



Cooperation opportunities between AGH University of Science and Technology and University of Florence

Paweł Gładysz, PhD

pawel.gladysz@agh.edu.pl

paweljakub.gladysz@unifi.it

Scope of the presentation



- Short academic CV
- About AGH University and Faculty of Energy and Fuels
- International cooperation funding schemes available in Poland
- Selected past and on-going R&D projects at AGH University
- Future cooperation opportunities

Short academic CV (1)



- **AGH University of Science and Technology, Faculty of Energy and Fuels, Department of Fundamental Research in Energy Engineering, Kraków, PL**



- **Silesian University of Technology, Faculty of Energy and Environmental Engineering, Department of Thermal Technology, Gliwice, PL**



Short academic CV (2)



- **MSc thesis (2010):** *Thermo-economic analysis of repowering a metallurgical CHP to a high-efficiency combined CHP unit.* Silesian University of Technology, Poland.
- **PhD thesis (2015):** *System analysis of an integrated oxy-fuel combustion power plants.* Silesian University of Technology, Poland.
- **Habilitation planned in 2Q of 2022:** *Comprehensive assessment of modern energy systems.* AGH University of Science and Technology, Poland.
- **Postgraduates studies (2013 & 2016):** *The Functioning of the Energy Market.* Warsaw School of Economics, Poland & *Project Management.* AGH University of Science and Technology, Poland

Short academic CV (3)



Research interests:

- **Modelling and optimization** of thermal processes (2010 – present)
- Geothermal energy including **enhanced geothermal systems** (2017 – present)
- **Exergy analysis** and optimization (2012 – 2015 & 2020 – present)
- **Thermo-ecologic cost** analysis including LCA (2010 – present)
- **Techno-economic** analysis (2010 – present)
- **Carbon capture, storage and utilization** technologies (2011 – present)
- Coal-to-Nuclear and Gas-to-Nuclear **retrofits** (2020 – present)
- **Machine learning** and AI in predictive and prescriptive maintenance (2019 – present)
- **Cogeneration** technologies (2010 – 2012 & 2017 – 2020)
- Thermal engineering in **iron & steel** industry (2016 – 2020)

Scope of the presentation



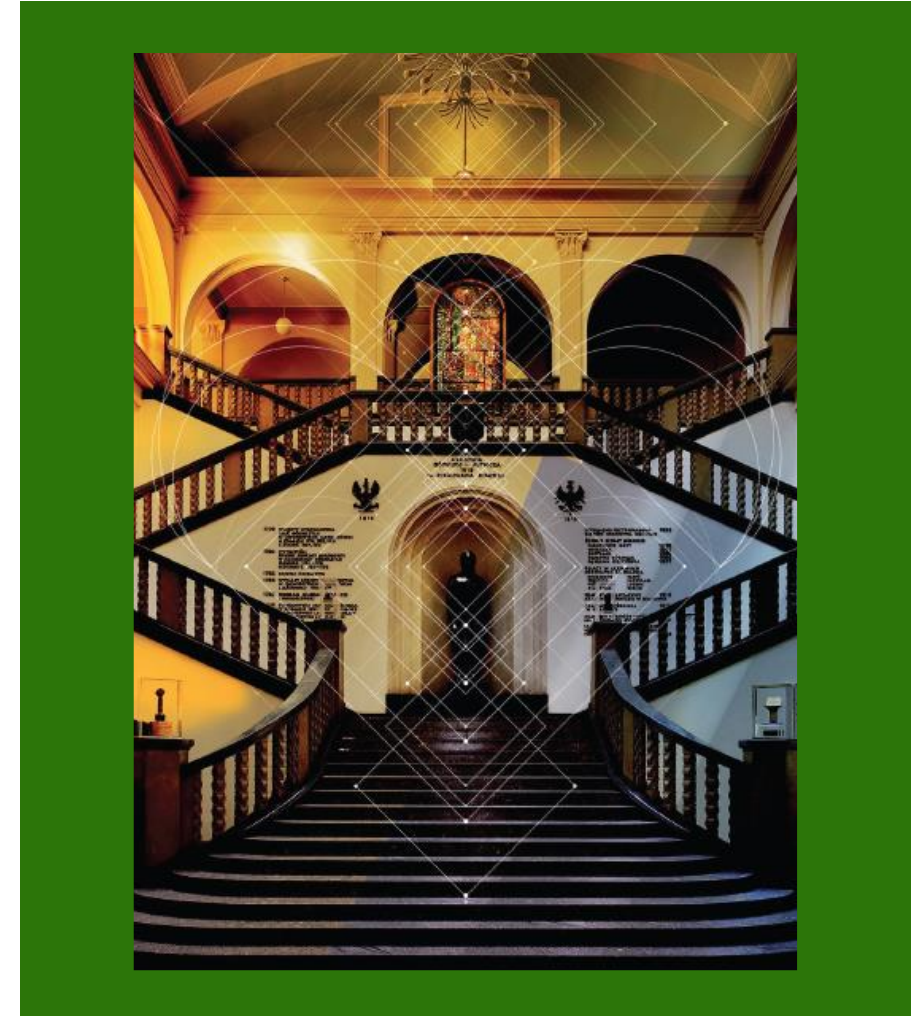
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AGH University (1)



AGH UST in numbers:

- **16** faculties + interdisciplinary units
- **67** programmes of study
- more than **200** specialisation
- total number of **students (2020): over 24,000**
 - full-time students: 17 680
 - part-time students: 2 996
 - doctoral students: 1 062
 - postgraduate students: 1 832
 - foreign students: 1 208
- nearly **200 000** alumni
- more than **2 000** academic teachers
(including 700 senior academic staff members)





AGH University educational offer:

- **first-cycle programmes of study**
students obtain a Bachelor of Science or Bachelor of Arts degree
- **second-cycle programmes of study**
students obtain a Master of Arts degree
- **doctoral studies "AGH UST Doctoral School"**
- **postgraduate studies**

High-quality and modern education



AGH University (3)



AGH UST Doctoral School studies offer:

engineering and technical sciences:

- automatics, electronics and electrical engineering
- technical computer studies and telecommunications
- biomedical engineering
- chemical engineering
- civil engineering and transport
- materials engineering
- **mechanical engineering**
- **environmental engineering**
- **mining and power engineering**

natural sciences:

- computer science
- mathematics
- chemical sciences
- physics sciences
- Earth and environment sciences

social sciences:

- management and quality sciences
- Sociological sciences

humanities:

- culture and religion sciences



AGH University (4)



Priorities of the Polish market and economy:

- Computer science and telecommunications
– *“Digitalisation”*
- Power Engineering
– *“Energy transformation and zero-emission”*
- Geoscience
– *“Climate change”*
- Cutting-edge technologies
– *“Circular economy”*
- Mechanics, automatics, and robotics
– *“Industry 4.0”*
- ...

AGH UST educates
specialists for the market –
our social mission



AGH University (5)



Effects of AGH UST research activity:

	2020
Professors	23
Postdoctoral qualifications	52
Doctoral degrees	85
Patents	97
Patent applications	62
Local (national) projects	378
International projects	41
Horizon projects	21



AGH University (6)



AGH UST – International University

- “Well-balanced” international cooperation based on **bilateral research and teaching programmes**
- “Double degree” education
- “**Visiting professors**” programmes
- **Summer schools and courses**
- Special cooperation programmes with **international industry**
- “UNESCO AGH Chair for Science, Technology and Engineering Education” cooperation
- ...

AGH UST International University



AGH University (7)



AGH UST – International University

- Currently, about **1,200 foreign students** (mainly from Ukraine)
- **21 programmes of study in English** (3 – BSc, 18 – MSc)
- University **Database of Electives** in foreign languages (**183 courses**)
- Emphasis on student exchange programmes
- **Double degree programmes**
- **588 bilateral agreements** within the framework of **Erasmus+** programme and over 283 bilateral agreements
- UNESCO Chair for Science, Technology and Engineering Education at the AGH UST (about 120 fellows annually from developing countries)
- Educating engineers to work for international industries, e.g., in Vietnam: VINACOMIN and PETROVIETNAM or in India

AGH UST International University



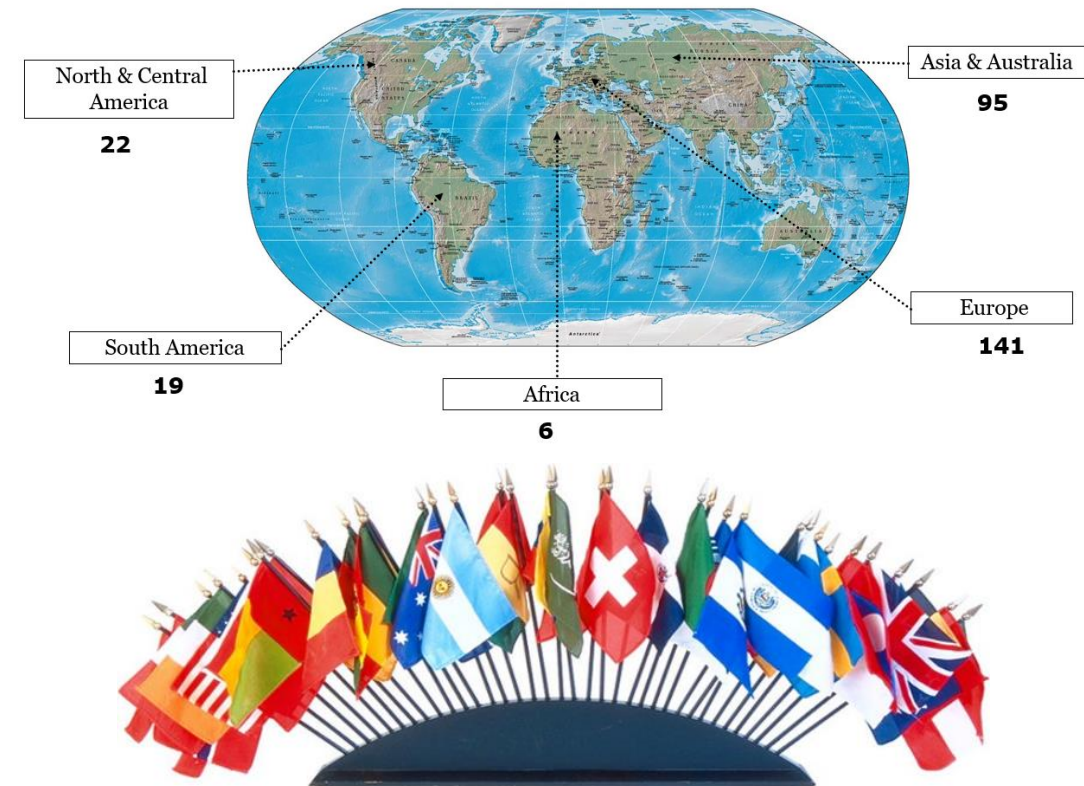
AGH University (8)



AGH UST – International University – priorities

- Active cooperation with leading academic and research centres in **about 70 countries** (incl.: Europe, the USA, Canada, Russia, China, Japan, Israel, Turkey, Vietnam, Korea, Mexico, Chile, Brazil...)
- Cooperation with the **world's largest companies and corporations** (e.g. ArcelorMittal, IBM, Valeo, Comarch, Motorola, Nokia, HSBC, EDF, L.G., Philips, RWE Power AG, Lafarge, Cemex, Delphi, Siemens, KGHM, ...)
- Participation in the most **recognisable academic programmes and networks in Europe** and the world, e.g. ERASMUS+, T.I.M.E., SMILE, CEEPUS, VULCANUS, ERASMUS MUNDUS, ...

283 cooperation agreements between the AGH UST and world universities



AGH University (9)



AGH UST facilities - in the last 15 years, more than 20 large construction projects have been carried out.



Department of
Telecommunications, II



Academic Centre for Materials and
Nanotechnology



Centre of Energy



ACK CYFRONET



Department of
Telecommunications, I



Centre of Computer Science



Centre of Ceramics



Main Library

AGH University (10)



AGH UST facilities - Investment Programme for the 100 Years of the AGH UST.



Multi-functional sports hall



Building of the Faculty of Drilling, Oil and Gas, and the Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering



Construction of a new teaching facility for the Faculty of Humanities, the Faculty of Applied Mathematics, the Department of Foreign Languages



The Faculty of Physics and Applied Computer Science

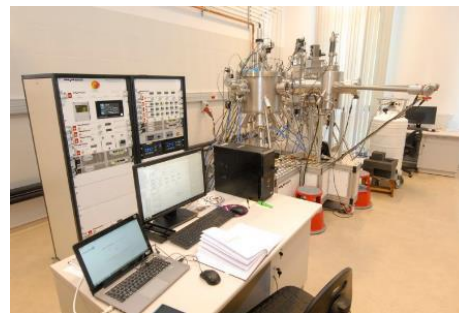
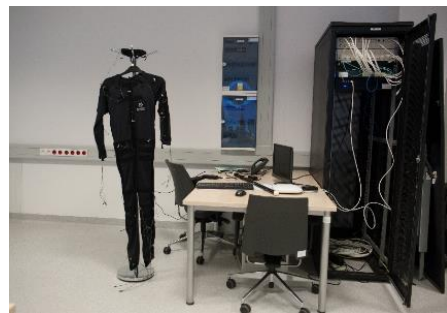
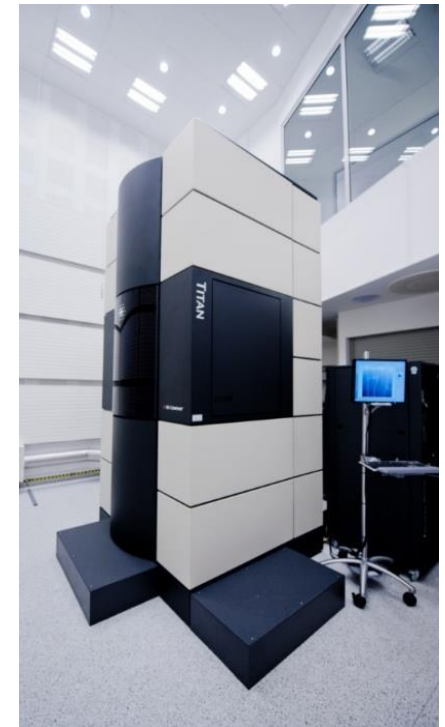


Student Construction Centre

AGH University (11)



AGH UST facilities - unique and modern world-class equipment.



