CO_2 Transportation Risk Assessment for Carbon Capture and Storage (CO2TRACCS)

Camelia Vasile – Institute for Studies and Power Engineering (ISPE)

Contents

- Consortium partners
- Project objectives
- Project summary
- Expected results
- Impact of project results
- Conclusions

1. Consortium Partners and Duration

- National Technical University of Athens (NTUA) - Coordinator
- Institute for Studies and Power Engineering (ISPE)
- Technical University of Sofia (TUS)
- Middle East Technical University (METU)

Start date: 01/12/2011, End date: 31/01/2014

2. Project Objectives

- To develop a novel predictive model providing the thermodynamic properties of pure CO_2 and its mixtures with water and other impurities, as well as CO_2 hydrates, that could be used for the design of a pipeline network typical for the Black Sea Region.

- To provide a detailed understanding of the hazards presented by pipelines transporting pressurised CO2 across land areas subject to landslides and earthquakes, as well as evaluate the corrosion, design and construction error risk;

- To embody the developed understanding and predictive capabilities in decision support tools in order to improve existing safety and risk assessment methods for CO_2 pipeline design and produce best practice guidelines.

3. Project Summary

WP1: Thermodynamic Analysis and Design of Pipeline Network for CO_2 Transportation (1)

WP Leader: NTUA

- *Task 1.1*: **Development of a predictive model for pure CO_2 and mixtures of CO_2 with hydrocarbons and water and of hydrate formation** - in the design of the CO_2 transport system 2 important issues need to be taken into account:
  - ✓ the influence of certain impurities contained in CO_2 streams from different processes on the physical behavior of the bulk gas;
  - ✓ the water content in CO_2 should be permanently controlled because of risks for corrosion and hydrate formation in the pipeline

Start date: M1, End date: M18

Deliverables/Milestones

- D1.1: A new predictive model for pure CO_2 and mixtures of CO_2 with other substances (M18)
- D1.2: A new predictive model for hydrate formation (M18)
  - ✓ Work is in progress

WP1: Thermodynamic Analysis and Design of Pipeline Network for CO_2 Transportation (2)

- *Task 1.2*: **Design of the pipeline network for the transportation of CO_2** - the task aims in the design of a pipeline network for CO_2 transportation in the Black Sea Region, corresponding to a situation representative of the countries involved in the project, namely large lignite-fired power plant clusters at a distance of 100-200 km from candidate storage sites with a mixed geographical terrain.

  Start date M6, End date M22

  Deliverables/Milestones

  - D1.3: Design of pipeline network for CO_2 transportation (M22)
    - ✓ Work is in progress

WP2: Multi-Hazard Risk Analysis (1)

WP Leader - METU

- *Task 2.1*: **Landslide risk (**Task Leader - **ISPE**) - General stability analysis and the analysis of deformability during pipeline operation will be performed. These analyses will include the influence of the calamities, such as: floods, unfavorable anthropogenic actions on slopes and embankments. Basic steps:
  - ✓ Establishing the possible locations of the pipeline routes, focusing on the existence of land filling areas, caves, foundations and abandoned constructions, mining fields, quarries and the correlation with natural and anthropogenic events
  - ✓ Establishing the land stratification and the delimitation of the various layers, the type and the physical state of the natural soils and solid rocks
  - ✓ Chemical determinations necessary for the characterization and classification of land categories and for the determination of land and groundwater chemistry impact on concrete, metals and soil
  - ✓ Hydro-geological research, respectively hydro-geological mapping, measurements of groundwater level, flow direction and aquifer layer types

Start date: M1, End date: M22

Deliverables/Milestones

- D2.1: Technical framework based on adequate algorithms for the landslides risk (M21)
  - ✓ Work is in progress

WP2: Multi-Hazard Risk Analysis (2)

- Task 2.2: **Seismic risk (**Task Leader - **METU)** - The probabilistic seismic hazard analysis (PSHA) methodology will form the basis for the development of seismic hazard maps for the region where the pipeline will be located. Basic steps:
  - ✓ Identification of the region selected as the affected area and compilation of a seismic database and subdivision of the region to be studied into discrete seismic sources
  - ✓ Plotting of a seismotectonic map that shows distribution of earthquake epicenters and their relationships with active faults
  - ✓ Selection of the appropriate probabilistic and stochastic models for the description of the earthquake magnitude distribution
  - ✓ Development or selection of a ground motion estimation (attenuation) equation
  - ✓ Preparation of a computational algorithm which will aggregate the seismic threat nucleating from different sources
  - ✓ Consideration of different sources of uncertainties
  - ✓ Plotting of the seismic hazard maps for the selected ground motion parameter corresponding to specified return periods for the region where the pipeline is to be located

Start date: M1, End date: M22

Deliverables/Milestones

- D2.2: Technical framework for the earthquake risk assessment standards (M20)
  - ✓ Work is in progress

WP2: Multi-Hazard Risk Analysis (3)

- Task 2.3: **Corrosion risk (**Task Leader - **TUS)** – activities of this task:
  - ✓ CO_2 streams composition evaluation related to carbon capture processes within Black Sea region power generation context;
  - ✓ Corrosion experiments for understanding the role of typically low grade coal induced impurities such as H_2S, SO_2, and NOx as well O_2 on the corrosion behavior of different pipeline construction materials;
  - ✓ Development of mitigation strategy for corrosion protection of CO_2 transport pipelines with CO_2 streams having high level of impurities by utilizing adequate carbon capture technology and/or new or improved pipeline construction materials and techniques.

