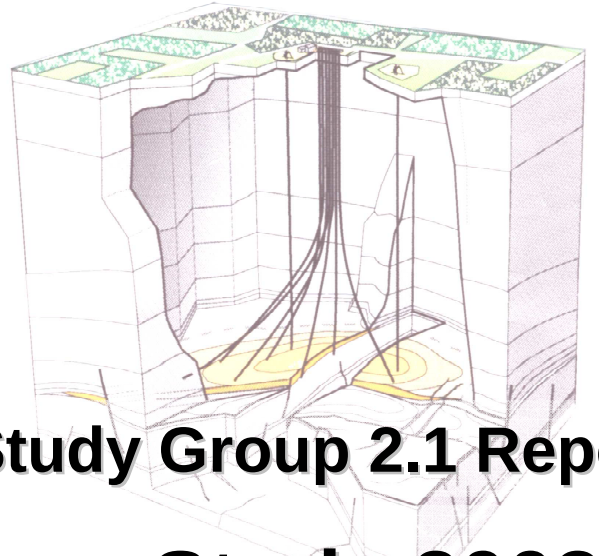
WOC 2 Session

Security of Gas Supply
- The role of Underground Gas Storage -



Study Group 2.1 Report

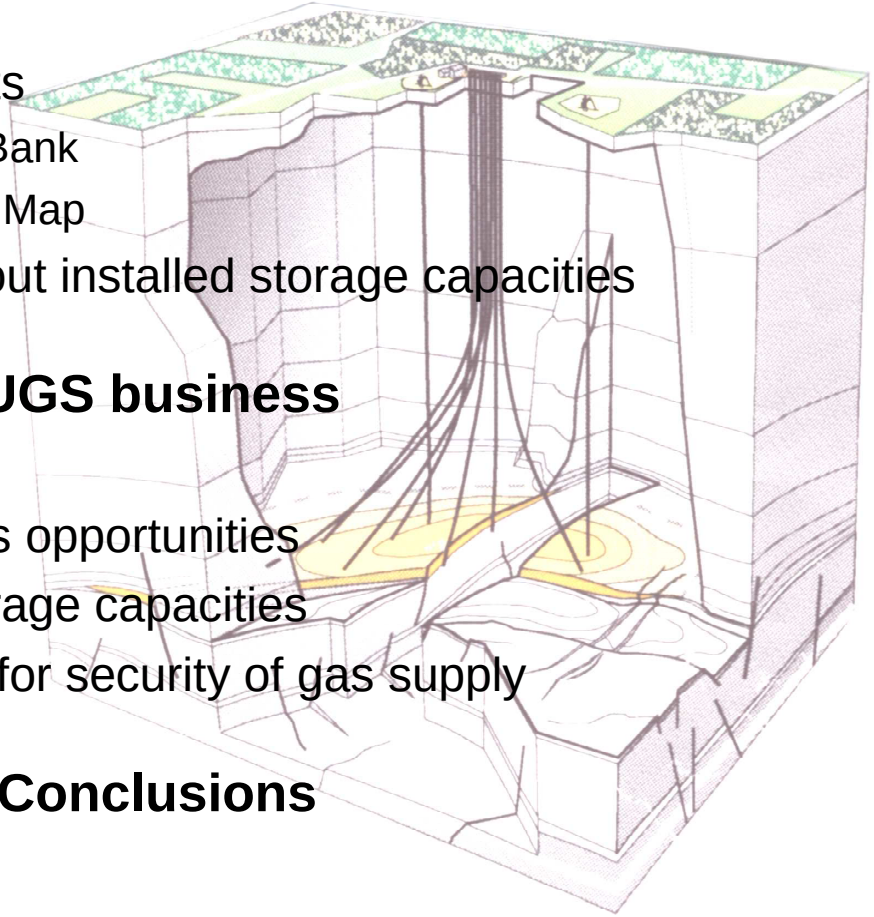
Storage Study 2003-2006
Trends in the UGS Business

Joachim Wallbrecht

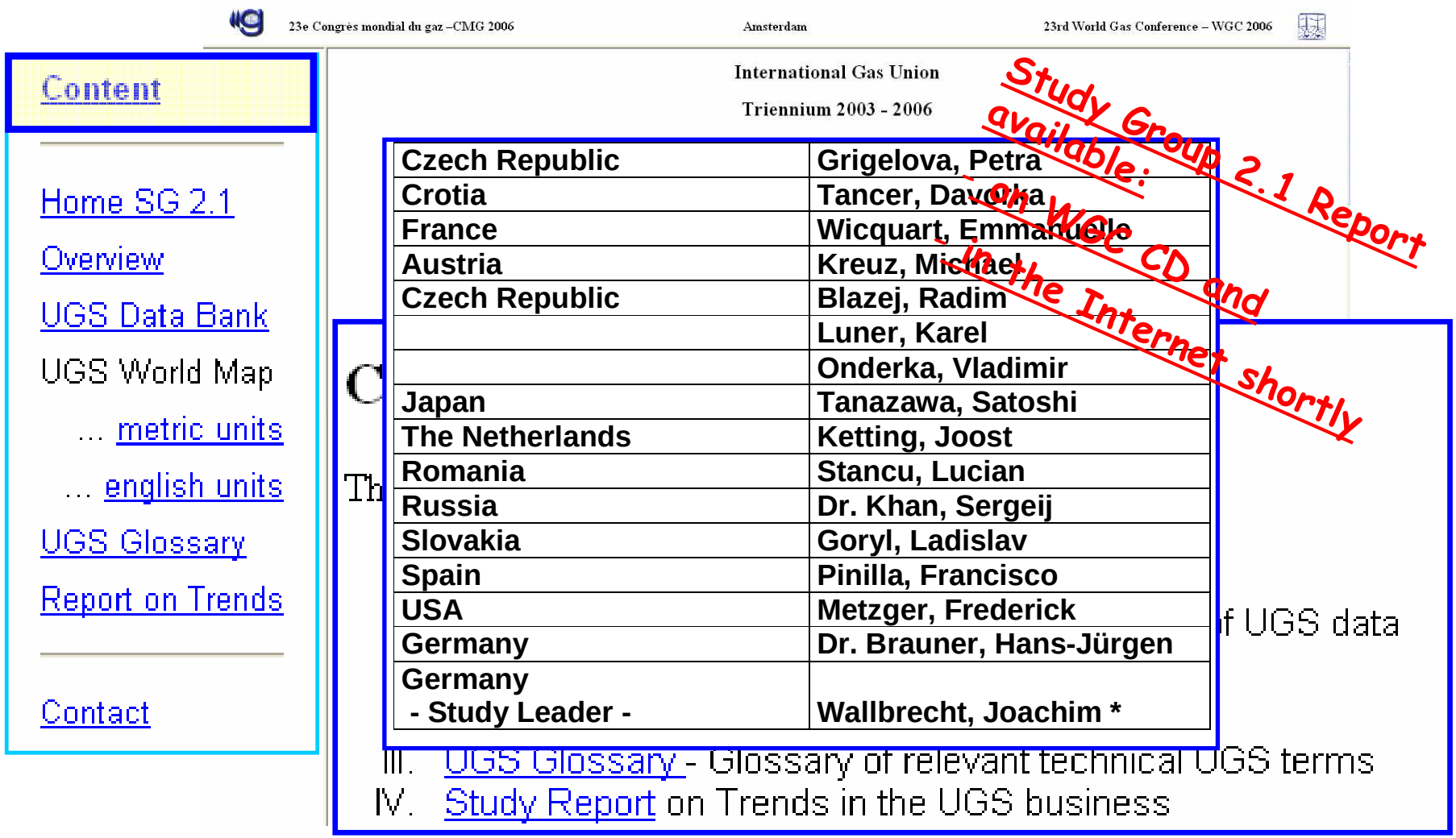
BEB Transport und Speicher Service GmbH - Germany

Agenda

- **Study Group 2.1-Report - Storage Study 2006 - UGS in the world**
  - Structure
  - Main elements
    - UGS Data Bank
    - UGS World Map
  - Overview about installed storage capacities
- **Trends in the UGS business**
  - General
  - New business opportunities
  - Outlook - storage capacities
  - Role of UGS for security of gas supply
- **Summary and Conclusions**



Storage Study 2006 - Report Structure



UGS Data Bank

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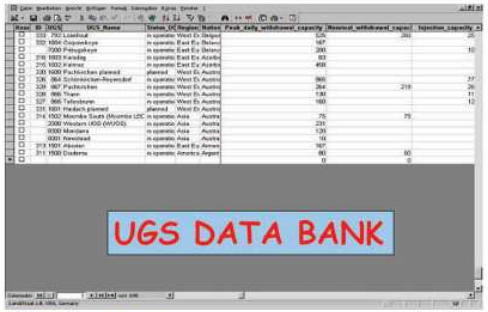
UGS Data Bank

Explore UGS data in a MS-Access database



MS-Access Database

Select from the following table options:

UGS World Data in metric units

- All 2006
- All in operation 2006
- All planned 2006
- Summary by Nations 2006 - in operation metric
- Summary by States 2006 - in operation metric
- Summary UGS Key Data 2006 in operation metric

UGS World Data in English units

- Summary by Nations 2006 – in operation english
- Summary by States 2006 – in operation english
- Summary UGS Key Data 2006 in operation english

Database available as:

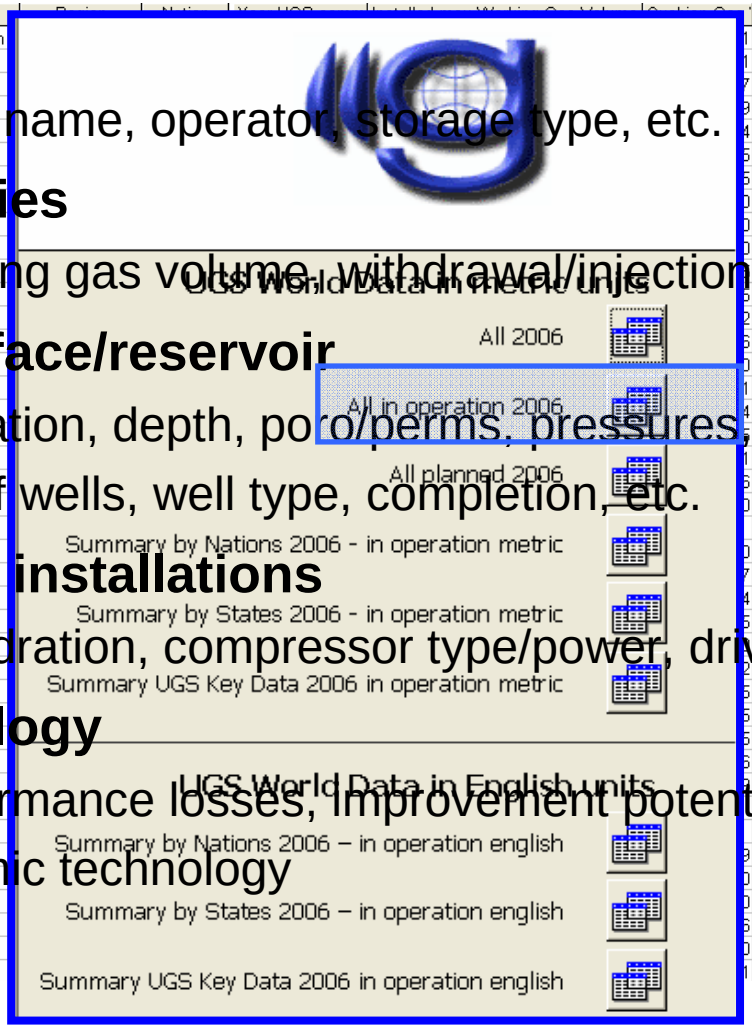
MS Access file

MS Excel table

UGS Data Bank - Content

- **General**
  - UGS name, operator, storage type, etc.
- **Capacities**
  - working gas volume, withdrawal/injection rates, etc.
- **Subsurface/reservoir**
  - formation, depth, poro/perms, pressures, etc.
  - no. of wells, well type, completion, etc.
- **Surface installations**
  - dehydration, compressor type/power, driver
- **Technology**
  - performance losses, improvement potential
  - seismic technology

UGS ID	Name of UGS Facility	Peak Withdraw	Nominal Withdr	Injection Rate o	Total No of Storage Wells/C	No of vertical Sl	No of
817	Inzenham West Horizon	280	280	140	24	24	
808	Epe HC	2125	1830	515	32	32	
852	Brugherio	416		291	8		
851	Sergnano	2440		870	34	3	
850	Cortemaggiore	1000		704	36		
849	Rough	1721		543	30		
848	Hornsea (Atwick)	712		80	9	9	
847	Lussagnet	937	833	900	44	44	
846	Izaute	312	234	625	16	16	
854	Settala	1800	632	690	27	6	
818	Kalle	400		225	9		
855	Minerbio	2630		830	51		
816	Huntorf	550		150	6	4	
815	Crossfe	300	300	90	2	2	
814	Ketzin	100	100	80	18	18	
1680	Skallen	40	37	18	1	1	
813	Fronhofen	75	70	20	4	2	
812	Frankenthal	150	130	50	12	11	
811	Etzel	1320	350	300	9	9	
810	Eschenfelden	130	93	50	12	12	
820	Kirchheilingen	125	125	108	7	7	
1628	Hole House	111			2	2	
795	IL Torup	600	600	165	7	7	
896	Stockt	200		50	2	1	
895	Kraak	250	150	80	4	3	
894	Bremen-Lesum EMGSG	360	360	120	2		
892	Lehrte	137	137	21	3	1	
891	Epe TG	660	520	170	7	7	
890	Bad Lauchstädt Caverns	1200	1200	833	18	18	
880	Kiev/a	237	237	187	4		
853	Lipnica	1270		791	35	5	
867	Puchkirchen	290	219	264	14	8	
861	Norg	2083	2083	1000	6	0	
1629	Hatfield Moor	216	110	70			
1636	Southwest Kinsale	118	76	42	3	3	
866	Thann	130		115	17	17	
865	Tallesbrunn	160		125	24	24	
862	Grijpskerk	2292	2292	500	9	0	
860	Alkmaar	1500	1500				
857	San Salvo	2000		1258	54	54	
856	Sabbioncello	940		380	31	1	



UGS Data Bank - Summary

- **UGS Data Bank covers:**
  - No. of UGS facilities in operation: 606
  - No. of UGS nations: 33
  - Installed working gas volume: 333 G m³
  - Withdrawal rate: 206 M m³/h
  - Storage wells: abt. 22550

- **Excellent database based on:**
  - Data from 584 storage facilities covering 319 G m³ of working gas volume received directly, i.e.: 96% of total working gas volume
  - Data from previous studies and publications

- **UGS Data Bank available in metric and english units !**

UGS World Map

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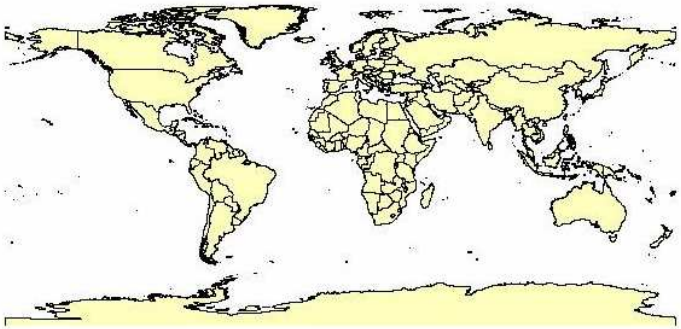
UGS-World Map in metric units

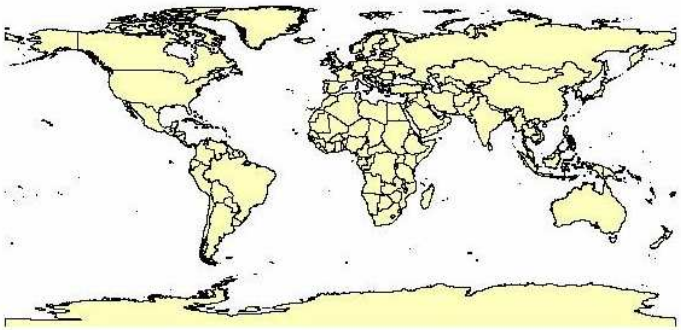


Explore UGS location and data on maps

Please click on the area of interest ! (metric units)

