2nd CACHET Workshop
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SP1-WP5 Task 2:

Review the pre-combustion CO_2 capture / H_2 technologies in Eastern Europe

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Task 2: Objectives and Accomplishment

- ***Objectives***

  Survey Central and East European countries to establish organizational and technical competence and capability in the area of CO_2 capture with H_2 production from natural gas, through review of technical literature, journals and proceedings with a special focus on Russia, AC countries and new member states.

- ***Accomplishments***

  More than 320 papers, reports and publications have been reviewed and analyzed;

  General directions in Eastern Europe CO_2 capture R&D works have been specified;

  Several prospective CO_2 capture with H_2 production technologies have been identified

CO_2 capture R&D projects in Eastern Europe

- There are not currently systematic CO_2 capture R&D studies in this part of Europe with the exception of projects funded by EU;
- Some countries like Poland and Czech Republic are going to develop CO_2 capture projects oriented to local coal utilization;
- Russia is more interested in H_2 production and fuel cells development than in CO_2 capture;
- Turkey is going to develop non-fossil fuels based hydrogen production projects like H_2S extraction from Black Sea and Boron compounds based technology.

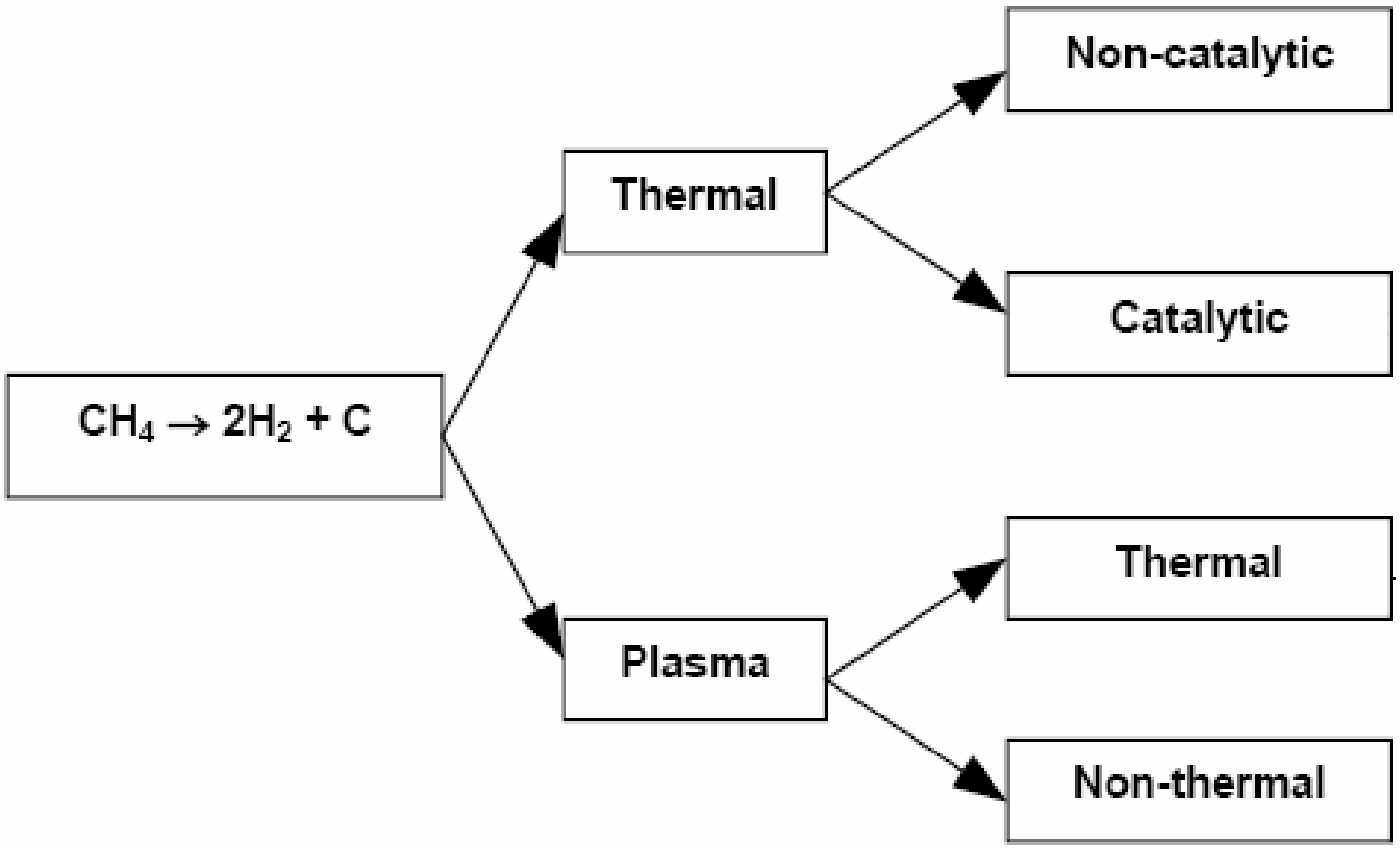
Lack of CO_2 capture projects in Eastern Europe: reasons and fears