Start date: M1, End date: M22

Deliverables/Milestones

- D2.3: Determination of the CO_2 streams composition oriented to typical Black Sea region located lignite fired power plants (M8)
- D2.4: Realization of corrosion test program with pipeline construction materials in supercritical CO_2-water environments in the presence of different impurities (M18)
- D2.5: Development of mitigation strategy for corrosion protection of CO_2 transport pipelines accounting for the CCS induced impurities (M22)
  - ✓ Work is in progress

WP2: Multi-Hazard Risk Analysis (4)

- Task 2.4: **Design and construction error risk (**Task Leader - **NTUA)** - based on the pipeline design results from Task 1.2, a study of the risks related to design and construction errors will be conducted. This will include the determination of the most probable errors that can arise in the design and construction of the pipelines, e.g. increased CO_2 flow due to erroneous design considerations or other causes, reduced pressure upstream the pipeline, intermediate compression stations design, materials defect, errors in support constructions, etc. and will assess the risks associated to the selected errors, in terms of safety and operability of the pipeline network

  Start date: M1, End date: M22

  Deliverables/Milestones

  - D2.6: Report on pipeline design and construction risks (M22)
    - ✓ Work is in progress

WP3: Risk Assessment Guidelines

WP Leader – ISPE

- In this work package a guide containing the results of the research performed in WP2 will be prepared. All project partners will summarize the obtained results of their specific research performed during the project. These summaries will be used for the preparation of the respective guidelines.

Start date: M22, End date: M24

Deliverables/Milestones

- D3.1: Risk assessment guidelines (M24)

WP4: Dissemination

WP Leader – TUS

- Four workshops and one seminar are planned for the entire duration of the project, in order to disseminate the on-going project results to interested parties from the energy sector and academia and provide training

  Start date: M1, End date: M26

  - ✓ Task 4.1: **Workshop in Turkey (Month 6)** - Task Leader: **METU** (completed)
  - ✓ Task4.2: **Workshop in Romania (Month 11)** - Task Leader: **ISPE** (completed)
  - ✓ Task 4.3: **Workshop in Athens (Month 16)** - Task Leader: **NTUA**
  - ✓ Task 4.4: **Workshop in Bulgaria (Month 21)** - Task Leader: **TUS**
  - ✓ Task 4.5: **Seminar in Romania (Month 24)** - Task Leader: **ISPE** - training for the Romanian national gas transmission company; the main support materials will be the risk assessment guidelines developed in WP3

WP5: Coordination

WP Leader – NTUA

Start date: M1, End date: M26

- **Kick-off meeting in Athens (Month 1)** - completed
- **Intermediate project meeting in Athens (Month 16)**
- **Final project meeting in Athens (Month 25)**

4. Expected Results

- Development of a new predictive model for pure CO_2 and its mixtures and for hydrate formation
- Pipeline network design for CO_2 transportation in the Black Sea region
- Technical frameworks for the landslides and earthquake risk assessment standards
- Corrosion test program with pipeline construction materials in supercritical CO_2-water environments for CO_2 streams composition for typical Black Sea region lignite-fired plants
- Development of mitigation strategy for corrosion protection of CO_2 transport pipelines
- Technical framework for the pipeline design and construction risks
- Development of risk assessment guidelines

5. Expected Impacts of Project Results

- The results of the project are expected to have a significant impact on the development of the principles of engineering and construction for CO_2 transportation pipelines and of the technical prescriptions for their design, construction and operation.
- The CCS technologies in Black Sea Region will be mostly implemented in large fleet of power plants fired with typical for this region low grade lignite. The predictive model for CO_2 mixture with impurities, as well as the analysis of their influence on the corrosion behavior, will be used for the development of a pattern for the CO_2 transportation pipelines in the Black Sea region.
- The study regarding the landslides and seismic risk effects over the CO_2 pipelines will help to the creation of the background support for the development of norms and regulations needed for the design, construction and operation of pipelines for CO_2 transportation.
- Risk assessment guidelines will be developed based on the obtained results.

6. Conclusions

- The successful outcome of the project requires good cooperation between the teams.
- PMT including one member from each research team was created.
- PMT specified the course of actions and the planning methodology and created a schedule that is regularly updated in six-monthly intervals through face to face meetings or teleconferences; the project progress is discussed and, if required, corrective actions are taken in order to fulfill the schedule for the deliverables.
- Each research team prepare six-monthly progress reports for the coordinator so that he can set the future course of actions.
- First interim report – February-March 2013

Thank you for your attention

Contact

Camelia Vasile

Institute for Studies and Power Engineering
Energy and Environment Division
Nr. 1-3, Lacul Tei Blvd,
020371, Sector 2
Bucharest

Tel.+ 4021 2061268
Fax. + 4021 2061317
E-mail: camelia.vasile@ispe.ro