EPA-COUNCIL-10-xxx

The Honorable Lisa P. Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Review of the Second Section 812 Prospective Study of the Benefits and Costs of the Clean Air Act (August 2010)

Dear Administrator Jackson:

The Advisory Council on Clean Air Compliance Analysis (Council) met September 2-3, 2010 to review a revised draft of the Agency's Second Section 812 Prospective Study of the benefits and costs of the Clean Air Act Amendments (CAAA). The Second Prospective Study evaluates benefits and costs for air quality scenarios with and without the CAAA for the years 2000, 2010, and 2020. The study estimates human health benefits that would result from reduced ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone, as well as benefits to a limited set of welfare and ecological endpoints. The report concludes that benefits far exceed costs, with the great majority of benefits attributed to reduced premature mortality due to lower ambient concentrations of $PM_{2.5}$. Even without considering health benefits, the value of improvements in visibility and crop and forest yields exceed the estimated costs of compliance with CAAA provisions.

The Council is impressed with the quality, scope, and presentation of the Second Prospective Report. The report provides a state-of-the-art analysis of the benefits and costs of the 1990 CAAA. It is comprehensive in scope, sophisticated in methodology, and is accessible to both specialist and non-specialist readers. The report includes methodological innovations that enhance our understanding of the benefits and costs of air-quality regulations. These innovations should be further refined and applied in future regulatory analysis. The Council commends the EPA Project Team for its work.

The Second Prospective Study has reinforced the need to invest in development of methods and studies to predict and value changes in ecosystem services and additional human health impacts (such as changes in morbidity and health effects of pollutants other than fine particulate matter and ozone). In important areas, the 812 Project Team was hampered by methodological and data gaps, for example in the area of health effects of hazardous air pollutants (HAPs) and in understanding and valuing ecosystem responses to air pollutant exposure.

The Council is pleased with the revisions made to the preliminary draft of the prospective study in response to its previous advice (EPA-COUNCIL-10-004). No analysis of the scope and complexity of the 812 Study is ever perfect, however, and the Council has suggestions to further improve the report. For the most part, our recommendations concern the presentation rather than its substance. We anticipate that this report will be of significant interest and value to many parties, which puts a premium on clear and comprehensive presentation. We urge the Agency to make the data, methodologies, and findings of the Second Prospective Study widely available through a variety of distribution mechanisms, including the EPA Web site.

The Council appreciates the opportunity to interact with the 812 Project Team over the course of the Second Prospective Study, and the openness of the Agency to Council recommendations and advice. We look forward to your response, and to future opportunities to assist the Agency with benefit-cost assessments of Clean Air Act programs.

Sincerely,

Dr. James K. Hammitt, Chair
Advisory Council on Clean Air
Compliance Analysis

NOTICE

This report has been written as part of the activities of the EPA Advisory Council on Clean Air Compliance Analysis (Council), a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Council is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names of commercial products constitute a recommendation for use. Reports of the Council are posted on the EPA Web site at http://www.epa.gov/advisorycouncilcaa.

U.S. Environmental Protection Agency
Advisory Council on Clean Air Compliance Analysis

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1. EXECUTIVE SUMMARY

Section 812 of the Clean Air Act Amendments (CAAA) of 1990 calls for EPA to periodically prepare a comprehensive analysis of the impact of the CAAA on the public health, economy, and environment of the United States, and to seek the review and recommendations of the Council before issuing a final report. Over the past year, the Council and its technical subcommittees have reviewed numerous documents prepared for the Second Section 812 Prospective Study.

The Second Prospective Study evaluates benefits and costs for air quality scenarios with and without the CAAA for the years 2000, 2010, and 2020. The study estimates human health benefits that would result from reduced ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone, as well as benefits to a limited set of welfare and ecological endpoints. The report concludes that benefits far exceed costs, with the great majority of benefits attributed to reduced premature mortality due to lower ambient concentrations of $PM_{2.5}$. Even without considering health benefits, the value of improvements in visibility and crop and forest yields exceed the estimated costs of compliance with CAAA provisions.

