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# Quantifying the future, transport-related impacts of land use policies for Cambridge, UK

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Newcastle University**



# Research Projects

- **SOLUTIONS (Sustainability Of Land Use and Transport In Outer Neighbourhoods)**
  - Design, development and testing of city-scale land use and transport options at the neighbourhood Level
  - Case-study driven (London & South-east, Tyne & Wear, Cambridge)
  - See: <http://www.suburbansolutions.ac.uk>
- **ReVISIONS (REgional Visions of Integrated Sustainable Infrastructure Optimised for Neighbourhoods)**
  - Expansion of SOLUTIONS into the regional level
  - Include water, waste and energy sectors
  - Include air-quality (and other) transport indicators
  - See: <http://www.regionalvisions.ac.uk/ReVISIONS/Home.aspx>
- Both projects funded by UK Engineering and Physical Sciences Research Council (EPSRC)

# SOLUTIONS Scenarios (1)

- **Baseline 2001 scenario**
- **Business As Usual (Trend) scenario to 2021**
  - ◆ Existing policies extrapolated
  - ◆ Mixture of public and private transport improvements
  - ◆ Favour public transport provision over highway improvements
- **Urban Compaction to 2021**
  - ◆ High density living within existing urban footprint
  - ◆ Target central areas and public transport



# Solutions Scenarios (2)

## ■ **Market Dispersal to 2021**

- ◆ *Market-driven development at medium to low density*
- ◆ *Private transport oriented*

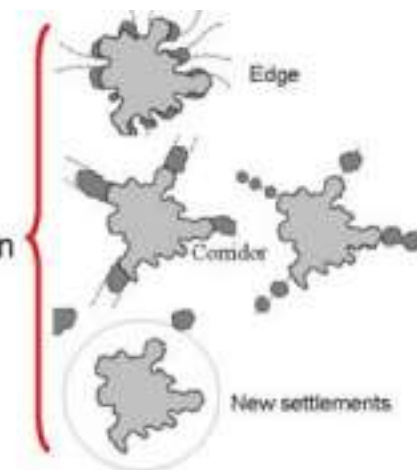
Market  
Dispersal



## ■ **Planned Expansion to 2021**

- ◆ *Planned extensions of existing developments*
- ◆ *Some new settlements*
- ◆ *Target areas with strong employment growth*
- ◆ *Mixture of public and private transport provision*

Planned  
Expansion



## ■ **Road User Charging (RUC) to 2021**

# Cambridge Region

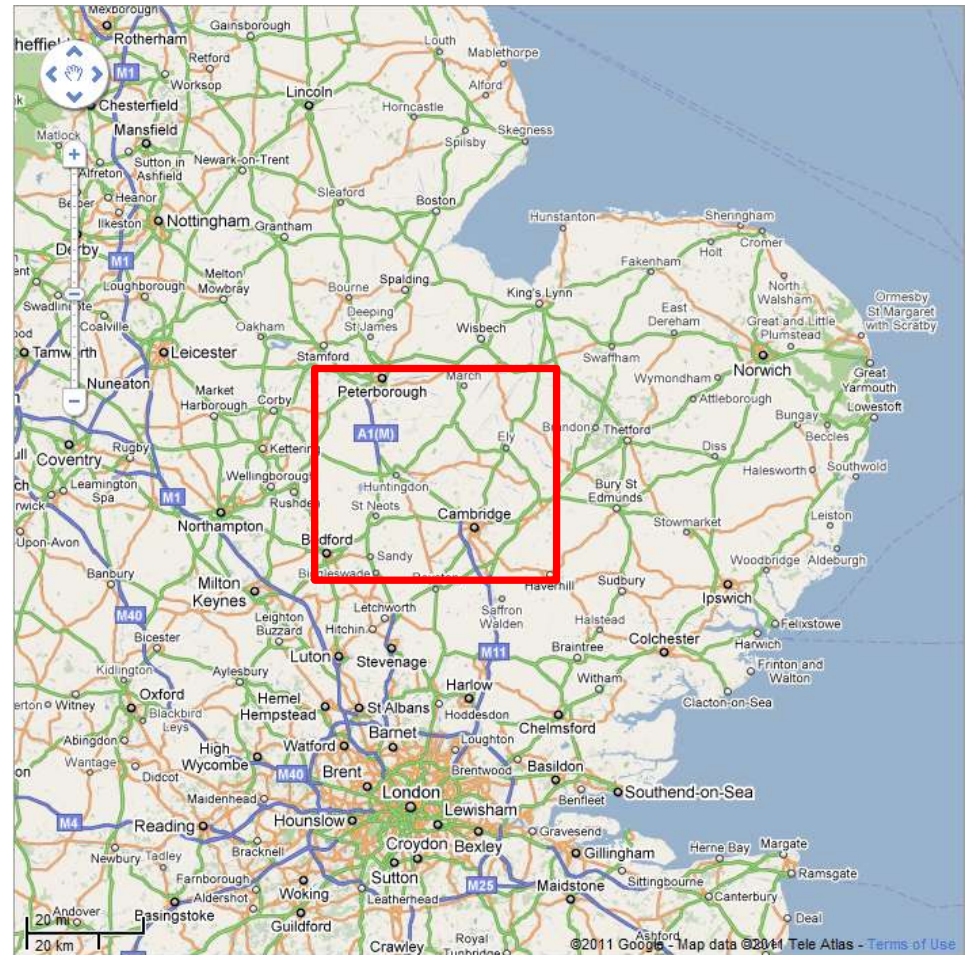
## Cambridgeshire, UK

- *Situated: 50km NNE of London*
- *Area: 3,389 km<sup>2</sup>*
- *Population: 770,000 (2001 Census)*
- *Population density: 227 / km<sup>2</sup>*
- *County town: Cambridge*

## Cambridge

- *Area: 116 km<sup>2</sup>*
- *Population: 108,863 (2001 Census)*
- *Famed for 2<sup>nd</sup> oldest University in the English-speaking World*
- *Population includes: 22,000 students*
- *Recent growth in high-tech industries*

(Sources: UK Office for National Statistics, Cambridgeshire.gov.uk, and Wikipedia)



(Sources: Google Maps, Tele Atlas)

# Current Situation

## UK Targets for CO<sub>2</sub> reduction

- 34% reduction by 2020 on 1990 levels
- 80% reduction by 2050 on 1990 levels

## Cambridge AQMAs

- Cambridge City Centre and Cambridge-Huntingdon Corridor
- 7 areas declared for NO<sub>2</sub> and 1 for PM<sub>10</sub>
- Cambridge (and UK-wide) issues with calculated NO<sub>2</sub> concentrations not matching expected reductions
- UK as a whole likely to be fined by the EU for not meeting AQ targets – Central government likely to pass fines on to local authorities

(Sources: [Cambridgeshire.gov.uk](http://Cambridgeshire.gov.uk) – Local Transport Plan 3, Images: [traveladvisor.co.uk](http://traveladvisor.co.uk) and [Cambridgeshire County Council](http://Cambridgeshire County Council))



# MODELLING TOOL



# PITHEM (Platform for Integrated Traffic, Health and Emission Modelling)

Traffic Modelling

```
graph TD; A[Traffic Modelling] --> B[Emission Modelling and Mapping]; B --> C[Dispersion Modelling and Mapping]; C --> D[Health Modelling];
```

The diagram illustrates a four-stage process. It begins with 'Traffic Modelling' in a gold bar, followed by 'Emission Modelling and Mapping' in a grey bar, then 'Dispersion Modelling and Mapping' in a dark grey bar, and finally 'Health Modelling' in a green bar. Each stage is connected to the next by a downward-pointing arrow.

Emission Modelling and Mapping

Dispersion Modelling and Mapping

Health Modelling

### Map Control

Select a Network Year and Scenario

Network Year: 2005 Network with East Leeds Radial

Scenario: AM Peak

---

View SATURN/Roadfac

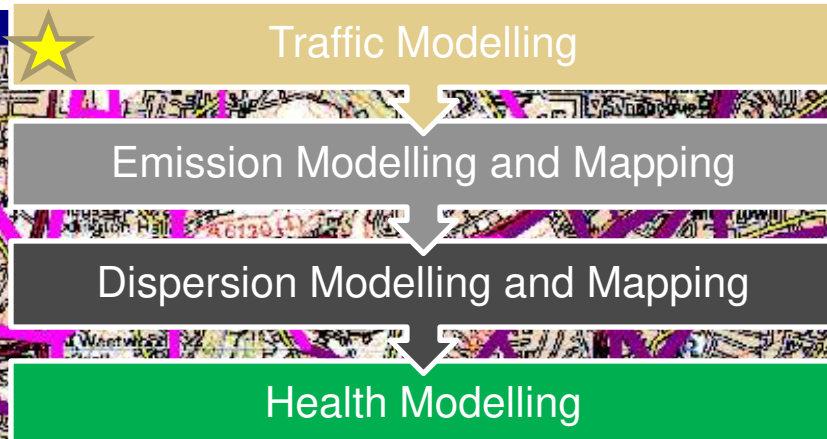
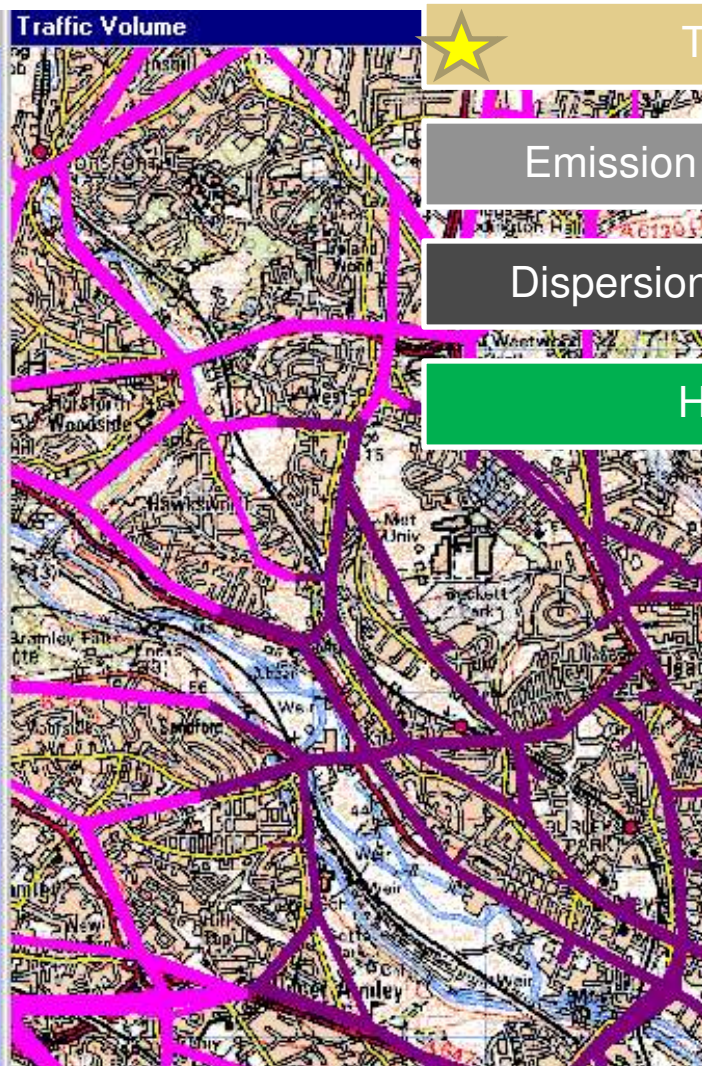
---

