Deliverable C2.1, Part 1: Summary report on methods and models for scenario analysis

Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis

Final report

LIFE ClimatePath2050 (LIFE16 GIC/SI/000043)

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Deliverable C2.1, Part 1: Summary report on methods and models for scenario analysis was prepared within the project LIFE ClimatePath2050 "The Slovenian Path Towards the Mid-Century Climate Target" (LIFE Podnebna pot 2050, Slovenska podnebna pot do sredine stoletja, LIFE16 GIC/SI/000043). The project is being carried out by a consortium led by the Jožef Stefan Institute (JSI), with partners: ELEK, the Building and Civil Engineering Institute ZRMK (GI ZRMK), the Institute for Economic Research (IER), the Agricultural Institute of Slovenia (AIS), PNZ and Slovenian Forestry Institute (SFI).

ŠT. POROČILA/REPORT NO.:
IJS-DP-13746

DATUM/DATE:
16. December 2021

AVTORJI/AUTHORS:
Matevž Pušnik, Ph.D., JSI
Andreja Urbančič, M.Sc., JSI
Matjaž Česen, JSI
Stane Merše, M.Sc., JSI
Marko Đorić, JSI
Tadeja Janša, JSI
Marko Kovač, Ph.D., JSI
Boris Sučić, Ph.D., JSI
Jaka Bizjak, for JSI
Gregor Pretnar, M.Sc., PNZ
Lea Rikato Ružić, M.Sc., PNZ
Boštjan Mali, Ph.D., SFI
Gal Kušar, Ph.D., SFI
Jože Verbič, Ph.D., AIS
Boris Majcen, Ph.D., IER
Renata Slabe Erker, Ph.D., IER
Kaja Primc, Ph.D., IER

REPORT TITLE/NASLOV POROČILA:

Deliverable C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis, Part 1: Summary report on methods and models for scenario analysis, final report

Poročilo projekta št. C2.1, Metode in modeli za analizo strateških scenarijev blaženja podnebnih sprememb do sredine stoletja, Prvi del: Metode in modeli za scenarijsko analizo - Povzetek, končno poročilo

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Table of Contents

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Introduction

In the scope of LIFE ClimatePath2050[1] the **Deliverable C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis**, Part 1: Summary report on methods for scenario analysis was prepared. The document presents the information on the models developed or updated in the scope of the project along with some basic results of models use.

The composite deliverable C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis consists of several parts, namely:

- **Part 1: Summary report on methods and models for scenario analysis**, condense summary report on methods and models for scenario analysis;
- **Part 2: Energy sector models**, includes the detailed information on sectoral models used for climate mitigation scenario analysis, the report enlightens general approach and presents final energy demand and supply models including households, services and agriculture energy use, energy use in transport and industry, models for district heating expansion analysis and CHP cross sectorial impact, distributed electricity production assessment and optimisation of power sector operation;
- **Part 3: LULUCF model**, includes the detailed information on Carbon Budget Model (CBM-CFS3) that is used for simulating the dynamics of forest carbon pools, considering various assumptions such as the type of forest management, land use changes, the occurrence of natural disturbances and timber harvesting;
- **Part 4: Other IPCC sectors agriculture, sector process emissions, IPCC sector waste**, includes information on the models used for assessing emissions from agriculture sector, industrial process emissions and emissions from waste sector in accordance with IPCC;
- **Part 5: Macroeconomic model**, includes the detailed information on the newly developed multi-sectoral Computable General Equilibrium model (CGE) of the Slovenian economy (GreenMod Slovenia) that was developed and used specifically for the analysis of energy and environmental issues, considering the quantitative results of the energy sector models.

The deliverable **Part 1: Summary report on methods and models for scenario analysis**, represents a condense summary report on methods and models developed and/or revised in the scope of LIFE ClimatePath2050 project. The models were used to assess the Climate Mitigation Mid-century Strategy scenarios.

1 LIFE ClimatePath2050 (Slovenian Path Towards the Mid-Century Climate Target)

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Integrated Resource Planning and analysis

Modern energy planning must meet a number of economic, social and environmental requirements due to its complexity, which requires a comprehensive approach to planning. Such an approach must include all these, often contradictory requirements, and in this context address the widest possible range of traditional and alternative energy sources. Traditional energy planning was based on an increase in supply sources that were able to meet the expected growth in consumption, while minimizing the economic costs associated with this growth. Until recently, these criteria dictated energy strategies through increasing electricity generation capacity, or whether it was an improvement in the economics of production volumes, without emphasizing energy efficiency.

The increased cost of supply and the environmental constraints of today have led to a comprehensive update of the traditional concept of energy planning. Modern approach such as **Integrated Resource Planning (IRP)** is based on the integration of a wider range of cost and technological components, including environmental and sociological costs, energy efficiency, energy consumption measures and dispersed energy production resources. The expected outcome of such an approach are gradual changes in the market towards new economic environments, with a focus on the development and use of efficient end-use technologies and less environmentally burdensome energy supply. Successful development and implementation of integrated energy plans can lead to significant energy savings, reduce the need to build large and expensive units for energy production and transmission, improve the financial impact of energy supply companies, reduce emissions of harmful substances into the environment, increase national security, improve economic productivity and relations between energy companies and their end users. For such comparisons, such a methodology is necessary as it deals equally with all the possibilities on the energy use and energy supply side for the provision of energy services, the key condition of which is the use of energy, such as the provision of lighting, heating, cooling, transport, the operation of information and communication devices, mechanical work, chemical energy and power. IRP can also be defined as a process of planning energy services in a way of achieving and considering a greater number of different energy resource exploitation targets.

Each country, or region, sets its own objectives in the energy services management and planning. Such objectives are often contradicted at different levels and have different scopes and effects. Regulation, decision-making and implementation of energy strategies and policies requires a whole range of objective analyses and the use of procedures to carry out evaluation involving both the interested public and other decision-makers involved in the development of strategic plans and policies.

With the emergence of industrialization, national planning in energy has also evolved, but to a very limited extent. Energy was then still seen as the input parameter of production and treated as work or capital. Later, when the authorities began to formulate national economic policies,

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

energy became a market commodity, which also meant that they kept documentation on energy use and supply. After the Second World War, the national energy planning process relied heavily on simple macroeconomic approaches. Rapid technological advances after the war and exponential growth in energy use brought new parameters to the planning and the design of national energy systems became increasingly complex, and the use of new statistical and information technologies was necessary. The transition from traditional planning methods and the use of integrated planning methods in energy have made it possible to integrate and study the conflicting objectives of individual energy sectors into a comprehensive energy system at national level. For that purpose, national energy system models are used to analyse long-term strategic decisions and solutions in modern energy.

Policy and those responsible for energy decisions and strategies have long been trying to find the best solutions to modern energy problems and to propose solutions and strategies in this very dynamic and complex area. National energy systems have become extremely complex to study as they depend on the input and output parameters of subsystems, which can be very dynamic and susceptible to uncertainties.

The whole system is therefore a conglomerate of complex energy subsystems, which include energy supply technologies, which can be divided into renewable and non-renewable energy sources, transformation technologies and sectoral energy use, where each sector is treated as a subsystem.

Models of national energy systems and subsystems are used for the study of energy systems and a wide range of energy, economic or environmental analyses and for the production and forecasting of long-term energy balances. Basically, the model of the national energy system is a set of programs and tools by which we mathematically describe the individual subsystem correlated with all the parameters that affect such a subsystem and then integrate these subsystems together into an appropriate whole, representing the national energy system.

