



Centrum pro otázky  
životního prostředí  
Univerzita Karlova v Praze

# **EXTERNAL COSTS OF BREACHING THE REGIONAL ECOLOGICAL LIMITS IN THE NORTH BOHEMIAN BROWN COAL BASIN**

## **THE CASE OF CSA AND BILINA OPENCAST MINES**



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# STRUCTURE OF THE PRESENTATION

1. Assignment of the study
2. Regional ecological limits
3. Methodology used for calculation of external costs
4. Presentation of estimated external costs
5. Summary and results' discussion

# ASSINGMENT OF THE STUDY (1)

## What the study deal with

- The study quantifies social impacts (so called external costs) from burning coal, which is located beyond the regional ecological limits in the opencast mines Bílina and Československé armády (ČSA), in the Czech power plants and heating plants.
- The study covers mainly the following impacts:
  - on human health (increased morbidity, reduction in life expectancy)
  - on agricultural production
  - damages due to climate change
  - damage to building materials
  - loss of biodiversity
  - effect of heavy metals on human health

# ASSINGMENT OF THE STUDY (2)

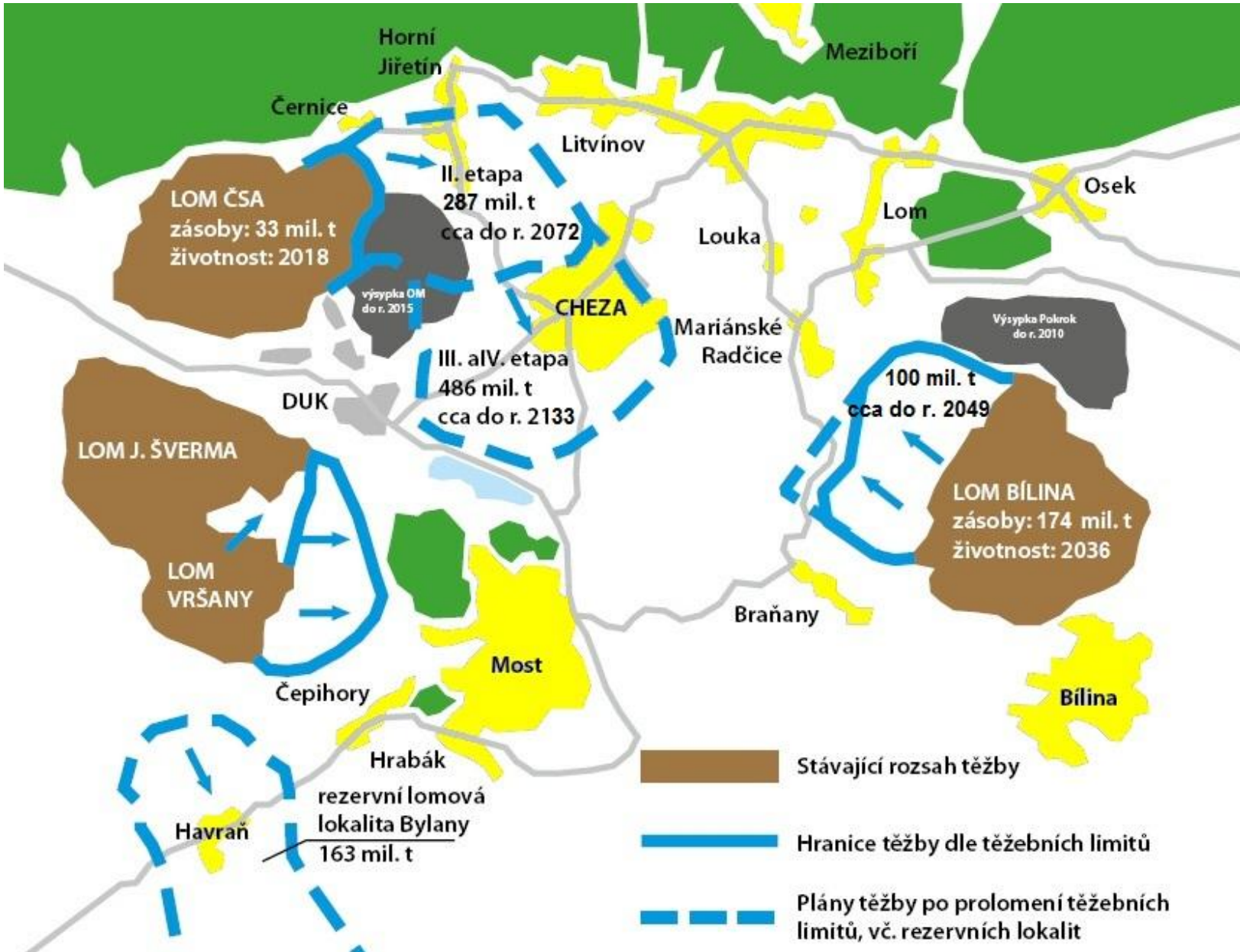
## What the study doesn't deal with

- Other external costs:
  - impacts from the mining itself (e.g. noise, air pollution, resettlement)
  - impacts from the processing and transport of coal
- Private costs from breaching the limits:
  - costs of mining companies for the redemption of land, opening the mines, operation of mines or recultivation
  - costs on electricity and heat production, transmission and distribution of energy
- Economic benefits from breaching the limits:
  - maintaining jobs in the mining and heat supply industry
  - maintaining the stability of the domestic security in energy supply

