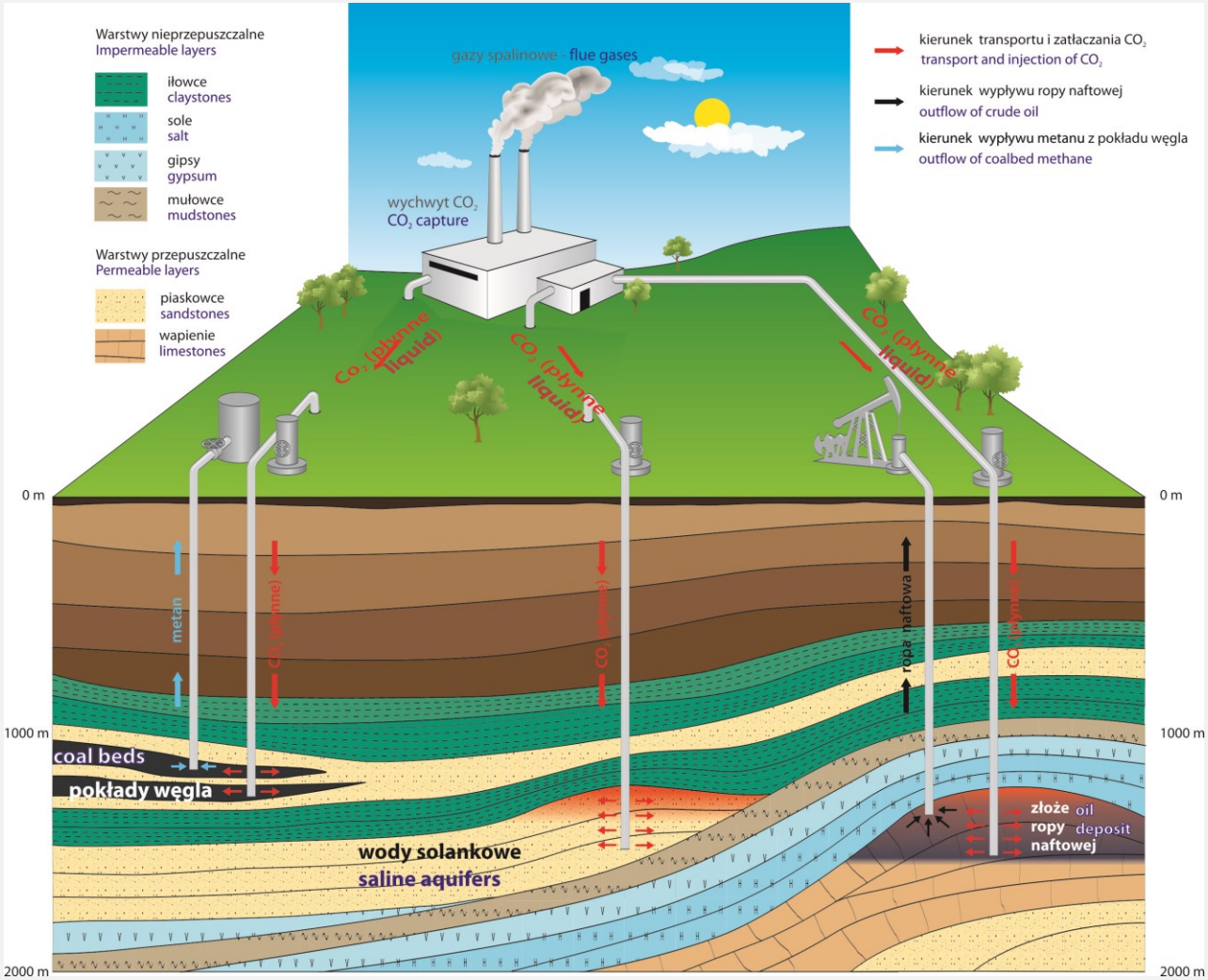
Is CO2 storage at a larger scale than a demo project illegal in Poland?
Did NGOs lobby for this legislation in a bid to divert funds to their preferred projects?
CO2 EOR potential in Poland - what is the storage potential? 50-100Mt?
Coal bed methane fields where up to 20 Mt of CO2 might be stored

Adam Wójcicki, PGI-NRI

…….. POGC Warsaw, 18.11.2014

CO2 storage options in Poland

- Saline aquifers (a high potential – mostly onshore)
- Depleted hydrocarbon fields (a low potential – mostly onshore)
- Unmineable coal beds/CBM fields (a very low potential - onshore)



Is CO2 storage at a larger scale than a demo project illegal in Poland?

(after *The Geological Mining Law Act, October 2013; Jendrośka UCL report, 2014*)

The transposition of the CCS Directive consisted in the amendment of existing legal acts (the GMLA and some other). The GMLA/CCS Act is supplemented with the executive regulations pertaining to technical issues, like these in Annexes I and II to the Directive. CO2 storage is allowed only in case of the demonstration projects (this rules out not only commercial projects but also, according to the government interpretation, test injection up to 100 kt not in the frames of a demonstration project), till 2024/26. An executive regulation allows presently offshore storage only.

Important provisions of the GMLA/CCS act

- CO2 storage is allowed only in case of the demonstration projects, till the end of 2024(2026);
- Transposition of the Directive provisions on exploration (or prospecting for) of the storage complexes is similar to the existing regulations of the GMLA (e.g., prospecting and exploration of hydrocarbons);
- So, in order to obtain the exploration (or prospecting for) permit a geological workplan is necessary and as a result of these works the geological (hydrogeological, geological-engineering) reports are produced. In order to obtain the storage permit the site development plan (including the monitoring, corrective measures and temporary post-closure plans) approved by the State Mining Authority (an agenda of the Ministry of Environment) is necessary. Exploration activities are charged about 25 €/km2 and CO2 storage – about 1.2 €/t of CO2 injected;
- The exploration (prospecting for) or storage permits can be granted upon EIA decision (according to the EIA 2008 Act – after public consultations, in. NGOs) issued by the commune (local authority*) and respectively, an opinion (in case of the exploration/prospecting for) of the local authority or an approval of the local authority, Minister of Economy and an opinion of the EC (in case of the storage permit). Additionally, in both cases an opinion of the Regional Director for Environmental Protection is required (on the protected areas' impact).

*maritime authority or n/a offshore

Important provisions of the GMLA/CCS act

- In the EIA 2008 Act, the CCS full chain installations were added (demos);
- The National Administrator of Underground CO2 Storage Sites (KAPS-CO2) is created to assume the tasks related to post-closure activities and fulfil obligations stemming from the transfer of responsibility (after a routine site closure) or takeover or responsibility (after a withdrawal of the permit; all assets of the storage site are taken over by the State);
- The State Mining Authority is responsible for overseeing a proper conduct of the storage site operations, in relation to the operator's duties concerning monitoring and reporting;
- The financial security (various financial instruments allowed) is to ensure that all the obligations imposed in the storage permit will be fulfilled, including the closure and post-closure expenditures (~20 years). The security means (various financial instruments) are to provide funding for the KAPS-CO2 duties after the transfer of responsibility (e.g. the site monitoring for 30+ years);
- CCS readiness – to be included in the EIA report (new power blocks>300 MW);
- In the Energy Law 1997 a special chapter was added to address the issue of the transport of CO2 – about the transport networks and operator's duties.
- The development and maintenace of the CO2 transport network as well as exploration/prospecting for storage sites and CO2 storage are the activities that might serve the 'public goals' (the Management of Real Estate Act 1997);

