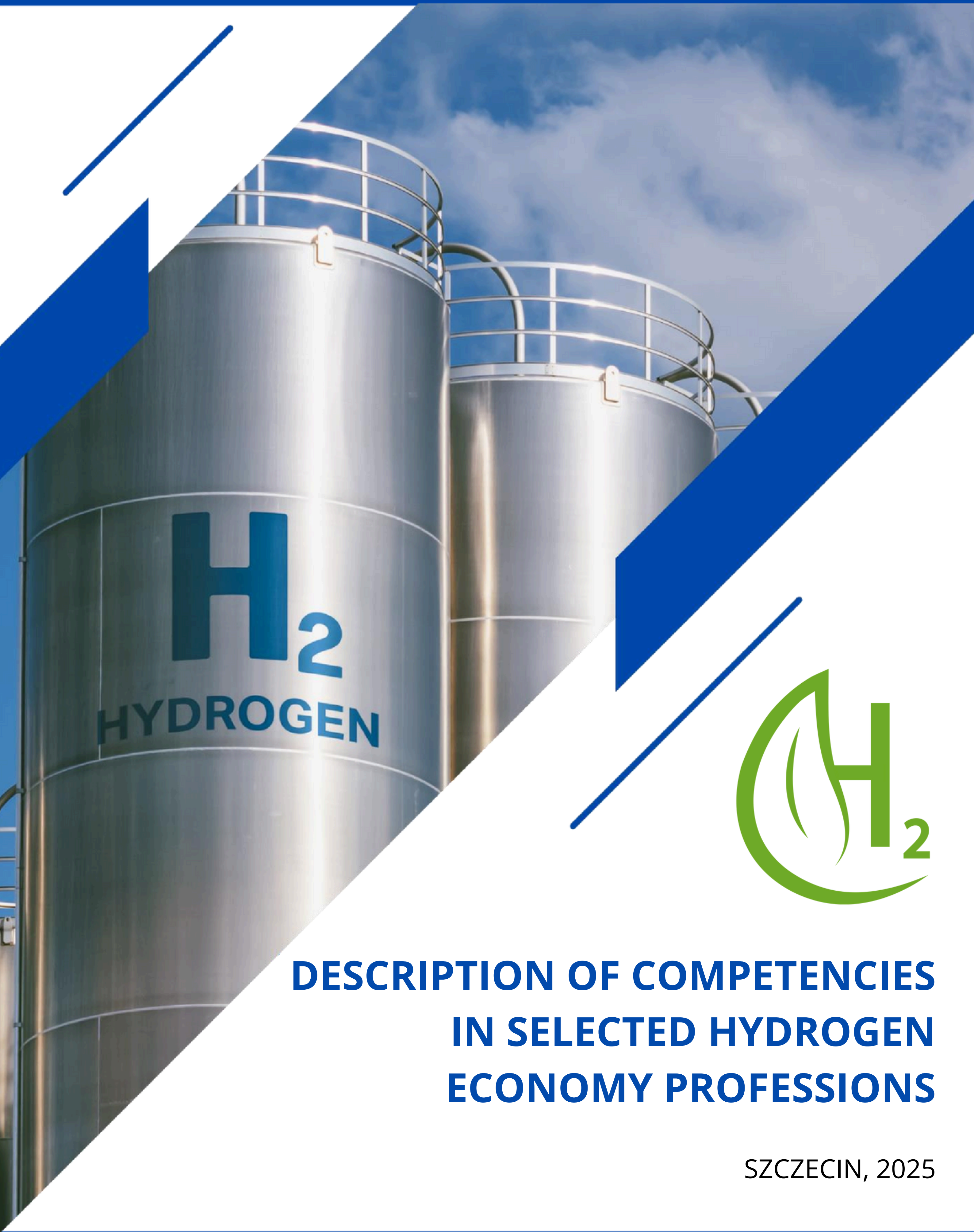

DESCRIPTION OF COMPETENCIES IN SELECTED HYDROGEN ECONOMY PROFESSIONS

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SPECIALISATION FRAMEWORK: Hydrogen system designer

In the face of global decarbonisation and energy transition efforts, hydrogen is gaining importance as a key energy carrier of the future. Its versatility and potential for reducing emissions make it increasingly used in sectors such as energy, transport or the chemical industry. In this context, the role of the **Hydrogen Plant Designer** becomes indispensable for the efficient and safe implementation of hydrogen technologies.

The hydrogen systems designer is responsible for the complex design of systems related to the production, storage, distribution and use of hydrogen. This includes both the creation of concepts and the detailed development of technical documentation that complies with current standards and regulations. This specialist works closely with engineers from various disciplines, clients and regulatory authorities to ensure that the designed systems are not only efficient, but above all safe and environmentally compliant.