Select a variable to Map

CO   
 NOX   
 VOC   
 PM10

---

Map Toolbox



#### Legend

Traffic Flows on Buffer Links  
pcu/hour - ROADFAC

- 4,000 to 8,000 (9)
- 2,000 to 4,000 (105)
- 1,000 to 2,000 (130)
- 500 to 1,000 (121)
- 250 to 500 (47)
- 100 to 250 (31)
- 0 to 100 (13)

Traffic Flows on Simulation Links  
pcu/hour - ROADFAC

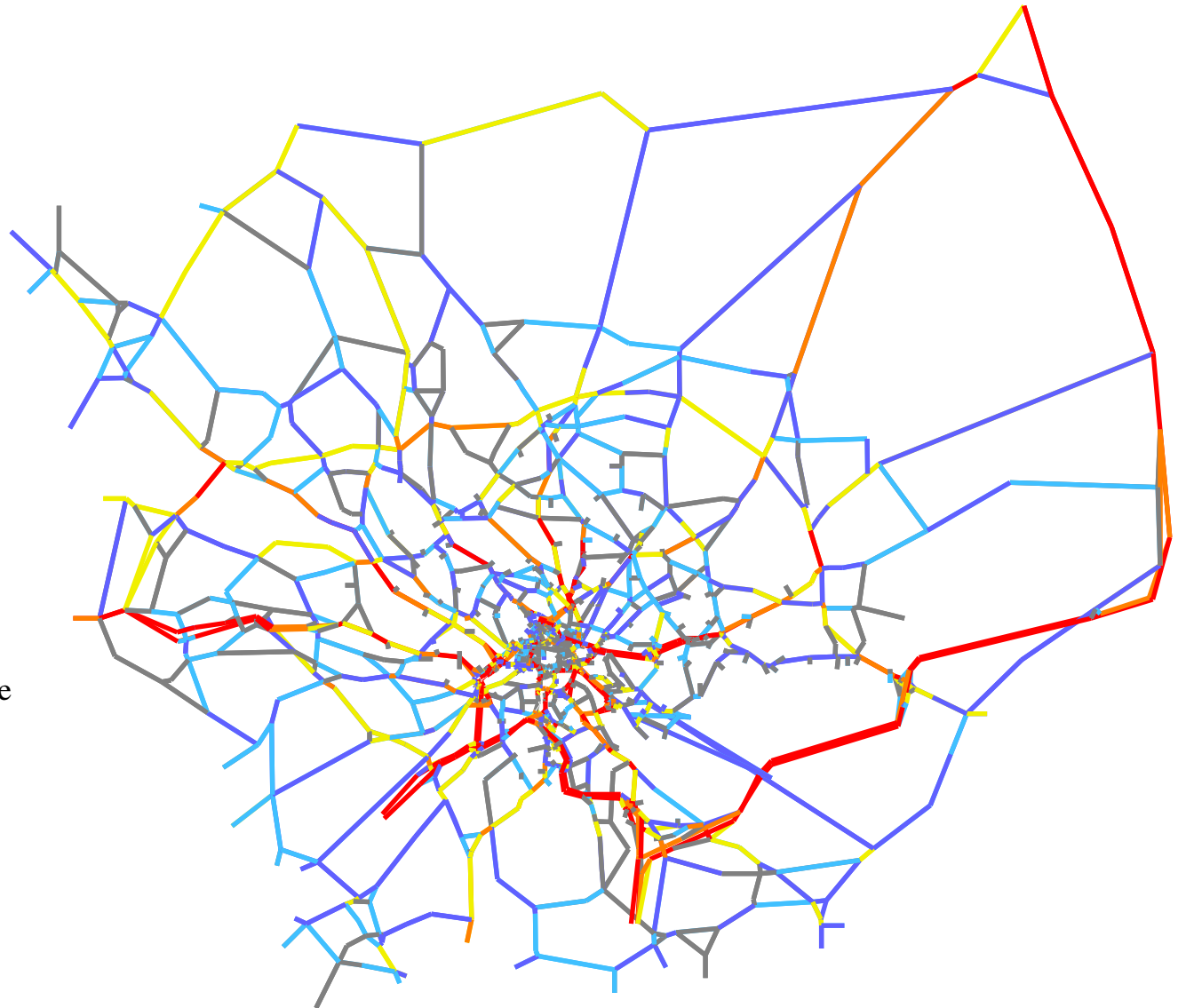
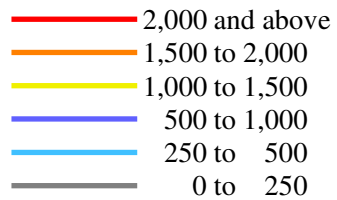
- 4,000 to 8,000 (17)
- 2,000 to 4,000 (237)
- 1,000 to 2,000 (419)
- 500 to 1,000 (328)
- 250 to 500 (214)
- 100 to 250 (179)

#### Table Window - Simulation Links

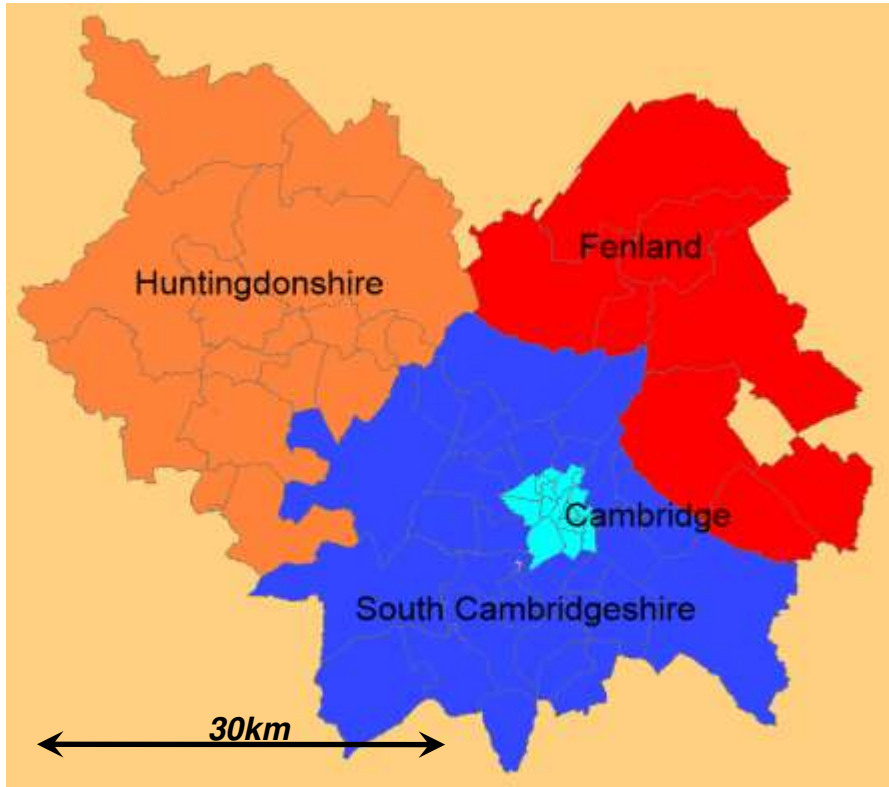
	Id	ABnodes	Flows	Speed	Petrol	Diesel	CO	NOx	VO
<input type="checkbox"/>	1	41330532	3,728.78	119.7	170,808.07	63,067.65	61,907.99	9,966.51	
<input type="checkbox"/>	2	54050532	796.97	10	38,812.55	14,484.67	25,681.94	1,213.06	
<input type="checkbox"/>	3	18360532	4,483.41	73.74	135,887.67	66,681.51	53,850.33	7,956.45	
<input type="checkbox"/>	4	53190598	1,648.47	62.58	49,363.64	24,321.28	18,683.96	2,882.35	
<input type="checkbox"/>	5	30651000	375.37	10	22,516.83	7,359.15	16,670.49	563.57	

