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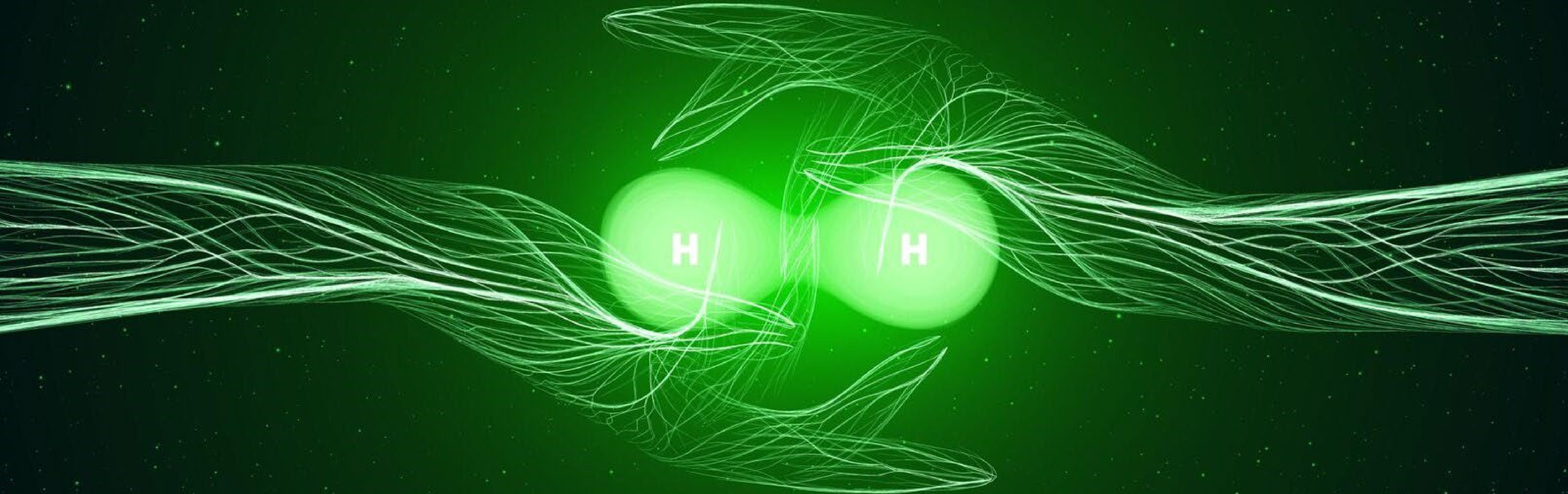

Powering the Future: Hydrogen Technologies at CEET

Dr. Jan Veres
Project manager for hydrogen activities

3rd Czech-German Business Meeting, 18.3.2026

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…

Faculty of Mining and Geology

Faculty of Materials Science and Technology

Faculty of Mechanical Engineering

Faculty of Economics

Faculty of Electrical Engineering and Computer Science

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Faculty of Civil Engineering

Faculty of Safety Engineering

IT4Innovations National Supercomputing Center

CEET
CENTRE FOR ENERGY AND ENVIRONMENTAL TECHNOLOGIES

ENET CENTRE

CEET-CENET

NANOTECHNOLOGY CENTRE

CEET-CNT

INSTITUTE OF ENVIRONMENTAL TECHNOLOGY

CEET-IET

ENERGY RESEARCH CENTRE

CEET-ERC

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.

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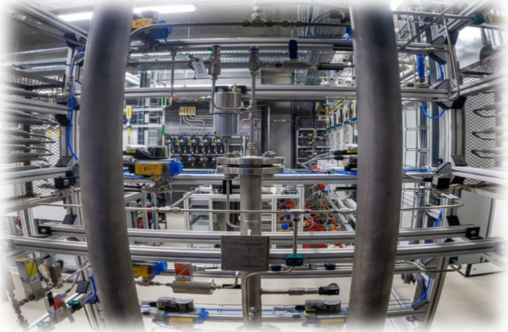
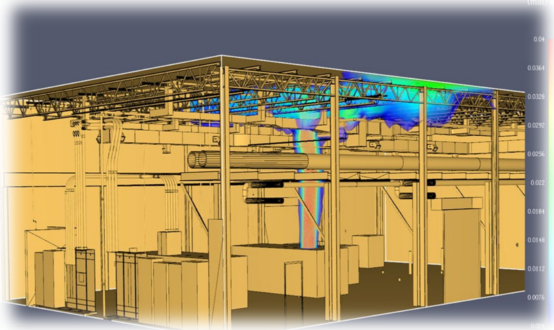
Centre for Energy and Environmental Technologies









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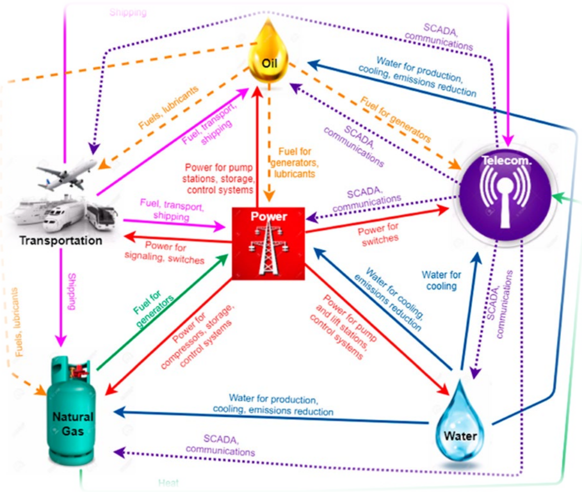
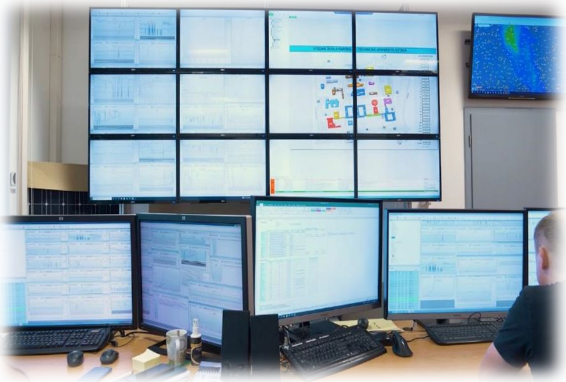
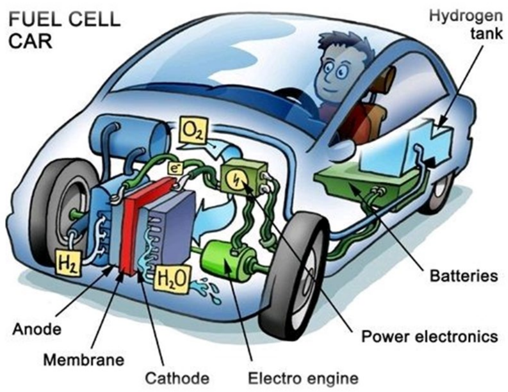
CEET – Research, development, innovation

- 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







Laboratory of hydrogen technologies

- Acta AES 1000 stack AEM electrolyser

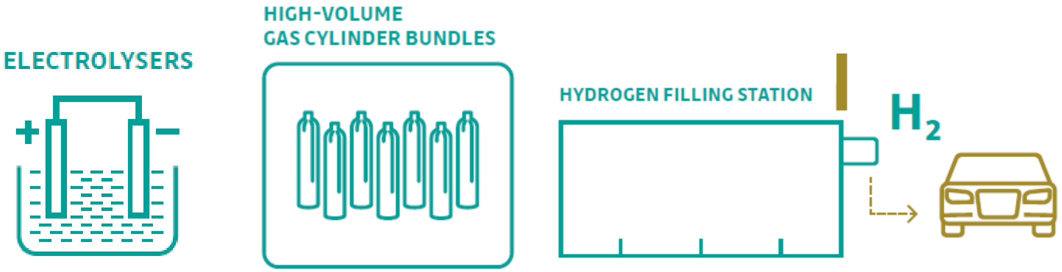
Composed of 4 stacks, each **containing 19 cells,** with a total **production** capacity of **250 Nl H_2/h per stack**.

- 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**.

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.



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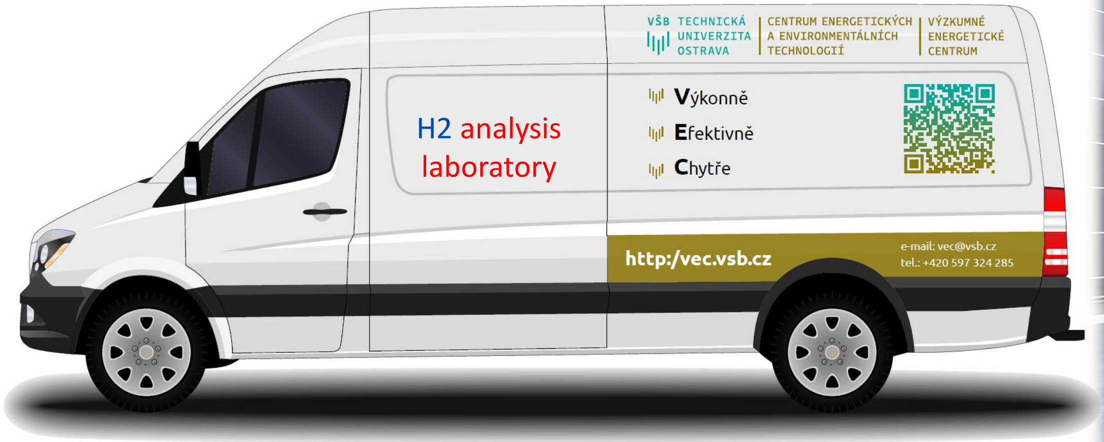
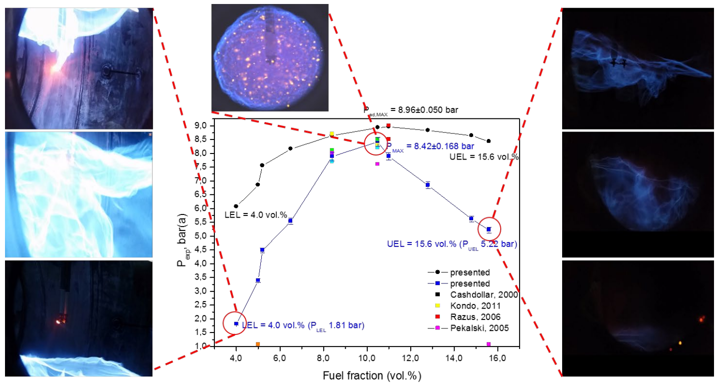
Hydrogen purity analysis and sampling at high pressures

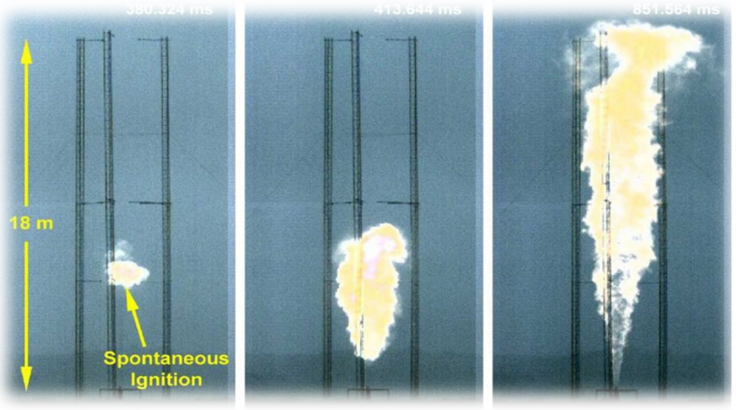
- **Accredited methodology** – determination of H_2 purity with continous measurement
- Development and **validatation** of **sampling** method
- **Optimization of analytical techniques** for high-pressure hydrogen (GC, MS, FTIR)
- Ensure **compliance with international standards** (ISO 14687)
- Enhance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

