Memorandum

REVIEW OF THE *WORLD ENERGY OUTLOOK 2008*

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This memorandum presents the results of a review of the *World Energy Outlook 2008* (WEO 2008) conducted by the Renewable Energy Technology Deployment Implementing Agreement (RETD) of the International Energy Agency (IEA). It examines the scenario framework and scenario assumptions of the WEO 2008 as they relate to renewable energy technology deployment and climate change. This review is not meant to be comprehensive, but rather is meant to guide the development of future editions of the *World Energy Outlook*. A summary of the key findings is provided below.

Summary of Findings of the RETD's Review of the WEO 2008

Key Issue	Description
Choice of Scenarios	The two policy intervention scenarios are a significant improvement over previous "alternative" scenarios. However, it would be potentially more informative to replace the 550 Scenario with one that (i) explores alternative approaches to achieving the 450 ppm CO_2-eq target, such as a renewable-energy-intensive scenario, or (ii) has more aggressive targets (e.g., 350-400 ppm CO_2-eq).
Emphasis on the Reference Scenario	Although the WEO 2008 notes that the Reference Scenario is not a likely outcome, it places disproportionate weight on its assumptions and outcomes. Notably, the WEO 2008 does not provide complete results and investment implications for the two policy scenarios, despite the importance of these results to policymakers, investors and other stakeholders.
Transparency	The WEO 2008 presents too little information regarding its assumptions, methodology and results across the scenarios. In particular, detailed results of the 550 and 450 Policy Scenarios were not published.
Renewable energy technology assumptions and market shares	It appears there is little difference in technology cost and performance assumptions, including learning rates, across the scenarios. This approach is problematic given the stated sensitivity of the World Energy Model to these assumptions, and indications that the WEO 2008 underestimated the sizes and growth rates of renewable energy markets.
Fossil fuel prices	The WEO 2008 has a robust methodology for estimating long-term fossil fuel prices. Nevertheless, fuel prices are very uncertain and the WEO 2008 does not give enough consideration to the impact of differing fuel prices or fuel price volatility, despite their importance to renewable energy and energy efficiency adoption.
Analysis of the costs and benefits of different scenarios	The WEO 2008 primarily focuses on climate change mitigation "costs" even though the report's results (see Chapter 19) indicate that the overall economic outcomes of the 550 and 450 Policy Scenarios are superior to the Reference Scenario (i.e., the benefits of avoided investments and reduced energy procurement costs more than offset the incremental investment costs). Given this encouraging result and the numerous other positive economic impacts not currently quantified in the report (such as job creation, rural economic development, reduced energy price volatility, and reduced climate change adaptation costs), the emphasis on costs seems misplaced.
Analysis timeframe	Given the long time horizon needed to achieve climate stabilization, and that 2030 is now only 21 years away, the WEO 2008 analysis timeframe of 2030 is too short.

Introduction

The RETD recognizes that modeling the global energy system is a complex and challenging task. The challenge has grown over the last few years, given the dramatic changes occurring in technology, policy and energy markets. For the IEA, part of the challenge is that the World Energy Model (WEM) is now being used in a different way than was originally intended. Specifically, there is now greater interest and emphasis on greenhouse gas (GHG) emissions and the role of new technology in the world's energy future. In the past, the focus was on traditional forms of energy generation and use and on energy balances (e.g., oil supply and demand; primary energy use). The WEM was also developed when the global energy system was expected to evolve gradually, whereas now, the world is experiencing rapid system-wide changes and the rise of new, potentially disruptive, technologies. This suggests that new or modified modeling approaches and tools may be necessary. With that in mind, the following sections describe in detail the key issues identified in the WEO 2008.

Choice of scenarios

Without question, the WEO 2008 represents a significant improvement from previous editions, and it now includes many elements that are consistent with the RETD's general position on global energy scenarios. Most importantly, the WEO 2008 has replaced the old terminology and constructs of its "alternative policy" scenarios with two climate stabilization scenarios (it has retained the Reference Scenario, which freezes current policies to form a baseline for making comparisons). The two policy intervention scenarios ("550 Policy Scenario" and "450 Policy Scenario") are based on existing Intergovernmental Panel on Climate Change (IPCC) scenarios that examined the stabilization of atmospheric GHG concentrations consistent with global average temperature increases of 3°C and 2°C, respectively[1]. Moreover, the two scenarios are not backcasts (as was the case with the 450 ppm stabilization case in the WEO 2007), but fully integrated analyses using the WEM based on assumptions about the implementation of different policies to achieve these GHG concentrations.

