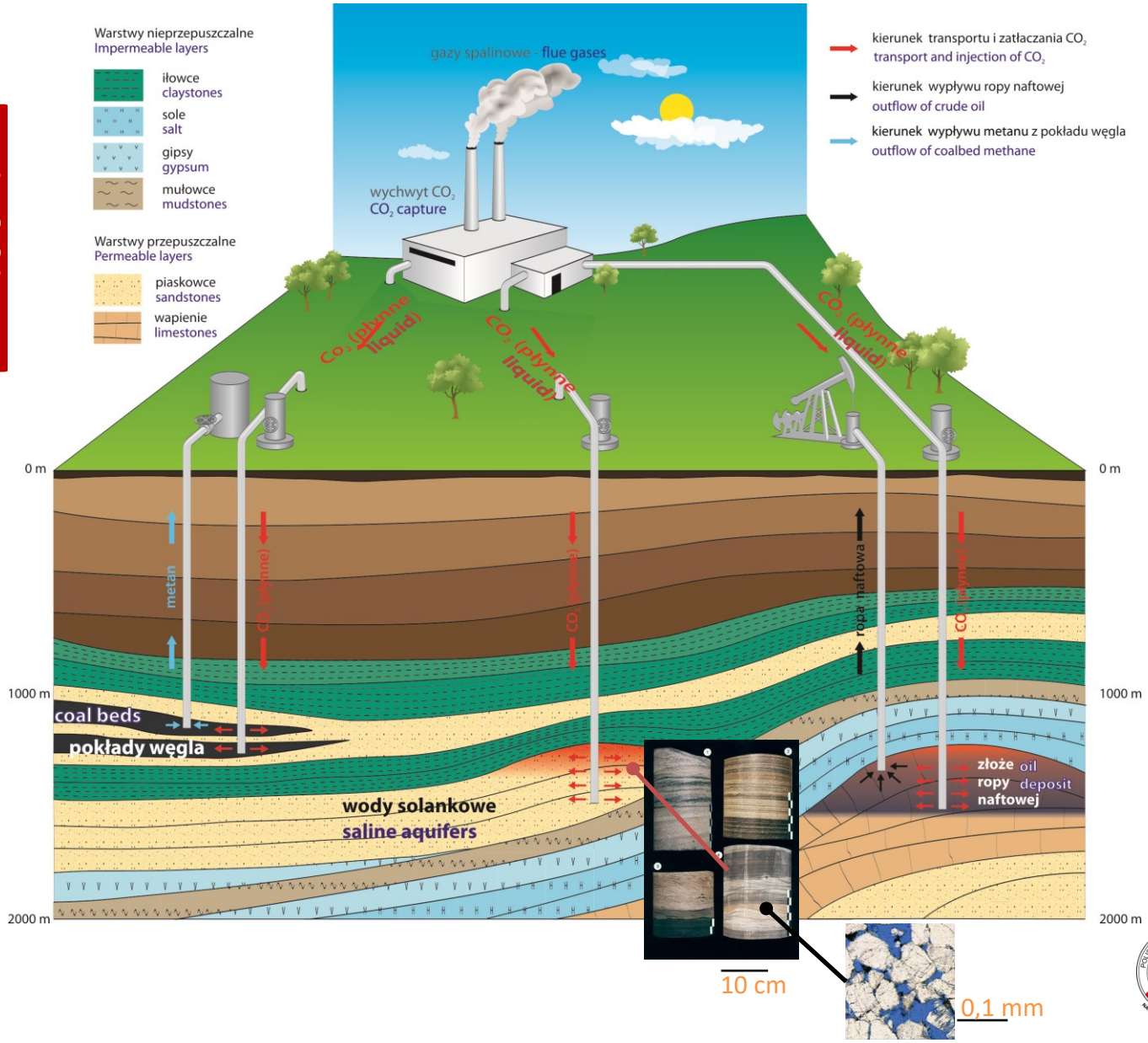
New attempt of the implementation of CCS technology in Poland – experiences, opportunities and challenges

Adam Wójcicki, PGI-NRI

Kaunas, 13.10.2022

Polish Geological Institute
National Research Institute

CCS (Carbon Capture and Storage)
CGS (Carbon Geological Storage)

