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Transition to a low-emission economy in Poland in view of the results of mulitisectoral energy model

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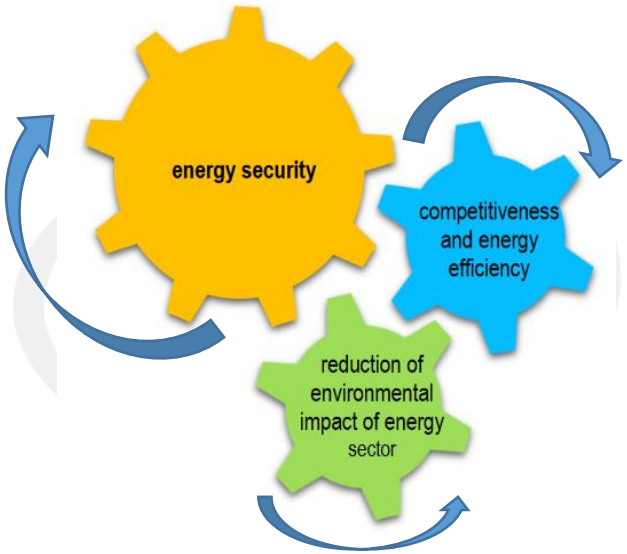
Presentation plan

1. Introduction.
2. Current condition of the energy system.
3. Model structure.
4. Scenarios of a low-emission transition.
5. Results.
6. Conclusions and directions of the further research.

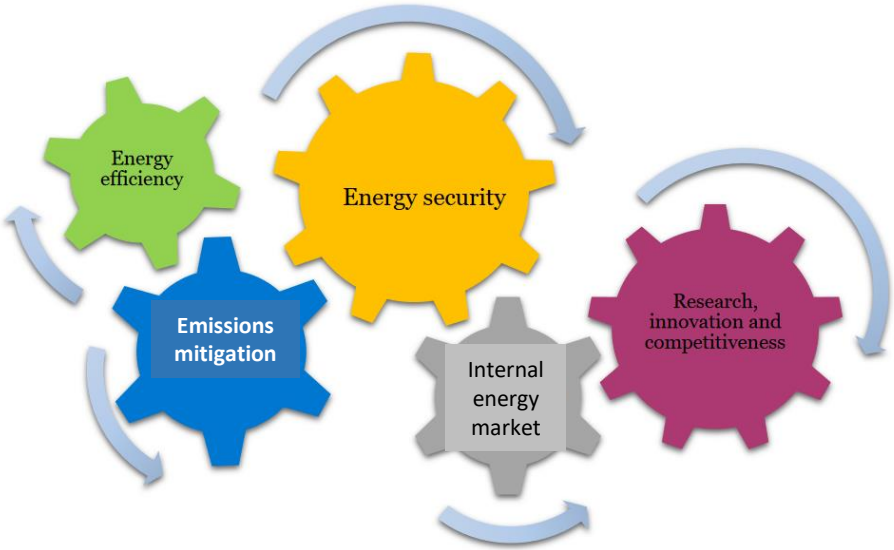
1. Introduction

- Polish energy system is facing the biggest challenge in its history;
- Low-emission transition proces needs long-term planning;
- The scope of two main goverment plans for the energy system:

Energy Policy of Poland until 2040 (2018). Ministry of Energy. Warsaw



National Energy and Climate Plan for the years 2021-2030 (2019). Ministry of Energy. Warsaw



1. Introduction

Tab. 1. EU and Polish objectives on climate and energy

	CO2 emission mitigation [in %]		RES share in final energy consumption [in %]		Energy efficiency improvement [in %]		Documents	
	EU	PL	EU	PL	EU	PL	EU	PL
2020	20	20	20	15	20	20	20C&EP	PEP40/ NECP30
2030	40	30	32	21	32,5	23	30C&EF	PEP40/ NECP30
2050	80-95	?	?*	?	?	?	Road Map50	-

Source: Own elaboration.

* - more than 80% of electricity will be produced from RES

2. Current condition of the energy system

Facts:

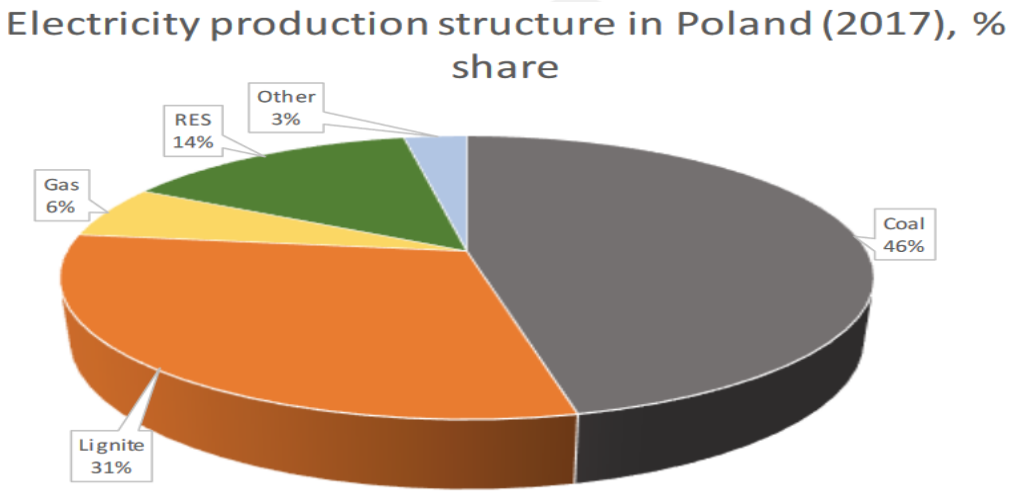
- Polish energy sector is historically based on fossil fuels;
- large use of coal causes high cost of buying CO2 emission allowances;
- noticeable significant lower capacity factor of RES.

Tab. 2. Structure of Cand electricity generation in Polish electric power system as at 31 December 2017

Power plant type:	Installed capacity [in MW]	%share	Electricity generation [in GWh]	%share
hard coal	20 247	46.6	79 868	48.2
lignite	9 352	21.5	51 983	31.3
natural gas	2 341	5.4	7 172	4.3
captive	2 813	6.5	10 057	6.1
hydropower	2 328	5.4	2 767	1.7
wind and other renewables	6 341	14.6	14 005	8.4
TOTAL	43 422	100.0	165 852	100.0

Source: PSE S.A. (Polish Electricity Networks Inc.) Databases.

