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OP Vzdělávání pro konkurenceschopnost

INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

CLIMATE CHANGE AND FOSSIL FUELS

Filip Černoch

FSS MU

ESS411 – Environmental aspects of energy

Explaining the climate change

- *„How could scientists predict the climate in 100 years when they cannot predict the weather tomorrow?"*
- Climate: atmospheric conditions over a long period of time (years to centuries).
- Weather: short time (minutes to weeks).
- Consequences for prediction – climate undergoes more gradual change (than weather) and is easier to predics.

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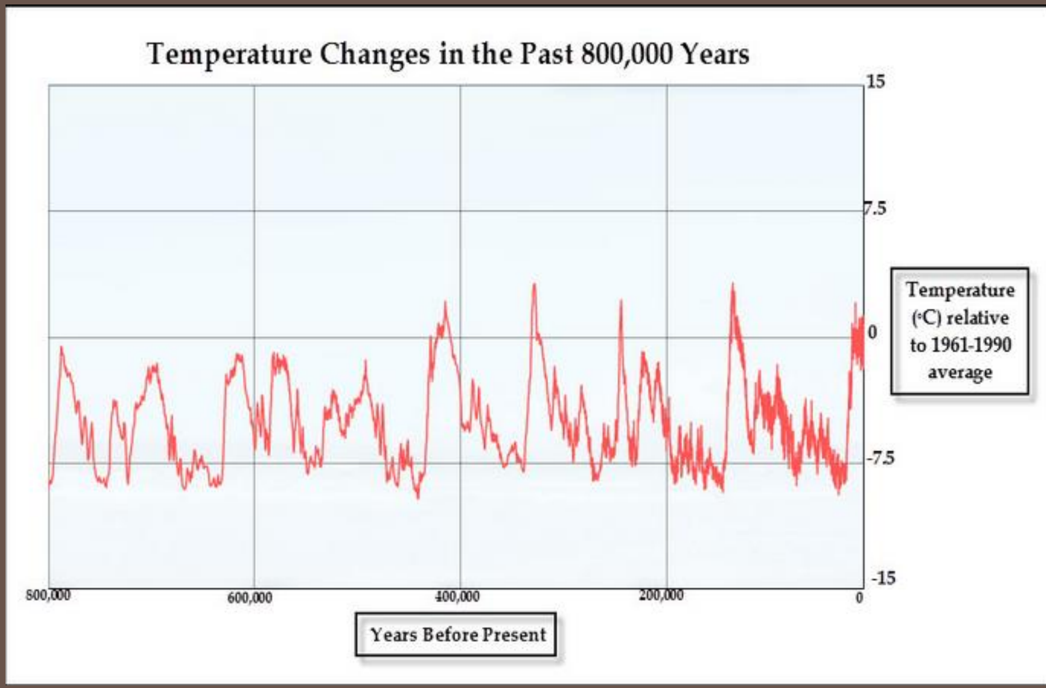
Climate change explained

(1) The planet´s temperature is rising

- Over the past 130 years the global average temperature has increased by 0,8°C (more than half of that in last 35 years).
- Ancient ice samples (from Antarctica and other places) are analysed – they layers are dated and gas bubles inside are analysed.
  - CO_2 concentration is measured by infrared spectroscopy or mass spectrometry.
  - Isotope ratios of water molecules are measured to determine historical temperatures.

Climate change explained

- Earth´s climate has always fluctuated. The cooler period – ice ages or glacial periods, the warmer period – interglacial periods.



- The rate of change has become more dramatic since the Industrial Revolution = anthropogenic origins.

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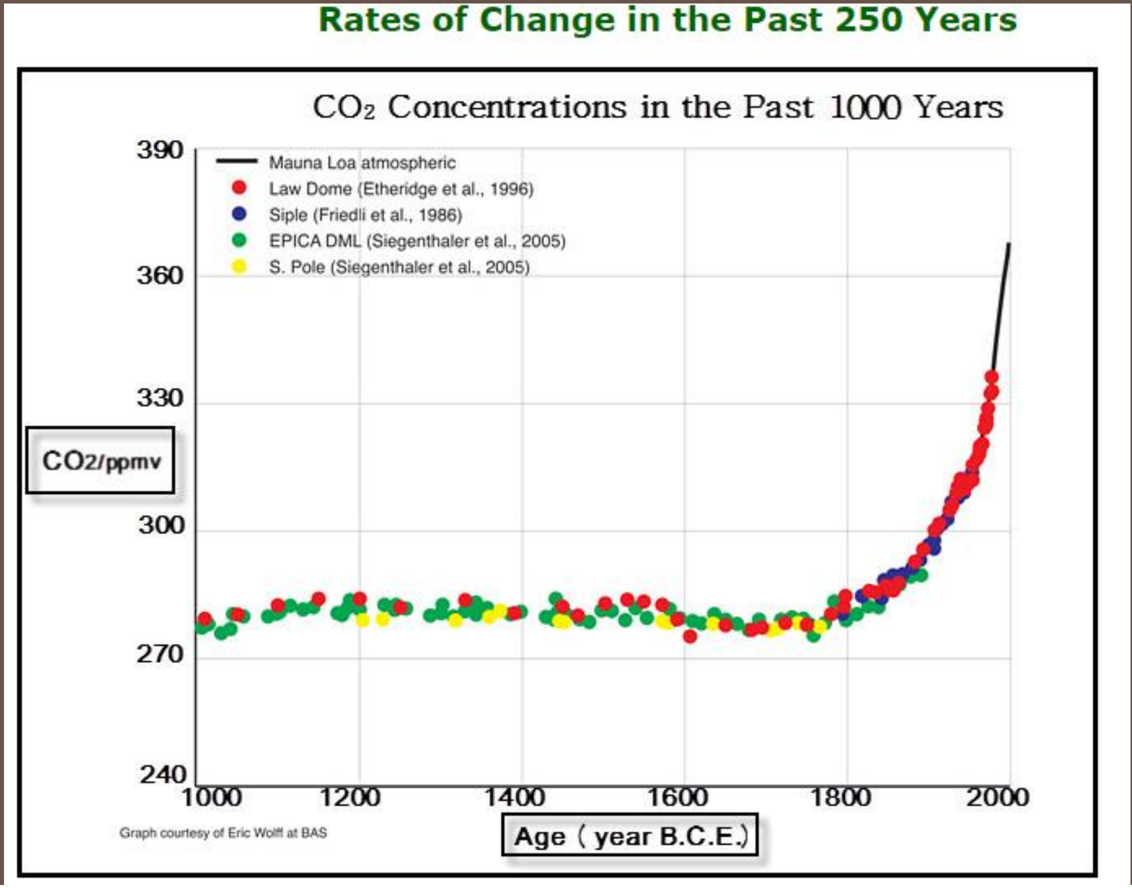
Climate change explained

(2) Carbon dioxide levels are increasing in the atmosphere (also methane and nitrous oxide).



Climate change explained

(3) We are responsible for the increase in CO_2

- Human CO_2 emissions (20 billion tonnes/y) are small compared to natural emission (776 billion tonnes/y).
- But natural absorptions (788 billion tonnes/y) roughly balance natural emisssions.
- Carbon 12 isotope to carbon 13 isotope ratio increases (isotope = different atoms with the same chemical behavior but with different masses).

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Climate change explained

(4) Increased CO2 is the primary driver of global warming (greenhouse effect).

- Inbound solar radiation has short wavelenghts and high energy contents. This radiation passes through the atmosphere. Some energy is absorbed by the ground (warming it up). Some energy is reflected back to the space.
- That reflected ratdiation has lower energy levels and longer wavelengths. 80% of the outgoing radiation is trapped in the lower troposphere.
- Energy trapped in the troposphere wams the surface.
- More GHGs in the atmosphere trap more outbound solar radiation, thus warming the planet – anthropogenic climate change.

