AESC 2021

Presentation of Results

Amended May 14, 2021

Synapse Team

Outline

1. Main findings
2. Chapter results
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   b) Fuel oil & other fuels
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   g) Non-embedded environmental costs
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   i) Avoided T&D costs
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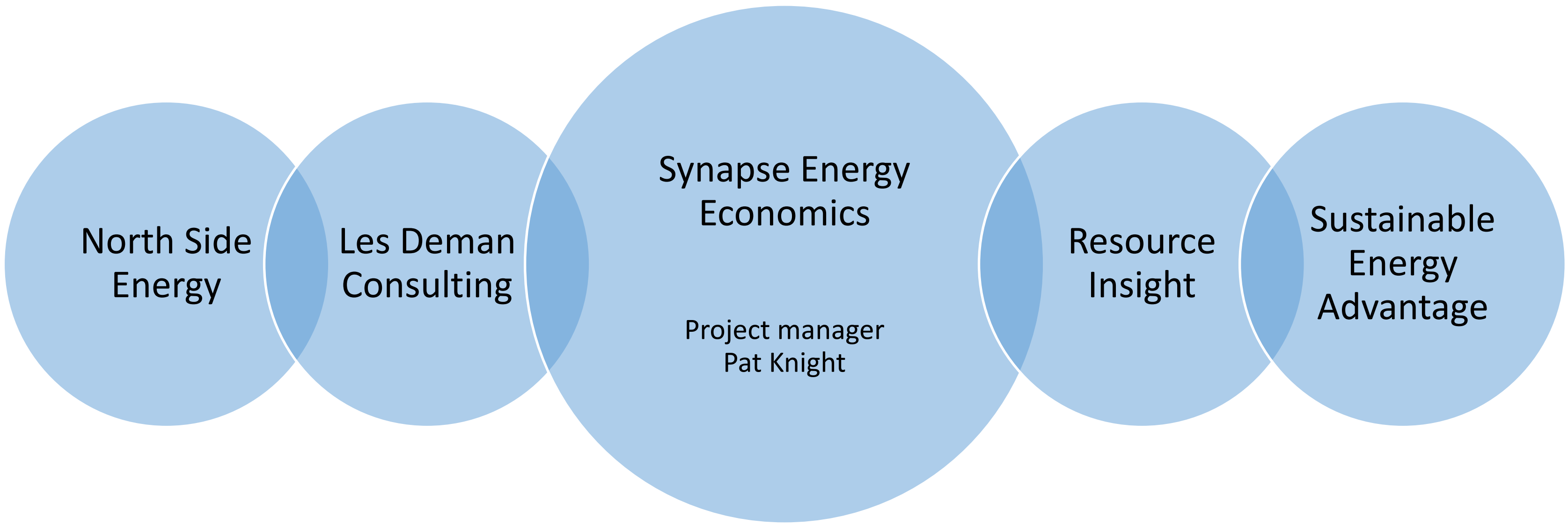
Project Team and Responsibilities

The Synapse Team



North Side Energy
- Avoided natural gas

Les Deman Consulting
- Long-term natural gas forecasting

Synapse Energy Economics
- Project management
- Project QC
- Electricity dispatch and capacity expansion modeling
- Fuel oil and other fuels forecasting
- Non-embedded costs
- Avoided T&D recommendations
- Support and modeling on natural gas, capacity, DRIPE, reliability
- User Interface development

Resource Insight
- Avoided capacity
- DRIPE
- Reliability
- Avoided PTF

Sustainable Energy Advantage
- Renewable energy buildouts
- REC/CEC prices
- Avoided cost of REC/CEC compliance

1. Main Findings

- Generally lower avoided costs when comparing with AESC 2018. Main drivers are:
  - Lower costs for natural gas & RGGI
  - Shallower supply curves for capacity, DRIPE
- RPS compliance is higher due to changes in RPS policies
- Non-embedded cost is higher due to higher projection of offshore wind costs and lower energy prices
- Prices and loads are calculated for all 8,760 hours in 2021-2035, for all regions

