



A model to investigate the environmental impacts of transport operations associated with fracking in Europe.

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# Introduction

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- Unconventional hydrocarbon exploitation will require some surface transportation:
  - Exploration activities and test drilling
  - Access road and pad construction
  - Rig mobilisation and well construction
  - Operational drilling materials
  - Staff movements to and from site
  - WATER, SAND/PROPPANT and CHEMICAL demands
  - FLOWBACK and PRODUCED WATER removal (NORMS...?)
  - Pipelines for inputs and production?
  - Recycling on-site of wastewater?
  - REFRACTURE EVENTS
  - Decommissioning and landscaping
- Use of heavy vehicles for 70%+ of requirements:  
Tankers



# Transport Issues

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- Vehicle operations:
  - Burn hydrocarbon fuel : typically diesel
  - Produce greenhouse gas emissions (CO<sub>2</sub> + others)
  - Produce local AQ emissions (NO<sub>x</sub>/NO<sub>2</sub>, Particles, CO)
  - Produce noise
  - Damage road surface and underlying structure
  - Cause congestion, severance and annoyance
  - Accidents and spills
  - Secondary effects (e.g. law enforcement issues)
- Both spatial and temporal in nature, and evolve with time



# Transport Issues - Continued

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- Impact of one well (or pad) may be negligible
- Impact of multiple wells (or pads) in an area may have cumulative/non-linear effects ('salami tactics')
- Intensity of operations dictates 'short-term' AQ events
- Issues may be 'normalised' away if not careful
- **CONTEXT IS EVERYTHING** : e.g. road type, location, population exposure



