



**Seminar on African  
Electrical Interconnection**

**Module 3 – Resource Development**



# Module 3 – Resource Development



## *Index:*

- 1. Resource planning? Why?**
- 2. Developing a Generation Resource Plan**
- 3. Managing Uncertainties**



# Module 3 – Resource Development



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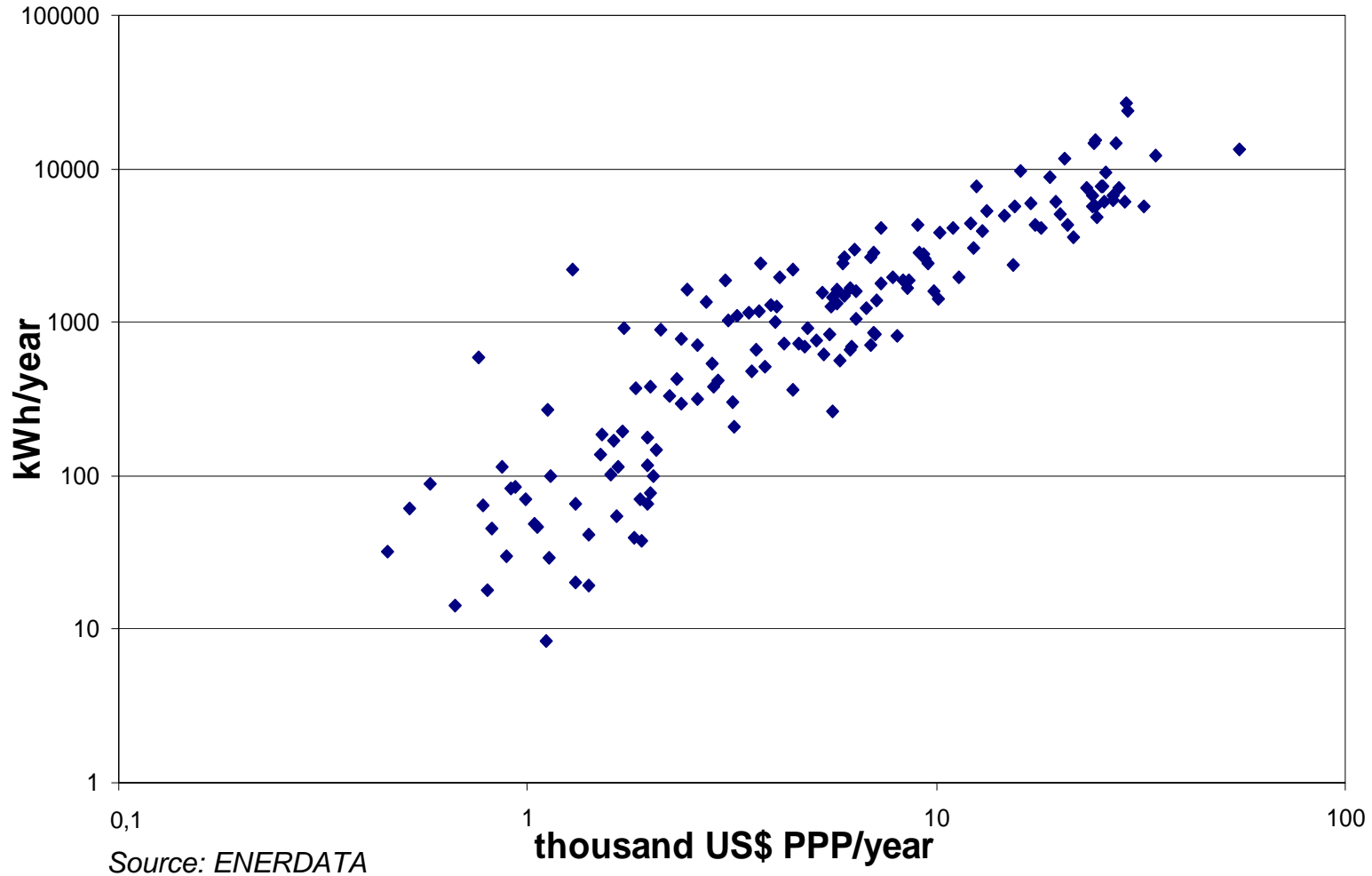
# Characteristics of electricity



- It is a production factor
- It is a primary good for families and social development
- It can be obtained from any primary energy sources
- It is the only exploitation vector for some energy sources (hydro, geo and nuclear)
- It cannot be replaced in many processes/appliances
- Totally “clean” at the point of use



# Per-capita electricity and per-capita income in 158 countries in 2001





# Characteristics of electricity



- High demand volatility (daily, weekly, seasonal)
- Impossibility to be stored (supply/demand coincidence in real time, generation system to be designed for the maximum demand)
- Very high quality required (micro-interruptions, wave shape) for an increasing number of “high tech” appliances
- Laws of physics dominate in the transmission/distribution networks (Kirchoff)



