Future Carbon Dioxide Emissions from the World Transportation Sector Related to Projected Conventional Oil Production

John H. Walsh

Energy Advisor

Abstract

The carbon dioxide emissions associated with the energy required by the transportation sector of the world specified in six scenarios covering a wide range of possibilities formulated in a report of the World Energy Council/International Institute for Applied Systems Analysis (WEC/IIASA) were plotted on the assumption that all the energy required for this purpose originated from oil. Also plotted were the carbon dioxide emissions associated with four parabolic projections of world conventional oil production based upon the Year 2000 Resource Assessment of the U.S. Geological Survey. These in turn were compared with the sustainable value of emissions of this gas derived from the fossil fuels.

Two of the WEC/IIASA Scenarios with almost the same transportation energy requirements – C1 and C2 – remain below the sustainable limit of carbon dioxide emissions until after 2070. For the other four scenarios, transportation requirements exceed the limit in the years ranging between 2022-2043. All four cases for the projection of world oil production exceed the sustainable limit from 2037 at the earliest (Case 3) until 2067 at the latest (Case 4). The Mean Case 1 exceeds the limit until 2050. The supply of conventional oil can meet the requirements of the transportation sector (100% allocation basis) until 2026 at the earliest to 2069 at the latest.

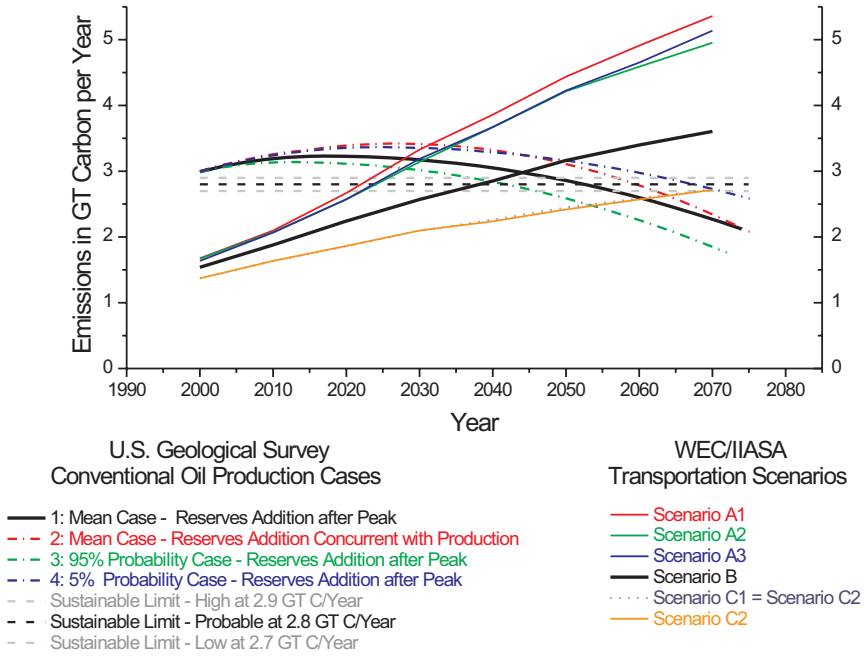
Six Scenarios were formulated to cover the range of interest in the World Energy Council/International Institute for Applied Systems Analysis (WEC/IIASA) study *Global Energy Perspectives* published in 1998.[1] Case A includes three separate scenarios of a 'future designed around ambitiously high rates of economic growth and technological progress. It incorporates the conviction that there are essentially no limits to human technological ingenuity. Case A presumes favourable geopolitics and free markets. Economic growth runs about 2% per year in the OECD countries and is twice as high in the developing countries.' 'In Scenario A1 there is a high future availability of oil and gas resources and the dominance of oil and gas is perpetuated to the end of the 21st century.' 'Scenario A2 assumes oil and gas resources to be scarce, resulting in a massive return to coal.' In Scenario A3, 'rapid technological change in nuclear and renewable energy technologies results in a phaseout of fossil fuels for economic reasons rather than due to resource scarcity.'

Case B represents the Middle Course. 'It incorporates more modest estimates of economic growth and technological development, and the demise of trade barriers and expansion of new arrangements facilitating international exchange.' It is the most pragmatic of the scenarios and, with the exception of the coal-intensive Scenario A2, results in the greatest reliance on fossil fuels of any of the six chosen for elaboration in this study.

