Direct Testimony of Robert Fagan

Q. Please state your name and occupation.

A. My name is Robert M. Fagan and I am a Principal Associate at Synapse Energy Economics.

Q. Please describe Synapse Energy Economics.

A. Synapse Energy Economics is a research and consulting firm specializing in electricity industry regulation, planning and analysis. Synapse works for a variety of clients, with an emphasis on consumer advocates, regulatory commissions, and environmental advocates.

Q. Please summarize your qualifications.

A. I am a mechanical engineer and energy economics analyst, and I've analyzed energy industry issues for more than 25 years. My activities focus on many aspects of the electric power industry, in particular: production cost modeling of electric power systems, general economic and technical analysis of electric supply and delivery systems, wholesale and retail electricity provision, energy and capacity market structures, renewable resource alternatives, including wind and solar PV, and assessment and implementation of energy efficiency and demand response alternatives. I hold an MA from Boston University in energy and environmental studies and a BS from Clarkson University in mechanical engineering. My resume is included as Attachment 1 hereto.

Q. On whose behalf are you testifying in this case?

A. I am testifying on behalf of the Conservation Law Foundation ("CLF").

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to address and critique aspects of The Analysis Group's ("TAG's") March 10, 2015 Testimony of Susan F. Tierney and Pavel G. Darling submitted on behalf of Petitioners Exelon West Medway, LLC and Exelon West Medway II, LLC, in regards to the proposed natural gas and oil-fired 200 megawatt (MW) Medway power station (the "Medway Project"). I address some aspects of the functionality of the Analysis Group's SAS modeling mechanism[1], which is used by Ms. Tierney and Mr. Darling to estimate greenhouse gas ("GHG") emissions[2] (actual or avoided) over the 2018-2030 time frame. I address how the use of different assumptions in the modeling process leads to different results and what that implies for the robustness of TAG's findings. I also discuss the New England electric power sector in the 2030-2050 period and how modeling of the New England system for earlier periods (such as 2018-2030) can inform considerations for environmental impacts of the Medway Project in those later years. Lastly, I summarize and discuss CLF's recommendation for an Energy Facility Siting Board ("EFSB")-imposed mitigation of GHG emissions from the facility: an emissions-limiting cap on the proposed Medway Project analogous to the emissions cap included by the EFSB in the Certificate of Environmental Impact and Public Interest issued in EFSB 13-1 (Footprint Power Salem Harbor Development) (the "Footprint Mitigation Measure"). CLF's proposed GHG emissions cap – declining from an initial value in 2030 consistent with a 15% capacity factor to a value of zero in 2050 – recognizes that the Medway Project is a proposed peaking plant with expected energy-producing operations considerably less than (i.e.,

[1] TAG Testimony, Attachment ST/PD-4, page 1.
[2] I note that throughout this testimony, I use GHG emissions reduction as interchangeable with CO_2 emissions reduction. I take no account of any incremental GHG emissions associated with methane emissions that could arise as a consequence of building and using a new natural-gas-fired power plant.

lower annual capacity factor) a combined cycle facility.

Q. How is your testimony organized?

A. My testimony is organized as follows: first, in this section I briefly identify background technical issues that should influence the outcome of the EFSB's decision in this case with respect to the Facility's expected GHG emissions. Those include, especially, the current and possible future resource options available to provide reliable and clean power supplies for Massachusetts and New England in general, in order to comply with the statutory obligations of Massachusetts' Global Warming Solutions Act ("GWSA"). Next, I briefly summarize my findings and conclusions based on a review of TAG's testimony and Petitioners' discovery responses. In the body of this testimony, I present analysis and discussion of TAG's 2018-2030 electric power sector modeling and related issues, as well as a discussion of the electric power sector in the 2030-2050 timeframe and a critique of TAG testimony relating to that period. Lastly, I provide my conclusions that result from such analysis, and explain my resulting recommendations to the EFSB regarding its findings for the proposed Medway Project.

Q. What are the relevant technical background issues considered in your testimony?

A. The relevant technical background issues include:

- The nature, extent, and timing of supply and demand-side resource changes occurring throughout the electric power industry, including in Massachusetts and New England. In particular, the pace (and ultimate installation timing) of renewable supply increases, including solar PV, onshore and offshore wind power;
- The impact of energy efficiency improvements and demand response capabilities in

Massachusetts and across New England;

- Whether (and if so, when) increased supplies of Canadian hydro imports will occur, and at what level;
- The timing of fossil-fuel plant retirement in New England; and
- To what extent (and if so, when) bulk storage of electricity will increase on the New England grid, in support of capacity needs.

Each and all of these areas will impact the timeframe for how long (and to what extent) New England will need to rely on fossil-fuel technologies like the proposed Medway Project to provide electric energy and to support electricity use and delivery, and thus inform the EFSB on mechanisms that could mitigate GHG emission (and other) environmental impacts that would stem from the proposed Medway Project, especially for future years when its ability, if any, to offset other GHG emission is particularly uncertain. Notably, all of these resource options will affect the level of peaking energy supplied by the proposed Medway Project. Massachusetts GHG emission policies[3], the Footprint Mitigation Measure, and capacity needs pursuant to ISO-NE's forward capacity market are also among the relevant background issues I considered.

Q. Please summarize your findings.

A. My three primary findings are as follows:

(1) TAG's production cost simulation model, offered as evidence that the Medway Project will comply with the GWSA and with the state GHG Policy on the basis of avoided emissions, is inadequate. It fails to capture key operational aspects of the ISO-NE grid in the

[3] Such as described in the "Massachusetts Clean Energy and Climate Plan for 2020", available at http://www.mass.gov/eea/docs/eea/energy/2020-clean-energy-plan.pdf.

near-, mid-, and long-term that are critical to any such avoided emissions analysis. Its lack of an economic unit commitment process, use of single-zone topology for New England, and failure to capture key plant operating characteristics and system reserve requirements reveal a lack of precision that would be required to accurately discern relatively small changes in GHG emissions in the scenario analyses undertaken.

(2) Even if one ignores the model's imprecision, TAG's original conclusions regarding avoided emissions based on the model are not robust. The lack of sensitivity analysis using reasonably foreseeable future changes to the New England power system (including: increased levels of imports of Canadian hydro-power, the addition of regional offshore wind power; increases in solar PV generation beyond current ISO NE projections; and/or the installation of storage as a capacity resource) indicates a failure to gauge likely patterns of decline in the Medway Project's ability to avoid GHG emissions over the 2018-2030 period. Modeling in response to CLF's discovery requests reveals how avoided GHG emissions attributable to the project vary widely with system resource assumptions.

(3) TAG's testimony regarding the potential environmental impacts of the proposed project for years after 2030 is not supported with any modeling. TAG's assertions that the Medway Project will represent one of the relatively efficient gas-fired resources that might be required under one of the two 2050 scenarios discussed in the Massachusetts Clean Energy and Climate Plan are weak and unsupported. A reasonable projection of resource options likely to be in place after 2030, combined with an understanding (as revealed in the modeling, its functional flaws notwithstanding) that the Medway Project illustrates diminishing returns to

GHG emission avoidance over time leads to a conclusion that it will not be a contributor to GHG emission avoidance in the longer term and thus merits mitigation as a condition of its operation.

TAG Modeling and Analysis for 2018-2030

Q. Please summarize TAG's modeling construct for the 2018-2030 period.

A. TAG estimated certain GHG and other emissions reductions ascribed to the Medway Project for the period 2018-2030 based on their use of a proprietary supply/demand matching model that they state "mimics a full production cost simulation model."[4]

Q. Did you review this model's workings in detail?

A. No. The model is proprietary and TAG did not provide the model itself in response to discovery responses which sought to obtain the model for close inspection.[5] I instead relied upon the description provided in Attachment ST/PV-4 and remaining responses to discovery requests.[6]

Q. Does that affect your confidence in your conclusions regarding the use of TAG's model to calculate avoided emissions?

A. No. I would have preferred to obtain the model for closer inspection and manipulation, but I am nonetheless confident in my conclusions about the model given what has been disclosed about it by TAG in its testimony and through Petitioners' various discovery responses.

Q. Is this model suitable for assessing GHG emissions from the electric power sector in New England?

[4] TAG Testimony, Attachment ST/PD-4, page 1.
[5] CLF-2-1.
[6] CLF 2-1.3, 2-1.4.

A. Only to a limited extent: while the model may be suitable for obtaining rough estimates of near-term grid operations, it has particular limitations related to precise quantification of differential impacts due to the addition of the Medway Project – which is what TAG has used the model for. The model itself is a reduced form of a production cost simulation model that does not address the effect of transmission constraints on power plant dispatch[7], does not perform any "unit commitment" in determining which plants are available for real-time dispatch[8, 9] and does not account for the need for operating reserve provision when determining an energy dispatch for New England.[10] Thus it does not address key operational issues associated with dispatch of the Medway Project in the context of the actual dispatch of the New England electric power system.

Q. Please explain your analysis regarding how the TAG model addresses key operational issues of, or relating to, the Medway Project.

