International Energy Agency, 'BLUE Map' (2010)

1. Purpose of the activity

The IEA's 'Energy Technology Perspectives 2010' publication provides an IEA perspective on how low-carbon energy technologies can contribute to deep CO2 emissions reduction targets. Using a techno-economic approach that assesses costs and benefits, the ETP2010 examines least-cost pathways for meeting energy policy goals while also proposing measures to overcome technical and policy barriers. It analyses and compares various scenarios, including a 'Baseline' scenario assuming no new energy and climate policies are introduced, and a 'BLUE Map' scenario.

The BLUE Map scenario (with several variants) is target-oriented: it sets the goal of halving global energy-related CO2 emissions by 2050 (compared to 2005 levels) and examines the least-cost means of achieving that goal through the deployment of existing and new low-carbon technologies. The BLUE scenarios also enhance energy security (e.g. by reducing dependence on fossil fuels) and bring other benefits that contribute to economic development (e.g. improved health due to lower air pollution).

2. Model / scenario description

a) timespan and region	2050, global[1]
b) scenario type:	Backcasting, quantitative computer model, normative, expert, whole energy system
c) what the approach has been designed to achieve	Global energy-related CO2 emissions are reduced to half their current levels by 2050 (consistent with long-term global rise in temperatures of 2 -3 °C). Baseline scenario assumes no new policies are introduced. Variant scenarios examine different assumptions in different sectors, including electricity (deployment of nuclear, renewables, CCS), buildings (deployment of fuel cells, heat pumps and solar thermal), industry (growth in production for energy intensive materials) and transport (different demand scenarios).
d) description of modelling method	The primary tool for the analysis of the BLUE scenarios is the IEA-ETP model which belongs to the MARKAL family with least-cost optimisation to identify mix of energy technologies and fuels to meet the demand for energy services. It is a global, 15-region model which permits the analysis of fuel and technology choices throughout the energy system, with about 1000 individual technologies represented. Cooperation with modelling groups on national and regional scales to refine analysis. Detailed demand-side models for all major end-uses in the industry, buildings and transport sectors. [ETP2010, 653]
e) references, links	Scenarios described in 'Energy Technology Perspectives 2010' published by IEA, see http://www.iea.org/techno/etp/. Some background data from IEA's World Energy Outlook, http://www.iea.org/weo/.

[1] This summary is for global scenarios. ERP analysis on the ETP scenarios for OECD Europe will be published separately.

3. Key Assumptions

Energy price, demographic and macro-economic assumptions are summarised in ETP2010 Annex A, which contains references to full details.

a) carbon & energy prices	Energy prices respond to changes in demand and supply. Taken from World Energy Outlook 2009 (WEO) to 2030, from 2030 – 2050 they have been developed for ETP taking account of long term oil supply cost curve. E.g. crude oil imports costs for BLUE Map scenario in 2008: US$97/bbl; 2030: US$90/bbl; 2050: US$70/bbl. Baseline scenario assumes carbon prices in the ETS sectors increase from US$ 43t/CO2 in 2020 to US$83/tCO2 in 2050.
b) final energy demand	The decoupling of energy use and economic growth continues in all scenarios. In the Baseline scenario, global final energy intensity falls by 1.8% per year, a rate similar to that seen over the past 30 years. This means that, by 2050, the amount of energy used on average to produce one unit of GDP will be less than half that needed today. In the BLUE Map scenario, the global improvement in energy intensity increases to an average of 2.6% a year between 2007 and 2050, resulting in the energy used per unit of GDP in 2050 being only about one-third of that in 2007.
c) economic conditions	Global GDP grows by more than three times between 2007 and 2050, on average by 3.1%, main growth outside OECD
d) social conditions	World population grows by more than 32% from 6.6bn in 2007 to 9.2bn in 2050, 90% of the growth in non-OECD countries, population in OECD Europe rises 5%.
e) learning rates	Not specified, but scenarios are based on “optimistic but plausible technology assumptions”.
f) technology costs	The BLUE scenarios assume that technologies that are not available today are developed to the point at which they become commercial. It also requires the rapid and widespread uptake of such technologies into the market. Investment and O&M costs, now and in 2050, given by technology in ETP2010, Ch. 3 – 7.
g) policies	The analysis does not reflect on the likelihood of technology development occurring, or on the precise mix of climate policy instruments that might best help achieve these objectives. But it is clear that achieving the outcomes implicit in the BLUE scenarios will depend on the implementation of a wide range of policies and measures to overcome barriers to the adoption of the necessary technologies.

