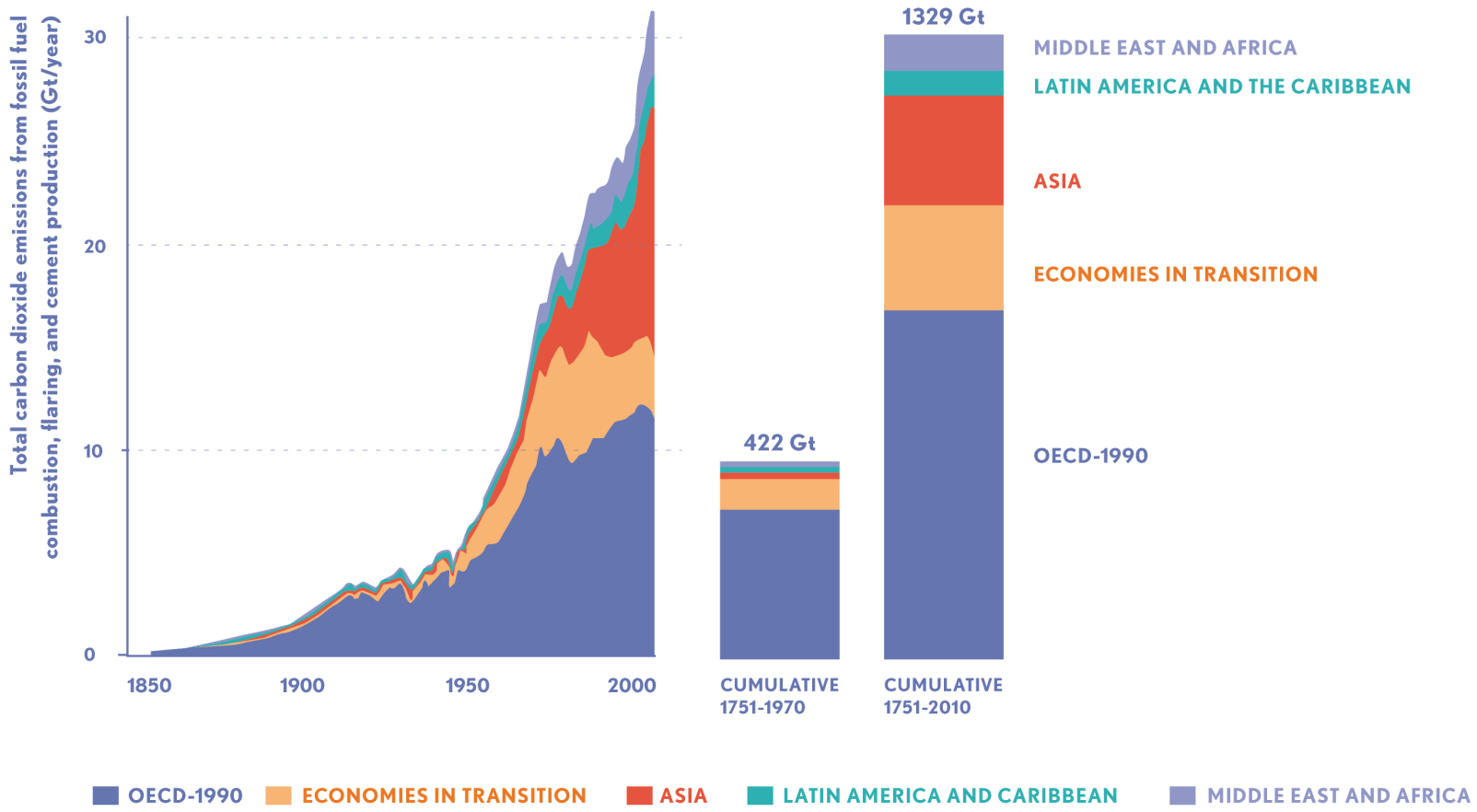
IPCC 5. ASSESSMENT REPORT

WORKING GROUP 3
MITIGATION OF CLIMATE CHANGE

“Mitigation” is a human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Contribution of the Working Group III for IPCC’s Fifth Assessment report examines the results of scientific research about mitigation, with a special attention on how knowledge has evolved since the Fourth Assessment Report (AR4) published in 2007. Throughout, the focus is on the implications of its findings for policy, without being prescriptive about the policies that governments should adopt. The report does not recommend any particular option for mitigation.

Since 1850 global carbon dioxide emissions have increased substantially.



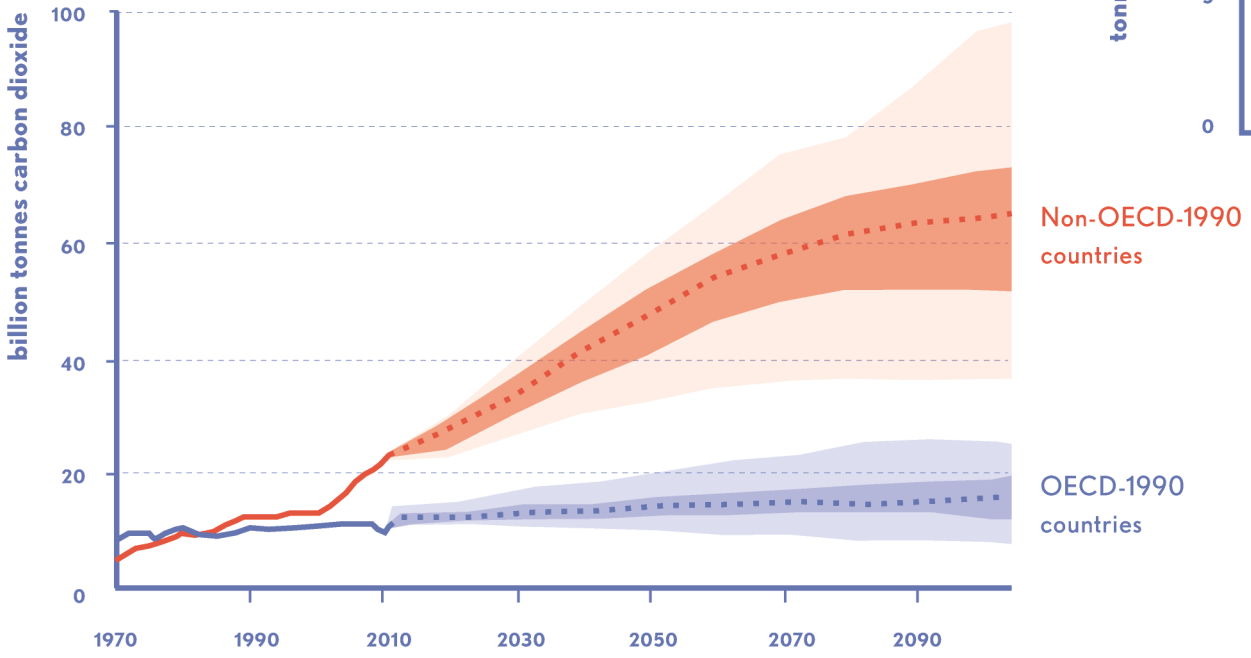
Gt/yr = gigatonnes (billion tonnes) per year

