VSB TECHNICAL UNIVERSITY OF OSTRAVA | CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

Integrated Hydrogen Technologies and Research Infrastructure for Decarbonisation of Energy Systems

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29th Internation Energy and Environmental Conference

Outline for today's presentation

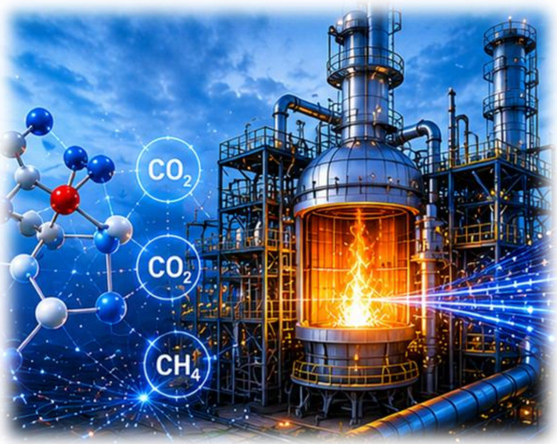
- Overview of the CEET
- Development of hydrogen technologies and infrastructure: from research to application
- Overview of innovative research projects: safety, separation, storage, production…
- Overview of innovative application projects: filling station, purity determination, hydrogen polygon…

Introduction of the Centre for Energy and Environmental Technologies

- Established on **1 January 2021** by merging four research units: Nanotechnology Centre, Energy Research Centre, ENET Centre and Institute of Environmental Technology.
- Operates in line with **low-carbon**, **sustainable energy** and **circular economy** principles to support the transition from fossil fuels to clean energy.
- CEET team consists of more than **300 regular employees**.
- Most important activites are focused on research and development and **cooperation with industrial partners.**
- CEET generates more than a **third of all cooperation with the application sphere** within VSB-TUO.

CEET – Research, development, innovation

- Use of alternative fuels, **renewable** energy sources and **waste** energy
- Advanced processes of thermal and **thermochemical transformation**
- Industrial **safety**, risk analysis and accident prevention
- **Hydrogen technologies** and hydrogen mobility
- **Energy** monitoring, **digitalization** and optimization
- **Smart grids** and intelligent energy management



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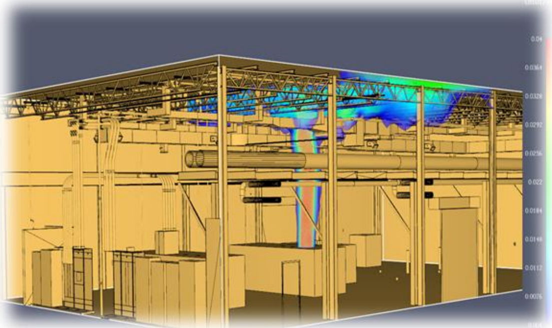
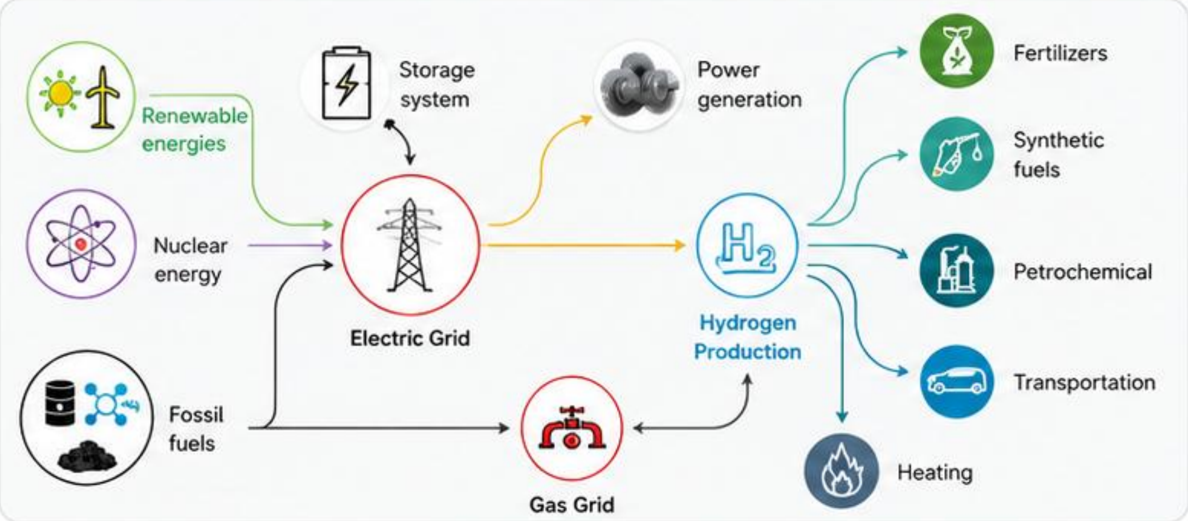
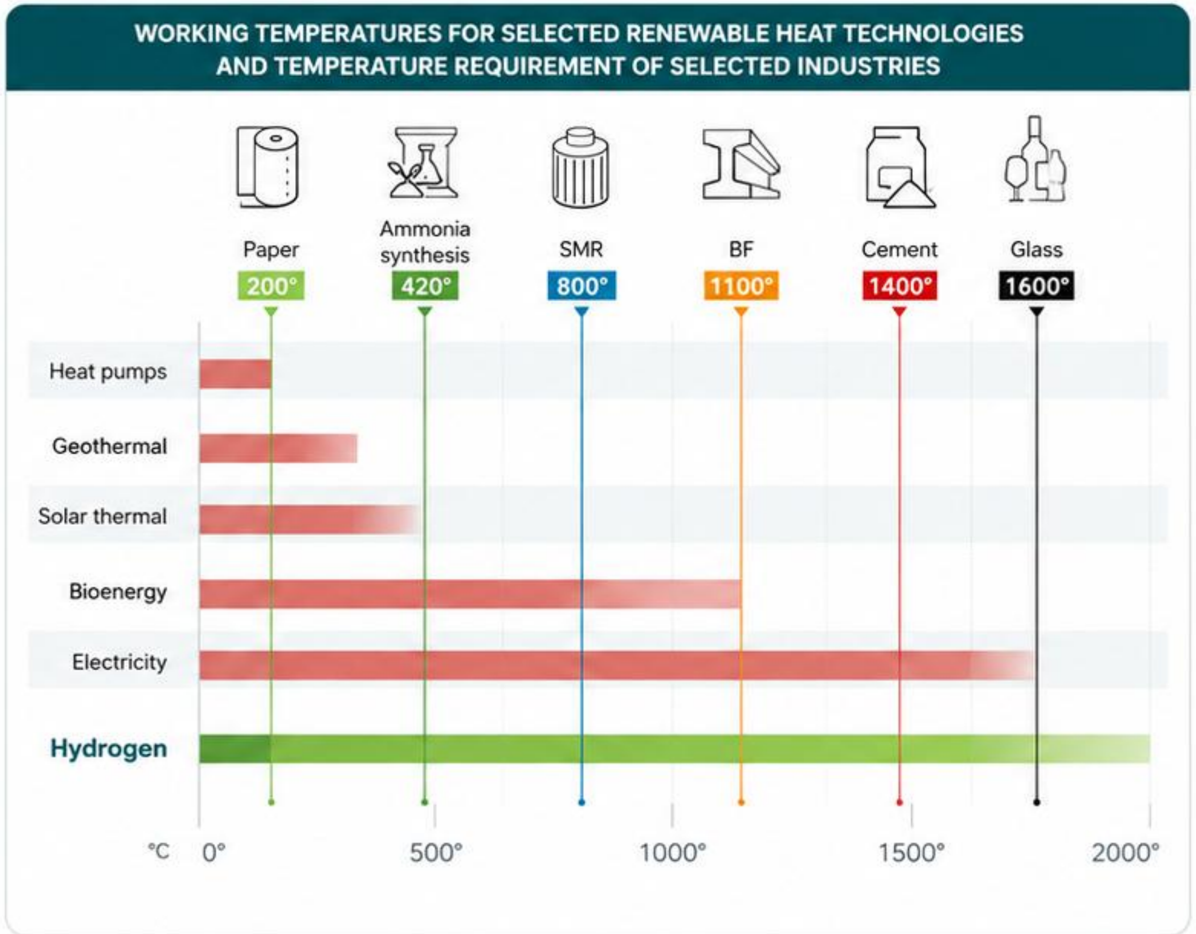
Centre for Energy and Environmental Technologies