- Natural gas is not produced in all Eastern Europe countries except Russia. As a result it is not estimated as an option for the future. Coal is the only indigenous source and CO_2 capture options based on IGCC process is more acceptable in Central Europe;
- H_2 production based on expensive natural gas and accompanied with CO_2 capture would have non-affordable price in any case;
- Conventional CO2 sequestration strategies (e.g., ocean and geologic CO2 sequestration) offer rather expensive solutions associated with uncertain long-term ecological consequences. It is not yet possible to predict with confidence storage volumes, formation integrity and permanence over long time periods.

H_2 production and carbon capture in Russia: research projects based on direct decarbonization

- Direct decarbonization of hydrocarbons could be accomplished via dissociation (or decomposition, pyrolysis) of hydrocarbons in air-water free environment with production of hydrogen and elemental carbon;
- Methane dissociation reaction: $CH_4 \rightarrow C + 2H_2$ is moderately endothermic, and the energy requirement per mole of hydrogen produced (37.8 kJ/mole H_2) is considerably less than that for the steam reforming process (63.3 kJ/mole H_2);
- Unlike SMR, which is a multi-step complex process, methane dissociation is a single-step relatively simple process. In addition to hydrogen as a major product, the process produces a very important byproduct: clean carbon.

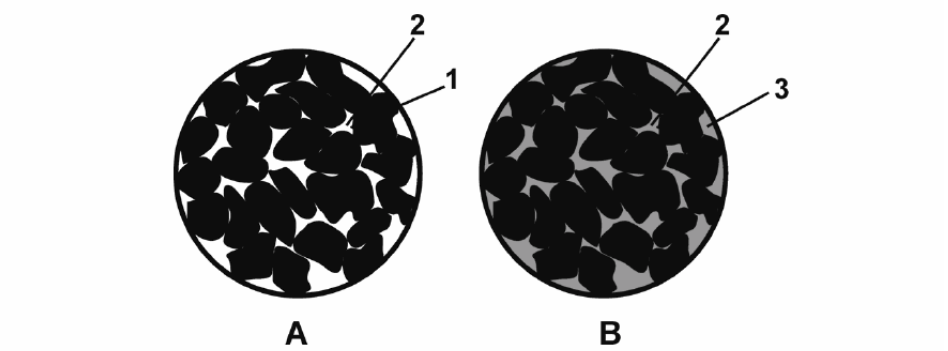
Technological approaches to methane direct decarbonization



Institute for High Temperatures

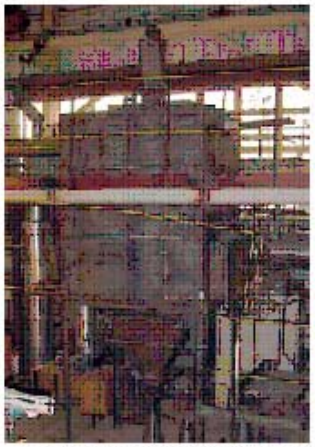
Russian Academy of Science - **IVTAN**

- **Thermal Pre-combustion Natural Gas Decarbonisation with Hydrogen and Carbon Production**
- **Two-stage pyrolysis of natural gas: At the first stage thermal decomposition of the natural gas is carried out as a homogeneous process producing hydrogen and dispersed black carbon. The black carbon is then granulated to produce porous pellets. At the second stage these pellets are heated and used as the initial porous matrix to be stuffed with pyrocarbon during heterogeneous decomposition of natural gas**

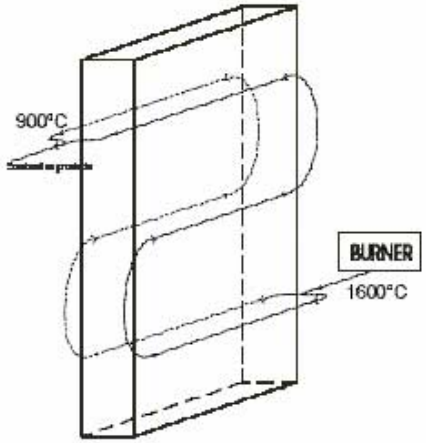


A – the initial structure of charcoal; B –the same structure after stuffing with pyrocarbon. 1 - particles of dispersed carbon, 2 – inner pores free and stuffed, 3 – the exterior pores stuffed with pyrocarbon structure.