Pic. 1. Electricity production by energy carrier in Poland in 2017



Source: *National Energy and Climate Plan for the years 2021-2030*. Draft. (2019). Ministry of Energy

2. Current condition of the energy system

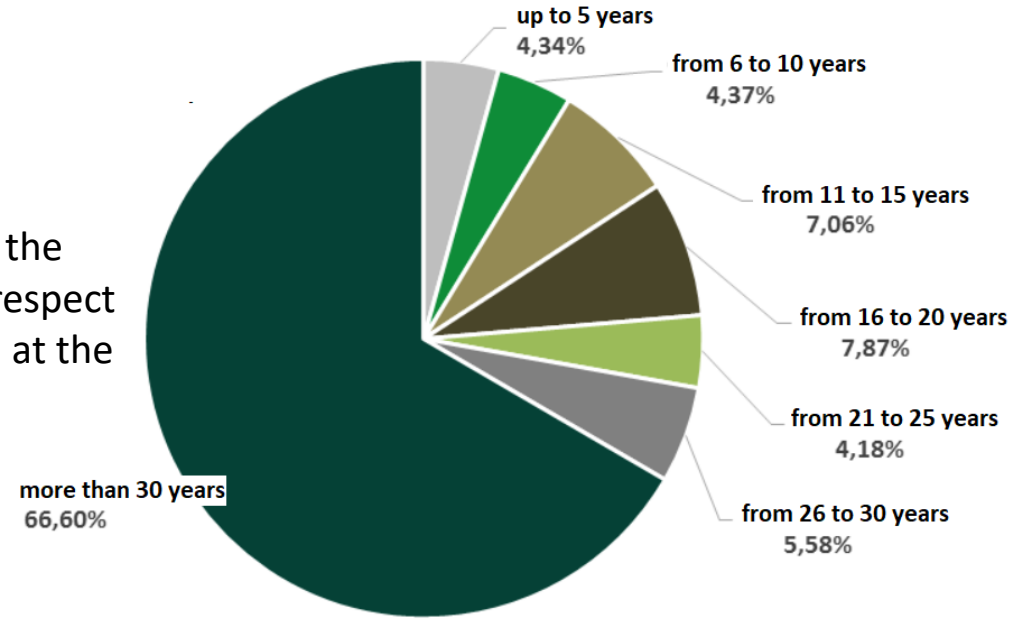
Facts:

- the majority of existing power plants and installations are old;
- energy sector requires significant investments…

Tab. 3. Scenarios for disabling the obsolete power plant blocks [power loss in MW]

	2020	2025	2030	2035
„Modernization" scenario	3000	3200	5700	13900
"Turn off" scenario	6600	9900	17300	20300

Pic. 2. Age structure of the power plant blocks [with respect to their installed capacity] at the end of 2015



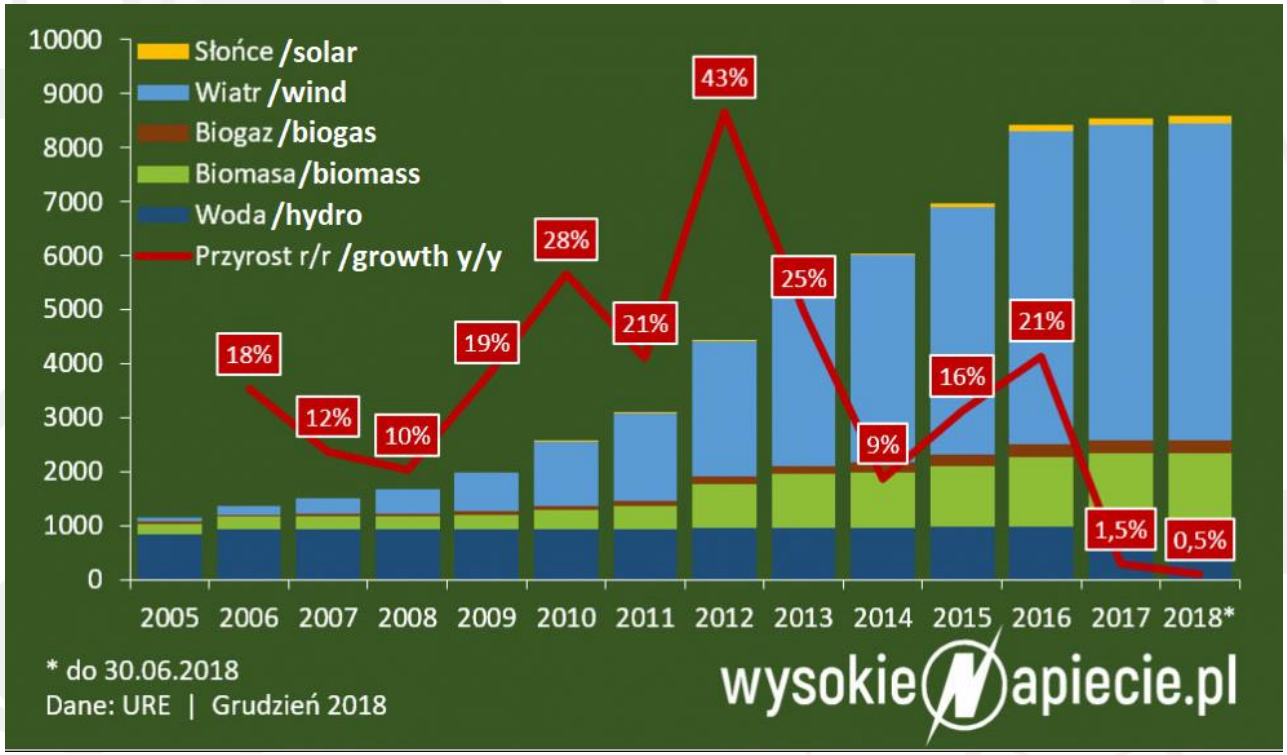
Source: PSE S.A. (Polish Electricity Networks Inc.) Databases.

2. Current condition of the energy system

Facts:

- we made a huge progress in the development of RES…
- … but we won't reach the level of 15% of share requirement in 2020.