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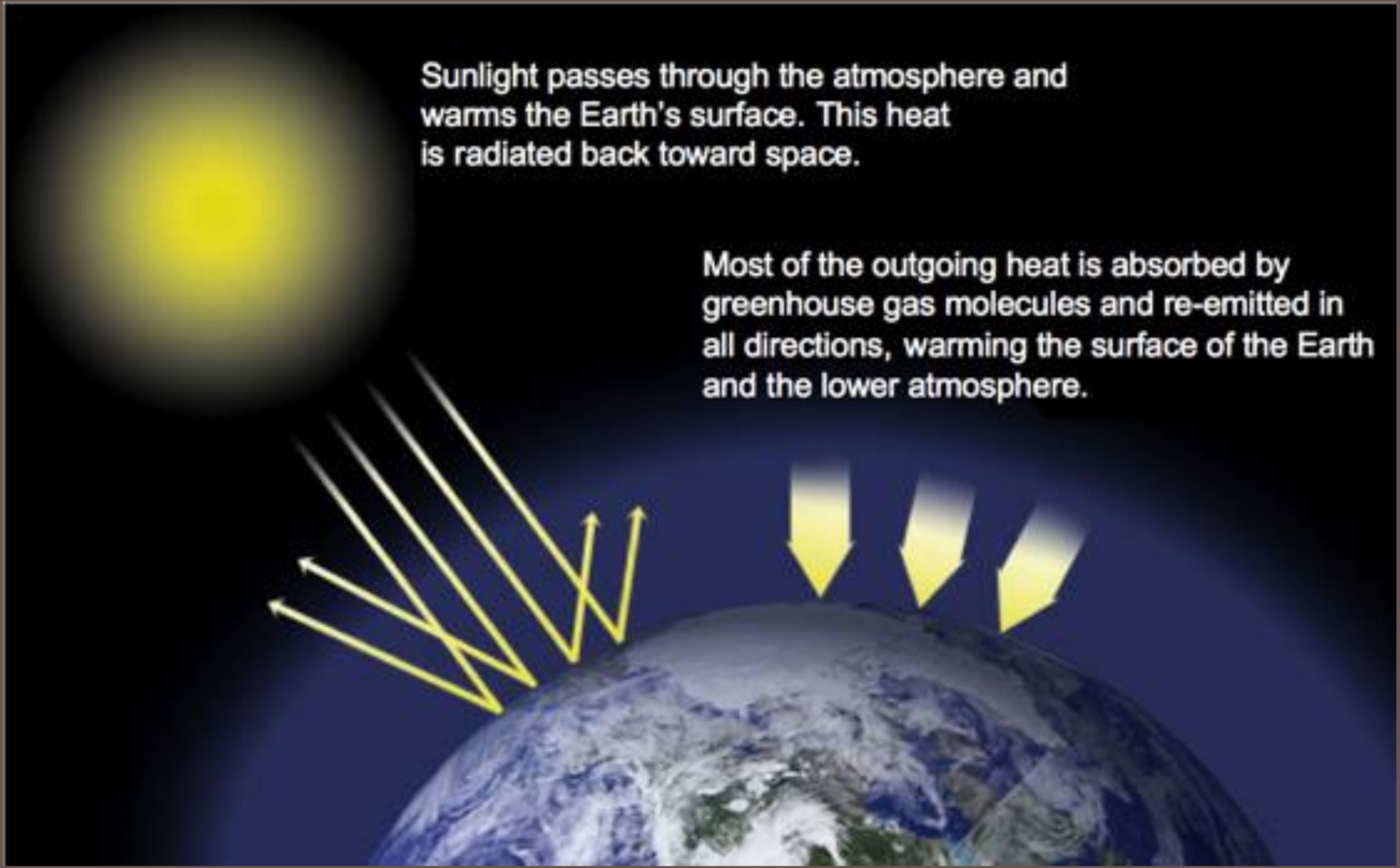
Climate change explained



Climate change explained

- CO_2 traps infrared radiation (thermal radiation). Proven by laboratory experiments and satellites (satelit data from 1970; direct experimental evidence) that find less heat escaping out to space over the las few decades.
- Temperature – average kinetic energy of the molecules within a substance = the more radiation trapped in the atmosphere the higher temperature is.

Climate change explained

- The extra CO_2 in the atmosphere amplified the original warming (positive feedback).

- Positive/negative feedbacks – examining different period throughout Earth´s history shows that positive feedbaks amplify any initial warming
- Positive feedback – warming keeps more water in the air and more wapour traps more heat.
- Negative feedback – more water vapour causes more clauds, reflecting sunlight.

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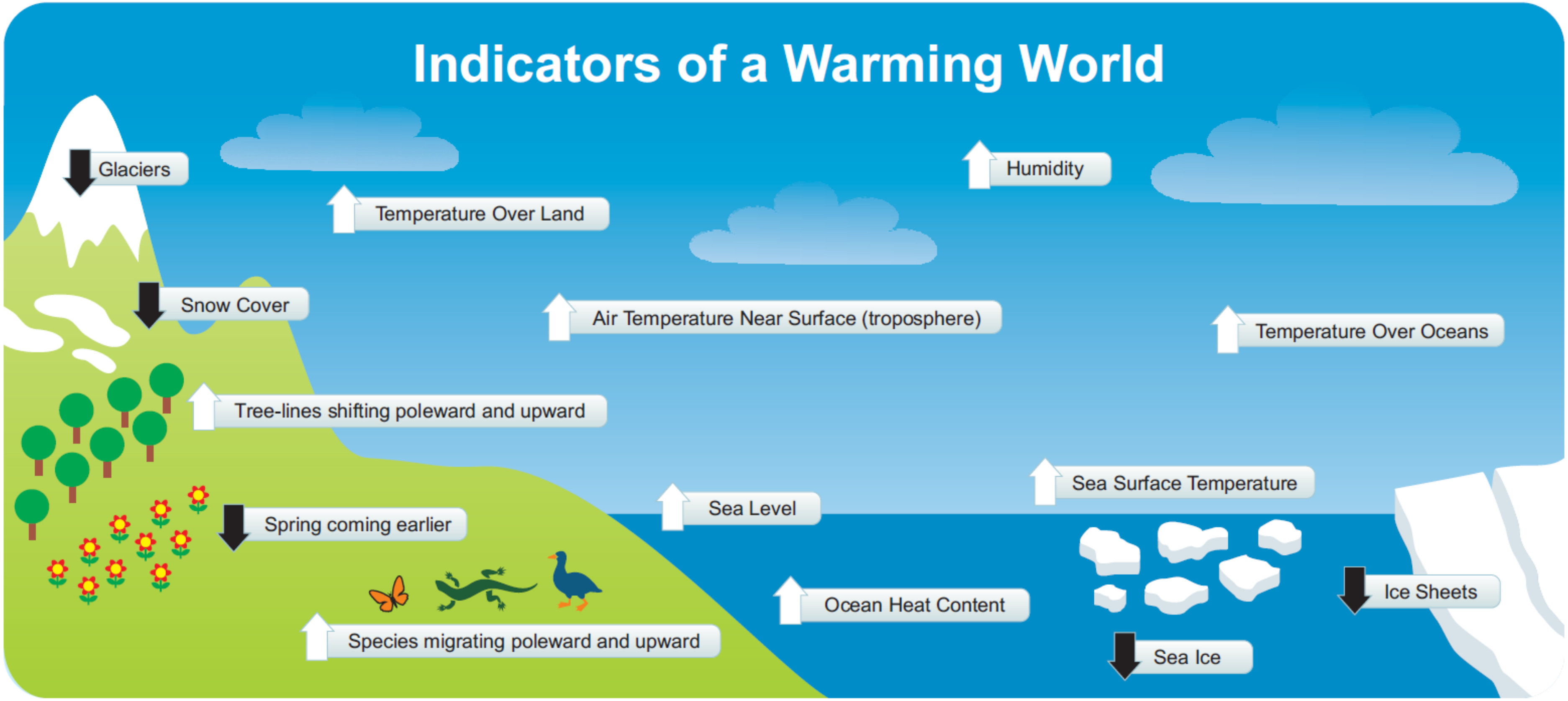
Climate change explained



Parmesan & Yohe 2003[32], NOAA[34]

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Summary

- Earth´s climate has undergone changes over long periods of time (several ice ages, period of warming).
- Previous changes were dramatic but gradual (thousands of years).
- Today´s change is extremely fast and increasing. Until 250 years ago the highest rate of temperature increase recorded was approximately 0,003°C/y. For the last ten years, it is 0,017°C.