OECD = the Organisation for Economic Co-operation and Development

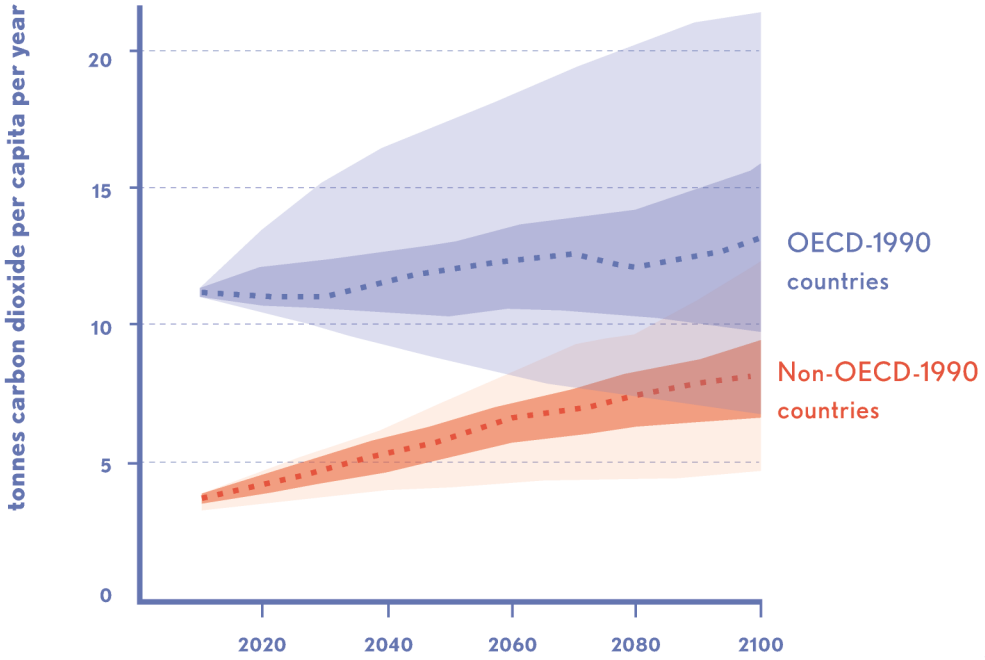
Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

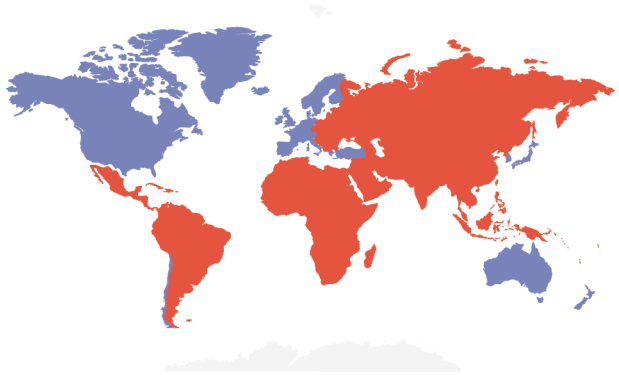
Historically, OECD-1990 countries have been responsible for the majority of greenhouse gases. Other countries, particularly in Asia, have increased their emissions in recent years along with changes in the world economy. Emissions from non-OECD-1990 countries are projected to increase. However, per capita emissions are projected to remain higher in the OECD countries than in the non-OECD countries up to the year 2100.

