



**IAEA**

International Atomic Energy Agency  
*Atoms for Peace and Development*

# IAEA Modelling Tools for National Energy & Climate Plans (NECPs)

Vienna  
March 2019

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# Introduction to the IAEA

and its

## Planning and Economic Studies Section (PESS)

# Introduction to the IAEA

## IAEA

- Set up in 1957 for cooperation in the nuclear field
- Promotes the safe, secure and peaceful use of nuclear technologies
- Nobel peace prize in 2005 to IAEA & its Director General (Mohamed ElBaradei)
- Headed by Yukiya Amano as Director General
- 170 member states
- 2500 employees from > 100 countries



# Introduction to PESS

## Planning & Economic Studies Section



*To strengthen Member States' capacities in energy system analysis, guided by national sustainable energy strategies*

*To investigate the most suitable mix of energy technologies*



# Energy Modelling & Capacity Building at PESS

## Supporting Member States (MS) with

### ... energy data & analytical tools

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- Development of new tools with multi-lingual user interfaces
- Updates of existing models
- Provision of tools to MS at no cost

### ... training local experts

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- Distance e-learning
- Expert missions, fellowships & exchange of experience
- Online support & manuals

### ... support to energy planning

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- Technical guidance & assistance in conducting national studies

# Energy Planning Tools

by the Planning and Economic Studies Section (PESS)



# PESS Energy Planning Tools

are used by

- 147 Member States (MS)
- 21 Regional & International Organizations
- ~20 ongoing national & regional technical cooperation projects

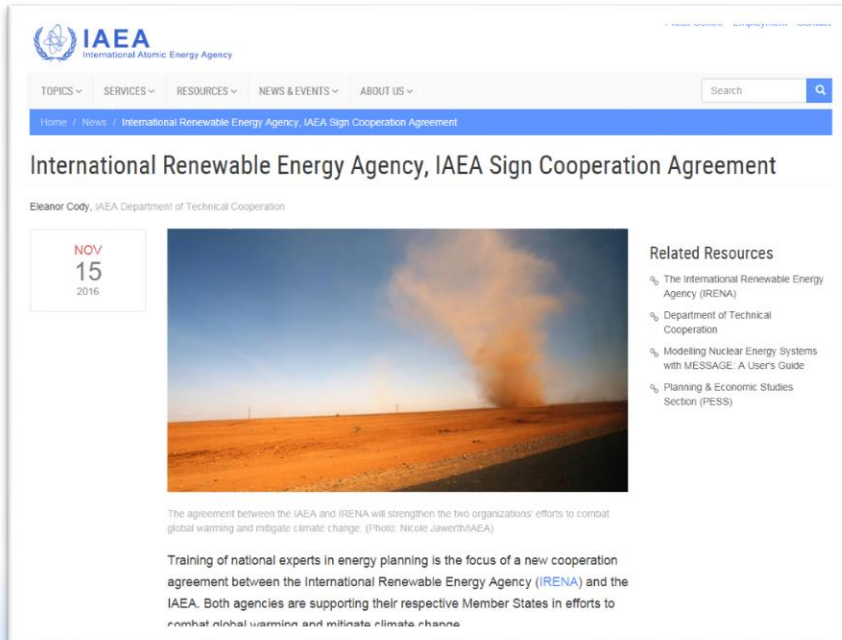
>100 MS not engaged in nuclear power



# Example of Partners using PESS tools

## IRENA

- IRENA uses IAEA energy modelling tools
- IAEA draws on IRENA's analytical work
- Joint support to Member States (e.g., Sierra Leone, Eswatini)



The screenshot shows a news article on the IAEA website. The header includes the IAEA logo and navigation menus. The article title is "International Renewable Energy Agency, IAEA Sign Cooperation Agreement" by Eleanor Cody. A date box indicates "NOV 15 2016". The main image is a desert landscape with a large dust storm. Below the image, the text states: "The agreement between the IAEA and IRENA will strengthen the two organizations' efforts to combat global warming and mitigate climate change. (Photo: Nicole Jawerth/IAEA)". A "Related Resources" section lists: "The International Renewable Energy Agency (IRENA)", "Department of Technical Cooperation", "Modelling Nuclear Energy Systems with MESSAGE: A User's Guide", and "Planning & Economic Studies Section (PESS)".