Strategic decisions in energy are, by their very nature, multi-criterion - they pursue several objectives and, as a rule, there is no strategy that is best in all the criteria that we follow when we decide. The criteria cannot, for the most part, be expressed by a common measure without relying on subjective assessments, for example on the monetary value of each criterion or on the evaluation of the interchangeability of those criteria to balance the objectives. The analysis of energy strategies has therefore established the tradition of using a structured analysis method to increase transparency of analyses, which allows cooperation with decision-making and a wider range of experts at different stages of the analysis process. To this end, we use specific methods to support this type of decision-making, and these methods are called **multicriteria decision-making methods (MCDM)**. The purpose of multicriteria decision-making methods is to improve the quality of the decisions themselves so that they are more explicit, rational and effective.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Energy Models

The energy system can be defined as a set of processes for the exploitation of primary energy, processes for energy transformation, processes for energy transmission and distribution and processes for the conversion of useful energy of consumers – final energy. The links between the individual processes of the energy system are extremely complex and impossible to assume without prior detailed analysis of the system. Even the slightest change in the structure of consumption (e.g. higher electricity consumption or lower use of fuel oil) is dictated by changes in the overall energy system, which are reflected in the lower need for crude oil, i.e. lower necessary production capacity of refineries and corresponding increase in the amount of power plant power, energy consumption for energy transformations and increased losses on energy transmission and distribution. The analysis of such complex systems is time-consuming and complex, especially when we want to examine several different scenarios for the development of the energy system.

Energy models can be defined as a mathematical description of energy flows of the addressed energy system. The model is given in the form of a computer algorithm that reflects the real energy system and addresses energy flows. The general characteristic common to all energy system models is that the model represents a simplified complex real energy system and addresses both quantitative and qualitative parameters related to a particular energy problem. The results or outputs of the energy system model must reflect the selected modeling assumptions and approximations that the model designer has envisaged.

Furthermore, we can also distinguish models of energy systems according to the basic methodology of the model, which determines the characteristics and structure of the model. Some of the most commonly used basic modelling methodologies are:

- **Econometric models** – the methodology is based on the use of statistical techniques to extrapolate aggregated data from the past to predict energy and economic interactions in the future. The weakness of such systems is mainly in aggregated data, which do not allow detailed assessment of individual technologies.
- **General** equilibrium models – the methodology is based on ensuring a general or partial balance of systems. In energy, it is necessary to ensure a balance between energy consumption and energy supply. Such models are also called resource allocation models;
- **Optimization models** – models are based on linear programming techniques with which we optimize investment costs according to selected variables, considering the border conditions of the system itself. Optimization models are often used for the analysis of smaller energy systems, but they are also suitable for analyses of national energy systems. At this stage, however, it should be stressed that the design of such models requires a high level of mathematical knowledge and a detailed analytical description of all the processes that form such a system.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

- **Simulation models** – we use such models in the scenario analysis of energy systems. They are based on a logically simplified description of the real energy system. Dynamic simulation models treat the system over the selected time horizon (example: 2020-2050 with a 5-year interval). The use of such models is widespread and suitable for addressing more complex energy systems, such as the national energy system.

In summary, the purpose of energy systems models is to understand a specific segment in energy and to demonstrate how such a segment affects society, its sociological components, economics and the environment.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Models Used in the Scenario Analysis

General context for the use of models is strongly linked to the requirements for the preparation of national strategic documents. Several strategic documents require expert bases in a form of projections (i.e., National Energy and Climate Plan of the Republic of Slovenia and Slovenian Climate Long-Term Strategy 2050, GHG Reporting (**UNFCCC** - United Nations Framework Convention on Climate Change, reporting under energy Union Governance Regulation), reporting under **N**ational **E**mission reduction **C**ommitments Directive – air pollutants). Models are used also for the assessment of the national goals and for monitoring and reporting on the policy implementation. Furthermore, energy models can also provide the quantitative bases for dialogue with national stakeholders and EU representatives.

The purpose of the energy models is to understand a specific segment and show how that segment affects society, its sociological components, economy and environment.

In the scope of LIFE ClimatePath 2050 project 6 models have been developed or renewed and are presented in the following.

1. **REES-SLO** (**R**eference **E**nergy and **E**mission **S**ystem model for **SLO**venia, simulation model)
2. **Power System Optimisation** model (Monte Carlo optimisation model)
3. **PRIMOS** (Transport activity model)
4. **Macroeconomic model** (General Equilibrium Model)
5. **LULUCF Model** (Land Use, Land Use Change and Forestry Carbon Budget Model)
6. **Agricultural model** (AGRI AIR, Livestock and Soils model)

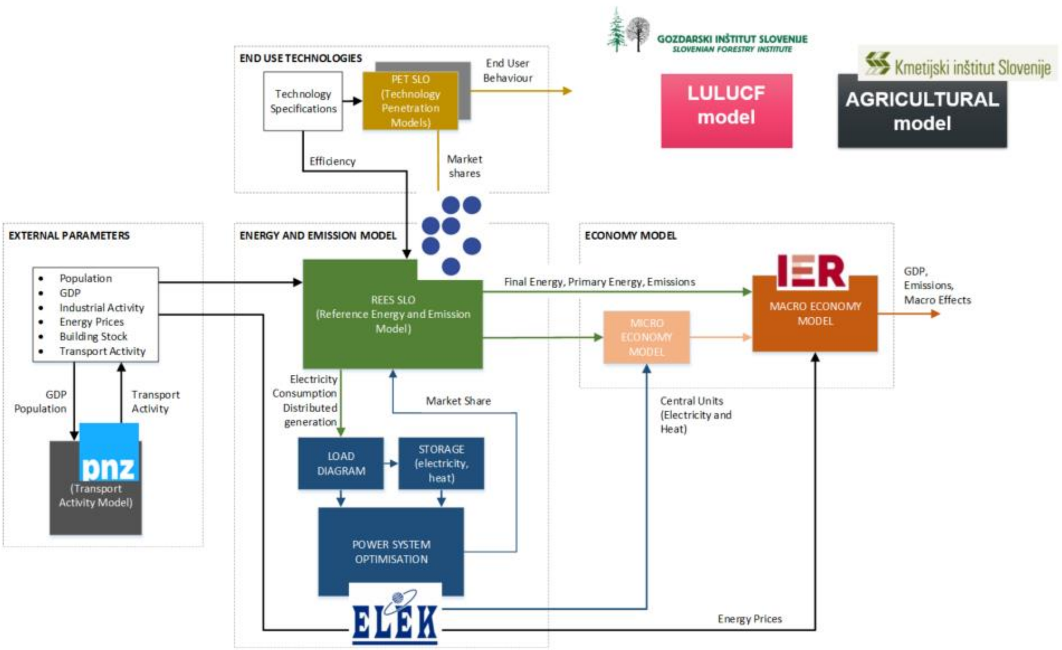

Figure 1: Models developed in the scope of LIFE ClimatePath 2050 project and responsible partners

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

First 4 models are interconnected and are communicating with each other, whilst LULUCF model and Agricultural model are standalone models and do not have any connections with other models.