ACTUAL AND PROJECTED CARBON DIOXIDE EMISSIONS OF OECD AND NON-OECD COUNTRIES



PROJECTED PER CAPITA CARBON DIOXIDE EMISSIONS IN THE OECD-1990 AND NON-OECD COUNTRIES

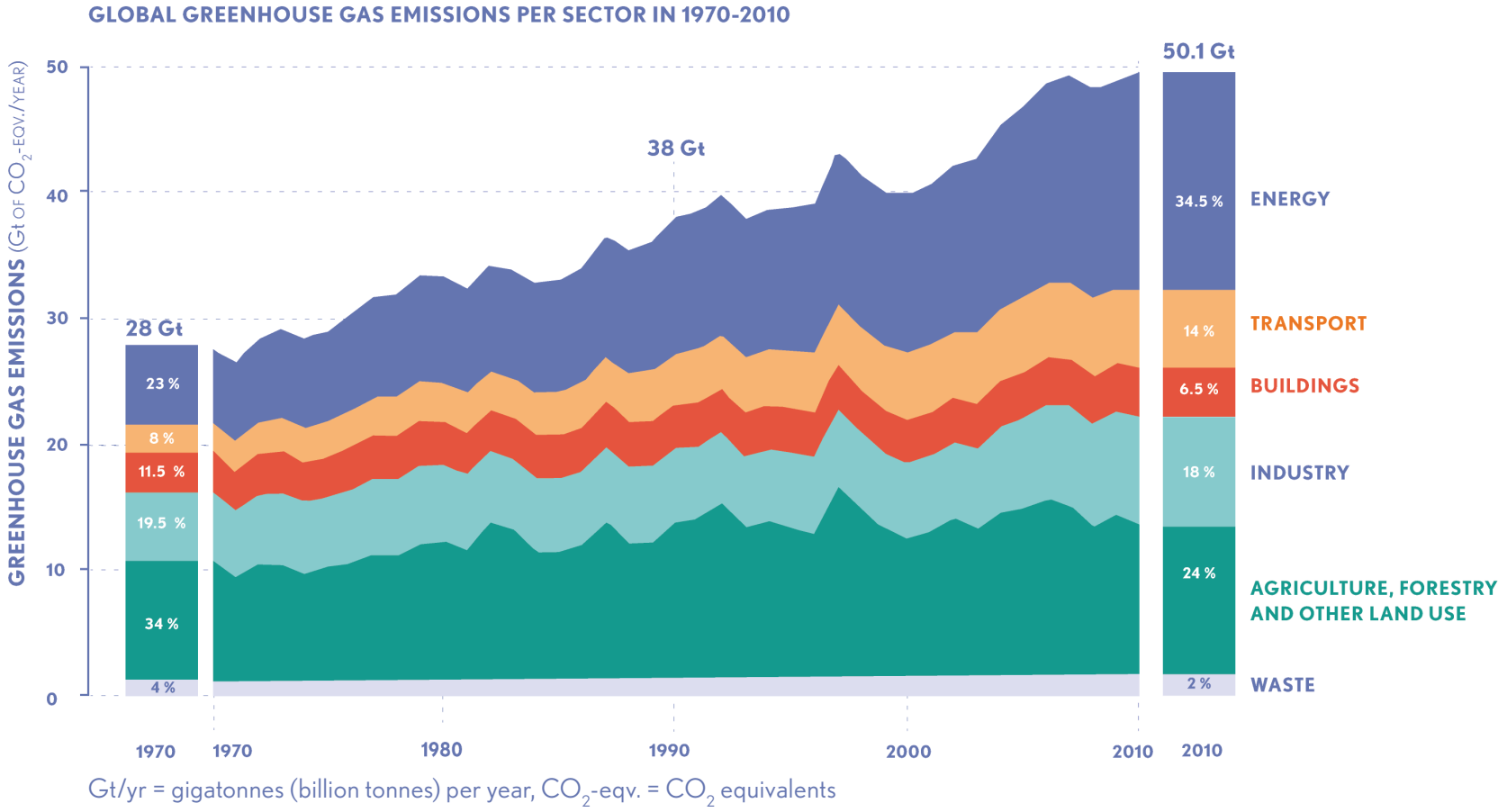




Non-OECD-1990 countries
OECD-1990 countries

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

Global greenhouse gas emissions have increased in nearly all sectors.
Contrary to the other sectors, emissions from the agriculture, forestry and other land use (AFOLU) sector have decreased, as more and more countries are adopting forest protection policies and because improved crop yields in agriculture decrease the need to convert natural forests into croplands.



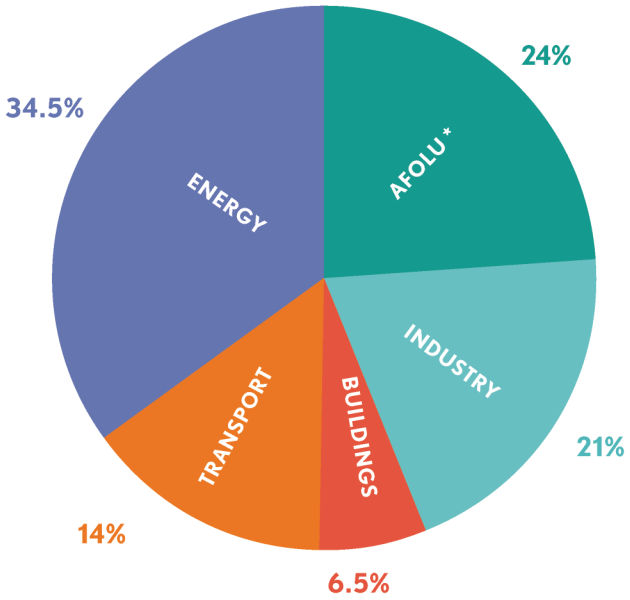
Gt/yr = gigatonnes (billion tonnes) per year, CO_2-eqv. = CO_2 equivalents