There is strong language throughout the WEO 2008 regarding the unsustainability of the current trajectory of the energy system (i.e., the Reference Scenario), and there is a clear message regarding the need for strong and decisive policy action on climate change. Thus, in many respects, the WEO 2008 contains the right messages. For example, on page 411, when discussing the rationale for the WEO 2008 stabilization scenarios, the authors write (with respect to the implementation of climate

[1] When discussing different targets for stabilization of greenhouse gas concentrations in the atmosphere in the context of the WEO scenarios, it is important to distinguish between concentrations of *carbon dioxide* (CO_2) and *carbon dioxide equivalents* (CO_2-eq). The latter includes all climate forcings from CO_2 and other GHGs. The two WEO 2008 climate stabilization scenarios are defined in terms of CO_2-eq, such that the 550ppm CO_2-eq scenario corresponds to achieving CO_2 concentrations of about 450ppm, and the more aggressive 450ppm CO_2-eq scenario corresponds to achieving CO_2 concentrations of about 380ppm (based on information provided in the WEO 2008). In contrast, recent arguments have been made by some scientists, such as James Hansen, that we need to achieve **at most** 350ppm CO_2 to avoid serious negative impacts from climate change. For reasons explained in their technical papers, Dr. Hansen and his co-authors chose to discuss their climate stabilization goals in terms of CO_2 only, not CO_2-eq. Achieving 350ppm CO_2, according to the WEO 2008, corresponds to a CO_2-eq concentration of about 400ppm. Source: *Target atmospheric CO_2: where should humanity aim?* J. Hansen, M. Sato, P. Kharecha, D. Beerling, R. Berner, V. Masson-Delmotte, M. Raymo, D.L. Royer, J.C. Zachos, http://arxiv.org/abs/0804.1126 and http://arxiv.org/abs/0804.1135.

change mitigation efforts under the 550 Policy Scenario), "The next few years are, therefore, crucially important. Any delay will result in an increased risk of a still higher temperature increase, which could give rise to irreversible change or demand even more costly and rapid emission-reduction rates later on."

Given this type of clear messaging in the WEO 2008, the RETD believes that the IEA could have chosen different scenarios to examine pathways to achieving climate stabilization at levels that avoid, with a high probability, the worst impacts of climate change. Specifically, one can argue that the 550 Policy Scenario, with a 3°C temperature rise, is highly undesirable in terms of the eventual climate impacts. Moreover, the modeling of this scenario does not provide much additional insight relative to the 450 Policy Scenario, since both require aggressive near-term actions. As constructed, both scenarios achieve peak annual energy-related CO_2 emissions around the year 2020 (at about 32.5 gigatonnes, see Figure 17.4). The main difference is that in the 550 Policy Scenario, emissions flatten and only fall after 2030, whereas in the 450 Policy Scenario they begin falling rapidly after 2020. If it is only realistic for the WEO to contain two policy intervention scenarios, then the RETD believes it would be more informative for the IEA to model a more aggressive scenario than the 450 Policy Scenario, e.g., a 350 or 400 ppm CO_2-eq stabilization level.

One of the arguments in favor of a more aggressive scenario is that the 550 and 450 Policy Scenarios do not describe pathways that achieve the desired temperature rises with a high probability (specifically, they achieve their respective temperature rise with only a 50% probability). Therefore, there is a need for scenarios that are more aggressive in terms of GHG concentrations and thus have higher probabilities of achieving the desired temperature rise, as well as lower probabilities of passing climate system tipping points (e.g., the world's oceans becoming a net carbon emitter instead of a sink) that could result in rapid additional warming.

In summary, there are three issues at hand with respect to GHG concentrations that should be kept in mind when choosing scenarios. One is the long-term stabilization level; the second is the path taken i.e., when do emissions peak and then start to decline (and at what pace); and the third is what are the key technology solutions for achieving the necessary reductions. A slower pace of emission decline will result in a higher peak concentration such that more will need to be done to reduce the concentration to the stabilization level desired, and it will take longer. Different technology solutions carry different levels and types of risks, and have significantly different implications for the future configuration of the global energy system.