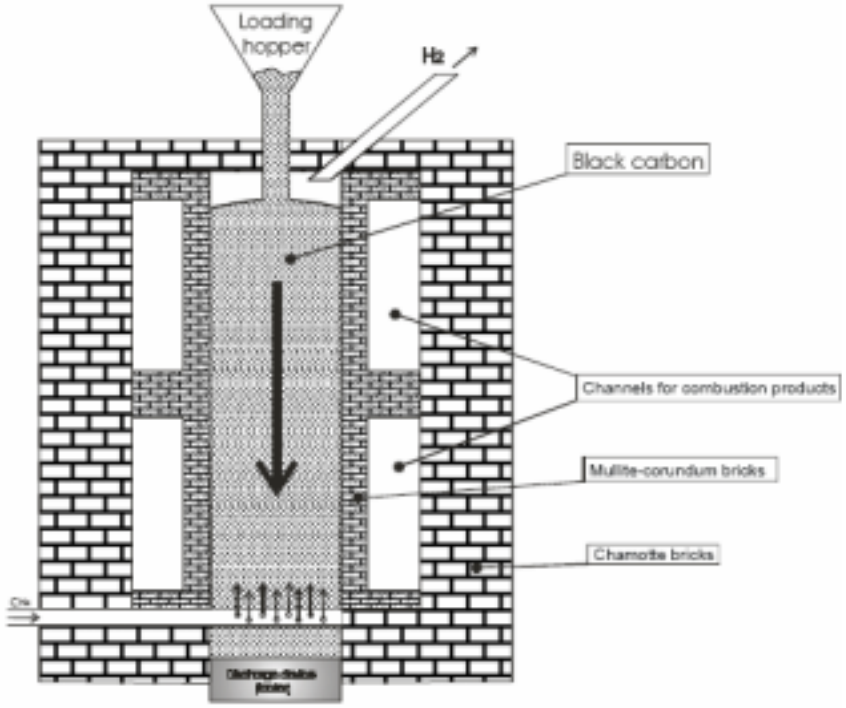
IVTAN natural gas pyrolysis: large test facility



A general view of a pilot facility.

