

450 Scenario: Methodology and Policy Framework

The 450 analysis in the 2011 *World Energy Outlook* is based primarily on the pledges announced in association with the Copenhagen Accord and Cancun Agreements, alongside the rapid implementation of plans to remove fossil fuel subsidies announced by the G20 in 2009. Emission reductions in the energy sector on the scale and at the pace described in the 450 Scenario would require an international agreement on a structured framework of effective international policy mechanisms and their implementation. Such an agreement could take many forms but, for modelling purposes, the 450 Scenario assumes that different groups of countries adopt binding economy-wide emissions targets in successive steps, reflecting their different stages of economic development and their respective responsibility for past emissions.

Three regional groups are considered:

- OECD: OECD countries and those countries that are members of the European Union but not of the OECD.
- China, Russia, Brazil, and South Africa: The largest emitting countries outside OECD (based on their total emissions of energy-related CO₂), with GDP per capita (in PPP terms) that is expected to exceed \$14 000 in 2020.
- Other Countries: This group comprises all other countries, including India, Indonesia, the African countries (excluding South Africa), the countries of Latin America (excluding Brazil), Middle East and the countries of Other Asia and Eastern Europe/Eurasia (excluding Russia).¹

We assume that countries which have announced targets or pledges in association with the Copenhagen Accord put in place policies from 2013 to meet these targets. Other countries are generally not assumed to adopt economy-wide targets before 2035, with the exception of those, such as India and Indonesia, which have announced such targets.

We assume a plausible combination of policy instruments, notably:

- Carbon pricing (either through taxes or carbon markets),
- Sectoral agreements, and
- National policies and measures.

These measures and their applications are tailored to the circumstances of specific sectors and groups of countries. Our assumptions about the measures adopted by the respective groups of countries may be summarised as follows:

- *Carbon pricing*: For OECD countries, in addition to the emissions trading schemes already in place in the European Union and New Zealand, we assume that Australia introduces a CO₂ price from mid-2012 and an emissions trading scheme from 2015, while Japan and Korea introduce CO₂ pricing in 2020. All other OECD countries are assumed to introduce CO₂ pricing by 2025, either through cap-and-trade schemes or carbon taxes. We assume that trading schemes are linked at a regional level from 2025, when CO₂ prices start to converge. For Non-OECD countries, in addition to China (where a CO₂ price covering all sectors is in place in 2020), Brazil, Russia and South Africa are also assumed to implement domestic CO₂ pricing from 2020, either through cap-and-trade schemes or carbon taxes. All trading schemes have access to carbon offsets.

¹ See Annex 2 in the WEM methodology description for more detail on regional definitions

- *Sectoral agreements:* For the purposes of the WEO-2011, sectoral agreements are defined as international agreements that commit participating countries to adopting common processes or objectives in order to reduce greenhouse-gas emissions from a specific sector. One example is an agreement to reduce energy intensity in the steel sector by a specified amount over a set period. We assume that international agreements with particular sectoral commitments are adopted in the iron and steel and cement industries and cover all countries with effect from 2013.² The highest efficiency levels, “best available technology”, are used to set sectoral targets. In the transport sector, international agreements which, similarly, set international standards are assumed to apply to passenger light duty vehicles (PLDVs) and aviation, with common effect from 2013.
- *National policies and measures:* These measures are assumed to be adopted at the national level in pursuit of national policy and not in discharge of any international commitment. In the buildings sector, all countries adopt national policies and measures, such as buildings standards, labelling of appliances, and minimum energy performance standards. Countries are assumed to undertake national policies and measures, in line with their development objectives, across all sectors not covered by international sectoral agreements.

Power generation

The policy framework assumed in the power-generation sector in the 450 Scenario includes four key pillars:

- Carbon pricing (also covering the industry sector) is implemented in most OECD countries by 2020. EU has carbon pricing from the beginning of the period; it is introduced from mid-2012 in Australia, and also in Japan and Korea from 2020 and 2015 respectively. For the US and Canada, a shadow carbon price – affecting only the investment decisions in power sector – is in place from 2015, with full carbon pricing from 2020. Among the non-OECD countries, carbon pricing is introduced from 2020 in China, Brazil, South Africa and Russia.
- Removal of subsidies for fossil-fuel inputs.
- Support for renewable technologies.
- National policies and measures, including for example increases in the lifetimes of nuclear plants, support for CCS, and targets to increase the share of renewables and nuclear in the energy mix.

Transport

The policy framework assumed in the transport sector in the 450 Scenario includes five key pillars:

- International sectoral agreements in the passenger light-duty vehicles (PLDV) sector and aviation (both domestic and international) as of 2013, which provide CO₂ emission limits for new cars and aircraft in all countries.
- Full technology spill-over from PLDVs to light commercial vehicles (LCVs).
- Improve efficiency of medium- and heavy-duty vehicles by 20% in 2035 relative to the New Policies Scenario.
- Alternative fuel support policies.

² The power sector is not covered by a formal sectoral approach in the scenarios, though countries may, in reality, decide to pursue other forms of collaboration in this sector in order to facilitate technology transfer.