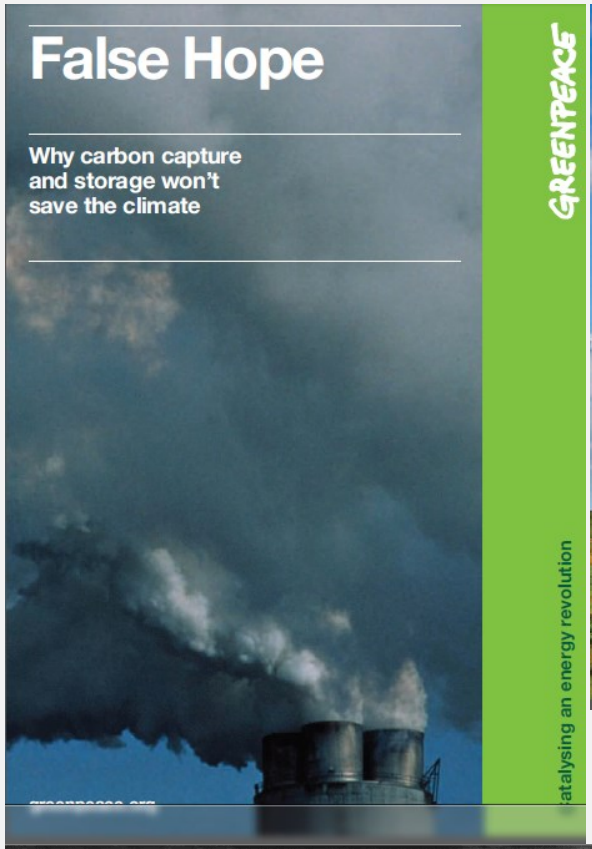
The status of CCS in Europe (EC report on the implementation of Directive 2009/31/EC, 2014; Shogenova et al., 2013, CGS Europe D2.10, 2012);

-allowed in France, Lithuania, Norway, Portugal, Romania, Slovakia, Spain, the Netherlands, U.K., Hungary, Belgium (excl. Brussels), Italy (excl. seismic areas), Greece (storage complexes not extending outside GR territory), Poland (demos);

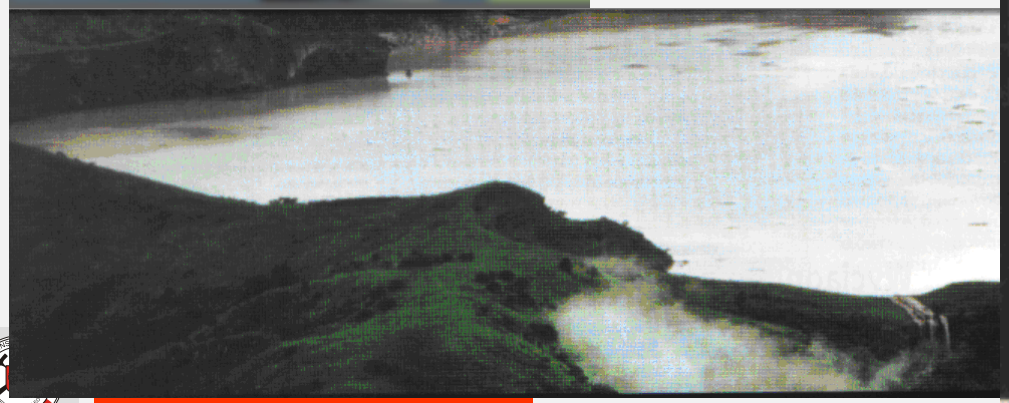
-restricted temporarily in Austria, Czech Republic, Denmark (offshore EOR allowed now), Latvia, Sweden or by other means in Germany and Bulgaria;

-not allowed in Brussels region, Estonia, Finland, Luxembourg, (no storage potential), Ireland, Slovenia.

Did NGOs lobby for this legislation in a bid to divert funds to their preferred projects?



Actually the said NGOs cite directly or indirectly the GREENPEACE brochure (2008), including the case of limnic eruption at the Nyos volcano in 1986 as their main weapon against CCS.

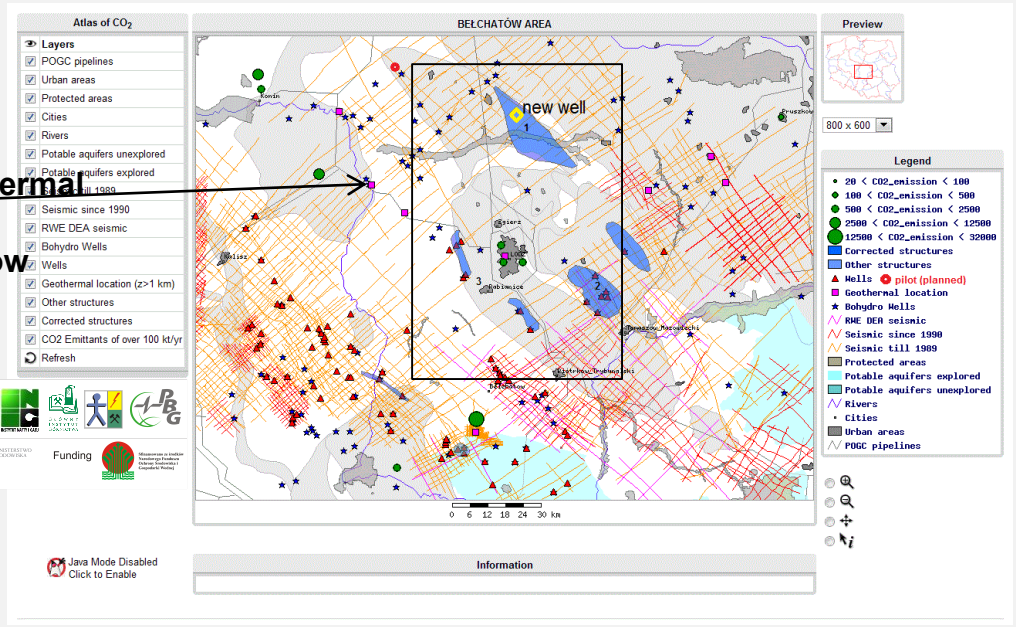


The NGOs' opposing views towards CCS

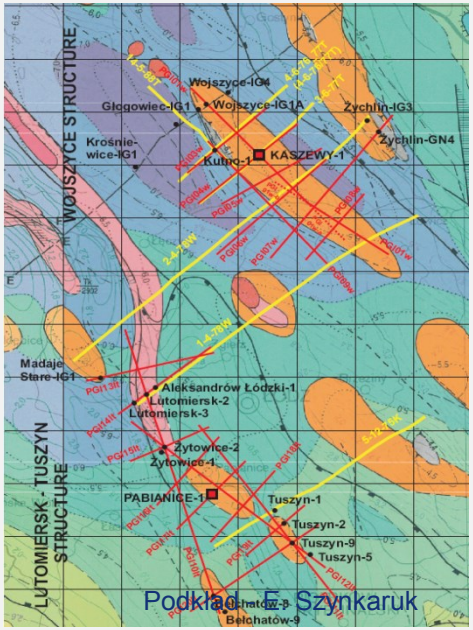
-GREENPEACE says in the brochure (2008; keeps the stance) „*The promise of CCS diverts attention away from sustainable energy solutions and risks locking the world into an energy future that fails to save the climate. Priority should be given to investments in renewable energy and energy efficiency which have the greatest potential to provide energy security and reduce emissions*" and it should be noted the brochure was published when the question arised whether, or to what extent, the EEPR was to support CCS and/or renewables.

-Two Polish NGOs most active in case of CCS and critical against the Bełchatów demo project (CZR – www.czr.org.pl; ESOS – www.esos.org.pl) argued there will be another Nyos lake/volcano eruption when a storage site is established or even a well drilled (Polska Dziennik Łódzki 9.03.2012; an even more interesting press release in Polska Dziennik Łódzki 25.02.2010 said there was a CCS project at the Nyos volcano(?!)). These NGOs, and their counselors, had got ideas of some projects to be funded instead of Bełchatów demo and have kept them persistently.

The demo project and CZR goals and proposals



Geothermal plant Uniejów



The Bełchatów demo project had considered three storage sites/areas (top-left) and eventually the NE site was selected after the appraisal phase (2D seismic & gravity surveys, appraisal wells – top-right).