# REGIONAL ECOLOGICAL LIMITS (ÚEL)

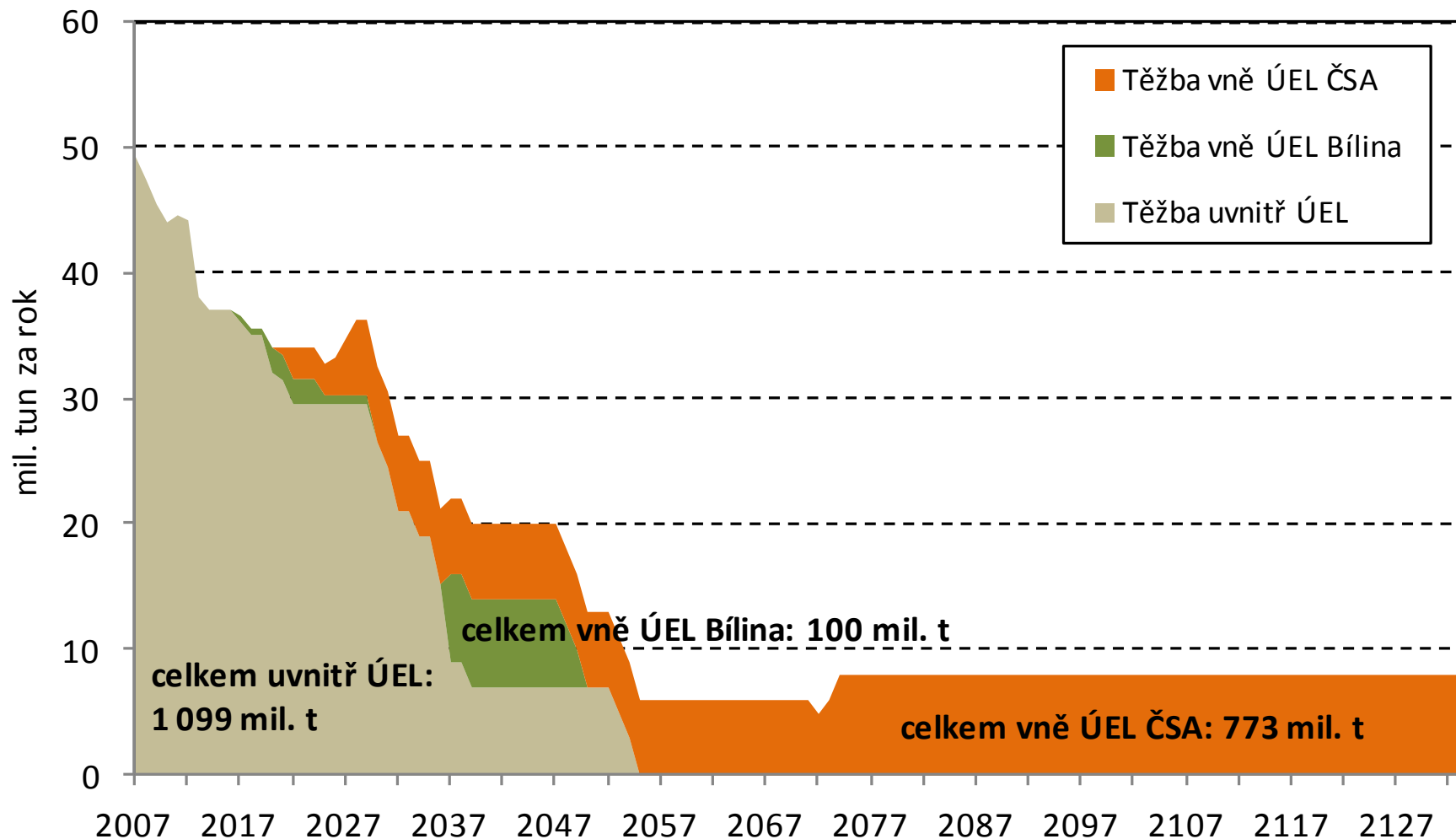
- ÚEL „*set the binding lines on limits of mining, beyond which natural ecosystems and urban settlements must not be disturbed and destroyed...*”(Ludvík 2010)
- ÚEL primarily relate in the North Bohemian Brown Coal Basin (NBBCB):
  - Resolution of the Czech Government # 444 from 30 of October, 1991, to report on the regional ecological limits of coal mining and energetics in NBBCB
  - Resolution of the Czech Government # 1176 from 10 of September, 2008, to the regional ecological limits on mining of brown coal in NBBCB
- Breaching of ÚEL mainly refers to these mining sites:
  - **opencast mine Československé armády (ČSA)** – which is operating by energy group Czech Coal (Litvínovská uhelná a.s.)
  - **Opencast mine Bílina** – which is operating by mining company Severočeské doly, a. s., owned by ČEZ, a.s.
- **Around 873 mil. tonnes of brown coal is located beyond ÚEL**

# GEOGRAPHICAL BOUNDARIES OF THE REGIONAL ECOLOGICAL LIMITS AT THE MOSTECKÝ REGION



Source: adjusted according to Kořeny (2012) and Invicta Bohemica (2010, in VŠE 2011)

# ANNUAL BALANCE OF BROWN COAL MINING WITHIN AND BEYOND THE REGIONAL ECOLOGICAL LIMITS (IN MIL. TONNES PER YEAR)



Source: adjusted according to Invicta Bohemica (2010, in VŠE 2011)

# DEFINITION OF EXTERNAL COSTS

An external cost arises, when the social or economic activities of one group of persons have an impact on another group and when that impact is not fully accounted, or compensated for, by the first group.

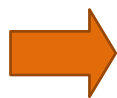
- physical change influences welfare or profit
- effect is not compensated
- effect is not caused through market (or prices), but directly





# METHODOLOGY USED – IMPACT PATHWAY ANALYSIS

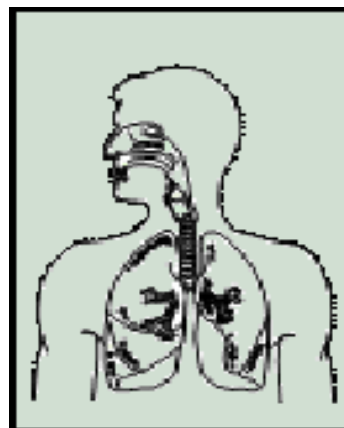
Release of emissions



Transport & chemical transformation



Physical impacts



Monetary valuation



- ExternE (*Externalities of Energy*) methodology  $\Rightarrow$  is developed and used over 20 years in the European research projects for monetary valuation of external costs arising from electricity and heat production (more [www.externe.info](http://www.externe.info))
- Based on the impact pathway analysis (*Impact Pathway Approach, IPA*)  $\Rightarrow$  analysis of externalities from bottom up, so called *bottom-up* approach

Source: European Commission (2005)

