MODELLING MACROECONOMIC AND SOCIAL IMPACTS

TASK C.2.1

Workshop on methods and models for the preparation of GHG emissions projections up to 2050
15. September 2021

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je financiran iz finančnega mehanizma LIFE, ki ga upravlja Evropska komisija, in iz Sklada za podnebne spremembe Ministrstva za okolje in prostor RS.

Objectives and the macroeconomic concept

1. exploring the macroeconomic and sector-level effects of climate and energy policy;
2. to develop the first CGE energy model in Slovenia (*GreenMod Slovenia*), which includes the energy and environmental modules.

„**c**omputable“

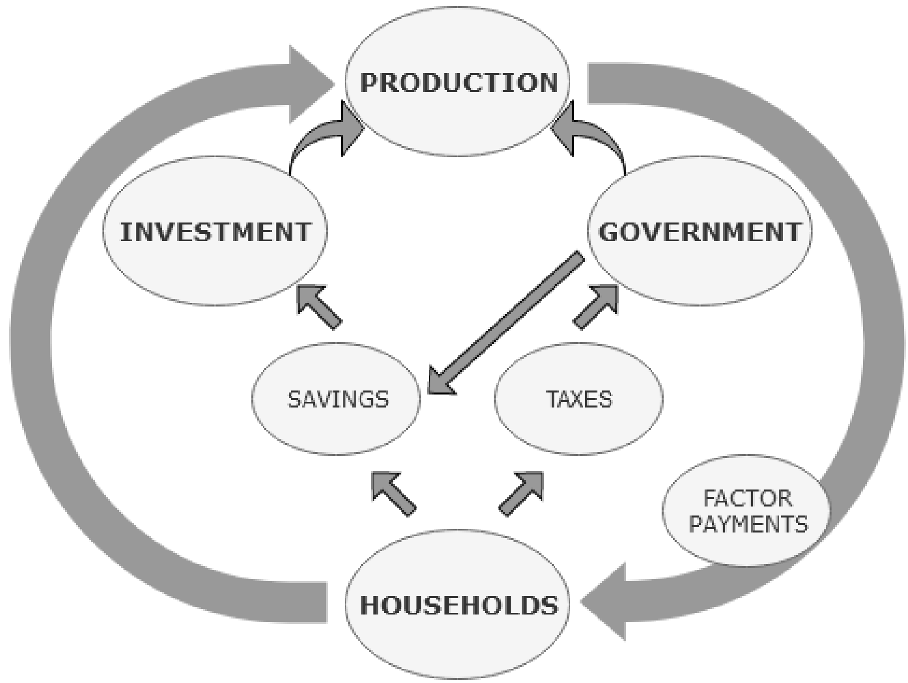
- *the ability of the model to quantify the effects of a shock on an economy;*

„**g**eneral“

- *describes all economic activities in an economy simultaneously, and the linkages among them;*

„**e**quilibrium“

- *supply and demand are in balance at some set of prices and quantities.*



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.

Main characteristics (advantages) of the *GreenMod Slovenia* tool

- It covers the interaction between the economy, the energy system and the environment.

- It computes simultaneously:
  - the competitive market equilibrium,
  - the optimal balance of energy demand/supply,
  - emissions/abatement.

- Consistent evaluation of distributional effects across branches, agents and HH income quintiles.

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.