CZR was active in W/SW area (Lutomiersk-Pabianice), close to existing low enthalpy geothermal plant in Uniejów, where also a number of other such plants has been planned. They had also an idea of a geothermal plant within salt dome NNW of Łódź, in the same general area.

They proposed as an alternative to the demo project and PGE power plant (5.5 GWe now): UCG (lignite), geothermics (petrothermal or geoplutonic), hydrogeothermal plants, etc.

CZR goals, proposals and resources

CZR was assisted by counselors (who also seemed to be ringleaders of protests against the CCS demo project): prof. R. H. Kozłowski (Technical University of Cracow) and prof. J. Zimny (AGH University of Science and Technology in Cracow). According to the principal databases of peer-reviewed publications (Scopus, Web of Science) their expertise lies in materials engineering, mechanical engineering and renewables. They are not geoscientists, but enthusiasts of geothermal (political geothermal?).

CZR and their counselors proposed alternatives to the Bełchatów demo project and entire power plant – geothermal and geothermic plants (www.czr.org.pl). Though it is a quite possible to duplicate a low enthalpy geothermal plant like Uniejów in the general Bełchatów area (actually there is such a plant being developed in Kleszczów) provided sufficient funding is gathered it should be noted the new block is 858 MWe, the entire plant is 5.5 GW and Uniejów (direct heat use, balneology) is 3.2 MWt!!! Considering deeper (3-5 km), hydrogeothermal resources or dry rock one could produce both heat and electricity (CHP) but still the plant (dublet) output is tiny.

Another idea is so called geoplutonic by B. Żakiewicz (US patent, 2004) where Earth's heat at depth minimum 10-12 km is to be utilized (temperature minimum 350-400 C, power minimum 100 MWe) but the technology seems to be in infancy and no papers of the said author are listed in the principal databases of peer-revieved publications (some other information is available).

Prospects for geothermal (and geothermics in Poland)

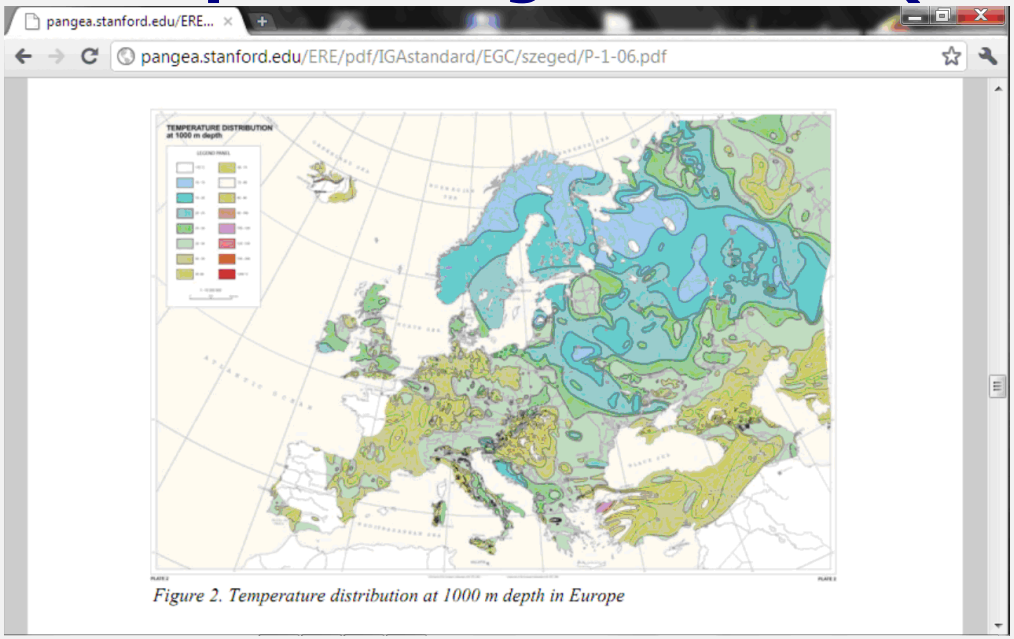


Figure 2. Temperature distribution at 1000 m depth in Europe

Because sedimentary formations within CHP depth range (3-5 km) are usually of high salinity and low reservoir properties hot dry rock/enhanced geothermal systems are considered instead. Research on geothermics' potential, including case studies has been completed recently – such installations might produce 1-3 MWe/dublet and/or an order of magnitude higher thermal power (Wójcicki A., Sowiżdżał A., Bujakowski W. (eds), 2013).

According to CZR counselors geothermal resources of Poland are enormous. However, according to the atlas of geothermal resources in Europe (2002 – see on the left) the geothermal gradient in Poland is rather average. It is true hydrogeothermal resources (water/brine in sedimentary rocks at certain depths) are abundant but their theoretical potential – Heat in Place (HiP) till depth of 3 km is one quarter of such potential in Hungary (Górecki, 2006). But HiP has nothing to do with reserves – because of the fact practically all existing low enthalpy geothermal projects in Poland required a substantial part of CAPEX to be covered by grants, the reserves are assumed to be zero now.

ESOS goals, proposals and resources

ESOS (Cracow) has been also a staunch opponent of CCS. They asked (also on behalf of AGH-UST) EU Commissioner for Research J. Potocnik in 2007 for support for their programme on CO2 utilization (synthetic fuel production), pretending to be a leader of a huge international consortium, and also sued, together with some other entities, EU Commisioners to the Court of Justice of the European Union for „disregarding threats to lives of EU population and environment (concerning CCS)". In both writings AGH University of Science and Technology in Cracow was supposed to be involved, however AGH-UST officially dissociated from any such initiatives.

Their key expert is prof.(?) T. Petrys, who however is not present in databases of Polish Ministry of Science and Higher Education (http://www.nauka-polska.pl/) where all scientists of PhD degree and above are supposed to be listed. There is also no trace of such a person in the principal databases of peer-reviewed publications (Scopus, Web of Science).

They asked for support and presented apocalyptic scenarios on CCS wherever possible (since 2008 those poor cows perished at Nyos volcano were displayed in every writing of theirs) all over Poland, EU and the world. They were especially active during the appraisal phase of Bełchatów demo project. The initiative on synthetic fuel production (CO2 SYNTHEFU), obviously out of place in case of such a small NGO, was not the only one.

ESOS writings – example 1

Europejskie Stowarzyszenie Ochrony Środowiska

European Erwironment Society

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mobile. 0517875905

www.esos.org.pl
biuro@esos.org.pl

Chairman:
Jerzy Walosik PH.D.
Mobile: O 517 875 905
fax: 012 256 03 29
biuro@esos.org.pl

Chairman of Scientific Council:
prof. T Petrys
mobile. 0606946317
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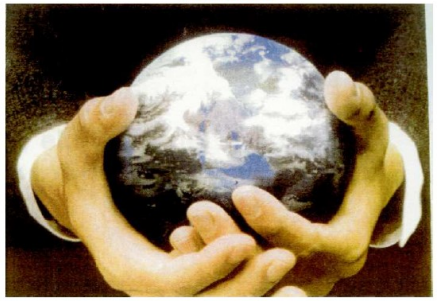
LET'S TAKE SAFETY OF OUR LIFES INTO OUR HANDS



Kraków, 9 stycznia 2009.

