

Doctoral Thesis Assignment

Student:

Study Programme: P1032D020005 Fire Protection and Safety

Topic: Hydrogen dispersion in confined, partially confined and unconfined environment by a hybrid machine learning approach
Rozptyl vodíku v uzavřených, částečně uzavřených a otevřených prostředích s využitím hybridní metody strojového učení

The thesis language: English

Supervising centre: 025 Centre of Excellence for Safety Research

Rules for elaboration:

A short annotation of the proposed dissertation:

As hydrogen becomes increasingly integrated into energy, mobility, and industrial systems, assessing the consequences of accidental releases is crucial for ensuring safety. A key aspect of such assessments is understanding hydrogen dispersion under different temperature conditions — from ultra-low (associated with liquid hydrogen) to ambient — as this directly influences flash fire and vapour cloud explosion scenarios in unconfined, partially confined, and confined environments. While computational fluid dynamics (CFD) models can accurately simulate these phenomena, their computational demands remain too high for practical risk assessment and decision-making. Therefore, this dissertation proposes a hybrid framework that combines physics-informed machine learning techniques with numerical simulations and experimental data to enable fast and reliable predictions of hydrogen dispersion across various conditions.

Intended objective of the proposed dissertation:

The main objective of the dissertation is to develop and validate a hybrid simulation–machine learning framework capable of significantly accelerating the prediction of hydrogen dispersion at different initial temperatures. This will be achieved by:

- generating and integrating datasets from CFD simulations and controlled experimental releases of hydrogen under diverse conditions,
- training and applying physics-informed and residual-aware machine learning models to emulate dispersion dynamics with orders-of-magnitude computational speed-up,
- synthesizing these fast predictions into an operational decision-support tool that provides actionable safety recommendations.

Expected contribution to the scientific field and to practice:

The proposed research is expected to advance the state of knowledge in hydrogen safety by establishing a data-driven, physics-informed modelling approach for rapid dispersion assessment. Scientifically, it will contribute to the integration of hybrid modelling techniques combining first-principles physics and machine learning in the context of safety engineering. In practice, the resulting framework will enable near real-time consequence evaluation and risk-informed decision-making for hydrogen infrastructures, supporting the safe deployment of hydrogen technologies in energy and mobility sectors.

Supervisor: **dr hab. inž. Rafal Porowski**

Consultant:

Chairman of Studies Board: prof. Ing. David Řehák, Ph.D.

In IS EDISON assigned:

Doctoral Thesis Assignment

Student:

Study Programme: P1032D020005 Fire Protection and Safety

Topic: A multi-criteria approach for the sustainability of green hydrogen based on experimental data and machine learning
Vícekriteriální přístup k hodnocení udržitelnosti zeleného vodíku na základě experimentálních dat a strojového učení

The thesis language: English

Supervising centre: 025 Centre of Excellence for Safety Research

Rules for elaboration:

A short annotation of the proposed dissertation:

In the view of emission reduction of energy production, green hydrogen is considered as an efficient zero carbon solution. However, the extensive use of this gas poses significant challenges due to the current high cost, even if it may become less problematic as technological advances in electrolysis and declining renewable energy costs could make hydrogen commercially viable at competitive prices. Besides, successful implementation requires careful consideration of multiple factors, including safety and environmental aspects. These aspects will be analysed in the doctorate study, with specific reference to green hydrogen production and utilization. To this aim, key performance indicators will be established to enable the quantitative assessment of hydrogen sustainability and the comparison with other forms of traditional and renewable energy. Experimental investigations will provide the foundational data necessary for machine learning model development and implementation.

Intended objective of the proposed dissertation:

The sustainability assessment will be based on the definition of specific key performance indicators (KPI), which will quantitatively compare the production and the storage of green hydrogen with fossil-fuel-derived hydrogen. Also, the KPI will compare the use of green hydrogen for fuel cells, as a direct burner, as a blended fuel with methane and ammonia, and in the ideal case of pure oxygen-hydrogen combination. For the complex system, experiments for the safety and environmental indicators will be specifically designed. The experiments will be the basis for a data-driven machine learning approach.

Expected contribution to the scientific field and to practice:

The research question is manifold and includes the development of advanced numerical tools, the design of experimental tests, and the definition of advanced, however practical methodology for the energy-decision-makers.

Supervisor: **Dr. Ernesto Salzano**

Consultant:

Chairman of Studies Board: prof. Ing. David Řehák, Ph.D.

In IS EDISON assigned: