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OPENING LECTURE :

POWER SYSTEM DEVELOPMENT AND NETWORK USE

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INTRODUCTION

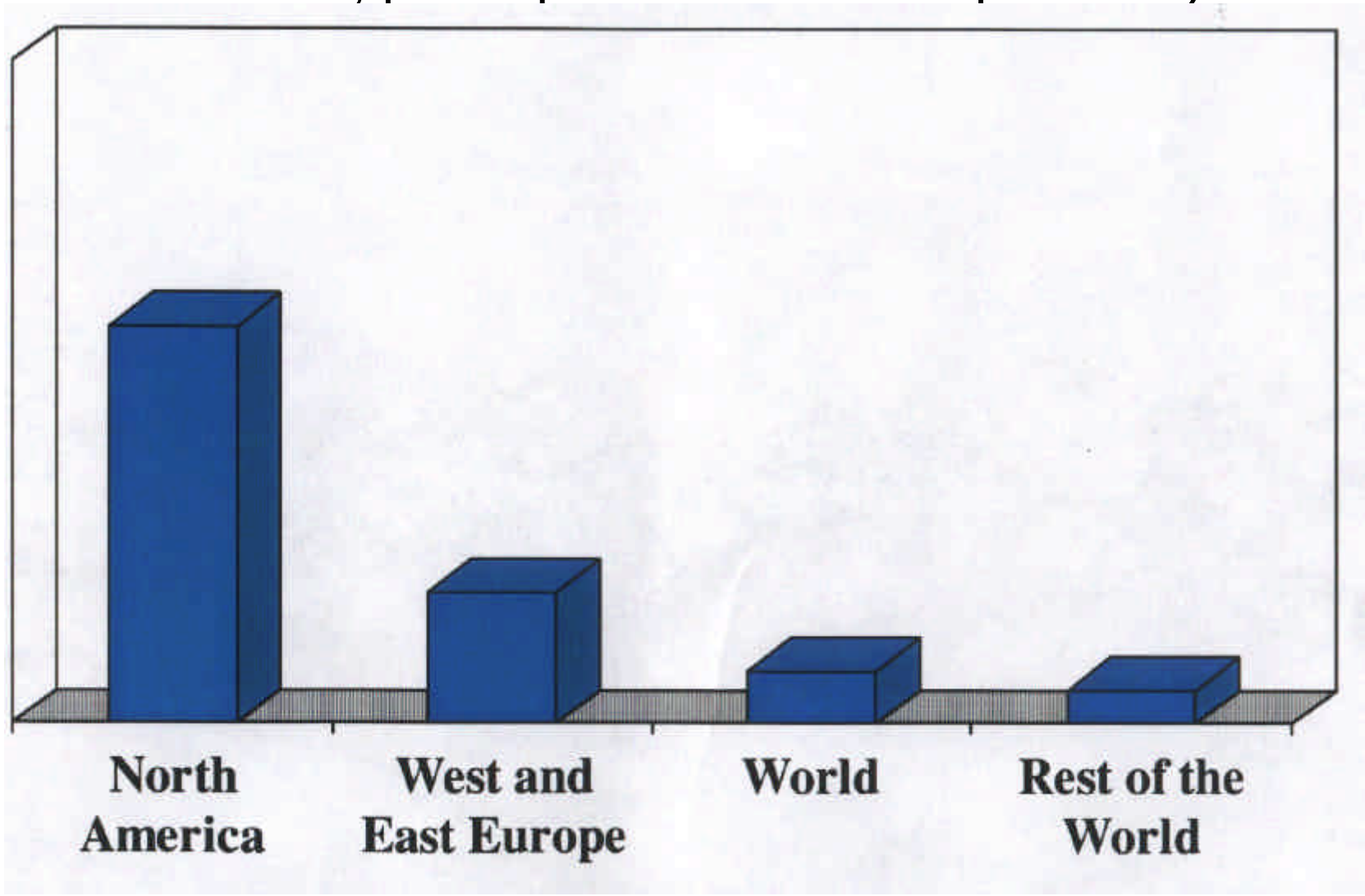
The use of power cables in electrical power transmission and distribution networks is strictly related to the development of power systems.

