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POTENTIAL FOR A REDUCTION OF THE CARBON DIOXIDE EMISSIONS OF CZECHIA BY RENOVATING THE NATIONAL BUILDING STOCK

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BACKGROUND AND MOTIVATION

- **Buildings are responsible for approximately 40% of energy consumption and 36% of CO_2 emissions in the EU [1].**
- **At the same moment, the building sector has the highest potential for delivering significant and cost-effective GHG reductions [2].**
- **Countries shall have estimations of their building stocks potential to contribute to climate change mitigation goals**

[1] European Commission, Buildings, (2018). https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings (accessed April 10, 2018)

[2] United Nations, Buildings and Climate Change: Summary for Decision Makers, 2009. doi:10.1127/0941-2948/2006/0130

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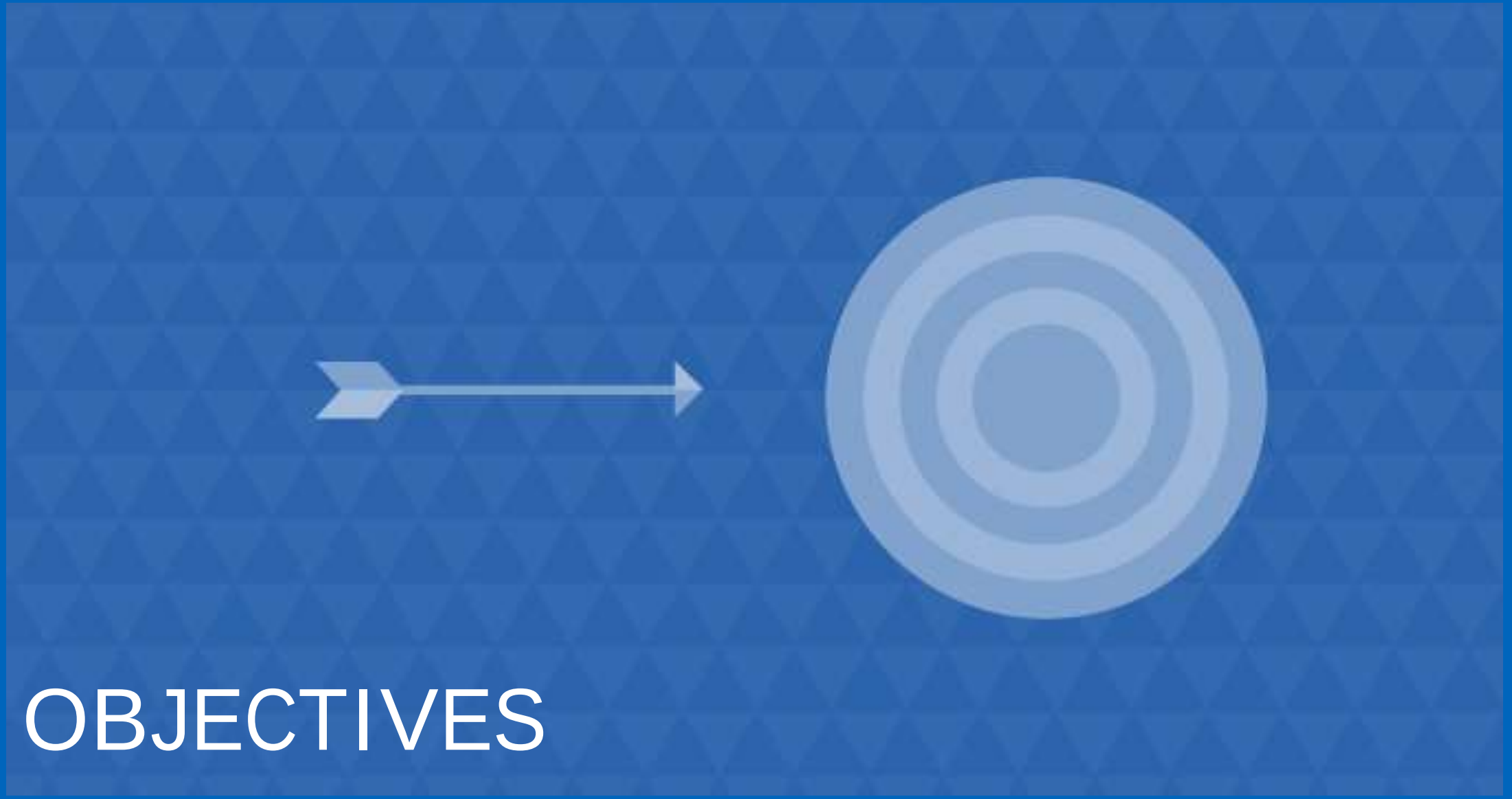

