A Review on the Membrane Research Activities in Italy

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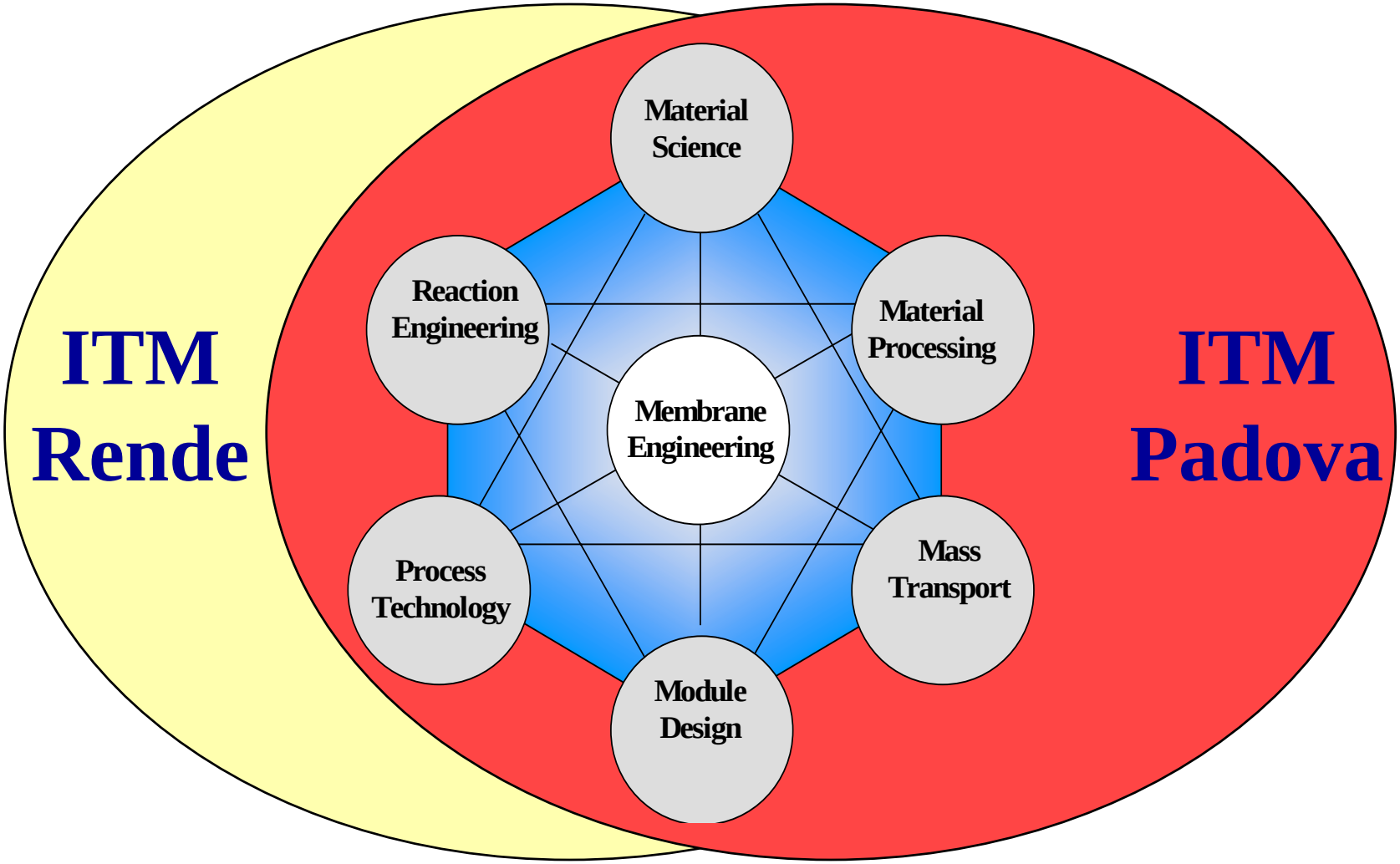
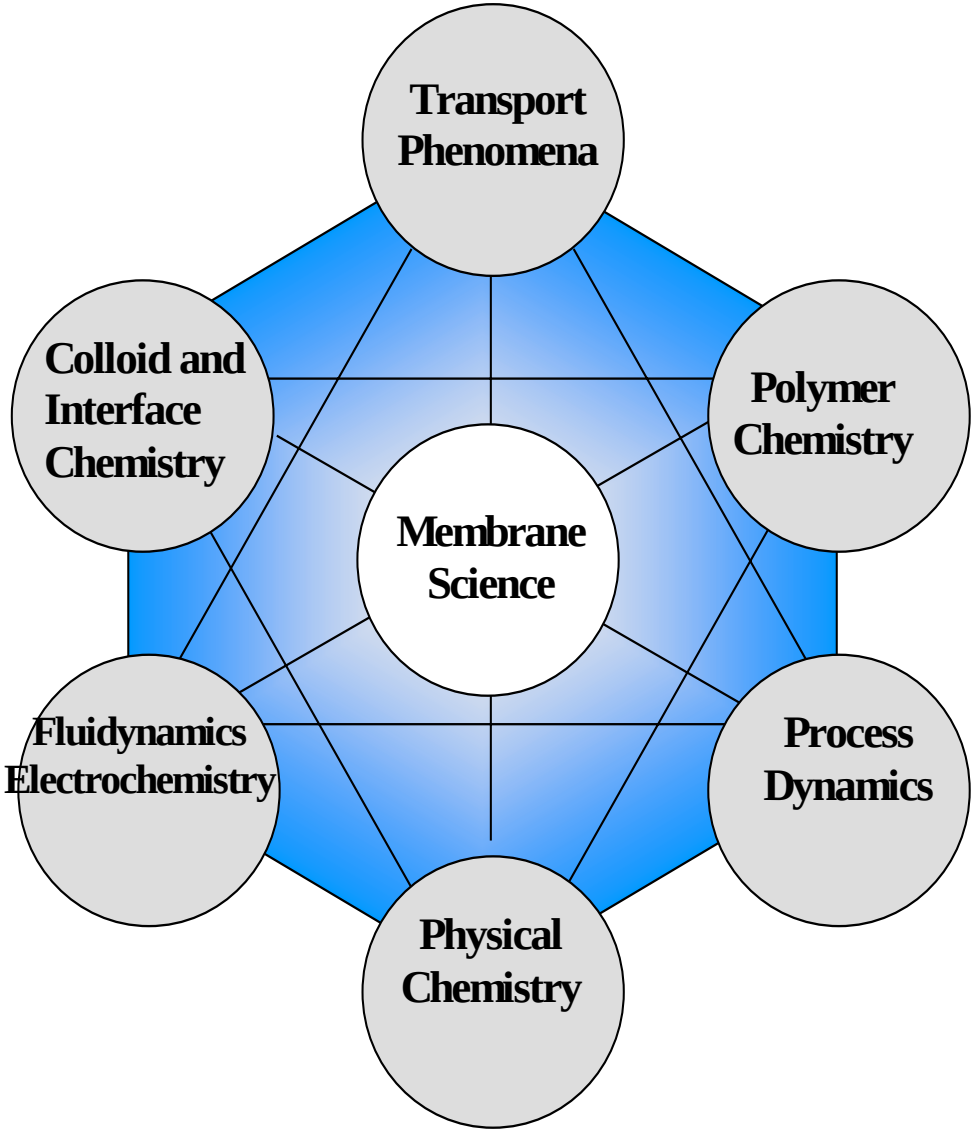
ITM - CNR
Istituto per la Tecnologia delle Membrane