AGH University IDUB (1)

“Excellence Initiative – Research University”



AGH UST – research activities

TOP 10 in Poland – “Excellence Initiative – Research University” (IDUB) programme

- 3rd scientific position among Polish universities (also according to the Academic Ranking of World Universities)
- 5 faculties awarded A+ category, 8 faculties with A category, 2 faculties with B category
- Worldwide recognition within respective disciplines
- Active cooperation with the economy
- High research activity of students and doctoral students

AGH University IDUB (2)

“Excellence Initiative – Research University”



AGH UST – priority research activities of “Excellence Initiative – Research University”

1. Sustainable energy technologies, renewable sources of energy, and energy storage
2. New technologies for the circular economy
3. Water–energy–climate: interdisciplinary approach to sustainable development
4. Technical solutions: from fundamental research, through modelling and design, to prototypes
5. Materials, technologies, and processes inspired by nature
6. Intelligent information, telecommunication, computer, and control and operation technologies
7. Design, production, and testing of modern materials and technologies of the future
8. Crossing boundaries: experimental high energy physics, extreme states of matter, transdisciplinary applications



Modern laboratories at the AGH University - examples

Faculty of Energy and Fuels

- Laboratory of Mercury Analysis
- Laboratory of Coal and Biomass Gasification and Pyrolysis
- Laboratory of Lithium Batteries
- Laboratory of Solid Oxide Fuel Cells

Faculty of Mining and Geoengineering

- Research Laboratory of Mining Aerology
- Laboratory of Geoengineering Hydrology and Hydraulics
- Laboratory of Building Structures

Faculty of Geology, Geophysics and Environmental Protection

- Hydrogeochemical Laboratory
- AGH UST Education and Research Laboratory of Renewable Sources and Conservation of Energy
- AGH UST – KGHM Polska Miedź SA Laboratory of Critical Elements

Faculty of Drilling, Oil and Gas

- Laboratory of Geoenergetics
- Laboratory of Advanced Oil Deposit Exploitation Methods
- Laboratory of Modelling Multi-Phase Flows in Porous Media



Faculty of Energy and Fuels – research areas

- energy conversion,
- technologies of coal gasification and coal pyrolysis,
- nuclear energy and coal-nuclear synergy,
- technology of fuels and biofuels, and the distribution of gaseous fuels,
- fluid-flow machines and power engineering devices,
- fuel cells and lithium batteries,
- renewable energy sources,
- planning and modelling in the power industry,
- adsorption and catalysis in industrial processes and environmental protection,
- environmental analytics.





AGH UST Centre of Energetics – research areas

- supporting education for the programmes of study offered by AGH UST faculties in the field of Energy,
- organising research and development activities carried out in the Centre's laboratories by means of collaboration with AGH UST scientific research teams,
- direct collaboration with commercial entities in the area of research and development,
- initiating new areas of research and development in the field of Energy,
- development and implementation of innovative solutions,
- alongside educational activity, the Centre of Energetics carries out projects related to many aspects of power engineering in the area of its efficient production, transformation and storage, as well as in the field of the development of renewable energy sources.

Faculty of Energy and Fuels (1)



About the Faculty:

- staff: 120 persons, 80 academics
- about 1500 students, 40 PhD students
- annual budget ~ 5M €
 - 70% teaching
 - 30% grants & contracts



Faculty of Energy and Fuels (2)



Departments within the Faculty:

- Department of Coal Chemistry and Environmental Sciences
 - Prof. Katarzyna Zarębska,
- Department of Fuel Technology
 - Prof. Piotr Burmistrz
- Department of Sustainable Energy Development
 - Prof. Wojciech Suwała,
- Department of Hydrogen Energy
 - Prof. Janina Molenda
- **Department of Fundamental Problems of Energy**
 - **Prof. Grzegorz Brus**
- Department of Thermal and Fluid Flow Machines
 - Prof. Łukasz Mika

38 laboratories (15k m²): teaching and commercial



Faculty of Energy and Fuels (3)



Research areas:

- **Department of Fundamental Problems of Energy**
 - Modelling of energy processes
 - Mathematical and numerical methods for energy technologies
 - Modelling of heat and mass transfer
 - Analysis of strong magnetic fields on paramagnetic fluids convection
- **Department of Thermal and Fluid Flow Machines**
 - Modeling of thermal and fluid processes
 - Heat exchangers
 - Individual and district heating systems
 - Pulverized fuel and fluid boilers
 - Heat pumps and renewable energy sources in energy technologies
 - Measurements and diagnostics in the multiphase systems



Faculty of Energy and Fuels (4)



Research areas:

- **Department of Coal Chemistry and Environmental Sciences**
 - Chemistry and radiochemistry of environment
 - Adsorption – engineering and technologies
 - Physical chemistry of surface phenomena
- **Department of Fuel Technology**
 - Technologies for solid and gaseous fuels
 - Chemical treatment of coal
 - Catalytic processes in the environment protection
 - Engine's fuels
 - Nanomaterials
 - Modeling of sorption processes
- **Department of Sustainable Energy Development**
 - Renewable Energy Sources
 - Energy Policy & Energy Systems Modelling
 - Fuel Cells
- **Department of Hydrogen Energy**
 - Transport properties of cathode materials
 - Catalytic properties of perovskites
 - Defect structure and ionic conductivity of ceria based electrolytes
 - Synthesis of materials for Li-batteries:
 - Transport properties of materials for Li-batteries
 - Li-batteries assembly and testing

Faculty of Energy and Fuels (5)



International Education Programs:

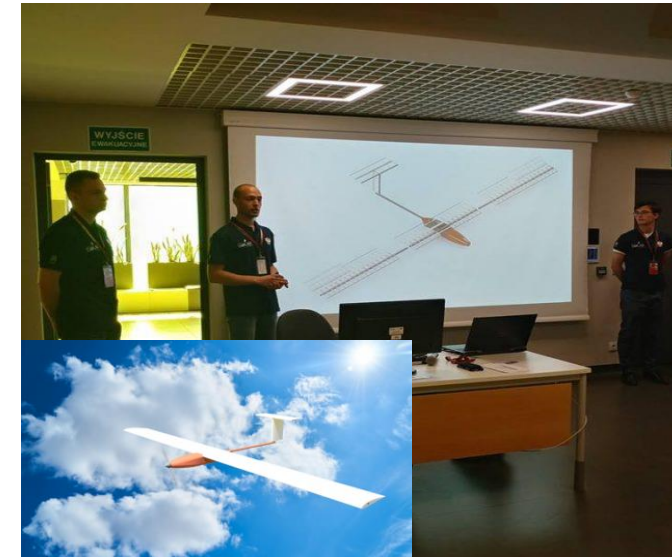
Faculty of Energy and Fuels offers three second-cycle degree programmes and one third-cycle degree programme (doctoral studies):

- Second-cycle (MSc) degree programmes in English
 - Chemical Technology: Energy Transition
 - Chemical Technology: Sustainable Fuels Economy
 - Energy Technology: Sustainable Energy Development
 - Energy Technology: **Energy and Environmental Engineering** (*new programme in cooperation with SHIBAURA Institute of Technology, Japan*) – I will come back to that!
- Third-cycle (PhD) degree programme in English (*new Doctoral School – programme canceled*)
 - Chemical Technology: Clean Coal Technologies

Faculty of Energy and Fuels (6)



Student activities at the Faculty:



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Funding schemes in PL (1)



3 main sources of R&D funding in Poland



- basic research
- industrial research and development works
- commercialization
- teaching programs
- international cooperation

Funding schemes in PL (2)



POLONEZ BIS: fellowship programme (2021-2026)

- the Principal Investigator: **must hold a PhD degree** and mobility requirement must be met (3 year prior the submission not working in Poland)
- duration: **24 months**
- funding terms: host institution must employ the principal investigator (**full-time employment**), PI must reside in Poland for 100% of the time, mentor, ...
- budget: **salary for PI of 107 160 EUR** (4 465 EUR gross per month), PhD students and co-investigators funds (up to ca. 2 500 EUR per month), **other costs of 100 000 EUR**
- indirect costs: 20% indirect costs and **2% indirect costs for Open Access**
- submission deadline: **15th of June 2022**

Funding schemes in PL (3)



The Polish National Agency for Academic Exchange – dedicated to scientists

- **The Ulam NAWA Programme**

- has obtained the Seal of Excellence certificate under the Marie Skłodowska-Curie Actions Individual Fellowships programme
- 6 to 24 months
- living allowance: up to 10 000 PLN per month (ca. 2 300 EUR per month) + one-off mobility allowance and costs of training

- **Programme Canaletto Bilateral Exchange of Scientists (Italy)**

- mobility for researcher from Italy
- scope: Mathematics, Physics and Chemistry; Space; Agriculture, Food and Sustainable Environment; Nano-sciences and Advanced Materials; Information and Communication Technologies, including technologies applied to Cultural Heritage; Medicine and Health
- short-term (up to 12 days) and long-term (up to 1 month) stays

Funding schemes in PL (4)



The Polish National Agency for Academic Exchange – dedicated to institutions

- **STER Internationalisation of Doctoral Schools’ programme**
 - programme is directed at Polish universities and scientific institutions that run doctoral schools with objective to support the internationalisation of doctoral schools
- **Welcome to Poland**
 - increasing competencies of the academic staff and the institutions’ potential to receive people from abroad
- **Strategic Partnerships Programme**
 - durable solutions in the area of scientific, implementation and teaching process cooperation, pursued within the framework of international academic partnerships
- **Programme KATAMARAN**
 - establishing and conducting joint second-cycle studies

Funding schemes in PL (4)



“Excellence Initiative – Research University” at AGH University

- **international visits of AGH Staff in foreign institutions:** short-term visits (Task 1), international internships (Task 6) and international internships in research centers (Task 10)
- **international visits of foreign researches at AGH University:** **obtaining subsidies for long-term stays of foreign scientists at AGH UST (Task 11):**
 - eligible costs of remuneration for foreign scientists coming to AGH for a period of 12 months
 - possibility of extension for a maximum of another 12 month
 - the costs of research

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Selected past R&D projects (1)



- Research Project (national funds) ***“Development of dedicated computer application for creating high-efficiency, large-scale cogeneration strategy, taking into account economic and environmental criteria, including CO₂ emissions”*** (SUT, 2010 – 2012)
- Strategic Program (national and private funds) ***“Advanced Technologies of Energy Generation. Project no 2: Oxy-combustion technology for pulverized-coal and fluidized-bed boilers with CO₂ capture”*** (SUT, 2010 – 2015)
- Research Project (Norway grant) ***“Mild Oxy Combustion for Climate and Air”*** (SUT, 2016 – 2017)
- Research Project (national funds) ***“Theoretical and computational investigations of new concepts of power plant with Stirling engine fed with cryogenic exergy”*** (SUT, 2016 – 2017)

Selected past R&D projects (2)



- Industrial R&D Project (national and private funds) “***Development and validation of a computer-aided model for the gas management optimization at ArcelorMittal Poland SA - Unit in Dąbrowa Górnicza***” (SUT, 2017 – 2020)
- Industrial R&D Project (national and private funds) “***Development of the methodology for risk analysis and parameters forecasting of the steelworks technological processes supporting an effective implementation of new technology and allowing the process planning including the economic and ecological effectiveness***” (SUT, 2017 – 2020)
- Research Project (national funds) “***Determination of the structure for a biomass-fired combined heat and power plant with CO₂ capture integrated with CO₂ enhanced geothermal system***” (AGH, 2017 – 2021)

Selected past R&D projects (3)



Name of the project: **Determination of the structure for a biomass-fired combined heat and power plant with CO₂ capture integrated with CO₂ enhanced geothermal system**

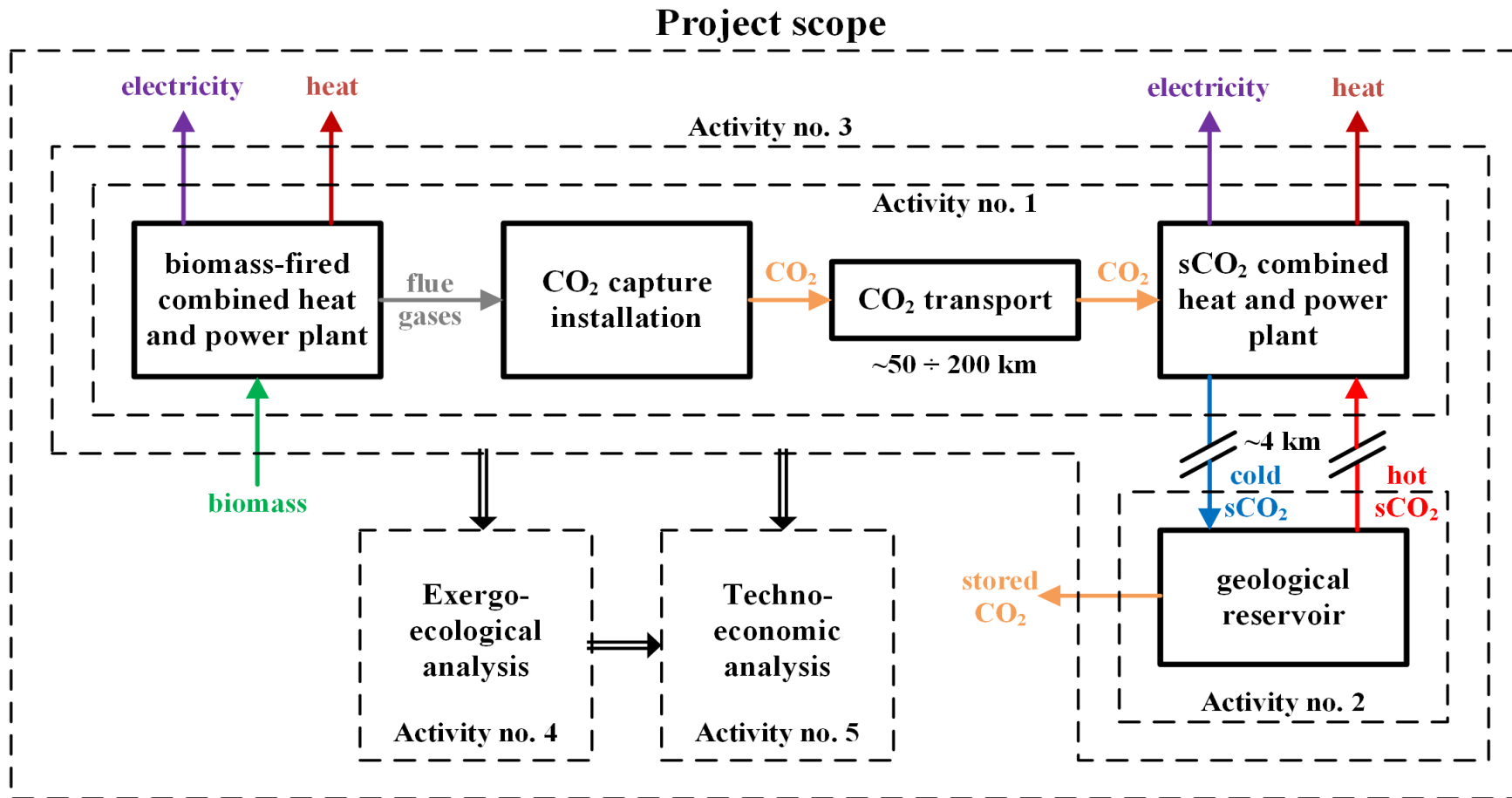
Duration: **36 months** (incl. 6 month international internship) + 12 „covid” months (ended on the 8th of October, 2021)

Funding organisation: **National Science Centre, Poland**

Funding: 642 269 PLN (~**150 000 EUR**)

Programme goals: **Increase national** (moving to AGH from SUT) **and international** (internship at LUT) **mobility of young researchers** (up to 4 year after PhD) **who are active in the area of applied or basic research.**

Selected past R&D projects (5)



Project team:

- **Principal Investigator** (Paweł Gładysz, PhD)
- **3 co-investigators**
 - geologists
 - CO₂-EGS operation model development
 - data for the LCA and economic assessment
 - support in modelling and case study selection

Selected past R&D projects (4)



Cogeneration and
waste heat utilization

Energy
effectiveness

CO₂ emission
reduction

CO₂ capture, storage
and/or utilization
technologies

Renewable
energy sources

Biomass and
geothermal energy (hot
dry rocks)

Selected publications:

- Gładysz, P.; Sowizdzał, A.; Miecznik, M.; Hacaga, M.; Pająk, L. ***Techno-Economic Assessment of a Combined Heat and Power Plant Integrated with Carbon Dioxide Removal Technology: A Case Study for Central Poland.*** *Energies* 2020, 13, 2841.
- Gładysz, P.; Sowizdzał, A.; Miecznik, M.; Pająk, L. ***Carbon dioxide-enhanced geothermal systems for heat and electricity production: Energy and economic analyses for central Poland.*** *Energy Conversion and Management* 2020, 220, 113-142.
- Sowizdzał, A.; Gładysz, P.; Pająk, L. ***Sustainable Use of Petrothermal Resources - A Review of the Geological Conditions in Poland.*** *Resources* 2021, 10, 8.

