**Journées d' échanges Université-Industrie sur les Piles à Combustible et les systèmes Piles à Combustible**

Le 4 et 5 avril 2006, Technocentre Renault - Guyancourt

# *Research Projects on H2FC in Romania A Brief Presentation of the Romanian Alliance for Hydrogen & Fuel Cell Technologies*

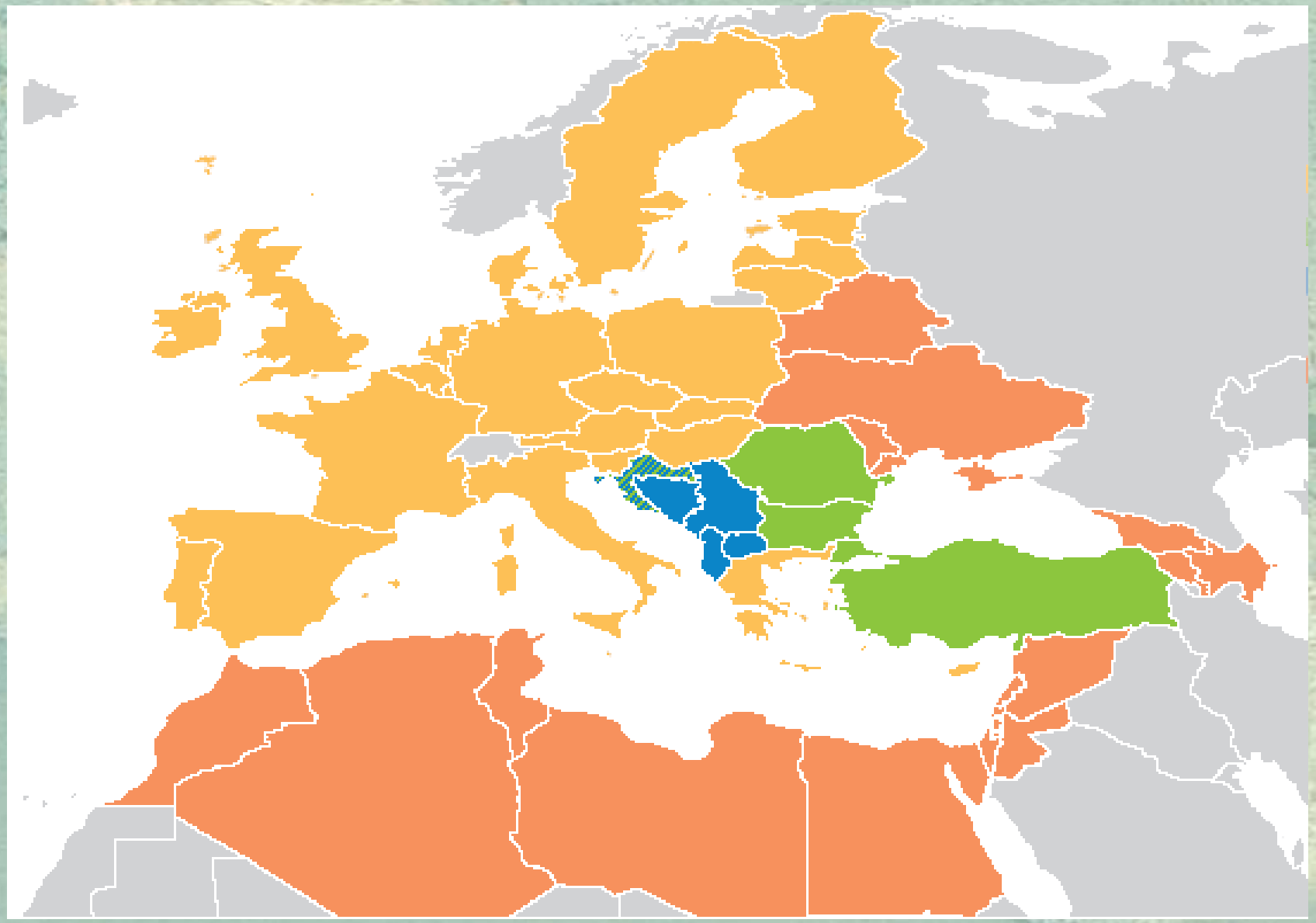
Prof. Dr. Eden MAMUT

**"Ovidius" University of Constantza**

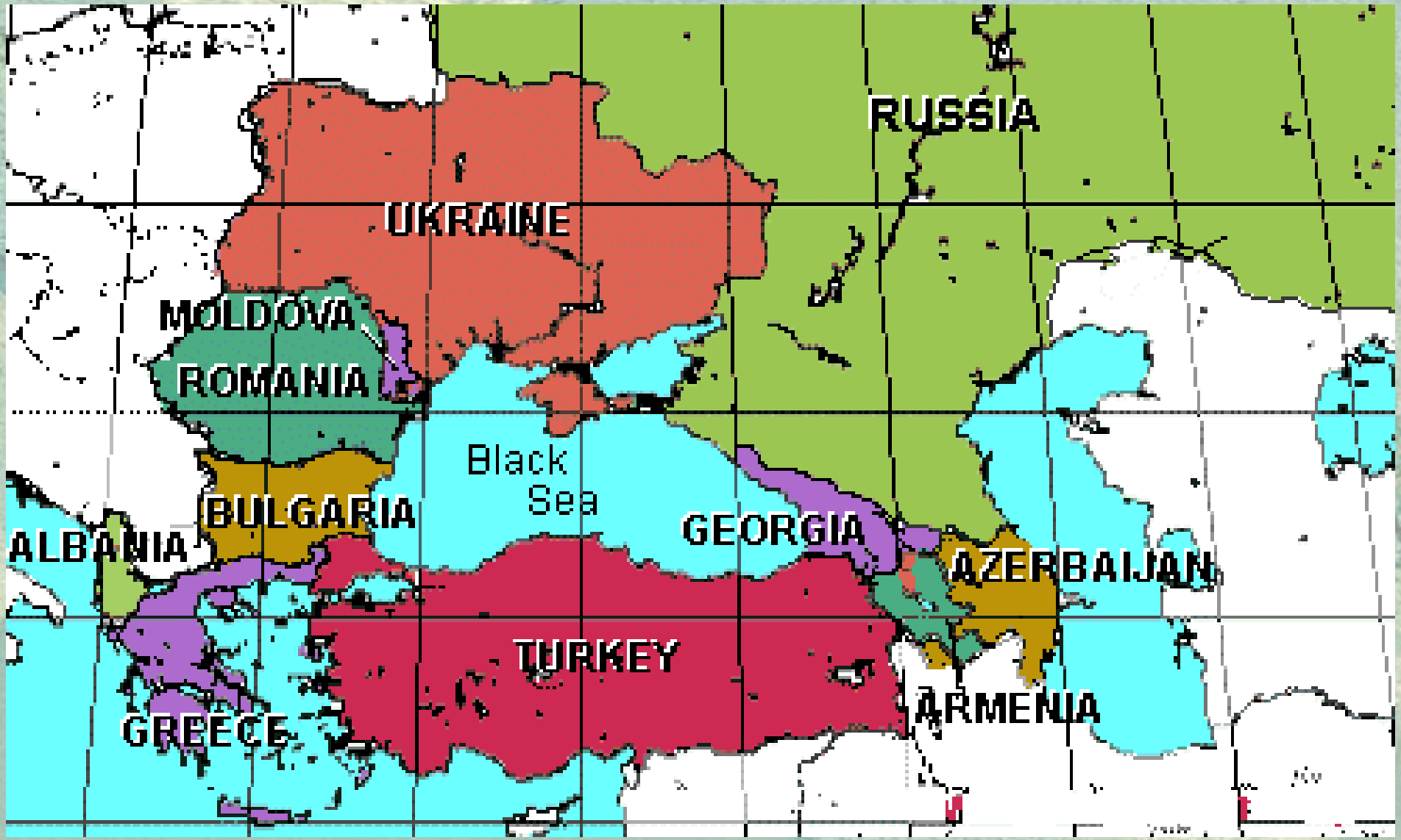
# OUTLINE

1. Romania – General information
2. Major concerns
3. SWOT
4. Research groups
5. Romanian Alliance on H2&FC
6. PROMETHEUS
7. METEORA
8. NANOFLUIDS
9. VENTURE
10. HY DANUBE