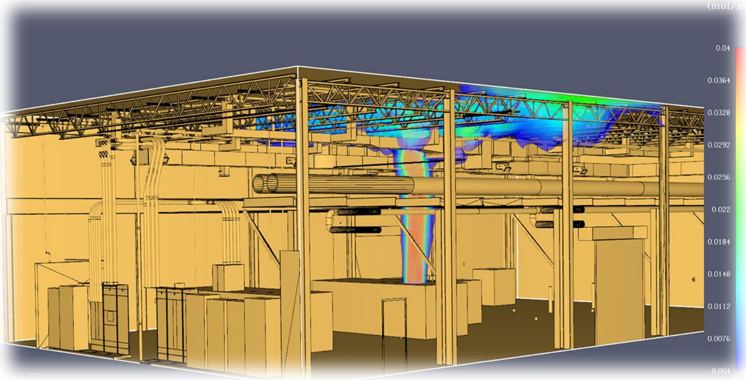


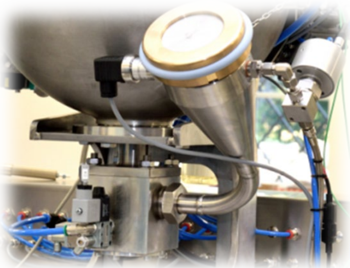
Hydrogen safety properties

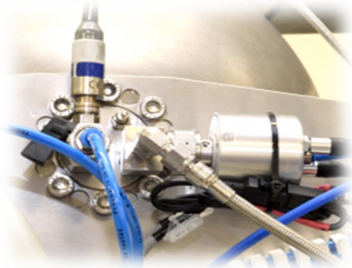
- **Analysis of experimental factors** influencing the determination of explosion parameters
- **Research modelling tools** available for hydrogen mixtures (EFFECT, ALOHA)
- **Experimental verification** of the limits of flammability and explosiveness











Process safety and methodology

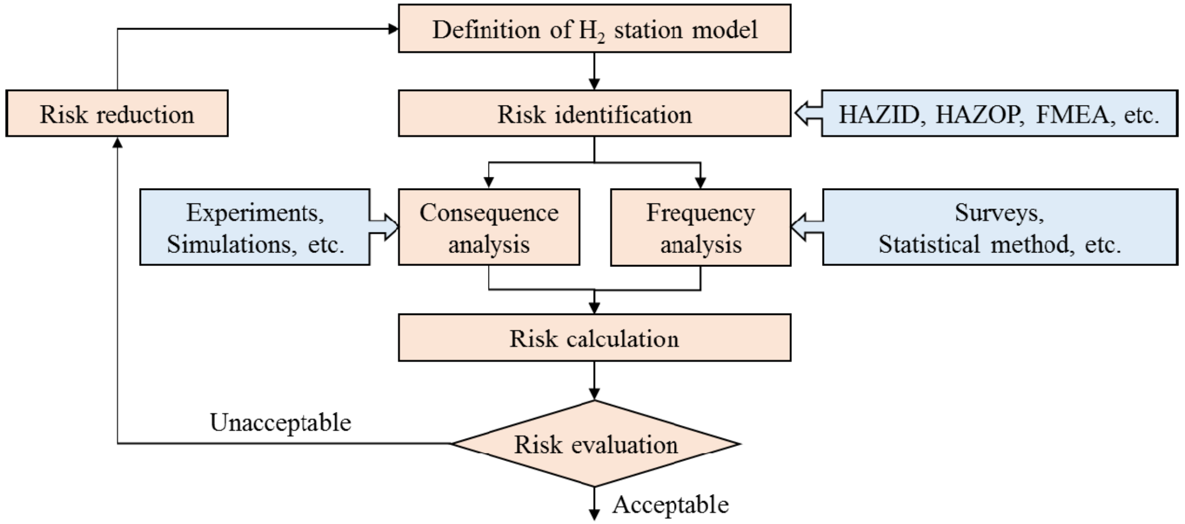
The goals of safety planning are to:

- **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 by those involved 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

Fundamental safety considerations

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

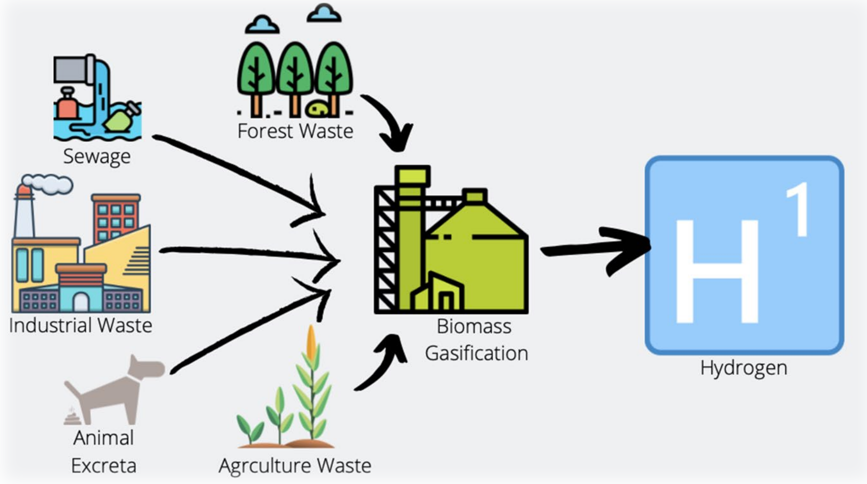
FAILURE MODE	SOURCE OF FAILURE	EFFECT	SEVERITY (1-10)	PROBABILITY OF OCCURRENCE (1-10)
Fire and explosion	Ignition in the vicinity of H2 and O2 mixture	Equipment damage and possible injuries	10	2
Hydrogen leak in piping	Mechanical failure/improper joints and fittings	Potential fire and explosion	7	3
Hydrogen leak in electrolyser	Overpressure causing rupture of membrane	Potential fire and explosion	8	3
Hydrogen leak in storage tank	Mechanical failure/improper joints and fittings	Potential fire and explosion	8	3
Compressor failure	Equipment failure, worn out seals	Potential H2 leaks	5	6
Hose pressure rating verification error	Human error	Overpressure in vehicle tank, potential H2 leaks	6	3
Leak at breakaway fitting	Equipment failure at dispenser	Potential fire	7	2
Improper fill speed at fuel dispenser	Failure to follow standard operating procedures, deficiency in procedures, software failure	Overheating on receiving fuel tank	5	4
Incorrect check valve installation	Human error, inadequate inspections	Property damage	7	2
Vehicle crashing into refuelling system	External factor	Property damage and injuries	7	2

