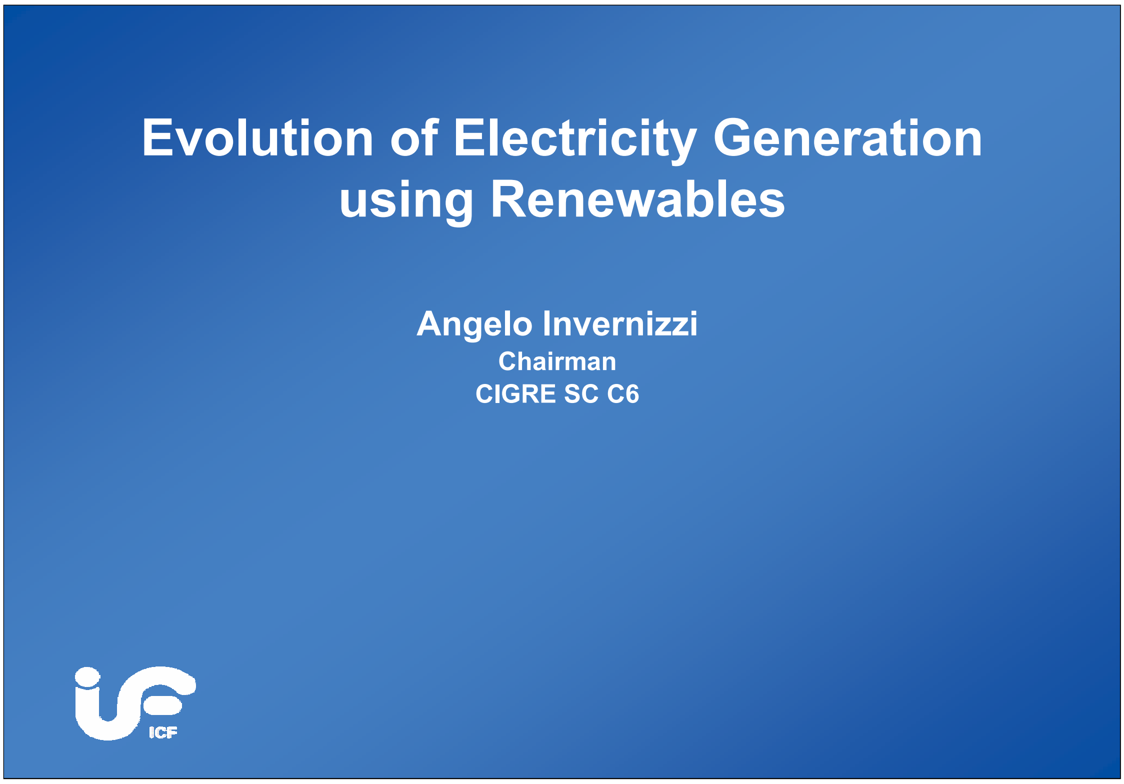
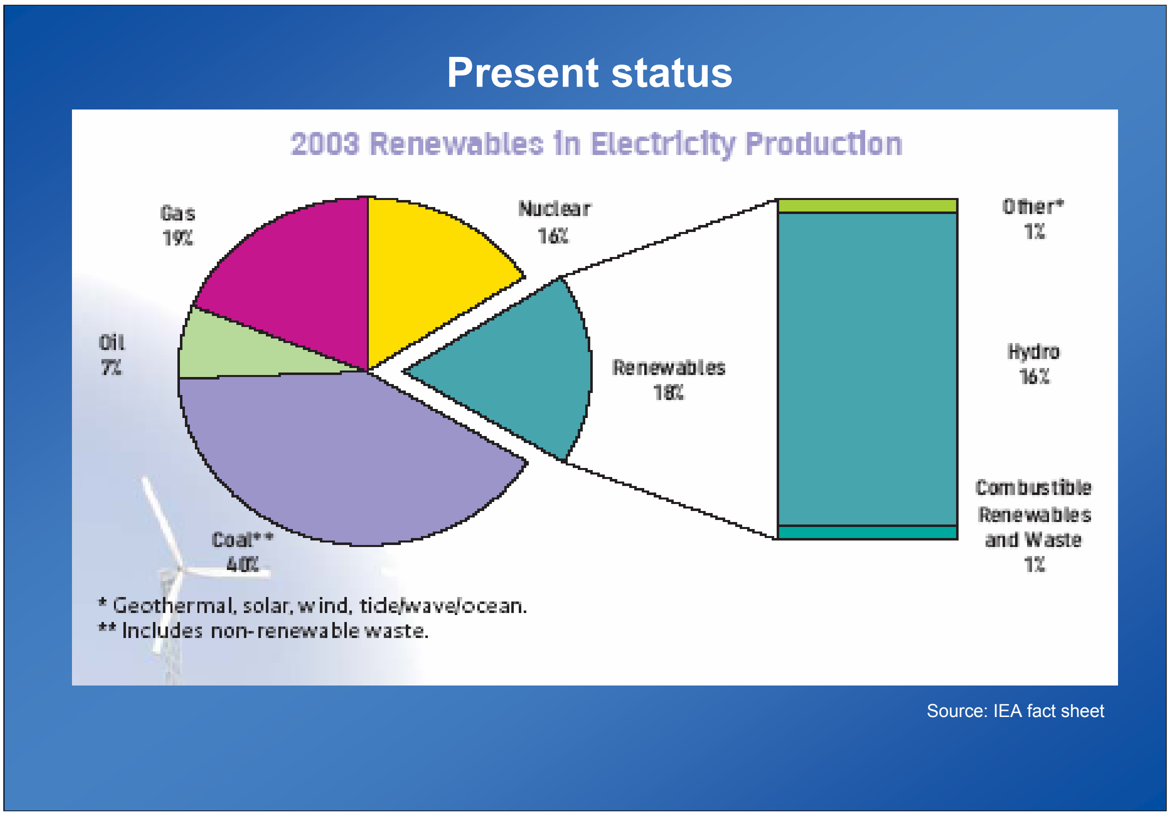