## Characteristics of the electricity industry



- **Long-term view (long lead time and long service life of equipment)**
- **Economy of scale and Capital-intensive**
- **Operational complexity that spans many time frames**
- **Complex product (mix of energy, capacity, reliability, voltage control, ...)**
- **Natural monopolies in transmission and distribution**
- **Externalities (economic and environmental)**



## And then.....why a resource planning?



- Selection of the optimal supply sources among those available in a given region
- Research of the economic optimum to satisfy the demand with an adequate quality level of the service
- Selection of the most suitable generation system
- Economic evaluation of the generation system





## Optimising the generation mix and unit sizes for a given region



### Requires:

- A thorough knowledge of the region's energy potential;
- The capacity to agree on who develops what, when, where and at what cost,

### Brings forth the following benefits:

- A diversified production base capable of meeting electricity demand at the best cost;
- Development choices that respect the principles of sustainable development and avoid the use of highly polluting energy sources.

Is facilitated by the interconnection of power systems that creates favorable conditions for the optimum integrated use of a region's available resources



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# Developing a generation resource plan.....



- Following a «classic» process that generally involves:
  - area demand forecast;
  - alternative demand management options;
  - supply side resource options;
  - political, environmental and cultural issues and constraints;
  - utility goals;
  - evaluation of alternatives;
  - selection and approval of a plan.



# .....step by step



*Input* ———  
*Output* - - -  
*Models* ———  
*Decision making* DM

National/regional scenario (economy, demography, technology, etc.)  
Sectoral and global policies

ENERGY DEMAND FORECAST

Electricity (and non-electric energy) demand

LOAD FORECASTING AND LOAD SHAPE

Load curves (daily, weekly, seasonal)  
Peak load, duration curve

RELIABILITY ANALYSIS

Generation system optimisation and reliability indexes  
Generation costs

GENERATION RESOURCES AND CAPACITY EXPANSION

PRODUCTION/OPERATION SIMULATION

TRANSMISSION/INTERCONNECTION PLANNING

Network development plan

ECONOMIC/FINANCIAL ANALYSIS

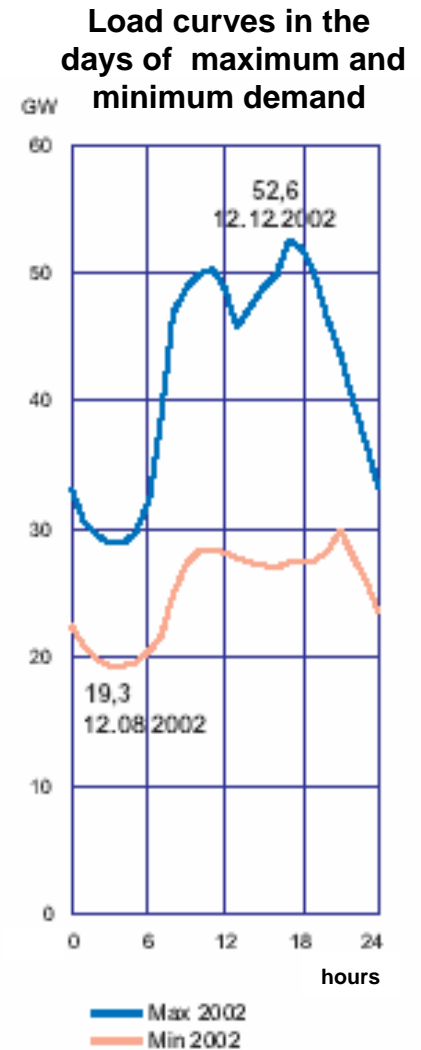


# Load forecasting and load shape (*energy and capacity*)



From energy forecasts, capacity peak demand and load curves are worked out on the basis of:

- ✓ historical sectoral load curves;
- ✓ contemporary factors;
- ✓ expected trends in economic structure;
- ✓ expected evolution of habits and lifestyles;
- ✓ expected DSM actions.