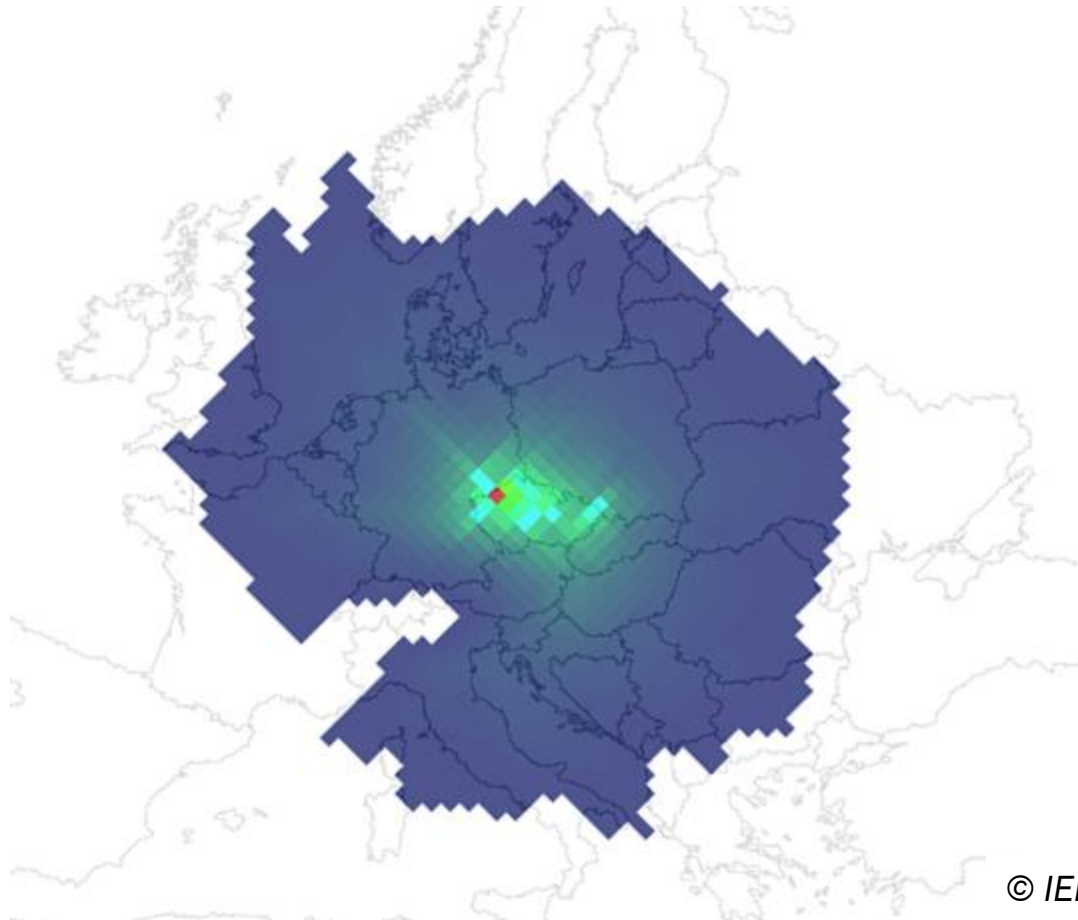
# BACKGROUND FOR EXTERNAL COSTS' CALCULATION (I)

- The demand structure of brown coal usage beyond the limits  $\Rightarrow$  planned consumption for energy and heat purposes estimated by Invicta Bohemica (2010)
- **Emission characteristics** for power and heating plants
  - Classical airborne pollutants  $\text{SO}_2$ ,  $\text{NO}_x$  and PM
  - Marginal values of emissions according to EU Directive (2010/75/EU) on industrial emissions (Appendix V, part 2)
- Calculation of emissions on **NMVOC and heavy metals** (Cd, Hg, Pb, As, Cr, Cr-VI, Ni)
  - Emission factors from the manual on airborne pollutants inventory EMEP/EEA for energetics – burning (EMEP/EEA 2010)
- Atmospheric dispersion of pollutants and calculation of external costs  $\Rightarrow$  **software EcoSenseWeb 1.3** (<http://ecosenseweb.ier.uni-stuttgart.de/>)
  - Local, regional and North-hemispheric module
  - Emission scenario for 2020, meteorological year – future

# BACKGROUND FOR EXTERNAL COSTS' CALCULATION (II)

- Valuation of damages related to **greenhouse gas emissions** (CO<sub>2</sub>)
  - Based on marginal damage cost approach ⇒ conservative values from the European project NEEDS (Anthoff 2008)
  - Estimates derived from model FUND 3.0 ⇒ integrated impact assessment model on climate change impacts <http://www.fund-model.org/>
  - Premature deaths due to heat stress, infections, migration due to sea level rise, impacts on energy consumption, agriculture, water resources and ecosystems

# ATMOSPHERIC DISPERSION MODELLING OF PARTICULATE MATTERS PM<sub>10</sub> USING EcoSenseWeb V1.3 (v $\mu\text{g}/\text{m}^3$ )