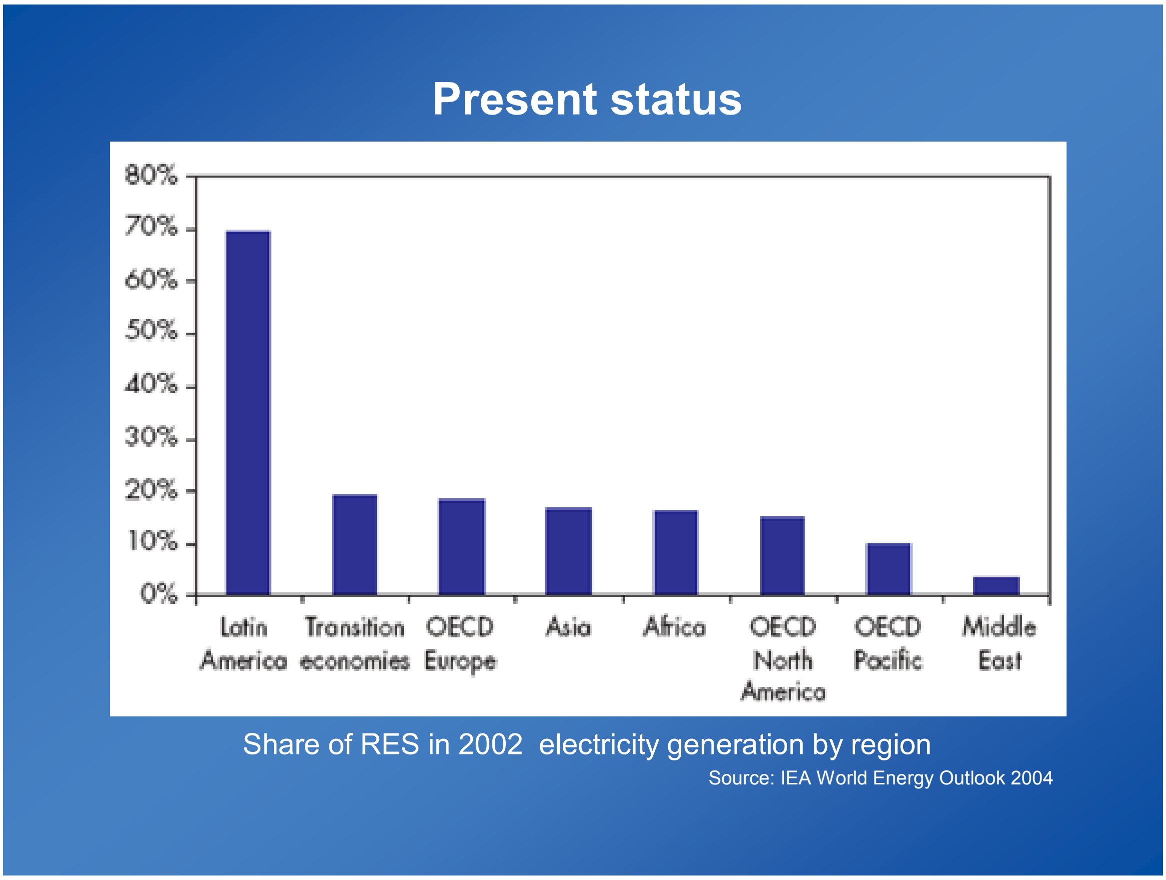
Ladies and gentlemen,

In my talk on renewables I will focus on the following topics:

- The present status
- The expected trend
- The driving factors
- The technologies
- The impact on transmission and distribution network development.



Renewables account for only 18% in electricity production; hydro is the source mostly used.



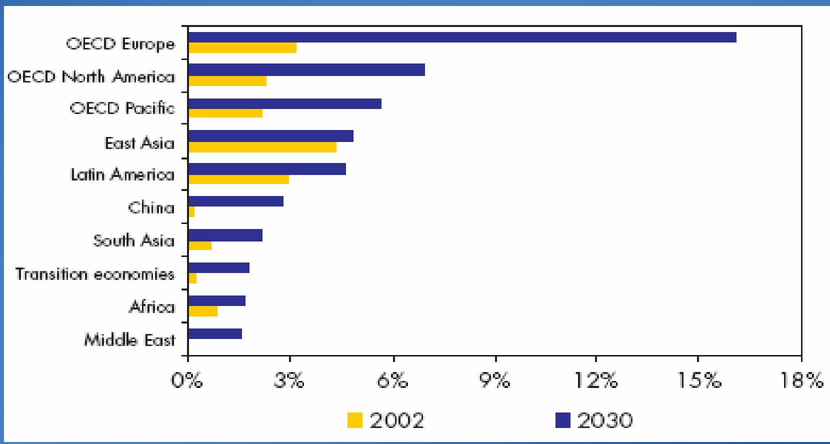
The share of renewables in the world is far from homogeneous. The large share of 70% in Latin America stems from hydropower.