1.1 REES-SLO model

1.1.1 Short description

With the aim to describe technical, economic and environmental characteristics of the Slovenian energy system, new Reference Energy and Environmental System model (REES-SLO) has been developed. REES-SLO model is the central tool to calculate energy balances, emissions and costs of energy use and supply in Slovenia, created in the MESAP environment in the form of a linear network model of processes and interconnections, which enables consistent modelling of energy consumption based on energy service needs and calculations of sectoral energy, economic, environmental and other impacts. A reference model of an energy system is essentially a set of programmes and tools that mathematically describe an individual subsystem in the interdependence of all the variables that affect such a subsystem, and then integrate those subsystems into an appropriate whole that represents the real energy system.

The REES-SLO model is a technology-oriented (bottom up) linear simulation model developed at the Jožef Stefan Institute, Energy Efficiency Centre. The model consists of several energy demand and supply sub-models, namely: industry, households, transport, services and other sectors, on demand side and local and central systems, on supply side.

Main input parameters of the REES-SLO model are sector specific: i.e. industrial activity, building stock, demography, transport activity and energy prices.

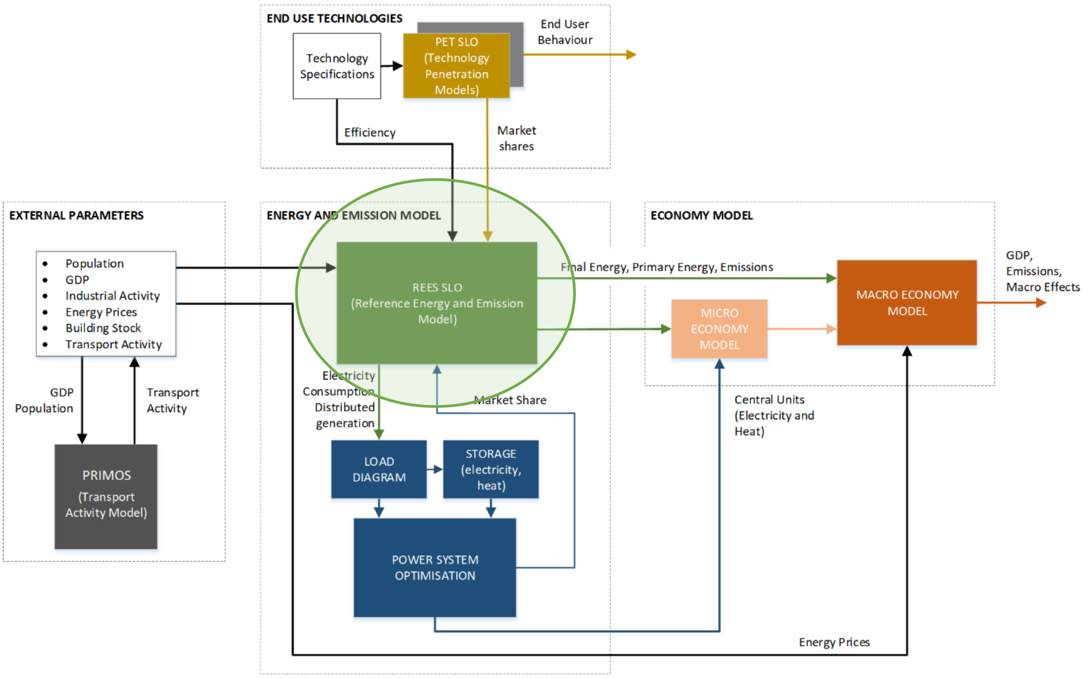

Figure 2: REES-SLO model interconnections

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

1.1.2 What was done in the scope of the project

In the scope of the LIFE ClimatePath 2050 project a complete renewal of the REES-SLO model has been done, namely:

- **new model for industrial sector** has been developed enabling more detailed assessment of energy intensive industry and other branches;
- **new model for household sector** was developed and linked with geographical information systems (GIS) enabling development of heat maps and spatial analysis;
- for **transport sector** a link with PRIMOS transport activity model has been established and new models for vehicle fleet have been developed;
- furthermore, **the technology database** for existing and future technologies **has been updated** (new technologies, market shares and efficiencies);
- the **link with Macroeconomy model has been established** for the first time in Slovenian environment.

More information on REES-SLO model is available in the Deliverable *C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis, **Part 2: Energy sector models.***

1.1.3 Applicability

The REES-SLO model was used as a decision support tool for national strategic energy planning, namely to support the preparation of the National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050. Since the modelling results have significant influences on decisions of energy systems planning and emission management, our imperative was to develop an advanced energy systems model which can effectively handle peculiarities of the small energy systems and provide sound decision supports. During the development process we were fully aware that the national energy systems are extremely difficult to model since they are depending on many very complex input parameters. Value added of the new REES-SLO is very strong environment component which was added to the classical Reference Energy System concept and clear focus on interactive and dynamic characteristics of relatively small Slovenian energy systems with the aim to objectively tackle decision problems, such as future energy infrastructure development, power generation expansion and greenhouse gases (GHG) emission reduction.

1.1.4 Future work and challanges

The model requires constant updating and adaptation to changes, due to the improvements and availability of new statistical data, technology descriptions and external influencing factors. The following research challenges or fields can be highlighted in relation to the improvements of the REES-SLO model:

- improvements in the field of circular economy, resource efficiency, product design and sustainability;
- evaluation of socio-economic effects such as energy poverty and behaviour changes;
- addressing changes in the economic and social paradigm (energy efficiency vs. energy sufficiency);

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

- evaluation of the impact of scenarios on the structure of the economy in support of national strategies of economic development.

The model will have to be upgraded to enable better representation of changing energy system, namely improved sector coupling will have to be developed and also more detailed spatial and time resolution analysis will be required.

REES-SLO model along with other connected models and sub-models represent an overall methodological framework for assessing different decarbonisation pathways. The tools and models developed in the scope of LIFE ClimatePath 2050 enabled the transparent and consistent approach to policy development and implementation support.

1.2 Power Sector Optimisation model

1.2.1 Short description

Long-standing practice in Slovenia has shown the inadequacy of the use of foreign models in the determination of development plans for power plants, which are characterized by major specificities; inflexibility, high technical minima, provision of frequency services, high requirements for the provision of manual reserve, mainly only daily accumulations of Hydro power plants and their specificity, high energy power system openness and connectivity, all of this should therefore be taken into account for the assessment of operation and planning.

Models, both commercial and other freely available, which can be used for larger systems, do not address these specifics, resulting in unrealistic calculations for "small systems" like Slovenian . These were the main arguments for developing our own model.

The Power Sector Optimisation model is a probabilistic optimisation model developed by ELEK company. The model analyses the narrow specificities common to the electricity generation sector. The model integrates the operation of both conventional producers and existing and planned renewable electricity sources into the total Power system. The basic processing time step is one hour. The simulation-based model calculates the individual states of future development of electricity generation, subject to limitations. Geographically it is limited to the production of electricity covering large facilities in the area of Slovenia and also includes links with neighbouring systems.

The model addresses the power production processes and for the selected time horizon, specifies:

- the schedule of starting and shutting down of each production unit,
- the load on each production unit,
- calculation of LOLE (loss of load expectation) and ENS (energy not supplied) reliability indicators,
- formulation of a market offering (power plants and imports) and a consumer curve (transfer-level spot) and a cross-section point;
- treatment of both existing and planned production units.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

The preparation and analysis of data on electricity consumption are the basis for modelling daily consumption diagrams in the model for long-term planning of production development in the power system. The model relies on the data provided by Slovenia's electric power transmission system operator ELES, which have an hourly dynamic of consumption at the level of the transmission network. The starting point is the base year, after which the characteristics of the annual consumption are summarized. In our case, we started from 2016, which we later upgraded to 2017.