Tab. 2. Increase of RES installed capacity [MW] in Poland in 2005-2018



Source: *wysokienapiecie.pl*

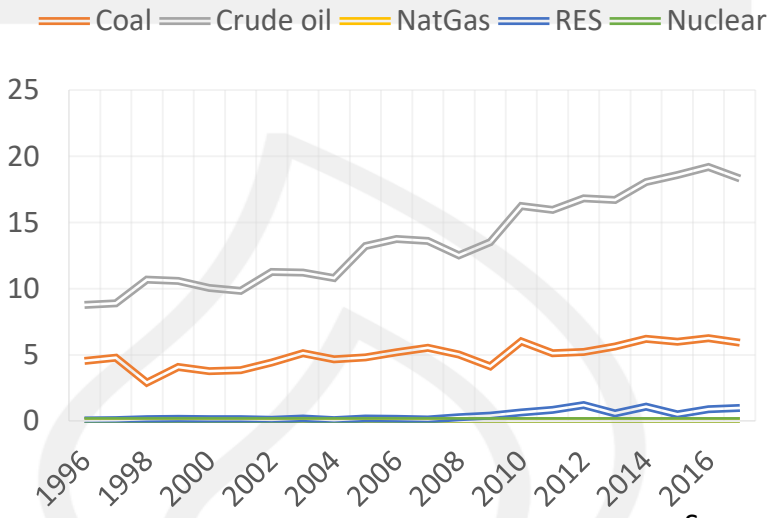
	2005	2010	2015	2016	2017
Gross final consumption of energy from RES [%]	6.9	9.3	11.7	11.3	10.9

2. Current condition of the energy system

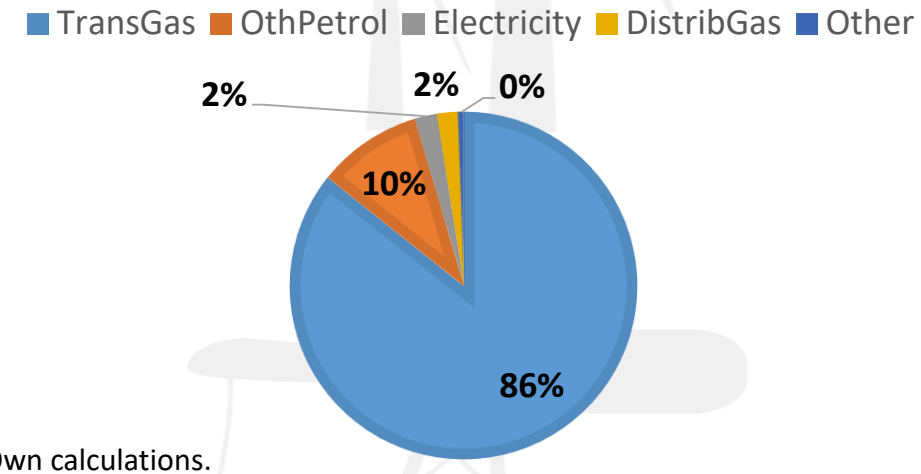
Facts:

- increasing transformation energy intensity in petroleum refining and coking sector;
- very low utilization of electricity in transportation sector;
- ensuring energy security by changing import directions of natural gas.

Pic. 3. Primary energy intensity [TJ/mln zl] of transformation processes in the petroleum refining and coking sector



Pic. 4. Direct energy consumption in the transportation sector in 2017



Source: Own calculations.

Tab. 4. Historical and planned main directions of crude oil and natural gas import

	2005	2010	2015	2020	2025	2030	2035	2040
Crude Oil	Russia	Russia	Russia	Russia	Russia	Russia	Russia	Russia
		Norway	Iraq					
Natural Gas	Russia	Russia	Russia	Russia	Norway	Norway	Norway	Norway
	Uzbekistan	Germany	Germany	Germany	USA	USA	USA	USA
	Kazakhstan			USA	Germany	Germany	Germany	Germany

Source: *National Energy and Climate Plan for the years 2021-2030* (2019). Ministry of Energy. Warsaw

2. Current condition of the energy system

Solutions for Polish energy system:

- first nuclear power plant in Poland (availability factor in GW):

	2020	2025	2030	2033	2035	2040	2043
Nuclear power plant	0	0	0	1.0-1.5	1.5-2.6	4.5-5.2	6.0-9.0

Source: *National Energy and Climate Plan for the years 2021-2030* (2019). Ministry of Energy. Warsaw

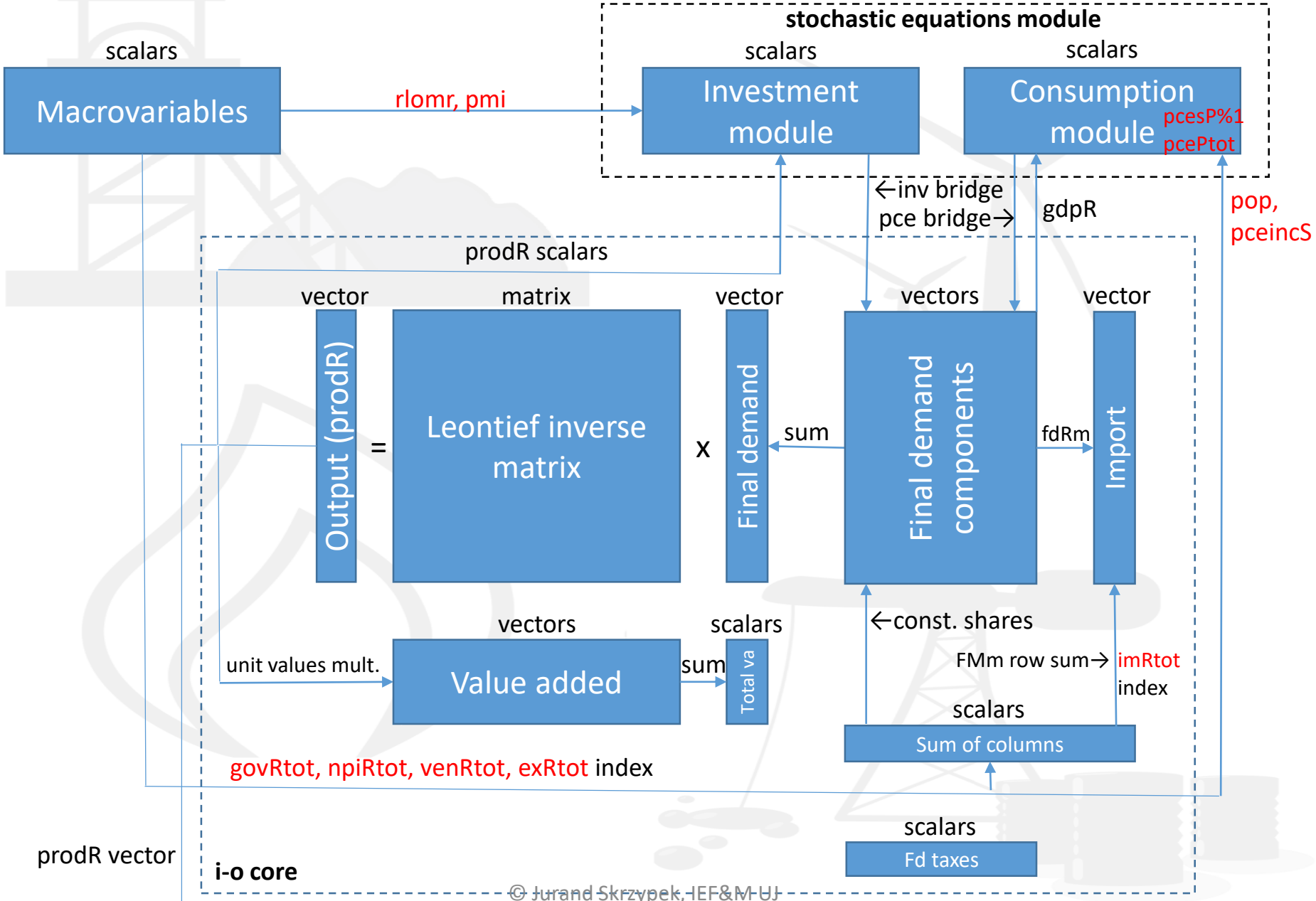
- supporting offshoring programme:
  a) more than 23 bln EUR budget;
  b) building 8-15 GW of offshore installed capacity in 2020-2035.
- strong support for the development of RES:
- decentralization of electricity generation. Industrial and individual prosumption;
- big hope in a new technologies of the energy storage;
- utilization of alternative fuels. Development of electro-mobility.