# PESS Energy Planning Tools

cover sustainable energy from demand to supply



# MAED

## Model for Analysis of Energy Demand

Bottom-up scenario simulation tool

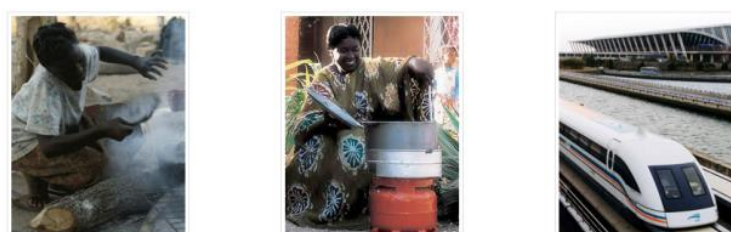
Considers energy forms (incl. traditional fuels) in all economic (sub-)sectors at end-use level

**2 Modules:** Energy (MAED-D) and Electricity (MAED-EL)

**Outputs:** useful & final energy/electricity demand by sector/fuel, hourly electric load, load duration curve

Planning and Economic Studies Section PESS  
 Department of Nuclear Energy  
 IAEA  
 MAED  
 Model for Analysis of Energy Demand

En Es Fr



"...with availability of modern energy, life changes"

**MAED - D**  
 A Model for Analysis of Energy Demand...  
 The IAEA works for the safe, secure and peaceful uses of nuclear science and technology. Its key roles contribute to international peace and security, and to the world's Millennium Goals for social, economic and environmental development.

**MAED - EL**  
 A Model for Analysis of Energy Demand...  
 The IAEA works for the safe, secure and peaceful uses of nuclear science and technology. Its key roles contribute to international peace and security, and to the world's Millennium Goals for social, economic and environmental development.

Manage Case Studies MAED - D (A Model for Analysis of Energy Demand)

Case Study: Manual Data

hide menu

- Definitions
- Social & Economic Data
- Energy Intensities and Factors

Industry

Energy Intensities ACM & Manufacturing

Efficiencies & penetrations in ACM

Efficiencies, penetrations & factors in Manufacturing

Transport

- Freight
- Intercity
- Urban
- International
- Household
- Services

Calculate

Results

Basic Data & Factors Energy Intensity Penetration & Efficiencies

Service Sector

Item	Unit	2000
<b>Basic data for useful energy demand</b>		
Labour force in Service Sector	%	45
Floor area per employee	m <sup>2</sup> /cap	8
Total labour force in Service Sector	Million	1.68903
Total Floor Area	Million m <sup>2</sup>	13.51224
<b>Factors for Space Heating</b>		
Share of area requiring SH	%	100
Area actually heated	%	50
Specific energy requirements	kgoe/m <sup>2</sup> /y	60
<b>Factors for Air conditioning</b>		
Floor area with AC	%	10
Specific cooling requirements	kgoe/m <sup>2</sup> /y	50