Skills needs in a 10-year perspective

Over the next decade, the demand for hydrogen system design professionals is forecast to increase significantly. This is a result of global trends towards increasing the share of hydrogen in the energy mix and the development of hydrogen infrastructure. Key factors driving this demand are:

- **Hydrogen technology development**: Investment in new technologies for the production and use of hydrogen requires modern and innovative design solutions.
- **Infrastructure expansion**: Numerous projects are planned for the construction of electrolysers, hydrogen refuelling stations and storage systems, generating the need for qualified designers.
- **Safety regulations and standards**: The growing number of regulations relating to the safety of hydrogen systems requires specialists capable of interpreting and implementing them in projects.
- **Sustainability**: The drive to reduce CO_2 emissions and achieve climate neutrality is making hydrogen a key component of many countries' energy strategies.

Description of professional qualification

The hydrogen system designer should have the following qualifications and skills:

- **Technical education**: Preferred majors are chemical, mechanical, energy engineering or related.
- **Knowledge of hydrogen technologies**: In-depth knowledge of hydrogen production methods, storage, transport and applications.
- **Ability to design systems**: Experience in creating process flow diagrams (PFDs), P&ID diagrams and using CAD software.
- **Knowledge of standards and regulations**: Proficiency in national and international standards for hydrogen installations, such as ISO, IEC or NFPA.

- **Risk analysis**: Ability to carry out safety assessments, HAZOP analyses and develop contingency plans.
- **Interpersonal competence**: Effective communication with the project team, clients and regulators.

Areas of professional activity

A hydrogen designer can find employment in various sectors such as:

- **Energy industry**: projects related to the integration of hydrogen in energy systems, including hydrogen power plants and energy storage.
- **Transport**: Design of hydrogen refuelling stations for passenger vehicles, trucks and public transport.
- **Chemical industry**: installations for the production of ammonia, methanol and other hydrogen-based chemicals.
- **Research and development**: Participation in innovative projects to develop new hydrogen technologies.
- **Consultancies**: advice on the design, optimisation and safety of hydrogen systems.

Competence 1: Application of safety principles in the design of hydrogen systems

- Identifies and assesses potential risks associated with the operation of hydrogen systems, such as the risk of explosion, fire or leakage.
- Select construction materials and safety devices resistant to hydrogen, taking into account its physical and chemical properties.
- It applies the applicable technical standards and safety guidelines for plant design, such as ISO/TR 15916, EN 60079 or API RP.
- Analyses the specifics of hydrogen systems in terms of the risk of hydrogen embrittlement, corrosion and material damage.
- Include in the designs preventive measures against potential failures due to the properties of hydrogen, including detection, ventilation and emergency gas shut-off systems.

Competence 2: Risk analysis and management of emergency situations in projected installations

- Carries out detailed risk analyses using methods such as HAZOP, FMEA or 'fault tree analysis' (FTA) at the plant design stage.
- It develops scenarios for emergency events, such as fire, explosion or plant leakage, and strategies to minimise and control them.
- Creates emergency procedures and emergency and preventive action plans for designed hydrogen systems.

- It takes into account emergency mechanisms in the design, such as ignition from a spark or explosion due to exceeding flammability limits.
- Works with safety teams and emergency services to ensure an effective response to potential incidents.

Competency 3: Application of knowledge of the physico-chemical properties of hydrogen in design

- It analyses the physical properties of hydrogen, such as flammability, explosivity, diffusivity or density in different states of matter, in the context of their impact on the designed installations.
- Takes into account in designs the effects of ortho and para-hydrogen on storage and plant operation processes.
- It selects structural materials taking into account the risk of hydrogen embrittlement and the effects of hydrogen on different materials such as steel, aluminium and composites.
- He designs installations taking into account the explosive limits of hydrogen in air and its high chemical reactivity.

Competence 4: Application of legislation, industry standards and technical standards in design

- Interprets and applies national and European legislation governing the design, construction and operation of hydrogen systems.
- It incorporates the requirements of ISO, EN, IEC standards for the safety of hydrogen systems and explosion-proof equipment into its designs.
- It prepares technical documentation in accordance with current legislation and technical standards, including operating instructions, UDT documentation or safety procedures.
- It follows legislative and normative changes in the field of hydrogen technology, updating design solutions in accordance with the latest requirements.

Competence 5: Inspection and safety audit of designed hydrogen systems

- It designs systems to monitor plant operating parameters such as pressure, temperature, hydrogen concentration or structural integrity.
- Applies a methodology for auditing hydrogen systems for compliance with regulations and safety standards from the design stage.
- Analyses the technical data of the designed installations, identifying potential risks and anomalies.
- Prepares audit reports and recommendations for improving the technical safety of installations.

- Implements procedures for the continuous improvement of the safety of designed hydrogen facilities, taking into account the results of audits, potential incidents and recommendations from regulators.

Competence 6 - Personal competence

- Communicates clearly and accurately with other team members and customers.
- Prepares reports and documentation on hydrogen logistics.
- Works effectively in a team.
- Shares knowledge and experience with other team members.
- Resolves conflicts in a constructive manner.
- Implements measures to support local communities in developing the hydrogen economy.
- It builds and develops relationships with representatives from industry, local government and the scientific sector.
- Adapts work to the demands of the global market and cultural differences.