3. Model structure

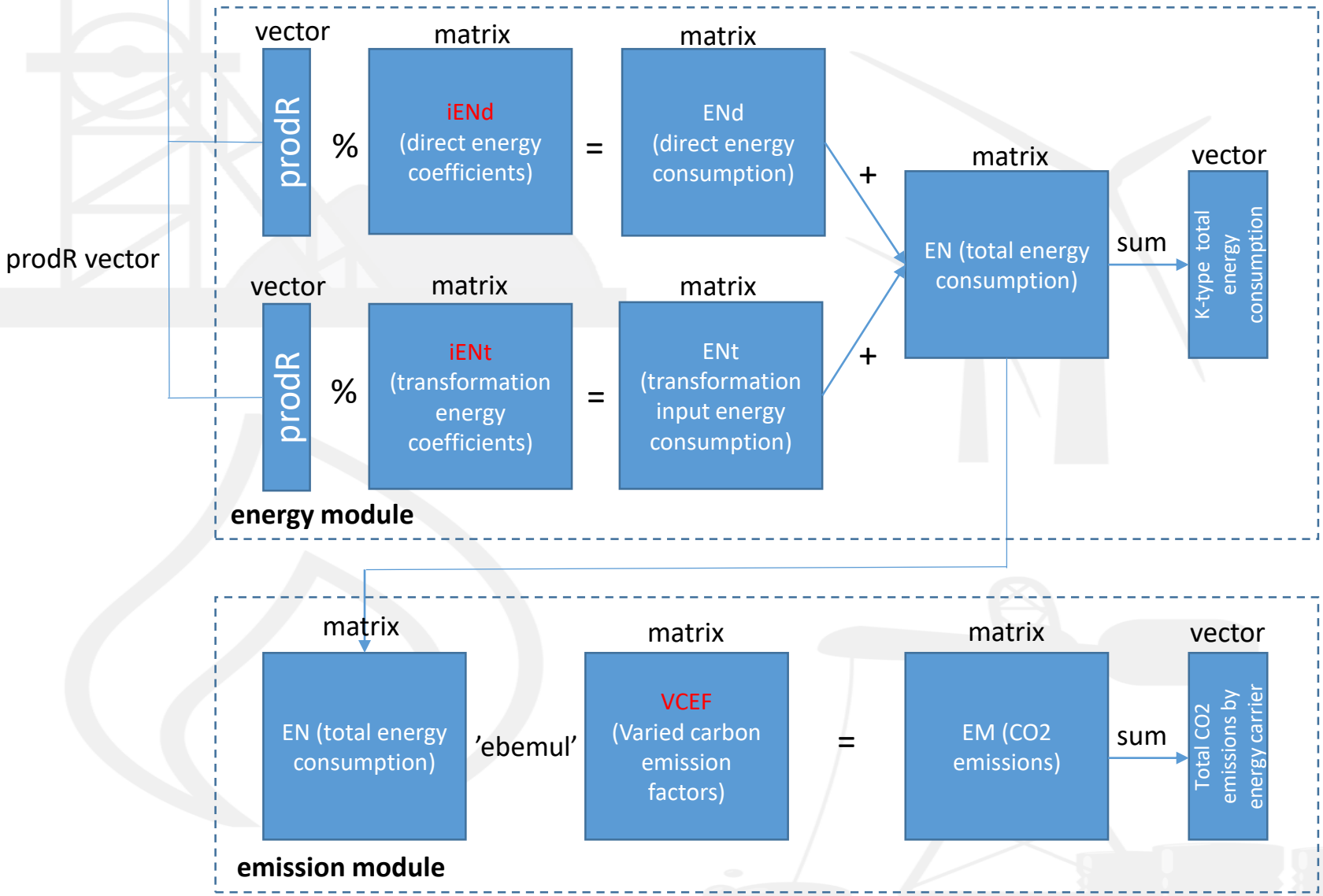
Main features of the MEM model:

- combines i-o analysis with econometric methods (economic core);
- there is a loop between i-o core and stochastic equations;
- has energy (16 energy carriers) and environmental (CO2 emissions) extensions;
- distinguishes 77 sectors + HH;
- covers mainly the period 1996-2017;
- operates on unified unique database, based on Statistics Poland data;
- developed in InterDyme software;