Selected past R&D projects (5)



PROJECT

Determination of the structure for a biomass-fired combined heat and power plant with CO₂ capture integrated with CO₂ enhanced geothermal system

NETs

CO₂-EGS

CO₂-EGS & NETs

CO₂-EGS

PROJECT PROPOSAL (Norway grants, 2019, P. Gładysz)
Technically Feasible and Socially Accepted Climate Positive Industrial Processes with CO₂ Capture and Storage

PROJECT PROPOSAL (Norway grants, 2019, A. Sowizdział)
CO₂-Enhanced Geothermal Systems for Climate Neutral Energy Supply

PROJECT PROPOSAL (national funds, 2020, P. Gładysz)
Strategy development for CO₂ capture, transport, utilization and storage in Poland, and pilot implementation of Polish CCUS Cluster

PROJECT PROPOSAL (national funds, 2020, P. Gładysz)
Comparative assessment of enhanced geothermal systems with advanced exergy analysis



On-going R&D projects (1)

- R&D Research Project (national and private funds) „***Development and demonstration of a computer system for controlling operation and managing the availability and reliability of industrial infrastructure based on artificial intelligence algorithms***”:
 - duration: 36 months (10.2020 – 09.2023)
 - consortium: TAURON Wytwarzanie S.A. (Łagisza 460 MW power plant), **Silesian University of Technology**, Sumitomo SHI FW Energia Polska Sp. z o.o.
 - project leader: Wojciech Adamczyk (SUT)
 - budget: ca. 21 M PLN (ca. 4.5 M EUR)
 - my role: management, subcontractors coordination, predictive and prescriptive maintenance models development

On-going R&D projects (2)

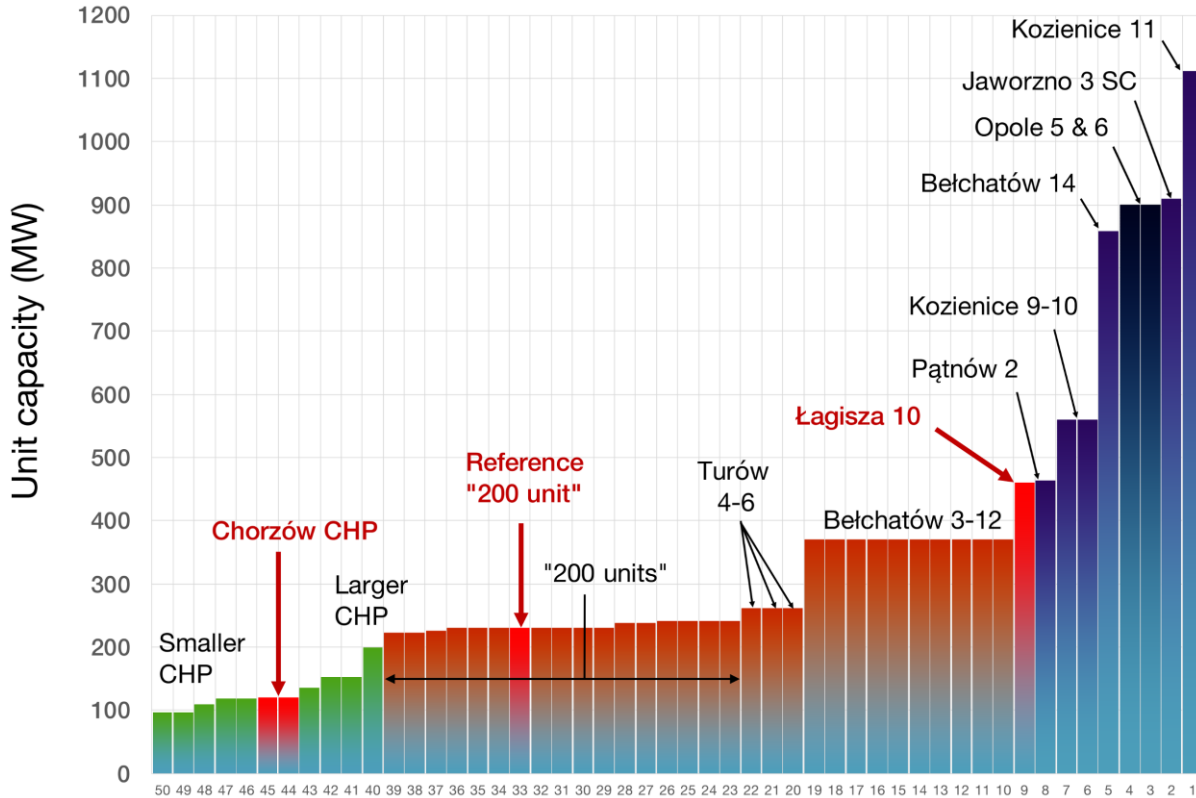


- R&D Research Project (private funds) **„Re-using coal and gas power plant assets in a fully decarbonized Polish power sector”**:
 - duration: 24 months (11.2019 – 12.2021) – *additional 2 years planned (negotiations in progress)*
 - project leaders: Paweł Gładysz and Łukasz Bartela
 - hired by: Qvist Consulting Limited (Staffan Qvist)
 - my role: **coal-to-nuclear CHP plants retrofit**, **gas-to-nuclear CHP plants retrofit**, **gas-to-nuclear power plants retrofit**, process modelling, technical assessment, techno-economic assessment

- Qvist, S.; Gładysz, P.; Bartela, Ł.; Sowizdzał, A. Retrofit Decarbonization of Coal Power Plants - A Case Study for Poland. *Energies* **2021**, *14*, 120.
- Bartela, Ł.; Gładysz, P.; Andreades, C.; Qvist, S.; Zdeb, J. Techno-Economic Assessment of Coal-Fired Power Unit Decarbonization Retrofit with KP-FHR Small Modular Reactors. *Energies* **2021**, *14*, 2557.

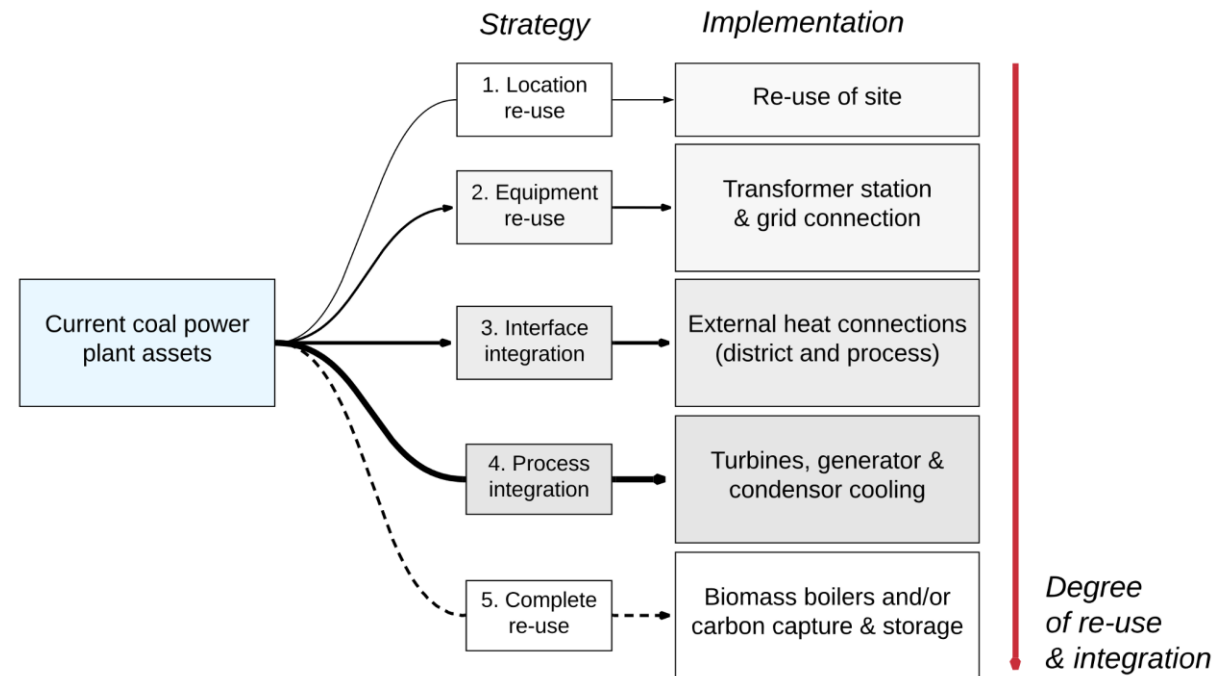


On-going R&D projects (2.1)



Categorization of the 50 largest modern or modernized coal power units in Poland.

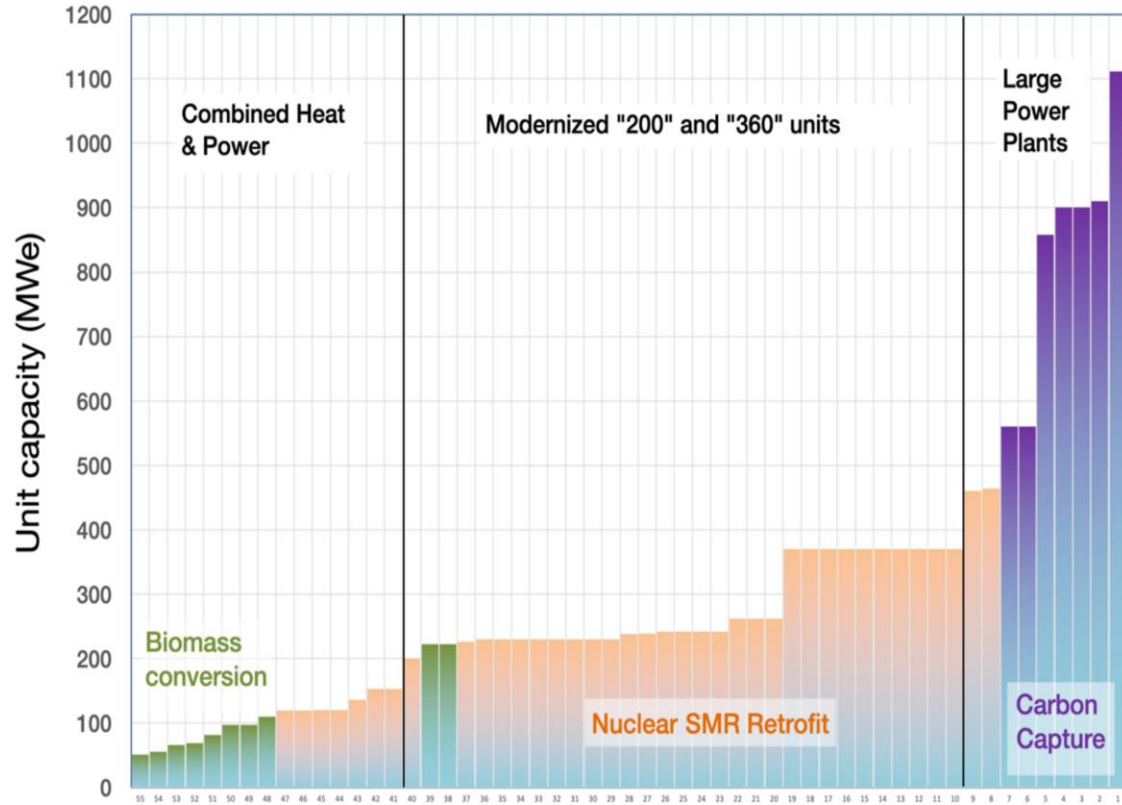
General scope of re-utilization options for existing coal units.