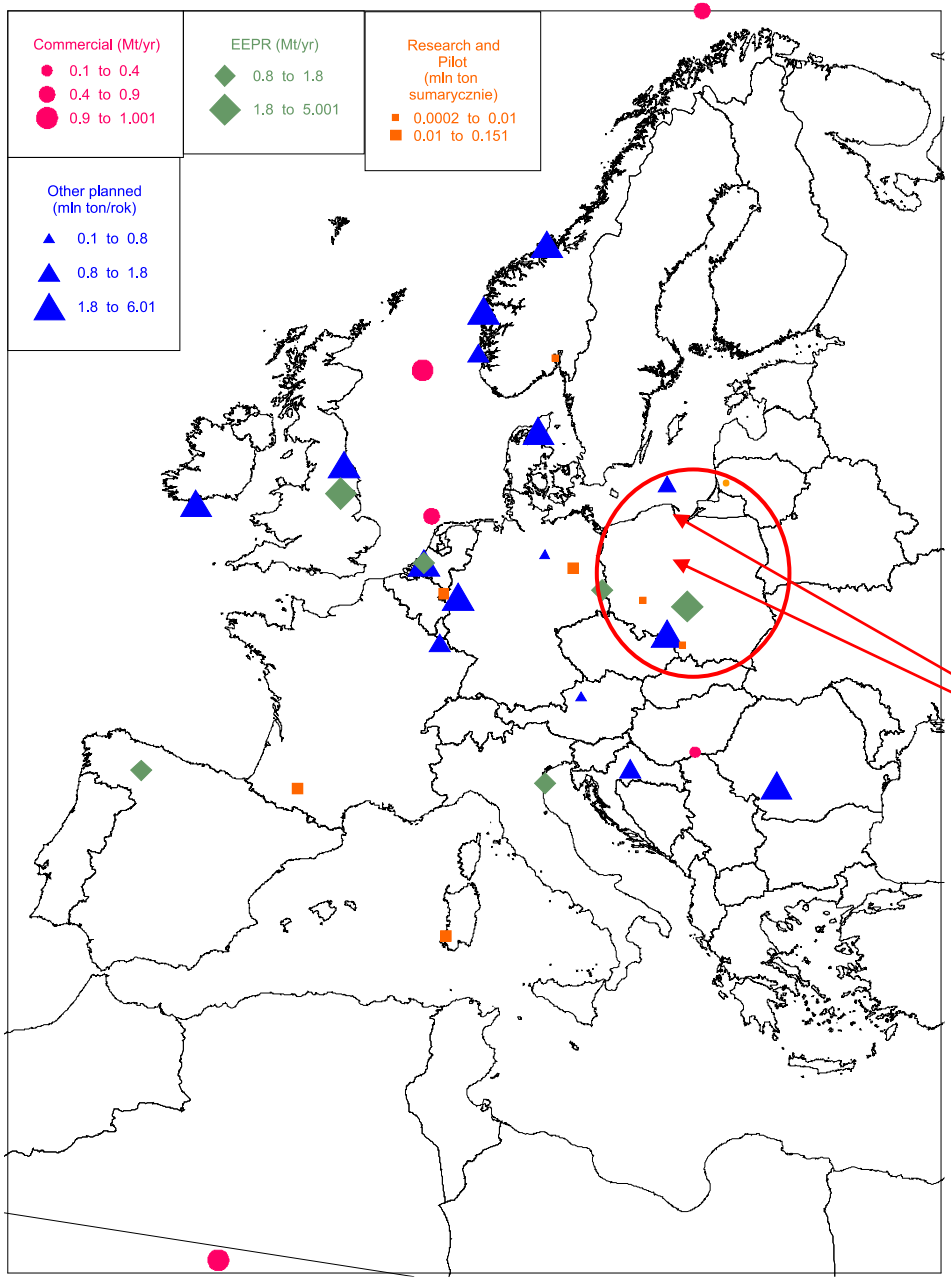


23 large scale (>=0.4 Mt/yr) CCS projects operating worldwide (GCCSI, 2020), mainly in North America, first since 1972, about 70% in CO2-EOR (~40 Mt/year, total about 340 Mt).

Hundreds of EOR projects utilizing CO2 from natural sources/fields since 1972, mostly in the US; about 1 Gt (?) of (natural) CO2 (re)injected.

Polish Geological Institute
National Research Institute

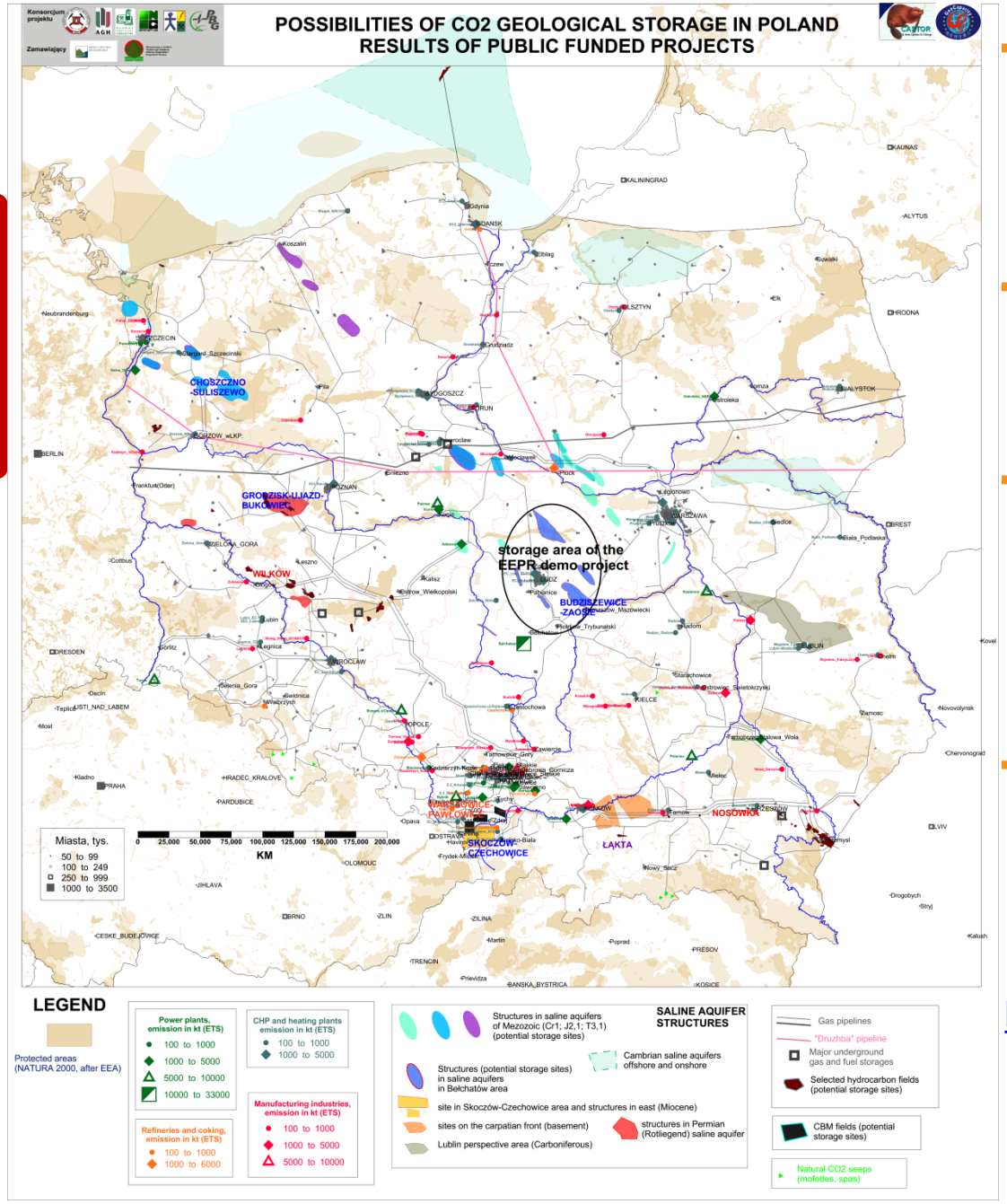
CCS projects – Europe and Poland (a history)



- 1995-.. Borzęcin gas field (inj. acidic gas ~80% CO2, ~20% H2S; INiG-PIB, POGC)
- 2004-2008 Kaniów coal beds (RECOPOL&MoVeCBM; CMI)
- PGE Bełchatów demo CCS project (EEPR funding; PGI-NRI, AGH-UST & SLB involvement; cancelled in 2013)
- PKE/ZAK Kędzierzyn demo CCS project (cancelled in 2011)
- LOTOS EOR? (2011-2015 baseline marine survey in FP7 ECO2 project)
- Poland – EU CCS Interconnector (Gdańsk) and LaFarge Kujawy cement plant (2021/2022…)
- Norway grants: CO2MARINE , MUSE, PRO_CCS, SHALESEQ, AGASTOR, SALTPRECO2…
- New power blocks – CCS readiness to be asssessed (prefeasibility studies on the full CCS chain; 2009-2013; 2021-)
- Regional studies & planned pilot project on injection into Jurassic aquifer (central PL; cancelled) >