The expected trend

The total share of RES is expected to increase slightly, from 18% in 2002 – 2003 to 19 % in 2030:

> Hydropower share will fall

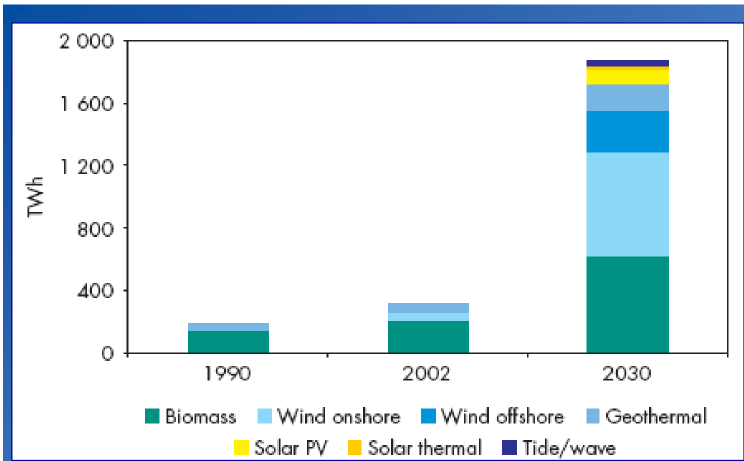
> Non-hydro RES (biomass, wind, geothermal, solar, tide/wave) will triple their share



Share of Non-Hydro RES in electricity generation

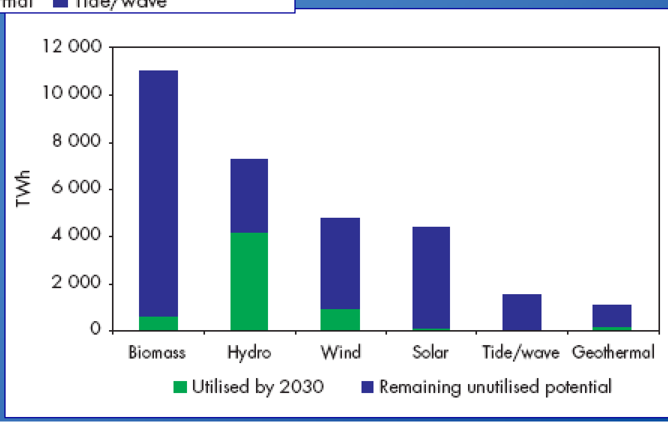
Source: IEA World Energy Outlook 2004

The expected trend



World electricity generation from Non-Hydro RES

Source: IEA World Energy Outlook 2004



World long term RES potential for electricity generation

There are other types of renewables (RES), different from hydropower that will increase in the future, especially wind energy based on onshore and offshore applications. Interesting is also to look at the very high potential for additional electricity generation from biomasses.

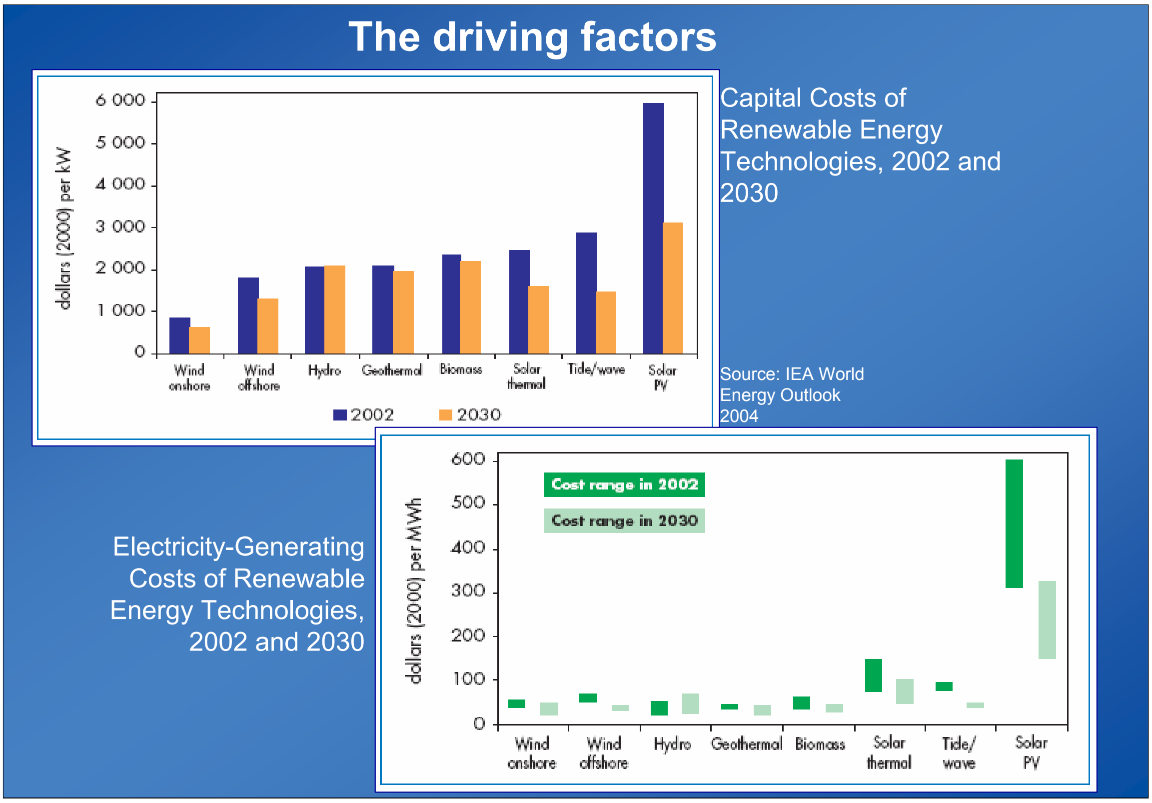
The driving factors

The development of Power Electric Systems (PES) is now characterized by:
> Need to replace ageing infrastructures
> Rising primary energy import dependency
> Increasing demand for energy and increasing oil and gas prices
> World climate getting warmer