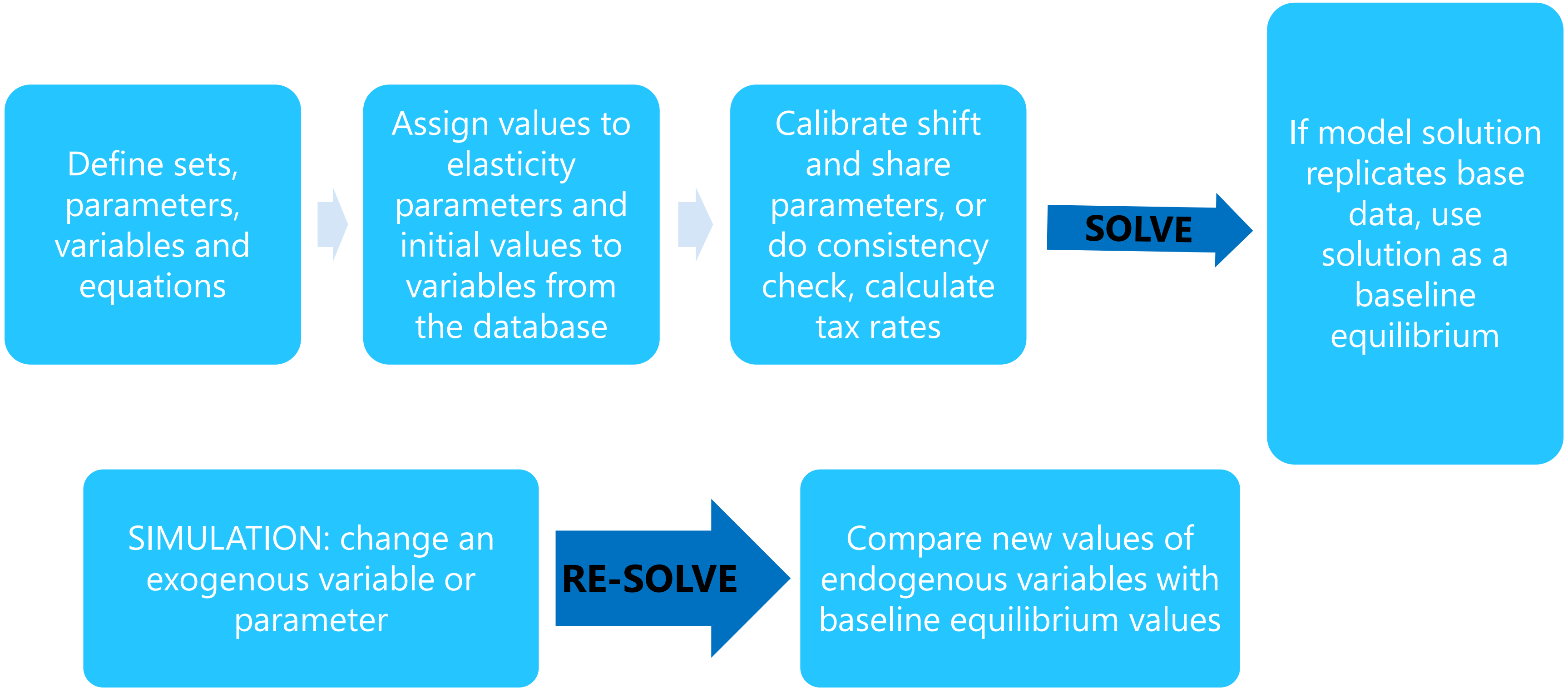
Data preparation

- Using data from 2015 supply and use tables to create a social accounting matrix (SAM)
- SAM disaggregation: 22 commodities (of which 9 energy products), 22 activities (incl. electricity production by technologies), factors (labour, capital), institutions (government, firms, HH - quintiles) and other accounts
- Projections of the main exogenous factors (assumption that the economy is in a steady state equilibrium);
- Using the results of the REES-SLO model for the period 2015-2050 and adapting the data form to be used in the *GreenMod Slovenia* (e.g. energy consumption, CO_2 emissions, energy efficiency, emission coefficients, investments);
- Scenarios: All data were prepared for the BAU scenario (including existing measures), the DU scenario (with additional measures) and the DUA scenario (with ambitious additional measures). Two options of DU and DUA scenarios were considered: with synthetic gas (from 2026 onwards in DUA scenario / from 2031 onwards in DU scenario) and with nuclear power plant (the new plant from 2036 onwards)

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.

Development of the CGE model

The programming code of the CGE model is lengthy, therefore, we organized it into a number of blocks that accomplish different tasks, as seen below:



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.