A. The model fails to adequately deal with a number of important operational issues relevant to the proposed project and its ability to offset regional GHG emissions. While the model appears to adequately capture the benefit associated with the relatively low heat rate of the proposed project as compared to older and less efficient peaking facilities in New England,

[7] TAG states the model has "single zone" topology in New England. Attachment ST/PV-4, page 2.
[8] In response to discovery request CLF-2-1.3, TAG describes how it determines which plants are available for dispatch, and even uses the phrase "unit commitment logic". However, the model does not perform an economic unit commitment that accounts for the attributes of actual plant operating constraints, a process that the ISO NE does perform in the actual wholesale markets.
[9] Unit commitment is the process ISO NE performs to determine which plants to start up, or stop, in order to have units available to meet all electric energy needs while respecting actual system and unit-specific physical constraints. Its algorithms (as with the algorithms used for dispatch itself) consider physical plant characteristics such as (but not limited to) minimum operating levels, start-up times and ramp rates.
[10] ISO NE co-optimizes energy and reserves scheduling in the real-time market. See, e.g., Potomac Economics, "2014 Assessment of the ISO New England Markets", June 2015, page 29.

it does not appear to incorporate a unit commitment process, or include minimum run times or ramp rates.[11] In order to minimize total production costs, ISO-NE tells generators which units will be needed the following day based on such constraints. Because generators take a non-zero amount of time to start up, this unit commitment process will, for example, tell a generator to turn on even if it is not needed at 3PM so that it can serve load at 5PM. By not including this process, the TAG model is assuming the power system is much more flexible than it actually is. One possible implication of such behavior is that "baseload" power plants such as the existing base, and potential future additions, of natural gas combined cycle units that are more efficient and cleaner that the proposed project, would operate more than in the TAG analysis. Such increased operation would result in lower predicted avoided emissions reasonably attributable to the Medway Project.

Q. Is this the only flaw associated with use of the model?

A. No. The model results are not at all robust since TAG did not perform a set of sensitivities to see how the GHG emissions may change under different, but realistic, scenarios of resource alternatives in the New England system. No sensitivities were provided (for any future years at all), as part of TAG's testimony, to test the model's results for any or all of following reasonable future scenarios: (i) increased levels of imported Canadian hydro-power; (ii) the addition of offshore wind power in New England; (iii) increases in solar PV generation beyond current ISO NE projections; and/or (iv) the installation of storage as a capacity resource. Any scenarios that contain these resources would likely show even lower levels of operation of

[11] Petitioners' Response to CLF-2-1.3.

the Medway Project, and thus even lower levels of avoided GHG emissions.

Q. How did TAG use their model?

A. For their original testimony, TAG conducted two New England region model runs: a "base" case run and an "alternative" case run, each for the period 2018 through 2030. The base case excluded the Medway Project; the alternative case included the Medway Project. Based on the differential New England generation outputs between those two simulations, they estimated the quantity and source of net avoided emissions due to the presence of the Medway Project.

Q. What did TAG's modeling results show?

A. The modeling found average CO_2 emissions of 55.8 kilotons (kTons) per year for the Medway Project, or a total of 712.6 kTons emitted for the 2018-2030 period. The TAG model predicted that operation of the Medway Project at about a 6% capacity factor would result in avoided CO_2 emissions of 226.5 kTons over the same period, or an average of 17.42 kTons per year. For the CLF-1-10 scenario with increased New England generation plant retirement, the model predicted avoided CO_2 emissions of 126.6 kTons over the same time frame, or an average of 9.74 kTons per year. For the CLF-2-1.5 scenario, with increased New England generation plant retirement and resource assumptions including more renewables, Canadian hydro, demand response and storage, the TAG model predicted avoided CO_2 emissions for 2030 (only one year was modeled) of 2.14 kTons.

Q. How material are the avoided CO_2 emissions predicted by TAG's modeling results?

A. TAG's avoided CO_2 emissions modeling results are not very material, even if we were to

assume they are accurate. In 2013, New England CO_2 emissions were 40,901 kTons, based on the New England ISO's air emission report; Massachusetts' CO_2 emissions were 17,026 kTons.[12] TAG estimates that the Medway Project avoids, on average, 17.4 kTons/year, just 0.04% of the 2013 base year New England emissions and just 0.10% of 2013 Massachusetts emissions.

Q. What is the driving source for avoided emissions in TAG's modeling results?

A. The fundamental source of emission reduction seen in the model runs is the lower per-unit emission characteristics of the Medway Project compared to TAG's estimate of the emissions characteristics of the existing generation base in New England and, for the runs in response to CLF-1-10 and CLF-2-1.5, the new simple cycle combustion turbine (CT) and combined-cycle combustion turbine (CC) generation units included.

Q. Did TAG conduct any modeling of the New England power sector post-2030?

A. No. Their quantitative analysis was limited to the period through 2030.

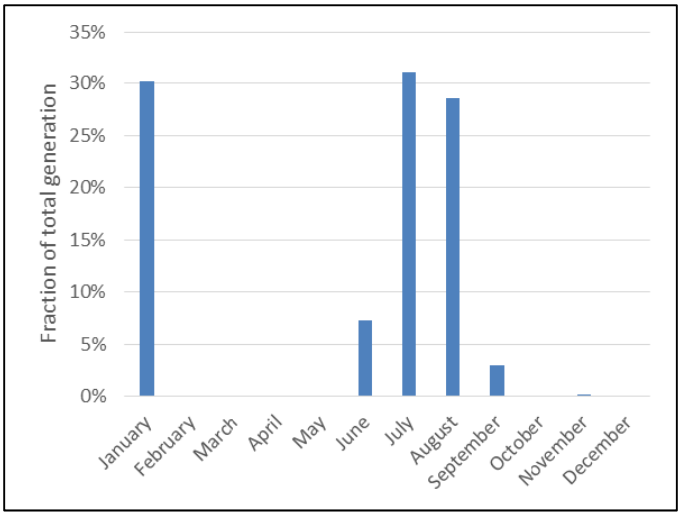
Q. Can you describe the general patterns of operation at the Medway Plant in the TAG modeling?

A. Yes. Within the TAG model, the plant generally operates as a peaking plant, with most annual generation occurring in January, July, and August. In the summer, it appears to be operating for roughly 12-14 hours at a time, on relatively high load days. During those periods, it is operated at or close to its maximum capacity until it is no longer needed, at which point the model shows the unit shut down entirely. In the winter, it runs on oil for 7 days per month each January, and it appears that it is only operated for these days, running only on oil. These

[12] ISO-NE, *2013 ISO New England Electric Generator Air Emissions Report*, at 19.

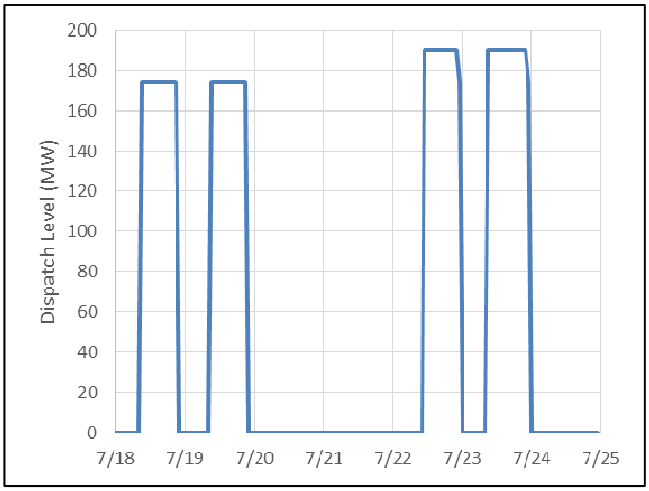
patterns are seen for the cumulative period 2018-2030 in (Figure 1); and for representative weeks in July (Figure 2) and January (Figure 3) of 2020, under the scenario conducted for CLF 1-10.[13]

Figure 1. Fraction of total Medway generation, by month, cumulative 2018-2030



Source: Response to CLF-2-1.

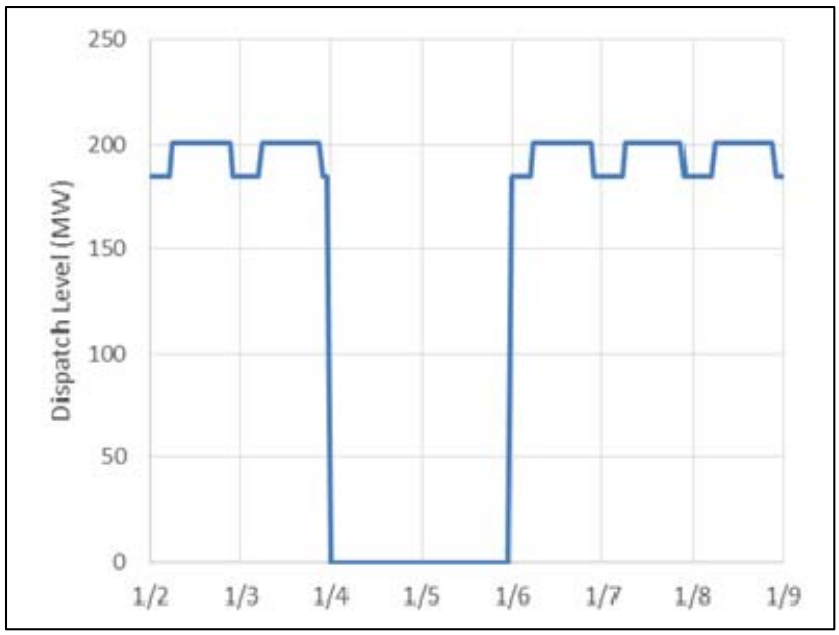
Figure 2. Representative Medway Dispatch, Week in July 2020



Source: Response to CLF-2-1.

[13] This scenario, run by TAG, included additional retirements to those modeled under TAG's original analysis, based on ISO-New England's December 2012 Generator Retirements Study

Figure 3. Medway Dispatch, Week in January 2020



Source: Response to CLF-2-1.