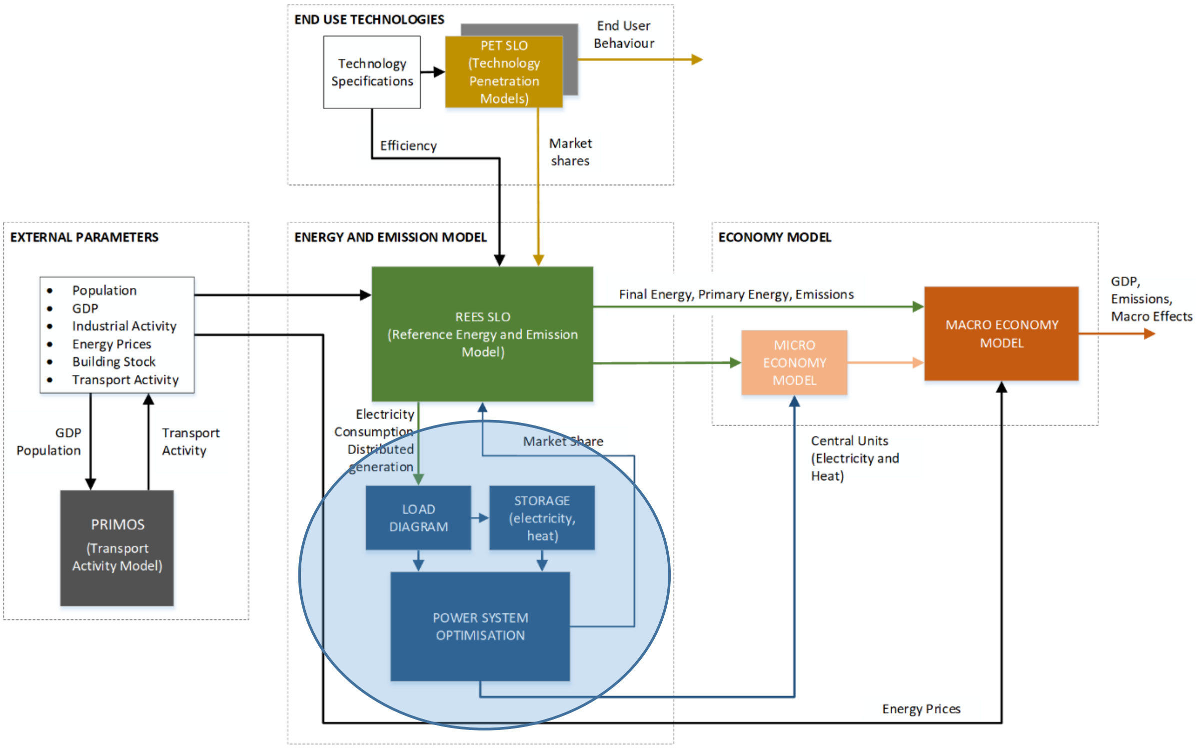

Figure 3: Power Sector Optimisation model interconnections

1.2.2 What was done in the scope of the project

In the scope of the LIFE ClimatePath 2050 project a complete renewal of the Power System Optimisation model has been done, namely:

- new hourly electric demand curves (year 2017);
- update of technical, economic and environmental data for existing and new power plants, (hydroelectric, nuclear, thermal and pumped hydro storage);
- update of hydrological data with inclusion of impact of climate change on hydrological conditions
- application of new interface for hourly operation of wind and photovoltaic power plants.

More information on Power System Optimisation model is available in the Deliverable *C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis,* ***Part 2: Energy sector models.***

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

1.2.3 Applicability

The Power Sector Optimisation model was used in support of national strategic energy planning, namely to support the preparation of the National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050, hence it passed the applicability test. Several power production scenarios have been calculated and assessed using the aforementioned model, considering the complex integration of dispersed energy sources (Solar, Wind, small Hydro, Hydro, and CHP). Also, LOLE (loss of load expectation) and ENS (energy not supplied) reliability indicators have been assessed with this model. Power Sector Optimisation model is connected with REES-SLO model assuring the consistent approach to power sector inputs required for the future energy and emission projections.

1.2.4 Future work and challenges

Future development of the model is strongly tied to the improvements in the statistical basis. Also, the load diagrams for dispersed electricity production and their inclusion in the hourly diagrams represent an important challenge. Direct connection with the models assessing the potentials for dispersed electricity production (solar, wind, CHP) is foreseen in the near future. For those potential assessment models, the connection with GIS (geographical information systems) is essential, hence a connectivity framework connecting various models has to be established in the future. Also, a lot of work has to be done in the field of modelling different storage technologies.

1.3 Transport activity model PRIMOS

1.3.1 Short description

Transport is an integral part of the world so it also depends on its fundamental laws. It is also characterized by dynamic and constant changing, but at the same time it is one of the factors which connects parts together. The current generally accepted way of life requires passenger and cargo transport. The first one is carried out for a number of purposes, the other one for various types of goods. All this has important effects on development, including the development of Slovenia. The level of development is measured by various indicators, covering cultural, social, health, environmental, economic and other aspects. Transport affects all of them, both positively and negatively.

Transport models are among the mathematical models, which were initially of deterministic nature. Since the traffic at a more detailed level is a random phenomenon, the stochastic transport models that are closer to the real phenomena are in use recently. Like many others, also the transport models were developed in order to allow the measures envisaged could be previously tested to determine if they bring the expected and desired effects and improvements of the situation or not. It is whether they point to the direction of development and are in economical limits or not.

In the scope of LIFE ClimatePath 2050 project the existing national transport model PRIMOS was upgraded in order to enable modelling of CO_2 emissions, testing different scenarios of transport policies and prepare scenarios for 2030 and 2050. PRIMOS is a disaggregated simultaneous stochastic transport model with a dynamic character. All levels of the model are

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

mutually interdependent and ultimately balanced. Both passenger and cargo traffic are modelled.

The main input driving parameter for transport sector is GDP. Growth in gross domestic product effects on traffic growth and traffic growth affects the growth of gross domestic product. For freight transport, this represents a part of the production and marketing process. Transport of raw materials, semi-finished and finished goods distribution is a part of this process. Therefore, the growth of gross domestic product and growth of freight transport are closely correlated. The rapid growth of gross domestic product requires rapid growth of freight traffic and vice versa. Rapid growth of freight transport shows the rapid growth in gross domestic product, as the growth of freight transport facilitates and encourages production. For passenger traffic greater gross domestic product causes the availability of additional resources for personal consumption, which results in more (especially non-working) trips. Passenger traffic growth accelerates consumption, which in turn increases production.

In addition, the growth in gross domestic product is related also to the mere construction of transport infrastructure.

Basic model unit are vehicles or passengers per annual average workday.