Assumptions of the model for the BAU scenario

LIFE CLIMATE PATH 2050

- The economy is in a steady state equilibrium with 1.5% annual growth rate of GDP
- Changes in consumption of energy products (IJS CEU data , REES-SLO2)
- Changes in energy efficiency (energy consumption in GJ per million EUR of production activity)
  - Data on energy consumption are derived from REES-SLO2 projections
  - To obtain the monetary value of production we use IJS CEU quantitative data on production -> calculate growth rates relative to baseline data from 2015 -> apply of growth rates on baseline data from SAM 2015)
- Investments related to existing measures (IJS CEU data)

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.

Example of the model code

```
* ======================= Specification of the equations =======================


EQCF(i,f)..          PX(i)*CF(i,f) =E= alpha_CF(i,f)*CFBUDGET(f);
EQCFBUDGET(f)..      CFBUDGET(f) =E= YFD(f)-SUM(ag,TRANS(ag,f)) - SF(f);
EQCG(i)..            PX(i)*CG(i) =E= alpha_CG(i)*CGBUDGET;
EQCGBUDGET..         CGBUDGET =E= CGBUDGET_REAL*PINDEXGOV;
*EQCH(i,h)..          PX(i)*CH(i,h) =E= PX(i)*CHMIN(i,h)+alpha_LES(i,h)*(CHBUDGET(h)-SUM(ii,PX(ii)*CHMIN(

*EQCH(i,h)..          PXCH(i)*CH(i,h) =E= PXCH(i)*CHMIN(i,h)+alpha_LES(i,h)*(CHBUDGET(h)-SUM(ii,PXCH(ii)*

* With energy efficiency
EQCH(i,h)..          PXCH(i)*CH(i,h)*ENER_EFF_HH(i,h) =E= PXCH(i)*CHMIN(i,h)+alpha_LES(i,h)*(CHBUDGET(h)
                                         -SUM(ii,PXCH(ii)*CHMIN(ii,h)));



EQPXCH(i)..          PXCH(i) =E= (1+tc(i))*PX(i);
EQPXIC(i)..          PXIC(i) =E= (1+tic(i))*PX(i);

EQCHBUDGET(h)..      CHBUDGET(h) =E= YHD(h)-SH(h)-SUM(ngov,TRANS(ngov,h));
EQCHBUDGET_REAL(h).. CHBUDGET_REAL(h) =E= CHBUDGET(h)/PINDEXCH;
EQIC(j)$ICZ(j)..     IC(j) =E= io(j)*XD(j);

$ontext
EQCO2EMISH(h)..       CO2EMISH(h)          =E=    sum(ien, CO2EMISIH(ien,h));
EQCO2EMISHTOTAL..     CO2EMISHTOTAL        =E=    sum(h, CO2EMISH(h));
EQCO2EMISIH(ien,h)..  CO2EMISIH(ien,h)     =E=    CO2EmissionFactorsIENHH(ien,h)*PXCH(ien)*CH(ien,h)/Ener
EQCO2EMISIJ(ien,j)..  CO2EMISIJ(ien,j)     =E=    CO2EmissionFactorsIENJ(ien,j)*PXIC(ien)* DI(ien,j)/Ener
EQCO2EMISJ(j)..       CO2EMISJ(j)          =E=    sum(ien, CO2EMISIJ(ien,j));
```

```
* ======================= Policy instruments ==============================
 ENER_EFF.FX(inen,j)    = ENER_EFFZ(inen,j);
* ENER_EFF.FX(ien,j) = 1.015*ENER_EFF.L(ien,j);

ENER_EFF.FX(ien,"A-AGRI") = (1-0.008)*ENER_EFF.L(ien,"A-AGRI");
ENER_EFF.FX(ien,"A-MINING") = 1.001*ENER_EFF.L(ien,"A-MINING");
ENER_EFF.FX(ien,"A-PAPER") = (1-0.003)*ENER_EFF.L(ien,"A-PAPER");
ENER_EFF.FX(ien,"A-CHEMICAL") = 1.0073*ENER_EFF.L(ien,"A-CHEMICAL");
ENER_EFF.FX(ien,"A-NONMETAL") = (1-0.0023)*ENER_EFF.L(ien,"A-NONMETAL");
ENER_EFF.FX(ien,"A-BASICMETAL") = (1-0.0048)*ENER_EFF.L(ien,"A-BASICMETAL");
ENER_EFF.FX(ien,"A-OTHMAN") = 1.0062*ENER_EFF.L(ien,"A-OTHMAN");
*ENER_EFF.FX(ien,"A-ELEGAS") = 1.0081*ENER_EFF.L(ien,"A-ELEGAS");
ENER_EFF.FX(ien,"A-ELEGAS") = 1.0045*ENER_EFF.L(ien,"A-ELEGAS");
*ENER_EFF.FX(ien,"A-LANDTRANS") = 1.0125*ENER_EFF.L(ien,"A-LANDTRANS");
*ENER_EFF.FX(ien,"A-LANDTRANS") = 1.001*ENER_EFF.L(ien,"A-LANDTRANS");
ENER_EFF.FX(ien,"A-LANDTRANS") = 1.00*ENER_EFF.L(ien,"A-LANDTRANS");

ENER_EFF.FX(ien,"A-WATERTRANS") = 1.0242*ENER_EFF.L(ien,"A-WATERTRANS");
ENER_EFF.FX(ien,"A-AIRTRANS") = 1.0071*ENER_EFF.L(ien,"A-AIRTRANS");
ENER_EFF.FX(ien,"A-OTHSER") = 1.0133*ENER_EFF.L(ien,"A-OTHSER");
ENER_EFF.FX(ien,"A-CONS") = ENER_EFF.L(ien,"A-CONS");
ENER_EFF.FX(ien,"A-PUBSER") = 1.0118*ENER_EFF.L(ien,"A-PUBSER");

$ontext
A-AGRI     0.08
A-MINING     -0.10
A-PAPER     0.03
A-CHEMICAL     -0.73
A-NONMETAL     0.23
A-BASICMETAL     0.48
A-OTHMAN     -0.62
```