Personal competences with additional verification criteria

1. **Communicates clearly and accurately with other team members and customers.**
   Verification criteria:
   - Conducts effective conversations with customers and the team in simulated scenarios (e.g. discussing a logistics plan).
   - Creates clear and precise messages, adapting the style to the audience (e.g. technical details for the team, simplified information for the client).
   - It uses tools to support communication, such as presentations, visual reports and summary documents.
2. **Produces reports and documentation on hydrogen logistics.**
   Verification criteria:
   - Produces/reports on the implementation of the logistics project, including technical data, risk analysis and recommendations.
   - Develops clear instructions and procedures, good practice in the design of hydrogen systems.
   - Prepares documentation in accordance with legal requirements and industry standards.
3. **Cooperates effectively in a team.**
   Verification criteria:
   - Actively participates in simulated group tasks (e.g. joint development of a logistics plan).
   - Supports team members in solving technical or organisational problems.

- Provides constructive feedback and suggestions to improve the work of the team.

4. **Shares knowledge and experience with other team members.**
   Verification criteria:
   - Provides a short training session or presentation to the team on a selected aspect of hydrogen instillation design.
   - Shares developed materials (e.g. reports, checklists) with other team members.
   - Involves mentoring or coaching less experienced team members.
5. **Resolves conflicts in a constructive manner.**
   Verification criteria:
   - Simulates conflict resolution in a team (e.g. differences of opinion on hydrogen system designs).
   - Identifies causes of conflict and proposes realistic solutions.
   - Uses negotiation and mediation techniques in difficult team situations.
6. **Implements measures to support local communities in developing the hydrogen economy.**

Verification criteria:

- It initiates and participates in hydrogen education projects targeting local communities.
- It works with local organisations and institutions to promote awareness of hydrogen technologies.
- Prepares promotional material (e.g. brochures, presentations) on the benefits of the hydrogen economy for local communities.

7. **It builds and develops relationships with representatives from industry, local government and the scientific sector.**

Verification criteria:

- It organises meetings and workshops with representatives from different sectors to share knowledge and experience.
- Produces reports summarising the needs and expectations of various stakeholders in the context of the hydrogen economy.
- It implements joint initiatives such as pilot or demonstration projects.

8. **Adapts work to the demands of the global market and cultural differences.**

Verification criteria:

- Negotiates and cooperates with foreign partners, taking into account cultural and legal differences.
- Prepares project documentation and reports in English.
- Participates in international industry events (conferences, trade fairs, training courses) and applies the knowledge gained to local projects.

Competence 7 - Social competence

- He is responsible for his own safety and that of others.
- Conscientiously performs its tasks.
- Takes action in line with professional ethics.
- Independently plans and carries out assigned tasks.
- Shows initiative in finding new solutions.
- Able to make decisions in crisis situations.
- He is aware of the need to continuously improve his qualifications.
- Keeps abreast of technological innovations and regulatory changes.
- Participates in training courses and conferences.
- It is involved in initiatives to promote sustainable solutions in hydrogen logistics.
- It initiates activities for cooperation between the public, private and scientific sectors in the context of hydrogen logistics.
- He is involved in international logistics projects, taking an active role in the management and coordination of activities.

Social competence with verification criteria

1. **He is responsible for his own and others' safety.**
   Verification criteria:
   - Simulates a situation requiring a safety response.
   - Identifies potential risks in the logistics process and proposes preventive actions.
   - Monitors compliance with safety rules among team members.
2. **Performs his/her tasks conscientiously.**
   Verification criteria:
   - Provides regular reports and documentation according to the agreed schedule.
   - Performs tasks with due diligence, meeting project guidelines.
   - Commits to team goals, supporting other team members.
3. **Takes action in accordance with professional ethics.**
   Criteria for verification:
   - Carries out an analysis of the script for compliance with professional ethics.
   - Makes decisions that take into account the welfare of the team and clients.
   - Assesses the consequences of professional actions from a social responsibility perspective.
4. **Independently plans and carries out assigned tasks.**
   Verification criteria:
   - Creates a work schedule for a selected logistics task.