Hydrogen production overview

- **How** do we replace fossil fuels while ensuring **energy security**, **economic stability**, and **environmental responsibility**?
- Hydrogen offers a **cleaner substitute** to fossil fuels for power generation and heating
- **Green hydrogen** is a particularly attractive source for hard-to-decarbonize sectors
- Hydrogen is already in wide use but scaling up green hydrogen will require **technological advances** and **lower cost**





- Cleaner energy for a sustainable future
- Enabling energy security and economic stability
- Powering hard-to-abate industries
- Driving innovation, reducing costs
- Building a resilient hydrogen economy

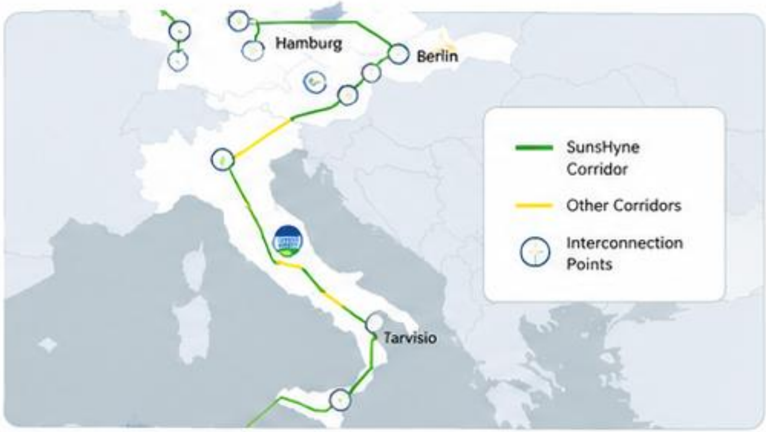
Possible hydrogen transport scenarios for the Czech Republic

1 Czech-German Hydrogen Interconnector – CGHI

- Connecting Czech **Republic with Germany**
- Pipeline length: ~550 km
- Capacity: Up to 4 Mt H_2/year
- **Strengthening energy security and market integration**

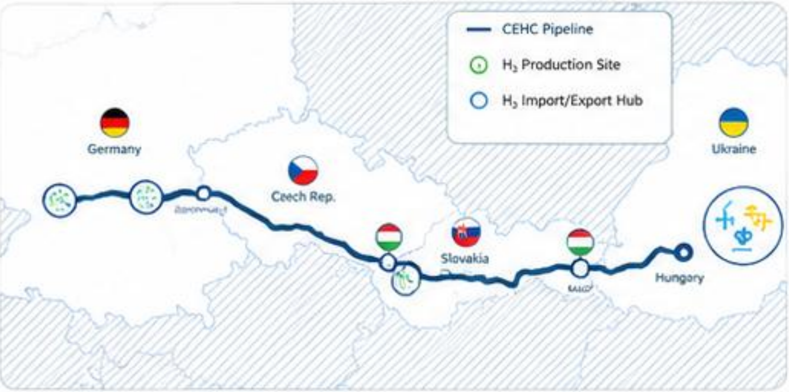
2 SunsHyne Corridor

- North–South corridor in Central Europe
- Pipeline length: ~3,000 km
- Capacity: Up to 10 Mt H_2/year
- **Enabling renewable hydrogen** flows from **North to South**



3 Central European Hydrogen corridor – CEHC

- East–West corridor **across Central Europe**
- Pipeline length: ~1,150 km
- Capacity: Up to 6 Mt H_2/year
- Enhancing regional **cooperation and supply diversity**



4 Central European Hydrogen corridor – CEHC

- Connecting Southern and South-Eastern Europe
- Pipeline length: ~2,000 km
- Capacity: Up to 8 Mt H_2/year
- **Supporting decarbonisation and industrial development**

Strengthening energy security | Enabling regional cooperation | Supporting clean hydrogen economy | Driving industrial decarbonisation | Building a resilient hydrogen network

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Laboratory of hydrogen technologies

Acta AES 1000 stack AEM electrolyser

Composed of 4 stacks, each containing 19 cells, with a total production capacity of **250 Nl H_2/h per stack**.

- **4 stacks** 19 cells per stack
- **250 Nl H_2/h** per stack
- **Operating pressure** Up to 30 bar
- **Alkaline Electrolyte Membrane (AEM)**

Nedstack 8-XXL fuel cell

Composed of 5 stacks with a total power of **5x 8kW**. Operating temperature: **65°C**, maximum hydrogen pressure: **0.45 bar**.

- **5 stacks** Fuel cell stacks
- **5 x 8 kW** Total power
- **Operating temperature** 65 °C
- **Maximum H_2 pressure** 0.45 bar

Advanced test infrastructure | Research & innovation | Flexible & modular design | Supporting the hydrogen transition

Hydrogen vehicle filling station

- **700 bar hydrogen refueling** for modern fuel-cell vehicles.
- **Real-time monitoring** of pressure, temperature, and flow.
- **Integrated safety systems** for risk elimination.

HYDROGEN FLOW: FROM PRODUCTION TO VEHICLE

- High-pressure 700 bar refueling
- Continuous monitoring of key parameters
- Advanced safety and leak detection
- Robust, reliable station design
- Supporting clean mobility future

Hydrogen purity analysis and sampling at high pressures

- **Accredited methodology** – determination of H_2 purity with continuous measurement
- **Development and validation** of **sampling** method
- **Optimization** of **analytical techniques** for high-pressure hydrogen (GC, MS, FTIR)
- **Ensure compliance with international standards** (ISO 14687)
- **Enhance safety** and **risk management**

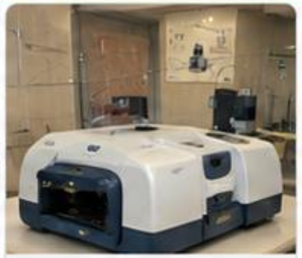
ANALYTICAL EQUIPMENT FOR HIGH-PRESSURE HYDROGEN

GC

Gas chromatography for permanent gases and impurities

MS

Mass spectrometry for trace-level impurity detection



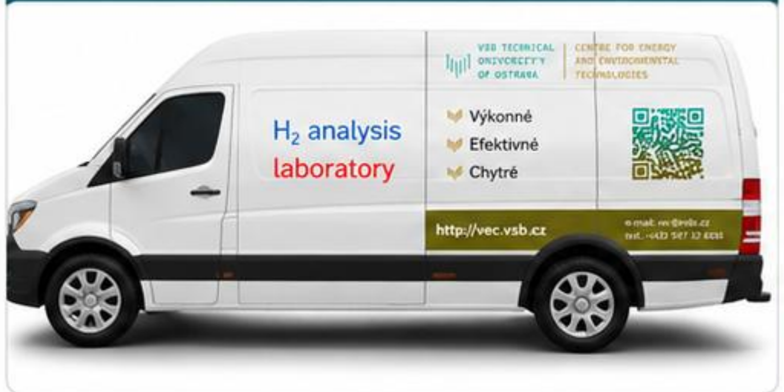
FTIR

Fourier transform infrared spectroscopy for molecular impurity identification

SAMPLING MANIFOLD

High-pressure sampling system with safe and repeatable operation

MOBILE H_2 ANALYSIS LABORATORY



HIGH-PRESSURE SAMPLING STATION

ON-SITE SAMPLING

HIGH-PRESSURE CYLINDERS & STORAGE

- Accurate purity determination
- Reliable sampling and validation
- Advanced analytical capabilities
- Compliance with ISO 14687
- Enhanced safety and risk control
- Supporting the hydrogen economy

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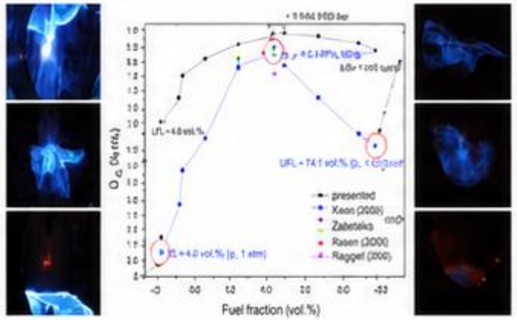
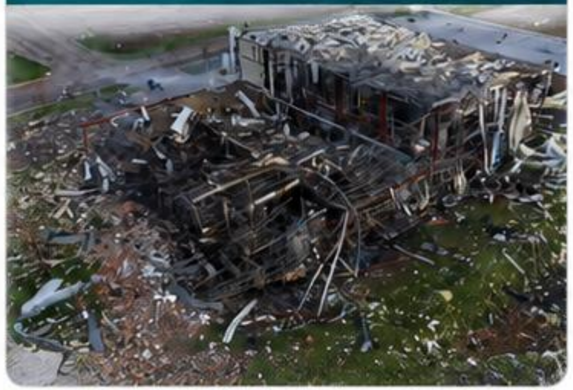
Hydrogen safety properties