- Global warming vs. climate change. The first suggests that Earth´s climate is warming on average, but it is not fully true. Factors such as precipitation and evaporation are also changing. And these changes often affect climate patterns elsewhere in the world.

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Summary

- There is scientific consensus on
  - Corelation between the concentration of CO_2 and temperature.
  - That humans release anthropogenic compounds into the environment, resulting in previously unseen rises in atmospheric gas concentrations and temperature.

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Climate change impacts

- Melting ice
  - The vast majority of the world´s glaciers are melting faster than are replenished.
  - 1/3 of North Pole´s ice sheets melted since 90s.
- Accelerated sea level rise, increase coastal flooding
  - 20 cm in the last century (40% thermal expansivity, 60% melting).
  - Actual rate 3mm/y.
  - Problem for low-lying communities.
- Increase in extreme weather events
  - Climate change increases certain types of extreme weather events – heat. waves, coastal flooding, extreme precipitation events, more sever droughts.

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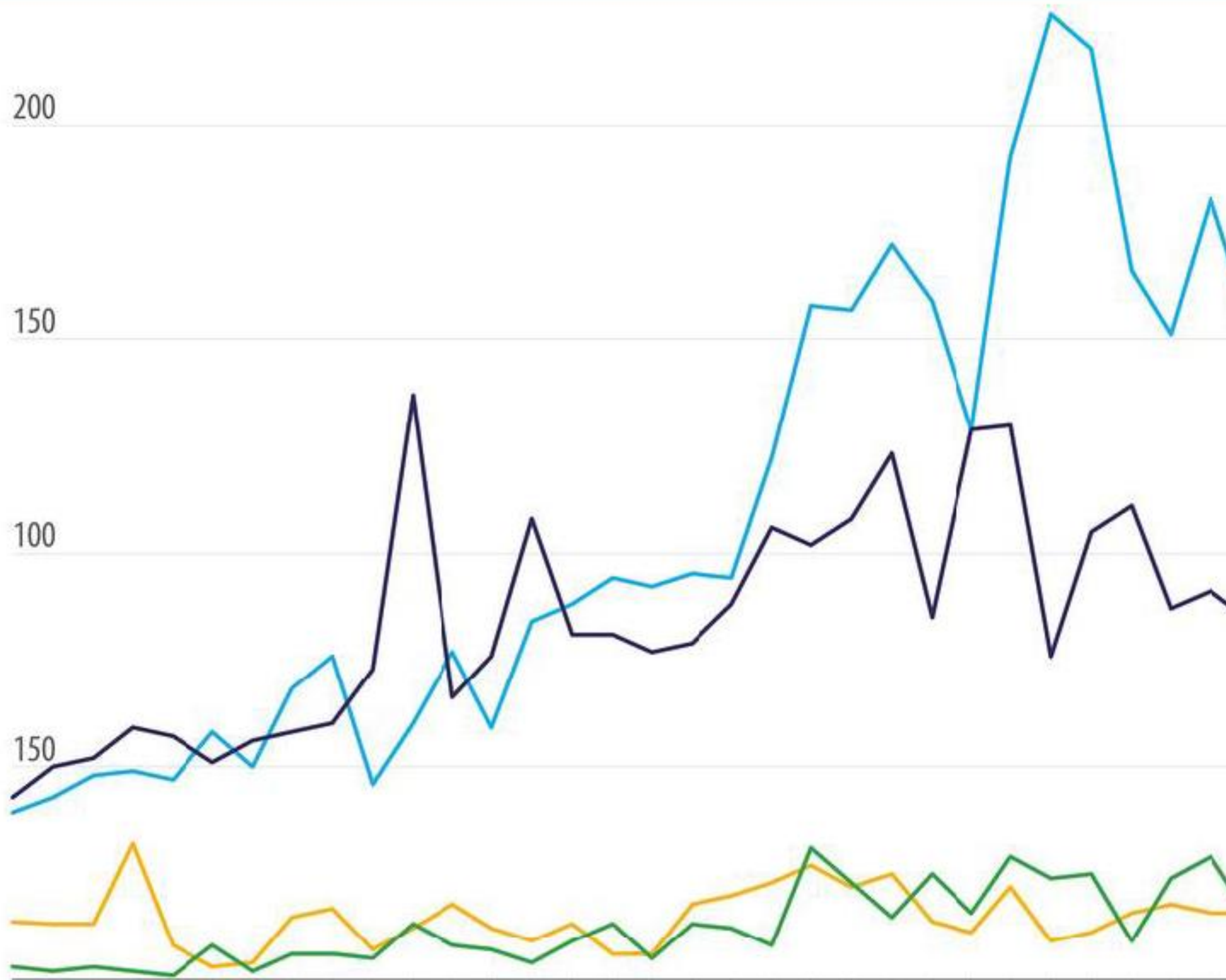
[N]umber of Climate-related Disasters Around the World (1980-2011)

3455 FLOODS

2689 STORMS

470 DROUGHTS

395 EXTREME TEMPS



	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
FLOOD	39	43	48	49	47	58	50	68	76	46	60	77	59	84	88	94	92	95	94	122	158	157	172	159	129	193	226	218	166	151	188
STORM	43	50	52	59	57	51	56	58	60	73	137	66	76	108	81	81	77	79	88	106	102	108	123	85	129	130	76	105	111	87	9[illegible]
DROUGHT	14	13	13	32	8	3	4	15	17	7	12	18	12	9	13	6	6	18	20	23	27	22	25	14	11	22	9	11	16	18	1[illegible]
EXTREME TEMPERATURE	3	2	3	2	1	8	2	6	6	5	13	8	7	4	9	13	5	13	12	8	31	23	15	25	16	29	24	25	9	24	2[illegible]

UNISDR
[U]nited Nations Office for Disaster Risk Reduction
www.unisdr.org

[...]d on 13 June 2012

[S]OURCES

[...]T - http://www.emdat.be/ - The OFDA/CRED International [...] Database; Data version: 13 June 2012 - v12.07

[...]itarian Symbol Set(2008): www.ungiwg.org/map/guideline.php

Climate change impacts

- Health impacts
  - Increased air pollution, a longer and more intense allergy seasons, the spread of insect-borne diseases, more frequent heat waves, flooding = costly risks to public health.
- Food problems and water
  - According to IPCC 1°C = 65 million people starving
  - Increase of the temperature of more than 2°C = 3 billion people without water supply
  - Between 18-35% of plant and animal species is committed to extinction by 2050 (oceans are absorbing much of the CO_2 in the air, which leads to ocean acidification – destabilising the whole oceanic food chain). An estimated 1 billion people depend on the ocean for more than 30% of their animal protein.
  - Climate refugees.

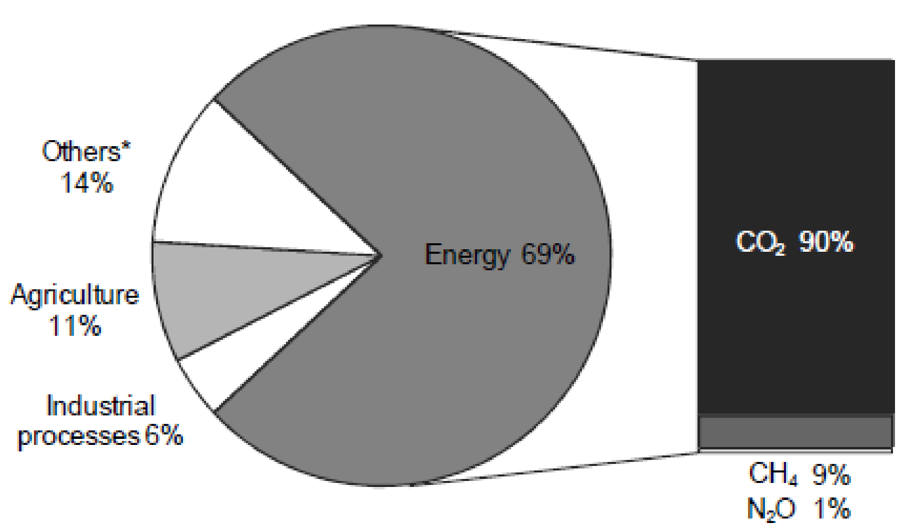
Summary

- Rich will adapt and poor will suffer.