North-America South-America Europe Asia

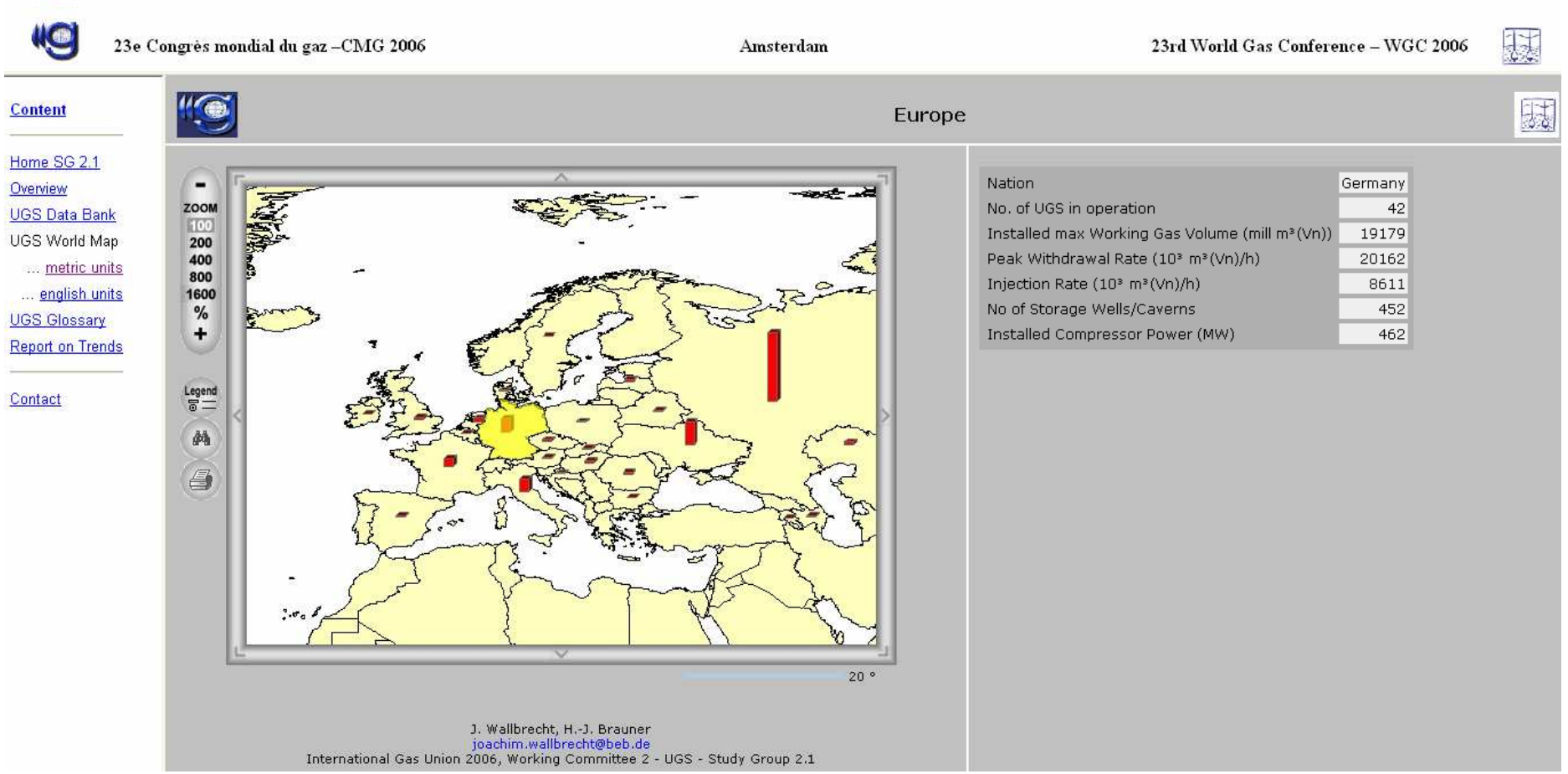
UGS-World Map in english units



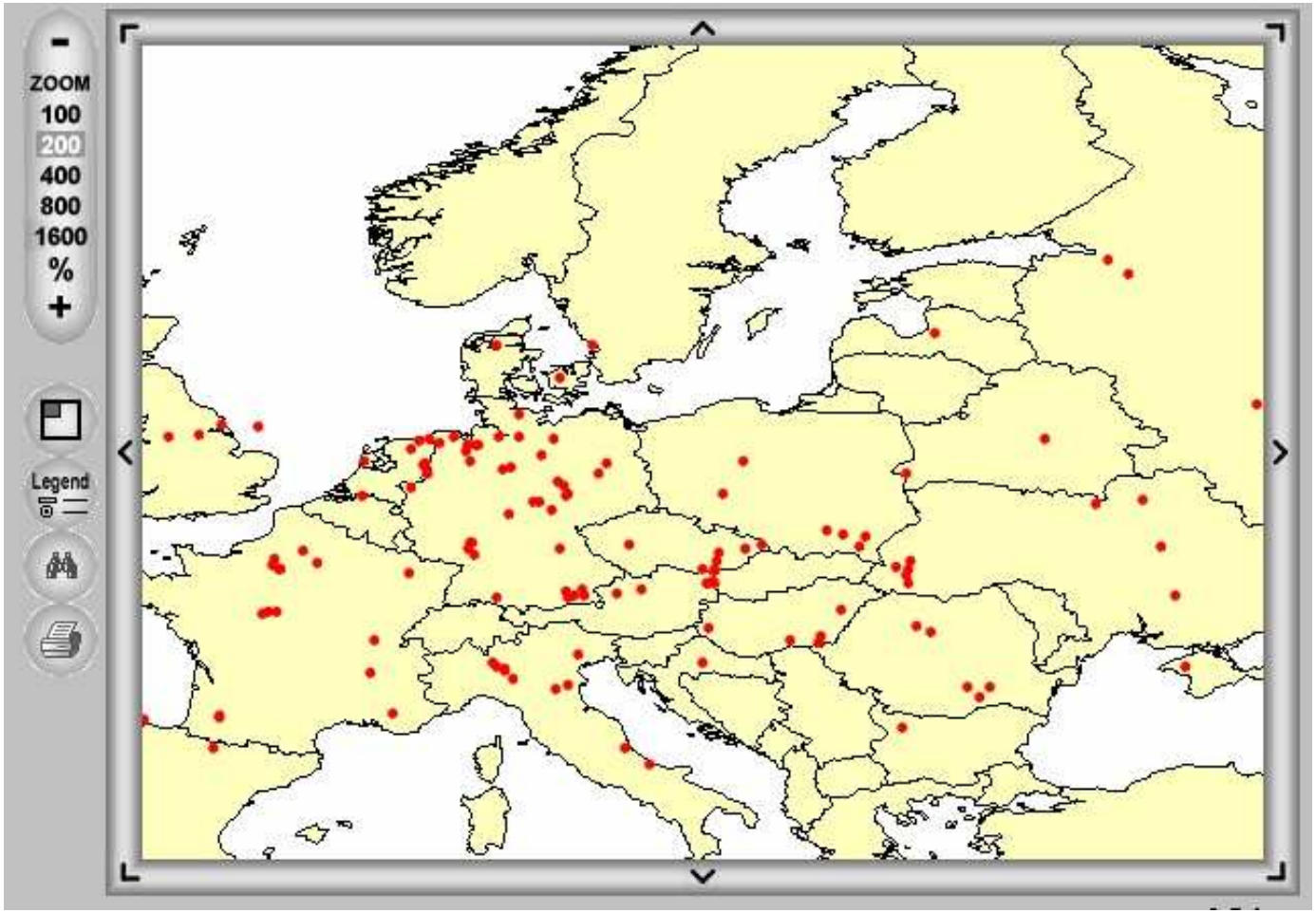
Explore UGS location and data on maps

Please click on the area of interest ! (english units)

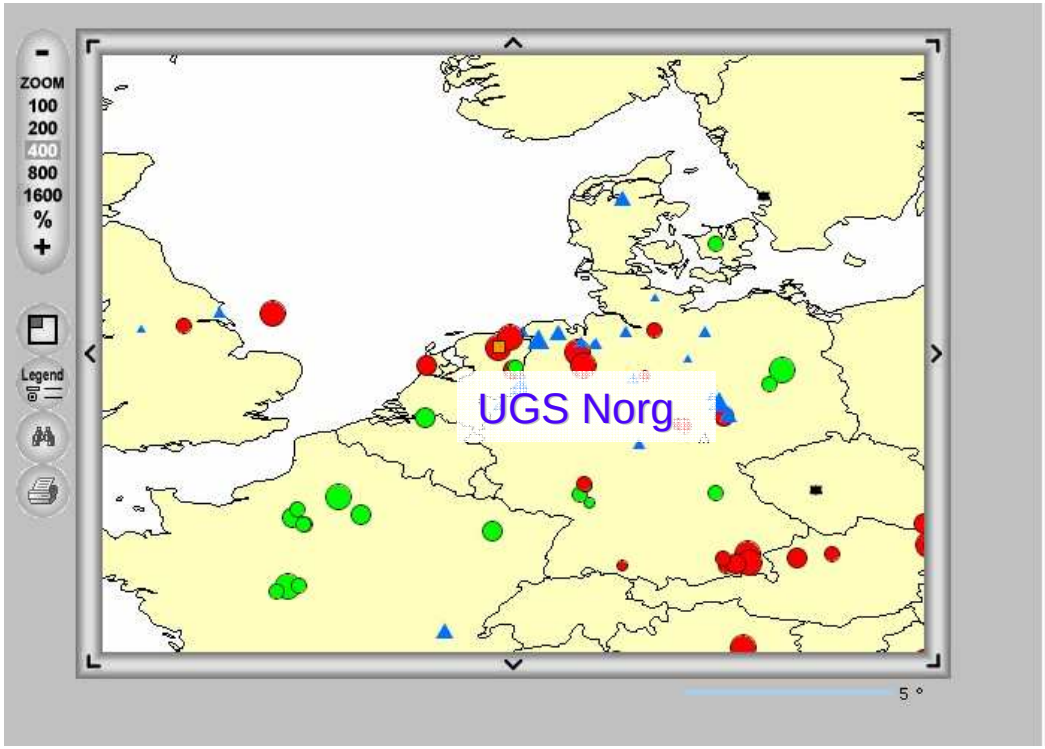
UGS World Map – Navigation to an UGS I



UGS World Map – Navigation to an UGS II



UGS World Map – Navigation to an UGS III



Installed max working gas volume of UGS facility [mill m³(Vn)]

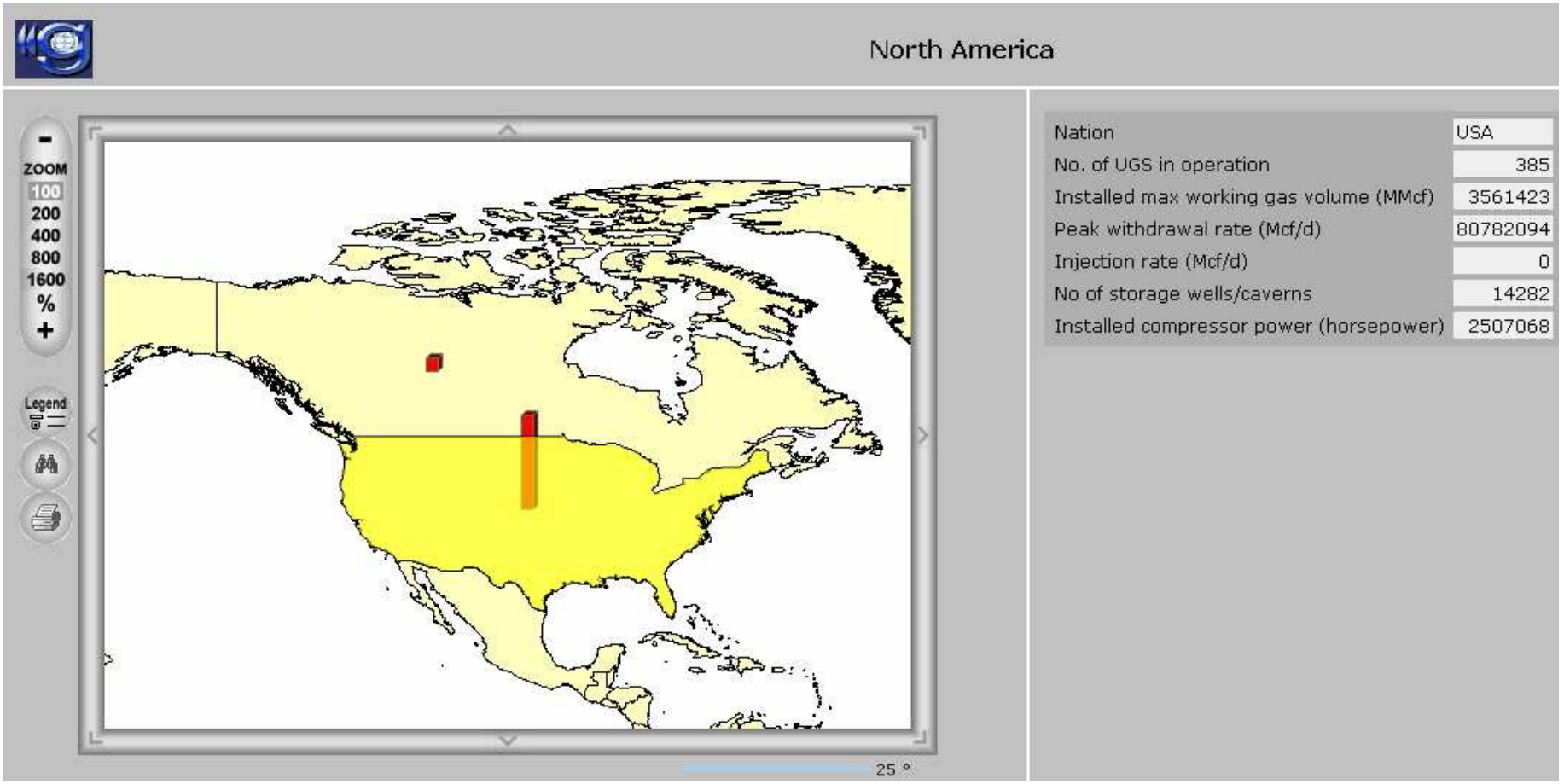
UGS_ID	861
Name of UGS facility	Norg
Type of storage	Oil/Gasfield
Status of storage facility	in operation
Nation	Netherlands
Company for contact	NAM
Actuality of data	2004
Installed max working gas volume of UGS facility (mill m³(Vn))	3000
Cushion gas volume (incl. inj. + indig.) of UGS facility (mill m³(Vn))	23609
Peak withdrawal rate of surface facilities (10³ m³(Vn)/h)	2083
Last day withdrawal rate of surface facilities (10³ m³(Vn)/h)	0
Injection rate of surface facilities (10³ m³(Vn)/h)	1000
No of storage wells/caverns	6
Installed compressor power (MW)	76
Name of storage formation	ROSL
Depth top structure/cavern roof (metre)	2540
Minimum storage pressure (BHP bar)	0
Maximum allowable storage pressure (BHP bar)	327
Net thickness (metre)	180
Porosity (average) (%)	18
Permeability (average) (mD)	300