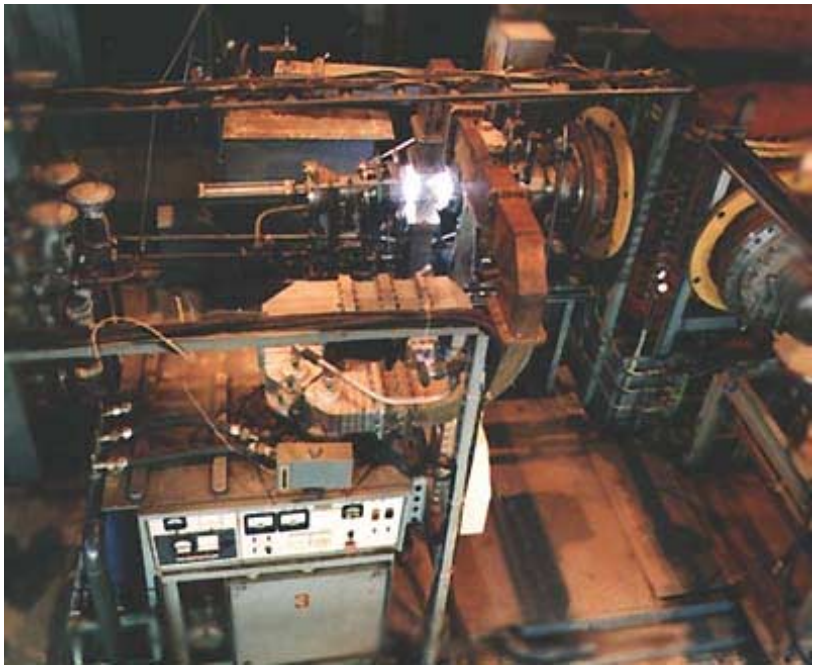


The scheme of heating



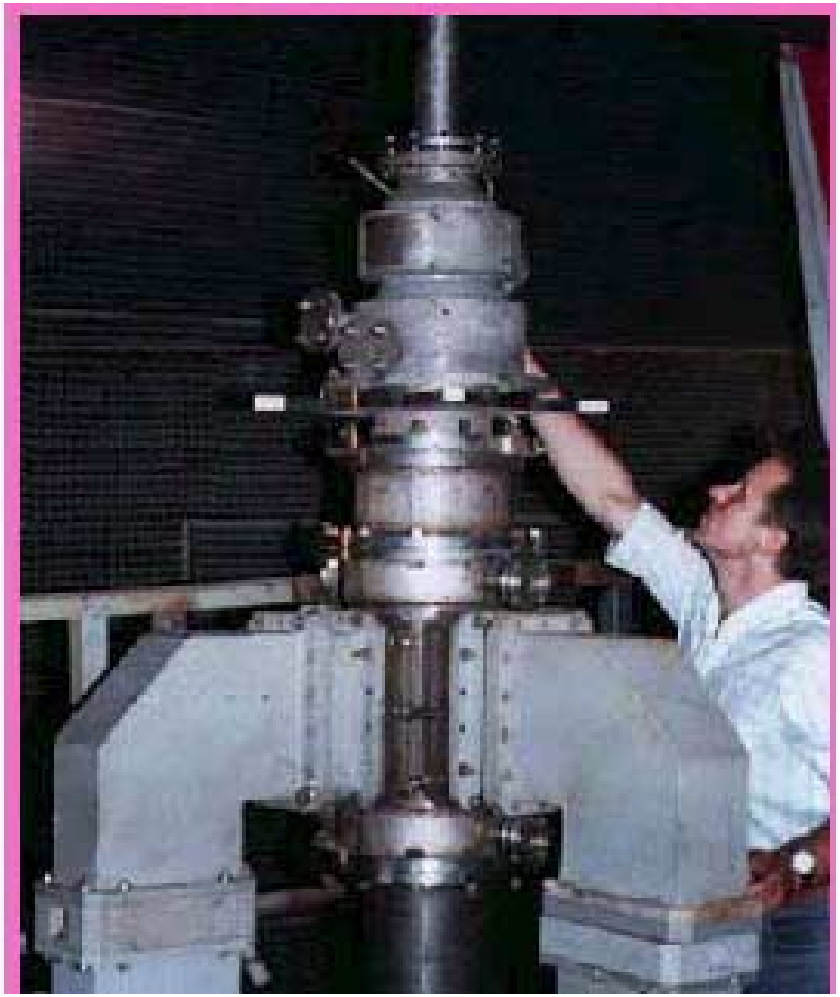
Hydrogen Energy and Plasma Technologies Institute: major Hydrogen related projects

- Test Facility “POVOD” for Development and Scaling of Plasma Assisted Processes of Hydrogen and Syngas Production
- plasma replaces catalysis and accelerates chemical reactions
- POVOD has been designed to investigate gas-phase plasma chemical processes under effect of stationary microwave discharge

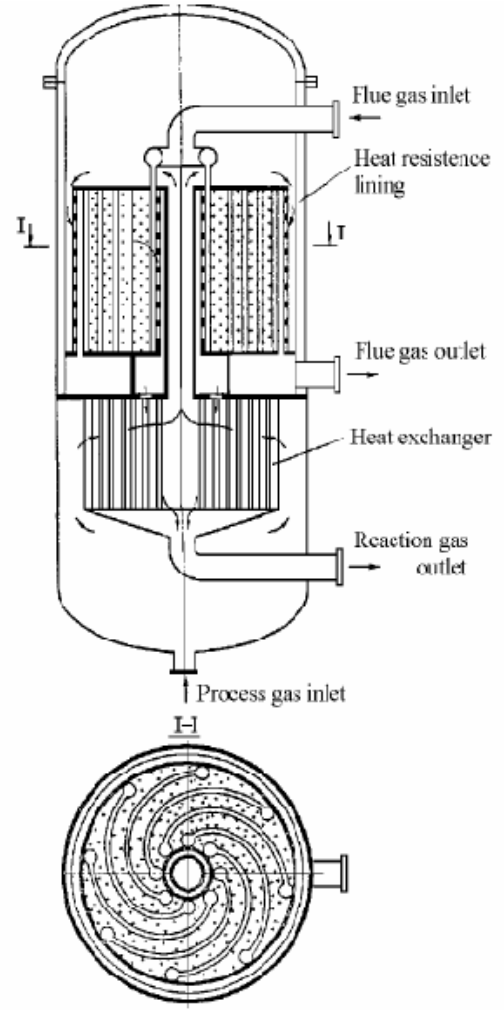


Hydrogen Energy and Plasma Technologies Institute: major Hydrogen related projects