List of possible hazards of the H2 station

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 (nicekel based, dolomite, noble metals)



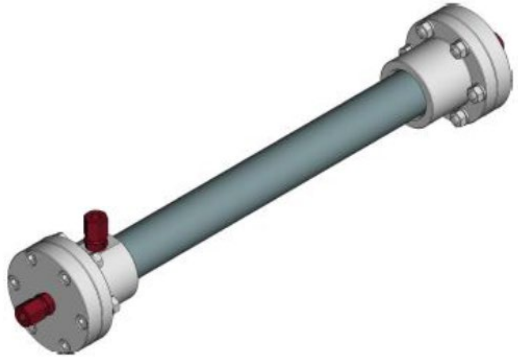
WASTE	Municipal waste	Refuse derived fuels
H_2 [%]	48-50	38-40
CO [%]	36-39	37-39
CO_2 [%]	1-2	2-4
CH_4 [%]	4-6	0-1
N_2 [%]	5-7	16-19

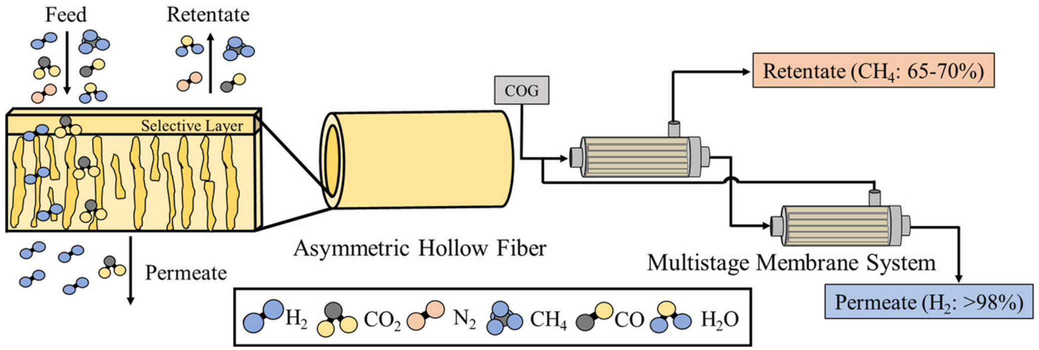
BIOMASS	Autothermal gasification	Allothermal gasification	Autothermal gasification using $H_2O + O_2$
Calorific value [MJ/Nm^3]	4-6	12-14	12-15
H_2 [%]	11-16	35-40	25-30
CO [%]	13-18	25-30	30-35
CO_2 [%]	12-16	20-25	23-28
CH_4 [%]	3-6	9-11	8-10
N_2 [%]	45-60	< 1	< 1

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

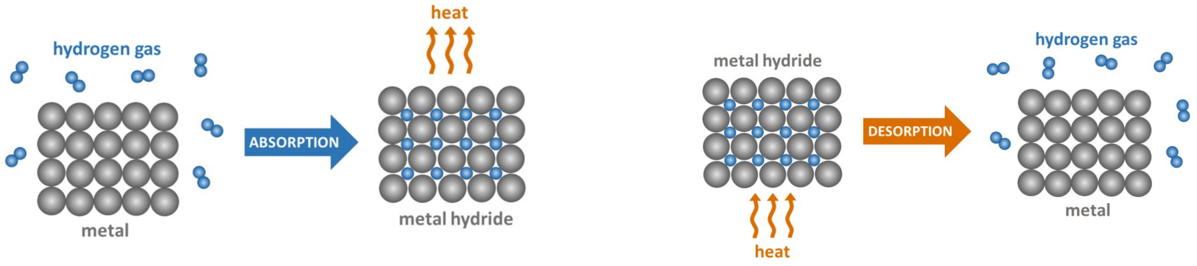
Small-scale membrane unit





Hydrogen storage in metal hydrides

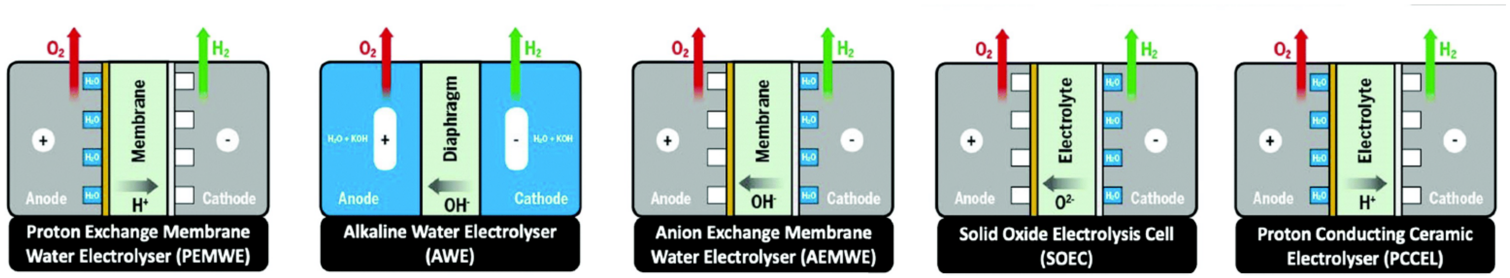
- **Thermodynamics** of metal hydrides
- **Improve** hydrogen **storage capacity** and kinetics
- Enhance **lifecycle** and **economic feasibility**



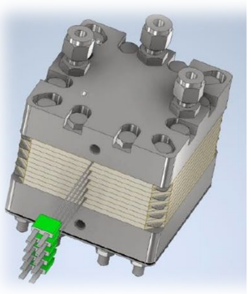
MyH_2 2000 abs. capacity 2000 Nl, max. p. 30 bar, op. temp. 10 – 65 °C.