Membrane Science and Technology



Membrane Science



Institute for Membrane Technology

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Istituto per la Tecnologia delle Membrane

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Institute on Membrane Technology

ITM - CNR
Istituto per la Tecnologia delle Membrane

- The **Institute on Membrane Technology** (ITM-CNR) is a structure created by the National Research Centre of Italy (CNR – Consiglio Nazionale delle Ricerche) for the development, at national and international level, of membrane science and technology.

- The Institute is located in the existing structure of the **University of Calabria, Rende (Cosenza),** and has a section located at the **University of Padova** (which is involved in the synthesis of new materials to be used in the preparation of membranes).

Personnel

- The Institute has **28 units of permanent staff** and about **30 temporary units** constituted by visiting professors, researchers, Ph.D. students, post-doctoral fellowships, high-educational fellowships from **national and international Institutions**.
- It is a **multidisciplinary Institute** based on backgrounds in chemical engineering; process engineering; chemistry (organic and physical); biological science; food science; material science and physics.

Collaborations

- A significant **exchange of young researchers**, e.g. with Spain, France, Holland, Slovakia, Poland, Russia, Algeria, Argentina, South Korea, China, Japan, USA, is strongly encouraged to **integrate research activities at international level**.

- Formal **bilateral and multilateral agreements** with Japan, South Korea, China, Russia, France, Marocco, and Egypt have been approved.

Research activities

- The activity of the Institute is focused on the **research and development of membrane science and technology**. The main research activities are related to the following topics:

1. Catalytic membranes and catalytic membrane reactors;
2. Integrated membrane operations;
3. Membrane distillation and membrane contactors;
4. Membrane preparation and characterisation;
5. Fundamental studies of transport phenomena in organic and inorganic membranes.
6. Polymeric membranes for artificial organs

Examples of research topics

- Catalytic membranes and catalytic membrane reactors
  - Inorganic membranes,
    - *e.g.* steam reforming, partial oxidation of methane to syngas
  - Biocatalytic membranes
    - *e.g.* enzyme membrane reactions, continuous membrane fermentations, enantioselective membranes
- Integrated membrane operations. Integration of classical engineering processes with membrane separation technology
  - Wastewater treatment and product recovery in leather industry
  - Production of fruit juices
  - Etc..

Examples of research topics (2)

- Membranes as artificial organs
- Membrane distillation and membrane contactors
  - Potable water production from seawater and brackish water
  - *Water/alcohol separations*
  - *Purification of physiological solutions*
  - *Preparation of water with controlled gas composition*
- Transport phenomena in organic, inorganic and hybrid membranes
  - Experimental study of fundamental aspects of mass transport in relation to membrane preparation and membrane structure.
  - Theoretical support by molecular dynamics simulations.

Research activities of Padova section

1. Understanding transport phenomena through membranes by theoretical studies of weak intermolecular interactions
2. Catalytic membranes and degradation of organic pollutants
3. Polymeric membranes incorporating fullerenes and nanotubes
4. Transition metal complexes in membrane-mimetic systems
5. Supramolecular chemistry. Reactivity and molecular recognition in micelles, vesicular aggregates and polymeric membranes

Some new technologies

Membrane contactors

Membrane crystallizers

Emulsion membrane reactors

Selection of collaboration projects of ITM-CNR

Brite-Euram1
Grace
PERMOD
Murst
INCO-Copernicus

Research activities on membranes in **academic institutes** in Italy

Academic research activities

- University of Calabria
  - see also ITM-CNR
- University of Turin
  - Polymers for membrane formation, synthesis and applications
  - Molecular imprinting polymers
  - Inverse phase transfer catalysis
  - Bioremediation of waste water
- Polytechnic of Milan
  - Material properties and transport phenomena of membranes
- University of Perugia
  - Inorganic and protonic membranes for fuel cells

Academic research activities (2)

- University of Genua
  - UF, MF, RO, PV, Membrane reactors
  - Wastewater treatment
- University of Bologna
  - Membrane separations and diffusion in polymers
  - Thermodynamics and thermomechanical properties of polymeric fluids
  - Chemical processes in microelectronics
  - Catalytic membranes and kinetics of heterogeneous processes
  - Membrane distillation
  - Pervaporation
- University of Palermo
  - Anodic ceramic membranes

Membrane processes and research activities in the **Italian industry**

Industrial membrane activities

- Membrane activities in the Italian industry concern both **application** and **research**, and are currently experiencing a **strong growth**.
- Typical examples are in food and dairy industry, energy conversion, (waste)water treatment, electrochemical applications, integrated processes *et cetera*.
- Many R&D projects are carried out in **close collaboration** with other research institutes and are **financed by the European Union and national government**.
- There is no more industrial production of new membranes in Italy

Membrane and material manufacture

- Belco SpA - Biomedical applications
- FilterPar Srl - Water treatment (UF, MF)
- Millipore SpA - Pure and ultrapure water (sales in Italy)
- Permacare - Water treatment (RO, NF, UF, MF)
- Separem - Impermeable and breathable tissues