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

Global and Finnish greenhouse gas emissions per sector

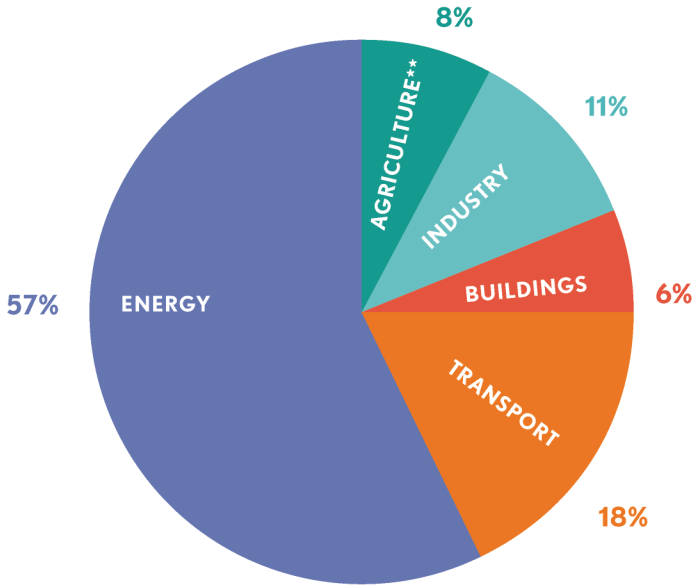
GLOBAL 2010

Total emissions: 50.1 billion tonnes



FINLAND 2010

Total emissions: 74.3 million tonnes

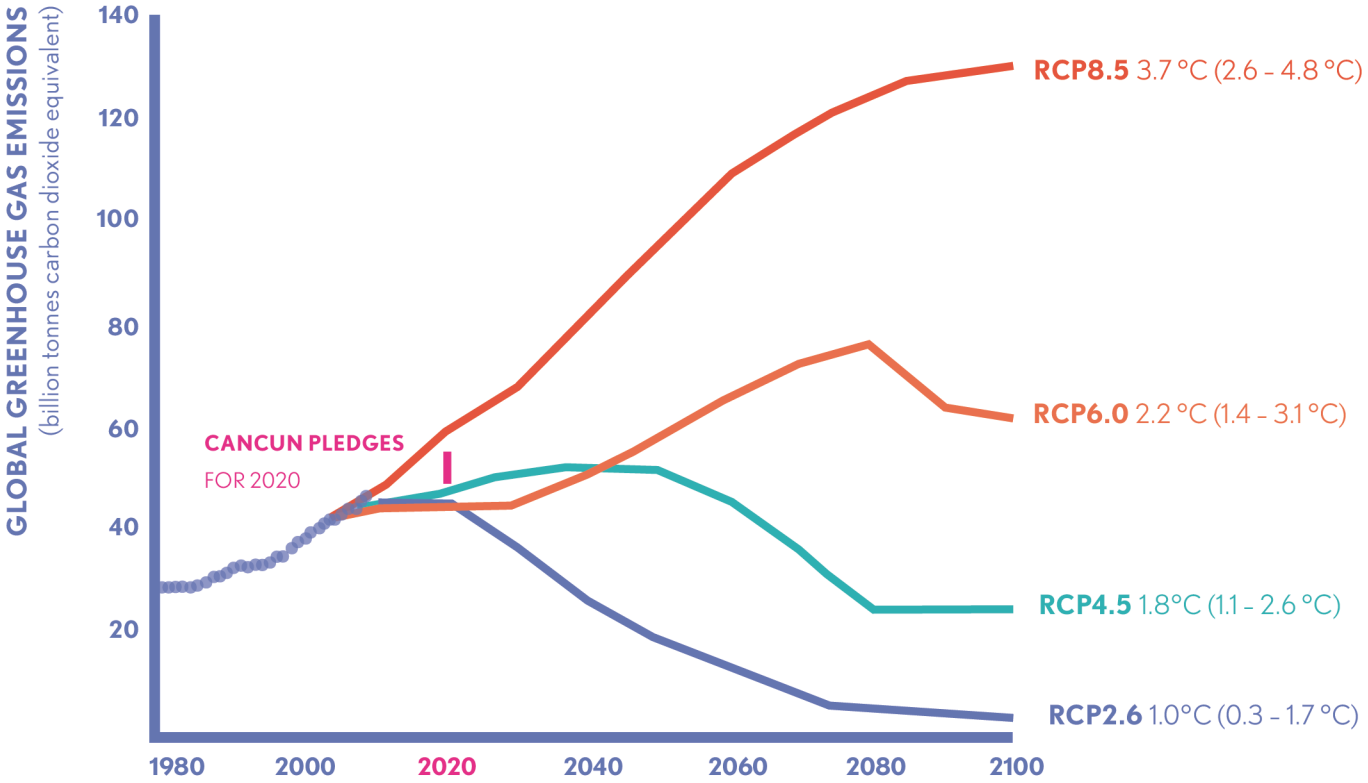


The share of the energy sector is high in Finland due to energy-intensive industry and high demand of energy for heating.

* AFOLU = Agriculture, forestry and land use.
** In Finland carbon sink in the land use, land use change and forestry sector is larger than emissions. The size of the carbon sink was about 21.1 millions tonnes carbon dioxide equivalents in 2010.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment. Data for Finland received from Statistics Finland.

Current pledges to reduce greenhouse gas emissions (so-called Cancun pledges) are not high enough to keep the average global temperature rise below 2 degrees Celsius by 2100.



RCP (REPRESENTATIVE CONCENTRATION PATHWAYS) SCENARIOS

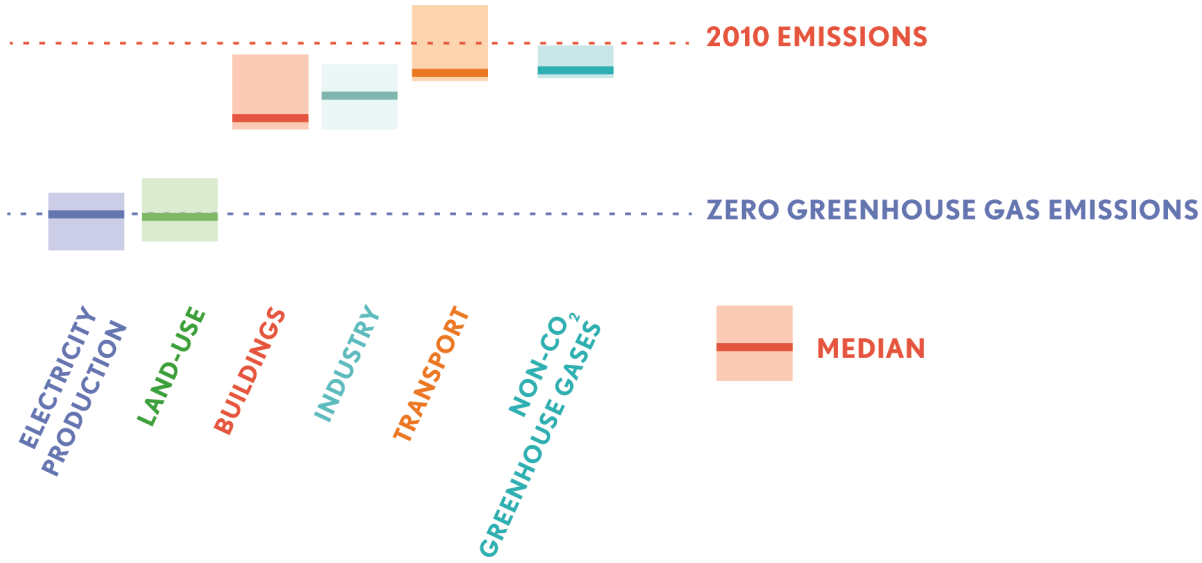
Represent possible future emission pathways assuming different levels of mitigation extending from non-mitigation to a very high level of mitigation.

RCP8.5 Increasing emissions, reaching an atmospheric concentration of ca. 1370 ppm in 2100
RCP6.0 Stabilisation of concentration level to ca. 850 ppm after 2100
RCP4.5 Stabilisation of concentration to 650 ppm before 2100
RCP2.6 Increase of emissions to 490 ppm sometime before 2100, and then reduction to 450 ppm by 2100

ppm = parts per million

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

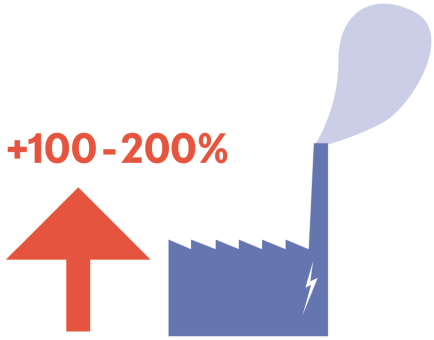
Projected greenhouse gas emissions (low emissions scenario) in 2050 compared to 2010 in different sectors.



The ability to reduce emissions varies between sectors. In some sectors mitigation is cheaper than in others. In order to reach low emissions levels, mitigation measures are needed in all sectors. In addition to carbon dioxide (CO_2), the most important greenhouse gases are methane (CH_4), and nitrous oxide (N_2O).