Q: Can you describe the characteristics of the installed base of natural gas combined cycle units in New England?

A. Yes. New England has a substantial quantity of existing natural gas-fired combined cycle units. While the proposed Medway Plant is quite efficient for its class of simple-cycle plants, these combined cycle units generally have substantially better heat rates and would be committed and dispatched first, before the Medway Plant. In total these combined cycle units represent 13,303 MW of capacity in 2014, as seen in Figure 4. This figure does not include new CC's under construction, such as the new Footprint Power plant in Salem.

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Figure 4. Gas Combined Cycle Units in New England

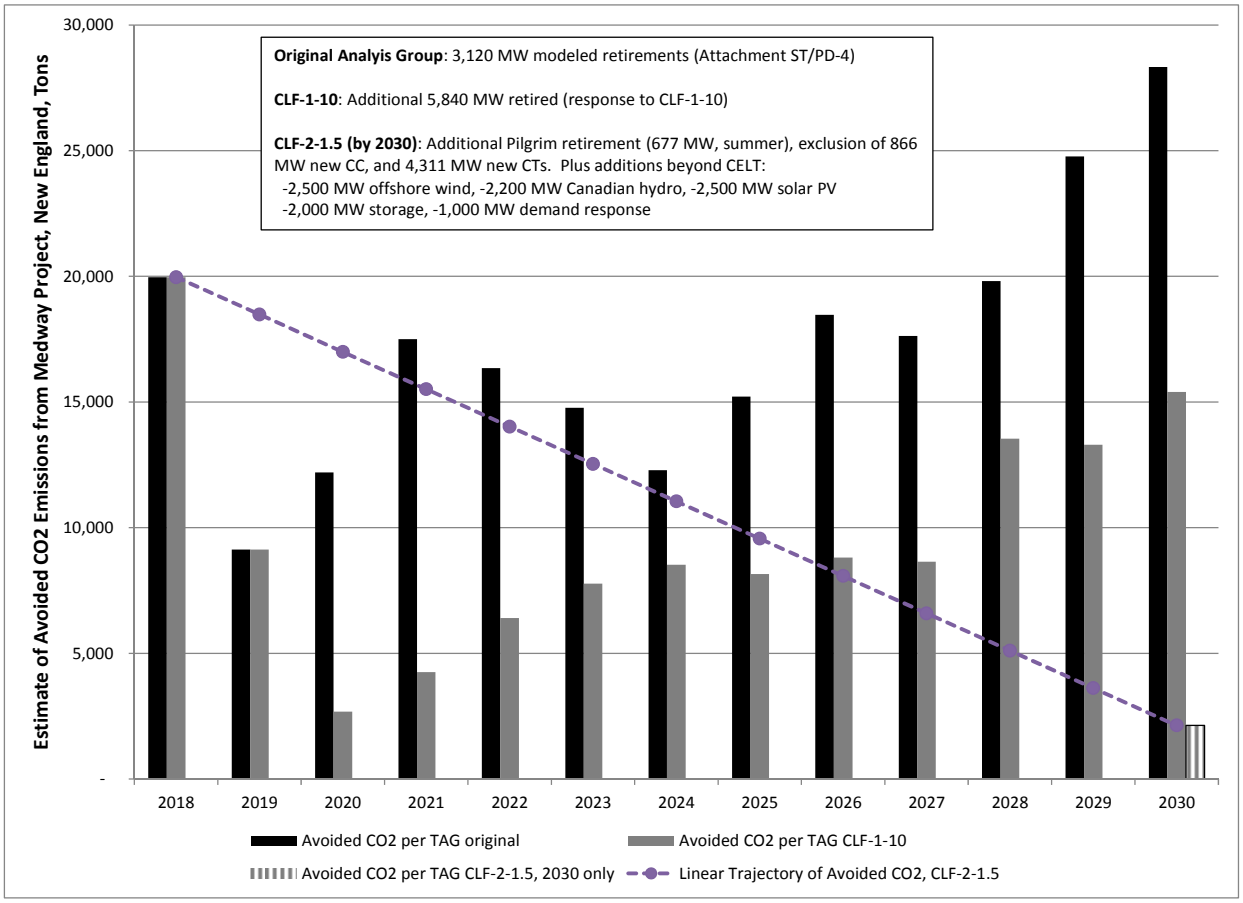
	Nameplate Capacity (MW)	Heat Rate, Btu/kWh
Mystic Generating Station	1,744	7,714
Potter Station 2	101	10,584
Cleary Flood	118	10,772
Manchester Street	515	8,026
Stony Brook	360	9,669
Bellingham Cogeneration Facility	386	8,219
Ocean State Power	254	8,701
Dartmouth Power Associates LP	77	9,582
Pawtucket Power Associates	69	14,024
Ocean State Power II	254	8,672
L'Energia Energy Center	85	8,691
Milford Power LP	178	8,371
Dighton Power Plant	200	7,682
Berkshire Power	289	6,034
Bridgeport Energy Project	520	7,219
Tiverton Power Plant	273	7,326
Maine Independence Station	550	7,352
Millennium Power	360	7,252
Rumford Power, Inc	275	7,721
Entergy Rhode Island State Energy LP	596	7,299
Milford Power Project	578	7,461
Lake Road Generating Plant	840	7,376
Granite Ridge	790	7,319
ANP Bellingham Energy Project	578	7,626
ANP Blackstone Energy Project	578	7,733
Westbrook Energy Center Power Plant	564	7,129
Fore River Generating Station	872	7,390
EP Newington Energy LLC	606	7,596
Kleen Energy Systems Project	693	7,108
Total	13,303	

Source: EIA Form 860 and Form 923, Average Annual Heat Rates.

Q. Please summarize the GHG emissions avoidance predicted by TAG for the Medway Project under their original assumptions, and for the assumptions used in response to discovery requests CLF-1-10 and CLF-2-1.5.

A. Figure 5 below is a column graph of the CO_2 emissions avoided by the Medway Project based on TAG's modeling. It illustrates the critical role that scenario assumptions play in estimating CO_2 emission avoidance. For the scenario modeled in response to discovery request CLF-2-1.5, I have added one possible linear trajectory of the pattern of CO_2 emission avoidance the Medway Project could bring to the New England system. However, other trajectories are possible, if the resource options defining the scenario were to be implemented in New England more quickly than illustrated with the simple linear interpolation (between the 2018 and 2030 avoided emission values) seen in the graph.

Figure 5. Modeled Avoided CO_2 Emissions from Medway Plant, 2018-2030



Sources: TAG original model run; TAG CLF-1-10 model run; TAG modeling of CLF- 2-1.5.

Q. Please discuss what this graph shows regarding the TAG assertion that the Medway Project would offset regional GHG emissions during the 2030-2050 period.

A. Figure 5 illustrates the point that under different assumptions for the development of the resource base in New England over the next 15 years, the proposed Medway Project's contribution to avoiding GHG emissions varies widely. In general, the more the resource base conforms to future scenarios envisioned by Massachusetts as described in its Clean Energy and Climate Plan for 2020, the Medway Project would result in lower avoided GHG emissions. TAG's original testimony presented a scenario with the highest level of avoided GHG emissions, but as seen with the model runs undertaken in response to CLF-1-10 – which I posit is a more reasonable "baseline" for retirement in New England – GHG emission avoidance is much lower (44% lower on a cumulative basis, 2018-2030). And under a scenario like that in CLF-2-1.5, where the type of renewable supply actions envisioned by the Clean Energy and Climate Plan are modeled along with reasonably considered storage resources and increased levels of solar PV, the marginal contribution to avoided GHG emission due to the Medway Project drops precipitously to near zero. In this illustration, those resource developments were modeled in place for 2030, but it is not unreasonable to assume that some, if not many, may actually come to fruition somewhat sooner than 2030 in which case the TAG model would predict Medway Project avoided emissions on the order of the 2030 values shown in the graph for the CLF-2-1.5 scenario, but much earlier (i.e., changing the pattern of the linear trajectory seen in the graph).

Q. Does this graph provide support for the emission avoidance results computed by TAG?

A. No. It only shows the results of the three modeling cases on a common graph, along

with a projection of how GHG emissions avoidance may change under a linear trajectory between two end points. I have previously described my concerns with the accuracy of the TAG model for this type of analysis.

Q. Has TAG provided any estimates of avoided GHG emissions for any scenarios in which the Medway Plant operates at a capacity factor near the 33% "expected actual" level described in the DEIR?[14]

A. No. The TAG testimony contains no analysis of the GHG emissions impact at levels higher than the 4%-10% shown in TAG's original simulation and its subsequent discovery response simulations.

Q. Is it then possible, absent GHG emission mitigation approaches such as CLF's recommendation for an emissions cap, that the facility if permitted as requested could operate in such a manner that the avoided GHG emissions predicted by TAG, and as shown in Figure 5 above, are different - even negative?