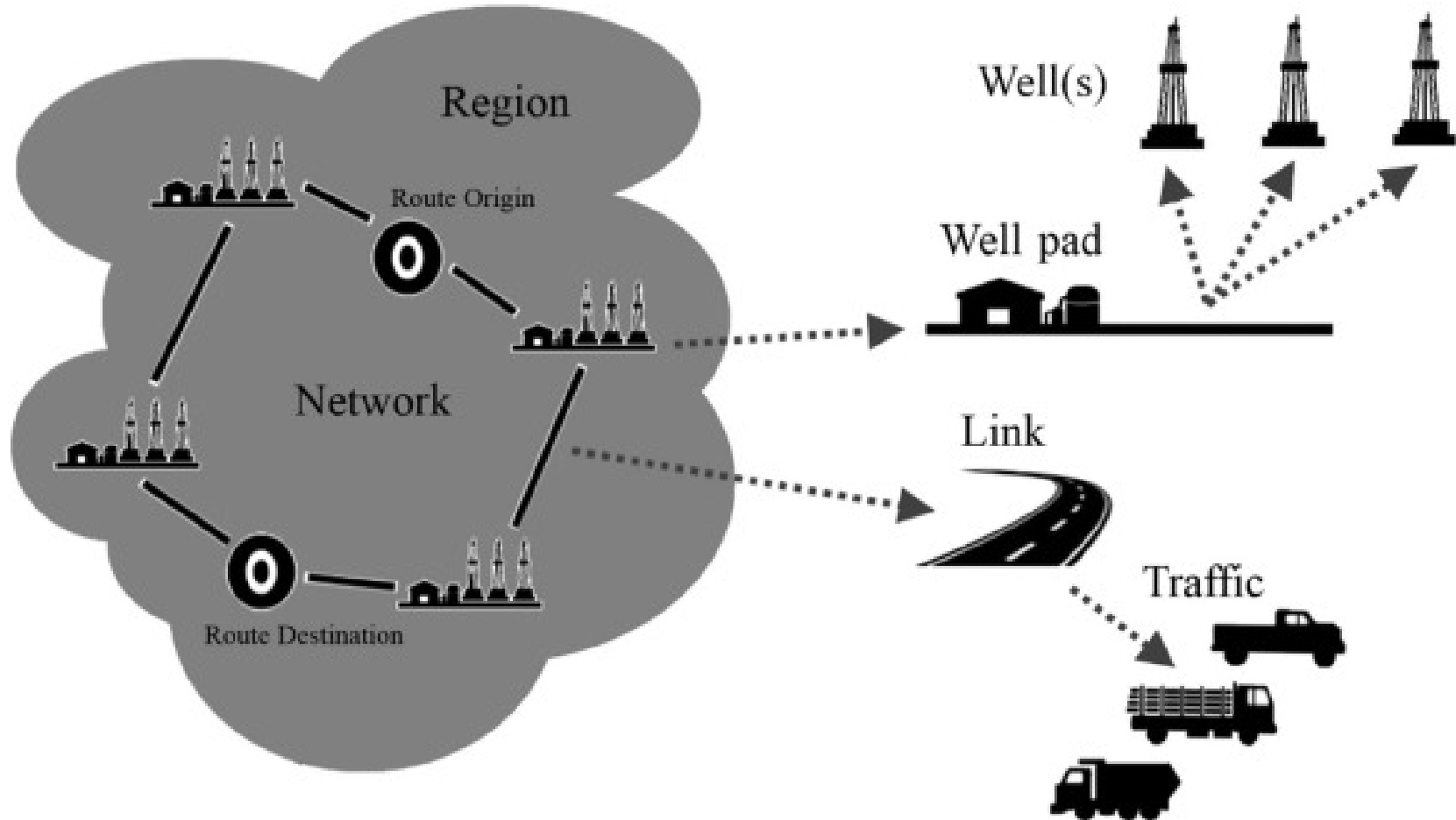
# Previous Work

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- Traffic Impacts Model (TIM) as part of the ReFINE (Researching Fracking In Europe) project (<http://www.refine.org.uk/>)
- Goodman PS, Galatioto F, Thorpe N, Namdeo AK, Davies RJ, Bird, RN. Investigating the traffic-related environmental impacts of hydraulic-fracturing (fracking) operations. *Environment International*. **89-90** (2016), 248-260: <https://doi.org/10.1016/j.envint.2016.02.002>
- TIM : Originally based on Newcastle University's PITHEM software
- TIM2 : New code and model for M4Shale