- Completes the task within the agreed time, reporting on progress and difficulties encountered.
    - Makes amendments to the plan based on changing design conditions.
5. **Shows initiative in finding new solutions.**
   Verification criteria:
    - It proposes innovative approaches to hydrogen design challenges.
    - Identifies improvements to existing logistics processes.
    - Makes recommendations at team meetings, supported by data analysis.
6. **Able to make decisions in emergency situations.**
   Criteria for verification:
    - Simulates the response to an emergency situation (e.g. hydrogen leak, accident).
    - Assesses possible action scenarios and selects the optimal option.
    - It implements decisions quickly and effectively, minimising losses and risks.
7. **Is aware of the need for continuous improvement of skills.**
   Verification criteria:
    - Prepares a professional development plan, including training and certifications.
    - Assesses own skills in the context of labour market needs.
    - He regularly updates his knowledge of new technologies and logistics solutions.
8. **Keeps abreast of technological innovations and regulatory changes.**
   Verification criteria:
    - Presents new technologies and regulations during team meetings.
    - Develops notes or reports on regulatory changes in the design of hydrogen instillations.
    - Uses newly learned tools or technologies in practical tasks.
9. **Participates in training courses and conferences.**

MODULE 1: INTRODUCTION TO HYDROCONIC TECHNOLOGY (16 hours)

MODULE 2: PHYSICOCHEMICAL PROPERTIES OF HYDROGEN AND INSTALLATION SAFETY (20 hours)

MODULE 3: STANDARDS AND REGULATORY PROVISIONS FOR HYDROCONIC INSTALLATIONS (16 hours)

MODULE 4: DESIGN OF HYDROGEN PRODUCTION INSTALLATIONS (24 hours)

MODULE 5: DESIGN OF HYDROGEN TRANSMISSION SYSTEMS (20 hours)

MODULE 6: DESIGN OF HYDROGEN STORAGE SYSTEMS (20 hours)

MODULE 7: DESIGN OF HYDRORINE USE SYSTEMS (24 hours)

MODULE 8: RISK ANALYSIS AND EMERGENCY MANAGEMENT (20 hours)

MODULE 9: AUTOMATISATION AND MONITORING OF HYDROTECHNICAL INSTALLATIONS (18 hours)

MODULE 10: ECONOMICS AND COST ANALYSIS OF HYDROLOGY (16 hours)

MODULE 11: MEGATRENDS AND INNOVATIONS IN hydrogen TECHNOLOGY (14 hours)

MODULE 12: INTEGRATED DESIGN OF A WATER SYSTEM (30 hours)

Total of 12 modules 238 hours

MODULE 2: INTRODUCTION TO HYDROGEN AND ITS PROPERTIES

Duration: 20 hours (8 hours lecture, 8 hours exercise, 4 hours workshop).
EQF level: 4-5

Aim: To understand the basic physical and chemical properties of hydrogen, which are key to safe storage and transport.

Topics:

1. 1. Hydrogen, properties, characteristics (1 hr - lectures, 1 hr - exercises).

- Physical properties of hydrogen (physical state, colour, odour, density and solubility in different substances, melting and boiling points, thermal and electrical conductivity
- Chemical properties of hydrogen (reactivity with other elements and chemical compounds, flammability,
- The role of hydrogen in industry, energy

2 Hydrogen: ortho and vapour - implications for storage (1 hr - lecture, 1 hr - exercise).

- Explaining the differences between ortho- and para-hydrogen.

- The importance of hydrogen isomerism in the context of storage and stability at low temperatures.
- Calculations of energy changes in ortho- and para-hydrogen transformations.
- Analysis of liquid hydrogen storage processes in relation to isomer content.

3. density of hydrogen in different states of matter (1 hr - lectures, 1 hr - exercises).

- Density of hydrogen in the gaseous, liquid and solid states - differences and their technological significance.
- Effect of pressure and temperature on hydrogen density.
- Hydrogen density calculations at different pressure and temperature parameters.
- Analysis of hydrogen phase diagrams.

4 Key temperatures for hydrogen (boiling, critical, triple point) (1 hr - lecture, 1 hr - exercise).

- Explanation of key temperatures: boiling point, critical point, triple point.
- The importance of these parameters for liquid and gaseous hydrogen storage.
- Analysis of hydrogen phase diagrams.
- Exercise: identifying suitable storage conditions for hydrogen based on its thermodynamic parameters.

5 Explosive range and flammability limits of hydrogen (1 hour - lecture, 1 hour - exercise).

- Discussion of the flammability limits of hydrogen and its explosive range in air.
- Causes and mechanisms of hydrogen explosions.
- Analysis of hydrogen-related explosion cases in industry.
- Defining safety conditions for working with hydrogen.

6 Hydrogen diffusivity and its consequences (1 hour - lectures, 1 hour - exercises).

- High hydrogen diffusivity and its impact on storage and transport safety.
- Discuss the potential risks of diffusion.
- Calculations for the diffusion of hydrogen through different materials.
- Selection of suitable materials for hydrogen storage.

7 Corrosive properties of hydrogen (1 hour - lecture, 1 hour - lab).

- The phenomenon of hydrogen embrittlement and its impact on structural materials.
- Corrosive properties of hydrogen in contact with metals.

- Analysis of hydrogen resistance data for materials.
- Exercise: design of hydrogen-resistant systems.

8. hydrogen hazards: causes of explosions and fires, hydrogen embrittlement (2 hrs - workshop)

- A case study of hydrogen-related failures.
- Designing safety procedures for working with hydrogen.

9. hydrogen detection methods and alarm systems (1 hr - lectures, 1 hr - workshop).