# MESSAGE

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

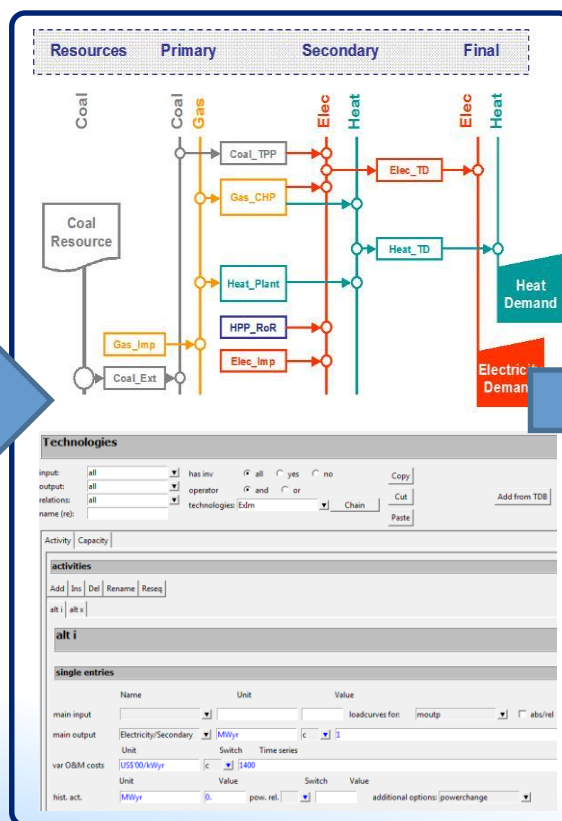
Long-term energy system model to analyze cost optimal energy pathways.

Originally developed by IIASA, enhanced by IAEA with new features & user interface

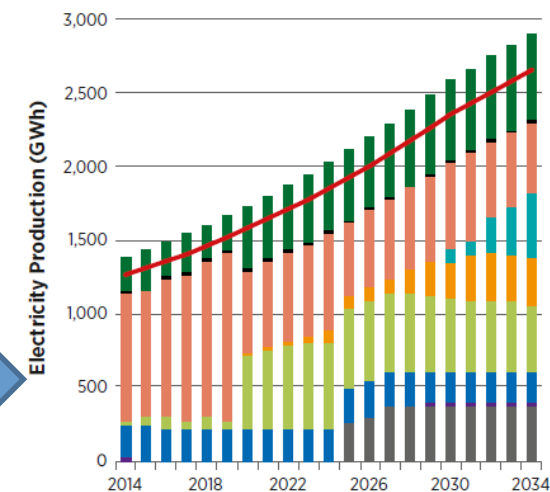
### INPUT

- Energy system structure
- Energy demand projections (MAED)
- Technology and resource options, incl. techno-economic performance
- Technical, environmental and other policy constraints

### MESSAGE



### OUTPUT



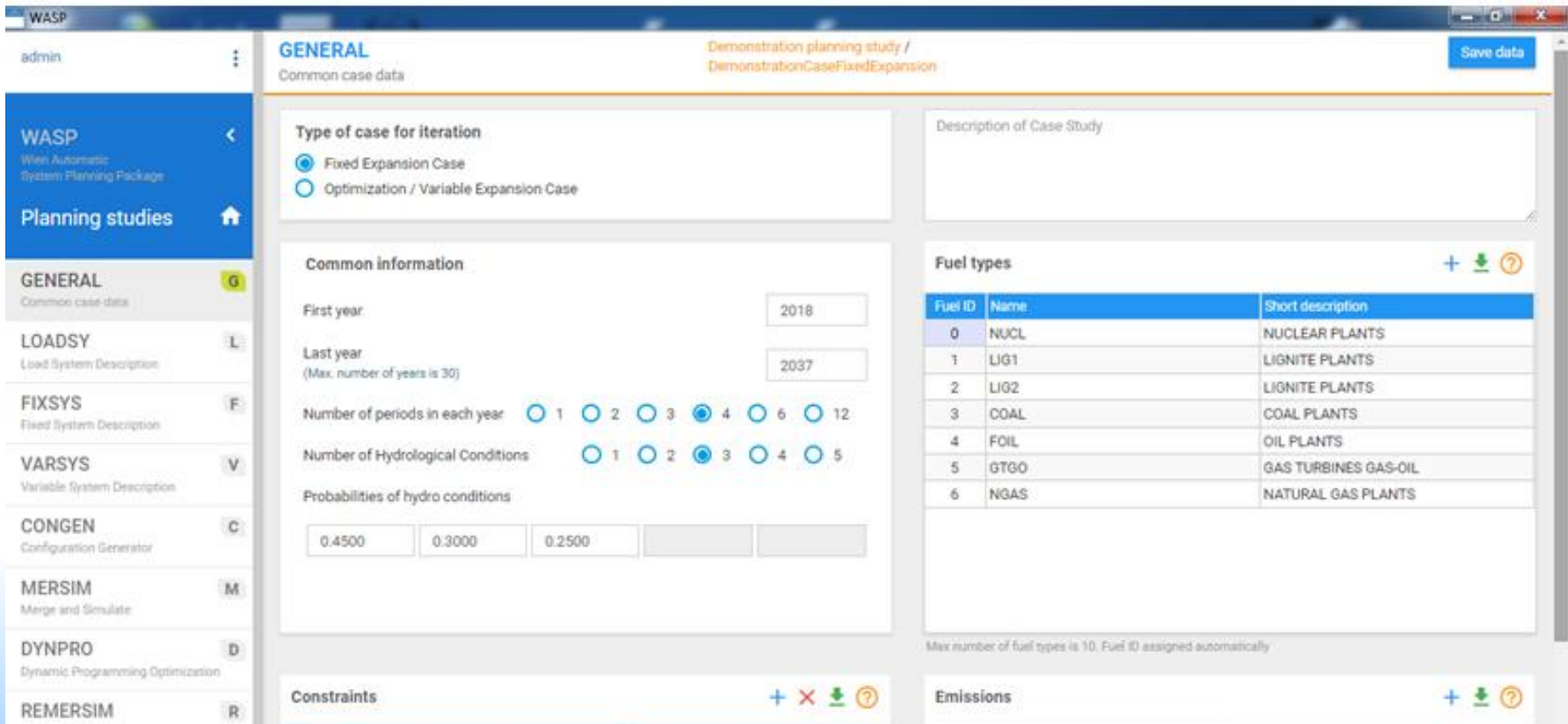
- Primary & final energy mix
- Emissions
- Resource use
- Import dependence
- Investment requirements
- Land & water use, etc.