The Polish National Project on CGS (2008-2012)

www.pgi.gov.pl

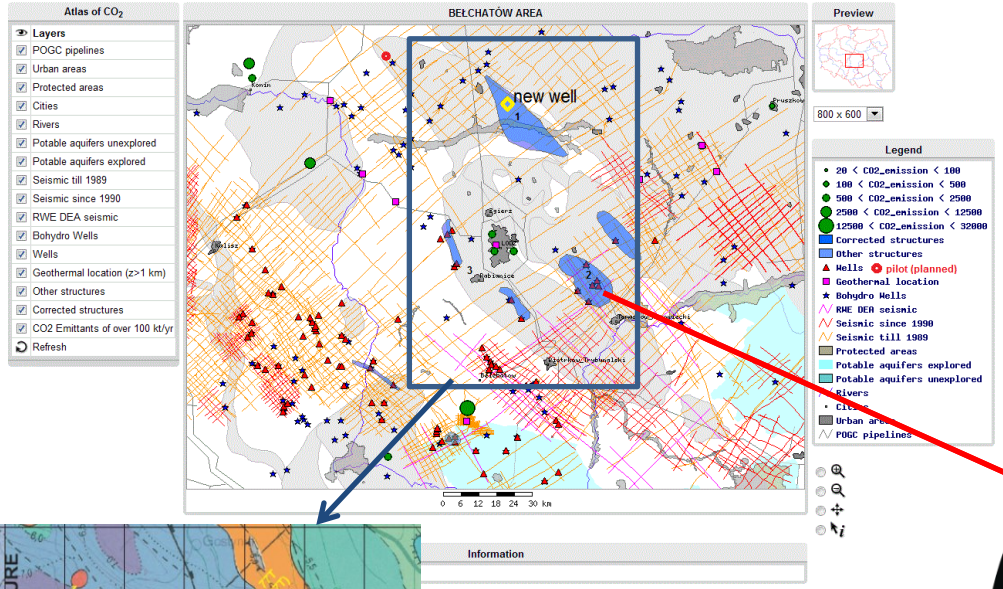


- Comprehensive regional studies on formations and structures (after EU GeoCapacity methodology) were completed for Ministry of Environment; minor revisions in 2021
- 8 case studies (4 structures in saline aquifers, one oil, one gas field, one gas field+saline aquifer, one CBM area; denoted in CAPITAL LETTERS)
- Estimated realistic/effective storage capacity for Poland is about 10-15 Gt ((46+4) saline aquifers: 90-93%, (39) hydrocarbon fields: 7-10%, incl. oil ~1%, coal beds: <<1%); over 90% is onshore
- ETS installations of Poland make about 0.17 Gt/yr (2020) – i.e. the storage potential corresponds to 60-90 years.

https://skladowanie.pgi.gov.pl/twiki/pub/CO2/WebHome/seq-summ.pdf

Polish Geological Institute
National Research Institute

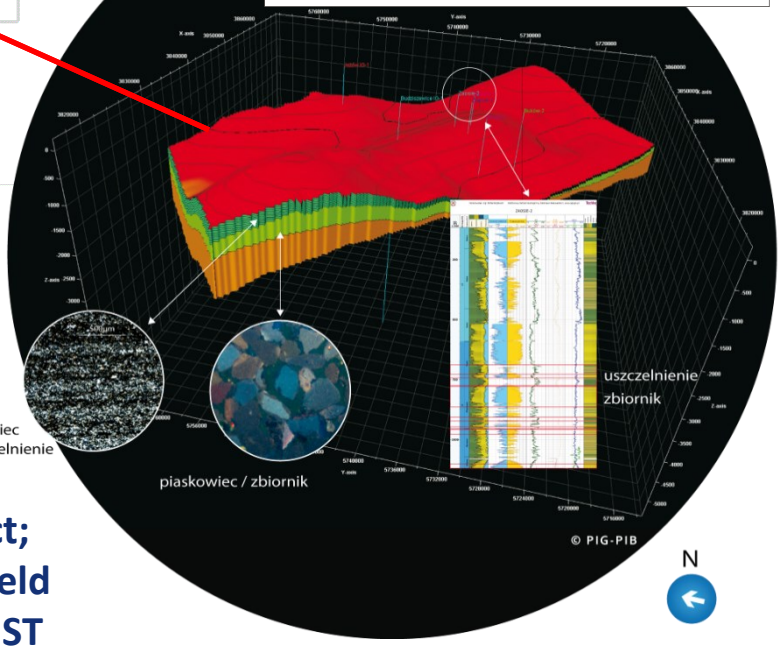
Supporting Bełchatów demo CCS project (~2 Mt/yr)

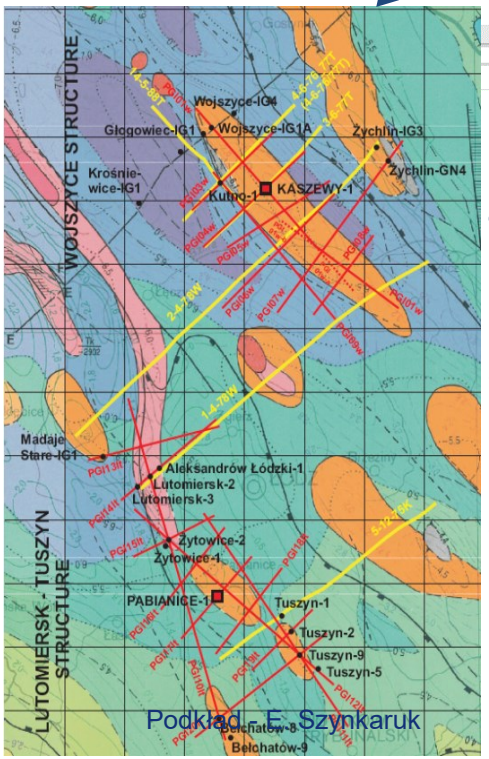


One structure was assesed (a case study) in the national project in 2008-2009, basing on archive data and new laboratory analyses of archive core samples.

Zamawiający MINISTERSTWO ŚRODOWISKA

Finansujący Sfinansowano ze środków Narodowego Funduszu Ochrony Środowiska i Gospodarki Wodnej





PGE

Two other structures (and surroundings) were explored (2D seismic & gravity, new wells) in the frames of storage component of the demo project; PGI designed and supervised field works, cooperated with AGH-UST and SLB on interpretation and site selection and helped PGE (the operator) on public outreach and communication (2009-2013).

Polish Geological Institute
National Research Institute

Planned pilot project on CO2 injection (Jurassic aquifer)

www.pgi.gov.pl

AGH

PROJEKT PRAC GEOLOGICZNYCH NA WYKONANIE OTWORÓW WIERTNICZYCH DZIWIE 1 I DZIWIE 2I DLA ZBADANIA CHŁONNOŚCI UTWORÓW JURY

Wykonano na zamówienie Ministrą Środowiska za środki finansowe wypłacone przez narodowy Fundusz ochrony Środowiska i gospodarki Wodnej w ramach przedsięwzięcia „Rozpoznanie formacji i struktur do bezpiecznego geologicznego składowania CO2 wraz z ich programem monitorowania", Zadanie 1.1.18.