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

ENERGY SUPPLY SECTOR

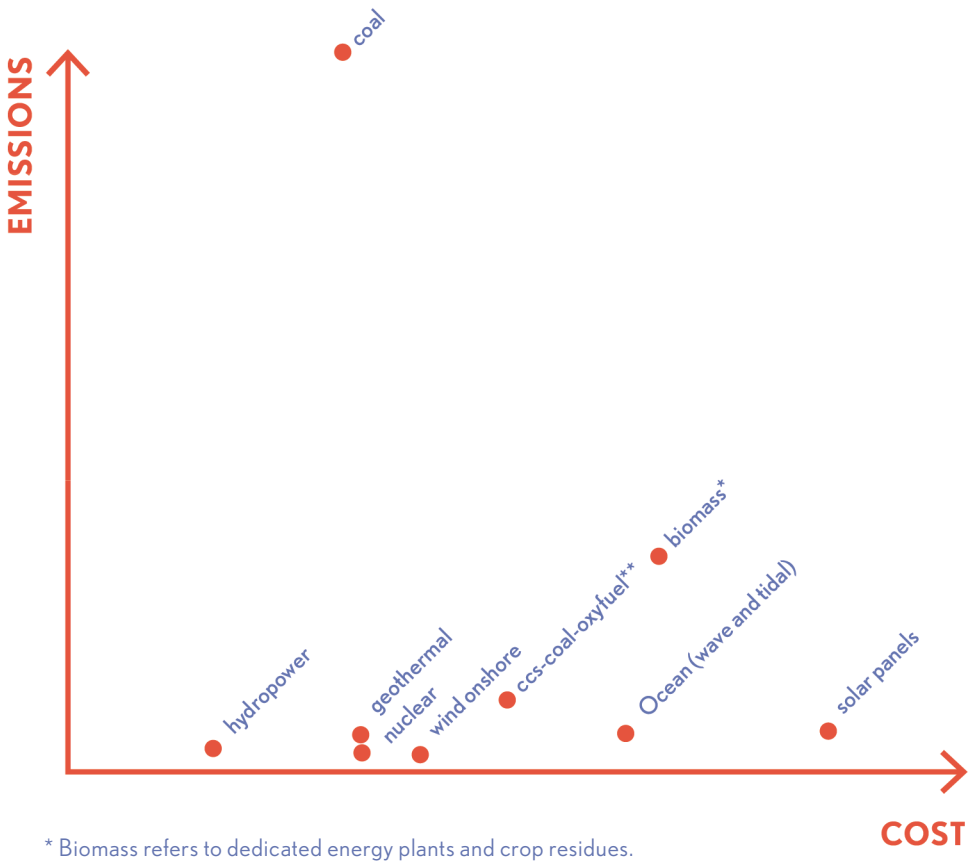


PROJECTED INCREASE IN GLOBAL CARBON DIOXIDE EMISSIONS OF THE ENERGY SUPPLY SECTOR BY 2050 WITHOUT ADDITIONAL MITIGATION MEASURES

The energy supply sector is the largest contributor to global greenhouse gas emissions, with an increasing demand for energy services and a growing share of coal in the global fuel mix contributing most to the increasing trend of its emissions. Decarbonizing (i.e. reducing the carbon intensity of) electricity generation is a key to cost-efficient mitigation strategies. Cost and performance of renewable energy technologies have developed a lot during the past years. However, as many of them still need indirect or direct support in order for their market shares to increase, additional enabling policies are needed to enhance their integration in the future energy systems.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

GREENHOUSE GAS EMISSIONS AND COSTS OF DIFFERENT ENERGY TECHNOLOGIES



* Biomass refers to dedicated energy plants and crop residues.

** CCS oxyfuel = carbon capture and storage with the oxyfuel method.

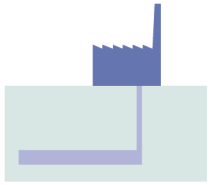
Renewable energy sources offer an efficient way to substantially reduce greenhouse gas emissions. However, cost is one of the main factors limiting the wide-spread application of the new energy technologies. While the cost of some low-carbon energy technologies (such as hydropower and geothermal energy) is already close to that of fossil fuels, many others are still much more expensive.

MITIGATION MEASURES FOR THE ENERGY SUPPLY SECTOR

There are many different options to reduce greenhouse gas emissions in the energy supply sector. The reduction and stabilization of emissions to a low level requires profound changes in the energy production system.

Renewable energy replacing fossil fuels

Carbon capture and storage (CCS)* used with fossil fuels



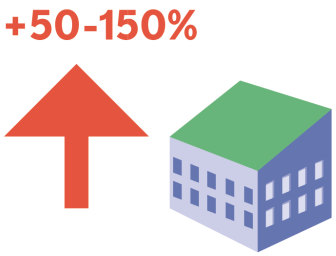
Methane leakage prevention, capture and treatment

Nuclear replacing fossil fuels

*CCS (carbon capture and storage) refers to a technology, where carbon dioxide is separated from the emissions of a power plant and deposited in an underground storage for long-term isolation from the atmosphere.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

BUILDING SECTOR



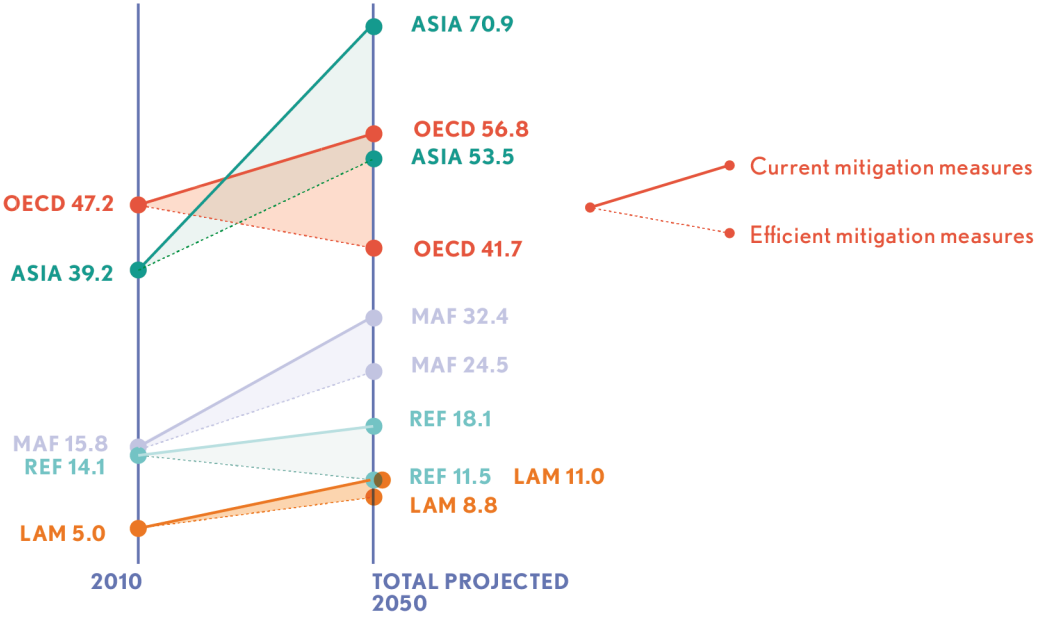
PROJECTED INCREASE IN GLOBAL CARBON DIOXIDE EMISSIONS OF THE BUILDING SECTOR BY 2050 WITHOUT ADDITIONAL MITIGATION MEASURES