# Vehicle flows (PCU/hr)

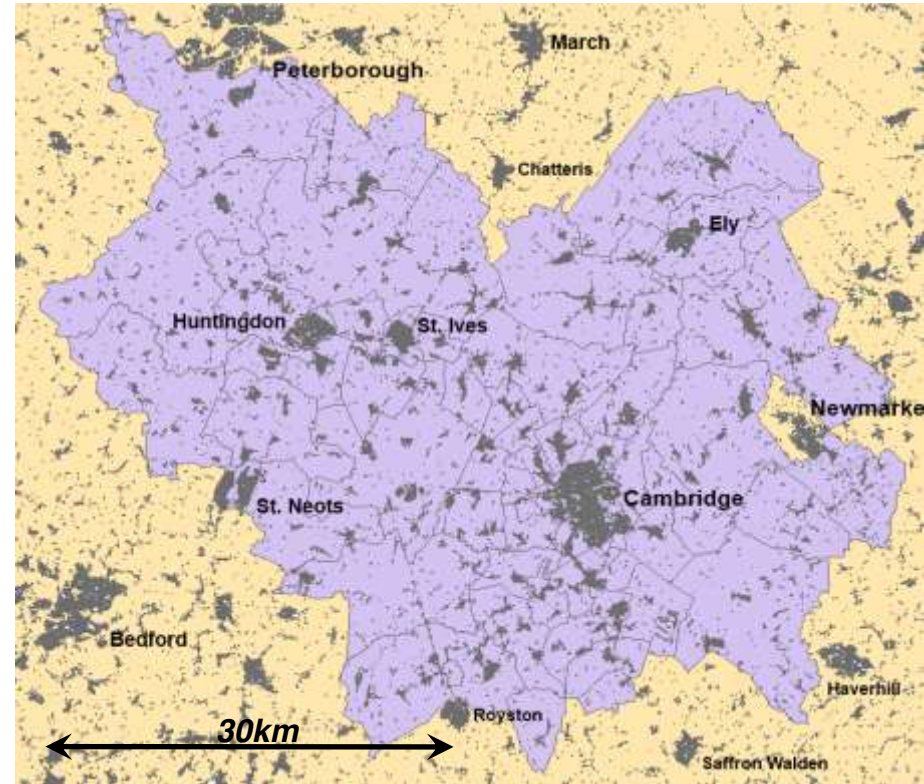
2005 Do Min Zero Charge  
Flows (PCU)



# LUTI Model Zones

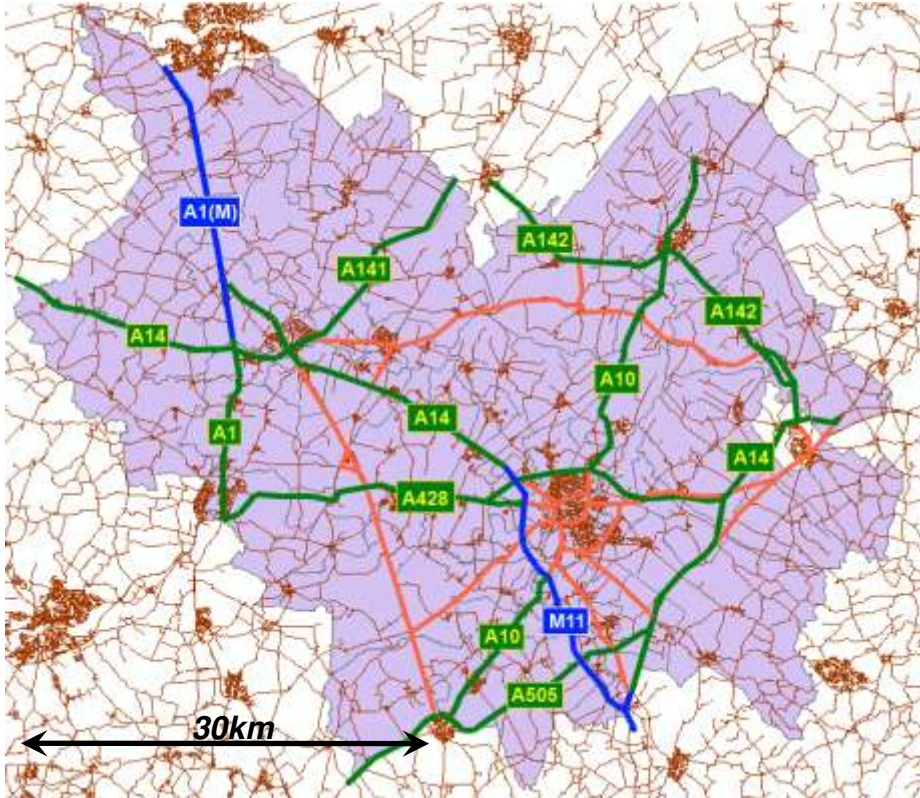


**67 Internal Zones in 4 Administrative areas**  
14 Zones in Cambridge City  
10 External Zones for rest of UK



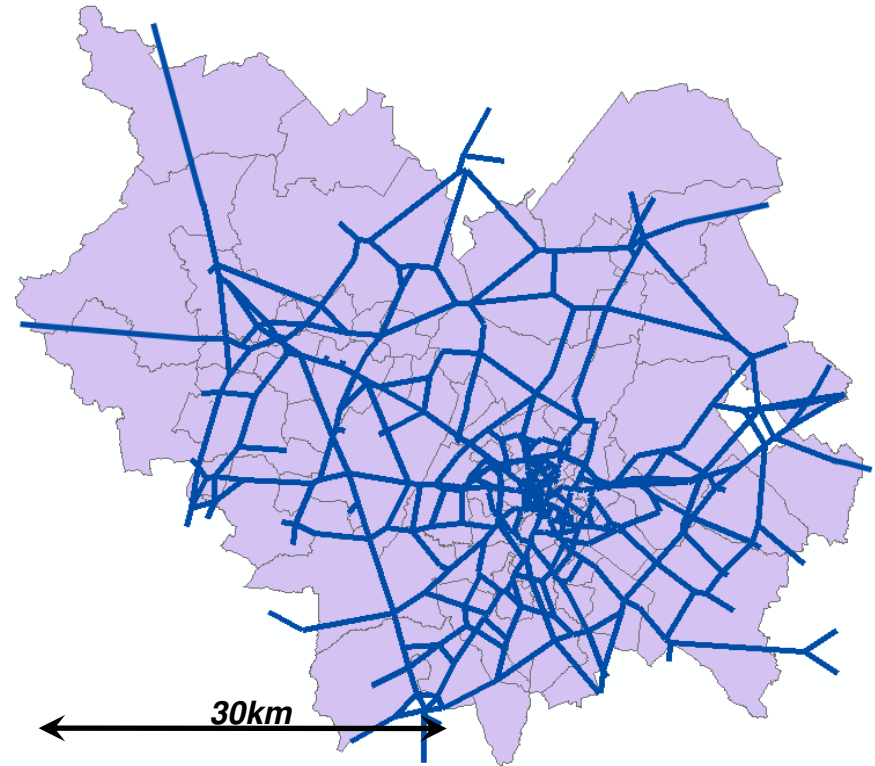
**Major built-up areas in grey**  
Peterborough UA (NW) : pop. 160,000 (2001)  
Bedford (WSW) : pop. 147,000 (2001)  
Other towns : pop. 7,000 – 26,000

# Road Transport Network



## **Actual Road Network:**

Motorway (Blue), Primary 'A' Roads (Green),  
Secondary 'B' Roads (Brown), Other (Red)



## **Modelled Road Network:**

SATURN Software

(<https://www.saturnsoftware.co.uk/7.html>)

# Emissions Modelling (1)

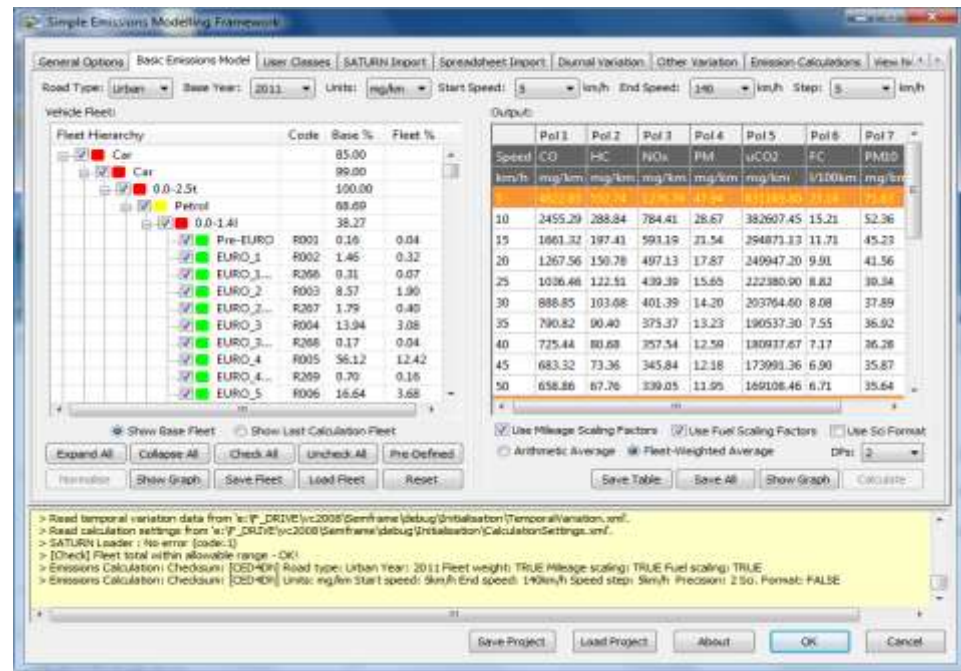
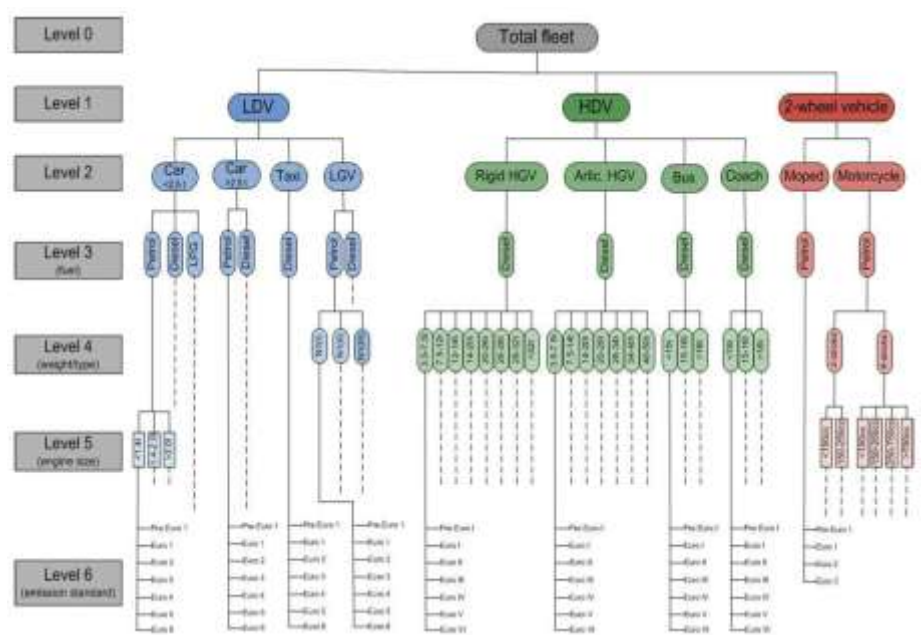
- ***Based on UK emissions inventory***