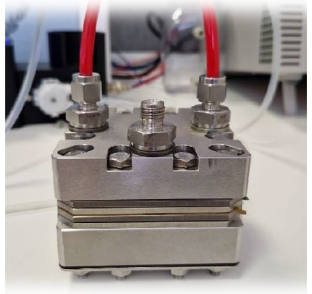
PEM/AEM membranes preparation and testing for H_2 production

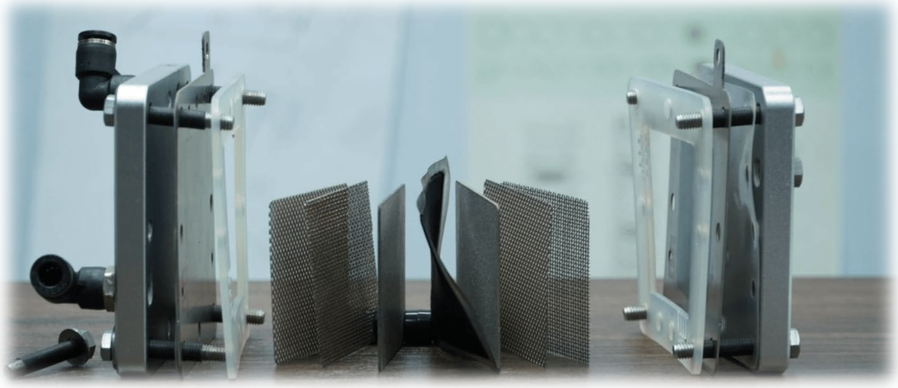
- Preparation of **new membranes** using magnetic sputtering method
- Parameter **testing** of electrolysers **under various conditions**



Operating temperature	50–80 °C	70–90 °C	40–60 °C	700–850 °C	300–600 °C
Operating pressure	<70 bar	1–30 bar	<35 bar	1 bar	1 bar
Electrolyte	PFSA membranes	Potassium hydroxide (KOH) 5–7 mol L^{-1}	DVB polymer support with KOH or $NaHCO_3$ 1 mol L^{-1}	Yttria-stabilised zirconia (YSZ)	(Y,Yb)-Doped-$Ba(Ce,Zr)O_{3-\delta}$
Separator	Solid electrolyte (above)	ZrO_2 stabilised with PPS mesh	Solid electrolyte (above)	Solid electrolyte (above)	Solid electrolyte (above)
Electrode/catalyst (oxygen side)	Iridium oxide	Nickel coated perforated stainless steel	High surface area nickel or NiFeCo alloys	Perovskite-type (*e.g.*, LSCF, LSM)	Perovskite-type (*e.g.*, LSCF, LSM
Electrode/catalyst (hydrogen side)	Platinum nanoparticles on carbon black	Nickel coated perforated stainless steel	High surface area nickel	Ni/YSZ	Ni/YSZ, Ni-BZY/LSC, BCFYZ
Porous transport layer anode	Platinum coated sintered porous titanium	Nickel mesh (not always present)	Nickel foam	Coarse nickel-mesh or foam	Coarse nickel-mesh or foam
Porous transport layer cathode	Sintered porous titanium or carbon cloth	Nickel mesh	Nickel foam or carbon cloth	None	None
Bipolar plate anode	Platinum-coated titanium	Nickel-coated stainless steel	Nickel-coated stainless steel	None	None
Bipolar plate cathode	Gold-coated titanium	Nickel-coated stainless steel	Nickel-coated stainless steel	Cobalt-coated stainless steel	Cobalt-coated stainless steel
Frames and sealing	PTFE, PSU, ETFE	PSU, PTFE, EPDM	PTFE, silicon	Ceramic glass	Ceramic glass

