



EVROPSKÁ UNIE



MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY



OP Vzdělávání
pro konkurenceschopnost



INVESTICE
DO ROZVOJE
VZDĚLÁVÁNÍ

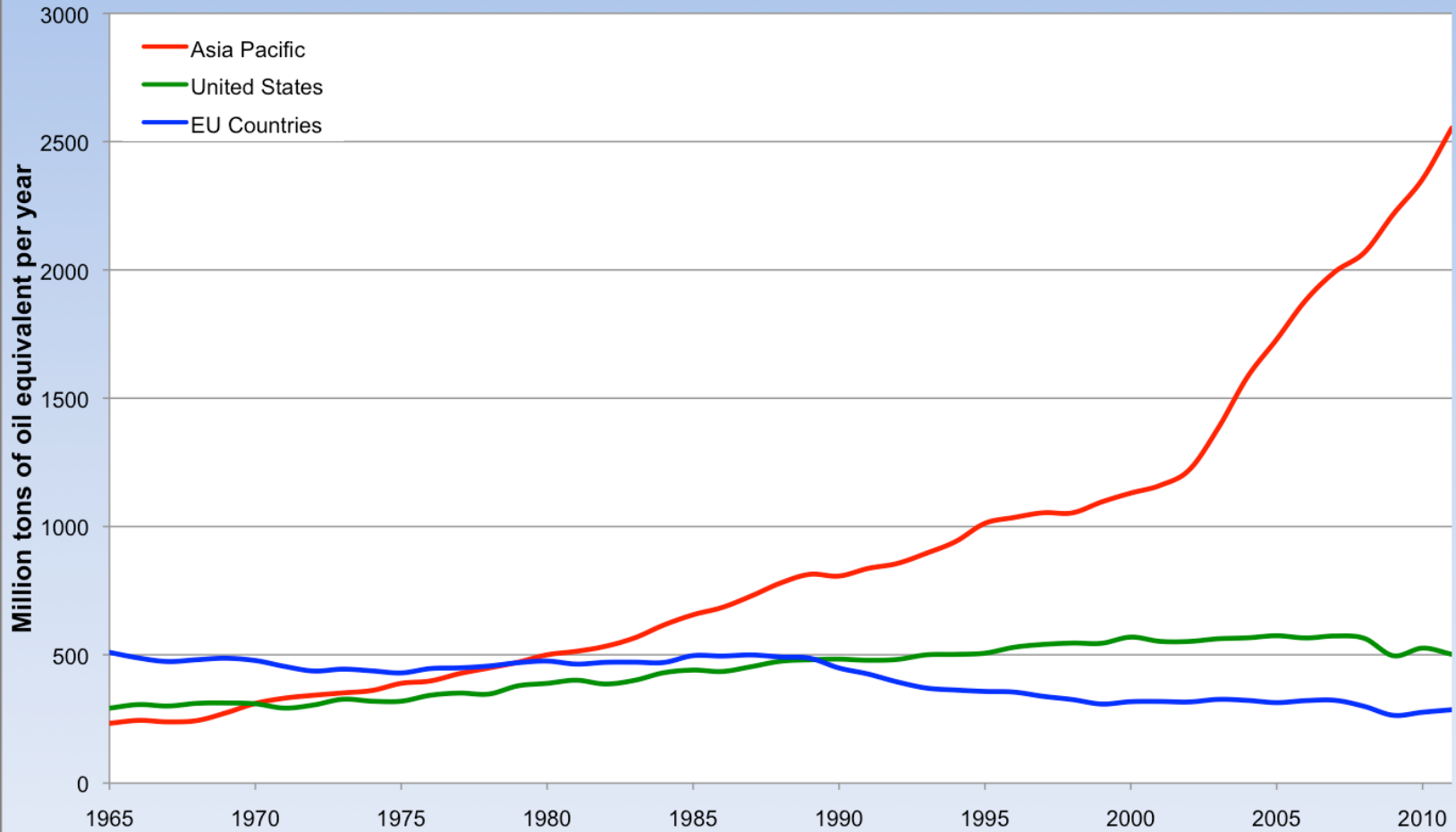
FOSSIL FUELS: COAL

Filip Černoch

FSS MU

ESS411 Environmental aspects of energy