5000 - 30000

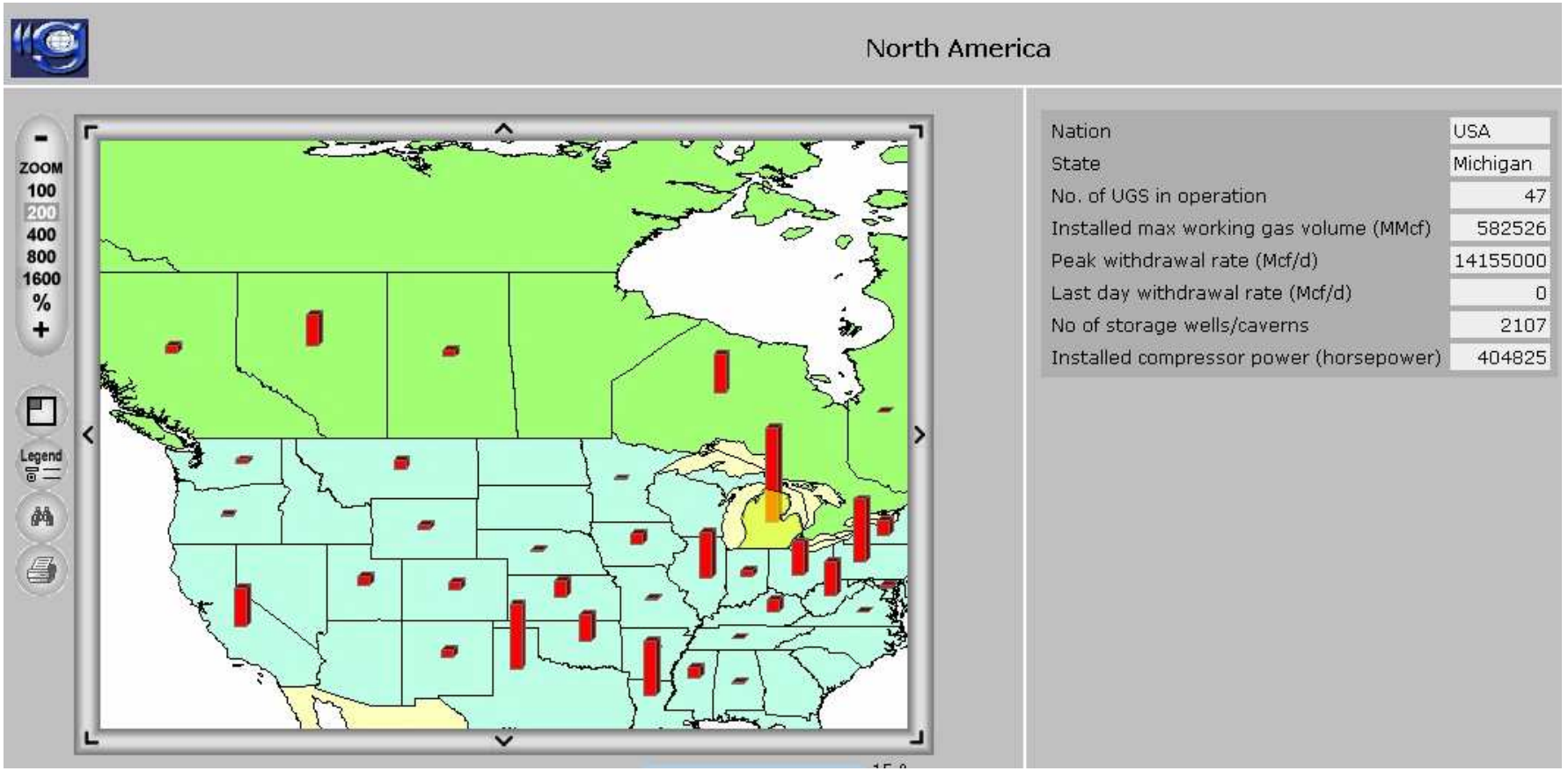
Abandoned mine

0 - 100

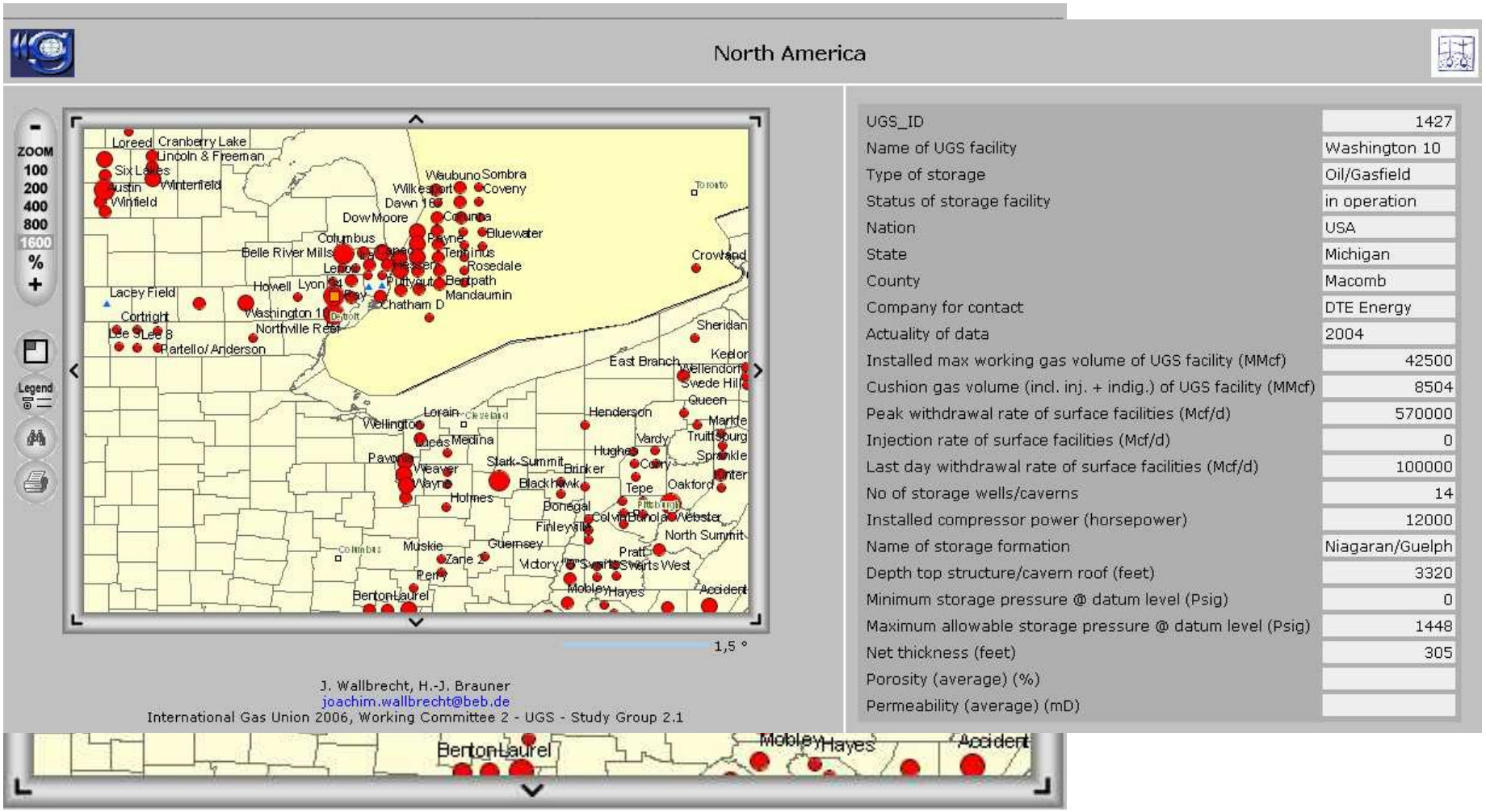
UGS World Map – North America - Nation - Level



UGS World Map - North America - State Level



UGS World Map – US UGS Locations



UGS_ID	1427
Name of UGS facility	Washington 10
Type of storage	Oil/Gasfield
Status of storage facility	in operation
Nation	USA
State	Michigan
County	Macomb
Company for contact	DTE Energy
Actuality of data	2004
Installed max working gas volume of UGS facility (MMcf)	42500
Cushion gas volume (incl. inj. + indig.) of UGS facility (MMcf)	8504
Peak withdrawal rate of surface facilities (Mcf/d)	570000
Injection rate of surface facilities (Mcf/d)	0
Last day withdrawal rate of surface facilities (Mcf/d)	100000
No of storage wells/caverns	14
Installed compressor power (horsepower)	12000
Name of storage formation	Niagaran/Guelph
Depth top structure/cavern roof (feet)	3320
Minimum storage pressure @ datum level (Psig)	0
Maximum allowable storage pressure @ datum level (Psig)	1448
Net thickness (feet)	305
Porosity (average) (%)	
Permeability (average) (mD)	

Glossary of relevant UGS Terminology

Глоссарий ПХГ - русский язык

Глоссарий терминологии связанной с технологией Подземного Хранения Газа

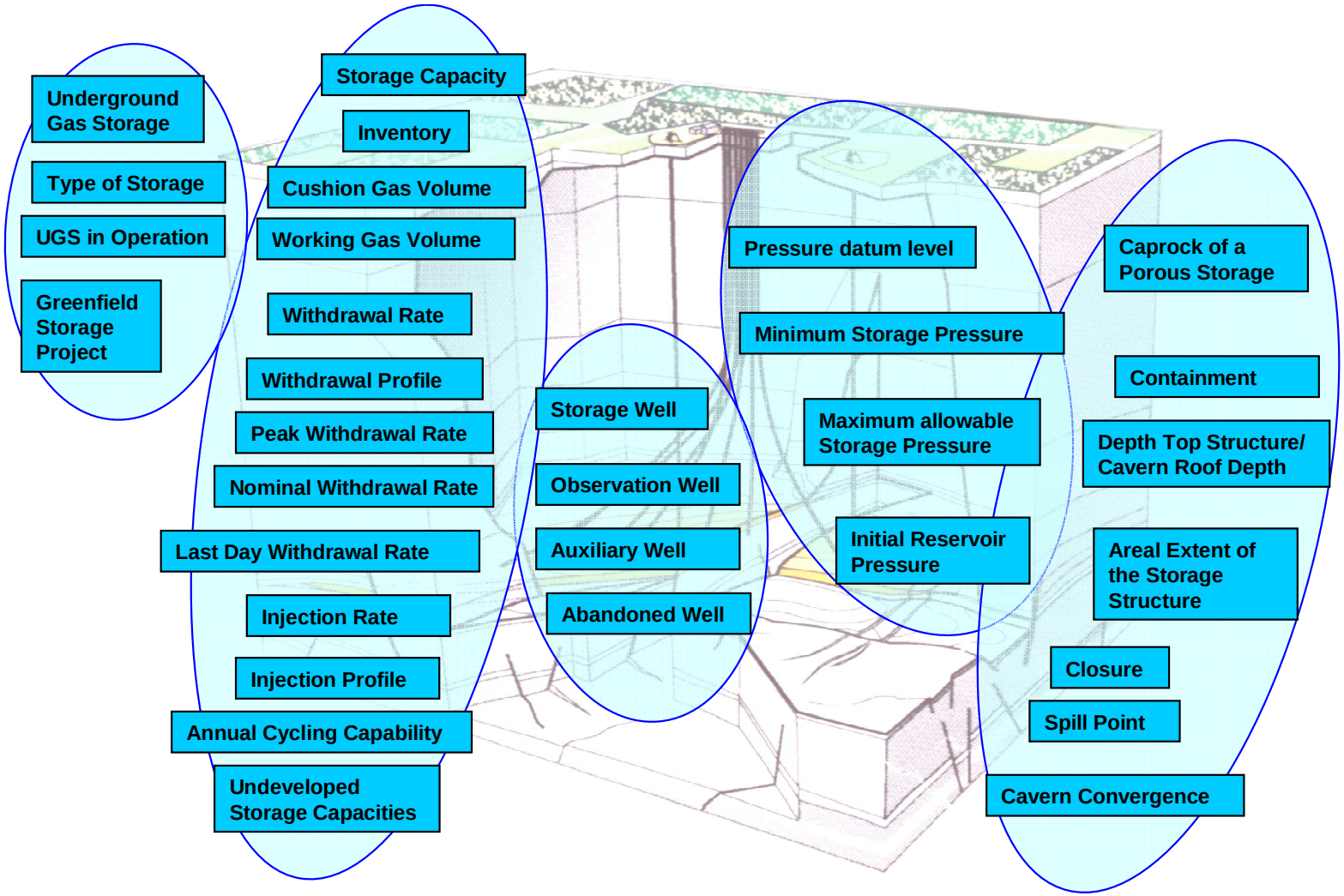
Возможности Глоссария
Глоссарий охватывает техническую терминологию, связанную с хранением природного газа в подземных газовых хранилищах. Терминология может быть пригодна и для хранения водорода, CO_2, O_2 и других газов.

English Term	Термин	Определение
Underground Gas Storage (UGS)	Подземное хранилище газа (ПХГ)	Сложное геолого-технические сооружение, создаваемое в естественных пластовых структурах, пригодное для закачки, хранения и отбора природного газа и предназначающееся для регулирования неравномерности газопотребления путем образования запасов газа.
Type of Storage	Типы хранилищ	Есть несколько типов подземных газовых хранилищ, которые отличаются механизмом формирования и хранения:
	России не	