In recent years the electrical sector is underongoing fundamental changes, driven by several technological and political factor : the new gas-turbine technology, the shift to natural gas as primary fuel for power generation, the liberalisation process with the consequent restructuring of the power industry, etc.

These new trends in power system development will be illustrated, trying to understand and to forecast their impact on the development and on the way-to-use of the electrical networks, cables included.

PER-CAPITA ENERGY CONSUMPTION

(Relative values ; per-capita world consumption = 1)



POWER GENERATION : *Previous trend*

• Continuous increase of generating unit size : up to 1 500 MVA (R&D for cryogenic up to 3 000 MVA)

• Construction of very large power plant, based on : remote hydro ; nuclear ; steam condensing, fuelled by oil and coal (often at minemouth)

POWER GENERATION : *Factor for change*

- Hydro nearly fully exploited in some countries, the remaining source requiring huge investments
- Serious difficulties in the siting of the new nuclear and large thermal power plant
- Concern for emission problems (greenhouse effect, etc.) and consequent pressure for better utilisation of fuel, use of renewables, of waste, etc.
- Technology break-through : high temperature and large power gas-turbines, used in combined cycles with efficiency up to 55% (in the future 60%)

POWER GENERATION : *New trend emerging*

- Units and power plant of smaller size, dispersed on the territory often of the combined cycle-type, fuelled by natural gas
- Local exploitation of renewables (wind, solar) and of waste
- Increasing use of district heating (combined generation of heat and electricity)
- Possible diffusion of even smaller generating plant (microturbines, fuel cells, etc.) at medium voltage level

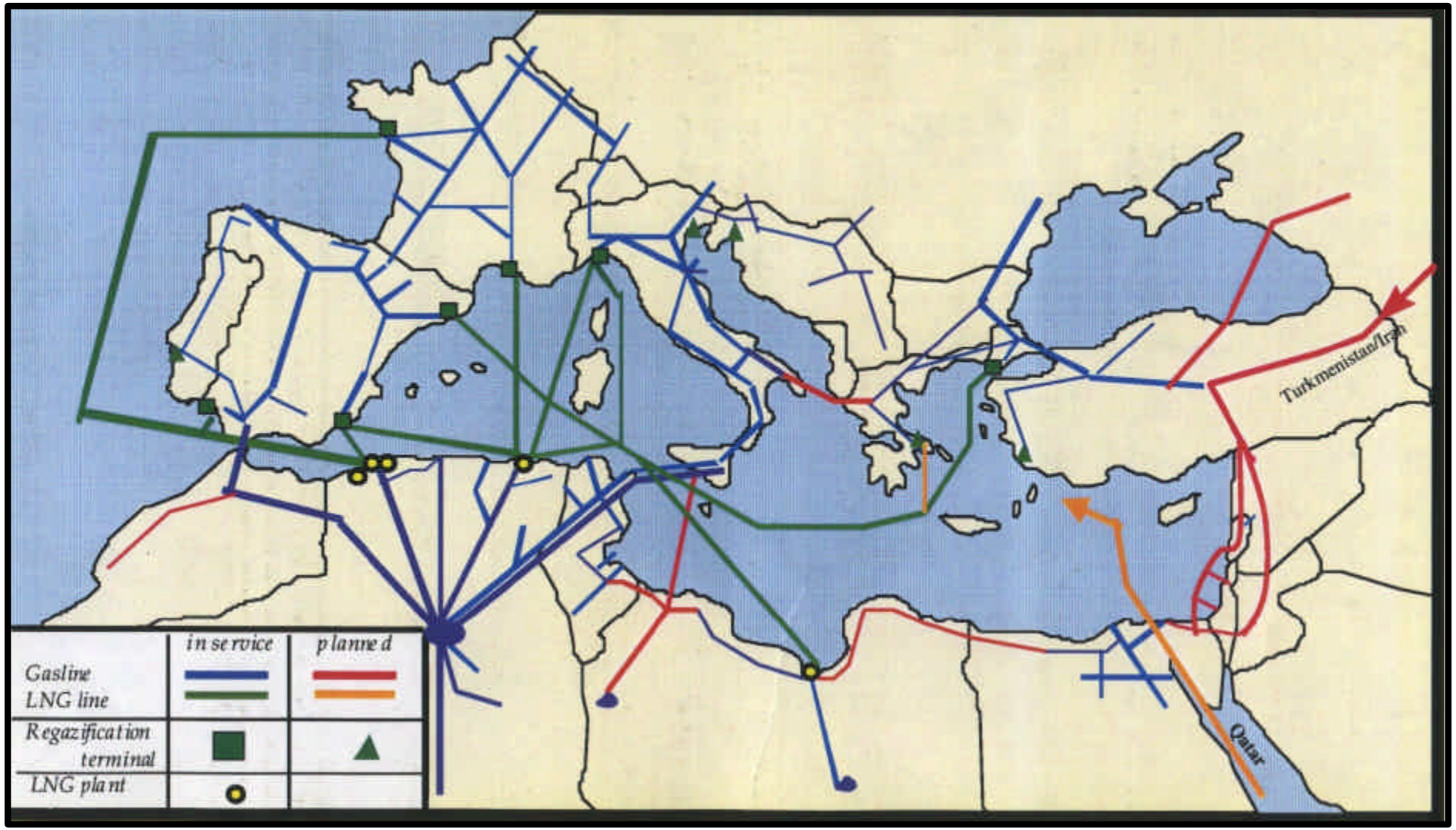
POWER GENERATION :
Additional factors in favour of the new trend

