Shelter and Escape in the Event of a Release of CO_2 from CCS Transport Infrastructure (S-CAPE)

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Pipelines are acknowledged as one of the most efficient and cost-effective methods for transporting large volumes of various fluids over long distances and therefore the majority of proposed schemes for CCS involve high pressure pipelines transporting CO_2. For natural gas pipelines, existing and accepted Quantitative Risk Assessment (QRA) techniques can be implemented to define safety zones based on the thermal hazards. However for CO_2 pipelines, for which the hazard is toxic, the consequences of failure need to be considered differently as they relate to the toxic dosage that an individual receives during the release event. This will have a direct impact on how the QRA assessment is conducted and on how safety distances are defined for CO_2 pipelines.
In this regard, there has not been a detailed study of the effect of shelter and escape on the CO_2 dosage that an individual receives under different environmental conditions.

Aims

The aim of this project is to develop validated and computationally efficient shelter and escape models describing the consequences to the surrounding population of a carbon dioxide (CO_2) release from Carbon Capture and Storage (CCS) transportation infrastructure. The models will allow pipeline operators, regulators and standard setters to make informed and appropriate decisions regarding pipeline safety and emergency response.

Research proposed

In this research two models will be produced that can be used in QRA studies. In this respect, a key requirement of the models is that they are computationally efficient whilst maintaining required levels of accuracy.

1 An indoor ventilation model will be developed to calculate the change in CO_2 concentration with time and therefore the dose that individuals in buildings will receive during a release event. The model will be based on ventilation theory and air change rates, taking into account wind and buoyancy driven ventilation and will incorporate varying cloud heights, internal divisions within the building, differing internal and external temperatures and the effect of impurities on the dosage.

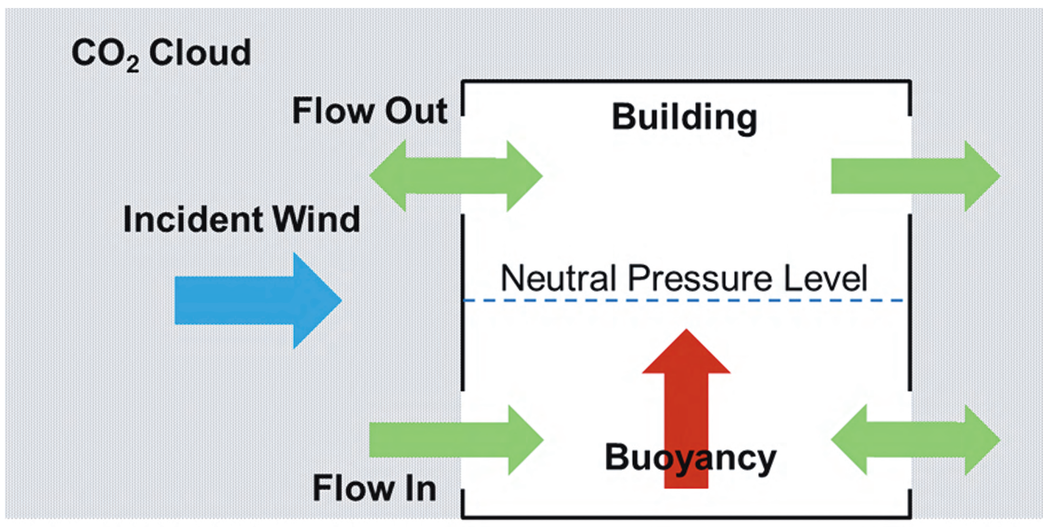

Figure 1: Schematic of ventilation air flow due to wind and buoyancy effects

2 An outdoor escape model will be developed to calculate the dosage experienced by individuals outside during a CO_2 release. The model will incorporate options for multi-decision making by the individual in terms of the direction and speed of running, wind direction, the time taken to find shelter and the time required to make a decision, on becoming aware of the release.

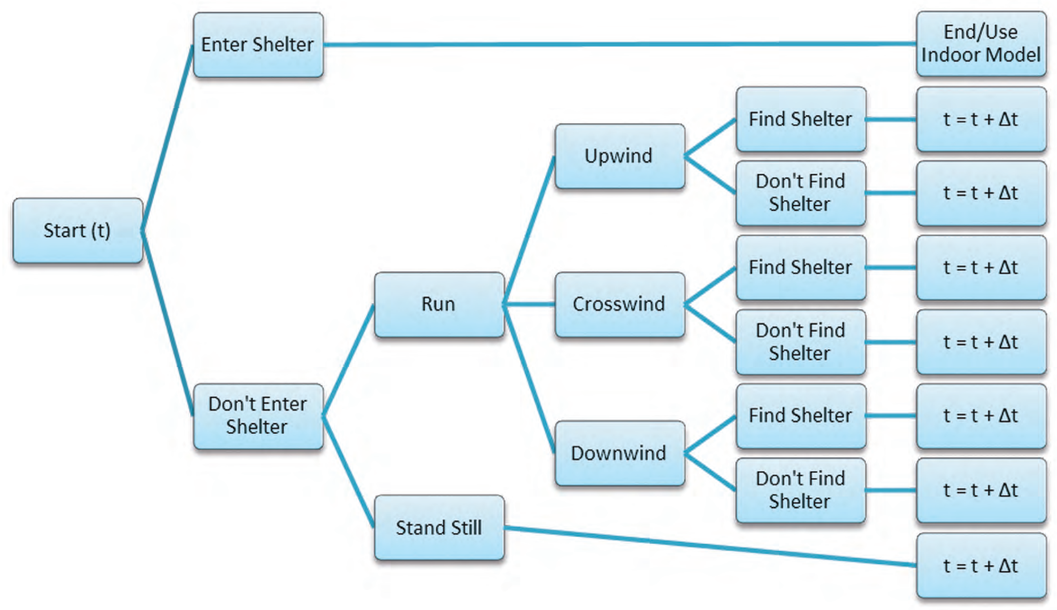

Figure 2: Example escape decision tree at any instant in time

The output of the models will be validated against Computational Fluid Dynamics (CFD) models as well as experimental data provided by National Grid. The validated model will then be used to conduct sensitivity studies on a range of scenarios investigating the effect that different variables will have on the consequences to the population in the vicinity of the release.

Deliverables:

The primary deliverables from this research will be:

- Robust and experimentally verified indoor ventilation and outdoor escape models that can be used by practitioners assessing the risks posed by CO_2 clouds. These models will provide direct input into QRA assessments used by pipeline operators, planners and developers and regulatory bodies.
- Guidance on the use of the models for emergency response planning; e.g. providing estimates of the protection afforded by shelter and the build-up and decay of dangerous levels of CO_2 concentration in the shelter following a release.
- A validated CFD model that can be used for further detailed analysis of release scenarios.

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