Autorzy części technologicznej projektu zatłaczania i monitoringu	Autorzy części geologicznej i geofizycznej
prof. dr hab. inż. Andrzej Goaat, AGH	dr hab. Zdzisław Modliński prof. nzw. PIG-PIB, upr. 010053
prof. dr hab. inż. Henryk Marcak, AGH	dr Lesław Skrzypczyk, upr. IV-0410, PIG-PIB
prof. dr hab. inż. Stanisław Stryczek, AGH	mgr inż. Teresa Adamczak, upr. IX-0394, PIG-PIB
prof. dr hab. inż. Jakub Siemek, AGH	mgr inż. Grzegorz Wrobel, PIG-PIB
dr hab. inż. Stanisław Nagy, prof. nzw., AGH	dr Anna Feldman-Olszewska, PIG-PIB
dr hab. inż. Rafał Wiśniowski, prof. nzw., AGH	dr Jadwiga Wagner, upr. nr. 040284, PIG-PIB
mgr inż. Łukasz Klimkowski, AGH	dr Jacek Kasiński, upr. nr 030933, PIG-PIB

Koordynator zespołu AGH — Dyrektor PIG-PIB

dr hab. inż. Stanisław Nagy, prof. nzw. — dr hab. Jerzy Nawrocki, prof. nzw.

Rozdzielnik:
Egz. 1, 2, 3, 4 Ministerstwo Środowiska w Warszawie
Egz. 5 Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy
Egz. 6 Akademia Górniczo-Hutnicza

Warszawa-Kraków, grudzień 2010 r.

1

MINISTER ŚRODOWISKA

Warszawa, dnia [illegible] 2011 r.

DGiKGhg-4730-[illegible]/11/MK

DECYZJA

Działając na podstawie art. 33 ust. 1 oraz art. 103 ust. 2 pkt 2 lit. c ustawy z dnia 4 lutego 1994 r. *Prawo geologiczne i górnicze* (Dz. U. z 2005 Nr 228, poz. 1947, z późn. zm.) oraz art.104 K.p.a., na wniosek Państwowego Instytutu Geologicznego – Państwowego Instytutu Badawczego w Warszawie oraz po rozważeniu możliwości oddziaływania projektowanych prac geologicznych na obszary Natura 2000, zgodnie z art. 96 ust. 1 ustawy z dnia 3 października 2008 r. o *udostępnianiu informacji o środowisku i jego ochronie, udziale społeczeństwa w ochronie środowiska oraz o ocenach oddziaływania na środowisko* (Dz. U. z 2008 r. Nr 199, poz. 1227, z późn. zm.)

zatwierdzam

„Projekt prac geologicznych na wykonanie otworów wiertniczych Dziwie 1 i Dziwie 2I dla zbadania chłonności utworów jury", zlokalizowanych na terenie miejscowości Dziwie, gmina Przedecz, powiat koński, województwo wielkopolskie, opracowany przez Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy w Warszawie oraz Akademię Górniczo – Hutniczą w Krakowie, obejmujący wykonanie:

1) otworu wiertniczego „Dziwie 1" do głębokości 1430 m ± 10%;
2) otworu wiertniczego „Dziwie 2 I" do głębokości 1390 m ± 1%;
3) badań laboratoryjnych w zakresie:
   a) powierzchniowych zdjęć gazowych i monitoringu środowiska naturalnego w strefie otworów „Dziwie 1" i „Dziwie 2I" przez rozpoczęciem wiercenia i po jego zakończeniu;
   b) własności fizycznych (porowatość i przepuszczalność) i chemicznych próbek rdzeni pobranych z otworu „Dziwie 1";
   c) analiz mikrofaunistycznych i petrograficznych w otworze „Dziwie 1";
   d) analiz wód złożowych, płuczki oraz płynów porównawczych w otworach „Dziwie 1" i „Dziwie 2I";
   e) parametrów zaczynu i kamienia cementowego w otworach „Dziwie 1" i „Dziwie 2I";
4) profilowania geofizycznego w otworach „Dziwie 1" i „Dziwie 2 I";
5) pomiarów i analiz wód podziemnych;
6) pilotażowego zatłaczania dwutlenku węgla otworem „Dziwie 2 I" w łącznej ilości do 27 072 ton;
7) monitoringu powierzchniowego i międzyotworowego procesu zatłaczania dwutlenku węgla;
8) likwidacji otworów „Dziwie 1" i „Dziwie 2I";
9) dokumentacji wynikowej.

Lokalizację otworów wymienionych w pkt 1 i 2 niniejszej decyzji opisują następujące współrzędne prostokątne w układzie 1992:

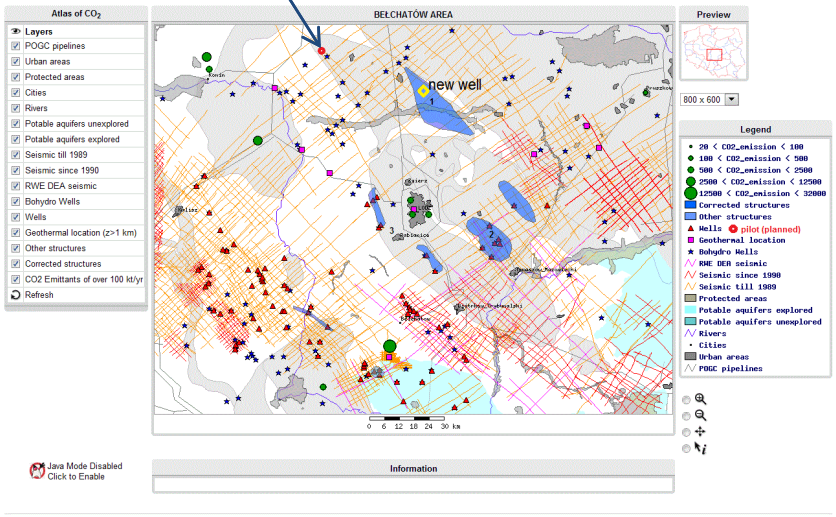
Nazwa otworu wiertniczego	x	y
Dziwie 1	495 112	494 806
Dziwie 2I	495 184	494 789

Szczegółowy zakres i harmonogram prac został ustalony w projekcie prac geologicznych, stanowiącym integralną część niniejszej decyzji.

Projekt prac geologicznych składa się z 116 stron i 3 załączników.

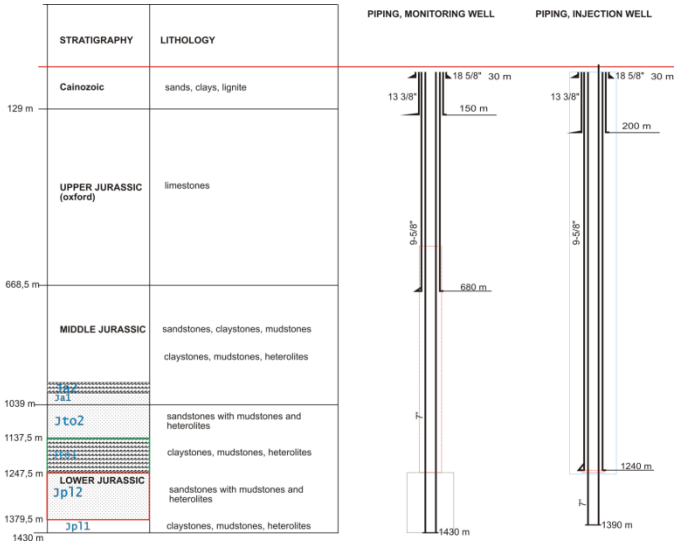
Wszystkie próbki geologiczne, w tym rdzenie wiertnicze uzyskane w wyniku przeprowadzenia prac geologicznych zalicza się do próbek geologicznych trwałego przechowywania.