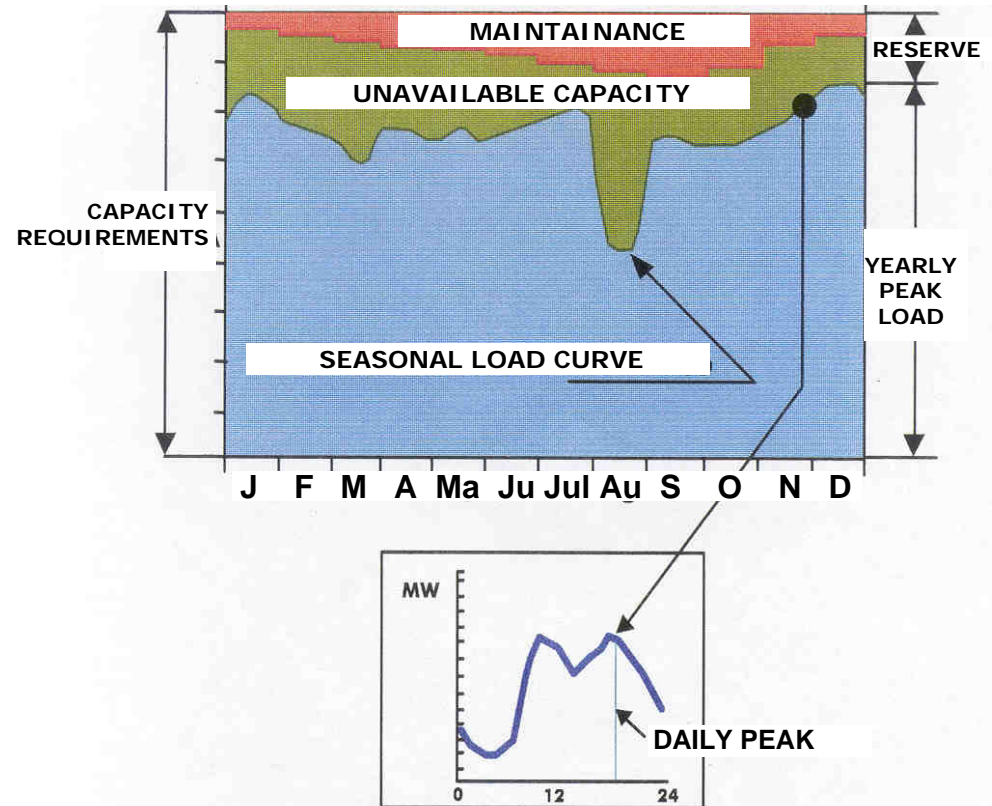


# Reliability analysis

## Reserve margin



- The **acceptable reliability target** for the system is a key parameter, either set by regulators or by customers' "quality demand"
- The loss-of-load-probability (LOLP) is commonly used to translate a reliability target index into a **reserve margin level**





# Generation resources and capacity expansion



- Once the future capacity demand (peak load+reserve margin) has been projected, all the options, which can contribute to cover it, must be considered. Among them:
  - existing generation plants and their decommissioning dates;
  - possible options/technologies for new generation plants;
  - viable DSM programs;
  - energy conservation plans.
- At this stage, fuel cost projections are crucial parameters



# Generation resources and capacity expansion



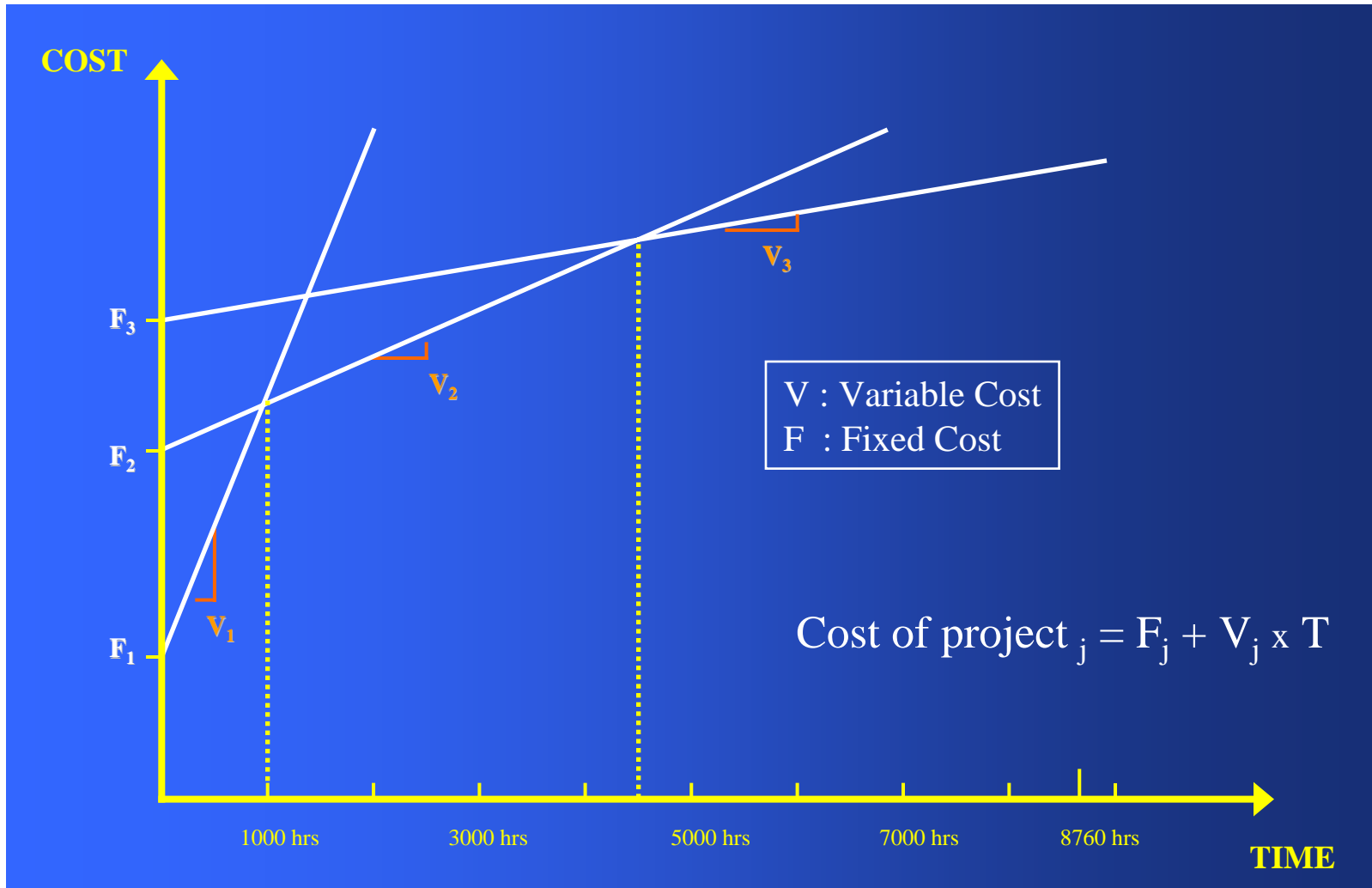
- The analysis must take into account:
  - domestic energy resources;
  - options regarding energy imports and development of interconnections.
- Various strategies can be analysed
  - Market penetration
  - Fuel convergence
  - Portfolio (equipment, location, fuel)
  - Specialization