- Overview of hydrogen detection technology, including sensors and alarm systems.
- The role of detection systems in providing security.
- Configuration and testing of hydrogen sensors.

MODULE 3: LAW, STANDARDS AND REGULATIONS CONCERNING SAFETY. EMERGENCY PROCEDURES IN HYDROGEN MANAGEMENT

Duration: 20 hours *(8 hours lecture, 8 hours practical exercises, 4 hours workshop)*
EQF level: 6

Module objective: To familiarise participants with national and international regulations on the safety of hydrogen systems, including current technical standards, legislation and principles for developing and implementing emergency procedures. Participants will acquire the ability to interpret the regulations and their practical application in industry and transport.

1. national and international legislation on hydrogen and hydrogen facilities *(2 hours lecture + 2 hours exercise)*

- Key EU and Polish legislation:
  - Seveso III Directive
  - CLP Regulation, REACH
  - Environmental Protection Act
  - National Hydrogen Strategy
- Provisions for facilities with increased and high risk (HCAs and HZRs) - Operators' responsibilities
- Legal liability in the event of an accident involving hydrogen
- Exercises: analysis of infringement cases and legal consequences

2 Technical and safety standards for hydrogen systems *(2 hours lecture + 2 hours exercise)*

- Overview of key standards:
    - ISO/TR 15916: General principles for the safety of hydrogen systems
    - ISO 19880 (parts 1-8): Hydrogen refuelling, transfer systems
    - IEC 60079: Electrical apparatus for explosive atmospheres
    - PN-EN 60079, PN-EN ISO 45001 (BHP)
- Mandatory technical documentation (e.g. DoZW - Explosion protection document)
- Exercises: Assignment of appropriate standards to selected installation components

Hydrogen transport and ADR, RID, IMDG regulations *(2 hrs lecture + 2 hrs exercise)*

- Formal and documentary requirements for the transport of hydrogen in its various forms (gas, liquid, chemical compounds):
    - ADR - road transport
    - RID - rail transport
    - IMDG - Maritime transport
- Hazard classification, labelling, packaging, loading and unloading rules
- Obligations of the consignor, the carrier and the consignee
- Exercises: completing ADR documentation for the transport of liquid hydrogen, methanol, ethanol and ammonia

4 Development and implementation of emergency procedures for hydrogen systems *(2 hrs lecture + 2 hrs exercise)*

- Types of emergency scenarios: leakage, ignition, explosion, cooling system failure
- Principles for building emergency response procedures in hydrogen systems
- Coordination of internal activities and cooperation with external services (PSP, UDT, environmental inspection)
- Exercises: development of an emergency procedure for a selected situation (e.g. leakage at a refuelling station, failure of an electrolyser)

MODULE 4: DESIGN OF HYDROGEN PRODUCTION FACILITIES

Duration: 24 hours (12 hours of lectures, 8 hours of practical exercises, 4 hours of workshops)

EQF level: 6

Aim: To acquire the knowledge and skills necessary to design hydrogen production facilities, taking into account different production technologies, integration with renewable energy sources and aspects of safety and operational efficiency.

1. hydrogen production methods (6 hours - 3 hours lecture, 3 hours exercise):

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- Overview of the main hydrogen production technologies:
    - Water electrolysis (low-temperature and high-temperature)
    - Steam reforming of methane
    - Pyrolysis
    - Production of hydrogen from biomass
- Analysis of the efficiency, cost and environmental impact of the various methods.
- Practical exercises: calculations of yield and energy efficiency of various hydrogen production processes.

2. Integration of renewable energy sources with hydrogen production (4 hours):

- Use of solar and wind energy to power electrolysis processes .
- Issues related to energy storage and variability management of renewables.
- Case studies: analysis of existing installations using RES for hydrogen production.

3. Design of electrolysis systems (6 hours - 3 hours lecture, 3 hours exercise):

- Selection of electrolyser technologies: PEM, alkaline, SOEC
- Selection criteria: efficiency, cost, sustainability, purity of hydrogen produced.
- Practical exercises: design of electrolysis system for given production parameters.

4. Safety in the design of hydrogen production facilities (4 hours):

- Identification of risks associated with hydrogen production and maintenance.
- Safety standards and norms applicable to hydrogen systems.
- Risk minimisation strategies and emergency procedures.

5. Design workshop: development of a concept for a hydrogen production plant (4 hours):

- Work in groups to develop a design for a hydrogen production facility, taking into account the choice of technology, energy sources, risk analysis and economic aspects.
- Presentation and discussion of projects with emphasis on innovation, efficiency and safety

MODULE 5: DESIGN OF HYDROGEN TRANSFER SYSTEMS

Duration: 20 hours (10 hours of lectures, 6 hours of practical exercises, 4 hours of workshops)

EQF level: 6

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Aim: To acquire the knowledge and skills necessary to design safe and efficient hydrogen transfer systems, taking into account its specific properties, current standards and the latest technological trends.