Coal Consumption 1965-2011



Data source: 2012 BP Statistical Review of World Energy

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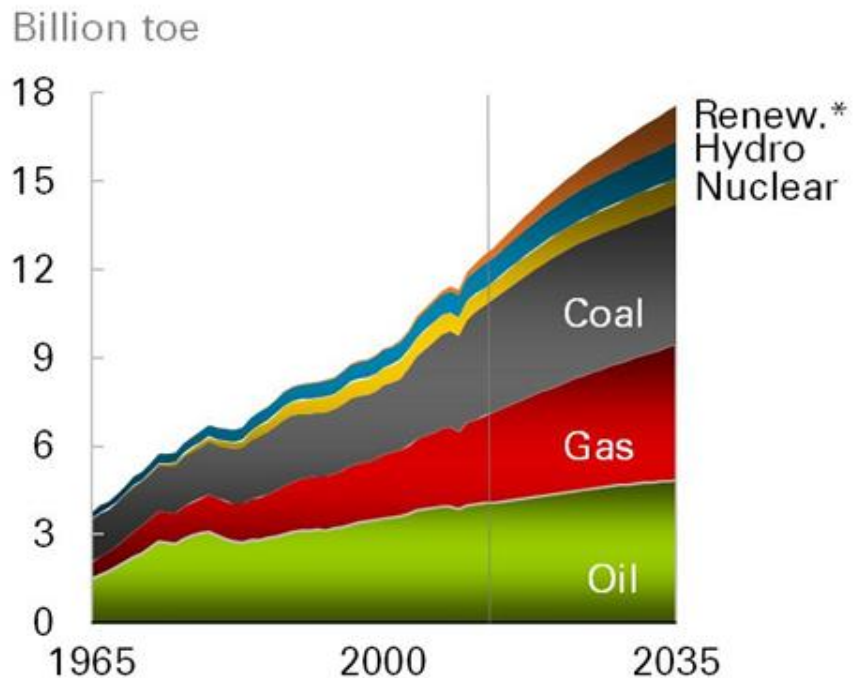


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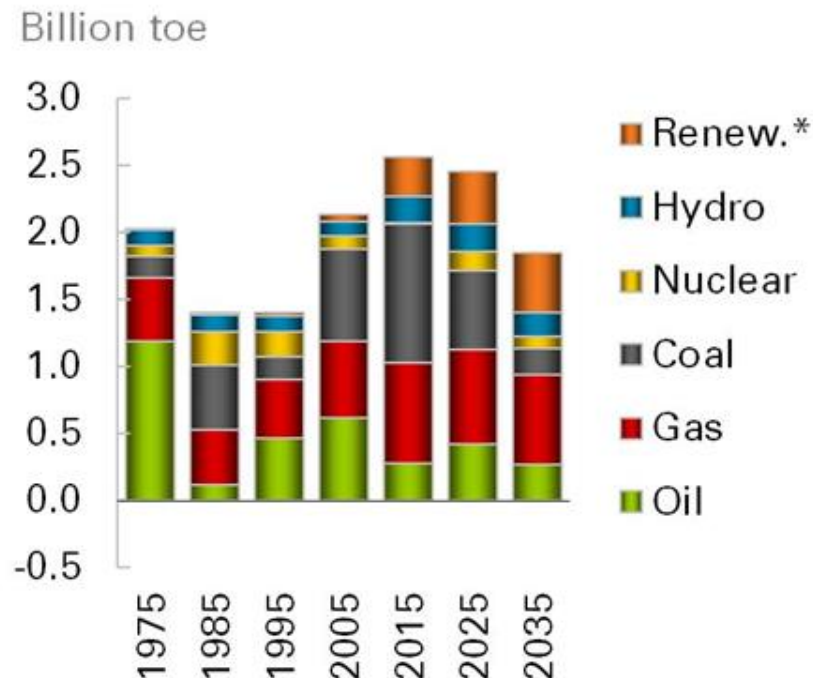


