Republic of Serbia
Ministry of Finance
Department for Controlling and Financing of EU
Funded Programmes
Ministry of Mining and Energy

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#ЕУ ЗА ТЕБЕ

Further Development of Energy Planning Capacity

EuropeAid/135625/IH/SER/RS
Contract no: 48-00-00140/2019-28

Modelling tools and approach

8th October 2021

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ABBREVIATIONS

ADB	Asian Development Bank
CGE	Computable General Equilibrium
DG	Directorate General
EC	European Commission
EMS	"Elektromreža Srbije" the Transmission System Operator of Serbia
EnC	Energy Community
ENTSO-E	The European association for the cooperation of Transmission system Operators for Electricity
ETSAP	The Energy Technology Systems Analysis Program
GDP	Gross Domestic Product
GHG	Greenhouse Gass
GTAP	Global Trade Analysis Project
IEA	International Energy Agency
IMF	International Monetary Fund
MAF	Mid-Term Adequacy Forecast
MANAGE	Mitigation, Adaptation and New Technologies Applied General Equilibrium
MIT	Massachusetts Institute of Technology
MoME	Ministry of Energy and Mining
NDC	Nationally Determined Contributions
NECP	National Energy and Climate Plan
NMM	Non-Metallic Minerals
RES	Renewable Energy Source
SEMS	Serbian Energy Modelling System
TIMES	The Integrated MARKAL-EFOM System
TSO	Transmission System Operator
TYNDP	Ten Year Network Development Plan
UN	United Nations
WG	Working Group

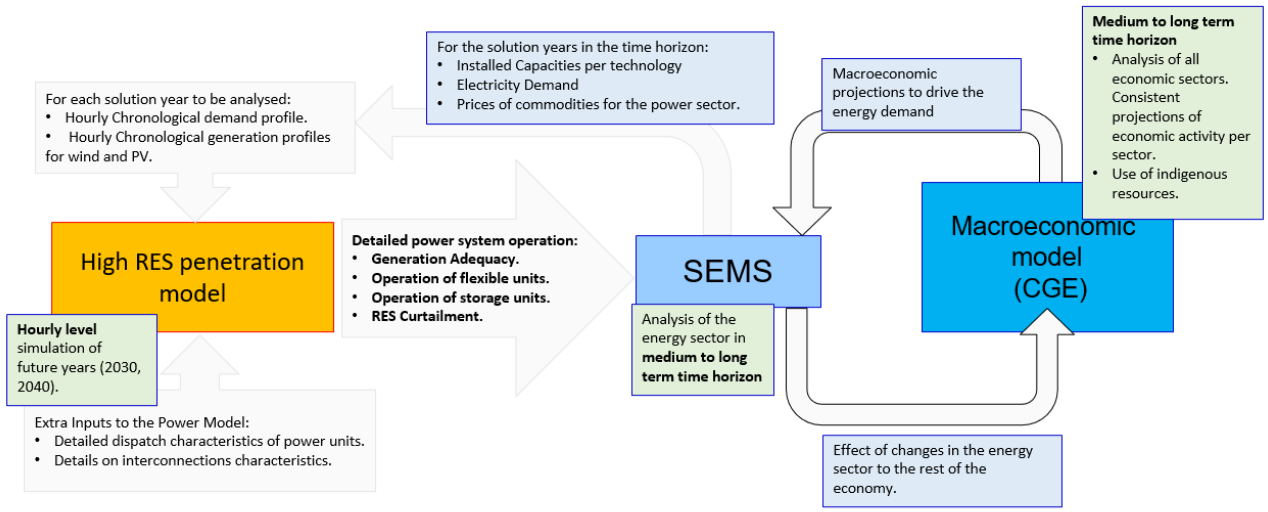
1 INTRODUCTION

In accordance with the Energy Community (EnC) Ministerial Council Recommendation Serbia should prepare the analytical, institutional and regulatory preconditions for the development and adoption of a National Energy and Climate Plan (NECP) for the period from 2021 to 2030. Further development of the capacity for energy and climate planning is needed in order for Serbia to fulfil its obligations as per the recommendation adopted by the EnC. Based on the deliverables of the previous project (EuropeAid/135625/IH/SER/RS - Development of Energy Planning Capacity Republic of Serbia), further assistance including the following tools will supplement the energy planning capacities already built in Ministry of Mining and Energy (MoME) and in the relevant Energy Companies participating in the Projects' Working Group:

- Serbian Energy Modelling System (SEMS) already developed by the previous project will be updated to the latest version of TIMES and enhanced with input data of recent years. The following tools will also be developed and linked with SEMS (used as inputs) improving energy and climate planning capacities in Serbia:
- A macroeconomic analysis tool to ensure an interactive linkage between the predictions of the energy sector development and the development of the economy and other industries
- A high RES penetration market tool (RES tool) for a more accurate analysis of the development of the power system for scenarios of rapid increase in electricity generation from RES.

