Cyprus power system: Distributed Generation on going research projects in Cyprus

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1. The electricity sector in Cyprus

Present status

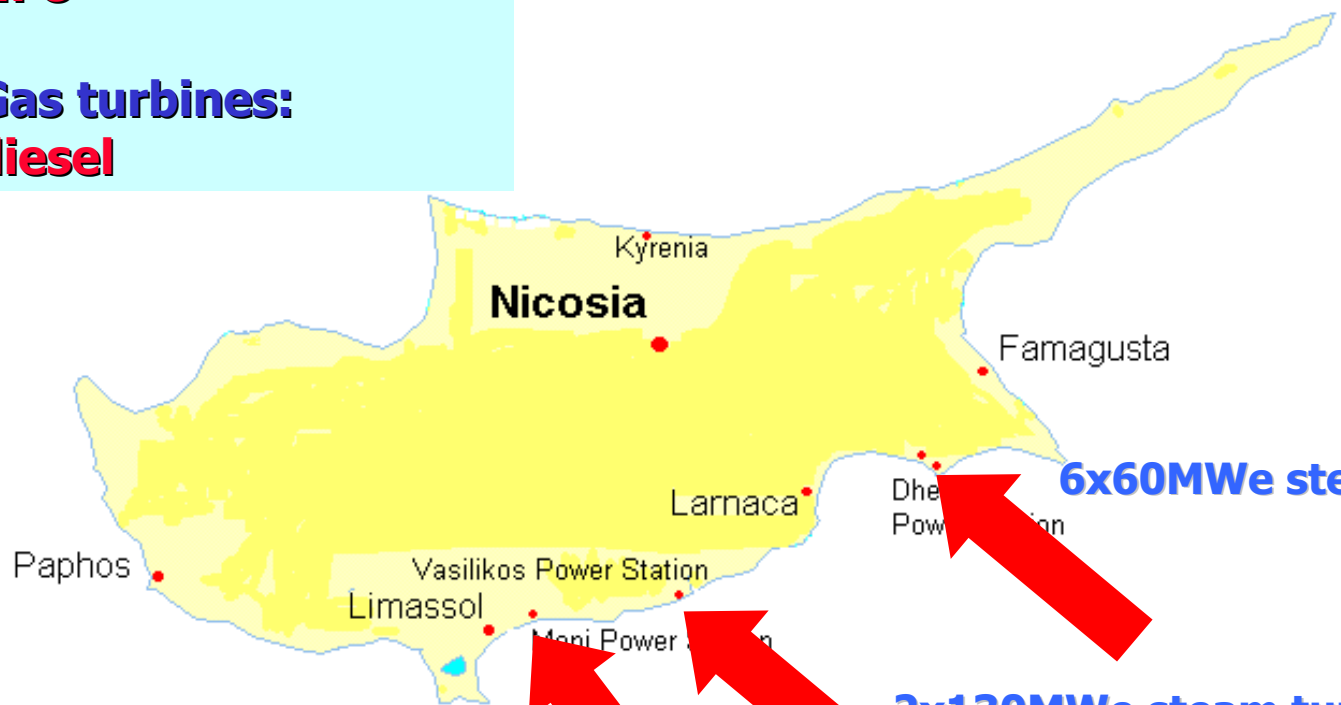
- Small isolated island power system
- Depend on fossil fuels
- Installed capacity 988MWe (in 2004)
- Generation 4.176 million kWh (in 2004)
- Peak load 821MWe (in 2004)

The electricity sector in Cyprus

Present generation system

Steam turbines:
HFO

Gas turbines:
diesel

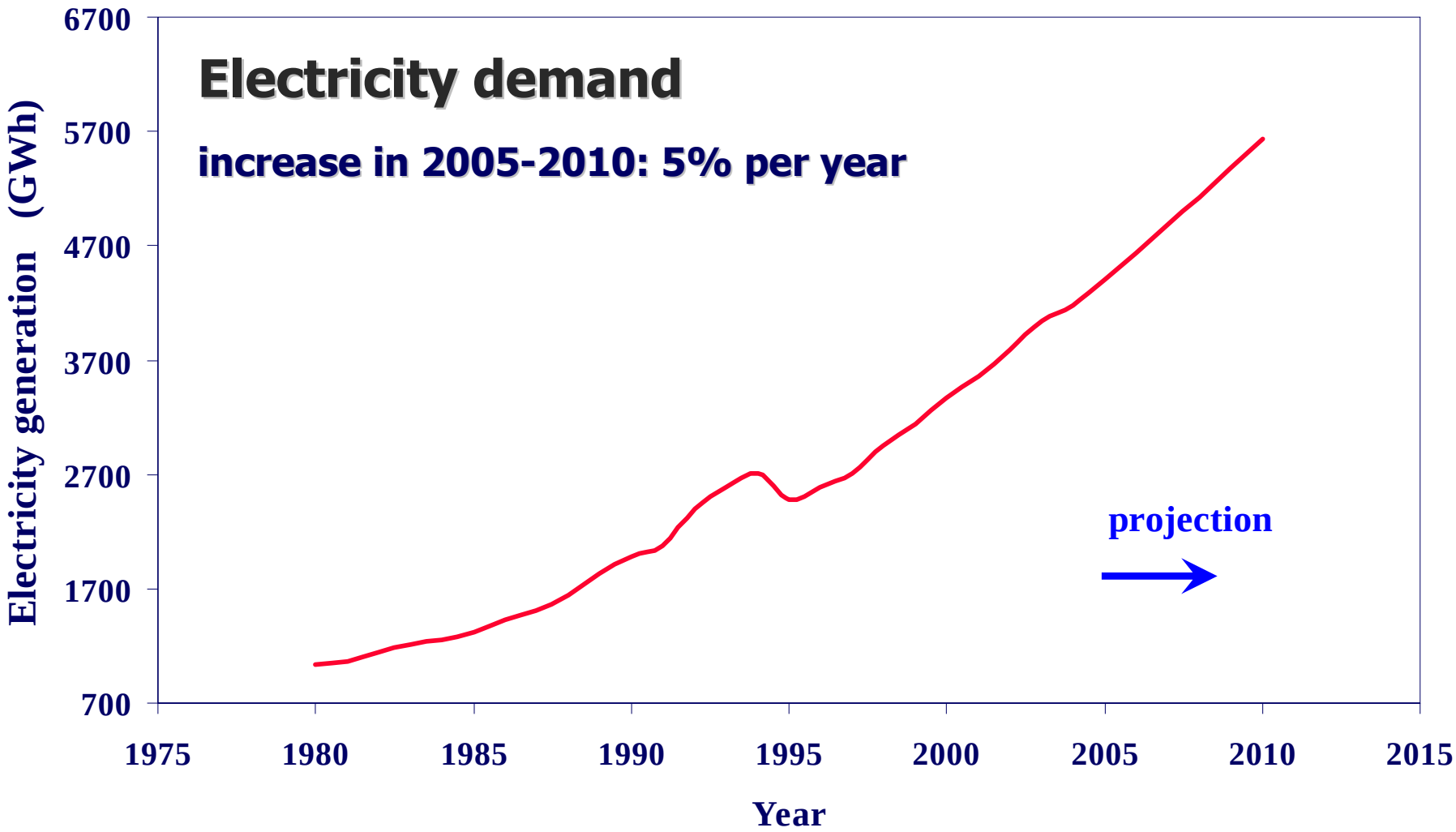


6x60MWe steam turbines

2x130MWe steam turbines
1x38MWe gas turbines
1x130MWe steam turbine
(under commissioning)