- *Speed-emissions curves* (Source: DfT/TRL, 2009 – Regulated Emissions, AQEG, 2005 – Particulate Matter)
- *Hierarchical model of vehicle classes* (Source: TRL, 2009)
- *Fleet Projections from 1996 to 2026* (Source: DfT/AEAT, 2009 – National Fleet Projections)

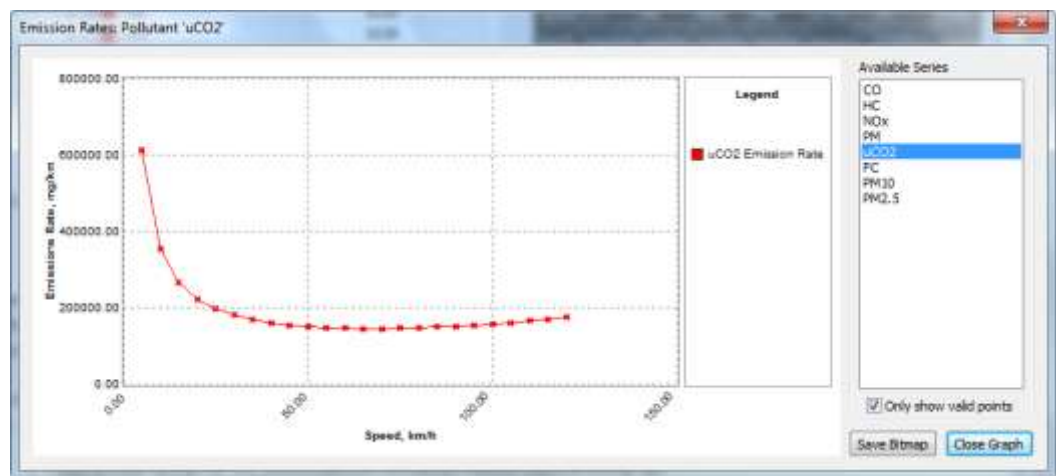
- ***Scenarios modelled using:***

- *Flows and speeds from SATURN model* (Source: SOLUTIONS Project)
- *Peak-period data scaled to Weekday, Saturday and Sunday traffic*  
(Source: UK National Transport Statistics, DfT, 2011)
- *In-House software PITHEM used*

# Emissions Modelling (2)

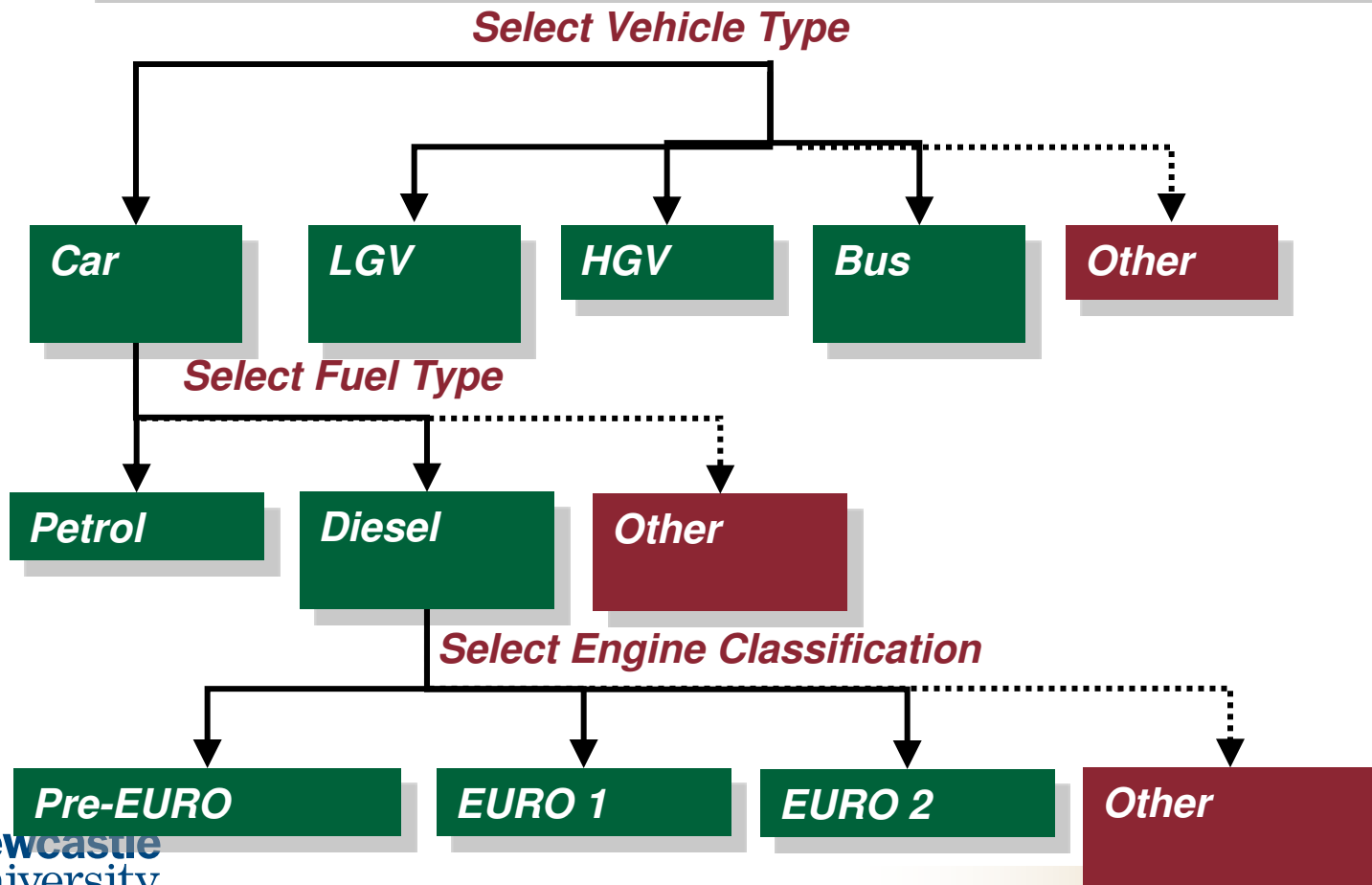


- Top Left: Fleet Hierarchy (source TRL, 2009)
- Top Right: Emissions Calculator
- Bottom: Sample CO<sub>2</sub> Emissions Curve



# Vehicle Emissions Modelling

*Most Emission models typically use a similar 'tiered' classification system at the front end:*

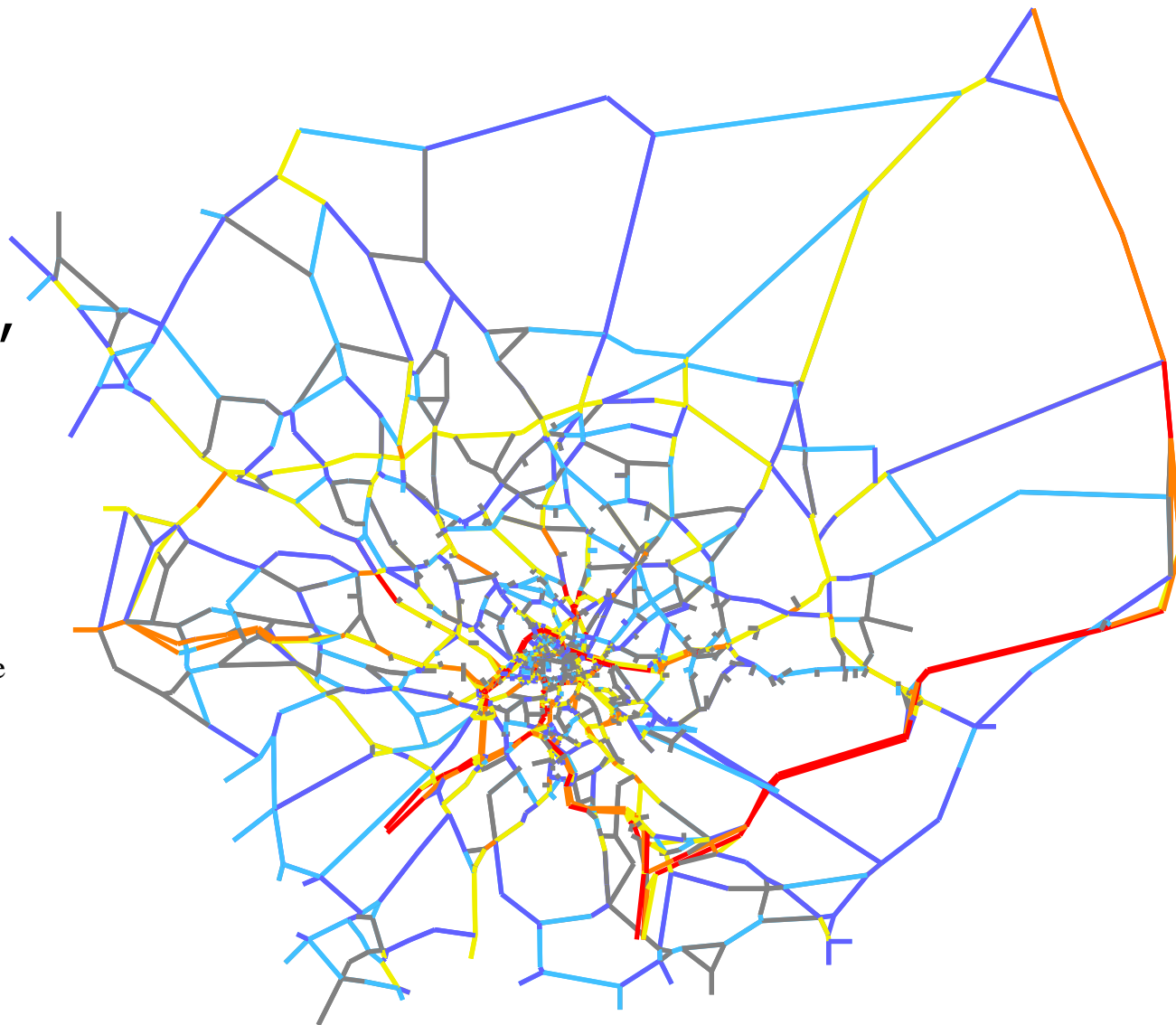
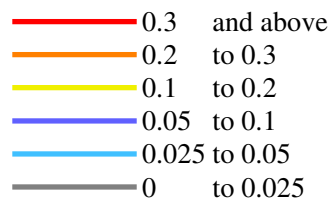