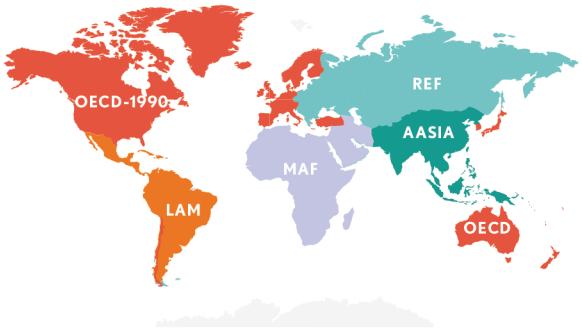
The building sector was responsible for 32% final energy use and 8.8 $GtCO_2$ emissions in 2010. If current trends continue, energy demand is projected to approximately double and carbon dioxide emissions to increase by 50-150% by mid-century. This energy demand growth results from improvements in wealth, lifestyle, access to modern energy services and adequate housing, and urbanisation. For new buildings, the adoption of very low energy building codes is an important mitigation measure. In existing buildings, savings of 50-90% in the heating/cooling energy use have been achieved through retrofits.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

DEVELOPMENT OF ENERGY CONSUMPTION OF THE BUILDING SECTOR IN DIFFERENT REGIONS

Projected development of the total energy consumption in the building sector in 2050, in exajoules.





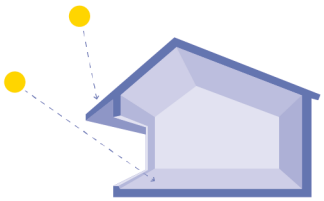
OECD-1990 = Countries that belonged to the OECD in 1990
MAF = Africa and Middle East
LAM = Latin America and Caribbean
REF = Eastern Europe and former Soviet Union

MITIGATION MEASURES FOR THE BUILDING SECTOR

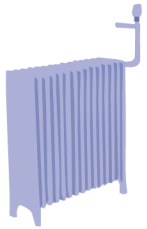
In new buildings, low or zero energy building codes are a key to reducing sector's energy demand. In existing buildings energy-efficient renovation is a key mitigation measure as reductions of cooling / heating energy use by 50–90% have been achieved

- Fuel switching
- Renewable energy systems incorporation
- Green roofs

- Retrofits of existing buildings (e.g. cool roof, passive solar, etc.)
- Exemplary new buildings
- Efficient equipment

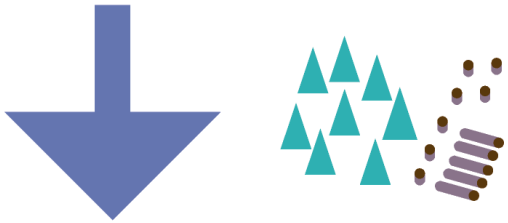


- Behavioural changes reducing energy demand



Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

AGRICULTURE, FORESTRY AND OTHER LAND USE



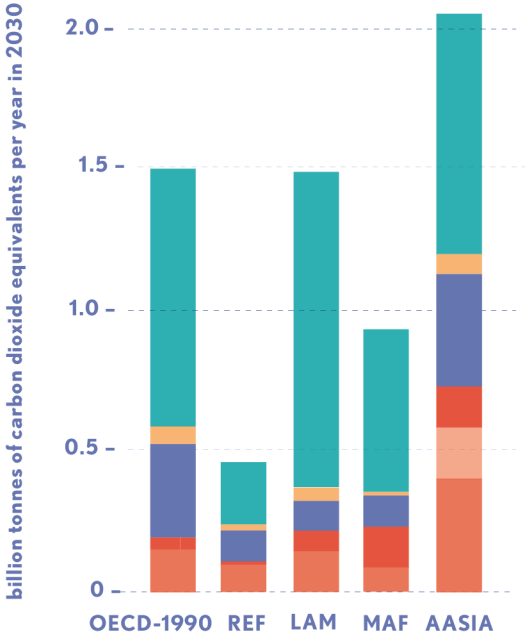
-50%

PROJECTED DECREASE IN CO_2 EMISSIONS BY 2050 WITHOUT ADDITIONAL MITIGATION MEASURES

Net annual baseline carbon dioxide emissions from agriculture, forestry and other land use are projected to decline over time, with emissions potentially less than half of the 2010 level by 2050 due to technological change, and declining rates of agricultural area expansion resulting from slowing down of population growth. The agriculture, forestry and other land use sector is an important part of the mitigation scenarios. Large-scale bioenergy deployment or carbon sequestration are examples of these mitigation options. However, there are potential implications for e.g. biodiversity and food security, which need to be taken into consideration.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

ECONOMIC MITIGATION POTENTIALS IN THE AGRICULTURE, FORESTRY AND OTHER LAND USE SECTOR BY REGION IN 2030 (Carbon price of 50$ per t CO_2-eq.)



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Forest management, Reduced deforestation, Afforestation

Livestock

Restoration of degraded lands, Restoration of cultivated organic soils

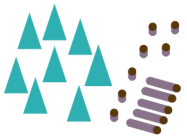
Grazing land management
Rice management
Cropland management

EXAMPLES OF MITIGATION OPTIONS IN THE AGRICULTURE, FORESTRY AND LAND USE SECTOR:

Forest management: Extended rotation cycles, fertilisation, more efficient wood use.

Reducing deforestation: Protecting forests in reserves, controlling other anthropogenic disturbances.

Afforestation: Improving biomass stocks by planting trees on e.g. non-forested agricultural lands.



Livestock: Improved breeds with higher productivity, improved manure storage.

Restoration of cultivated organic soils: Soil carbon restoration on peatlands and soil carbon emission reduction through improved land management

Restoration of degraded lands: Land reclamation (e.g. afforestation, soil nutrients management).

Grazing land management: Improved grass variaties (e.g. deep-rooting or more productive grasses), reduced stocking densities.)