Raw material production

- Ausimont - Production of fluorinated polymers

Water and wastewater treatment

- Purification, demineralisation, Ind. effluent recycling
  - Bono Sistemi SpA
- Equipment manufacture
  - Culligan Italiana - FDT Srl
  - Hydro air research - Hytek Srl
- Water purification, pyrogene-free steam production
  - Stilmas SpA
- Technology development
  - Tecnomil

Special membrane processes

- Impianti Elettrochimici O. De Nora
  - Chlor alkali plants to produce chlorine, caustic soda, caustic potash, and downstream derivatives such as hydrochloric acid and sodium hypochlorite.
  - Materials and services for mercury and diaphragm chlor-alkali plants and their revamping and upgrading.

- Tecno Project Industriale
  - Treatment of air and industrial gases
  - CO_2 production and recovery

Miscellaneous membrane operations

- Purification of pharmaceutical products & intermediates
  - Bracco SpA
- Filtration and filtration equipment manufacture
  - Diemme Filter division
- Filtration, concentration, purification in pharmaceutical, chemical, biotechnological, food and beverage industry. Membrane processes and membrane unit production.
  - Koch Membrane Systems
  - Permeare Srl

Selected institutions

ENEA

- The ***National Institute for Alternative Energy*** *(ENEA)* was founded to study the use of nuclear energy. With the decision of the Italian government to **freeze the use of nuclear energy**, ENEA has focussed on **new energy sources** and on **new processes for energy conversion**:

- Membrane and Membrane Reactor development
  - Metal membranes, Integrated systems separator/reactor

- Process development
  - Methanol partial oxidation, water gas shift reaction, hydrogen purification, fuel cells

De Nora Group

- The *De Nora Group* was originally established to design, manufacture and install **electrochemical plants**, **electrolyzers** and **electrodes**.

De Nora Group / Nuvera fuel cells

- Nuvera Fuel Cells, one of the joint ventures of the De Nora Group, is an international company based in Milan and Cambridge (USA), producing from small portable fuel cell units to large industrial power plants.

- Nuvera has extensive collaborations with ITM-CNR in the development of combustion cells and membrane reactors.

1 kW Hydrogen Power Module

www.nuvera.com

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Enel Green Power / ERGA

Enel GreenPower
CNR-ITM

Membrane systems for the treatment and valorization of gas emissions from geothermal plants

PROPOSTA DI RICERCA AI SENSI D.M. 593, Art. 5

EnelGreenPower

Consiglio Nazionale delle Ricerche

⇒ Enel GreenPower: Firms controlled by Enel and finalized to the production of renewable energy (geothermal, mini-hydro, wind, photovoltaic, biomass, and biogas plants)

