



**Towards a Sustainable Urban Environment (SUE)**

# **Considering Uncertainty in Sustainability Assessment**

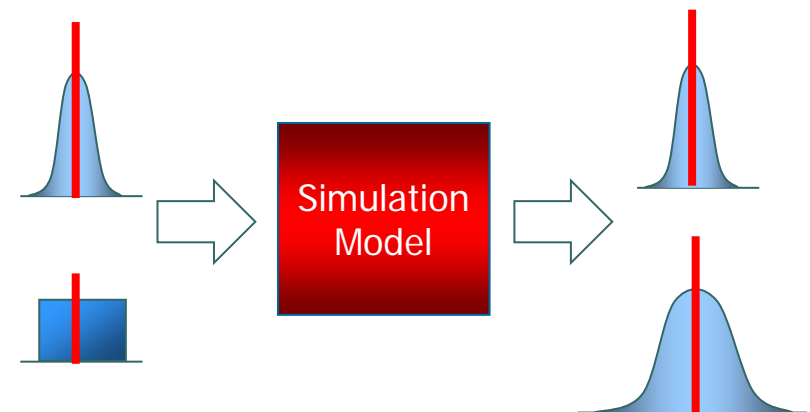
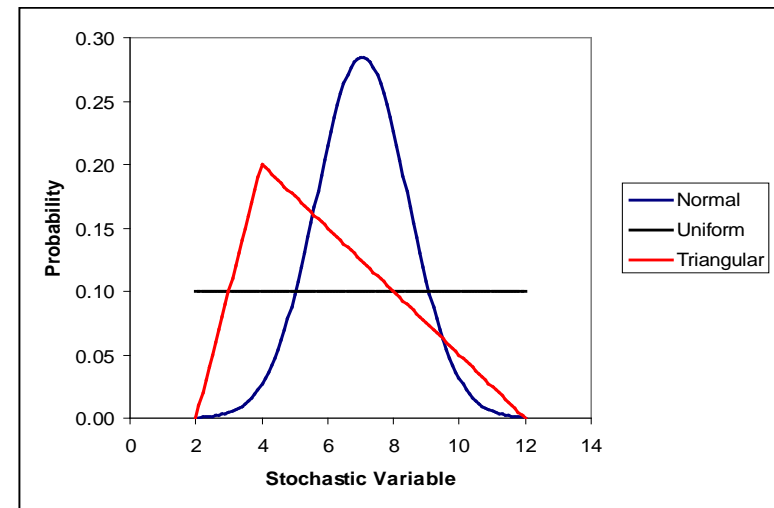
**PurE launch event 24<sup>th</sup> June 2009**

# Outline

- Overview of uncertainty and MCDA analysis
- Description of case study
- Dealing with uncertainty
- Multi-criteria decision analysis
- Conclusions

# Uncertainty in decision making

- Uncertainty exists in:
  - Data/models/knowledge
  - Decision making process itself
  
- Uncertainty analysis
  - Identification
  - Characterisation
  - Quantification
  
- Robust solution(s)



