

Risk assessment in the framework of Blue Hydrogen

Federica Tamburini - *PhD-student at NTNU*



In recent years, the global concentration of carbon dioxide in the atmosphere has increased drastically due to the continuous consumption of fossil fuels. With the aim of curbing climate change and meeting the increasingly stringent net-zero emission targets, blue hydrogen technology may be seen as the short-term decarbonization strategy in the prolonged period of the energy transition. In this context, the climate mitigation potential of blue hydrogen technologies derives from its peculiarity of coupling steam methane reforming (SMR) in existing plants with carbon dioxide capture and sequestration (CCS) technique. The potential introduction of this new technology in civil and industrial applications implies the presence of unexplored safety aspects that are fundamental for its effective implementation. For this reason, the present research project aims at developing a consistent quantitative risk assessment (QRA) methodology and a thorough evaluation of the safety associated with systems for blue hydrogen production.

Risk assessment in the framework of Blue Hydrogen

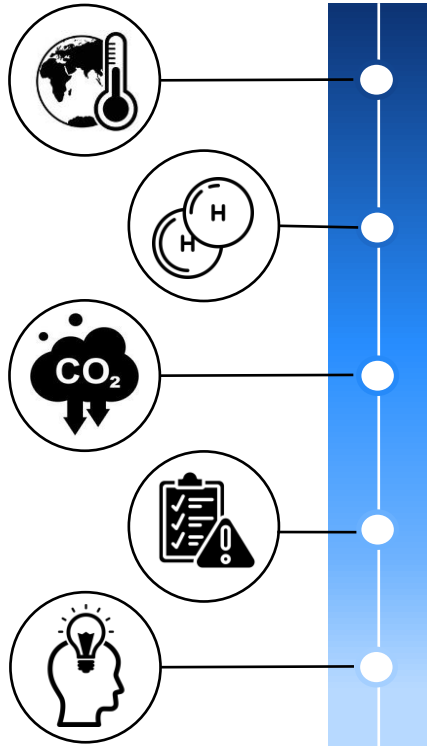
Federica Tamburini

PhD candidate

NTNU – Norwegian University of Science and Technology

MTP – Department of Mechanical and Industrial Engineering

Research activity outline



Introduction

The global warming issue

Blue Hydrogen

The low-carbon solution supporting the energy transition

Carbon dioxide Capture and Sequestration (CCS)

