Environment Center
Charles University
in Prague

# 3E impact assessment and behavioral aspects of energy consumption

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*Discussion Seminar on*
*CRITICAL REFLECTION OF THE ENERGY POLICY IN AUSTRIA AND CZECH REPUBLIC AFTER 10 YEARS*
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# Outline

1. Externality and environmental benefits – „External Costs of Breaking Mining Restriction in Most Region“
2. Regulation‘s Impacts Assessment – Questions and Tools
    - Energy system modelling: Model MESSAGE
3. Residential energy consumption
    - Energy-saving behavior

# The Study on „External costs of breaching the regional ecological limits in the North Bohemian brown coal basin “ (Melichar, Máca, Ščasný, 2012)

# Externalities

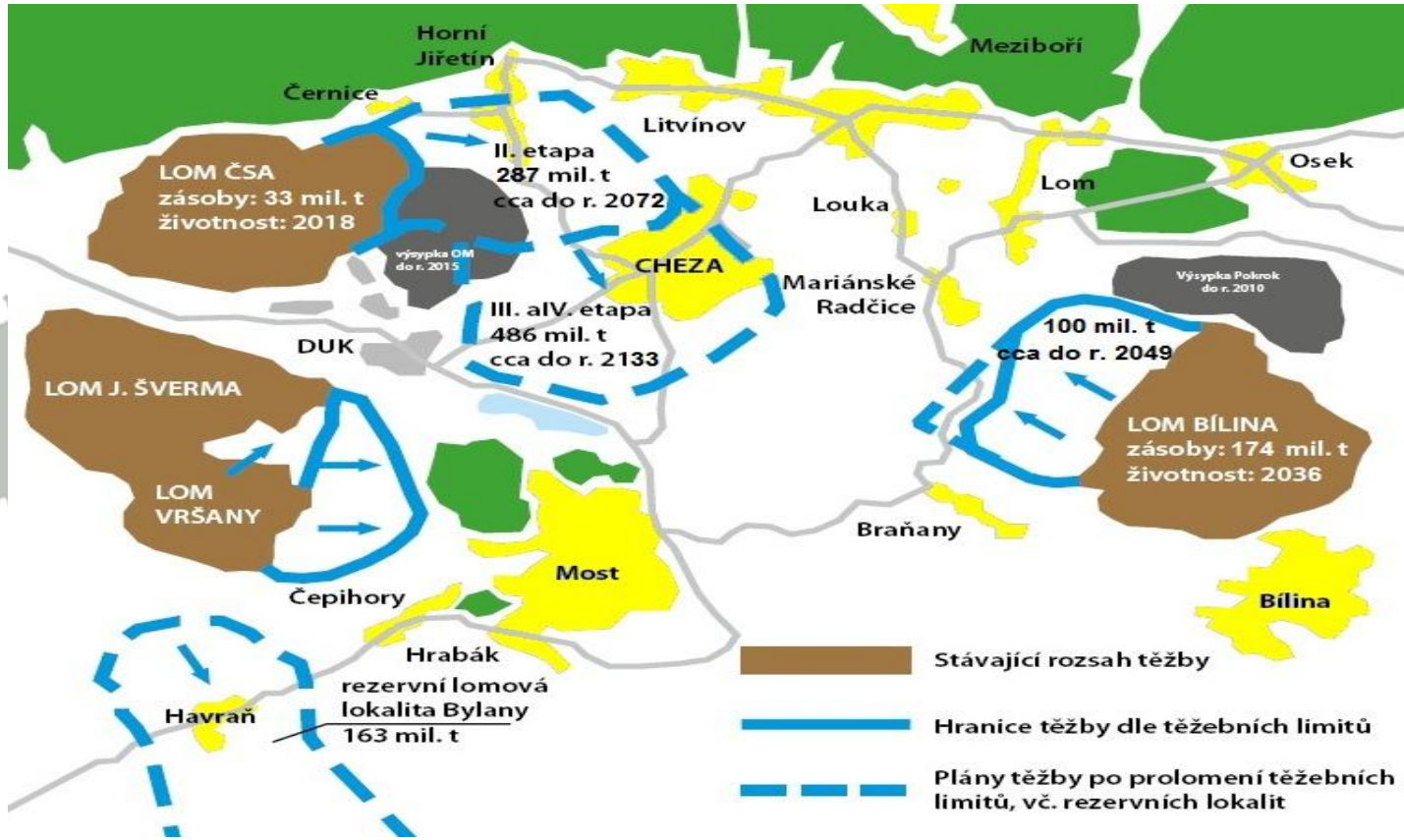
ExternE method

- bottom-up approach
- Impact Pathway Analysis: from emission → to dispersion and transport (concentration) to → physical effects (CRFs) and → monetary valuation of the impacts

Policy-relevant results

- Kč per kWh
- instrument design
- ranking technologies
- CBA
- impact indicators