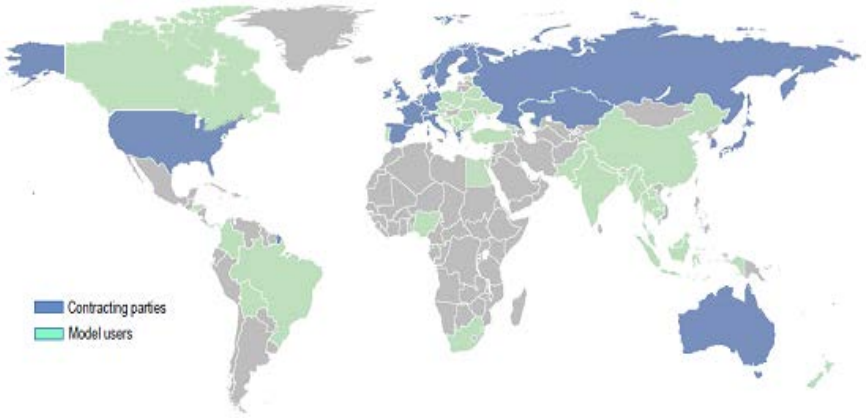
These software tools will provide comprehensive analysis in all aspects of energy planning. Models soft-linking is presented in the following chart, explaining major input and output data that will supplement and improve the final results of the SEMS model, but also provide crucial insights for decision making process and complication of the NECP.

The following sections define basic modelling approaches of each of the tools. Detailed design reports can be provided by the Ministry of Mining and Energy.



2 SERBIAN ENERGY MODELLING SYSTEM (SEMS)

The Serbian Energy Modelling System will have a time horizon until 2050 and is developed using the TIMES modelling framework (The Integrated MARKAL-EFOM System), an energy systems model generator that was developed by the ETSAP Technology Collaboration Programme of the International Energy Agency (IEA). TIMES is a dynamic, bottom-up, technology rich, partial equilibrium optimisation model, which is used to analyse various scenarios for the medium to long term future development of an energy system. This framework has been used in more than 60 countries and 200 institutions which attest to the success of the methodology and approach, and the relevant insights gained from the application of the system.