3. Model structure



3. Model structure



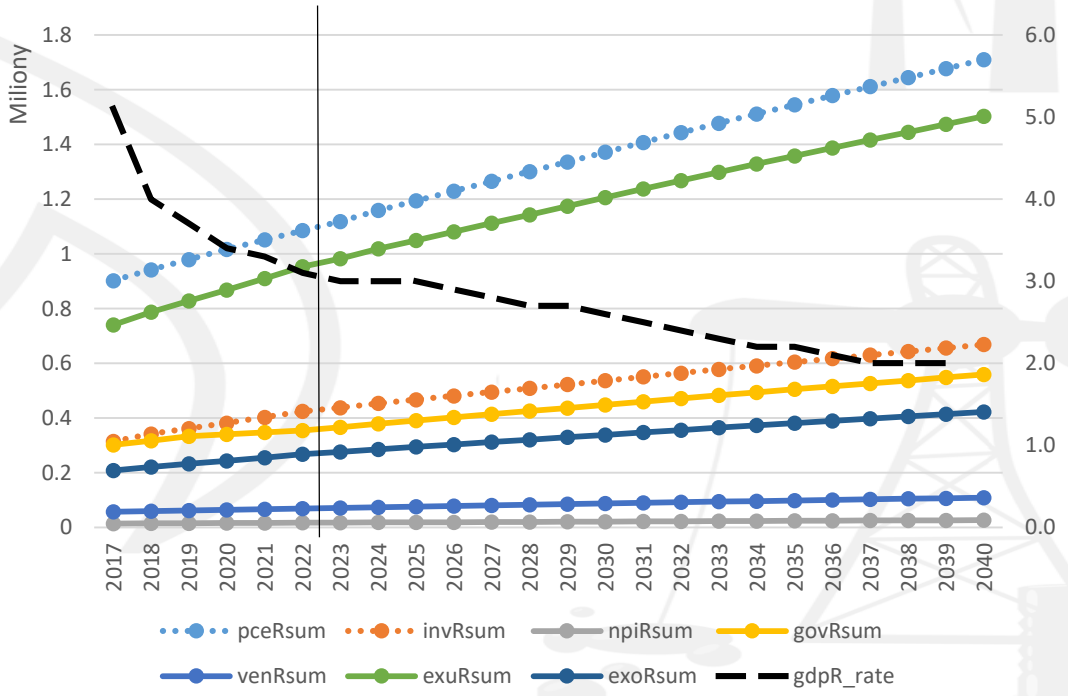
Source: Own elaboration

4. Scenarios of a low-emission transition

Scenario for macrovariables (*.xg file):

- Sources: Eurostat and *Macroeconomic Outline* by the Ministry of Finance
- Time scope: 2015(2017)-2040

Pic. 5. Forecast of main ingredients of the final demand [left scale, in bln zł] and real GDP growth rate [right scale, in %]



Source: Own elaboration

4. Scenarios of a low-emission transition

pce module:

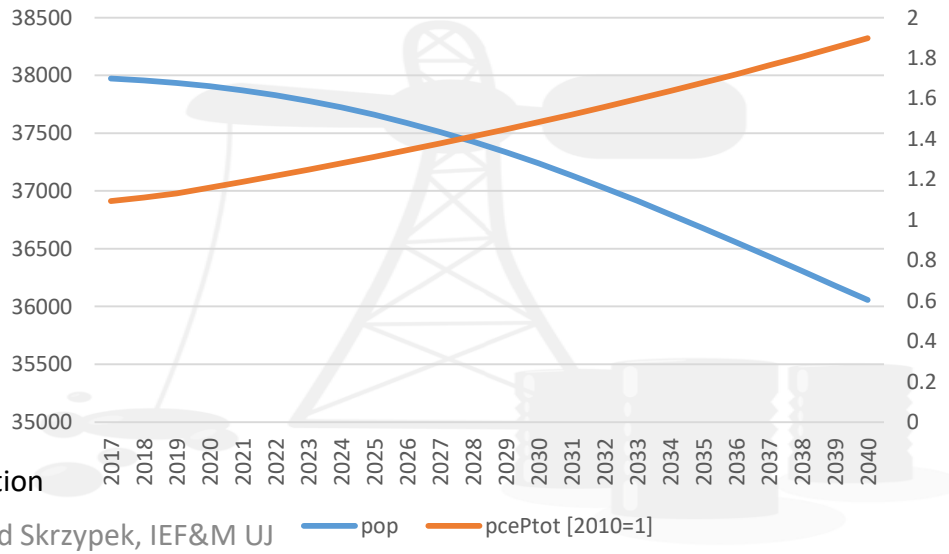
```
id pceRtot = pceincS * gdpR
f pcepctot = pceRtot / pop
f dpcepctot = pcepctot - pcepctot[1]

do{
fex pcepc%1 = pcesR%1 / pop
f pcerP%1 = pcesP%1 / pcePtot
r pcepc%1 = pcepctot, dpcepctot, pcerP%1
id pcesR%1 = pcepc%1 * pop
cc pces[%1] = pcesR%1[t];
}(1-44)
```

Scenario for pce module (*.xg file):

```
# pces%1 - indexed by CPI target 2,5%
         fdates 2017 2050
         f yearNo = @cum(yearNo,1,0)-1
         f rat25 = @exp(yearNo *
@log(1+0.025))
         do{
         f pcesP%1 = pcesP%1{2017} * rat25
         }(1-44)
# pceincS[t] = pceincS{2017} = 0.58
```

Pic. 6. Population [in th., left scale] and pce price index [2010=1, right scale] forecasts



Source: Own elaboration

4. Scenarios of a low-emission transition

inv module:

- Investment expenditures in specific sector -> bridge -> investment demand for a product;
- individual analytical approach to each of the sector;
- base model:

```
r invsR%1 = !caprep, dprodR%1, dprodR%1[1], dprodR%1[2], rlomr, rlomr[1], pmi
```

Soft constraints: `con [] 1=a1`

Scenario for investment module:

- rlomr – close to 0% value [Fisher formula];
- pmi:

```
# pmi -> CAGR from last availabe years
      fdates 2017 2050
      f rat005 = @exp(yearNo * @log(1+0.005))
      f pmi = pmi{2017} * rat005
```

4. Scenarios of a low-emission transition

- ODN scenario (BAU) [*.vfx file]

Tab. 5. Structure of transformations input in energy sector

	2015	2020	2025	2030	2033	2035	2040
Coal	0.89	0.85	0.84	0.83	0.74	0.66	0.45
Petroleum products	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural gas	0.04	0.07	0.09	0.09	0.13	0.17	0.23
RES	0.06	0.07	0.07	0.08	0.09	0.10	0.11
Nuclear	0.00	0.00	0.00	0.00	0.03	0.07	0.21

Tab. 6. Structure of transformations input in coke-petroleum sector

	2015	2020	2025	2030	2035	2040
Coal	0.27	0.26	0.25	0.25	0.25	0.25
Crude oil	0.67	0.67	0.68	0.68	0.68	0.68
Natural gas	0.02	0.02	0.02	0.02	0.02	0.02
RES	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum products	0.05	0.05	0.05	0.05	0.05	0.05

Tab. 7. Dynamics of final energy intensity in indicated groups

	2015	2020	2025	2030	2033	2035	2040
Manufacturing	1.000	0.958	0.854	0.764	0.735	0.715	0.674
	2015	2020	2025	2030	2033	2035	2040
Agriculture	1.000	1.026	1.014	1.003	0.996	0.991	0.980
Services	1.000	0.914	0.829	0.743	0.709	0.686	0.600
Transport	1.000	1.126	1.098	1.058	1.016	0.988	0.924
Households	1.000	1.018	1.006	0.997	0.992	0.988	0.981