- The specification of the model equations.
- The identification of the policy instruments used.

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.

Key results – examples for 2030

- Additional energy investments increase energy efficiency and thus reduce the consumption of energy inputs in final consumption of households.
- Lower input costs have a favorable effect on rising labor demand and lowering the unemployment rate as well as on increasing production.
- The final effect on relative consumer prices is positive, as they are expected to decrease slightly compared to the BAU scenario (by -0.3%).
- The increase in disposable household income is reflected in higher final private consumption (by 2.2%) compared to final private consumption in the BAU scenario.
- The positive consequences of the planned additional measures under the ambitious scenario are finally reflected in GDP, which is expected to be 2.1% higher compared to GDP in BAU scenario.

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.

Significant improvements made by the *GreenMod Slovenia*

LIFE CLIMATE PATH 2050

- First CGE energy model in Slovenia;
- Modelling the economy as a whole system (it is not a partial model);
- Disaggregation by branches and technologies (hydro, thermal, nuclear and renewable energy sources) & products (including 9 energy products) enables more detailed assessments of the results;
- Disaggregation by households‘ income quintiles enables the insight into the structural change in socio-economic welfare of residents and assessment of the impacts on inequality.

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.

Use of the results

- Technical basis for the estimation of the macroeconomic and sector effects of the National Climate Energy Plan 2030;
- Technical basis for adapting and upgrading the model in the future and for testing different scenarios;
- Technical basis for evaluation of specific future projects
- Monitoring the consequences of the planned measures in the field of energy and the environment.

Future tasks on the maintenance & development of the model

- Improving data quality
- Additional breakdown of energy products and technologies (e.g. inclusion of hydrogen as a fuel)
- Consideration of economic instruments to achieve the emission reduction objectives (e.g. carbon taxation and excise duties on energy products)

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.

THANK YOU FOR YOUR ATTENTION

Projekt LIFE ClimatePath2050 (LIFE16 GIC/SI/000043) je financiran iz finančnega mehanizma LIFE, ki ga upravlja Evropska komisija, in iz Sklada za podnebne spremembe Ministrstva za okolje in prostor RS.