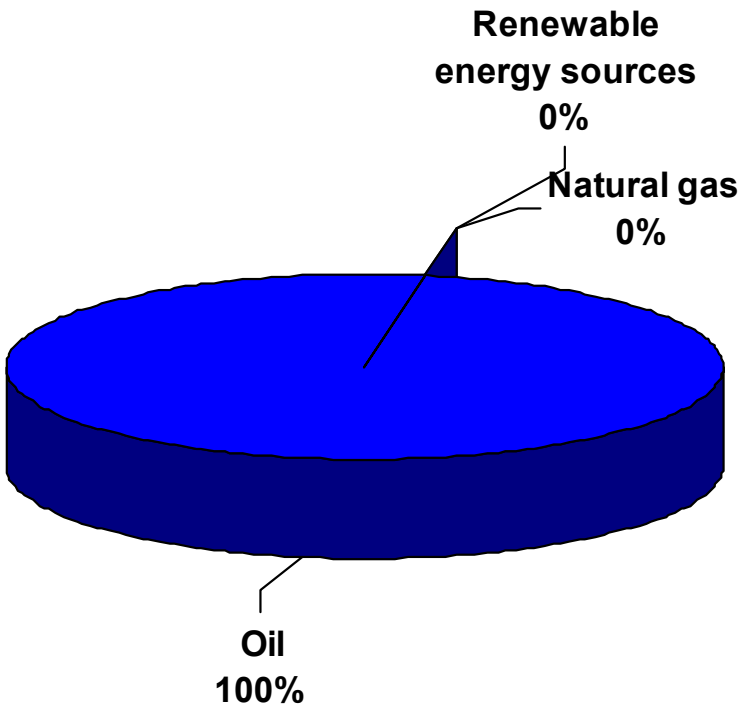
6x30MWe steam turbines
4x37,5MWe gas turbines

The electricity sector in Cyprus



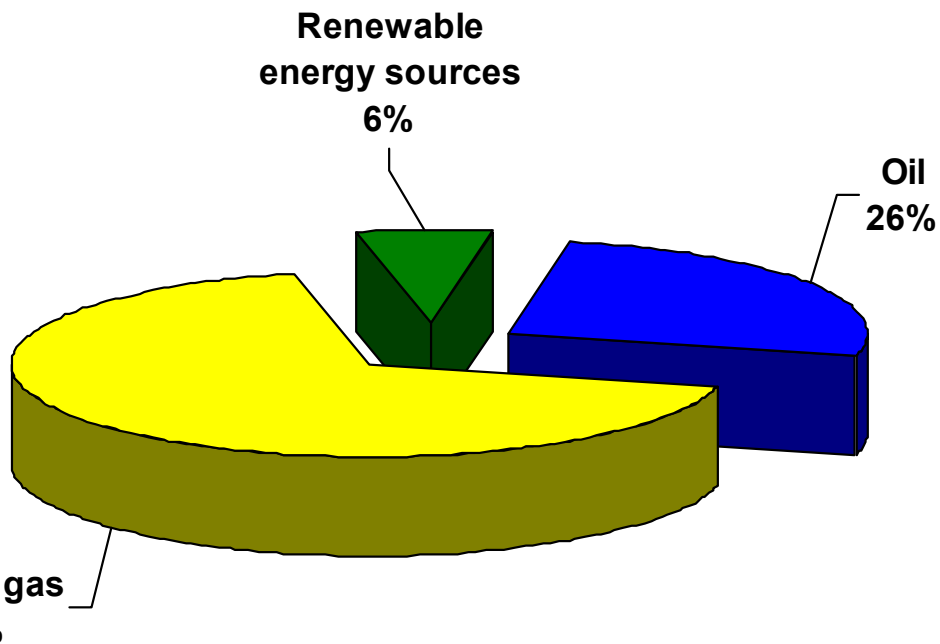
The electricity sector in Cyprus

Cyprus fuel share in electricity



Today

Year 2010



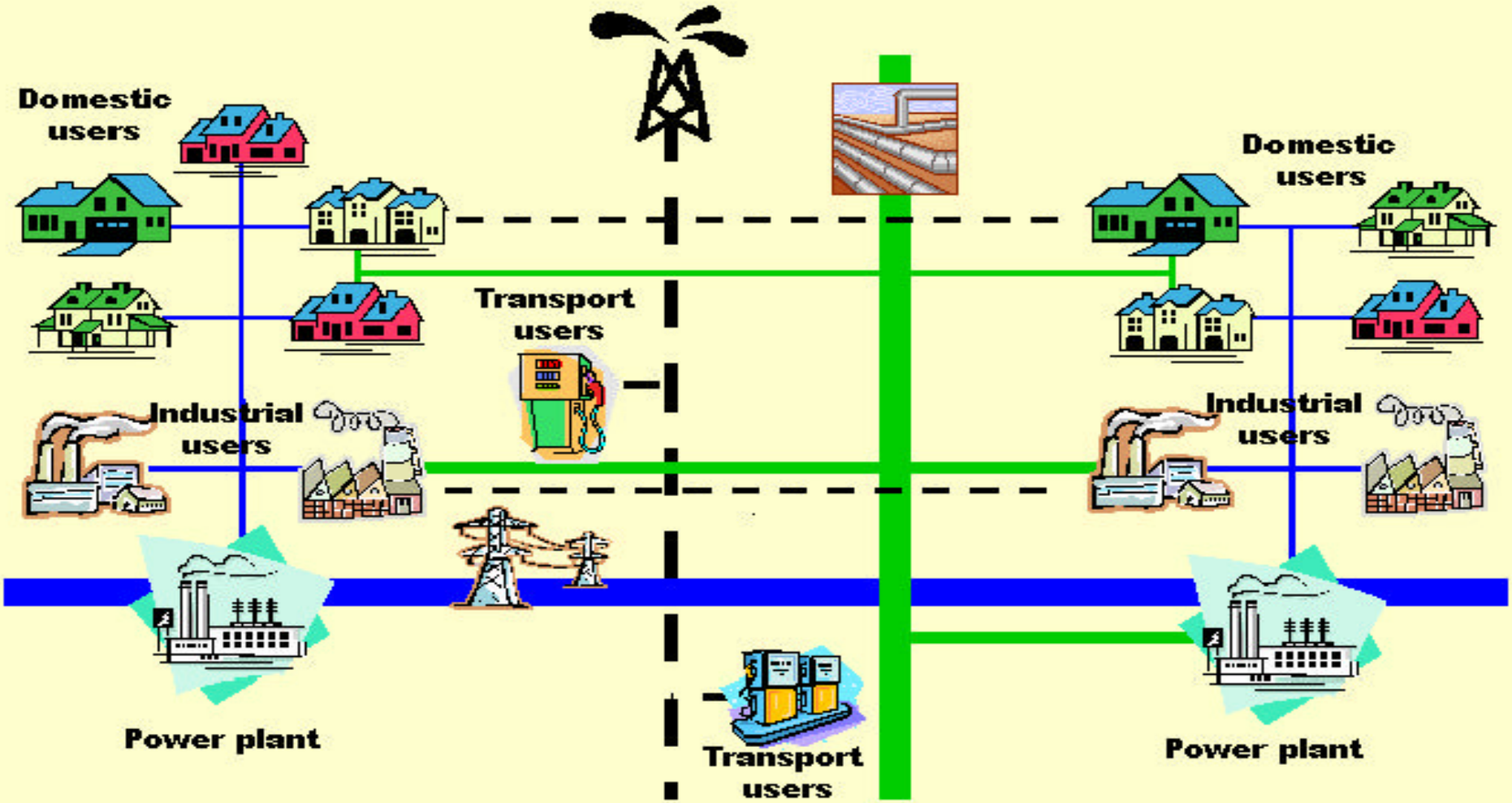
Future plans

- 1x130MWe steam turbine by 2005-06 (HFO)
- 1x220MWe combined cycle by 2008 (diesel or natural gas)
- 2x180MWe combined cycle by 2009 (diesel or natural gas)
- RES: Wind Park (6MWe), PV system (80kW)
- RTD (long term strategic planning)