• Liberalisation of the electric industry : smaller plants requiring less capital investments can be built by small companies or by industrial customers (in the past only large utilities – often state owned, could face the heavy investments, the risks, the long pay-back-period involved in the construction of a large nuclear, thermal or hydro plant)

• The progressive extension of the networks of pipelines, for natural gas transport and distribution, permits to spread the new generation in the territory, often close to load

INTERCONNECTED MEDITERRANEAN NETWORKS :
as considered in the SYSTMED Study

NATURAL GAS NETWORKS
IN THE MEDITERRANEAN REGION :



DEMAND OF ELECTRICITY : *Drivers*

Contrasting forces are present :

- Actions to boost the efficiency of electricity end-utilisation : high efficiency lamps, heat pumps, better thermal insulation of buildings, electronic driven motors, etc.

- Pressure of the regulatory bodies and of the governments to introduce DSM (demand side management) and IRP (integrated resource planning) in order to reduce the total energy consumption

- Competition and privatisation that force the electric companies to improve their incomes, by enlarging the market and the use of electricity

- Selling services instead than simply selling kWhs : the service of lightning, of space heating and cooling, of real time pricing with related customer load-management, can provide added value to companies, for the same kWhs sold

- Environmental reasons may favour the use of electricity instead of fuel particularly in large cities (electric transportation, climatization, etc.)

DEMAND OF ELECTRICITY : *Forecasts*

In industrialised countries :

• The result of these contrasting forces is that, despite the fact that energy intensity has decreased during the past decade, the electricity penetration – the share of primary energy made available to consumers through electricity – has been increasing (from 32% in 1980 to about 40% now, for the OECD countries) and this trend is expected to continue. We therefore have a steady, althought moderate, increase in electricity consumption.

In newly industrialised and developing countries :

• The main factors limiting the electricity growth are in this case the poor economic conditions and the lack of capital. But, the per-capita consumption being far from saturation levels, a robust rate-of-growth of electricity demand can be envisaged

SUMMARY OF MID-TERM SCENARIOS FOR GENERATION AND DEMAND :

In industrialised countries :

1. A steady increase in the demand for electricity, although much lower than years ago
2. A trend towards smaller and more widely dispersed generating plant, often fuelledby natural gas.

In newly industrialised and developing countries :

1. A robust increased in the demand of electricity, strictly correlated to the economic development of the country
2. Still possible to install large plants (e.g. : hydro and mine-mouth coal), although with limitations due to lack of capital. Coal continues to be main energy source.