- Analysis of **experimental factors** influencing the determination of explosion parameters
- Research **modelling tools** available for hydrogen mixtures (EFFECT, ALOHA)
- **Experimental verification** of the limits of flammability and explosiveness

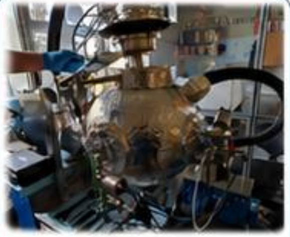
EXPLOSION PHENOMENA & DATA ANALYSIS



INCIDENT ANALYSIS



High-pressure reactor systems



Explosion vessels

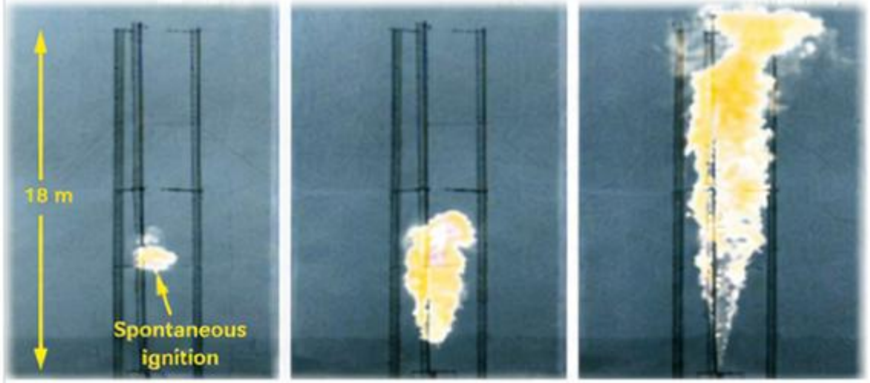
Gas handling and dosing

Pressure & temperature measurement

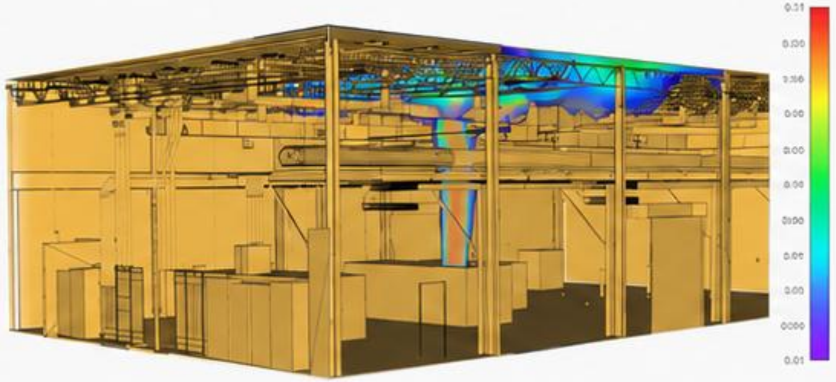
Ignition & data acquisition

20 L explosion vessel (1 – 100 bar)

FLAME BEHAVIOUR & IGNITION



MODELLING & SIMULATION



Reliable experimental data	Advanced modelling capabilities	Accurate risk assessment and prediction	Safer design and operation	Supporting the hydrogen economy

Process safety and methodology

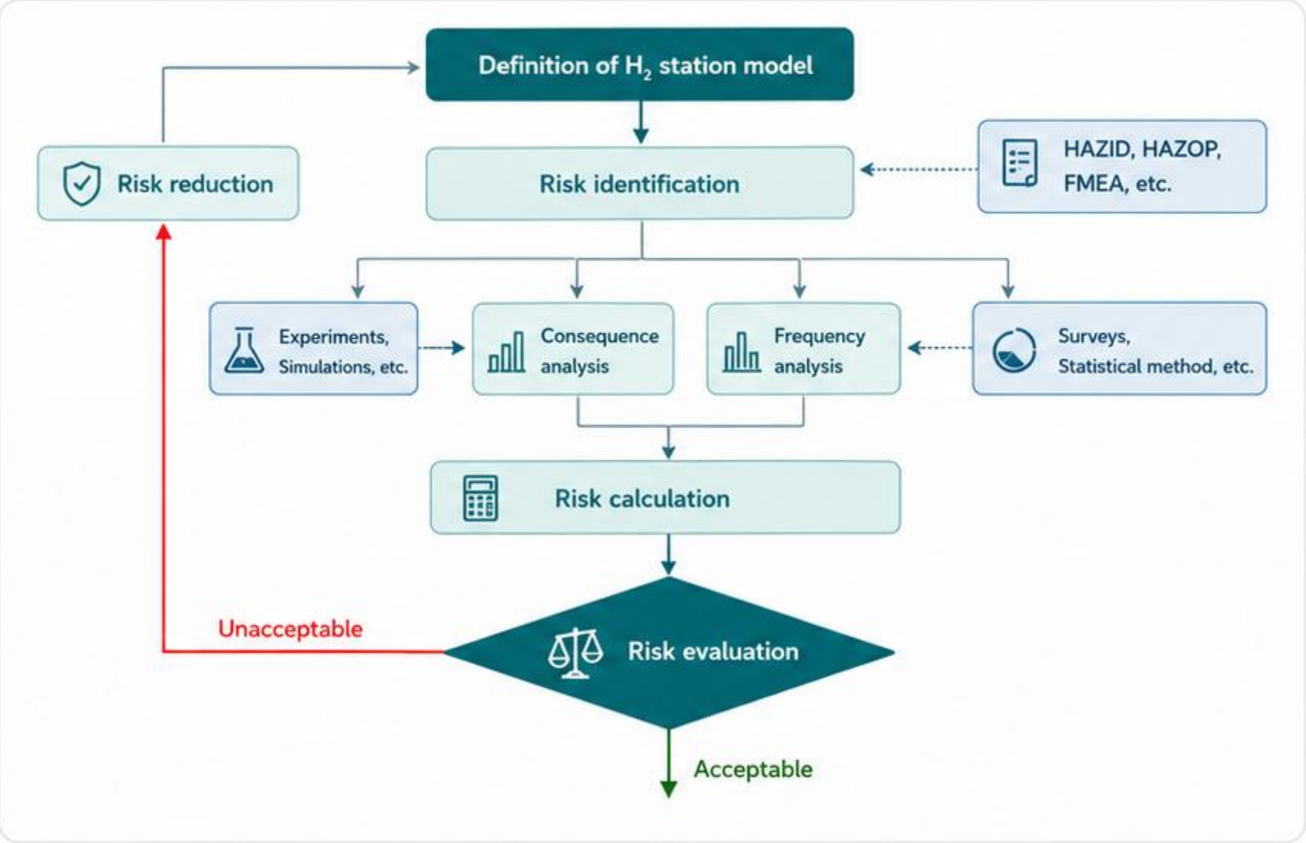
THE GOALS OF SAFETY PLANNING ARE TO:

- **Identify hazards**
- **Evaluate risks** by considering the likelihood and severity/consequence of an incident associated with the hazards
- **Minimize the risks** associated with a project/facility

To achieve these goals, various **hazard analysis and risk assessment** techniques are used, in conjunction with **safety reviews**.

COMMON METHODS EMPLOYED IN SYSTEMS SAFETY TODAY INCLUDE:

- Hazard and operability studies (HAZOPs)
- Failure modes effects and criticality analysis (FMECA)
- Preliminary hazards analysis (PHA)
- Fault tree analysis (FTA)
- Event tree analysis (ETA)



Schematic of risk assessment of hydrogen fueling station

Identify hazards early | Assess risks systematically | Apply proven methodologies | Implement effective risk controls | Protect people, assets and environment

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Fundamental safety considerations

A hazard and operability study (**HAZOP**) was carried out to identify all possible hazards and possible ways of handling them.