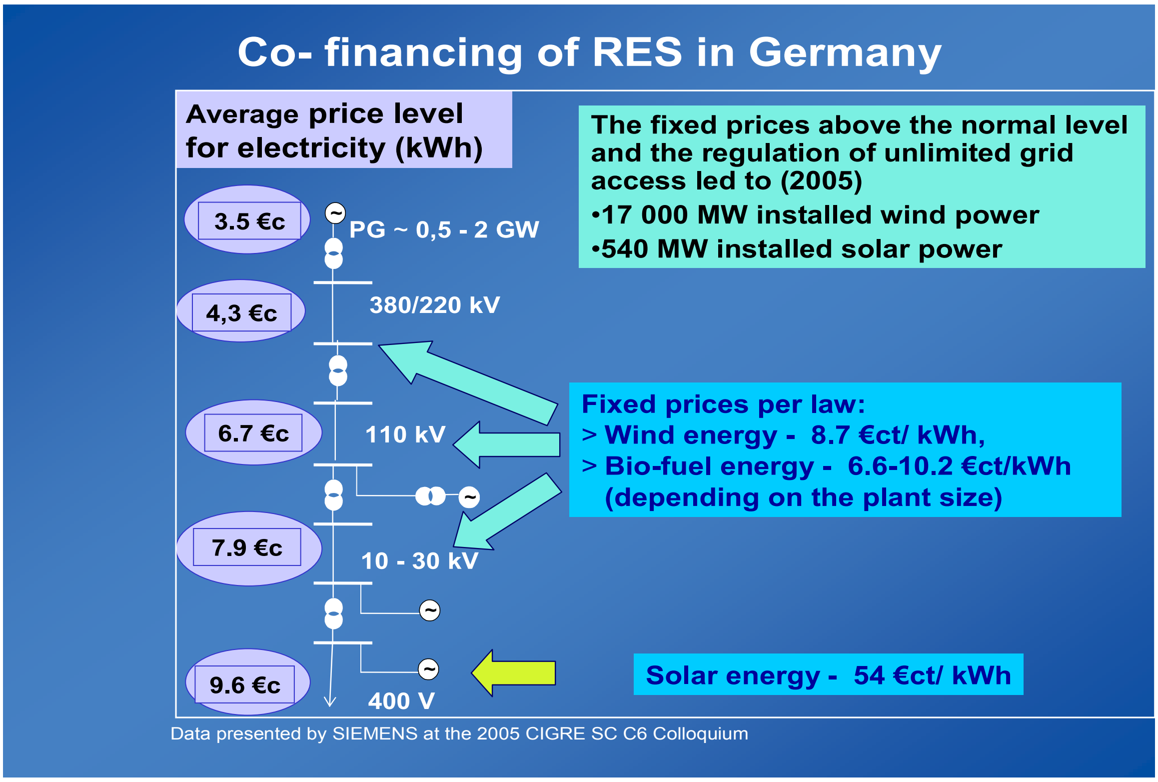
Concern of populations for:
> higher electricity prices
> threats on security of energy supply
> changes in climate
is putting pressure on national governments and on regional / international organizations to assess suitable strategies for the development of PES

Significantly assessed strategies and undertaken actions are:
•The Kyoto Protocol aims to achieve, by 2012, a 5.2 reduction of 1990 CO_2 emission. Stated in 1997, it has been agreed by 158 countries (August 2004)
• In spring 2006 EU stated a Green Paper : A European Strategy for sustainable, competitive and secure energy. Increasing the use of RES, over the 2010 target of 21%share of electricity from RES, is one of the priorities
• Recently, June 21, in a EU – US summit it was agreed on an annual strategic review of EU – US energy cooperation and it was launched a Dialogue on Climate Change, Clean Energy and Sustainable Development

The key driving factors now and in the future, promoting the use of renewables for electricity generation, are the sustainable development of power systems and the security of energy supply.
Such factors induce some actions that are particular incentives and subsidies for the development and exploitation of renewables. There could be mandatory amounts in the electricity generation of renewables (in Italy we have an action like this). There could also be economic incentives like contributions for investments, feed-in tariff systems, market mechanisms like green certificate systems.



One may ask why incentives are necessary? If we look at the present and future cost of renewables, it is clear, that in general electricity from renewables is not so economical and competitive with other sources. Especially solar energy is absolute out of any competition.



Here you can see some examples of these incentives, based on the case in Germany. You may compare the average price at the different levels of the transmission systems with the provided incentives. This may explain the incredible increase of the exploitation of wind energy.