# WASP

## Wien Automatic System Planning Package

Long-term power system model based on probabilistic production cost simulation & optimisation.

**Outputs:** Construction schedule of individual plants, generation, emissions, LOLP, etc.



The screenshot displays the WASP web interface. The top navigation bar includes the user 'admin' and a 'Save data' button. The main content area is titled 'GENERAL' and 'Common case data'. It features several sections:

- Type of case for iteration:** Radio buttons for 'Fixed Expansion Case' (selected) and 'Optimization / Variable Expansion Case'.
- Description of Case Study:** A text input field.
- Common information:**
  - First year: 2018
  - Last year: 2037 (Max. number of years is 30)
  - Number of periods in each year: Radio buttons for 1, 2, 3, 4 (selected), 6, 12.
  - Number of Hydrological Conditions: Radio buttons for 1, 2, 3 (selected), 4, 5.
  - Probabilities of hydro conditions: Input fields for 0.4500, 0.3000, 0.2500, and two empty fields.
- Fuel types:** A table with columns 'Fuel ID', 'Name', and 'Short description'.
 

Fuel ID	Name	Short description
0	NUCL	NUCLEAR PLANTS
1	LIG1	LIGNITE PLANTS
2	LIG2	LIGNITE PLANTS
3	COAL	COAL PLANTS
4	FOIL	OIL PLANTS
5	GTGO	GAS TURBINES GAS-OIL
6	NGAS	NATURAL GAS PLANTS
- Constraints:** A section with a '+' icon and a 'Max number of fuel types is 10. Fuel ID assigned automatically' note.
- Emissions:** A section with a '+' icon.

