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Building Integration of Solar Thermal Systems – TU1205 – BISTS


POLLUTION

Presenter: Dr. Georgios Florides


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POLLUTION


Definition


- Pollution is the introduction of harmful substances or products into the environment
- We will examine three main areas of pollution
 - Water Pollution
 - Air Pollution
 - Land Pollution

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1. Water Pollution


- Point sources:
easy to identify and control
- Non-point sources:
not clearly defined and harder to control





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Point Sources


- Some point sources of water pollution include waste from:
 - factories
 - sewage systems
 - conventional and atomic power plants
 - underground mines-coalmines
 - oil wells



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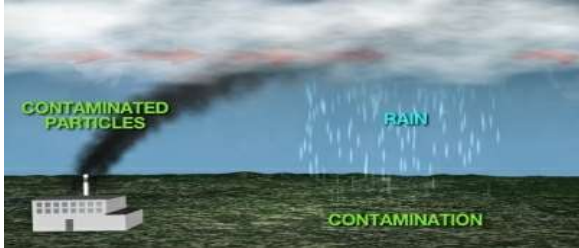
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Non-point Sources

- Include a large range of sources such as:
 - Diluted pollutants in rain or snow and carried into a major body of water
 - the runoff of fertilizers from animal farms and crop land
 - air pollutants getting washed or deposited to earth
 - storm water drainage from lawns, parking lots, and streets



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http://www.weather.com/blog/weather/8_24226.html

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Water Pollution Effects


- Pollution of ground water from nonpoint sources
- Loss of habitats such as wetlands.
- Contamination of life (fish etc) by the remaining discharges and sources of toxic substances.
- Also, microbial contamination of drinking water still presents problems in many communities.


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- Eutrophication:** Rapid growth of algae in bodies of water due to nutrients like phosphates. When the algae decay, the process depletes the supply of oxygen and results in premature "aging" of a lake or pond, including the disappearance of desirable varieties of fish.

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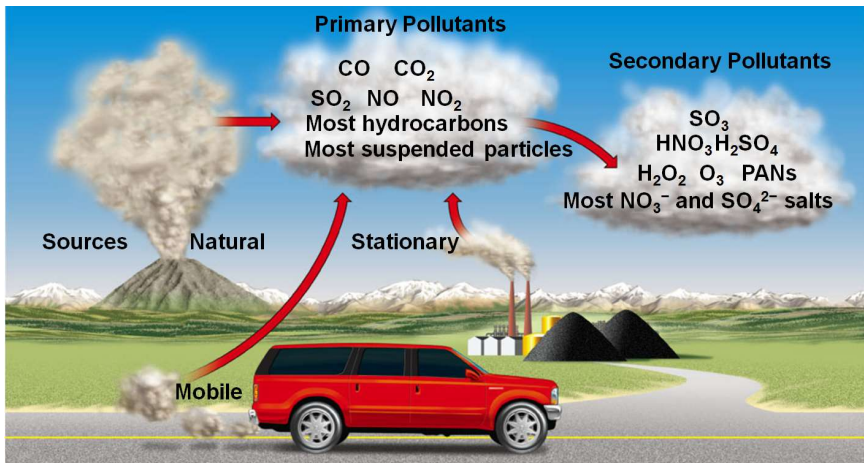
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2. Air pollution





The diagram illustrates the sources and types of air pollution. It shows three main sources: Natural (a volcano), Stationary (a factory with smokestacks), and Mobile (a red SUV). Arrows from these sources point to two clouds representing different types of pollutants. The left cloud, labeled 'Primary Pollutants', contains CO, CO₂, SO₂, NO, NO₂, Most hydrocarbons, and Most suspended particles. The right cloud, labeled 'Secondary Pollutants', contains SO₃, HNO₃, H₂SO₄, H₂O₂, O₃, PANs, and Most NO₃⁻ and SO₄²⁻ salts. The background shows a landscape with mountains and a road.

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Air pollution

- Natural pollutants (volcanoes)
- Greenhouse effect
- Ozone depletion
- acidification
- smog formation
- human health
- ecosystem health




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Natural Air Pollutants

- Natural air pollutants can include:
 - Smoke from wild fires
 - Methane released from live stock
 - Volcanic eruptions




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Greenhouse effect

- What changes climate?
- Is greenhouse effect real?
- How do we know?
- Why should we care?
- How sure are scientists?




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What changes climate?

- Changes in:
 - Sun's output
 - Earth's orbit
 - Interplanetary and galactic space
 - Drifting continents
 - Volcanic eruptions
 - **Greenhouse gases**

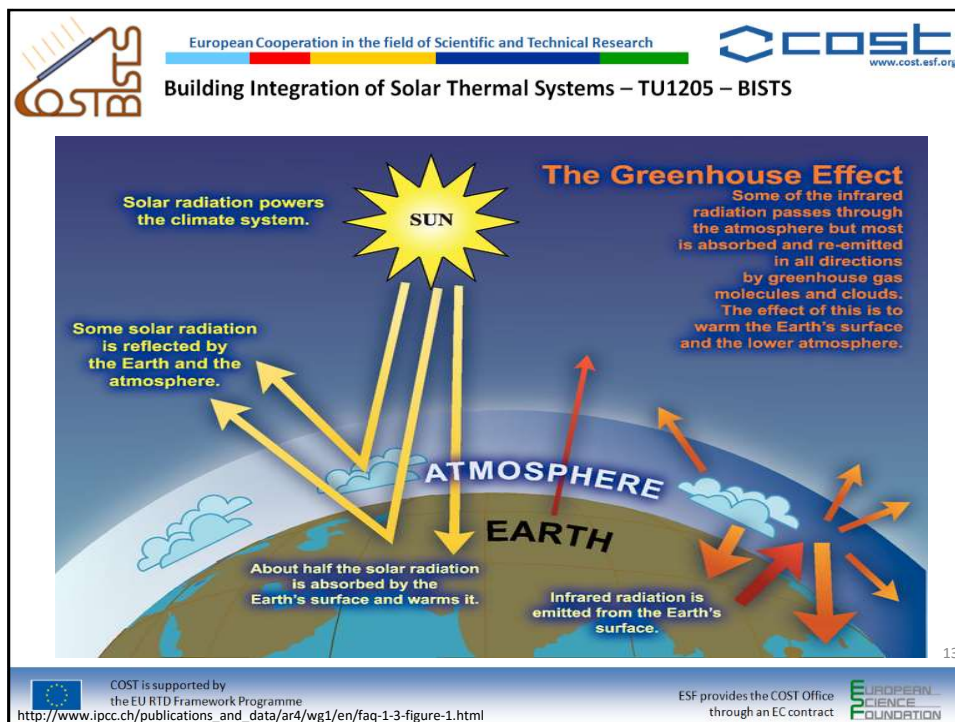


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How do we know?