A. Yes. No modeling results were presented that show the GHG emission effect if the unit operates at the requested permitted level – 60% annual capacity factor[15] – or at levels at or near Petitioners' "expected actual" level of about 33% annual capacity factor.[16] The only GHG emission avoidance estimates presented were (i) the original TAG simulations, where the unit runs at annual average capacity factors of roughly 6%; (ii) a simulation in response to CLF-1-10, where the unit runs at annual average capacity factors of roughly just under 6%; (iii) a "high

[14] Response to EFSB-A-12.
[15] Response to EFSB-A-12 indicates a request to operate at up to 60% capacity factor (5,256 full load hours per year), including up to 720 hours per year on oil.
[16] See Draft Environmental Impact Report for the West Medway II Project, EEA No. 15363 ("DEIR"), Attach. E (Greenhouse Gas Technical Appendices) at 1-2.

load" simulation in response to CLF-1-11, where the unit runs at an average annual capacity factor of about 9%; and (iv) a simulation in response to CLF-2-1.5, where the unit in 2030 runs at an annual capacity factor of about 4%. Notably, TAG's modeling limited the unit to running on oil to just 7 days (or 168 hours) per year, and it produced roughly 30% of its total annual energy during this time. If the unit were to operate on oil for 720 hours per year as Petitioners' under "expected actual" conditions, the avoided GHG emissions could be lower than any of TAG estimates, and could conceivably be negative – i.e., the operation of the unit on oil for economic reasons displaces gas-fired generation with lower GHG emission rates.

Q. Do you see any risk of the Medway Plant operating at capacity factors at or near Petitioners' "expected actual" level of about 33% annual capacity factor?

A. Yes. While I have not done any detailed predictive analysis regarding such operations (nor has TAG conducted emission modeling for such a scenario), there is certainty that the actual dispatch of the Medway Plant, and which fuel it would be most economical for it to run on, will depend on the system-wide economics at any particular moment: the load, the availability of lower variable cost generation, and especially the relative price of natural gas to ULSD. It is not unreasonable to envision scenarios where ULSD is less expensive than natural gas such that, without restrictions placed on it otherwise, the plant could run more than 7 days per year on ULSD such that its annual average capacity factor approaches the 33% range.

TAG Analysis for 2030-2050

Q. Does the TAG provide any quantitative assessments of the proposed Medway Project avoided GHG emissions after 2030?

A. No. TAG's testimony provides no estimate of what will happen with the dispatch or avoided emissions of the proposed Medway Project after 2030. However, TAG does provide a discussion of the relevant issues in their testimony, at pages 63-66. They allude to a number of resource options, and describe possibly different power system scenarios, the common theme being that the power system is changing, and different technologies and operations may be in place during that period.

Q. Do you agree with TAG's testimony suggesting that without emissions restrictions imposed on it, the Medway Project complies with the GWSA?

A. No. To the extent the Medway Project might help reduce regional GHG emissions, its ability to do so declines over time, and such a decline could be very rapid depending on the mix of resource options that come onto the grid, and the timing of those installations. TAG appears to recognize this risk when they admit that changes to the grid "are likely to be profound," and "[b]eyond 2030, there could be very different technology options than the ones we're willing to incorporate into simulations today."[17] TAG seems to correctly note that once a non-fossil resource becomes the marginal energy resource in New England, cleaner (than existing fossil units) fossil-fueled peaking resources will no longer be able to contribute to avoiding GHG emissions.[18] This is critical – for example, with the advent of commercially-viable battery storage, the need for fossil-based peaking resources declines.[19]

[17] TAG Testimony, page 64.
[18] TAG Testimony, page 43.
[19] I note that a utility-scale, 100 MW battery storage resource was recently approved for purchase by Southern California Edison under a least-cost-influenced competitive solicitation for capacity resources in Southern California "Decision Approving, in Part, Results of Southern California Edison Company Local Capacity Requirements Request for Offers for the Western LA Basin Pursuant to Decisions 13-02-015 and 14-03-004". This

Also, TAG's testimony notes the reduction in cost for wind and solar generating capacity.[20] I note that solar PV in particular has the potential to reduce summer peak period "net demand"[21] on the grid, reducing the need for energy from fossil-fueled peaking resources like the proposed Medway Plant. I also note that wind output is usually higher in the winter season than the summer season, and can contribute to lower requirements for fossil-fueled peaking resources like the proposed Medway Plant in the winter months.

Q. Is it reasonable to think that there will be little or no use of fossil fuels to produce electricity in Massachusetts by 2050?

A. Yes, in my opinion the most reasonable presumption is that by 2050 there will be no or very little fossil-fuel use for electricity generation in Massachusetts. It is not reasonable to presume that the Medway Project would be one of the natural-gas fired units operating in the 2050 timeframe under the second scenario (efficiency and conservation) referenced below. The "Massachusetts Clean Energy and Climate Plan for 2020" (December 29, 2010) posits two possible scenarios to reach the statutory GHG emissions level for 2050 described in the GWSA. The Climate Plan states, for these two scenarios: "By 2050, 100% of the electricity consumed in Massachusetts comes from near zero carbon sources: renewables, pre-2000 nuclear facilities, and a small amount of biomass, and this constitutes 112% of what total Massachusetts

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seminal event illustrates that the economics of large scale battery resources as limited-energy-providing capacity resources are improving, and could soon prove to be viable competitors to traditional fossil peaking generation in other regions including New England (this Proposed Decision illustrates it is ***now*** a viable competitor in this California region). Proposed decision available at http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M154/K510/154510750.PDF.

[20] TAG Testimony, page 63.

[21] Net demand in this instance is essentially the demand seen by the system after accounting for the output of solar PV resources.

electricity use was in 2007, or 9 times the amount of low carbon supply in 2007. *The state no longer uses any electricity from natural gas, coal, or oil*." (Electrification Scenario, page 99, emphasis added) and "By 2050, about 80% of the electricity consumed in Massachusetts comes from near zero carbon sources: renewables, pre-2000 nuclear facilities, and a small amount of biomass used in high efficiency combined-heat-and-power applications. The low-carbon power is about five times the amount used in Massachusetts in 2007 (about half the amount of low carbon power needed in the electrification scenario). The remainder is from natural gas generation." (Efficiency and Conservation Scenario, page 101). It also states, in "Policies not in the 2020 Plan that are needed for 2050", the following: "Decarbonizing the electricity supply — In both scenarios for 2050, the vast majority of electricity supply must be low-carbon (70 or 80 percent lower than the average emissions from the New England grid at present). Less of this supply is needed in the efficiency/lifestyle scenario than in the electrification scenario. The resources to achieve this shift are theoretically available, if not entirely in Massachusetts (given our small size and limited supply of renewable resources), then in imports from the region and beyond. The current RPS requires that the state's distribution utilities supply percent of their power from qualifying renewable sources by 2020. For 2050 we will need far more resources from both RPS-eligible and non-RPS qualified sources. Part of this we expect will be obtained from offshore wind resources, which are ample in federal waters off Massachusetts. Part will come from non-RPS sources such as Canadian hydro and wind power. To ensure that sufficient supplies are available, new policy mechanisms will need to be developed that go beyond the RPS, such as the Clean Energy Performance Standard discussed earlier in this Plan." (Plan, page

106).

Q. Does this plan account for the recent dramatic declines in solar PV prices in the US?

A. No, it does not, since it was published in December of 2010. Over the past several years, there has been a dramatic reduction in solar PV prices in the US.[22] This provides even greater economic opportunities to reduce fossil-fuel use for electricity under the GWSA.

Q. Please comment on how the TAG testimony frames this aspect of the Clean Energy and Climate Plan.

A. TAG references the scenario that still includes generation from natural gas in its testimony at page 66. TAG states the following: "Presuming that the Medway Project is one of the more efficient peaking units on the system starting in 2018, it is reasonable to presume that it stands a good chance of being one of the generating units in place at that point in time, even if its operations are then subject to emission-control policies not now known." TAG provides no evidence, however, of the reasonableness of their presumption that the Medway Project will be one of the generating units in place at that time. I posit that it is more reasonable to think that the most efficient form of natural gas generation – combined cycle facilities, even such as those that are existing today with heat rates lower than the Medway Project (i.e., more efficient at energy production than the Medway Project), will be the type of fossil fuel generation that might be providing the last vestiges of fossil-fuel generated electricity in

[22] See, for example, US Department of Energy, Sunshot, "Photovoltaic System Pricing Trends, Historical, Recent, and Near-Term Projections, 2014 Edition", September 22, 2014, available at http://www.nrel.gov/docs/fy14osti/62558.pdf. See also, Bolinger, Mark, Samantha Weaver, and Jarett Zuboy, Lawrence Berkeley National Laboratory. "Is $50/MWh Solar for Real? Falling Project Prices and Rising Capacity Factors Drive Utility-Scale PV Toward Economic Competitiveness", May 2015, available at http://emp.lbl.gov/sites/all/files/lbnl-183129.pdf.

Massachusetts, by or before 2050. Given that grid-scale battery storage is now commercially available and given the historical trend of increased efficiency in gas turbine technologies, it is simply not credible to suggest, as TAG does above, that there is a "good chance" that the 2015 technology proposed for the Medway Project will be in operation as one of the most efficient peaking technology, fossil-fueled or otherwise, in the 2050 timeframe. Peaking needs – i.e., requirements to provide energy for shorter durations, and usually at times known in advance – are more likely to be provided by highly dispatchable energy storage systems by 2050 – if not much sooner than 2050 (see footnote 19). Solar PV and demand response can currently provide summer peaking period energy, and Canadian hydro, offshore wind, and demand response can provide winter period peaking energy. While it is very difficult to estimate just what the portfolio mix of energy supply resources will look like in 2050, 2040, or even 2030, it is far from clear that a combustion turbine that produces energy at efficiencies less than that of many existing combined cycle units is likely to still be a contributor to GHG emission reductions by 2050, or be representative of the types of technologies considered in the 2020 Clean Energy and Climate Plan for 2050.

Conclusions and Recommendations

Q. What are the main conclusions you draw based on a review of TAG's testimony and Petitioners' related discovery responses, and your understanding of the current and likely future electric power sector in New England?

A. I conclude that TAG's estimation of avoided GHG emissions from the Medway Project in the 2018 – 2030 period is subject to error because of the nature and quality of the model they

use for that purpose. While the TAG model can provide a high-level indication of system-wide plant dispatch and associated GHG emissions for a given scenario, using the tool to reliably determine differential GHG effects – i.e., avoided GHG emissions – appears to be beyond the precision and capability of the tool, except perhaps in the first few years of potential plant operation, because it does not contain an economic unit commitment step, it does not account for transmission constraints, and it does not include operating reserve requirements and constraints when determining the energy dispatch. These parameters are important in today's electric power sector; they are even more important for a modeling tool used to assess a future world with more renewable supply, since the intermittent output of these resources increases the importance of day-ahead planning steps that include a unit commitment process and a real-time dispatch process that accurately accounts for all of the characteristics of the system.

I also conclude that TAG's estimates of avoided GHG emissions, even if one discounts the nature of the model's flaws noted above, are not robust. Under a scenario put forth by CLF (as discovery request CLF-2-1.5), the avoided emissions drop dramatically in comparison to TAG's original offered testimony – by 92% of the original, already small, avoided GHG emissions predicted for the year 2030. The scenario put forth by CLF (as discovery request CLF-1-10) that includes increased retirement of fossil units in New England compared to TAG's base case also show significant drops in GHG emissions – roughly 44% over the 2018-2030 period.[23] Both of those resource scenarios (i.e., CLF-1-10 and CLF-2-1.5) are reasonable and taken together with TAG's original results demonstrate that the Medway Project's avoided GHG emissions are

[23] (226,464 minus 126,630)/226,464. Testimony Attachment SD/PD-5 and Attachment CLF-1-10.

highly sensitive to resource option scenarios for the 2018-2030 timeframe.

Regarding the period of anticipated operation beyond 2030, I conclude that TAG has not provided any evidence that the proposed Medway Project will contribute to GHG emission avoidance in the years after 2030. To the contrary, my analysis suggests that to the extent the state complies with its 2020 climate plan, and almost certainly if it continues to make significant progress towards meeting its statutory 2050 emissions targets, it is unreasonable to conclude, as TAG does, that the Medway Project's operation will continue to produce avoided GHG emissions in that future period.

Q. Based on your analysis, do you have any recommendations for the EFSB in permitting this proposed facility?

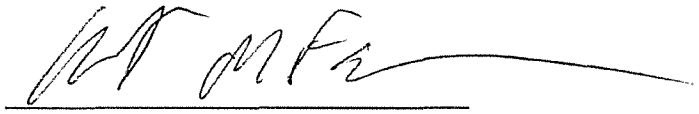
A. Yes. I recommend that if the EFSB approves the construction of the Medway Plant, it should mitigate the environmental impacts of the proposed Medway Project, in consideration of compliance with the GWSA and the state GHG Policy which requires such mitigation, and that it do so in a manner consistent with the Footprint Mitigation Measure: that is, by capping the overall CO_2 emissions allowed from the plant between the years 2018 and 2030, with the cap declining starting in 2031 to zero effective emissions by 2050. While not agreeing with the determinations made by TAG in their modeling of the New England power sector and their avoided GHG emissions findings, I would support an emissions cap for 2018 to 2030 at a level based on plant operations at the highest annual capacity factor seen in TAG simulations, about 9% per its CLF-1-11 simulation of low-probability, high demand. Given that all of TAG's other "normal load" simulations result in a predicted capacity factor of about 6% or less, a 15%

annual cap would not be unreasonable to increase the allowance to account for error or for unusually high periods of demand, particularly in the context of a more robust retirement scenario than was used in CLF-1-11 (e.g., like the one modeled in CLF-1-10 which represents a reasonable assumption about the future grid: if these resources do not retire early in the decade, it is reasonable to expect their retirement by 2030).[24]

Q. Does that complete your testimony?

A. Yes.

I declare under penalty of perjury, pursuant to the laws of the United States and the Commonwealth of Massachusetts, that the foregoing is true and correct. Executed this 13th day of November, 2015, at Boston, Massachusetts.



Robert M. Fagan

[24] The ISO NE 2015 Regional Electricity Outlook states "It's an expected market outcome for aging, uneconomic plants to retire at some point" (page 21).

Robert M. Fagan, Principal Associate

Synapse Energy Economics I 485 Massachusetts Avenue, Suite 2 I Cambridge, MA 02139 I 617-453-7040
rfagan@synapse-energy.com

SUMMARY

Mechanical engineer and energy economics analyst with over 25 years of experience in the energy industry. Activities focused primarily on electric power industry issues, especially economic and technical analysis of transmission, wholesale electricity markets, renewable resource alternatives and assessment and implementation of demand-side alternatives.

In-depth understanding of the complexities of, and the interrelationships between, the technical and economic dimensions of the electric power industry in the US and Canada, including the following areas of expertise:

- Wholesale energy and capacity provision under market-based and regulated structures; the extent of competitiveness of such structures.
- Potential for and operational effects of wind and solar power integration into utility systems; modeling of such effects.
- Transmission use pricing, encompassing congestion management, losses, LMP and alternatives, financial and physical transmission rights; and transmission asset pricing (embedded cost recovery tariffs).
- Physical transmission network characteristics; related generation dispatch/system operation functions; and technical and economic attributes of generation resources.
- RTO and ISO tariff and market rules structures and operation.
- FERC regulatory policies and initiatives, including those pertaining to RTO and ISO development and evolution.
- Demand-side management, including program implementation and evaluation; and load response presence in wholesale markets.
- Building energy end-use characteristics, and energy-efficient technology options.
- Fundamentals of electric distribution systems and substation layout and operation.
- Energy modeling (spreadsheet-based tools, industry standard tools for production cost and resource expansion, building energy analysis, understanding of power flow simulation fundamentals).
- State and provincial level regulatory policies and practices, including retail service and standard offer pricing structures.

- Gas industry fundamentals including regulatory and market structures, and physical infrastructure.

PROFESSIONAL EXPERIENCE

Synapse Energy Economics, Inc., Cambridge, MA. *Principal Associate*, 2004 – Present.

Responsibilities include consulting on issues of energy economics, analysis of electricity utility planning, operation, and regulation, including issues of transmission, generation, and demand-side management. Provide expert witness testimony on various wholesale and retail electricity industry issues. Specific project experience includes the following:

- Analysis of PJM and MISO wind integration and related transmission planning and resource adequacy issues.
- Analysis of California renewable energy integration issues, local and system capacity requirements, and related long-term procurement policies.
- Analysis of Nova Scotia resource policies including effects of potential new hydroelectric supplies from Newfoundland; analysis of new transmission supplies of Maritimes area energy into the New England region.
- Analysis of Eastern Interconnection Planning Collaborative processes, including modeling structure and inputs assumptions for demand, supply and transmission resources. Expanded analyses of the results of the EIPC Phase II Report on transmission and resource expansion.
- Analysis of need for transmission facilities in Maine, Ontario, Pennsylvania, Virginia, Minnesota.
- Ongoing analysis of wholesale and retail energy and capacity market issues in New Jersey, including assessment of BGS supply alternatives and demand response options.
- Analysis of PJM transmission-related issues, including cost allocation, need for new facilities and PJM's economic modeling of new transmission effects on PJM energy market.
- Ongoing analysis of utility-sponsored energy efficiency programs in Rhode Island as part of the Rhode Island DSM Collaborative; and ongoing analysis of the energy efficiency programs of New Jersey Clean Energy Program (CEP) and various utility-sponsored efficiency programs (RGGI programs).
- Analysis of California renewable integration issues for achieving 33% renewable energy penetration by 2020, especially modeling constructs and input assumptions.
- Analysis of proposals in Maine for utility companies to withdraw from the ISO-NE RTO.
- Analysis of utility planning and demand-side management issues in Delaware.

- Analysis of effect of increasing the system benefits charge (SBC) in Maine to increase procurement of energy efficiency and DSM resources; analysis of impact of DSM on transmission and distribution reinforcement need.
- Evaluation of wind energy potential and economics, related transmission issues, and resource planning in Minnesota, Iowa, Indiana, and Missouri; in particular in relation to alternatives to newly proposed coal-fired power plants in MN, IA and IN.
- Analysis of need for newly proposed transmission in Pennsylvania and Ontario.
- Evaluation of wind energy "firming" premium in BC Hydro Energy Call in British Columbia.
- Evaluation of pollutant emission reduction plans and the introduction of an open access transmission tariff in Nova Scotia.
- Evaluation of the merger of Duke and Cinergy with respect to Indiana ratepayer impacts.
- Review of the termination of a Joint Generation Dispatch Agreement between sister companies of Cinergy.
- Assessment of the potential for an interstate transfer of a DSM resource between the desert southwest and California, and the transmission system impacts associated with the resource.
- Analysis of various transmission system and market power issues associated with the proposed Exelon-PSEG merger.
- Assessment of market power and transmission issues associated with the proposed use of an auction mechanism to supply standard offer power to ComEd native load customers.
- Review and analysis of the impacts of a proposed second 345 kV tie to New Brunswick from Maine on northern Maine customers.

Tabors Caramanis & Associates, Cambridge, MA. *Senior Associate*, 1996 – 2004.

- Provided expert witness testimony on transmission issues in Ontario and Alberta.
- Supported FERC-filed testimony of Dr. Tabors in numerous dockets, addressing various electric transmission and wholesale market issues.
- Analyzed transmission pricing and access policies, and electric industry restructuring proposals in US and Canadian jurisdictions including Ontario, Alberta, PJM, New York, New England, California, ERCOT, and the Midwest. Evaluated and offered alternatives for congestion management methods and wholesale electric market design.
- Attended RTO/ISO meetings, and monitored and reported on continuing developments in the New England and PJM electricity markets. Consulted on New England FTR auction and ARR allocation schemes.

- Evaluated all facets of Ontario and Alberta wholesale market development and evolution since 1997. Offered congestion management, transmission, cross-border interchange, and energy and capacity market design options. Directly participated in the Ontario Market Design Committee process. Served on the Ontario Wholesale Market Design technical panel.
- Member of TCA GE MAPS modeling team in LMP price forecasting projects.
- Assessed different aspects of the broad competitive market development themes presented in the US FERC's SMD NOPR and the application of FERC's Order 2000 on RTO development.
- Reviewed utility merger savings benchmarks, evaluated status of utility generation market power, and provided technical support underlying the analysis of competitive wholesale electricity markets in major US regions.
- Conducted life-cycle utility cost analyses for proposed new and renovated residential housing at US military bases. Compared life-cycle utility cost options for large educational and medical campuses.
- Evaluated innovative DSM competitive procurement program utilizing performance-based contracting.

Charles River Associates, Boston, MA. *Associate*, 1992 – 1996.

Developed DSM competitive procurement RFPs and evaluation plans, and performed DSM process and impact evaluations. Conducted quantitative studies examining electric utility mergers; and examined generation capacity concentration and transmission interconnections throughout the US. Analyzed natural gas and petroleum industry economic issues; and provided regulatory testimony support to CRA staff in proceedings before the US FERC and various state utility regulatory commissions.

Rhode Islanders Saving Energy, Providence, RI. *Senior Commercial/Industrial Energy Specialist*, 1987 – 1992.

Performed site visits, analyzed end-use energy consumption and calculated energy-efficiency improvement potential in approximately 1,000 commercial, industrial, and institutional buildings throughout Rhode Island, including assessment of lighting, HVAC, hot water, building shell, refrigeration and industrial process systems. Recommended and assisted in implementation of energy efficiency measures, and coordinated customer participation in utility DSM program efforts.

Fairchild Weston Systems, Inc., Syosset, NY. *Facilities Engineer*, 1985 – 1986.

Designed space renovations; managed capital improvement projects; and supervised contractors in implementation of facility upgrades.

Narragansett Electric Company, Providence RI. *Supervisor of Operations and Maintenance*, 1981 – 1984.

Directed electricians in operation, maintenance, and repair of high-voltage transmission and distribution substation equipment.

EDUCATION

Boston University, Boston, MA
Master of Arts in Energy and Environmental Studies – Resource Economics, Ecological Economics, Econometric Modeling, 1992

Clarkson University, Potsdam, NY
Bachelor of Science in Mechanical Engineering – Thermal Sciences, 1981

ADDITIONAL EDUCATION

- **Utility Wind Integration Group**: Short Course on Integration and Interconnection of Wind Power Plants into Electric Power Systems, 2006
- **University of Texas at Austin**: Short course in Regulatory and Legal Aspects of Electric Power Systems, 1998
- **Illuminating Engineering Society**: courses in lighting design, 1989
- **Worcester Polytechnic Institute and Northeastern University**: Coursework in Solar Engineering; Building System Controls; and Cogeneration, 1984, 1988 – 1989
- **Polytechnic Institute of New York**: Graduate coursework in Mechanical and Aerospace Engineering, 1985 – 1986

REPORTS AND PAPERS

Luckow, P., B. Fagan, S. Fields, M. Whited. 2015. *Technical and Institutional Barriers to the Expansion of Wind and Solar Energy.* Synapse Energy Economics for Citizens' Climate Lobby.

Stanton, E. A., P. Knight, J. Daniel, R. Fagan, D. Hurley, J. Kallay, E. Karaca, G. Keith, E. Malone, W. Ong, P. Peterson, L. Silvestrini, K. Takahashi, R. Wilson. 2015. *Massachusetts Low Gas Demand Analysis: Final Report.* Synapse Energy Economics for the Massachusetts Department of Energy Resources.

Fagan, R., R. Wilson, D. White, T. Woolf. 2014. *Filing to the Nova Scotia Utility and Review Board on Nova Scotia Power's October 15, 2014 Integrated Resource Plan: Key Planning Observations and Action Plan Elements.* Synapse Energy Economics for the Nova Scotia Utility and Review Board.

Fagan, R., T. Vitolo, P. Luckow. 2014. *Indian Point Energy Center: Effects of the Implementation of Closed-Cycle Cooling on New York Emissions and Reliability.* Synapse Energy Economics for Riverkeeper.

Fagan, R., J. Fisher, B. Biewald. 2013. *An Expanded Analysis of the Costs and Benefits of Base Case and Carbon Reduction Scenarios in the EIPC Process.* Synapse Energy Economics for the Sustainable FERC Project.

Fagan, R., P. Luckow, D. White, R. Wilson. 2013. *The Net Benefits of Increased Wind Power in PJM.* Synapse Energy Economics for the Energy Future Coalition.

Hornby, R., R. Fagan, D. White, J. Rosenkranz, P. Knight, R. Wilson. 2012. *Potential Impacts of Replacing Retiring Coal Capacity in the Midwest Independent System Operator (MISO) Region with Natural Gas or Wind Capacity.* Synapse Energy Economics for the National Association of Regulatory Utility Commissioners.

Fagan, R., M. Chang, P. Knight, M. Schultz, T. Comings, E. Hausman, R. Wilson. 2012. *The Potential Rate Effects of Wind Energy and Transmission in the Midwest ISO Region*. Synapse Energy Economics for the Energy Future Coalition.

Woolf, T., M. Wittenstein, R. Fagan. 2011. *Indian Point Energy Center Nuclear Plant Retirement Analysis.* Synapse Energy Economics for the Natural Resources Defense Council (NRDC) and Riverkeeper.

Napoleon, A., W. Steinhurst, M. Chang, K. Takahashi, R. Fagan. 2010. *Assessing the Multiple Benefits of Clean Energy: A Resource for States*. US Environmental Protection Agency with research and editorial support from Stratus Consulting, Synapse Energy Economics, Summit Blue, Energy and Environmental Economics, Inc., Demand Research LLC, Abt Associates, Inc., and ICF International.

Peterson, P., E. Hausman, R. Fagan, V. Sabodash. 2009. *Synapse Report and Ohio Comments in Case No. 09-09-EL-COI, "The Value of Continued Participation in RTOs."* Synapse Energy Economics for Ohio Consumers' Counsel.

Hornby, R., J. Loiter, P. Mosenthal, T. Franks, R. Fagan and D. White. 2008. *Review of AmerenUE February 2008 Integrated Resource Plan.* Synapse Energy Economics for the Missouri Department of Natural Resources.

Hausman, E., R. Fagan, D. White, K. Takahashi, A. Napoleon. 2007. *LMP Electricity Markets: Market Operations, Market Power, and Value for Consumer.* Synapse Energy Economics for the American Public Power Association.

Fagan, R., T.Woolf, W. Steinhurst, B. Biewald. 2006. “Interstate Transfer of a DSM Resource: New Mexico DSM as an Alternative to Power from Mohave Generating Station.” Proceedings and presentation at 2006 American Council for Energy Efficient Economy (ACEEE) Summer Study on Energy Efficiency in Buildings Conference, August 2006.

Fagan, R., R. Tabors, A. Zobian, N. Rao, R. Hornby. 1999. *Tariff Structure for an Independent Transmission Company*. Tabors Caramanis & Associates Working Paper 101-1099-0241.

Fagan, R. 1996. *The Market for Power in New England: The Competitive Implications of Restructuring*. Tabors Caramanis & Associates and Charles River Associates for the Office of the Attorney General, Commonwealth of Massachusetts.

Fagan, R., D. Gokhale, D. Levy, P. Spinney, G. Watkins. 1995. “Estimating DSM Impacts for Large Commercial and Industrial Electricity Users.” Proceedings and presentation at The Seventh International Energy Program Evaluation Conference in Chicago, IL, August 1995.

Fagan, R., P. Spinney. 1995. *Demand-side Management Information Systems (DSMIS) Overview*. Charles River Associates for Electric Power Research Institute. Technical Report TR-104707.

Fagan, R., P. Spinney. 1994. *Northeast Utilities Energy Conscious Construction Program (Comprehensive Area): Level I and Level II Impact Evaluation Reports*. Charles River Associates, Energy Investments (Abbe Bjorklund) for Northeast Utilities.

PRESENTATIONS

Fagan, R., R. Tabors. 2003. "SMD and RTO West: Where are the Benefits for Alberta?" Keynote kaper prepared for the 9th Annual Conference of the Independent Power Producers Society of Alberta, March 2003.

Fagan, R. 1999. "A Progressive Transmission Tariff Regime: The Impact of Net Billing". Presentation at the Independent Power Producer Society of Ontario Annual Conference, November 1999.

Fagan, R. 1999. "Transmission Congestion Pricing Within and Around Ontario." Presentation at the Canadian Transmission Restructuring Infocast Conference in Toronto, June 1999.

Fagan, R. 1998. "The Restructured Ontario Electricity Generation Market and Stranded Costs." Presentation to the Ontario Ministry of Energy and Environment on behalf of Enron Capital and Trade Resources Canada Corp., February 1998.

Fagan, R. 1998. "Alberta Legislated Hedges Briefing Note." Presentation to the Alberta Department of Energy on behalf of Enron Capital and Trade Resources Canada, January 1998.

Fagan, R. 1997. "Generation Market Power in New England: Overall and on the Margin." Presentation at Infocast Conference: New Developments in Northeast and Mid-Atlantic Wholesale Power Markets in Boston, MA, June 1997.

Spinney, P., J. Peloza, R. Fagan presented. 1993. "The Role of Trade Allies in C&I DSM Programs: A New Focus for Program Evaluation." Charles River Associates and Wisconsin Electric Power Corp presentation at the Sixth International Energy Evaluation Conference in Chicago, IL, August 1993.

TESTIMONY

California Public Utilities Commission (Docket No. A.14-11-014): Testimony examining Pacific Gas and Electric's Marginal Energy Costs and LOLE Allocation among TOU Periods. On behalf of the California Office of Ratepayer Advocate. May 1, 2015.

California Public Utilities Commission (Docket No. A.14-01-027): Testimony examining San Diego Gas & Electric's proposal to change time-of-use periods in its application for authority to update its electric rate design. On behalf of the California Office of Ratepayer Advocate. November 14, 2014.

California Public Utilities Commission (Docket No. R.12-06-013): Rebuttal testimony regarding the relationship between California investor-owned utilities hourly load profiles under a time-of-use pricing

and GHG emissions in the WECC regions in the Order Instituting Rulemaking on the Commission's Own Motion to Conduct a Comprehensive Examination of Investor Owned Electric Utilities' Residential Rate Structures, the Transition to Time Varying and Dynamic Rates, and Other Statutory Obligations. On behalf of the California Office of Ratepayer Advocate. October 17, 2014.

California Public Utilities Commission (Docket No. R.13-12-010): Direct and reply testimony on Phase 1a modeling scenarios in the Order Instituting Rulemaking to Integrate and Refine Procurement Policies and Consider Long-Term Procurement Plans. On behalf of the California Office of Ratepayer Advocate. August 13, 2014, October 22, 2014, and December 18, 2014.

New York State Department of Environmental Conservation (DEC #3-5522-00011/000004; SPDES #NY-0004472; DEC #3-5522-00011/00030; DEC #3-5522-00011/00031): Direct, rebuttal, and surrebuttal testimony regarding air emissions and electric system reliability impacts of closed-cycle cooling as the "best technology available" 9BTA) for the Indian Point nuclear power plant. On behalf of Riverkeeper. February 28, 2014, March 28, 2014, and July 11, 2014.

California Public Utilities Commission (Docket No. RM.12-03-014): Reply and rebuttal testimony on the topic of local reliability impacts of a potential long-term outage at the San Onofre Nuclear Power Station (SONGS) in Track 4 of the Order Instituting Rulemaking to Integrate and Refine Procurement Policies and Consider Long-Term Procurement Plans. On behalf of the California Office of Ratepayer Advocate. September 30, 2013 and October 14, 2013.

Nova Scotia Utility and Review Board (Matter No. M05419): Direct examination regarding the report *Economic Analysis of Maritime Link and Alternatives: Complying with Nova Scotia's Greenhouse Gas Regulations, Renewable Energy Standard, and Other Regulations in a Least-Cost Manner for Nova Scotia Power Ratepayers* jointly authored with Rachel Wilson, Nehal Divekar, David White, Kenji. Takahashi, and Tommy Vitolo. In the Matter of The Maritime Link Act and In the Matter of An Application by NSP MARITIME LINK INCORPORATED for the approval of the Maritime Link Project. On behalf of Board Counsel to the Nova Scotia Utility and Review Board. June 5, 2013.

Prince Edward Island Regulatory and Appeals Commission (Docket UE30402): Jointly filed expert report with Nehal Divekar analyzing the Proposed Ottawa Street – Bedeque 138 kV Transmission Line Project in the matter of Summerside Electric's Application for the Approval of Transmission Services connecting Summerside Electric's Ottawa Street substation to Maritime Electric Company Limited's Bedeque substation. Oh behalf of the City of Summerside. November 5, 2012.

New Jersey Board of Public Utilities (Docket No. GO12070640): Direct testimony regarding New Jersey Natural Gas Company's petition for approval of the extension of the SAVEGREEN energy efficiency programs. On behalf of the New Jersey Division of the Ratepayer Advocate. October 26, 2012.

California Public Utilities Commission (Docket No. RM.12-03-014): Direct and reply testimony regarding the long-term local capacity procurement requirements for the three California investor-owned utilities in Track 1 of the Order Instituting Rulemaking to Integrate and Refine Procurement Policies and

Consider Long-Term Procurement Plans. On behalf of the California Office of Ratepayer Advocate. June 25, 2012 and July 23, 2012.

California Public Utilities Commission (Docket No. A.11-05-023): Supplemental testimony regarding the long-term resource adequacy and resource procurement requirements for the San Diego region in the Application of San Diego Gas & Electric Company (U 902 3) for Authority to Enter into Purchase Power Tolling Agreements with Escondido Energy Center, Pio Pico Energy Center, and Quail Brush Power. On behalf of the California Office of Ratepayer Advocate. May 18, 2012.

New Jersey Board of Public Utilities (Docket No. GO11070399): Direct testimony in the matter of the petition of Pivotal Utility Holdings, Inc. D/B/A Elizabethtown Gas for authority to extend the term of energy efficiency programs with certain modifications and approval of associated cost recovery. On behalf of New Jersey Division of Rate Counsel. December 16, 2011.

New Jersey Board of Public Utilities (Docket No. EO11050309): Direct testimony regarding aspects of the Board's inquiry into capacity and transmission interconnection issues. October 14, 2011.

Federal Energy Regulatory Commission (Docket Nos. EL11-20-000 and ER11-2875-000): Affidavit regarding reliability, status of electric power generation capacity, and current electric power procurement policies in New Jersey. On behalf of New Jersey Division of Rate Counsel. March 4, 2011.

New Jersey Board of Public Utilities (Docket Nos. GR10100761 and ER10100762): Certification before the Board regarding system benefits charge (SBC) rates associated with gas generation in the matter of a generic stakeholder proceeding to consider prospective standards for gas distribution utility rate discounts and associated contract terms. On behalf of New Jersey Division of Rate Counsel. January 28, 2011.

New Jersey Board of Public Utilities (Docket No. ER10040287): Direct testimony regarding Basic Generation Service (BGS) procurement plan for service beginning June 1, 2011. On behalf of New Jersey Division of Rate Advocate. September 2010.

State of Maine Public Utilities Commission (Docket 2008-255): Direct and surrebuttal testimony regarding the non-transmission alternatives analysis conducted on behalf of Central Maine Power in the Application of Central Maine Power Company and Public Service of New Hampshire for a Certificate of Public Convenience and Necessity for the Maine Power Reliability Program Consisting of the Construction of Approximately 350 Miles of 345 and 115 kV Transmission Lines, a $1.55 billion transmission enhancement project. On behalf of the Maine Office of the Public Advocate. January 12, 2009 and February 2, 2010.

Virginia State Corporation Commission (CASE NO. PUE-2009-00043): Direct testimony regarding the need for modeling DSM resources as part of the PJM RTEP planning processes in the Application of Potomac-Appalachian Transmission Highline (PATH) Allegheny Transmission Corporation for CPCN to construct facilities: 765 kV proposed transmission line through Loudoun, Frederick, and Clarke Counties. On behalf of Sierra Club. October 23, 2009.

Pennsylvania Public Utility Commission (Docket number A-2009-2082652): Direct and surrebuttal testimony regarding the need for additional modeling for the proposed Susquehanna-Roseland 500 kv transmission line in portions of Luckawanna, Luzerne, Monroe, Pike, and Wayne counties to include load forecasts, energy efficiency resources, and demand response resources. On behalf of the Pennsylvania Office of Consumer Advocate. June 30, 2009 and August 24, 2009.

Delaware Public Service Commission (Docket No. 07-20): Filed the expert report *Review of Delmarva Power & Light Company's Integrated Resource Plan* jointly authored with Alice Napoleon, William Steinhurst, David White, and Kenji Takahashi In the Matter of Integrated Resource Planning for the Provision of Standard Offer Service by Delmarva Power & Light Company Under 26 DEL. C. §1007 (c) & (d). On behalf of the Staff of Delaware Public Service Commission. April 2, 2009.

New Jersey Board of Public Utilities (Docket No. ER08050310): Direct testimony filed jointly with Bruce Biewald on aspects of the Basic Generation Service (BGS) procurement plan for service beginning June 1, 2009. On behalf of the New Jersey Division of the Ratepayer Advocate. September 29, 2008.

Wisconsin Public Service Commission (Docket 6680-CE-170): Direct and surrebuttal testimony in the matter of the alternative energy options available with wind power, and the effect of the MISO RTO in helping provide capacity and energy to the Wisconsin area reliably without needed the proposed coal plant in the CPCN application by Wisconsin Power and Light for construction of a 300 MW coal plant. On behalf of Clean Wisconsin. August 11, 2008 and September 15, 2008.

Ontario Energy Board (Docket EB-2007-0707): Direct testimony regarding issues associated with the planned levels of procurement of demand response, combined heat and power, and NUG resources as part of Ontario Power Authority's long-term integrated planning process in the Examination and Critique of Demand Response and Combined Heat and Power Aspects of the Ontario Power Authority's Integrated Power System Plan and Procurement Process. On behalf of Pollution Probe. August 1, 2008.