The Council is impressed with the quality, scope, and presentation of the Second Prospective Report. The report provides a state-of-the-art analysis of the benefits and costs of the 1990 CAAA. It is comprehensive in scope, sophisticated in methodology, and is accessible to both specialist and non-specialist readers. The report includes methodological innovations that enhance our understanding of the benefits and costs of air-quality regulations. These innovations should be refined and applied in future regulatory analysis. The Council commends the EPA Project Team for its work.

Given the extensive previous reviews by the Council of data and methodologies used in the Second Prospective Study, the focus of the current report is primarily on the presentation of study results, including possible improvements to the clarity and context of key findings. The Council endorses the preparation of a Summary Report in addition to the more complete Integrated Report. The Summary Report (which the Council reviewed in draft form) provides an accessible and comprehensive summary of the Second Prospective Report and should be widely read and quoted.

To further improve the reporting of the study, the Council recommends that the EPA Project Team post on the EPA Web site the numerous stand-alone documents and technical memoranda that provide supporting information about analytic methods and intermediate results. These materials should be supplemented by a short guide that orients readers to the background materials and reports any significant differences between the methods and results as described in these materials and as incorporated in the Second Prospective Report.

Looking forward, the Council notes that the benefits quantified in the Second Prospective Report are dominated by reductions in mortality risk associated with fine particulate matter, as was the case for the Retrospective Report (U.S. EPA, 1997) and First Prospective Report (U.S.

EPA, 1999). This dominance reflects not only the magnitude and importance of reductions in mortality risk, but also the limited extent to which other benefits are quantified. Because of limitations in methods and data, effects of other pollutants (notably Hazardous Air Pollutants or HAPs) and effects on ecosystems, agriculture, forestry, and construction materials are represented incompletely, in some cases only by case studies. The Council recommends that EPA stimulate research on methods to quantify these effects more comprehensively, which will allow EPA to provide a fuller understanding of the effects of air quality regulation that will be invaluable for future policy-making.

2. INTRODUCTION

2.1. Background

Section 812 of the Clean Air Act Amendments (CAAA) of 1990 calls for EPA to periodically prepare a comprehensive analysis of the impact of the Clean Air Act on the public health, economy, and environment of the United States, and to seek the review and recommendations of the Council before issuing a final report. Over the past year, the Council and its technical subcommittees have reviewed numerous studies prepared for the Second Section 812 Prospective Study, including reports on air emissions inventories and air quality modeling (EPA-COUNCIL-10-002 and 10-005); effects of future emissions scenarios on human health (EPA-COUNCIL-10-001), welfare and ecosystems (EPA-COUNCIL-10-003); and economic benefits and costs of compliance (EPA-COUNCIL-10-004).

On September 2-3, 2010 the Council met to review a revised draft of the integrated report that presented the full array of technical results (the Integrated Report; U.S. EPA, 2010a) and a short, less technical document (the Summary Report; U.S. EPA 2010b) that summarizes the analytical methods used and the results and findings from the study.

2.2. Charge to the Council

Consistent with the statutory language defining the role of the Council in reviewing the 812 studies, EPA requested that the Council consider the following questions during its review:

1) Does the Council support the data choices made by the 812 Project Team for the development of the full integrated report and the summary report? If not, are there alternative data sets that should have been used?

2) Does the Council support the methodological choices made for analyzing the data referenced in Charge Question 1? If not, are there alternative methodologies that should have been used?

3) Does the Council have advice regarding potential revisions to the revised draft integrated report and/or the summary report that might enhance the utility of the final versions of these documents?

Given the extensive previous reviews by the Council of data and methodologies used in the Second Prospective Study, the focus of the current Council report is primarily on the presentation of study results, including possible improvements to the clarity and context of key findings.