# ROMANIA – GENERAL INFORMATION I



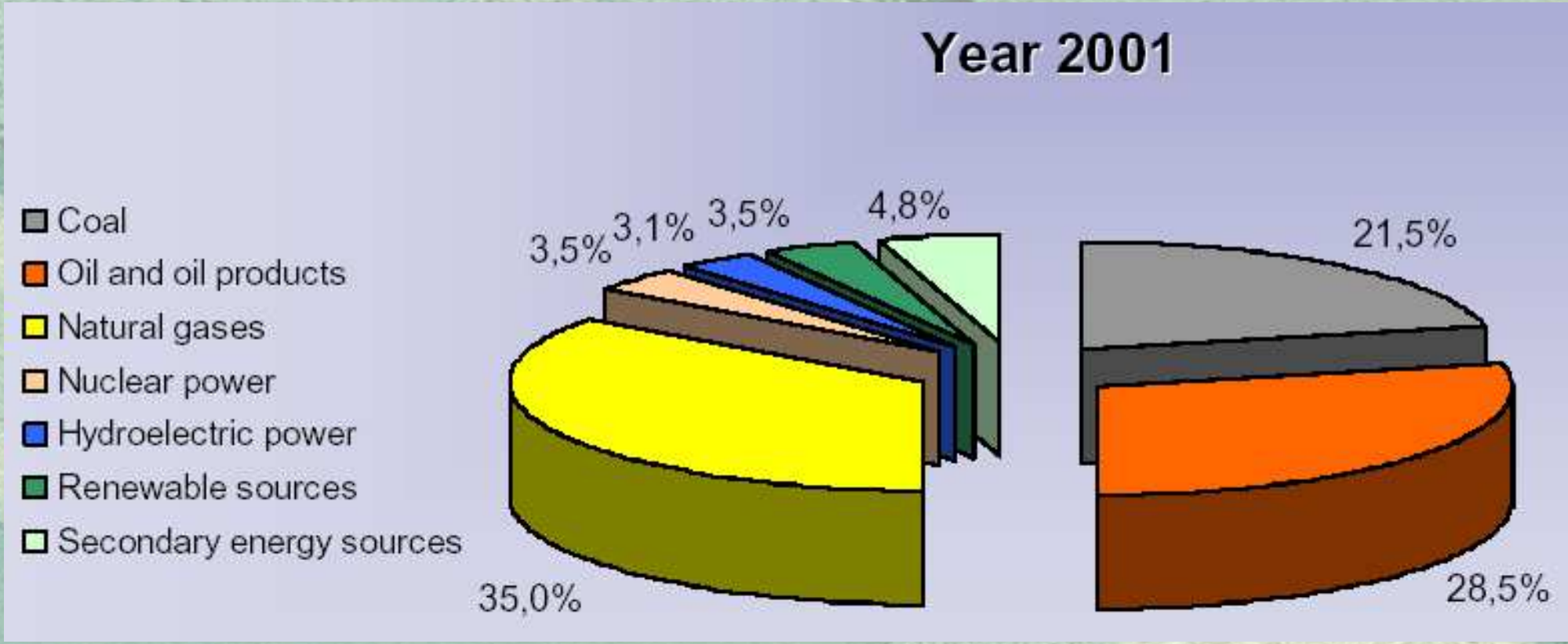
# ROMANIA – GENERAL INFORMATION II



# ROMANIA – GENERAL INFORMATION III

| | |
|---|---|
| • Population | 22,329,977 (July 2005 est.) |
| • Territory Surface | 237,500 $km^2$ |
| • Gross Domestic Product | $186.4 billion (2005 est.) |
| • GDP per head | $8,300 (2005 est.) |
| • Export | $27.72 billion f.o.b. (2005 est.) |
| • Growth rate | 5.2% (2005 est.) |
| • Structure of the Economy | |
| – Industry | 33.7 % |
| – Agriculture | 13.1 % |
| – Commerce & Services | 53.2 % |
| • Electricity production/consumption | 51.7/45.16 billion kWh (2003) |
| • Oil production/consumption | 119,000/ 235,000 bbl/day (2003 est.) |
| • NG production/consumption | 12.6/18.5 billion $m^3$ (2003 est.) |
| • Oil proved reserves | 1.055 billion bbl (1 January 2002) |
| • NG proved reserves | 111.1 billion $m^3$ (1 January 2002) |

# ROMANIA – GENERAL INFORMATION IV



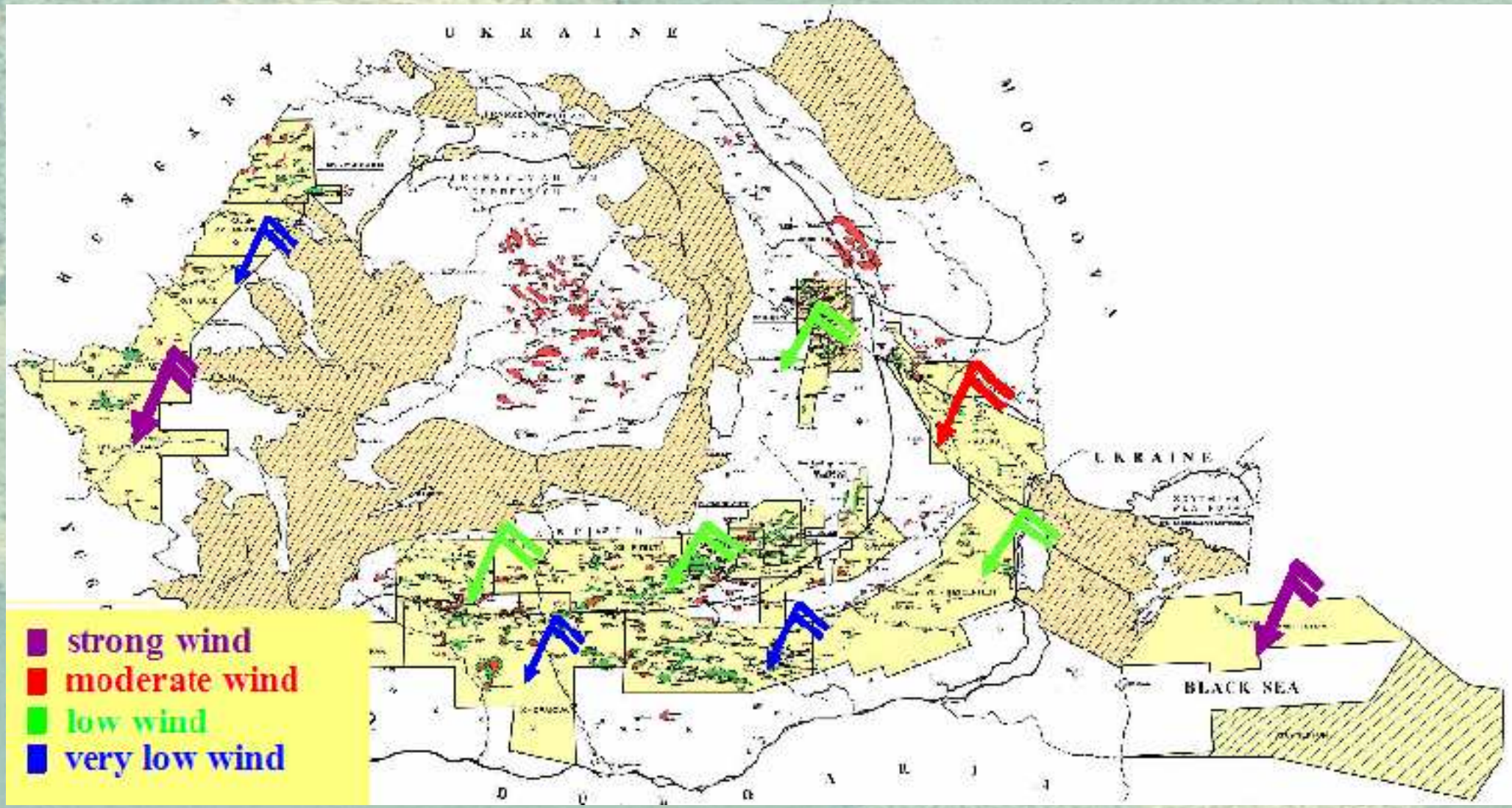
# POTENTIAL ON RES I

- **The "The National Strategy on Renewable Energy Sources", drawn up by the Ministry of Economy and Commerce in 2003, proposes for 2015 as target a share of renewable sources of about 10% of the overall demand.**

- **The overall hydroelectric potential 40 TWh/ year**

- **Wind energy resources 2000 MW**

# POTENTIAL ON RES II



# THE BLACK SEA


**Surface: 413 488 Km$^2$**

**Maximum depth: 2245 m**

**Volume of water: 529 955 km$^3$**

**Average salinity: 18 mg/liter**

**Shore length: 4790 km**

**Riparian countries: Georgia, Russia, Ukraine, Romania, Bulgaria, Turkey**

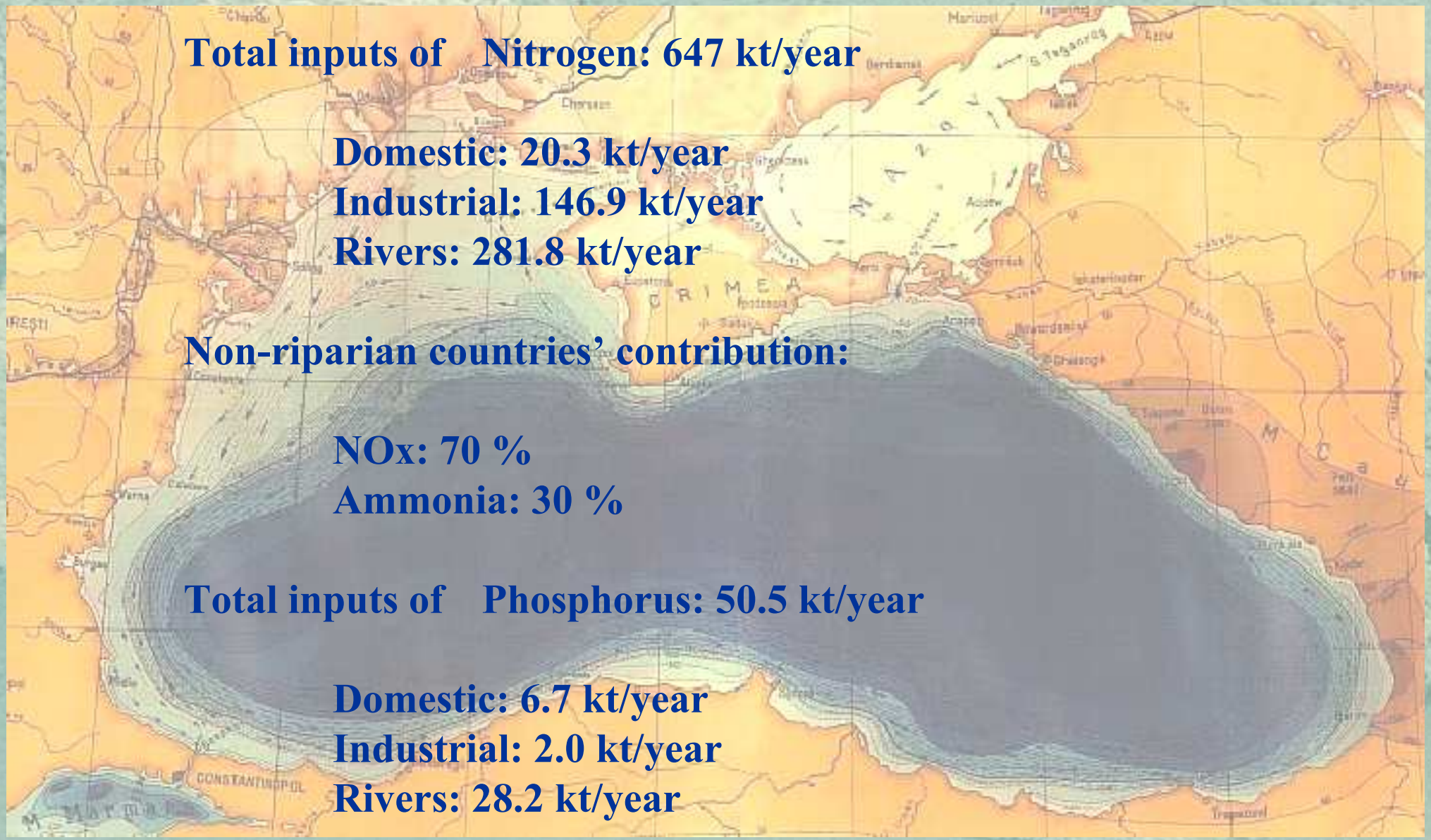
**Main Rivers: Danube, Dniestr, Dnieper – 70% fresh water supply**