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Consumption by fuel



Ten year increments by fuel



*Includes biofuels

Energy Outlook 2035

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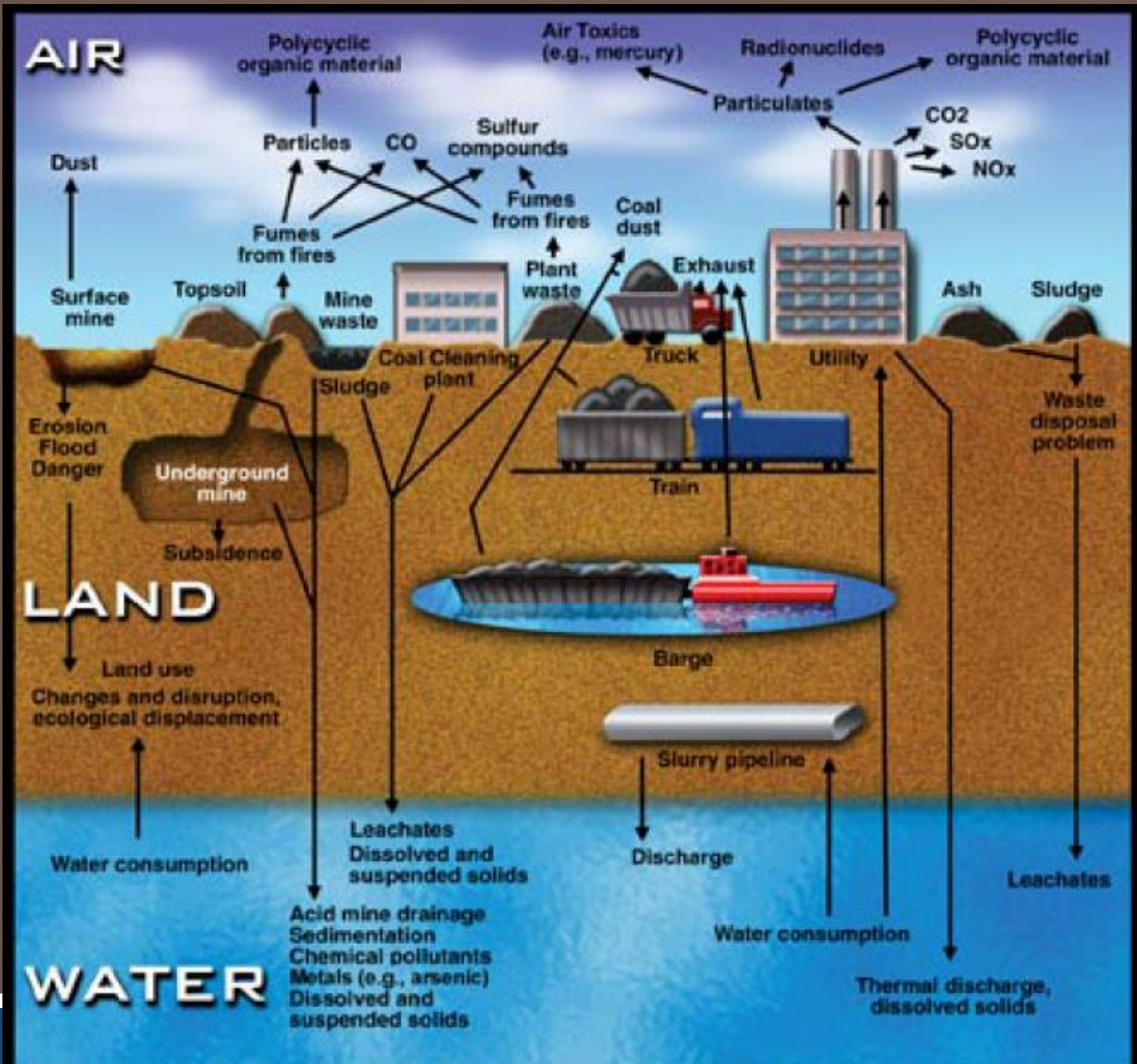
History of coal usage

- The first known depleted coal mine Fu Shun in China in 1000 BC. 300 BC Theophrastus described combustion of coal in Greece. Romans used coal in 400BC.
- Coal substituted wood (charcoal) in glass and metal production – first energy revolution.
- Deforestation of London surroundings in 1200, by 1500 production moved to Ireland, Scotland, Wales.
- Coal depletion at Newcastle upon Tyne – spreading the mining activities across the country, new professions emerged.
- 1352 coal the very first internationally traded commodity.
- Start of industrial revolution, steam engine, production of steel, coke.
- In navy shift from sails to steam.
- In 1910 coal represented 60% of world energy mix, declining between world wars.

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Environmental impacts

- Mining (opencast/surface m.) – land use, water and air pollution, dust. Impact on biotops and landscape. Noise. Aesthetical damages.
- Preparation for further processing – removal of impurities – acids, heavy metals, chemicals are released.
- Transport – dust from coal, transport-related pollution.
- Workers – exposition to the dust and chemicals, mining risks.
- Coal combustion – GHG, primary pollutants, smog, acid rains.
- Solid waste – ash.