3. COMMENTS ON THE SUMMARY REPORT

The Council endorses the EPA Project Team's decision to produce a stand-alone Summary Report (U.S. EPA, 2010b) as a complement to the Integrated Report. The summary is of a length and level of methodological detail that will make it more accessible and widely read than the Integrated Report. In the interest of improving the draft summary report, the Council offers the following suggestions:

- **Ensure that all results in the Summary Report also appear, with appropriate support, in the Integrated Report**. The Council noted one example of a result that does not seem to appear in the Integrated Report, the figure of $275,000 per avoided fatality (on p. 17).
- **Ensure that each Exhibit is sufficiently well labeled that it stands alone**. When describing effects that are evaluated, the pollutants whose effect is quantified should be identified when this is not evident (e.g., for welfare and ecological effects in Exhibit 11). Many readers will not read the full document and some will wish to use results from it in their own presentations. To ensure easy and accurate reproduction, it would be useful to make digital versions of the Exhibits available (e.g., as presentation slides). Moreover, each graphic should be thoroughly examined to make sure that it is reasonable and can be explained or else it will harm the credibility of the work (e.g., some of the increases in $PM_{2.5}$ in Exhibit 7 may be artifacts of MATS or other modeling steps).
- **Ensure that the time periods to which monetary values, averted fatalities, and other effects pertain are clear** (e.g., annual, cumulative, present value, and dates). Also, whether monetary amounts are nominal or real, and if real the year to which they are indexed, should be clear.
- **Provide more context to help readers understand the magnitudes of the effects of the CAAA**. For example, it would be helpful to describe how air quality with and without the CAAA changes over time, and how levels compare with levels observed in different locations and/or over time in the United States. This is relevant to understanding how much of the benefit comes from improving air quality since 1990 compared with preventing degradation that might otherwise have occurred and to understanding the extent to which estimates of health and other damages require extrapolating beyond conditions observed in epidemiological and other studies.
- **Describe benefits and costs on a per-capita or per-household level, in addition to national aggregates, to provide further perspective**. In 2020, for example, the average mortality-risk reduction is approximately 10 percent (age-specific results might be preferable), the benefits average about $6,000 per capita (around 10 percent of average income), and the direct costs average about $200 per capita.
- **Add additional text boxes, FAQs, or other material to address important and difficult topics**. Examples include the concept of premature mortality (including life expectancy gain), the concept and methods used to estimate the monetary value of mortality-risk reduction, and the use of probability distributions and fractiles to describe

uncertainty. It may be useful to address the extent to which estimated benefits are associated with reductions in pollutant concentrations below the NAAQS and, if these are significant, to address the apparent conflict between threshold-motivated NAAQS and the continuous exposure-response functions used in the 812 analysis.

- **Further discuss the possibility that PM components are differentially toxic**. In the Summary Report, it might be useful to report how the population-weighted average $PM_{2.5}$ composition differs between the with- and without-CAAA scenarios (nationally and perhaps regionally) to address how much differential toxicity could affect the results.

- **Clarify that there are uncertainties associated with estimates of costs, as well as benefits**. It is striking that the summary of non-quantified effects (Exhibit 17) and key uncertainties (Exhibit 18) include nearly only benefits. There are uncertainties about costs beyond the one included in Exhibit 18 (unidentified measures for NAAQS compliance), e.g., treatment of learning-curve effects, unquantified quality degradation of products. Those that are judged most important should be identified.

4. COMMENTS ON THE INTEGRATED REPORT

The Integrated Report (U.S. EPA, 2010a) provides a clear description of the data, methods, and results of the second prospective analysis. One general comment is that it would be preferable to provide more of the uncertainty analysis in the chapters to which it pertains, and reserve the uncertainty section of Chapter 7 (Comparison of Benefits and Costs) for an integrative perspective on how the uncertainties combine. Each section describing a primary component of the analysis (e.g., emissions, air quality modeling, health effects) should include a statement of overall uncertainty in that component, e.g., something like "overall, air quality modeling results are viewed as contributing substantial/moderate/limited uncertainty to the estimated total benefits. These uncertainties contribute directly/indirectly/multiplicatively/… to the uncertainties in the estimation of mortality/morbidity/ecological benefits."

Additional comments are provided below, organized by topic and chapter, and detailed technical comments are provided in Appendix A. (For the Council's comments on the preliminary draft of the Integrated Report, see EPA-COUNCIL-10-004.)