**Outflow through Bosphorous: 610 km$^3$/year**

**Danube contribution: 250 km$^3$/year**

**Anoxic waters: under 150m**

# THE BLACK SEA POLLUTION




**Total inputs of Nitrogen: 647 kt/year**

**Domestic: 20.3 kt/year**
**Industrial: 146.9 kt/year**
**Rivers: 281.8 kt/year**

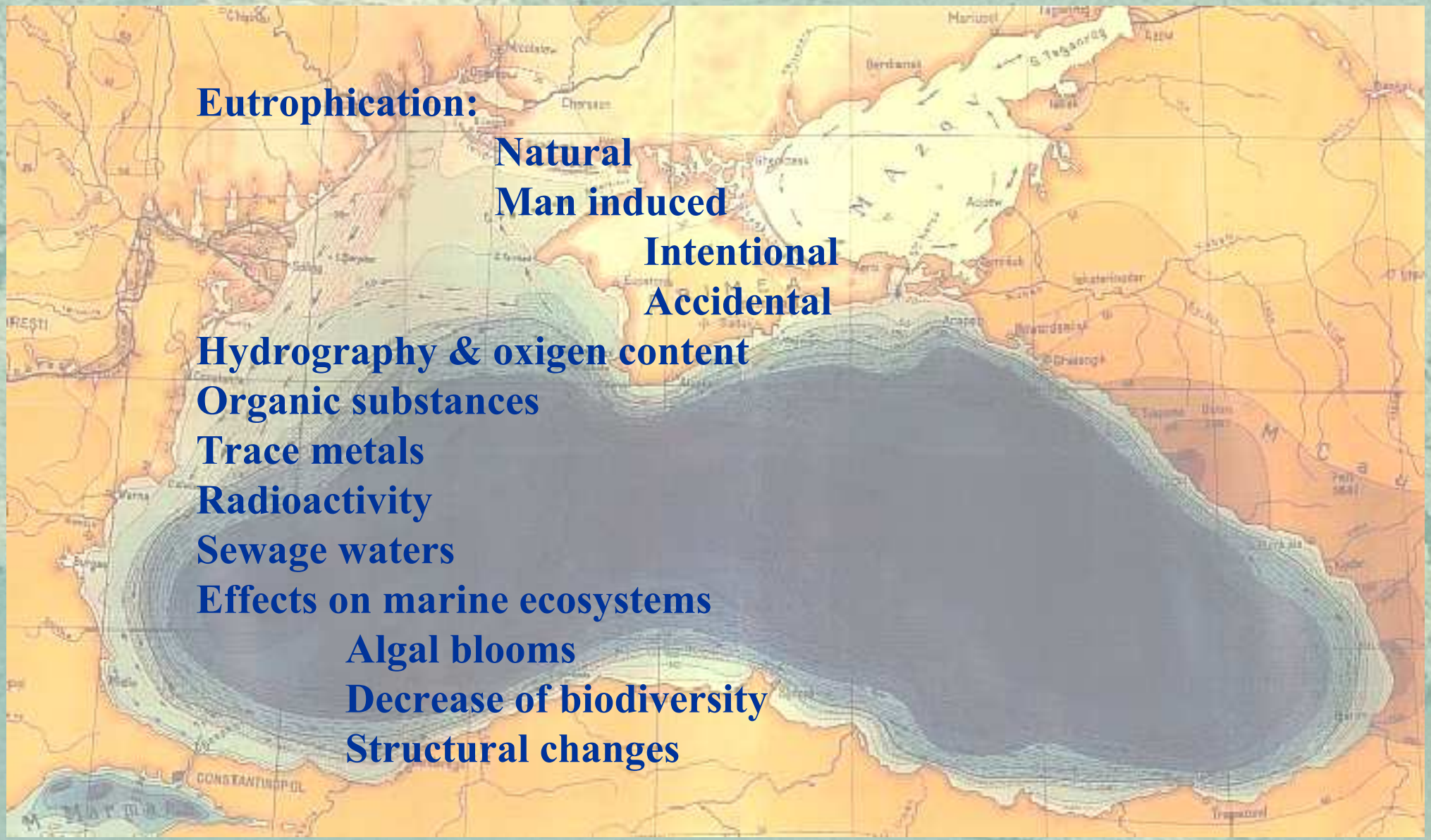
**Non-riparian countries' contribution:**