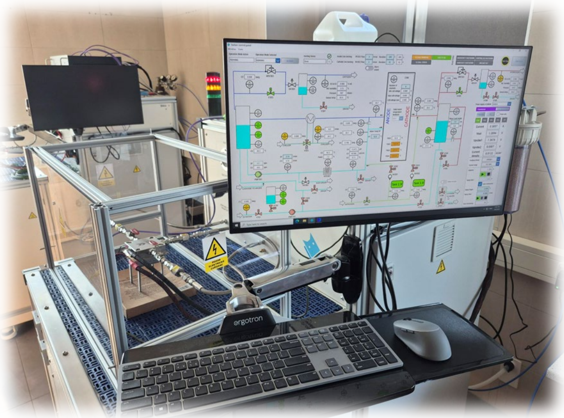


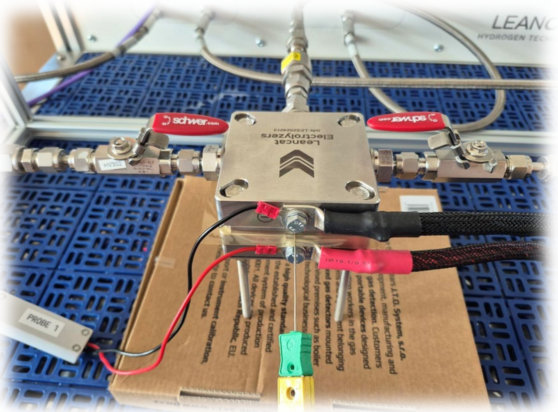


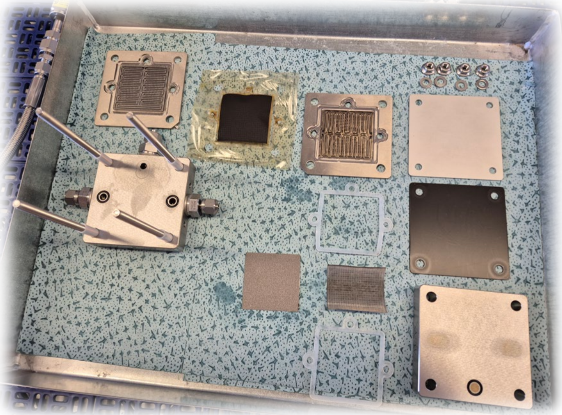


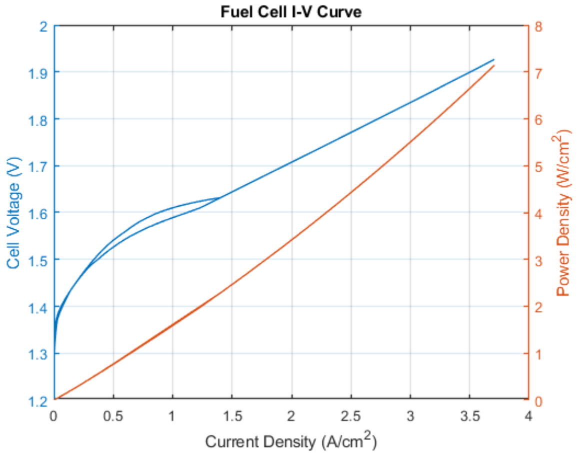
PEM/AEM membranes preparation and testing for H_2 production

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



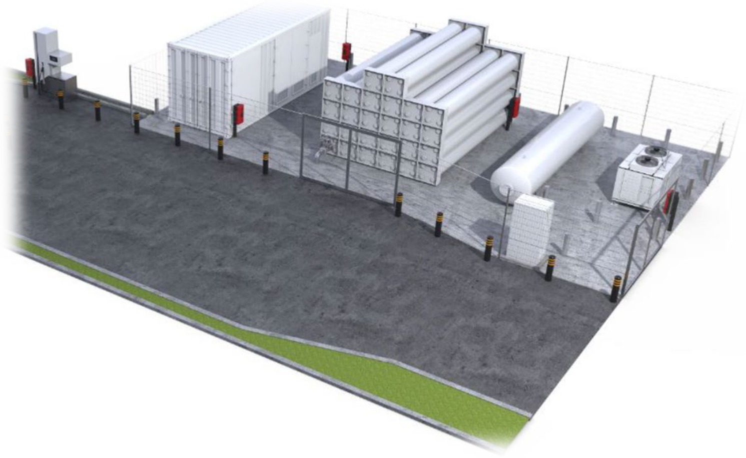


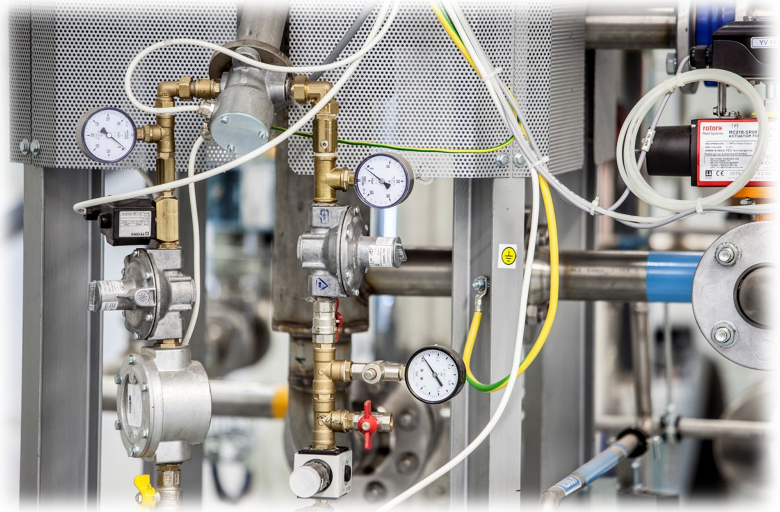




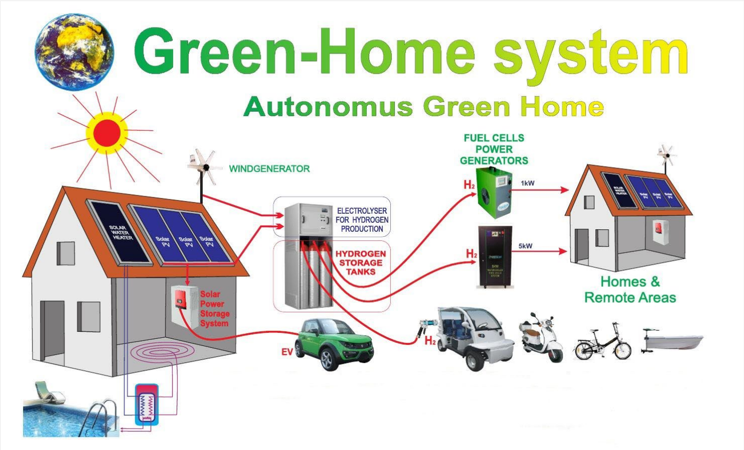
Unique package of hydrogen energy services