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Combustion of coal

Carbon	Carbon reacts with oxygen, producing CO ₂ and CO.	CO ₂ (Carbon dioxide) – main GHG CO (Carbon monoxide) – produced when there is not enough oxygen to produce CO ₂ . Imperfect combustion, mainly in transport (in cities), metalurgical processes, chemical production, wood combustion at home. Inversion → smog.
Hydrogen	H reacts with O producing wated	
Nitrogen	N turns to Nitrogen monoxide NO and Nitrogen dioide.	NO _x – produced by engines, during industrial processes and combustion of fossil fuels.
Sulphur	Turns to Sulphur dioxide.	SO ₂ – in oil, coal, metal ores. Produced by combustion of fossil fuels, during oil refining or in metalurgy. It is a precursor for acid rain and atmospheric particulates.
Oxygen		
Other elements		Nickel, mercury, arsen, chromium, cadmium, lead, florine, chlorine.
		<p>Particular matters, PM</p> <p>Primary – from combustion, directly to atmosphere. Coarse-grained particles.</p> <p>Secondary – produced in atmosphere from gaseous emissions. Sulphates from SO₂ from power plants and industry instalations, nitrates from NO_x from power plants, cars and other combustion processes, soot from organic emission from cars and industrial instalations</p>

CO	Visual impairment, reduced work capacity, reduced manual dexterity, poor learning ability, difficulty in performing complex tasks.
S02	Can affect respiratory system and lung functions, aggravation of asthma and chronic bronchitis, makes people more prone to infections of the respiratory tract; irritation of eyes; cardiac disease aggravated ; ischemic stroke risk
Nitrogen monoxide NO and Nitrogen dioxide.	Asthma development (suspected), asthma exacerbation, chronic obstructive pulmonary disease, stunted lung development; cardiac arrhythmias, ischemic stroke. Reacts with VOCs in sunlight to form ground- level ozone Increases an amount of nitrogen in soil and country – change of diversity. In aquasystems causes eutrofization. Increases acidity of soil and water.
PM	Respiratory: asthma development (suspected), asthma exacerbation, chronic obstructive pulmonary disease, stunted lung development (PM2.5), lung cancer; Cardiovascular: cardiac arrhythmias, acute myocardial infarction, congestive heart failure (PM2.5). Nervous system: ischemic stroke.

Secondary pollution

- London smog
 - Smoke and fog, typically in winter (combination with inversion). $\text{SO}_2 + \text{PM} =$ transport of gaseous matters of smog to the lungs.
 - <http://www.youtube.com/watch?v=bSlwGIapFJI>
- Photochemical smog
 - Primary pollutants ($\text{NO}_x + \text{Volatile Organic Compounds}$ created during fossil fuel combustion) interacts under the influence of sunlight = ozone O_3 plus other pollutants.
 - Ozone – bronchial constriction, coughing, wheezing, respiratory irritation, eye irritation, decreased crop yields, retards plant growth, damages plastics,...
 - Directly impacts 30 % of city population, 20 000 premature deaths. .
- Acid rains
 - Acidic rains caused by emissions of sulfur dioxide and nitrogen oxide = with water produce acids.

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Emissions	Amount of pollutants (in tons per 1TWh – 1000MW plant for 1000hrs)
SO ₂	2600
NO _x	2800
CO ₂	1 200 000