- National policies and measures in other segments of the transport sector.
- Retail fuel prices are kept (through taxation in OECD countries and subsidy removal in non-OECD countries) at a level similar to that reached in the Current Policies Scenario. This scheme is necessary to offset the rebound effect that could occur due to lower oil prices.

Sectoral targets for PLDVs are used or are under discussion in several countries. Their use is justified by the fact that the PLDV (and aviation) sectors are global, dominated by several international companies using homogenous technology. Use of a common sectoral target allows for long-term planning and security in investment and technology development. Further, it harmonises technology across countries and allows for cost reductions through centralised manufacturing.

The sectoral targets for PLDVs relate to the sales of new vehicles. They are on-road targets for new sales, taking account of both efficiency improvements and deployment of alternative fuels, and do not assume significant behavioural changes by consumers. The CO₂ targets in 2035 for OECD (65 gCO₂/ km in the 450 Scenario) and non-OECD countries (100 gCO₂/km in the 450 Scenario) are averages for each region. For aviation, the sectoral agreement assumed requires the global aviation fleet to improve its average fuel consumption by 45% over today's level, to 2.5 litres per 100 revenue passenger kilometres (RPK) in 2035.³

Industry

The policy framework assumed in WEO-2011 includes three key pillars:

- Carbon pricing is implemented in most OECD countries by 2020 (see power generation section for details). Among the non-OECD countries, carbon pricing is introduced from 2020 in China, Brazil, South Africa and Russia.
- International sectoral agreements for the iron and steel, and non-metallic minerals sectors for all countries as of 2013.
- National policies and measures for other industries.

International sectoral agreements are assumed for the iron and steel, and non-metallic minerals sectors. The international sectoral agreements function as a complement to carbon pricing and national policies by limiting carbon leakage. These agreements help accelerate improvement in energy efficiency in these industrial sub-sectors.

Many countries implement national policies to improve energy efficiency in industrial sectors, in the form of government R&D and preferential tax and credit policies for the deployment of more efficient equipment. In the 450 Scenario, the introduction of equipment with the best available technology in its class in terms of efficiency, recycling and adoption of new materials are assumed, together with promotion of fuel switching to lower-carbon fuels. Importantly, China is assumed to rebalance its economy by promoting the growth of the services and light industry sectors to a greater extent than it does in the New Policies Scenario.

Buildings

Achieving the 450 Scenario requires strong policy intervention to reduce emissions from the buildings sector, especially after 2020. This includes a wide range of policies and measures in all major economies, from net zero-energy buildings in the United States and Japan, zero-carbon

³ Revenue passenger kilometres' is a common aviation industry measure of demand.

footprint buildings in the European Union applicable to new buildings, to mandatory building code standards and labelling requirements for equipment and appliances in Russia, China and India. The implementation of those policies and measures is responsible for about two-thirds of the energy saving in the building sector. Further savings are achieved by the higher electricity prices in the 450 Scenario compared with the Current Policies Scenario. The higher electricity prices, resulting from the assumed increase in prices of CO₂, play an important role in promoting energy efficiency measures installations, ensuring that energy costs become key purchasing criteria for consumers in the building sector, and also pave the way for the greater switch towards the use of renewable building materials.

Assumptions underlying calculation of uncertainty about level of energy-sector emissions resulting from Copenhagen Accord

The pledges made in association with the Copenhagen Accord are, in many cases, lacking in transparency. This is because they are often expressed in terms of a range of ambition, or against an unknown baseline. This means that there is substantial uncertainty about the level of emissions that will arise from these pledges in 2020. In total, we estimate that the uncertainty about energy-related emissions in 2020 under the Copenhagen Accord amounts to 3.9 Gt. Of this, around 700 Mt is uncertainty about Annex I countries emissions, and about 3.2 Gt is uncertainty about non-Annex I countries emissions. The table below sets out the assumptions made in calculating this uncertainty.

	Ambition		Low end	High end	Baseline	Low end	High end
China	Range of pledge	of	40% improvement in CO ₂ intensity compared with 2005	45% improvement in CO ₂ intensity compared with 2005	GDP growth rate 2008-2020	7.9%	8.81%
India	Range of pledge	of	20% improvement in CO ₂ intensity compared with 2005	25% improvement in CO ₂ intensity compared with 2005	GDP growth rate 2008-2020	7.4%	9%
Brazil	Range of pledge	of	163 Mt reduction in CO ₂ emissions from energy sector compared with BAU	207 Mt reduction in CO ₂ emissions from energy sector compared with BAU	Level of business as usual emissions	581 Mt CO ₂	901 Mt CO ₂
Indonesia*	Abatement taking place in energy sector		97 Mt CO ₂	309 Mt CO ₂	Level of business as usual emissions in energy sector	1001 Mt CO ₂	n.a.
Annex I	Range of pledge	of	Various by country, resulting in energy-related emissions of around 11.3 Gt in 2020	Various by country, resulting in energy-related emissions of around 10.6 Gt in 2020	Fixed	n.a.	n.a.

* For the purposes of calculating the uncertainty of emissions arising from the Copenhagen Accord pledges, Indonesia's maximum reduction in emissions is considered to be 26% below BAU, as stated in Indonesia's communication to the UNFCCC. This differs from the 450 Scenario, in which Indonesia's separate statement that a 41% reduction compared with BAU would be possible