Wood rings

Ice cores

Palaeontological material

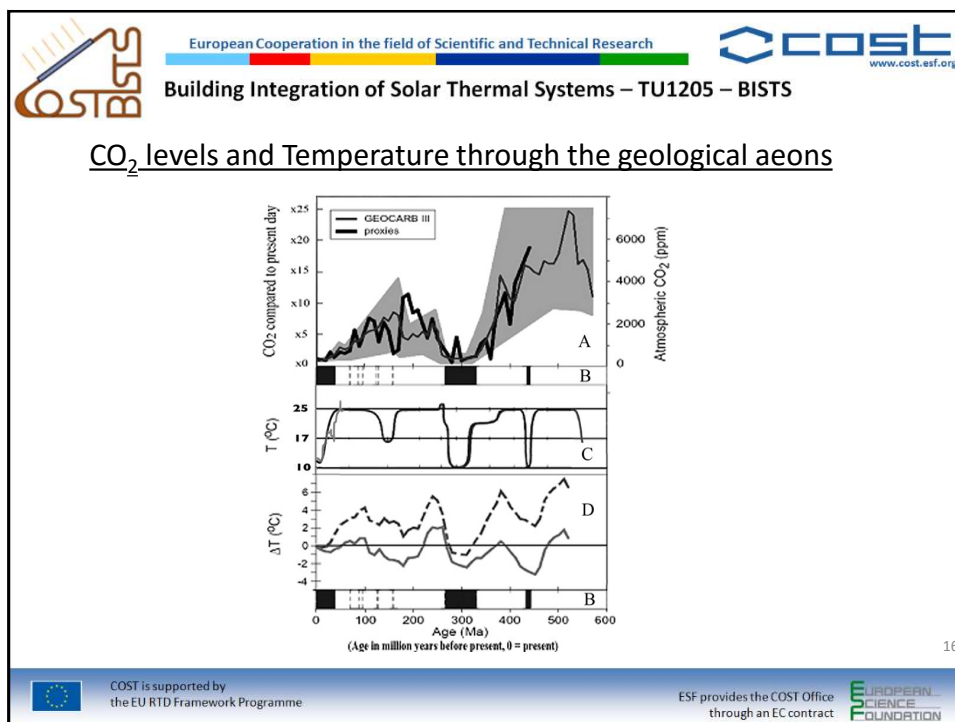
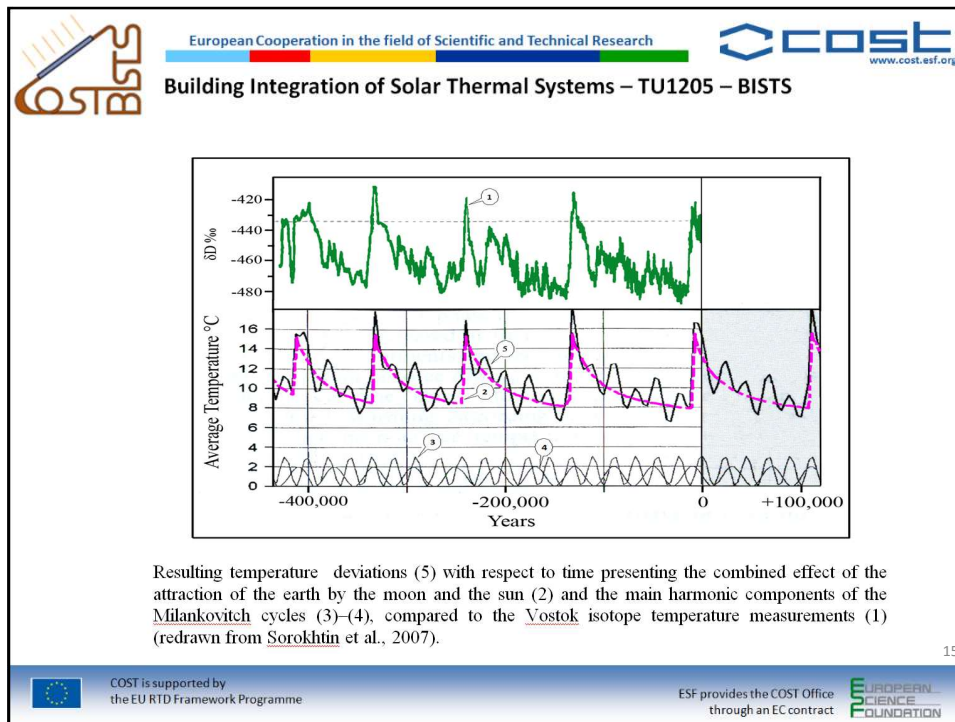
corals

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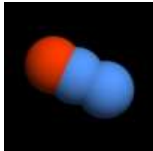


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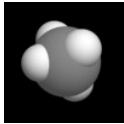
Greenhouse gases