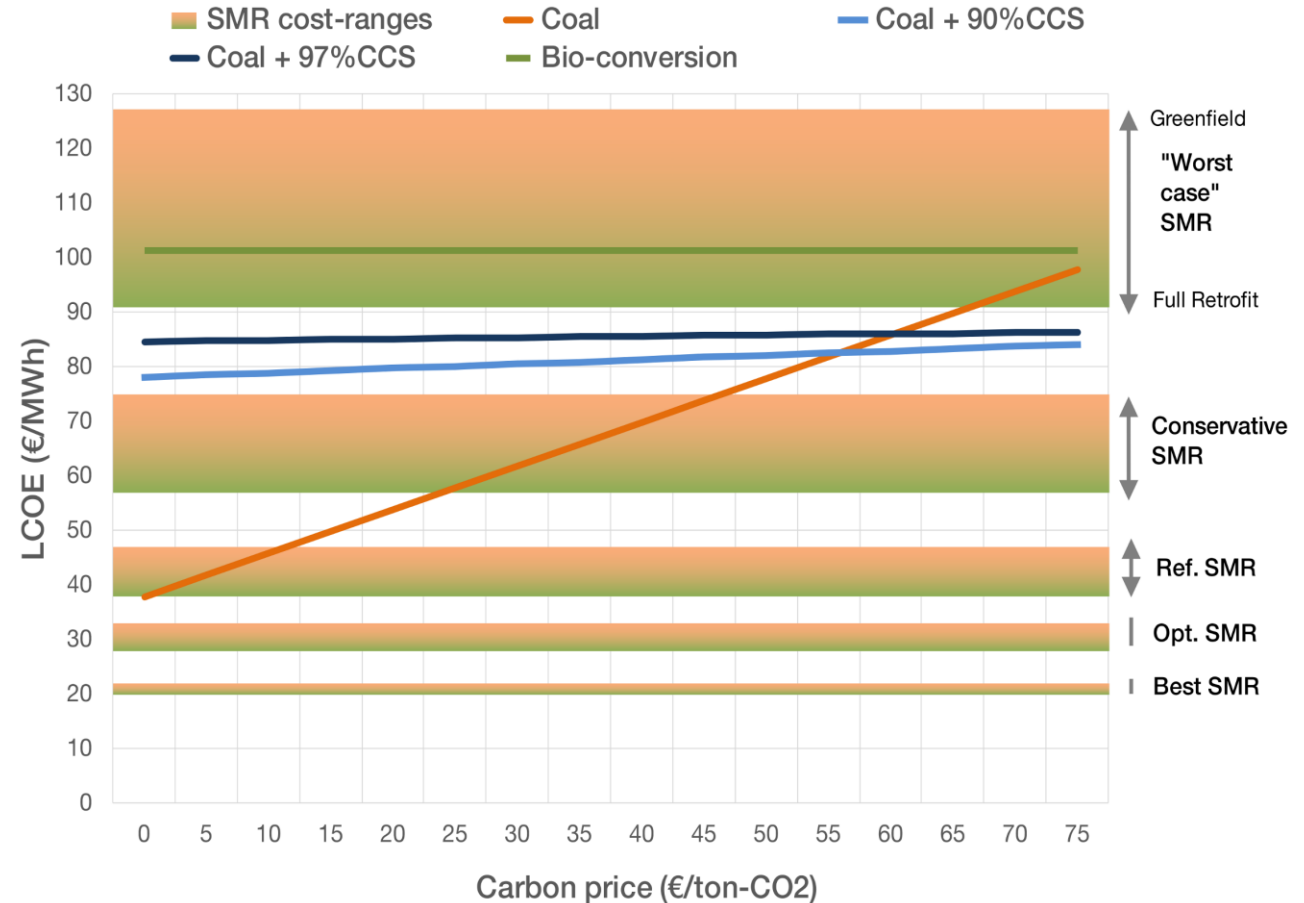
On-going R&D projects (2.2)



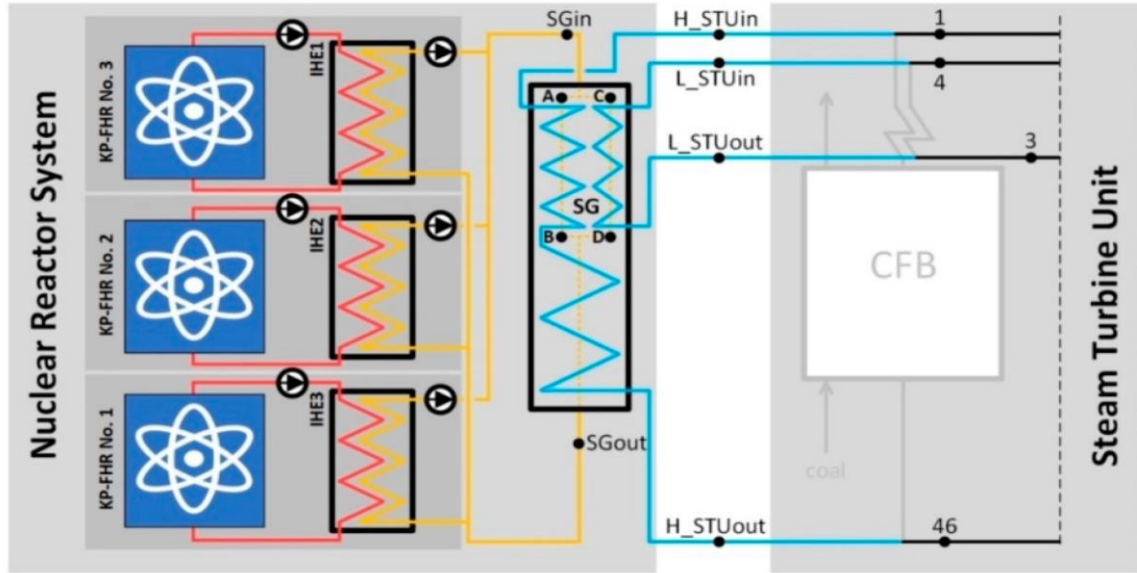
Rough indicative LCOE comparison of firm dispatchable power alternatives in Poland.



Potential retrofit decarbonization pathways for 55 large and modern or modernized Polish coal units.

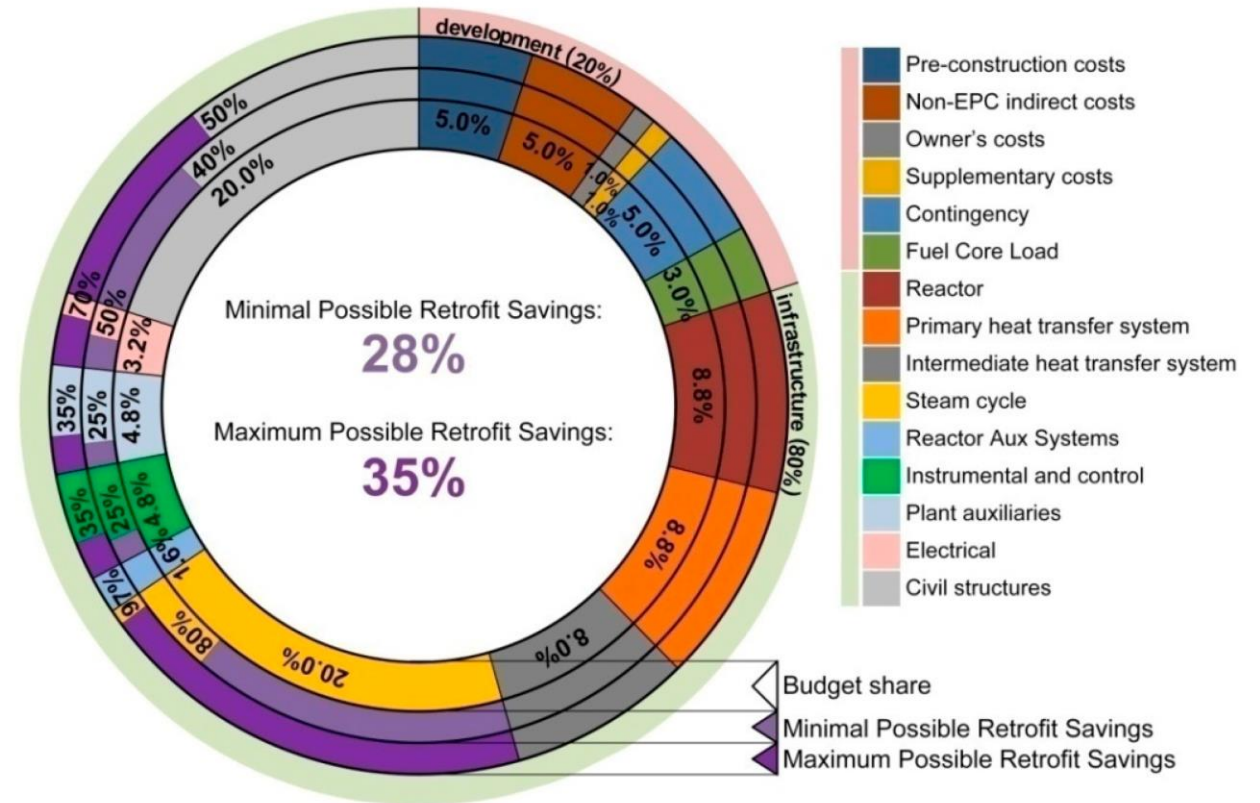


On-going R&D projects (2.3)

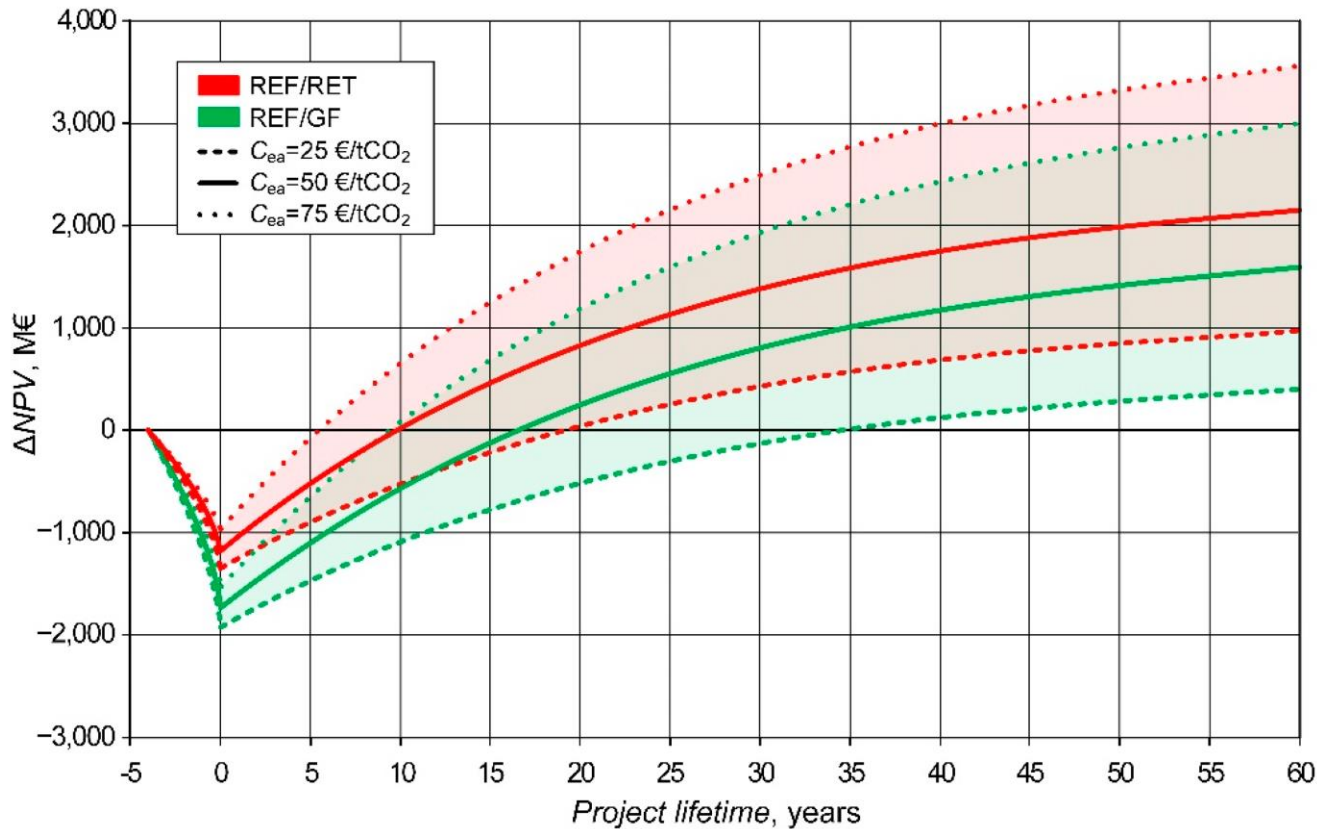


Integration diagram of KP-FHR system with the reference steam turbine unit.

Overnight capital cost breakdown of an advanced SMR.

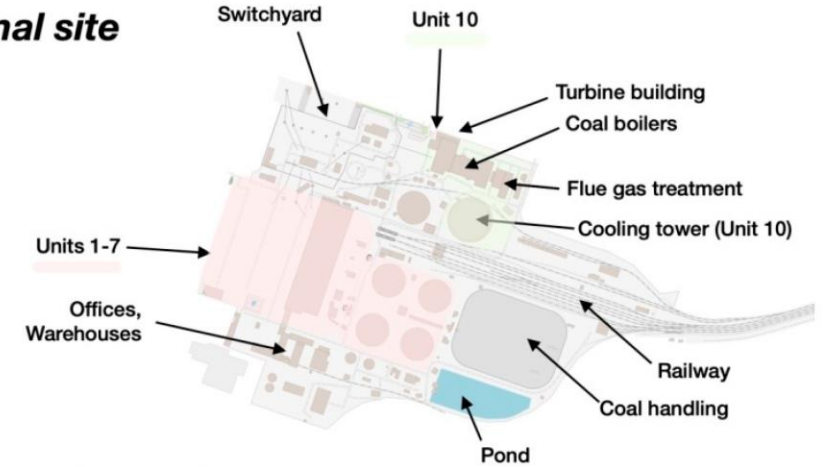


On-going R&D projects (2.4)

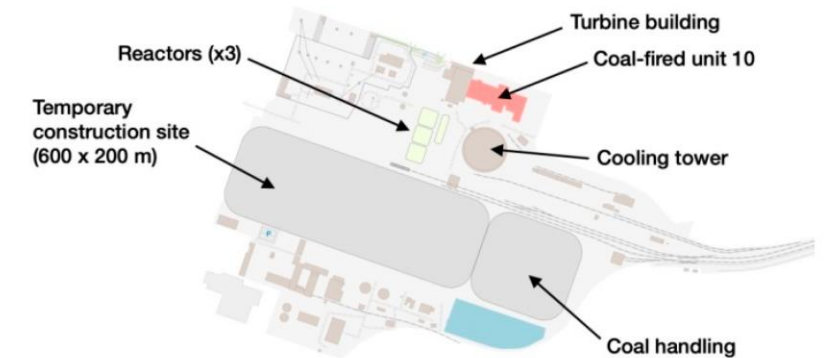


ΔNPV as a function of project lifetime for the GF and RET investment pathways.