1

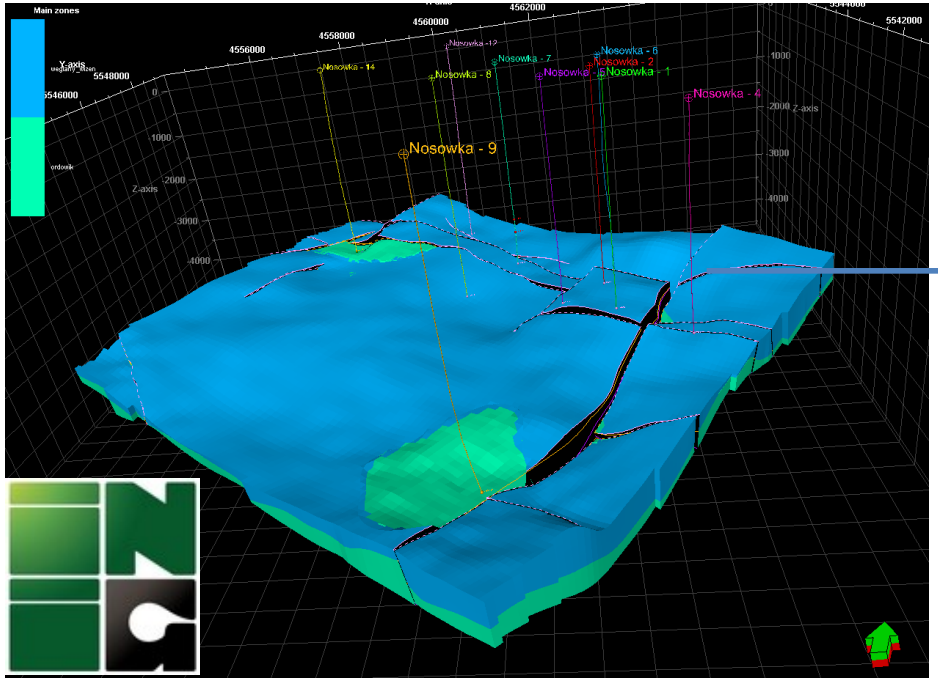


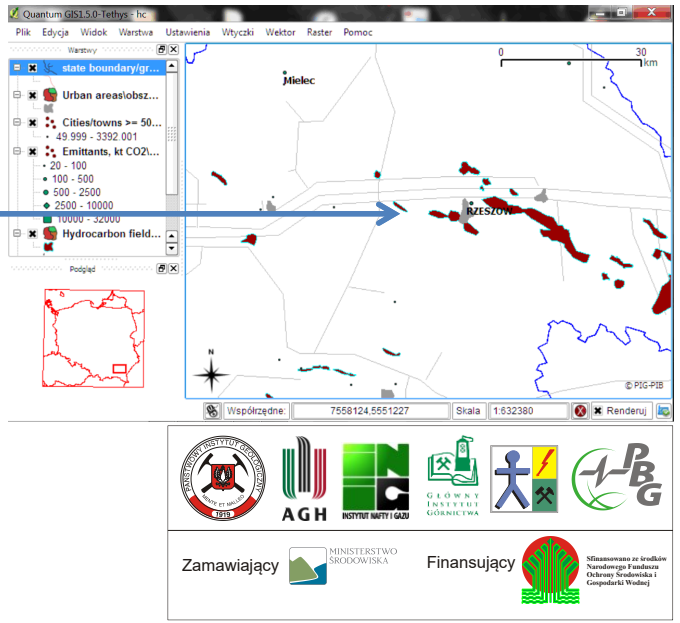
In the frames of the national (CGS) project assumptions and documentation for the research/injection permit were elaborated and the permit (for pilot injection of ~27 kt CO2 at Dziwie, about 40 km WNW of the selected demo site, into the same aquifer) was granted by Ministry of Environment (the competent authority) in 2011.

The project was to be financed by key Polish energy operators (including PGE), encouraged by the Ministry, but they eventually became reluctant and finally did not sign the contract.



CO2-EOR case study in the national programme (2010-11)





AGH

Zamawiający MINISTERSTWO ŚRODOWISKA

Finansujący

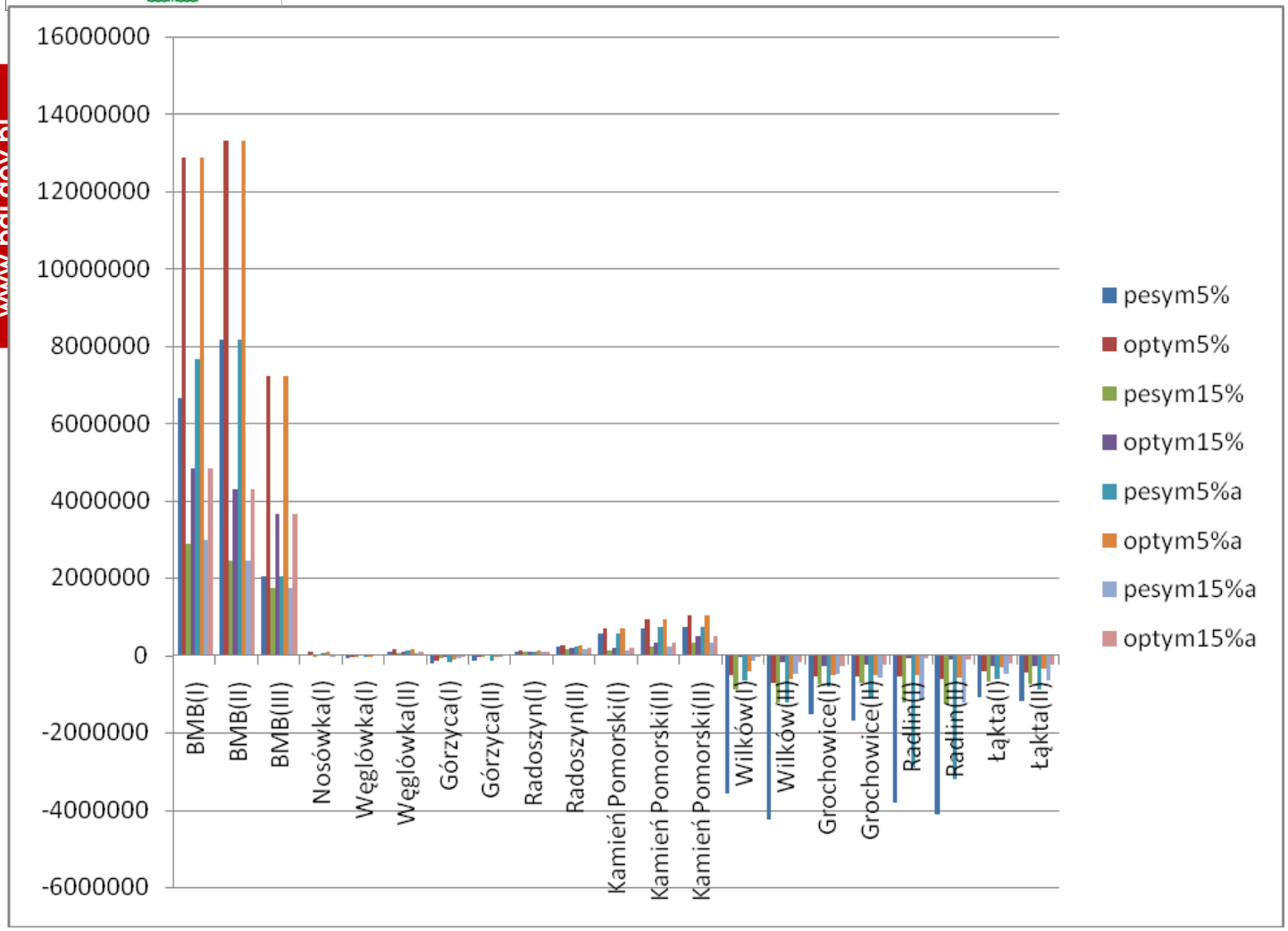
Sfinansowano ze środków Narodowego Funduszu Ochrony Środowiska i Gospodarki Wodnej