The technologies: Hydropower

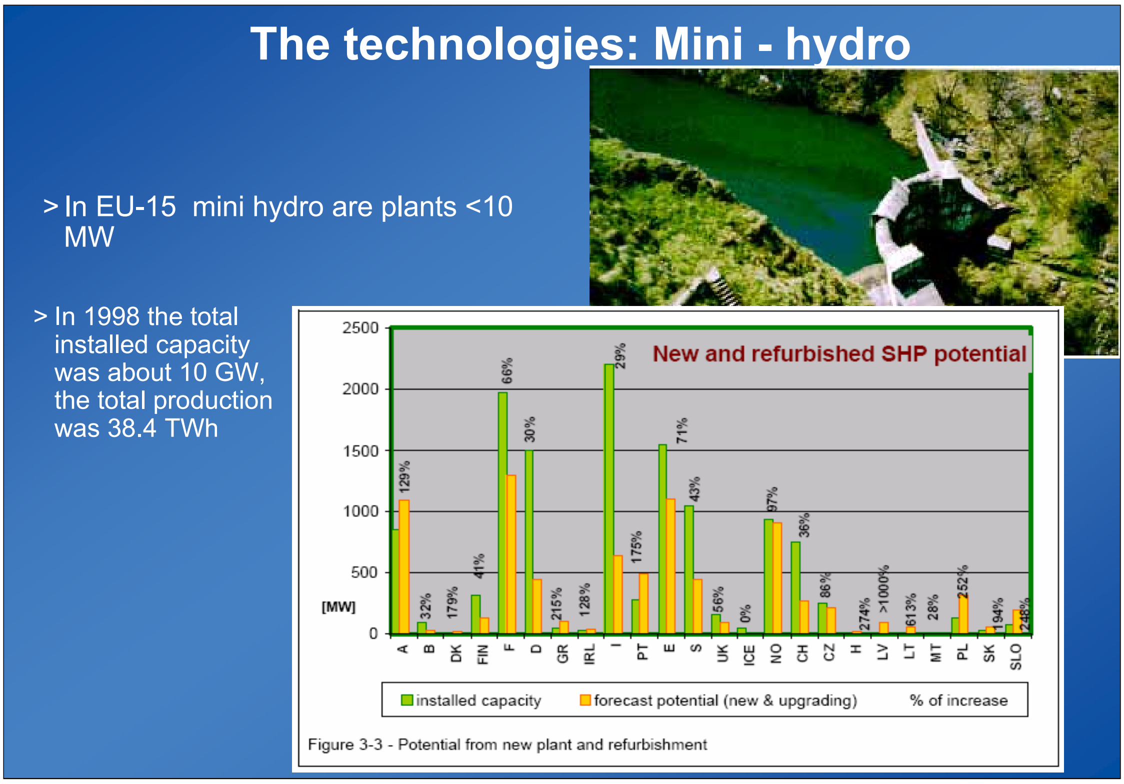
Itaipu (Brazil)
Capacity: 18 x 700 MW (12.6 GW)
Energy: 88 TWh/y (2005)

> Expected 4250 TWh by 2030
> China and Latin America will account 60% of increase
> China will have the largest capacity

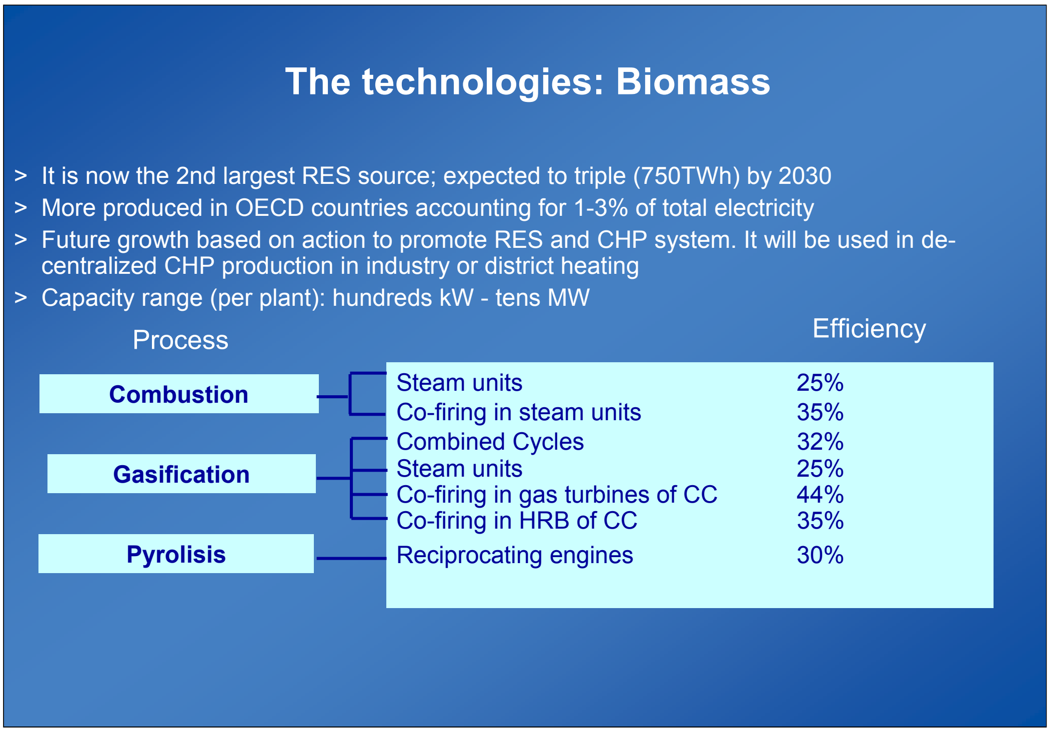
Three Gorges Power plant (China - 2009)
Capacity: 26 x 700 MW (18.2 GW)
Generation: 84 TWh/y

Now let us talk about the technologies. I will give you some details, just to explain what could be the expected impact on the development of transmission and distribution. Of course this information is very different depending on the type of energy source. Hydropower plants are basically very large power plants.

Here you can see examples in Itaipu, Brasil, and Three Gorges, China. Of course these types of projects create a deep impact on the environment. The relevant investments are very big, requiring the availability of enormous financial resources. The sites of these hydro power plants are very far from load centers, therefore very long overhead lines with high transmission capacity have to be developed.



Hydropower may also be used with so-called mini hydro plants. In Europe hydropower plants are considered to be mini hydro with less capacity than 10 MW. But the expected contribution in thermal energy is very low.