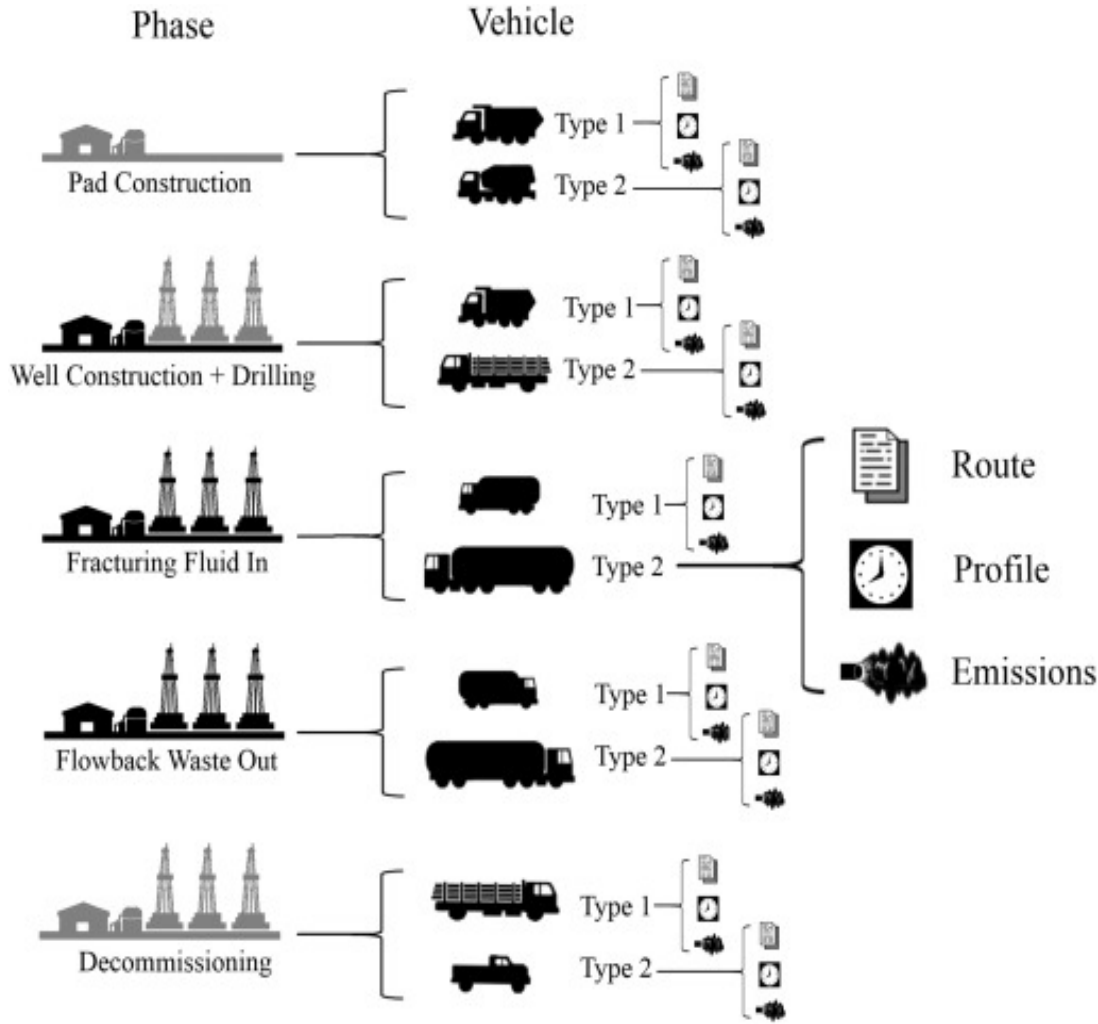


# Model Concepts

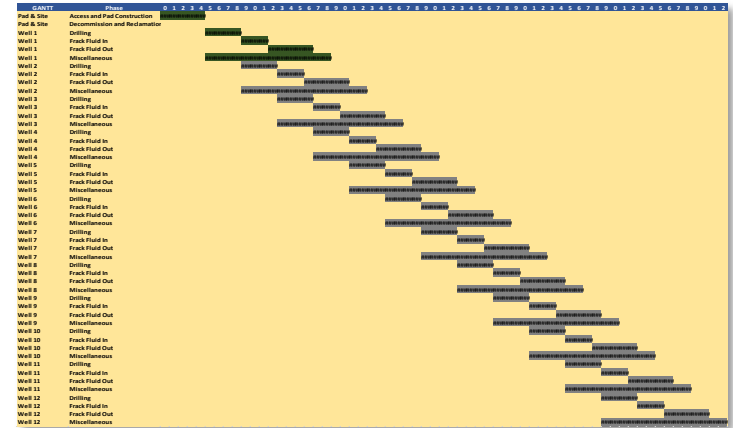


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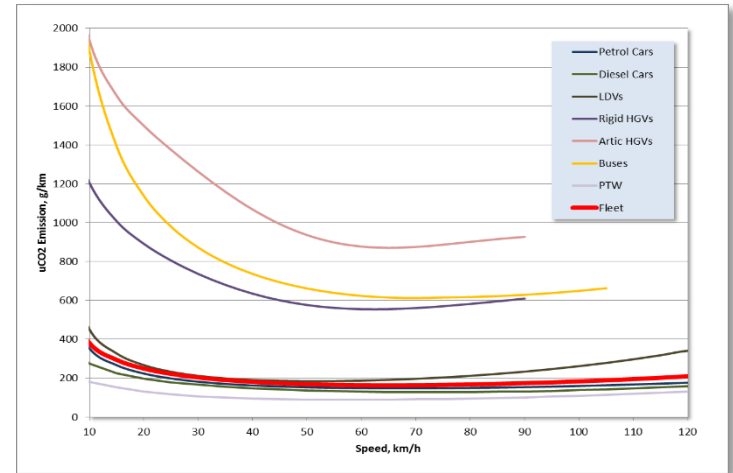
# Model Concepts - Continued



## User-defined activities



## Speed-based emissions factors



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# Modelling Considerations

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- How to model fleets?
  - Vehicle kilometres travelled, chassis types and fuel splits
  - Where from?
    - National Atmospheric Emission Inventory (UK)
    - COPERT (EU) – EMISIA
- How to model emissions?
  - Look-up tables are simple:
  - $E = \text{fn}(\text{pollutant}, \text{chassis type}, \text{speed}, \text{road type}, \text{gradient}, \text{loading})$
  - Where from?
    - Emission Factors Toolkit, HA IAN-185/15 (UK)?
    - Handbook Emission Factors for Road Transport (HBEFA) (AU, CH, FR, D, N, SE)
    - COPERT (EU) - EMISIA
- How to model noise?
  - (Very) simplified model derived from CNOSSOS-EU
  - Broadband  $L_{Aeq}$  levels at roadside
- How to model road damage?
  - Equivalent Standard Axle Loadings (ESAL) – AASHTO “4<sup>th</sup> power” law