Original site



Decarbonized site



Łagisza unit B10 retrofit with 3xKP-FHR footprint comparison, while unit remains in operation

On-going R&D projects (3)

- Research Project (national funds) “***Plan of decarbonisation of the domestic power industry through modernization with the use of nuclear reactors***”:
 - duration: 36 months (*planned start from April 2022*)
 - consortium: **Silesian University of Technology**, Ministry of Climate and Environment, Energoprojekt Katowice S.A., Institute of Nuclear Chemistry and Technology, Sobieski Institute
 - project leader: Łukasz Bartela (SUT)
 - budget: ca. 6 M PLN (ca. 1.3 M EUR)
 - my role: **technical assessment of retrofitted power plants, potential locations assessment and integration options for the retrofits, investment and operational cost assessment, project results dissemination**

On-going R&D projects (4)



- R&D Research Project (national funds) „***Strategy development for CO₂ capture, transport, utilization and storage in Poland, and pilot implementation of Polish CCUS Cluster***”:
 - duration: 36 months (04.2021 – 03.2024)
 - consortium: **AGH University of Science and Technology**, Ministry of Economic Development and Technology, WiseEurope Institute
 - project leader: Wojciech Nowak – R&D manager & Paweł Gładysz – project manager
 - personel: **AGH – 40 people**, WiseEuropa – 15 people, Ministry – 5 people
 - budget: ca. 10 M PLN (ca. 2.1 M EUR)
 - my role: **project management and coordination, head of process modelling group, Carbon Dioxide Removal technologies, techno-economic assessment, CCUS clusters**

On-going R&D projects (4.1)



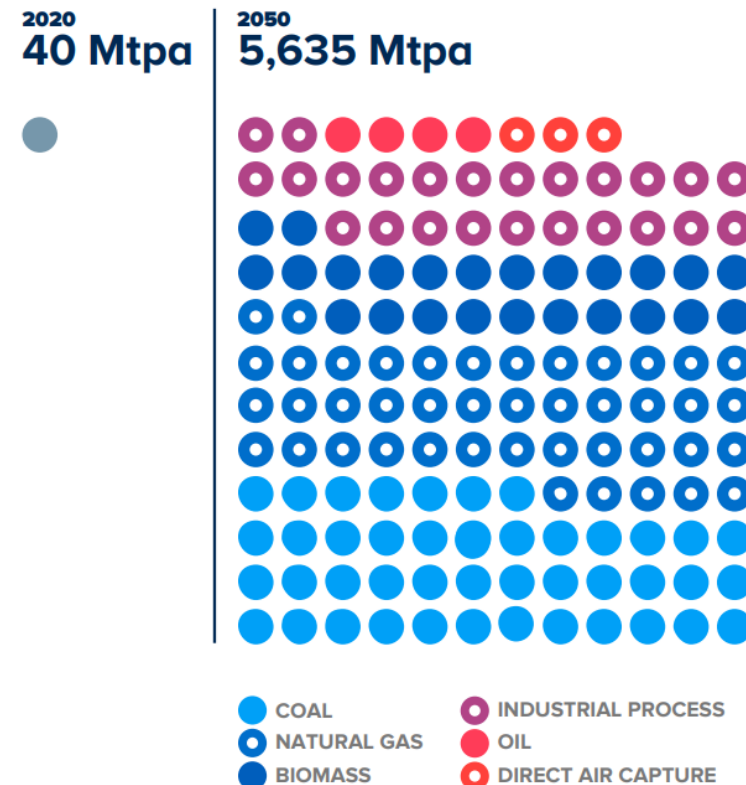
Global status of CCS technologies in 2021:

- **27 commercial operational installations** (total capture capacity of **36.6 Mt CO₂ per year**),
- 2 facilities suspended operation,
- 4 facilities in construction,
- 58 facilities in advanced development,
- 44 facilities in early development.

Total capture capacity of facilities in construction, advanced and early stage development is over **110 Mt CO₂ per year**.



Source and more:
<https://www.globalccsinstitute.com/resources/global-status-report/>



The role of CCS technologies in accordance with the IEA SDS scenario in year 2050

On-going R&D projects (4.2)




Source and more:
<https://www.globalccsinstitute.com/resources/publications-reports-research/the-carbon-capture-and-storage-readiness-index-2018-is-the-world-ready-for-carbon-capture-and-storage/>

Are we ready for the CCS/CCU technologies?

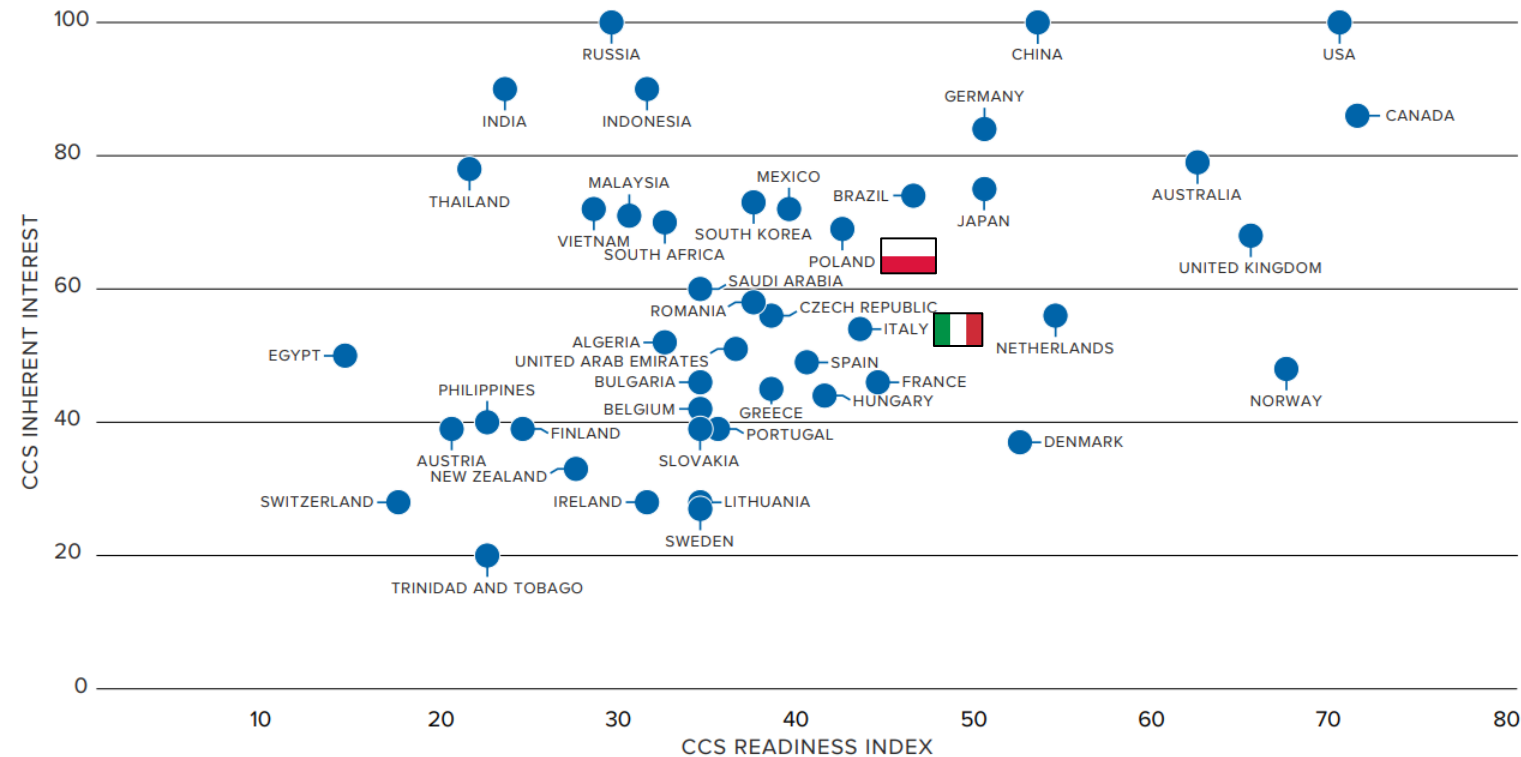
CCS Readiness Index (CCS-RI):

- policy developments
- legal and regulatory frameworks
- geological CO2 storage

vs inherent CCS interest.

For Poland (2018) :

- **CCS inherent interest: 52 / 100 points**
- **CCS-RI: 42 / 100 points, incl.:**
 - geological CO2 storage: 68 / 100 points
 - legal framework: 51 / 100 points
 - **policy development: 7 / 100 points**



On-going R&D projects (4.3)



Main project goals:

1. preparation of the **strategy for the development of CCUS technology** in Poland,
2. preparation of appropriate **legal and regulatory framework stimulating this development** in an sustainable manner, taking into account economic, social and environmental aspects,
3. preparation of the first **Polish CCUS Cluster**.

Other goals:

4. development, validation and complementary demonstration of **research tools** for the selection and assessment of the impact of CCUS technologies at the level of individual installations, as well as energy and industrial clusters from the technological, economic, environmental and socio-economic point of view;
5. preparation of a number of **reports and studies** on the key aspects of the development of CCUS technologies in Poland;
6. preparation and implementation of a series of **activities disseminating** the effects of the project dedicated to various groups of stakeholders.

On-going R&D projects (4.4)



Phase A (first 18 months) – main outcomes



AGH

- CCUS technological database.
- Assessment methods for individual installations and CCUs clusters.
- **Universal process model for simulation and optimization studies of CCUS clusters.**



WiseEuropa

- National-level fuel and energy model including CCUS technologies (in energy sector and industry).
- Macroeconomic model including CCUS technologies in an integrated approach.

On-going R&D projects (4.5)

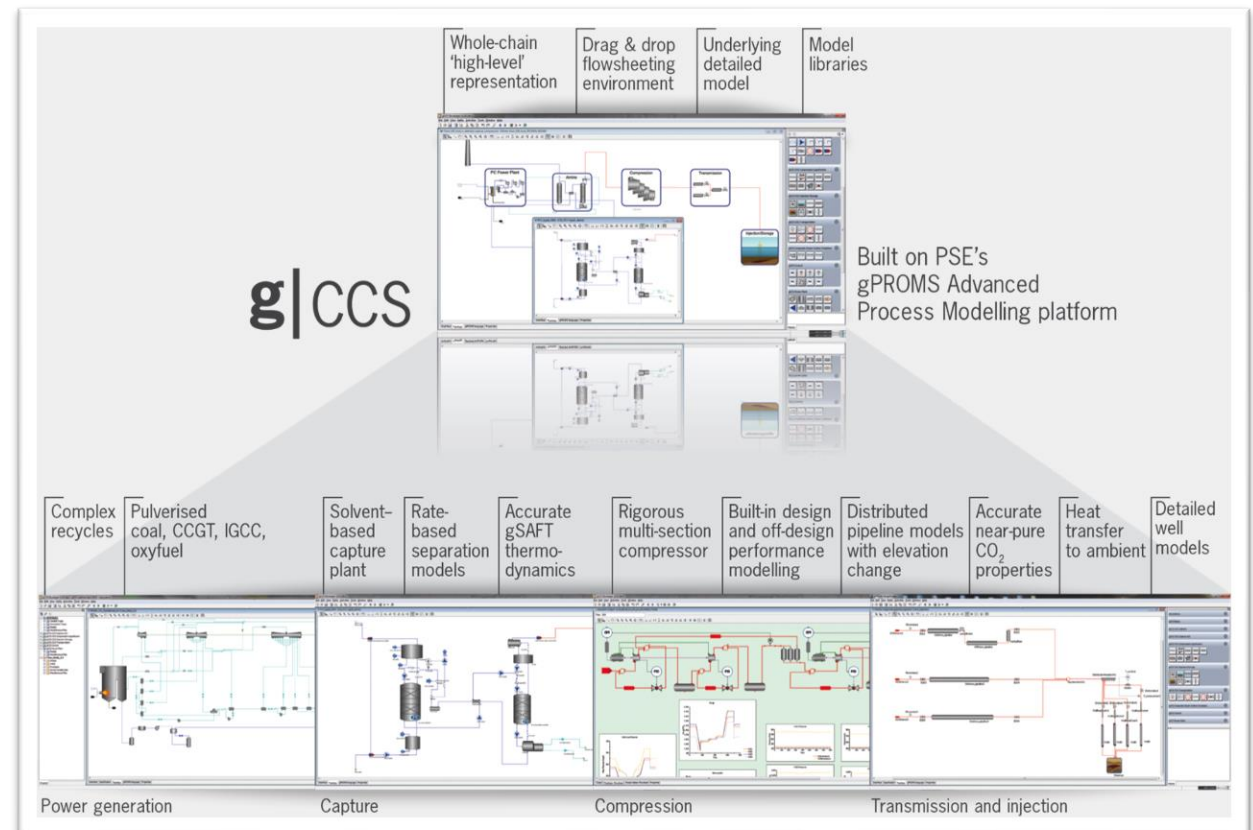


gPROMS software for the process modelling and optimization of CCUS installations and clusters.

Specialized research team (14 people) at AGH University devoted to the process simulations and optimization of CCUS installations and cluster using gPROMS software.

Team experience:

- participation in **extensive training by software provider** (Siemens PSE Enterprise),
- **case studies development** for Polish energy sector and industry,
- previous **R&D&I projects**.



On-going R&D projects (4.6)



Phase B (second 18 months) – main outcomes



AGH

- Preparation of **technological procedures and guidelines** for the implementation of CCUS technologies.
- Pilot of the **first Polish CCUS cluster**.
- Dissemination activities: thematic seminars, forum, online course.



WiseEuropa

- Quantitative and qualitative analyses in the area of CCUS technologies.
- Reports supporting the implementation of the strategy.
- Information policy framework.
- Dissemination activities: thematic seminars.

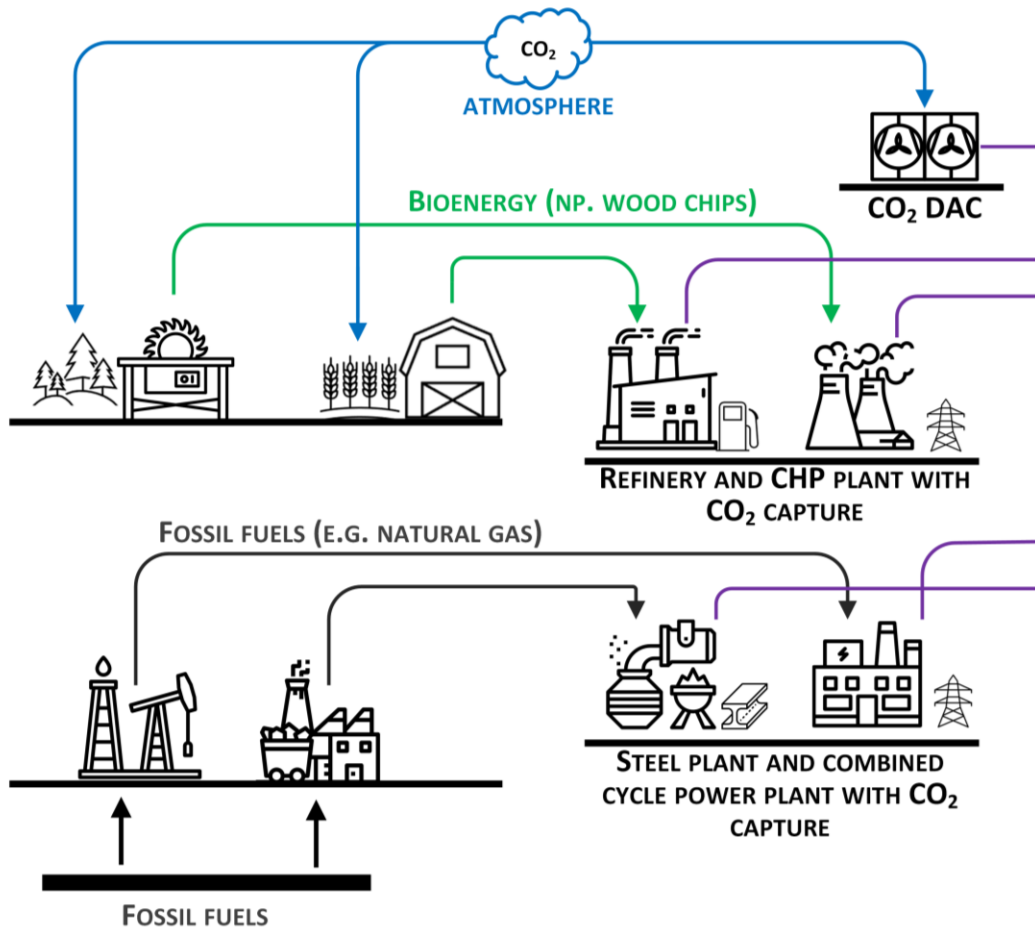


Ministerstwo Rozwoju,
Pracy i Technologii

Ministry

- Strategy for the development of CCUS technologies in Poland.
- Draft legal and regulatory framework in the area of technology development and energy-industrial clusters of CCUS technologies.
- Dissemination activities: thematic seminars.