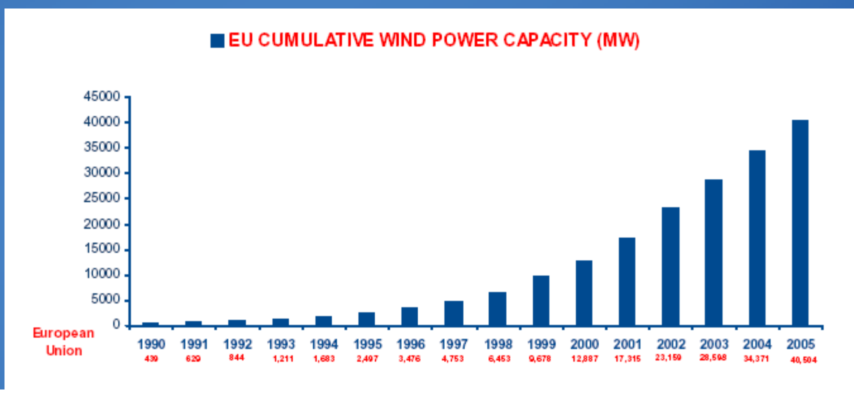


The potential of biomass is very high, the development is expected to triple by 2030.

The technologies: Wind power

The technologies: Wind power

- Capacity range (per generator) : 10 kW- 5 MW
- Expected 930 TWh by 2030 (the 2nd largest RES source after hydro)
- Most existing wind farm are on-shore.
- Substantial contribution expected from off-shore wind farms by 2030 (in Europe a 40% share of total wind generation is expected)
- In Europe the target of 40 GW scheduled for 2010 already achieved in 2005
- Very high penetration (due to government incentives) in Germany (18.4 GW), Spain (10 GW) and Denmark (3 GW) achieved in 2005



The technologies: Photovoltaic conversion

- > Capacity range : few kW - 3MW
- > Expected 95 TWh by 2030

The technologies: Solar thermal

Expected 21 TWh by 2030

Solar Two tower pilot plant (USA, California)

- > Capacity: 10 MW
- > Generation: one-month performance goal of 1500 MWh
- > Operation: since April 1999

10 kWe Dish Stirling solar generator system

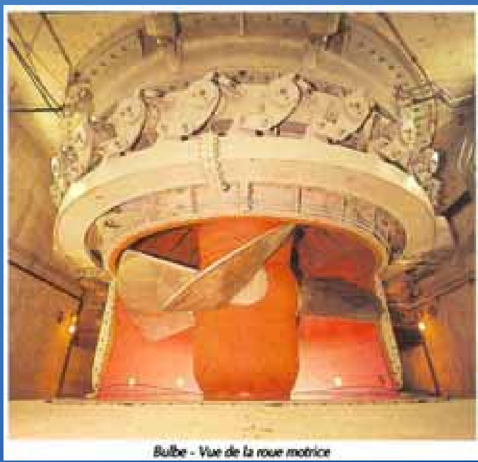
The technologies

Geothermal power

- Capacity range (per plant): tens of MW
- Expected 167 TWh by 2030
- 40% of expected growth in North America

Tide and wave

- Capacity range (per plant): tens to hundreds MW
- Expected 35 TWh by 2030
- Existing plants in France, Canada, China, Russia, Norway, UK



La Rance (France)
24 x 10 MW
500 GWh/y

The impact on T&D

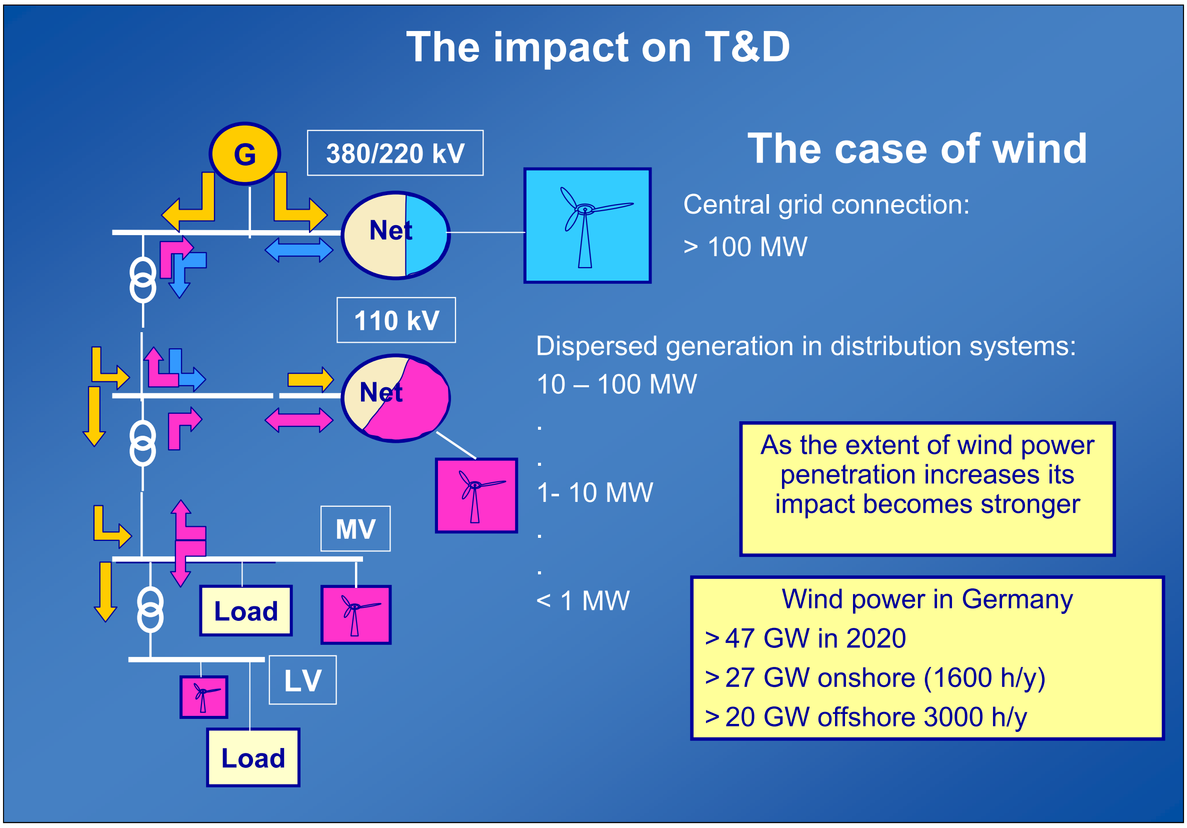
Hydropower

- large plants (few GW to tens GW) far (hundreds km) from load centers
- Development of long overhead transmission systems with high transmission capacity are required
- Technology: ac at 400 – 765 – 1200 kV or dc up to 600 kV and over