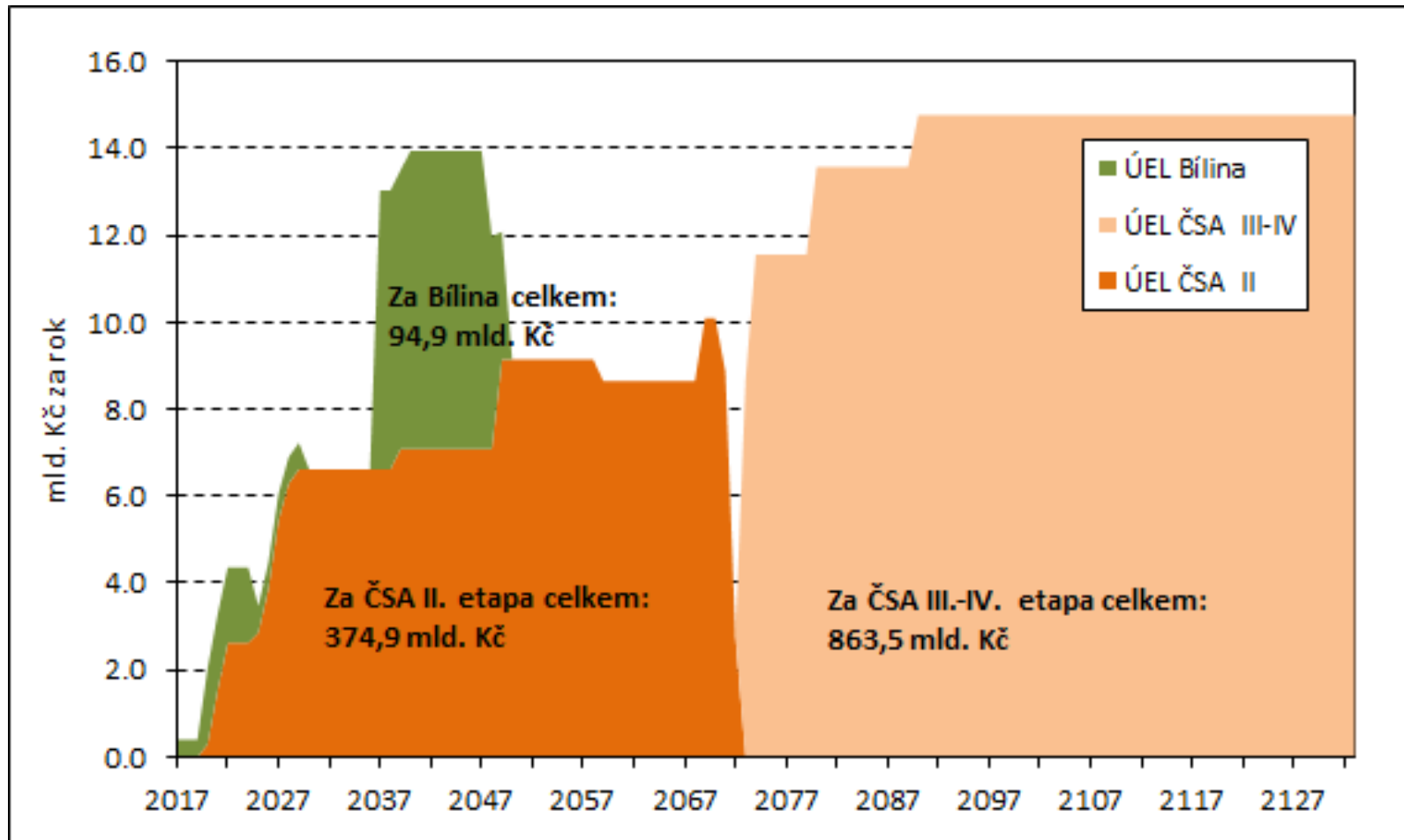


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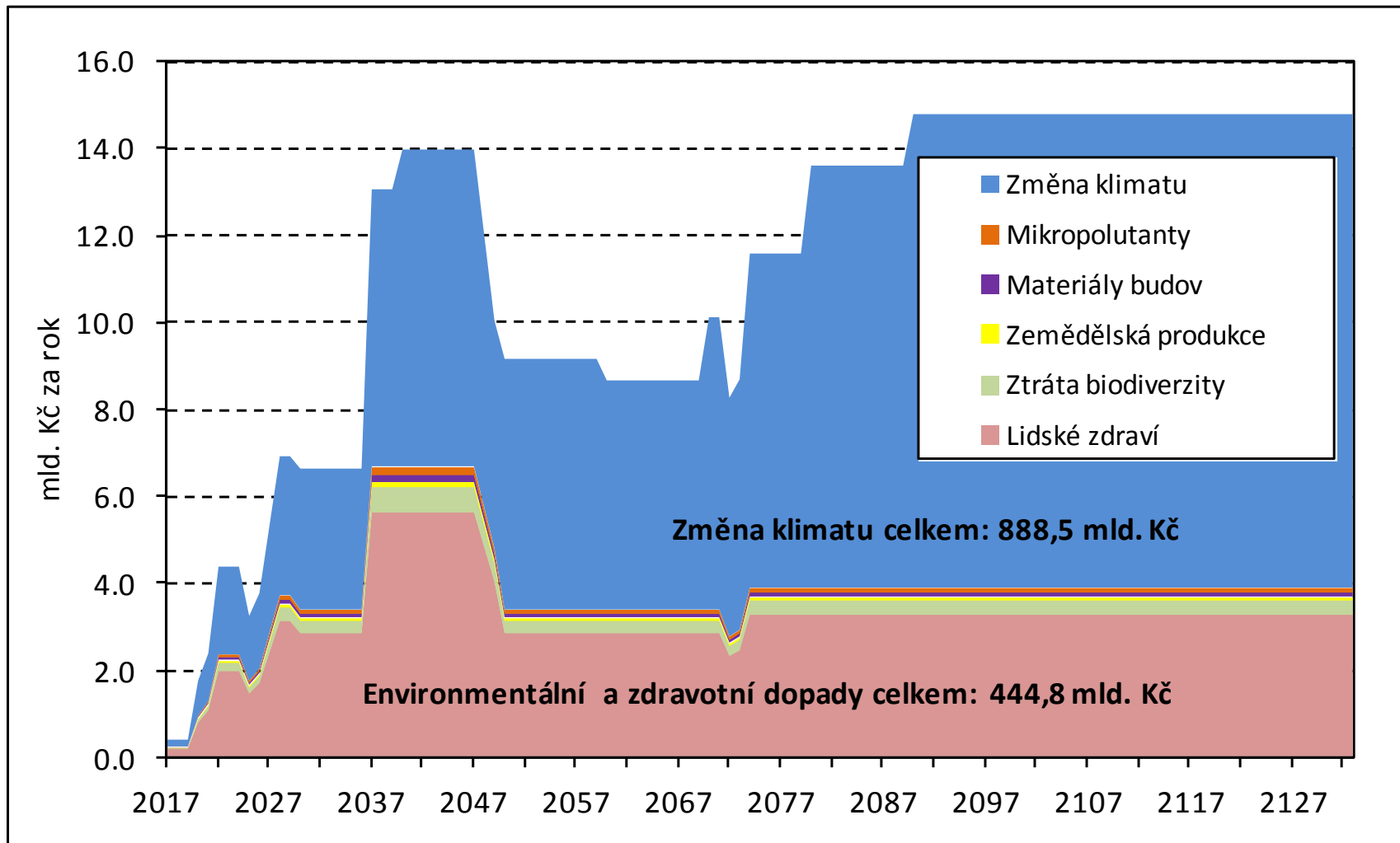


# EXTERNAL COSTS OF ELECTRICITY AND HEAT PRODUCTION FROM COAL LOCATED BEYOND THE LIMITS FOR BÍLINA AND ČSA MINES (IN BILL. CZK, 2011 PRICES)

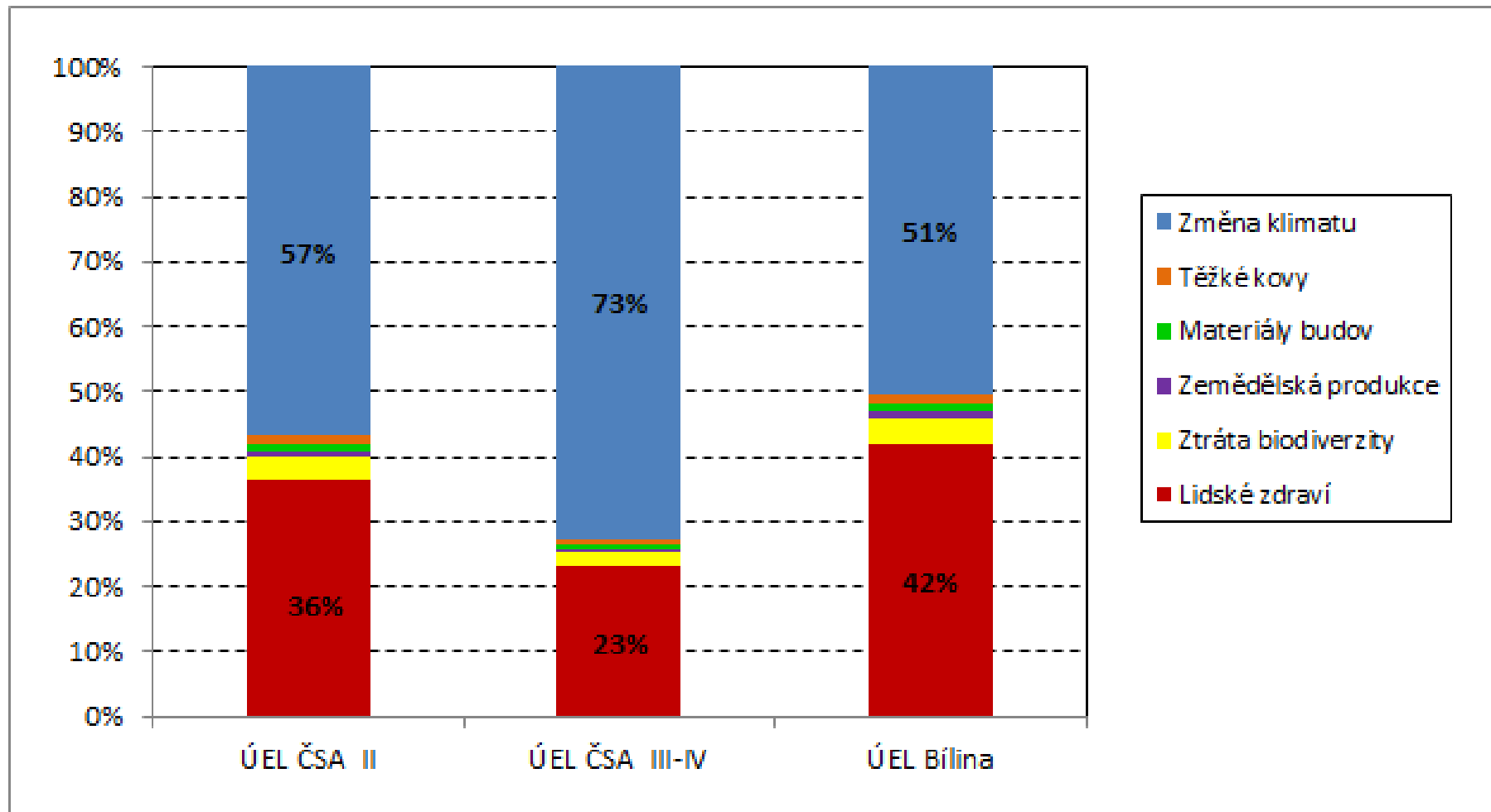
External costs in total  $\Rightarrow$  1.33 trillions CZK in the period 2017-2133