Source: Own elaboration

iENt (transformation energy coefficients)

iENd (direct energy coefficients)

ihhENd (direct energy coefficients)

4. Scenarios of a low-emission transition

- PEK scenario (introducing of energy & climate policy) [*.vfx file]

Tab. 8. Structure of transformations input in energy sector

	2015	2020	2025	2030	2033	2035	2040
Coal	0.89	0.86	0.81	0.75	0.67	0.58	0.41
Petroleum products	0.00	0.01	0.01	0.01	0.01	0.01	0.01
Natural gas	0.04	0.06	0.08	0.10	0.12	0.14	0.18
RES	0.06	0.07	0.10	0.14	0.15	0.16	0.17
Nuclear	0.00	0.00	0.00	0.00	0.06	0.12	0.23

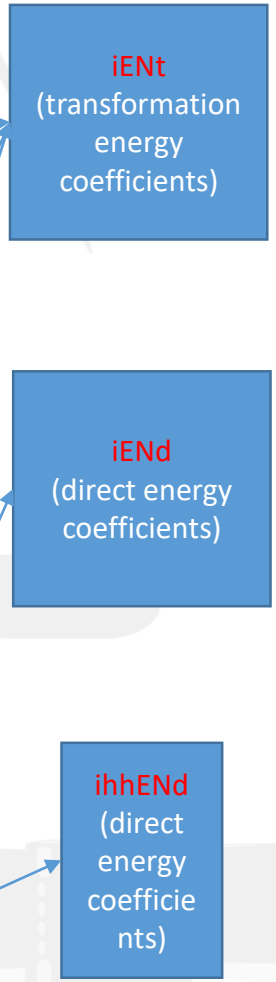
Tab. 9. Structure of transformations input in coke-petroleum sector

	2015	2020	2025	2030	2035	2040
Coal	0.27	0.27	0.27	0.27	0.27	0.27
Crude oil	0.67	0.68	0.67	0.67	0.67	0.66
Natural gas	0.02	0.01	0.02	0.02	0.02	0.02
RES	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum products	0.05	0.04	0.04	0.05	0.05	0.05

Tab. 10. Dynamics of final energy intensity in indicated groups

	2015	2020	2025	2030	2033	2035	2040
Manufacturing	1.000	0.924	0.799	0.694	0.661	0.639	0.597
	2015	2020	2025	2030	2033	2035	2040
Agriculture	1.000	1.000	0.960	0.919	0.897	0.882	0.847
Services	1.000	0.886	0.743	0.657	0.606	0.571	0.514
Transport	1.000	1.034	0.955	0.876	0.834	0.805	0.743
Households	1.000	0.993	0.882	0.797	0.781	0.770	0.754

Source: Own elaboration

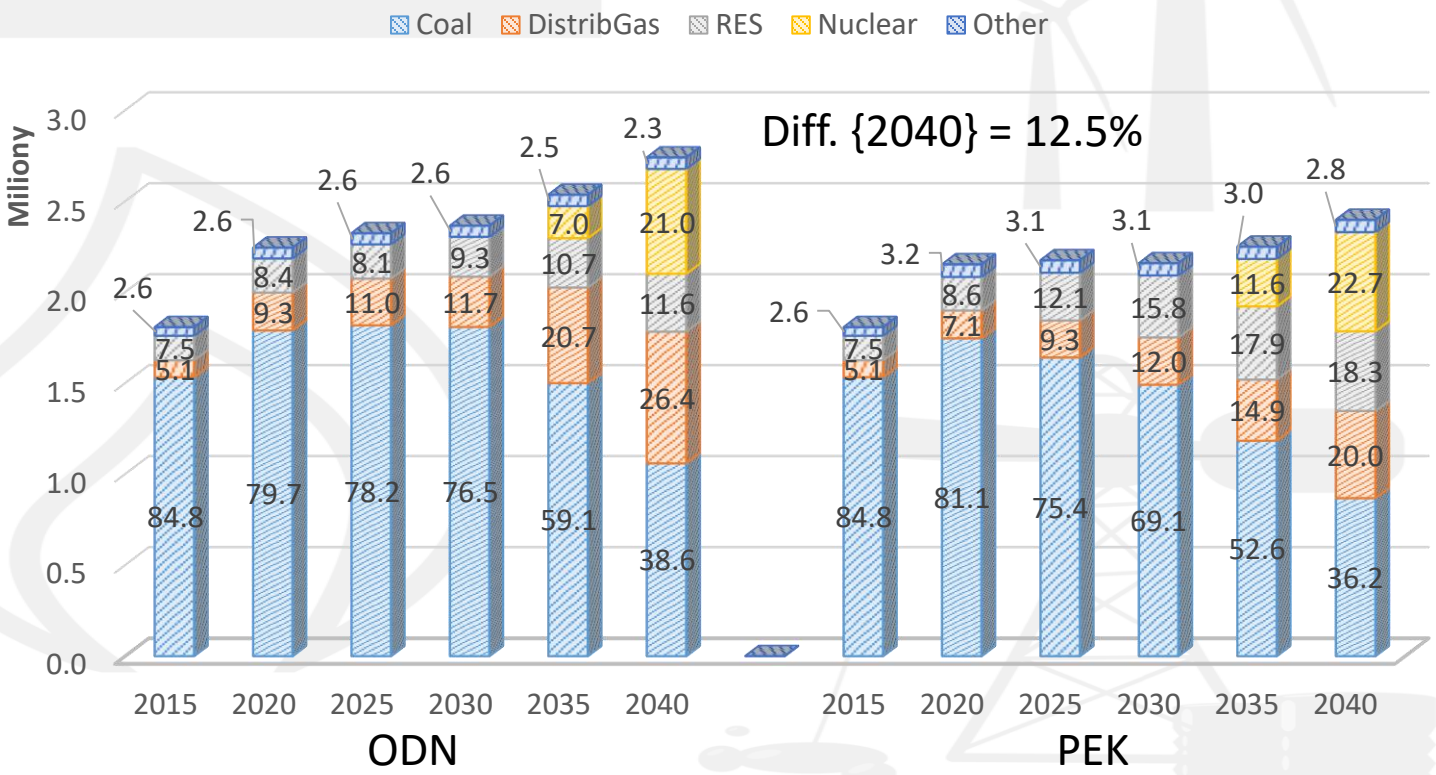


5. Results

Run specification

Start Date	1997	End date	2040
Macro equation start date	1997	Discrepancy year	2010