4. Outputs

(a) final energy demand	Final global energy demand in 2050 is 4 477 million tonnes of oil equivalent (Mtoe) (31%) lower in the BLUE Map scenario than in the Baseline scenario. Around 29% of this reduction occurs in industry, 36% in the transport sector and 35% in the buildings sector. Energy efficiency improvements average 0.7% in the Baseline scenarios, and 1.5% in the BLUE Map scenario. [ETP2010 p. 77]
(b) how demands were met by fuel	- Global electricity demand rises 119% from 17 PWh in 2007 to 37 PWh in 2050, but with demand in OECD countries increasing by 1/3rd. [ETP2010, Ch. 4] Share of electricity in final consumption under the BLUE Map scenario rises from 17% in 2007 to 27% in 2050. - Transport… [electricity use in transport is 11% of overall demand] - Share of biomass in final energy consumption is 18% in 2050, mostly due to transport biofuel increasing from 34 Mtoe in 2007 to 764 Mtoe in 2050. - Hydrogen is introduced after 2030 with 200 Mtoe used in transport and 97 Mtoe used by small-scale FC-CHP in buildings.
(c) power generation by technology	Generation in 2050 comes from: [ETP2010, Ch. 3, Table 3.1] Nuclear: 24 % Coal: 13 % (of which 90 % with CCS) Gas: 16 % (of which 30 % with CCS) Hydro: 14 % Wind: 12 % (of which 66 % onshore) Solar: 12 % (similar amounts from PV and CSP) Biomass and waste: 6 % Geothermal: 3 % Ocean: < 1 % Emissions intensity falls under BLUE Map scenario from 507 g/kWh in 2007 to 67 g/kWh in 2050.
(d) role for bioenergy	By 2050, 13% of electricity from biomass is generated in plants using CCS. Biomass mostly used in dedicated plants by 2050, co-firing with coal increases to 2020.
(e) role of enabling technologies	• Smart Grid: potential to reduce CO2 emissions between 0.9 $GtCO_2$ and 2.2 $GtCO_2$ a year. • Storage: Estimated global electricity storage needs in 2050 have been modelled using different approaches: - Electricity storage only: 189 GW - ES + using Electric Vehicles storage: 122 GW - ES + heat pump deployment: 154 GW - Current global storage is 100 GW, mostly pumped hydro. Thermal storage likely to become increasingly important in the long term as thermal loads begin increasingly to use electricity generated through heat pump technologies and as CHP plays a stronger role. More detailed modelling is needed. (ETP2010 Ch. 4]

(f) extent of decentralised energy production and role of CHP	Use of CHP triples in the BLUE Map scenario to 2050, providing 13% of power generation by 2050.
(g) costs of achieving goals	- Between 2015 and 2030, investment envisaged by BLUE Map is 8.6% (US$13 trn) higher than Baseline, between 2030 and 2050 it is 16% (US$ 33 trn) higher. (Baseline investment 2010 – 2050 is US$270 trn, US$240 tn of which is accounted for by investments consumers will make in capital equipment that uses energy.) - Transport sector accounts for 50% of total additional investment, buildings 27%, power 20% and industry 4%. - Total fuel savings from the BLUE Map scenario are around 180 000 Mtoe over the period 2010 to 2050, with an undiscounted value of US$112 trn. - Discounting additional investment and fuel savings at 3% yields net savings of US32 trn, at 10% net savings are us$8 trn. [ETP2010 Ch. 14]

5. Key messages

In the absence of new policies, global energy demand and CO2 emissions will double by 2050. To reduce CO_2 emissions by 50% by 2050, emissions must peak around 2020 and thereafter show a steady decline. If this does not happen, the 50% reduction by 2050 will become much more costly to achieve, and possibly unachievable at any realistic price. Urgent action is needed.

Using a combination of existing and new technologies, as envisaged in the BLUE scenarios, it is possible to halve worldwide energy-related CO_2 emissions by 2050. Achieving this will be challenging, and will require significant investment. But the benefits in terms of environmental outcomes, improved energy security and reduced energy bills will also be large.

The outcomes envisaged in the BLUE scenarios are not possible with only the technologies that are commercially available today. The electricity sector will need to be substantially decarbonised through the use of renewable energy, nuclear power and fossil-fuel-based generation combined with carbon capture and storage (CCS). The rate of energy efficiency improvement will need to increase substantially across all end-use sectors. New low-carbon technologies will be required in transport, buildings and in industry. Fuel switching to low- or zero-carbon fuels will be a significant source of carbon reductions. In the BLUE Map scenario, biomass use doubles and low-carbon electricity is increasingly used in buildings, transport and industry. Hydrogen plays a role after 2030.

Many of the investments made in the next 10 years in buildings, industrial installations and power plants will still be in operation in 2050. If costly early scrapping is to be minimised, then from now on investments in energy infrastructure will need to take account of long-term CO2 emission goals.

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October 2010