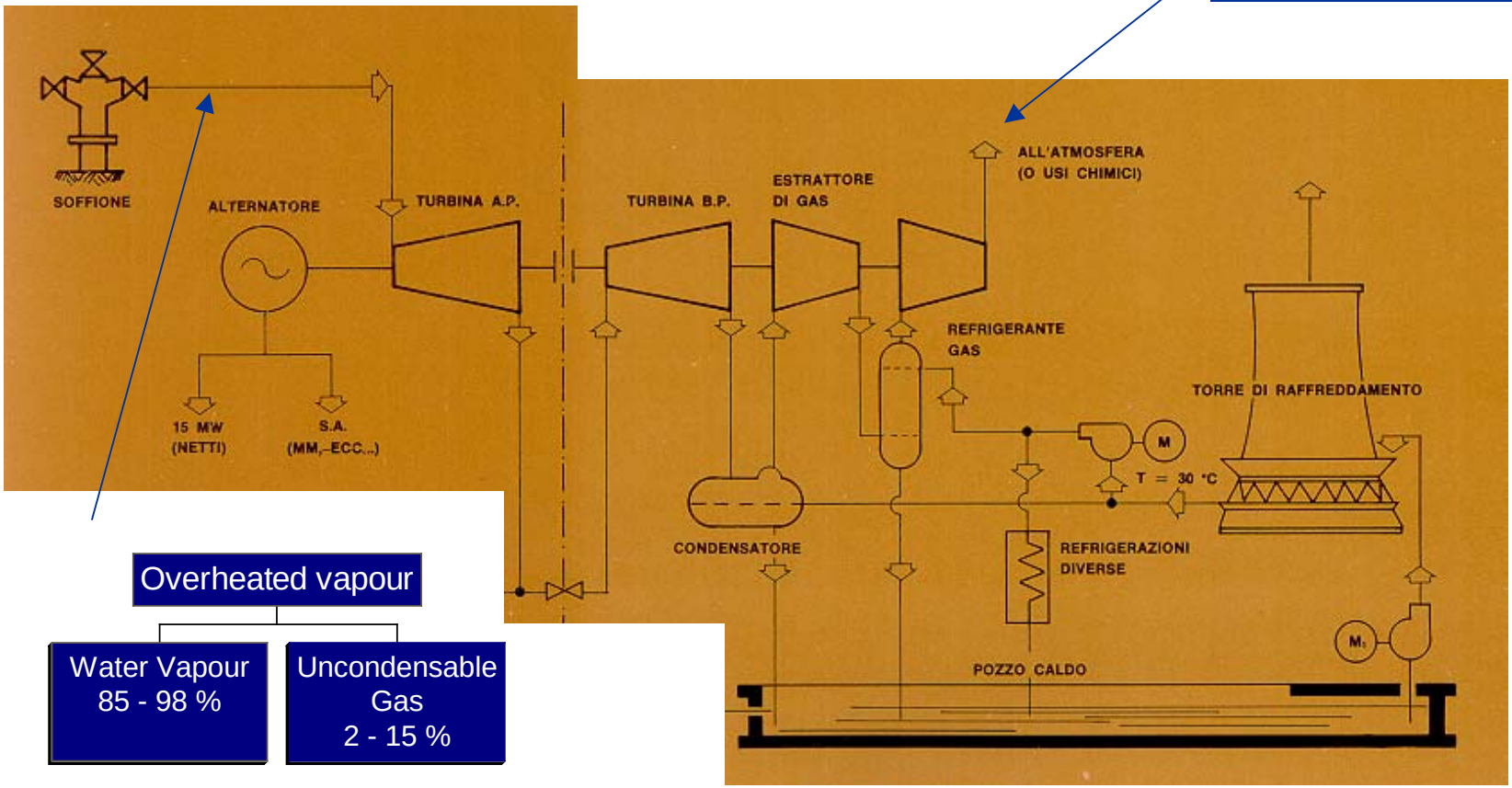
Via Andrea Pisano, 120 - PISA

⇒ CNR-ITM: Istituto per la Tecnologia delle Membrane

c/o Università della Calabria, Arcavacata di Rende (CS)