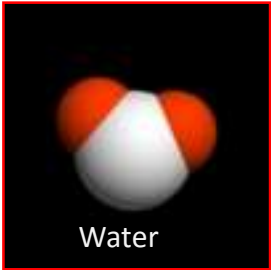
Nitrous oxide



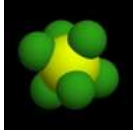
Carbon dioxide



Methane



Water



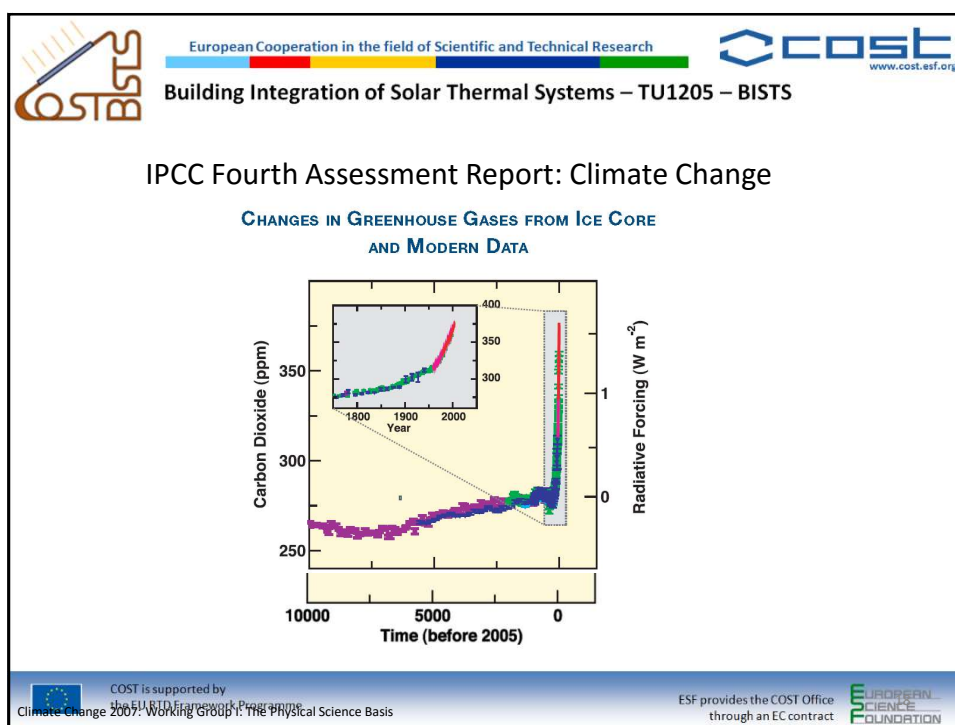
Sulfur hexafluoride

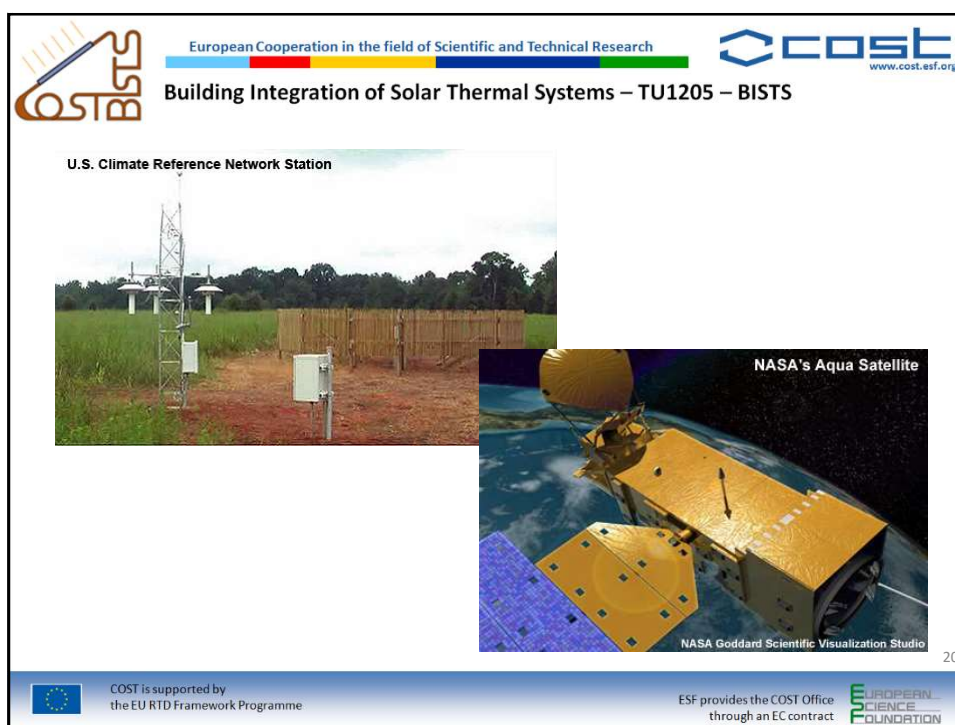
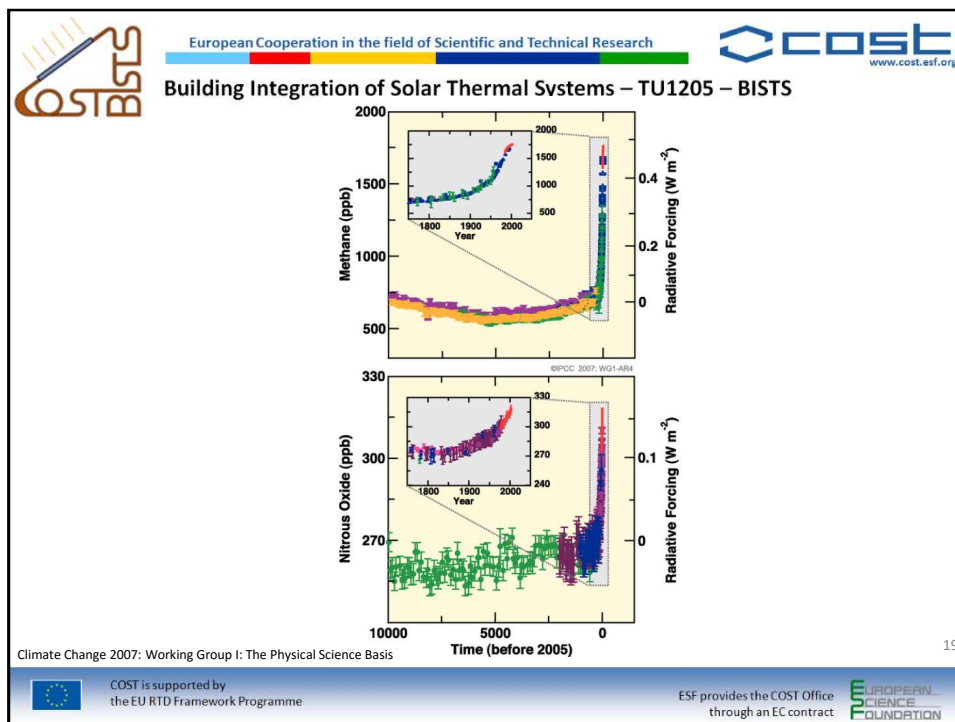
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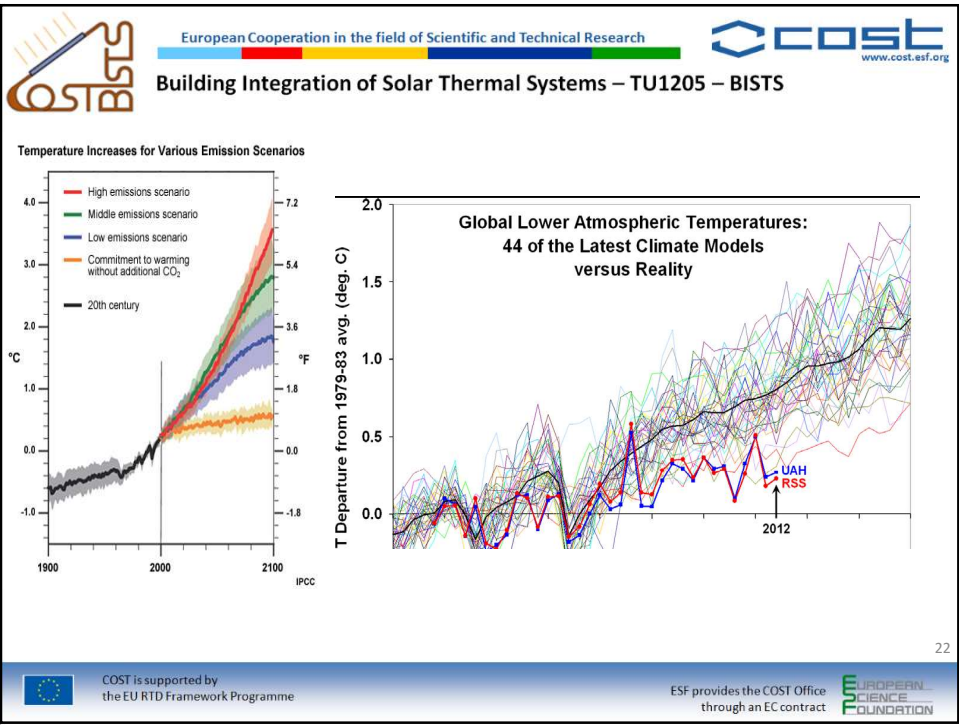
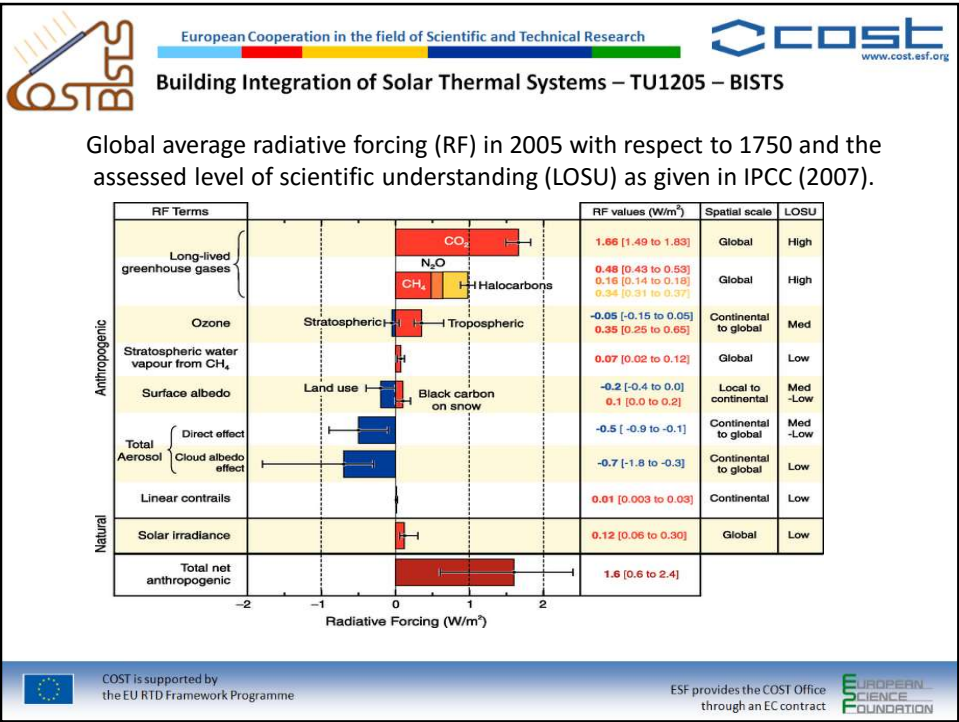
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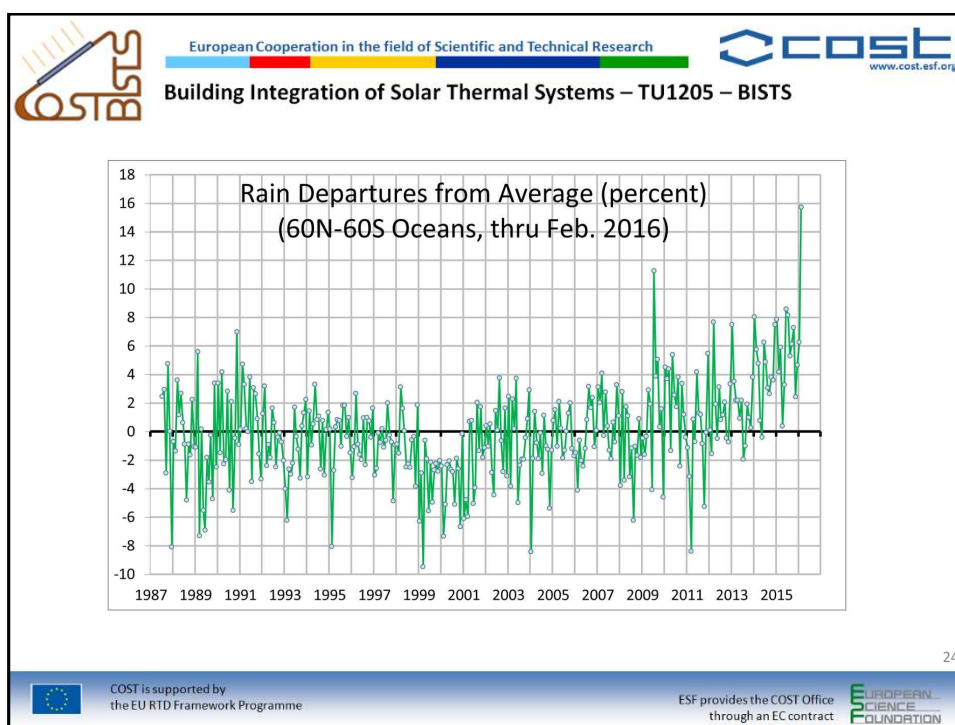
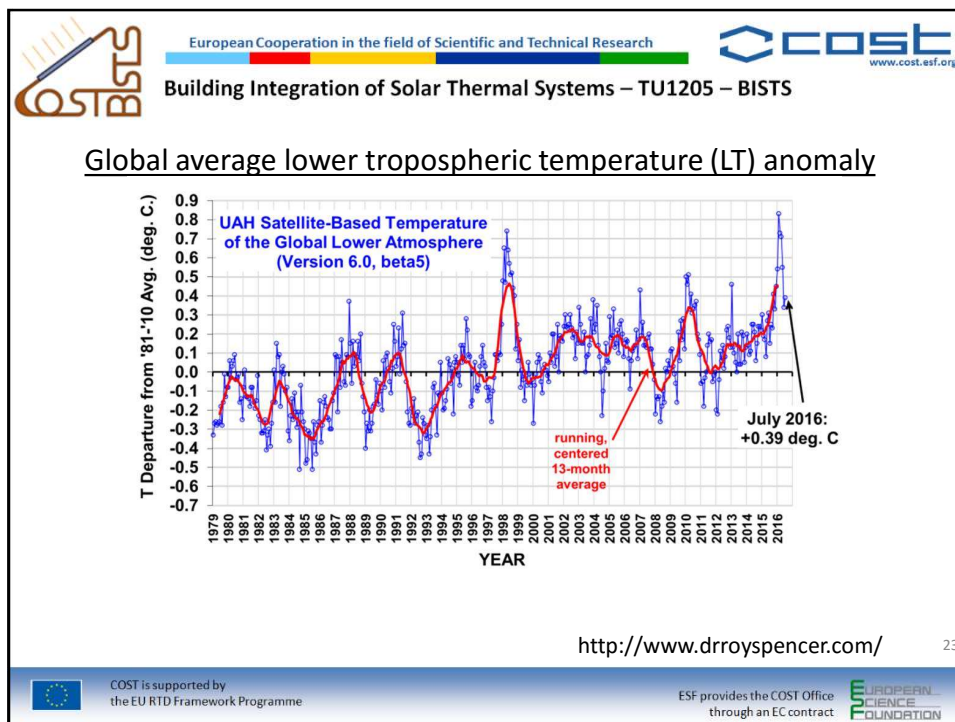
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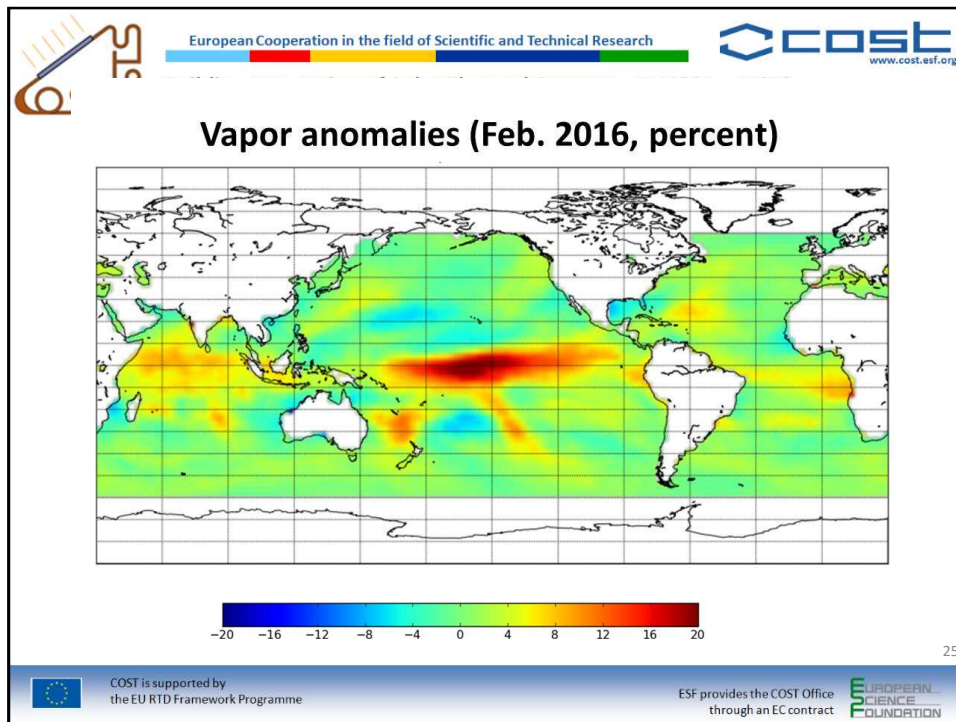
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Ozone depletion