# The Problem: Regional Ecological Limits (REL) for coal mining in Most region



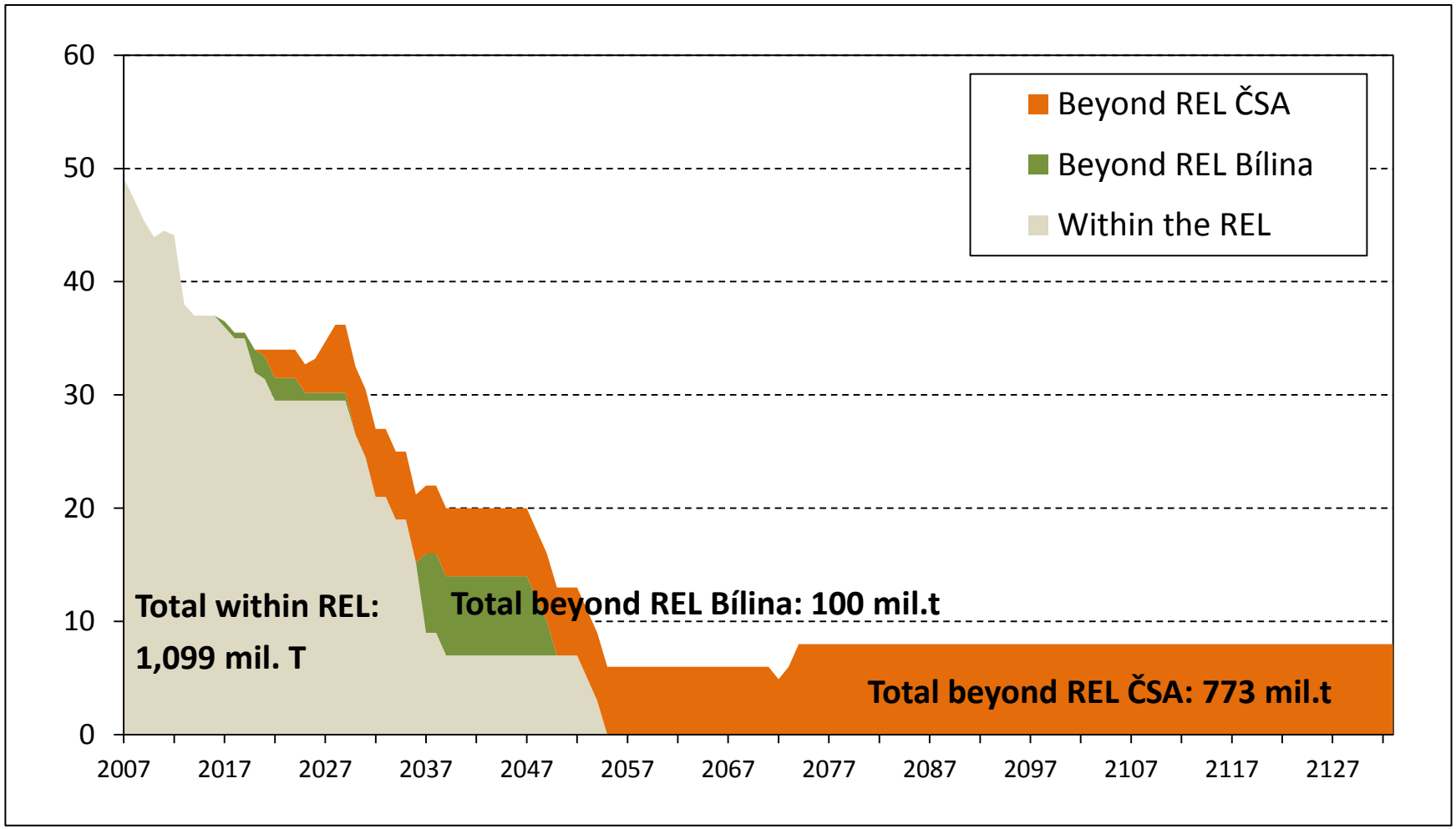

**Time horizon:**

- **2017-2133**

**Only Exteranalities from Combustion of Coal from ČSA & Bílina beond REL**

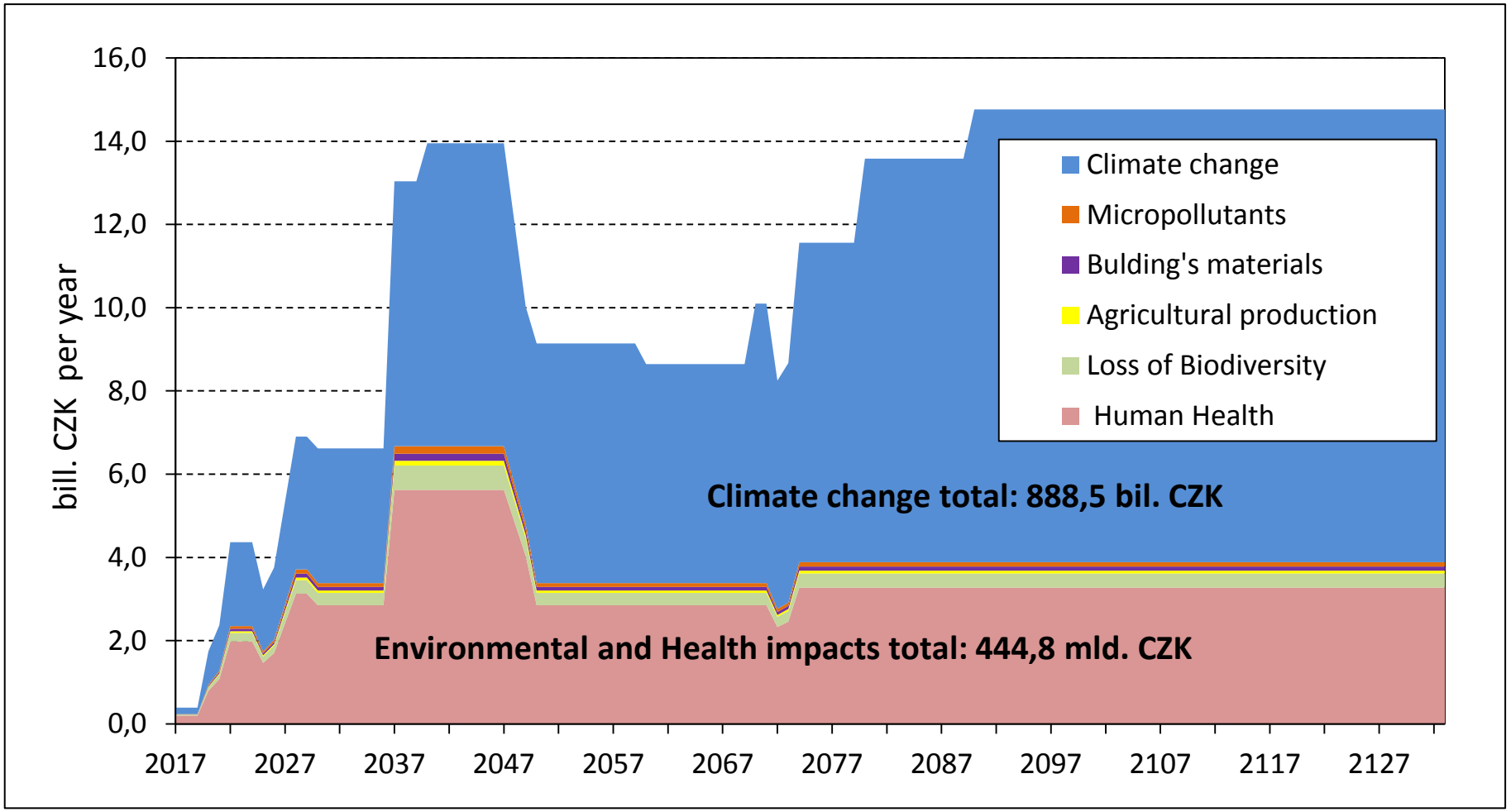
Source: adjusted by Melichar et al., 2012 according to Kořeny (2012) and Invicta Bohemica (2010, in VŠE 2011)