1. Starostwo Powiatowe w Trzebnicy
   Powiatowy Zesp. *Zarządzania* Kryzysowego Przew.
   Starosta Pan Robert Adach Ul Ks. Bochenka 6
   05-100 Trzebnica
2. Urząd Miejski Żmigród
   Gminny Zesp. Zarządzania Kryzysowego Przew.
   Burmistrz, Pan Robert Lewandowski Pl. Wojska Polskiego 2/3 55-140 Żmigród
3. Ministerstwo Środowiska
   Gabinet Ministra, Pan Minister Maciej Nowicki Ul. Wawelska 52/54 02-067 Warszawa
4. Sejm RP
   Komisja Ochr Śr i Zaś. Nat. i Leś. Przew.
   Pan poseł M. Kuchciński Ul. Wiejska 4/6/8
   00-902 Warszawa
5. Prokuratura Okręgowa we Wrocławiu
   Szef Prokuratury Pani prok. K. Boć-Orzechowska Ul. Podwale 30 50-950 Wrocław

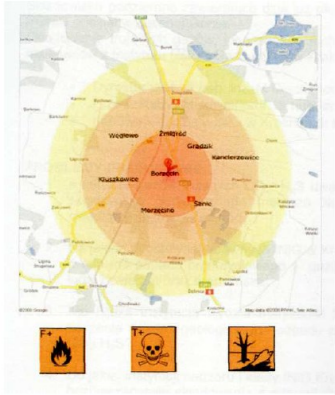
Dotyczy.
Grozi nam w Polsce „mały Czarnobyl" ?

Widmo pierwszej w Polsce katastrofy ze składowania bezzbiornikowo odpadu węgla i siarkowodoru (CO_2, przemysłowego trujących gazów dwutlenku złożach geologicznych.
Zagrożenie katastrofą uduszenia ludności gminy Żmigród trującymi gazami CO_2, H_2S uwalniającymi się z bezzbiornikowego podziemnego składowiska w Borzęcinie
(gmina Żmigród, powiat Trzebnicki, woj. Dolnośląskie) utworzonego przez naukowców z Instytutu Nafty i Gazu w Krakowie, ul. Lubicz 25 A.

Czy katastrofa ta jest nieunikniona?

Widmo katastrofy ekologicznej w Borzęcinie

(Gmina Żmigród, Województwo Dolnośląskie)



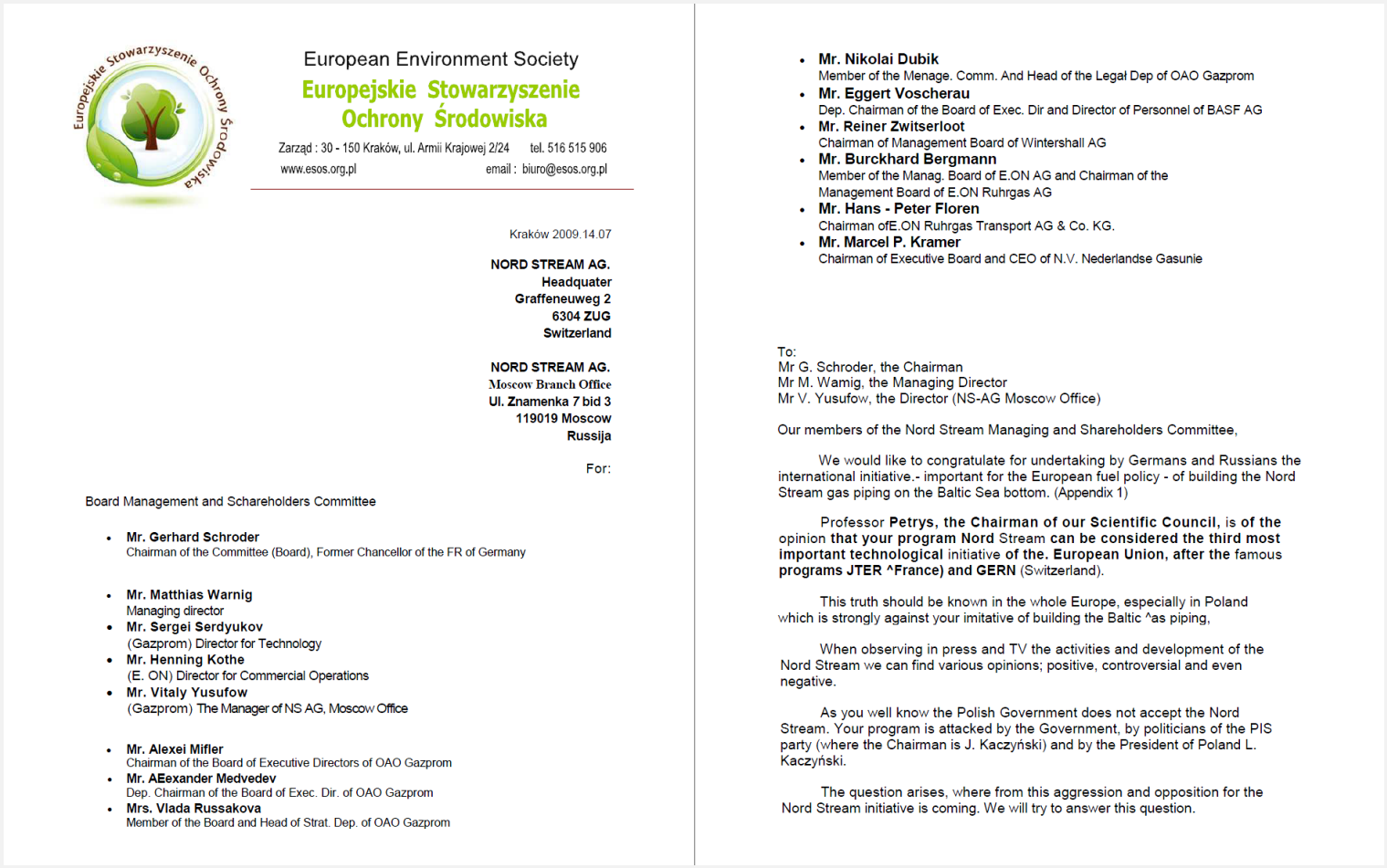
Szacunkowa ocena skutków katastrofy:

ok. 20 000 mieszkańców rej. Borzęcin uduszonych gazami.
ok. 60 000 zwierząt domowych zabitych gazami.
Całkowita degradacja upraw rolnych trującymi gazami

Podejrzenie naruszenia prawa przez INiG w Krakowie przez bezprawne tłoczenie oraz bezzbiornikowe składowanie kwaśnych trujących gazów **CO2 HbS** do podziemia nad strefą zamieszkała gminy Żmigród

Apocalyptic scenarios regarding Borzęcin gas field where acidic gas (60% CO2) was reinjected in 1995-2010: 20 000 people dead, 60 000 animals perish, total degradation of agriculture. Regional prosecutor as well as the Parliament, central and regional government were notified (www.esos.org.pl).

ESOS writings – example 2



European Environment Society
Europejskie Stowarzyszenie Ochrony Środowiska

Zarząd : 30 - 150 Kraków, ul. Armii Krajowej 2/24 tel. 516 515 906
www.esos.org.pl email : biuro@esos.org.pl

Kraków 2009.14.07

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NORD STREAM AG.
Moscow Branch Office
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119019 Moscow
Russija

For:

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- **Mr. Gerhard Schroder**
  Chairman of the Committee (Board), Former Chancellor of the FR of Germany

- **Mr. Matthias Warnig**
  Managing director
- **Mr. Sergei Serdyukov**
  (Gazprom) Director for Technology
- **Mr. Henning Kothe**
  (E. ON) Director for Commercial Operations
- **Mr. Vitaly Yusufow**
  (Gazprom) The Manager of NS AG, Moscow Office

- **Mr. Alexei Mifler**
  Chairman of the Board of Executive Directors of OAO Gazprom
- **Mr. AEexander Medvedev**
  Dep. Chairman of the Board of Exec. Dir. of OAO Gazprom
- **Mrs. Vlada Russakova**
  Member of the Board and Head of Strat. Dep. of OAO Gazprom

- **Mr. Nikolai Dubik**
  Member of the Menage. Comm. And Head of the Legal Dep of OAO Gazprom
- **Mr. Eggert Voscherau**
  Dep. Chairman of the Board of Exec. Dir and Director of Personnel of BASF AG
- **Mr. Reiner Zwitserloot**
  Chairman of Management Board of Wintershall AG
- **Mr. Burckhard Bergmann**
  Member of the Manag. Board of E.ON AG and Chairman of the Management Board of E.ON Ruhrgas AG
- **Mr. Hans - Peter Floren**
  Chairman ofE.ON Ruhrgas Transport AG & Co. KG.
- **Mr. Marcel P. Kramer**
  Chairman of Executive Board and CEO of N.V. Nederlandse Gasunie

To:
Mr G. Schroder, the Chairman
Mr M. Wamig, the Managing Director
Mr V. Yusufow, the Director (NS-AG Moscow Office)

Our members of the Nord Stream Managing and Shareholders Committee,

We would like to congratulate for undertaking by Germans and Russians the international initiative.- important for the European fuel policy - of building the Nord Stream gas piping on the Baltic Sea bottom. (Appendix 1)

Professor **Petrys, the Chairman of our Scientific Council,** is **of the** opinion **that your program Nord** Stream **can be considered the third most important technological** initiative **of the. European Union, after the** famous **programs JTER ^France) and GERN** (Switzerland).