**NOx: 70 %**
**Ammonia: 30 %**

**Total inputs of Phosphorus: 50.5 kt/year**

**Domestic: 6.7 kt/year**
**Industrial: 2.0 kt/year**
**Rivers: 28.2 kt/year**

# EFFECTS OF POLLUTION



**Eutrophication:**

- **Natural**
- **Man induced**
  - **Intentional**
  - **Accidental**

**Hydrography & oxigen content**

**Organic substances**

**Trace metals**

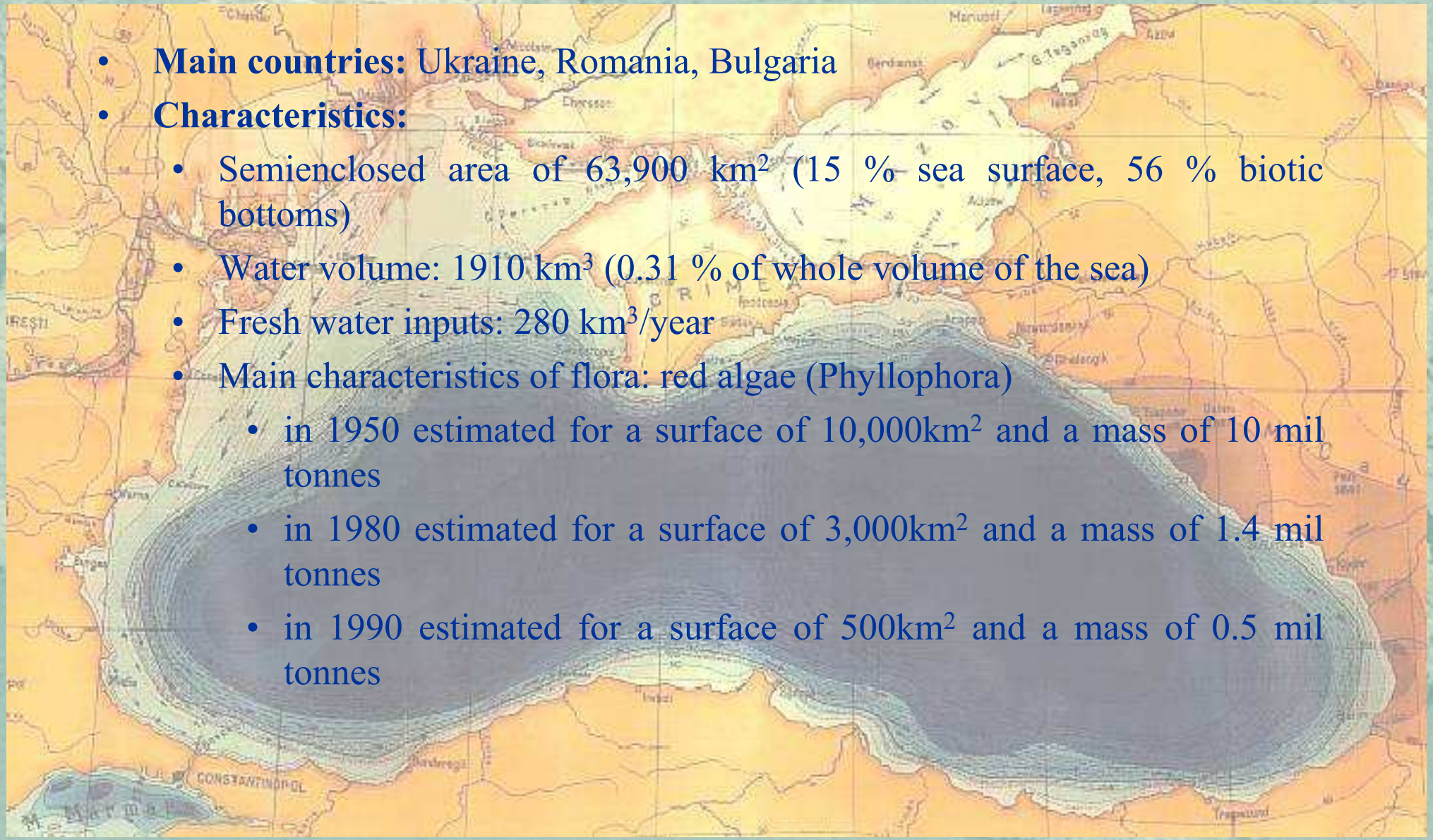
**Radioactivity**

**Sewage waters**

**Effects on marine ecosystems**

- **Algal blooms**
- **Decrease of biodiversity**
- **Structural changes**

# BLACK SEA WEST COAST

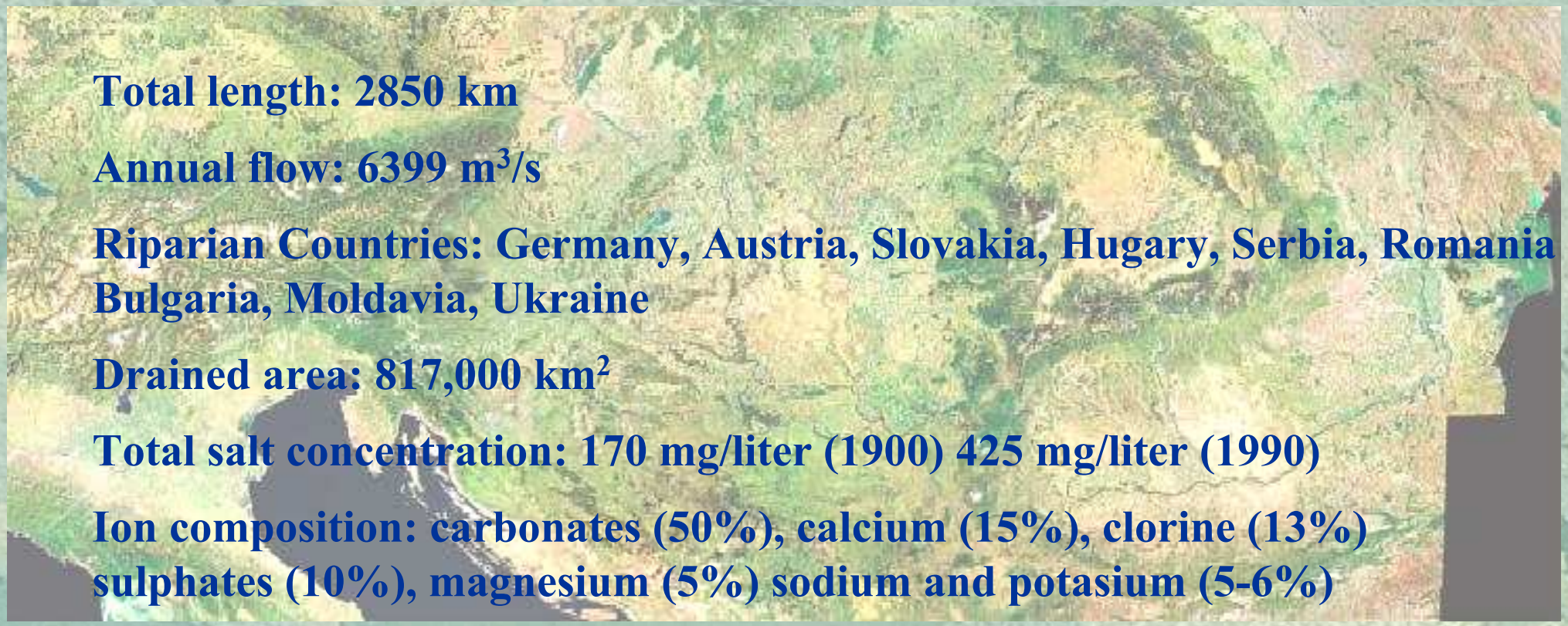


- **Main countries:** Ukraine, Romania, Bulgaria
- **Characteristics:**
  - Semienclosed area of 63,900 km$^2$ (15 % sea surface, 56 % biotic bottoms)
  - Water volume: 1910 km$^3$ (0.31 % of whole volume of the sea)
  - Fresh water inputs: 280 km$^3$/year
  - Main characteristics of flora: red algae (Phyllophora)
    - in 1950 estimated for a surface of 10,000km$^2$ and a mass of 10 mil tonnes
    - in 1980 estimated for a surface of 3,000km$^2$ and a mass of 1.4 mil tonnes
    - in 1990 estimated for a surface of 500km$^2$ and a mass of 0.5 mil tonnes

# DANUBE


GERMANY
SLOVAKIA
AUSTRIA
HUNGARY
ROMANIA
CROATIA
SERBIA
MOLDOVA
UKRAINE
Black Sea
Vienna
Budapest
Belgrade
Sofia
Bucharest
Istanbul

# DANUBE



**Total length: 2850 km**

**Annual flow: 6399 $m^3/s$**

**Riparian Countries: Germany, Austria, Slovakia, Hugary, Serbia, Romania Bulgaria, Moldavia, Ukraine**

**Drained area: 817,000 $km^2$**

**Total salt concentration: 170 mg/liter (1900) 425 mg/liter (1990)**

**Ion composition: carbonates (50%), calcium (15%), clorine (13%) sulphates (10%), magnesium (5%) sodium and potasium (5-6%)**

**Total inputs of nitrogen: 355 kt/year (1992) versus 50 kt/year (1960)**

**Total inputs of phosphorus: 22 kt/year (1992) versus 14 kt/year (1960) maxium 63 kt/year (1988)**

# DOBROGEA

**Total surface: 1,557 kha**

**Farming land: 931.5 kha**

**Forests: 128.3 kha**

**Inland water surface: 396.8 kha**

**Shore line: 245 km**

**Total cereals: 1,166 mt/year**

# CONSTANTZA

# PAST EXPERIENCE ON $H_2$

- National Program initiated in 1976
- Production & storage
- Fuel cells
- National Program: MENER
- European Technology Platform for Fuel Cells
- Project HyWays

# STRENGTHS

- Potential on RES
- Processing Industry
  - Oil processing industry
  - Food & Chemical Processing Sector
  - Sewage treatment
  - Biotechnologies & bioprocessing
- Research Facilities & Expertise
  - Specialized research institutes
  - National Programs: MENER, BIOTECH, MATNANTECH, CEEX
  - Network of Industry & Research
    - Romanian Alliance on Hydrogen & Fuel Cell Technologies
    - National Platform for Energy
    - Industry WG on Alternative Fuels

# WEAKNESSES

- Lack of Investment Funds
  - The upgrade of the Romanian society to EU standards require huge investment funds
  - Low economical performances
  - Low involvement of the private & venture capitals
- Lack of Managerial & Marketing Culture
  - Unfinished transition from a centralized economy to free market economy
- Non-mature Energy Market
  - Weak Actors with low experience

# OPPORTUNITIES

- A significant National Market for AF
  - Estimation of the Romanian market in 2015
  - Perspectives
- A growing EU Market
  - Estimation of the EU market in 2015
  - Perspectives
- Available EU Funds for RTD
  - Research
  - Demonstration
  - Kyoto Protocol

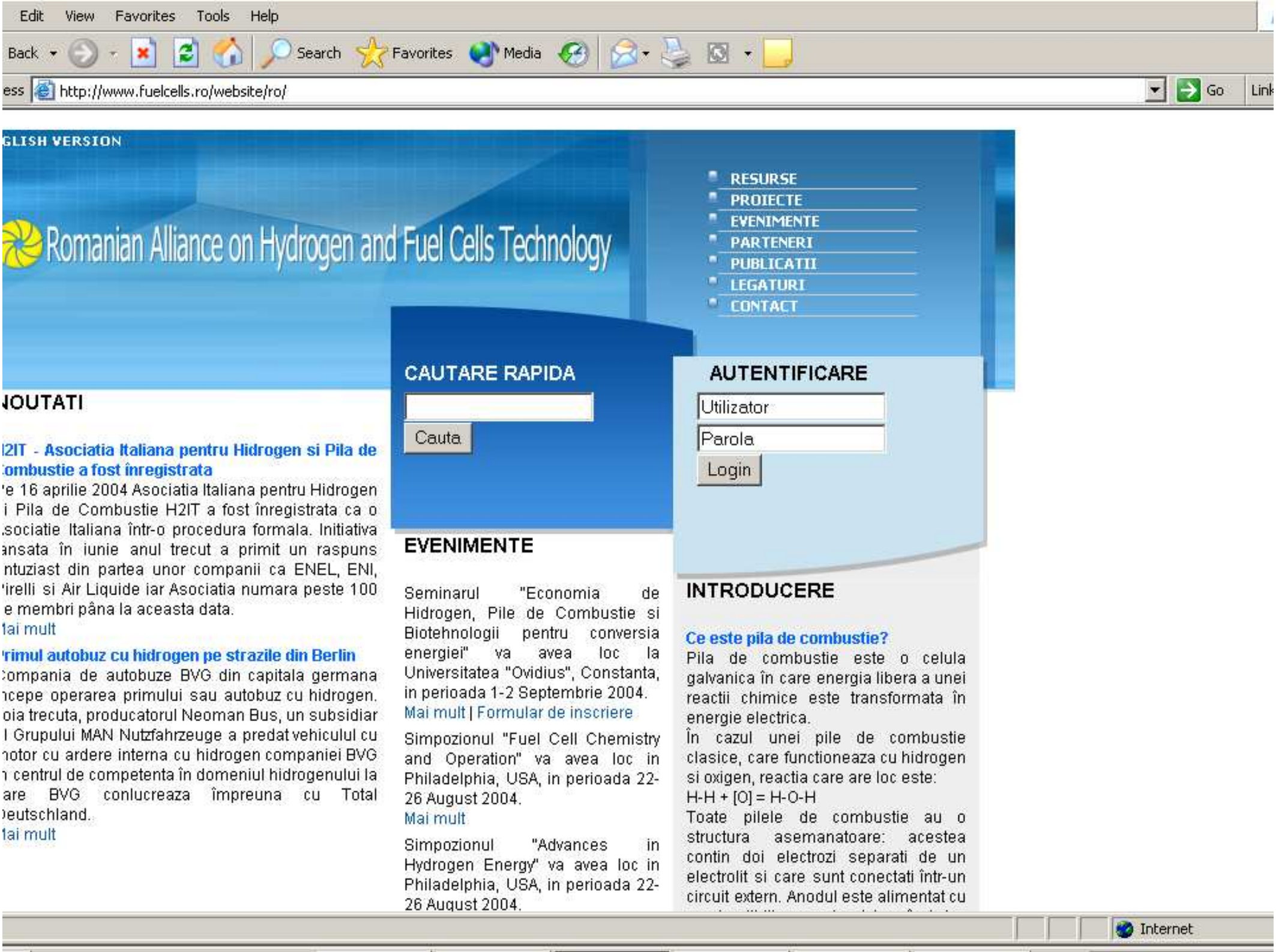
# THREATS

- Competition within EU
  - Existence of major players that have invested in technology, have resources to enter in the market and have marketing experience
- Costs of Implementation & Production
  - Production costs are higher than classical fuels
  - Costs of marketing, distribution & service