Case C is ecologically driven with two scenarios. 'It is optimistic about technology and geopolitics, but unlike Case A, it assumes unprecedented progressive international cooperation focused explicitly on environmental protection and international equity.' Both scenarios in this case 'meet the CO_2 emissions ceiling in 2100, but they describe two very different paths that nuclear power might take.' In Scenario C1, nuclear power 'proves only a transient technology that is eventually phased out entirely by the end of the 21st century' in direct contrast to Scenario C2 with its large and continuing nuclear component.

The authors of the study provided tables of the energy required for the world transportation sector for each of the six scenarios at the IIASA Web Site (Web: www.iiasa.ac.at). In this note, this estimated

Figure 1
Carbon Emissions from WEC/IIASA Transportation Scenarios

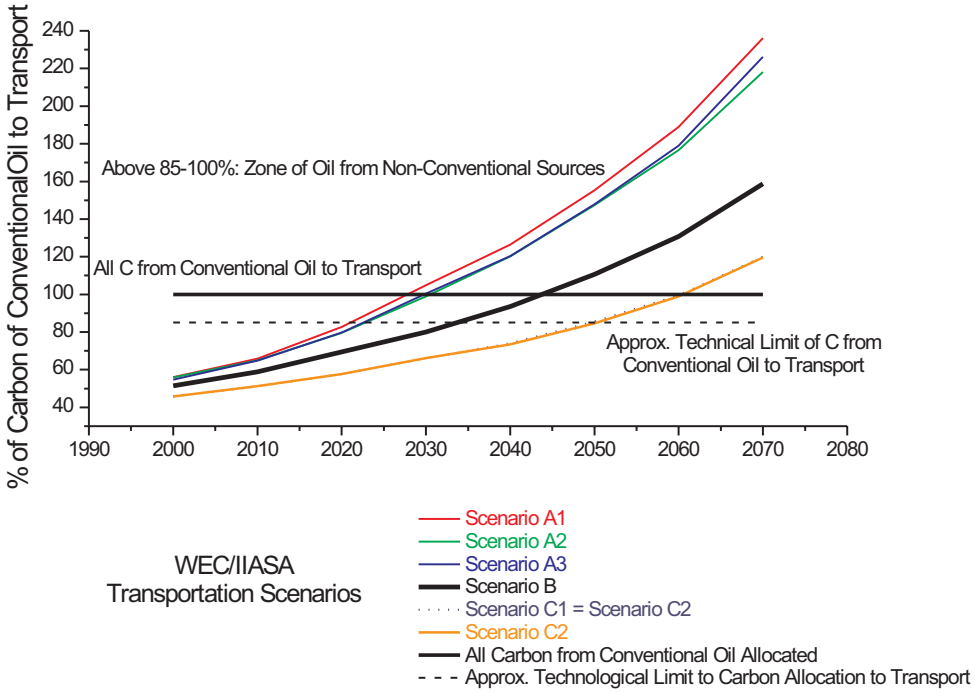


energy requirement was converted to carbon dioxide emissions (calculated as carbon) using a factor of 19.9 GT C per exajoule assuming all this energy consumed in this sector would be derived from oil. The carbon emissions from these six scenarios were then plotted up to 2070 in Figure 1. Because of the wide range in the basic assumptions underlying the formulation of the WEC/IIASA scenarios, the actual emissions may be expected to lie somewhere between the extreme values of these curves. That not all transportation energy is derived from conventional oil introduces an error not likely to exceed a few percentage points for at least the early decades of the new century—the overestimate of emissions should be less than 5%.

The future carbon dioxide emissions from the transportation sector may be compared with the emissions of this gas associated with the projected production of oil from conventional sources in Figure 1. The four oil production cases were calculated in accordance with a new parabolic projection technique devised by this author[2] which were based upon the Year 2000 Assessment of world petroleum resources published by the U.S. Geological Survey in 2000.[3] These cases cover a wide range of resource possibilities. Case 1 is the Mean Value with the Reserves Addition only contributing to production after the peak; Case 2 is again the Mean Value but with the Reserves Addition contributing throughout the full production period; and Cases 3 and Case 4 represent the extreme ends of the expected discovery range at 95% and 5% probability respectively. In both these latter Cases, the Reserves Addition was only assumed to contribute to production after the peak as in Case 1.