# Example of Applications

Assessing Nationally Determined Contributions (NDCs)  
in collaboration with our partners, such as UNFCCC and IRENA

## Regional NDC Workshops

for Europe, Asia, Africa and Latin America

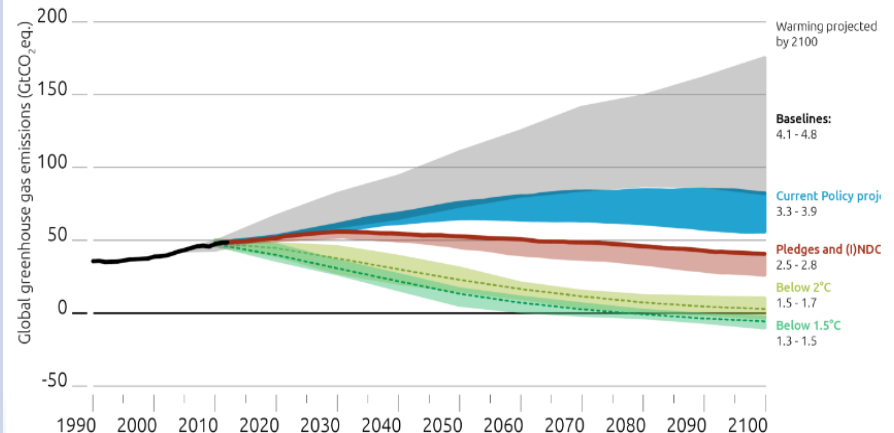
**National energy plans:** 20 countries currently supported

**Research programmes**



## Outputs

- Investment pathways
- Greenhouse gas (GHG) emission profiles
- Optimal technology mix to achieve GHG targets
- Strengthened expertise for evaluating energy options





# IAEA Tools for NECPs Practical Experience

# PESS Tools to inform NECPs

## Example from Practice

### Five dimensions of NECP

1. Security, solidarity & trust - diversification
2. Fully integrated internal energy market
3. Energy efficiency
4. Climate action
5. Research, innovation & competitiveness

Demand analyses with MAED (e.g., energy efficiency and savings, fuel switching...=

Supply analyses with MESSAGE/WASP (e.g., supply diversification, regional markets, system flexibility)

# General approach

- Scenario analysis
  - Iterative Demand-Supply analysis
  - Predefined set of scenarios – Current policies (Existing measures), Additional measures, *Deep measures*, *Net zero emission (by 2050)*
- Planning/analysis period (predefined)
  - Annual until 2030, outlook for 2040
  - Models developed for 5-year steps resolution
- Work overlapped with National Energy Strategy development (harmonization and synergy)

# Tools applied

- MAED
  - Energy demand projections
  - Separate module for demand in transport
  - Synthesis of future hourly load curves
- MESSAGE
  - Electricity and centralised heat (CHPs)
- *PLEXOS (commercial software)*
  - *Checking feasibility of hourly operation for selected years*
- Energy balances compilation
- *Other aspect*
  - *Grid development/impact*
  - *Expert estimates for several areas and Re-use of existing studies*
  - *Extremely short period for drafting (less than six months)*
  - *Core modelling team – 8 experts (cumulative experience of 100+ years), extensive previous knowledge and data sets on national energy system*

# Demand Analysis 1

- NECP requires detailed demand categories to be considered (to take into account targets, model various measures and policies and be able to calculate required indicators, i.e. to conform to a predefined structure)
  - Bottom-up demand analysis and consumption sectors structure should be aligned to NECP requirements
  - Need to clearly connect demand modelling with “real world” measures
  - Data availability issues (measures require fine granularity)
  - Estimate of financial needs for each measure or group of measures (not directly modelled within software – scenario/variants approach; out of model estimates)



# Demand Analysis 2

- Demand in transport modelled with high level of details (other demand categories should follow similar approach)
  - Expertise and data were immediately available
  - Expertise in individual fields needed
  - Data sets needed
- Synthesis of future hourly load curves and customer storage operation
  - Pre-optimised charging of electrical vehicles to reduce peak loads

# Supply Analysis 1

- Electricity system
  - Divided into two sub-regions
  - Zonal modelling of RES potential and availability (solar, hydro, wind)
  - Grid and customer-side batteries
  - Interconnections/market
- Centralised heating systems (only CHP part)
  - Possible energy storages and flexibility provision (heat accumulators, electric boilers...)
  - Switching to alternative solutions (heat pumps)

# Supply Analysis 2

- Grid analysis
  - Relatively high level conclusions, especially for distribution
  - Regional cooperation considerations
- Smart networks/systems
  - Expert judgment