4.1. Emissions and Air Quality Modeling (Chapters 2 and 4)

Given the large differences between projected 2020 emissions and air quality with and without the CAAA, it would be useful to add context with some illustrations of historical changes in PM and/or ozone concentrations in the recent past. For example, there is likely to be some ozone and PM data available for locations like Los Angeles, Pittsburgh, or New York from the late 1970s or early 1980s. Reference to proportionate historical changes in related indicators (such as PM_{10}, other PM size fractions, or visibility) also might be employed here if older $PM_{2.5}$ measurement data are elusive.

It would be helpful to provide more discussion about uncertainties in secondary organic aerosol (SOA) formation. Figure 4-1 should be modified to include the use of the Modeled Attainment Test Software (MATS) to adjust modeled air quality. (Air quality modeling was done using the Community Multiscale Air Quality, CMAQ, model and MATS was used to adjust CMAQ outputs using monitoring data. For more discussion, see EPA-COUNCIL-10-002 and 005.)

It appears that the MATS application may have introduced some small errors in the adjusted model results. For example, there appear to be anomalous localized increases in $PM_{2.5}$ concentrations in several western states in the 2020 with vs. without CAAA plots (Figure 4-7, reproduced as Exhibit 7 in the Summary Report). If these increases are errors, it would be important to understand, explain and if possible correct them. If they are not errors, the text should adequately explain them.

The tabular listings and associated discussions of key uncertainties at the ends of these chapters are informative. It would be helpful to add an overview summary of the general magnitude of the total uncertainties associated with emissions inventories, projections, and MATS-adjusted CMAQ results, which collectively are likely to be moderate compared with uncertainties in other components of the analysis.

4.2. Direct Costs (Chapter 3)

The Council suggests that there be greater acknowledgment of the conceptual and empirical uncertainty about cost reductions that occur over time, and whether they are best modeled as learning-curve effects or as some other form of endogenous or exogenous technological change. A recent working paper suggests that it is difficult to distinguish learning-curve effects from exogenous technological change and that the effect of learning on reducing costs typically will be overestimated (Nordhaus 2008).

The assumption that costs of identified control measures will not exceed $15,000 per ton of pollutant could be better supported, using information on regulations adopted in California that was described by the EPA project team at the Council meeting. It also would be useful to specify the pollutants to which this assumption applies.

When comparing cost estimates with econometric estimates, another relevant citation is the 2005 NAPAP retrospective report (National Science and Technology Council, 2005).

Some of the costs of the CAAA are not reflected as increased market prices, but can be characterized as reductions in product quality. For example, motor-vehicle emission controls may reduce performance. The stricter emissions regulations on automobiles than on light duty trucks (LDTs) likely contributed to the shift in the vehicle fleet toward LDTs, with some consumers who would have preferred automobiles purchasing LDTs. Substitution of other devices for charcoal lighting fluid, reformulation of paints, and other product changes also may have reduced the quality of products consumed. The Council suggests including some discussion of the components of costs that are not likely to be captured in the analysis.

4.3. Human Health Benefits (Chapter 5)

The Council suggests including more discussion of the evidence related to differential toxicity of $PM_{2.5}$ components, perhaps integrated with information on how PM composition differs between the with- and without-CAAA scenarios. The current discussion should be expanded to include references that provide evidence of heterogeneity among effect estimates by PM type and to note that this is an ongoing area of research. Future efforts may be able to quantitatively address this issue as the scientific literature develops.

Some discussion should be provided of the uncertainty and possible bias in estimated health effects that come from reliance on fixed ambient-air-quality monitors rather than personal exposure. The current approach can be described as a reduced-form relationship that has embedded within it people's behavior, including the extent to which they vary their activity in ways that alters PM exposure.

It would be useful to explain why different model runs, time periods, and domains were used to estimate $PM_{2.5}$ and ozone exposures and to provide a brief explanation of the enhanced Voronoi Neighbor Averaging procedure.

With regard to monetary valuation of health risk, the Council recommends further clarification of the concept of value per statistical life (VSL) and acknowledgment of uncertainty

about the appropriate value(s) for use in this analysis. As nicely described in the Summary Report, the extent to which VSL depends on age and health status and on the source of risk are significant uncertainties. These are important because most of the VSL estimates relied on are obtained by studies of working-age populations and concern the risk of fatal occupational injury rather than older (and younger) populations and risk of heart attack or disease from ambient air. An additional uncertainty concerns the potential bias in using estimates of VSL that correspond to very small risk changes for the rather large risk changes associated with the CAAA (averaging on the order of a 10 percent reduction in total mortality risk). It is clear that an individual's incremental willingness to pay to reduce mortality risk declines as he purchases more increments, but the rate at which it declines is uncertain. Moreover, a case could be made that willingness to accept compensation to forgo air quality improvement is the relevant measure, and incremental willingness to accept could increase with increasing air quality improvement.

It would be useful to compare estimated benefits in this report with estimates that could be derived for the appropriate changes in air quality using econometric studies of housing markets (Chay and Greenstone, 2005; Bayer et al., 2009). In making this comparison, it should be recognized that the econometric studies estimate the full benefits of improved residential air quality, including changes in mortality, morbidity, visibility, materials damage, and perhaps others.

4.4. Ecological and Other Welfare Benefits (Chapter 6)

There are potentially large ecological benefits of air-pollution control that are not currently quantified. Some of the most important categories of unquantified effects may include the effects of nitrogen deposition on estuaries, sulfur deposition on terrestrial ecosystems, and interactive and synergistic effects of multiple air pollutants. Some effects of air-pollution control may be adverse, at least in the short term, such as reductions in nitrogen deposition at sites where it is a limiting nutrient. Also important, but more subtle, are the long-term effects of a wide range of air pollutants on ecosystem structure and function, and therefore the ecosystem services on which society depends.

The values in Figures 6-2 (NOx and SOx deposition) and 6-3 (total N deposition) appear high compared with National Atmospheric Deposition Program (NADP) measurements. It would be useful to verify and explain important differences between what is modeled and what is measured.

The FASOM model, used to estimate agricultural benefits, should be more fully explained. Issues that merit attention are the accuracy with which it has predicted results in previous studies, the effects of assuming farmers have perfect foresight, and the assumption that imports are fixed and do not respond to domestic prices.

The chapter notes that the Air Pollution Emissions Experiments and Policy (APEEP) model was used to simulate ambient SO_2 levels as input to the estimation of materials damage under the various emissions scenarios. The discussion of APEEP should make clear that CMAQ is a far more sophisticated model. In addition, some characterization of how well APEEP replicates CMAQ results should be provided to supplement the statement that APEEP has been statistically tested against CMAQ (p. 6-32). Logically, APEEP might be described in Chapter 4

on air quality modeling, but given its limited use perhaps it is better to keep the description in Chapter 5.

4.5. Benefit-Cost Comparison (Chapter 7)

This chapter could be better organized by focusing sequentially on benefit and cost results, uncertainties, methodological advances, and other issues. At present, these topics are somewhat mixed together. As noted earlier, much of the discussion of component-specific uncertainties should be moved to the relevant chapters with this chapter providing integration and overview.

The information on benefits per ton emitted from different sources is useful. It would be improved by providing a short explanation of why the sectors rank as they do, as it seems counterintuitive that EGU emissions have the highest benefit per ton (rather than sources that are closer to populations).

4.6. Computable General Equilibrium Analysis (Chapter 8)

The inclusion of benefit-side effects (reductions in mortality, morbidity, and health-care expenditures) in a computable general equilbirum (CGE) model represents a significant step forward in benefit-cost analysis. (In the past, only cost-side effects have been included.) The Council's primary concern is that the Summary and Integrated Reports be clear about which effects are, and are not, included in the CGE model. To this end, we suggest that references to the adjustments use uniform terminology, such as "labor force" and "health expenditure" adjustments, and not risk confusion by also using alternative terms such as "labor market" or "health benefits." In the Summary Report, it would be better to substitute "productivity" for "efficiency" in the phrase about "the limited 'economic efficiency' terms reflected in the macroeconomic model's measure of household welfare" (p. 20). Also, the Summary Report should make clear that the CGE model accounts for household leisure as well as income.