2. EC long term policy for energy systems

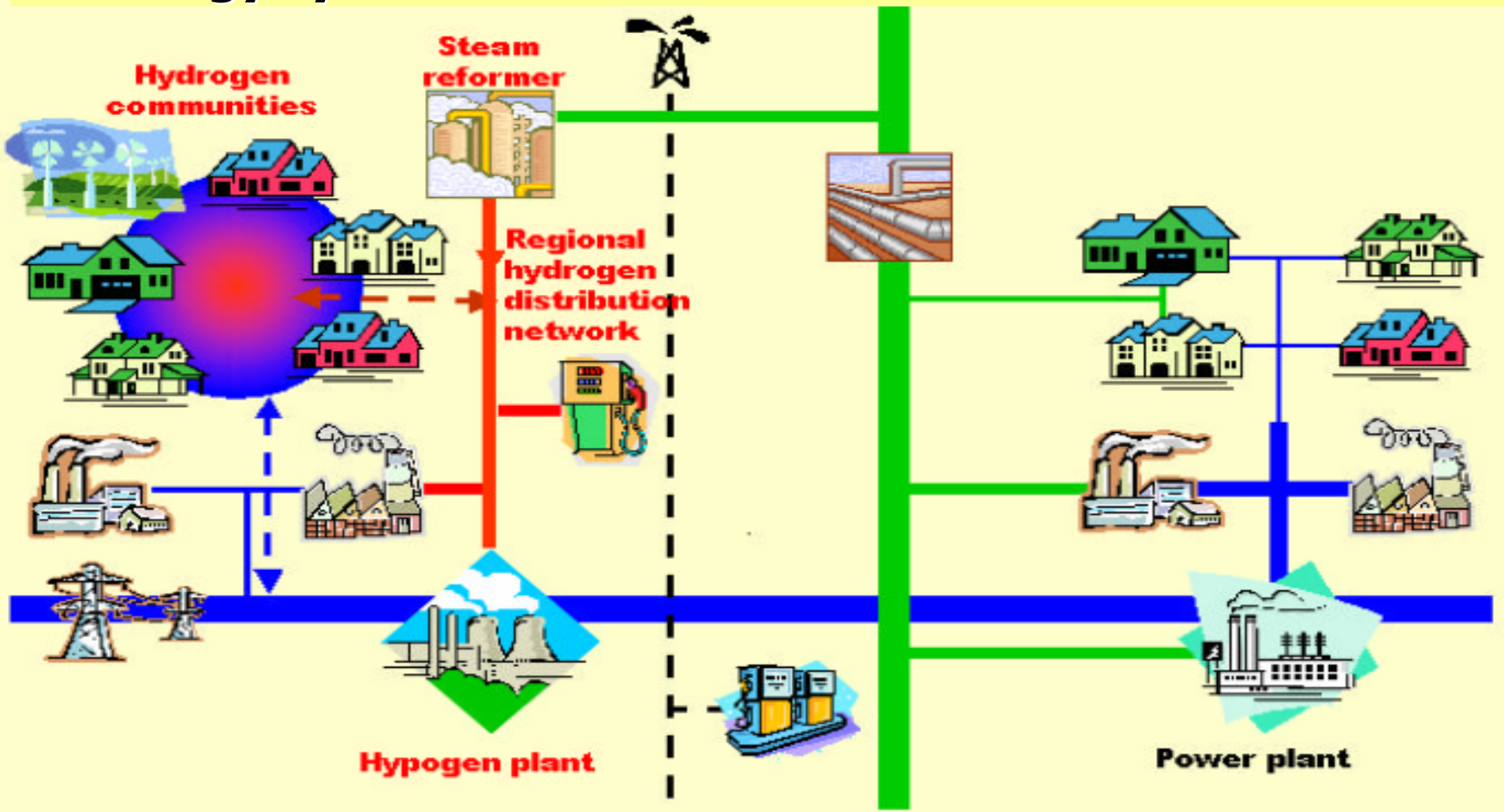
EU long term policy for energy systems

EU energy system today



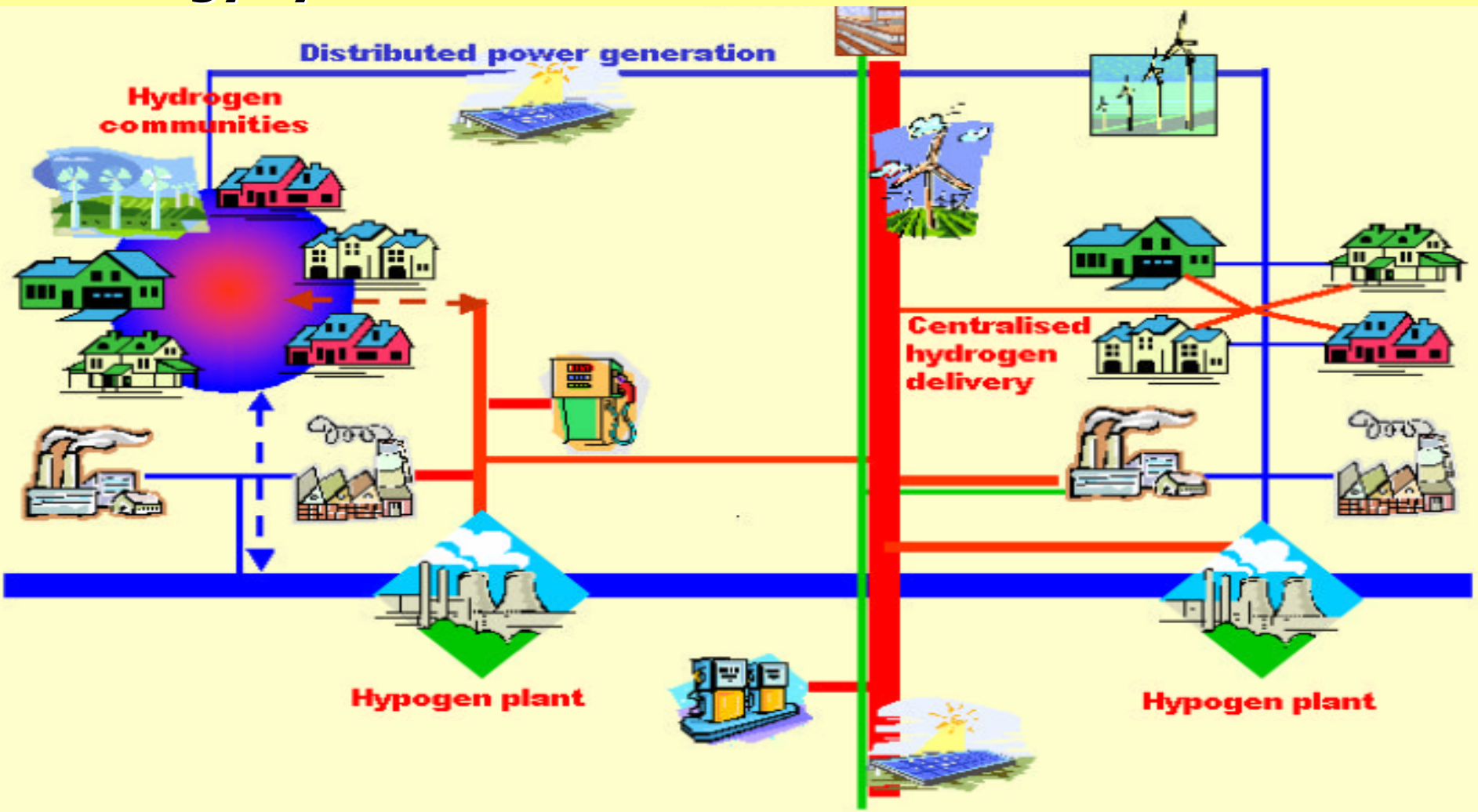
EU long term policy for energy systems

EU energy system in 2020



EU long term policy for energy systems

EU energy system in 2040



3. DG technologies

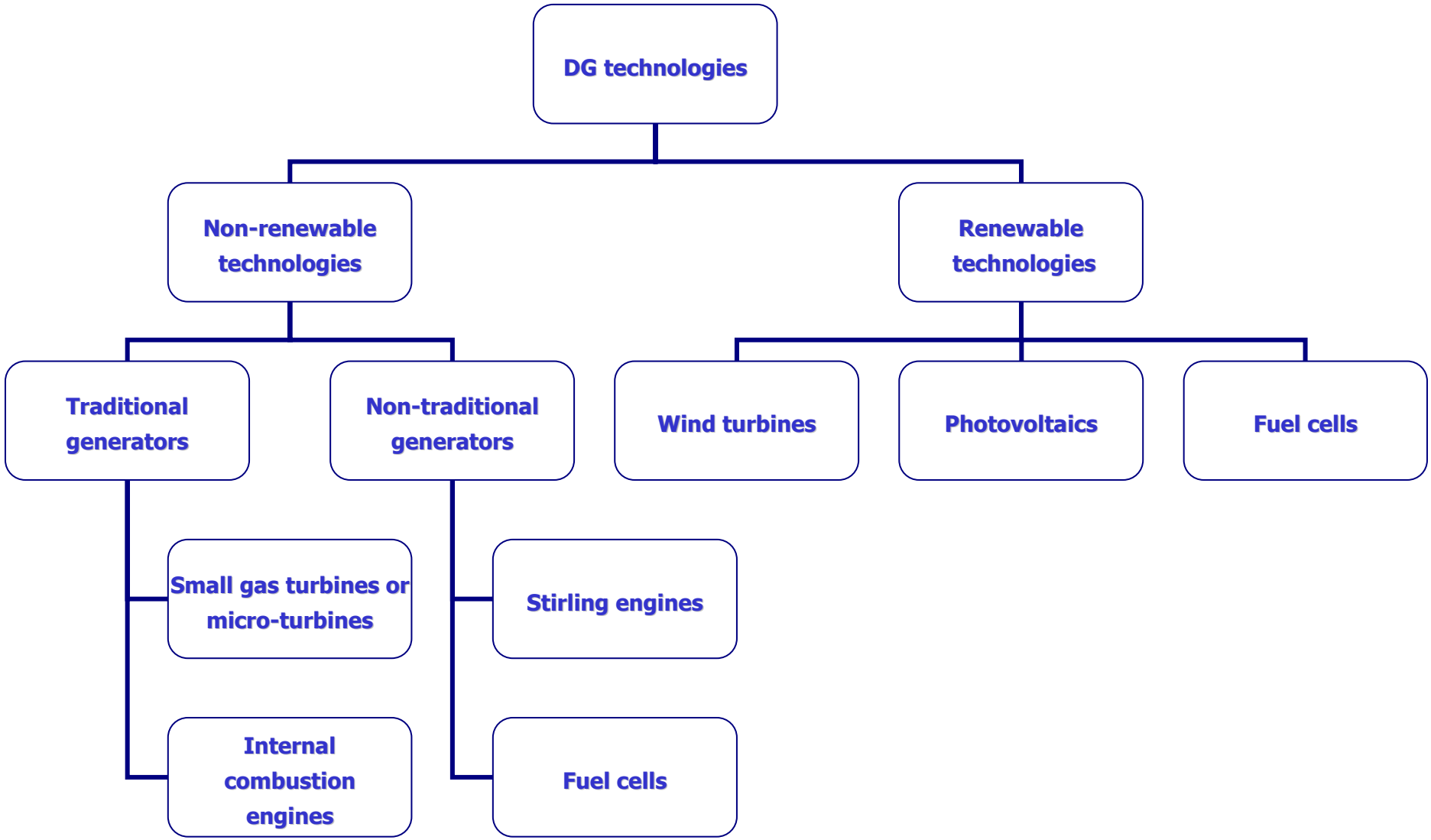
DG technologies

- **Definition:**
  Distributed Generation (DG) is an electric power source connected directly to the distribution network or on the customer site of the meter

- **Capacity categories:**
  - (a) Micro DG, 1We – 5kWe,
  - (b) Small DG, 5kWe – 5MWe,
  - (c) Medium DG, 5MWe – 50MWe,
  - (d) Large DG, 50MWe – 300MWe

- **Type categories:**
  - (a) Non-renewable DG,
  - (b) Renewable DG

DG technologies



DG technologies

Commercially available and emerging DG technologies

DG technology	Commercially available	Emerging technology
Internal combustion engines	√	
Gas turbines	√	
Wind turbines	√	
Photovoltaic systems	√	
Micro-turbines	√	
Fuel cells	√	√
Stirling engines		√

4. DG on-going projects in Cyprus

DG on-going projects in Cyprus

- **EU-DEEP (funded by FP6)**
  - **The birth of a European distributed energy partnership that will help the large-scale implementation of distributed energy resources in Europe (Contract No: SES6-CT-2003-503516)**

- **H2/KYPSELES (funded by RPF)**
  - **Distributed electricity generation with the use of H_2/Fuel Cells, with zero CO_2 emissions (Contract No: TEXNO/0603/03)**

- **DISTRES (funded by FP6)**
  - **Promotion and consolidation of all RTD activities for renewable distributed generation technologies in the Mediterranean region (evaluated successfully - on contract period)**