Glossary

English Deutsch Francais Italiano Czech Russia

Glossary of relevant UGS Terminology - Content



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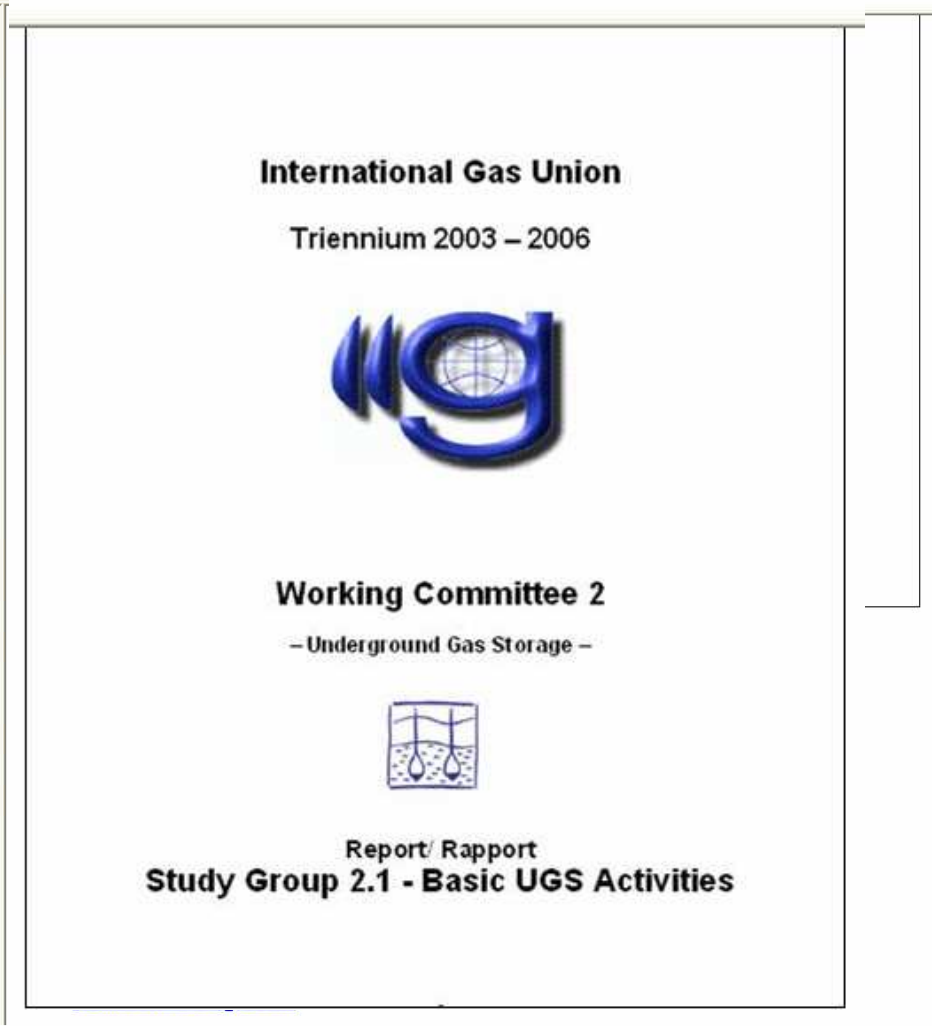
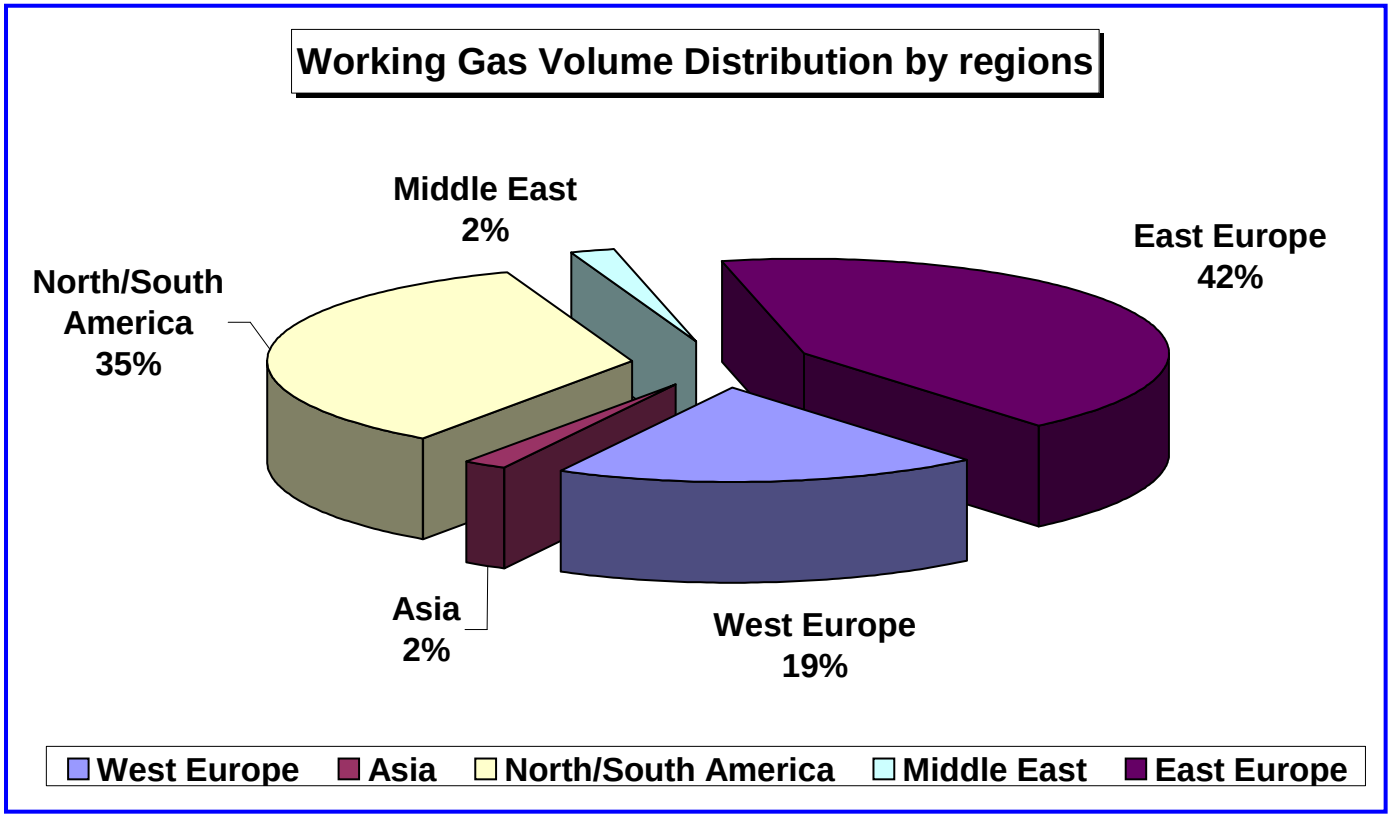
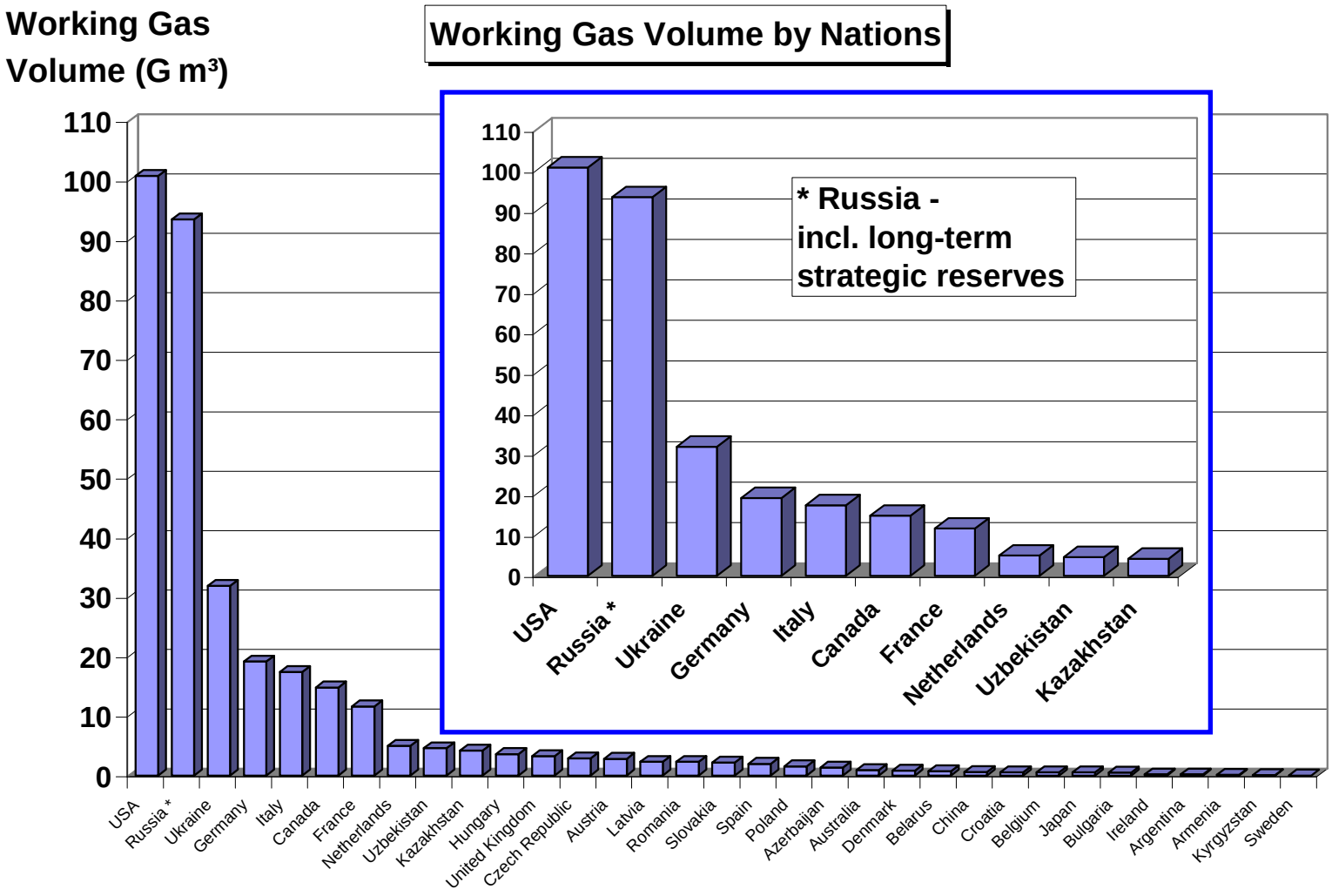


Storage Capacities in the World - Regions

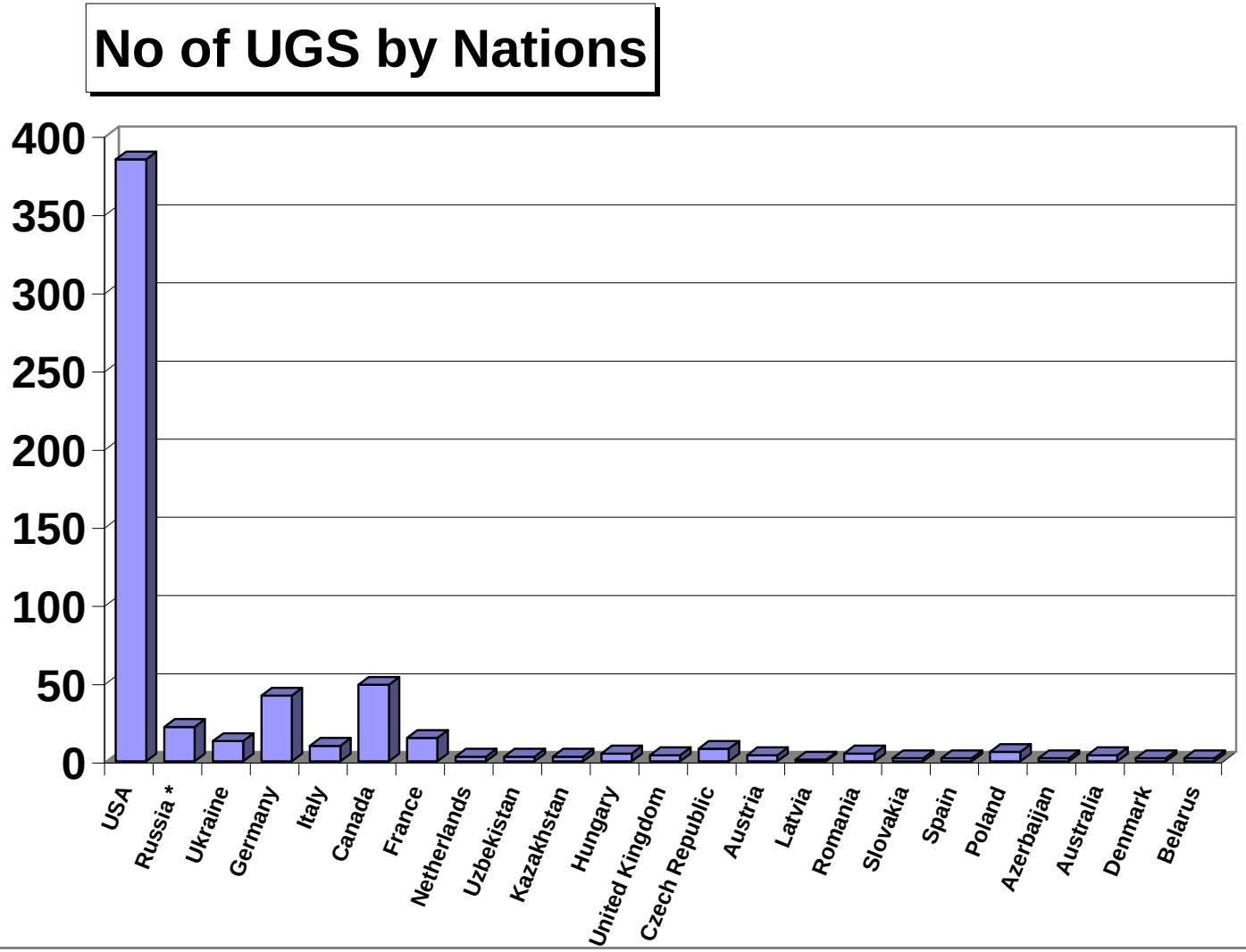
Installed Working Gas Volume: 333 G m³ in 606 UGS (incl. strategic reserves)



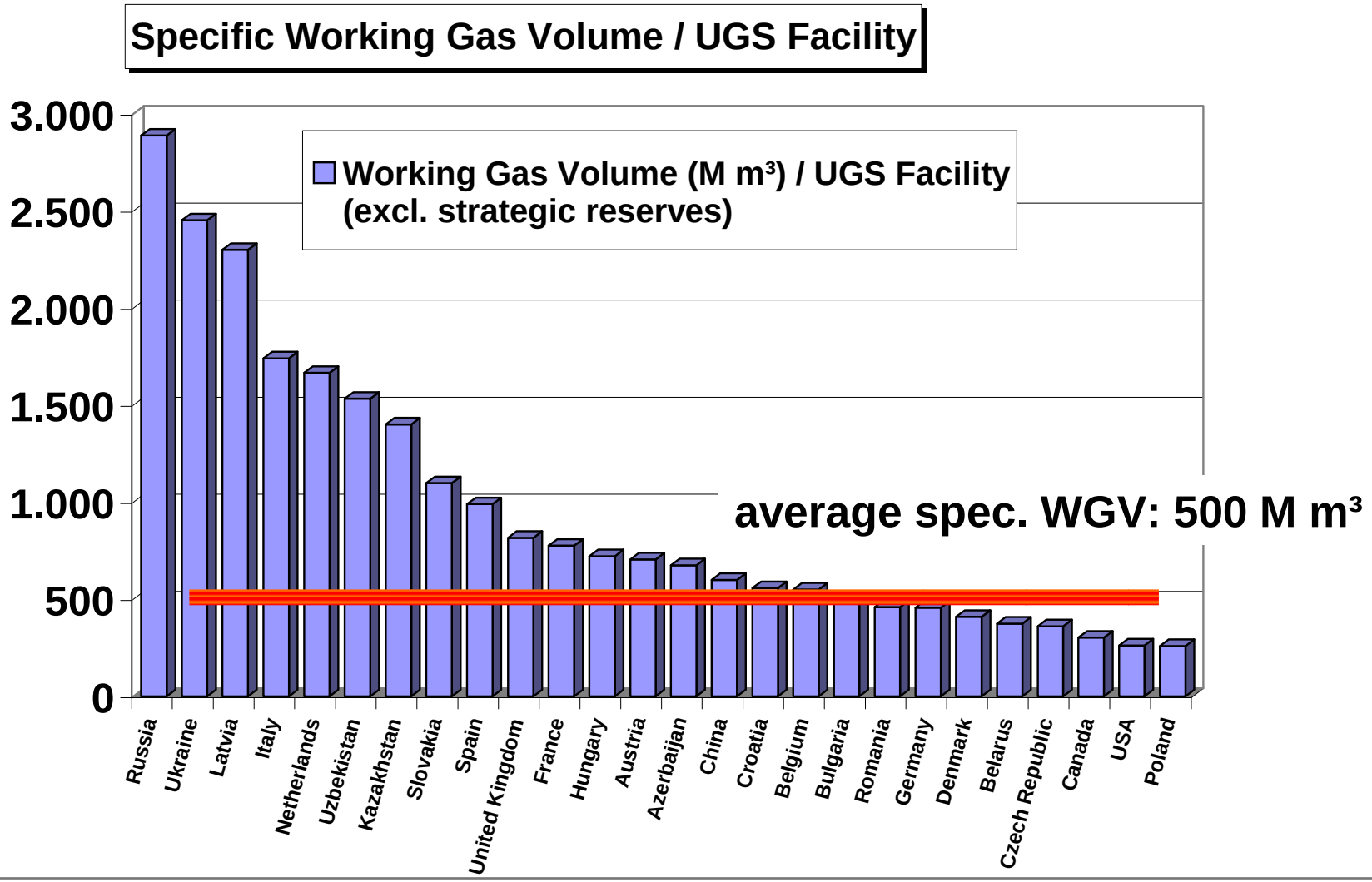
Storage Capacities in the World - Nations



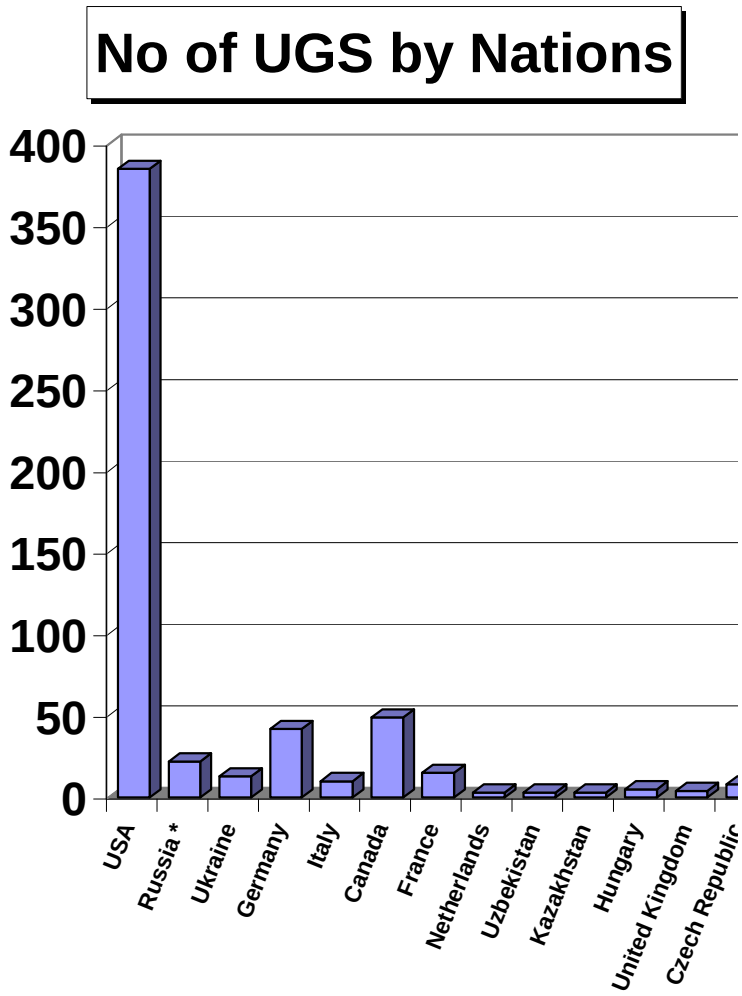
Storage Capacities in the World - UGS No.