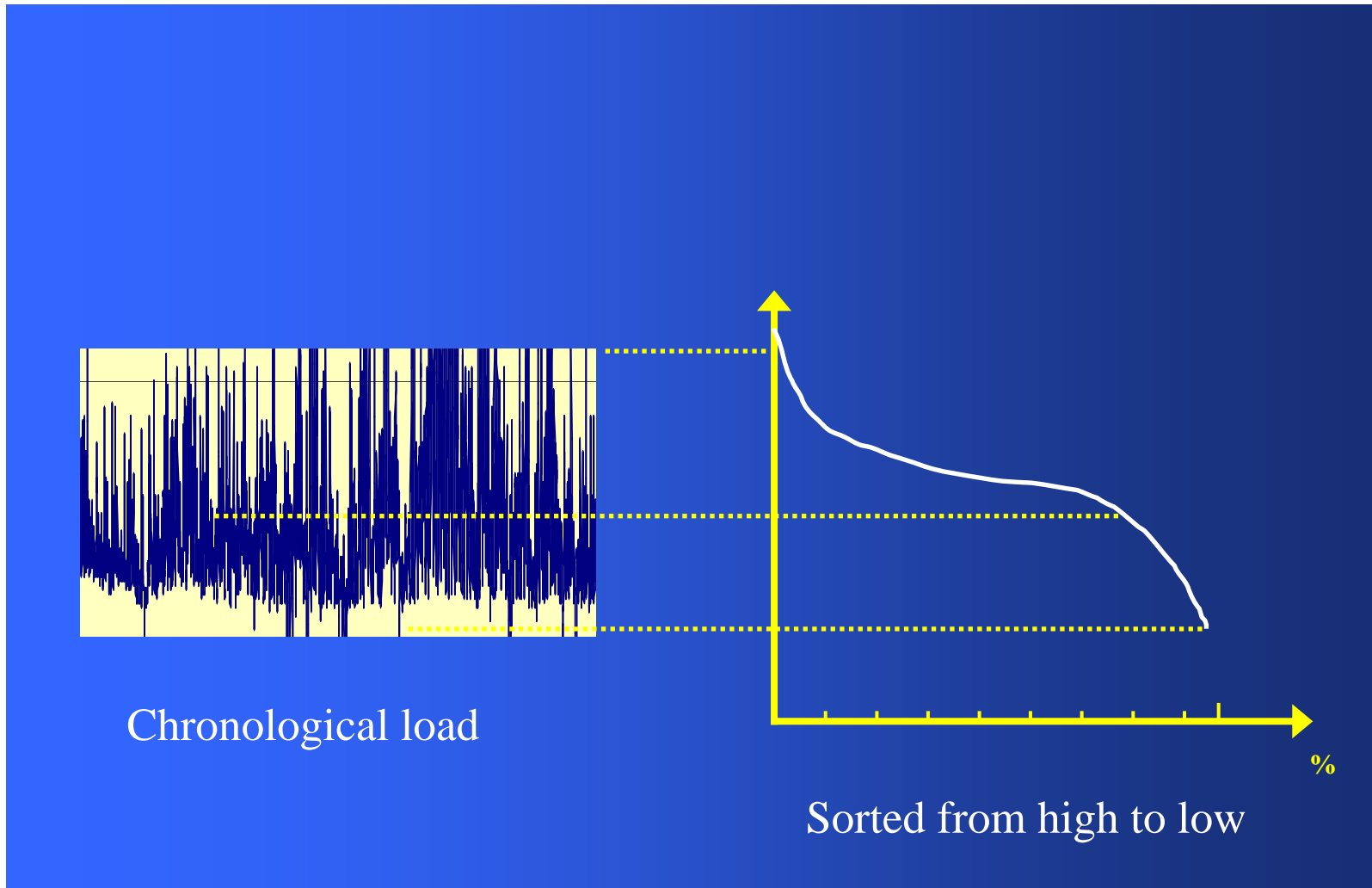
## Role of equipment

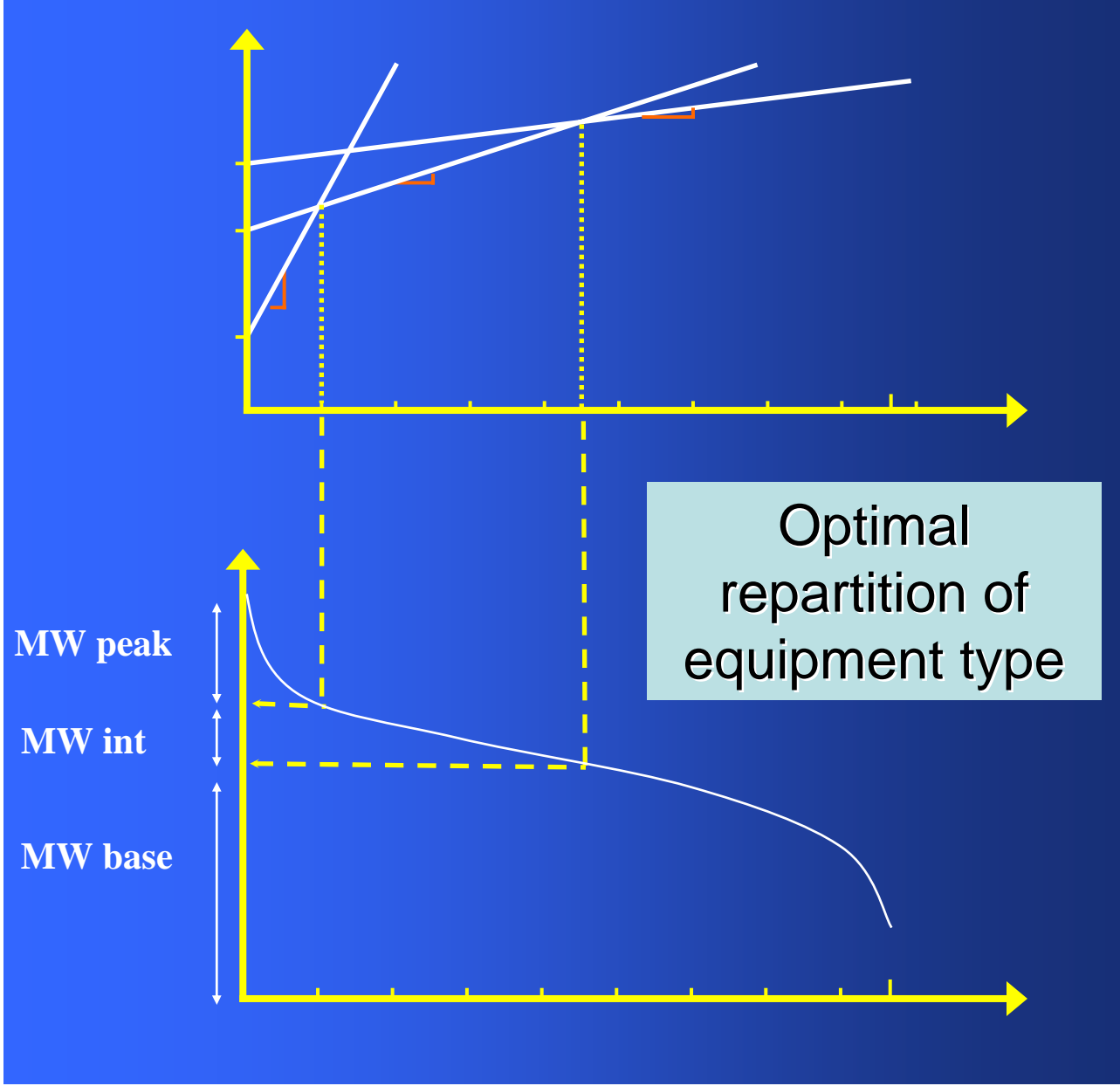
- Peaking, Intermediate, Base
- Related to cost structure
- Related also to flexibility of operation
- Role of equipment may vary over time
  - because of aging
  - because of external condition