Recent trends in CO2 emission

- Steady level of CO2 (280 ppm) in the –pre-industrial era, in 2013 396 ppm (40% higher than in the mid-1800s). Average growth of 2 ppm/y.
- Significant increases in levels of methane and nitrous oxide.
- The use of energy represents by far the largest source of emissions.

Shares of global anthropogenic GHG, 2010*



* Others include large-scale biomass burning, post-burn decay, peat decay, indirect N_2O emissions from non-agricultural emissions of NO_x and NH_3, Waste, and Solvent Use.

Source: IEA estimates for CO_2 from fuel combustion and EDGAR 4.2 FT2010 estimates for all other sources.

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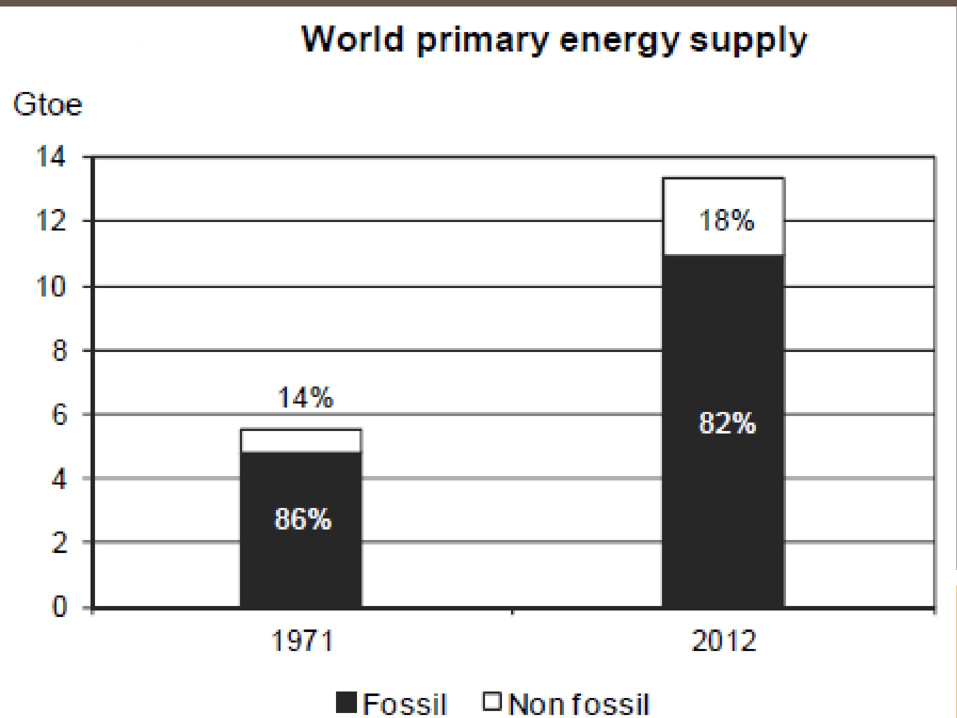
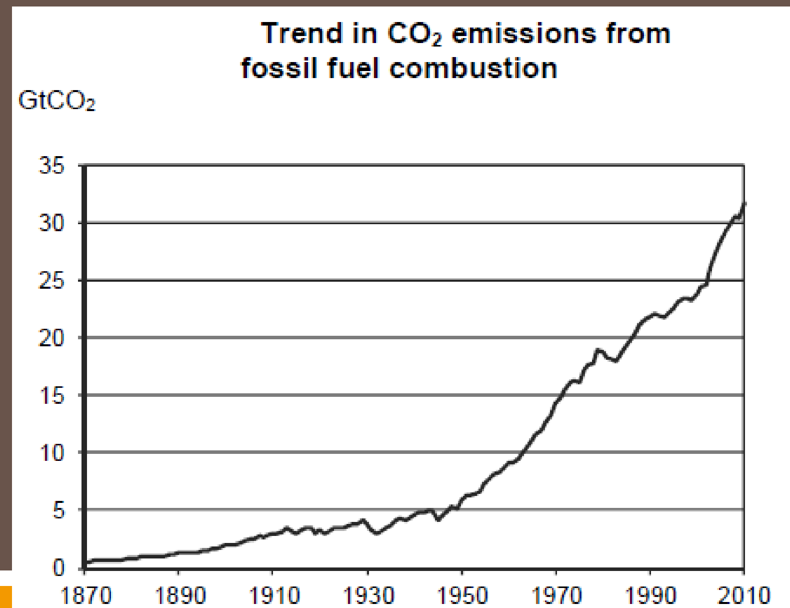
Recent trends in CO_2 emission

- Fossil fuels account for most of the world energy supply (82% of the global energy supply in 2012).
- Since 1870, CO_2 emissions from fuel combustion have risen exponentially.
- Since the Industrial Revolution, annual CO_2 emissions from fuel combustion increased from near zero to almost 32 $GtCO_2$ in 2012.





Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tenn., United States.

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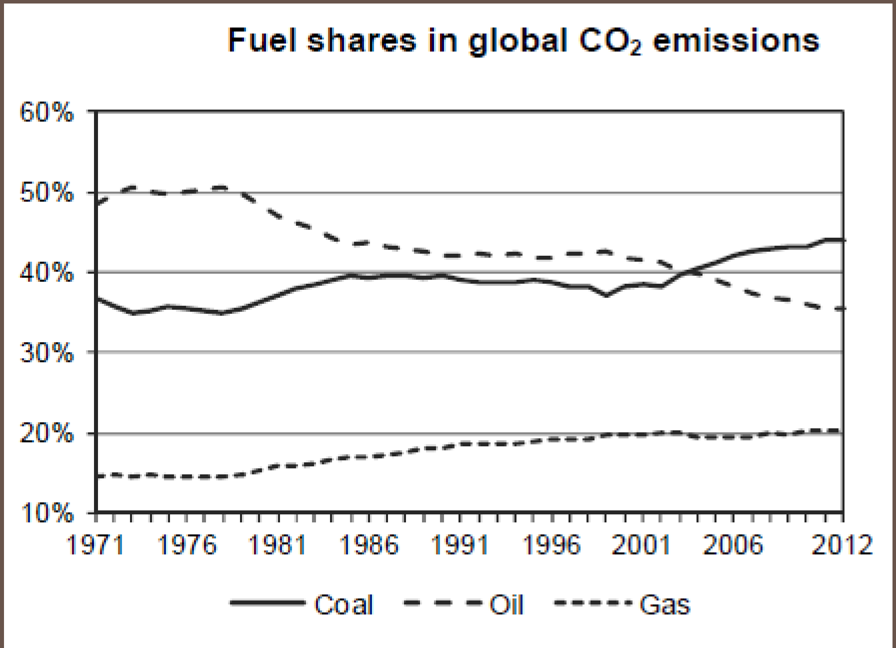
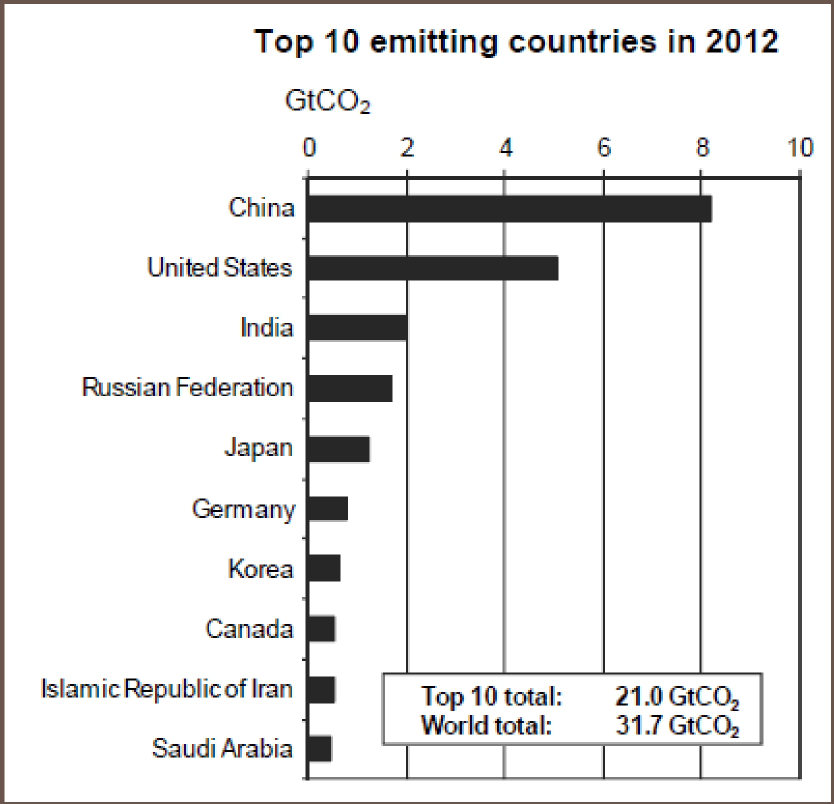
Recent trends in CO_2 emission