# Considerations - Continued

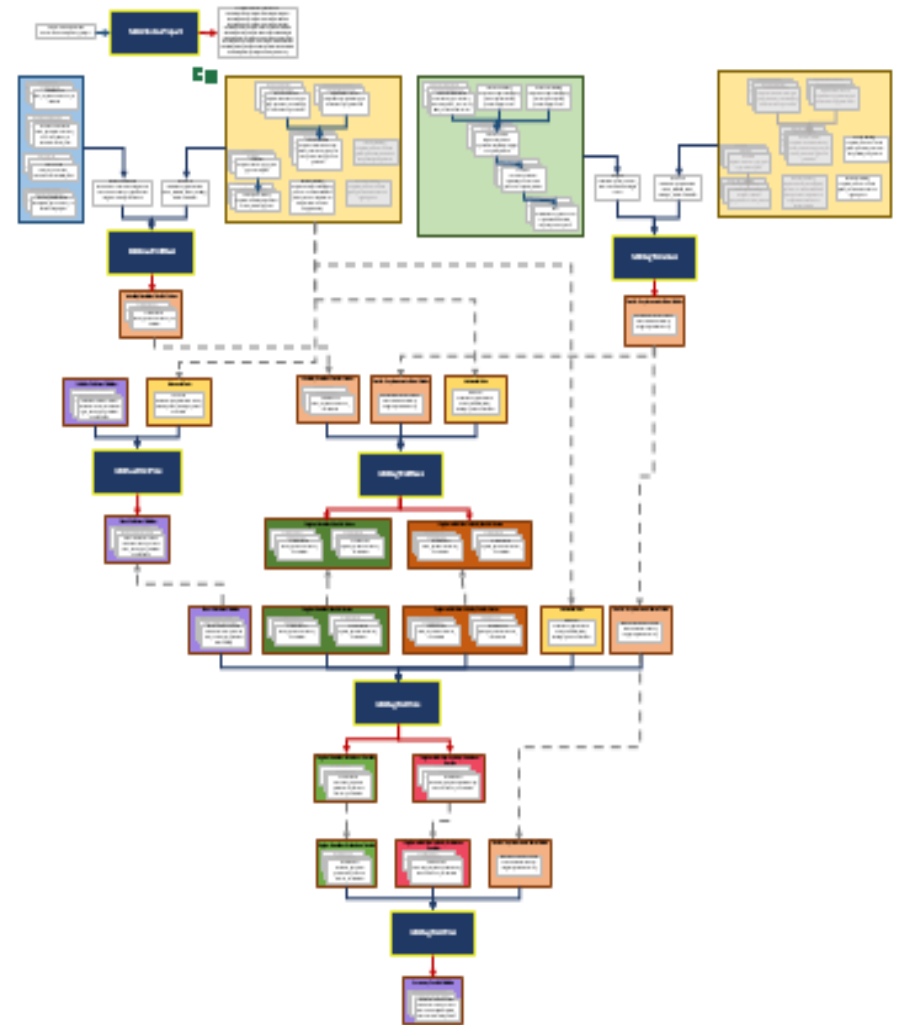
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- Baseline traffic data
  - Fleet information
  - 24/7 Coverage? (Use DfT road profiles in sample data)
  - Road types : “cost – flow” curves for assignment
- Traffic Assignment
  - Time-sliced to one hour
  - “Fixed assignment” (given flows on given links)
  - “Free assignment” (e.g. “Frank-Wolfe”, “All-or-Nothing”, etc.)
  - “Scaled assignment” (based on prior assignment in another hour)
- Temporal handling
  - Process (sort) activities at pads/wells into a timetable of event periods
  - Calculate occurrences of days and hours in a period
  - Calculate emissions once per day/hour, then scale
  - Run for “Baseline” vs. “Sites Active” and compare results