- 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



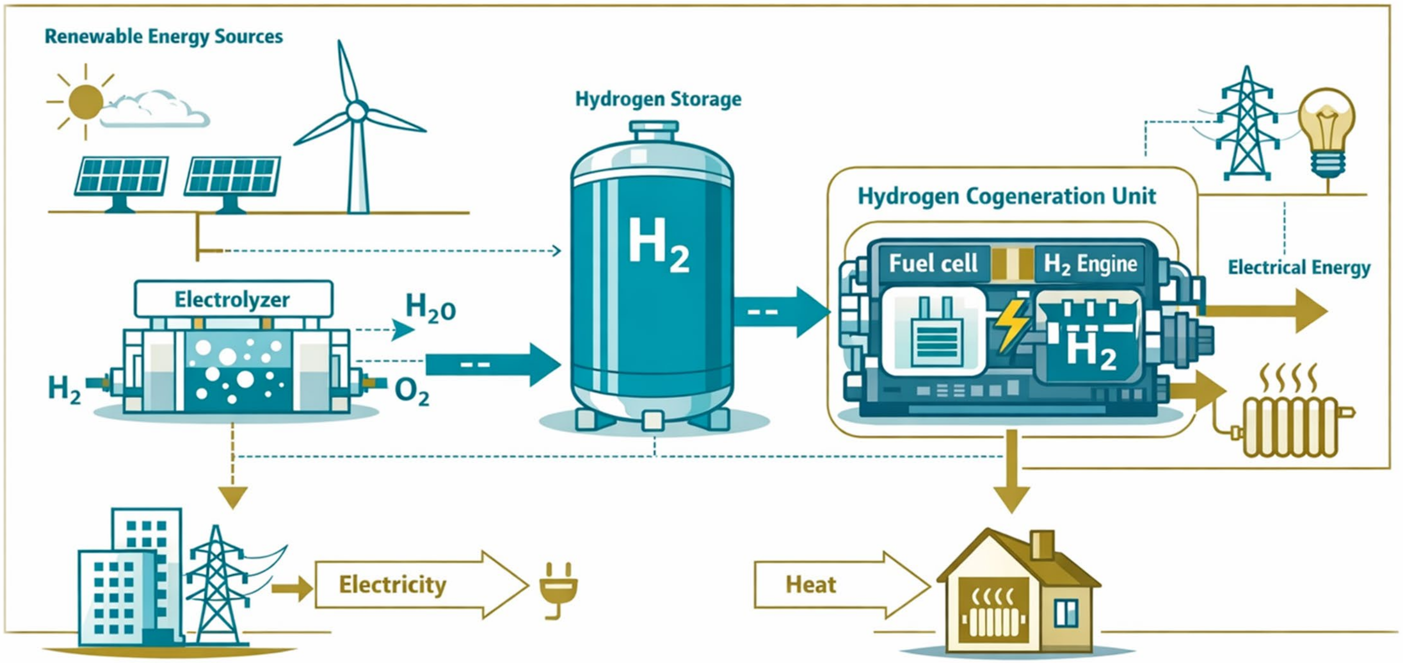


Hydrogen battery system for households



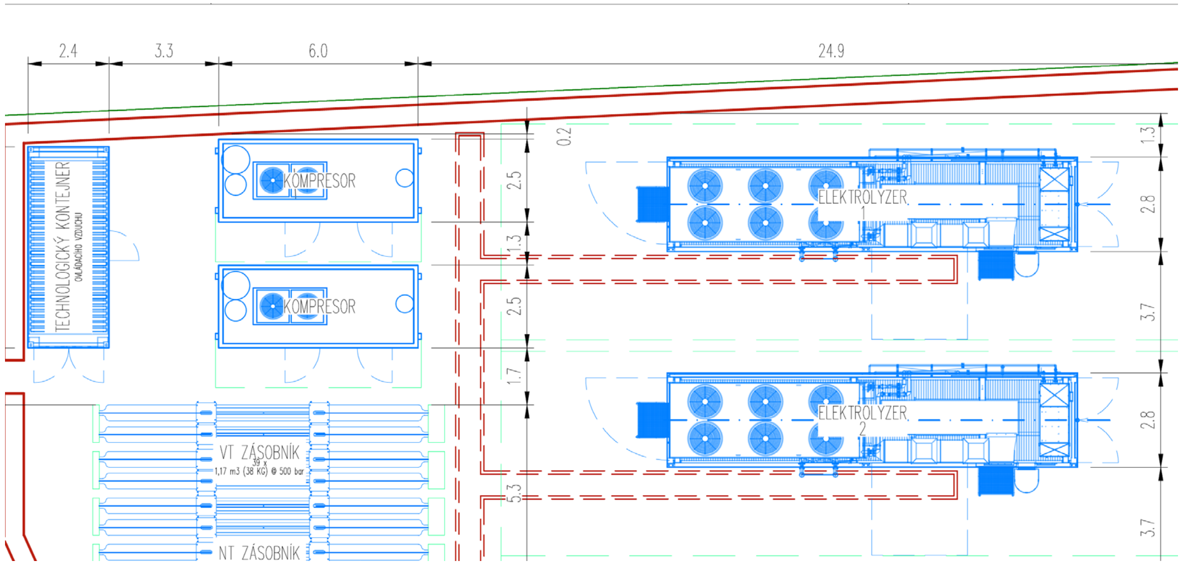
Autonomus system for green home

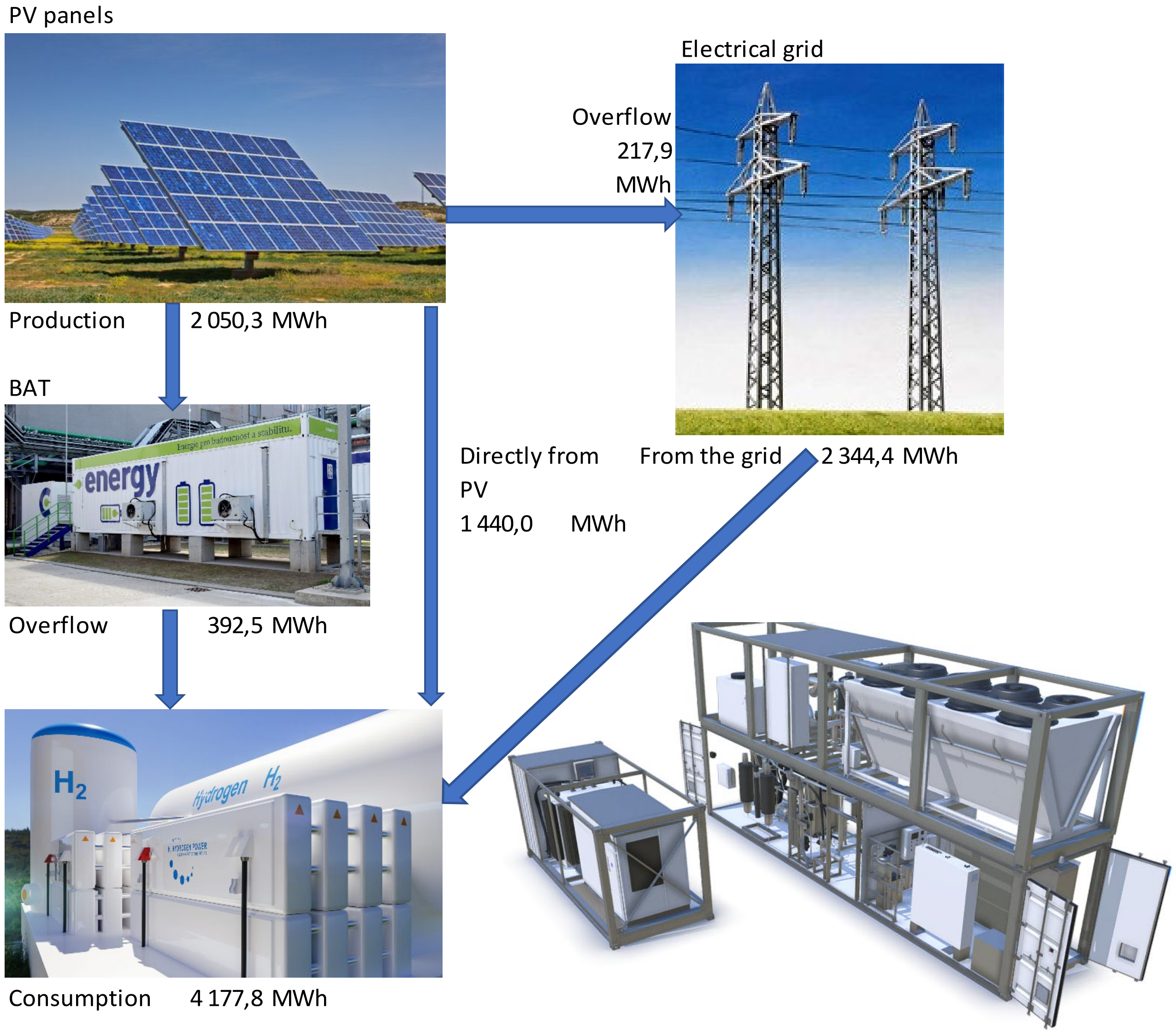
- Electrolysis system
- Hydrogen storage
- Fuel cell power system



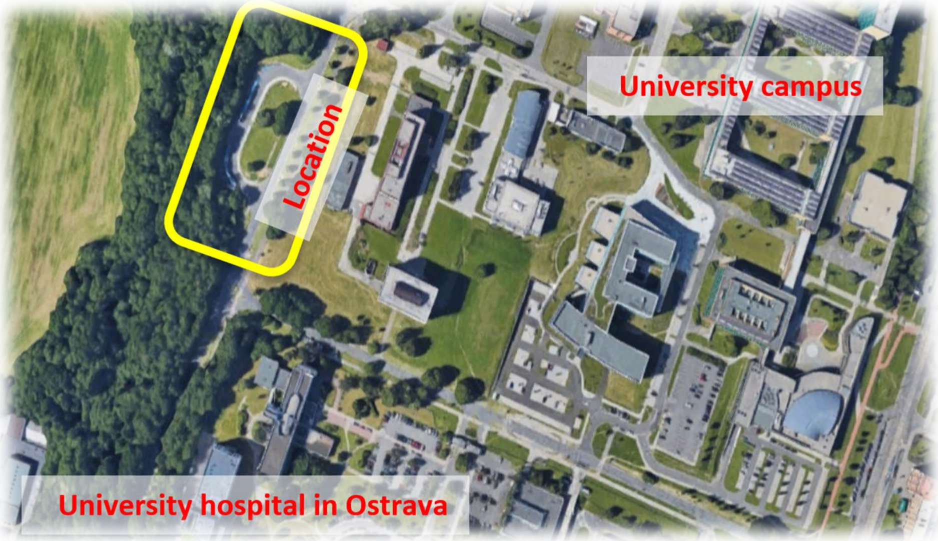