On-going R&D projects (4.7)



CCUS technologies analysed in the project:

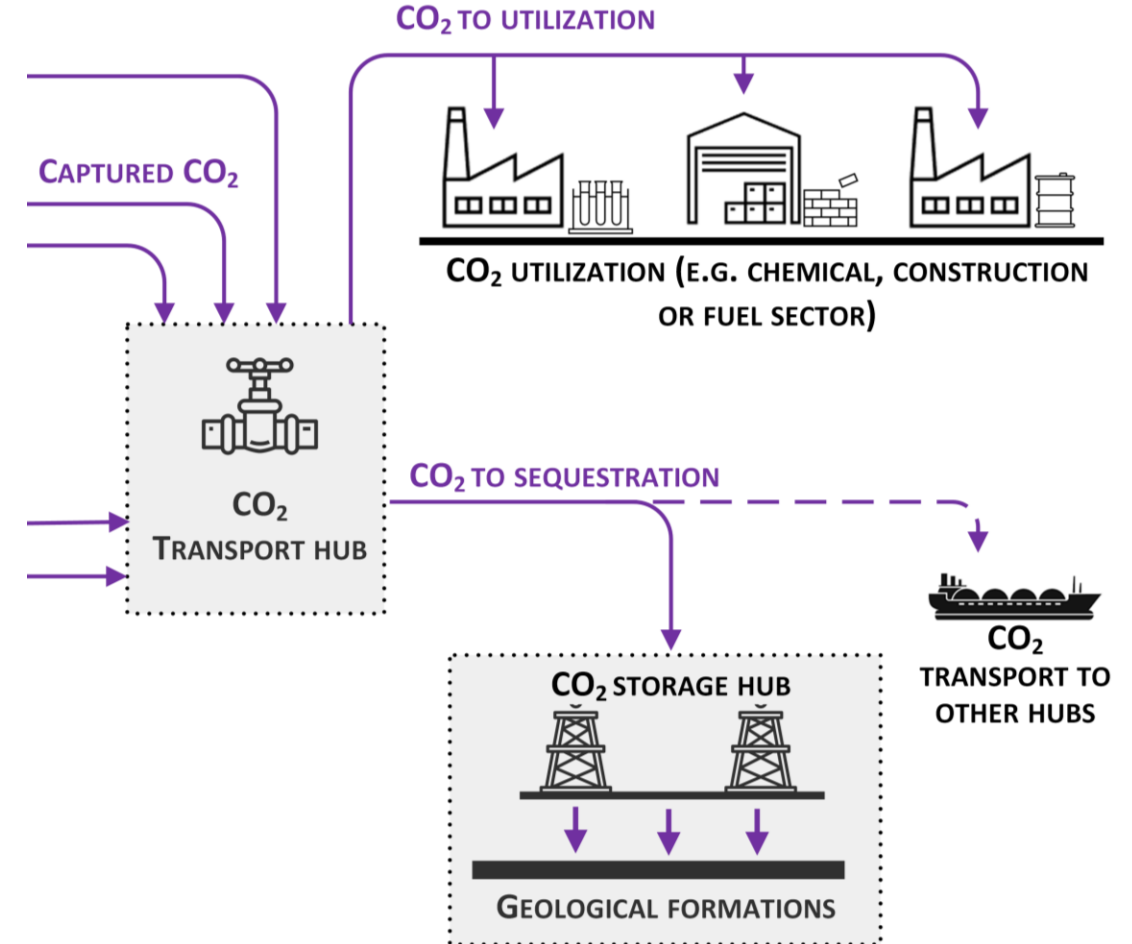
- CO₂ capture from **power and CHP plants** (main focus on gas-fired units);
- CO₂ capture from **industrial sources** (including integrated steel mills, cement plants, refineries and other point sources of emissions to the atmosphere);
- technologies for capturing CO₂ from sources using **bioenergy** (BECCUS - Bio-Energy CCUS);
- technologies for **direct removal of CO₂ from the atmosphere** (DAC - Direct Air Capture) and methods of their process integration

On-going R&D projects (4.8)



CCUS technologies analysed in the project:

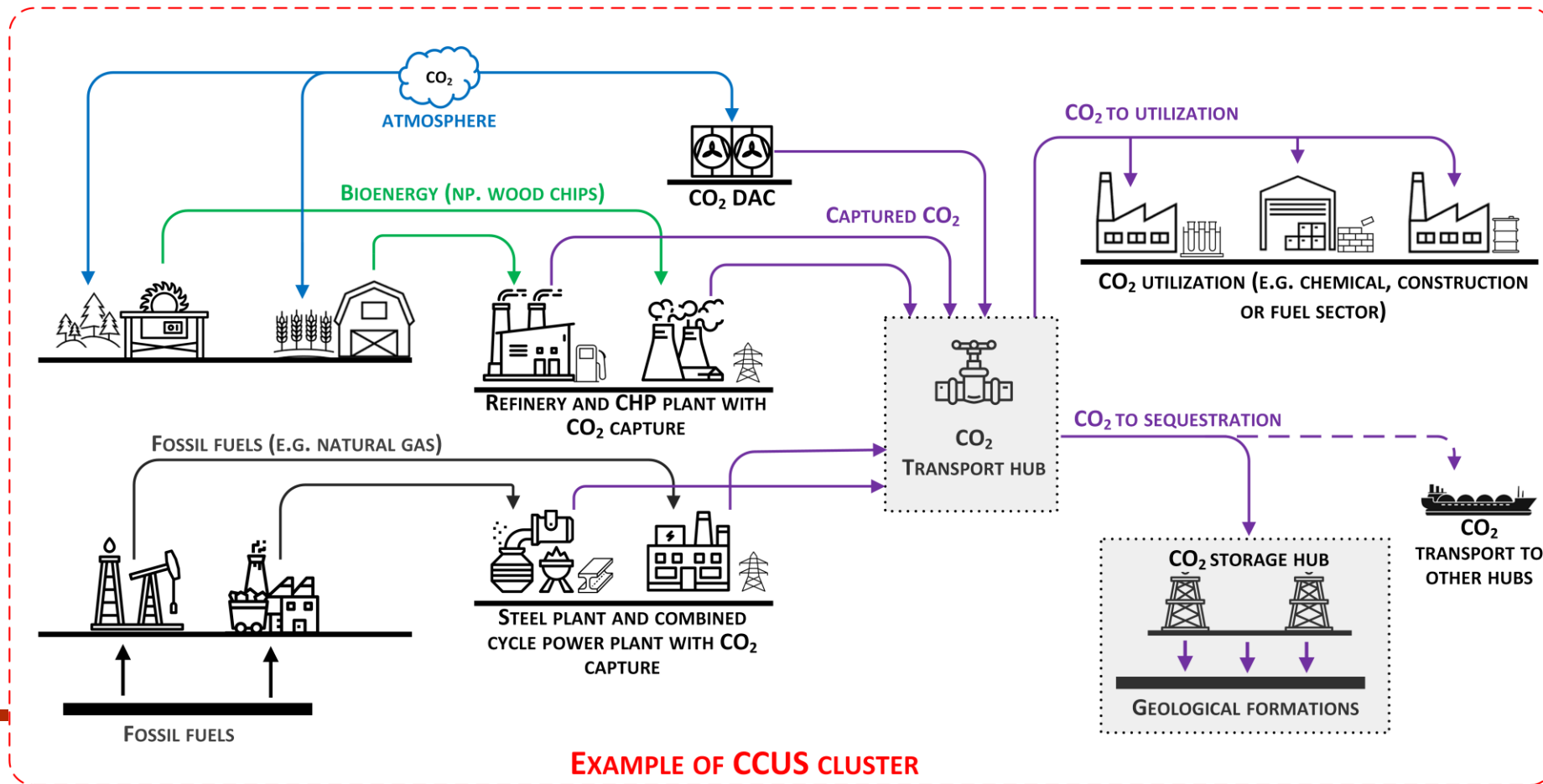
- **CO₂ transport technologies** for various scales and distances (overground and submarine pipelines, tankers and cisterns), including transport hubs;
- technologies for the **industrial use of CO₂** in the economy (e.g. hydrogen economy, production of synthetic fuels, enhanced oil and gas recovery; enhanced coal bed methane, mineralisation);
- technologies and **locations for CO₂ storage in Poland**, including cross-border cooperation and CO₂ storage hubs.



On-going R&D projects (4.9)



CCUS clusters to be analysed – theoretical case studies and first Polish CCUS cluster case study



EXAMPLE OF CCUS CLUSTER

On-going R&D projects (5)

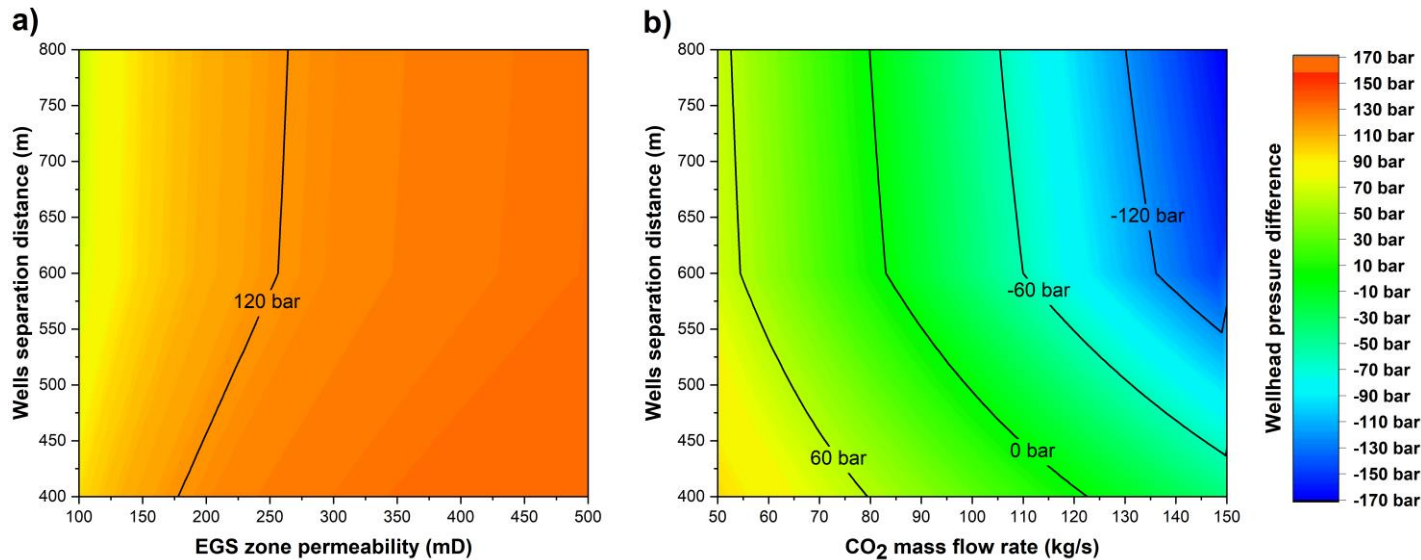


- R&D Research Project (Norway grant) „*CO₂-Enhanced Geothermal Systems for Climate Neutral Energy Supply*”:
 - duration: 36 months (10.2020 – 09.2023)
 - consortium: **AGH University of Science and Technology**, SINTEF Energi AS, The Norwegian University of Science and Technology, Mineral and Energy Economy Research Institute Polish Academy of Science, Exergon Sp. z o.o.
 - project leader: Anna Sowizdzał (AGH)
 - budget: ca. 6 M PLN (ca. 1.5 M EUR)
 - my role: case studies definition, process modeling of subsurface installations (direct sCO₂ cycles, ORC cycles, hybrid systems), techno-economic and environmental (LCA) assessment

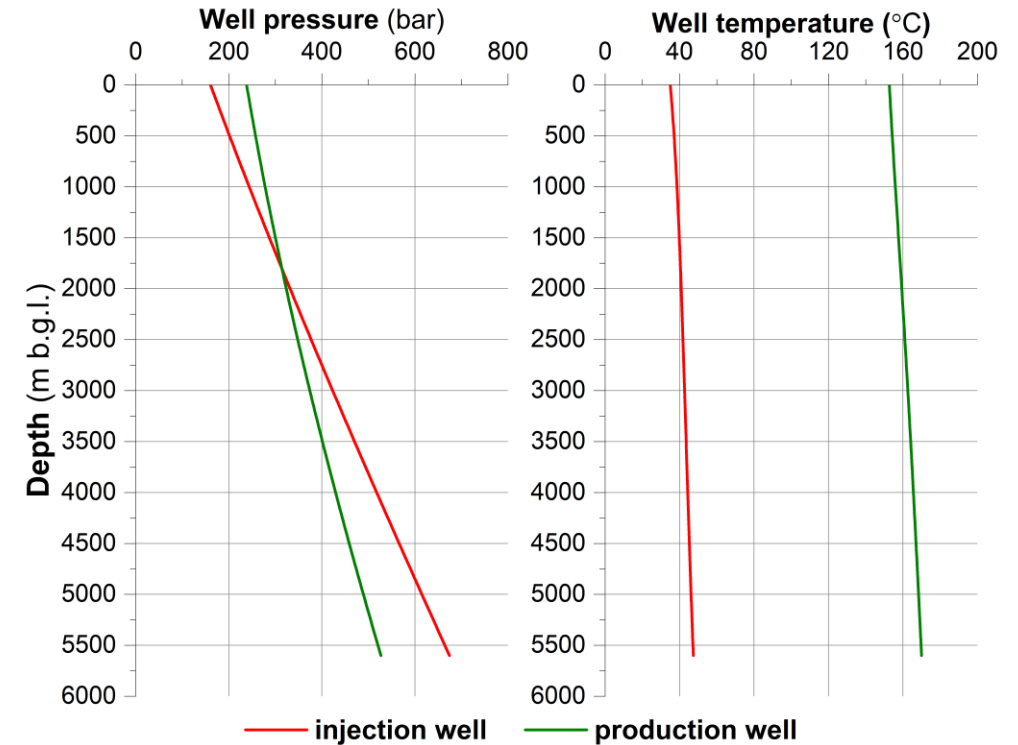
On-going R&D projects (5.1)



Some of the previous results...