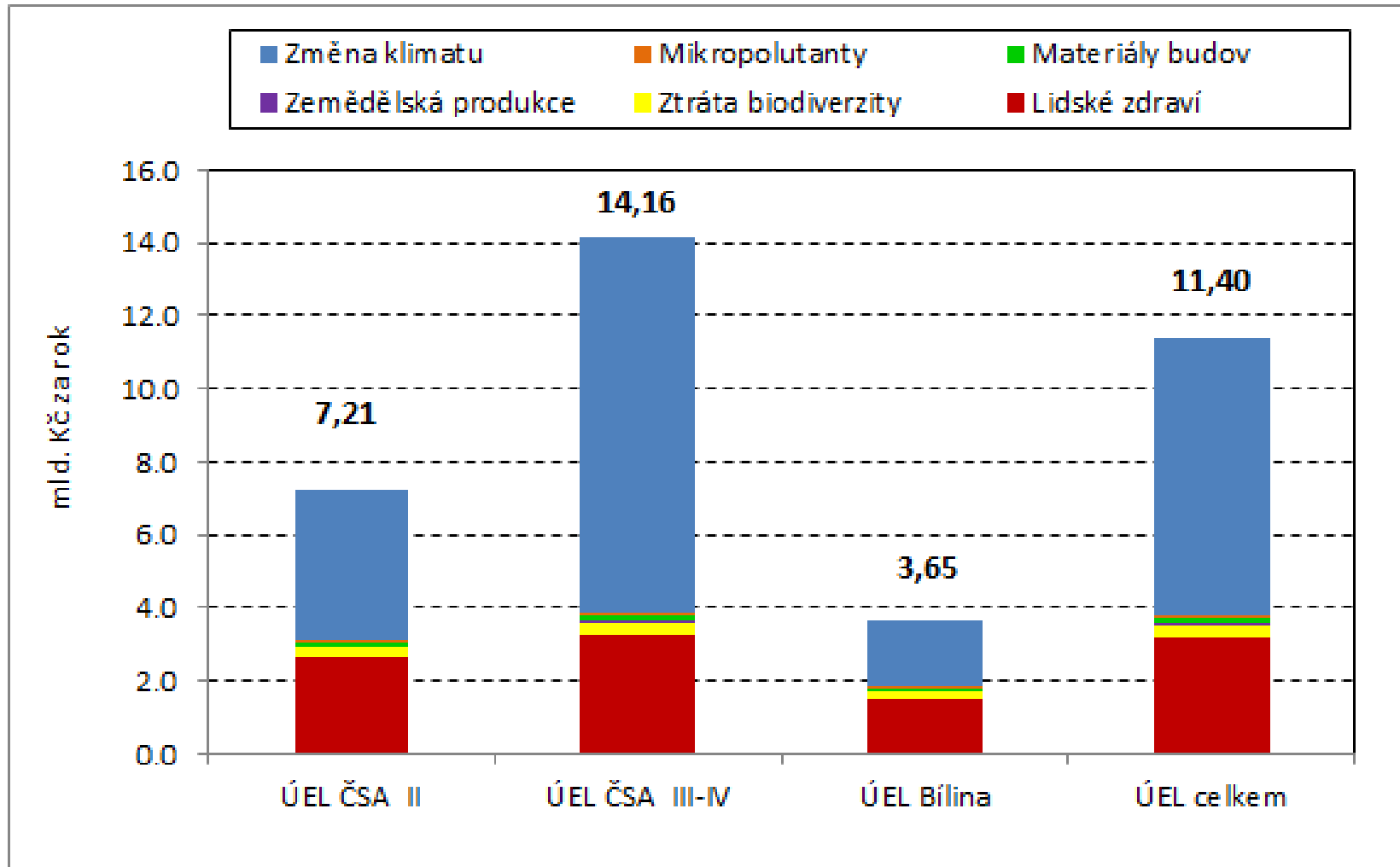
# ANNUAL BALANCE OF EXTERNAL COSTS INCLUDING DAMAGES RELATED TO CLIMATE CHANGE (IN BILL. CZK, 2011 PRICES)