SYSTEMATIC APPROACH
Comprehensive risk identification

HAZARD AWARENESS
Understanding potential causes and effects

PROACTIVE PREVENTION
Mitigating risks before they occur

SAFE DESIGN & OPERATION
Protecting people, assets and environment

FAILURE MODE	SOURCE OF FAILURE	EFFECT	SEVERITY (1–10)	PROBABILITY OF OCCURRENCE (1–10)
Fire and explosion	Ignition in the vicinity of H_2 and O_2 release	Equipment damage and possible injuries	10	2
Hydrogen leak in piping	Mechanical failure, improper joints and fittings	Potential fire and explosion	7	3
Hydrogen leak in electrolyzer	Overpressure, improper gaskets or connections	Potential fire and explosion	8	3
Hydrogen storage tank	Mechanical failure, improper joints and fittings	Potential fire and explosion	8	3
Compressor failure	Equipment failure, worn out seals	Potential H_2 leak	5	6
Fans power rating ventilation error	Human error	Overpressure in vessels with potential H_2 leaks	6	3
Leak in low-voltage cabling	Equipment failure or damages	Potential fire	7	2
Inappropriate operator and response	Failure to follow emergency operating procedures, deficiency in procedures, and/or training	Overpressure on recieving fuel tanks	5	4
Incorrect check valve installation	Human error, inadequate inspection	Property damage	3	2
Weak or corroding nuts retaining system	External factor	Property damage and injuries	3	2

List of possible hazards of the H_2 station

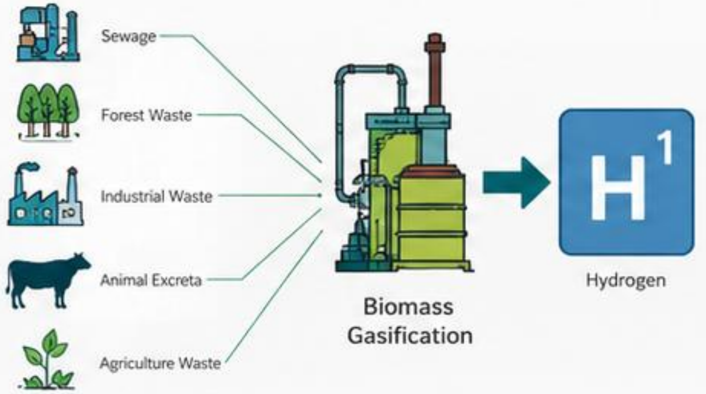
Safety by design in every stage | Identify hazards. Assess risks. | Implement controls. Prevent incidents. | Protect people, assets and the environment.

Hydrogen production via biomass gasification

Factors that influence hydrogen production

- Temperature (700 – 1000 °C – optimal for maximizing hydrogen in the syngas)
- Type of reactor (Fixed bed → Fluidized bed → Entrained flow → Dual fluidized bed)
- Feeding materials (moisture content, volatile matter, C/O ratio, ash content)
- Catalysts (nickel based, dolomite, noble metals)

BIOMASS TO HYDROGEN



WASTE COMPOSITION (VOL. %)

COMPONENT	MUNICIPAL WASTE	REFUSE DERIVED FUELS
H_2 [%]	48–50	38–40
CO [%]	36–39	37–39
CO_2 [%]	1–2	2–4
CH_4 [%]	4–6	0–1
N_2 [%]	5–7	16–19

BIOMASS GASIFICATION – CALORIFIC VALUE (MJ/Nm³)

COMPONENT	AUTOTHERMAL GASIFICATION	ALLOTHERMAL GASIFICATION	AUTOTHERMAL GASIFICATION USING $H_2O + O_2$
Calorific value [MJ/Nm³]	4–6	12–14	12–15
H_2 [%]	11–16	35–40	25–30
CO [%]	13–18	25–30	30–35
CO_2 [%]	12–16	20–25	23–28
CH_4 [%]	3–6	9–11	8–10
N_2 [%]	45–60	< 1	< 1

FLUIDIZED BED REACTOR

DUAL FLUIDIZED BED REACTOR

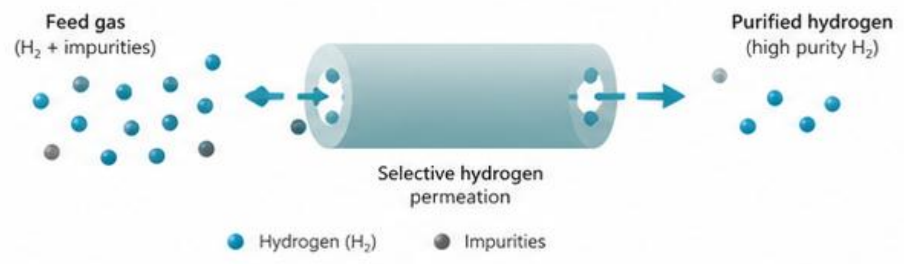
PILOT GASIFICATION UNIT

Sustainable feedstock utilization | Optimized process conditions | High hydrogen yield and efficiency | Supporting the hydrogen transition

Membrane technology for hydrogen separation

- Development of **membrane-based hydrogen purification** technology
- Experimental **verification** of membrane separation performance
- Testing **hydrogen admixtures** for gas applications
- **Separation of hydrogen** from low-concentration gas streams

MEMBRANE SEPARATION PRINCIPLE



EXPERIMENTAL TEST BENCH

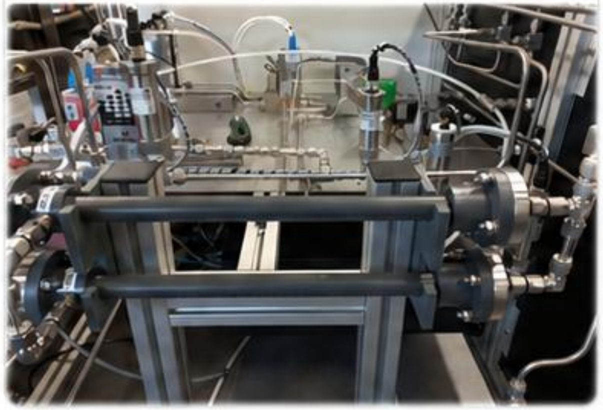
Flexible setup for membrane testing under controlled conditions

MEMBRANE MODULES

Advanced membrane materials and module development

SEPARATION SYSTEM

High-pressure testing and performance evaluation of membrane modules



- High separation performance
- Reliable and robust operation
- Scalable and modular design
- Enabling clean hydrogen applications

Advanced membrane materials | Proven performance through testing | Efficient separation of low-concentration streams | Supporting the hydrogen economy

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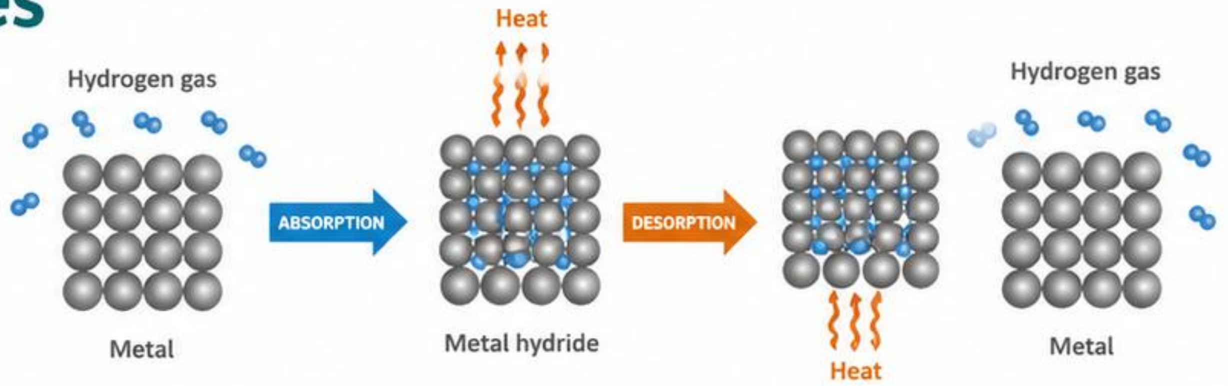
Hydrogen storage in metal hydrides

- **Thermodynamics** of metal hydrides
- Improve hydrogen **storage capacity** and kinetics
- Enhance **lifecycle** and **economic feasibility**



High hydrogen storage capacity | Fast kinetics and response | Long cycle life and durability

MyH$_2$ 2000
abs. capacity 2000 Nl, max. p. 30 bar, op. temp. 10 – 65 °C.