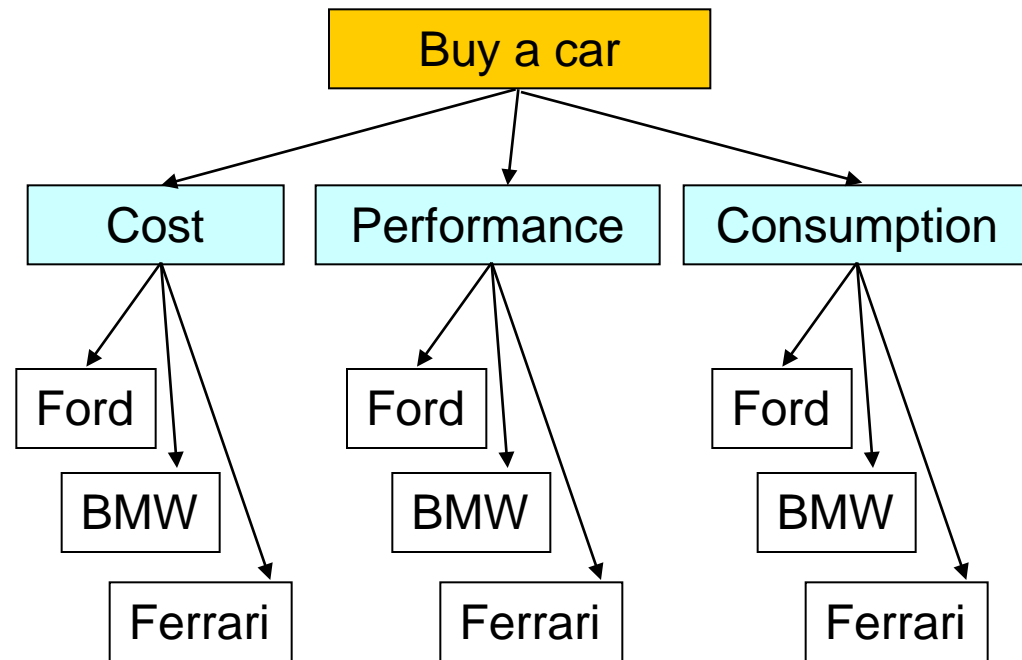
# Multi-criteria decision analysis

- Choose best option based on multiple criteria
- Input:
  - Impact matrix
  - User preferences
- Result
  - Ranked list of options
- Large number of methods available

Criteria	Cost (£K)	Performance (acc. in sec)	Consumption (mpg)
Options			
Ford	20	10	40
BMW	40	5	45
...			
Ferrari	120	3	20

# Analytical hierarchy process

- Problem decomposed into a hierarchy of sub-problems
- Pairwise comparisons
- Method used widely



**Solution Explorer**

- Problem Definition
  - Qualitative Description
  - Decision Criteria Selection
  - Pathway Selection
- Scenario A
- Scenario B
- Multi Criteria Decision Analysis
  - Sustainability Indicators

## Multi Criteria Decision Analysis - Sustainability Indicators

Overview Analysis 1 Analysis 2 Analysis 3

MCDCA Analysis: Analysis 3

Description:

Goal:

**Analytic Hierarchy Process**

In the context of your goal above, please select the indicators that you wish to base this MCDA analysis on. Then rate their relative preference using the pairwise comparisons.

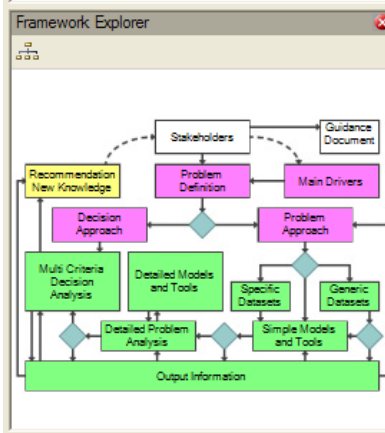
**Indicators**

- Human Health Impact - Morbidity
- Life Cycle Toxicity - Human
- Human Health Impact - Mortality

**Run Analytic Hierarchy Process**

Rank	Scenarios	Score
1	Scenario A (Unnamed Scenario)	0.34...
2	Scenario B (Unnamed Scenario)	0.81...

Consistency Index:



**Framework Help**

home index search

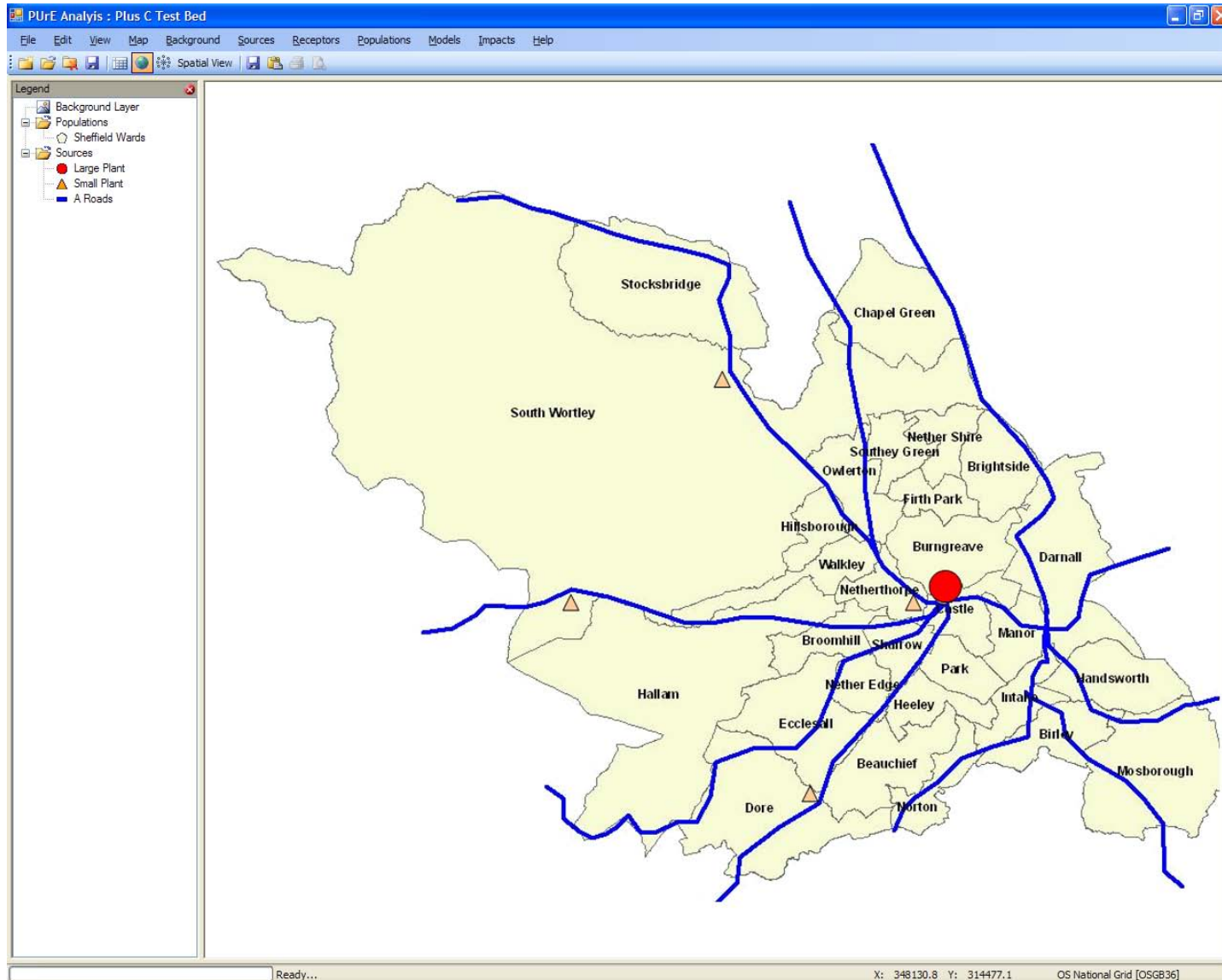
## Welcome to the PUrE Knowledge Base

Here you will find a large number of articles providing information on a wide range of subjects including various models and tools, organisations and theories. To get started click on either the index tab above for an alphabetical list of all the articles within the knowledge base or on the search tab to search for an article on a specific subject.