EU-DEEP project

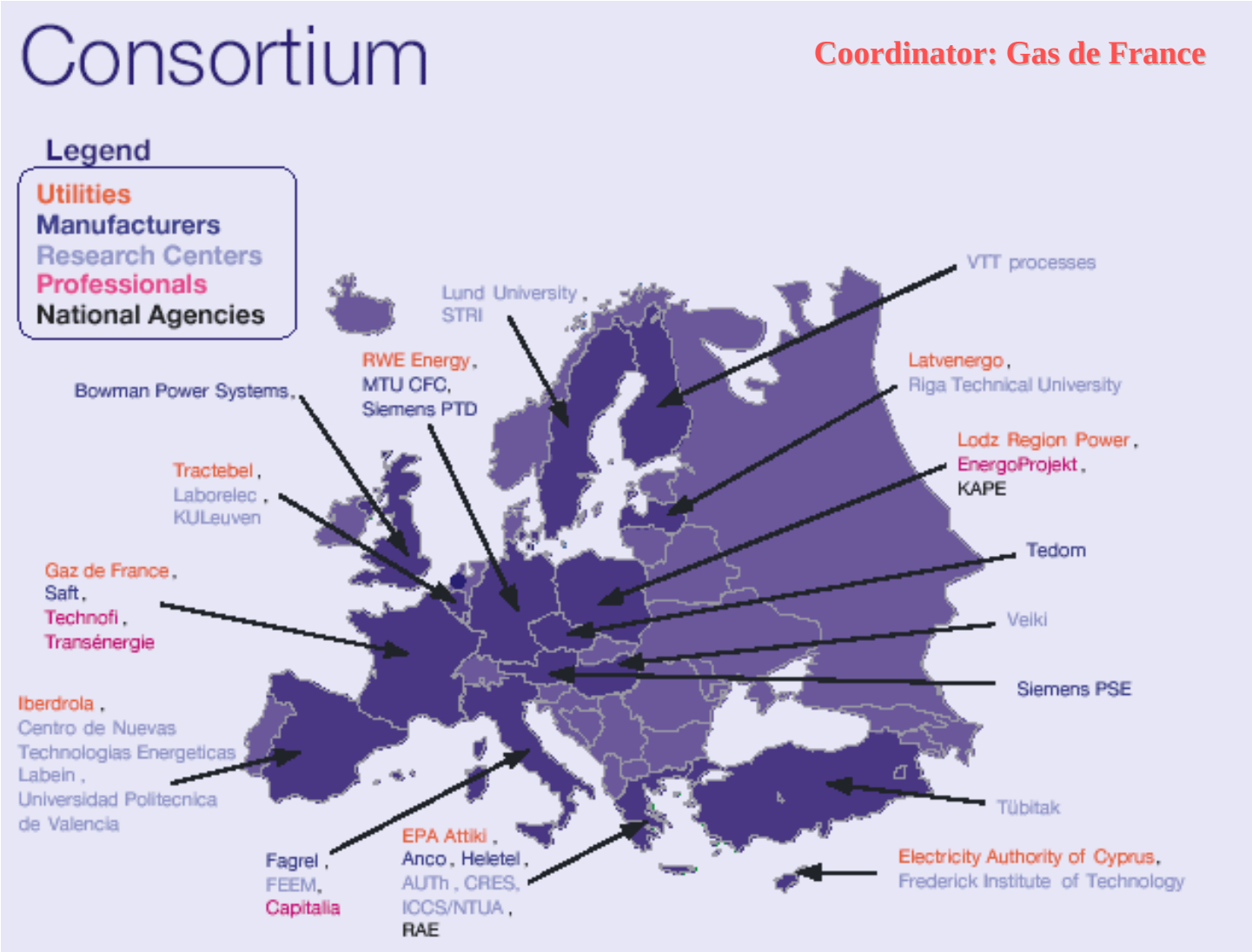
The birth of a European distributed energy partnership that will help the large-scale implementation of distributed energy resources in Europe (EU-DEEP)

Contract No: SES6-CT-2003-503516

EU-DEEP project

- **Objectives:**
  - **Determination of the technical and economic factors for the introduction of DG technologies into European electricity sector**
  - **Market research concerning the barriers opposing the competitiveness of DG technologies**
  - **Development of a partnership of the various participating utilities for the future penetration of DG technologies**

EU-DEEP project



EU-DEEP project

The use of DG technologies for isolated communities:

A cost-benefit analysis*

* Poullikkas A., "Implementation of distributed generation technologies in isolated power systems", Renewable and Sustainable energy reviews, 2006.

Poullikkas A., "A parametric cost-benefit analysis for the use of distributed generation technologies in the island of Cyprus", *Proceeding of CIGRE Symposium on Power Systems with Disperse Generation*, 2005.

EU-DEEP project

I . P . P . Algorithm v2.0*

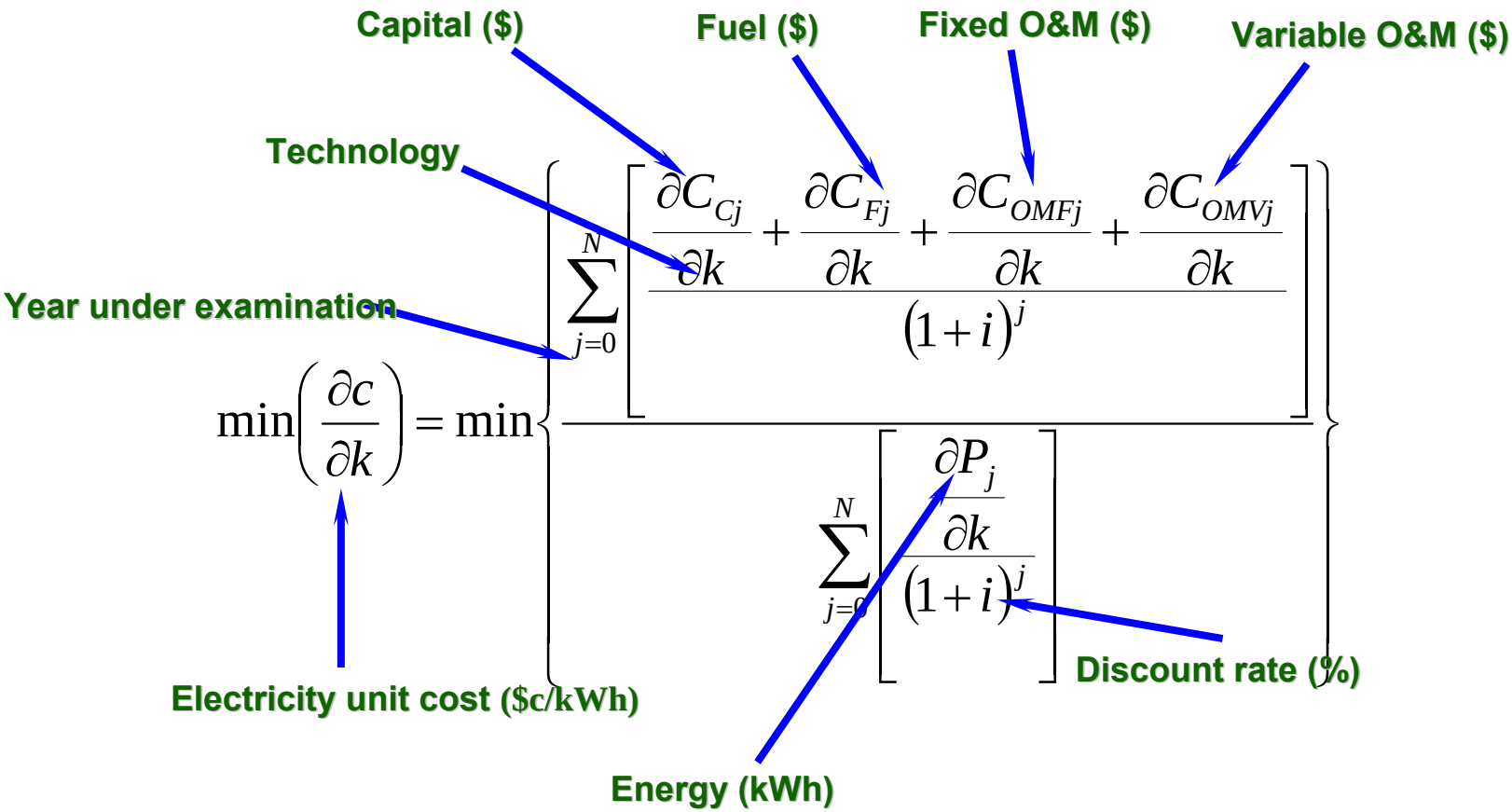
(Software for power technology selection in competitive electricity markets)