1. **Physico-chemical properties of hydrogen and requirements for transmission systems (3 hours):**
    - Hydrogen characteristics: low density, high diffusivity, flammability.
    - Effects of hydrogen properties on transmission system materials and components, including the risk of hydrogen embrittlement.

2. **Materials and technologies used in the construction of hydrogen pipelines (4 hours - 2 hours lecture, 2 hours exercise):**
    - Selection of hydrogen-resistant materials, such as specialised steels and composites.
    - Modern technologies for connecting and sealing pipelines in the context of minimising leakage.
    - Practical exercises: case study of material damage in existing hydrogen systems.

3. **Adaptation of existing gas infrastructure for hydrogen transmission (4 hours):**
    - Opportunities and constraints of using current gas networks to transport hydrogen.
    - Case study: gas infrastructure adaptation projects in Poland and internationally.
    - Discussion of GAZ-SYSTEM's plans for hydrogen infrastructure in Poland.

4. **Safety and regulation in hydrogen transmission (5 hours - 3 hours lecture, 2 hours exercise):**
    - Review of national and international norms and standards for hydrogen transmission.
    - Procedures for dealing with emergency situations such as spills or fires.
    - Practical exercises: simulation of incident response in hydrogen transfer systems.

5. **Design workshop: development of a hydrogen transfer system concept (4 hours):**
    - Team work on the design of the hydrogen transfer system, including material selection, risk analysis and compliance with standards.
    - Presentation and discussion of projects with emphasis on innovation, efficiency and safety aspects.

MODULE 6: DESIGN OF HYDROGEN STORAGE SYSTEMS

Duration: 20 hours (10 hours of lectures, 6 hours of practical exercises, 4 hours of workshops)

EQF level: 6

Aim: To acquire the knowledge and skills necessary to design safe and efficient hydrogen storage systems, taking into account different storage technologies, hydrogen properties and applicable norms and standards.

1. Hydrogen storage methods (4 hours - 2 hours lecture, 2 hours exercise):

- Overview of the main hydrogen storage technologies:
    - Storage of compressed hydrogen in high-pressure tanks.
    - Liquid hydrogen storage at low temperatures.
    - Storage of hydrogen in the form of chemical compounds such as metal hydrides or methanol, ethanol, ammonia.
- Practical exercises: comparative analysis of the effectiveness and applications of different storage methods.

2. Materials and design of storage tanks (4 hours - 2 hours lecture, 2 hours exercise):

- Selection of hydrogen-resistant materials, taking into account the risk of hydrogen embrittlement and gas permeability.
- High-pressure and cryogenic tank design: strength, thermal and safety requirements.
- Practical exercises: design of basic components of storage tanks taking into account safety standards.

3. Safety and regulation in hydrogen storage (4 hours):

- An overview of national and international standards and norms for hydrogen storage, such as ISO 19880-1.
- Identification of risks associated with hydrogen storage, including the risk of leaks, fires and explosions.
- Emergency procedures and hazard detection and neutralisation systems.

4. Integration of storage systems with energy infrastructure (4 hours):

- The role of hydrogen storage in energy systems, including in the context of grid stabilisation and integration with renewable energy sources.
- A case study of the use of hydrogen storage in various industrial and transport sectors.
- Discuss the challenges of scaling up hydrogen storage technology.

5. Design workshop: development of a hydrogen storage system concept (4 hours):

- Team work on the design of a hydrogen storage system, taking into account technology selection, risk analysis, compliance with standards and economic aspects.

- Presentation and discussion of projects with a focus on innovation, efficiency and safety.

MODULE 7: DESIGN OF HYDROGEN UTILISATION SYSTEMS

Duration: 24 hours (12 hours of lectures, 8 hours of practical exercises, 4 hours of workshops)

EQF level: 6

Aim: **To** acquire the knowledge and skills necessary to design hydrogen systems in various economic sectors, with a focus on fuel cell technology, transport applications and electricity and heat generation.

1. Fuel cell technologies (6 hours - 3 hours lecture, 3 hours exercise):

- Overview of fuel cell types: PEMFC, SOFC, DMFC and their characteristics.
- Principles of operation, efficiency and potential applications of individual fuel cell technologies.
- Practical exercises: analysis of operating parameters and performance of different types of fuel cells.

2. Hydrogen applications in transport (6 hours - 3 hours lecture, 3 hours exercise):

- Use of hydrogen as a fuel in vehicles: cars, buses, trains, ships.
- Integration of hydrogen storage systems with propulsion systems.
- Practical exercise: design of a hydrogen power system for a selected means of transport.

3. Production of electricity and heat from hydrogen (6 hours - 3 hours lecture, 3 hours exercise):

- Use of hydrogen in power and heating plants: cogeneration, trigeneration.
- Analysis of the energy and economic efficiency of hydrogen-based systems.
- Practical exercise: simulation of a hydrogen-fuelled cogeneration system.