Emphasis on the Reference Scenario

With the WEO 2008, the focus of the scenario analysis is clearly shifting to climate change policy (the main subject of Part C). The report also tries to make it clear that the projections of the Reference Scenario "cannot be considered forecasts of what is likely to happen". One could therefore infer that it is **more** likely that at least one, if not both, of the Policy Scenarios will occur. Despite this, there is too much emphasis on the results of the Reference Scenario. Part A and Annex A contain information only on the Reference Scenario, and the WEO 2008 does not provide a complete set of results for the 550 or 450 Policy Scenarios.

A better approach would have been to present the stabilization scenarios as the "main" scenarios, with the Reference Scenario presented in such a way that it is clearly seen as a baseline with which to make comparisons, and not a stand-alone scenario of equal or greater importance. Consistent with this approach, the WEO 2008 should have included the same amount of quantitative detail for all three scenarios.

Transparency

Given the continued importance of the WEO to policymakers and industry, there should have been greater transparency regarding the WEM, the entire WEO production process, and the modeling results. Amplifying the opacity are the significant changes that have been implemented in the WEO 2008 relative to previous versions of the report. The WEO 2008 does provide some description of the WEM, including the types of changes that have been made since last year, and some of the basic assumptions that go into the model. Separate documents describing the WEM and some of the power generation technology assumptions used in the WEO 2008 are also freely available on the WEO website (http://www.worldenergyoutlook.org/). Despite these efforts, there are many details regarding the modeling methodology and input assumptions that remain unclear due to incomplete documentation (e.g., the WEO 2008 technology assumptions are only provided for the Reference Scenario, and only for the years 2015 and 2030).

Beyond a lack of transparency as to how the results are generated, the report does not have complete, tabular results for the two climate stabilization scenarios, at the same level of detail to what was published in Annex A for the Reference Scenario. Instead, selected results are provided in Part C. While these results are useful, the lack of a complete set detracts significantly from the value of the report, and leads the reader to an overreliance on the results of the Reference Scenario. Moreover, given some of the more important results of the modeling (see *Analysis of the costs and benefits of different scenarios* below), these omissions could lead some readers to believe that the IEA has "something to hide".

Where tabular data are presented, they are not always shown at a sufficient level of detail. For example, in Annex A, tidal and wave are not shown separately, and neither are solar photovoltaic (PV) and solar thermal, nor are onshore and offshore wind. Also, the details of renewable energy deployment (capacity and generation, for example) presented in Part C are incomplete and are given differently for the two policy scenarios (for example, compare Table 18.7 to 18.12 on pgs. 456 and 471, respectively).[2] This makes it very difficult to compare the scenarios to each other and to the Reference Scenario. While the data provided are useful, their utility would rise significantly if the publication contained a complete set of tabular results as an Annex, which would allow readers to decide what data to use/analyze, instead of having to rely on what is selected for inclusion in the main text.[3]

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[2] Figure 18.9 does give renewable energy generation by technology in the 550 Policy Scenario, but it is hard to compare this to the tables in Annex A. There is also no comparable figure for the 450 Policy Scenario.

[3] Alternatively, if the authors felt that adding this information would make the report too cumbersome, they could post the details as a separate file to the WEO website and provide password protected access to those people who purchased the main

Renewable energy technology assumptions and market shares

As with the WEO 2007, there appears to be little difference between the basic technology assumptions across the three scenarios in the WEO 2008. Both policy scenarios assume accelerated government research and development spending and there is mention in the report of "…accelerated learning resulting from faster deployment of renewables and nuclear…" (p.468). However, it is not clear if this simply means that improved performance is the result of more rapid deployment (using the same learning rates), or if faster learning rates are the result of the implementation of the various policies of the scenarios.[4] In the absence of more complete documentation of the scenarios, it is not possible to know precisely how the three scenarios differ in terms of technology cost and performance.

Nevertheless, based on the information that is available in the WEO 2008, it seems likely that overall, the authors have been fairly conservative with regard to technology learning. This approach likely leads to an overestimation of renewable energy costs (especially in the latter years of the forecast) and therefore an underestimation of renewable energy potential, especially the 450 Policy Scenario. The WEO 2008 also does not examine the potential for technology breakthroughs or the deployment of disruptive technologies on a large scale, which would be particularly important and more likely to occur in the 450 Policy Scenario. While one cannot predict technology breakthroughs or exactly when certain technologies will pass key cost and performance hurdles that lead to rapid deployment, there is increasing evidence to suggest that some key technologies are poised to "take off", and when they do, they could have dramatic impacts on the global energy system. Some consideration of this is likely warranted in the WEO.