Other major features of the model: the model includes the entire Slovenian population and area; allows interactive modelling of land use and traffic; specifies people's decision on how, where, when and with what means of transport they travel; it's a tool for prediction and analysis of the effects of various policies and measures; also enables the modelling of the impact of road tolling, congestion charging, charging pollution and/or extra tolling to internalise external costs and to enforce the parking policy (influences on the mode choice, distribution of traffic across the network, etc.); integrally includes impacts on the environment (air pollution, noise) and road safety; represents a framework for determination of traffic demand on more detailed regional and local level; represents a comprehensive database and makes a wide range of detailed analysis possible, in particular, transport, economic and environmental.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

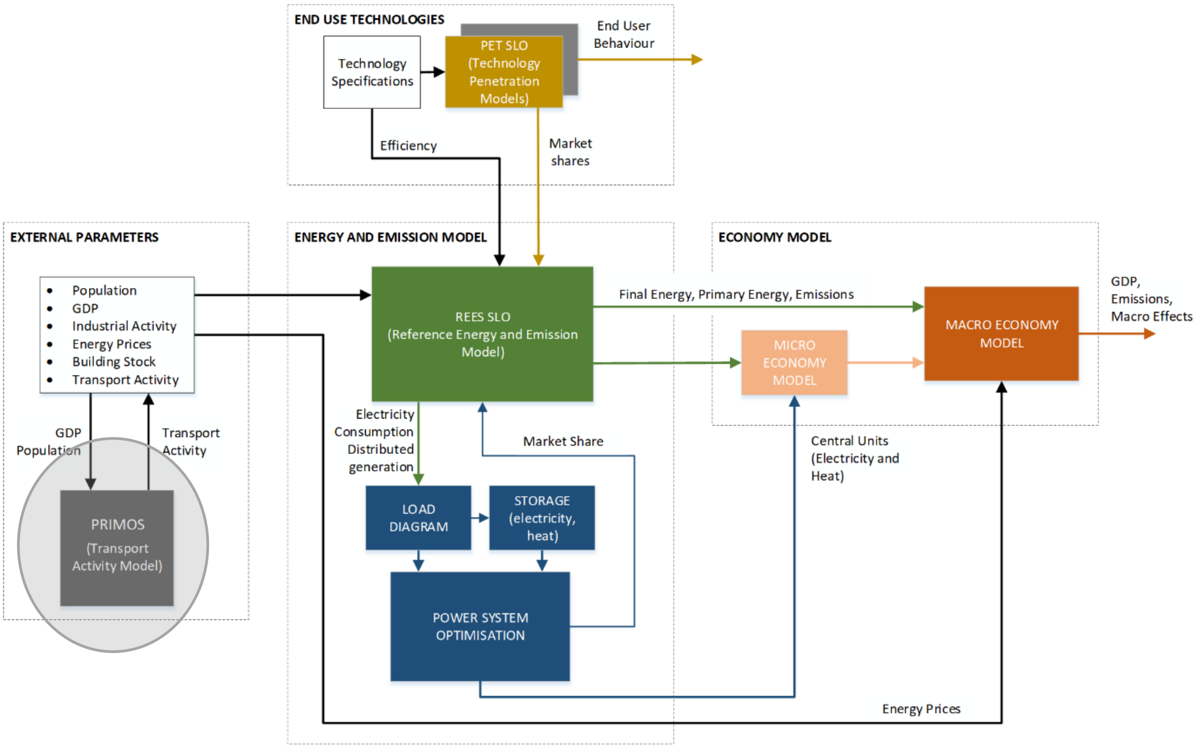

Figure 4: National Transport model of Slovenia (PRIMOS) interconnections

1.3.2 What was done in the scope of the project

In the scope of the LIFE ClimatePath 2050 project an update of the existing National Transport Model of Slovenia has been done, namely:

- existing national transport model of Slovenia was **upgraded** to calculate effects of proposed measures to GHG emissions;
- model was **upgraded** to enable calculation of emissions (GHG) using **HBEFA 4.1** (Handbook emission factors for road transport) methodology
- model was used to **calculate scenarios** of transport policies and infrastructural measures in support of National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050
- model was connected to REES-SLO model.

More information on existing National Transport model PRIMOS is available in the Deliverable *C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis*, ***Part 2: Energy sector models.***

1.3.3 Applicability

National Transport Model of Slovenia – PRIMOS (*PR*ometni *I*ntegralni *MO*del *S*lovenije) is national model and was used for evaluation of national transport and spatial policies and their consistency, the main national flows and infrastructures, their effects, etc. National transport model PRIMOS was updated within LIFE ClimatePath 2050 project. It was extensively used to calculate transport activity by modes for different scenarios and modelled years. These results were direct input to other models (REES-SLO model), mainly modelling of energy consumption

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

and CO_2 emissions in transport sector. PRIMOS model was used in support of national strategic energy planning, namely to support the preparation of the National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050.

1.3.4 Future work and challenges

Review of methodology in EU shows that such detailed transport modelling for the purpose of climate strategies is relatively rare. It raises significantly the reliability and robustness of the emissions results. As any model, it is sensitive to reliability of input parameters, especially for forecast and simplifications. Main challenge laying ahead of the models are their updates and further use within planning appropriate measures.

1.4 Macroeconomic model

1.4.1 Short description

The model (GreenMod Slovenia) is a dynamic multi-sectoral model of the Slovenian economy for energy and environmental analysis developed by the Institute for Economic Research (IER). It embodies considerable detail on the nature of production and demand in the economy. It is called a multi-sectoral model because it treats the economy as a system of inter-related industry sectors. The model captures the interdependencies between industries that arise from the purchase of each other's outputs of goods and services; competition for available resources, such as labour and capital; and other constraints that generally operate (e.g. the balance of trade, budget constraints, etc.). The model incorporates considerable detail on individual industries within an economy-wide framework. Because of this, the model can be used to analyse a vast range of issues, either broad in scope or industry-specific. It provides information on the effects of energy policies and other changes on the economy generally, outputs of individual industries, imports and exports of different commodities, employment patterns, commodity prices, etc.

The GreenMod Slovenia is calibrated on the Social Accounting Matrix for 2015. The model is solved using the general algebraic modelling system GAMS. It has a recursive dynamic structure composed of a sequence of several temporary equilibria, in which current savings determine future capital accumulation and the growth rate of the economy. The recursive sequence equilibrium approach assumes myopic expectations. In each time period, the model is solved for equilibrium, given the exogenous conditions assumed for that particular period. The endogenous determination of investment behavior is essential for the dynamic part of the model. Investment is not only a demand category but also depends on dynamic economic processes, as follows: a homogenous composite investment commodity is allocated between activities according to the current (year) net rate of return on fixed capital in particular activity. The current net rate of return on fixed capital is derived as the ratio of the rental rate for capital services in particular activity to the price of composite investment commodity in year t less the depreciation rate for particular activity. The model is solved dynamically with annual steps.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

The most important external influence factors considered in the CGE (Computable general equilibrium) model are energy use and the structure of energy inputs, anticipated energy efficiency improvement, and investments in energy efficiency.