# Some observations

- IAEA's tools were used for core demand-supply modelling
- Several other tools/utilities used to complement analysis or provide aggregated inputs (e.g. Improvement of thermal insulations in buildings; system flexibility needs; grid impact...)
- Expertise still dominates models
  - I.e. it is important to have a well trained experts
  - Use of several models (i.e. not one catch-all model)
- Some challenges
  - First of a kind activity, limited time
  - Data availability, reliability (estimates) and verification
  - Data management and team coordination
  - Automatization of overall process and connecting the models

# Potential future work

- Demand side
  - Improve background data and modelling (sectoral market studies, increase resolution of consumption categories, uses, fuels, technologies...)
- Supply side
  - Integrate other subsectors (target – total energy system integration into one software?)
- Models, teams and work-flow integration (connecting plan production chain – demand-supply-balances)



# Organisational aspects are important



- Study/work was conducted by a team external to the ministry in charge of energy and environment
  - Ability of national bodies to conduct, monitor, follow and/or direct process
  - This is not a one-time effort and stable planning/modelling teams are needed (e.g. a planning system should be established)
  - Lead times to establish teams/planning structure
  - Effort to maintain and train teams/experts should not be underestimated
  - Imposing plans prepared by „outside“ does not fit well (create partnership through knowledge sharing)
  - Secure system “memory” (databases and detailed documentation – irrespective of modelling platform and teams)
  - Part of required reporting was compiled from other studies (i.e. it was not possible to “model everything”)
  - Harmonization of assumptions across all sectors (i.e. coherent scenarios development)

# Engaging with us

# IAEA energy planning support

Requested through National Liaison Officer (NLO)

## Technical Cooperation Projects

### Design

- 2 year cycle (2018/2019)
- Objectives
- Activities
- Team

### Implementation

- 2 year cycle (2020/2021)
- Trainings
- Expert Missions
- Fellowships
- Workshops

~Apr 2018

Country Programme Note

~May 2019

Finalised projects

~Aug 2018

Draft project designs

~Nov 2019

Approval by Board of  
Governors

Each IAEA Member State has one NLO, who is in charge of overall coordination of the project design stage (and assigning project counterparts).

# RER Project Design for 2020/2021

## **Member States**

Eastern European Countries, incl. Black and Caspian Sea and beyond, overlapping with those of the Energy Community

## **Key Outputs**

1. Strengthened expertise to evaluate and assess energy technologies and their potential contribution to climate change mitigation to support countries in defining their commitments under the Paris Agreement (NDCs).
2. Knowledge and expertise in all aspects of nuclear power technologies, including SMRs, increased

## **Key Activities under Output 1**

1. Capacity building and exchange of experience on assessing energy technologies
2. Develop case studies

## **Topics currently discussed under Output 1 – Key Activity 1**

- Paris Agreement & NDCs: Implications for the Energy/Power Sector
- Low-Carbon Electricity Systems – Upcoming challenges
- Assessing Future Energy Technology Mixes in Support of NDCs
- Economic and Financial Analysis of Low Carbon Power Generation

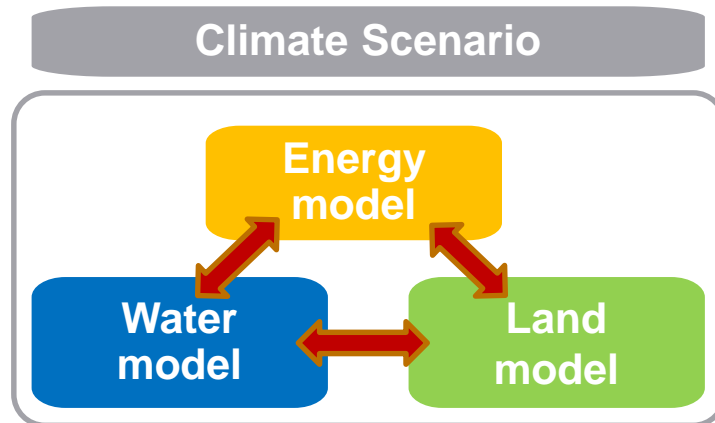
# Further Examples of our Work & Collaborations

outside of NECPs

# Examples of our Work

## CLEW - Supporting integrated energy planning

- SDGs are highly interlinked
- Need for integrated energy planning
- CLEW: combined analysis of **C**limate, **L**and-use, **E**nergy & **W**ater