# Case study: MSW treatment



# GIS mapping in PUrEView





# Air dispersion modelling: Input data



- **Emissions**

- **Transport**

- **Stack heights**

- **Pollutant Emission rates**

- **Meteorology**

- **Statistical weather data**

# Air dispersion modelling

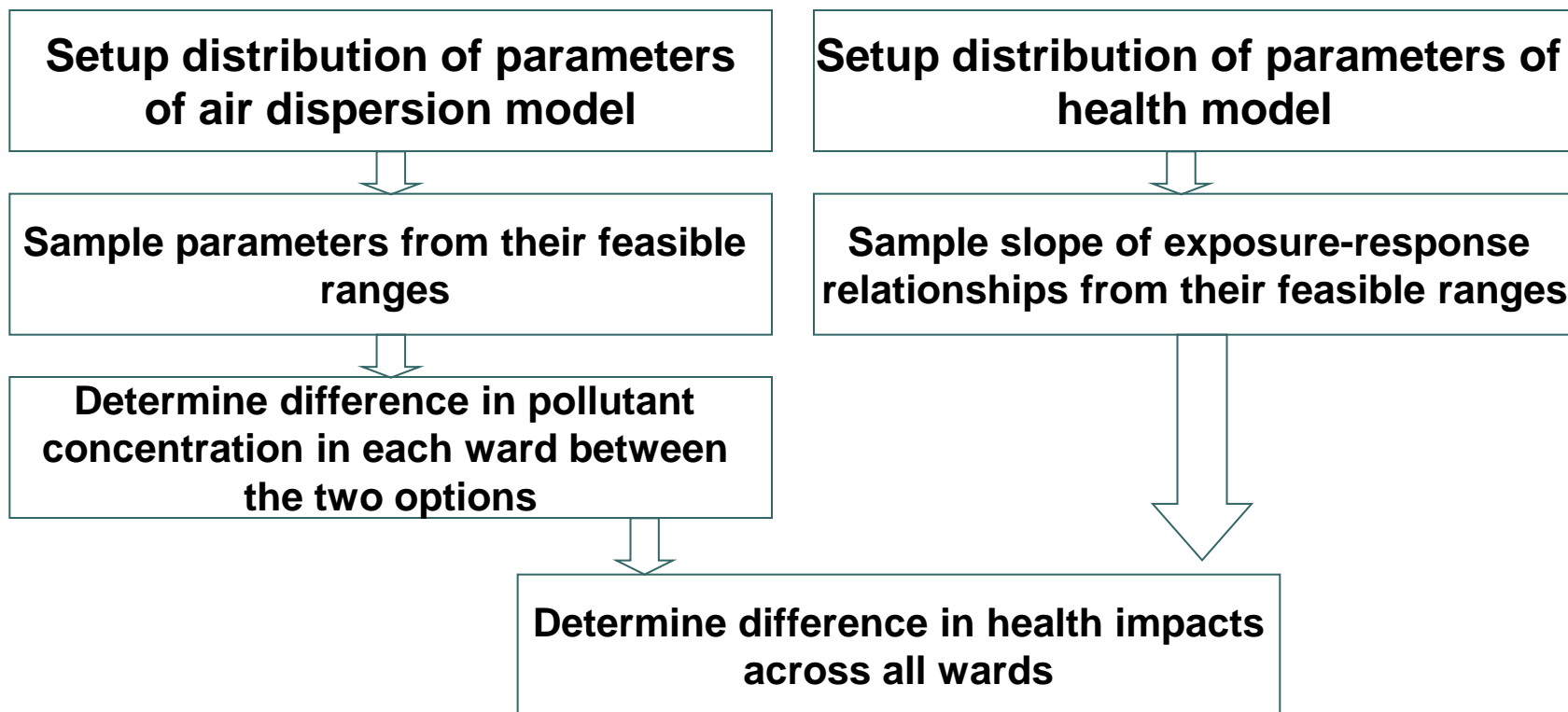


- Step 1. Characterise the uncertain dispersion parameters
  - Emission scenarios
  - Meteorological conditions
- Step 2. Sample parameters from defined ranges
- Step 3. Run the model with sampled parameters
- Step 4. Characterise and quantify the uncertainty in the pollutant outputs

# Health impact estimation

- Take modelled changes in pollution
- Map them to population distribution
- Estimate health impacts by ward including mortality and morbidity impacts
- Calculate change in events by option
- Sum across wards in community

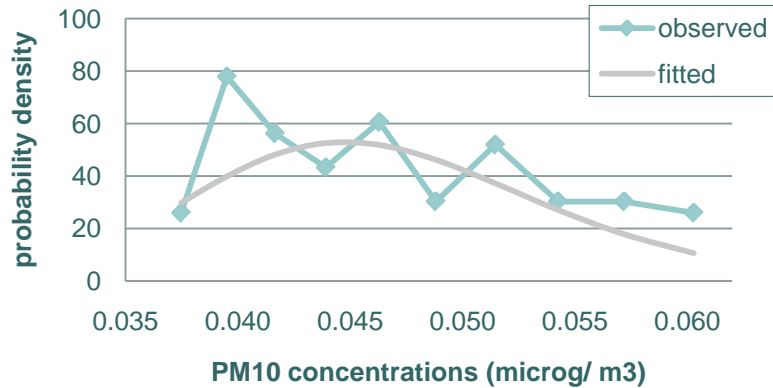
# Propagation of uncertainty using Monte Carlo simulations



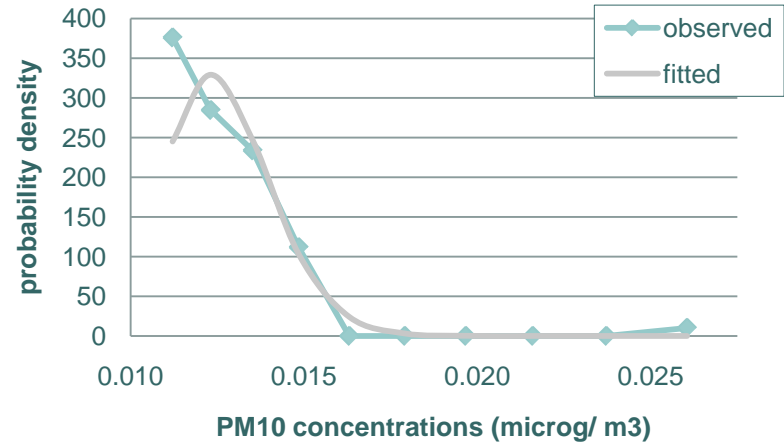
# Ward A (PM10)