# Coal extraction within and outside of the ecological limits [mil. ton per year]



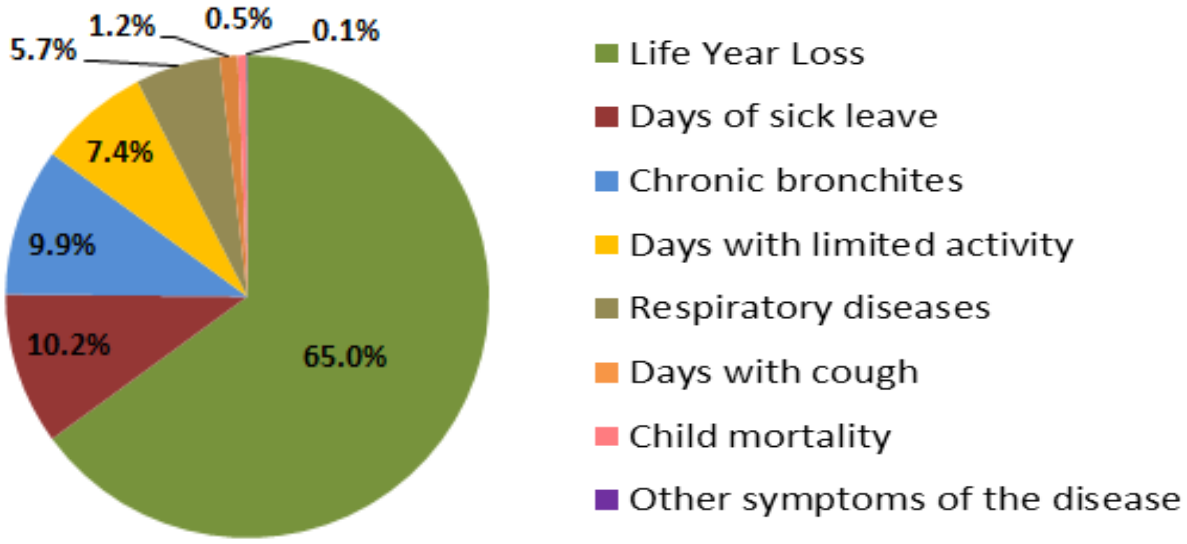

Source: Melichar et al., 2012 based on Invicta Bohemica (2010, in VŠE 2011)

# Annual balance of external costs incl. damages related to clim. change [bill. CZK, 2011 prices]




Source: Melichar et al., 2012

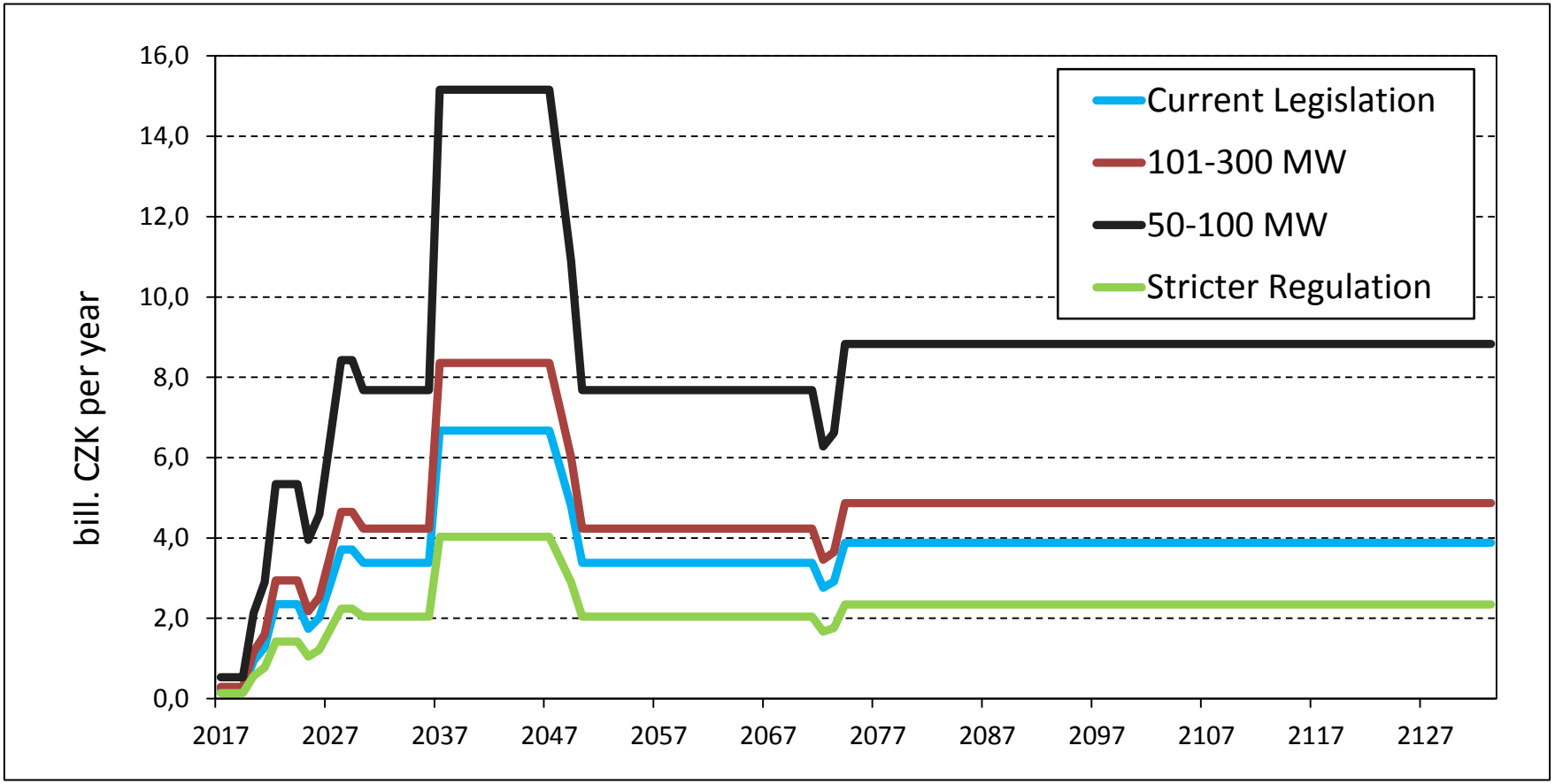
# Health impacts (monetary value)




| Health impacts | unit | Impact |
|---|---|---|
| Chronic bronchites | cases | 8 820 |
| Cardiovascular diseases – hospitalizations | cases | 2 064 |
| Respiratory diseases – hospitalizations | cases | 4 417 |
| Sickness leave | days | 6 126 821 |
| Life Year Loss | years | 287 957 |