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PEM/AEM membranes preparation and testing for H_2 production

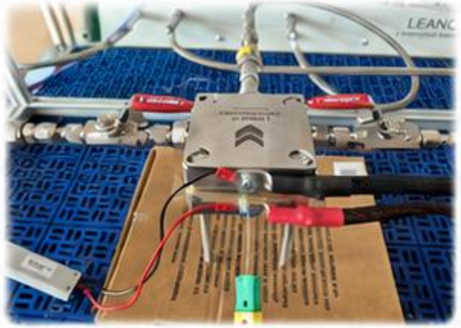
- Experimental evaluation of **electrolyser performance**
- Testing under varying **operational conditions** (temperature, pressure, load)

TEST BENCH & CONTROL SYSTEM

Advanced test bench with real-time monitoring and data acquisition.

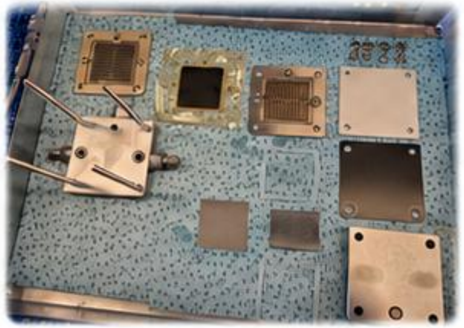
SINGLE CELL TESTING SETUP

Flexible single cell holder for accurate and reproducible measurements.



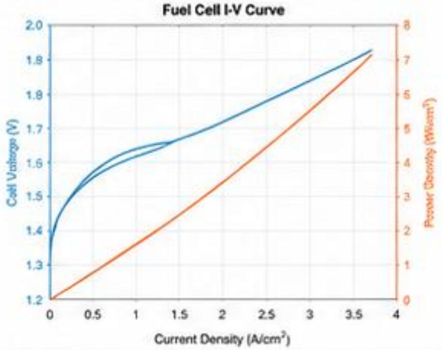
MEMBRANE & COMPONENT PREPARATION

Preparation and characterization of PEM/AEM membranes and components.



PERFORMANCE EVALUATION

Analysis of IV curves and performance metrics under various conditions.



- Precise evaluation of electrolyser performance
- Wide range of operational conditions
- Reliable data for R&D and scale-up
- Quality, safety and repeatability

Advanced research infrastructure | Expertise in membrane technologies | Data-driven optimization | Supporting the hydrogen transition

Unique package of hydrogen energy services

- Processing of **technical** and **economic studies** focusing on **hydrogen** technologies
- Energy **monitoring** and **optimization**, energy **management**
- Monitoring of **renewable** resources
- Complex **design** and **construction** activities in **hydrogen** sector

TECHNICAL & ECONOMIC STUDIES

Feasibility studies, techno-economic analyses and system assessments for hydrogen technologies.

ENERGY MONITORING & OPTIMIZATION

Real-time monitoring, data analytics and optimization to improve efficiency and reduce operating costs.

RENEWABLE RESOURCE MONITORING

Assessment and monitoring of renewable energy resources to support sustainable hydrogen production.

DESIGN & CONSTRUCTION IN HYDROGEN SECTOR

Engineering, detailed design and turn-key construction for hydrogen technologies and infrastructures.

Expertise & experience | Tailored solutions | Efficiency & performance | Sustainable future

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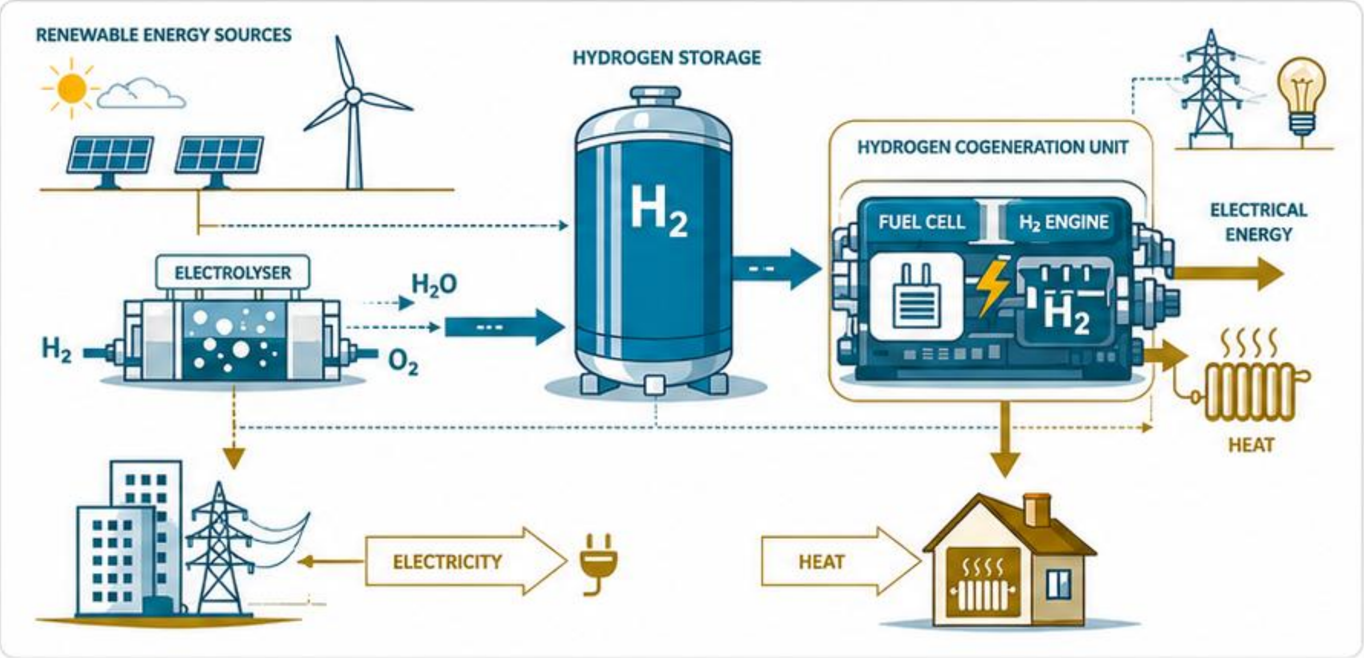
Hydrogen battery system for households

Autonomous system for green home

- Electrolysis system
- Hydrogen storage
- Fuel cell power system



CLEAN & RENEWABLE
Uses renewable energy to produce and store clean hydrogen.

ENERGY INDEPENDENCE
Provides reliable power and heat for homes and remote areas.

COST EFFECTIVE
Reduces energy costs by using stored hydrogen when needed.

SUSTAINABLE LIVING
Zero-emission solution supporting a greener future.

Smart hydrogen energy for a clean, independent and sustainable home.

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Development of a techno-economic concept for the hydrogen storage and refuelling station

- **General description** of the installation
- **Overview** of available technologies
- **Conducting** in-depth technical analysis
- **Determining** the best technical configuration
- **Determining** the energy and material consumption of the process

H_2 PRODUCTION & REFUELLING SYSTEM

CLEAN ENERGY | HIGH EFFICIENCY | SAFE & RELIABLE | COST OPTIMIZED

1 DISPENSER (HRS)
Hydrogen refuelling dispenser for cars, buses and heavy-duty vehicles.

2 STORAGE
High-pressure hydrogen storage (350 bar) ensuring safe and reliable supply.

3 COMPRESSOR
Multi-stage compression system to increase pressure efficiently.

4 ELECTROLYSER
PEM electrolyser converting water and electricity into hydrogen.

5 POWER & CONTROL
Integrated power electronics and control system for safe operation.

KEY OUTCOMES OF THE CONCEPT

SUSTAINABLE SOLUTION
Utilizes renewable energy and green hydrogen for decarbonization.

ECONOMIC EFFICIENCY
Optimized CAPEX and OPEX leading to lower total cost of ownership.

SCALABLE & FLEXIBLE
Modular design allows easy scaling and future technology integration.

KNOWLEDGE & IMPACT
Supports R&D, education and collaboration with industry and SMEs.

A comprehensive techno-economic concept driving innovation, sustainability and the transition to clean hydrogen mobility.