Ozone depletion describes two distinct but related phenomena observed since the late 1970s:

- A **steady decline of about 4% per decade** in the total volume of ozone in Earth's stratosphere (the ozone layer) and
- A much larger **springtime decrease** in stratospheric ozone over Earth's polar regions referred to as the **ozone hole**.

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Pollution is not always disastrous!

Plant dry weight (biomass) responses to atmospheric CO₂ enrichment, for 600 ppm atmospheric CO₂ concentration.

Cereals		Vegetables	
Barley	40%	Cabbages	29%
Rice	36%	Tomatoes	32%
Wheat	33%	Cucumbers	45%
Legumes		Other	
Beans	64%	Coffee	175%
Peas	33%	Olive trees	36%
Soybeans	46%	Citrus	30–60%
Roots and tubers			
Carrots	78%		
Potatoes	30%		

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Ozone depletion: CFCs

- Chlorofluorocarbons (CFCs) contribute to air pollution by reducing the amount of ozone of the stratosphere. CFCs come from a variety of places such as:
 - the burning of plastic foam items
 - leaking refrigerator equipment
 - spray cans

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Biological effects

- UVB (the higher energy UV radiation absorbed by ozone) is generally accepted to be a contributory factor to skin cancer and to produce Vitamin D.
- For the present ozone layer depletion in most locations has been typically a few percent and no direct evidence of health damage is available in most latitudes.

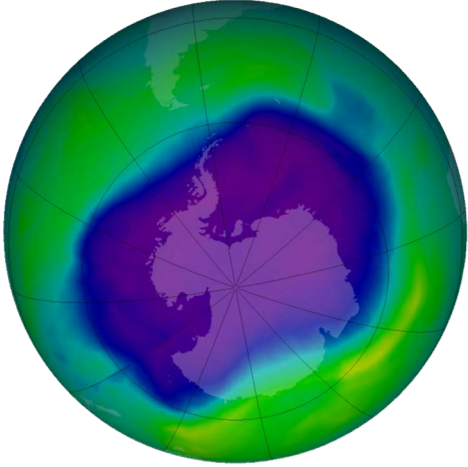


Image of the largest Antarctic ozone hole ever recorded (September 2006), over the Southern pole

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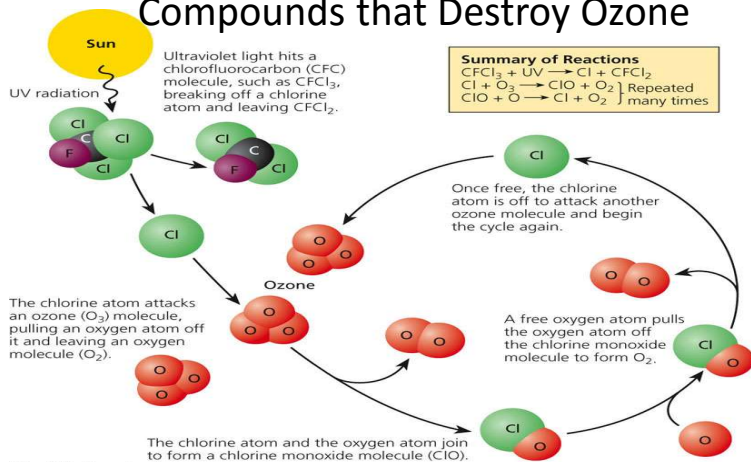
http://en.wikipedia.org/wiki/Ozone_depletion

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Summary of CFCs and Other Chlorine-Containing Compounds that Destroy Ozone



Ultraviolet light hits a chlorofluorocarbon (CFC) molecule, such as CFCl_3 , breaking off a chlorine atom and leaving CFCl_2 .

Summary of Reactions

$$\begin{aligned} \text{CFCl}_3 + \text{UV} &\rightarrow \text{Cl} + \text{CFCl}_2 \\ \text{Cl} + \text{O}_3 &\rightarrow \text{ClO} + \text{O}_2 \quad \text{Repeated many times} \\ \text{ClO} + \text{O} &\rightarrow \text{Cl} + \text{O}_2 \end{aligned}$$

Once free, the chlorine atom is off to attack another ozone molecule and begin the cycle again.

The chlorine atom attacks an ozone (O_3) molecule, pulling an oxygen atom off it and leaving an oxygen molecule (O_2).

A free oxygen atom pulls the oxygen atom off the chlorine monoxide molecule to form O_2 .


The chlorine atom and the oxygen atom join to form a chlorine monoxide molecule (ClO).

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GLOBAL WARMING IMPACT (GWI)


- The depletion of the stratospheric ozone layer leads to global warming and was identified as a major environmental problem during the last 30 years.
- Air conditioners, heat pumps and refrigerating machines are thought to be major contributors to the ozone depletion.
- Examination of the global warming impact of these machines requires consideration of both direct and indirect effects.
- The direct component relates to release of refrigerants that are greenhouse gases, and the indirect one to carbon dioxide production in powering the equipment.