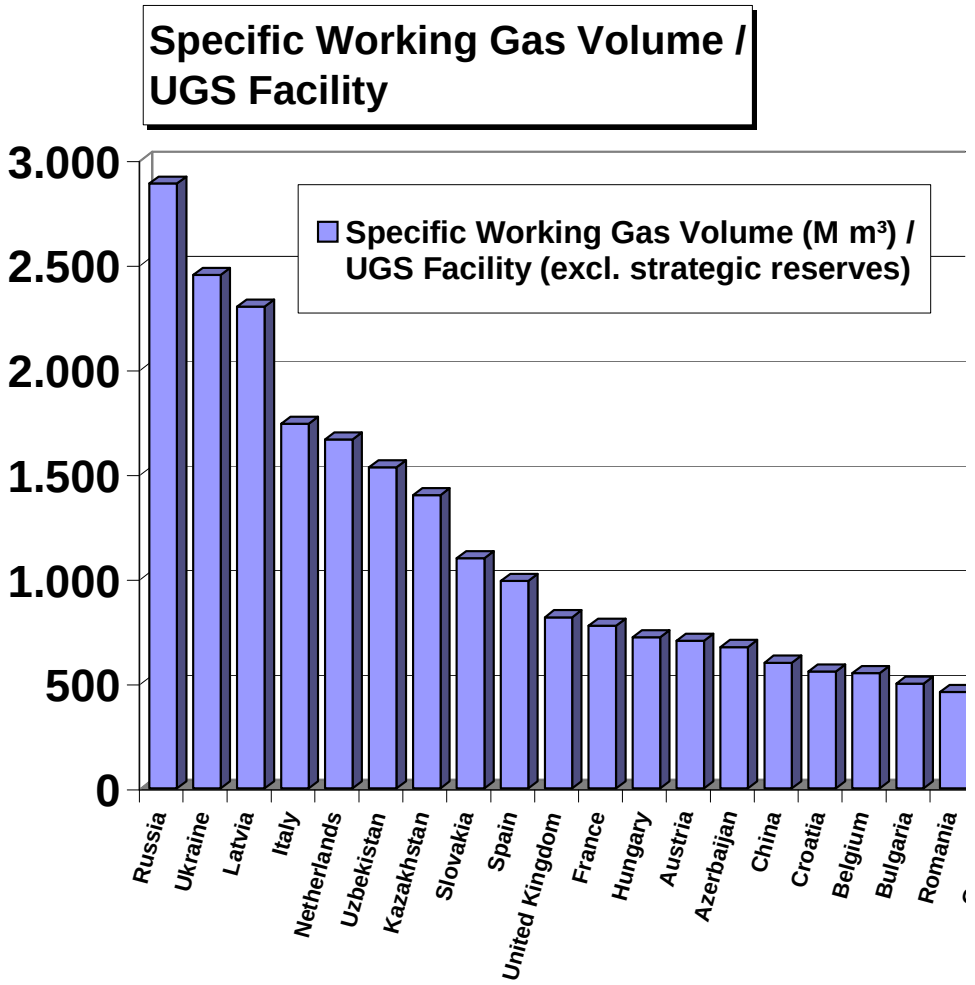


Storage Capacities in the World - spec. WGV

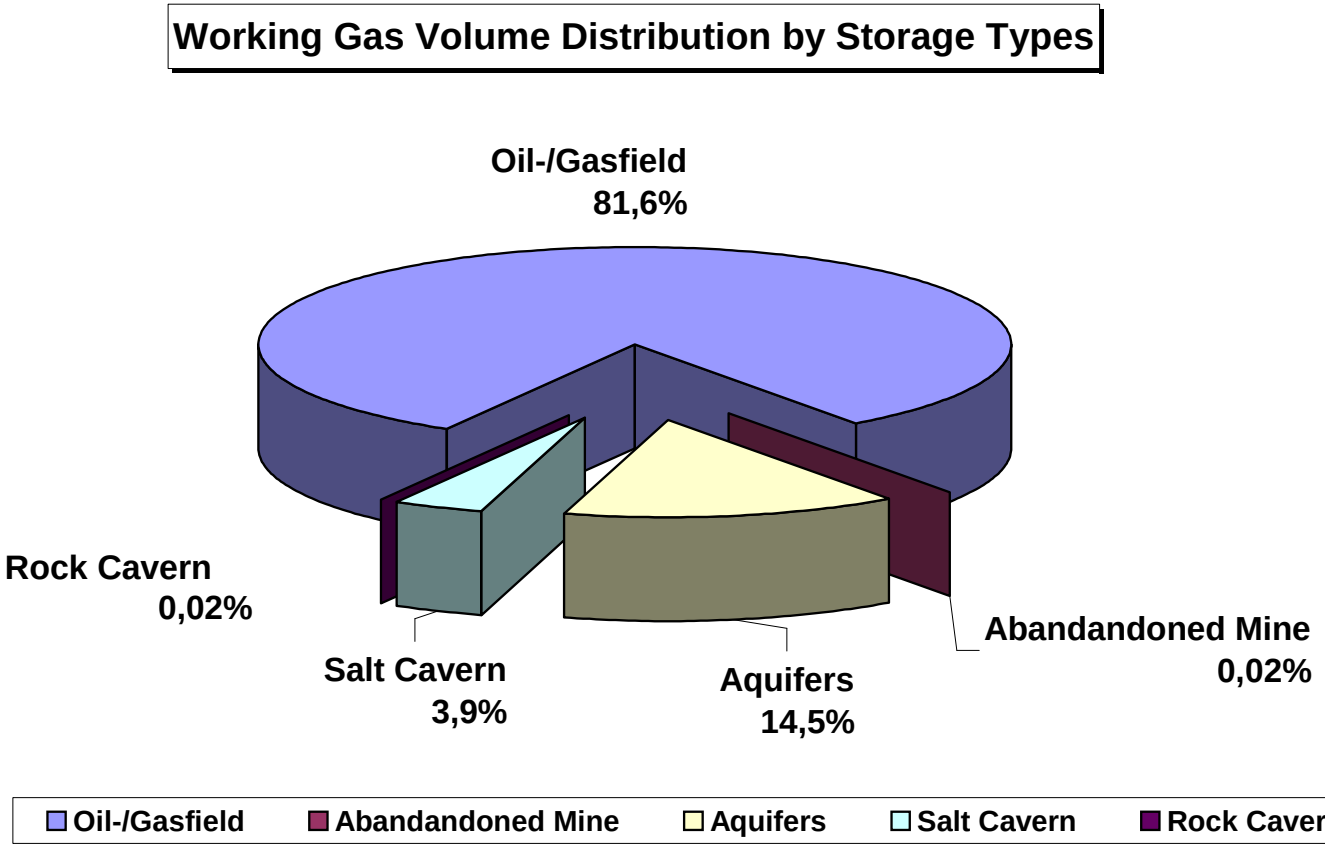


Storage Capacities in the World - UGS No., spec. WGV

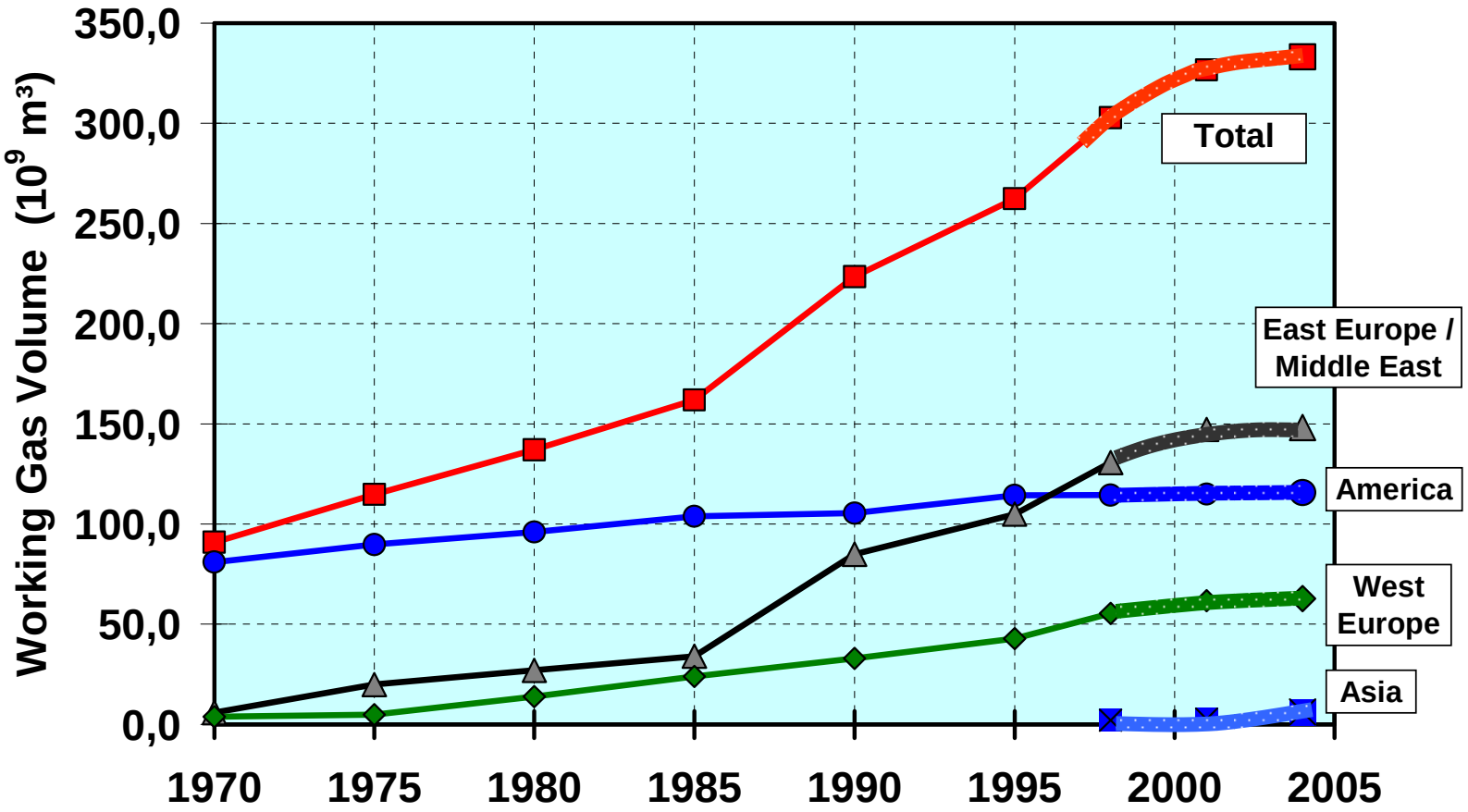




Storage Capacities in the World - Storage Type



Storage Capacities in the World - Working Gas vs Years



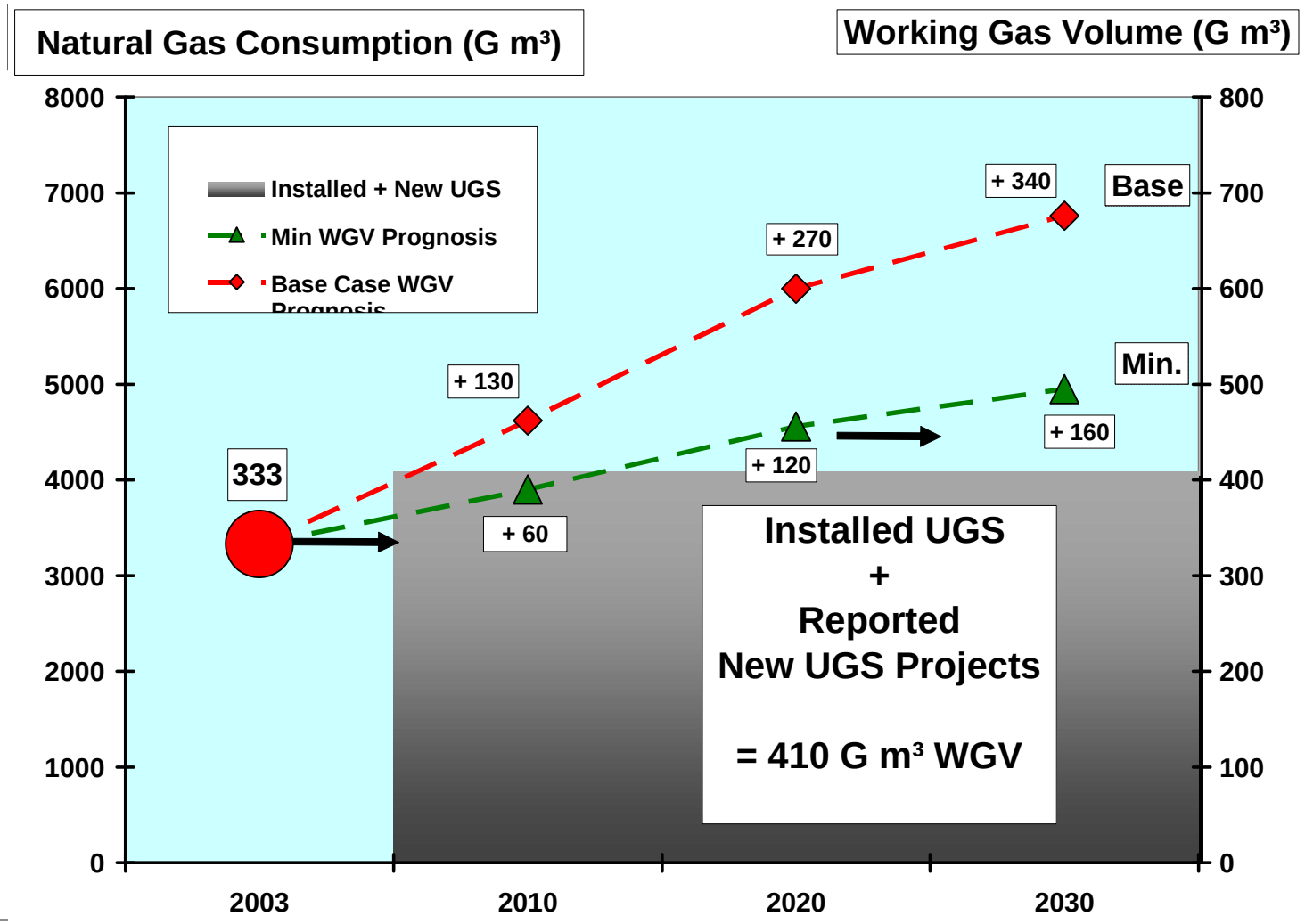
Trends in UGS Business - General

- **Gradual increase of storage capacities only from 2000 onwards**
- **UGS is all the more indispensable within the gas chain for:**
  - balancing, security of supply, etc. requirements fulfilled
  - development of liberalised market
  - essential for further extension of gas market
- **UGS business is undergoing changes in many countries due to:**
  - liberalisation of gas market, more competition
  - storage as trading tool in combination with hubs
  - reconstruction of “old” UGS-facilities due to new requirements
  - uncertainties about future profitability, cost cutting initiatives
  - reluctance in development of new projects
  - increasing environmental/regulatory requirements
  - required expertise/qualification of staff for oncoming tasks

Trends in UGS Business – New Business Opportunities

- **New business opportunities for the storage industry:**
  - higher demand for flexibility and peak gas rates
  - gas demand is expected to rise severely
  - increasing import volumes and declining indigenous production
  - increasing import via long distance transport at high load factors
  - higher dependency from remote reserves / politically critical reserves
  - higher Security of Supply provisions expected - preferred downstream
  - storage as tool for trading
  - required for transformation of liberalised gas market
  - unconventional storage -Compressed Air Energy Storage (CAES), CO_2, H
- **Installed and planned storage capacities insufficient**
- **New UGS have to be developed for new requirements, especially for demand increases and new Security of Supply requirements**