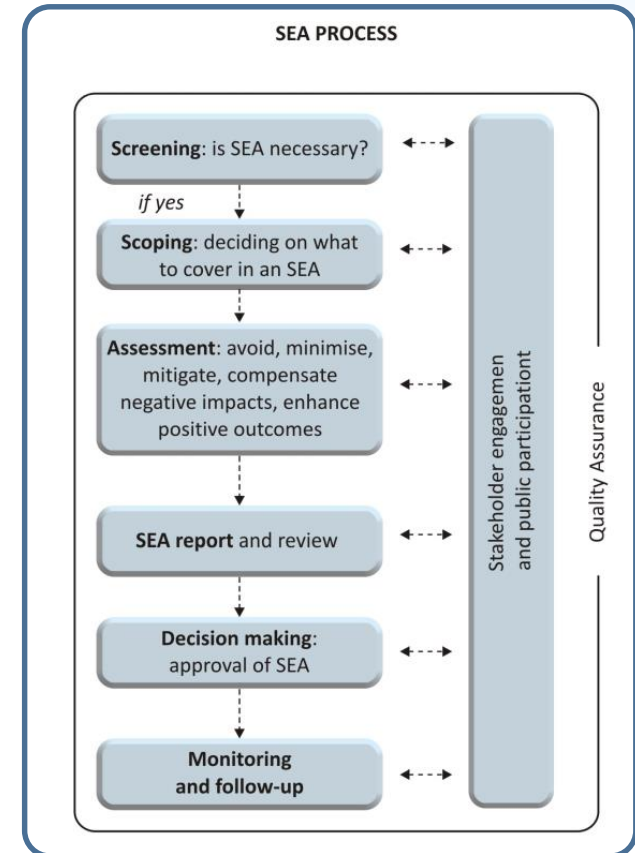


# Examples of our Work

## Supporting environmental assessments

### Strategic Environmental Assessments for nuclear power programmes

- A process to ensure that environmental impacts arising from policies, plans & programmes are considered
- PESS developed guidelines and organises training workshops

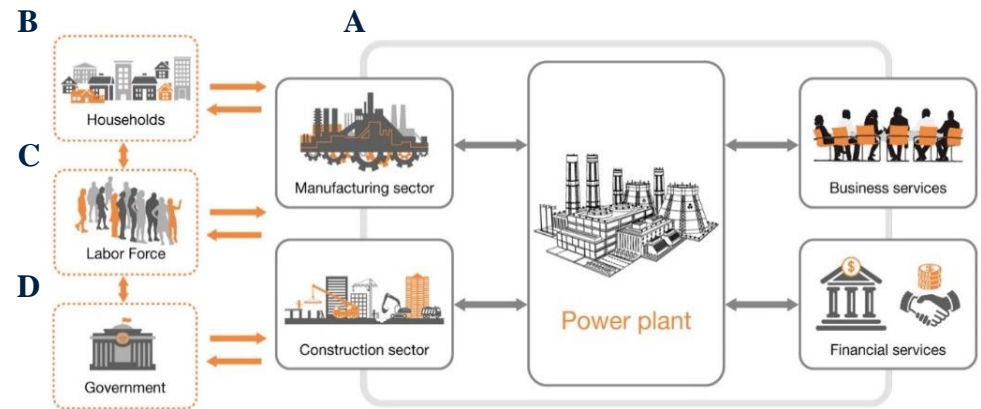
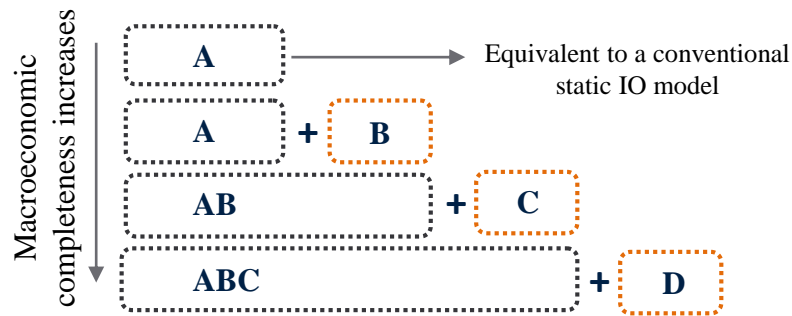