The above comments are all the more important given that the authors of the WEO 2008 acknowledge that their projections are "very sensitive to assumptions about technological developments" (see p. 73). This is not surprising, given the sensitivity of technology costs (and the associated cumulative investment requirements) to learning rates.[5] Given this fact, and the importance of new technology in the 550 and 450 Policy Scenarios, it is regrettable that so many of the details of technology cost and performance are missing from the report. Complete details regarding these assumptions are crucial since they have far-reaching impacts on all the modeling results. Among the more significant impacts is the effect of technology cost and performance on the estimates of total investment, energy prices, total energy expenditures, and carbon prices (i.e., the economic costs and benefits of the different scenarios). As an example, the 550 Policy Scenario requires a carbon price of $90/tonne by 2030, and the 450 Policy Scenario requires a price of $180/tonne by 2030. These prices imply that there are still

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report. This is not dissimilar from online technical journals which now often publish supporting information separately for their main articles.

[4] The concept of technological learning reflects the well established empirical evidence that technology costs typically decline by a fixed percentage for every cumulative doubling of production. The issue at hand here is whether or not the learning rates (i.e., the percent reduction per doubling) in the WEM are the same in all scenarios. If yes, then the only impact on costs between the scenarios is accelerated deployment (e.g., say through mandates). Conversely, higher spending on R&D, all else equal, has the potential to increase the learning rate (i.e., the percent reduction per doubling is larger).

[5] For example, see McDonald Alan and Schrattenholzer, Leo, "Learning rates for energy technologies", *Energy Policy*, 29 (2001), p.255-261.

substantial premiums for renewable energy out to 2030, but the foregoing discussion suggests that these result could be quite different with different technology assumptions.

The RETD also believes that the WEO 2008 underestimates the market potential for renewable energy and overestimates it for other low-carbon technologies that carry significantly higher risks and uncertainties. Figure 18.4 (see p. 446) and the related text indicate that energy efficiency and renewable energy, are, in that order, the two most important sources of energy-related CO_2 emissions reductions in the two policy scenarios. Third is carbon capture and sequestration (CCS). While the rank order seems reasonable, the relative size of the contribution of CCS, which is about 2/3 the amount for renewable energy in the 550 Policy Scenario (0.8 Gt of CO_2 for CCS vs. 1.2 Gt for renewable energy) raises questions. CCS, when compared to renewable energy, is at a very early development stage, lacks a sufficient regulatory framework, and entails much larger technology and investment risks than renewable energy deployment. In the text, the WEO 2008 notes that to achieve the CCS targets for the 550 Policy Scenario will require the addition of 10 power plants with CCS (7 coal, 3 natural gas) **every year** to 2030. However, few of these plants are likely to be built before 2015, which implies even higher rates in the 2015-2030 period.

In comparison the WEO 2008 notes that achieving the renewable energy targets of the 550 Policy Scenario, requires, among other things, the construction of an average of 12,000 3 MW wind turbines every year (see p. 446). How does this compare to the current state of the wind industry? In 2008, a record 27 GW were installed worldwide. Assuming an average wind turbine size of 2 MW for 2008, the industry is already producing and installing turbines at a rate greater than the average required by the 550 Policy Scenario, albeit at a smaller turbine size. Analysis of PV shows a similar inconsistency, where the annual market size in 2008 (~4.5 GW AC) is already nearly as large as the average annual market size estimated in the 550 Policy Scenario for the period 2007-2020 (5.6 GW AC) (i.e., the PV market, which grew 80% in 2008, is likely to be much larger than what is being projected by the WEO 2008).

These simple comparisons suggest that there is a disconnect between the technology assumptions and deployment timelines of the WEO 2008 compared to the realities of the market. Specifically, the RETD believes that the WEO 2008 is underestimating the potential contribution of renewable energy and overestimating the potential contribution of CCS.

Lastly, it is worth noting that the continued use of primary energy as a key metric is not useful for comparing renewable energy to conventional technologies. Rather, it is the useful output and the related GHG emissions (or lack thereof) that matter more in the context of the different scenarios.