Trends in UGS Business - Future Storage Demand



Role of UGS for Security of Gas Supply

- **Security of Supply more imported in the future**
- **More provisions required for:**
  - technical interruptions upstream/downstream
  - political/regulatory risks
  - economical risks/lack of investment for development
- **Security of Supply can be provided by different measures**
- **Underground Gas Storage is one essential tool to contribute**
- **Security of Supply is a joint upstream and downstream task**
- **Upstream located storage capacities are not as efficient as downstream UGS developments near the market**
- **New UGS down-/upstream strategic cooperations recommended**
  - downstream/producers joint ventures in few huge UGS locations at market

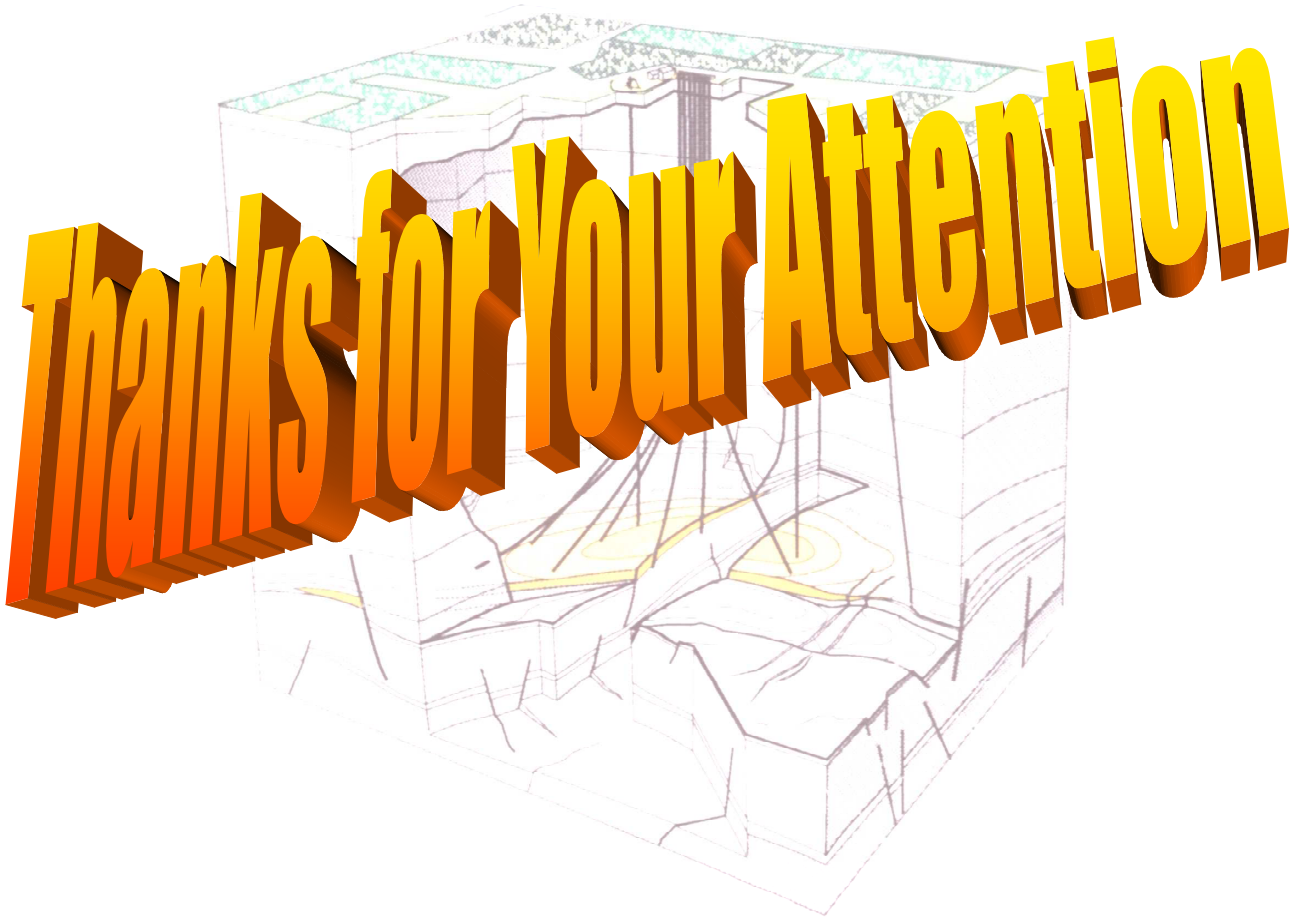
Summary and Conclusions

- Storage Study extended - excellent easy to use data base
- Role of UGS is changing
- New requirements/opportunities and more competition coming up
- Significant additional storage capacities have to be developed
- Downstream/upstream strategic storage cooperations required
- Good business opportunities expected assuming stable economic environment
- Insufficient economics and restrictive regulation will hamper the development of the required additional storage capacities
- Storage demand study required for decision guidance

Storage Business Opportunities

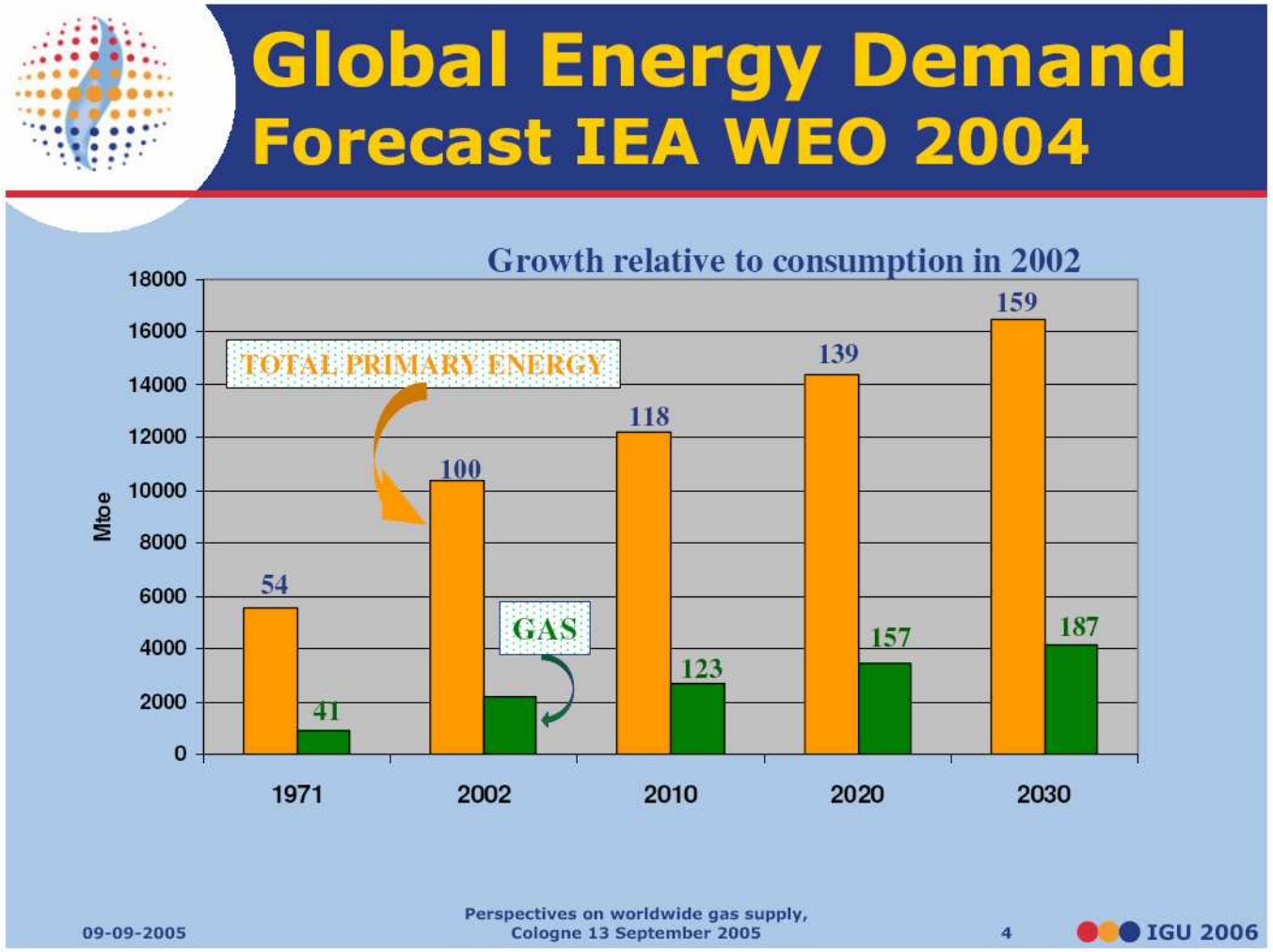
There are better opportunities !

Thanks to the Audience

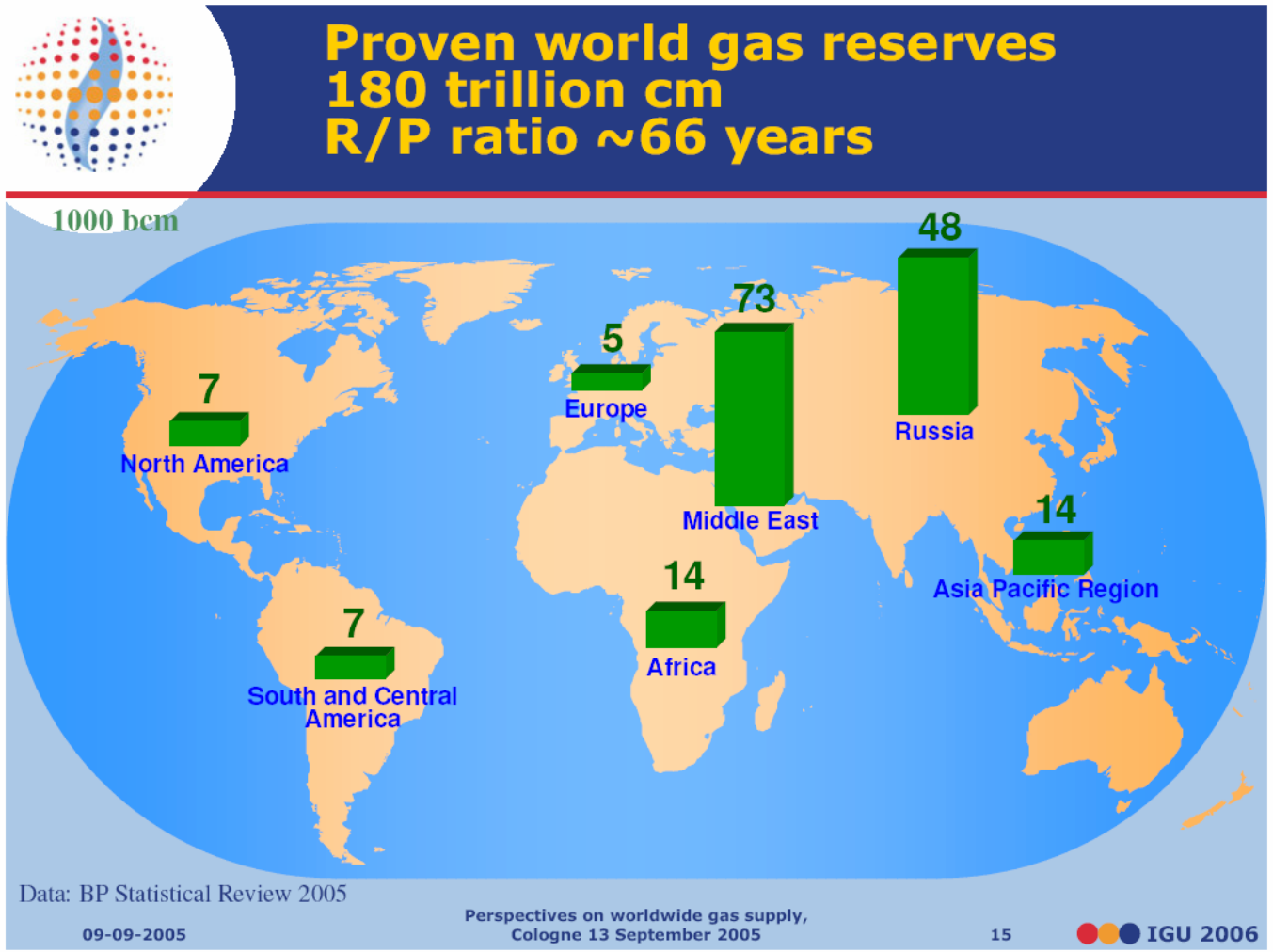


End

Gas Demand Forecast



Gas Reserves Distribution



Security of Supply - Definition

Definition of security of gas supply

Security of gas supply is the capability to manage, for a given time, external market influences which cannot be balanced by the market itself.

In open markets, supply and demand can be balanced by the market according to the preferences of market participants. Open markets ensure that gas goes to its highest value use. They provide a variety of instruments to mitigate external market influences in line with the preferences of market participants.

Security of supply has always been a question of how to handle external supply disruptions. In open markets, ensuring reliable gas supply all the way to final customers according to their preferences raises other issues.

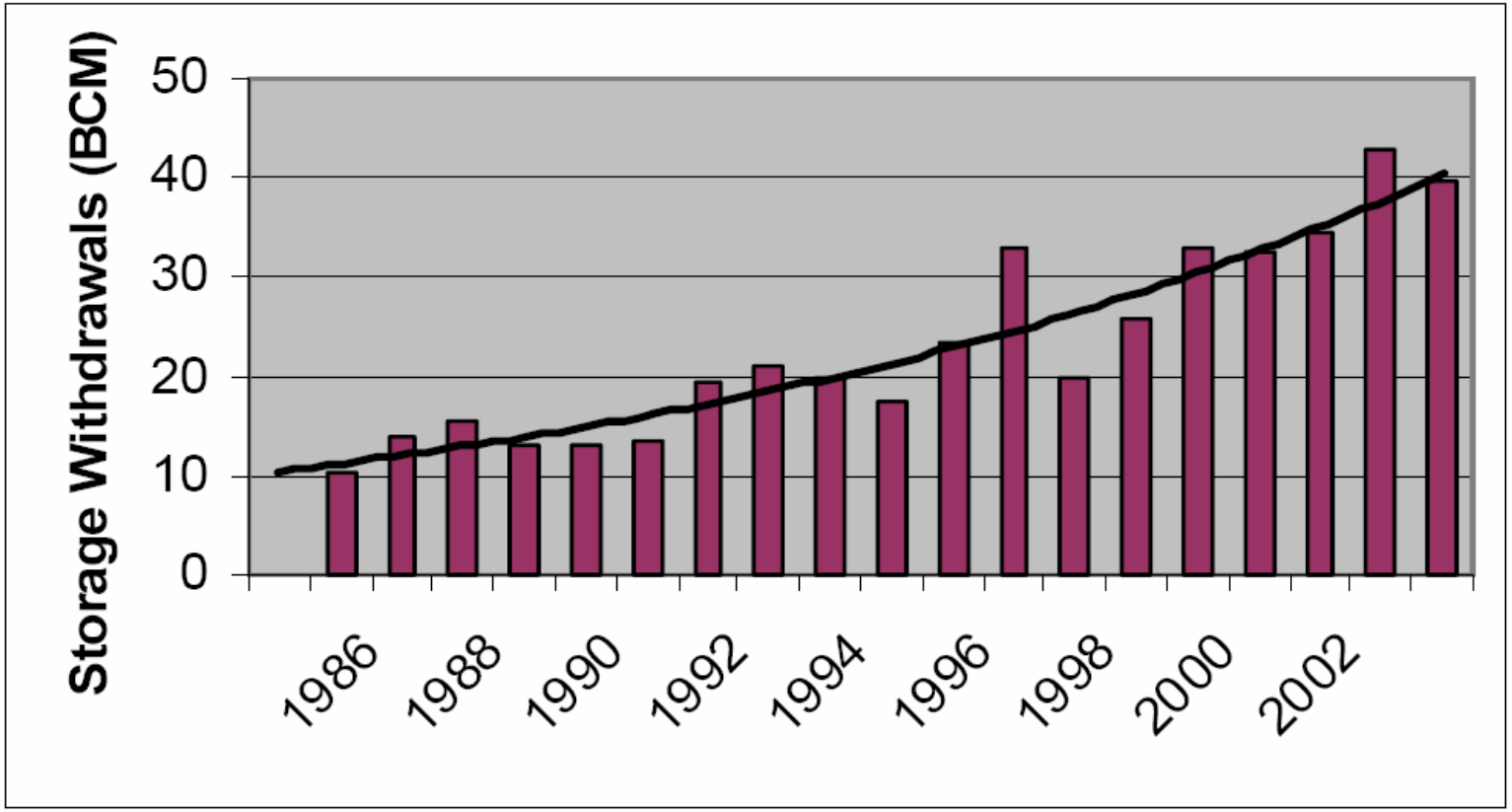
For most small customers, individual demand reaction is limited and, for household customers in particular, demand itself varies strongly depending on the temperature. Customers linked to a distribution grid with a 'public good' character cannot individually value reliability of supply.