DEVELOPMENT OF A TECHNO-ECONOMIC CONCEPT
FOR THE HYDROGEN STORAGE AND REFUELLING STATION

Towards a sustainable and efficient hydrogen ecosystem

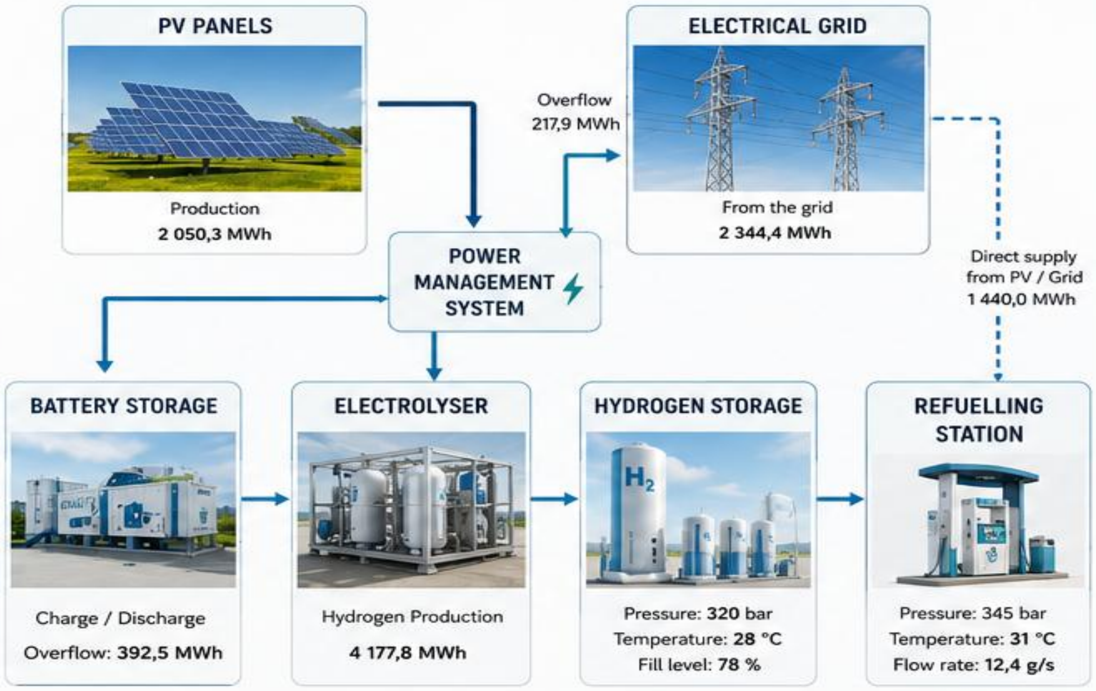
PROJECT OVERVIEW

- General description of the installation
- Overview of available technologies
- Conducting in-depth technical analysis
- Determining the best technical configuration
- Determining the energy and material consumption
- Techno-economic evaluation
- Environmental and sustainability assessment

SITE LAYOUT – CONCEPTUAL DESIGN

1. PV panels
2. Power & control building
3. Hydrogen storage
4. Refuelling dispensers
5. Compression & pre-cooling system

ENERGY & HYDROGEN FLOW DIAGRAM



Total annual energy balance	Hydrogen production capacity	Refuelling capacity	CO_2 avoided
≈ 4 570 MWh	≈ 1 050 kg H_2/day	≈ 200–250 kg H_2/day	≈ 1 500 t CO_2/year

KEY BENEFITS

- Utilization of renewable energy from PV and grid
- High-efficiency hydrogen production and storage
- Modular and scalable solution
- Zero-emission refuelling for heavy-duty and light vehicles
- Contribution to energy independence and decarbonization

KEY TECHNOLOGIES

- PEM Electrolyser
- High-pressure hydrogen storage (350 bar)
- Cascade compression system
- Advanced cooling and drying
- Smart energy management system
- Automated refuelling dispensers

TECHNO-ECONOMIC OUTCOMES

CAPEX (est.)	OPEX (est.)	LCOH (est.)	PAYBACK TIME (est.)
≈ 3.2 – 3.8 M€	≈ 110 – 150 k€/year	≈ 4.5 – 6.5 €/kg	≈ 7 – 10 years

A FUTURE-PROOF SOLUTION FOR CLEAN MOBILITY AND SUSTAINABLE ENERGY SYSTEMS

LIFE CYCLE ASSESSMENT (LCA) OF HYDROGEN

Evaluating environmental impacts across the entire hydrogen value chain

WHAT IS LCA?

- Methodology for evaluating environmental impacts during the entire hydrogen life cycle
- Assessment includes:
  - Hydrogen production
  - Compression and storage
  - Transport and distribution
  - End-use application
  - Decommissioning and recycling

THE HYDROGEN LIFE CYCLE

1. PRODUCTION
2. COMPRESSION & STORAGE
3. TRANSPORT & DISTRIBUTION
4. END-USE APPLICATION
5. END OF LIFE

1. e.g., Electrolysis using renewable electricity
2. Compression and storage in tanks or other carriers
3. Pipeline, truck, ship or other transportation
4. Industry, mobility, power generation, heating, etc.
5. Decommissioning, recycling and material recovery

MAIN ENVIRONMENTAL INDICATORS

- Greenhouse gas emissions (CO_2 eq.)
- Energy consumption
- Water footprint
- Resource depletion
- Air pollution impacts (NO_x, SO_x, PM, etc.)

COMPARISON OF HYDROGEN PRODUCTION PATHWAYS

HYDROGEN TYPE	MAIN SOURCE / TECHNOLOGY	TYPICAL CO_2 EMISSIONS (kg CO_2 eq./kg H_2)	RELATIVE IMPACT
GREY H_2	Natural gas (Steam Methane Reforming – SMR)	9 – 12	HIGH
BLUE H_2	Natural gas (SMR) + Carbon Capture and Storage (CCS)	2 – 4	MEDIUM
GREEN H_2	Water electrolysis using renewable electricity	0.5 – 1.5	VERY LOW
TURQUOISE H_2	Methane pyrolysis (solid carbon by-product)	1 – 3	LOW

Values are indicative and depend on technology, energy mix, efficiency and system boundaries.

KEY FACTORS INFLUENCING LCA RESULTS

- Electricity mix used for electrolysis
- Efficiency of hydrogen production technology
- Compression and storage method
- Transport distance and infrastructure
- Material selection and equipment lifetime

BENEFITS OF GREEN HYDROGEN

- Decarbonization of industry and transport
- Integration of renewable energy sources
- Reduction of fossil fuel dependency
- Support for sustainable energy systems

FUTURE RESEARCH DIRECTIONS

- Optimization of hydrogen supply chains
- Integration with digital twins and smart monitoring
- Circular economy approach for hydrogen technologies
- Standardization of LCA methodologies for H_2 systems

LCA provides a comprehensive understanding of environmental impacts and supports informed decisions towards a sustainable and low-carbon hydrogen economy.