OBJECTIVES

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OBJECTIVES

To contribute to the national discussion of the GHG emissions saving potential by:

- **Reviewing the renovation options of the existing building stock**
- **Defining renovation scenarios**
- **Quantifying the potential of CO_2 savings for each scenario towards 2050**
- **Considering potential impact of the future reduction of emission factors**
- **Evaluating the potential share of building stock on the national GHG emissions savings**

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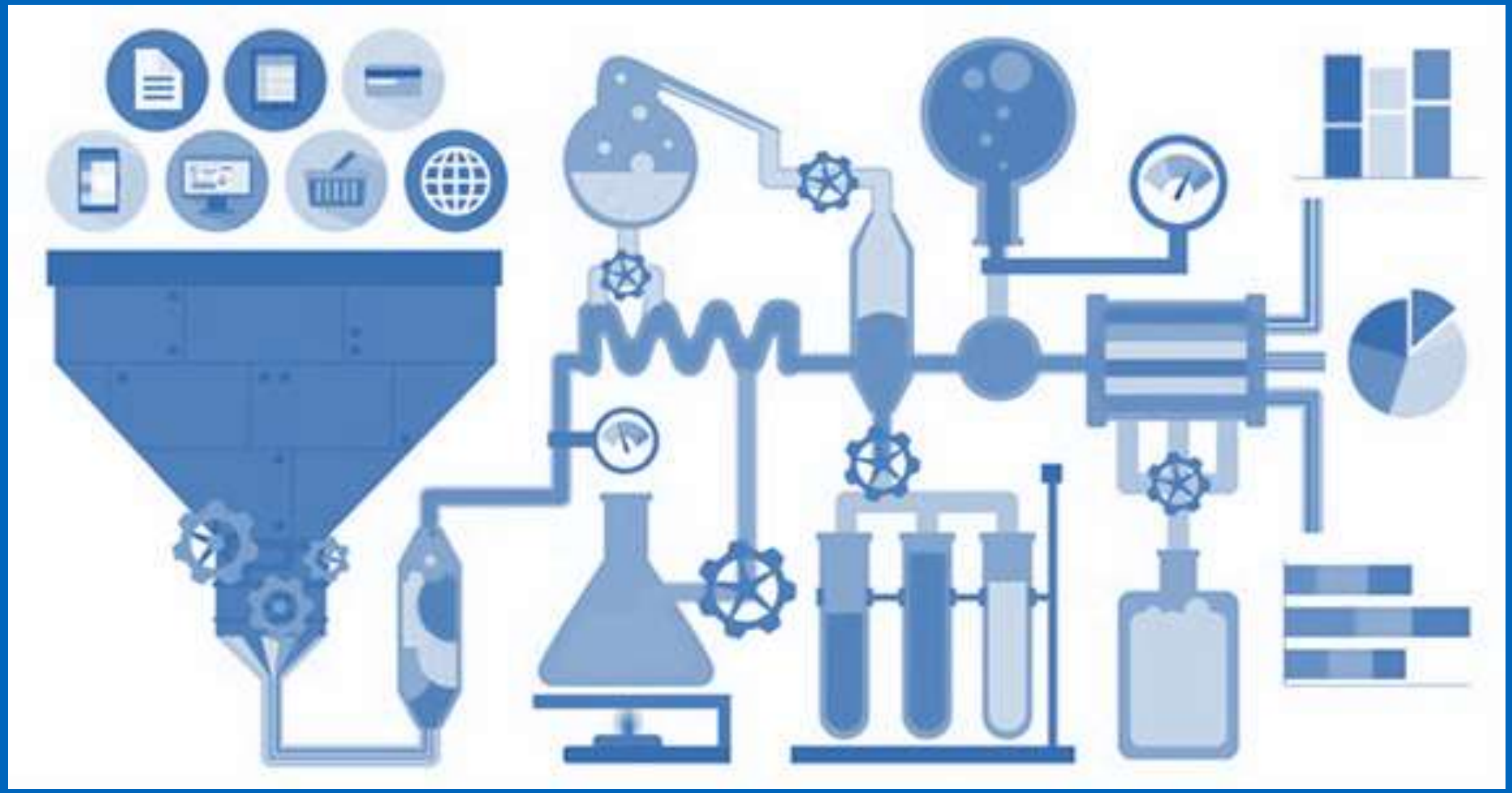