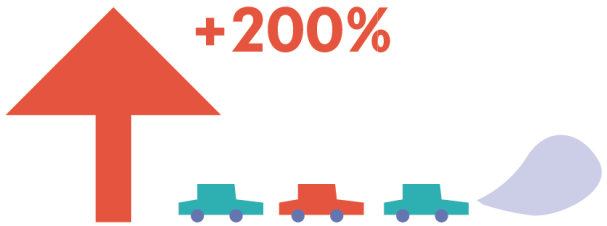
Rice management: Water management, nitrogen fertiliser application rate, type and timing.

Crop land management: Improved nitrogen use efficiency, fertilizer input to increase yields, reduced tillage intensity.

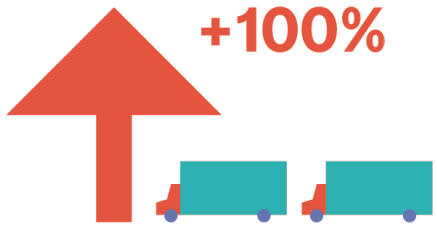
Lifestyle
Reduced losses in the food supply chain, changes in human diets, changes in wood demand and demand for forestry products

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

TRANSPORT SECTOR



DEMAND FOR PASSENGER TRANSPORT 2050



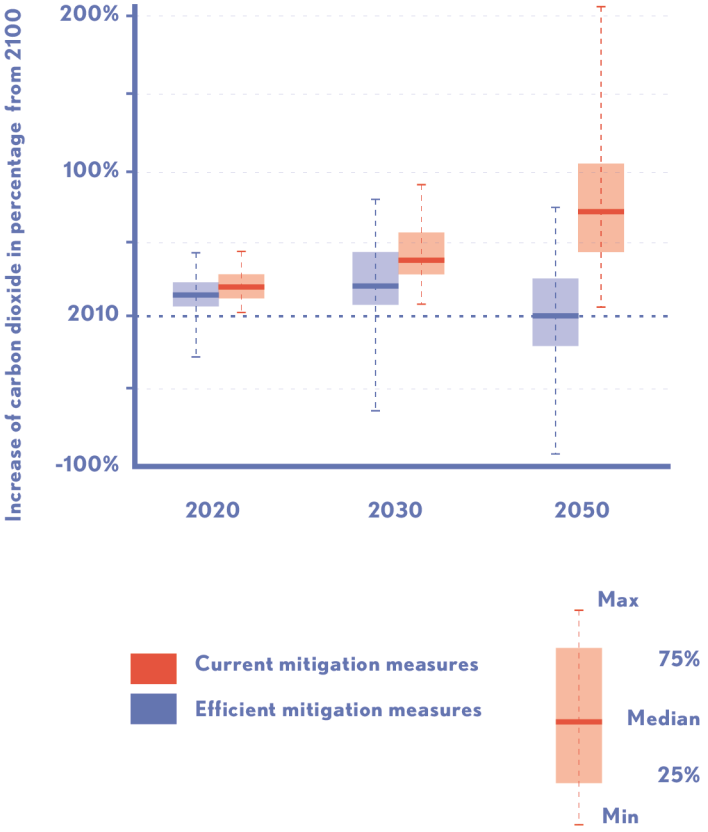
DEMAND FOR FREIGHT TRANSPORT 2050

According to the scenarios, demand for passenger transport will almost triple and freight transport will double by 2050. Without additional mitigation efforts, carbon dioxide emissions of the sector are projected to double by the same year. In the short term it is possible to reduce sector's energy demand by 30-50% compared to baseline by adopting more energy-efficient vehicle and engine technologies. In the long term, reductions in emissions of 20-50% can be achieved through integrated urban planning, development of public transportation and more compact urban form that supports walking and cycling.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

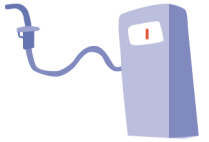
PROJECTED INCREASE IN THE GLOBAL CARBON DIOXIDE EMISSIONS FROM THE TRANSPORT SECTOR

Global carbon dioxide emissions from the transport sector are projected to increase less than transportation demand, due to improvements in vehicle fuel efficiency and carbon intensity.



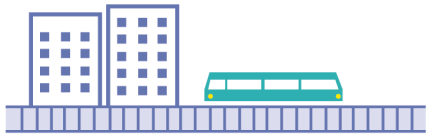
MITIGATION MEASURES FOR THE TRANSPORT SECTOR

Reduction of fuel carbon intensity:
e.g. electricity, hydrogen, compressed natural gas, and biofuels



Reduction of energy intensity:
- Fuel efficient engines and vehicle design
- Lighter materials in designs

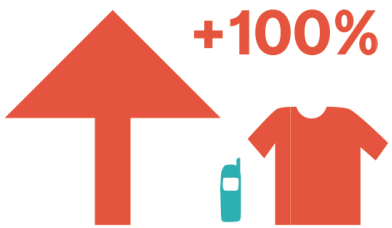
Improved infrastructure:
- Compact urban form and improved transport infrastructure
- Shift from private cars to public transport or bicycles/walking.



Lifestyle:
- Journey reduction and avoidance (e.g. through remote work or use of bicycles instead of cars)
- Higher number of passengers per vehicle (e.g. carpooling)

