McKinsey, 'Pathways to a low-carbon economy' (2009)

1. Purpose of the activity

McKinsey & Company's Greenhouse Gas (GHG) abatement cost curve provides a quantitaive basis for discussions about what actions would be most effective in delivering emissions reductions, and what they might cost and which investments are required. It provides a global mapping of opportunities to reduce the emissions of GHG across regions and sectors relative to a Business as Usual (BAU) trajectory of 66 $GtCO_2e$ in 2030. This analysis draws on he updated figures in 'Impact of the financial crisis on carbon economics' (2010).

The report does not specify scenarios, though five different implementation scenarios are used to demonstrate the impact on global GHG mitigation efforts. The `Green World' scenario, that which has the highest level of committment cross nations globally, is described below.

2. Model / scenario description

a) timespan and region	Derivation of global GHG abatement curves beyond BAU for 2030.
b) scenario type	The model is illustrating economic potential (as per IPCC terminology), not likely outcomes. Assessment is undertaken using expert input to determine likely technology developments. Learning rates and associated cost reductions over time is fed in alongside an evaluation of particular technologies (or approaches) for maximum economic carbon abatement potential.
c) what the approach has been designed to achieve.	The exercise is seeking to demonstrate a reasonable estimate of technology costs given current knowledge of technolgical devlopment and its contribution to carbon abatement under certain pre-defined scenarios. There is also no ceiling / floor on carbon emissions, the model is assessing what is achieveable, given the particular technology characteristics and scenario backgrounds.
d) description of modelling method	- The McKinsey Abatement Cost Curve (MACC) curve is an evaluation of potential for various greenhouse gas abatement opportunities. It is an assembly of the range of opportunities into a cost curve, from cheapest to most expensive per tonne of CO2e saved. The approach allows a global assessment of costs against emissions reductions. Within the cost is an implicit evaluation of the likely success (in cost reduction) but it is not a detailed consideration of the role that various technologies could play. - No system modelling. Viability of supply portfolio is done via expert assessments, how fast technologies can be built and deployed. - The approach gives a clear indicator of system costs for achieving staged carbon reductions. It indicates the potential for emissions reductions, highlighting where there are low-hanging fruit (along with how much this will cost and the economic emissions reduction potential) and what requires further investment or development to be feasible. A possible approach for prioritisation of technology deployment and RD&D pipeline activity.
e) references, links	2009 report available from https://solutions.mckinsey.com/ClimateDesk/default.aspx. Updated 2010 global greenhouse gas abatement cost curve (version 2.1) available from http://www.mckinsey.com/clientservice/ccsi/.

3. Key Assumptions

a) carbon & energy prices	- The method effectively provides a cost/tonne of CO_2e. The cost assumptions are derived from expert inputs on technology development, learning rates etc. based on economic abatement potential from a BAU trajectory: the result is the derivation of an improvement in carbon productivity (ratio of GDP to tonnes of global GHG emissions). Detailed costs by sector available in Appendix VII of the report. - Data on baseline emissions is obtained from a variety of sources *e.g.* IEA for CO_2 emissions from fossil fuel combustion, UNFCCC and IPCC for land use change and forestry including peat, and US EPA for emissions of non-CO_2 GHGs. - \$115 bbl for oil from the IEA WEO 2009 (in 2008 prices).
b) final energy demand	BAU trajectory (form which the abatement potentials are derived) linked to population and economic growth and assumed to be 2.6% pa for electricity power growth (88% between 2005 to 2030).
c) economic conditions	GDP growth of 1.8% in the developed world and 4.8% in the developing world.
d) social conditions	Global population growth of 0.9% p.a. (0.2% developed world and 1.1% in developing world.
e) learning rates	Built into the abatement curves.
f) technology costs	Built into the abatement curves.
g) policies	Four policy areas considered important to reduce emissions are lowest possible cost: • Implementation of regulation to overcome market imperfections that prevent the energy efficiency opportunities with net economic benefits from materialising; • Establishing stable long term incentives to encourage power producers and industrial companies t develop and deploy GHG efficient technologies; • Provide sufficient incentives and support to improve the cost efficiency of promising emerging technologies; and • Ensuring that the potential in forestry and agriculture are effectively addressed, primarily in developing economies, linking any system to capture abatement closely to their overall development agenda. In the Green World Scenario: • All countries capture 100% of the technical levers <€80 per tCO_2e from 2010; and • All technical potential between €80 - 100 per tCO_2e and all behavioural changes potential fully captured.