1. Technical, economic and environmental analysis
2. Evaluation of candidate power technologies:
   - Capital cost
   - Fuel consumption and cost
   - Operation and maintenance cost
   - Plant load factor
   - Life expectancy etc.
3. Least cost power generation configuration

*Poullikkas A., *IPP algorithm version 2.0*, User manual, © 2000-2005.

EU-DEEP project

Final cost function*



*Poullikkas A., "A technology selection algorithm for independent power producers", *The Electricity Journal*, 2001.

EU-DEEP project

- **Set of equations**

$$\min \frac{\partial c}{\partial k} = \min \left[\begin{array}{l} \left(\frac{A_1 + A_2 + A_3 + A_4}{A_5} \right)_1 \\ \left(\frac{A_1 + A_2 + A_3 + A_4}{A_5} \right)_2 \\ \left(\frac{A_1 + A_2 + A_3 + A_4}{A_5} \right)_3 \\ \left(\frac{A_1 + A_2 + A_3 + A_4}{A_5} \right)_4 \\ \ldots \\ \left(\frac{A_1 + A_2 + A_3 + A_4}{A_5} \right)_k \end{array} \right]$$

Candidate technology 1

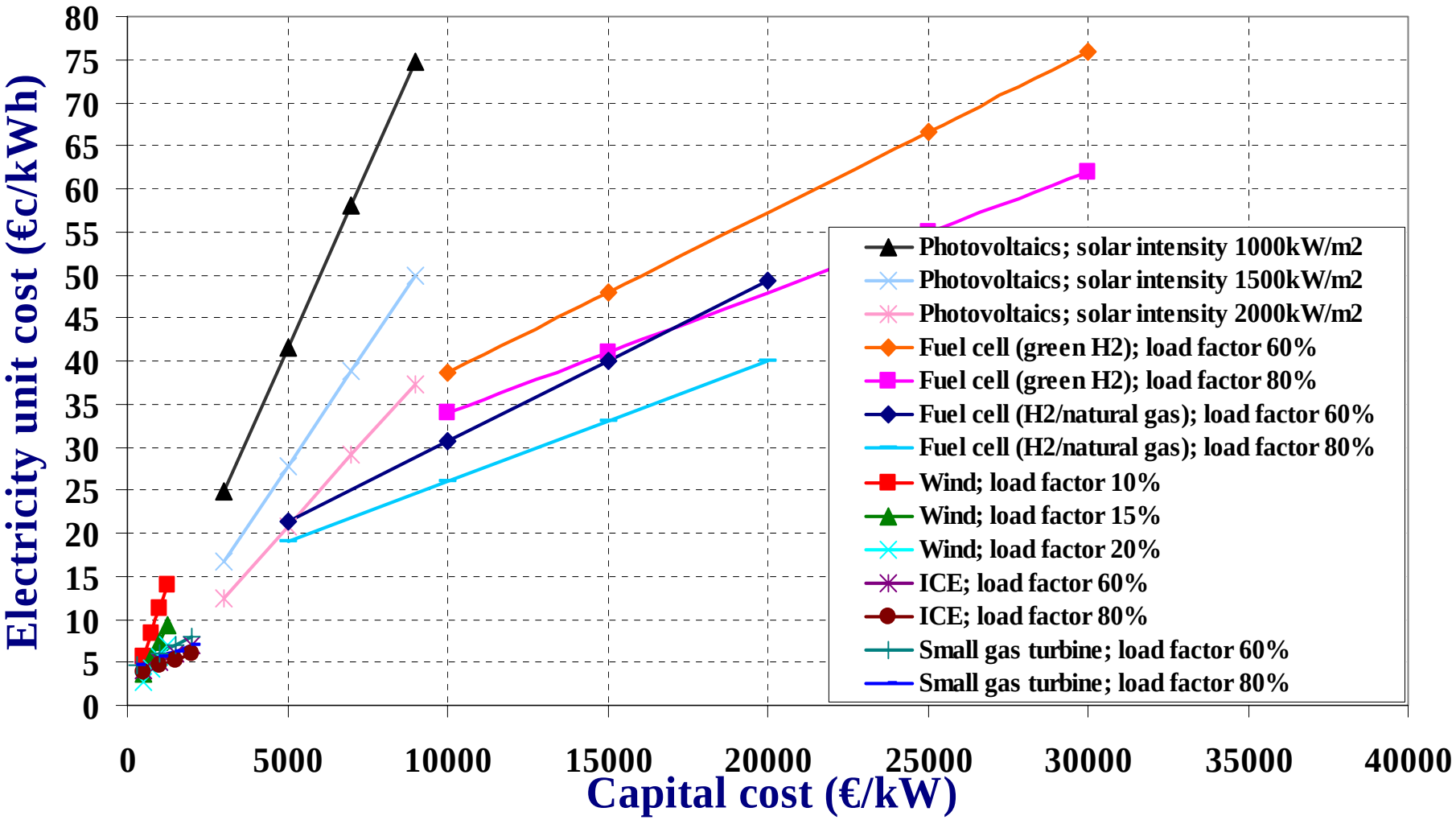
Candidate technology 2

Candidate technology 3

Candidate technology 4

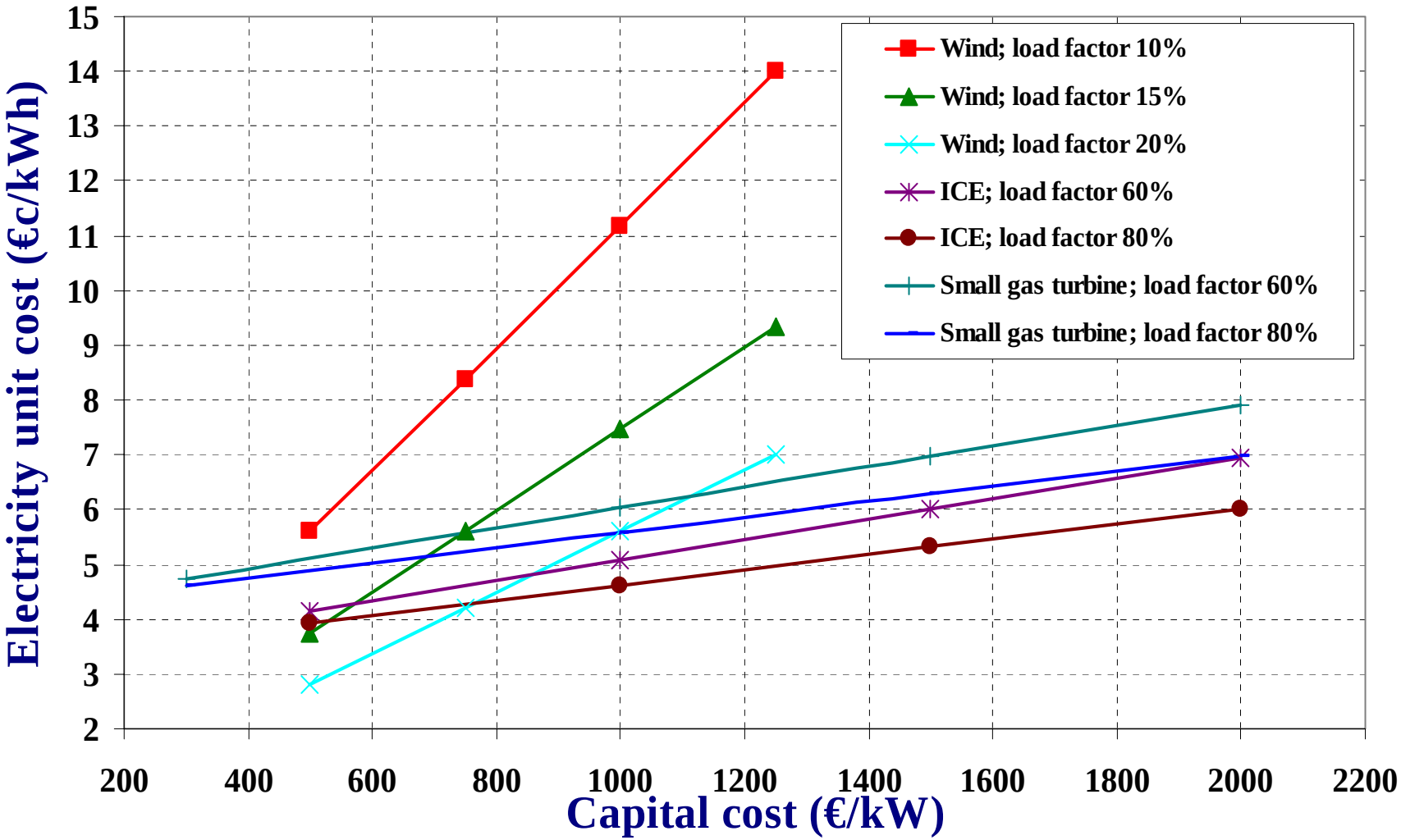
Candidate technology *k*

EU-DEEP project



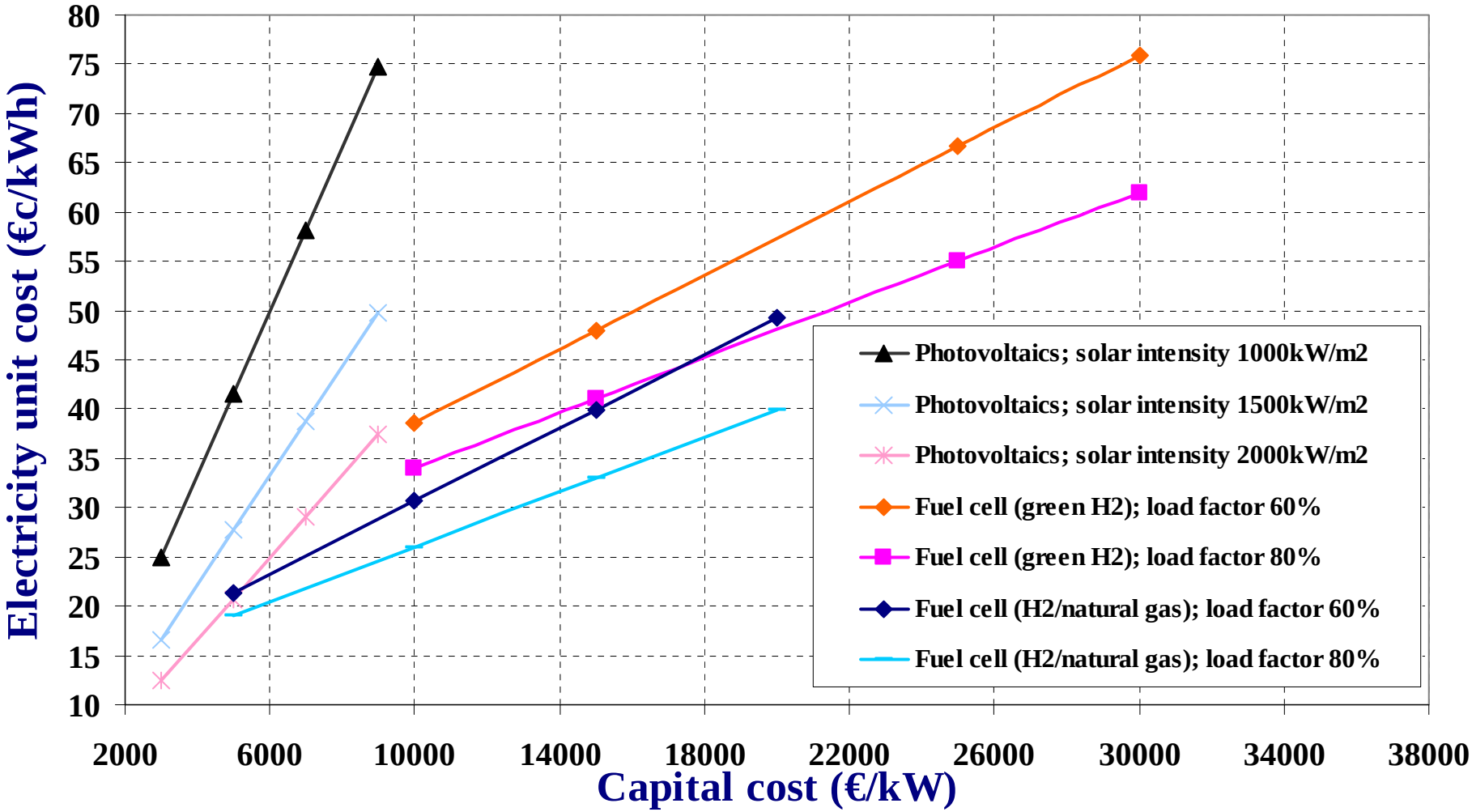
EU-DEEP project

"High" potential technologies



EU-DEEP project

"Low" potential technologies



H2/KYPSELES project

H2/ΚΥΨΕΛΕΣ

Distributed electricity generation with the use of H_2/Fuel Cells, with zero CO_2 emissions (H2/KYPSELES)