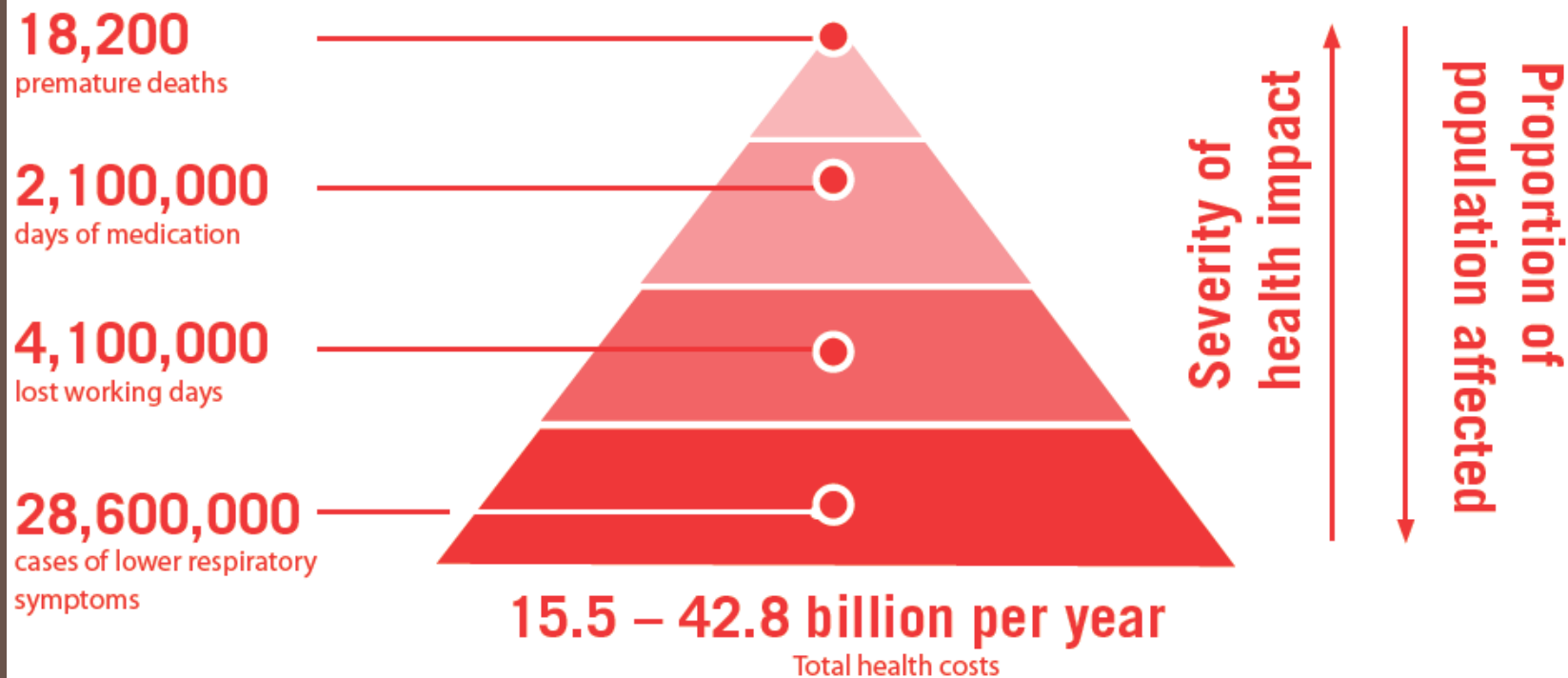
Typical 1000MW coal power plant= 6 million tons CO₂ per year = ekvivalent of 2 million cars. Plus 2 670 000 ton of ash.

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Health impacts



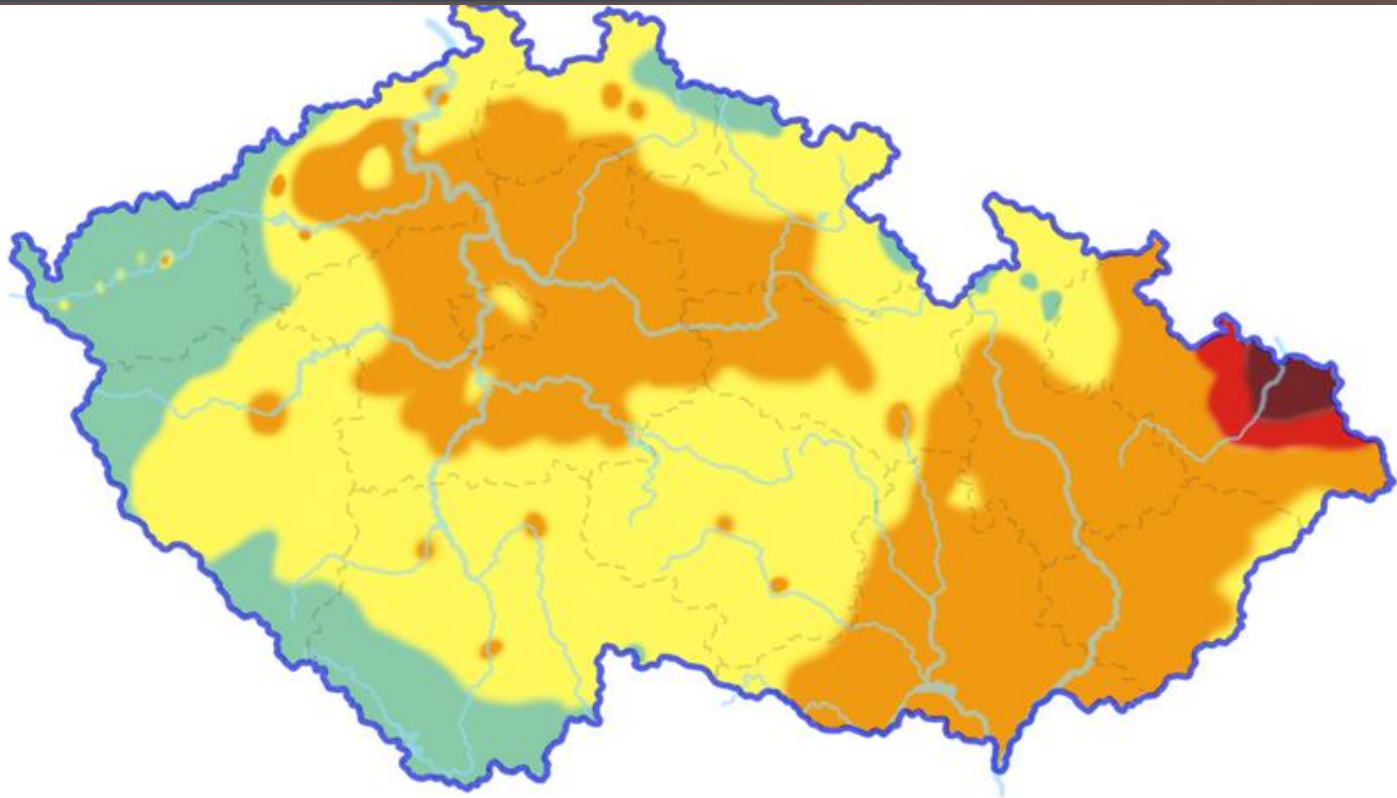
Annual health impacts caused by coal power plants in the EU (27 countries)