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http://www.engineeringtoolbox.com/Refrigerants-Environment-Properties-d_1220.html

Refrigerant	Ozone Depletion Potential (ODP)	Global Warming Potential (GWP)
R-11 Trichlorofluoromethane	1.0	4000
R-12 Dichlorodifluoromethane	1.0	2400
R-13 B1 Bromotrifluoromethane	10	
R-22 Chlorodifluoromethane	0.05	1700
R-32 Difluoromethane	0	650
R-113 Trichlorotrifluoroethane	0.8	4800
R-114 Dichlorotetrafluoroethane	1.0	3.9
R-123 Dichlorotrifluoroethane	0.02	0.02
R-124 Chlorotetrafluoroethane	0.02	620
R-125 Pentafluoroethane	0	3400
R-134a Tetrafluoroethane	0	1300
R-143a Trifluoroethane	0	4300
R-152a Difluoroethane	0	120
R-245a Pentafluoropropane	0	
R-401A (53% R-22, 34% R-124, 13% R-152a)	0.37	1100
R-401B (61% R-22, 28% R-124, 11% R-152a)	0.04	1200
R-402A (38% R-22, 60% R-125, 2% R-290)	0.02	2600
R-404A (44% R-125, 52% R-143a, R-134a)	0	3300
R-407A (20% R-32, 40% R-125, 40% R-134a)	0	2000
R-407C (23% R-32, 25% R-125, 52% R-134a)	0	1600
R-502 (48.8% R-22, 51.2% R-115)	0.283	4.1
R-507 (45% R-125, 55% R-143)	0	3300
R-717 Ammonia - NH ₃	0	0
R-718 Water - H ₂ O	0	
R-729 Air	0	
R-744 Carbon Dioxide - CO ₂		1*

• Global Warming Potential (GWP) is a measure of how much a given mass of a gas contributes to global warming. GWP is a relative scale which compares the amount of heat trapped by greenhouse gas to the amount of heat trapped in the same mass of Carbon Dioxide. **The GWP of Carbon Dioxide is by definition 1 and is the reference. Be aware that GWPs are highly controversial.**

• Ozone Depletion Potential (ODP) of a chemical compound is the relative amount of degradation it can cause to the ozone layer

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Compound	Estimated Atmospheric Lifetime (years)	Global Warming Potentials * (at time horizons of)			Source
		20 years	100 years	500 years	
CFC-11	50±5	5000	4000	1400	(b)
CFC-12	102	7900	8500	4200	(b)
CFC-113	85	5000	5000	2300	(b)
CFC-114	300	6900	9300	8300	(b)
CFC-115	1700	6200	9300	13000	(b)
HCFC-22	13.3	4300	1500	520	(b)
HCFC-123	1.4	300	93	29	(b)
HCFC-124	5.9	1500	480	150	(b)
HCFC-141b	9.4	1800	630	200	(b)
HCFC-142b	19.5	4200	2000	630	(b)
HCFC-225ca	2.5	550	170	52	(b)
HCFC-225cb	6.6	1700	530	170	(b)
HFC-23	264	9100	11700	9800	(c)
HFC-32	5.6	2100	650	200	(c)
HFC-43-10mee	17.1	3000	1300	400	(c)
HFC-125	32.6	4600	2800	920	(c)
HFC-134a	14.6	3400	1300	420	(c)
HFC-143a	48.3	5000	3800	1400	(c)
HFC-152a	1.5	460	140	42	(c)
HFC-227ea	36.5	4300	2900	950	(c)
HFC-236fa	209	5100	6300	4700	(c)
HFC-245ca	6.6	1800	560	170	(c)
Methane	12.2±3	56	21	6.5	(c)
NMHCs **	-	31	11	6	(a)

* GWP values are referenced to the absolute GWPs for CO₂ at each time horizon; typical uncertainty is ±35%.

** NMHCs = non-methane hydrocarbons

Sources: IPCC 1990 (a); 1995 (b); and 1996 (c).

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Acid Rain

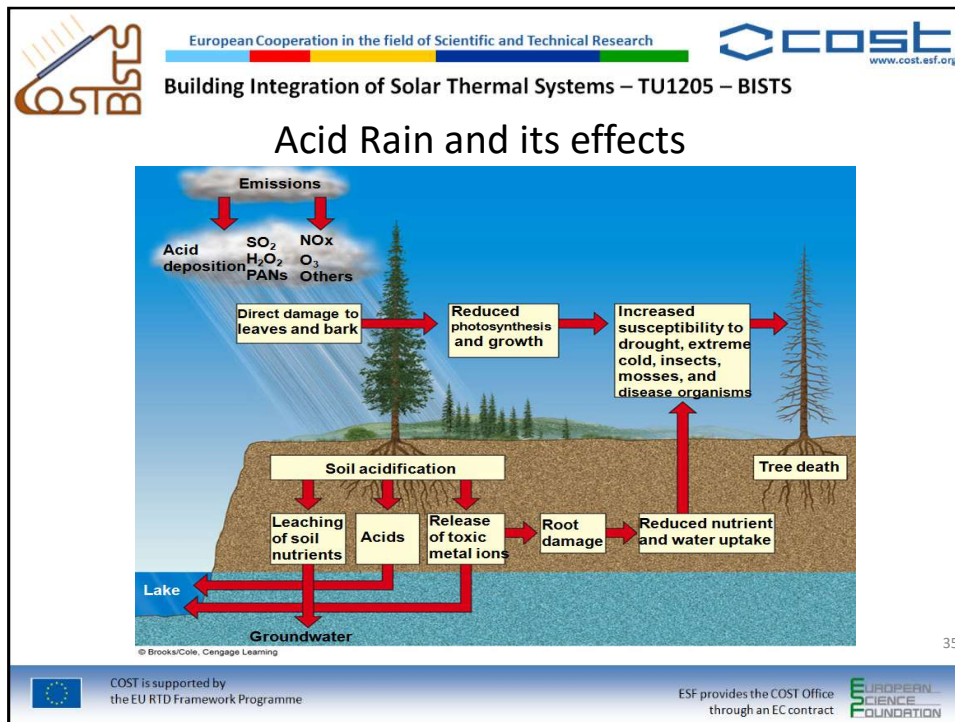
- When emissions of sulfur dioxide and nitric oxide from stationary sources are transported long distances by winds, they form secondary pollutants such as nitrogen dioxide, nitric acid vapor, and droplets containing solutions of sulfuric acid, sulfate, and nitrate salts
- These chemicals drop to the earth's surface in wet form as rain or snow known as acid rain, and in dry form as gases fog, dew, or solid acid deposition

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Smog

- Smog is caused by the burning of large amounts of coal within a city; this smog contains soot particulates from smoke, sulfur dioxide and other components. Modern smog, is derived from vehicular emission from internal combustion engines and industrial fumes that react in the atmosphere with sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog.
- photochemical smog has become predominant in many cities, which are located in sunny, warm, and dry climates with many motor vehicles
- Worst episodes of photochemical smog tend to occur in summer

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Smoggy cities



Beijing



São Paulo

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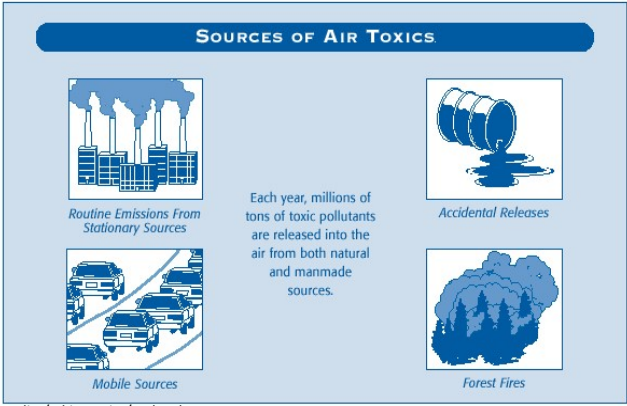
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Human health

EPA- Environmental Protection Agency: hazardous air pollutants are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or to cause adverse environmental effects.

SOURCES OF AIR TOXICS



Each year, millions of tons of toxic pollutants are released into the air from both natural and manmade sources.

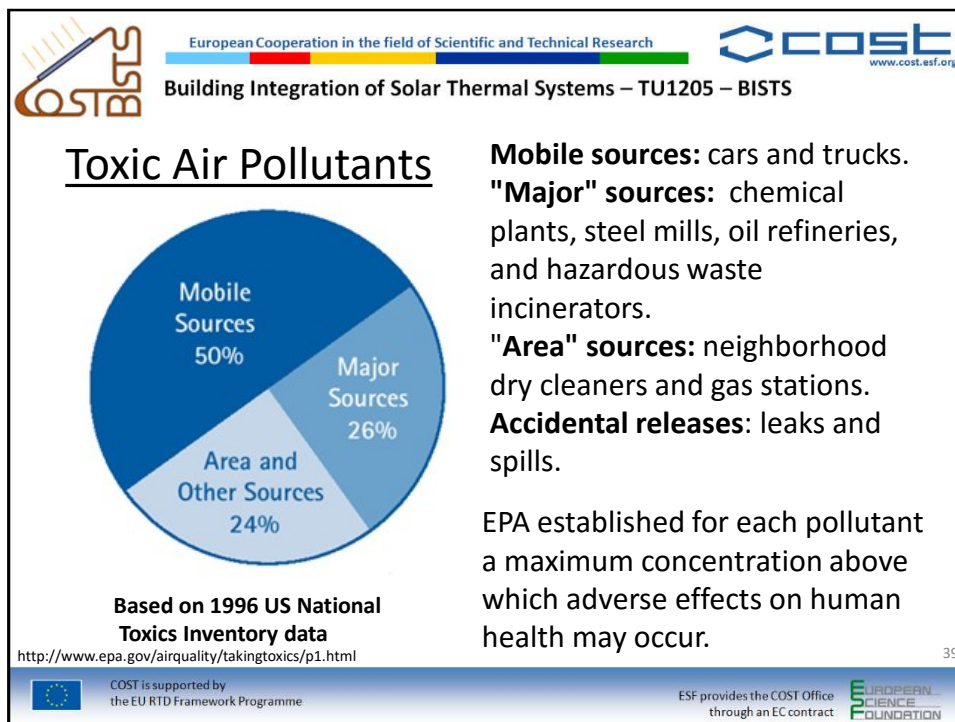
<http://www.epa.gov/airquality/takingtoxics/p1.html>