Contract No: TEXNO/0603/03

H2/KYPSELES project

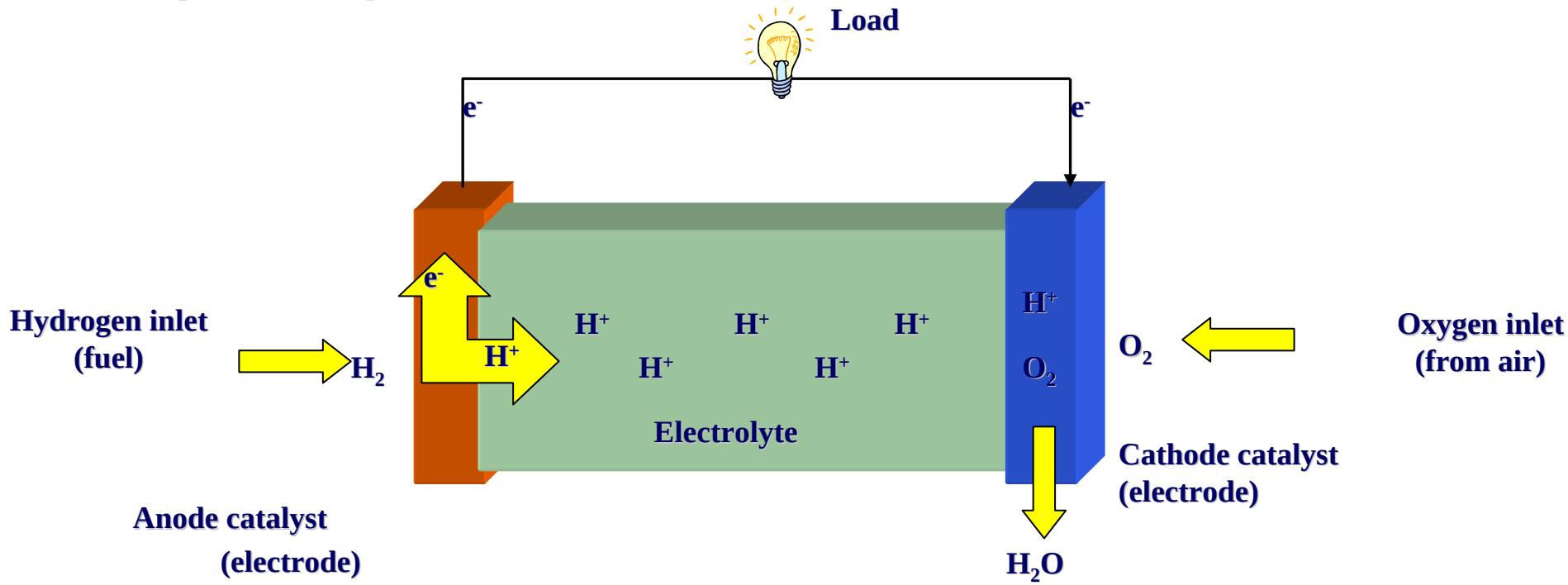
- **Objectives:**
  - Development of a hydrogen fuel cell DG technology
  - Demonstration via a grid connected pilot plant
  - Investigation of hydrogen fuel cell operation

- **Consortium:**
  - EAC (coordinator)
  - National Technical University of Athens
  - Frederick Research Center
  - Hystore Ltd.

H2/KYPSELES project

Fuel cells

Principle of operation



H2/KYPSELES project

Characteristics

1. **Fuel: hydrogen and oxygen – natural gas reforming or green hydrogen**

2. **High efficiency**

3. **Maintenance requirements are minimal**

4. **Environmentally friendly – zero emissions with green hydrogen**

H2/KYPSELES project

Disadvantages

- Not in commercial use yet
- Expensive fuel - natural gas

  reforming or green hydrogen
- High capital cost
- Strong subsidies required

H2/KYPSELES project

250kW fuel cell system in Germany

DISTRES project

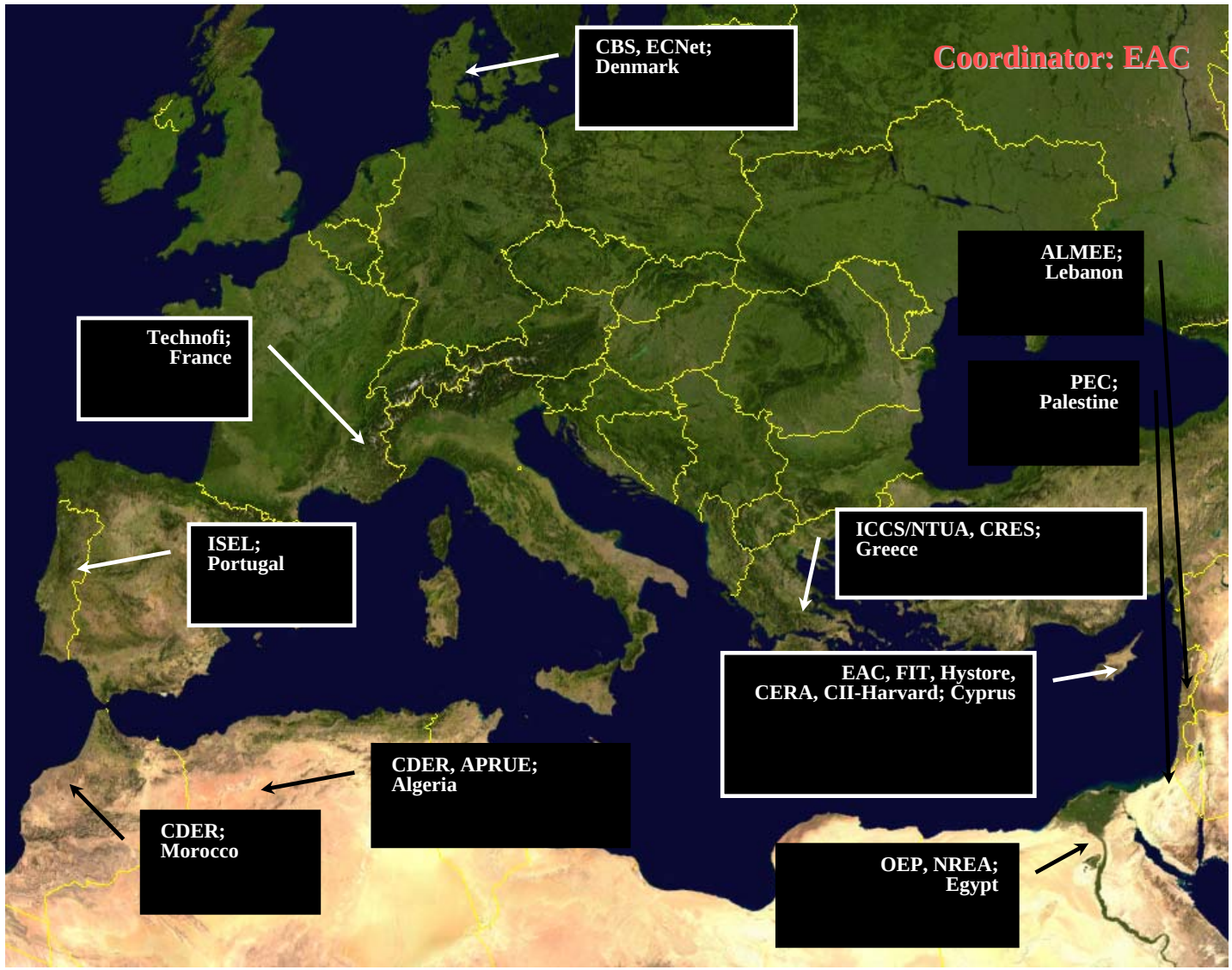
Promotion and consolidation of all RTD activities for renewable distributed generation technologies in the Mediterranean region (DISTRES)

Under contract period

DISTRES project

- **Objectives:**
  - **Co-ordinate RTD projects in RES-DG technologies**
  - **Promote the electricity generation from solar energy, photovoltaic systems and solar thermal systems, paving the way for pilot systems and products**
  - **Produce capacity building methodologies**
  - **To disseminate the results as widely as possible in the Mediterranean countries and in the EU**

DISTRES project




The End