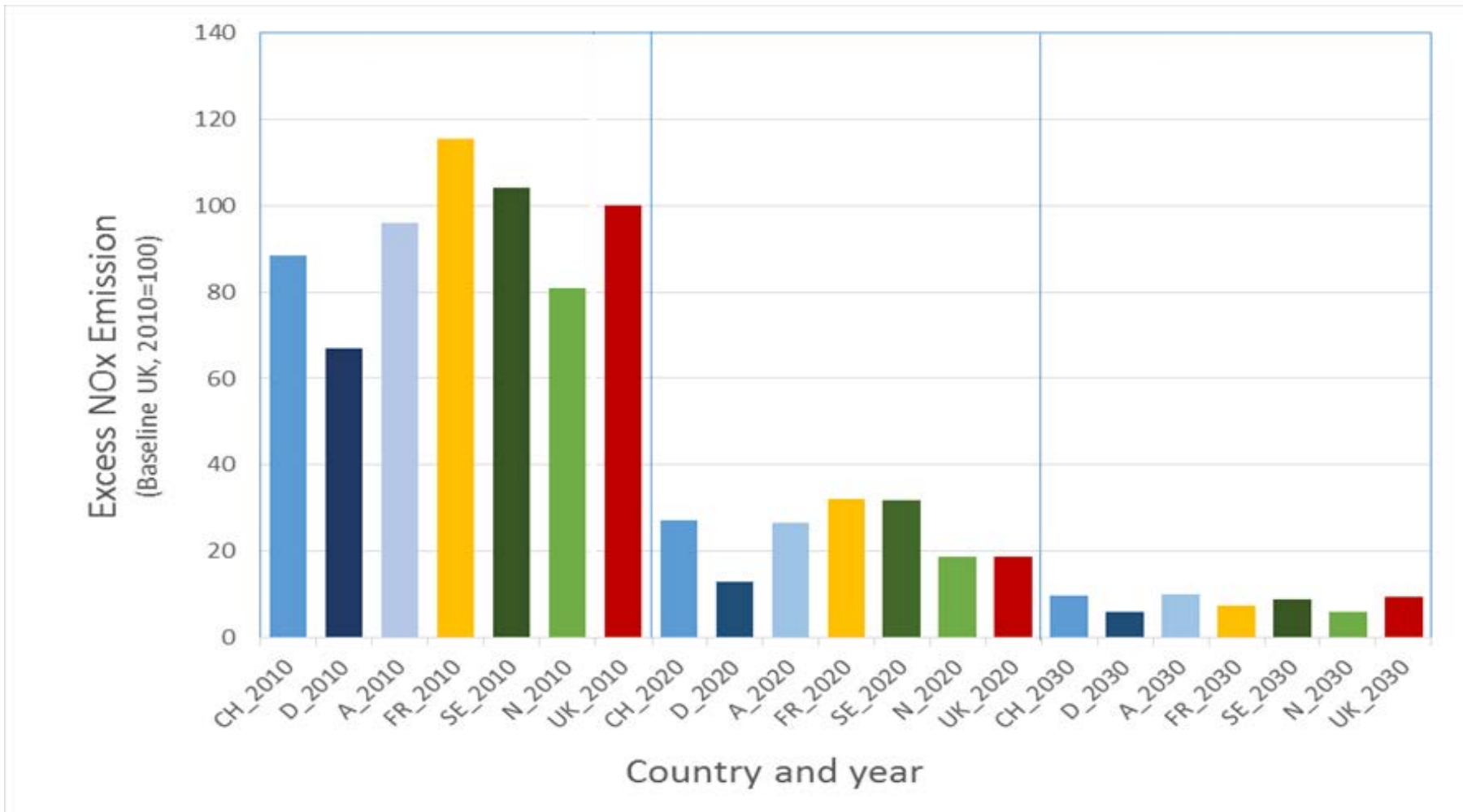


# (Current) Model Format

- Six (seven) separate executables for Windows
- C++/STL/Boost
- Each handles basic step: (e.g. calculating fleet-weighted emissions, weekly traffic flows etc.)
- Small, lightweight, but not exceptionally fast
- Little optimisation (single threaded, lots of small files produced)
- No GUI – yet
- Input and output via .csv/.json (text) files