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Air pollutants



- **Nitrogen Dioxide: NO₂**
 - brownish gas irritates the respiratory system. Originates from combustion (N₂ in air is oxidized); NO_x sum of NO, NO₂, other oxides of N
- **Ozone: ground level O₃**
 - primary constituent of urban smog
 - chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC). VOC + NO_x in presence of heat +sun light
 - Breathing ozone can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion
- **Carbon monoxide: CO**
 - product of incomplete combustion
 - reduces blood ability to carry O₂

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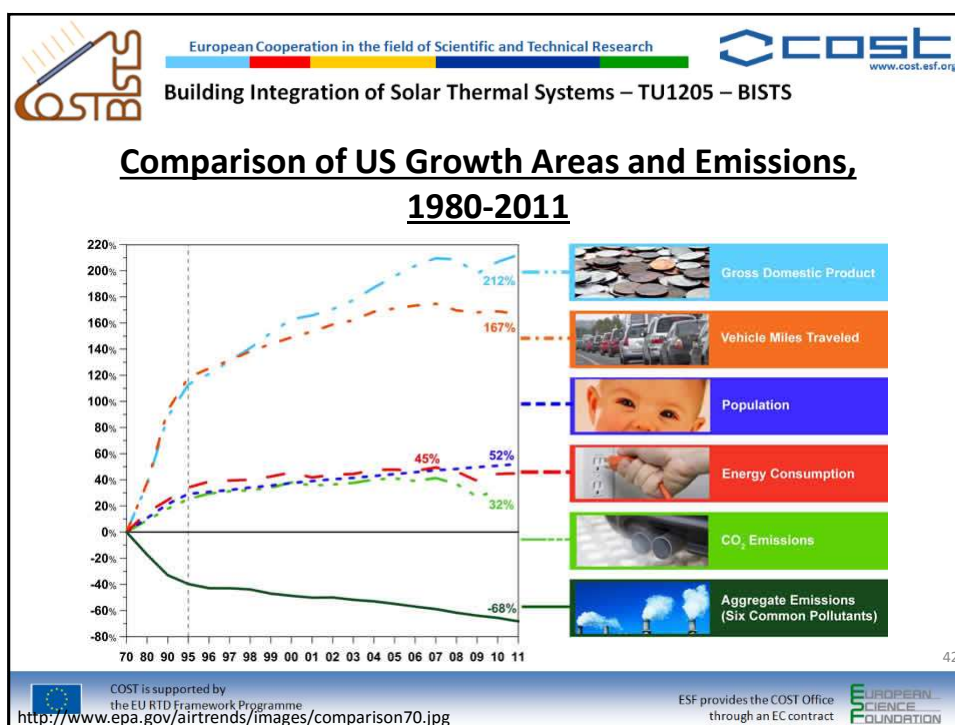

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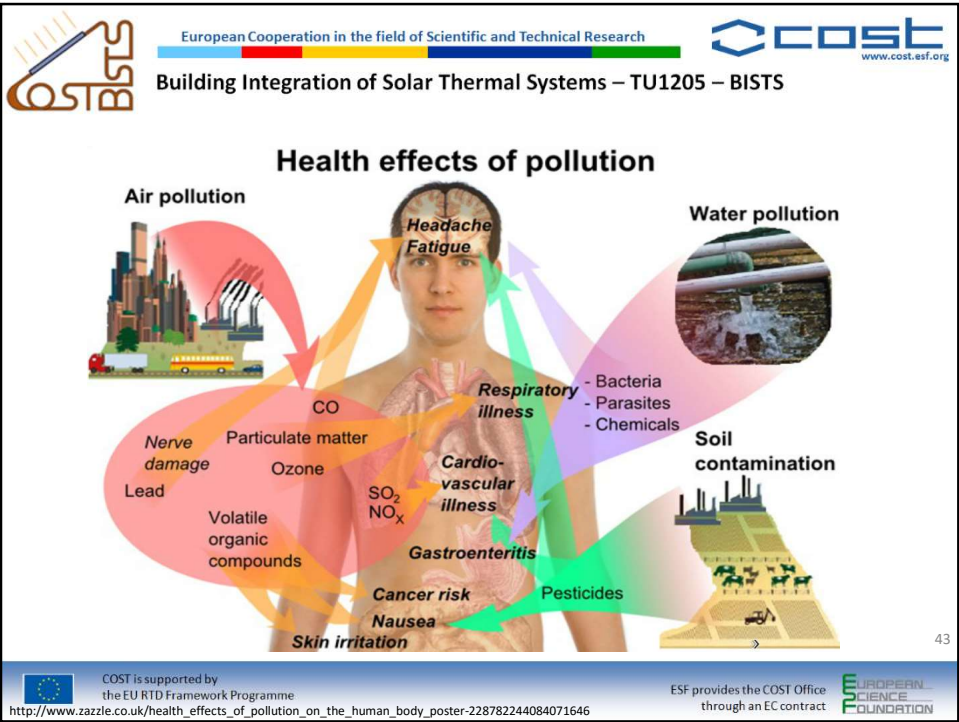
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- **Lead: Pb**
 - causes learning disabilities in children, toxic to liver, kidney, blood forming organs
 - tetraethyl lead – anti knock agent in gasoline
 - **leaded gasoline has been phased out**
- **Particulate Matter: PM**, is a complex mixture of extremely small particles and liquid droplets made up of acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.
 - respiratory disorders
- **Sulfur Dioxide: SO₂**
 - formed when fuel (coal, oil) containing S is burned and in metal smelting
 - precursor to acid rain along with NO_x

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Causes of Land Pollution


- Four Main causes of land pollution
 - Construction
 - Agriculture
 - Domestic waste
 - Industrial Waste


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Constructions

- Buildings take up resources and land, the trees are chopped down and used to make buildings
- Destroy ecosystem





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Agriculture

- As there are more and more people inhabiting the earth, food is in higher demand and so forests are chopped down and turned into farmland
- In addition, herbicides, pesticides, artificial fertilizers etc are washed into the soil and pollute it





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Domestic Waste

- Tons of domestic waste is dumped every day. Some waste from homes, offices and industries can be recycled or burnt in incinerators
- There is still a lot of garbage, such as refrigerators and washing machines that are dumped in landfills simply because they cannot be reused in anyway, nor recycled




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Industrial Waste

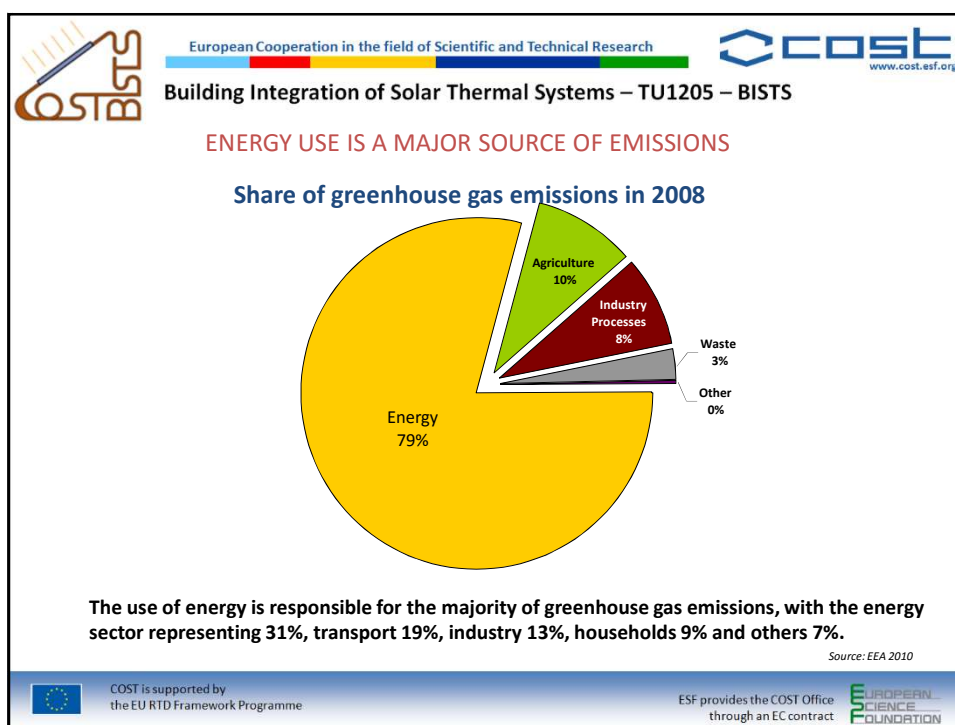
- Plastics factories, chemical plants, oil refineries, nuclear waste disposal activity, large animal farms, coal-fired power plants, metals production factories and other heavy industry all contribute to land pollution