The crucial short-term decarbonization strategy

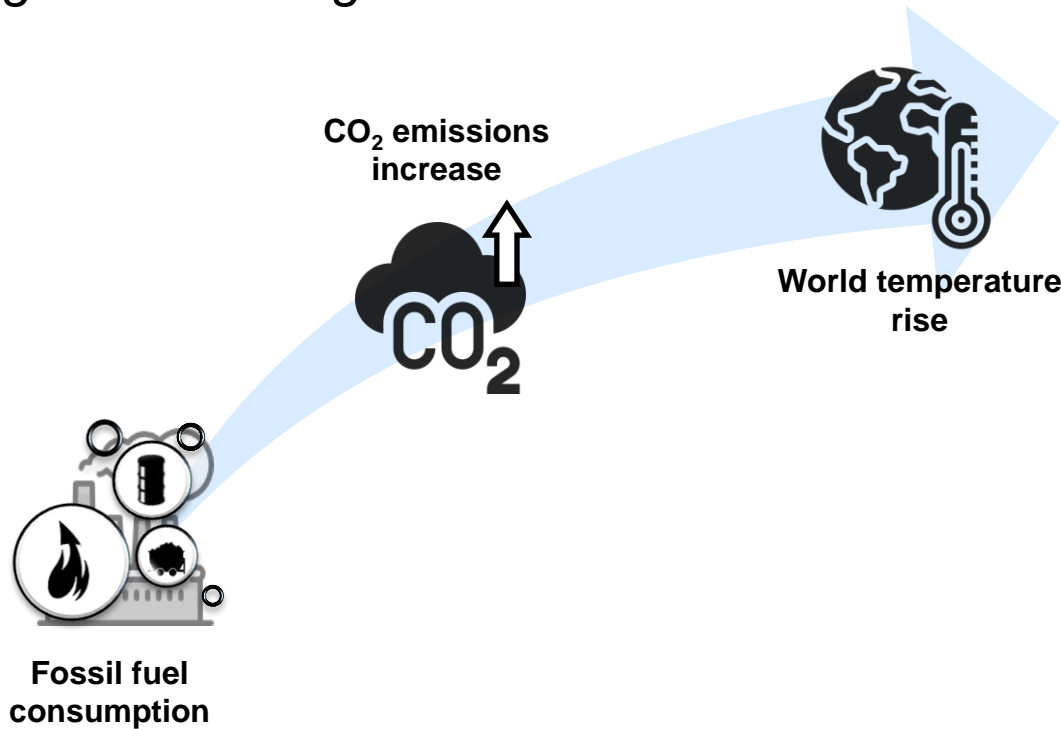
Risk assessment approaches

CO₂ transport and storage steps

Conclusions and future developments

Introduction

The global warming issue



Climate changes

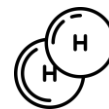
- Sea level rise
- Wildfires
- Water shortage
- Biodiversity loss
- Crop failure
- Extreme weather



Consequences

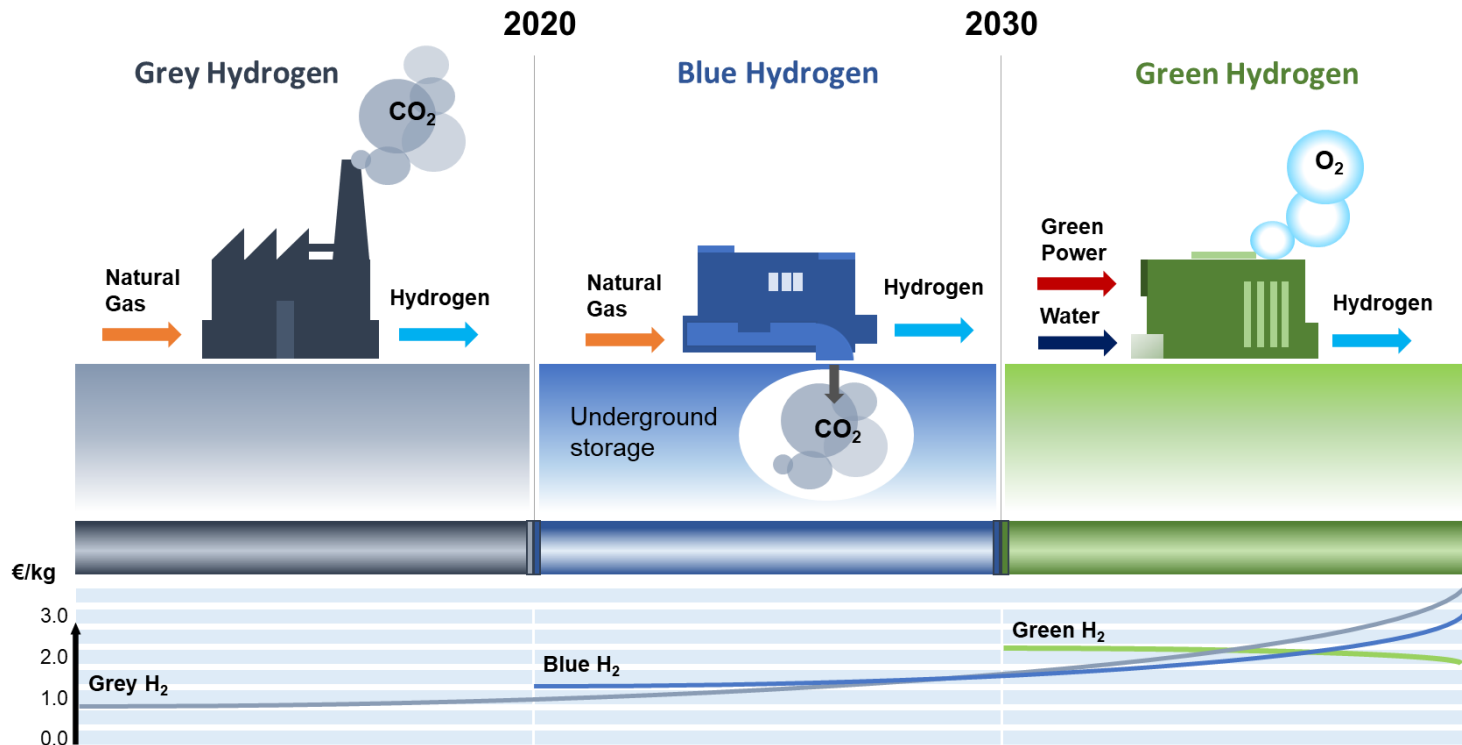
- Spread of diseases
- Increased risk of wars and conflicts
- Impacts on human rights

...urgent decarbonization actions MUST be taken!