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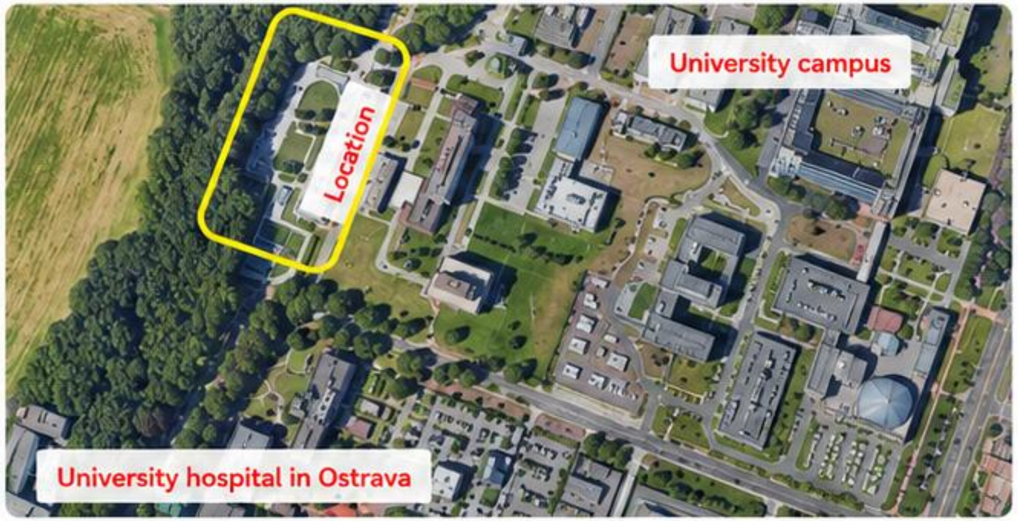
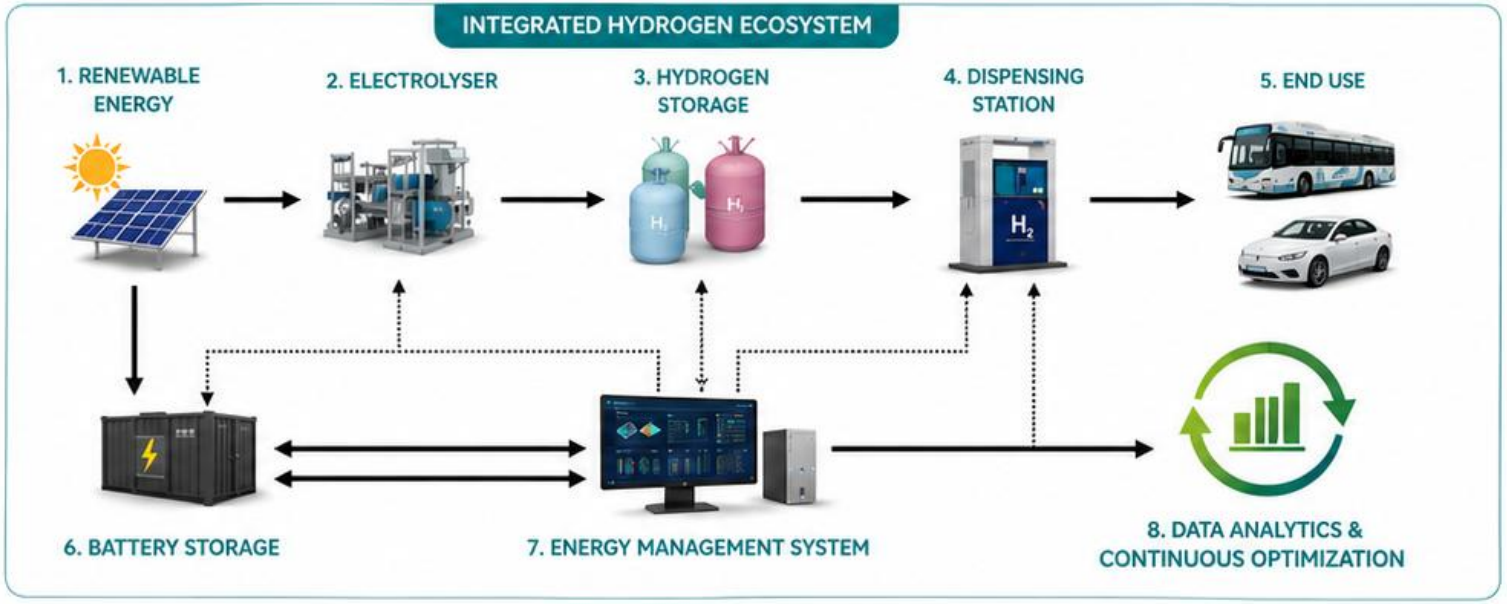
Project CEETe H_2

Creating a smart, integrated hydrogen ecosystem for sustainable mobility and energy

- The H_2 polygon will be integrated with the university **rooftop solar power plant** (~800 kWp).
- On-site **hydrogen production** for cars and buses.
- Fast combined **EV charging stations** supported by **battery storage**.
- Connection to the **university energy management system** for optimized operation.
- Real-world operation and **R&D use cases**.
- **Knowledge transfer** to SMEs and industry partners.
- **Continuous analysis** and **optimization** of operational data.





SUSTAINABLE SOLUTION
Utilizes renewable energy and hydrogen for zero-emission mobility.

ECONOMIC IMPACT
Supports innovation, creates value and new business opportunities.

EDUCATION & RESEARCH
Platform for students, researchers and industry collaboration.

SCALABLE MODEL
Replicable concept for other universities, cities and industrial sites.

A LIVING LAB FOR THE FUTURE OF CLEAN MOBILITY AND ENERGY SYSTEMS


VŠB TECHNICKÁ UNIVERZITA OSTRAVA
CENTRUM ENERGETICKÝCH A ENVIRONMENTÁLNÍCH TECHNOLOGIÍ
CEETe H2
88:88
H2 88:88
BUS
BUS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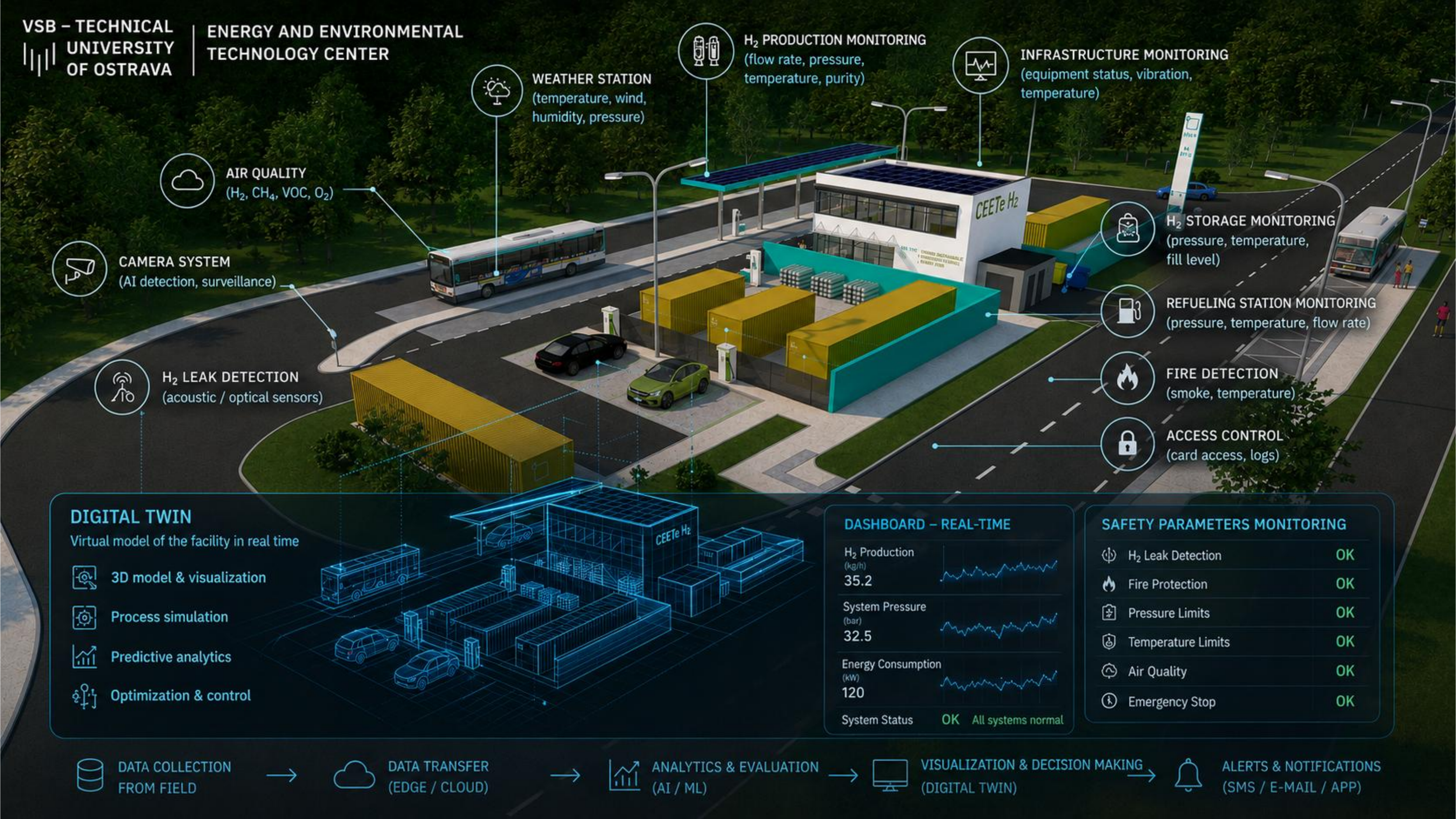
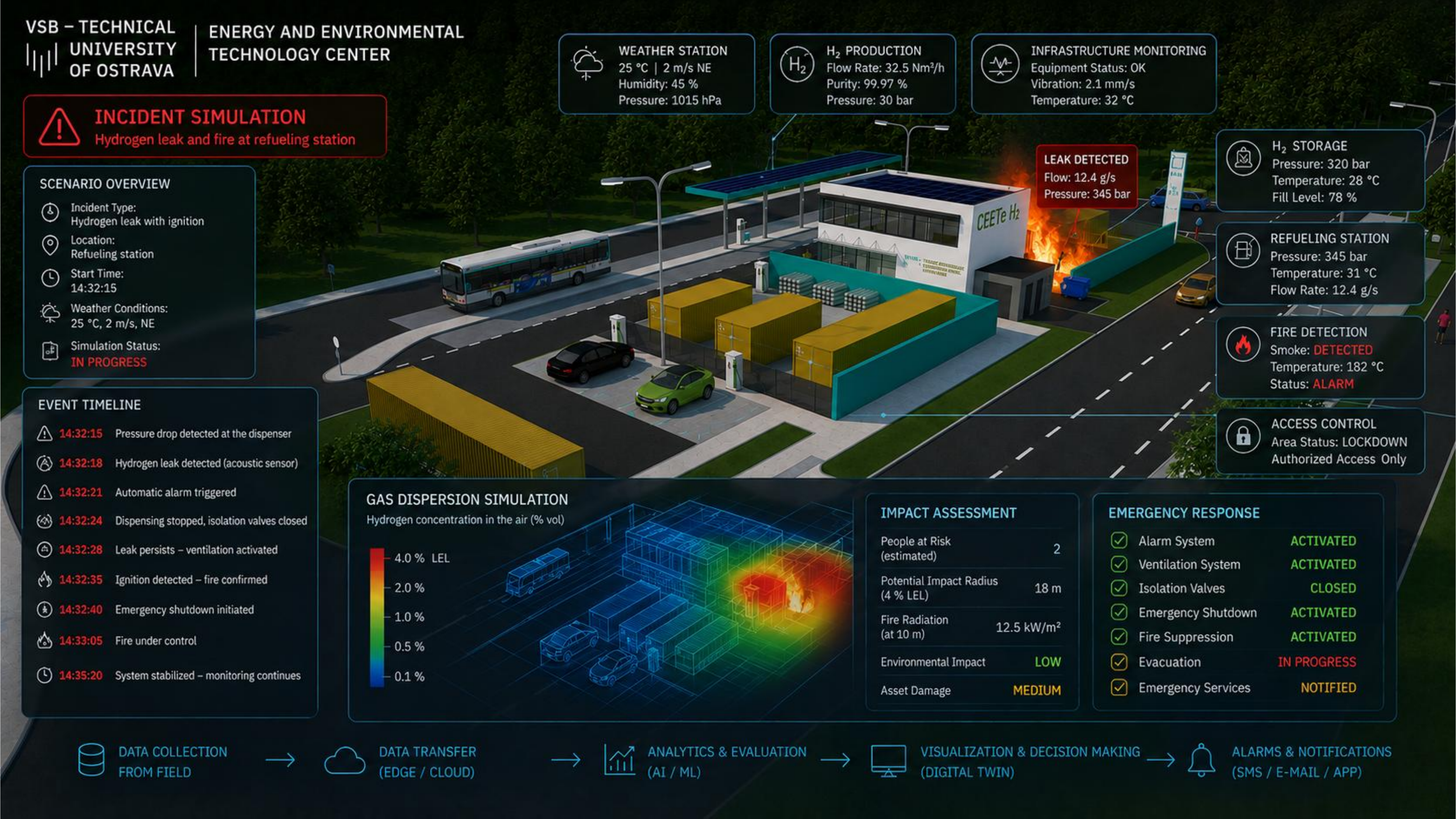
CENTRUM ENERGETICKÝCH A ENVIRONMENTÁLNÍCH TECHNOLOGIÍ
CEETe H2
H2