# Load duration curve



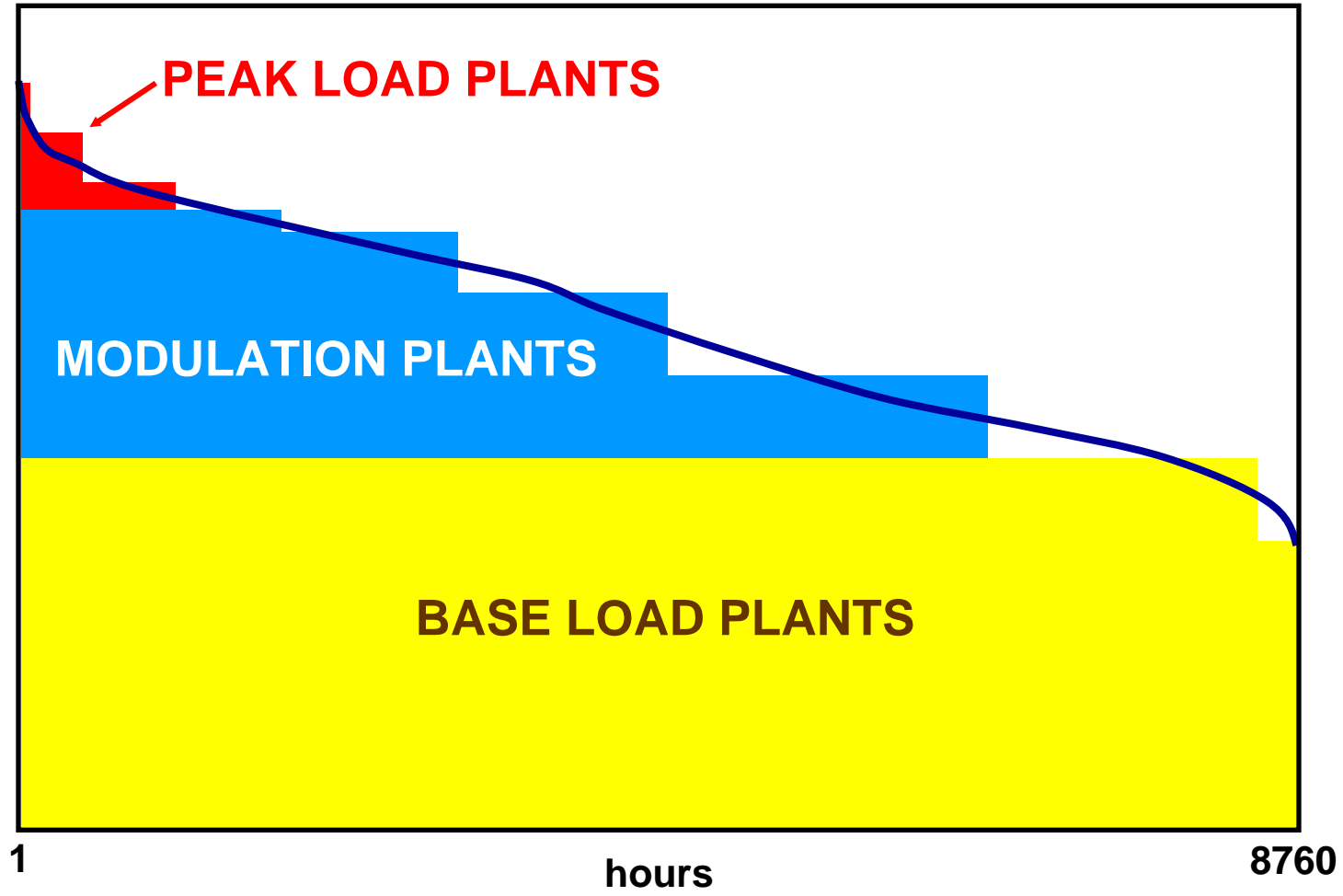




# Load duration curve coverage



MW



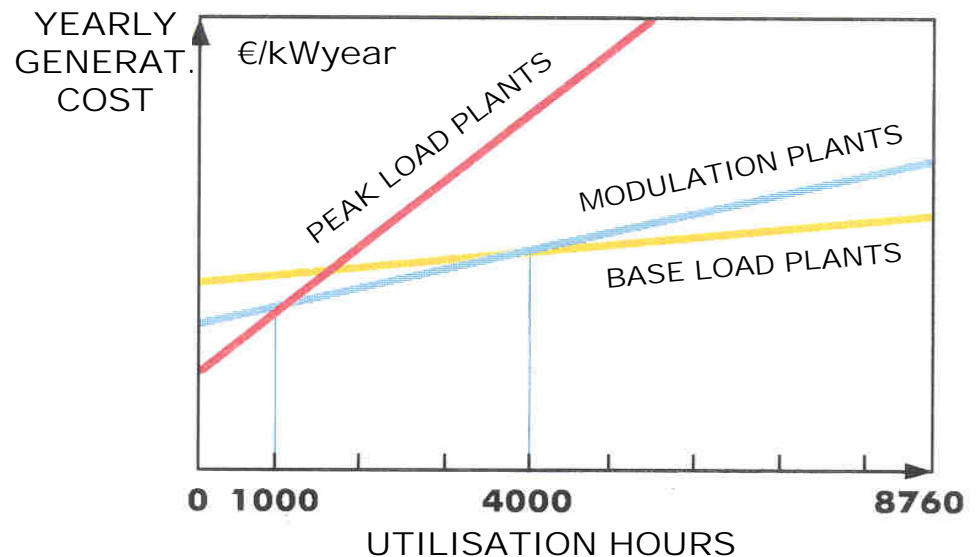
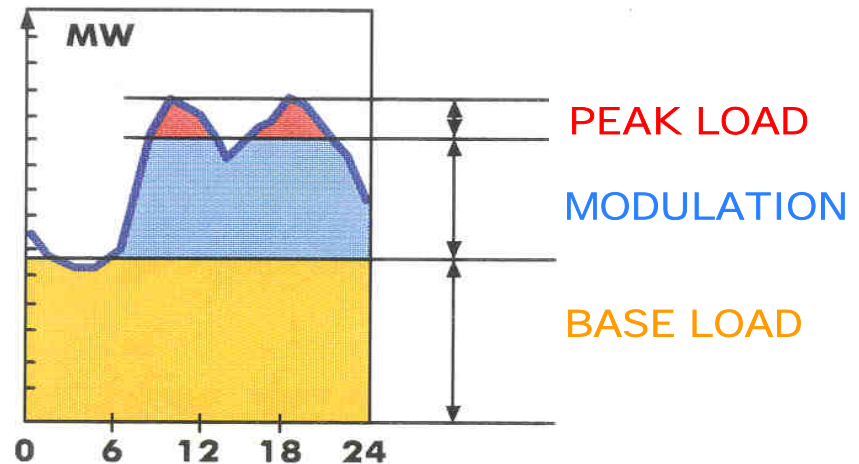


# Production/operation simulation



- The final target consist in working out a **least total system cost plan** (capital, operation, maintenance, fuel...)
- Tradeoffs among different types of plants can be very complex to evaluate, especially with respect to the future operation of the system. New models are being developed to optimise the options simultaneously