Nosówka oil field

- Reservoir – C1 (Visean); Caprock – lower Miocene;
- Total oil in Place 4.5 mln t (only a part of the field has been developed yet);
- GiP 0.585 Bcm;
- Initial recoverable oil resources 0.9 mln t, gas 0.117 Bcm;
- EOR simulations – injection of total 0.55 mln t CO2 would result in additional oil production of 0.42 mln t.

Polish Geological Institute
National Research Institute

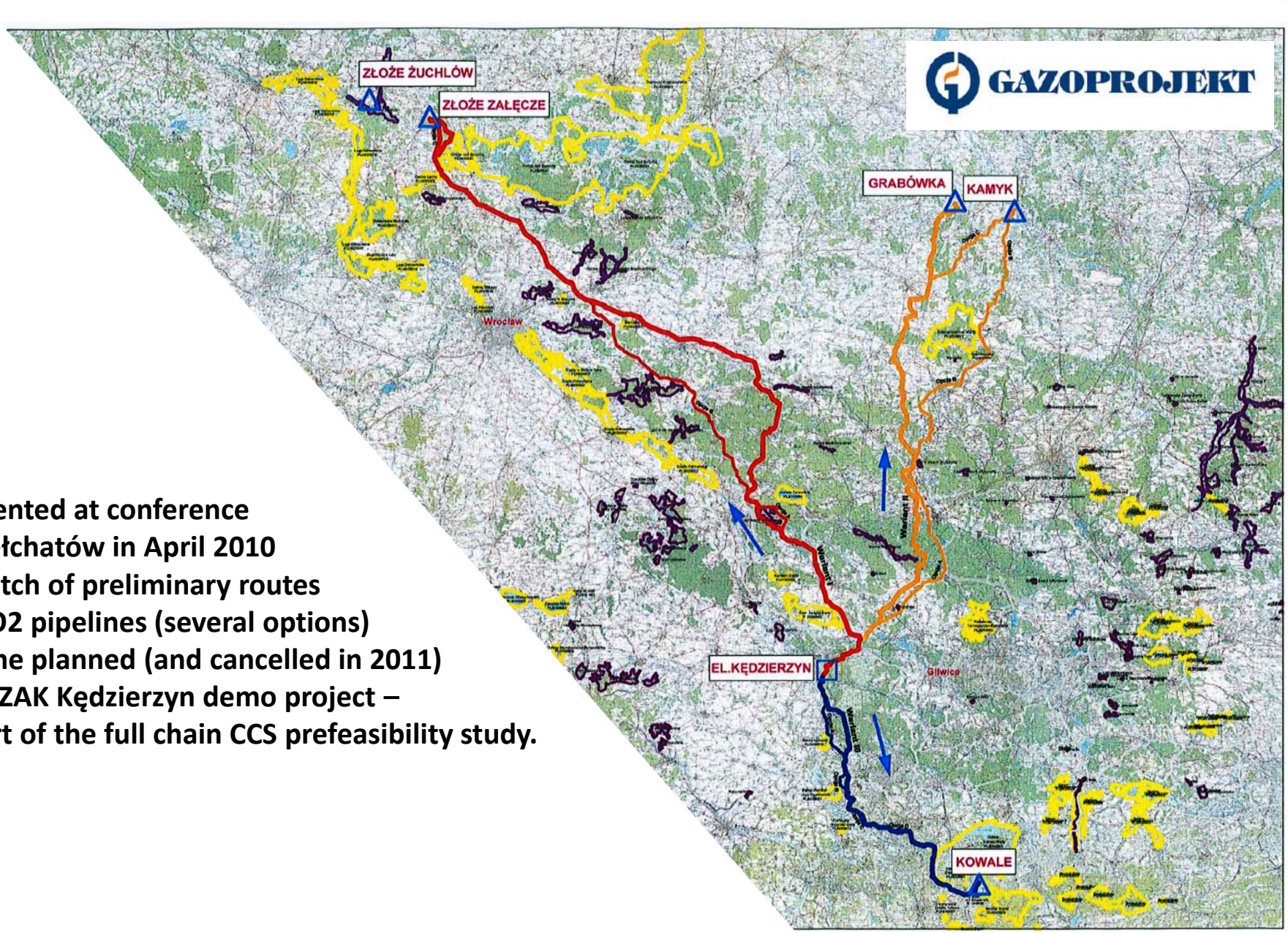
CO2-EOR/EGR prefeasibility studies (another project for Ministry of Environment; 2011-2012)



Preliminary economic evaluations for EOR & EGR cases – NPV in PLN (2012), two bank rates, CO2 obtained for free (optym) or 65 €/t (pesym).

EOR in case of bigger oil fields might be a quite profitable, for smaller – NPV close to zero, EGR is rather not profitable.

CCS ready studies – transport component (an example)



Presented at conference
In Bełchatów in April 2010
a sketch of preliminary routes
of CO2 pipelines (several options)
for the planned (and cancelled in 2011)
PKE/ZAK Kędzierzyn demo project –
a part of the full chain CCS prefeasibility study.