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PM in ČR



Průměrná roční koncentrace pevných částic PM_{2,5} v ovzduší v Česku v roce 2011

-  < 12 µg/m³
-  12–17 µg/m³
-  17–25 µg/m³
-  25–30 µg/m³
-  > 30 µg/m³
-  hranice krajů/border of regions

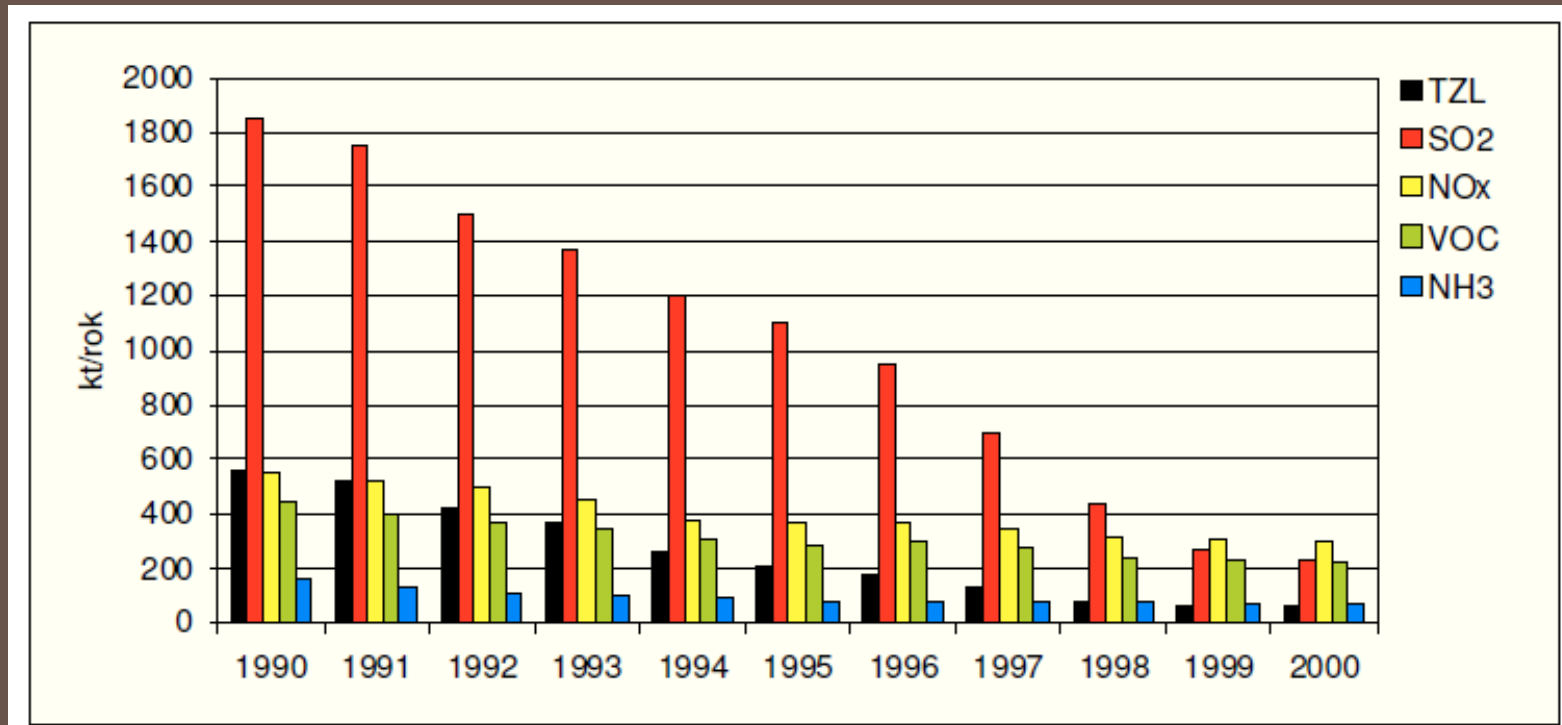
English: Annual average concentration of particulate matter PM_{2,5} in Czech Republic in 2011