Wellhead pressure difference as function of the EGS zone permeability, wells separation distance and CO₂ mass flow rate for different geological parameters (a: $\xi = 0.04$ mm, $\dot{m}_{\text{CO}_2} = 50$ kg/s; b: $\xi = 0.4$ mm, $K = 100$ mD; both: $t_{\text{res}} = 160$ °C, $t_{\text{inj}} = 35$ °C, $X_{\text{CO}_2, \text{seq}} = 5\%$)

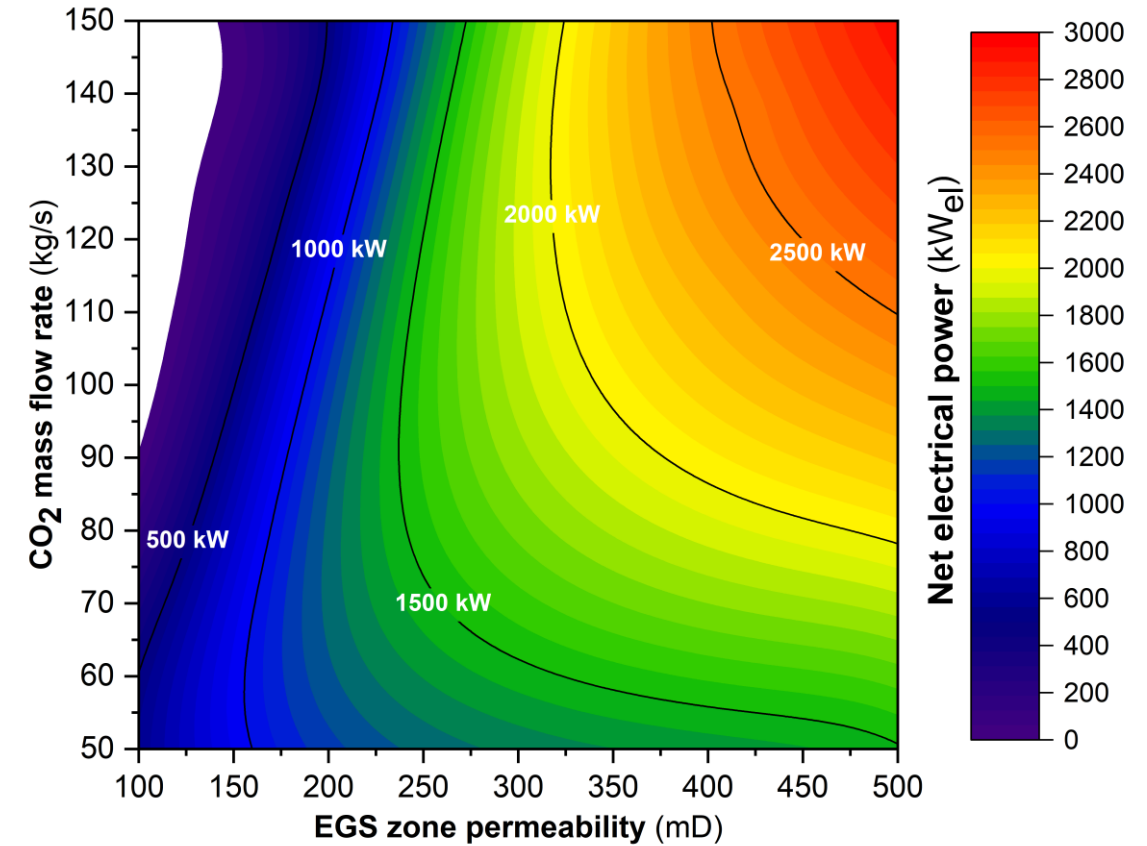
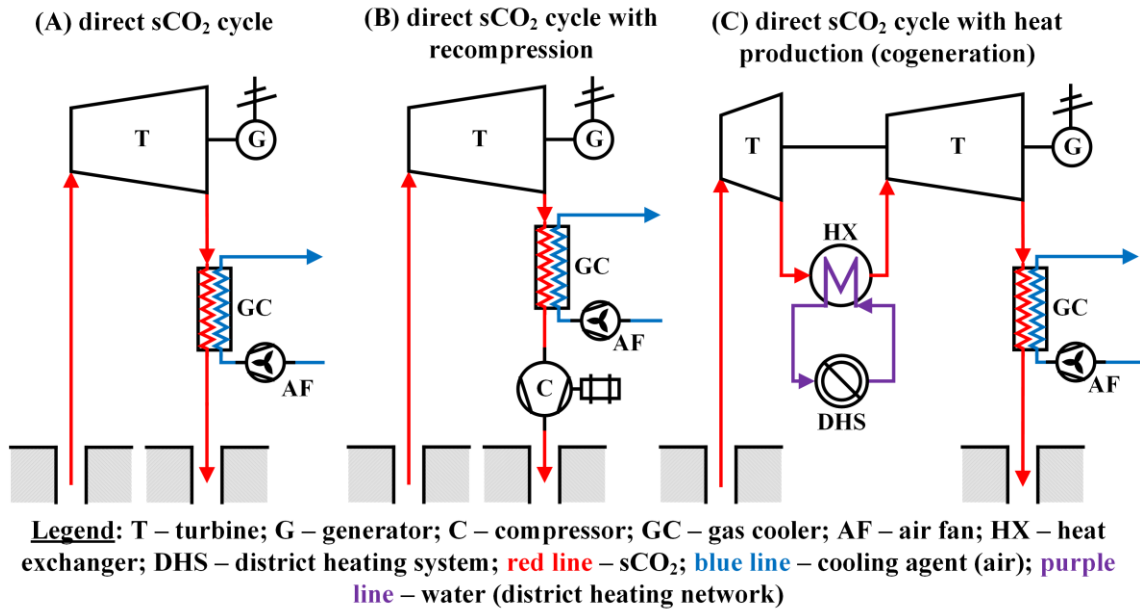


Pressure and temperature distribution along the injection and production wells ($t_{\text{res}} = 170$ °C, $t_{\text{inj}} = 35$ °C, $SD_{\text{wells}} = 600$ m, $X_{\text{CO}_2, \text{seq}} = 5\%$, $\xi = 0.04$ mm, $\dot{m}_{\text{CO}_2} = 50$ kg/s, $K = 100$ mD)

On-going R&D projects (5.2)



Some of the previous results...

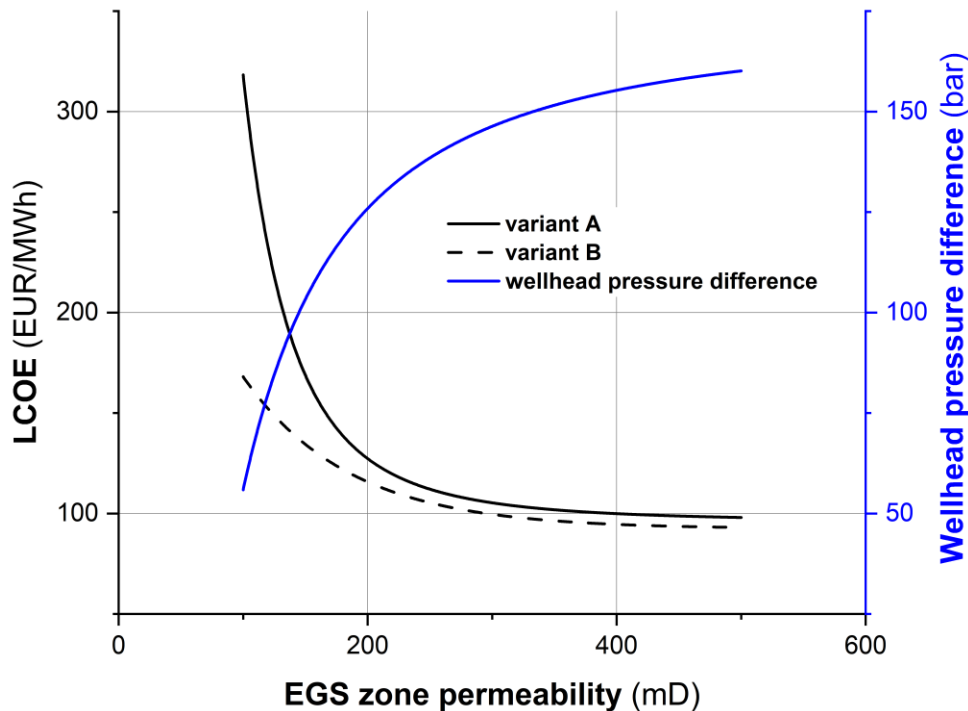


Impact of the EGS zone permeability and CO₂ mass flow rate on the net electrical power of the sCO₂ cycles in **variant A** (other constant geological parameters: $\xi = 0.4$ mm, $SD_{\text{well}} = 600$ m; $t_{\text{res}} = 160$ °C, $t_{\text{inj}} = 35$ °C, $X_{\text{CO}_2, \text{seq}} = 5\%$)

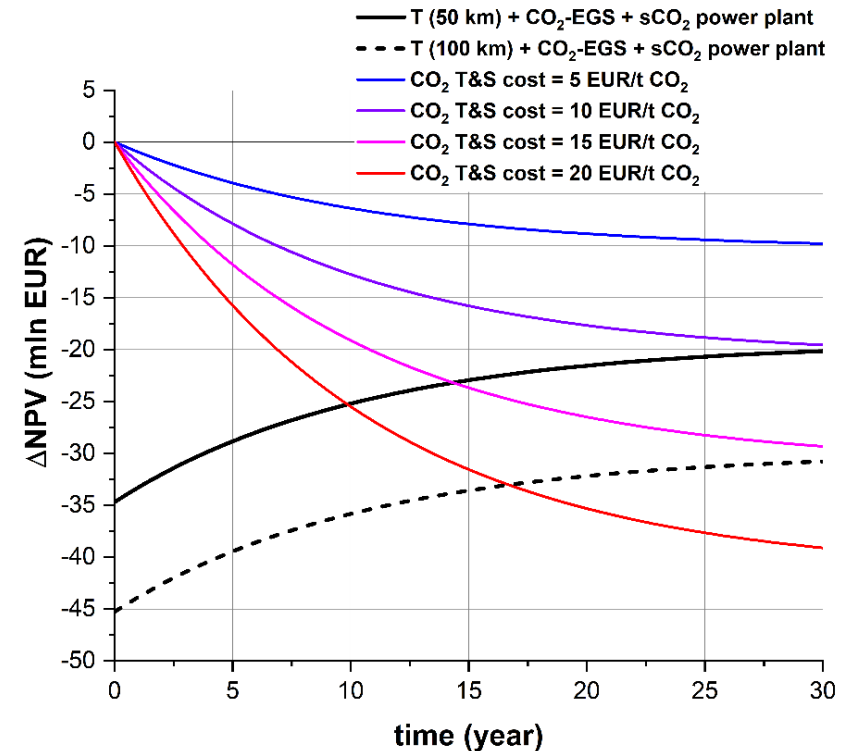
On-going R&D projects (5.3)



Some of the previous results...



Impact of the EGS zone permeability on the LCOE for selected geological parameters ($\xi = 0.4$ mm, $\dot{m}_{\text{CO}_2} = 100$ kg/s; $SD_{\text{well}} = 400$ m, $t_{\text{res}} = 180$ °C, $t_{\text{inj}} = 35$ °C, $X_{\text{CO}_2, \text{seq}} = 2\%$)



ΔNPV resulting from different options of capture CO₂ utilization and storage.

On-going R&D projects (5.4)



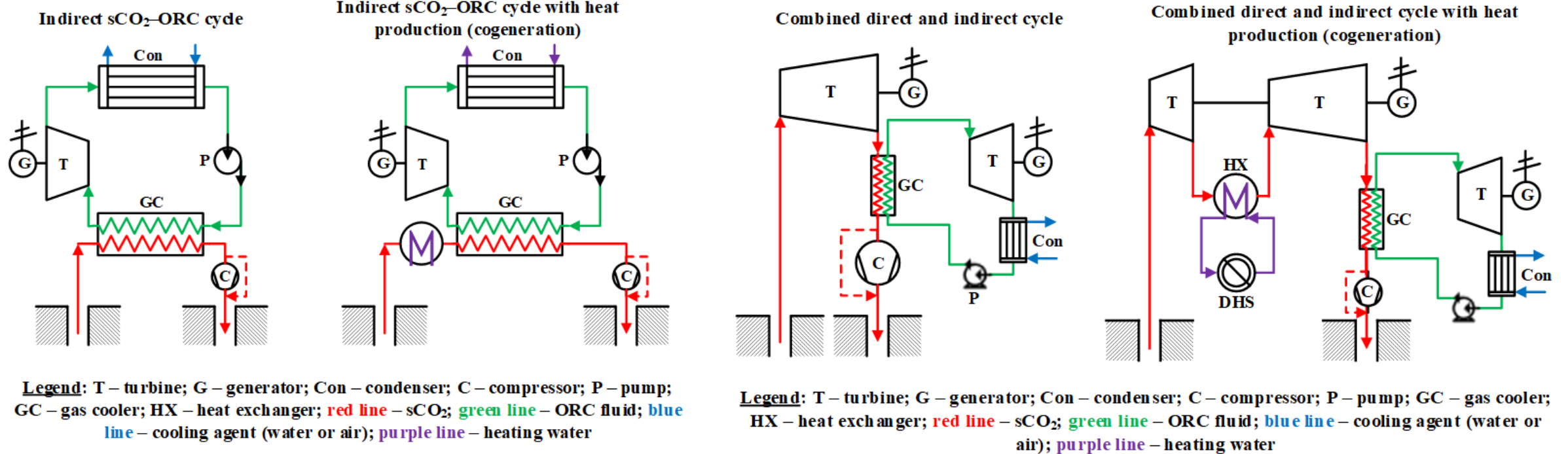
- Association with EnerGizerS project (CO₂-EGS)