The pilot CO2 capture projects (2010-2015)

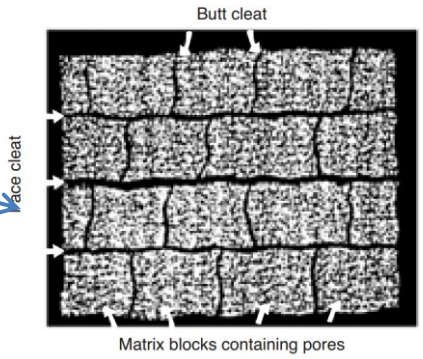
TAURON (formerly PKE, second power operator in Poland, partner of Kędzierzyn project, based in Upper Silesia) developed, in cooperation with research partners (under the programme on clean coal technologies supported by National Centre of Research and Development; 2010-2015), first laboratory/in house capture plants and finally mobile pilot capture plants (see an example above - that one is of capacity up to 500 t/yr).

Study on CO2 injection into gas bearing shales (2014-17)

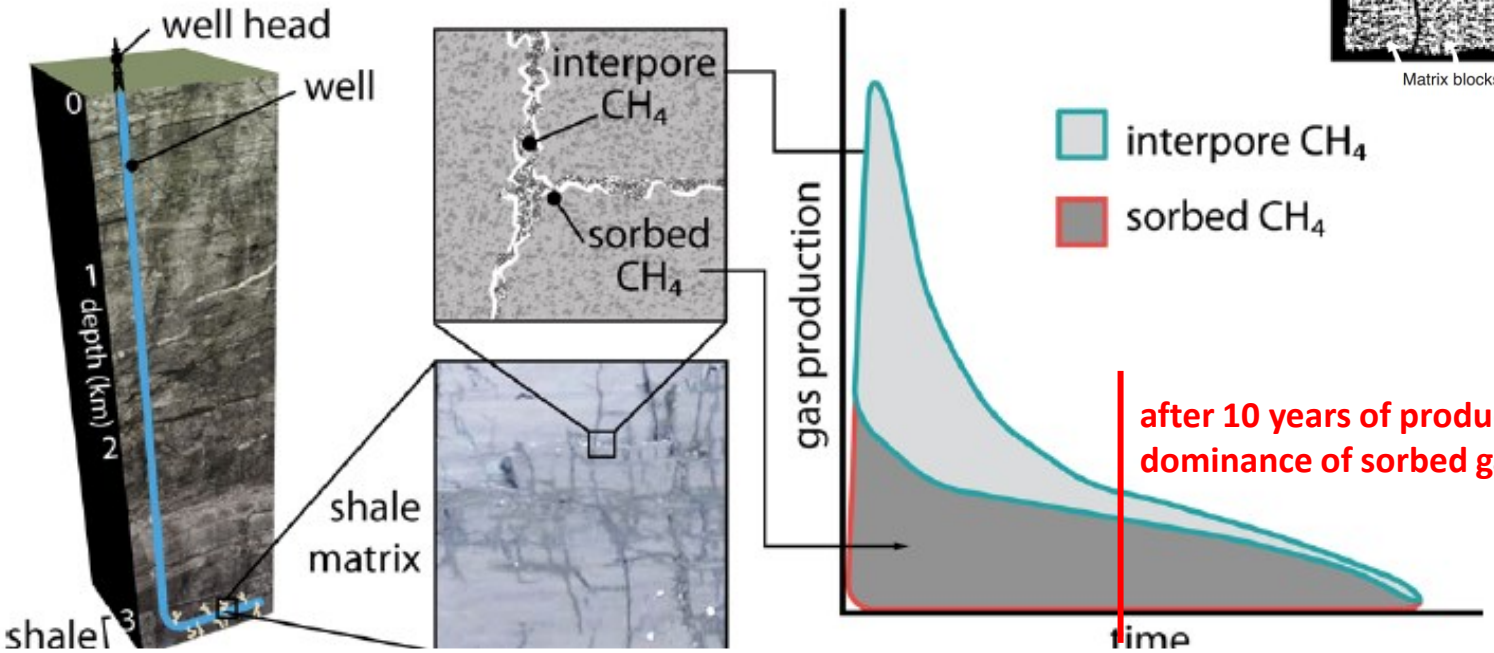
In course of production a change of the ratio: (interpore+fracture gas)/(desorbed gas) can be observed. After 10 years the share of free gas decreases significantly and dominance of desorbed gas can be observed.

Then CO2 injection could be used as a secondary method to gas recovery, similarly to CO2-ECBMR (CO2-CH4 replacement).

Possibly ~0.1 Mt of CO2 can be stored within one shale well (N PL) in order to enhance gas production



Shi et al., 2005



after Godec, 2013

The legal status and prospects on CCS in Poland

- **The amendment of Geological and Mining Law (and some other laws) adopted in November 2013 implemented, together with a number of subsequent accompanying regulations, the provisions of the EU CCS Directive** (Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006) **into Polish legal system.**