4. Safety and regulation in the use of hydrogen (4 hours):

- Overview of norms and standards for the operation of hydrogen systems in different sectors.
- Identification of potential hazards and emergency procedures.

5. Design workshop: development of a hydrogen utilisation system concept (4 hours):

- Team work on the design of a system using hydrogen in a chosen application (e.g. transport, energy).

- Presentation and discussion of projects with emphasis on innovation, efficiency and safety aspects.

MODULE 8: RISK ANALYSIS AND EMERGENCY MANAGEMENT

Duration: 20 hours (10 hours of lectures, 6 hours of practical exercises, 4 hours of workshops)

EQF level: 6

Aim: **To** acquire knowledge and skills in the identification, analysis and management of risks in hydrogen installations, as well as in responding effectively to emergency situations with hydrogen specificity.

1. Identification and classification of hazards in hydrogen systems (4 hours - 2 hours lecture, 2 hours exercise):

- Characterisation of potential risks associated with hydrogen production, storage and transport.
- Hazard identification techniques such as HAZID (Hazard Identification).
- Practical exercises: case study of historical incidents in hydrogen installations.

2. Risk analysis methods (4 hours - 2 hours lecture, 2 hours exercise):

- Introduction to methods such as HAZOP (Hazard and Operability Study), FMEA (Failure Mode and Effects Analysis) and FTA (Fault Tree Analysis).
- Assessing the likelihood and consequences of potential accidents.
- Practical exercise: carry out a risk analysis for a selected hydrogen plant.

3. Emergency management (4 hours - 2 hours lecture, 2 hours exercise):

- Develop and implement emergency plans and procedures for responding to hydrogen incidents.
- Role and responsibility of emergency teams and coordination of emergency response.
- Practical exercise: simulation of a hydrogen spill response in an industrial plant.

4. Communication and cooperation with emergency services (4 hours - 2 hours lecture, 2 hours exercise):

- Principles of effective communication during emergencies.
- Liaising with local emergency services and regulators.
- Practical exercise: developing a crisis communication plan for a hypothetical incident.

5. Workshop: simulation of crisis management in a hydrogen plant (4 hours):

- Team work on an emergency scenario involving a hydrogen leak and potential fire.
- Implementation of knowledge gained in risk analysis, contingency planning and communication.
- Discuss simulation results and draw conclusions for improving safety procedures.

MODULE 9: AUTOMATION AND MONITORING OF HYDROGEN SYSTEMS

Duration: 18 hours (8 hours lecture, 6 hours practical exercises, 4 hours workshop)

EQF level: 6

Aim: To acquire knowledge and skills in the design, implementation and management of automation and monitoring systems for hydrogen systems, taking into account the specific characteristics of hydrogen technology and safety requirements.

1. Fundamentals of process automation in hydrogen systems (4 hours - 2 hours lecture, 2 hours exercise):

- Overview of control and automation systems used in hydrogen systems.
- Integration of automation systems into hydrogen production, storage and distribution processes.
- Practical exercises: configuration of basic control systems for the hydrogen plant.

2. Plant condition monitoring technologies (4 hours - 2 hours lecture, 2 hours exercise):

- Methods and tools for monitoring hydrogen system performance, such as pressure, temperature, flow and leak detection.
- The use of hydrogen sensors and detection systems in various hazardous areas.
- Practical exercise: implementation of a monitoring system for a selected section of the hydrogen plant.

3. Safety and compliance in hydrogen plant automation (4 hours - 2 hours lecture, 2 hours exercise):

- Review of standards and norms for hydrogen plant automation and monitoring (e.g. IEC 61511).
- Identification and risk assessment of hydrogen process automation.
- Practical exercises: analysis of the compliance of the automation system with the applicable safety standards.

4. Integration of automation systems with IT and IoT infrastructure (4 hours - 2 hours lecture, 2 hours exercise):

- Use of Industry 4.0 technology in the management of hydrogen plants.

- Integration of SCADA systems with IoT platforms for remote monitoring and data analysis.
- Practical exercises: designing a monitoring system architecture using IoT technology.

5. Workshop: design and implementation of an automation system for a hydrogen plant (4 hours):

- Team work on the design of an automation system for a selected hydrogen plant, taking into account aspects of monitoring, security and integration with the IT infrastructure.
- Presentation and discussion of projects with emphasis on innovation, efficiency and compliance with standards.

MODULE 10: ECONOMICS AND COST ANALYSIS OF HYDROGEN TECHNOLOGIES

Duration: 16 hours (8 hours of lectures, 4 hours of practical exercises, 4 hours of workshops)

EQF level: 6

Aim: To acquire knowledge and skills in the economic aspects of hydrogen technologies, cost analysis of hydrogen production, distribution and use, and evaluation of the profitability of investments in hydrogen projects.

1. Economic aspects of hydrogen production (4 hours - 2 hours lecture, 2 hours exercise):

- Comparison of hydrogen production costs by technology: grey, blue and green hydrogen.
- Factors affecting production costs, such as the availability of raw materials, process efficiency and scale of production.
- Practical exercises: case study analysis of hydrogen production costs under different conditions.