Electric link of Itaipu plant to the Brazilian Transmission system

Biomasses, geothermal, wave and tide

- Medium size plants (few MW to tens or hundreds of MW) not so far from load centers
- Integration in existing ac HV (132 to 400 or 500 kV) transmission network



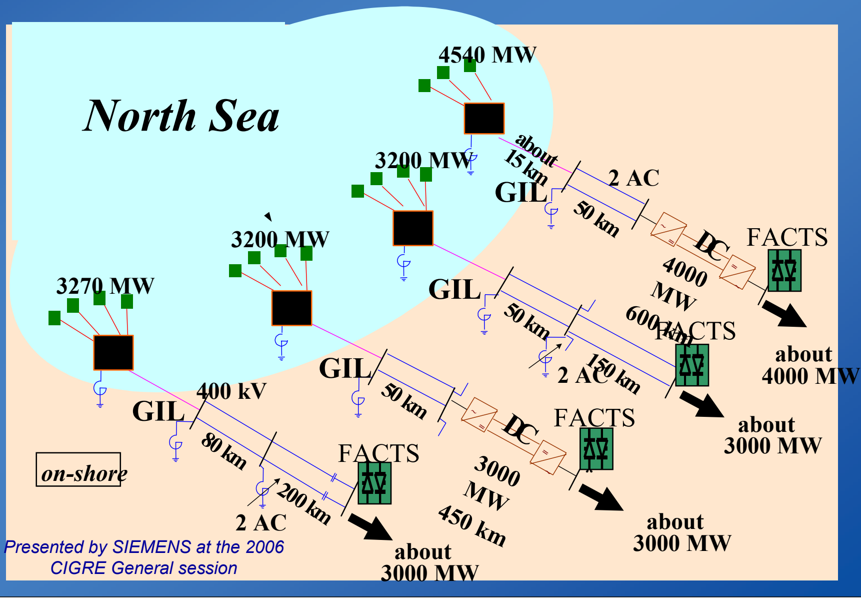
The case of wind is a little bit complicated. Wind may be installed at all the levels of the power system, depending on the location of the wind concentrators. Wind is a fluctuating generating system. The output is changed very quickly. This creates a lot of problems for the operation of the system.

The impact on T&D

The case of wind: technology issues

> Selection of turbine (variable speed) and of electric generator and (double feed asynchronous generator)

> Internal network of wind farm and connection to the public grid: ac versus dc (especially in the case of off-shore wind farms)



Presented by SIEMENS at the 2006 CIGRE General session

Here we see an offshore application in Germany. One problem is to connect these high concentration wind generators. Large quantities of submarine cables are needed as well as power electronic based devices. In addition, the existing transmission network has to be strongly reinforced.

Power system operation issues

Variability of wind energy, features of technologies adopted and rules presently stated for connection of wind generators to existing power systems are creating difficulties in network operation. System operators call for substantial changes in connection rules and actions to be undertaken to develop transmission systems.

>Impact on the grid operation:

Output fluctuations,

Unlimited in-feed of wind power,

Use of power electronic interface.

>New requirements for contribution in the grid operation

Avoidance of overloaded equipment

Contribution to secure fault ride through

Supporting voltage stability

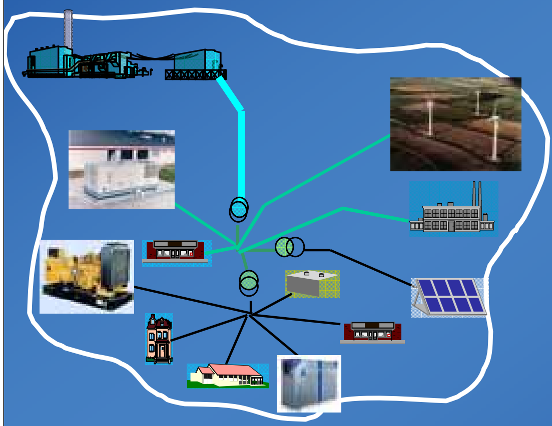
RES dispatched as the conventional power plants

>Reinforcement of interconnection of windy areas with other regions/countries to reduce the effect of output fluctuations

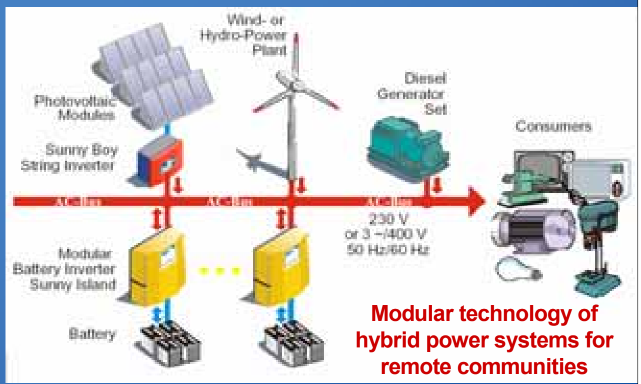
The impact on T&D of small size generators