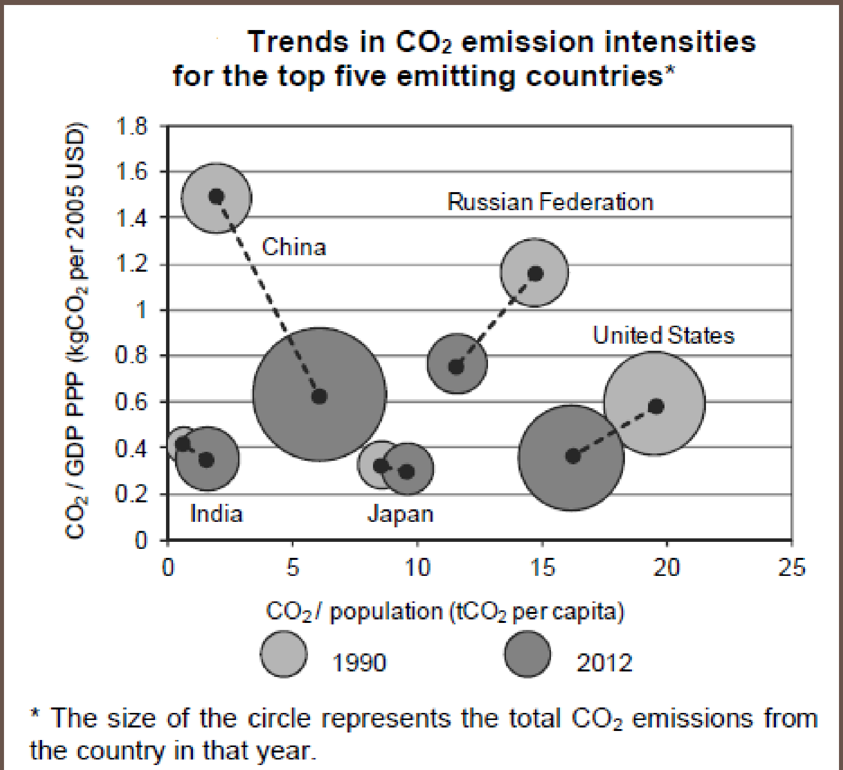
- In the last decade the coal have replaced oil as the largest source of CO2 emissions.
- The top 10 emitting countries account for 2/3 of global CO2 emissions.

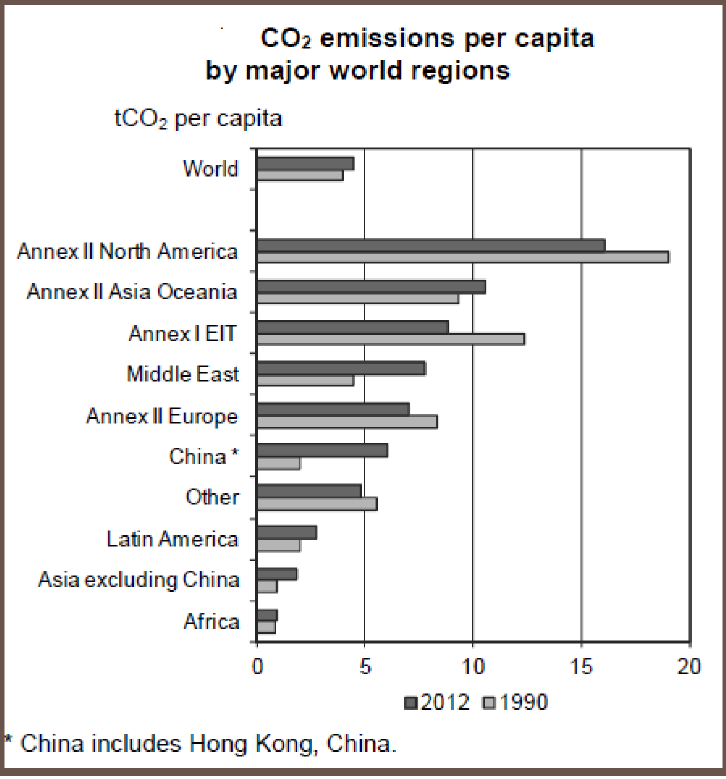




Recent trends in CO_2 emission

- Emissions per capita generally decrease in time accross regions.
- All top five emitters reduced emissions per unit of GDP, while emissions per capita showed contrasting trends.





Summary

- Economic growth strongly linked to consumption of fossil fuels.
- Substitution of fossil fuels is essential but extremely difficult.

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Climate change as a public policy problem

- Is uniquely global
  - Environmental problems usually regional (Beijing´s smog, waste from EU´s industry).
  - In the case of climate change, impacts may be regional, but phenomenon is global.
  - The global nature of climate change also complicates any sensible climate policy. It is tough to get voters to enact pollution limits on themselves, when those limits benefit them and only them, but it is tougher to get voters to enact pollution limits on themselves if the costs are felt domestically, but the benefits are global = a planetary free riding problem.

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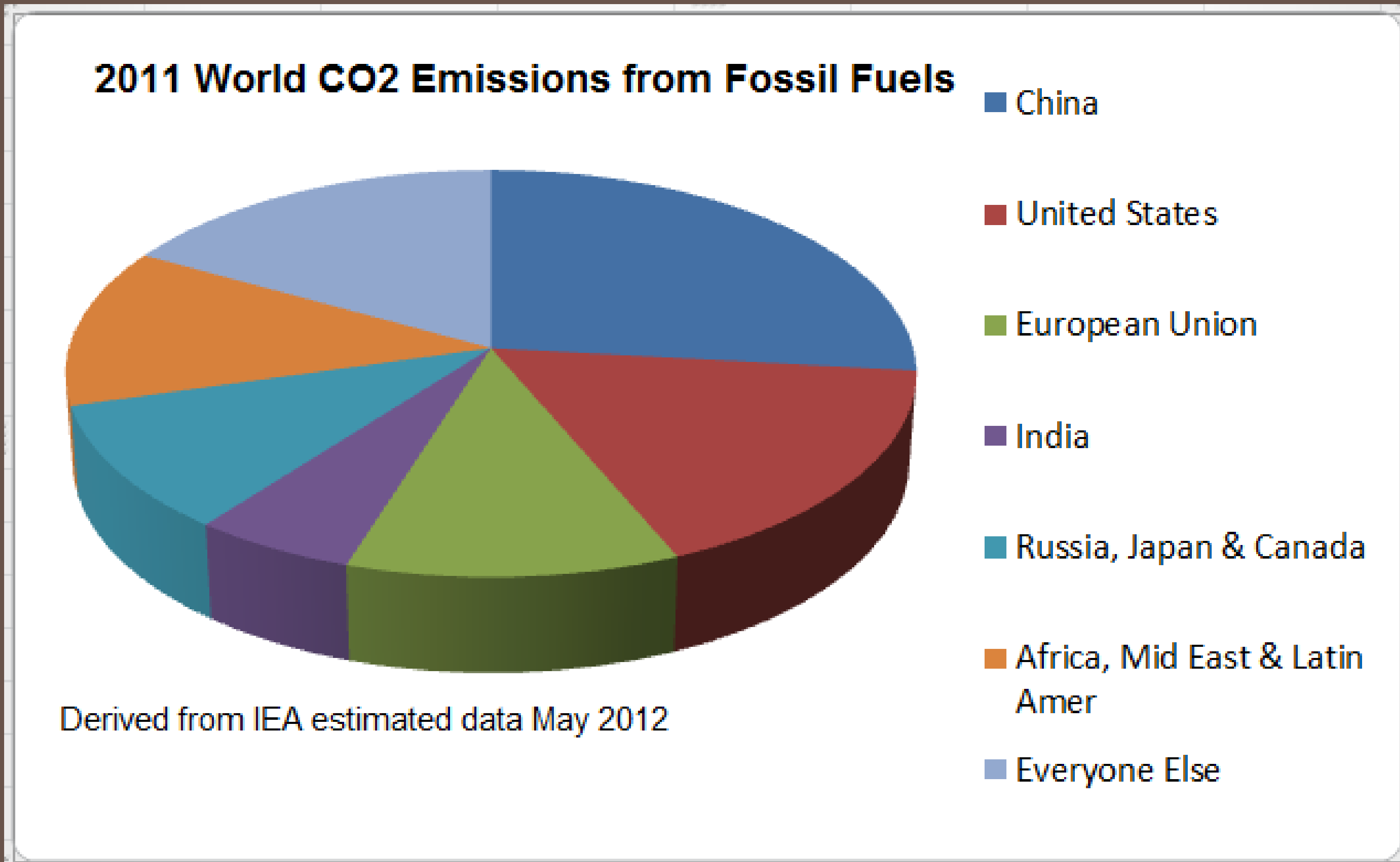
Climate change as a public policy problem