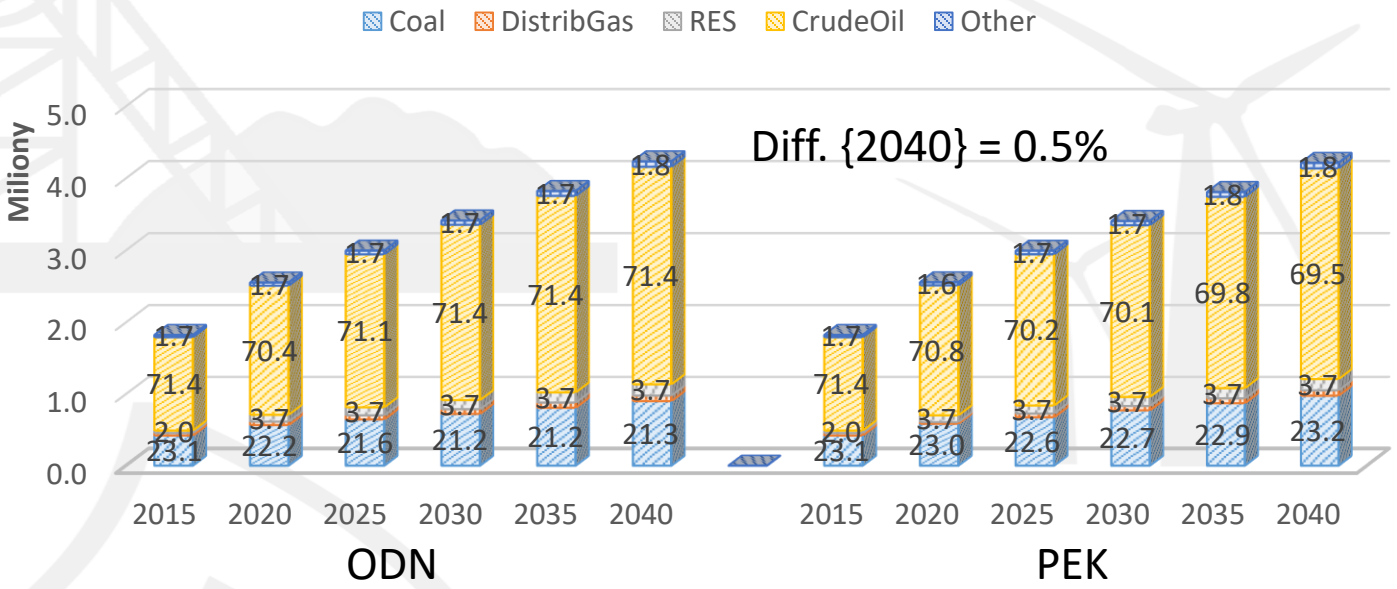
Pic. 7. Transformation input consumption in energy sector for electricity & heat production [in EJ]



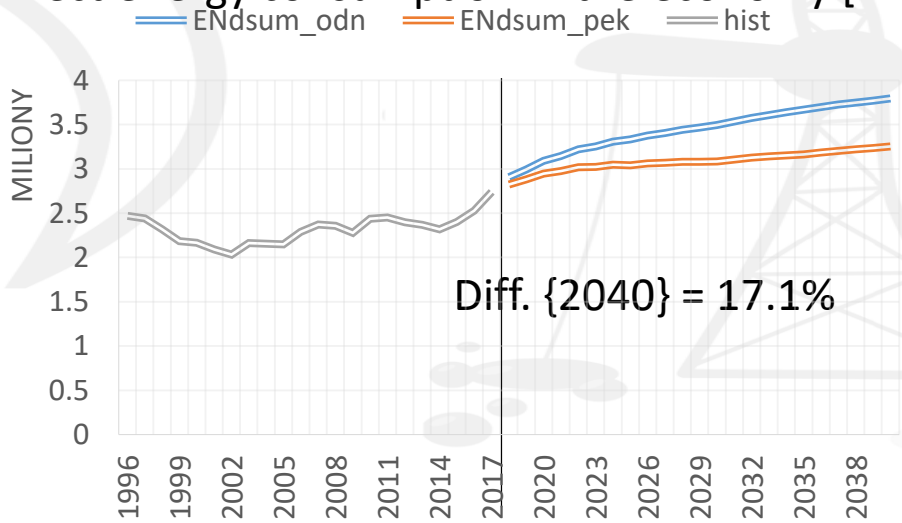
Source: Own elaboration

5. Results

Pic. 8. Transformations input in coke-petroleum sector [in EJ]



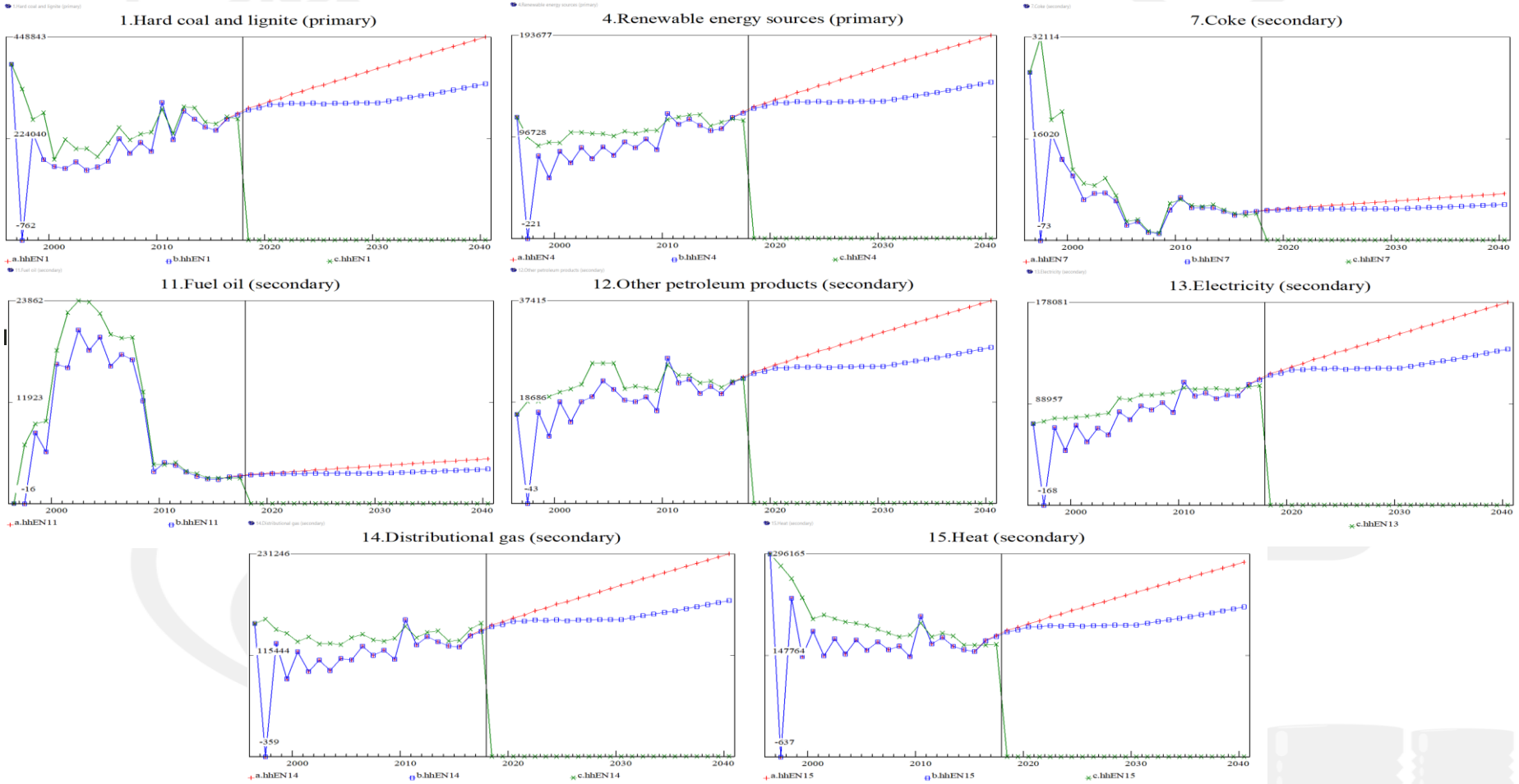
Pic. 9. Direct energy consumption in the economy [in EJ]