This truth should be known in the whole Europe, especially in Poland which is strongly against your imitative of building the Baltic ^as piping,

When observing in press and TV the activities and development of the Nord Stream we can find various opinions; positive, controversial and even negative.

As you well know the Polish Government does not accept the Nord Stream. Your program is attacked by the Government, by politicians of the PIS party (where the Chairman is J. Kaczyński) and by the President of Poland L. Kaczyński.

The question arises, where from this aggression and opposition for the Nord Stream initiative is coming. We will try to answer this question.

Some other initiative – mostly unrelated to CCS (though it is mentioned somewhere in the background). They asked GAZPROM and NordStream consortium for a support to undertake a campaign on convincing the Polish government to join NordStream and funding associated projects (www.esos.org.pl).

CO2 EOR potential in Poland – what is the storage potential? 50-100Mt?

CO2 storage potential of Poland (Wójcicki (ed.) 2013 – http://skladowanie.pgi.gov.pl)*

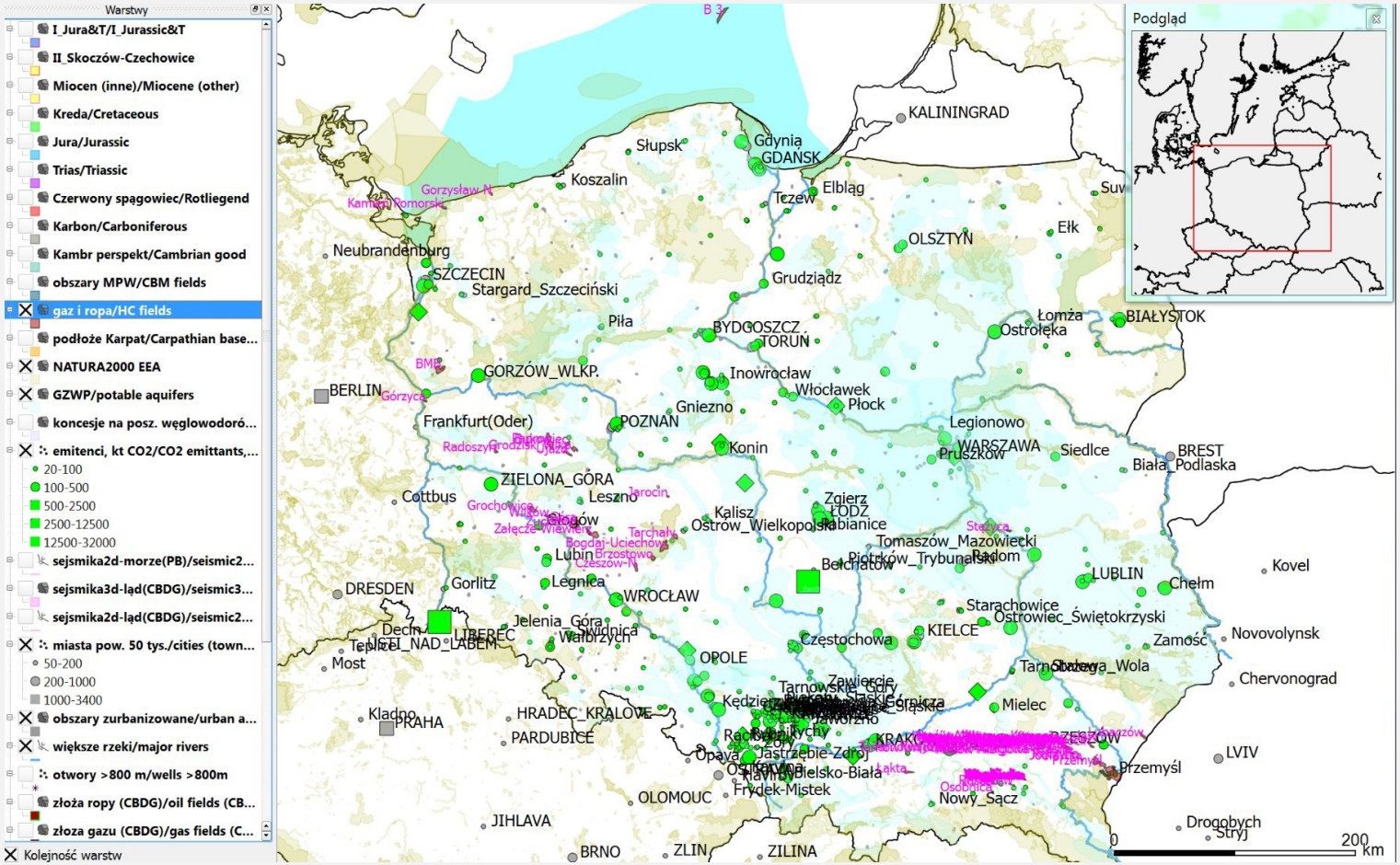
-Saline aquifer structures and regional aquifers 92-93% (~5% offshore)

-Hydrocarbon fields (7-8% or 0.8-1 Gt)

-Coal beds (CBM) <<1%

****Assessment of formations and structures for safe CO2 storage including monitoring plans (2008-2012/13; Ministry of Environment; 6 domestic partners, 200 persons involved in total; goals – supporting demo projects, future decisions of the competent authority on exploration permits, entities applying for permission to build new "CCS ready" power blocks)***

Hydrocarbon fields in question



10 oil (and gas) fields and 28 gas fields (including some multipart) were considered – exploited, of UR (Ultimate Recovery – standard technology) reserves at least of 0.1 Mt or 0.4 Bcm respectively.