Source: Melichar et al., 2012

# External cost across scenarios (without climate change)




Source: Melichar et al., 2012

# Summary of the results

- External costs estimated on **1.33 trillion CZK** for the entire mining period beyond the limits
  - 67 % covers external costs due to climate change (i.e. 888.6 bill. CZK),
  - health impacts cover 28 % (i.e. 374.8 bill. CZK)
- The use of coal in combustion technologies with installed capacity of **50-100 MW**
  - increased the health impacts by 2.5 times on 913 bill. CZK,
  - external costs including the climate change and environmental impacts will be 1.89 trill. CZK.
- **Emission production** for the period of mining
  - there is emission increase especially in 2037-2050, during which annual mining for both sites is supposed to by 13 mill. tonnes
  - emission of $CO_2$ more than 1.34 mil. kilotonnes
  - emission of $SO_2$ (716 thous. tonnes), $NO_X$ (869 thous. tonnes), PM (47 thous. tonnes)

# Regulation‘s Impacts Assessment – Questions and Tools

**Reseach qustions:**

- Prediction or simulation of How would a given system (economy) look like, if some of its parameters would be changed (e.g. prices). (*no forecast of the future)*
- What would be the impacts on the economy (GDP, output, employment), energy consumption, fuel mix, emission, and etc..?
- Which sectors or households will be the most affected by the regulation and what measures can compensate the negative impacts  at least costs?

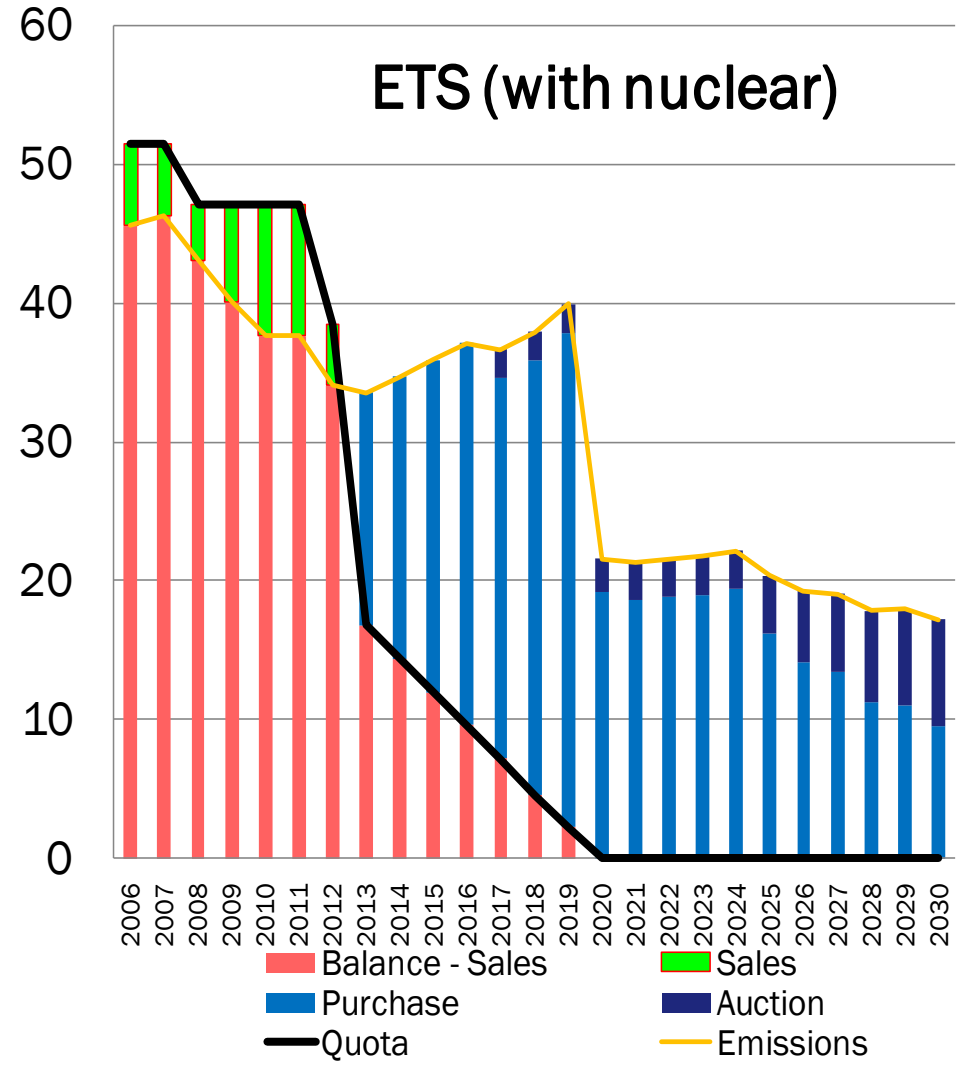
**Tools:**

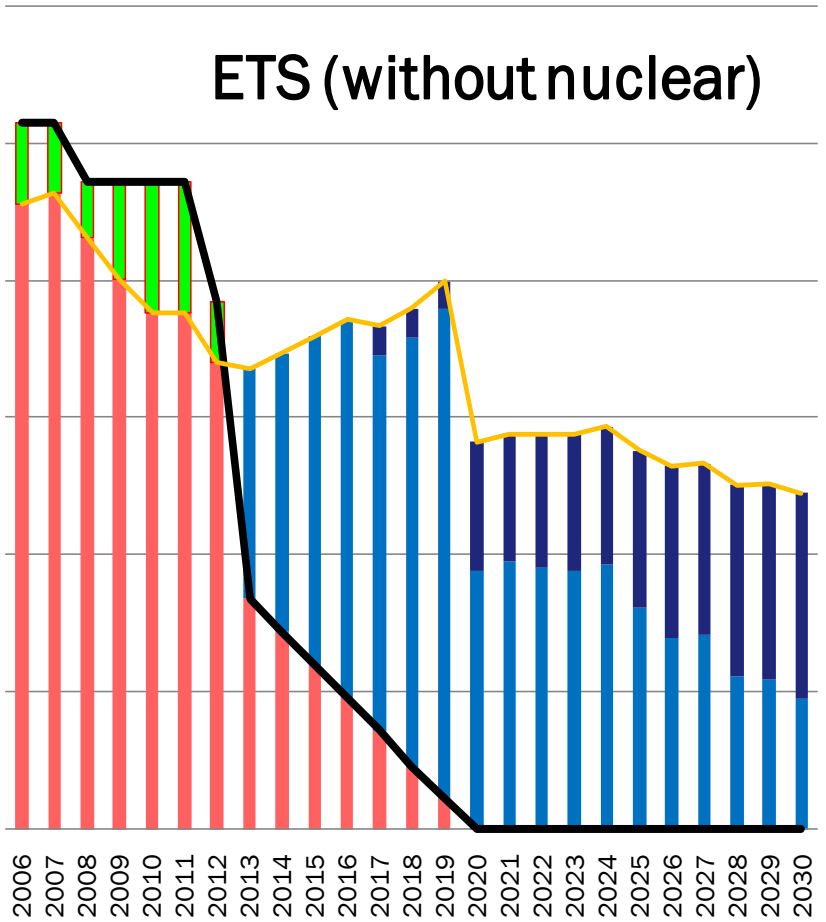
- Linear dynamic optimization models (e.g. MESSAGE, TREMOVE)
- Macro-structural models (e.g. CGECZE3, E3ME)
- Micro-simulation models  for prediction of distribution‘s impacts (e.g. DASMOD)