Source: Own elaboration

5. Results

Pic. 10. Households energy consumption [in TJ]

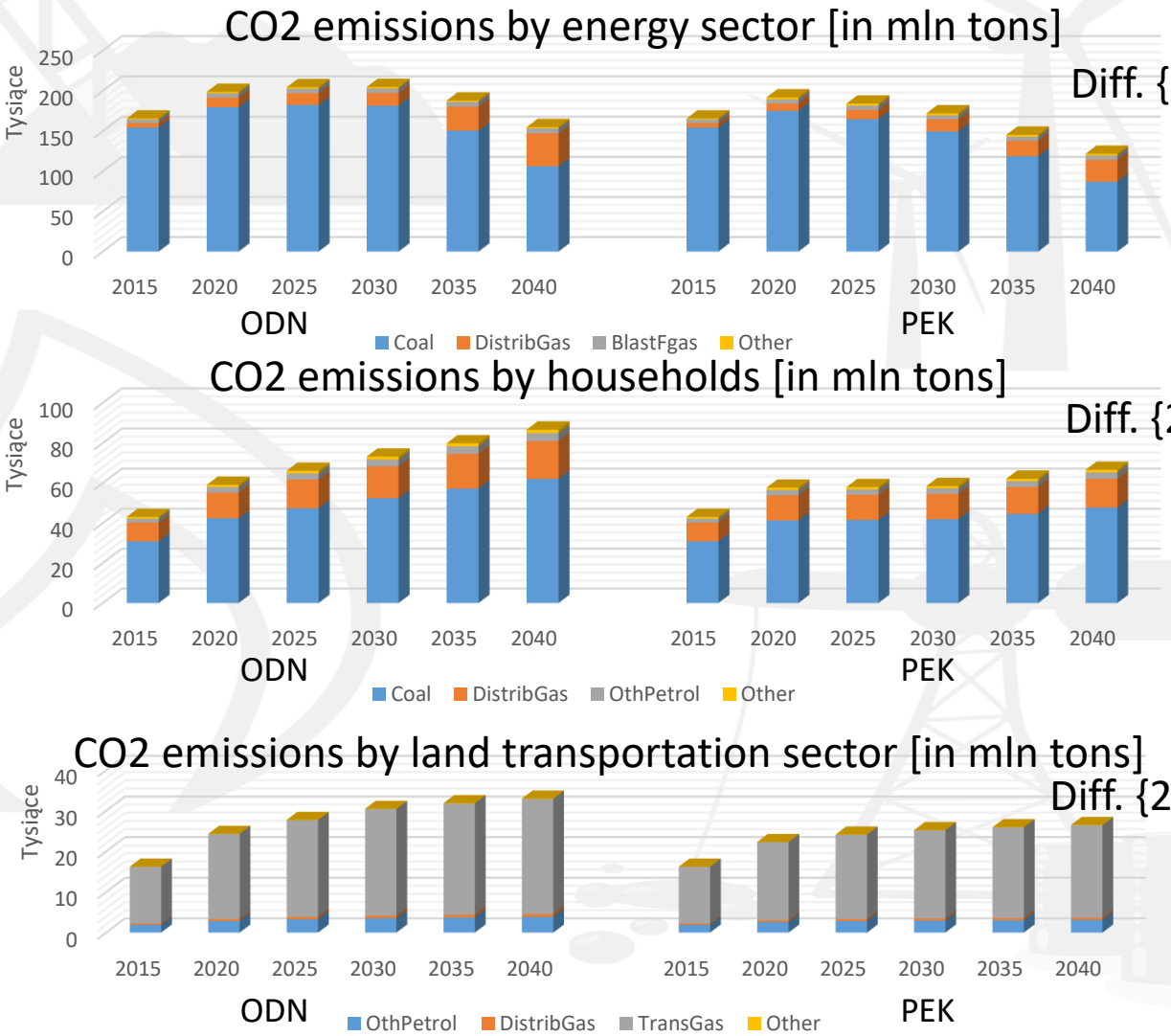


Source: G7 software. Own elaboration

Tot diff. {2040} = 23.1%

5. Results

Pic. 11. CO2 emissions by the main „air poisoners”



Source: Own elaboration

6. Conclusions and directions of the further research

DIRECTIONS OF FURTHER RESEARCH:

I. Inclusion of VCEF (Varied carbon emission factors) scenario.
II. Implementation of changes in energy prices.
III. Comparison of the results (own research vs. policy makers' analysis).
IV. Checking the feasibility of achieving the climate and energy EU objectives.

SUMMARY:

I. Results from MMM with eco-energy extension can enrich the discussion about the future of Polish energy system.
II. There is substantial difference between ODN and PEK simulation results, both in energy and emission dimension.
III. Introducing PEK scenario into the national energy policy can really change the dramatic situation in Polish energy system and could help the economy enter the low-emission track.