LONG TERM SCENARIOS
FOR GENERATION AND DEMAND :

The previous trends are not to be taken for granted in looking to long term future :

- Different solutions for generation could be : a new, safe, economical technology for the exploitation of nuclear energy ; or gas turbines being used to burn solid fuels, which have been gasified

- These solutions might provide clean electricity from large power plants. Their introduction will depend on reduction of capital costs and on possible limitation on the availability of natural gas

- This scenario – clean electricity and no constraints on the availability of primary energy – could favour higher electricity consumption (e.g. the electric car, etc.)

ELECTRICAL NETWORK : *Previous trend*

• Overhead lines and cables have in the past increased their voltage levels from 132 to 245/420/765 and up to 1 050 kV (ex USSR and Japan) ; the carrying capacity per circuit has correspondingly raised from tenths of MW to thousands of MWs.

• This trend was mainly caused by the need to transmit large amounts of power from a few huge power plants to large consumption centres (transport function)

ELECTRICAL NETWORK : *Future structure and use*

Depending on the previous consideration, two extreme – and quite different – network models can in principle be envisaged :

• One – similar to the present situation in most countries – and inline with the past trend in which a few large power plants supply, through the EHV or UHV grid, a number of large EHV and HV substations, with regular flow patterns, planned in advance, and with interconnection lines to share reserves and help out in emergency situations.

• A second model – which is beginning to appear in some countries – in which Independent Power Producers (IPP) increase the share of production delivered on the HV e MV local networks, which – depending on the local generation and load situation – may absorb from the grid widely-ranging amounts of power, or even inject power into the EHV grid.

VISION OF FUTURE NETWORK : *Industrialised countries*

TRANSMISSION FUNCTION :

• In most industrialised countries (Europe and USA), natural gas, primarily driven by environmental considerations will remain the main fuel for new plants : the latter will presumably be installed on the territory close to load centres, thus avoiding the need of new installations for long distance electricity transmission, HVDC included.

INTERCONNECTION FUNCTION :

• The opening of the electricity market, favours the interconnection of neighbouring countries (e.g. West to East Europe). This process is however driven more by the need to increase security and spot negotiation of electricity, than by the need of bulk power transmission. Therefore new Transmission lines will be limited to a minimum.

VISION OF FUTURE NETWORK : *Industrialised countries*

SUBTRANSMISSION AND DISTRIBUTION :

• In spite of the moderate rate of growth of energy consumption, the share of electricity is likely to increase – driven by environmental considerations – in large cities and conurbations. This will entail the construction of new H.V. powerfull feeders penetrating into the cities. The lack of space and aesthetic consideration will probably favour the use of cables (including superconductive, when commercially available).

VISION OF FUTURE NETWORK :
Newly industrialised and developing countries

TRANSMISSION FUNCTION :

• The point – to – point transmission of large amount of power over long distances is likely to remain in important option in Asia (namely China, India), South America and Africa for the exploitation of coal mines and remote hydro. Nevertheless in these countries too, the lack of capital and the public resistance to large hydro schemes will probably delay many of these potential plants and the related HVDC or EHV transmission links, thus encouraging the extension of gas pipelines and electricity generating units close to load centres. In the long term, coal will however remain the main option for base load. Dispersed and small generation will not play an important role.

VISION OF FUTURE NETWORK :
Newly industrialised and developing countries

INTERCONNECTION FUNCTION :

• As far as the national (or regional, in large countries as China) grids extend, the interconnection of these grids with the neighbouring ones will be pursued as a result of bilateral agreements (typical is the example of the African countries facing the Mediterranean basin).

SUBTRANSMISSION AND DISTRIBUTION :

•The shift from agricultural activities to industry and services will continue, with consequent migration from country side to cities and higher per-capita energy consumption. Therefore the existing need of rural electrification will be accompanied by the necessity to feed large conurbation. The use of HV cables in place on HV lines will depend mainly on economic rather than on environmental consideration.