Ontario Energy Board (Docket EB-2007-0050): Direct and supplemental testimony filed jointly with Peter Lanzalotta regarding issues of congestion (locked-in energy) modeling, need, and series compensation and generation rejection alternatives to the proposed line of in the matter of Hydro One Networks Inc.'s application to construct a new 500 kV transmission line between the Bruce Power complex and the town of Milton, Ontario. On behalf of Pollution Probe. April 18, 2008 and May 15, 2008.

Federal Energy Regulatory Commission (Dockets ER06-456, ER06-954, ER06-1271, ER07-424, EL07-57, ER06-880, et al.): Direct and rebuttal testimony addressing merchant transmission cost allocation issues on PJM Regional Transmission Expansion Plan (RTEP) Cost Allocation issues. On behalf of the New Jersey Division of the Ratepayer Advocate. January 23, 2008 and April 16, 2008.

State of Maine Public Utilities Commission (Docket No. 2006-487): Pre-file and surrebuttal testimony on the ability of DSM and distributed generation potential to reduce local supply area reinforcement needs in the matter of the Analysis of Central Maine Power Company Petition for a Certificate of Public

Convenience and Necessity to Build a 115 kV Transmission Line between Saco and Old Orchard Beach. On behalf of Maine Office of the Public Advocate. February 27, 2007 and January 10, 2008.

Minnesota Public Utilities Commission (OAH No. 12-2500-17037-2 and OAH No. 12-2500-17038-2; and MPUC Dkt. Nos. CN-05-619 and TR-05-1275): Supplemental testimony and supplemental rebuttal testimony on applicants' estimates of DSM savings in the Certificate of Need proceeding for the Big Stone II coal-fired power plant proposal In the Matter of the Application by Otter Tail Power Company and Others for Certification of Transmission Facilities in Western Minnesota and In the Matter of the Application to the Minnesota Public Utilities Commission for a Route Permit for the Big Stone Transmission Project in Western Minnesota. On behalf of Fresh Energy, Izaak Walton League of America – Midwest Office, Wind on the Wires, Union of Concerned Scientists, Minnesota Center for Environmental Advocacy. December 8, 2006 and December 21, 2007.

Pennsylvania Public Utility Commission (Docket Nos. A-110172 *et al*.): Direct testimony on the effect of demand-side management on the need for a transmission line and the level of consideration of potential carbon regulation on PJM's analysis of need for the TrAIL transmission line. On behalf of the Pennsylvania Office of Consumer Advocate. October 31, 2007.

Iowa Public Utilities Board (Docket No. GCU-07-01): Direct testimony regarding wind energy assessment in Interstate Power and Light's resource plans and its relationship to a proposed coal plant in Iowa. On behalf of Iowa Office of the Consumer Advocate. October 21, 2007.

New Jersey Board of Public Utilities (Docket No. EO07040278): Direct testimony on certain aspects of PSE&G's proposal to use ratepayer funding to finance a solar photovoltaic panel initiative in support of the State's solar RPS. September 21, 2007.

Indiana Utility Regulatory Commission (Cause No. 43114): Direct testimony on the topic of a proposed Duke – Vectren IGCC coal plant and wind power potential in Indiana. On behalf of Citizens Action Coalition of Indiana. May 14, 2007.

British Columbia Utilities Commission: Pre-filed evidence regarding the "firming premium" associated with 2006 Call energy, liquidated damages provisions, and wind integration studies In the Matter of BC Hydro 2006 Integrated Electricity Plan and Long Term Acquisition Plan. On behalf of the Sierra Club (BC Chapter), Sustainable Energy Association of BC, and Peace Valley Environment Association. October 10, 2006.

Maine Joint Legislative Committee on Utilities, Energy and Transportation (LD 1931): Testimony regarding the costs and benefits of increasing the system benefits charge to increase the level of energy efficiency installations by Efficiency Maine before in support of an Act to Encourage Energy Efficiency. On behalf of the Maine Natural Resources Council and Environmental Defense. February 9, 2006.

Nova Scotia Utility and Review Board: Direct testimony and supplemental evidence regarding the approval of the installation of a flue gas desulphurization system at Nova Scotia Power Inc.'s Lingan station and a review of alternatives to comply with provincial emission regulations In The Matter of an

Application by Nova Scotia Power Inc. for Approval of Air Emissions Strategy Capital Projects and The Public Utilities Act, R.S.N.S., 1989, c. 380, as amended. On behalf of Nova Scotia Utility and Review Board Staff. January 30, 2006.

New Jersey Board of Public Utilities (BPU Docket EM05020106): Joint direct and surrebuttal testimony with Bruce Biewald and David Schlissel regarding the Joint Petition Of Public Service Electric and Gas Company And Exelon Corporation For Approval of a Change in Control Of Public Service Electric and Gas Company And Related Authorizations. On behalf of New Jersey Division of the Ratepayer Advocate. November 14, 2005 and December 27, 2005.

Indiana Utility Regulatory Commission (Cause No. 42873): Direct testimony addressing the proposed Duke – Cinergy merger. On behalf of Citizens Action Coalition of Indiana. November 8, 2005.

Indiana Utility Regulatory Commission (Causes No. 38707 FAC 61S1, 41954, and 42359-S1): Responsive testimony addressing a proposed Settlement Agreement between PSI and other parties in respect of issues surrounding the Joint Generation Dispatch Agreement in place between PSI and CG&E. On behalf of Citizens Action Coalition of Indiana. August 31, 2005.

Illinois Commerce Commission (Dockets 05-0160, 05-0161, 05-0162): Direct and rebuttal testimony addressing wholesale market aspects of Ameren's proposed competitive procurement auction (CPA). On behalf of Illinois Citizens Utility Board. June 15, 2005 and August 10, 2005.

Illinois Commerce Commission (Docket 05-0159): Direct and rebuttal testimony addressing wholesale market aspects of Commonwealth Edison's proposed BUS (Basic Utility Service) competitive auction procurement. On behalf of Illinois Citizens Utility Board and Cook County State's Attorney's Office. June 8, 2005 and August 3, 2005.

State of Maine Public Utilities Commission (Docket No. 2005-17): Joint testimony with David Schlissel and Peter Lanzalotta regarding an Analysis of Eastern Maine Electric Cooperative, Inc.'s Petition for a Finding of Public Convenience and Necessity to Purchase 15 MW of Transmission Capacity from New Brunswick Power and for Related Approvals. On behalf of Maine Office of the Public Advocate. July 19, 2005.

Indiana Utility Regulatory Commission (Cause No. 38707 FAC 61S1): Direct testimony in a Fuel Adjustment Clause (FAC) proceeding concerning the pricing aspects and merits of continuation of the Joint Generation Dispatch Agreement in place between PSI and CG&E, and related issues of PSI lost revenues from inter-company energy pricing policies. On behalf of Citizens Action Coalition of Indiana. May 23, 2005.

Indiana Utility Regulatory Commission (Cause No. 41954): Direct testimony concerning the pricing aspects and merits of continuation of the Joint Generation Dispatch Agreement in place between PSI and CG&E. On behalf of Citizens Action Coalition of Indiana. April 21, 2005.

State of Maine Public Utilities Commission (Docket No. 2004-538): Joint testimony with David Schlissel and Peter Lanzalotta regarding an Analysis of Maine Public Service Company Request for a Certificate of

Public Convenience and Necessity to Purchase 35 MW of Transmission Capacity from New Brunswick Power. On behalf of Maine Office of the Public Advocate. April 14, 2005.

Nova Scotia Utility and Review Board (Order 888 OATT): Testimony regarding various aspects of OATTs and FERC's *pro forma* In The Matter of an Application by Nova Scotia Power Inc. for Approval of an Open Access Transmission Tariff (OATT). On behalf of the Nova Scotia Utility Review Board Staff. April 5, 2005.

Texas Public Utilities Commission (Docket No. 30485): Testimony regarding excess mitigation credits associated with CenterPoint's stranded cost recovery in the Application of CenterPoint Energy Houston Electric, LLC. for a Financing Order. On behalf of the Gulf Coast Coalition of Cities. January 7, 2005.

Ontario Energy Board (RP-2002-0120): Filed testimony and reply comments reviewing the Transmission System Code (TSC) and Related Matters, Detailed Submission to the Ontario Energy Board in Response To Phase I Questions Concerning the Transmission System Code and Related Matters. On behalf of TransAlta Corporation. October 31, 2002 and November 21, 2002.

Alberta Energy and Utilities Board (Application No. 2000135): Filed joint testimony with Dr. Richard D. Tabors in the matter of the Transmission Administrator's 2001 Phase I and Phase II General Rate Application pertaining to Supply Transmission Service charge proposals. On behalf of Alberta Buyers Coalition. March 28, 2001.

Ontario Energy Board (RP-1999-0044): Testimony critiquing Ontario Hydro Networks Company's Transmission Tariff Proposal and Proposal for Alternative Rate Design. On behalf of the Independent Power Producer's Society of Ontario. January 17, 2000.

Massachusetts Department of Public Utilities (Docket # DPU 95-2/3-CC-l): Filed a report (Fagan R., G. Watkins. 1995. *Sampling Issues in Estimating DSM Savings: An Issue Paper for Commonwealth Electric*. Charles River Associates). On behalf of COM/Electric System. April 1995.

Massachusetts Department of Public Utilities (Docket # DPU 95-2/3-CC-l): Filed initial and updated reports (Fagan R., P. Spinney, G. Watkins. 1994. *Impact Evaluation of Commonwealth Electric's Customized Rebate Program*. Charles River Associates. Updated April 1996). April 1994 and April 1995.

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