# Link Based NOx emissions

CO, NOx, PM<sub>10</sub>,  
SO<sub>2</sub>, Benzene,  
1,3-Butadiene,  
CO<sub>2</sub>

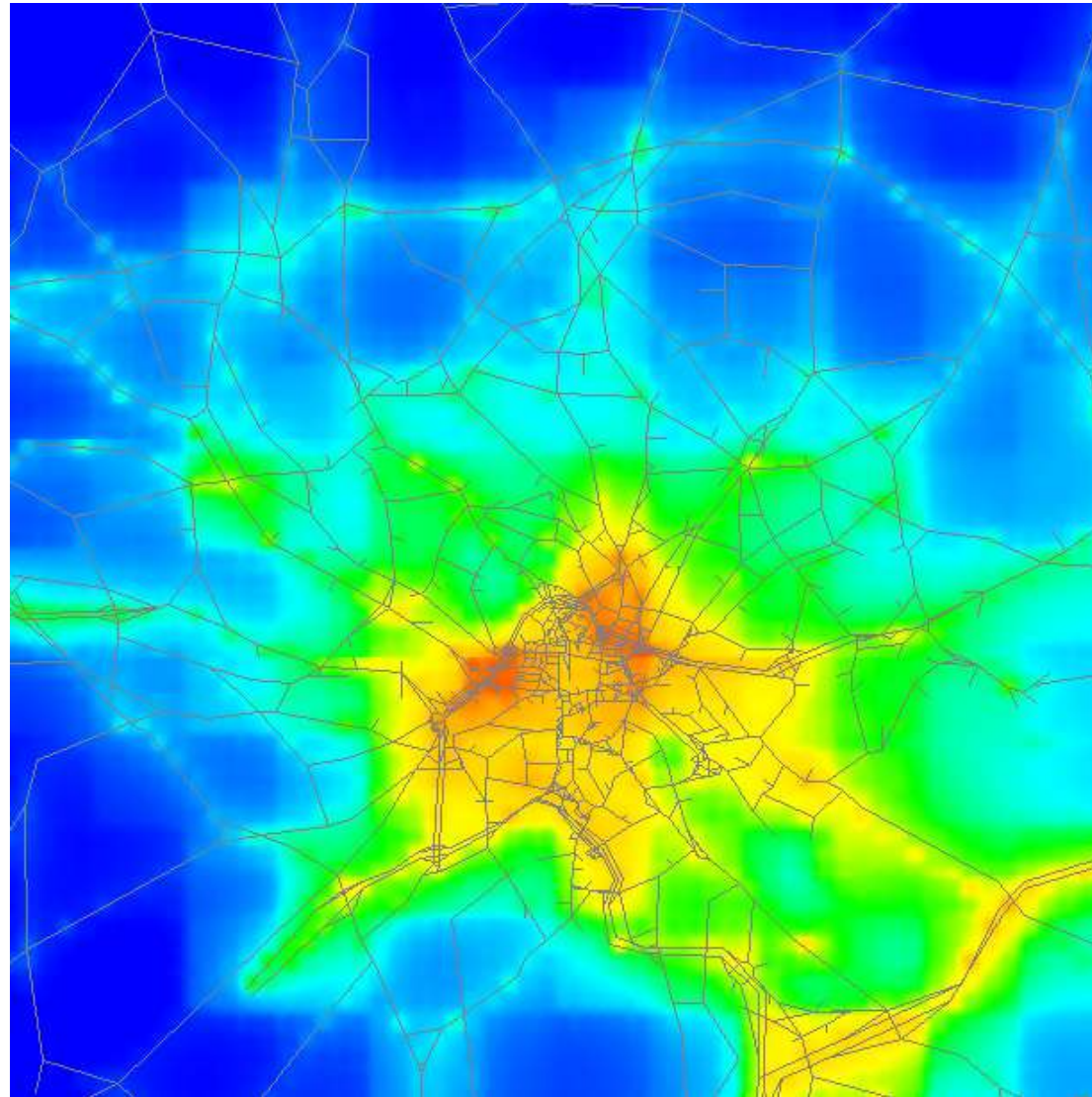
2005 Do Min - Zero Charge  
NOx Emissions (g/km/s)



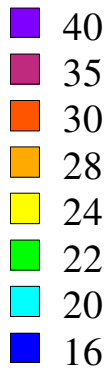
# Air Quality

***NO<sub>2</sub>***

***Annual Mean***



NO<sub>2</sub> Annual Mean (ug/m<sup>3</sup>)