The carbon emissions from all the six transportation scenarios exceed those expected from projected conventional oil production at some time in the period under study. The emissions from the Middle Course Scenario 'B' cross the U.S.G.S Mean Case 1 line in 2043 (both black lines). The intercepts from the three 'A' Scenarios and the two 'C' Cases (the latter almost identical in terms of the energy required for transportation) vary over four decades. The soonest occurs in 2025 given by the intercept of Scenario A1 with Case 3 and the latest in 2069 given by the intercept of the nearly identical Scenarios C1 and C2 with Case 4.

Figure 2
% C from Conventional Oil to Transportation Sector
U.S.G.S. Mean Case - Reserves Addition after Peak



If the sustainable level of carbon emissions from all the fossil fuels to the atmosphere is defined as the value which leads to constant concentrations of carbon dioxide in the atmosphere, the expected range of allowable emissions from the fossil fuels is from 2.7 to 2.9 GT C per year, with the mean taken as 2.8. These limits are plotted as the dashed horizontal lines in Figure 1. The carbon emissions from world conventional oil production alone exceed this range for all production cases in the early decades of this century. The point at which carbon emissions from conventional oil production is expected to fall to the middle-range sustainable value of 2.8 GT C per year ranges twenty-five years from 2042 to 2067.

In Figure 2, carbon emissions from each of the six transportation scenarios were plotted as a percent of the emissions from the U.S.G.S. Mean Case 1 for each year. The horizontal line at 100% indicates when all the carbon arising from conventional oil is equal to that emitted in the transportation sector. A horizontal line at 85% represents an approximation to the technical limit to the allocation of oil to this sector since not all the oil may be converted to liquids of adequate quality for mobile applications. The 100% line is intercepted as early as 2027 for Scenario A1 and as late as 2061 for Scenarios C1 and C2. If more oil is required for the transportation sector than can be supplied from conventional sources, presumably non-convention supply from one source or another will be produced.

In an earlier paper[4], it was argued that all conventional oil is likely to be produced because of its low technical cost of production and transportation. If so, the consumption of conventional oil alone will lead to more carbon emissions than the sustainable limit for carbon dioxide emissions for several decades or more. Nevertheless, if Scenarios C1 and C2 could be followed, the requirements of transportation remain below the sustainable limit for most of the century.

In summary, two of the WEC/IIASA Scenarios – C1 and C2 that require almost the same transportation energy requirements – remain below the sustainable limit of carbon dioxide emissions until after 2070. For the other scenarios, transportation require-

ments exceed the limit in the range between 2022-S2043. All four cases for the projection of world oil production exceed the sustainable limit from 2037 at the least (Case 3) until 2067 at the most (Case 4). The Mean Case 1 exceeds the limit until 2050. The supply of conventional oil can more than supply all the requirements for transportation (100% allocation basis) for a period ranging from 2026 at the earliest to 2069 at the latest.

References

1. N. Nakicenovic, A. Grübler and Alan McDonald, Editors, *Global Energy Perspectives*, ISBN 0 521 64569 7, Cambridge University Press, 1998.

2. J.H. Walsh, *Parabolic Assessment of World Conventional Oil Production Based upon Year 2000 Assessment of the U.S. Geological Survey*, Proceedings of the Canadian Association of the Club of Rome, Series 2, No. 3, Spring/Summer 2001.
(Web: pages.ca.inter.net/~jhwalsh/wusgs.html)

3. U.S. Geological Survey World Energy Assessment Team, *World Petroleum Assessment 2000 – Description and Results*, Digital Data Series DDS – 60, (Four CD-ROM Set)
(Web: energy.cr.usgs.gov/energy/worldenergy/Wenergy.html)

4. J.H. Walsh, *After the Peak in Conventional Oil Production has Passed*, December 2001. Proceedings of the Canadian Association for the Club of Rome, Series. 3 Number 3, (March) 2002.
(Web: pages.ca.inter.net/~jhwalsh/wpastpeak.html)

January 2002

19 Lambton Avenue, Ottawa, Ontario
Tel: (613) 745-6279
E-Mail: jhwalsh@ca.inter.net
Web: pages.ca.inter.net/~jhwalsh/index.html