IAEA TC Project INT/4/142: Promoting Technology Development and Application of Future Nuclear Energy Systems in Developing Countries

Workshop on IAEA Tools for Nuclear Energy System Assessment (NESA) for Long-Term Planning and Development

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Methodology and Tools for Energy Planning

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Background

Planning a sustainable future in energy is a complex arena with multiple factors:

- New emerging and changing issues: energy security, energy access and affordability, social acceptability, environmental sustainability and GHG policy compliance
- Country- and regional specific implications and consequences
- Trade-offs

Major Factors Influencing Energy Systems

- Demographic changes
- Economic development (structural changes)
- Social changes (life style, social behaviour, preference)
- Technology development
- Environmental concerns

Rationale

A suit of tools for energy planning is critical to the systematic and comprehensive analysis of all the factors that influence the evolution of energy systems:

- exploring linkages
- evaluating trade-offs
- comparing consequences
- examining the implications of pursuing alternative technology paths
- delivering informed solutions to develop an effective energy strategies that supports national sustainable development goals

Analytical Tools for Energy Planning

Model for the Analysis of Energy Demand

Wien Automatic System Planning Package

Model for Energy Supply System Alternatives and their General Environmental impacts

Financial Analysis of Electric Sector Expansion Plans

Simplified Approach for Estimating Impacts of Electricity Generation

Indicators for Sustainable Energy Development

MAED
Model for the Analysis of Energy Demand

- Energy sector data (energy balance)
- Scenario assumptions
  - Socio-economic
  - Technological
- Substitutable energy uses
- Process efficiencies
- Hourly load characteristics

OUTPUT

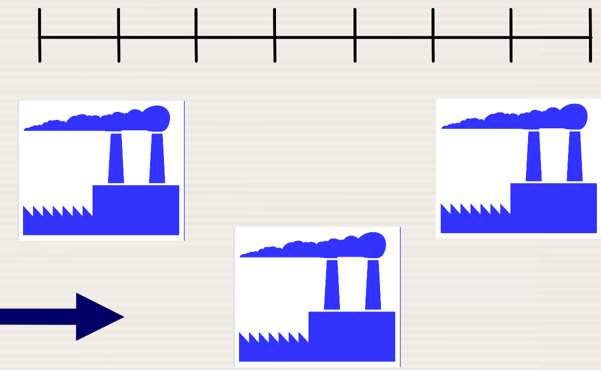
- Useful or final energy demand by sector/fuel
- Electricity demand
- Degree of electrification
- Hourly electric load
- Load duration curves

WASP
Wien Automatic System Planning Package

INPUT

- Load forecast
- Existing system
- Candidates
- Constraints:
  - Reliability
  - Implementation
  - Fuel
  - Generation
  - Emissions

OUTPUT



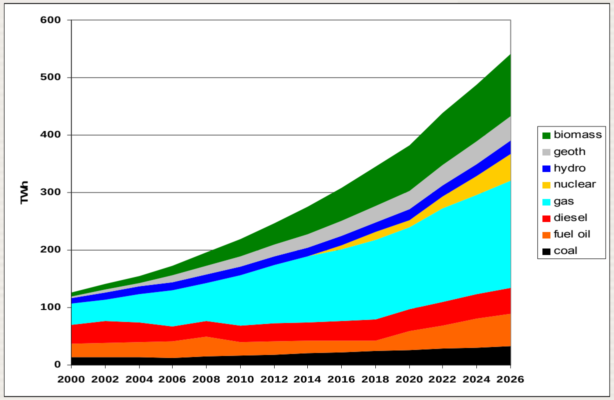
- Build schedule
- Generation
- Costs
- Fuel consumption
- Emissions

MESSAGE
Model for Energy Supply System Alternatives and their General Environmental impacts

INPUT

- Energy system structure (including vintage of plant and equipment)
- Base year energy flows and prices
- Energy demand projections (MAED)
- Technology and resource options & their techno-economic performance profiles
- Technical and policy constraints

OUTPUT



- Primary and final energy mix
- Emissions and waste streams
- Health and environmental impacts (externalities)
- Resource use
- Land use
- Import dependence
- Investment requirements

FINPLAN
Financial Analysis of Electric Sector Expansion Plans

INPUT

- Investment programme (= capacity additions) & operating expenses
- Economic and fiscal parameters (inflation, escalation, exchange rates, taxes)
- Financial parameters (credits, bonds…)

OUTPUT

<u>For each year:</u>

- Cash flows
- Balance Sheet, Statement of Sources, Applications of Funds
- Financial Ratios:
  - Working Capital Ratio
  - Leverage ratio
  - Debt Repayment Ratio
  - …
  - Global Ratio

SIMPACTS
Simplified Approach for Estimating Impacts of Electricity Generation

INPUT

Case 1 (minimum data requirements):
- pollutant emission rates
- regional population density (< 1000 km)
- source location (urban/rural)

Case 2 (some more data):
- stack characteristics
- local population (<50 km)

Case 3 (even more data):
- local meteorological data (wind directions & speed)
- population around the source (10x10 km)

Estimate 1

Estimate 2

Estimate 3

OUTPUT

Case 1 (minimal results):
- uniform world model (UWM) estimate for total exposure
- quantification of health impacts
- monetisation of impacts

Case 2 (more output):
- estimates 1 adjusted for effective stack height (including $H+V_{exit}+T_{exit}$)

Case 3 (even more output):
- Gaussian plume used for local exposure and impact estimate
- estimates 2 adjusted for more accurate pollutant & receptor distribution

Suite of Tools Supports Comprehensive Analysis

It forms the core of the IAEA's approach to integrated energy planning but in required steps:

- National economic and energy statistics
- Simulating multiple future scenarios by model
- Comparing the scenarios in line with specific development goals
- Defining critical aspects of the energy strategies
- Determining the most cost effective approach to meeting future energy needs

Benefits of Energy Modelling

- Formulating policy guidelines
- Making investment decisions
- Making technology choices
- Environmental protection
- Negotiations
- Supporting sustainable development

Tools in Action

- Usable: the programs are user-friendly
- Useful: the models provide useful information to analysts and decision-makers
- Used: there is permanent application of the models in IAEA Member States
- ‘Living’ – the models follow trends in Member States requirements in line with “Building Capacities”

Thank you for your attention