# CAMBRIDGE RESULTS

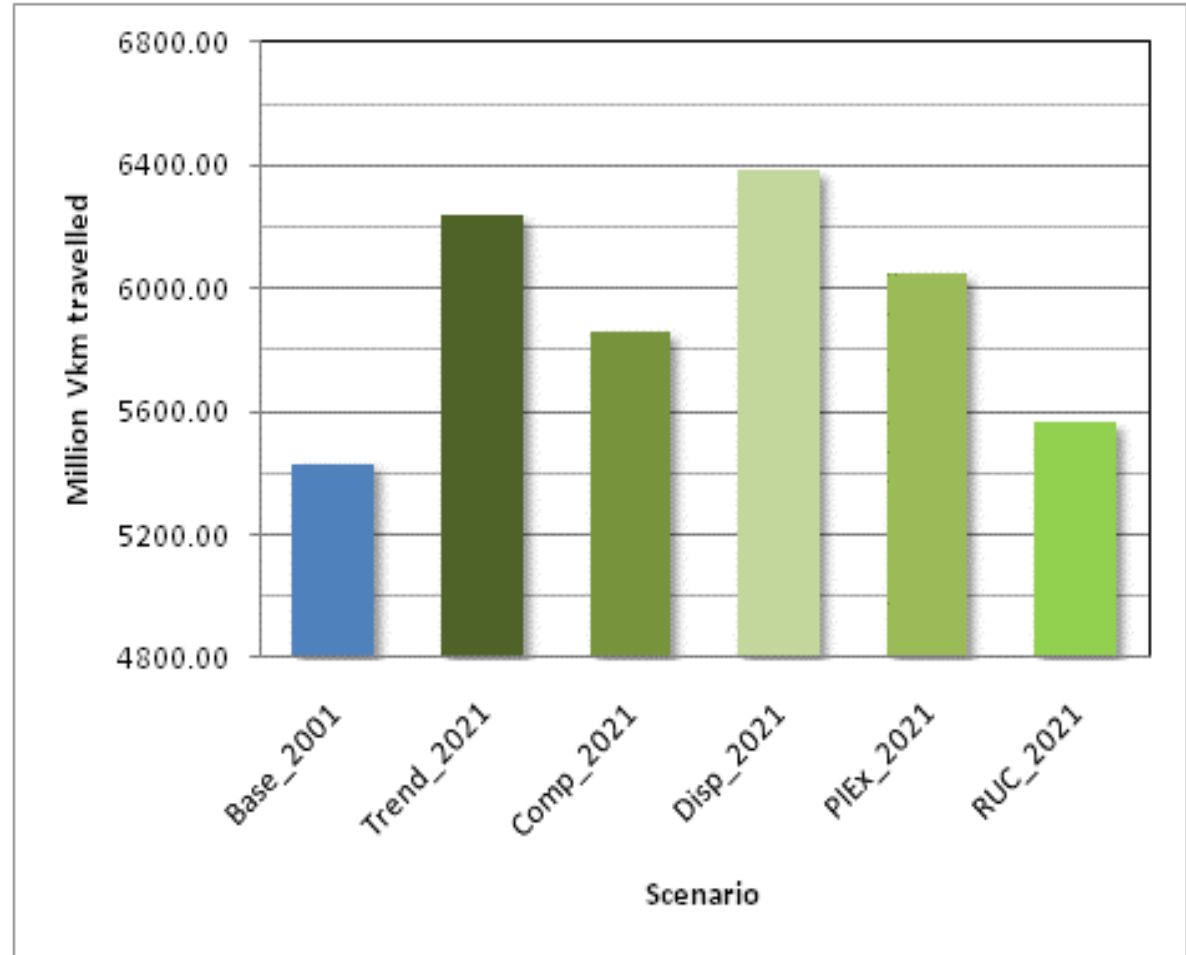
# Traffic Volume

## Million Vehicle.kms. Travelled

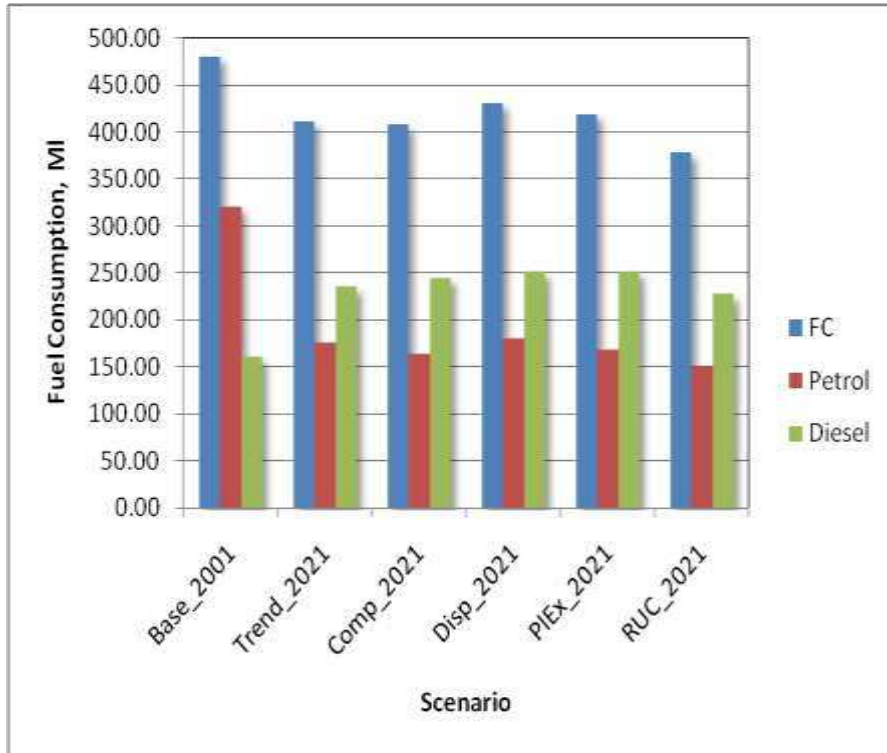
*BAU Trend 2021 is 15% higher than 2001 base*

*Difference between Compaction and Dispersal options is approximately 500 million veh.km*

*As modelled, Road User Charging is more effective in restraining traffic growth than all planning options*

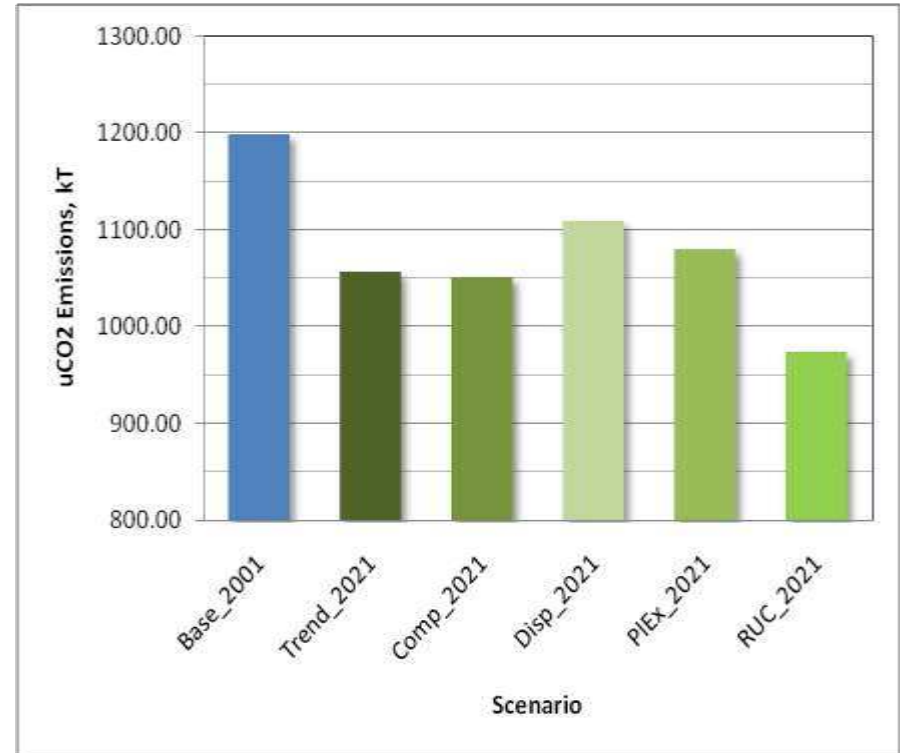


# Fuel Consumption and GHG



**Fuel Consumed, million litres**

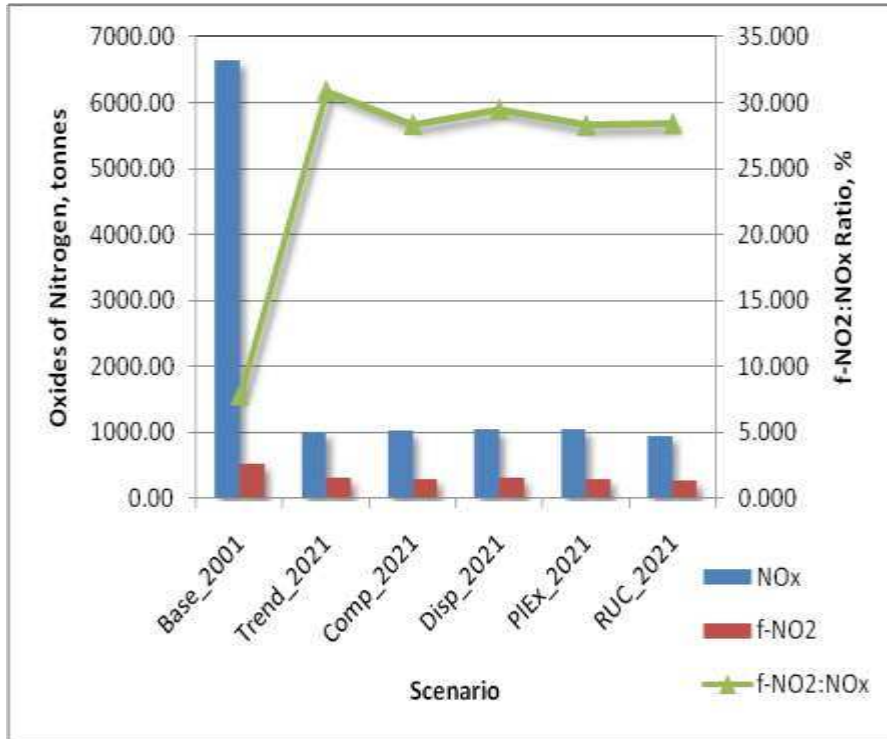
*Increase in diesel consumption driven partially by private car fleet and increased bus patronage*



**uCO<sub>2</sub> Emissions, Kilotonnes**

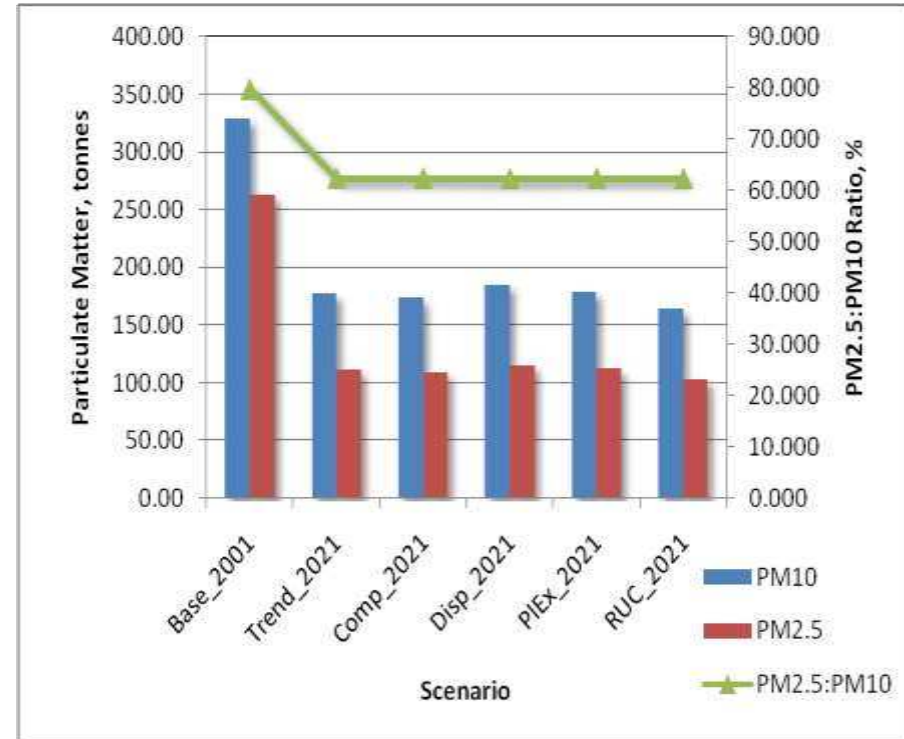
*BAU Trend 2021 is 12% lower than 2001 base  
RUC 2021 is 19% lower than 2001 base*