## RELATIVE PROPORTION OF EACH IMPACT CATEGORY ON THE STRUCTURE OF ESTIMATED EXTERNAL COSTS (IN %)

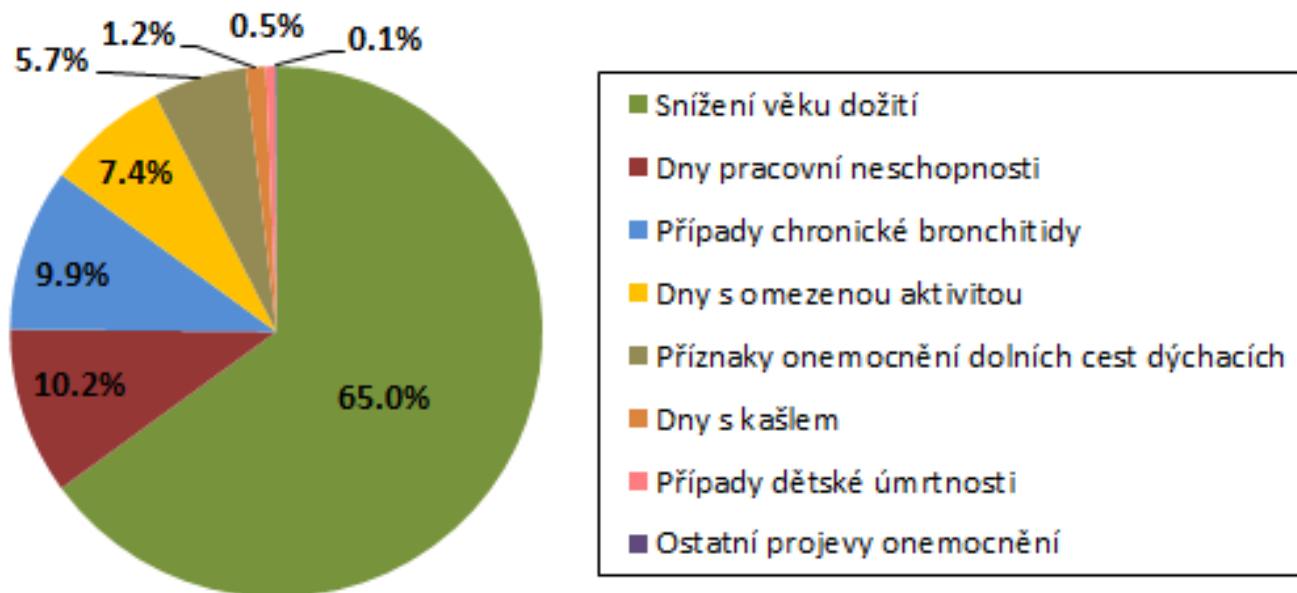


# ANNUAL AVERAGE EXTERNAL COSTS OF ELECTRICITY AND HEAT PRODUCTION FROM COAL LOCATED BEYOND THE LIMITS FOR BÍLINA AND ČSA MINES (IN BILL. CZK, 2011 PRICES)





## RELATIVE PROPORTION OF EACH MORBIDITY AND MORTALITY CATEGORY ON THE STRUCTURE OF ESTIMATED HUMAN HEALTH IMPACTS (IN %)



Human health impact	Unit	Impact
Cases of chronic bronchitis	cases	8 820
Hospitalization with heart diseases	cases	2 064
Hospitalization with respiratory diseases	casee	4 417
Days of sick leave	days	6 126 821
Reduction in life expactancy	years	287 957

# 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 be 13 mill. tonnes
  - emission of CO<sub>2</sub> more than 1.34 mil. kilotonnes
  - emission of SO<sub>2</sub> (716 thous. tonnes), NO<sub>x</sub> (869 thous. tonnes), PM (47 thous. tonnes)

# CONCLUSIONS

- The study deals only with a partial impact due to the breaching of ÚEL
  - doesn't cover either mining itself (external and private costs), private costs of electricity and heat production, or benefit from breaching the limits (private and external benefits)
- The estimated impacts are, however, substantial

**Broader context of externalities is → valuation of social costs and benefits**

*(Cost-Benefit Analysis, CBA)*

- We should consider all quantifiable costs and benefits
- Introducing of *status quo* option without breaching of ÚEL)
- Modelling the impacts of different scenarios on energy sector and the whole economy
- CBA is one of the main methods used in **Regulatory Impact Assessment (RIA)**

# CONTACT INFORMATION

## Research team

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# **ADDITIONAL SLIDES**

# UVAŽOVANÁ TĚŽBA ZA HRANICÍ ÚEL VELKOLOMU ČSA A BÍLINA VČETNĚ PARAMETRŮ UHLÍ V TĚŽEBNÍCH LOKALITÁCH

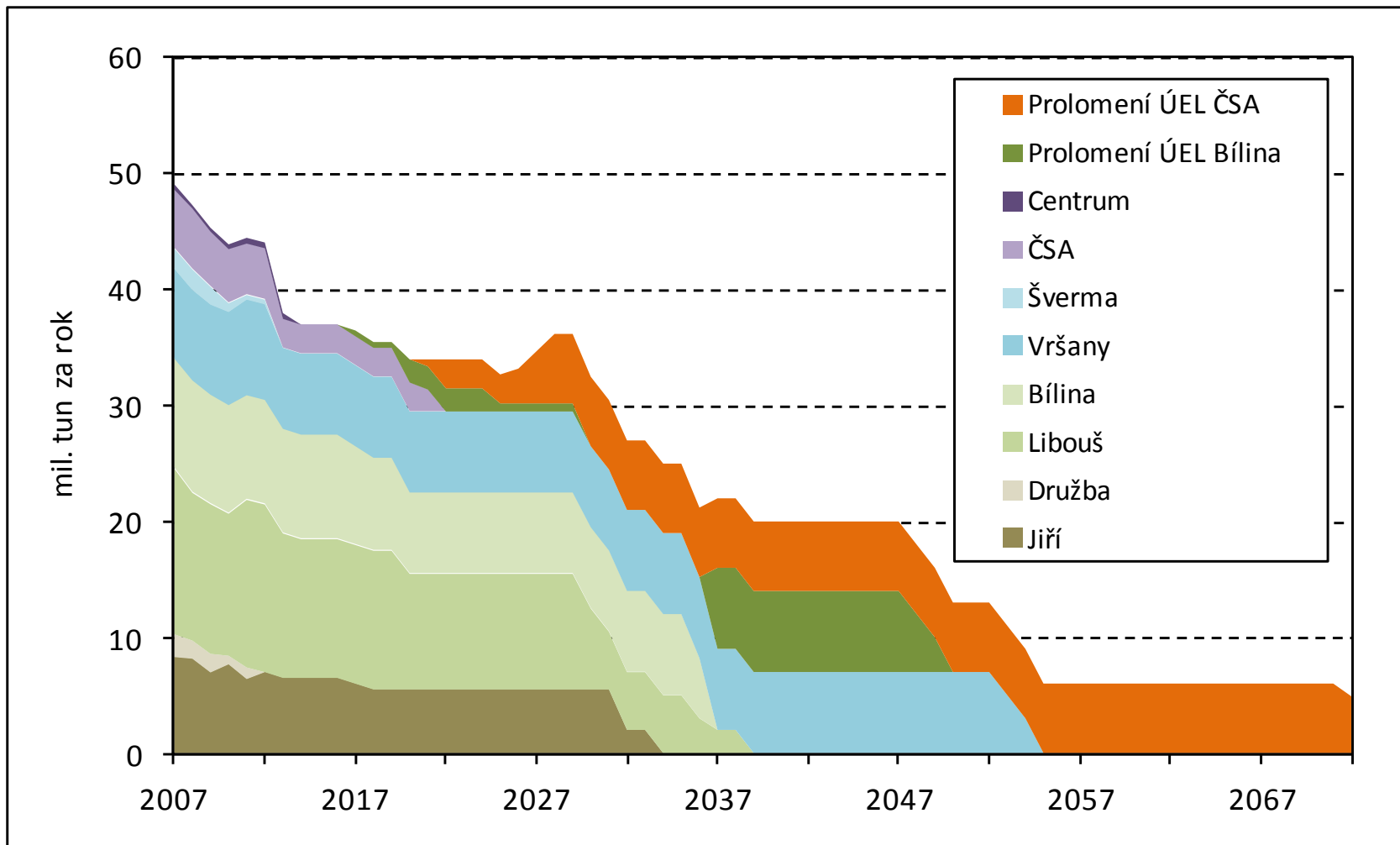
	Jednotky	ČSA II. etapa	ČSA III.–IV. etapa	Bílina
Využitelné uhelné zásoby	<i>mil. tun</i>	287	486*	100
Průměrná roční těžba	<i>mil. tun</i>	6	8	7
Začátek těžby		2021	2073	2017
Konec těžby		2072	2133	2049
Životnost ložiska		52	61	33
Výhřevnost	<i>MJ.kg<sup>-1</sup></i>	17.5	15	14.5