Tento projekt je spolufinancován E



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Situation in Czech Republic

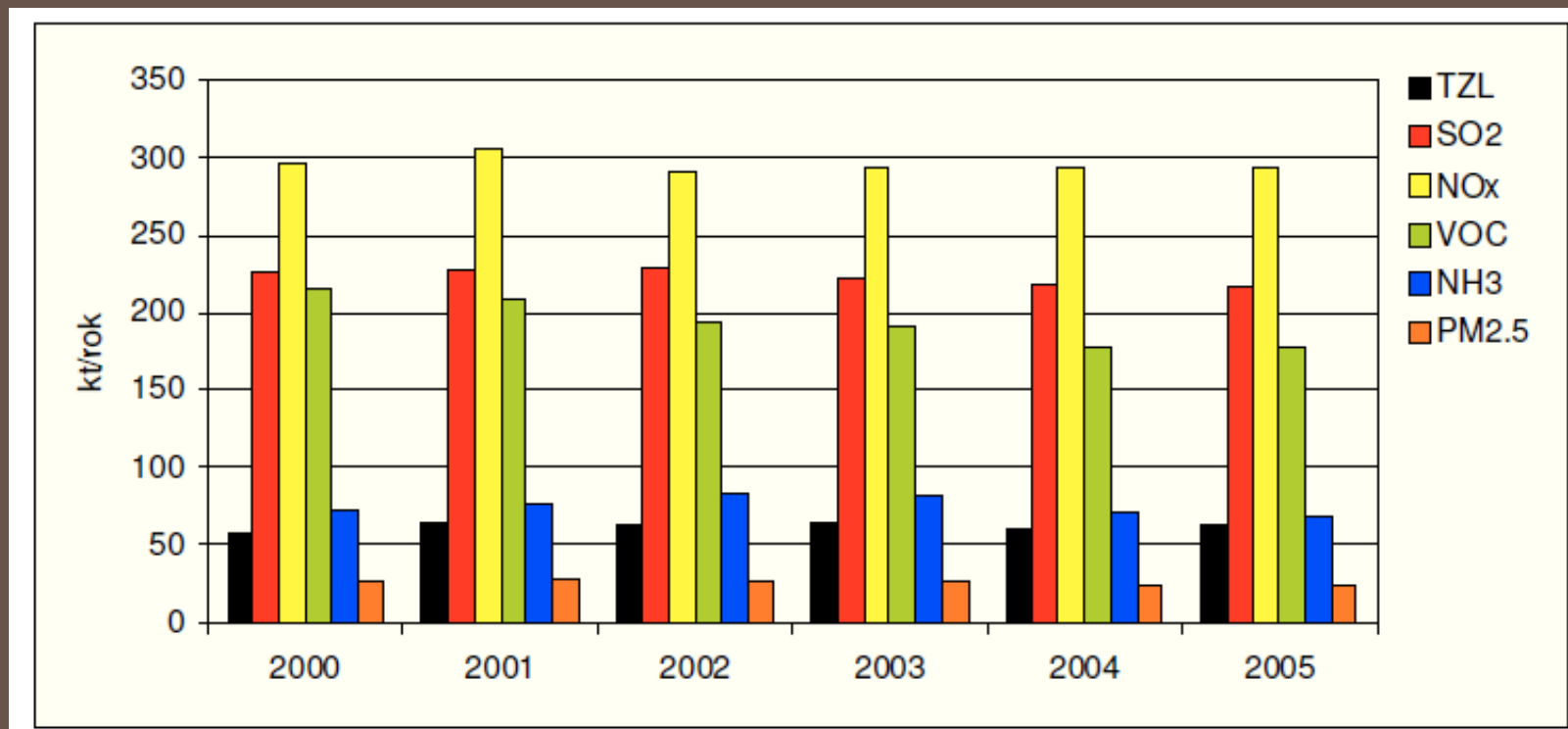


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Situation in Czech Republic



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Externalities

- A consequence of an economic activity that is experienced by unrelated third parties. An externality can be either positive or negative.