# Energy system modelling: MESSAGE

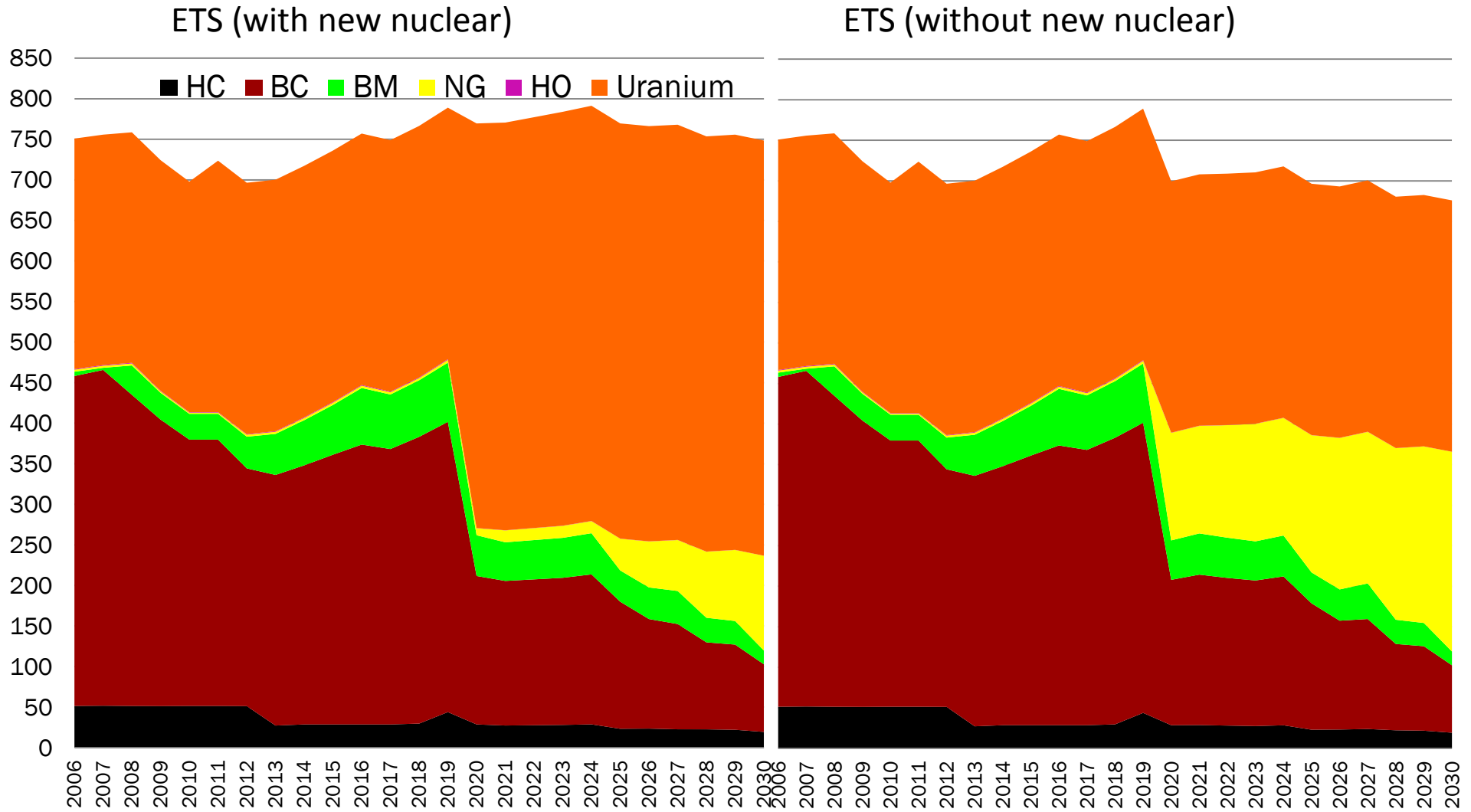
- bottom-up approach technology rich model
- dynamic model, i.e. Least costs over the period until 2030 (plan to 2050)
- optimisation model, i.e. Searching for the least cost mix
- linear model, i.e. fully exogenous aggregate energy demand
- model covers 95% of  2006 el. gross consumption (=81% gross production)
- forecasting and prediction of technology-mix, fuel-mix, fuel use, emissions, investment, total additional costs
- exogenous variables: restrictions on fuels or technologies, fuel prices, investment cost of new techs
- policy variables: fuel tax, emission charges, EU ETS, phasing out certain techs