2. Cost analysis of hydrogen distribution and storage (4 hours - 2 hours lecture, 2 hours exercise):

- Costs of transporting hydrogen by different methods: pipelines, road, sea and rail.
- Challenges and costs of storing hydrogen in compressed, liquid and compound form.
- Practical exercises: assessing the cost-effectiveness of different hydrogen distribution and storage methods in specific scenarios.

3. Evaluating the profitability of investment in hydrogen technologies (4 hours - 2 hours lecture, 2 hours exercise):

- Methods of economic analysis of investment projects: NPV (Net Present Value), IRR (Internal Rate of Return), payback period.

- The impact of energy policy, subsidies and regulation on the profitability of hydrogen investments.
- Practical exercises: carrying out a cost-effectiveness analysis of an example hydrogen project.

4. Workshop: Creating a business model for a hydrogen venture (4 hours):

- Team work to develop a comprehensive business model for the selected hydrogen technology, including cost analysis, potential revenue streams and risk assessment.
- Presentation and discussion of the prepared models with emphasis on innovation, feasibility and compatibility with current market trends.

MODULE 11: MEGATRENDS AND INNOVATIONS IN HYDROGEN TECHNOLOGIES

Duration: 14 hours (6 hours of lectures, 4 hours of practical exercises, 4 hours of workshops)

EQF level: 6

Aim: To familiarise participants with the latest trends, innovations and developments in hydrogen technology worldwide, in the context of the global energy transition and sustainable development.

1. Global megatrends in hydrogen technologies (4 hours - 2 hours lecture, 2 hours exercise):

- Analysis of key trends shaping the development of the hydrogen economy, such as decarbonisation, decentralisation of energy production and integration with renewable energy sources.
- Discuss the hydrogen policies and strategies of the world's leading economies and their impact on the global market.
- Practical exercises: case study analysis of hydrogen strategies of selected countries and their implications for the market.

2. Innovative technologies for hydrogen production (4 hours - 2 hours lecture, 2 hours exercise):

- An overview of modern methods of hydrogen production, with particular emphasis on water electrolysis using renewable energy and photoelectrochemical technologies.
- Discuss progress on efficiency and cost reduction in hydrogen production.
- Practical exercises: assessing the potential for the implementation of innovative hydrogen production technologies in various industrial sectors.

3. Innovative solutions in hydrogen storage and transport (4 hours - 2 hours lecture, 2 hours exercise):

- Demonstration of advanced hydrogen storage technologies, such as liquid, compound and metal hydride storage.
- Analysis of innovative methods of hydrogen transport, including the use of existing gas infrastructure and the development of new transmission networks.
- Practical exercises: conceptual design of hydrogen storage and transport systems taking into account the latest technologies.

4. Workshop: Future of hydrogen technologies - development scenarios (2 hours):

- Team work to develop scenarios for the development of hydrogen technologies in the short and long term.
- Identification of key factors influencing the implementation of innovation in the hydrogen sector.
- Presentation of the results of the group work and discussion of the challenges and opportunities related to the future of hydrogen technologies.

MODULE 12: INTEGRATED DESIGN OF THE HYDROGEN SYSTEM

Duration: 30 hours (10 hours of lectures, 10 hours of practical exercises, 10 hours of workshops)

EQF level: 6

Aim: **To** practically apply the knowledge and skills acquired in the previous modules by comprehensively designing a hydrogen plant, covering all stages from production, storage and distribution to the final use of hydrogen.

1. Introduction to integrated design (2 lecture hours):

- Discuss the aims and scope of the project.
- An overview of the key technical, economic and environmental aspects associated with hydrogen plant design.

2. Analysis of technical requirements and specifications (2 hours lecture, 2 hours exercise):

- Identification of end-user needs and site conditions.
- Determination of technical parameters for individual plant components.

3. Hydrogen production system design (2 hours lecture, 2 hours exercise):

- Selection of appropriate hydrogen production technology (e.g. electrolysis, reforming).
- Selection of energy sources with emphasis on integration with renewable energy sources.

4. Design of storage and distribution systems (2 hours lecture, 2 hours exercise):

- Selection of hydrogen storage methods (compressed, liquid, in compound form).
- Distribution infrastructure planning, taking into account transport safety and efficiency.

5. Integration of automation and monitoring systems (2 hours lecture, 2 hours exercise):

- Design of control systems and monitoring of plant operating parameters.
- Application of IoT technology and SCADA systems in plant management.

6. Economic analysis and project viability assessment (2 hours lecture, 2 hours exercise):

- Estimating investment and operating costs.
- Return on investment (ROI) analysis and financial risk assessment.

7. Design workshop (10 hours):

- Working as a team to develop a comprehensive hydrogen plant design.
- Presentation of the projects and discussion of the technical and economic solutions used.

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