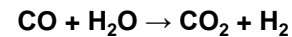
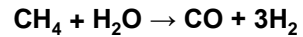
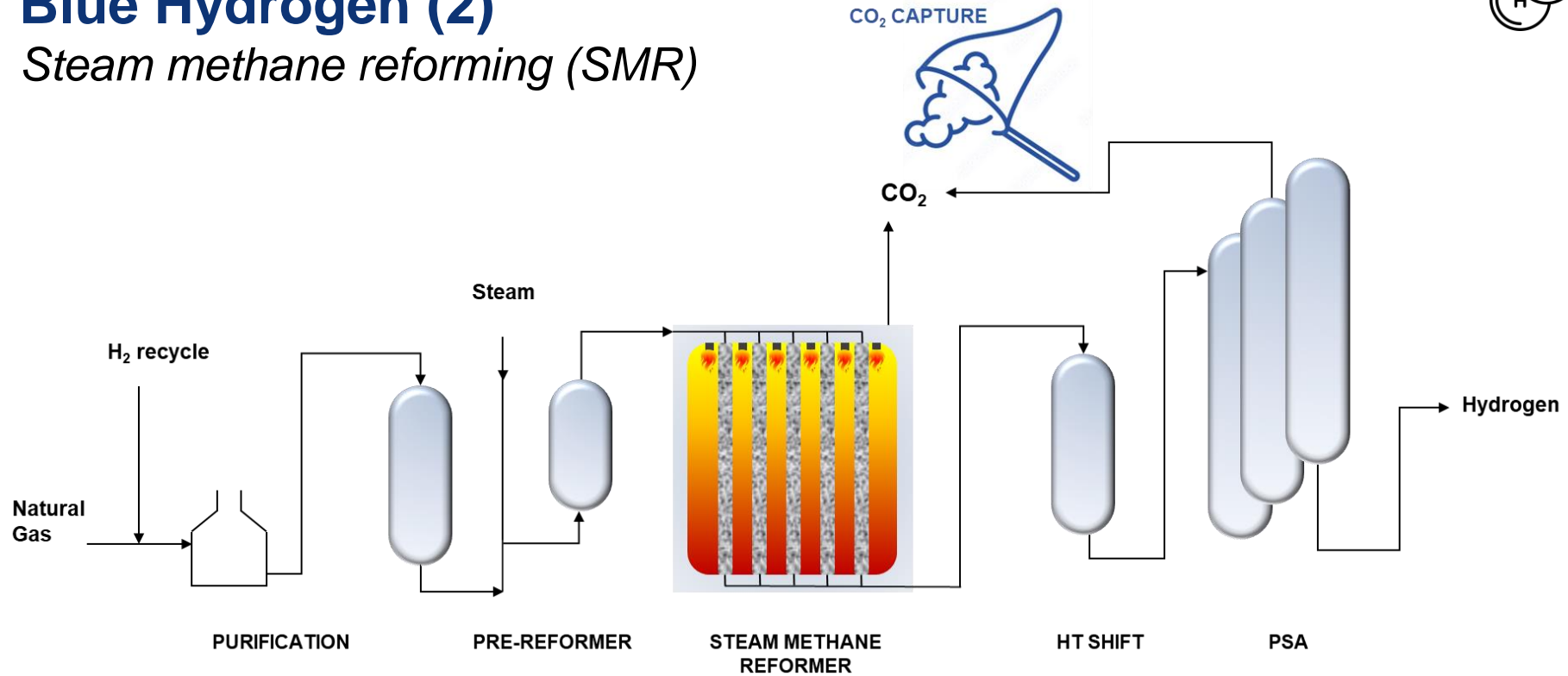
Blue Hydrogen (1)

The low-carbon technology supporting the energy transition



Blue Hydrogen (2)