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

INDUSTRY SECTOR

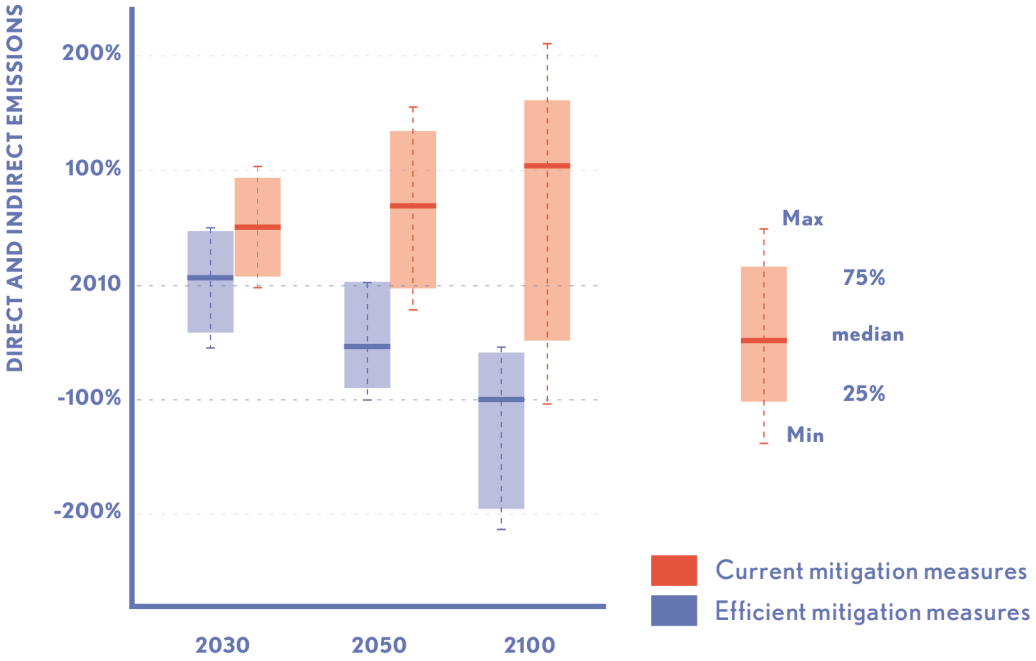


PROJECTED INCREASE OF GLOBAL CO_2 EMISSIONS WITHOUT ADDITIONAL MITIGATION MEASURES BY 2050

It is possible to reduce the energy intensity of the sector by as much as 25% from the present level by increasing the use of best available technologies especially in countries where they are not yet applied, and on less energy-intensive sectors. Through development of new technologies, additional reductions of up to 20% can be achieved.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

WITHOUT ADDITIONAL MITIGATION MEASURES, INDUSTRIAL GREENHOUSE GAS EMISSIONS WILL ALMOST DOUBLE BY 2050



MITIGATION MEASURES FOR THE INDUSTY SECTOR

With energy efficiency improvements, industrial energy use can be reduced by 40%.

-40%

Emissions related to the industrial energy use can be reduced by as much as 90% **through transition to low-carbon fuels.**

-90%

- Improving energy efficiency of products and production
- Transition to low-emission energy sources
- Adoption of new energy production technologies

e.g. carbon capture and storage (CCS)

- Improvements in material use
- Reduction of other greenhouse gas emissions

in addition to CO_2

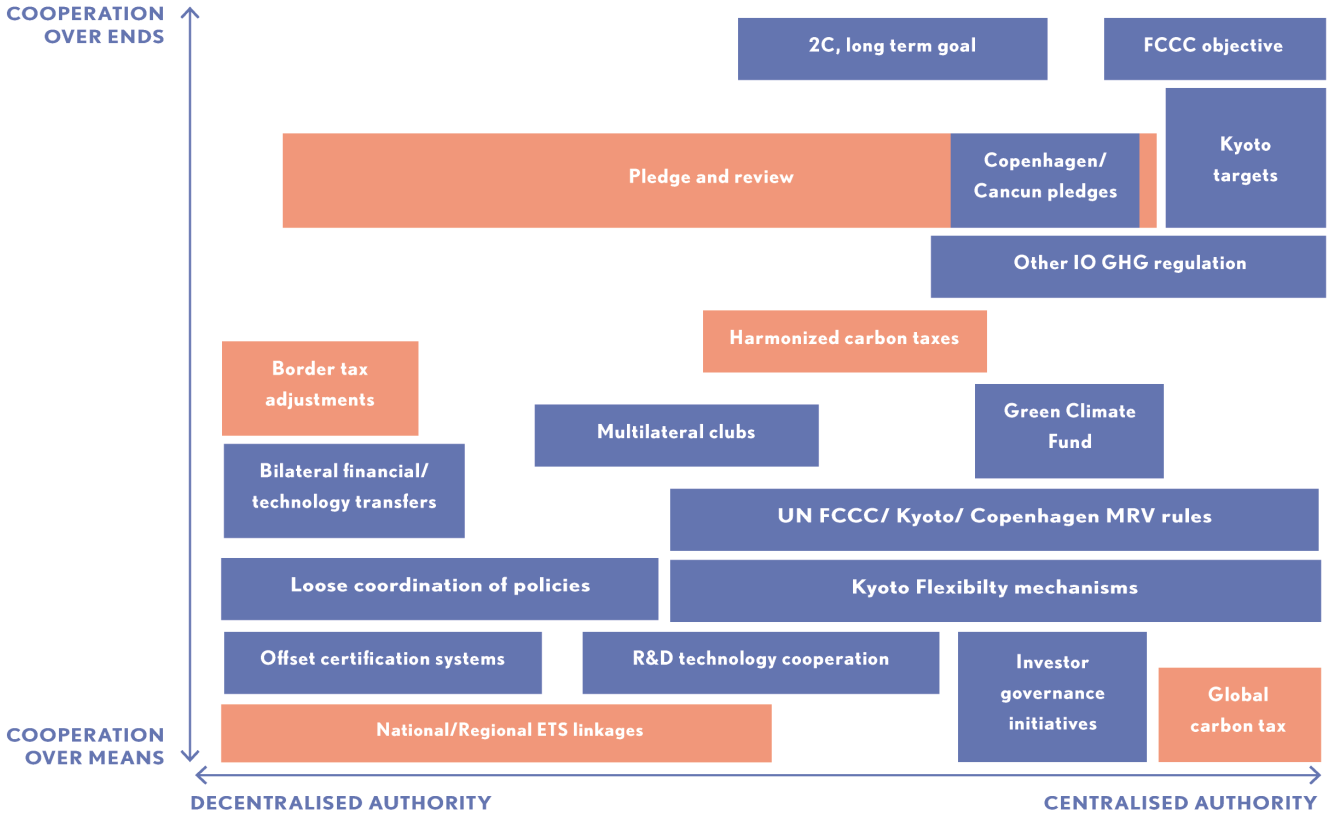
- Product development
- Reuse, recycling and energy utilisation of waste

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

REDUCTION IN GROSS DOMESTIC PRODUCT (GDP) GROWTH OVER THE PERIOD 2010-2100 REQUIRED TO KEEP THE GLOBAL TEMPERATURE FROM INCREASING ABOVE 2°C BY THE YEAR 2100.

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment

Policies and mechanisms of international climate politics



EXISTING MEASURES

PROPOSED MEASURES

- Climate change is a global problem and solving it will also require international cooperation.
- International cooperation in climate change mitigation has become more institutionally diverse during the past years.
- The Framework Convention on Climate Change of the UN remains the main multilateral forum but there are also other institutions

Based on IPCC Assessment Report 5, Working Group 3. VTT Technical Research Centre of Finland & the Ministry of the Environment