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Climate change as a public policy problem

- Is uniquely long-term
  - The past decade was the warmest in human history. The one before was the second-warmest. The one before was the third-warmest.
  - Changes are evident. Arctic sea ice has lost half of its are and three-quaters of its volume in only the past thirty years.
  - But the most of the worst consequences of climate change are still remote, often caged in global, long-term averages. The worst effects are still far off – but avoiding these predictions would entail acting now.

Climate change as a public policy problem

- Is uniquely irreversible
  - Stopping emitting carbon now we still would have decades of warming and centuries of sea-level rise locked in. Full melting of large West Antarctic ice sheets may be unstoppable.
  - Over 2/3 of the excess CO2 in the atmosphere that wasn´t there when humans started burning fossil fuels will still be present a hundred years from now. Over 1/3 will be there in 1000 years.

Climate change as a public policy problem

- Is uniquely uncertain.
- „Everything we know that we don´t know, and perhaps more importantly, what we don´t yet know we don´t know“ (Wagner, Weitzman).
- Last time concentration of carbon dioxide were as high as they are today, at 400 ppm, at Pliocene. That was over three million years ago, when average temperatures were around 1-2,5°C warmer than today, sea levels were up to 20 meters higher, and camels lived in Canada.
- We wouldn´t expect any of these dramatic changes today. The greenhouse effect needs decades to centuries to come into full force, ice sheets need decades to centuries to melt, global sea levels také decades to centuries to adjust accordingly. CO2 concentrations may have been at 400 ppm 3 million years ago, whereas rising sea levels lagged decades or centuries behind.

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Costs of climate change

- Around current climates masive investments and industrial infrastructures is build, that makes temperature increases costly.
- The current models estimates that warming of 1°C will cost 0,5% of global GDP, 2°C around 1% GDP, 4°C around 4% GDP.
- We could think about damages as a percentage of output in any given year. At a 3 percent annual growth rate, global economic output will increase almost twenty-fold in a hudred years.
- Or lets assume that damages affect output growth rates ragher than output levels. Climate change clearly affects labor productivity, esp. in already hot countries. Then the cumulative effects of damages could be much worse over time.

Summary

- Climate change is unlike any other public policy problem. It´s almost uniquely global, long-term, irreversible, uncertain. These factors are what make climate change so difficult to solve.

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International regime to fight climate change

- Intergovernmental Panel on Climate Change – 1988.

  = to provide comprehensive scientific assessments of current scientific, technical and socio-economic information about the risk of climate change, its potential environmental and socio-economic consequences and possible options for adapting to these consequences or mitigating the effects.

- Rio Summit on Earth – 1992 (UN conference on environment and development) → UNFCCC
- Kyoto Protocol
- – 1997, in force 2005

  = Existence of a generally accepted consensus on the climate change as well as the contribution of human activities to this change.

Kyoto Protocol (KP)

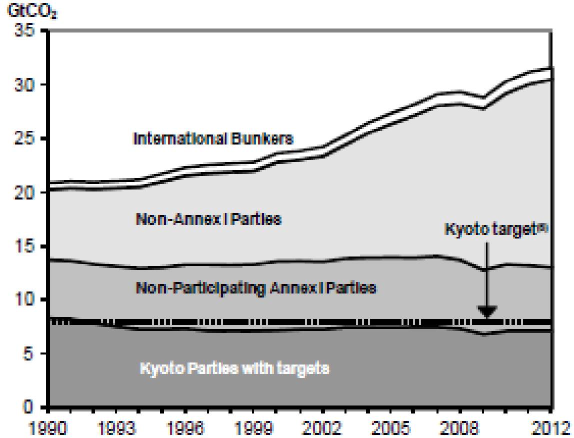
- 4 GHG (carbon dioxide, methane, nitrous oxide, sulphur hexafluoride) + hydrofluorocarbons and pefluorocarbons.
- Annex I. countries (37 industrialized countries + EU15), Non-annex I. parties.
- Reducing of GHG emissions by 5,2 % for the first commitment period of 2008-2012. (4,2 % after USA left). Base year 1990.
- Reduction of emissions from fossil fuel combustion; reduction emission in other sectors (land-use or direct industrial emissions); flexible mechanisms – Emission trading, CDM, JI.
- Common but differenciated responsibility

Kyoto Protocol (KP)

- In 2012, CO_2 emissions from fuel combustion across all Parties with KP targets were 14% below 1990 levels.
- Emissions in the EU-15 were 8% bellow 1990 levels.
- Some industrialised countries have seen significant increases (Australia +48%), New Zealand (+44%), Spain (+30%).
- Despite extensive participation of 192 countries the KP is limited in its potential – U.S. remains outside, developing countries do not have emission targets.
- The KP implies action on less than one-quarter of global CO_2 emissions.
- Through its flexibility mechanisms the KP has made CO_2 a tradable commodity, and has been a driver for the development of national emission trading schemes.

	1990 $MtCO_2$	2012 $MtCO_2$	% change 90-12	Kyoto Target
KYOTO PARTIES WITH TARGETS [1]	**8,339.6**	**7,157.0**	**-14.2%**	**-4.6%** [2]
Europe	*3,154.5*	*2,906.4*	*-7.9%*	
Austria	56.4	64.7	14.8%	-13%
Belgium	107.9	104.6	-3.1%	-7.5%
Denmark	50.6	37.1	-26.7%	-21%
Finland	54.4	49.4	-9.1%	0%
France [3]	352.8	333.9	-5.4%	0%
Germany	949.7	755.3	-20.5%	-21%
Greece	70.1	77.5	10.5%	+25%
Iceland	1.9	1.8	-2.5%	+10%
Ireland	30.6	35.5	16.3%	+13%
Italy	397.4	374.8	-5.7%	-6.5%
Luxembourg	10.4	10.2	-1.3%	-28%
Netherlands	155.8	173.8	11.5%	-6%
Norway	28.3	36.2	27.9%	+1%
Portugal	39.4	45.9	16.4%	+27%
Spain	205.2	266.6	29.9%	+15%
Sweden	52.8	40.4	-23.4%	+4%
Switzerland	41.6	41.3	-0.8%	-8%
United Kingdom	549.3	457.5	-16.7%	-12.5%
European Union - 15	3,082.7	2,827.1	-8.3%	-8%
Asia Oceania	*1,339.5*	*1,641.7*	*22.6%*	
Australia	260.5	386.3	48.3%	+8%
Japan	1,056.7	1,223.3	15.8%	-6%
New Zealand	22.3	32.1	44.0%	0%
Economies in Transition	*3,845.6*	*2,608.8*	*-32.2%*	
Bulgaria	74.9	44.3	-40.9%	-8%
Croatia	21.5	17.2	-20.1%	-5%
Czech Republic	148.8	107.8	-27.6%	-8%
Estonia	35.8	16.3	-54.3%	-8%
Hungary	66.4	43.6	-34.4%	-6%
Latvia	18.6	7.0	-62.4%	-8%
Lithuania	33.1	13.3	-59.8%	-8%
Poland	342.1	293.8	-14.1%	-6%
Romania	167.5	79.0	-52.9%	-8%
Russian Federation	2,178.8	1,659.0	-23.9%	0%
Slovak Republic	56.7	31.9	-43.8%	-8%
Slovenia	13.3	14.6	9.6%	-8%
Ukraine	687.9	281.1	-59.1%	0%