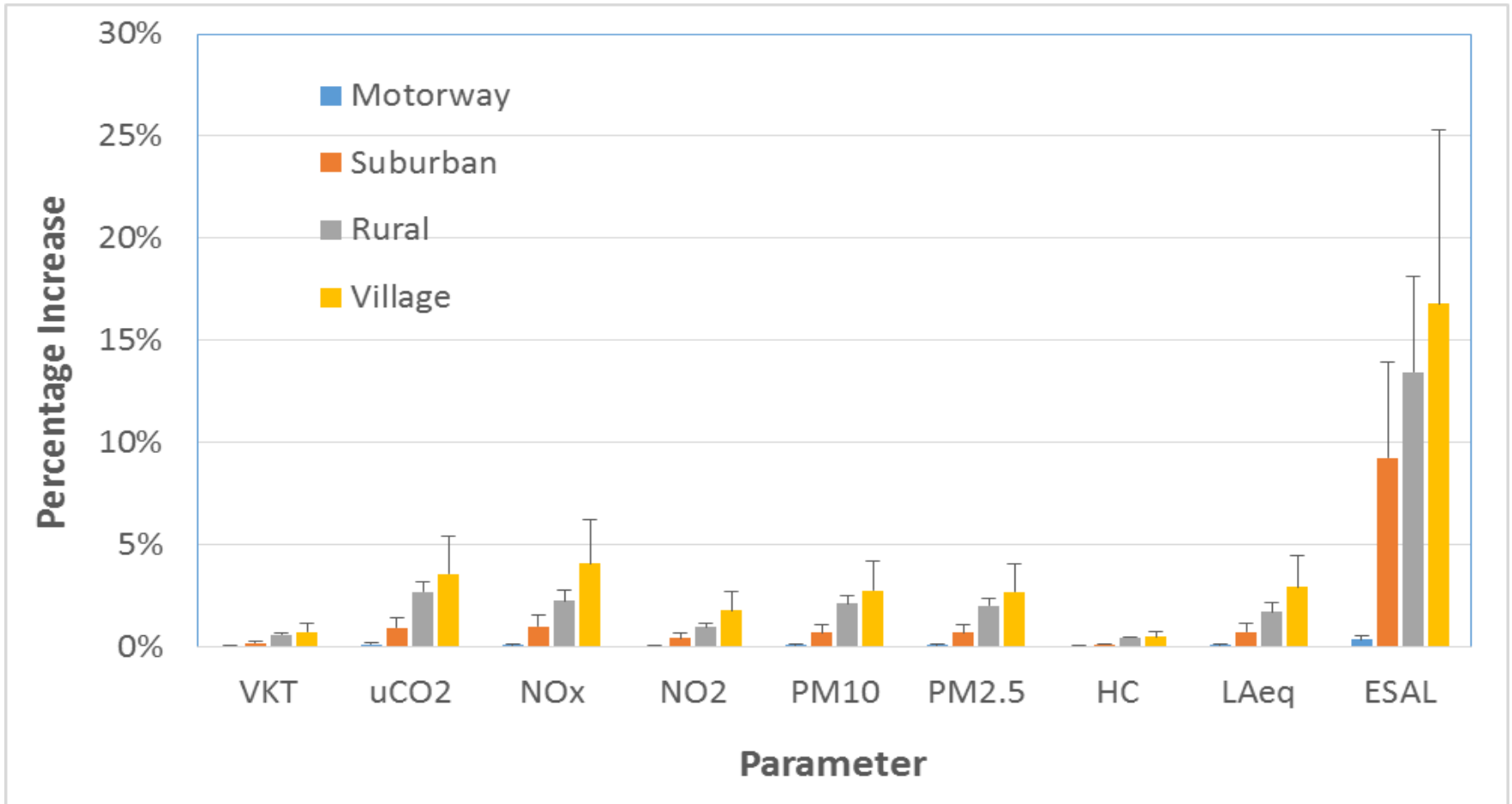


# Sample Results : Country Variation



Data sources: HBFEA, PITHEM/EFT, EMISIA COPERT v4

# Sample Results



Six-well pad, %-age increase over baseline traffic, 85-week operation, all water by tanker



# Conclusions

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- New Traffic Impacts Model (TIM2) developed on M4Shale
- Will be available to download (soon) from Newcastle University
- Results equivalent to previous ReFINE TIM when using UK data – highly context sensitive
- Further work ongoing on ReFINE regarding health impacts and GIS-based interface



# Contacts and Download

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TIM2 Download link (provisional - TBC) :  
– <http://research.ncl.ac.uk/uhtim>

# Disclaimer

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