Fossil fuel prices

The fossil fuel prices used in the WEO 2008 are considerably higher over the entire forecast period, relative to the WEO 2007. The WEO team concludes that this is a more accurate picture of future prices. Overall price levels in the WEO 2008 are more in line with a real price of $100/bbl vs. $60/bbl, which was used in the WEO 2007.

The WEO team appears to have put a lot of effort into understanding the petroleum and natural gas supply situation for the WEO 2008 (Part B is dedicated to this topic). For example, the nominal price of crude oil rises to about $200/bbl by 2030 in the Reference Scenario, but it is lower in the GHG stabilization scenarios due to lower demand. The WEO 2008 uses the same fossil fuel prices in both stabilization scenarios. At first glance, this may appear as an oversimplification, but the report reasonably assumes that in the 450 Policy Scenario, even though demand is lower than in the 550 Policy Scenario, the costs to develop new supplies will be higher.

Despite the effort and careful consideration that has gone into analyzing fossil fuel prices, the WEO 2008 does not contain scenarios built around different assumptions about fossil fuel prices. This approach has some practical considerations, since it is not possible to predict fossil fuel price fluctuations that are the norm for globally traded commodities, nor is it possible to effectively model market dislocations such as supply disruptions caused by geopolitical unrest, or demand destruction due to a global economic recession. Thus the WEM makes the reasonable assumption that over the long term, prices will track costs of production. Still, this leaves open the possibility to examine the effects of different fossil fuel price assumptions on the global energy system via scenarios that make different price assumptions within a reasonable range. It also allows for another scenario that could model the impact of fossil fuel price volatility on technology market shares. Such a scenario would favor renewable energy more than a scenario with the same average fossil fuel prices, but with no model of volatility. If the report is strictly limited to three scenarios, sensitivity analyses could still be conducted to assess the impacts of different fossil fuel prices and price volatility.

Analysis of the costs and benefits of different scenarios

The economic impact of the different scenarios is an important output of the WEM. The RETD's view is that the WEO 2008 focuses too heavily on the costs – such as infrastructure investment costs and increased electricity prices – of the stabilization scenarios, as opposed to the net economic benefits. For example, in Chapter 18, the report shows the increase in electricity prices resulting from climate change policies (Figure 18.1 on p. 438), but not the change in electricity expenditures (which is the product of prices and consumption), which could be lower than in the Reference Scenario, due to decreased consumption. Moreover, the general tone of the report is one which describes policies to reduce GHGs as being costs that lead to lower GDP growth rates (see p. 437). However, the WEO 2008 makes no attempt to estimate the GDP impacts of different scenarios, which is beyond the current capabilities of the WEM. More importantly, this bias towards viewing climate change mitigation as a "cost" is not supported by the results of the WEO 2008. As discussed below, the results contained in the WEO 2008 seem to suggest that the economic outcomes of the 550 and 450 Policy Scenarios are superior to that of the Reference Scenario (see the table below).

The amount of capital investment in energy infrastructure in all scenarios is very large – more than $26 trillion (in year-2007 dollars) in the Reference Scenario for 2007-2030. By comparison, the net incremental investments in the stabilization scenarios over the Reference Scenario are relatively modest. In the 550 Policy Scenario, when investment savings resulting from lower demand are factored in, the net investment cost is only ~$500 billion (~2%) higher[6] than the Reference Scenario (see p. 480-481)[7]. This small increase in investment costs is more than offset by substantial fuel cost savings through 2030 ($7 trillion, see p. 487). Moreover, additional fuel cost savings will accrue beyond 2030 for the investments made through 2030. It therefore seems logical to conclude that the long-term macroeconomic impacts of the 550 Policy Scenario are distinctly positive relative to the Reference Scenario, yet this important conclusion is not presented in the WEO 2008.

In the 450 Scenario, gross incremental investment over the 550 Scenario is about $5 trillion, driven in large part by accelerated replacement of capital stock (see pgs. 488-489). Unfortunately, the WEO 2008 does not provide information on investment savings to determine net incremental investment as was done above for the 550 Scenario. If one assumes that incremental investment savings are roughly equal to those of the 550 Policy Scenario ($3.7 trillion), the net investment is about $5.6 trillion (20%) higher than the Reference Scenario. Given the dramatic difference between this scenario and the Reference Scenario, the fact that investment requirements are only 20% above the Reference Scenario should be taken as very promising. Even more striking is that fuel cost savings under the 450 Policy Scenario ($5.8 trillion through 2030, with additional savings beyond that date, see pg. 489) still exceed the necessary incremental investment. Although no information on the discounting of either the investments or the fuel cost savings is provided in the WEO 2008, these data further support the conclusion that the macroeconomics of aggressive mitigation of climate change are generally positive, with long-term savings more than offsetting the incremental investment requirements.

Summary of Investment Costs and Fuel Costs Savings in the 550 and 450 Policy Scenarios

Scenario	Net Incremental Investment over Reference Scenario, $ trillion ($2007) (2010-2030)	Cumulative, undiscounted Energy Cost Savings over RS, $ trillion ($2007) (2010-2030)
550 Policy Scenario	$0.5	>$7.0
450 Policy Scenario	$5.6[8]	$5.8

An additional consideration is that these comparisons are made relative to the Reference Scenario, a hypothetical datum that is not a likely future given that it assumes no further policy developments take place (i.e., no new measures and investments designed to mitigate climate change are implemented). As such, comparisons to this scenario, which has unrealistically low investment costs and extraordinarily high GHG concentrations, overstate the incremental costs of the 450 and 550 Policy Scenarios, compared to some reasonable, “business-as-usual”, extrapolation of current trends.

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[6] Gross incremental investments over the Reference Scenario are about $4.2 trillion, which are offset by about $3.7 trillion in avoided investments in other areas due to lower demand.

[7] In the WEO 2009, the term “investment” is used to refer to both capital spending by businesses and spending by households and individuals on cars, equipment, appliances and other energy-related expenditures (see footnote 1 on pg. 480).

[8] This is an estimate. It assumes that the 450 Policy Scenario has the same investment savings over the Reference Scenario (due to higher efficiency) as the 550 Policy Scenario ($3.7 trillion). The actual value was not provided in the WEO 2008.

Moreover, there will be numerous positive economic impacts not currently quantified by the WEM, such as job creation, rural economic development, reduced energy price volatility, and importantly, reduced climate change adaptation costs. While this is beyond the current capabilities of the WEM, the economic benefits of lessening the costs of adapting to climate change could easily be much larger than the modest incremental costs of mitigation suggested by the WEO 2008 analysis. While this is a very complex topic, at a minimum, there needs to be an attempt made at a more balanced analysis and discussion of the full spectrum of economic impacts, both positive and negative.

In summary, there appears to be a general position within the WEO 2008 that climate change mitigation will entail "costs". However, the WEO 2008 results show that the value of avoided investments plus reduced energy procurement costs, more than offset whatever incremental investment costs are required. Assuming that future editions of the WEO will also concentrate on climate change, the RETD recommends that the WEO include a more complete analysis of all the economic costs and benefits, and a clear discussion of the conclusions. This includes:

- All direct investments in energy supply and energy efficiency (as currently done in the WEO)
- Energy costs, including an estimate of the energy cost savings beyond 2030 that result from investments made through 2030
- An estimate of climate change adaption costs in the different scenarios
- More detailed estimates, or at least, discussions of other benefits, such as job creation, reduced energy price volatility, rural development and improved energy security (there is some discussion of this in the WEO 2008)
- The use of different discount rates, applied to capital investments over time, as well as to energy costs over time, to aid in making more meaningful comparisons between scenarios

None of the foregoing discussion suggests that, implementing either the 550 or 450 Policy Scenarios was easy. Nevertheless, at the very least, the WEO 2008 should have provided a more complete and balanced discussion of economic costs and benefits, and more importantly, should have highlighted what appears to be a very exciting and promising conclusion – that even aggressive climate change mitigation is economically equivalent, or superior, to doing nothing.

Analysis timeframe

Given the long time horizon needed to achieve climate stabilization, and that 2030 is now only 21 years away, the WEO 2008 analysis timeframe of 2030 is too short. As an example of an alternate date, the IEA's *Energy Technology Perspectives* analysis runs through 2050. The IEA should strongly consider extending the time horizon for the WEO 2009 beyond 2030. This is likely to have implications for some methodologies used in the WEM[9] but is nevertheless an important consideration.

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[9] For example, the applicability of learning curves over such a long time period may not be suitable, particularly for technologies that could be disruptive within the timeframe, and result in wholesale changes to the energy system.