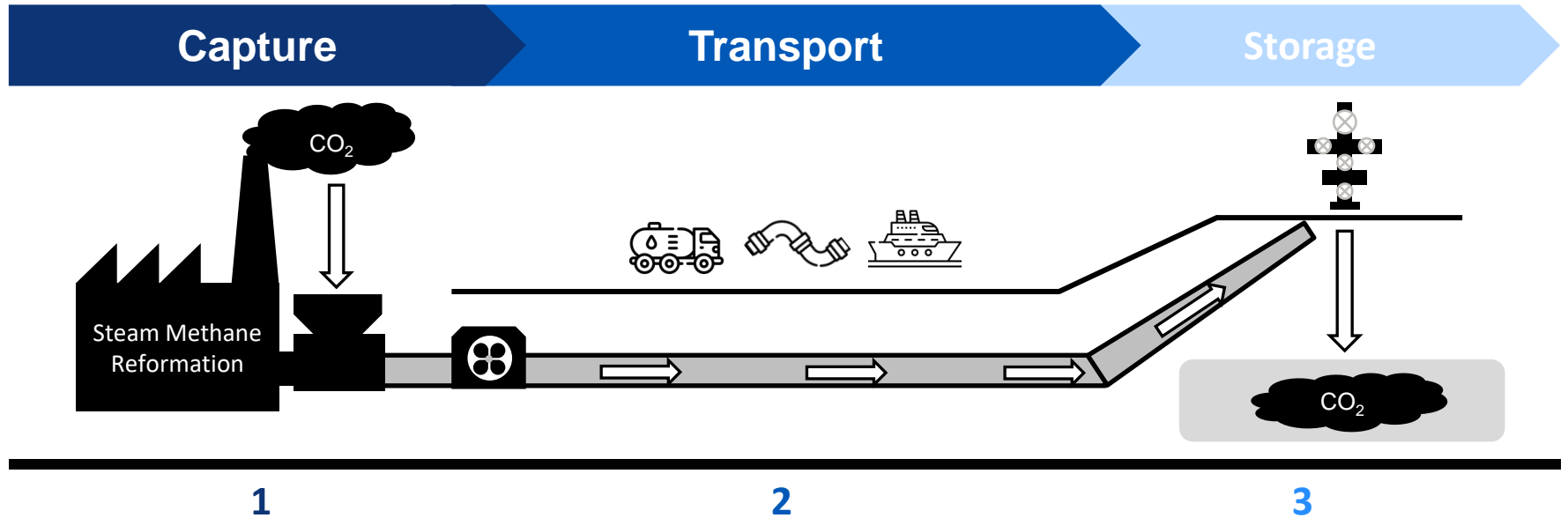
Steam methane reforming (SMR)





Carbon dioxide Capture and Sequestration (CCS)

The crucial short-term decarbonization strategy



Capture plants take effluent streams from **steam methane reformer** and separate the offtake into CO₂ and other substances

The purified and compressed **CO₂** is **pipelined, trucked** or **shipped** to the sequestration site

The pure **CO₂** is **injected** into rock formations **deep underground**



Risk assessment approaches (1)

CO₂ dangerous characteristics

For humans, CO₂ is both a **mildly toxic** and a **physical stressor**:

- ✓ toxicity thresholds: LC50_{hmn,30min} = 92000 ppm, IDLH = 40000 ppm
- ✓ cold burns threshold: -18 °C

For assets, CO₂ is a **physical stressor**:

- ✓ cold embrittlement
- ✓ erosion due to abrasive solid dry ice particles

For the marine biota, CO₂ is a **toxic stressor**:

- ✓ pH ↓



Risk assessment approaches (2)

Definitions

Blowout: uncontrolled release of oil and/or gas from wells after pressure control systems failures



When a wellhead blowout scenario occurs ...

