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MEMORANDUM

To: Fatih Birol (IEA)
Cc: Marco Baroni, Amos Bromhead, Cecilia Tam (IEA), and Henri Paillere (NEA)
From: Doug Koplow
Subject: Comments and suggestions for WEO nuclear chapter and updated Nuclear Roadmap
Date: May 1, 2014

Note: these meetings were conducted under Chatham House Rules, which allow the public discussion of meeting coverage areas, but not the attribution of specific topics to individuals at the meeting. This memo differs from the version sent to meeting organizers in that any references to individual commenters have been removed.

Thank you for the opportunity to participate in two interesting days of meetings on nuclear power related to IEA's upcoming nuclear chapter in the WEO and update of the Technology Roadmap for nuclear power. As both are IEA products, I thought it would be more efficient to provide a single set of input for your process going forward. My comments and suggestions follow; I hope they will be of value as these reports move towards completion.

1) Advance planning needed to ensure WEO and nuclear roadmap don't conflict. The WEO focuses on being technology-neutral, and staff clearly stated their objective to review nuclear issues rigorously and objectively. If the analysis concluded that other technologies were likely to be lower risk and more cost-effective, that finding would be put forward. The mission of the Nuclear Roadmap is different: to provide a fuel cycle-specific view on improving the efficiency of the nuclear sector and scaling it to meet the IEA's 2 degree scenario.

Policy recommendations in a roadmap to support a massive nuclear buildout will likely conflict with policies aimed at facilitating the lowest cost, lowest risk, and quickest options to achieve climate, power, or energy security goals. Planning for this conflict in advance will help avoid publications that seem at cross-purposes with each other. At the very least, it will be important to delineate the differing missions of the two efforts, and how this affects recommendations and issue framing.

2) Nuclear proliferation. Aside from a bit of intervention from one representative familiar with proliferation issues, the impact of nuclear scaling on the proliferation of weapons, know how, and facilities able to provide cover to military research was hardly

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discussed at either meeting. Also not addressed was the fact that a scaling of reactors on the magnitude the Roadmap recommends will trigger a concomitant scale-up in mining sites, enrichment and fabrication facilities, waste storage sites, and materials transport. A sizeable portion of this scale-up will occur in less developed, less stable parts of the world.

Proliferation is an externality of nuclear power in the same way that CO2 is an externality of coal. It needs to be addressed centrally in both reports. Similarly, there was a great deal of discussion about new reactor types, particularly SMRs, over the course of the two days. The proliferation impacts of those designs should be discussed directly as well.

Military planners and non-proliferation specialists do not have a rosy view of the ability of the IAEA to monitor what is going, particularly as the number of countries with reactors and fuel cycle facilities grows. They also tend to have more skeptical views of claims that particular emerging fuel cycles are "inherently safe" or enhance proliferation protections simply because they burn nasty wastes from prior nuclear activities. It is important that these more critical views not simply be ignored, but solicited during the writing and peer review process of these reports. The Carnegie Endowment for International Peace actually modeled out the implications for reactor buildout on fuel cycle facilities about five years ago. The Nonproliferation Policy Education Center has been looking at potential proliferation routes from commercial fuel cycles for over a decade (see, for example, this paper).

3) Financing and subsidies. While reactor financing was a central discussion point in both meetings, the dominant view among participants was that every "tool" able to subsidize construction and shift financing risk away from vendors and utilities (and onto ratepayers and taxpayers) needed to be pursued in order to finance the proposed $4.6 *trillion* in new reactor construction under IEA's 2 degree scenario.

This is a staggering sum. Yet it is probably too low by a large margin. The figure includes only the private investment in reactors, not the public subsidies associated with that investment as well. Further, the figure does not seem to include associated fuel cycle facilities needed to support the larger reactor count. It would not be surprising to see total societal investments (private plus public) exceeding $7 trillion through 2050.

The core questions that neither IEA report can ignore is what this massive expenditure is buying, and whether there are much cheaper, faster ways to achieve the core objectives of the buildout: more low carbon baseload energy and increased energy security for the nations involved.

Subsidies. Presenters and commenters argued that distortionary subsidies to renewables are unfairly destroying the future of nuclear power so many times over the

two days of meetings that I lost count. Given that the nuclear sector itself – around the world, since its inception, and including the entire fuel cycle – has been a massive recipient of government support, these comments were both ironic and myopic. Very large capital subsidies to build the nuclear fleets of the 1970 and 1980s certainly harmed non-nuclear competitors at the time. A similar competitive problem arose in the 1990s when tens of billions of dollars in stranded nuclear costs (associated with the plants not being competitive in the emerging deregulated market environment) was shifted to non-bypassable charges in rate structures, negating the financial savings to consumers from shifting to other power resources. And clearly, lifetime caps on accident liabilities at levels well below the damage a reasonably sized accident would cause create similar competitive impediments for non-nuclear resources.

Yes, renewable subsidies are now rising, and create some system complications for baseload power providers. It is fine to look at that. But doing so without integrating past and current subsidies to nuclear as well makes no sense.

Related to this point, the Roadmap table conveying planned investment by region needs to be more inclusive. Rather than just reporting on the private investment for the 2 degree scenario, it also needs to show the associated public subsidies. This is necessary for any apples-to-apples comparison with other energy options.

Financing subsidies. The Roadmap final write-up (page 7) states that "significant government involvement in the financing of nuclear projects will likely be limited to the first two or three projects." This differs markedly from what I heard from presenters and commenters alike – who argued reactors could not be built in the foreseeable future without large scale government support.

If the IEA team really believes subsidies are only available for the first few projects, then we've already filled the subsidized reactor quota with Vogtle (CWIP, federal loan guarantees, tax exempt debt, municipal take-or-pay hell-or-high-water PPAs), Hinkley (contract for difference price floors), Olkiluoto (large loan guarantees), and Akkuyu (large loan guarantees from both Russia and Turkey). In fact, most Russian and Chinese projects likely have significant embedded credit subsidies, though they may not be publicized. This would suggest that the Roadmap needs to focus instead on growth in a non-subsidized environment.

Yet this same summary of the Roadmap meetings then refers to Finland as having *not* received public support – which is incorrect given the substantial loan guarantees. So here we have a disconnect: if loan guarantees are not being considered "government involvement," any resultant analysis will be erroneous, and hugely so given the trillions in planned investment and the expectation by so many at the meetings that almost no new reactor would be built without sovereign guarantees. If the loan guarantees are properly being counted as subsidies, then the cost of capital

assumptions for the subsequent projects (i.e., most of the 2 degree scenario reactors) needs to be increased significantly.

Comparative financing costs. Comparative costs across countries are described, but not rigorously attributed to causal factors. This is important to do. Many meeting commenters pointed to higher costs in Western countries and blamed them on a misunderstanding of risk by capital providers (the markets are irrational) and inappropriately high regulations (the government and voters are irrational).

But maybe there are things in the low-cost countries that make them artificially cheap, rather than the West being artificially expensive. The WEO work should look in more detail at what allows for costs to be so much lower in places like China than they are in other countries. Is it all more rapid completion and lower overnight cost, or are there also big government subsidies through credit, land acquisition, or other factors that drive a significant portion of the difference? Even if more rapid reactor completion is an important driver in particular countries, additional context may be needed. For example, if there is no ability to review or challenge site or design problems, rapid completion is far less impressive than if the only cause is a well-trained, well-managed construction team.

Financing transparency in case studies. All case studies need to show cost escalation (from inception of project to current state); slippage in completion times from initial estimates; sources of financing and amounts – including identifying any source that has an associated sovereign guarantee or other public sector sweetener. Credit provided by a vendor or operating firm that itself is state-owned should be flagged as a sovereign guarantee. Without this context, projects can be presented as successes even though what they've actually demonstrated many of the same problems that have plagued reactor construction for decades.

4) Modeling scenarios. One of the great strengths of the WEO effort is the use of modeling scenarios to illustrate alternative futures, inflection points, and key drivers. Inclusion of the scenarios highlighted below can greatly increase the knowledge gained in the WEO nuclear review and the robustness of your presentation.

Reading the Roadmap draft recommendations illustrates the importance of testing the impacts on nuclear economics and market evolution should commonly-held projections by nuclear proponents not materialize. The Roadmap contains a slew of general recommendations and goals on how to tweak this, improve that, learn from experience, etc. In and of themselves, many of the suggestions and goals sound reasonable; the problem is that they are also quite similar to those in reports going back at least fifteen years.

Since these shifts haven't occurred, simply calling for them again probably doesn't get at the core of the problem; and assuming they will be achieved this time may not be a realistic way to proceed. Rather, it seems quite important to assess a variety of inputs, even if they end up indicating that nuclear is not likely to be competitive with other options for future low carbon power.

This suggestion, clearly stated by one participant, is relegated to the final bullet point of the Roadmap meeting write-up: "The outlook for nuclear given current cheap gas, rapid expansion of renewables and low CO2 prices is extremely challenging. The roadmap should also explore nuclear development realities under the current business as usual scenario." This comment needs to be a central part of scenarios assessed in both the WEO and the Roadmap, rather than the afterthought implied by its positioning in the write-up. I believe the following scenarios would be beneficial:

- **Inexpensive natural gas supplies in more locations** (i.e., fracking expands beyond the US), and that inexpensive competitive supply is available for (a) 20 years; and (b) for the entire period of analysis (i.e., through 2050).

- **Private finance required for future reactors.** All reactors built after 2014 must be financed privately and therefore have a significantly higher cost of capital than non-nuclear alternatives. The higher capital cost would have two primary drivers: the need to use larger amounts of equity during the construction phase; and debt and equity that would both be more expensive without sovereign credit guarantees.

- **Realistic first-of-a-kind (FOAK) learning curves.** Meeting participants continue to have high hopes for sharp reductions in reactor build costs once first-of-a-kind learning has occurred. But the past waves of construction in the US, and even in France, showed costs rising over time (per MWe) rather than declining. Lot sizes even in the 2 degree scenario may not be large enough for extensive economies of scale to take hold. Regulatory differences across countries are likely to limit the degree to which new plants can become cookie-cutter construction projects. In addition, because the buildout occurs over a very large geographic area and a long period of time, knowledge sharing will be more challenging, and shifts in operating and regulatory requirements more likely. Assumptions on FOAK learning should be clearly stated, and market projections assuming lower rates (or even negative) economies of learning should also be used in sensitivity tests.

- **Competitive markets for baseload, low-carbon power.** Would nuclear pass the market test? Many statements over the two days suggested nuclear was the only reliable option for the world to deal with climate change. At best, this is an untested claim -- particularly given the proposed scale of investment ($4.6-7 trillion) over a very long duration (plant openings through 2050, plus at least

another 40 years of licensed operation – so up to 75 years of innovation during the reactor installation and operation period). Think about how much has changed in our society since 1939.

In fact, within this timeframe and budget, entire industries are routinely upended. If one of those industries happens to be nuclear energy, the massive public investment being proposed will result in building lots of reactors that are uneconomic for much of their operating life. Far-fetched?

Probably not: nuclear assets were the single largest share of stranded assets in the US after power markets were deregulated. It would be best not to have a replay of this on steroids. Further, if the total societal cost of a nuclear buildout is higher than other options per unit CO2 abated, this strategy could have a large environmental opportunity cost as well – not only fewer mt of reductions, but also slower to arrive.

So, it is critical that scenarios, particularly in the WEO, look at what else can be developed over this time frame and with similar levels of societal investment. This can be simulated by looking at comparative rates of technical improvement that are faster in non-nuclear sectors than in nuclear – appropriate given that lots sizes in these other areas will be so much bigger, production cycles quicker, and opportunities for learning much larger. Another approach would be to assume a particular bottleneck innovation reaches key cost points by a particular date (e.g., functional battery storage by 2025) and estimate how it affects the continued viability of the reactors.

- **The no nuclear scenario**. Entire countries have signed off of their nuclear power fleets. While representatives from these "transition-away" nations were invited to the IEA meetings, none ended up coming. Although their input would have been a useful addition to the meeting, their approach can be captured via a modeling scenario that adopts their plans for growing energy supply and DSM without reactors.

5) Information framing and context. There are a number of areas in which the Roadmap and potentially WEO can showcase the presentation of nuclear projects in new ways in order to enhance the ability to make good policy recommendations and to leverage the efficacy of existing regulatory systems.

- **Progress and pitfalls since last nuclear Roadmap.** IEA's 2010 nuclear Roadmap contained a large number of goals and recommendations; the draft of the current publication does as well. Because the updated Roadmap is not a blank-slate project, it should begin with a section highlighting the most important

successes and failures from the 2010 recommendation set, and any major shifts in recommendations or goals between the two reports.

- **Standardizing reporting of job creation data.** Employment figures are promoted for nearly every reactor project, but these are not presented in a consistent manner. IEA should provide a normalized method for doing so, and use that approach in any case study assessment or modeling that is conducted. Rather than gross job numbers, this standardized approach should report job-years, and show the job-years created in three separate categories: construction, permanent administrative, permanent professional. Some figures include regional multipliers, often using different assessment models and assumptions. This factor should be stripped from the reported numbers to enhance comparability and reduce the ability to pad the employment estimates for political reasons.

- **SMRs as salvation**. Many participants seemed to pin a great deal of hope on emerging, small modular reactors – though to its credit IEA's coverage has been modulated, pointing out the higher costs per kWh. However, to the extent that SMRs are picked up as a theme in either report, a number of attributes in addition to the higher cost need also to be included: any reductions or exemptions these developers are looking for from standard liability, safety, staffing rules; and proliferation impacts.

- **Transparency and security of post-closure funds.** As with jobs data, it is useful to standardize reporting in another often contentious issue area: available funds to cover post-closure site management and decommissioning. For each plant, information on the years of license left, expected years of extension, already funded amount for decommissioning and where those funds are located (i.e., external trust fund or not) would greatly boost the understanding of potential shortfalls and pressure laggards to establish more secure funding sources.

6) Regulatory oversight and accident liability. A number of participants articulately presented their concerns about the serious risks associated with poor regulatory oversight, noting that radiation easily crosses national borders and regulator problems in one country can have dire impacts on its neighbors.

Earlier Roadmap meetings tried to address this concern in part by advocating that inspectors and regulators receive higher wages. This recommendation was removed following from the final summary due to objections from a number of the meeting participants. They argued that competence, not wages, is the only thing that matters. I am not clear that the two are so easily separated; and others noted that regulators are often weak relative to political interests, particularly in developing countries. Themes that may be useful to raise:

Regulatory compensation. There seems to be a fair bit of empirical work indicating that higher police wages do increase the capabilities of the people going into the profession and reduce corruption risks. This seems relevant to the nuclear issue, and though the pushback was strong at the last meeting, citing the policing studies may be useful in keeping the compensation issue at least under discussion as one tool that can be pursued to boost regulatory competence.

Structure regulatory system to enhance independence and accountability. Although not discussed, it is also important to bolster regulatory success through how inspections are structured and inspectors evaluated. For example, requiring a certain portion of inspections to be unannounced, requiring publication and peer review of inspection results, rotating which inspectors go to a particular facility, associating the name of an inspector with the inspection so there is public accountability if problems come up later, and publicizing how many inspections were done unannounced for each facility can all help achieve a system of higher regulatory competence and accountability.

Make accident liability coverage transparent for all plants. Even if more countries adopted international liability conventions, the coverage levels mandated would remain inadequate.

An interim, though powerful, strategy that the Roadmap should recommend is to adopt a simple liability disclosure summary that each plant prepares annually, and to include such a summary in any of the case studies being conducted. The sheet would list the plant, the relevant insurance types (e.g., off-site damage, on-site damage, power replacement), the coverage amounts for each coverage area, the underwriters, and whether premiums and damages are being paid by plant operators or by the state. The summary should also note what form the assets to pay for damages are in; if it is merely a corporate pledge, the post-accident risks of those funds not being available are extremely large.