ES-Table 1. Illustration of avoided retail summer on-peak electricity cost components, AESC 2021 Counterfactual #1 versus AESC 2018

	AESC 2018	**AESC 2018**	**AESC 2021**	**AESC 2021, relative to AESC 2018**		***Notes***
	2018 cents/kWh	*2021 cents/kWh*	*2021 cents/kWh*	*2021 cents/kWh*	*% Difference*	
Avoided Retail Capacity Costs	2.00	2.11	1.18	-0.93	-44%	3,4,5,6
Avoided Retail Energy Costs	5.05	5.32	3.85	-1.48	-28%	5,7,8
Avoided RPS Compliance	0.39	0.41	1.28	0.86	208%	5,7,9
Subtotal: Capacity and Energy	**7.48**	**7.85**	**6.30**	**-1.55**	**-20%**	
GHG non-embedded	**2.69**	**2.83**	**4.74**	**1.91**	**67%**	5,10
NO_x non-embedded	**0.18**	**0.19**	**0.08**	**-0.11**	**-55%**	5
Transmission & Distribution (PTF)	**2.26**	**2.38**	**2.02**	**-0.36**	**-15%**	3,5,11
Value of Reliability	**0.02**	**0.02**	**0.01**	**-0.01**	**-32%**	3,5,6,12
Electric capacity DRIPE	0.97	1.03	0.41	-0.62	-60%	5,6
Electric energy and cross-DRIPE	2.08	2.19	1.20	-0.99	-45%	5,7,13
Subtotal: DRIPE	**3.05**	**3.22**	**1.61**	**-1.60**	**-50%**	-
Total	**15.68**	**16.49**	**14.77**	**-1.72**	**-10%**	

Notes: GHG cost is based on New England marginal abatement cost (electric sector). For other notes, see Slide 23. We observe that the total cost in AESC 2021 was 16.05 cents per kWh in 2018 dollars or 16.91 cents per kWh in 2021 dollars.

1. Main Findings
Different Counterfactuals

New to this year's study, AESC 2021 features four different counterfactuals.

DSM component included?	**Counterfactual #1** *AESC for EE, ADM and building electrification*	**Counterfactual #2** *AESC for building electrification only*	**Counterfactual #3** *AESC for EE only*	**Counterfactual #4** *AESC for EE and ADM only*
Energy Efficiency (EE)	*No*	Yes	*No*	*No*
Active Demand Management (ADM)	*No*	Yes	Yes	*No*
Building electrification	*No*	*No*	Yes	Yes
Transportation electrification	Yes	Yes	Yes	Yes
Distributed generation	Yes	Yes	Yes	Yes

Because each AESC counterfactual represents a hypothetical future that lacks some amount of anticipated demand-side measures, AESC 2021 should not be used to infer information about actual future market conditions, energy prices, or resource builds in New England.

1. Main Findings
Different Counterfactuals

- Generally few differences across counterfactuals (CFs)
- CF#2 has lower load than the other three counterfactuals, which produces lower energy, capacity, RPS, and DRIPE values
- CF#1, CF#3, and CF#4 are largely similar, producing very similar avoided costs
  - CF#3 and CF#4 include some level of building electrification, while CF#1 does not.
  - This leads to marginally higher capacity, energy and REC prices.