# MESSAGE: Emission Trading [mil.t CO2]

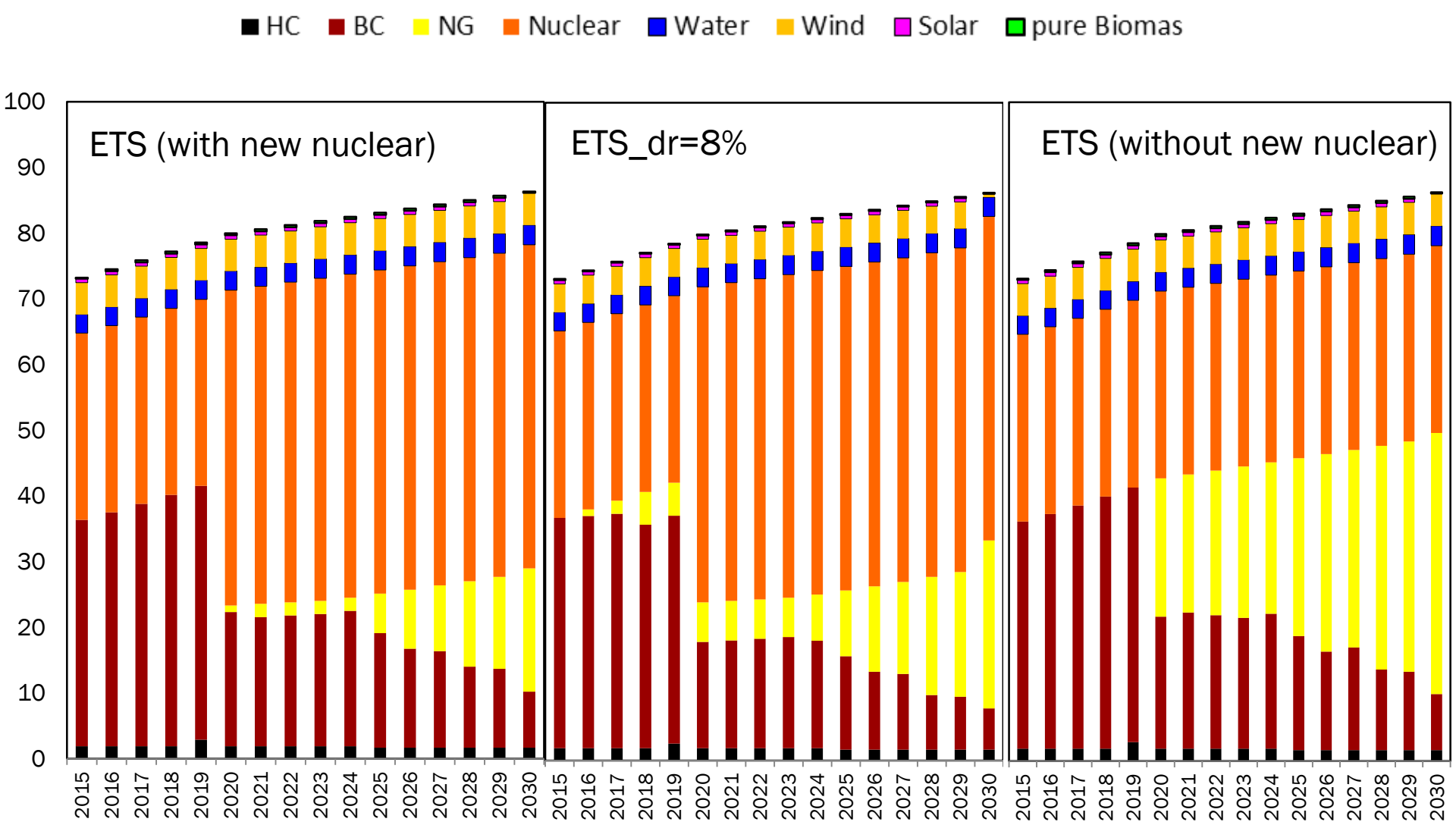


# MESSAGE: Fuel Mix (PJ)



# Structure of electricity production (TWh)



# Drivers of energy-related behavior

- energy prices, income, prices of other commodities -> demand models

- socio-psychological factors -> behavioral models
  - extend our knowledge of non-economic drivers of energy-related behavior
  - prove useful in designing non-economic policy measures

# Effect of environmental concern on energy saving

Forms of residential energy saving are extremely varied

- everyday energy-saving behavior (turning off lights, resetting of thermostat etc.)
- energy-saving retrofits (investments in EE durables, installation of thermal insulation, weather strips etc.)

Motivation to energy-saving is very complex

- economic factors, knowledge, attitudes, social norms, external constraints
- proenvironmental motivation is very interesting from policy point of view
  - independent of monetary incentives and constraints
  - *probably* does not produce auxiliary effects of re-spending and substitution (leading to rebound effect)
  - is likely to affect most of energy-saving behaviors

Urban, J., & Ščasný, M. (2012). Exploring domestic energy-saving: The role of environmental concern and background variables. *Energy Policy*, *47*, 69–80. doi:10.1016/j.enpol.2012.04.018

# Effect of environmental concern on energy-saving

- proenvironmental motives are secondary to energy-saving (Whitmarsh 2009)
- no effect of EC on energy use in 1970s (Heslop et al. 1981)
- newer studies published since 1990s report effect of EC on energy saving:
  - **curtailments** (Barr et al. 2005; Diekmann and Preisendörfer 1998, 2003; Scherbaum, Popovich, and Finlinson 2008)
  - **efficinency investments** (Barr et al. 2005; Diekmann and Preisendörfer 2003; Whitmarsh and O'Neill 2010)

# The study

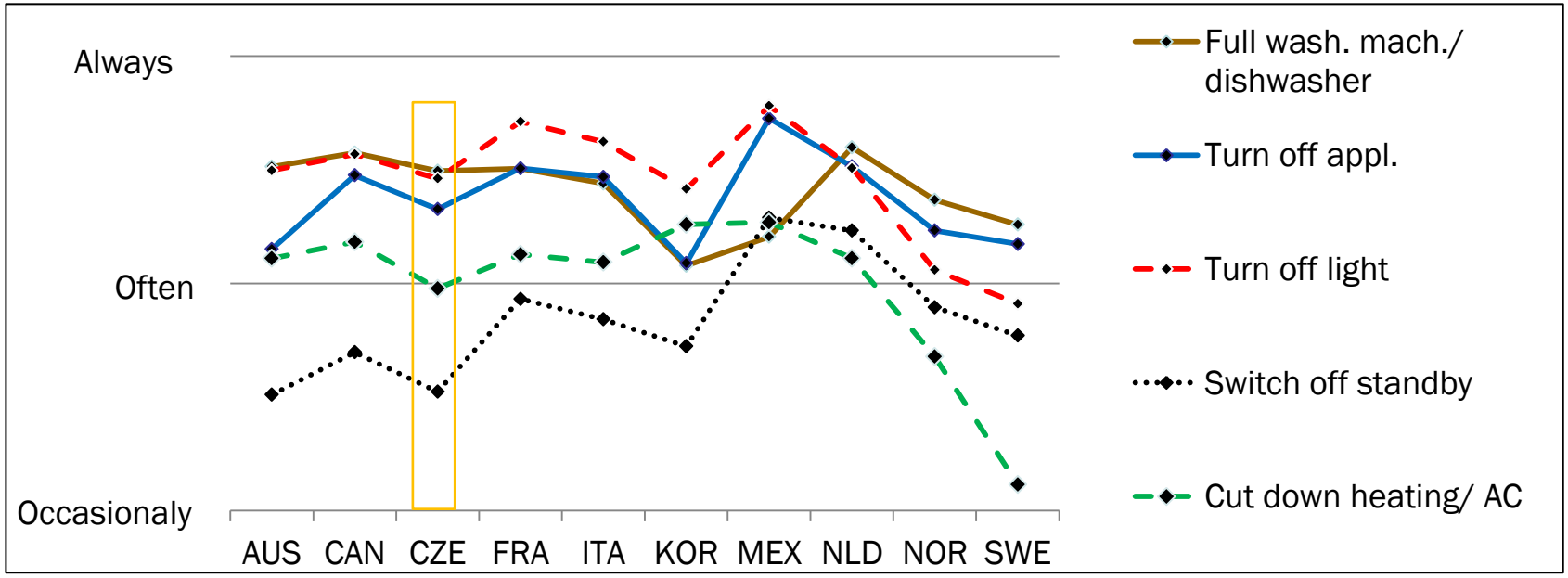
- 10-country survey coordinated by the OECD
  - Australia, Canada, France, Czech Republic, Italy, South Korea, (Mexico), Netherlands, Norway, Sweden
  - sample sizes between 701 observations (Czech Republic) and 1417 observations (Italy)