4. Outputs

(a) final energy demand overall;	Same as BAU - see above.
(b) how demands were met by fuel	Energy efficiency improvements in electricity consuming sectors reduces growth from 2.7 to 1.5% which in turn results in demand reduction in the power sector only of 3.3 $GtCO_2e$.

(c) power generation by technology	In the scenario where there is a maximum growth of renewable and nuclear energy - wind, solar photovoltaics, concentrated solar power, geo-thermal, biomass and hydro all contribute 5.4 $GtCO_2e$ abatement pa; Nuclear increases from ~2,700 TWh to ~5,200 TWh between 2005 to 2030 and results in 1.8 $GtCO_2e$ abatement pa; and carbon capture and storage at a large and economic (€40-70 tCO_2e) with a carbon abatement of 2.5 $GtCO_2e$.
(d) role for bioenergy	In power, Bio-energy and CCS new build ~55-80 tCO_2e (volume of dedicated biomass plants is limited by total demand for new capacity in many geographic regions). Biofuels both 1st Generation and 2nd Generation play a role in the transport sector in 2030.
(e) role of enabling technologies	Assumed to be a part of energy efficiency improvements.
(f) extent of decentralised energy production and role of CHP	Limited discussion on any decentralised energy production due to the fact the MACC are based on economic abatement potentials from a BAU trajectory. Some mention in the Chemicals Production section. Substantial CHP in all industry sectors as abatement levers. No CHP in the power sector, as objective is maximum abatement potential, which gives zero- and low-carbon technologies priority.
(g) costs of achieving goals	In order to achieve full technical levers for below €80 t/CO_2e would result in investment needs of over $890 bn annually by 2030.

5. Key messages

Key conclusions or messages from the scenario / model:

The key findings of the McKinsey & Company GHG abatement cost curves are as follows:

- There is potential by 2030 to reduce GHG emissions by 45% compared with 1990 levels, or by 70 % compared with the levels that would be seen in 2030 if the world collectively made little attempt to curb current and future emissions. This would make the potential of remaining below the 2^{o}C threshold better than 50%.
- Capturing enough of this potential to stay below the 2^{o}C threshold will, however, be highly challenging. All regions and sectors will have to capture close to full potential for abatement that is available to them; even deep emissions cuts in some sectors will not be sufficient.
- Action needs to be timely. A 10 year delay in taking abatement action would make it virtually impossible to keep global warming below 2^{o}C.
- If the most economically rational abatement opportunities are pursued to their full potential - an optimistic proposition - the worldwide total cost could be negative $200 to negative $50 Bn annually by 2030 (negative numbers due to high fuel prices). These numbers already include a high-level estimate for transaction costs of 1-5 EUR/tCO2e. The total upfront investment in abatement measures needed worldwide would be $322 Bn in 2020 per year or €864 Bn per year in 2030 – incremental to BAU investments.

There are no scenarios, rather the report identifies four major categories of abatement opportunities between present to 2030 relative to a BAU scenario. Three of which involve technical measures which have an abatement cost of <€80/tCO_2e and which add up to 38 $GtCO_2e$ abated relative to a BAU of 66 $GtCO_2e$. These include the following technologically proven technologies:

- Energy Efficiency (14 $GtCO_2e$ per year in 2030): Energy efficiency in vehicles (upto 42 Mn hybrid vehicles could be sold by 2030 (40% of all new car sales), buildings, and industrial equipment thereby reducing energy consumption;

- Low Carbon Energy Supply (12 $GtCO_2e$ per year in 2030): Shift in energy supply from fossil fuels to low carbon alternatives such as fossil fuel plants with Carbon Capture and Storage and use of biofuels; and
- Terrestrial Carbon (12 $GtCO_2e$ per year in 2030): Halting deforestation, reforesting marginal areas of land and sequestering more CO_2 in soils thourgh changing agricultural practices.

It is stated that 29% of total opportunity is located in the developed world and 71% in the developing world; the high share of abatement in the developing world is due to the large share of the opportunity in forestry and agriculture that lies there. This has no relation as to who should pay for the emissions reduction.

There are also 4 $GtCO_2e$ of mitigation measures which have an abatement cost of €80 - 100 /tCO_2e within these three categories and 4 tCO_2e from behavour changes (model shifts in transport, reducition in appliance use) which are highlighted as being subject to a high degree of uncertainty.

Mark Workman, ERP Analysis Team
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