ES-Table 1 through 4. Illustration of avoided retail summer on-peak electricity cost components

	CF#1 *2021 cents/kWh*	**CF#2** *2021 cents/kWh*	**CF#3** *2021 cents/kWh*	**CF#4** *2021 cents/kWh*	***Notes***
Avoided Retail Capacity Costs	1.18	1.16	1.22	1.22	*3,4,5,6*
Avoided Retail Energy Costs	3.85	3.63	3.92	3.90	*5,7,8*
Avoided RPS Compliance	1.28	0.98	1.40	1.40	*5,7,9*
Subtotal: Capacity and Energy	**6.30**	**5.77**	**6.54**	**6.52**	
GHG non-embedded	**4.74**	**5.08**	**4.68**	**4.69**	*5,10*
NO_X non-embedded	**0.08**	**0.08**	**0.08**	**0.08**	*5*
Transmission & Distribution (PTF)	**2.02**	**2.02**	**2.02**	**2.02**	*3,5,11*
Value of Reliability	**0.01**	**0.01**	**0.01**	**0.01**	*3,5,6,12*
Electric capacity DRIPE	0.41	0.39	0.41	0.41	*5,6*
Electric energy and cross-DRIPE	1.20	1.08	1.21	1.21	*5,7,13*
Subtotal: DRIPE	**1.61**	**1.47**	**1.62**	**1.62**	*3,4,5,6*
Total	**14.77**	**14.43**	**14.96**	**14.94**	

Notes: GHG cost is based on New England marginal abatement cost (electric sector)
For other notes, see Slide 23. We observe that the total cost in AESC 2021 was 16.05 cents per kWh in 2018 dollars or 16.91 cents per kWh in 2021 dollars.

2a. Natural gas

- AESC 2021 Henry Hub is 32.5 percent lower than AESC 2018 on a levelized basis
- Drivers of wholesale price changes in Henry Hub:
  - Higher gas production
  - Downward adjustment in breakeven drilling and operating costs in the major shale and tight gas producing regions
- Drivers of retail price changes:
  - Higher avoidable pipeline capacity costs, which mitigates lower gas commodity prices

ES-Table 5. Summary of 15-year levelized Henry Hub, Algonquin Citygate, and basis differentials for AESC 2021 and AESC 2018

	Henry Hub	Algonquin Citygates	Basis
AESC 2018	$4.78	$6.59	$1.24
AESC 2021	$3.23	$4.25	$1.03
% Change	-32.5%	-35.5%	-

Notes: All values are in 2021 $/MMBtu. AESC 2018 levelized costs are for 15 years (2018–2032) at a discount rate of 1.34 percent. AESC 2018 levelized costs are for 15 years (2021–2035) at a discount rate of 0.81 percent

ES-Table 6. Avoided costs of gas for all retail customers by end-use assuming no avoidable margin (2021 per MMBtu)

	No avoidable retail margin		Some avoidable retail margin	
	Southern New England	*Northern New England*	*Southern New England*	*Northern New England*
AESC 2018	$7.91	$7.57	$8.61	$8.06
AESC 2021	$6.48	$6.39	$7.67	$7.58
% Change	*-18%*	*-16%*	*-11%*	*-6%*

2a. Natural gas (cont.)

- Prices for Henry Hub and the resulting Algonquin Citygates are lower in AESC 2021 than in AESC 2018
- But, we observe a more complex set of trends for the avoided cost of natural gas for retail customers
  - The cost of expanding natural gas pipeline capacity into New England continues to rise. Because pipeline operators recover capital costs and most operating costs through a fixed monthly charge, the impact of the higher incremental pipeline charges is amplified for lower load factor end-uses, such as residential heating.
  - Comparing the two Southern New England and Northern New England regions, because the marginal gas transmission path used to calculate the avoided costs for both northern New England and southern New England runs from the Dawn Hub in Ontario through northern New Hampshire, additional gas pipeline charges cause the avoided costs for southern New England to be slightly higher.
  - The natural gas avoided cost estimates for Vermont use the end-use costing periods and methodology developed for previous AESC studies. The Design Day avoided cost is the marginal upstream supply and delivery cost, plus the marginal LDC transmission cost. The Canadian pipeline tolls that set the upstream delivery costs for VGS are slightly lower for AESC 2021 than for AESC 2018, due in part to the change in the Canadian dollar exchange rate. The avoided cost for the remaining nine Peak Days reflects the lower delivered cost of propane for the VGS peaking facility.