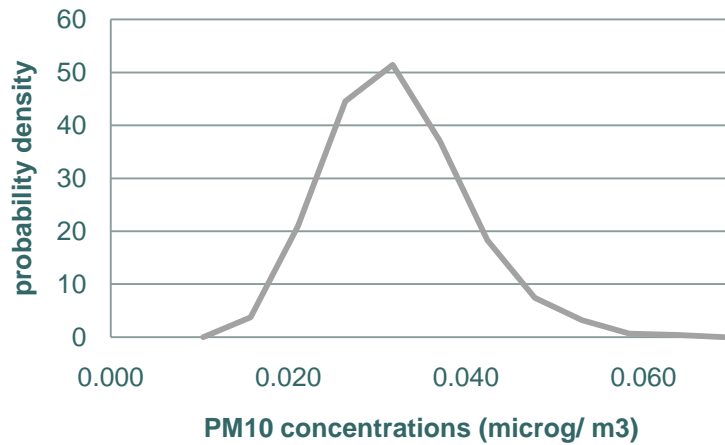
## Option 1 (Single Large Plant)



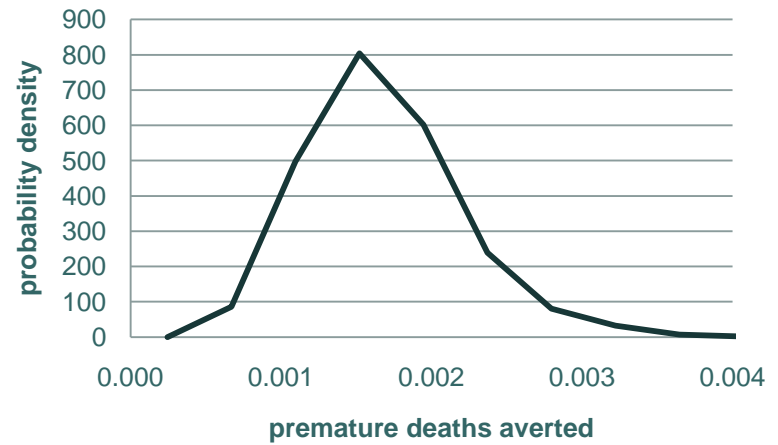
## Option 2 (4x Small Plants)