- method: multi-group SEM

# Measures of energy-saving /1/

**Curtailments** [4-point Likert-type scales: never-always]:

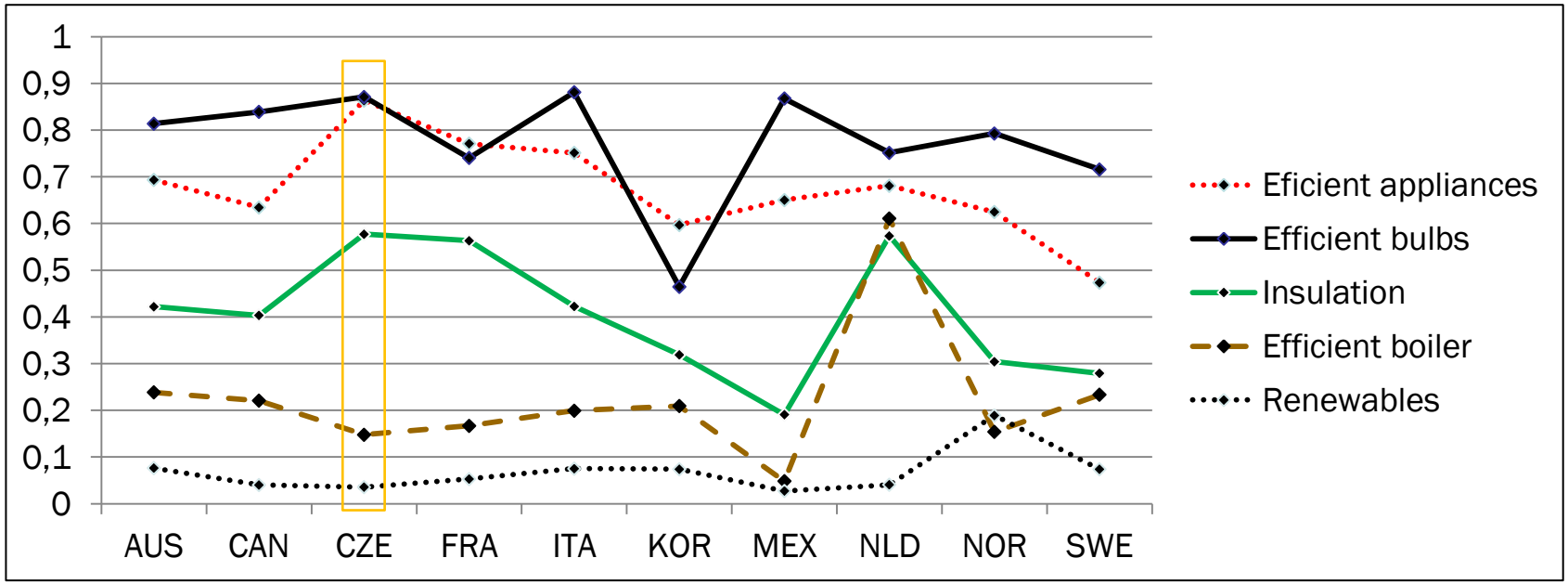
- switching off lights when leaving a room;
- turning down AC or heating when leaving a room;
- economic use of the washing machine and dishwasher;
- turning off unused appliances;
- turning off standby mode in household appliances.



# Measures of energy-saving /2/

**Curtailments** [binary indicator of EE upgrage]

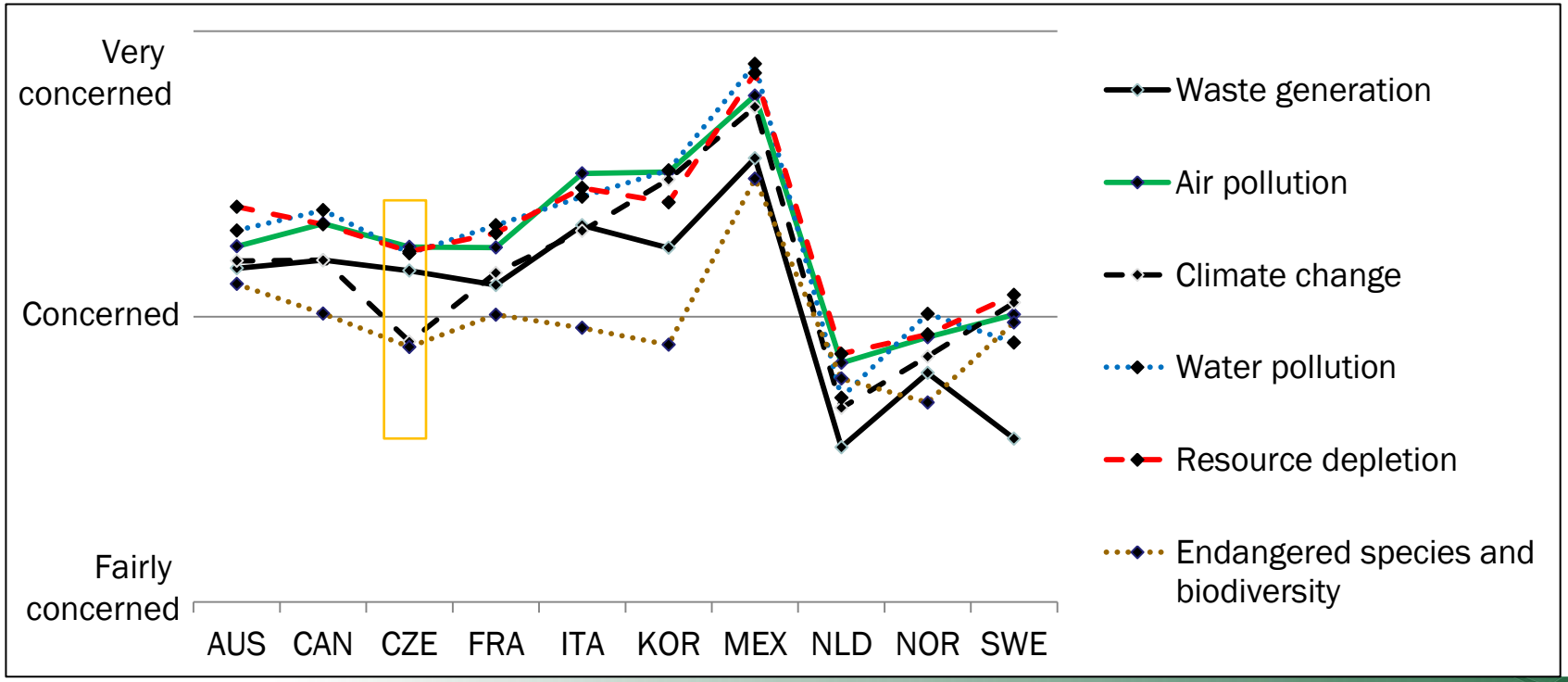
- energy-efficiency-rated appliances;
- low-energy light bulbs;
- thermal insulation (walls/roof insulation, double-glazing);
- energy-efficiency rated water heater;
- renewable resources.