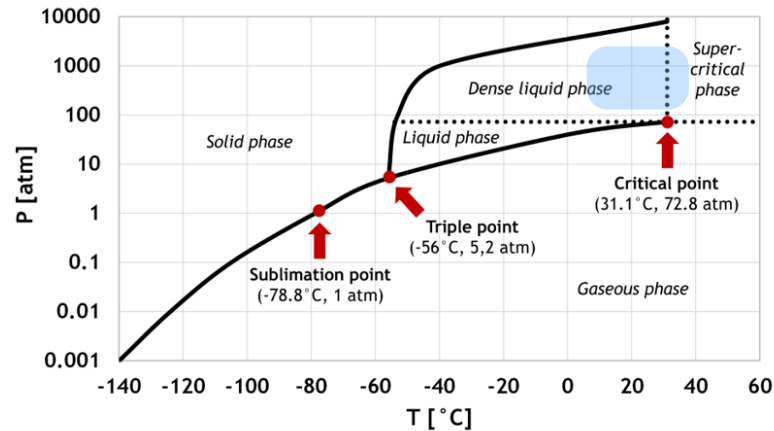
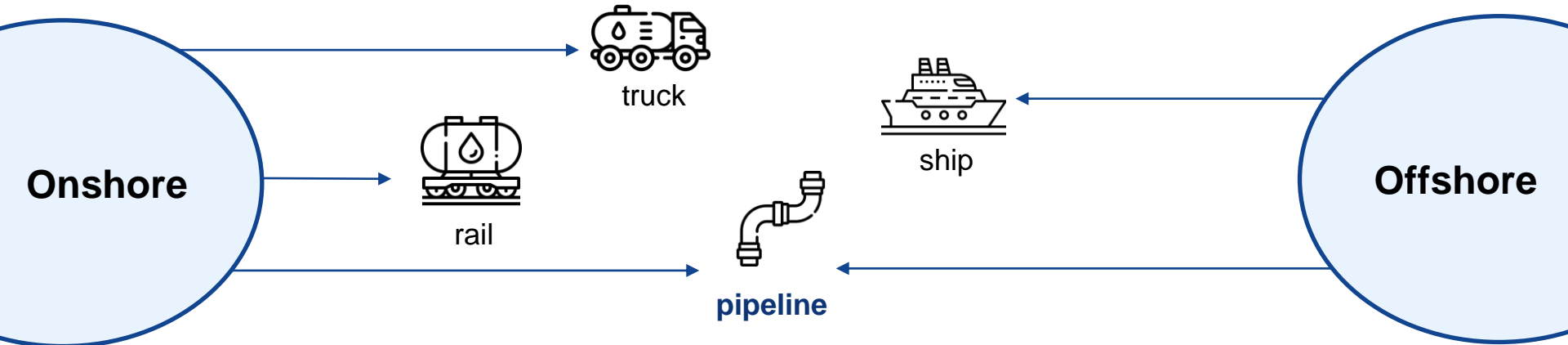


... the workers or animals located in the surrounding of the accident are at **RISK**



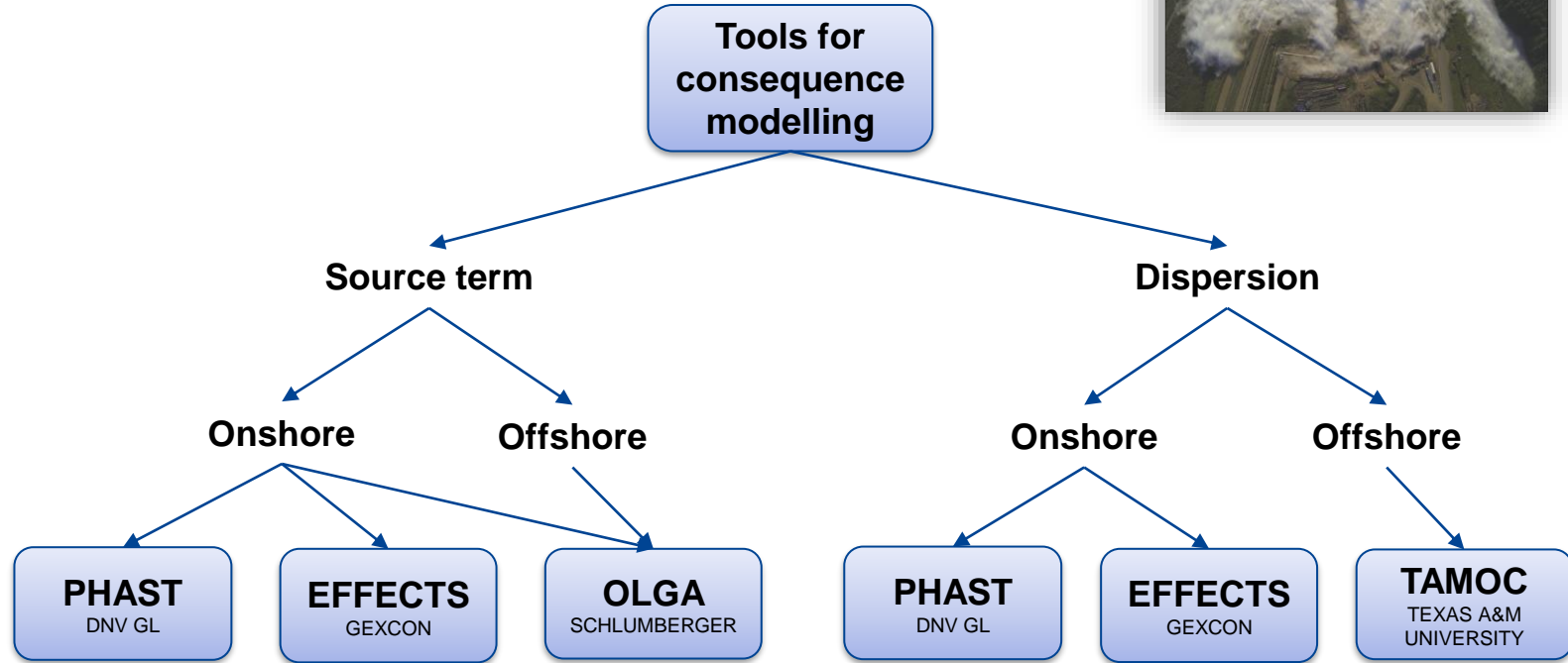
Risk assessment approaches (2)