In the short term, security of supply covers the adequacy of supply and capacity to avoid unforeseen interruptions of customers. In the long term, it includes the capacity to mobilise investment to develop supply and infrastructure as well as the insurance assets to ensure reliable supply.

Security of supply is best seen in terms of risk management, i.e., reducing to an acceptable level the risks and consequences of disruptions. Management of risk is a central activity for the gas industry and its customers. Where possible, market mechanisms should be the basis of security decisions. Nevertheless, governments do have a role to play:

- In providing a market framework and its implementation that ensure gas markets can work properly;
- In setting a framework in which risks can be managed and costs reduced, in particular through securing an international framework for investment and trade, and facilitating interconnection and exchanges among neighbouring countries;
- In determining acceptable reliability levels, especially where small customers and safety are concerned;
- In providing a clear policy for dealing with emergency situations.

OECD Europe Withdrawal from UGS increased by 8%/a



OECD Europe - expected Working Gas Withdrawal

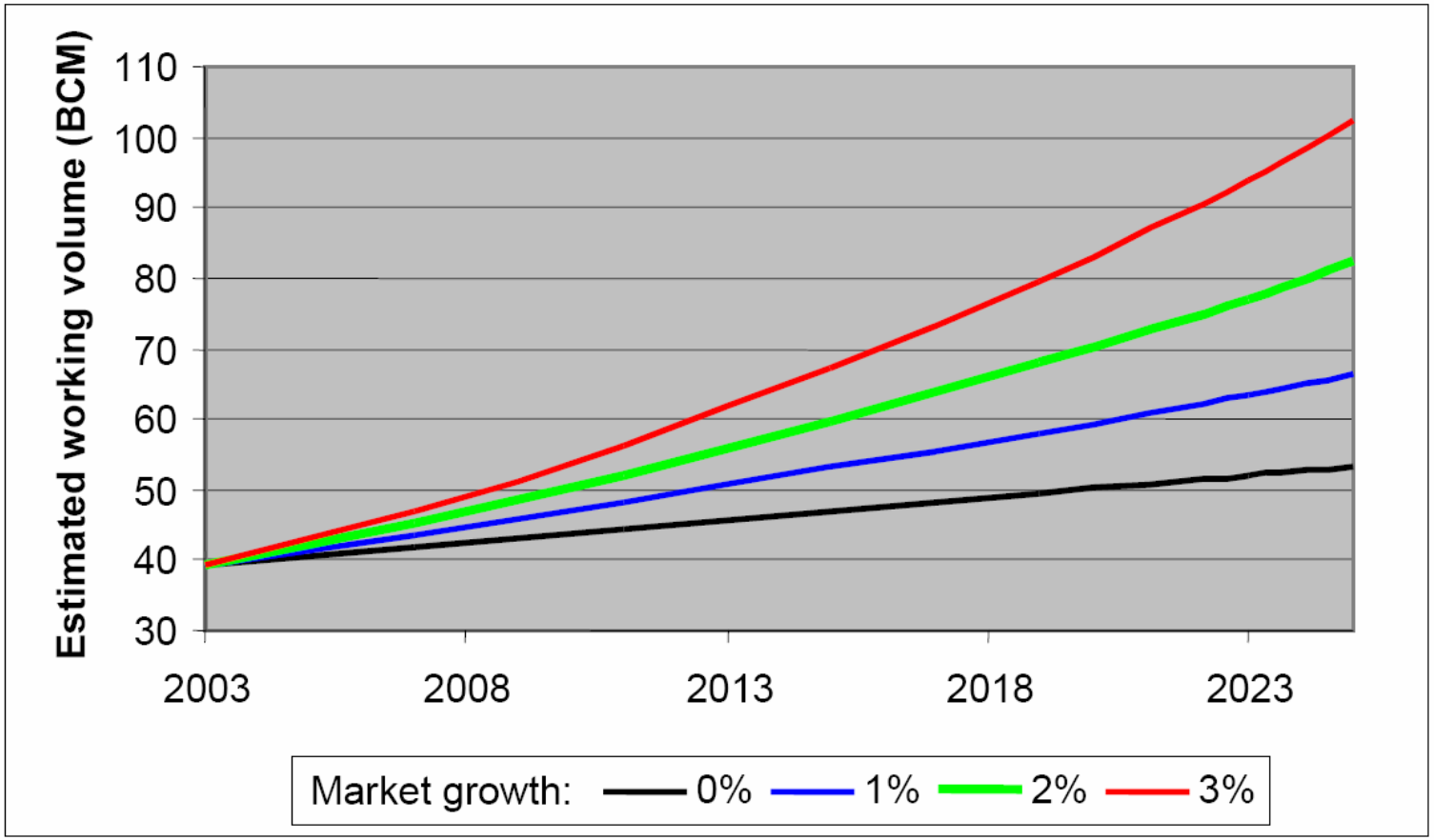


Figure 6: Required working volume for normal winters

OECD Europe - expected required Working Gas Volumes

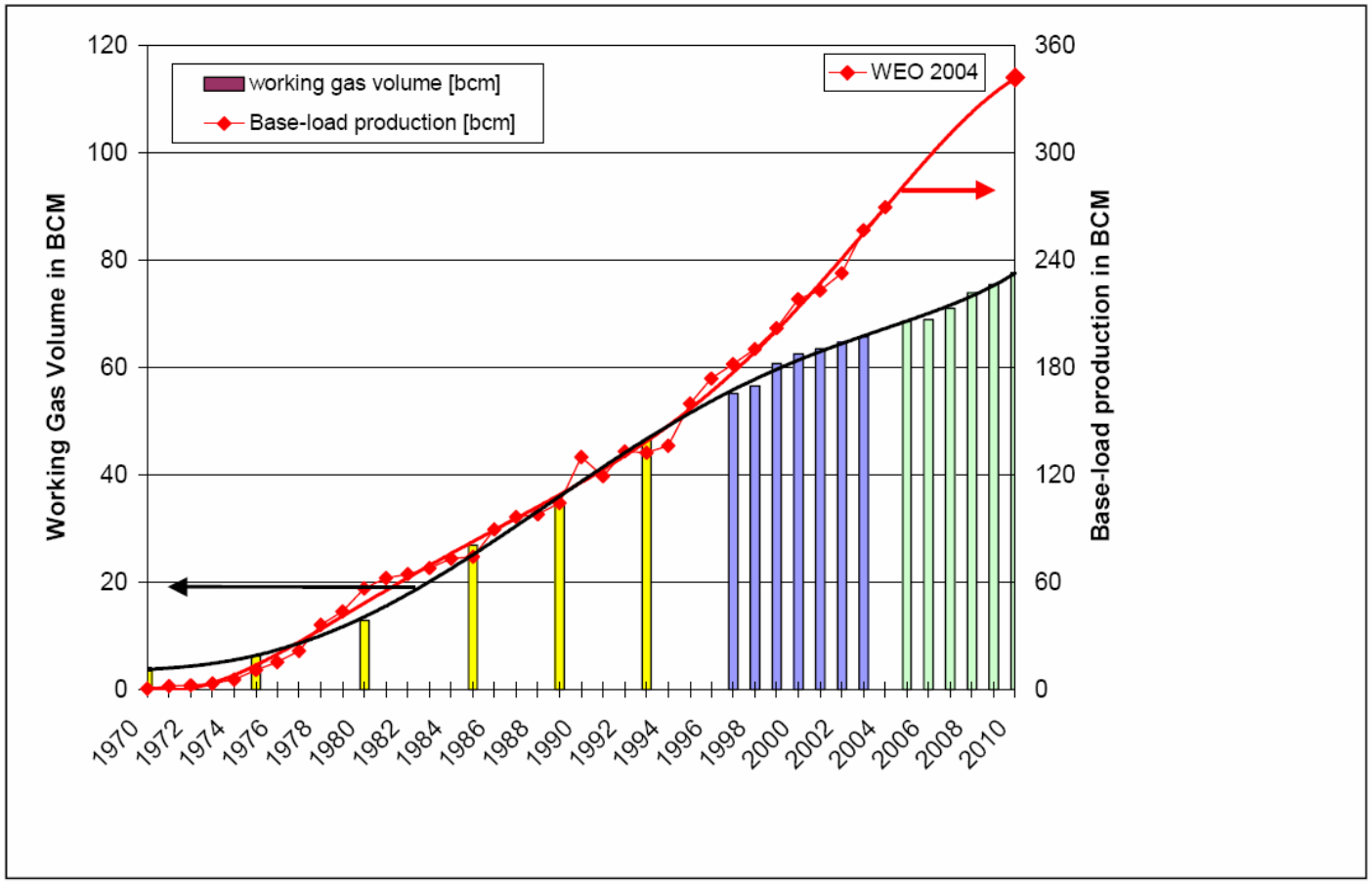


Figure 7. Build up of the storage working volume in OECD Europe in relation with the total base load production for Europe from Norway, Russia and Algeria[16].

OECD Europe – Storage Tariffs

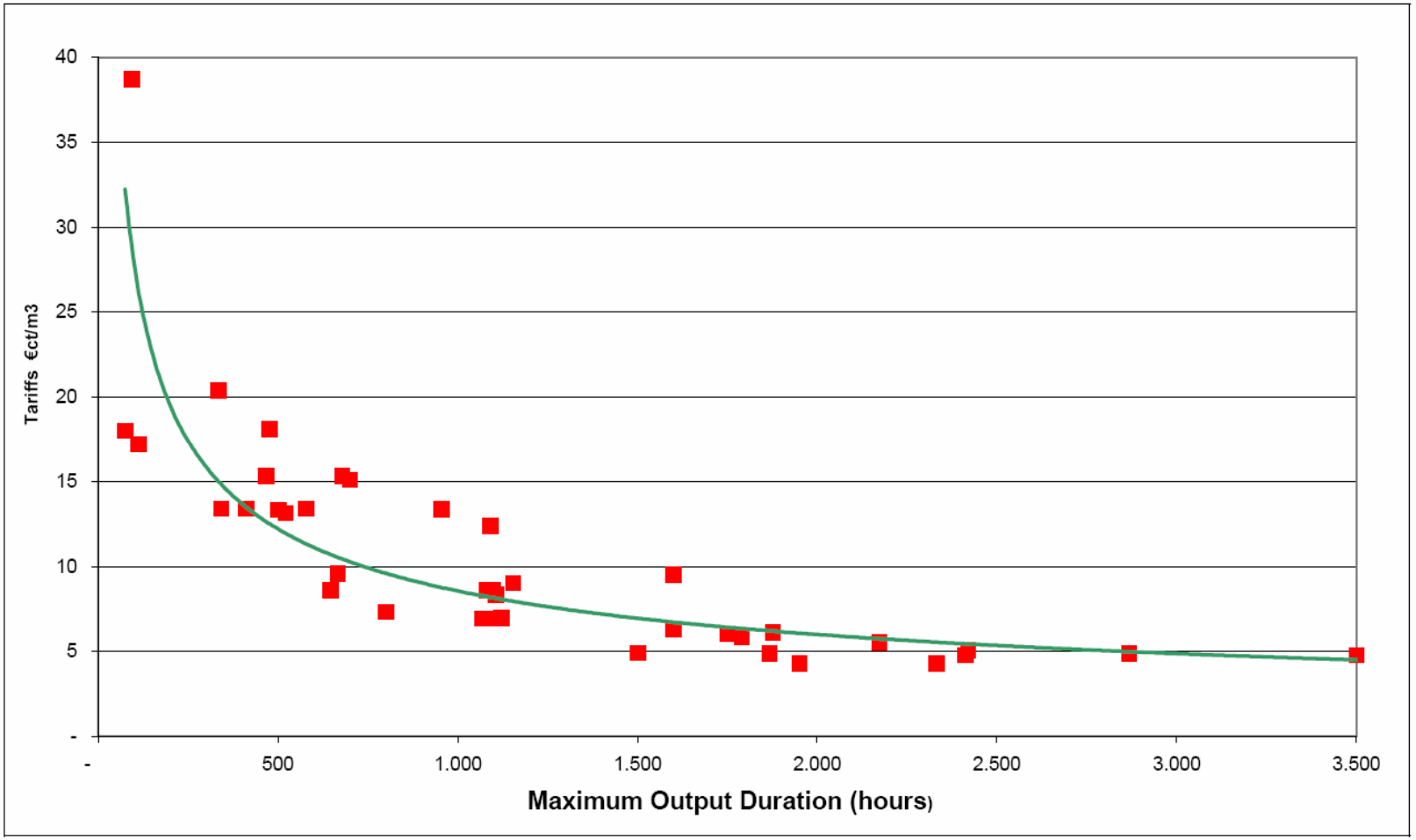


Figure 8: Storage Tariffs in North West Europe (2005)

Glossary of relevant UGS Terminology

Глоссарий ПХГ - русский язык

Глоссарий терминологии связанной с технологией Подземного Хранения Газа

Возможности Глоссария
Глоссарий охватывает техническую терминологию, связанную с хранением природного газа в подземных газовых хранилищах. Терминология может быть пригодна и для хранения водорода, CO_2, O_2 и других газов.