2b. Fuel oil and other fuels

- In general, we find that avoided levelized costs for residential fuel oil and other fuels are generally higher than was estimated in AESC 2018, except for the levelized costs for commercial residual fuel oil and biofuels which are lower than was previously estimated.
- The primary sources of these differences are changes in historical prices from the State Energy Data System (SEDS) and changes in the projected price of crude oil, which underlies many of the cost projections
- New to AESC 2021 is the addition of avoided costs for motor gasoline and diesel.

ES-Table 8. Avoided costs of retail fuels (15-year levelized, 2021 $ per MMBtu)

	Residential						Commercial		Transportation	
	No. 2 Distillate	Propane	Kerosene	BioFuel	Cord Wood	Wood Pellets	No. 2 Distillate	No. 6 Residual	Motor Gasoline	Motor Diesel
AESC 2018	$23.36	$32.78	$20.95	$24.06	$14.12	$22.76	$19.46	$17.13	-	-
AESC 2021	$24.04	$38.79	$29.59	$21.64	$20.84	$22.47	$22.25	$15.74	$22.07	$22.76
% change	2.9%	18.3%	41.3%	-10.1%	47.6%	-1.3%	14.3%	-8.2%	-	-

2c. Common electric assumptions (i.e., modeling inputs)

- Various parts of our avoided cost modeling use the same assumptions for the electric sector
- Demand
  - Assume no EE added in 2021 or later years (in CF#1, CF#3, and CF#4)
  - Annual load trajectory based on ISO New England's 2020 CELT forecast
  - Use default hourly load shapes from ISO New England
  - Rely on FCA 15 demand curve for forecasting capacity prices
- Supply
  - Assume that current renewable policies are in effect. This includes all laws that are currently on the books, as well as policy that is viewed as likely to happen by relevant state agencies.
  - Assume units with FCM commitments are built; model builds other CCs/GTs and storage dynamically
  - Rely on FCA 15 supply curve for forecasting capacity prices
- Input prices
  - Natural gas: Based on blend of near-term NYMEX futures with long-term prices from AEO 2021
  - RGGI: Based on RGGI floor price
- All modeling is conducted from 2021-2035; prices after 2035 are extrapolated
- Models used:
  - EnCompass – An electric-sector production-cost and capacity expansion model
  - REMO – A set of models developed by Sustainable Energy Advantage that estimate forecasts of scenario-specific renewable energy build-outs, as well as REC and clean energy certificate (CEC) price forecasts
  - FCM Model – A spreadsheet model that coordinates outputs on supply and demand with inputs from ISO New England's Forward Capacity Market

2d. Avoided capacity costs

- Avoided capacity costs are driven by actual and forecast clearing prices in ISO New England's Forward Capacity Market (FCM).
- Forecasted capacity prices are based on the experience in recent auctions and expected changes in demand, supply, and market rules.

ES-Table 9. AESC 2021 capacity prices (2021 $ per kW-month)

