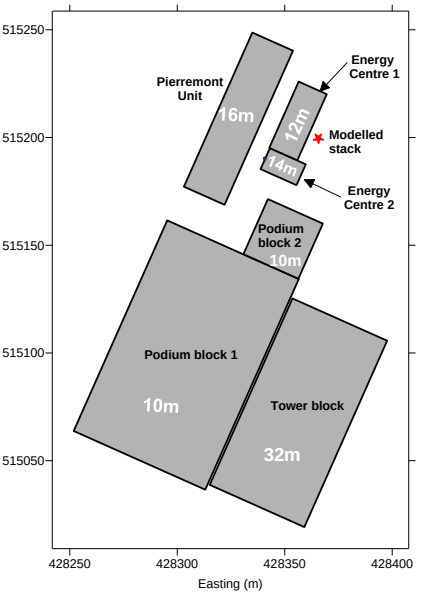
Modelled buildings for residential receptors





- Stack height = 27m
- These buildings were modelled for the gridded output
- Different approach used for hospital receptor output

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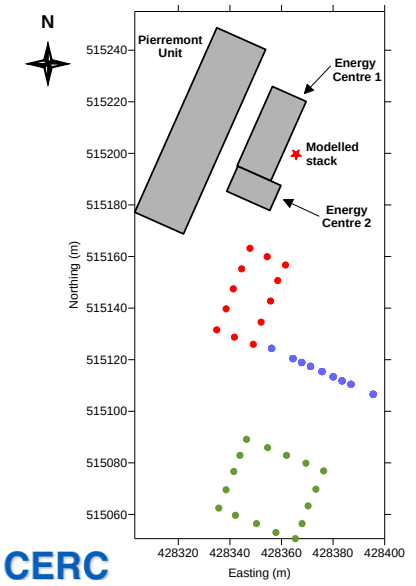
Modelled buildings for elevated receptor points



- Tower block facade
  - 7 different heights
  - From 2m to 24m above ground level
  - Represent windows
- Tower block plant
  - All at 34m above ground
  - Represent air intake vents
- Theatre plant room
  - All at 10m above ground
  - Represent air intake vents

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Accounting for background concentrations

- How to account for ‘process contribution’ (PC) plus background?
- Could model the surrounding roads, etc
  - but usually impractical
- Can report the PC values
  - Others can then ‘add’ this PC to any existing contour maps
- Can use planning guidance from Environmental Protection UK*
  - Includes a section on descriptors for the impacts of a development
  - Impacts can be described based on PC values (without explicitly accounting for the background concentrations)

**Development Control: Planning for Air Quality (2010 Update)*

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Example: Annual mean NO_2 over ground level grid

Magnitude of change	Annual mean increase
Large	> 4 µg/m³
Medium	2 - 4 µg/m³
Small	0.4 - 2 µg/m³
Imperceptible	< 0.4 µg/m³

Max NO_2 = 1.6 µg/m³

Background concentration ??

Absolute Concentration in relation to Objective	Change in concentration		
	Small	Medium	Large
Above (> 40 µg/m³)	Slight Adverse	Moderate Adverse	Substantial Adverse
Just below (36 - 40 µg/m³)	Slight Adverse	Moderate Adverse	Moderate Adverse
Below (30 - 36 µg/m³)	Negligible	Slight Adverse	Slight Adverse
Well below (< 30 µg/m³)	Negligible	Negligible	Slight Adverse

At worst = 'Slight Adverse' impact
Likely = 'Negligible' impact

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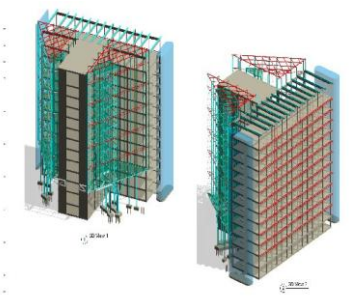
Another example: St. Thomas' Hospital

- CERC modelled a radioactive release from St. Thomas' Hospital
- Radionuclides are produced for the PET Centre
- Plans to fit cladding to one of the buildings
  - Concerns about changes to the aerodynamic properties of an existing discharge point



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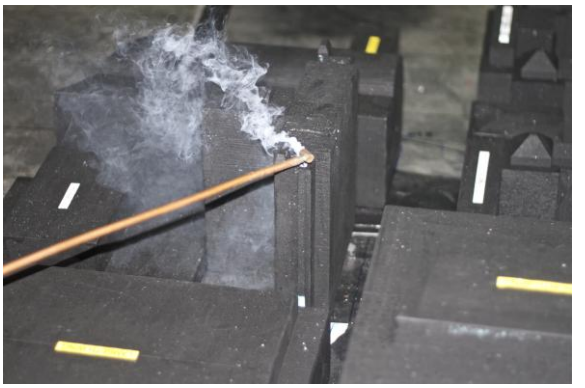
Wind tunnel modelling

- Wind tunnel modelling was carried out
- At Enflo, University of Surrey
- Modelled different stack heights and meteorological conditions



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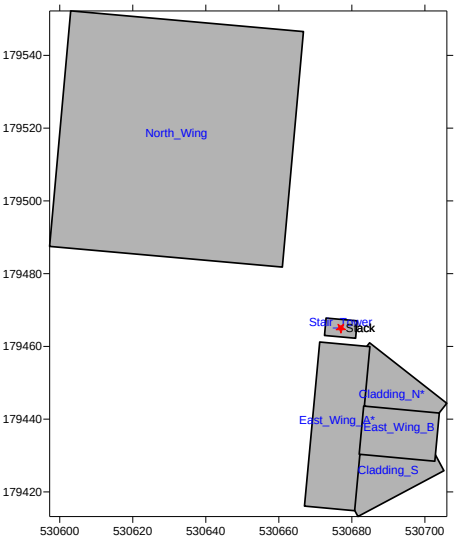
ADMS modelling



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Some final thoughts

- Sensitivity tests – try it!
- Communication
- Question all data and information provided
- Combine industrial and urban modelling skills and experience
- Background data – is an average value reasonable?
  - Roads
  - Car parks
  - Other hot-spots?

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Thank you.

Any questions?

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