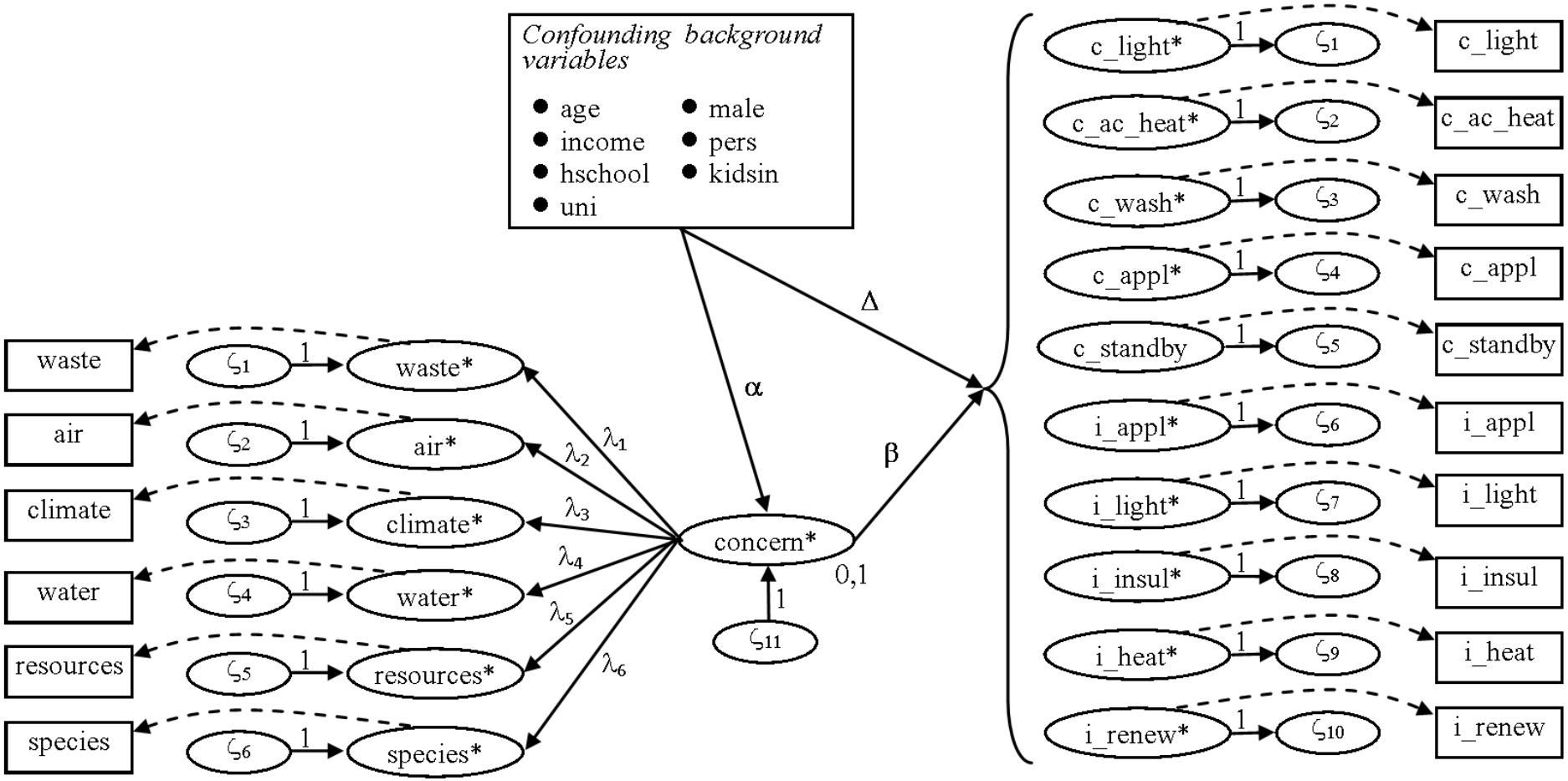
# Measures of environmental concern

**Environmental concern;** How concerned are you... [rate each item on a 4-point Likert-type scale: very concerned - not concerned]

- waste generation;
- air pollution;
- climate change;
- water pollution;
- natural resources depletion;
- endangered species and biodiversity.



# The model


Confounding background variables
age
income
hschool
uni
male
pers
kidsin
Δ
α
β
0,1
concern*
ζ11
1
waste
air
climate
water
resources
species
ζ1
ζ2
ζ3
ζ4
ζ5
ζ6
waste*
air*
climate*
water*
resources*
species*
λ1
λ2
λ3
λ4
λ5
λ6
c_light*
c_ac_heat*
c_wash*
c_appl*
c_standby
i_appl*
i_light*
i_insul*
i_heat*
i_renew*
ζ1
ζ2
ζ3
ζ4
ζ5
ζ6
ζ7
ζ8
ζ9
ζ10
c_light
c_ac_heat
c_wash
c_appl
c_standby
i_appl
i_light
i_insul
i_heat
i_renew

# Results

| | |
|---|---|
| Is there any positive effect of environmental concern on energy-saving investments? | YES |
| Is there any positive effect of environmental concern on every-day energy-saving activities? | YES |
| Are these effects similar in over the studied countries? | YES |
| Is environmental concern the primary factor of energy saving? | Most likely not (<10% of explained variability of energy saving) |

# Future research

**Macro analyses**

- maintenance, update and extension of energy system model
  - heat (co-)generation, loop on aggregate demand, restrictions on heat supply and biomass use, new technologies, etc.)
  - Inclusion of environmental damage and health effects
- hybrid modeling (linkage between micro- and macro-modelling)

**Micro analyses**

- behavioral models
  - energy-saving
  - energy consumption
- direct rebound effect
- smart metering and smart grids
- passenger vehicle ownership and use

# Thank for your attention and comments

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