# OPTIONAL STRATEGIES

- Definition of a National Strategy for Hydrogen Economy
  - National Strategy for Sustainable Development
  - Accession to EU
  - Sectorial strategies
- Identification of Niches on the EU Market
  - Active role in the European Technology Platform
- Concentration of Available Resources & Expertise
  - National RTD strategy
  - National Technology Platforms
- Development of strategic alliances with major players on the market

# RESEARCH GROUPS


Edit View Favorites Tools Help
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http://www.fuelcells.ro/website/ro/
Go
GLISH VERSION
Romanian Alliance on Hydrogen and Fuel Cells Technology
RESURSE
PROIECTE
EVENIMENTE
PARTENERI
PUBLICATII
LEGATURI
CONTACT
CAUTARE RAPIDA
Cauta
AUTENTIFICARE
Utilizator
Parola
Login
NOUTATI
I2IT - Asociatia Italiana pentru Hidrogen si Pila de Combustie a fost înregistrata
e 16 aprilie 2004 Asociatia Italiana pentru Hidrogen i Pila de Combustie H2IT a fost înregistrata ca o sociatie Italiana într-o procedura formala. Initiativa ansata în iunie anul trecut a primit un raspuns ntuziast din partea unor companii ca ENEL, ENI, irelli si Air Liquide iar Asociatia numara peste 100 e membri pâna la aceasta data.
Mai mult
Primul autobuz cu hidrogen pe strazile din Berlin
Compania de autobuze BVG din capitala germana ncepe operarea primului sau autobuz cu hidrogen. oia trecuta, producatorul Neoman Bus, un subsidiar l Grupului MAN Nutzfahrzeuge a predat vehiculul cu notor cu ardere interna cu hidrogen companiei BVG n centrul de competenta în domeniul hidrogenului la are BVG conlucreaza împreuna cu Total eutschland.
Mai mult
EVENIMENTE
Seminarul "Economia de Hidrogen, Pile de Combustie si Biotehnologii pentru conversia energiei" va avea loc la Universitatea "Ovidius", Constanta, in perioada 1-2 Septembrie 2004.
Mai mult | Formular de inscriere
Simpozionul "Fuel Cell Chemistry and Operation" va avea loc in Philadelphia, USA, in perioada 22-26 August 2004.
Mai mult
Simpozionul "Advances in Hydrogen Energy" va avea loc in Philadelphia, USA, in perioada 22-26 August 2004.
INTRODUCERE
Ce este pila de combustie?
Pila de combustie este o celula galvanica în care energia libera a unei reactii chimice este transformata în energie electrica.
În cazul unei pile de combustie clasice, care functioneaza cu hidrogen si oxigen, reactia care are loc este:
H-H + [O] = H-O-H
Toate pilele de combustie au o structura asemanatoare: acestea contin doi electrozi separati de un electrolit si care sunt conectati într-un circuit extern. Anodul este alimentat cu
Internet

# CENTER FOR ADVANCED ENGINEERING SCIENCES

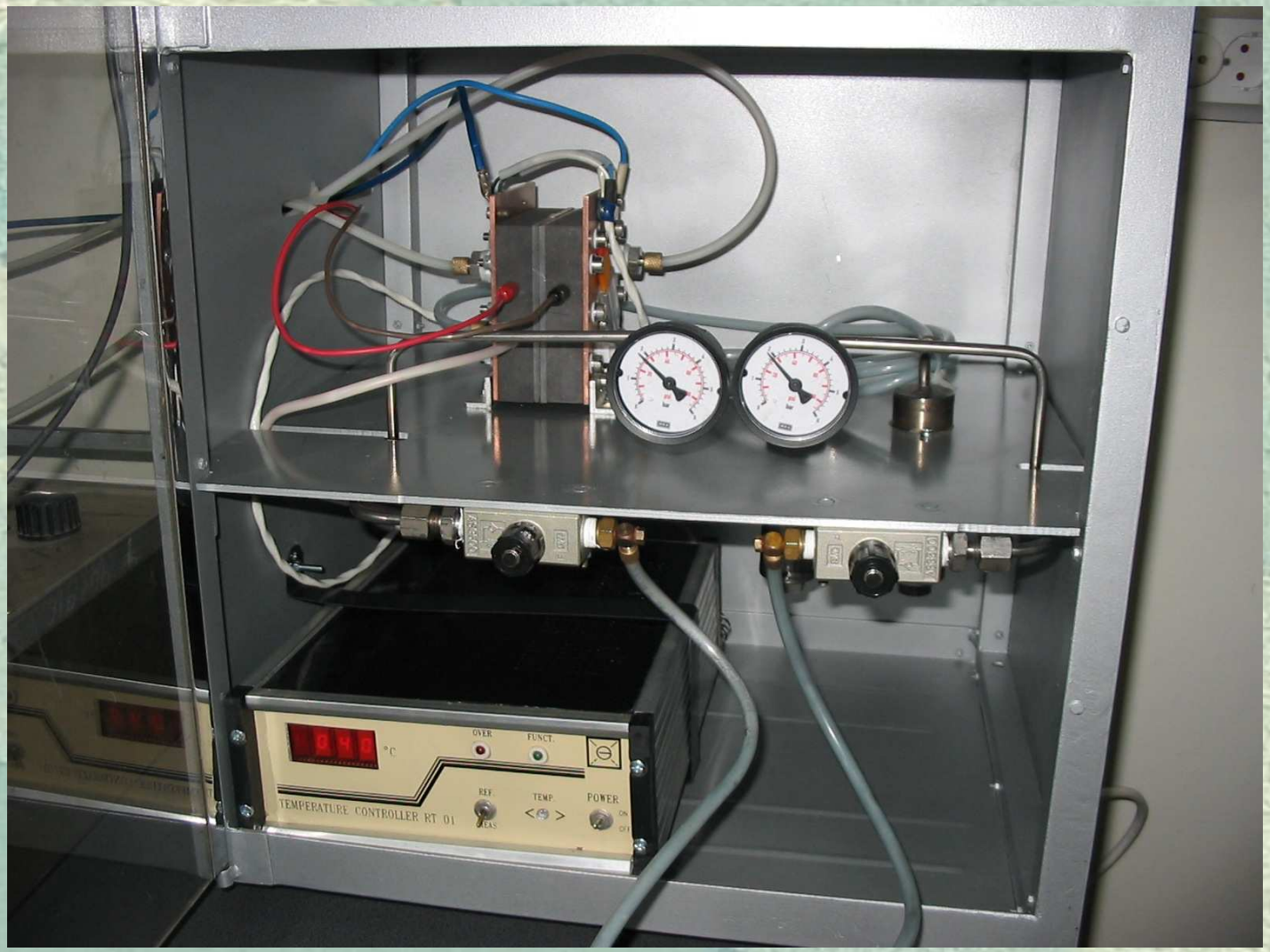
- **Aim:** To develop a resource of excellence for the Black Sea Region specialized in advanced engineering
- **Functions:** Research & Engineering, Graduate Programs, Technology transfer, Consultancy, Training & Networking
- **Structure:** Industry Consortium, International Steering Committee, President, Director, Full-time Research Staff, Project Based Teams, Graduate Students
- **Research Area:** Applied Thermodynamics, Advanced Energy Systems, CFD, CAD/CAM/CAE & Remote Engineering
- **Programs:**
    - PROMETHEUS
    - METEORA
    - NANOFLUID
    - VENTURE
    - HY DANUBE

# PROMETHEUS

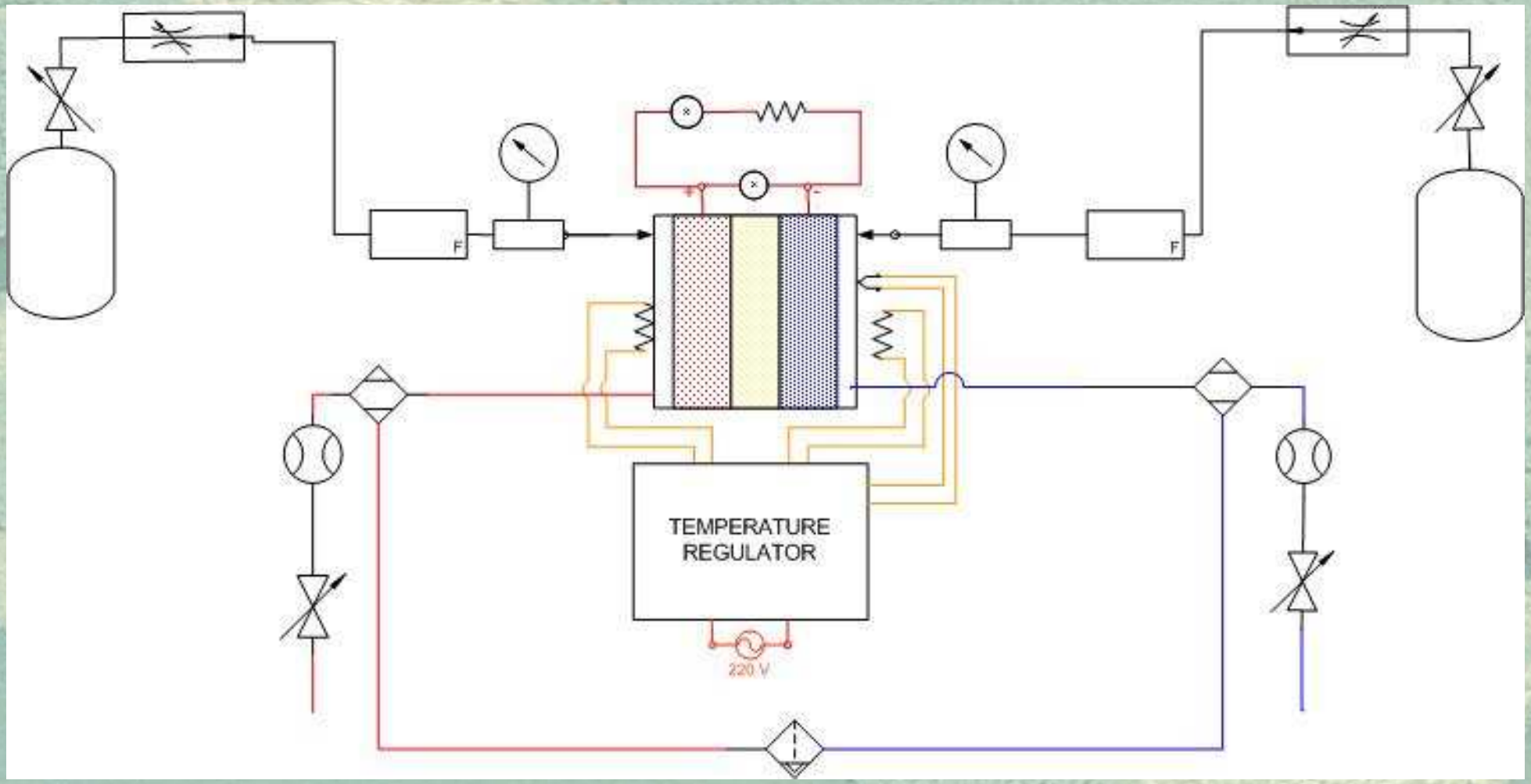
**P**rogram of **R**esearch on micr**O**-**ME**chanical sys**T**ems and tec**H**nologi**E**s for f**U**el cell**S**