Conversion energy sources like solar, wind, bio-masses, mini-hydro may consist of small size (few kW through few MW) generators

> Integration in distribution network



> Stand alone generating systems (to supply electricity demand in areas far from existing power electric network)

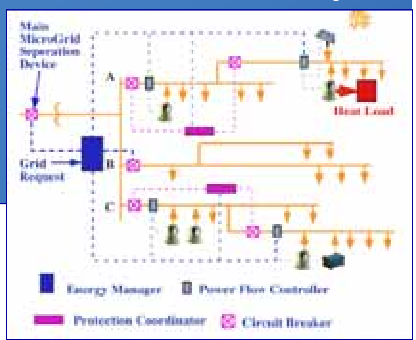


Modular technology of hybrid power systems for remote communities

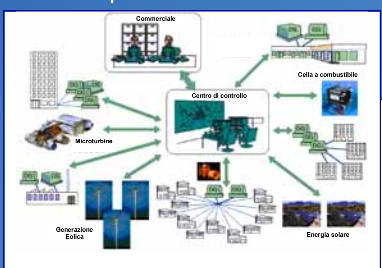
The impact on T&D of small size generators

Integration in distribution networks of small size, RES based generators and of fossil fuel based micro or mini CHP systems are the basis of the Dispersed Generation (DG) concept

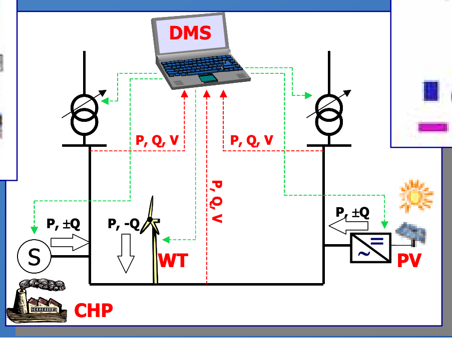
Microgrids

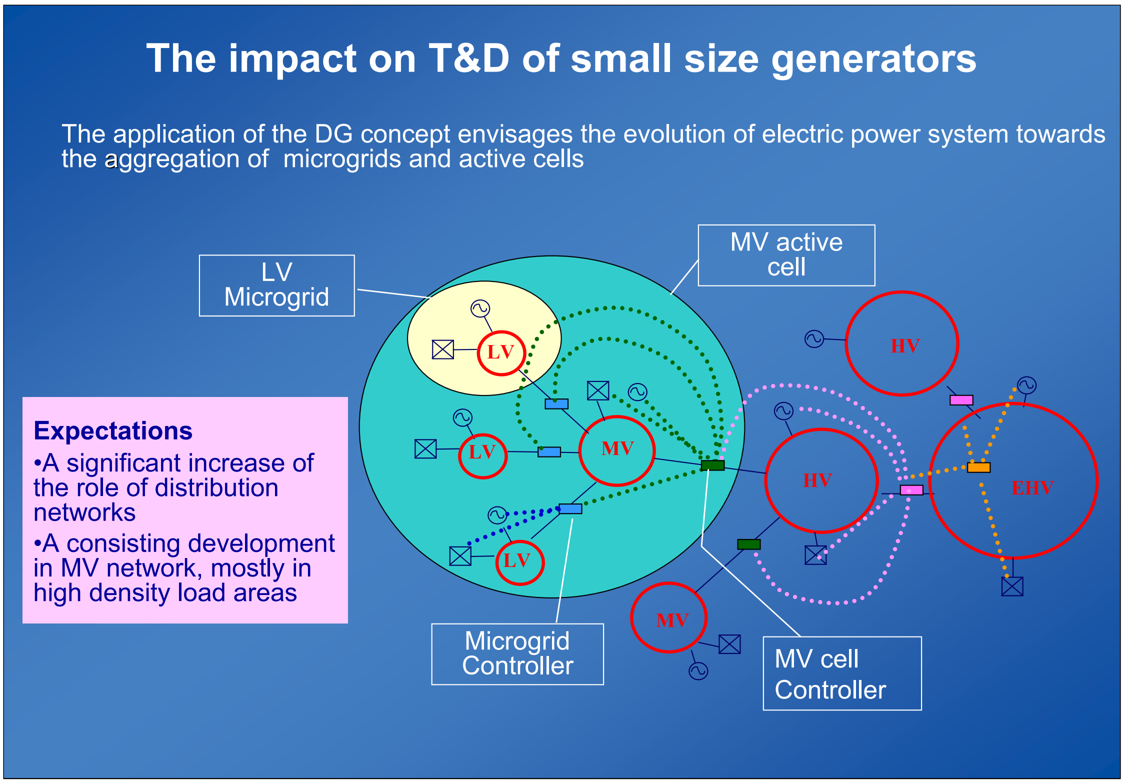


Virtual power



Active distribution networks





On the low voltage level and medium voltage level the Dispersed Generation (DG) concept is – may I say – a revolutionary concept, because it changes dramatically the role of the distribution in the power system. In the last 30 to 40 years the power systems were developed and the distribution networks were designed considering them as passive networks. The integration of generating systems within the distribution networks will change greatly the structure and operation. This concept was already introduced in the 90's. Now the development of this concept is in progress in many countries. If this Dispersed Generation concept is really developed, we may look at the future structure of the system very different from the situation now. Today the power system is a kind of monolithic system with all the generations connected to the transmission systems. In the future the power system may consist of the integration of small cells that may be operated autonomously or may be aggregated with all the other cells in a complete power system. This may be an idea which will be implemented in the far future. But 2 months ago during the CIGRE conference European countries and Japan presented many demonstration projects with this idea. The future seems to be nearer than we think.

Thank you for your attention.