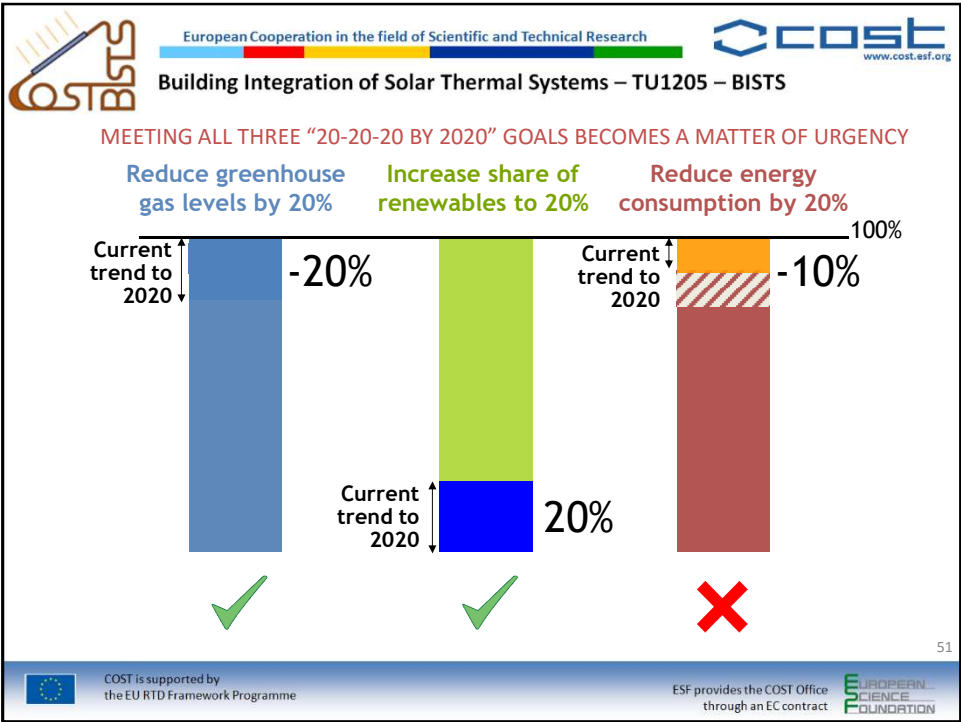


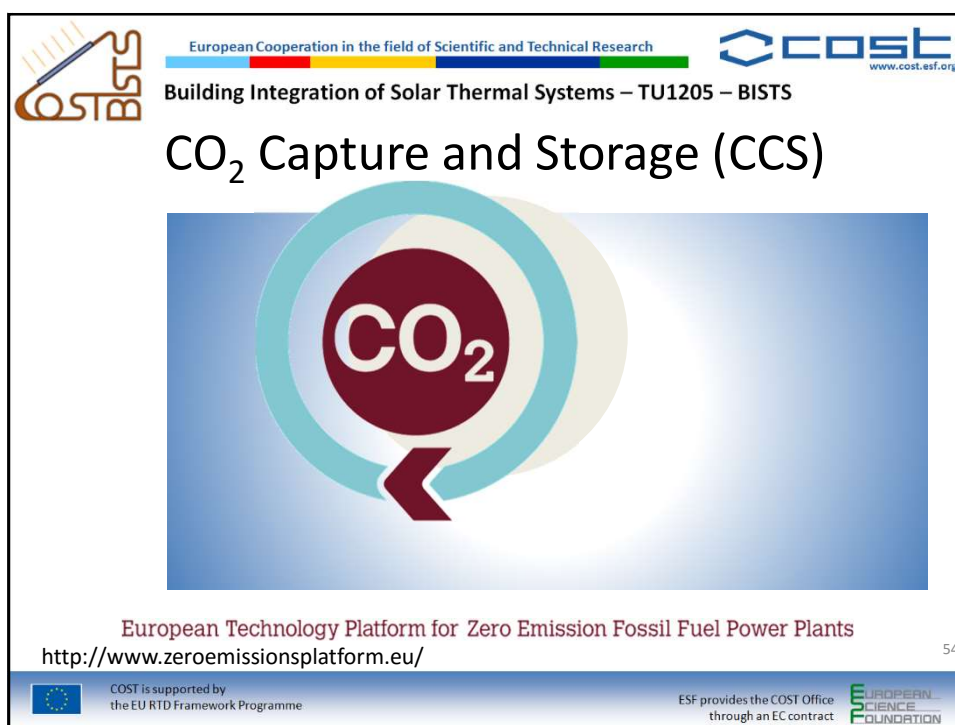
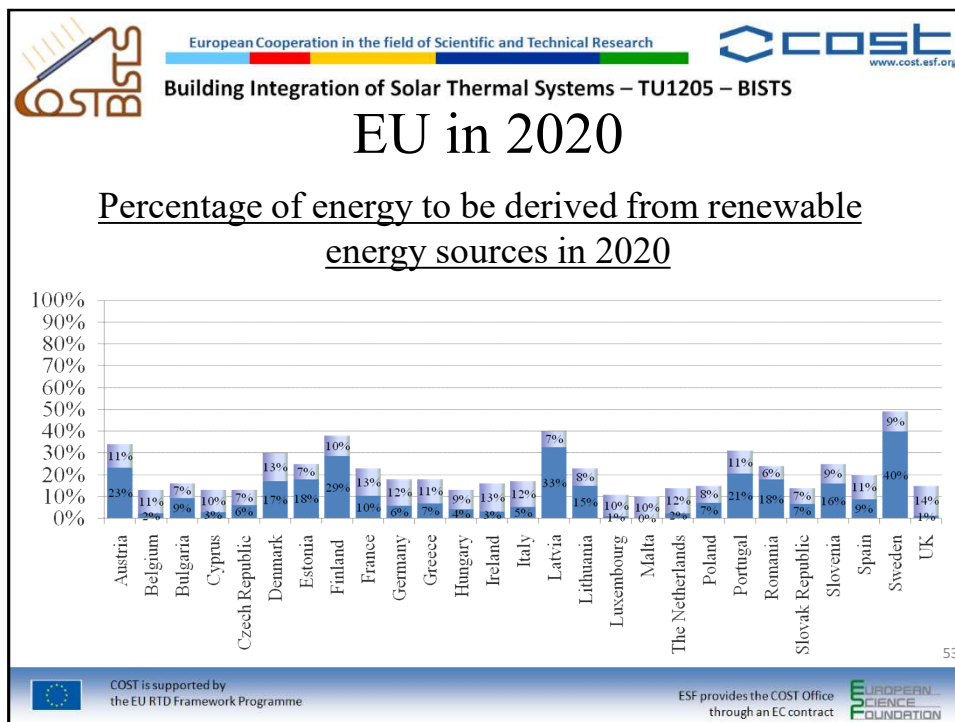
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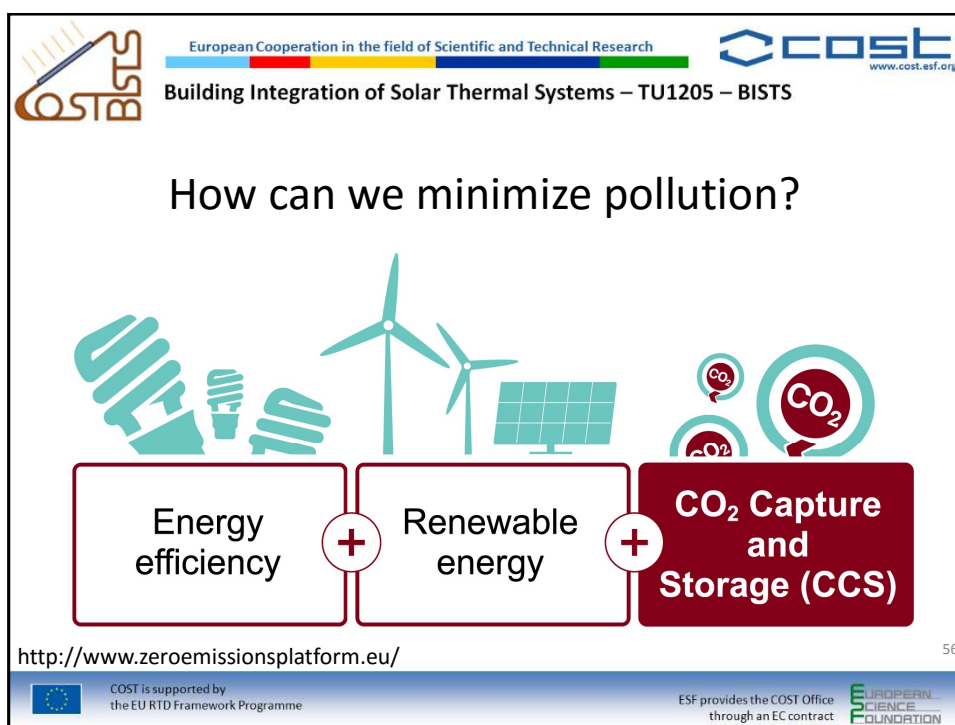
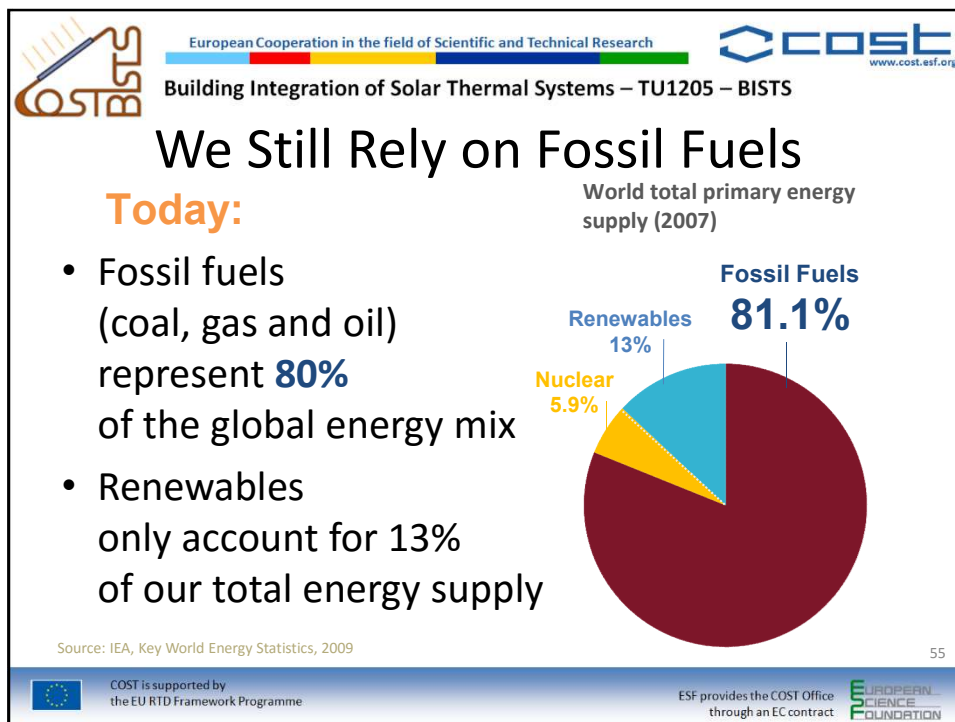
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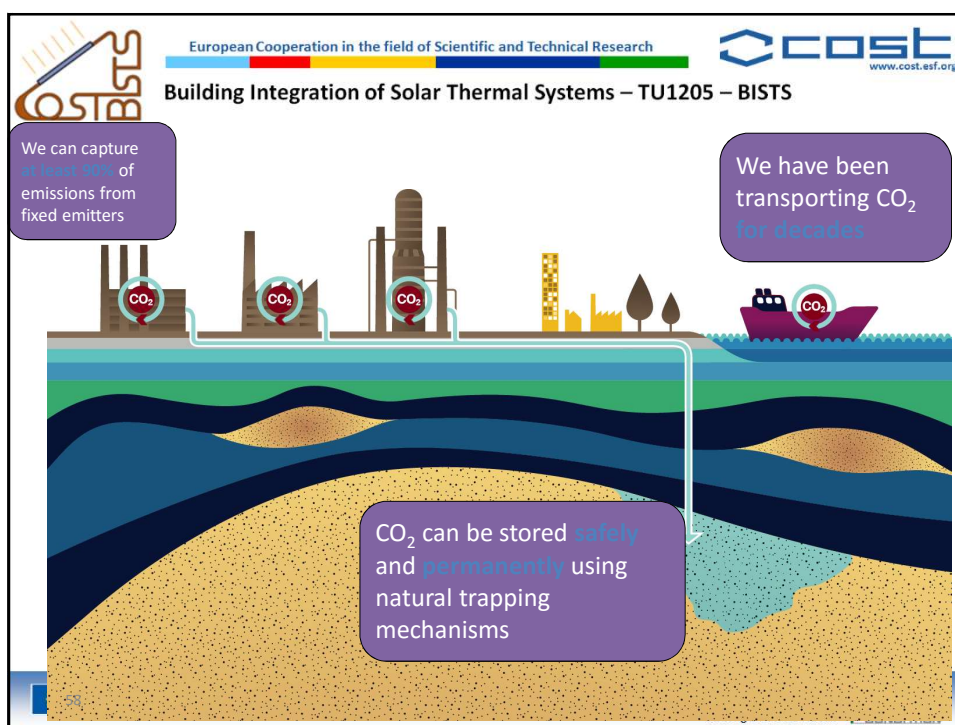
Carbon Capture alone will provide
up to 20% of the CO₂ emission reductions
needed to be made by 2050.