CO₂ transport modes



Risk assessment approaches (3)

Pipeline consequence analysis





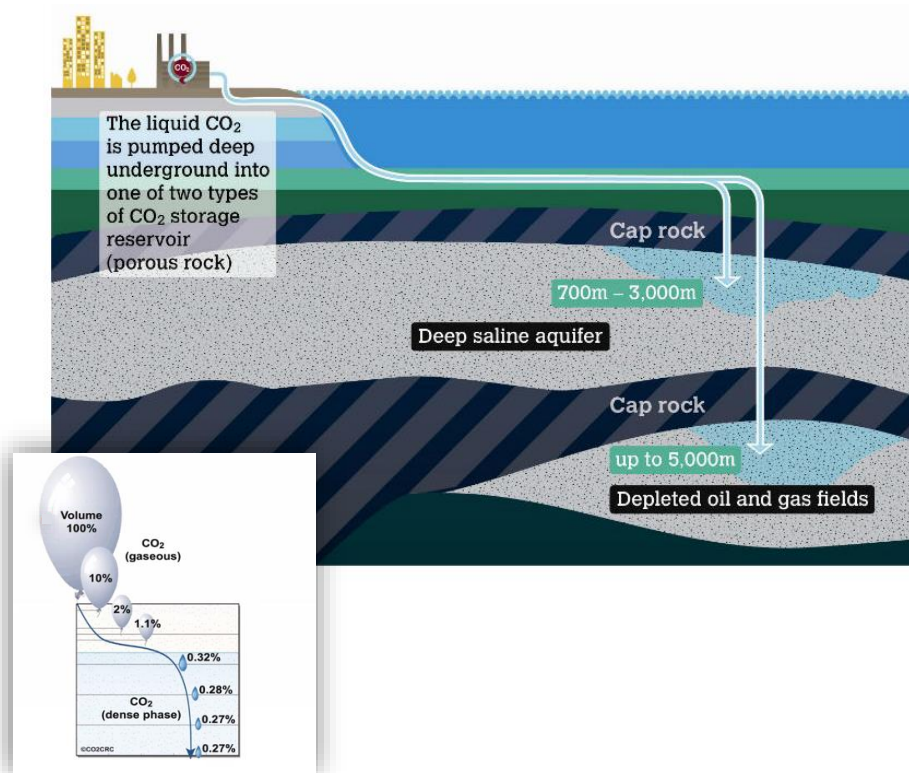
Risk assessment approaches (4)