It would be useful to provide information about how important the various adjustments are to the total effects on GDP and welfare (as calculated by the CGE model), i.e., are the labor-force adjustments significantly more influential on GDP than the reductions in health-care expenditure? Indeed, does the reduction in health-care expenditure increase or decrease GDP? For overall well-being, how important is the increased income associated with greater labor input compared with the additional leisure time available? If the labor-force adjustments dominate, that would help justify use of the "labor-force-adjusted" description; if not, perhaps some better term could be chosen.

Finally, the report notes the exclusion from cost estimates of motorist waiting time for inspection and maintenance programs (p. 8-11). It would be useful to indicate the likely importance of this exclusion based on the size of these costs within the total direct costs of the I&M programs.

5. CONCLUSIONS

Overall, the Council is impressed by the scope, sophistication, and clarity of the draft second prospective report. It will provide a state-of-the-art assessment of the benefits and costs of the 1990 CAAA and the Summary Report should be widely read and quoted.

The Second Prospective Report is not a single document, but consists of several. In addition to the Summary Report and Integrated Report, supporting material is provided by numerous stand-alone documents and technical memoranda, drafts of which were reviewed by the Council or its subcommittees. These documents include:

- *Benefits Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act – Draft*, November 2009 (prepared by Industrial Economics, Inc)
- *Uncertainty Analyses to Support the Second Section 812 Benefit-Cost Analysis of the Clean Air Act – Draft*, November 2009 (prepared by Industrial Economics, Inc)
- *Second Prospective Analysis of Air Quality in the U.S.: Air Quality Modeling – Draft Report*, September 2008 (prepared by ICF International)
- *Evaluation of CMAQ Model Performance for the 812 Prospective II Study*, November 2009 (memorandum prepared by ICF International)
- *Effects of Air Pollutants on Ecological Resources: Literature Review and Case Studies – Draft Report*, February 2010 (prepared by Industrial Economics, Inc.)
- *812 Economic Analyses Using the EMPAX-CGE Modeling System—Revised Draft,* April 2010 (prepared by ICF Inc.)
- *Direct Cost Estimates for the Clean Air Act Second Section 812 Prospective Analysis – Draft Report* (prepared by Pechan & Associates, Inc.)

To provide coherence, the Council recommends that the EPA Project Team prepare a short guide or table of contents to the full set of documents, so that readers can readily determine what exists and which parts are relevant to any particular topic. For these documents to serve their role of supporting the Second Prospective Report, any changes between the methods and results as presented in the final versions of these documents and as incorporated in the Second Prospective Report should be described, in the short guide or elsewhere. We urge that this guide and all the relevant reports be easily accessible through the EPA Web site.

Looking toward the future, the Council notes that the current report provides sparse quantitative information about the consequences of the CAAA on endpoints other than the human-health effects of $PM_{2.5}$ and ozone. Moreover, even the morbidity effects of these pollutants are less well quantified than the mortality effects. Health effects of hazardous air pollutants (HAPs) are represented only by a case study of the effects of benzene in the Houston metropolitan area and effects on unmanaged ecosystems are included only as a case study of lake acidification and recreational fishing in the Adirondacks. Some effects of single pollutants on large categories of endpoints are estimated nationwide, i.e., effects of ozone on commercial agriculture and forestry and effects of SO_2 on some building and infrastructure categories. In large part, the limited coverage of non-health endpoints reflects their physical complexity, site-specificity (and hence dependence on site-specific data), and limitations of methods and

estimates for economic valuation. The value of enhanced visibility is incorporated comprehensively for metropolitan regions but selectively for recreational sites (e.g., national parks) and the studies used for valuing visibility are dated.

In order to provide a more comprehensive understanding of the effects of the CAAA and other air-quality regulations, EPA should stimulate more research on the effects of air quality on managed and unmanaged ecosystems, on methods to comprehensively quantify human exposure to air pollutants whose concentrations vary dramatically in time and space (HAPs, but also $PM_{2.5}$ near traffic and other sources), and to improve estimates of the monetary value of changes in these endpoints. In addition, future studies that assess effects over multi-decadal periods should consider the effects of climate change, which can alter atmospheric concentrations of pollutants and the distribution, sensitivity, and other characteristics of agricultural and ecosystem receptors.

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APPENDIX A: Technical Corrections

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