Image credit: European University Institute

METHODS

METHODS

- Inventory of the Czech building stock
- Modelling energy consumption of the Czech building stock
- Defining renovation scenarios towards 2050
- Defining scenarios of shares of energy sources in future energy consumption and BIPV uptake potential
- Modelling energy consumption of residential and non-residential building stocks in scenarios
- Identification of the CO_2 emission factors
- Quantifying the potential of CO_2 savings for each scenario towards 2050
- Conducting sensitivity analysis reflecting the future reduction of emission factors
- Evaluating the potential share of building stock on the national GHG emissions savings

INVENTORY OF THE CZECH BUILDING STOCK

- Data from censes from the Czech Statistical Office
  - ENERGO 2015 census
  - Buildings 1-99 survey (2018)
- Data from national EPC registry provided by the Czech Ministry of Industry and Trade
- Data on renovations from the Czech associations

CZECH BUILDING STOCK MODELLING

Modelling:

- **Residential building stock**
  - **Based on stochastic model of 1000 single family and multifamily houses**
- **Non-residential building stock**
  - **Based on real models of 100 representative buildings**

- **Extrapolated to whole building stock per m^2**
- **Results calibrated by the data from energy audits and national inventories of energy consumptions**

DEFINING 4 RENOVATION SCENARIOS TOWARDS 2050

- **Baseline Scenario**

  Corresponds to the state-of-the art policy without any improvements (business as usual)