- **Phase:** Model Testing
- **Partners:** Center for Micro & Nanotechnologies, Institute for Microprocess Technology – Karlsruhe Research Center
- **Results:** 1 patent on Spiral Micro Heat Exchangers (Germany), 1 patent request on Spiral Micro Fuel Cells

# METEORA I



# METEORA II



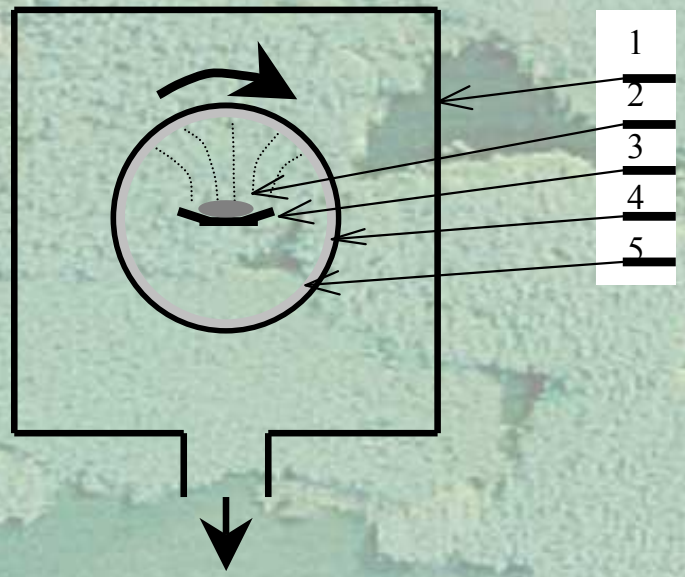
# NANOFLUIDS

- **Technologies** to produce nanofluids: one-step technology, two-steps technology

- **Types of nanofluids reported**: Ethylene Glycol – $Al_2O_3$, Ethylene Glycol – CuO, Ethylene Glycol – Cu, Glycerol - $Al_2O_3$, Water – $Al_2O_3$, Water – CuO, Water – Cu, Water – C-MWNT, Oil - $Al_2O_3$, Oil – Cu, Oil – $TiO_2$

- **Properties:**
  - Thermal conductivity enhancement
  - Lubrication properties enhancement
  - New possibilities for process control

# ONE-STEP TECHNOLOGY I




Vacuum Evaporation: 1. Vacuum Chamber; 2. Sample powders; 3. Heater, 4. Rotating Cylinder; 5. Liquid.

# ONE-STEP TECHNOLOGY II

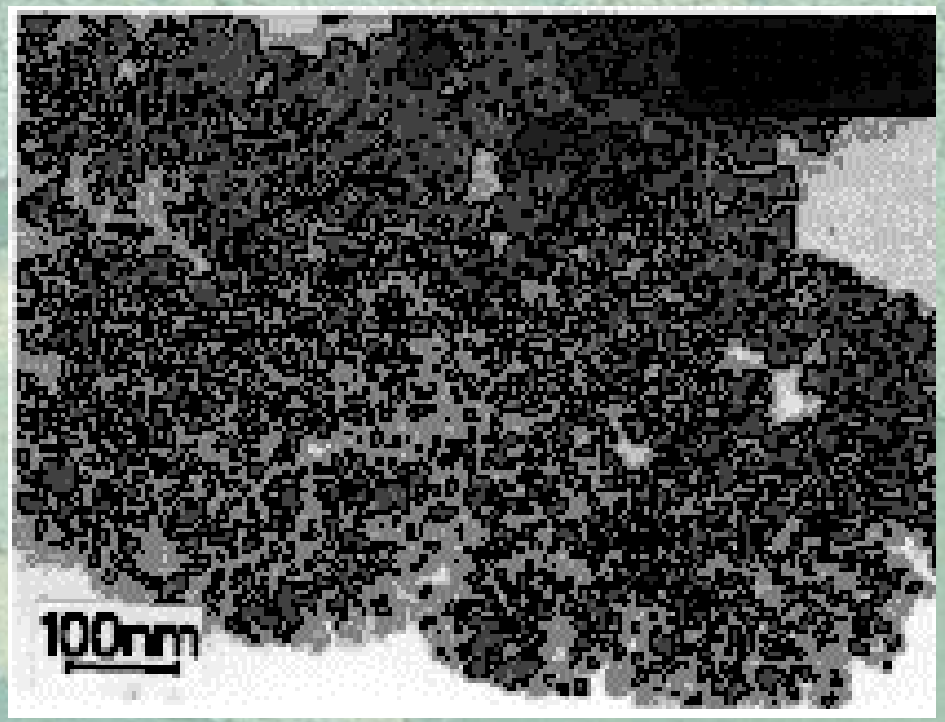

Vacuum Evaporation with Rotating Liquid – VERL Device

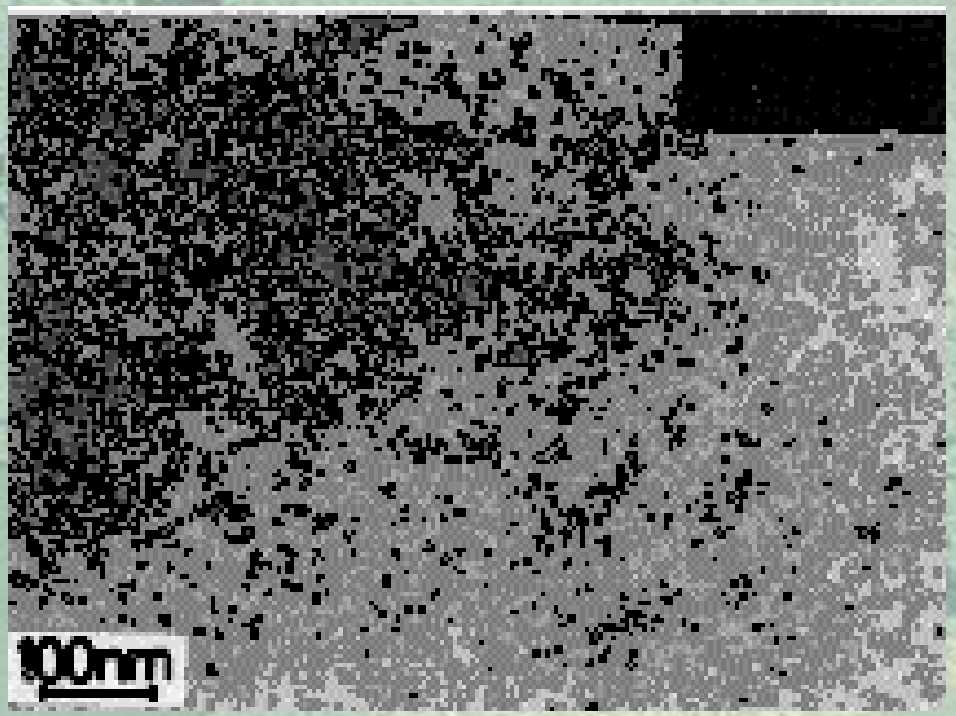
# ONE-STEP TECHNOLOGY III

- **Advantages:**
  - Doesn’t require additional equipment
  - The obtained suspensions are stable and with a good dispersion