VSB – TECHNICAL UNIVERSITY OF OSTRAVA
ENERGY AND ENVIRONMENTAL TECHNOLOGY CENTER
WEATHER STATION (temperature, wind, humidity, pressure)
H₂ PRODUCTION MONITORING (flow rate, pressure, temperature, purity)
INFRASTRUCTURE MONITORING (equipment status, vibration, temperature)
AIR QUALITY (H_2, CH_4, VOC, O_2)
CAMERA SYSTEM (AI detection, surveillance)
H_2 LEAK DETECTION (acoustic / optical sensors)
H_2 STORAGE MONITORING (pressure, temperature, fill level)
REFUELING STATION MONITORING (pressure, temperature, flow rate)
FIRE DETECTION (smoke, temperature)
ACCESS CONTROL (card access, logs)
CEETe H2
DIGITAL TWIN
Virtual model of the facility in real time
3D model & visualization
Process simulation
Predictive analytics
Optimization & control
DASHBOARD – REAL-TIME
H_2 Production (kg/h) 35.2
System Pressure (bar) 32.5
Energy Consumption (kW) 120
System Status OK All systems normal
SAFETY PARAMETERS MONITORING
H_2 Leak Detection OK
Fire Protection OK
Pressure Limits OK
Temperature Limits OK
Air Quality OK
Emergency Stop OK
DATA COLLECTION FROM FIELD
DATA TRANSFER (EDGE / CLOUD)
ANALYTICS & EVALUATION (AI / ML)
VISUALIZATION & DECISION MAKING (DIGITAL TWIN)
ALERTS & NOTIFICATIONS (SMS / E-MAIL / APP)


VSB – TECHNICAL UNIVERSITY OF OSTRAVA
ENERGY AND ENVIRONMENTAL TECHNOLOGY CENTER
INCIDENT SIMULATION
Hydrogen leak and fire at refueling station
WEATHER STATION
25 °C | 2 m/s NE
Humidity: 45 %
Pressure: 1015 hPa
H_2 PRODUCTION
Flow Rate: 32.5 Nm³/h
Purity: 99.97 %
Pressure: 30 bar
INFRASTRUCTURE MONITORING
Equipment Status: OK
Vibration: 2.1 mm/s
Temperature: 32 °C
SCENARIO OVERVIEW
Incident Type: Hydrogen leak with ignition
Location: Refueling station
Start Time: 14:32:15
Weather Conditions: 25 °C, 2 m/s, NE
Simulation Status: IN PROGRESS
LEAK DETECTED
Flow: 12.4 g/s
Pressure: 345 bar
CEETe H_2
H_2 STORAGE
Pressure: 320 bar
Temperature: 28 °C
Fill Level: 78 %
REFUELING STATION
Pressure: 345 bar
Temperature: 31 °C
Flow Rate: 12.4 g/s
FIRE DETECTION
Smoke: DETECTED
Temperature: 182 °C
Status: ALARM
ACCESS CONTROL
Area Status: LOCKDOWN
Authorized Access Only
EVENT TIMELINE
14:32:15 Pressure drop detected at the dispenser
14:32:18 Hydrogen leak detected (acoustic sensor)
14:32:21 Automatic alarm triggered
14:32:24 Dispensing stopped, isolation valves closed
14:32:28 Leak persists – ventilation activated
14:32:35 Ignition detected – fire confirmed
14:32:40 Emergency shutdown initiated
14:33:05 Fire under control
14:35:20 System stabilized – monitoring continues
GAS DISPERSION SIMULATION
Hydrogen concentration in the air (% vol)
4.0 % LEL
2.0 %
1.0 %
0.5 %
0.1 %
IMPACT ASSESSMENT
People at Risk (estimated) 2
Potential Impact Radius (4 % LEL) 18 m
Fire Radiation (at 10 m) 12.5 kW/m²
Environmental Impact LOW
Asset Damage MEDIUM
EMERGENCY RESPONSE
Alarm System ACTIVATED
Ventilation System ACTIVATED
Isolation Valves CLOSED
Emergency Shutdown ACTIVATED
Fire Suppression ACTIVATED
Evacuation IN PROGRESS
Emergency Services NOTIFIED
DATA COLLECTION FROM FIELD
DATA TRANSFER (EDGE / CLOUD)
ANALYTICS & EVALUATION (AI / ML)
VISUALIZATION & DECISION MAKING (DIGITAL TWIN)
ALARMS & NOTIFICATIONS (SMS / E-MAIL / APP)

VSB TECHNICAL UNIVERSITY OF OSTRAVA | CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

Thank you for your attention

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