Zdroj: Invicta Bohemica (2010, in VŠE 2011), Slivka a kol. (2011)

Poznámka: \*305 mil. tun III. etapa, 181 mil. tun IV. etapa (Musil 2010)

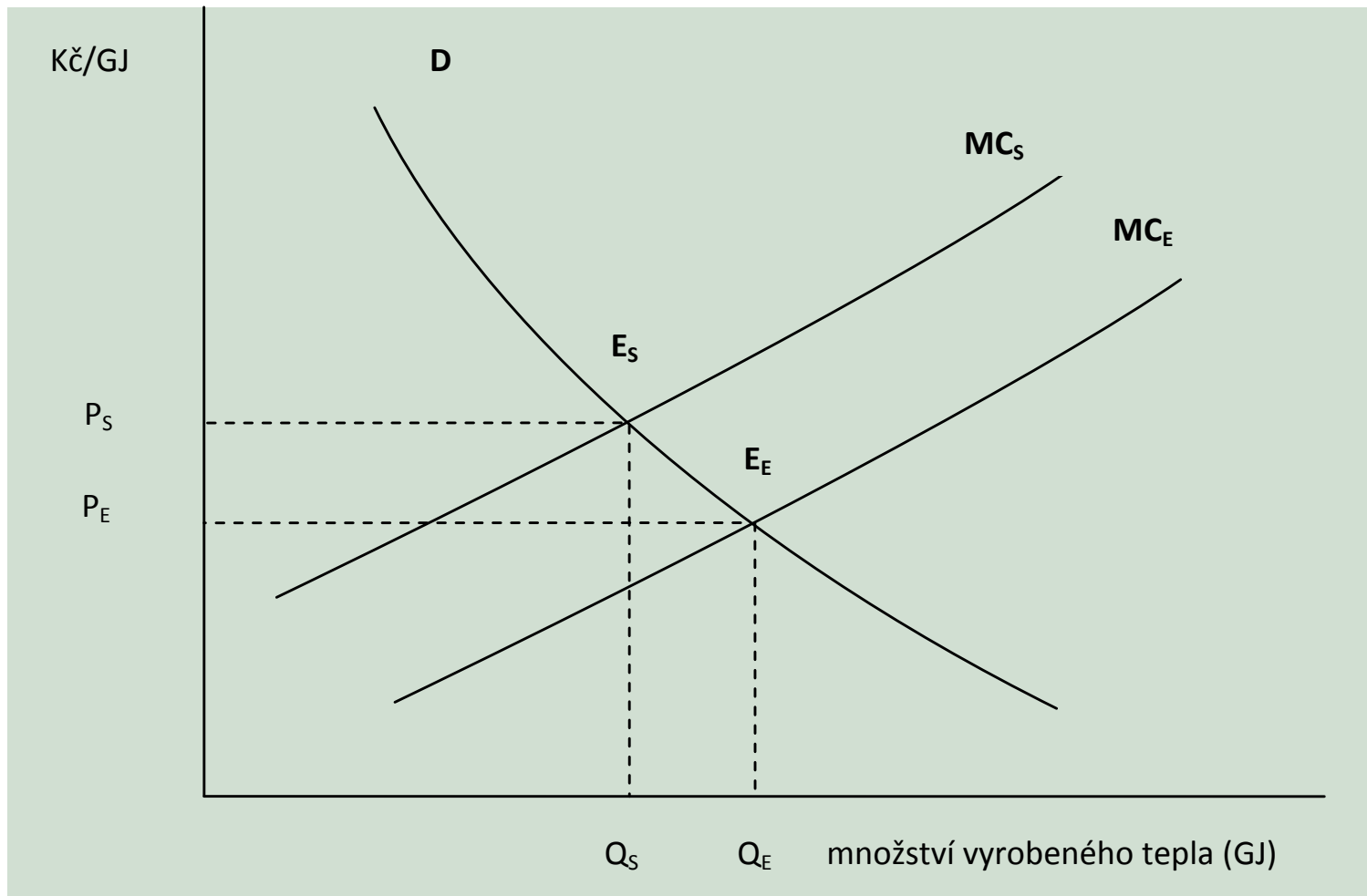
# ROČNÍ BILANCE TĚŽBY HNĚDÉHO UHLÍ NA JEDNOTLIVÝCH AKTIVNÍCH LOMECH UVNITŘ A VNĚ ÚEL PRO OBDOBÍ 2007–2072

(V MIL. TUN ZA ROK)



Zdroj: upraveno podle Invicta Bohemica (2010, in VŠE 2011)

# CELKOVÉ SPOLEČENSKÉ NÁKLADY VÝROBNÍ ČINNOSTI



Zdroj: upraveno podle Holmana (2002)



## PARAMETRIZOVANÉ HODNOTY EXTERNÍCH NÁKLADŮ NA 1 TUNU ŠKODLIVINY

Škodlivina	EURO(2000).t <sup>-1</sup>	Kč(2011).t <sup>-1</sup>
Cd	39 000	806 737
Hg	8 000 000	165 484 504
Pb	600 000	12 411 338
As	80 000	1 654 845
Cr	31 500	651 595
Cr-VI	240 000	4 964 535
Ni	4 000	82 742

Zdroj: upraveno podle Preisse a Klotze (2008)

## DOLNÍ INTERVAL ODHADU SPOLEČENSKÝCH NÁKLADŮ ZMĚNY KLIMATU

Období	EUR(2000).t <sup>-1</sup> CO <sub>2</sub>	Kč(2011). t <sup>-1</sup> CO <sub>2</sub>
2000–2009	6,96	144
2010–2019	10,54	218
2020–2029	13,67	283
2030–2039	15,21	315
2040–2049	17,39	360
2050–2059	27,06	560
2060–2069	24,73	512
2070–2079	31,56	653
2080–2089	39,87	825
>2090	44,73	925

Zdroj: upraveno podle Anthoffa (2008)