## Difference (large - 4x small)



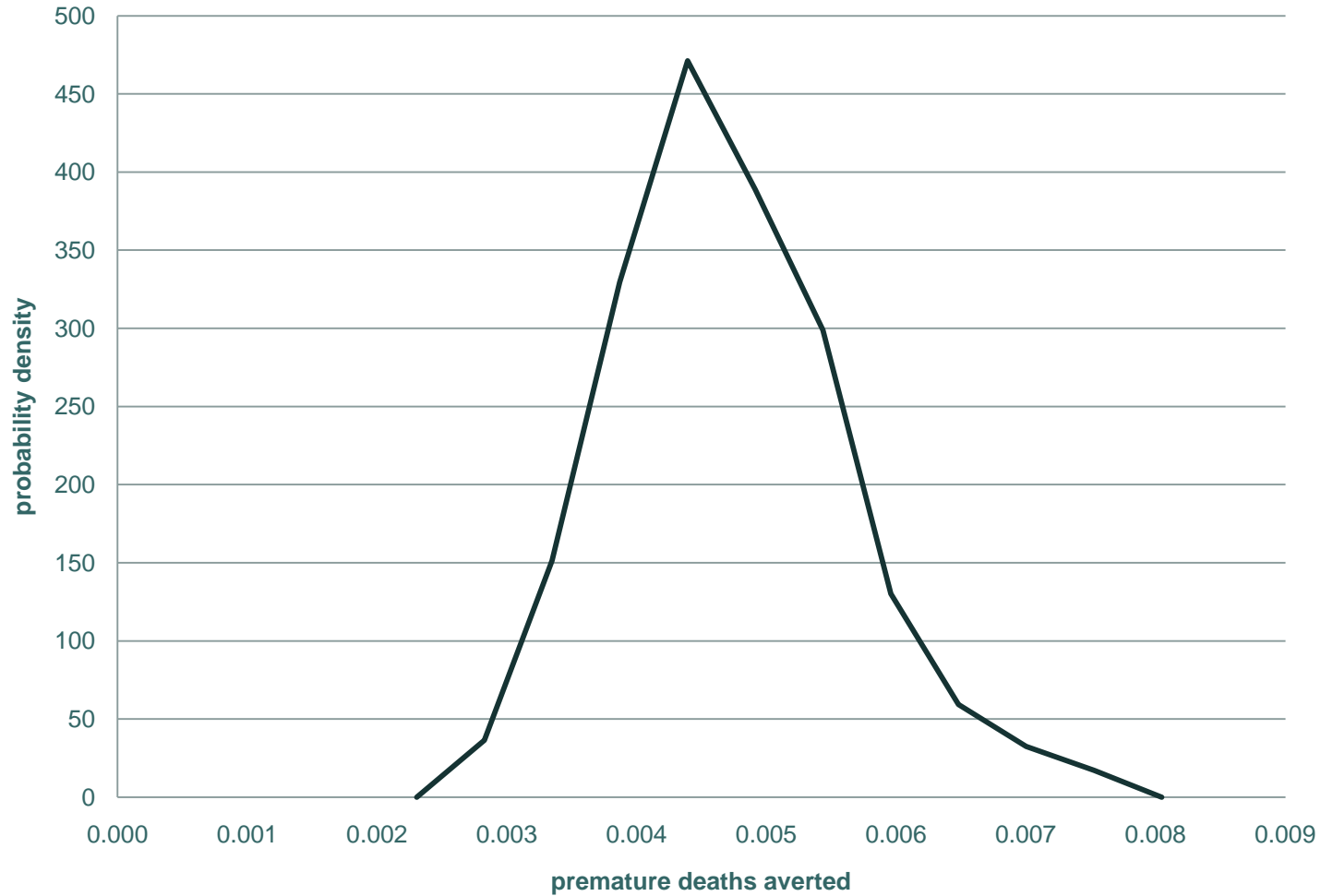
## Difference (large - 4x small)



# Total difference (PM10)



Difference (large - 4x small)



# Criteria used for comparative evaluation



Criteria	Option 1 Large plant		Option 2 4 x Small plant	
	Mean	Uncertainty (%)	Mean	Uncertainty (%)
Energy use (MJ)	315.71 kg/t MSW	-	904.57 kg/t MSW	-
Summer smog (Ethene-Equivalent)	0.07 kg/t MSW	15.54	0.03 kg/t MSW	3.45
Capital costs (for setting up plant) (one off £)	31 million	-	11 million x 4	-
Operating costs (£/tonne waste)	70	-	40 x 4	-
Traffic-related		-		-
<i>Total distance travelled (vehicle-km)</i>	546,745		587,379	
<i>Total trips (for refuse collection)</i>	17,520		78,207	
<i>Total trips (for chemical supply)</i>	3,927		3,927	

# MCDA hierarchy (AHP)

GOAL

Which option is preferred,:  
Option 1 (Large plant) or Option 2 (4 x Small plants)?

CRITERIA

Energy use  
(*minimise*)

Summer  
smog  
(*minimise*)

Traffic  
(*minimise*)

Capital  
costs  
(*minimise*)

Operating  
costs  
(*minimise*)

DECISION  
OPTIONS

OPTION 1

OPTION 2



# Pairwise comparisons in AHP

1. Equally important
2. Equally to moderately important
3. Moderately important
4. Moderately to strongly important
5. Strongly important
6. Strongly to very strongly important
7. Very strongly important
8. Very to extremely strongly important
9. Extremely important

# Results of MCDA

	Integrated Score
Option 1 (Large Plant)	0.797
Option 2 (4 x Small Plants)	0.203

# Conclusions

- The PURÉ decision support framework was used to evaluate and compare two thermal waste treatment options under uncertainty
- The uncertainty in the health impacts and the wider environmental impacts were quantified
- MCDA was used to compare the two options under a number of sustainability criteria
- It was shown that the large thermal plant was a more sustainable option