- **Governmental Scenario**

  Defined by the Ministry of Industry and Trade for the policy steering

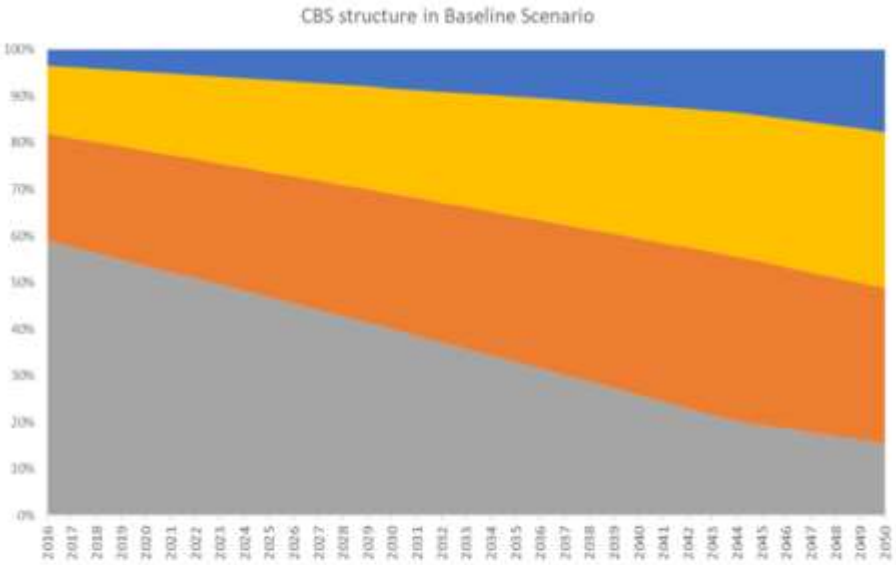
- **Progressive Scenario**

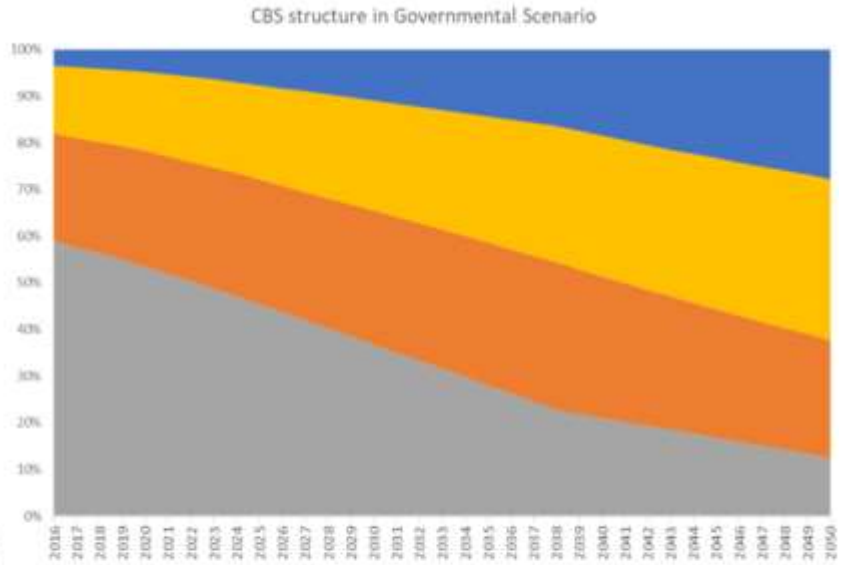
  Continuous deep energy retrofitting of the Czech building stock