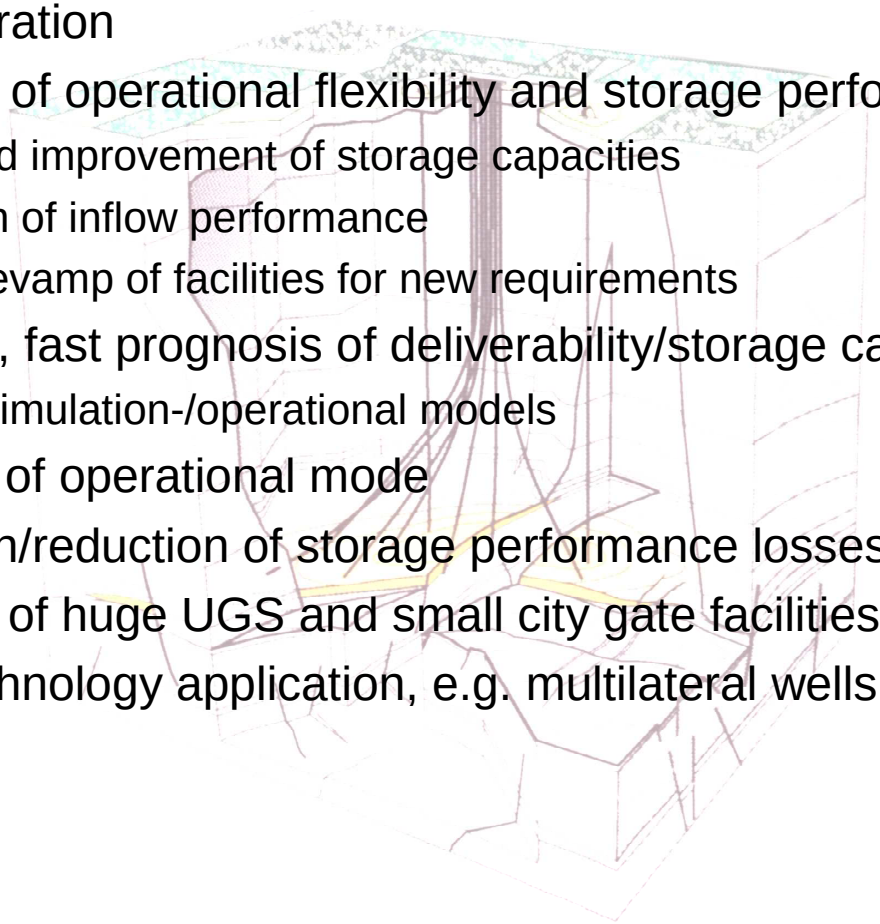
English Term	Термин	Определение
Underground Gas Storage (UGS)	Подземное хранилище газа (ПХГ)	Сложное геолого-технические сооружение, создаваемое в естественных пластовых структурах, пригодное для закачки, хранения и отбора природного газа и предназначающееся для регулирования неравномерности газопотребления путем образования запасов газа.
Type of Storage	Типы хранилищ	Есть несколько типов подземных газовых хранилищ, которые отличаются механизмом формирования и хранения: Хранилища в пористых средах

Glossary

English | Deutsch | Francais | Italiano | Czech | Russia

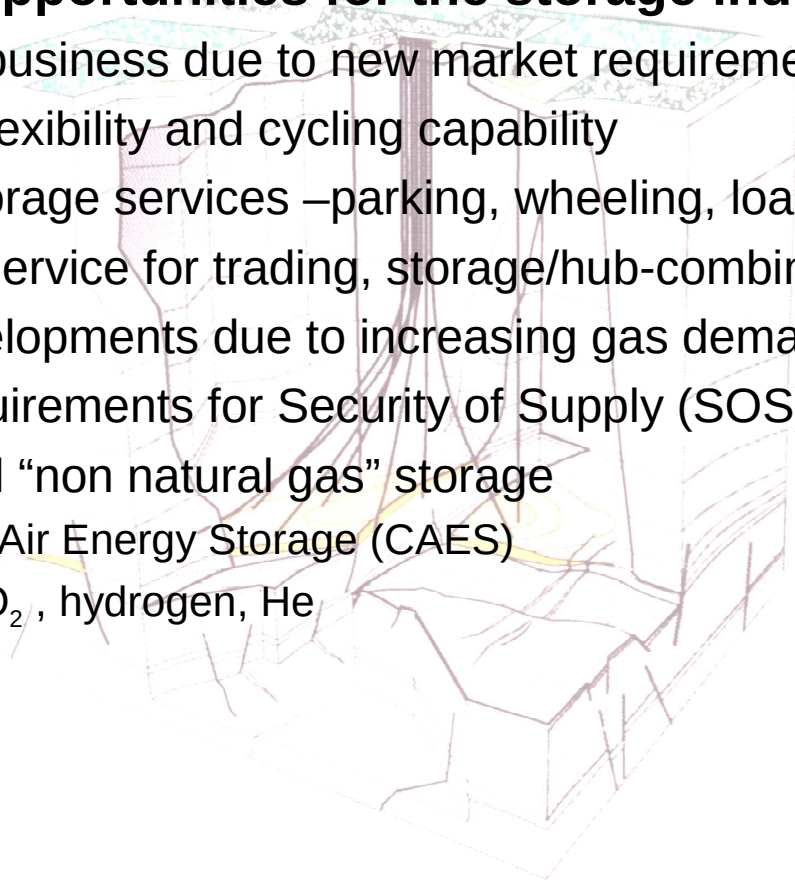
Trends in UGS Business Technological Issues

- **Technological issues related to:**
  - safety of operation
  - improvement of operational flexibility and storage performance
    - analysis and improvement of storage capacities
    - optimisation of inflow performance
    - re-design/revamp of facilities for new requirements
  - more precise, fast prognosis of deliverability/storage capacities
    - advanced simulation-/operational models
  - fast changes of operational mode
  - compensation/reduction of storage performance losses
  - development of huge UGS and small city gate facilities
  - improved technology application, e.g. multilateral wells

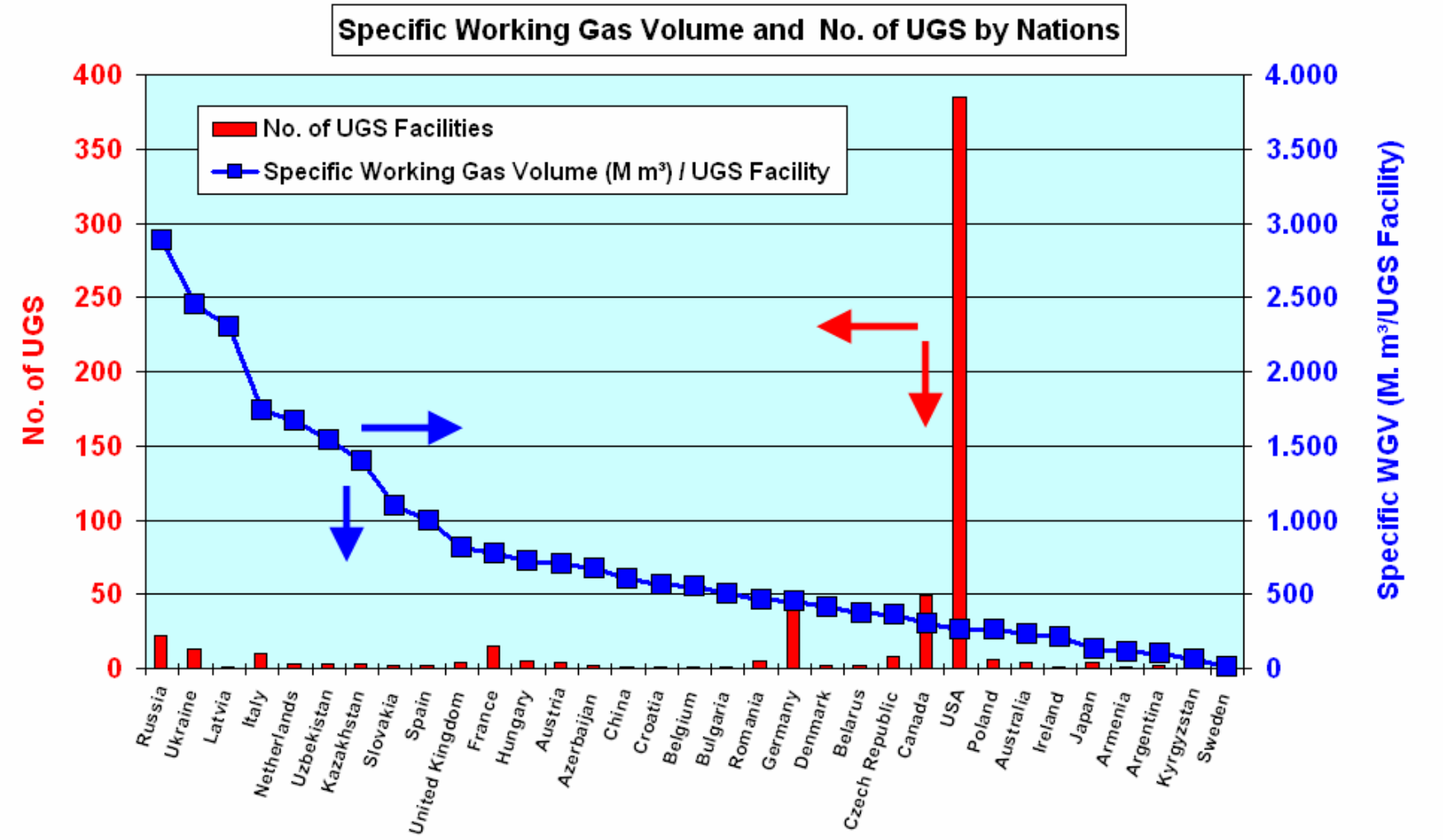


Trends in UGS Business - New Opportunities

- **New business opportunities for the storage industry:**
  - new products/business due to new market requirements / opportunities
  - higher peaks/flexibility and cycling capability
  - commercial storage services –parking, wheeling, loaning, title trading
  - more storage service for trading, storage/hub-combinations
  - new UGS developments due to increasing gas demand /loadstructure
  - increasing requirements for Security of Supply (SOS)
  - unconventional “non natural gas” storage
    - Compressed Air Energy Storage (CAES)
    - storage of CO_2 , hydrogen, He

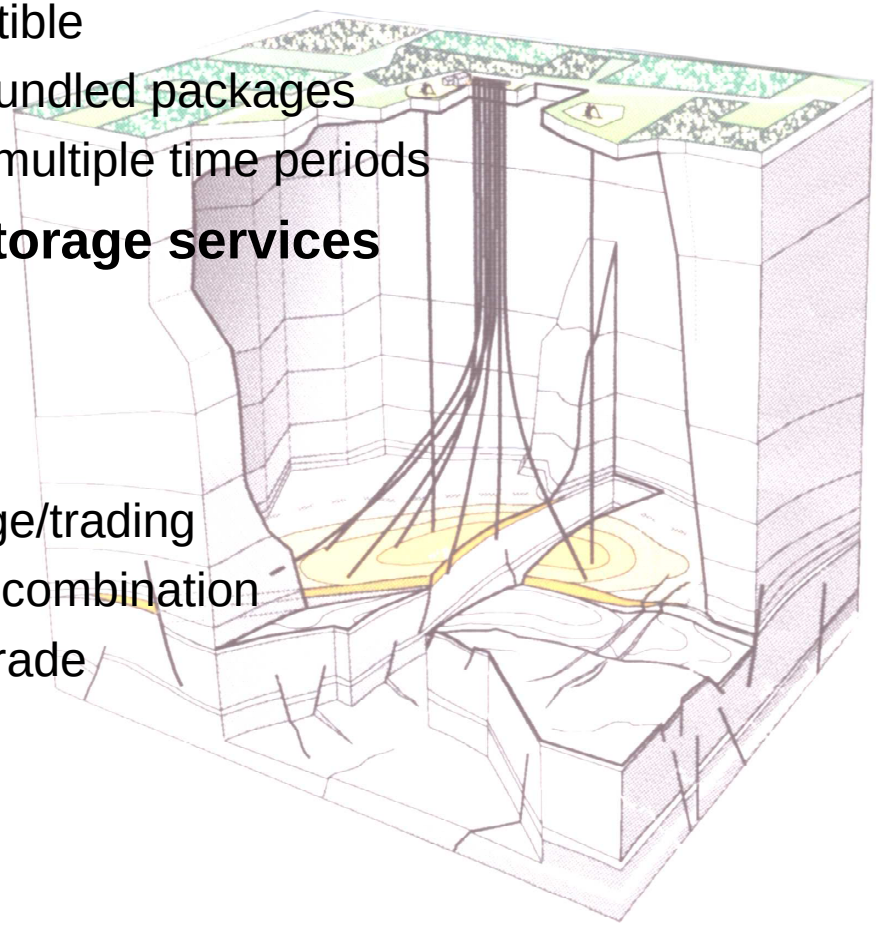


UGS Status in the World – No. of UGS

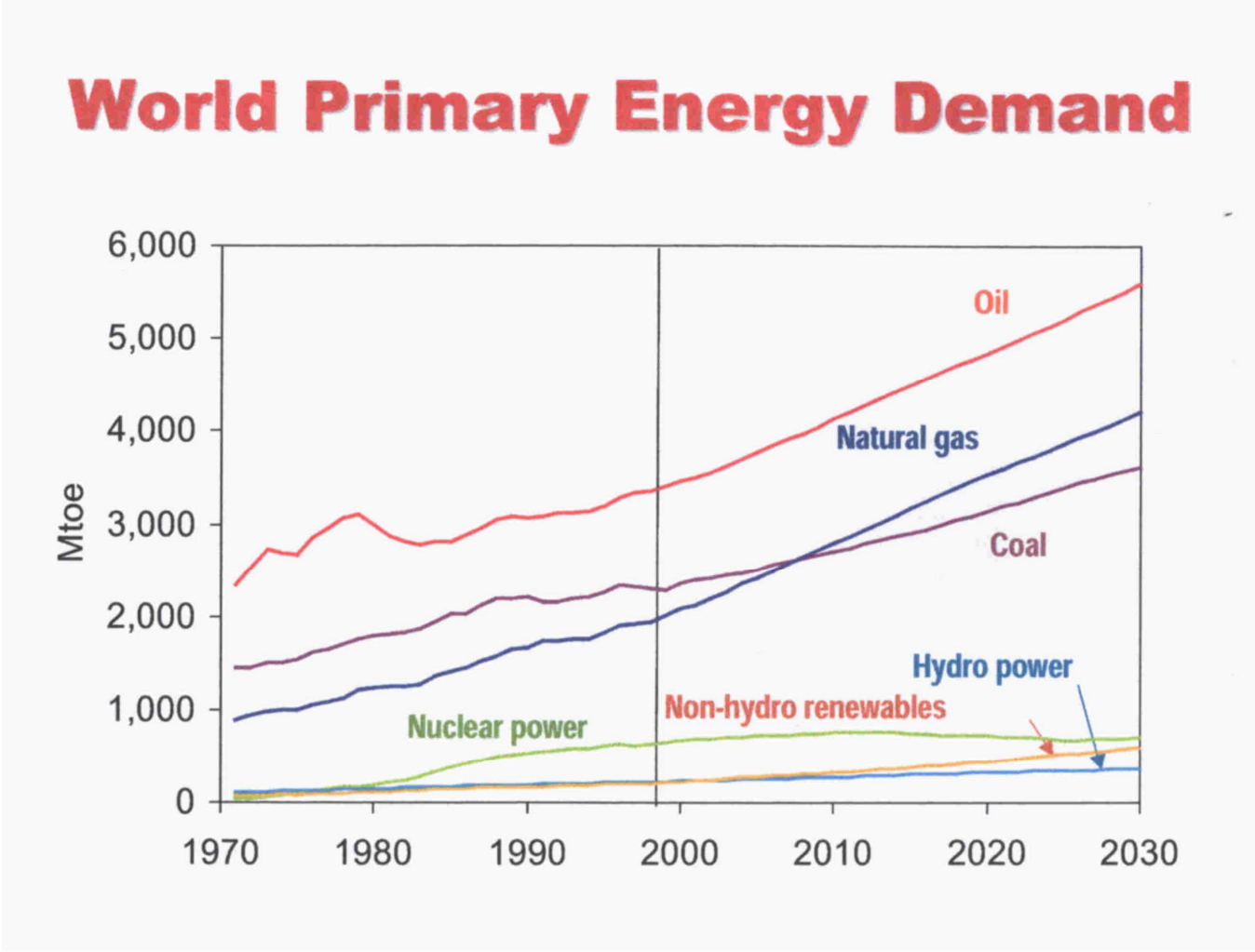


Future Trends in UGS Business Market Options

- **Variety of standard storage services:**
  - Firm/interruptible
  - Bundled/unbundled packages
  - Services for multiple time periods
- **Commercial storage services**
  - Parking
  - Wheeling
  - Loaning
  - Title exchange/trading
  - Storage/hub-combination
  - Hub-to-hub trade



World Energy Outlook - IEA 2002 -



Previous UGS Reports and Studies

Report	Published by	Status	Publication year	Data Content	Scope
Safety and environmental conditions for underground storage	IGU WOC A	1989	1991	Capacity and technical data per storage , incl. cushion gas	Some UGS in the world
Underground Gas Storage in the World - A new era of expansion	CEDIGAZ	1993	Dec. 1995	Capacity data per storage incl. cushion gas	All UGS in the world
Survey of Underground Storage of Natural Gas in the United States and Canada	AGA- American Gas Association	1996	1997	Capacity and technical data per storage incl. cushion gas	U.S. and Canada
WEFA Report	WEFA ENERGY	1996	1999	Capacity data per storage, incl. cushion gas	Europe + some East European Countries
Study on Underground Gas Storage in Europe and Central Asia	United Nations Economic Commission for Europe - Working Party on Gas	1995/96	1999	Capacity and technical data per storage (installed and planned, storage demand prognosis), incl. cushion gas	All UGS in Europe and Central Asia
U.S. Underground Storage of Natural Gas in 1997- Existing and Proposed	Energy Information Administration	1996/97	Sept 1997	Capacity data by state for planned projects	U.S.
Panorama of the Gas Industry in the IGU countries – Statistical Data (1995)/1999-2000 (2001)	IGU WOC 9- World Gas Prospects, Strategies and Economics – Statistics Group	2000/01	2001	Some capacity data per nation	All IGU UGS countries
WOC 2 Basic Activity Report – WGC 2003	IGU WOC 2	2001/02	2003	Capacity and technical data per storage (installed and planned, storage demand prognosis)	All UGS in the world