	1990 $MtCO_2$	2012 $MtCO_2$	% change 90-12	Kyoto Target
OTHER COUNTRIES	**12,014.7**	**23,497.4**	**95.6%**	
Non-participating Annex I Parties	*5,550.9*	*5,983.9*	*7.8%*	
Belarus	124.8	71.1	-43.0%	-8%
Canada [1]	428.2	533.7	24.6%	-6%
Malta	2.3	2.5	10.4%	none
Turkey	126.9	302.4	138.3%	none
United States	4,868.7	5,074.1	4.2%	-7%
Other Regions	*6,352.7*	*17,334.0*	*172.9%*	none
Africa	545.0	1,032.4	89.4%	none
Middle East	549.9	1,647.1	199.5%	none
N-OECD Eur. & Eurasia [4]	630.0	528.8	-16.1%	none
Latin America [4]	842.5	1,583.3	87.9%	none
Asia (excl. China) [4]	1,507.5	4,291.4	184.7%	none
China	2,277.7	8,250.8	262.2%	none
INTL. MARINE BUNKERS	**363.2**	**602.2**	**65.8%**	
INTL. AVIATION BUNKERS	**256.3**	**477.8**	**86.4%**	
WORLD	**20,973.9**	**31,734.3**	**51.3%**	



(1) On 15 December 2011, Canada withdrew from the Kyoto Protocol. This action became effective for Canada on 15 December 2012.

(2) The actual country targets apply to a basket of six greenhouse gases and allow sinks and international credits to be used for compliance. The overall "Kyoto target" is estimated for this publication by applying the country targets to IEA data for CO_2 emissions from fuel combustion, and is only shown as an indication. The overall target for the combined EU-15 under the Protocol is -8%, but the member countries have agreed on a burden-sharing arrangement as listed.

(3) Emissions from Monaco are included with France.

(4) Composition of regions differs from elsewhere in this publication to take into account countries that are not Kyoto Parties.

(5) The Kyoto target is calculated as percentage of the 1990 CO_2 emissions from fuel combustion only, therefore it does not represent the total target for the six-gas basket. This assumes that the reduction targets are spread equally across all gases.

Post-Kyoto system

- To limit global temperature increase to less than 2°C above pre-industrial level, countries are negotiating a new climate agreement (to be finalised at COP21 in Paris 2015).
- It builds on the voluntary emission reduction goals for 2020 that were made at COP15 in Cobenhagen.
- Developed and developing countries with these aims account for over 80% of global emissions. (goals nevertheless not sufficient to fulfill 2°C limit).
- The nationally-determined targets will be complemented by an agreed Framework for measuring, reporting and verifying emissions, and accounting for achievement of targets, and by enhanced actions on adaptation, technology development and on the provision of financial resources.

Post-Kyoto system

- While obligations are to start from 2020, emissions from the energy sector need to peak by 2020 if there is to be a reasonable chance of limiting temperature rise to below 2°C.
- Complementary initiatives outsode the UNFCCC are needed.

GHGs related policies

- Climate policies – dealing with emissions reduction as the primary goal and outcome.
  - Carbon pricing
  - Regulation of GHG emissions
  - Subsidy for emissions-reducting activities
  - Policies to develop CCS

GHGs related policies

- Energy policies – implemented primarily for other reasons with emissions reductions one of a number of their benefits.
  - Energy efficiency programmes to overcome barriers to cost-effective investment in energy-savings
  - Technology deployment policies (incl. RES support) which drive the deployment of cleaner energy options
  - Energy taxes and subsidies, which change the prices of fuels, impacting production and consumption choices.
  - Regulation of conventional pollutants from fossil-fueled power stations to improve air quality.

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A wide range of energy and climate policies reduce greenhouse gas emissions

Policy Type	Policy options
Price-based instruments	Taxes on CO_2 directly Taxes/charges on inputs or outputs of process (*e.g.* fuel and vehicle taxes) Subsidies for emissions-reducing activities Emissions trading systems (cap and trade or baseline and credit)
Command and control regulations	Technology standards (*e.g.* biofuel blend mandate, minimum energy performance standards) Performance standards (*e.g.* fleet average CO_2 vehicle efficiency) Prohibition or mandating of certain products or practices Reporting requirements Requirements for operating certification (*e.g.* HFC handling certification) Land use planning, zoning
Technology support policies	Public and private RD&D funding Public procurement Green certificates (renewable portfolio standard or clean energy standard) Feed-in tariffs Public investment in underpinning infrastructure for new technologies Policies to remove financial barriers to acquiring green technology (loans, revolving funds)
Information and voluntary approaches	Rating and labelling programmes Public information campaigns Education and training Product certification and labelling Award schemes

Source: Hood (2011), based on de Serres, Murtin and Nicolleti (2010).

Climate change policies

- Carbon pricing
  - Economics is applied – to decrease demand we need to raise its cost. If the price of fossil fuels is increased the amount of emission will decrease. Trying to find the balance of the costs and benefits of carbon production, not to reducing it entirely. To internalize the externalities.
  - Instruments that reach throughout the economy, influencing all production and consumption decisions.
  - Putting the price on GHGs emissions to reflect the societal costs of climate change caused by these emissions.
  - 1) figuring out how much carbon we want to put into the environment. 2) Then a cost must be applied.
  - Carbon tax or emission trading system.
  - Both these systems raise some revenue that could be used to offset the negative macroeconomic impacts of energy price rises.

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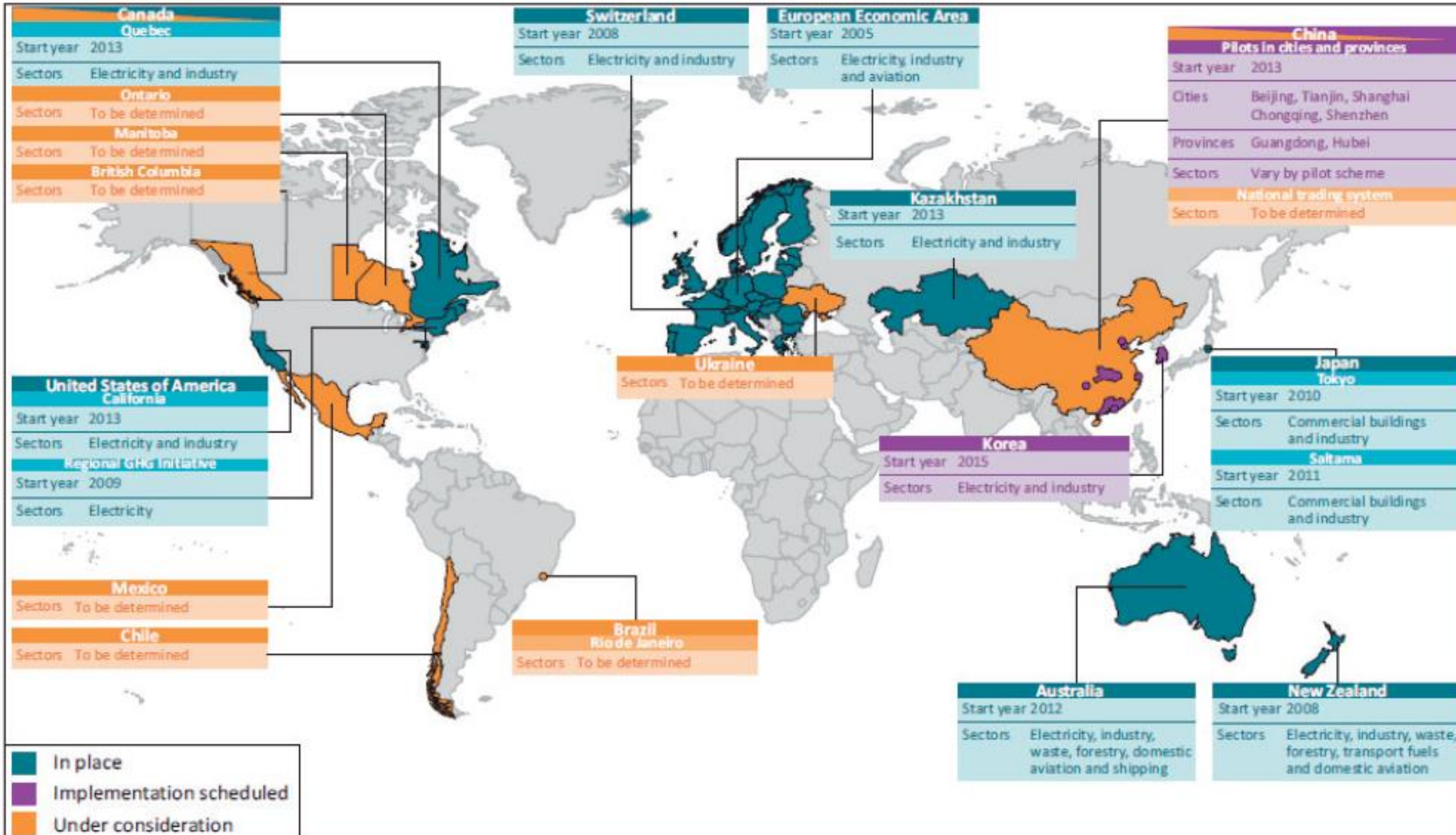
Post-Kyoto system