# Regulated Pollutants



**Oxides of Nitrogen, tonnes**

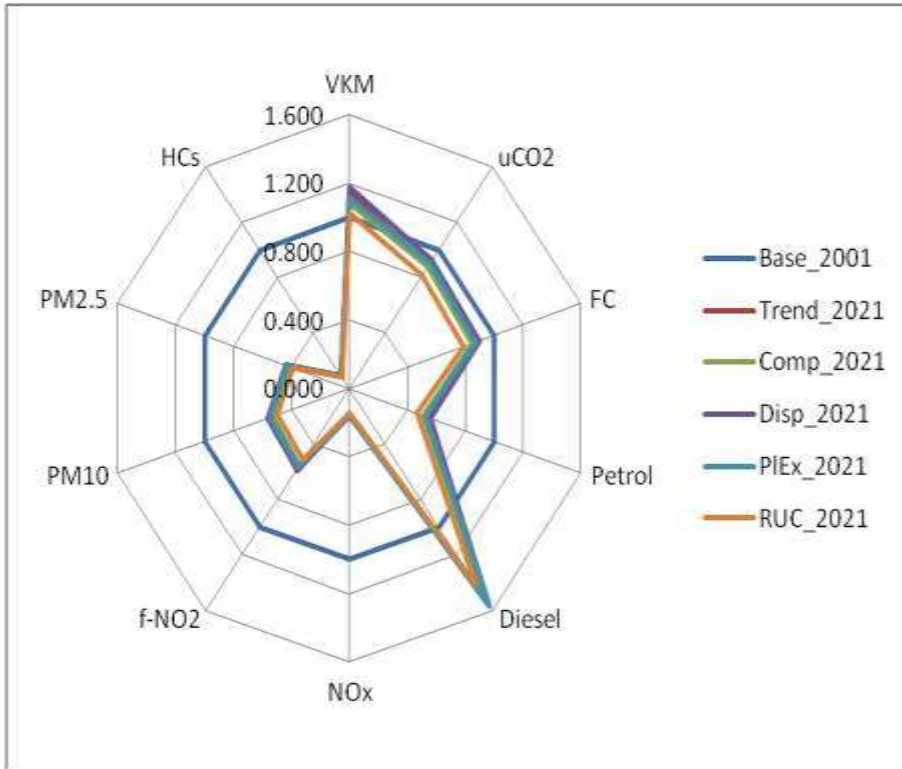
*EURO Class driven reduction of total NO<sub>x</sub> by around 85%, but total Primary NO<sub>2</sub> emissions only reduce by around 30%*



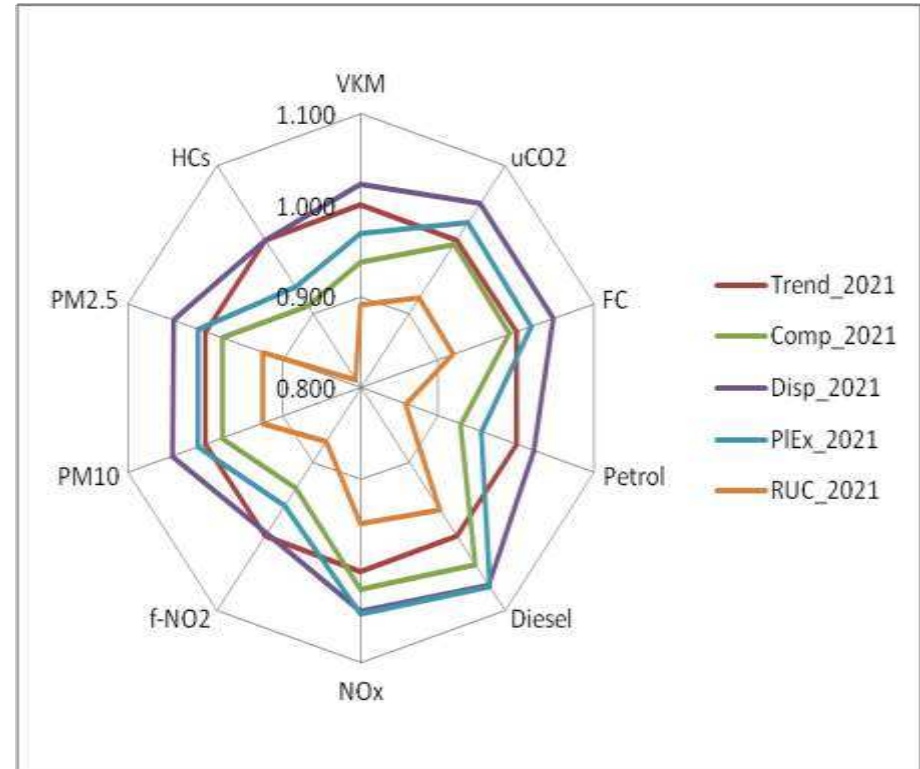
**Particulate matter, tonnes**

*EURO Class driven reduction of around 50% for PM<sub>10</sub> and 40% for PM<sub>2.5</sub>*

# Relative Performance



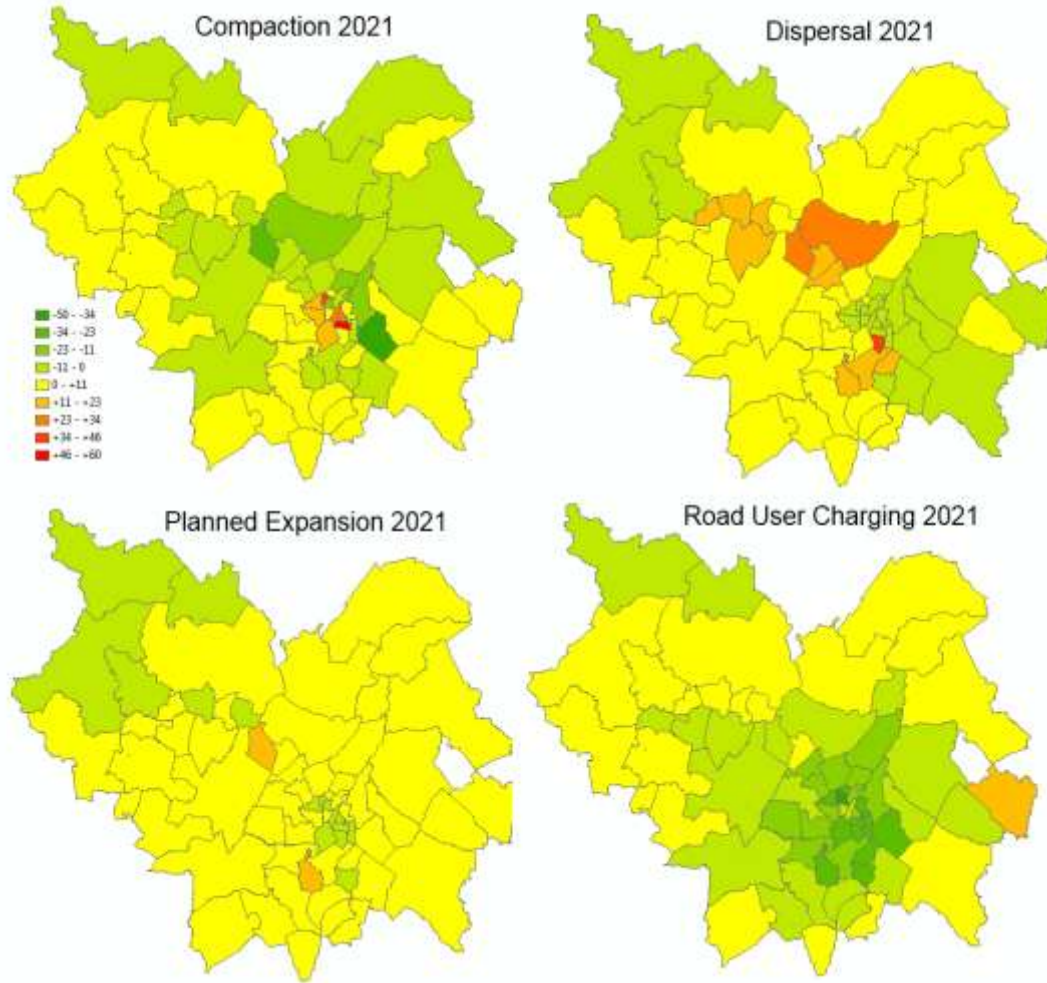
*Performance of options relative to 2001 Base Scenario*