- **Disadvantages:**
  - Time consuming
  - Low productivity

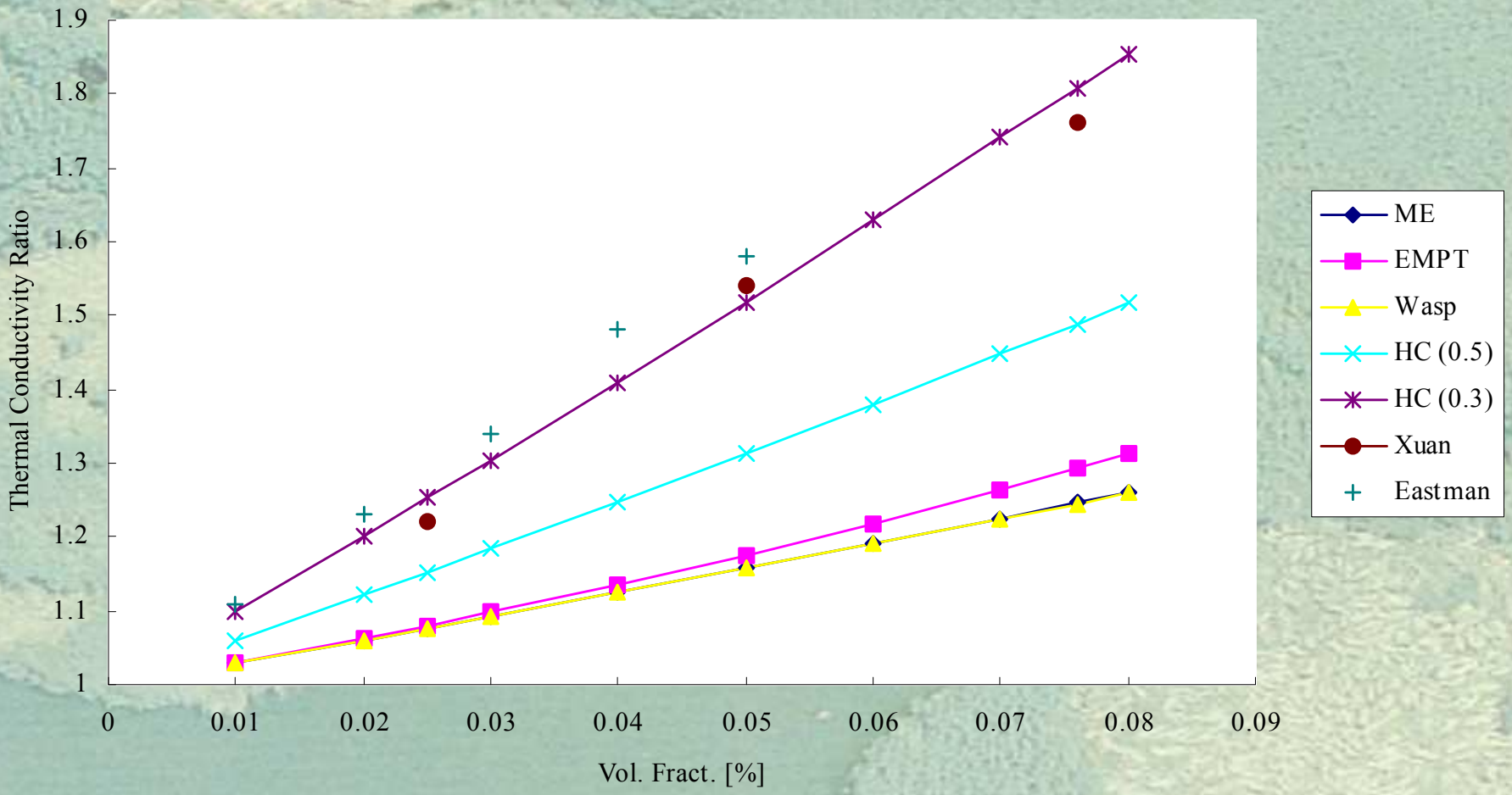
# OBTAINED NANOFLUIDS



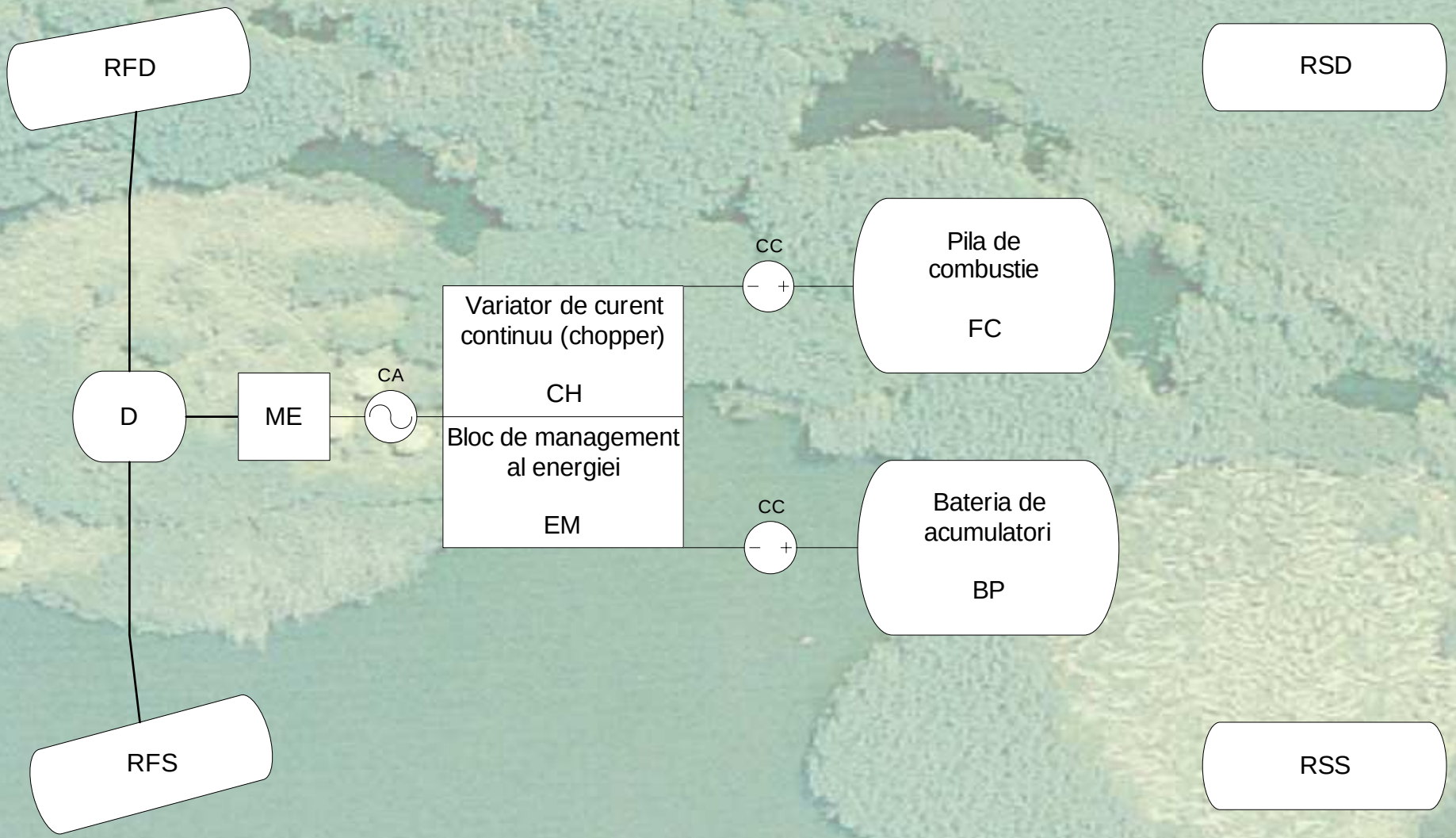

Silver & Copper Nanoparticles

# MODELING NANOFLUIDS




Available theoretical models

# PROJECT: *VENTURE*



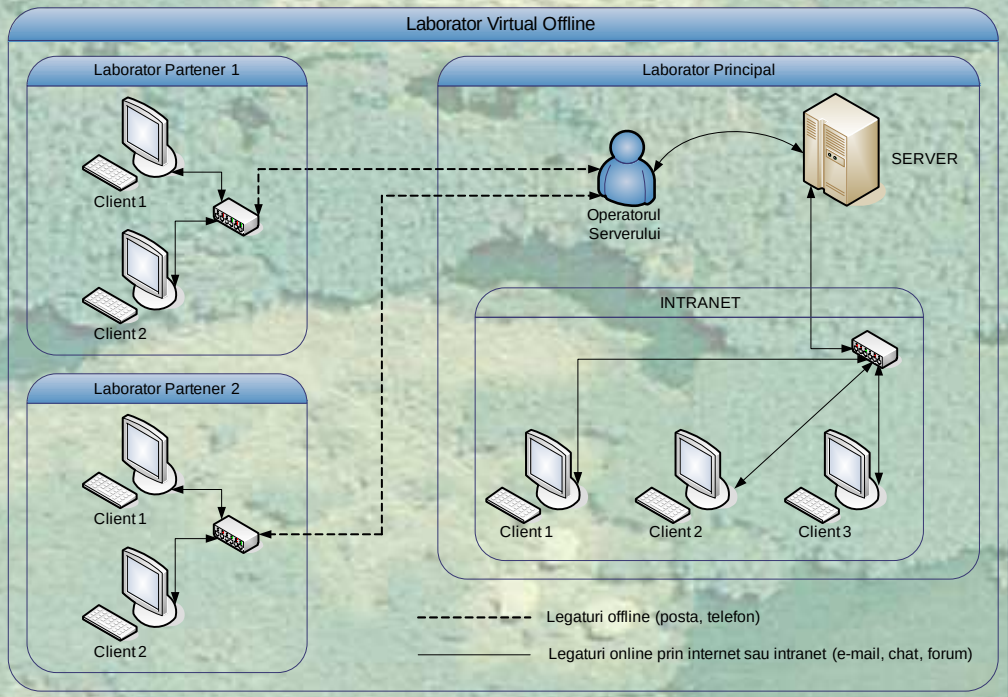
# HIERARCHICAL MODELING OF POWER TRAINS

- VEHICLE;
- STACK;
- CELL;
- THERMOFLUID;
- ELECTROCHEMISTRY .