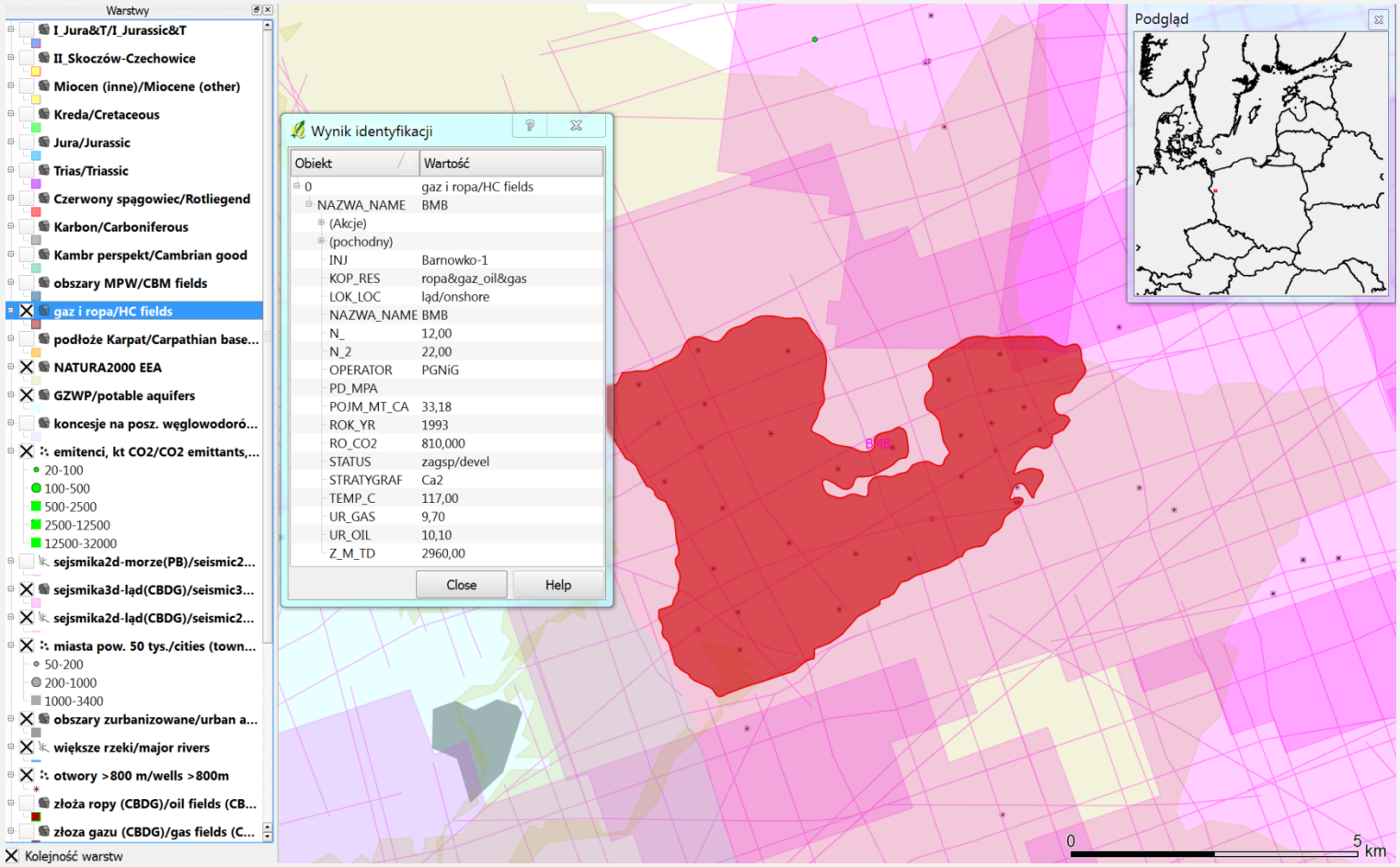
Ordered by (Min. of Environment) Funding

Oil fields in question

Gas fields make the most of storage potential for hydrocarbon fields in Poland (>90%), calculated with the use of volumetric method (Schuppers, 2003) taking into consideration the replacement of UR hydrocarbon reserves with CO2 (the static capacity, excl. EOR). Only one (onshore) might be interesting for a demo project, so do three gas fields. 10 oil fields have been ranked as follows (Wójcicki (ed.) 2013):

- BMB (the static storage capacity – 33.2 Mt) (NW Poland),
- B3 (7 Mt) (Baltic),
- Kamień Pomorski (3.9) (NW Poland),
- Nosówka (1.4) (the Carpathian overthrust front / the Carpathian foredeep),
- Radoszyn (1.1) (NW Poland),
- Górzyca (2.5) (NW Poland),
- Węglówka (1.9) (the Carpathians),
- Lubaczów (6.1) (the Carpathian overthrust front / the Carpathian foredeep; initially developed – mainly natural gas),
- Jaszczew (10.4) (the Carpathians),
- Osobnica (0.7) (the Carpathians).

Oil fields - example



BMB (the static storage capacity – 33.2 Mt) NW Poland), the biggest oil field in Poland.

EOR studies

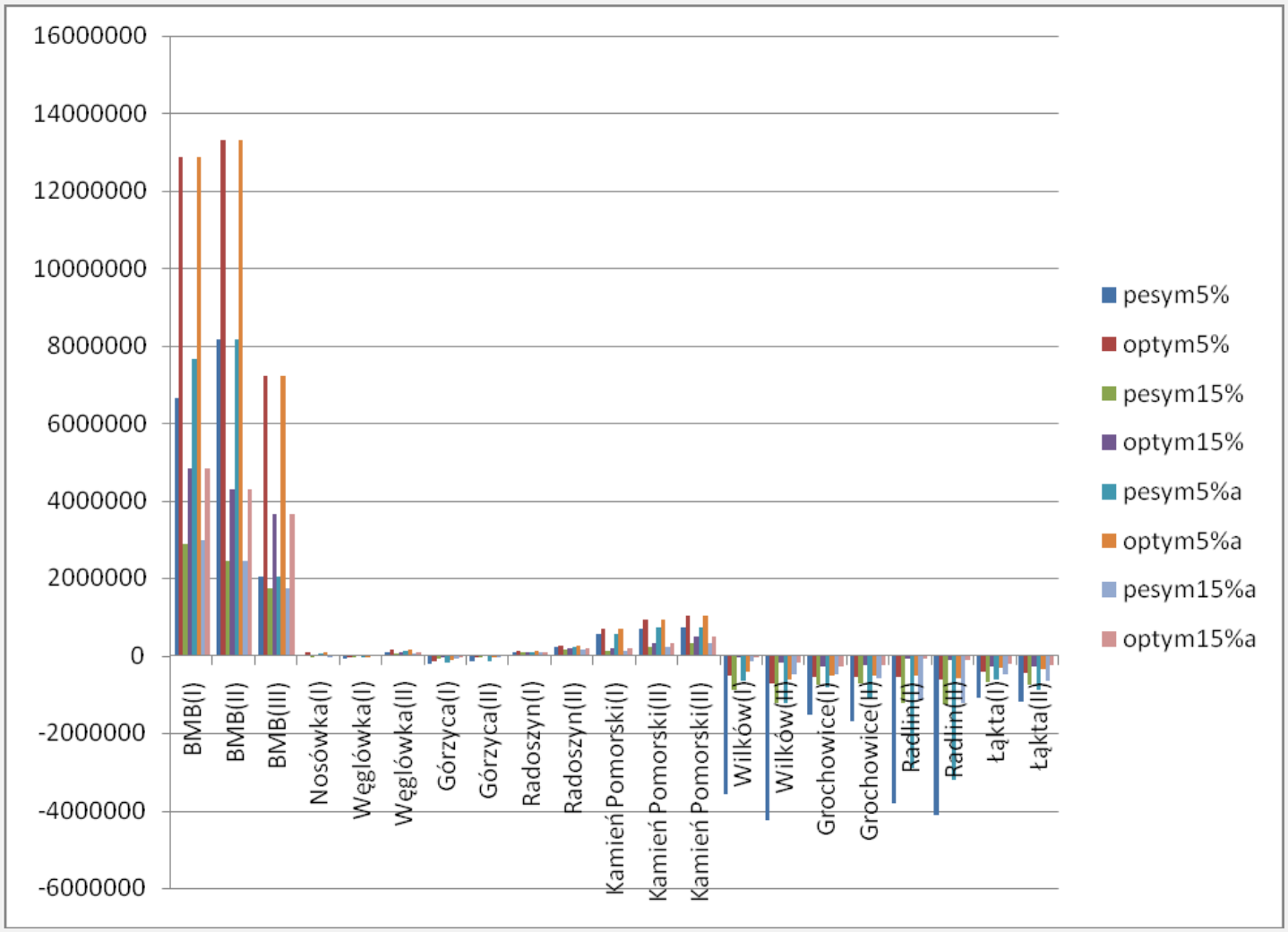
Except from case studies in the project ”Assessment of formations and structures…” (1 small oil field, two gas fields) EOR/EGR studies and evaluations have been conducted in another project (Lubaś (ed.), 2012)* for the following oil fields:

Oil field	BMB	Nosówka	Węglówka	Górzyca	Radoszyn	Kamień Pomorski
CO2 inj.[Mt]^	38-58	0.6	0.5-0.7	0.7-1.4	0.18-0.32	1.9-2.2
Oil prod.[Mmcm]	16-21	0.26	0.15-0.39	0.06-0.18	0.14-0.28	1.3-1.7

******Programme of oil and gas production from domestic hydrocarbon fields with the use of underground CO2 injection (2011-2012; Ministry of Environment; INiG (Oil and Gas Institute) & PGI-NRI; hydrocarbon databases; EOR&EGR criteria; site ranking & selection; reservoir simulations for 10 hydrocarbon fields; preliminary economic evaluations).*

^some part reinjected

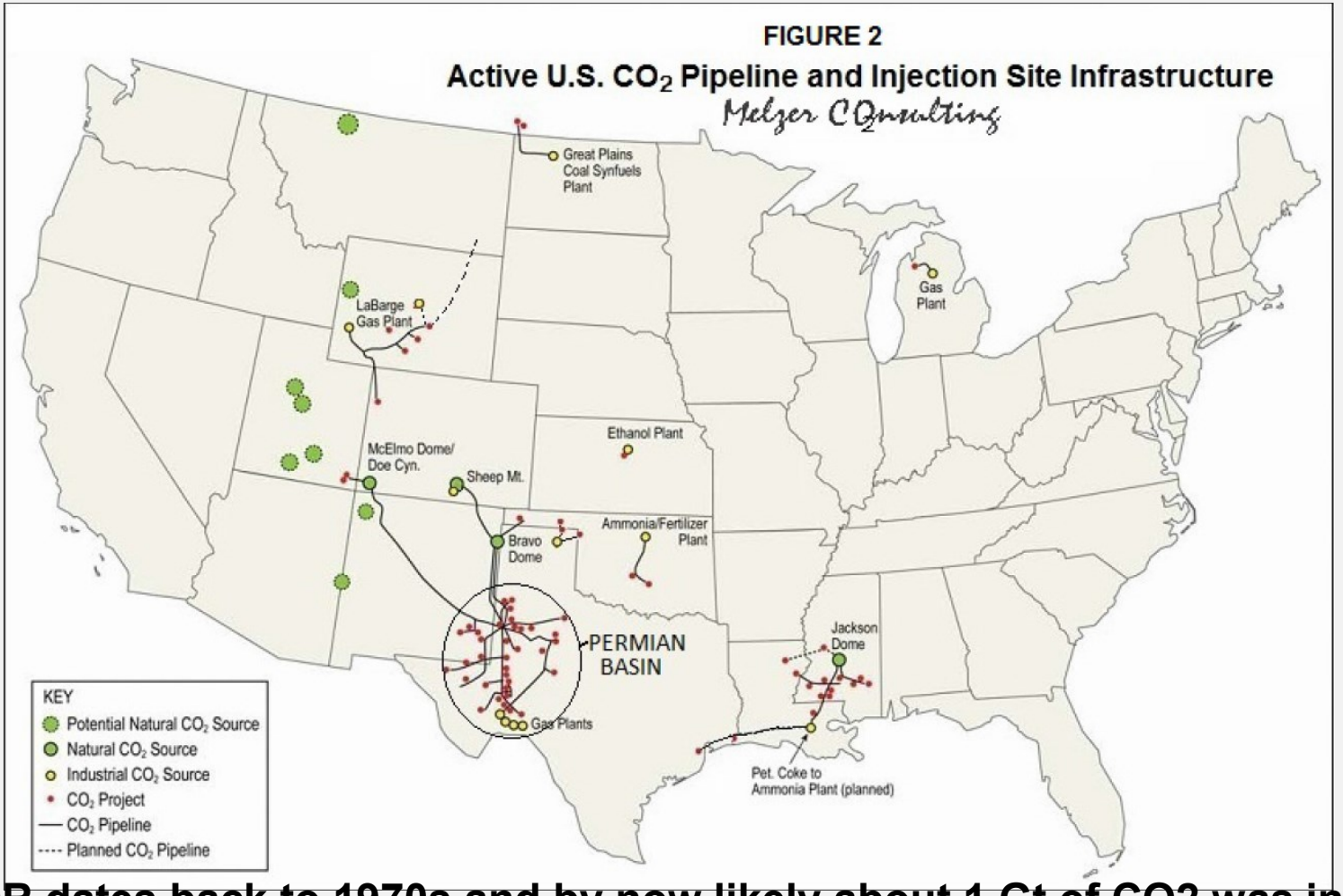
EOR(&EGR) studies



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

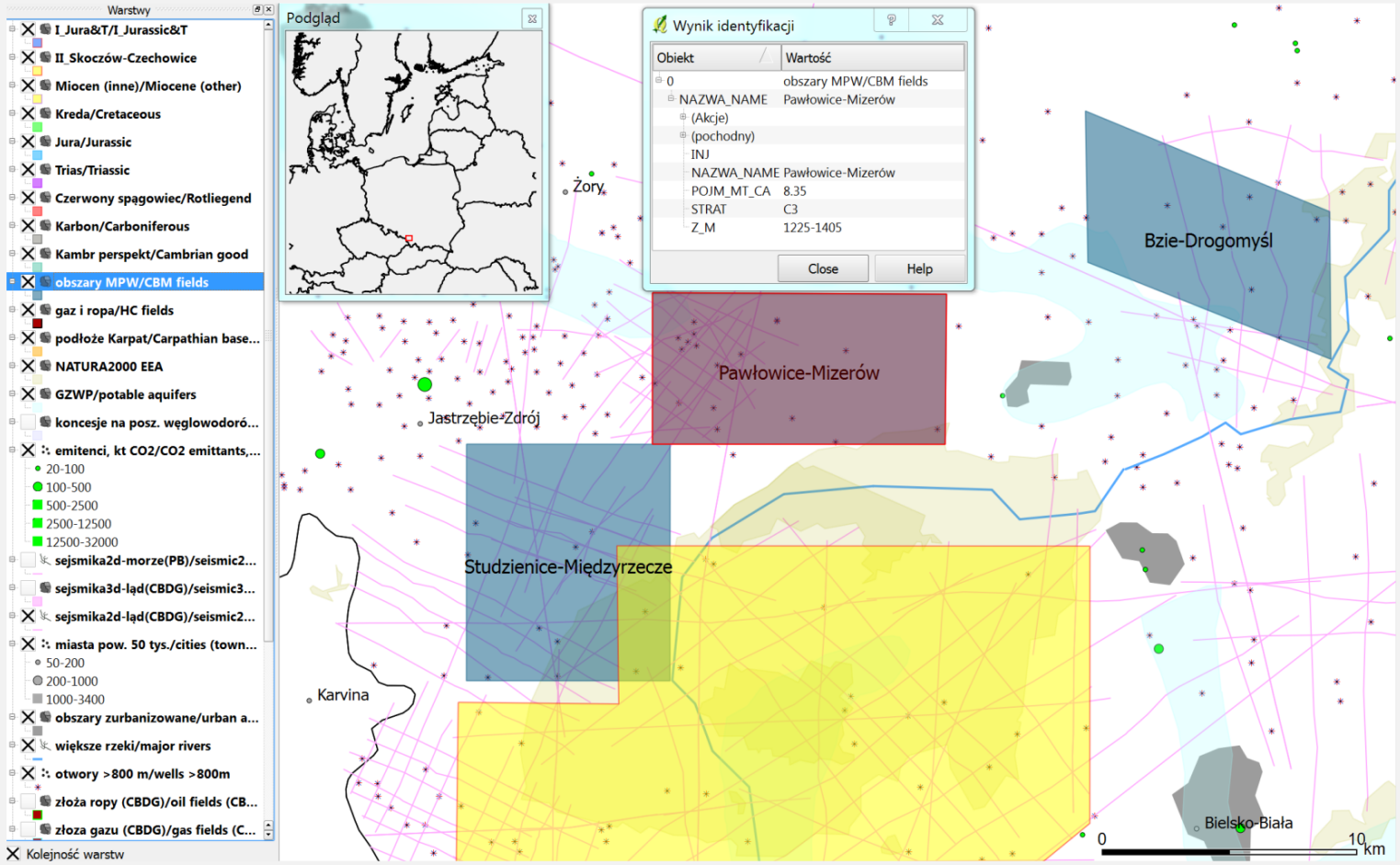
EOR in case of bigger oil fields can be profitable, for smaller – NPV close to zero, EGR is not profitable.