- Methane Conversion to $CO+H_2$ in Non-equilibrium Microwave Discharge;
- high efficiency methane conversion to synthesis gas ($CO + H_2$) in microwave plasma both for steam and carbon dioxide reforming



New steam methane reformer design in Russia: convectively heated reformer



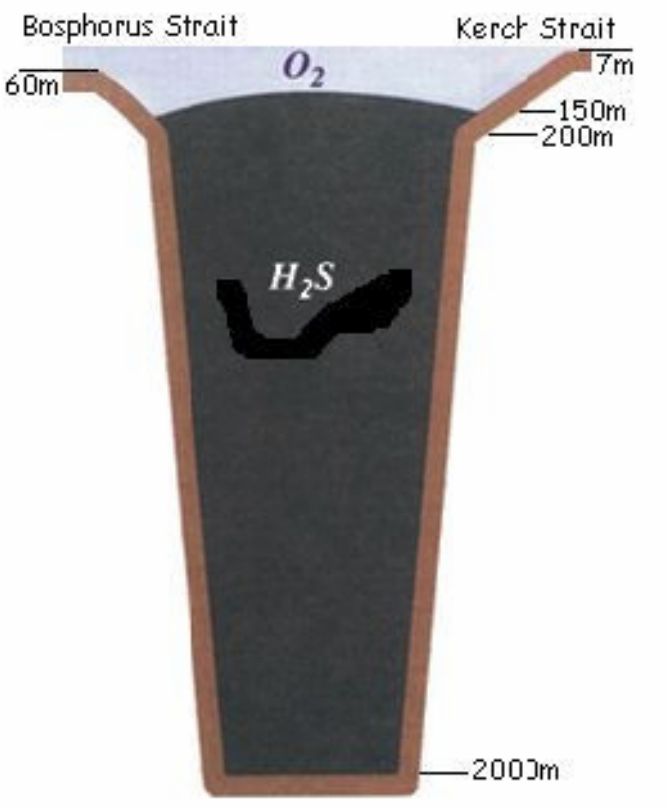
- A new reformer design features, so that in annular space of a radial reactor, filled with the granular material (catalyst), the walls were placed in the form of a planar Archimedean spiral, forming spiral-shaped passages, which have the same sections to the direction of fluid flow. The spiral-shaped walls are made of solid metal for adiabatic processes and with hollows if heat supply or removal from the catalyst bed. Inner spaces of hollows of spiral shaped walls are connected with pipes of inlet and outlet of the heat carrier.

Recently initiated Russian CO_2 capture projects:

- Prospective CO_2 Capture and Storage technologies based on Chemical Looping combustion processes;
- IGCC with CO_2 Capture;
- The first project has been awarded to the Karpov Institute of Physical Chemistry in May 2005;
- The second project has been awarded to the All-Russian (former All-Union) Thermal Engineering Institute – VTI, also in May 2005;
- It is expected these projects to select feasible CO_2 capture option for future large scale pilot facilities development

Unconventional approach to H_2 production in Turkey: Hydrogen Sulphide

- **Profile of the Hydrogen Sulphite Zone in the Black Sea**



- Black Sea contains H_2S after 60 m depth. The amount of H_2S is estimated at about 2.5-3.0 million tonnes
- Concentration of the hydrogen sulphide is 8 ml/lt in 1000 m depth and 13.5 ml/lt at the sea bed;
- This huge Hydrogen Sulphide potential can be evaluated as hydrogen fuel sources

Task 2 European Regions - Capabilities and Relevant Technology Developments: conclusions

- Due to historical development, new EU Member States and Associate Candidate Countries started to “discover” the CCS technologies somewhat later than the “old” EU-15.
- There are not currently new, high-potential CO_2 capture technology concepts or applications for CACHET technologies that could be of interest to CACHET;
- There are large set of R&D institutes with interest and experience in hydrogen production technologies that could be involved in future CCS projects