- **Hypothetical Scenario**

  Fast deep energy retrofitting of the Czech building stock

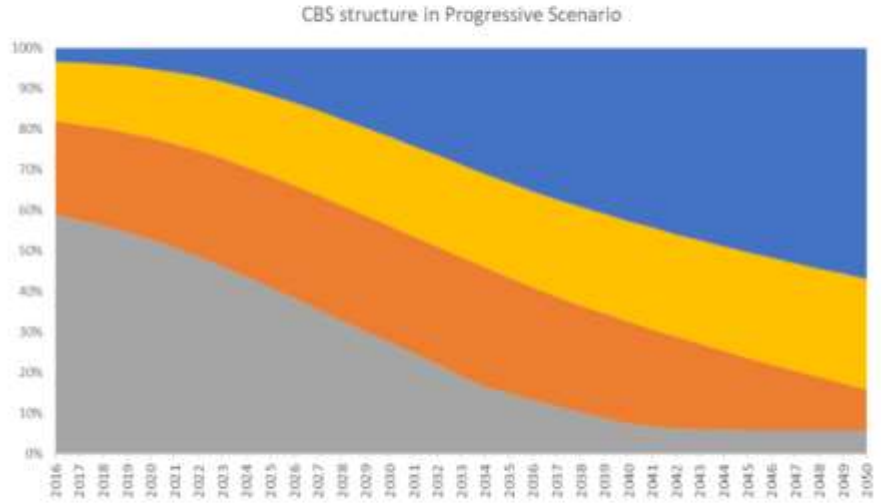
Baseline

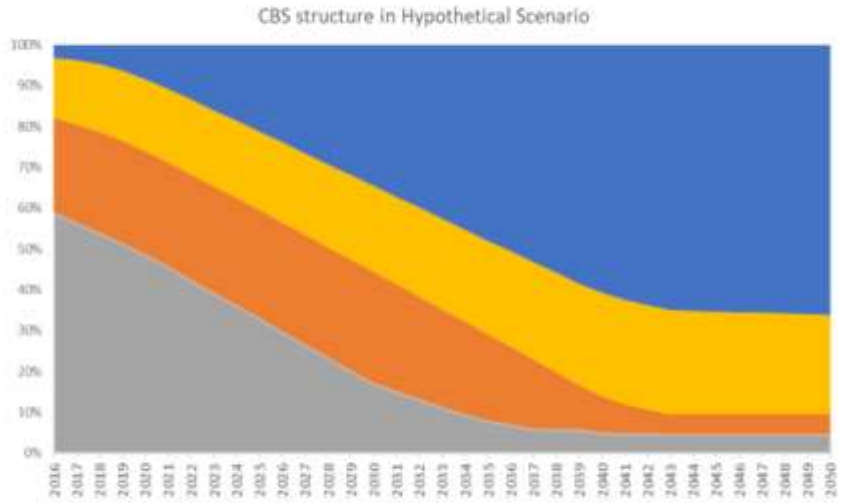




Governmental

Progressive





Hypothetical

non-renovated floor area
shallowly renovated floor area
moderately renovated floor area
deeply renovated floor area

Shares of renovation depths in the Czech building stock in time, according to the four scenarios

Scenarios of shares of energy sources in future energy consumption

Scenario		Baseline	Governmental	Progressive	Hypothetical
Energy Carrier/Source	**2016**	**2050**	**2050**	**2050**	**2050**
Residential building stock					
Fuel oils	0%	0%	0%	0%	0%
Natural gas	30%	25%	26%	23%	22%
Coal	12%	10%	3%	0%	0%
Biomass (excluding pellets)	20%	25%	20%	15%	12%
Pellets	0.3%	4%	9%	14%	16%
District heating	17%	16%	16%	15%	15%
Electricity	19%	10%	11%	8%	8%
Solar thermal	0.3%	2%	4%	6%	7%
Heat pumps	1%	9%	12%	19%	21%
Nonresidential building stock					
Gas cogeneration	2%	2%	2%	2%	2%
Natural gas	27%	26%	23%	22%	22%
Coal	0.2%	0.2%	0%	0%	0%
Biomass (excl. pellets)	0%	0%	0%	0%	0%
Pellets	0.3%	4%	8%	8%	9%
District heating	29%	28%	25%	25%	25%
Electricity	42%	39%	36%	36%	35%
Solar thermal	0.2%	2%	4%	4%	4%
Heat pumps	0%	0.2%	3%	3%	3%

Considered yearly amounts of electricity production in GWh from building-attached and building-integrated photovoltaics

Sector	Scenario	2016	2030	2040	2050
Residential	Baseline and Governmental	262	2944	4710	6477
	Progressive	262	5561	8995	12,430
	Hypothetical	262	5414	9707	14,000
Nonresidential	Baseline and Governmental	140	1560	2490	3420
	Progressive	140	2940	4755	6570
	Hypothetical	140	3129	5265	7400
Whole building stock	Baseline and Governmental	402	4504	7200	9897
	Progressive	402	8501	13,750	19,000
	Hypothetical	402	8543	14,971	21,400

CO_2 emission factors applied in the calculations

Fuel or Energy Carrier	Assumed Emission Factor (t CO_2/MWh)
Coal	0.35
Fuel oils	0.26
Natural gas	0.20
Biomass	0.00
Heat from solar collectors	0.00
Electricity from the national grid	0.60
Onsite-produced electricity from BIPV	(−)0.60
Heat from district heating system	0.30
Energy from gas cogeneration (proxy)	0.10
Heat from heat pumps	0.20

Variant scenarios for CO_2 emission factors applied in the sensitivity analysis for 2050

Fuel or Energy Carrier	Emission Factors for Variant Scenarios for 2050 (t CO_2/MWh)		
	EF1 (Baseline)	EF2	EF3
Electricity from grid	0.600	0.400	0.200
Heat from district heating system	0.300	0.225	0.150
Gas from gas distribution system	0.200	0.180	0.160