- Cap-and-trade systems
  - A govt assigns to itself the right to put emissions into the environment.
  - It defines what it believes to be the socially optimal quantity of emissions.
  - The govt generates a number of permits equal to the amount of allowable emissions.
  - These permits are allocated to emitters to trade with them – market is created.
  - = economically efficient, provides incentives for efectivity of the system. To develop technology that would allow one to reduce emissions at a cost lower than that of buying a permit, that suprs innovation and technological development.

Current and proposed emissions trading systems



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

Source: IEA (2013a)

Climate change policies

- Carbon taxes
  - Norway – CO_2 tax introduced in 1991. Applied to oil products, emissions from oil and gas production and gas used for heating and transport. Sectors covered by EU ETS exempted from carbon tax, with exeption of the offshore oil and gas sector. From 2013 the tax level has been increased to offset the falling EUA price.
  - Japan – introduced in 2012 to raise revenue for energy efficiency and RES programmes, not as a direct price incentive.
  - Switzerland – CO_2 levy intended as an incentive for energy efficiency and for shifting toward cleaner heating and proces fuels (not to raise revenue). In place since 2008. Increased from 12 CHF/tCO_2 to 120 CHF/tCO_2.

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Climate change policies

- Subsidies (or credits) for emissions-reducing activities
  - Since they do not (directly) raise energy prices could be politically easier to implement. But:
  - Subsidies rely on govt budgets, so they are vulnerable to cuts in difficult economic circumstances (instability).
  - The price signals are effective only for individual projects or narrow sectors of the economy – not suffucient to drive the long term decarbonisation transition.

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Climate change policies

- Regulation of greenhouse gas emissions
  - Regulatory controls of the GSGs emitted by new/existing fossil fuel infrastructure. May have an important role to play in driving the retirement of existing old, high-emissions infrastructure.
  - UK, Canada (new construction to be no more emissions-intensive than natural gas).
  - In 2013 EPA published regulations to limit emissions of newly-constructed power plants requiring CCS for any new coal-fired generation.

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Climate change policies

- Policies to develop CCS

Energy policies that affect emissions

- Energy taxes and subsidies
  - Non-climate objectives (funding of infrastructure, revenue rasing), can shift the average and relative prices of fuels, therefore act as a significant carbon price. (and vice versa).
- Energy efficiency
  - The primary motivation for energy efficiency policies is cost savings to consumers and society, improved energy security. Emissions savings a positive by-product.
  - Performance standards, information and labelling, energy provider obligations in lightning, equipment and buildings.
- Development and deployment of low-carbon supply
  - Technology support policies – research development to demonstration projects to support for deployment.

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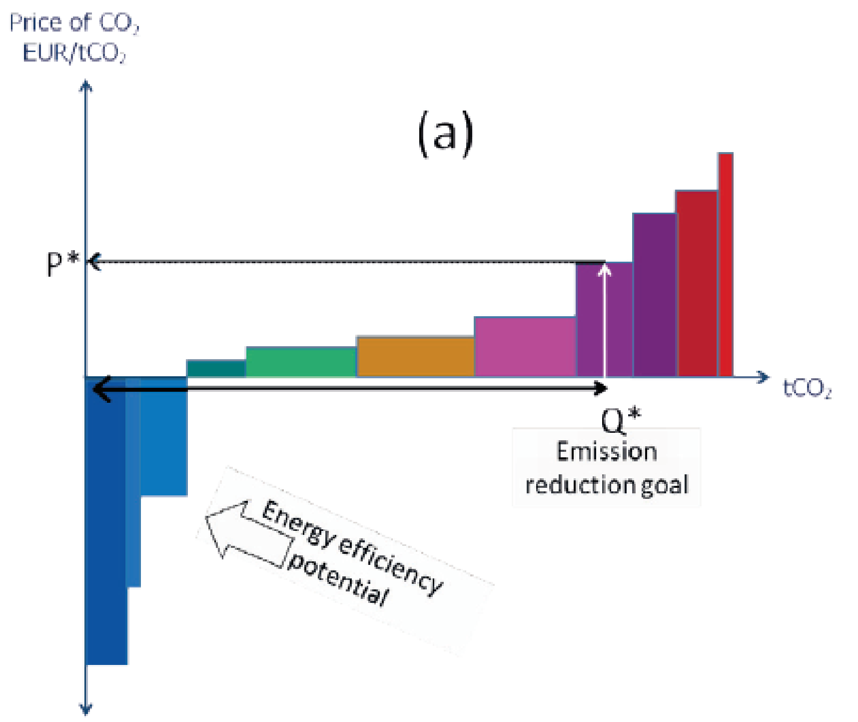
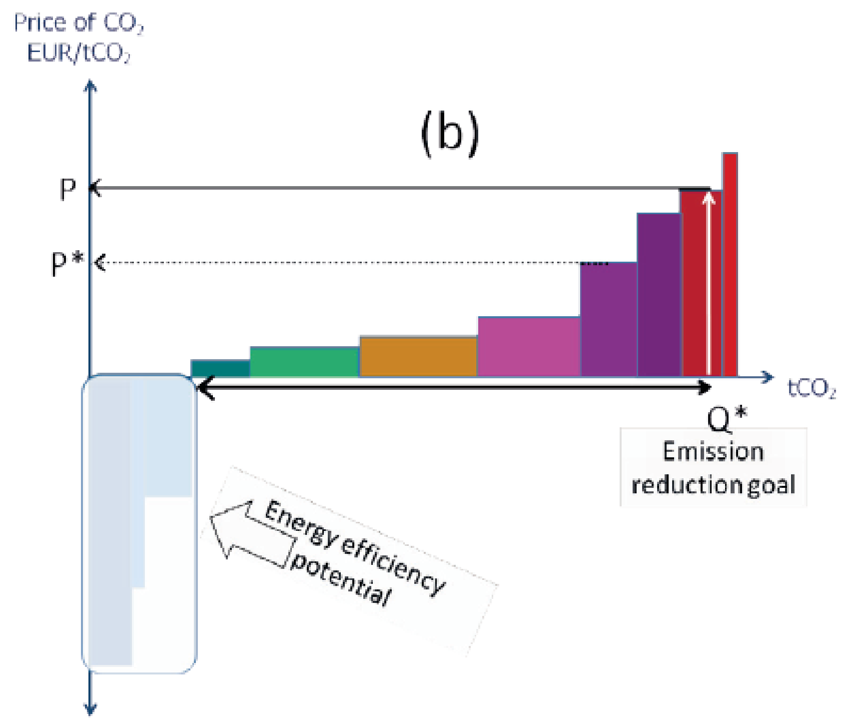
Combination of policies

- Energy efficiency policies alongside a carbon price

Ignoring energy efficiency potential can lead to higher carbon prices





Source: Hood (2011)