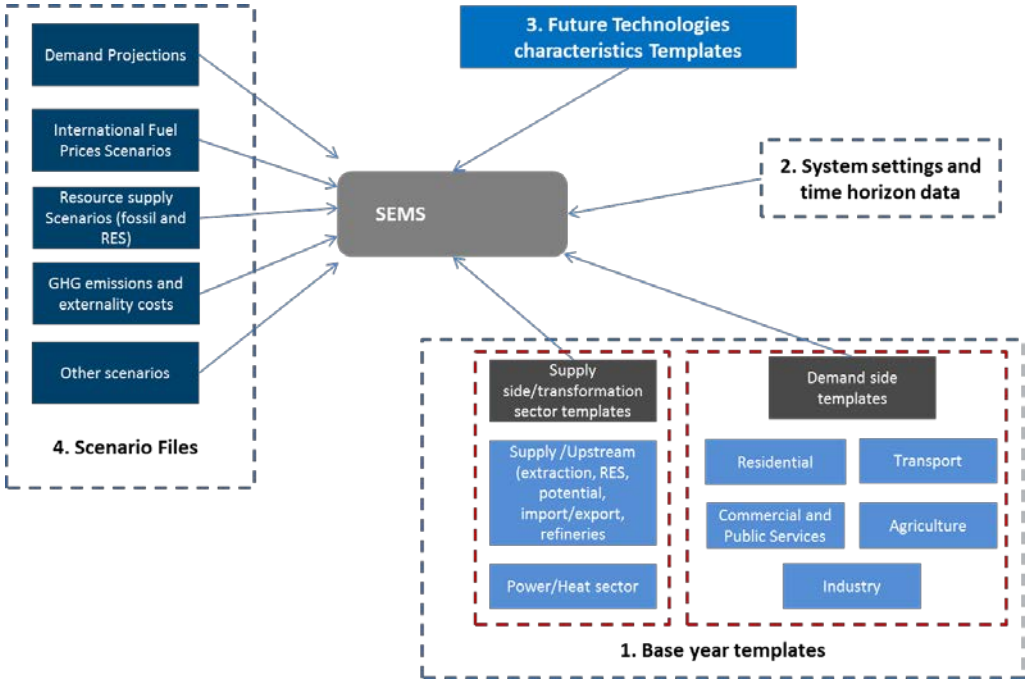


TIMES is a demand driven model, which means that the future development of a number of exogenously defined parameters is needed in order to project the demand for energy services in the future. These parameters are called drivers and they include GDP, Value Added per sector and population change. Each one of the energy service demands is associated with a number of drivers through a functional relationship and is then projected in the future.

The output of the model will be presented using a number of reporting templates, which will present an aggregated energy balance but also detailed tables per sub-sector of supply and demand as well as a list of energy system indicators for each year in the time-horizon of the model.

The Serbian Energy Modelling System (SEMS) was developed based on the principles described in the Model Design Report and was calibrated using the detailed data provided by the WG members during the EuropeAid/135625/IH/SER/RS - Development of Energy Planning Capacity Republic of Serbia. SEMS is expected to improve the capacities for energy planning within MoME, and will be used for complex energy analysis and for developing different scenarios and projections.

The data used in a SEMS model are stored and manipulated in a set of excel workbooks, usually called templates. This gives to the modeller the flexibility to view and analyse the data and the model structure in a user-friendly way. A general layout of the templates for the model of Serbia is shown in the following chart.



Under the current project, since more recent statistical data is now available, the model will be updated to include data for 2017, 2018 and 2019. The data which is used for the model recalibration is the following:

- Non-energy data: This data is used for the demand projections in the model, according to the following list. Each of these values is provided for each of the four statistical regions included in SEMS, namely Vojvodina, Belgrade, Šumadija and Western Serbia and Southern and Eastern Serbia:
-

Values	
Population (000)	Value Added Agriculture
Urbanisation (% of households in urban areas)	Value Added Commercial Buildings, Public Sector Offices, Private Sector Offices
Number of Persons per household	Transport Sector
Number of Households (000)	Industry (Iron and steel, Non ferrous metals, Chemicals, Fertilisers/inorganic chemicals, Petrochemicals, Other chemicals/cosmetics, Pharmaceuticals, Non metallic minerals, Cement and derived products, Ceramics, bricks, etc., Glass production, Other non metallic minerals, Pulp, paper, and printing, Paper and pulp production, Printing and publishing, Food, drink, and tobacco, Textiles, Engineering, Other industries)
Stock of Vehicles (per vehicle type)	Steel, Copper, Lead, Zinc, Other N. Ferrous, Cement, Glass Recycled, Glass Primary, Ceramics, Other NMM Production (ktons)
GDP (mil Euro)	
GDP per Capita	

- Energy Sector Data: This data can be further broken down in the following categories.
  - Supply and transformation data: This will include updates to the current situation of the supply side sector, namely:

- Power sector installed capacities by power plant type. The main change here is expected to be the installed capacities of RES technologies which were introduced in the power system in the period 2017-2019.
- Refineries upgrades, causing a change in the refining capacities and yields of the existing refineries as they are modelled in SEMS.
- Updated estimations of the potential of crude oil, natural gas and coal reserves, if these have been revised over the last years.
- Updated estimation of the potential of each RES (wind, solar, hydro, bioenergy), if these have been revised over the last years compared to the estimates included in SEMS.
- Updated statistics on the imported and exported quantities of each energy commodity.

- Demand Side data: Consumption per region, sector and energy commodity according to the breakdown of the demand sectors as included in SEMS.

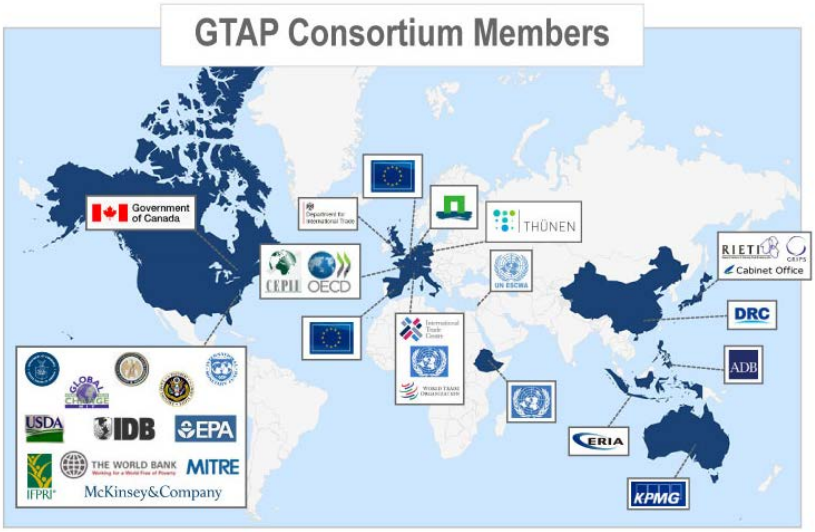
The main sources of data are the official statistical publications of Serbia and the detailed data which is available to the organisations participating in WG1 and WG2 of the project. For more information on the SEMS modelling approach see "Model Design Report"[1].

[1] SEMS "Model Design Report" is delivered to MoME under project "Development of Energy Planning Capacity Republic of Serbia"

3 MACROECONOMIC ANALYSES TOOL

To improve the reliability and quality of Serbian TIMES (SEMS) model projections, as well as to provide possibilities for the assessment of the economic impacts of various energy and environmental policies, a multi-sector recursive dynamic computable general equilibrium (CGE) model will be developed in this assignment. CGE models have been widely used for the assessment of economic impacts of climate mitigation, energy and environmental policies, including assessment of the Nationally Determined Contributions (NDCs), national energy strategies and international climate policies. While in most cases CGE models are used as a stand-alone modelling tool, in a number of applications soft-linkages between CGE and energy system models (like SEMS) have been introduced to provide a more refined representation of the economic and energy systems – an approach that will be also adopted in the current assignment.

The Macroeconomic analyses tool will be developed based on the core structure of the Mitigation, Adaptation and New Technologies Applied General Equilibrium (MANAGE) computable general equilibrium (CGE) model. MANAGE is a single-country recursive dynamic CGE model that provides a consistent representation of the entire economy of the country of interest, including interactions between key economic agents – producers, consumers and government. The model is specifically designed to analyse variety of issues related to the economics of climate change and environmental policies, including baseline emissions of CO2 and other greenhouse gases; greenhouse gas (GHG) mitigation policies – taxes, caps and trade; economy wide and sectoral impacts assessment of environmental policies. MANAGE is running as part of Global Trade Analysis Project (GTAP) since 1993. GTAP improves the quality of quantitative analysis of global economic issues within an economy-wide framework. The GTAP Consortium currently consists of 32 agency members such as: IMF, EC DG Trade, UN Trade and Development, World Trade Organisation, ADB, International Trade Center, MIT, etc.



Incorporation of the inter-sectoral linkages and high level of sectoral details provided in the MANAGE model, would enable accurate verification of different quantitative hypotheses related to the economic and environmental profiles of Serbian energy pathways. The proposed modelling approach would also provide rich details on economic-energy interactions, considering that MANAGE incorporates various emissions and allows for estimation of climate change impacts in the economy-wide context.

The Macroeconomic analyses tool will include a detailed representation of the Serbian economy disaggregating producers into 76 sectors, with 21 agricultural and food sectors, 18 service sectors and detailed manufacturing activities. Energy activities in the model will be represented by 5 fossil fuel sectors, 11 electricity and heat generation technologies, as well as transmission and distribution activity. The Macroeconomic analyses tool will have a 2050-time horizon and will rely on a detailed set of data inputs for the selected

reference year, combined in a social accounting matrix based on the Serbian national accounts, as well as the set of exogenous macro projections, such as GDP and population. The tool will also incorporate CO2 emission accounts and energy balances.

Macroeconomic analyses tool can neither identify specific technological choices that are implemented in the baseline or policy scenarios (e.g., specific type of power plants or vehicles) nor explicitly represent technology-specific policy options, such as emission or energy efficiency standards. All these limitations of the Macroeconomic analyses tool can be addressed in a bottom-up modelling framework – using energy system model, such as SEMS. The latter one provides a detailed representation of the energy technologies both on the supply and demand sides, allowing for an in-depth assessment of various energy transition scenarios. At the same time, energy system models like SEMS, lack proper representation of linkages between energy sector and other sectors of economy (services, households, manufacturing, etc.), essentially treating an energy demand as exogenous, which could potentially lead to the inconsistent assessment of the energy transition costs and outcomes. SEMS also does not represent macro-economic feedbacks of the specific scenarios implementation. Therefore, in the current assignment we aim to benefit from the soft-linkage of the Macroeconomic analyses tool and SEMS models to provide a more inclusive framework for the assessment of the energy and environmental policies in Serbia. In the next subsection we discuss some specifics of such model linkage.

For more information the modelling design and the set up see the "Macroeconomic analyses tool Design Report"[2].

[2] delivered to MoME under project "Further Development of Energy Planning Capacity"

4 HIGH RES PENETRATION MARKET TOOL (RES TOOL)

The High RES penetration market tool (RES tool) will be developed using the ANTARES simulator. ANTARES is a well-established open-source model developed by the French Electricity Transmission System Operator for its own purposes and keeps on improving and enhancing its capabilities. ANTARES is currently one of the key tools of ENTSO-E and is used for reference studies such as ENTSO-E's Ten Years Network Development Plan (TYNDP) and Mid-Term Adequacy Forecast (MAF). It is being used by a wide community of users (e.g., TSOs - MAVIR, Elia, GRTgaz) in several countries (e.g., Belgium, Hungary, Germany) including EMS, the Transmission System Operator (TSO) of Serbia. More generally, the tool has been proven very useful for assessing the economic performances, ecological impact and security of supply levels of power systems, as well as the contribution of its assets (generation units, interconnectors, storages, etc.) to these three axes.

In the context of the development of the RES tool for Serbia, ANTARES offers the following advantages:

- It can perform economic optimisation of the Serbian generation power system with sequential simulation of one-hour resolution and for a one-year time span. The hourly sequential simulation is necessary for adequate modelling of assets such as variable renewable generation as opposed to duration generation curve based or specific time-snapshots analysis.
- It is able to simulate one-year operation of the Serbian power system together with its neighbouring power systems in order to properly take into account its interconnections, which are important in provision of adequacy and flexibility.
- Its fast algorithm can perform simulations of such a regional model in limited time, making thus feasible to analyse multiple scenarios for the development of the Serbian power system.
- It is particularly suitable for economic assessment of generation projects. It is therefore appropriate for supporting NECP studies that typically need quick economic assessments of clusters of generation projects.

The RES tool will simulate the power system on an hourly basis, in selected years (e.g. 2030), using all the extra input which is required for this simulation and includes inter alia technical and economic characteristics of the power generation units and other flexibility resources such as storage units and interconnections with neighbouring systems. The detailed simulation of the power system in the RES tool will provide insights on generation adequacy, details on the operation of dispatchable units and the storage units and the level of curtailment of RES generation which is expected. This will provide inputs to SEMS in the form of new generation profiles from RES, incorporating curtailment, and other information on the necessity of flexibility options for the proper operation of the power system. Incorporating this in SEMS will lead to a solution, more realistic from the point of view of the power system operation.

Based on the achieved results, the RES tool will provide the following type of conclusions:

- Suitability of high RES integration in the power system in the expected capacity mix
- Economic efficiency of a specific scenario for the Serbian power system
- Power system flexibility needs for achievement of RES penetration targets
- Level of CO2 emissions of a specific scenario

The RES tool will be developed using the ANTARES simulator and will include a detailed representation of the Serbian power system and an adequate representation of the regional power system, as the electric power system of Serbia is very well interconnected to its neighbouring countries. Figure 1.1 shows the proposed

extend of this region, which comprises the rest of Western Balkans (Croatia, Bosnia and Herzegovina, Montenegro, Albania and North Macedonia), as well as Hungary, Slovenia, Greece, Bulgaria and Romania. In the RES tool, the Serbian system will be represented as two areas, one for the same system modelled in SEMS (RS01) and another one for the Autonomous Province of Kosovo and Metohija (RS02). As per the standard modelling approach, it is assumed that there are no transmission constraints inside each area ("copper plate" approach), as each TSO develops the transmission system accordingly. Therefore, each area is modelled as a single node with specific generation and demand profiles, while transmission limitations will be accounted for in the system borders, through the Net Transfer Capacities between the modelled zones.

For more information on the modelling approach of the RES tool see the "High RES penetration market tool Design Report"[3].

[3] delivered to MoME under project "Further Development of Energy Planning Capacity"