Scenario number	General location type	Specific location	Heat demand type	Type of energy generation	Type of energy cycle
1	Onshore (Poland)	Gorzów Block	District heating system	Combined heat and power	Direct sCO ₂ cycle
2	Offshore (Norway)	Åre Formation	Lack of heat demand	Power generation only	Combined direct and indirect cycle
3	Onshore (Poland)	Mogilno-Łódź Trough	District heating system	Combined heat and power	Indirect cycle with ORC
4	Offshore (Norway)	Åre Formation	Site-specific heat demand	Combined heat and power	Indirect cycle with ORC
5	Onshore (Poland)	Gorzów Block	District heating system	Combined heat and power	Combined direct and indirect cycle
6	Onshore (Poland)	Mogilno-Łódź Trough	Lack of heat demand	Power generation only	Combined direct and indirect cycle

On-going R&D projects (5.5)



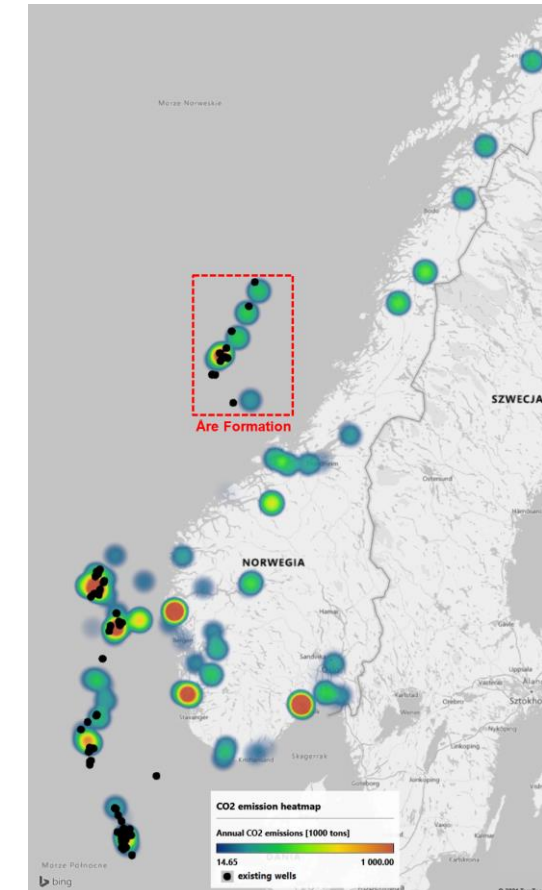
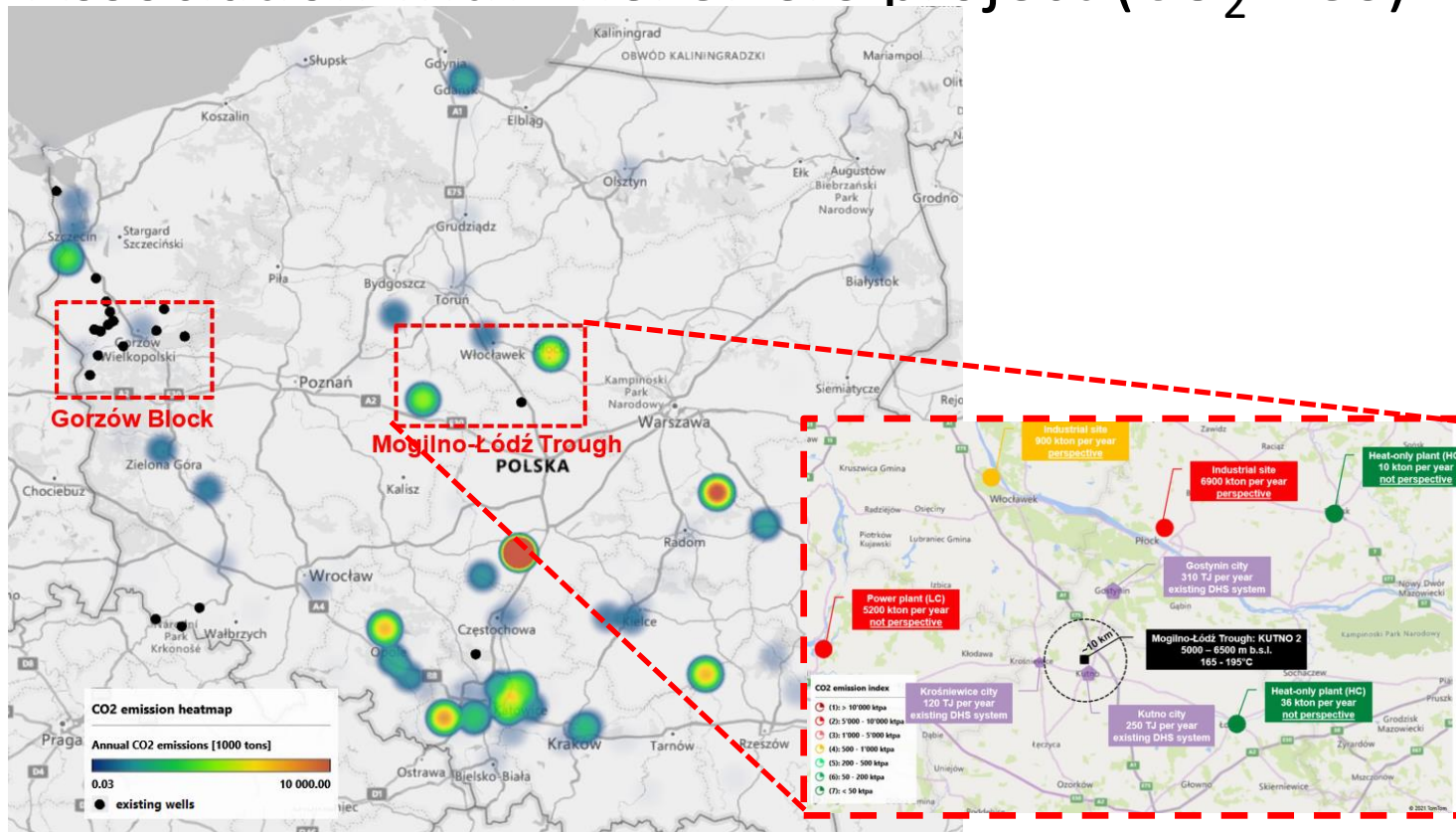
- Association with EnerGizerS project (CO₂-EGS)



On-going R&D projects (5.6)



- Association with EnerGizerS project (CO₂-EGS)



On-going R&D projects (6)



- R&D Research Project / Travel Grant (national funds) „***Comparative assessment of enhanced geothermal systems with advanced exergy analysis***“:
 - duration: 6 months (10.2021 – 03.2022)
 - budget: ca. 80k PLN (ca. 17k EUR)
 - scope: **comprehensive comparison of water- and supercritical CO₂-based enhanced geothermal systems:**
 - **process mathematical modelling**
 - **advanced environmental assessment – exergoenvironmental analysis**
 - **advanced economic assessment – exergoeconomic analysis**

On-going R&D projects (7)



- Grants for joint second-cycle programmes KATAMARAN NAWA „***E3: Energy and Environmental Engineering***” (<https://www.e3.agh.edu.pl/>):
 - duration: 09.2018 – 12.2023
 - scope: **launch of a new programme called Energy and Environmental Engineering to be delivered together with Shibaura Institute of Technology in Tokio, Japan**
 - consortium: **AGH University of Science and Technology** (Poland), Shibaura Institute of Technology (Japan)
 - budget: ca. 700k PLN (ca. 150k EUR)
 - project leader: Janusz Szmyd (AGH) and Akito Takasaki (SIT)
 - my role: **classes preparation: Modeling of Energy Systems, Environmental Assessment of Energy Systems, Techno-economic Assessment of Energy Systems**

Scope of the presentation



- ✓ Short academic CV
- ✓ About AGH University and Faculty of Energy and Fuels
- ✓ International cooperation funding schemes available in Poland
- ✓ Selected past and on-going R&D projects at AGH University
- Future cooperation opportunities**

Submitted project proposals in evaluation – examples of international cooperation



- **Bilateral Research Project** (national – Polish and German – funds)
“Advanced integration of methods for the exergetic, economic and ecological assessment of low-carbon technologies” (Silesian University of Technology, AGH University of Science and Technology, Technical University of Berlin) – results in November 2022



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Future cooperation opportunities (1)



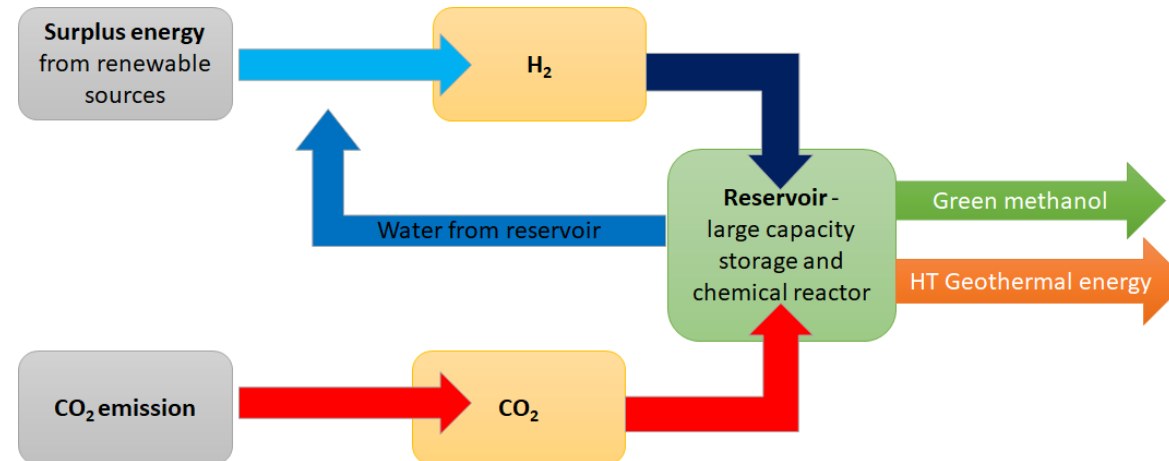
European HORIZON calls re-submission:

- **Enhanced CO₂ for Renewable Energy Conversion**
- Call: Sustainable, secure and competitive energy supply (HORIZON-CL5-2021-D3-03)
- New technology dedicated to storage systems, which enables integration of renewable energy technologies into a single energy generation system and fuels production systems including catalyst development and direct utilization of renewable energy sources.



Input source:

1. CO₂ from emission (e.g. by pipelines)
2. Surplus electrical energy from renewable (onsite converted on hydrogen - no pipeline needed)



Output:

1. Storage space for CO₂ and hydrogen.
2. Green methanol (green liquid chemical raw/intermediate product or fuel)
3. Renewable energy from geothermal (electricity and heat)

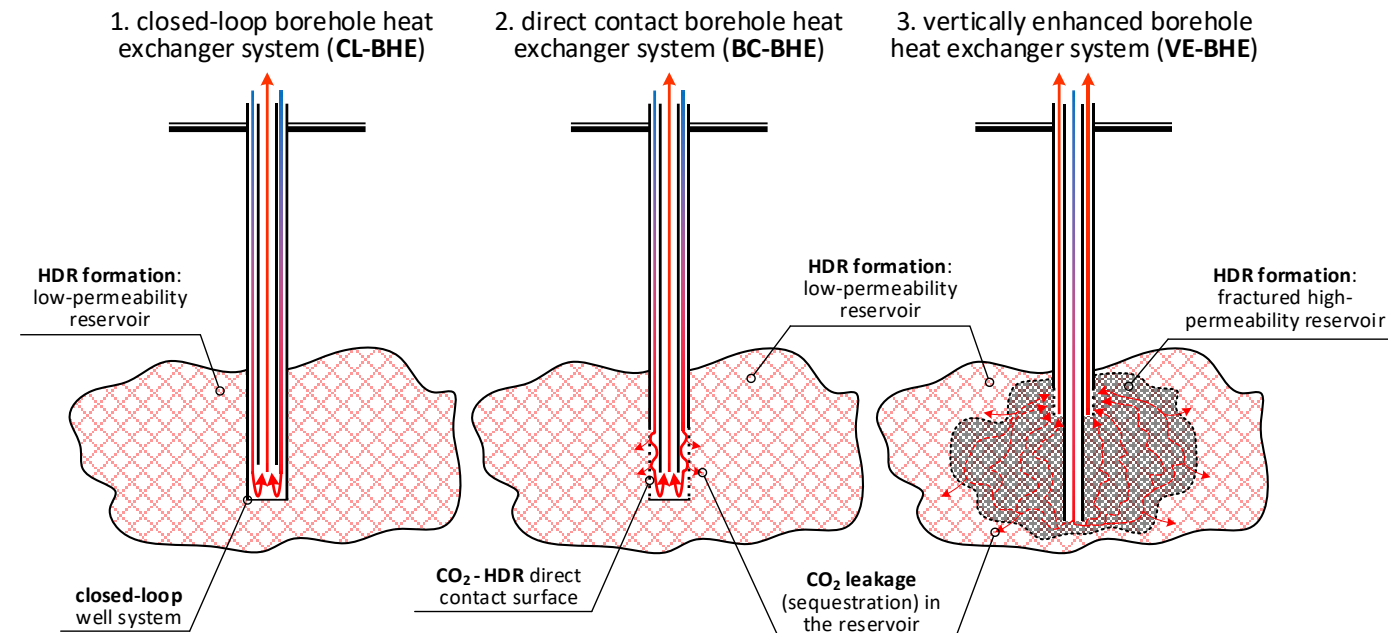
Future cooperation opportunities (2)



- Research Project (national funds) with international cooperation with UniFi “*Innovative borehole heat exchanger systems*” (Silesian University of Technology) – submission in Q2 of 2022 for SONATA BIS (NCN)

The fundamental novelty of the proposed project is:

- to study an integrated BHE systems by means of comprehensive numerical modelling;
- supercritical CO₂ as working fluid;
- to determine the effectiveness of proposed innovative designs in comparison with the conventional designs;
- to characterize the long-term energy, economic and environmental performance of the systems by means of advanced exergy analysis.



Future cooperation opportunities (3)



European HORIZON calls – selected new areas being pursued at AGH:

- Hydrogen economy
- Unconventional geothermal systems
- CO₂ utilization technologies
- Decarbonisation of district heating systems
- Small modular reactors and their application in industry and power sector
- ...



* The European Institute of Innovation & Technology (EIT) is not part of the Specific Programme

Discussion



Thank you for you attention.

Next seminars



- **Process modelling tools and their application in design and optimization of modern decarbonized energy systems** - 08.02.2022, 10:00 – 12:00, online
- **Thermo-ecological cost: an exergy-based lifecycle impact assessment – methods and applications** - 15.03.2022, 10:00 – 12:00, online