*Performance of options relative to 2021 Trend (BAU) Scenario*

# Spatial Distributions (1)

## *uCO<sub>2</sub> Emissions*

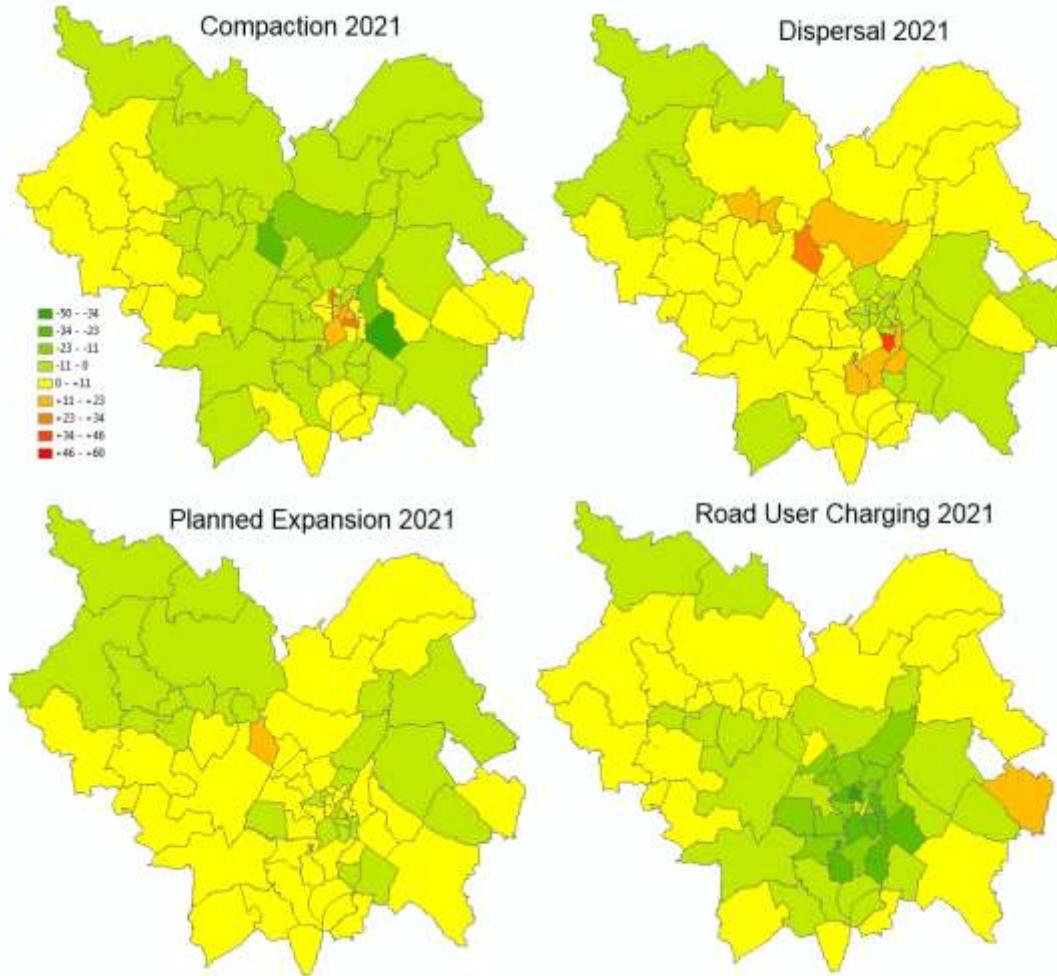


*Changes relative to Trend (BAU 2021)  
Scale range -40% (green) - +60% (red)  
Emissions normalised by zone area*



# Spatial Distributions (2)

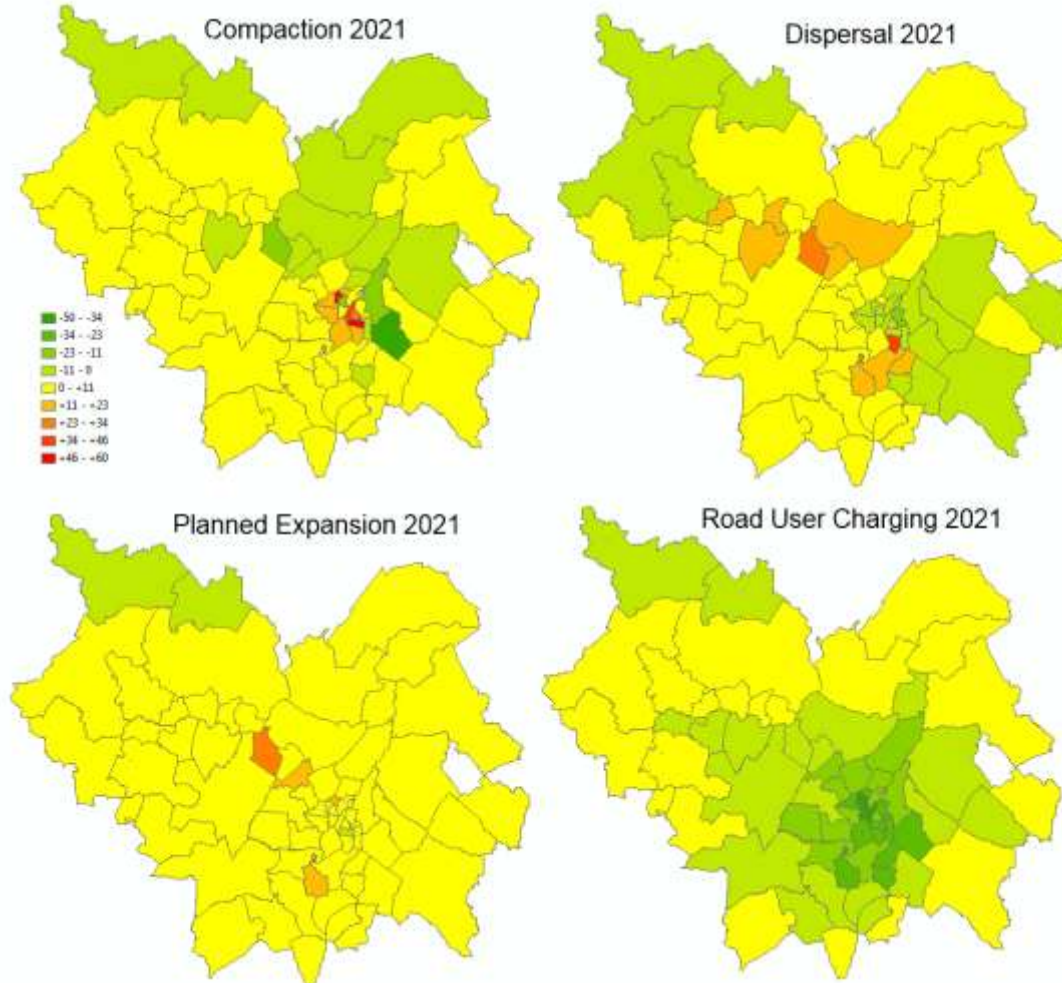
## *PM<sub>10</sub> Emissions*



*Changes relative to Trend (BAU 2021)  
Scale range -40% (green) - +60% (red)  
Emissions normalised by zone area*

# Spatial Distributions (3)

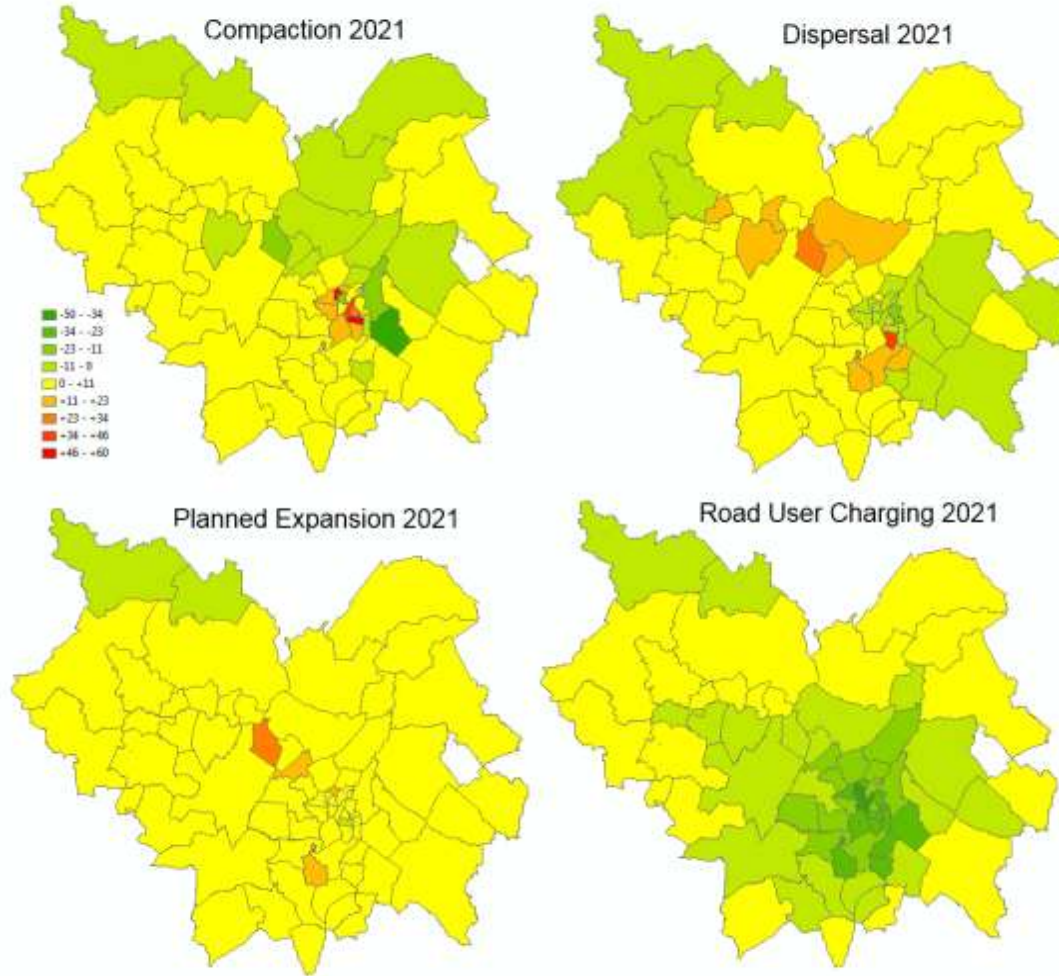
## *NO<sub>x</sub> Emissions*



*Changes relative to Trend (BAU 2021)  
Scale range -40% (green) - +60% (red)  
Emissions normalised by zone area*

# Spatial Distributions (4)

*f-NO<sub>2</sub> Emissions*



*Changes relative to Trend (BAU 2021)*  
*Scale range -40% (green) - +60% (red)*  
*Emissions normalised by zone area*

# Conclusions

## ■ **Conclusions from SOLUTIONS**

- ◆ *As modelled, no planning option is as effective as the use of Road User Charging*
- ◆ *CO<sub>2</sub> targets are challenging without further modal shift or behavioural change*

## ■ **Spatial-Analysis**

- ◆ *Clear differences in the distribution pattern of emissions with planning scenario – even though the absolute emissions values are comparable*
- ◆ *The compaction scenario could lead to issues within Cambridge City Centre, whilst reducing emissions for the county as a whole*
- ◆ *Dispersal option increases emissions to the north of the city towards Huntingdon*

# Future Work

- ***Expansion of PITHEM Software***
  - ◆ *Modules for road traffic noise, accidents, run-off and severance*
  - ◆ *Links to ADMS-Urban and AIRVIRO air-quality management software*
  
- ***Further environmental analysis in ReVISIONS***
  - ◆ *Further analysis and refinement of Cambridge Model*
  - ◆ *Proposed air-quality, population exposure and health/disease burden analyses*
  - ◆ *Expansion of scope to cover Greater South East region at the strategic level*

***Thank you and any questions?***

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