Commitment Period (June to May)	FCA	Actual	Actual but for post-2020 EE	AESC 2021				AESC 2018
				Counter-factual #1	Counter-factual #2	Counter-factual #3	Counter-factual #4	
2021/2022	12	$4.63	$4.77	$4.77	$4.63	$4.77	$4.77	$4.99
2022/2023	13	$3.73	$3.96	$3.96	$3.73	$3.96	$3.96	$5.10
2023/2024	14	$1.92	$2.47	$2.47	$1.92	$2.47	$2.47	$5.21
2024/2025	15	$2.46	$2.75	$2.75	$2.46	$2.75	$2.75	$5.50
2025/2026	16			$2.72	$2.69	$2.59	$2.59	$5.95
2026/2027	17			$2.88	$2.69	$2.75	$2.75	$6.46
2027/2028	18			$3.11	$3.33	$3.46	$3.43	$6.95
2028/2029	19			$3.30	$3.30	$3.65	$3.62	$7.45
2029/2030	20			$3.59	$3.41	$3.94	$3.92	$7.95
2030/2031	21			$3.42	$3.77	$3.97	$3.94	$6.95
2031/2032	22			$3.67	$3.81	$3.79	$3.77	$7.45
2032/2033	23			$3.90	$3.86	$4.02	$3.99	$7.95
2033/2034	24			$3.86	$4.02	$3.95	$3.92	$6.95
2034/2035	25			$4.67	$4.47	$5.09	$4.95	$7.45
2035/2036	26			$3.66	$3.86	$3.73	$3.71	$7.95
15-year levelized cost				**$3.51**	**$3.45**	**$3.65**	**$3.63**	**$6.63**
Percent difference				**-47%**	**-48%**	**-45%**	**-45%**	

Notes: Levelization periods are 2021/2022 to 2035/2036 for AESC 2021 2018/2019 to 2032/2033 for AESC 2018. Real discount rate is 0.81 percent for AESC 2021 and 1.34 percent for AESC 2018

2d. Avoided capacity costs (cont.)

- Prices for FCA 12-15 are based on observed auctions; all other prices are forecasted based on the FCA 15 supply and demand curves, as well as outputs from energy modeling
- Observed data from the past four capacity auctions indicate low prices that clear on a shallow part of the supply curve.
- Market-clearing prices in outyears are principally determined by whether the balance of the qualified and cleared capacity additions, primarily from battery storage and offshore wind, and retirements of thermal generation (fossil steam, combustion turbines, some older combined-cycle units, and some biomass), and how the resulting capacity compares to the growth in installed capacity requirements (ICR). Small year-on-year differences are due to changes in load, new resources coming online, and other resources retiring.
- Text on capacity price methodology, as well as text on treatment of uncleared resources has been restructured and clarified.

2e. Avoided energy costs

- On an annual average basis, prices in CF#1 are 20 percent lower than the prices modeled in the 2018 AESC study.
- Key drivers of these lower prices include lower Henry Hub natural gas prices, lower RGGI prices, more low- or zero-variable operating cost renewables (caused by changes to the RPS in states like Connecticut and Rhode Island), and the addition of a new transmission line from Canada. These factors are not listed in a particular order.
- Energy prices observed in other counterfactuals are similar to Counterfactual #1. Counterfactual #2 features the largest divergence, as a result of its lower projection of load. This decrease is larger than the change in avoided energy costs observed between the 2015 AESC study and the 2018 AESC study.

ES-Table 10. Comparison of energy prices for WCMA region (2021 $ per MWh, 15-year levelized)

	Annual All hours	Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
AESC 2018	$51.17	$58.66	$54.17	$45.22	$38.69
AESC 2021 Counterfactual 1	$40.85	$46.86	$45.20	$32.67	$29.86
AESC 2021 Counterfactual 2	$37.79	$42.98	$41.66	$30.87	$27.95
AESC 2021 Counterfactual 3	$41.34	$47.43	$45.63	$33.28	$29.93
AESC 2021 Counterfactual 4	$41.29	$47.40	$45.62	$33.17	$29.87
Pcnt Change: Counterfactual 1	-20%	-20%	-17%	-28%	-23%
Pcnt Change: Counterfactual 2	-26%	-27%	-23%	-32%	-28%
Pcnt Change: Counterfactual 3	-19%	-19%	-16%	-26%	-23%
Pcnt Change: Counterfactual 4	-19%	-19%	-16%	-27%	-23%

Notes: All prices have been converted to 2021 $ per MWh. Levelization periods are 2018–2032 for AESC 2018 and 2021–2035 for AESC 2021. The real discount rate is 1.34 percent for AESC 2018 and 0.81 percent for AESC 2021. Prices are wholesale.

2e. Avoided energy costs (cont.)