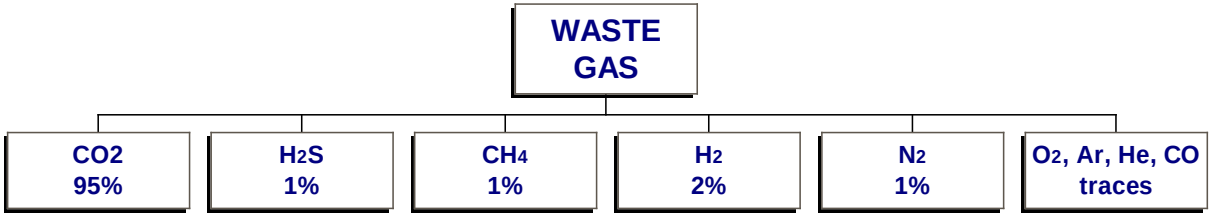
Geothermic Energy Production

Waste gaseous fraction emission



Overheated vapour

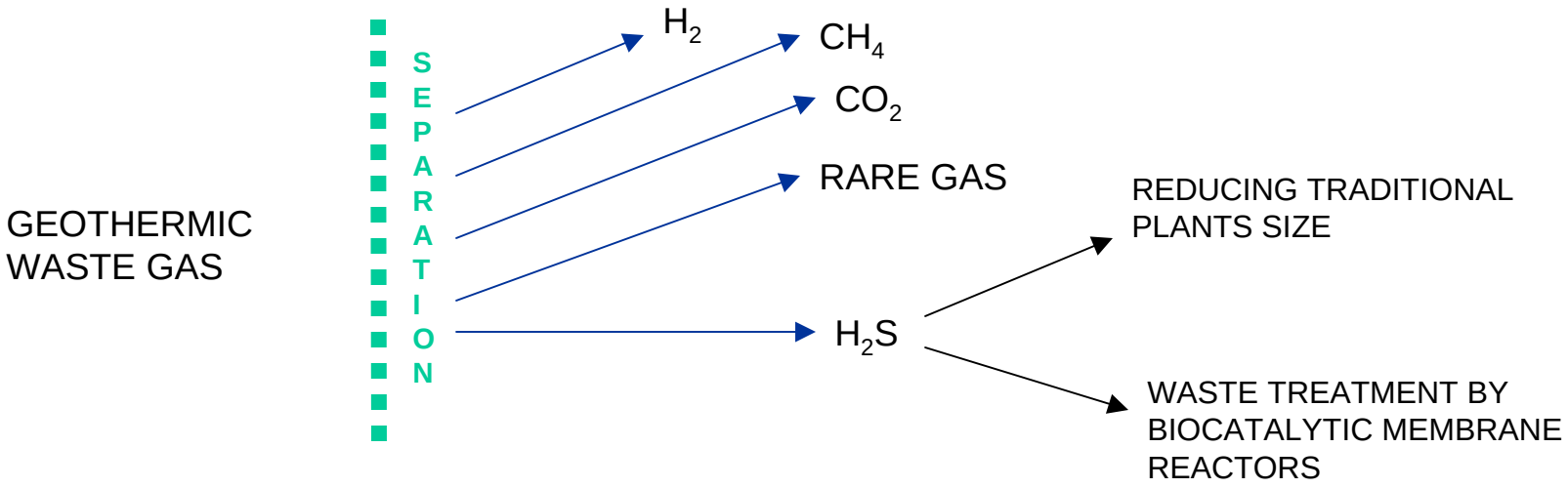
- Water Vapour 85 - 98 %
- Uncondensable Gas 2 - 15 %



Residual Geothermic Gas is regulated by the