Development of a techno-economic concept for the hydrogen storage and refuelling station

- 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

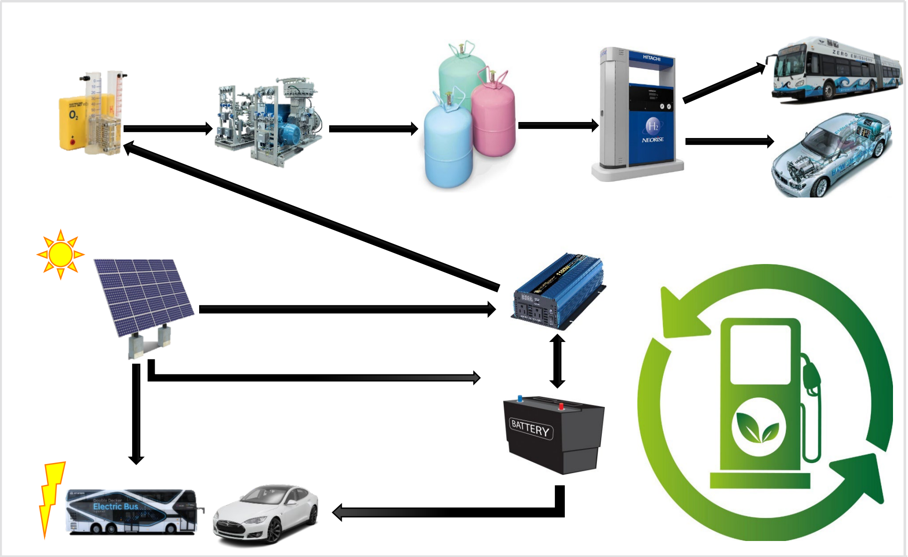




Project CEETe H_2



- 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.

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Thank you for your attention

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