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Advanced CO₂ Dispersion Modelling for Safe Carbon Capture and Storage (CCS)

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ABSTRACT

Carbon Capture and Storage (CCS) is a critical carbon abatement technology that is experiencing rapid global expansion, with hundreds of millions of tonnes of operational and planned capacity expected by 2030. However, the transportation and storage of dense-phase, liquid, or supercritical CO₂ introduce unique safety challenges. Accidental releases of CO₂ may pose significant hazards, including asphyxiation due to oxygen displacement, severe cold exposure and frostbite caused by low-temperature two-phase jets, and potential environmental impacts.

Recent advances in thermodynamic modelling, supported by fundamental research and large-scale experimental validation, have enabled more accurate prediction of CO₂ release behaviour. These developments have been implemented in consequence modelling tools such as DNV's empirical modelling software Phast and the Computational Fluid Dynamics (CFD) software KFX, enabling robust simulation of CO₂ dispersion from CCS infrastructure, including long pipelines (both above-ground and buried) and storage facilities.

This paper will examine the complex physical phenomena associated with CO₂ releases, including transient depressurisation, phase transitions, dry ice formation, and atmospheric dispersion. The modelling approach incorporates detailed representations of CO₂ thermophysical properties, meteorological conditions, terrain and topography, vegetation, and complex 3D geometries.

By applying advanced discharge and dispersion modelling techniques, safety professionals can perform more reliable consequence analysis and quantitative risk assessment (QRA). The results support the development of science-based safety distances, informed land-use planning decisions, and robust process safety management strategies for CCS facilities.

KEY WORDS

CO₂ dispersion, CCS, Software Modelling, Phast, KFX

BIOGRAPHY

Todd Yu is a Regional Sales Manager at DNV with over 14 years of experience in the engineering software and energy sectors, driving market development and customer success across the Asia-

Pacific region. He holds a Master's degree in Engineering and an MBA. His expertise includes process safety software, technical consulting, and market development. His professional background spans software engineering, consulting and business development. He actively supports the energy transition and digital transformation, helping organizations deploy engineering software solutions for emerging sectors such as hydrogen, ammonia, carbon capture and storage (CCS), and maritime decarbonization.

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