# Examples of our Work

## EMPOWER – Macroeconomic analysis

**EMPOWER** enables to quantify ex-ante and ex-post effects associated with construction & operation of nuclear power plant (NPP) programme.

Each model contains 4 different **modules**.





# IAEA Collaborations



**United Nations**  
Framework Convention on  
Climate Change



# Visit our webpage:

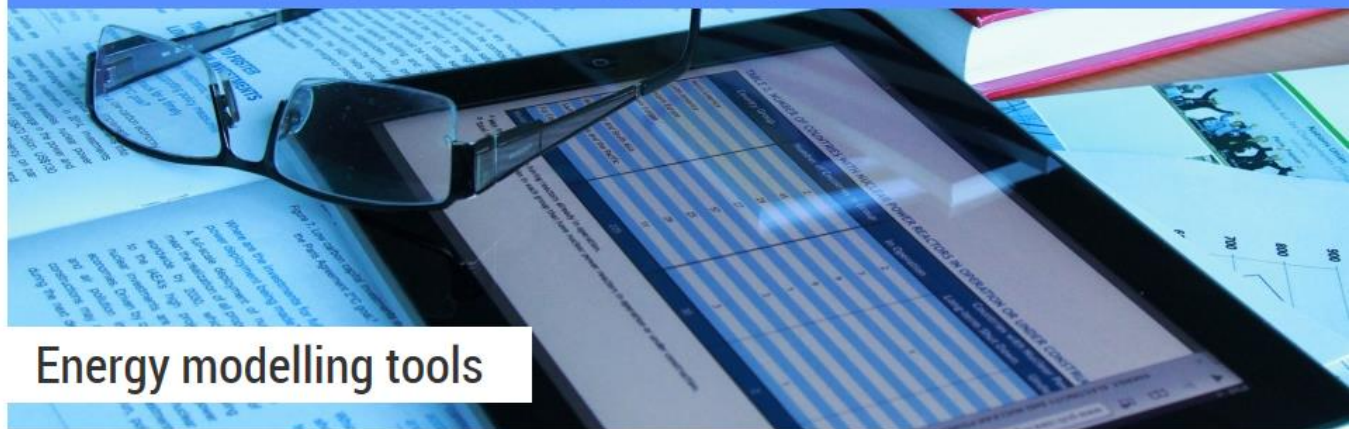
iaea.org/topics/energy-planning or google IAEA + energy planning)



## Energy planning

### Energy planning

- > Economics
- > Projections
- > Sustainability
- > Country case studies
- > Modelling tools
- > Assistance in energy planning
- > Analysis and comparative assessments



## Energy modelling tools

Decisions need to in energy su consistent assists Me strategies, energy.

The Agency assists Member States with practical solutions for their energy planning. It offers different types of energy modelling tools that enable States to make smart energy choices. The IAEA's Planning and Economic Studies Section develops, enhances, maintains and transfers analytical tools to assess different energy options and strategies, including the potential of nuclear power.

### IAEA tools for energy system planning and nuclear energy system assessments

The Section offers to Member States a wide-range of tools for integrated energy planning for sustainable development that are delivered through computer based software programs and manuals, trainings and e-learning sessions/platforms, upon request.

Over 135 countries and 20 international organizations have requested to use [IAEA analytical tools](#) for sustainable energy planning.



### Related

- > Planning Section
- > Assistance



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*Thank you!*