EVALUATING THE POTENTIAL SHARE OF BUILDING STOCK ON THE NATIONAL GHG EMISSIONS SAVINGS

According to the last national commitment in 2016, the Czech Republic supports the decarbonisation plan of the EU, but can contribute only by 80 % reduction of GHG in 2050 (compared to 1990)

- **National 2050 target 32.8 Mt CO_2**
- **NIR: national CO_2 production was 106.6 Mt CO_2 in 2016**
- **According to our calculations CO_2 emissions from operation of building stock were 36.9 Mt CO_2 (34.6 %)**

Virtual target for building stock in 2050 (equal contraction):

- **34.6 % X 32.8 = 11.4 Mt CO_2**

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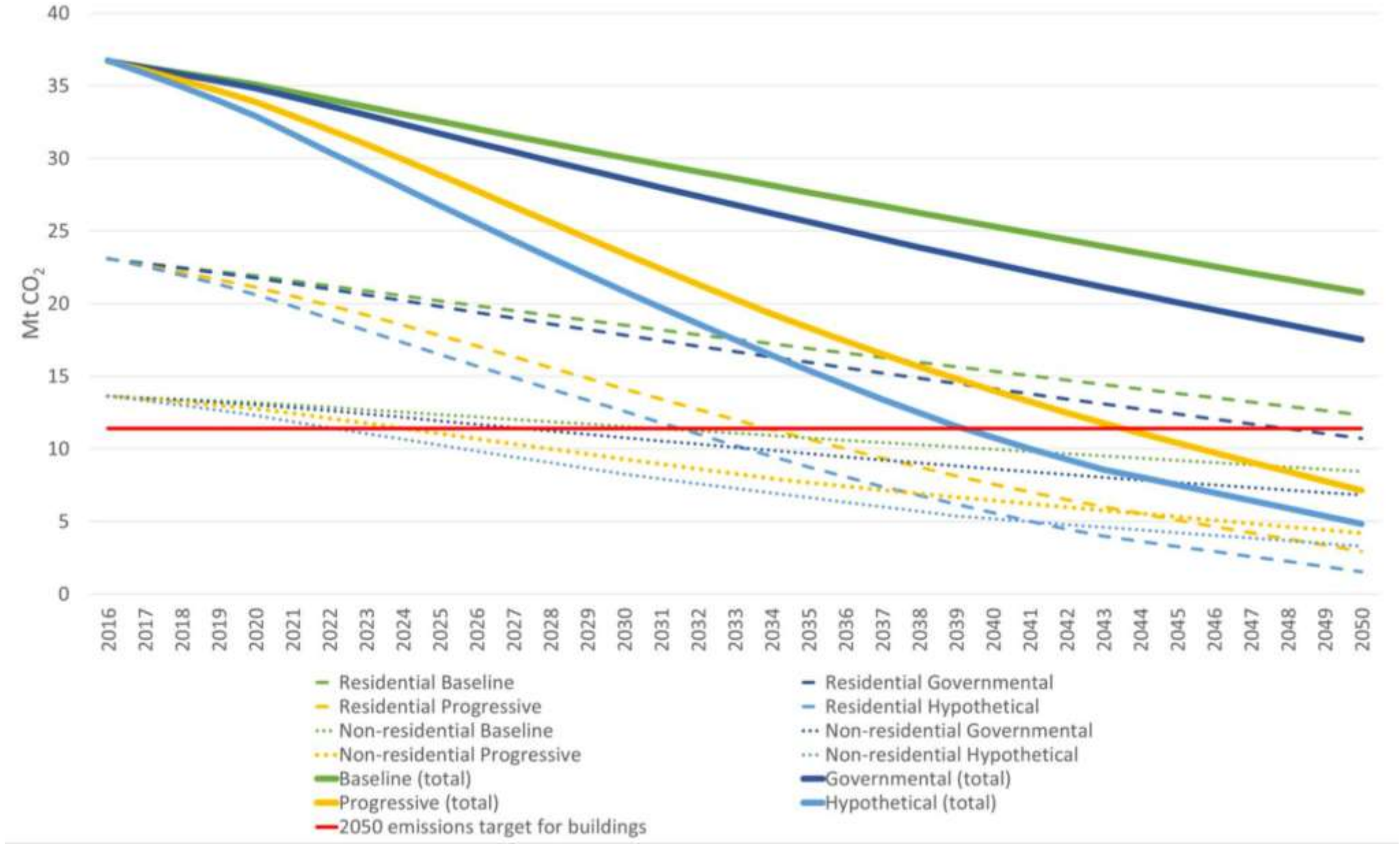
Image credit: traffective.com