CC(U)S vs CO2-EOR



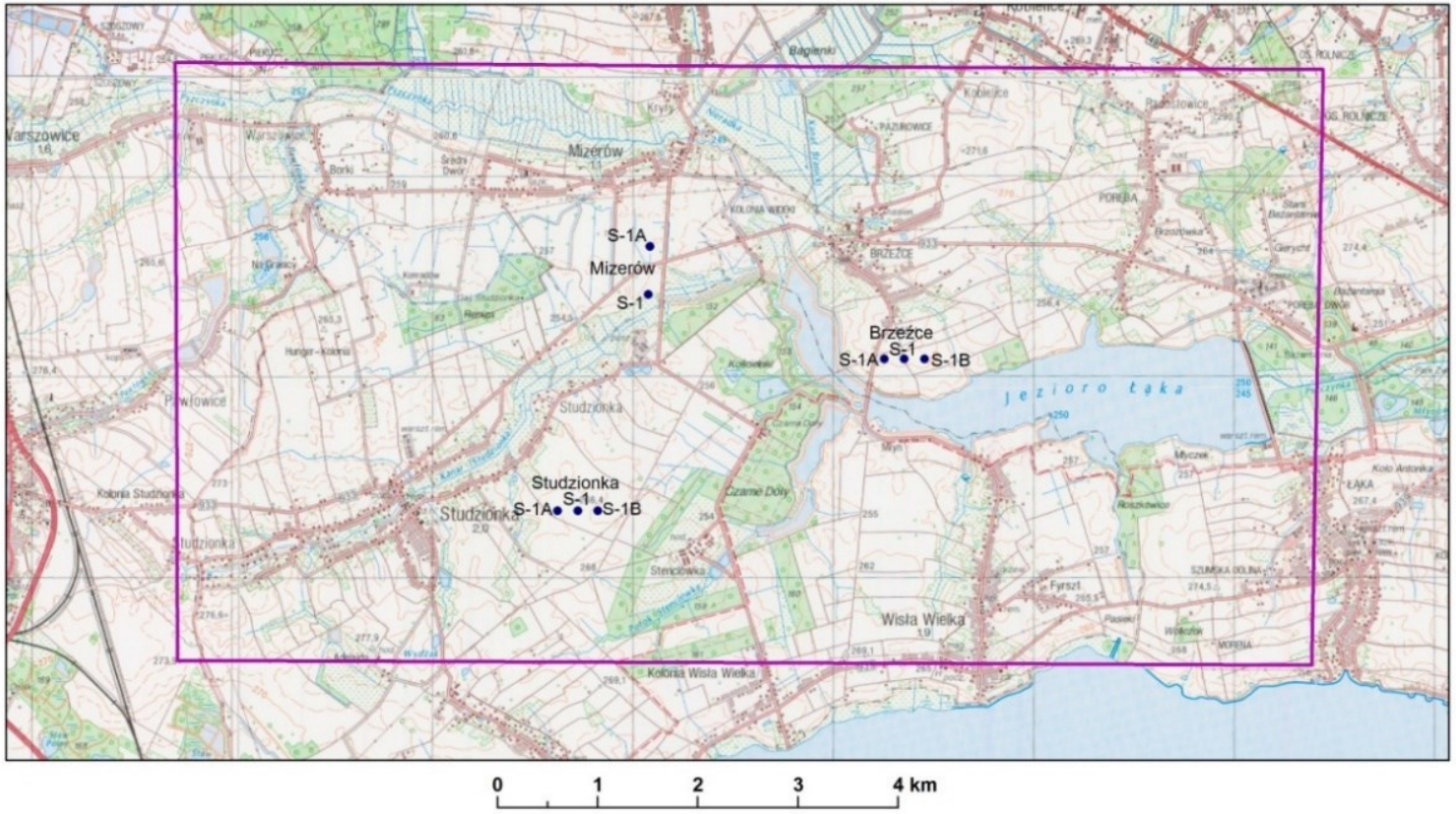
CO2-EOR dates back to 1970s and by now likely about 1 Gt of CO2 was injected, mostly in the US (40 Mt/yr in the US; Meyer, 2007; Melzer, 2012). However ~95% of CO2 came from large natural accumulations not anthropogenic sources (not CCS-CO2 aquisition far cheaper ~25 US$/t). The large CCS projects worldwide (1 MT/yr and more; 55 at various stages) utilize mostly EOR; a dozen - saline aquifers.

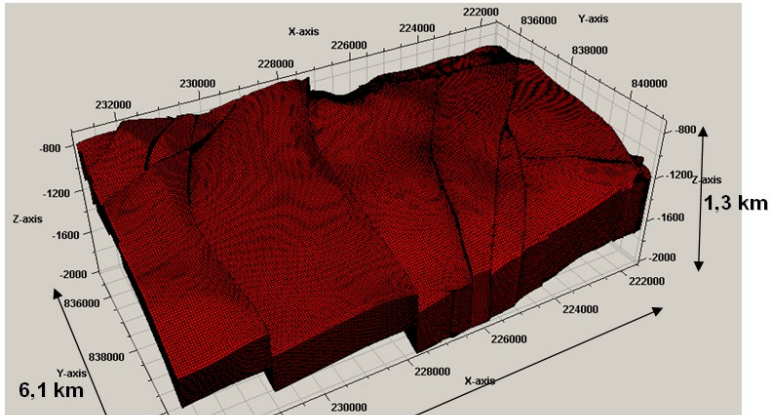
Coal bed methane fields where up to 20 Mt of CO2 might be stored



After RECOPOL project experiences three small CBM fields were selected in southern part of the Upper-Silesian Coal Basin where CO2 injection with methane recovery might be (most likely) feasible and safe now – static storage capacity ~20 Mt (Wójcicki (ed.), 2013). CBM is a quite abundand in USCB but industrial production failed in 1990s.

Coal beds, CO2-ECBM





Pilot injection (like RECOPOL) and industrial injection with horizontal wells were simulated. In latter case, injection of 35-203 kt of CO2 (for 2 years) gave the estimated total production (EUR) 36-62 Mmcm of methane – better than good shale gas wells in the US.

Conclusions and Remarks

- In Poland commercial CCS projects are not allowed till 2024/26 (only demos)

- There might be a conflict of interests with the use of subsurface, especially regarding geothermal (however geothermal resources are abundant but generally uneconomic – interestingly the appraisal well in Pabianice commune, where local residents instigated by a NGO and their counsellors fought valiantly against Bełchatów demo project, was not eventually adopted for geothermal purposes – the commune authorities decided definitely they cannot afford for such an investment – after meetings in September 2012 and June 2013). It should be noted there are some similarities between CO2 injection and reinjection of brine used in geothermal dublet into reservoir – in both cases leakages of brine into potable aquifer are the worst case scenaria (though rare in geothermal – only one case in Spain and one in Turkey are known) as likely also in shale gas exploration and production.

- The opponents of CCS (e.g., some NGOs) usually do not use scientific arguments and rarely have such background, at least in case of geology.

- The economic use of CO2 (CO-EOR, CO-ECBM) in Poland is limited.

Thank you for your attention:

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