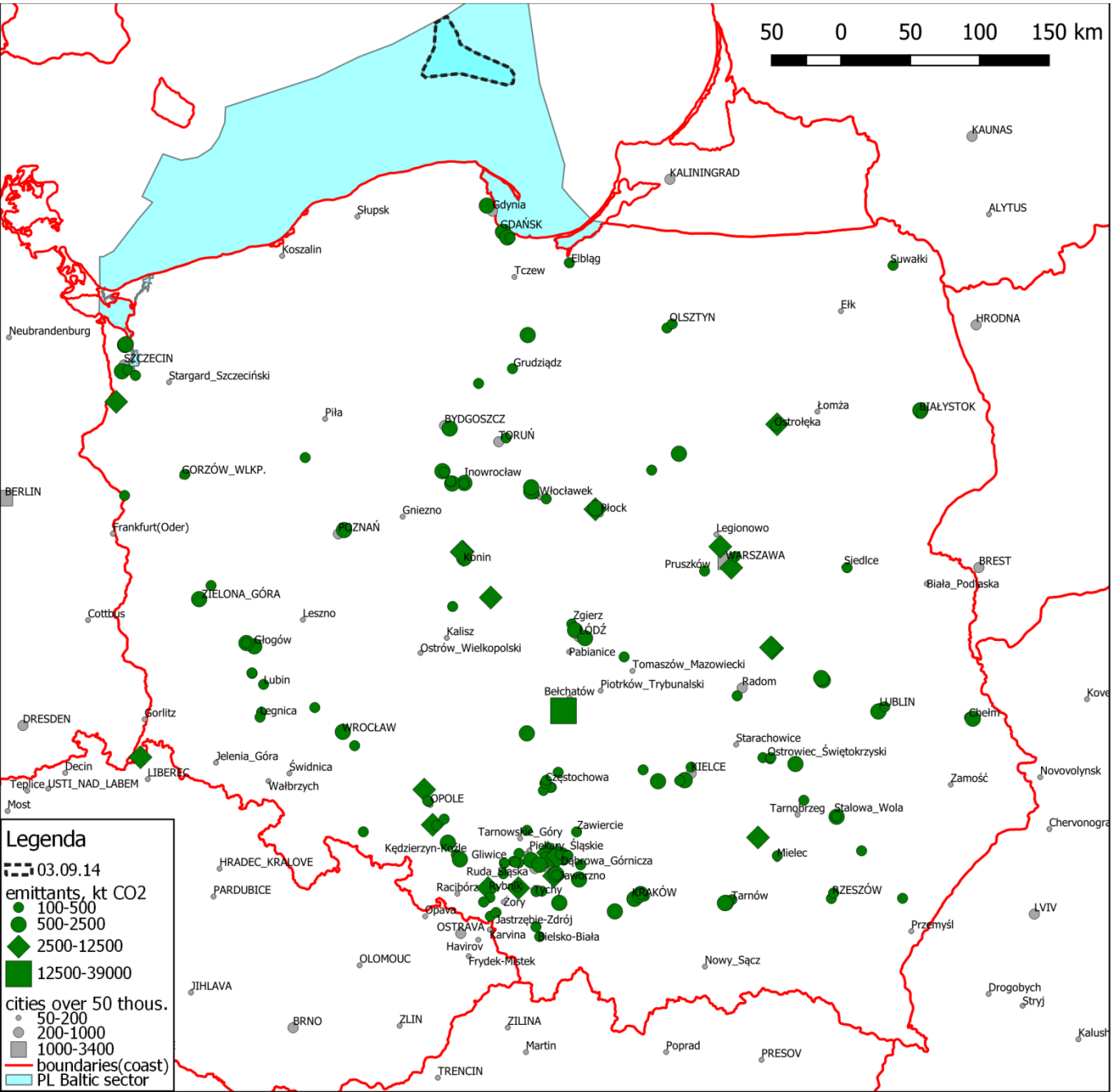
- **At this moment the law allows demo projects only (as in Commission Decision of 3 November 2010 (2010/670/EU)) and a regulation adopted in September 2014 defines an offshore area in NE part of Polish sector of Baltic Sea (Cambrian aquifer enclosing hydrocarbon fields) where exploration (and eventually storage) permits can be granted.**

- **However, the law and regulations are to be amended soon by Ministry of Climate and Environment (the draft law has been published in October 2021 then stakeholder, public and ministerial consultations took place and now the government shall submit the proposed law to the Parliament). The Ministry established in August/September 2021 the advisory group on development of carbon capture, storage and utilisation technologies where managers and experts from industry, research and government entities have been invited to provide solutions.**

Important provisions of the new law and regulations

- no longer only demo CCS projects are allowed, no restrictions on project size;
- the law allows both onshore and offshore storage (accompanying regulations to be amended);
- storage in saline aquifers and depleted/depleting hydrocarbon fields is allowed (including hydrocarbon production coupled with CO2 storage, i.e., EHR);
- exploration permits (concessions) are not required – instead storage operator could apply for permission to explore certain area on the base of geological work plan submitted to the Ministry of Climate of Environment (i.e. the same approach as used in case PGE Bełchatów to explore possible storage sites in 2009-2011) in order to characterize the selected storage site;
- storage permits will be issued upon delivering required documentation (including the scope as required in Annexes I and II to the EU CCS directive, and results of site exploration and characterization), also permits on both storage and hydrocarbon production (EHR) will be issued upon delivering required documentation (in case of still producing HC fields site exploration and characterization will be, of course, not so extensive as in case of saline aquifers or even abandoned HC fields).

The problem



According to the Union Registry in 2020 verified CO2 emissions of all industrial ETS installations in Poland were reported as 172 Mt.

CO2 allowance price is over 70 € now (=12 B€).

There are now 171 large industrial emission sources (over 100 kt CO2), of those 39 new/rebuilt (16 working before 2012 not included- closed) of total emission 160 Mt in 2020.

Over 80% of these emissions belong to energy sector installations, almost 95% are hard coal or lignite fired (other - gas or biomass). In case of industrial processes mainly coal is used as a fuel (in cement, steel or chemical industry), sometimes gas.

Polish Geological Institute
National Research Institute

Indicative costs – examples (KAPSCO2)

Case and storage option (total injected CO_2) / Costs	Capture (&compress.) [€/tCO_2] FOAK	Transport [€/tCO_2]	Storage [€/tCO_2]	Total unit costs [€/tCO_2]
1. Onshore saline aquifer (150 Mt)	52÷60	4÷5	4÷5	60÷70
2. Onshore gas field (75 Mt)	55÷63	5÷7	5÷7	65÷77
3. Onshore oil field (30 Mt)	58÷67	5÷6	9÷10	72÷83
4. Offshore oil field (10 Mt)	61÷70	8÷9	16÷17	85÷96

The presented above indicative costs of the full CC(U)S chain for possible large scale projects in Poland (coal and gas fired energy installations; another project for the Ministry) have been estimated basing on publications by GCCSI (2020, 21), Irlam (2017), EASAC (2013) and ZEP (2011).

Assuming the CO2 allowance price 70 € and profits from additional hydrocarbon production (case 2: 8÷9€/t CO2; case 3: 50÷55€/t; case 4: 50 €/t) the cases 3 and 4, employing CO2-EOR, seem to be highly profitable, the case 2 (onshore gas field) less, and the case 1 (onshore saline aquifer) might be borderline profitable taking into consideration current CO2 allowance price.

It should be noted the (pertaining to CO2 storage) financial security provisions included in the present regulations accompanying Polish CCS law are unrealistically high (an equivalent of 8-9 €/t CO2 injected) but will be amended soon, so more realistic rates, based on working CCS projects worldwide, are included in the tabele above. On the other hand, build up of clusters and hubs would decrease costs of storage and transport infrastructure.

Conclusions

- **CC(U)S development in Poland peaked a decade ago and stalled almost completely about 2015, similarly as in many other European countries, but has been revived in 2021/22.**

- **There were several research projects, some centered around the only demo project in the region, Bełchatów, active till 2013 (where one storage site was selected out of three after field works), as well as several full chain prefeasibility studies including various storage options (similar studies restarted last year).**
- **No field experiments of CO2 injection succeeded yet, except a small scale research project in coal beds and acid gas (re)injection into depleted gas field (one can also mention injection of brine with dissolved CO2 to ensure stable geothermal operations).**
- **Small scale laboratory and pilot capture units have been developed.**
- **Unfortunately, the law on CCS adopted in 2013 has been rather discouraging implementation of this technology, but new law (2021/22) is very promising and Polish government is encouraging industry to implement CC(U)S technologies.**

- **Recent massive growth of CO2 allowance prices as well as EU energy & climate policies are very efficient incentives compelling Polish industry and government to think about CC(U)S implementation. Particularly power as well as other industries in Poland are based on coal and gas (especially newest installations) combustion, so CC(U)S might be a solution to make future transition towards carbon neutral economy.**