CAPACITY DEMAND





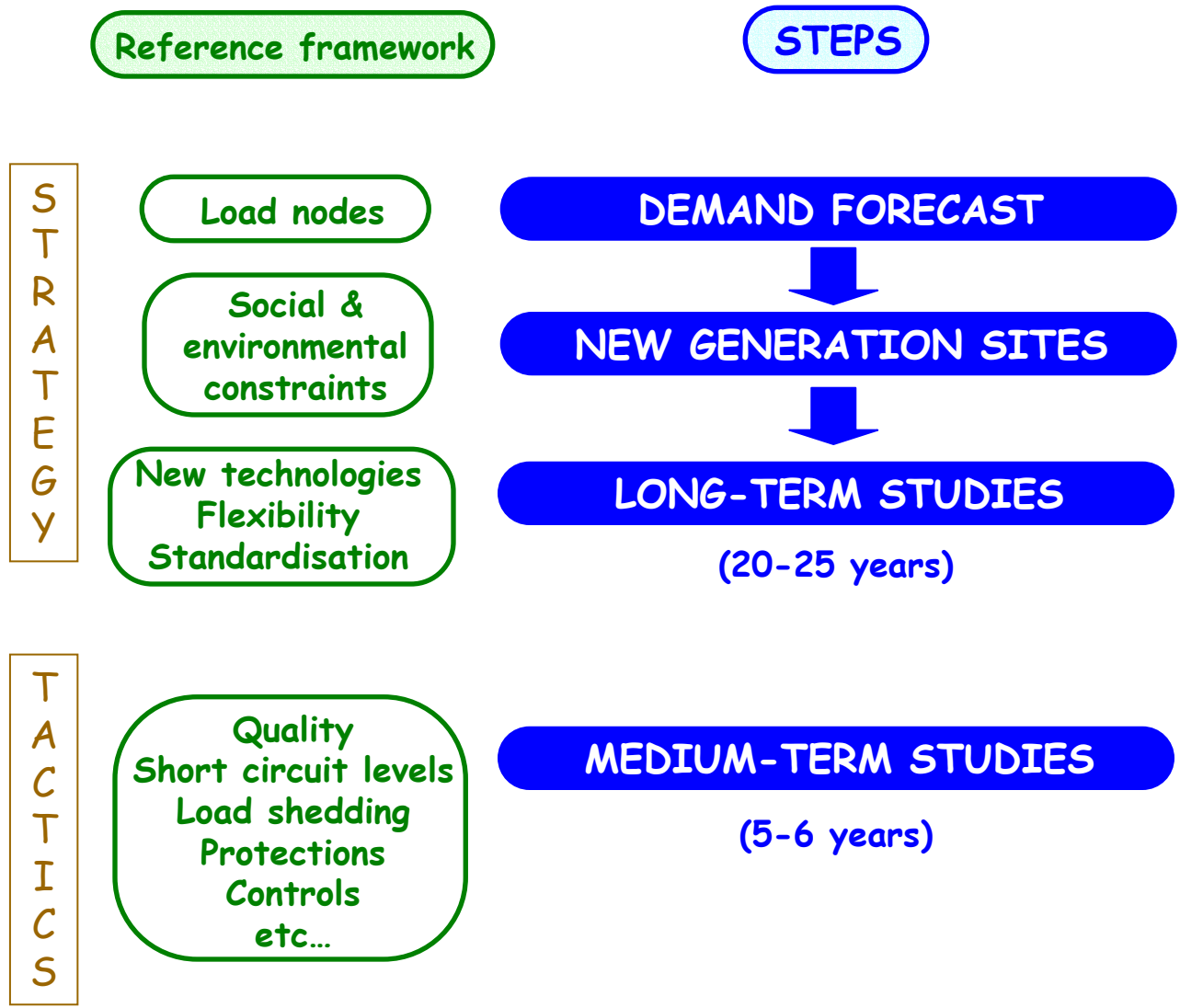
# Transmission/interconnection planning



- The target consists in the definition of **the best network growth pattern** related to expected load and generation future trends
- Alternative designs can be developed for the same horizon-year expected conditions
- The plan can be heavily affected by the **engineering judgment** and must fit with load levels well above present system peak load conditions
- It includes basically steady-state thermal loading and voltage conditions. With the expansion of the interconnected power system, it also includes transient stability, post transient voltage and reactive margin analysis



# Planning the transmission network







# Three approaches for evaluation of development plan



## TRADITIONAL

- Economic approach
- Financial approach

Very long term view

Long term / Medium term

## NEW PARADIGM

- Market approach

Short term



# Economic analysis



- It is aimed at evaluating the total **cost to society** (monetary and non monetary), at national and regional level
- It is used to calculate **marginal costs** (tariff studies)

## BASIC IDEA

To obtain a social optimum where:

- ✓ intergeneration benefits are maximised, and
- ✓ resources are optimally allocated between users



# Financial analysis



- It is generally used to evaluate and predict the **effect of investment decisions** on the organization's balance sheet, income statement and cash flows
- It normally includes a detailed description of organization's financial structure, accounting data and management policy information
- Used to establish revenue requirement (**Tariff level**) that will insure sufficient internal generation of funds and make it a **bankable** project

## BASIC IDEA

To generate enough revenue to pay current expenses, repay debt and accumulate capital for new investments



# Market approach



- Generation price is the value at which supply and demand are at equilibrium
- Used to
  - Screen market opportunities
  - Evaluate returns and risk
- Required by
  - Shareholders