actual legislation as waste and it's subjected to a specific control

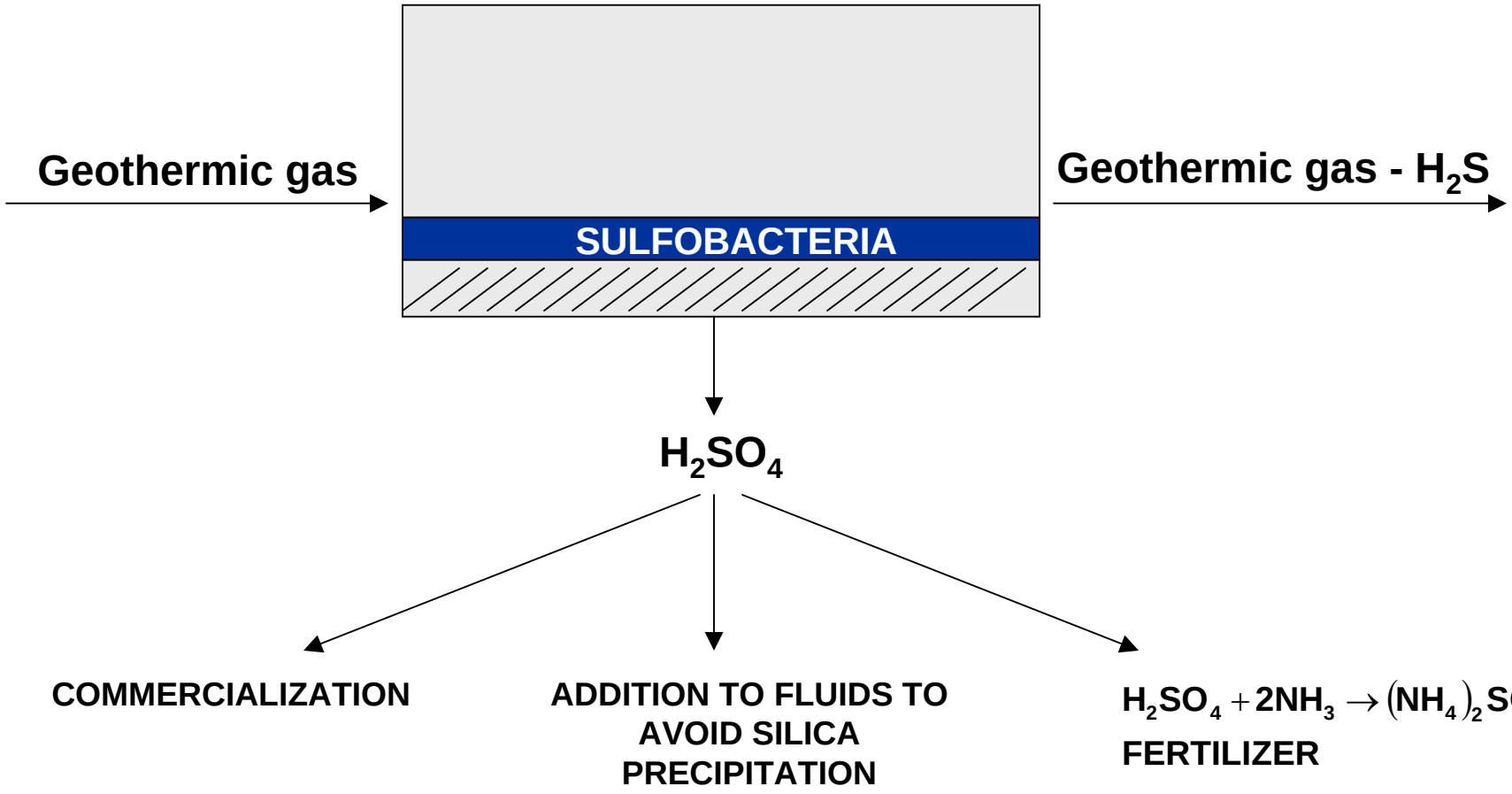
Being able to transform this critical problem in an opportunity through the application of innovative technology of membrane systems is the aim of this project.