Here's how it works...


<http://www.zeroemissionsplatform.eu/>

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Safely Storing CO₂

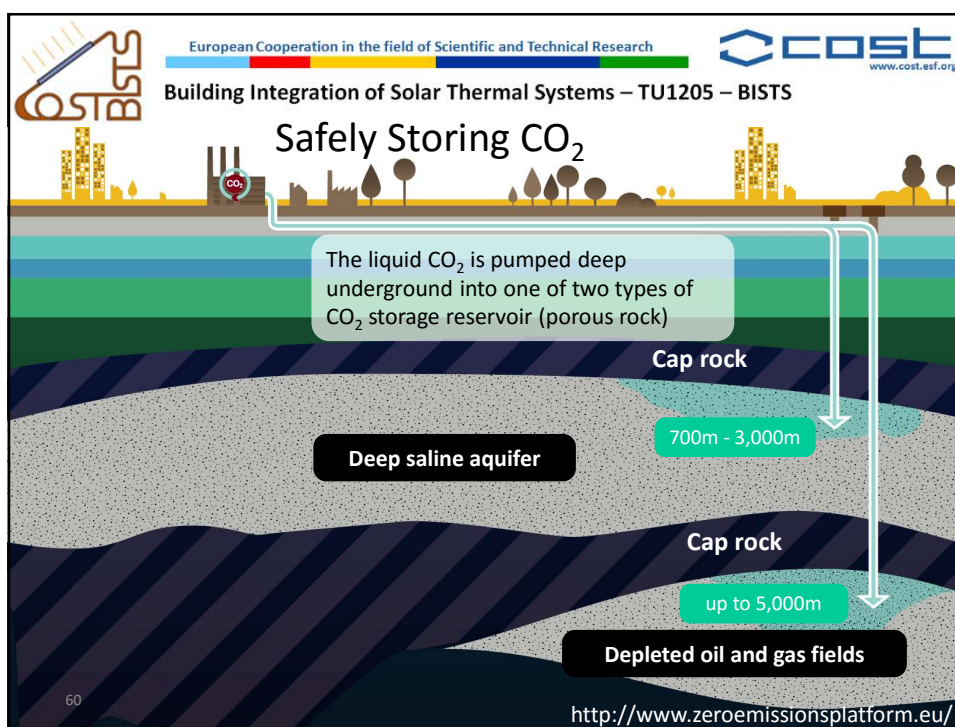
- CCS uses a **natural mechanism** that has trapped CO₂, gas and oil for millions of years
- Liquid CO₂ is pumped deep underground into one of two types of reservoirs:
 - deep saline aquifers (700m-3,000m)
 - depleted gas and oil fields (up to 5,000m)
- Both types of reservoirs have a layer of **porous rock** to absorb the CO₂ and an impermeable layer of **cap rock** to seal the porous layer

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The Safety of Stored CO₂ Increases Over Time

... due to 3 natural mechanisms

- Residual trapping**
CO₂ is trapped in tiny rock pores and cannot move
- Dissolution trapping**
CO₂ dissolves into surrounding salt water
- Mineral trapping**
CO₂-rich water sinks to the bottom of the reservoir and reacts to form minerals

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Monitoring CO₂ Storage Sites

- To ensure that a CO₂ storage site functions as it should, a rigorous monitoring process begins at the reservoir selection stage and continues for as long as required
- Monitoring continues even after a CO₂ injection well is closed and EU legislation requires that stored CO₂ is kept **safely** and **permanently** underground

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Thank you for your attention

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