RESULTS

A simplified overview of the modelled final energy annual consumptions [PJ]

Scenario	2016	2030	2040	2050
Residential building stock				
Baseline	253	234	219	204
Governmental		232	214	196
Progressive		206	154	126
Hypothetical		179	126	115
Nonresidential building stock				
Baseline	125	117	109	102
Governmental		113	102	93
Progressive		107	94	86
Hypothetical		98	85	83



Comparison of CO_2 reduction potential of all scenarios

Summary of scenarios including outcomes of the sensitivity analysis [Mt CO_2]

Scenario	2016	2050 without PV	2050 with PV
Target		At least 11.4	At least 11.4
Baseline	36.9	26.7	20.8
Governmental		23.5	17.5
Progressive		18.5	7.1
Hypothetical		17.7	4.8

EF2	EF3
5.8	4.4
4.2	3.5

UNCERTAINTIES

- **Emission factors**
  - **Current for the electricity from the national grid**
  - **Simplifications for the renewables – zero emission factors**
  - **Future emission factors**
- **Future development of shares of energy sources**
- **Future development of the building stock**
- **Changes of energy consumption in buildings due to changing climate**

(Study does not consider embodied emissions, which are allocated to industry, but would be significant and might be hard to achieve)

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CONCLUSIONS

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CONCLUSIONS

- **If the (weak) national commitment of 80 % GHG reduction is to be achieved (and buildings are to take the 34,6% share), the at least the Progressive scenario has to be followed**

- **Hypothetical scenario combined with reduced emission factors of electricity, gas and district heating enables almost complete decarbonisation, but to achieve it bold actions and high investments are needed now**

energies

MDPI

Article

Czech Building Stock: Renovation Wave Scenarios and Potential for CO_2 Savings until 2050

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Abstract: One of the major anthropogenic sources of greenhouse gases is the operation of building stock. Improving its energy efficiency has the potential to significantly contribute to achieving climate change mitigation targets. The purpose of this study was to roughly estimate such potential for the operation of the national building stock of Czechia to steer the national debate on the development of related national plans. The estimation is based on a simplified energy model of the Czech building stock that consists of sub-models of residential and nonresidential building stocks, for which their future energy consumptions, shares of energy carriers and sources, and emission factors were modeled in four scenarios. Uncertainties from the approximation of the emission factors were investigated in a sensitivity analysis. The results showed that the operation of the Czech building stock in 2016 totaled 36.9 Mt CO_2, which represented 34.6% of the total national carbon dioxide emissions. The four building stock scenarios could produce reductions in the carbon dioxide emissions of between 28% and 93% by 2050, when also considering on-side production from photovoltaics. The implementation of the most ambitious scenario would represent a drop in national CO_2 yearly emissions by 43.2% by 2050 (compared to 2016).

Keywords: national building stock; climate change mitigation; carbon dioxide; scenarios modelling; Paris Agreement; EU Green Deal; energy efficiency

Citation: Lupíšek, A.; Trubačík, T.; Holub, P. Czech Building Stock: Renovation Wave Scenarios and Potential for CO_2 Savings until 2050. *Energies* **2021**, *14*, 2455. https://doi.org/10.3390/en14092455

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