CO₂ storage sites

Europe

- In the **North Sea**
- Saline aquifers

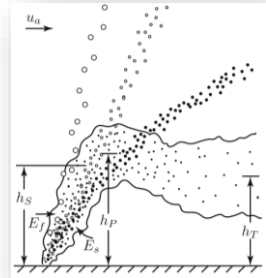
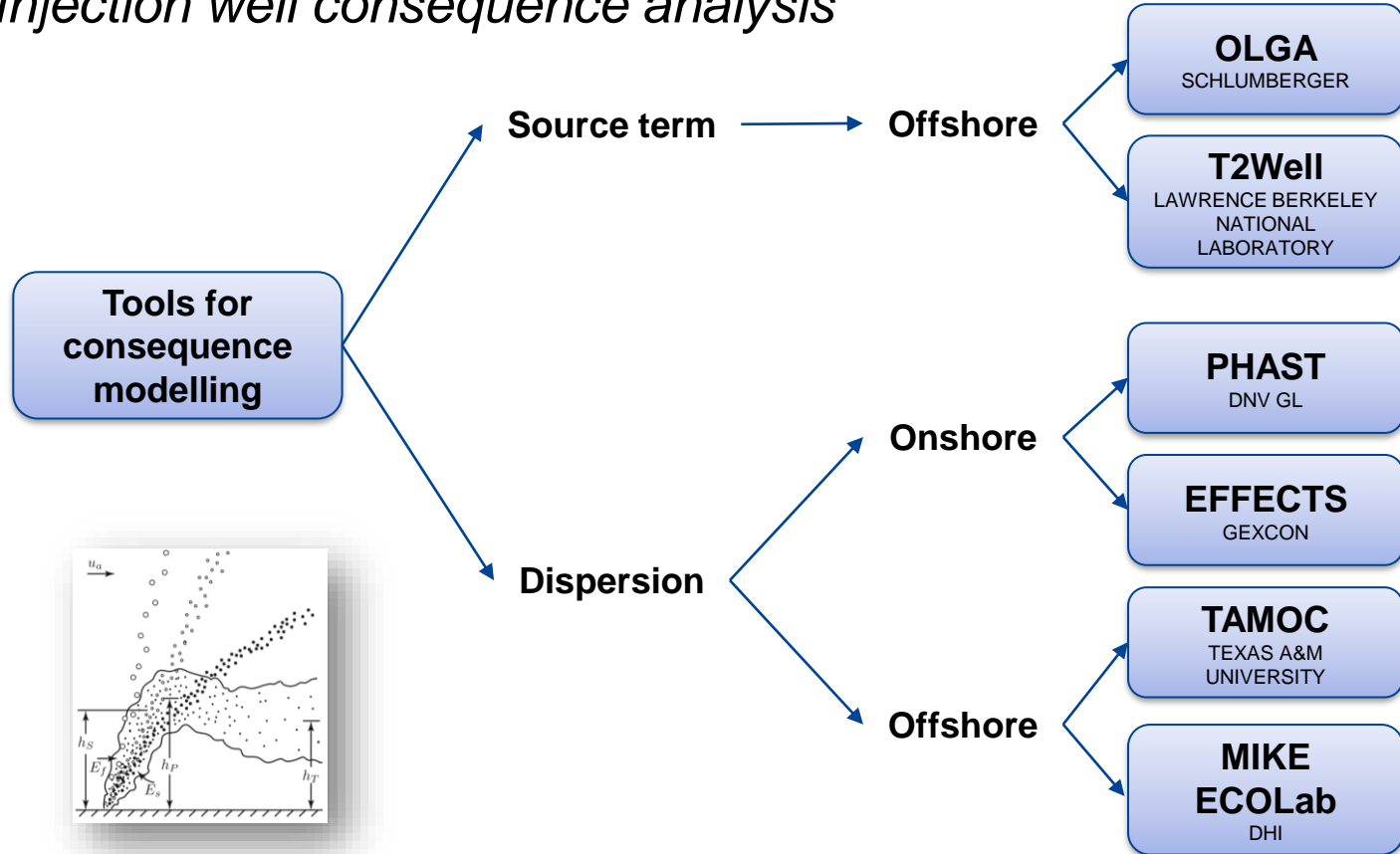
- In the **Adriatic Sea**
- Depleted natural gas fields





Risk assessment approaches (5)

Injection well consequence analysis





Conclusions and future developments

- Based on the peculiarities of CO₂, the adoption of more detailed consequence analysis tools (e.g., CFD) is suggested to strengthen the quantitative risk assessment structure
- Validation of consequence modelling tools against experimental data
- Improvement of the TAMOC code to account for two phases (liquid-vapour and solid-vapour) releases from CO₂ sealines

- Study of the Blue Hydrogen value chain
- Multi-objective analysis of the single step of the chain (i. e., bunkering process)
- Investigation into rapid phase transition and bleve phenomena

Thank you for your attention!

Federica Tamburini

NTNU – Department of Mechanical and Industrial Engineering (MTP)

federica.tamburini9@unibo.it