Aims



- **Separation through membrane systems of gaseous components and recovery of those commercially or energetically of interest (CO_2, H_2, CH_4)**
- **H_2S separation from waste fluid: size reduction of traditional plants**
- **H_2S reduction through biocatalytic membrane reactors**

H_2S REDUCTION THROUGH BIOCATALYTIC MEMBRANE REACTORS



Advantages

⇒ SIDE PROCESS OF GAS **COMMERCIALLY (CO_2) AND ENERGETICALLY (H_2, CH_4) OF INTEREST** ASSOCIATED TO THE TRADITIONAL PROCESS OF GEOTHERMAL PRODUCTION

⇒ REALIZATION OF **LOW BUDGET PROCESSES OF H_2S SEPARATION AND TREATMENT** (⇒ reduction of the volumes involved through separation of H_2S from total gas; ⇒ biocatalytic conversion)

⇒ **POSSIBILITY OF EXPLOITING GEOTHERMIC RESERVOIR RECENTLY NOT in USE** (low entalpic fluids but rich in uncondensable gas)

⇒ **INNOVATIVE AND PATENTABLE KNOW-HOW** (innovative use of membrane systems)

Tecnoalimenti

- Tecnoalimenti is a **non-profit organisation** dedicated to promotion and execution of **research programs in the food sector**, in particular focussed on the **small and medium enterprises**. Activities further comprise feasibility and market studies, financial consultancy, implementation of quality systems, scientific publishing and organisation of conferences.
- Tecnoalimenti collaborates with numerous other companies in the food sector and other institutes such as **ITM-CNR**
- A selection of the research projects involves wastewater treatment, cheese production methods, recovery of useful products from wine production waste.

Food, beverage and dairy industry

- Traditionally one of the strong industries in Italy.

  e.g. Parmalat has membrane based processes for, and corresponding research efforts in the field of:

  - production of calcium-enriched milk
  - milk and cream concentration for production of yoghurt and typical cheeses
  - production of long-lasting milk by pasteurisation through membranes
  - production of clear fruit juices
  - demineralisation of water

Conclusions and outlook

- Membrane research has a **bright future** in Italy. An increasing attention for a **healthy environment**, **low energy consumption** and **increased product quality** will promote the application of membrane based-processes.
- Considerable growth is expected in the traditionally strong industries, such as the food, beverage and dairy industry, and the leather and textile industry, which have a relatively high environmental impact.
- Among the many other promising sectors, also on a world-wide scale, are drinking water production and new processes for energy conversion (*e.g.* fuel cells).