# SOFTWARE

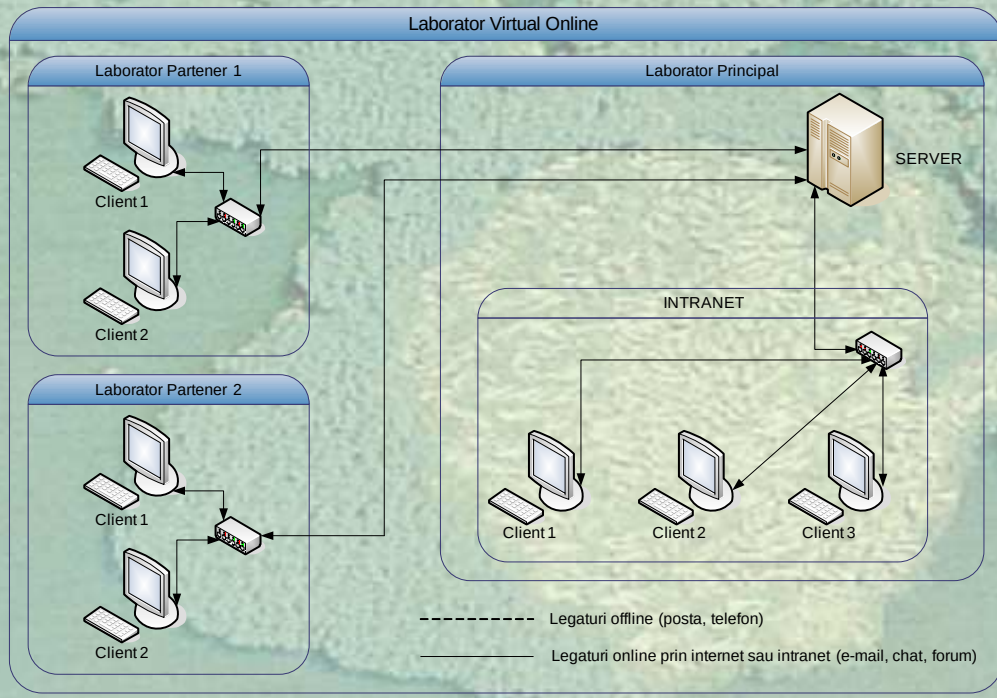
- ADVISOR;
- PSAT;
- GS TOOL;
- ANSYS CFX.

# VIRTUAL LAB - *VENTURE*




OFF LINE Lab

ON LINE Lab



# *HY DANUBE* - CONCEPT

**The aim of the project is to develop a demonstration project for de-polluting the Danube River waters by the production of biomass and conversion to hydrogen for fuelling a stationary fuel cells stack of a leisure complex in the Danube Delta, transport bus and leisure boats for tours in the Delta.**

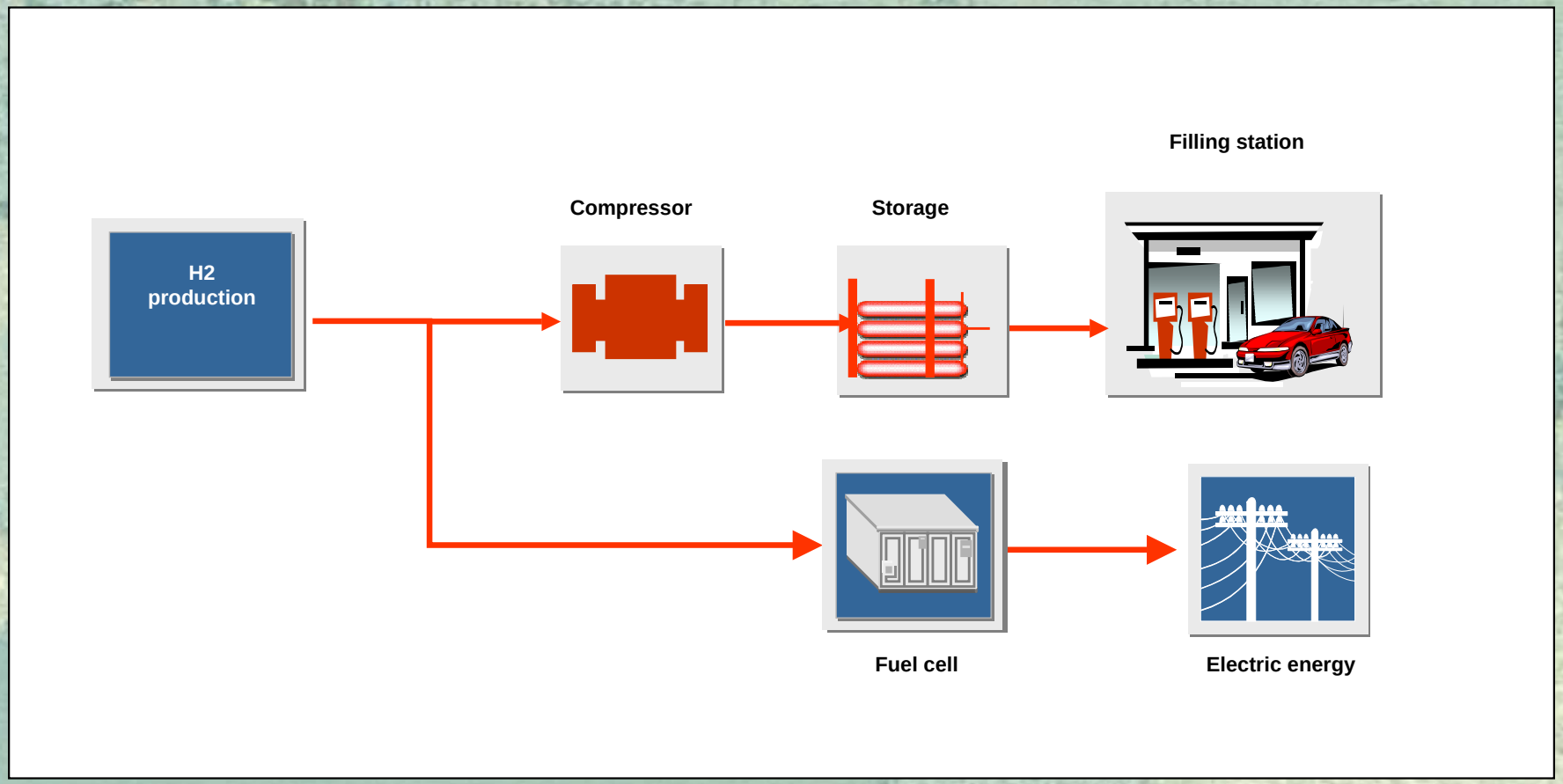
**The project will integrate the results of the last 3 decades of experiments developed in Romania for the de-pollution of different lakes and municipal sewage waters by accelerated production of biomass and processing of the obtained yields and the expertise of several European partners in the biomass reforming, stationary fuel cells and leisure boats.**

# PROIECT *HY DANUBE*

## Objectives:

1. The analysis of the existing hydrogen production facilities and possibilities to upgrade the facilities for higher efficiency and lower costs of hydrogen;
2. The synthesis of the studies that have been done for locating windmill facilities on the Black Sea area and the analysis of the possibilities to use them for hydrogen production;
3. The synthesis of the studies that have been done on biomass production and processing for producing biogas and hydrogen;
4. The studies on the hydrogen storage and distribution facilities;
5. The analysis of the most suitable solution for the use of hydrogen in transport either as fuel for internal combustion engines or fuel cells;
6. The analysis of stationary application of fuel cells for energy supply at a resort;
7. Value Chain Analysis starting from production till the tourism services as end-users;
8. Forecasting of different scenarios for early market development;
9. Business development analysis defining the interests for the public actors and the private actors in order to conceive win-win schemes;
10. Analysis of the suitable dissemination channels.

# PROJECT: *HY DANUBE*



# PROJECT *HY DANUBE*

| | |
|---|---|
| **Coordinator :** | UNIDO-ICHET, Istanbul |
| **Implementing partner:** | Ovidius University of Constantza |
| **European partner :** | ENEA – Ente per le Nuove Technologie, L'Energia e L'Ambiente, Italia |
| **Industrial partner :** | Rompetrol SA |
| **Estimated budget:** | 30 mil. USD |
| **Target starting date:** | 2010 |
| **Current phase:** | Concept development |

# EXISTING EXPERTISE I

**The researches carried out in Romania, have conducted to the development of economically sustainable technologies for cultivation of selected species of aquatic plants for the obtaining biomass through bio-conversion of the pollutants from sewage waters and polluted lakes and processing of biomass for obtaining valuable products.**

**Among the selected species the highest performance have been demonstrated with the followings:**

***Eichornia crassipes,***

***Pistia stratiotes,***

**These species don't act invasive and because of the temperate climate in Romania the economically relevant yields last about 150 days/year.**

# EXISTING EXPERTISE II

**The installations for production of seed plants, realized in Romania, are of greenhouse pyramid type installations, with different capacities and with a reduced consumption of energy (40 % reduction of energy consumption relative to the classical systems).**

**The process of production of seed plants is based on the bio-treatment process of used water under the following conditions:**

**Temperature range between 15 – 37 ˚C;**
**pH between 6.5 – 8;**
**CCO-Cr in mg/L : 200 – 1000;**
**Total suspensions mg/l: 800 - 1200**
**Concentration of active substances: 50 mg/l;**

# EXISTING EXPERTISE III

The pyramid type greenhouse for production of seed plants is a concrete structure with side walls made of glass. It includes a continuous channel fitted on the available surface at each level. The experimental setups have included a channel of 1,300 m long and narrow of 60 cm. The construction of the channel allows a very slow flow of the sewage water to assure the bio-conversion of the pollutants and the treatment of the water.

At the basement of the building there are rooms for laboratories, for biomass processing and other purpose.

The pyramidal types of bio-technological installations have the following advantages:

- Vertical disposure of the process for efficient land use;
- Reduce the required land area with 40 – 50 % , versus classical systems;
- Reduce the energy consumption with up to 80 % versus classical systems.

# EXISTING EXPERTISE IV

**The obtained yields are in the range of 5 – 8 tones of biomass/hectare/day, for an average of 150 days/year or 750 – 1200 tones of biomass / hectare / season. Efficient collection systems have been developed.**

**The conversion of biomass to $H_2$ may be done based on the following processes:**

- **bio-chemically processing of biomass (anaerobic fermentation),**
- **thermo-chemically processing of biomass (gasification).**

**For the case of anaerobic fermentation of biomass for obtaining biogas, the results that have been obtained on experimental tanks are of 105.4 – 254.7 liters of biogas/kg of biomass with a concentration of methane between 14 – 79.2 %.**


*Thank you!*