<http://www.youtube.com/watch?v=zcPRmh5AIrI>

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Coase theorem

Cannot work if:

- there are many affected parties, so it is expensive to coordinate the necessary contracts for the sale of property rights.
- one person can block the sale, regardless of the costs actually imposed on them.
- enforcement of the contract can be expensive, such as the costs of court proceedings if there is a breach of contract.
- the costs of monitoring the offending behavior are high.

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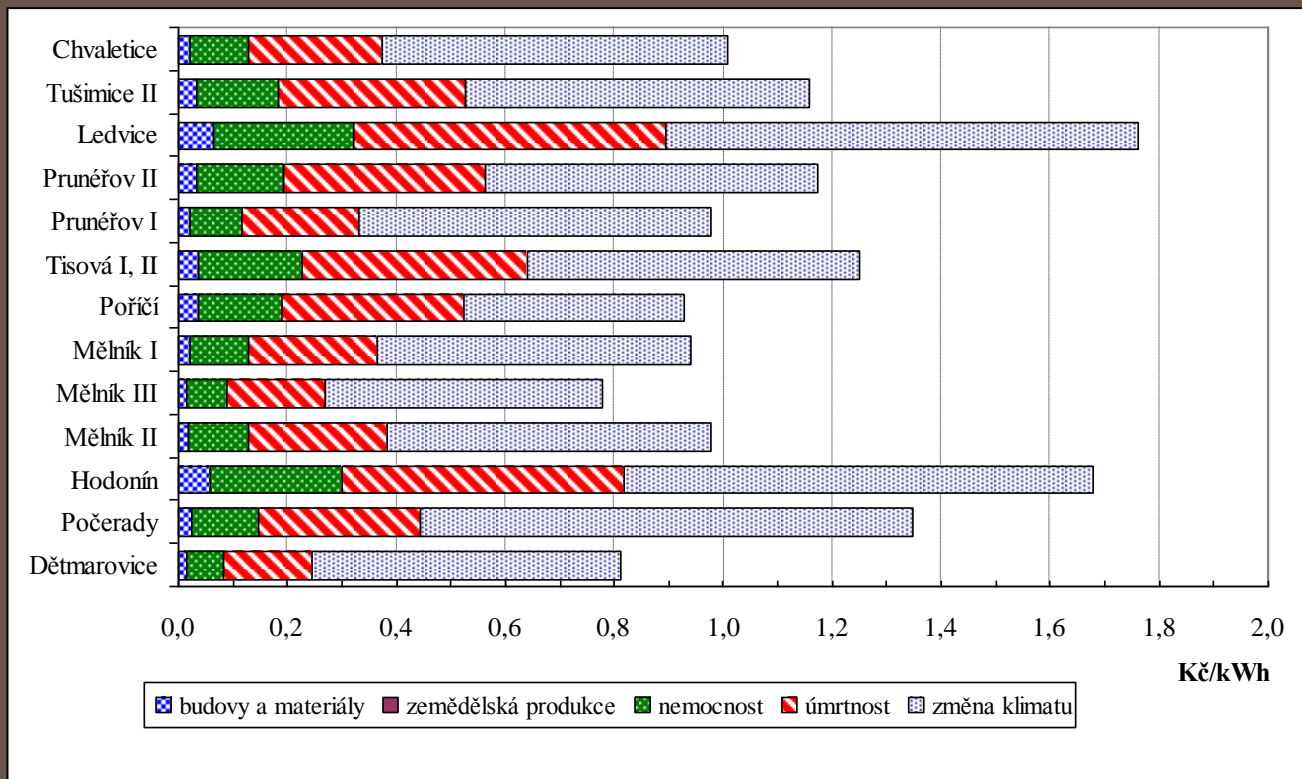
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Externalities of electricity production

Source: centrum pro otázky životního prostředí UK

Price of electricity in 2003 – 3-5 Kč/kWh

In Kč/kWh for selected energy sources in 2003



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Solution of the 'coal problem'?

- Source substitution
- Higher effectivity of coal consumption
- Limitation of coal pollutants

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