# PARAMETRY MODELOVÝCH SCÉNÁŘŮ PRO VÝPOČET EXTERNÍCH NÁKLADŮ PROLOMENÍ ÚEL

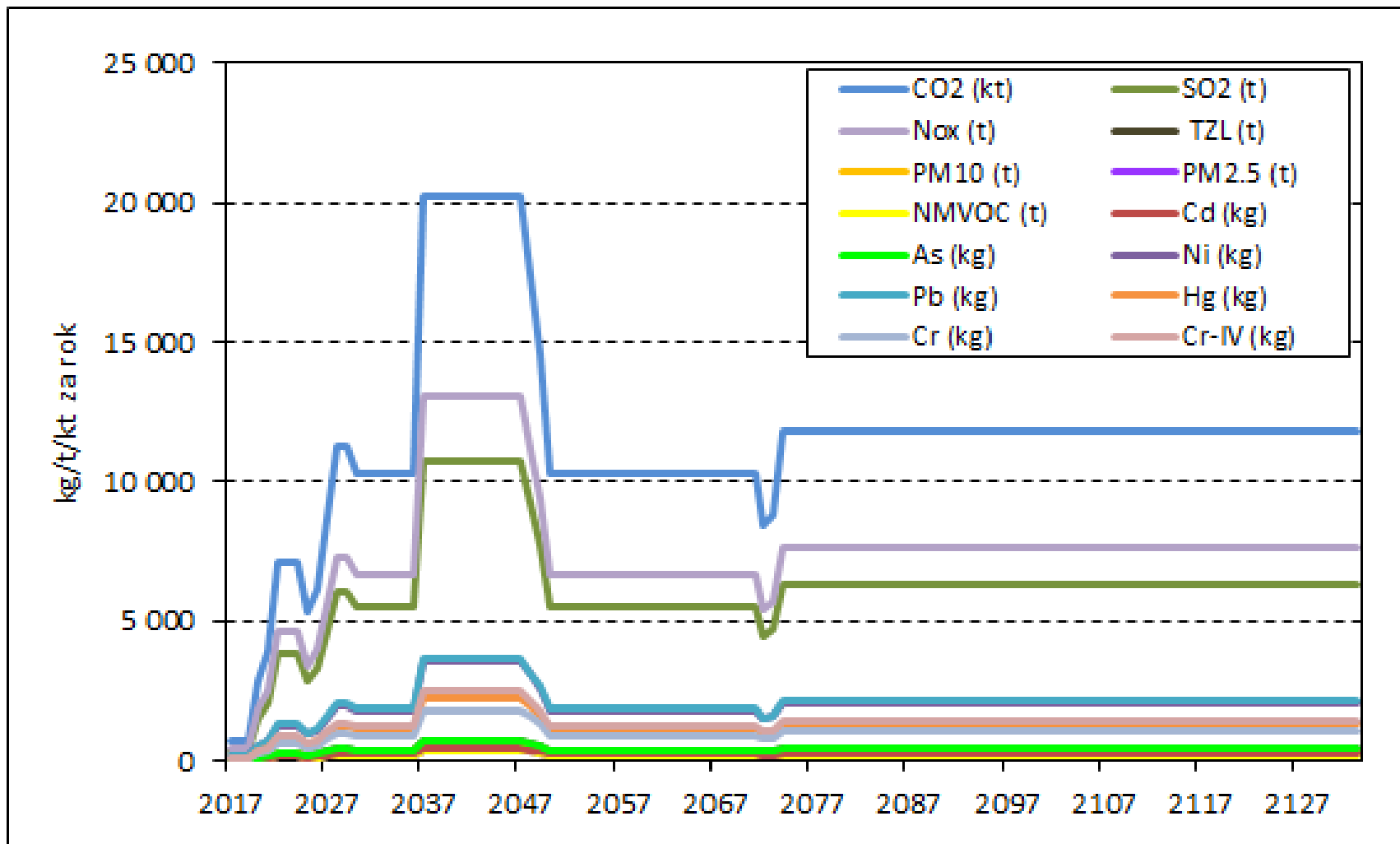
	Fluidní topeniště	Práškové uhlí	SO <sub>2</sub>	NO <sub>x</sub>	TZL	PM <sub>10</sub>	PM <sub>2.5</sub>	Podíl na spotřebě uhlí
<b>Scénář 1</b>								
>300		x	150	200	10	9.1	5.6	75.01%
>300	x	x	200	200	10	8.5	4.1	10.95%
>300	x		200	150	10	8.5	4.1	4.79%
101–300			200	200	20	18.2	11.2	8.12%
50–100		x	400	400	20	18.2	11.2	1.00%
50–100			400	300	20	18.2	11.2	0.13%
<b>Scénář 2</b>								
101–300			200	200	20	18.2	11.2	87.83%
50–100		x	400	400	20	18.2	11.2	10.81%
50–100			400	300	20	18.2	11.2	1.35%
<b>Scénář 3</b>								
50–100		x	400	400	20	18.2	11.2	88.89%
50–100			400	300	20	18.2	11.2	11.11%
<b>Scénář 4</b>								
>300			100	100	10	9.1	5.6	90.75%
101–300			150	150	10	9.1	5.6	8.12%
50–100			300	250	10	9.1	5.6	1.13%

Zdroj: směrnice 2010/75/EU, MŽP (2011a)

## CELKOVÉ MNOŽSTVÍ EMISÍ V DŮSLEDKU VÝROBY ELEKTŘINY A TEPLA Z UHLÍ VNĚ ÚEL ZA VELKOLOM ČSA A BÍLINA

Škodlivina	Jednotky	ÚEL ČSA II	ÚEL ČSA III-IV	ÚEL Bílina	ÚEL celkem
CO <sub>2</sub>	kt	492 155	714 347	142 086	1 348 587
SO <sub>2</sub>	t	261 010	379 693	75 848	716 552
NO <sub>x</sub>	t	316 432	460 850	91 953	869 235
TZL	t	17 308	25 198	5 030	47 536
PM <sub>10</sub>	t	15 580	22 681	4 528	42 789
PM <sub>2.5</sub>	t	9 318	13 564	2 708	25 591
NMVOC	t	8 538	12 378	2 465	23 381
Cd	kg	10 547	15 290	3 045	28 882
Hg	kg	17 579	25 483	5 075	48 137
Pb	kg	86 387	125 231	24 940	236 558
As	kg	88 396	128 144	25 520	242 060
Cr	kg	54 745	79 362	15 805	149 912
Cr-VI	kg	43 796	63 489	12 644	119 930
Ni	kg	59 266	85 914	17 110	162 290

# ROČNÍ BILANCE EMITOVANÝCH ŠKODLIVIN V DŮSLEDKU VÝROBY ELEKTŘINY A TEPLA Z UHLÍ VNĚ ÚEL ZA VELKOLOM ČSA A BÍLINA (V KG / T / KT ZA ROK)



# REGIONÁLNÍ ROZLOŽENÍ DOPADŮ

PODÍL Z CELKOVÉHO DOPADU V JEDNOTLIVÝCH ZEMÍCH REGIONU EVROPY