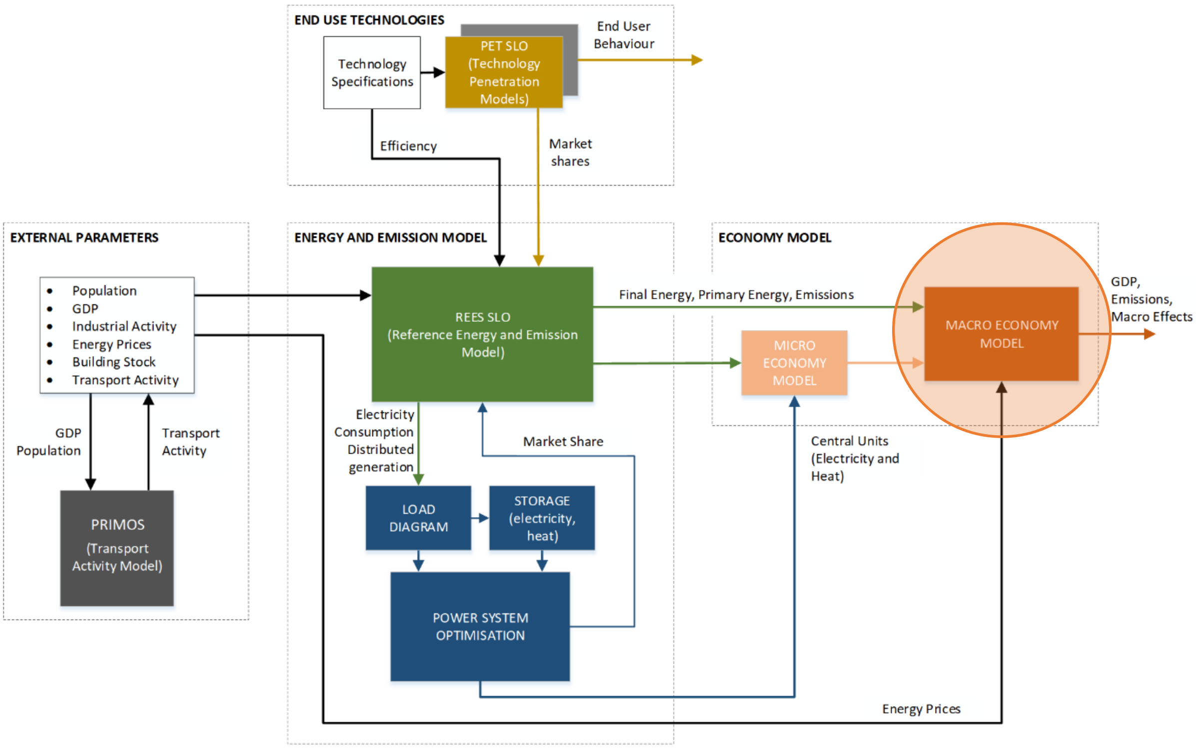

Figure 5: Macroeconomic model (GreenMod Slovenia) interconnections

1.4.2 What was done in the scope of the project

In the scope of the LIFE ClimatePath 2050 project Macroeconomic model (GreenMod) was developed, the following activities have been realised:

- modeling **macroeconomic** and sector-level effects of climate and energy policy;
- the Social Accounting Matrix (SAM) was **updated** with **additional commodities and activities** (e.g. Nuclear fuel and Synthetic gas, production from HPP, TPP, NPP, RES, Transmission, Distribution and Trading);
- **exogenous factors were extended** for the period 2015-2050 (established link with REES-SLO model);
- **additional data was prepared** (energy inputs, energy efficiency, investments etc.).

More information on Macroeconomic model is available in the Deliverable *C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis,* **Part 5: Macroeconomic model*.***

1.4.3 Applicability

For the first time the link with energy and emission model REES-SLO and Macroeconomic model GreenMod Slovenia model was established, enabling the assessment of various policy measures on national macroeconomic aggregates. Such connection has not been established

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

before in the Slovenian environment. Several different scenarios have been analysed using the model. Furthermore, the Macroeconomic model was used in support of national strategic energy planning, namely to support the preparation of the National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050, hence the model passed the applicability test.

1.4.4 Future work and challanges

GreenMod Slovenia is the first energy CGE model specially designed for Slovenia. Its operation and the results are considered as a technical basis for adapting and upgrading the model in the future, especially in terms of replacing or introducing new energy sources and introducing economic instruments to achieve emission targets and to test different scenarios or evaluate specific projects. Specific and important challenge remains in the necessary improvement of the quality of data used for the construction of the SAM.

1.5 LULUCF (CBM-CFS3) model

1.5.1 Short description

The model works on the basis of a forest inventory database and yield curves describing the development of growing stock in relation to the age of forest stand age. The CBM-CFS3 simulates the dynamics of forest carbon pools, considering various assumptions such as the type of forest management, land use changes, the occurrence of natural disturbances and timber harvesting. The model is consistent with the concept of the Intergovernmental Panel on Climate Change (IPCC) reporting standards. The spatial scale can range from individual forest stands to forest types and landscape spatial units. Simulation results are provided on an annual basis, separately for all five carbon pools. Advanced options for displaying the results allow analyses of carbon transitions between forest carbon pools, the atmosphere, and harvested wood products.

The CBM-CFS3 is a landscape-level model of forest ecosystem carbon dynamics that forest managers and analysts can use to assess carbon stocks and changes in carbon stocks in their operational forest areas. It was initially developed for use in even-aged forests where the age of the trees is known. However, if the yield curves realistically describe the development of individual stands of different species, the model can also be used in mixed forests with uneven age, typical of Slovenia. Although the model was primarily developed to assess carbon dynamics at the operational scale, it can also be used to study carbon dynamics for smaller areas down to the stand level. The model can be used to assess past changes in carbon stocks using information on past management actions and natural disturbances, or to assess future changes that would result from scenarios of management actions and natural disturbances. The CBM-CFS3 accounts for carbon stocks and stock changes in the tree biomass and dead organic matter pools (DOM).

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

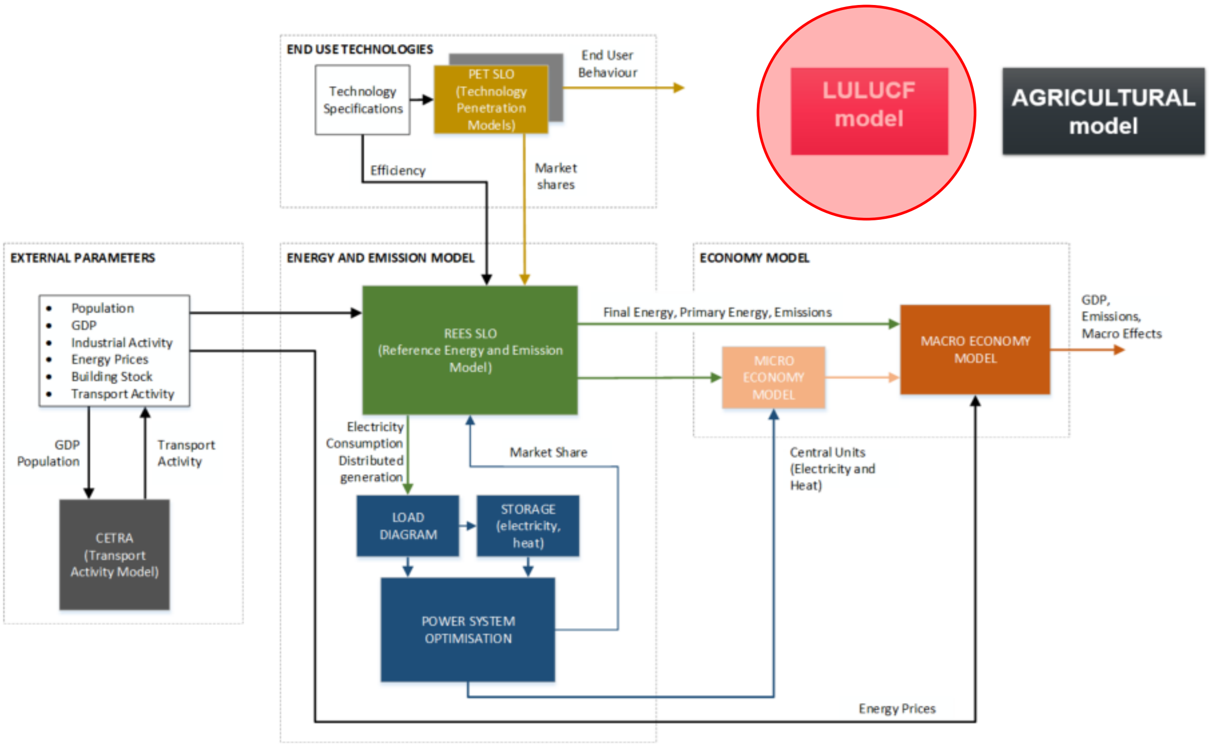

Figure 6: LULUCF model interconnections

Two basic data sources were used to run the model, both provided by the Slovenia Forest Service (SFS): 1) the 2014 Forest Compartment Database and 2) the Permanent Sample Plot (PSP) Database. The Forest Compartment Database consists of approximately 53,000 forest compartments with an average size of 22 ha, which are permanent forest planning categories and include information on all forests in the country. For each compartment, various forest attributes are available, such as forest area, forest type, growing stock, and tree species composition. Based on the forest type data, similar forest compartments were grouped together and represent the baseline forest condition in 2014. PSPs are part of the control sampling method in Slovenia. Each plot (500 m^2 each) is resurveyed every ten years, and common tree attributes are collected for each tree in the plot, such as location, tree species, DBH (Diameter at breast height), height of selected trees, and status between successive inventories (e.g. unchanged, harvested, dead, ingrown).

To initialise and run the CBM-CFS3, at least the following input data are required: areas by age classes and yield curves. Areas were calculated from the Forest Compartment Database and yield curves from the Permanent Sampling Plots (PSP) database. In Slovenia we do not classify forest stands into age classes when planning forest management, moreover we manage a significant area of uneven-aged stands, so we had to define the (approximate) age of each stand on PSPs, first. We did that following the ensuing methodology.

1.5.2 What was done in the scope of the project

In the scope of the LIFE ClimatePath 2050 project LULUCF model (CBM-CFS3) has been applied to the Slovenian circumstances. The following activities have been realised:

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

- Carbon Budget Model from Canadian Forest Service (CBM-CFS3 1.2) has been used as a basis and **applied to Slovenian circumstances;**
- inventory data from Slovenian Forest Service was used for the year 2014;
- for each forest type and sub-category of species mixture, **growth curve** was developed;
- alternative **harvesting scenarios for Slovenia** have been simulated using CBM-CFS model.

More information on LULUCF model is available in the Deliverable *C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis,* **Part 3: LULUCF model.**

1.5.3 Applicability

In the scope of LIFE ClimatePath 2050 project growth curves for different forest types were developed, Archive Index Database (AIDB) parameters were updated, and the disturbance matrix was adapted to Slovenian conditions. The model was used to generate GHG projections for forest land until 2050 in support of National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050, simulate the impact of forest management on carbon sink dynamics and provide guidance in setting future forest policy in Slovenia.

1.5.4 Future work and challenges

Other challenges of the model include identifying sources of uncertainty and improving the disturbance matrix, but this depends on improving assumptions about natural disturbances and climate change.

1.6 Agricultural (AGRI AIR) model

1.6.1 Short description

The model AGRI AIR aims to estimate greenhouse gas (GHG) and air pollutant emissions from agriculture. The emission estimates are based on assumptions about future trends in agricultural production volumes, assumptions about changes in agricultural practices, and the assumed effects of emission reduction measures. The model allows simultaneous estimation of methane, nitrous oxide, ammonia and nitric oxide emissions and quantification of gross and net nitrogen balance. The model enables the tracking of nitrogen in agriculture and the evaluation of the impact of different techniques to reduce greenhouse gas and air pollutant emissions.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

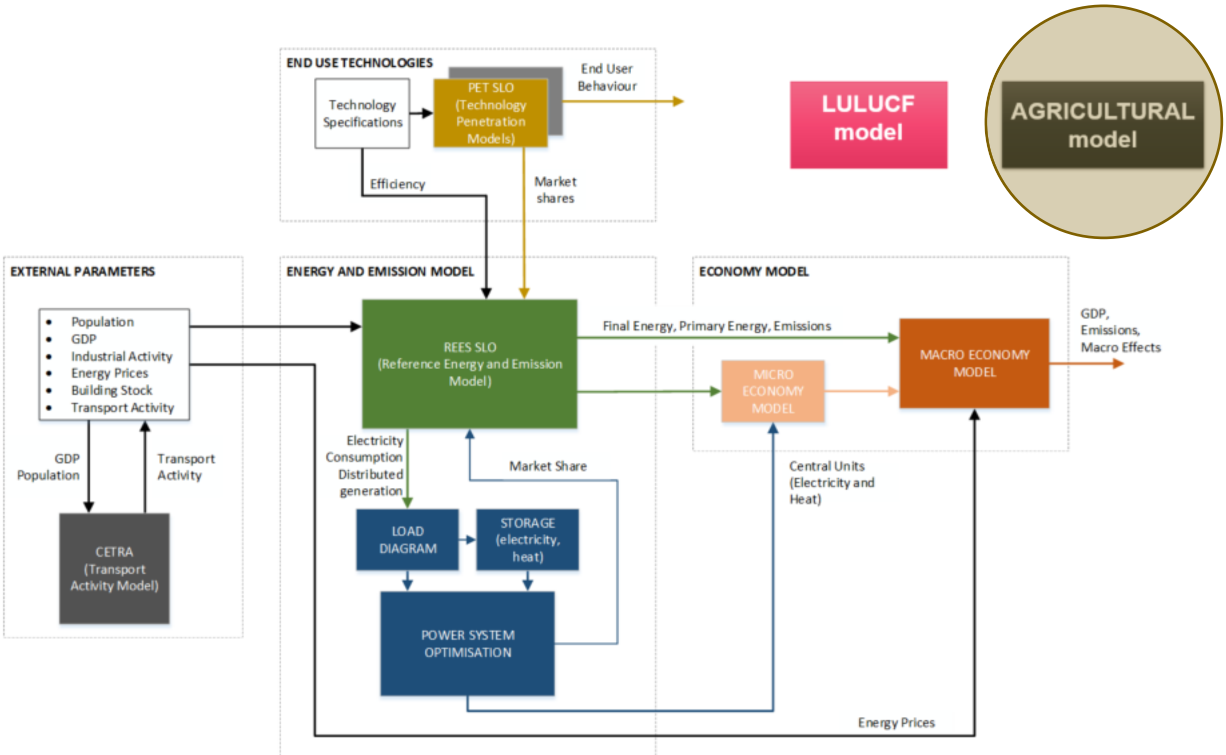

Figure 7: Agricultural (AGRIAIR) model interconnections

External influencing factors were considered qualitatively in the modelling, in the formation of key assumptions. It was taken into account that a large part of land in Slovenia is located in the less favoured areas for agriculture, that the structure of agricultural land is dominated by grassland and that Slovenia is characterized by fragmented ownership and fragmentation of agricultural land. To calculate emissions, data on the scale of agriculture and agricultural practices are needed. The scale of agriculture is described by the number of animals, land cultivated and crop yields. Livestock practices are described by rearing systems and the intensity of livestock production. Cultivation practices are described by the intensity of fertilization and by manure application techniques.

1.6.2 What was done in the scope of the project

In the scope of the LIFE ClimatePath 2050 project Agriculture model (AGRI AIR) was improved and upgraded. The following activities have been realised:

- The AGRI LIVESTOCK and AGRI SOILS models were linked;
- a module for estimating gross and net nitrogen balance was also added; the upgrade allows tracking of all forms of nitrogen in agriculture and modelling of nitrogen demand from mineral fertilisers based on information on emission reductions from animal housing, manure storage, manure application, and expected changes in nitrogen uptake by agricultural crops;
- new emission sources (rabbits, composts, digestate) were added to the model;
- an updated methodology for estimating emissions of nitrous oxide, ammonia and nitric oxide (EMEP / EEA 2019) was implemented;

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

- solutions were included in the model to assess the impact of some emission reduction measures (low protein feed rations, direction of fermentation in the rumen, nitrification inhibitors, efficiency of milk and meat production, …).

More information on Agriculture model AGRI AIR is available in the Deliverable *C2.1: Documentation of Methods and Models for Climate Mitigation Mid-century Strategy Scenario Analysis,* **Part 4: Other IPCC sectors agriculture, sector process emissions, IPCC sector waste.**

1.6.3 Applicability

The AGRI AIR model was used to produce projections of agricultural greenhouse gas emissions. The results were used for the Integrated National Energy and Climate Plan of the Republic of Slovenia and the Resolution on the Slovenian Climate Long-Term Strategy 2050. The model has also been used for projections of air pollutants in agriculture. In addition, it has proven useful for quantifying the impacts of measures of Rural Development Programme.

1.6.4 Future work and challenges

The model requires constant updating and adaptation to changes in the official methodology for reporting greenhouse gas emissions. Implementation of initiatives from audit reports to annual National Inventory Reports is also required. It would be useful to improve the procedures for estimating methane and nitrous oxide emissions in pig and small ruminant production so that the effects of production intensity can be taken into account. The model needs to be upgraded with solutions that allow quantification of the impact of emerging emission reduction techniques. The need to implement the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories will become apparent in the near future. It has already been adopted by the Intergovernmental Panel on Climate Change in 2019 but has not yet come into force. In the long term, the model will likely need to be adapted to the new approach to assessing the greenhouse effect of short-lived climate pollutants.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Concluding remarks and future steps

Climate change and increased energy costs have led to a major reform of the traditional concept of energy planning. The modern approach is based on the integration of a wider spectrum of economic, sociological and sustainable parameters and technologies that ensure the transition to a green sustainable future. This was somewhat of a red thread of our project activities in relation to model development. Comprehensive energy models and other models developed in the scope of LIFE ClimatePath 2050 project were used in support of energy and environmental policy development. The results of such approach are (or at least should be) the gradual changes in energy markets and, consequently, the creation of new business environments. The focus is on the development and use of energy efficiency technologies and environmentally less aggressive supply technologies.

The foundation of modeling of any process is to create a model that would help the users understand a certain phenomenon and would serve as a support for decision-making related to the real process. The general characteristic common to all energy system models is that the model represents a simplified real energy system and addresses both quantitative and qualitative parameters related to a particular energy problem. Trough the development and use of the models several challenges have arisen. Every model has some limitations that can affect the results. In that manner the most significant limitation can be highlighted, which is the uncertainty of the influential parameters, mainly energy markets (energy prices, emission allowances). Energy markets can have a significant impact on the results of the model used through their instability, which is bringing uncertainty into the model (very relevant in the current period). Such unexpected changes in energy markets, can have a significant impact on the emergence of new technologies on the market.

The inaccessibility of accurate and reliable energy and economic statistics is also a major problem. The model is planned according to the selected base year, whereby it is necessary to link the projection calculations with the available data for the so-called base year. In the initial preparatory phase one has to be aware of the availability of data for the modelling process, whilst missing information could be obtained through interviews, surveys and targeted research. Using more reliable and up-to-date data, the predictive strength of the model would be greater and the results more reliable and accurate.

One of the fundamental challenges of supporting decision-making in the formulation of energy and environment policies is to monitor the implementation impacts. The monitoring program for the implementation of strategies should be based on carefully selected indicators. Hence, special attention was given to the development of suitable indicators and model components, aligned with reporting standards and requirements.

In order to keep the proposed strategies alive and increase the implementation rate, it is necessary to continuously monitor implementation, which is a task for monitoring authorities. In line with the objective of effective decision-making support, it is necessary to develop in the future monitoring mechanisms for the implementation of strategies and procedures that are

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

flexible also in the light of the current energy market dynamics. With such an adaptive approach and a reliable policy implementation monitoring program, supported by suitable models and tools, the chances of overall success on the decarbonization path are significantly higher.

Maintaining and refreshing models is a constant task if they are to remain usable. Periodic calibrations and update of the models are needed to prepare energy balance projections, projections of meeting the targets set and to prepare the assessments in support of sectoral strategies and goals. The models will need to be further upgraded and further developed to meet new challenges and to allow for more complex assessments and consideration of new solutions in the field of climate change mitigation. All of the aforementioned activities require the long-term stability and project financing of the activities for future model development and upgrades additionally to the financing of the preparation of different projections.

The models developed in the LIFE Climate Path 2050 project for national scenario analyses represent a methodological framework, that will further support the process of energy and climate policy development.

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

Abbreviations, figures and tables

1.7 List of abbreviations

AIDB	Archive Index Database
CBM	Carbon Budget Model
CGE	Computable General Equilibrium
CGE	Computable General Equilibrium
CHP	Combined heat and power
DBH	Diameter at breast height
DOM	Dead Organic Matter
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
ENS	Energy Not Supplied
EU	European Union
GAMS	General Algebraic Modelling System
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographical Information Systems
HBEFA	Handbook Emission Factors
HPP	Hydro Power Plant
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Resource Planning
LIFE	EU's funding instrument for the environment and climate action
LOLE	Loss of Load Expectation
LTS	Long Term Strategy
LULUCF	Land Use Land-Use Change and Forestry
MCDM	Multicriteria Decision-Making Methods
MESAP	Modular Energy System Analysis and Planning Environment
NEC	National Emission reduction Commitments
NECP	National Energy and Climate Plan
NPP	Nuclear Power Plant
PP	Power Plant
PRIMOS	PRometni Integralni MOdel Slovenije
PSP	Permanent Sample Plot
REES-SLO	Reference Energy and Emission System model for SLOvenia
RES	Renewable Energy Sources
SAM	Social Accounting Matrices
TPP	Thermal Power Plant
UNFCCC	United Nations Framework Convention on Climate Change

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.

1.8 List of figures

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je sofinanciran iz sredstev LIFE, finančnega inštrumenta Evropske unije za Okolje in podnebne spremembe na prednostnem področju Podnebno upravljanje in informacije in iz sredstev Ministrstva za okolje in prostor RS, Sklada za podnebne spremembe.
With the contribution of the LIFE Programme of the European Union and the Ministry of the Environment and Spatial Planning, Republic of Slovenia, the Climate Change Fund.