## Comparison of the 3 approaches

	<b>BASIC IDEA</b>	<b>RESPONSIBLE TOWARDS</b>	<b>TARIFF SIGNAL</b>
<b>ECONOMIC APPROACH</b>	<b>Social Optimum</b>	<b>Society</b>	<b>Marginal Cost</b>
<b>FINANCIAL APPROACH</b>	<b>Carry-on Concern</b>	<b>Lenders</b>	<b>Revenue Requirement</b>
<b>MARKET APPROACH</b>	<b>Supply-demand Equilibrium</b>	<b>Shareholders</b>	<b>Market Prices</b>



## Comparison of the 3 approaches

	<b>RELIABILITY CRITERIA</b>	<b>REGULATORY NEEDS</b>
<b>ECONOMIC APPROACH</b>	<b>Included in the process</b>	<b>Moderate</b>
<b>FINANCIAL APPROACH</b>	<b>Exogenous constrain</b>	<b>Medium (Rate Base)</b>
<b>MARKET APPROACH</b>	<b>Accounted by market prices</b>	<b>High - Environnement - Market Power</b>



## Comparison of the 3 approaches

	<b>COST ELEMENTS</b>	<b>MEASUREMENT TOOLS</b>
<b>ECONOMIC APPROACH</b>	Monetary & Non-Monetary	NPV IRR
<b>FINANCIAL APPROACH</b>	Monetary	Financial Ratios
<b>MARKET APPROACH</b>	Market value	Share Value VAR MTM



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# Planning for uncertainties



- Significant changes in needs, costs or impacts are to be expected
- A resource plan should be **quickly and efficiently adjustable** through a continued balancing and rebalancing of numerous supply-side and demand side options
- A number of **alternative scenarios** should be considered and a response strategy for each should be prepared



## The “scenario” approach



- Future scenarios consisting in **different sets of coherent assumptions** should be evaluated focusing more on the consequences rather than the events themselves
- A subset of these scenarios based on their consequences should be established, defining the **most likely bounds** of what to expect in the future
- The future resource plan should focus on developing a **flexible action plan** covering the entire subset, consisting of strategic elements viewed as building blocks that can be put together in a number of ways to accommodate plausible future scenarios



**e7 - UNDESA Seminar on  
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