ES-Table 11. Avoided energy costs, AESC 2021 vs. AESC 2018 (15-year levelized costs, 2021 $ per kWh)

			Winter Peak	Winter Off-Peak	Summer Peak	Summer Off-Peak
AESC 2021	1	CT	$0.059	$0.057	$0.043	$0.040
	2	MA	$0.062	$0.060	$0.047	$0.044
	3	ME	$0.057	$0.056	$0.042	$0.039
	4	NH	$0.058	$0.057	$0.043	$0.040
	5	RI	$0.065	$0.064	$0.050	$0.047
	6	VT	$0.054	$0.053	$0.039	$0.036
AESC 2018	1	CT	$0.063	$0.059	$0.049	$0.043
	2	MA	$0.062	$0.058	$0.049	$0.043
	3	ME	$0.058	$0.054	$0.045	$0.039
	4	NH	$0.063	$0.060	$0.051	$0.044
	5	RI	$0.061	$0.057	$0.048	$0.042
	6	VT	$0.062	$0.058	$0.049	$0.042
Delta	1	CT	-$0.005	-$0.002	-$0.006	-$0.003
	2	MA	-$0.001	$0.003	-$0.002	$0.001
	3	ME	$0.000	$0.002	-$0.003	$0.000
	4	NH	-$0.005	-$0.003	-$0.008	-$0.004
	5	RI	$0.003	$0.007	$0.002	$0.005
	6	VT	-$0.008	-$0.005	-$0.010	-$0.006
Pcnt Diff	1	CT	-7%	-3%	-12%	-7%
	2	MA	-1%	5%	-4%	2%
	3	ME	0%	4%	-6%	1%
	4	NH	-8%	-5%	-15%	-8%
	5	RI	6%	12%	5%	12%
	6	VT	-13%	-8%	-20%	-14%

Notes: These costs are the sum of wholesale energy costs and wholesale RPS compliance costs, increased by a wholesale risk premium of 8 percent, except for Vermont, which uses a wholesale risk premium of 11.1 percent. All costs have been converted to 2021 dollars per kWh. Levelization periods are 2018–2032 for AESC 2018 and 2021–2035 for AESC 2021. The real discount rate is 1.34 percent for AESC 2018 and 0.81 percent for AESC 2021. AESC 2018 values are from AESC 2018 Chapter 5 and the AESC 2021 User Interface. Values do not include losses.

2f. Avoided cost of RPS compliance

- Relative to AESC 2018, AESC 2021 has higher prices for meeting RPS compliance
- This difference is attributable to increased supply-demand tension in the near-term, resulting in higher REC prices compared to AESC 2018, particularly for states that have recently adjusted their RPS policies.
- Even with higher prices, remainder of the study period is characterized by surplus, with policy-mandated purchases exceeding incremental RPS demands.
- The cost of RPS compliance has also increased as a result of the addition of new RPS categories (such as Clean Energy Standard-Existing (CES-E) and Clean Peak Energy Portfolio Standard (CPS) categories in Massachusetts).
- Renewable builds across the scenarios are identical; differences in REC prices are due to differences in supply-demand tension, as well as availability of "discretional" REC supply (e.g., from biomass or imported RECs)

ES-Table 12. Avoided cost of RPS compliance (2021 $ per MWh)

	CT	ME	MA	NH	RI	VT
AESC 2018	$4.00	$0.55	$3.84	$5.25	$2.57	$2.12
AESC 2021 Counterfactual 1	$7.93	$7.37	$11.81	$8.10	$14.99	$3.90
AESC 2021 Counterfactual 2	$4.77	$3.55	$9.04	$6.41	$5.66	$2.67
AESC 2021 Counterfactual 3	$8.84	$8.56	$12.93	$8.67	$16.81	$4.44
AESC 2021 Counterfactual 4	$8.84	$8.56	$12.93	$8.67	$16.81	$4.44
Pcnt Change: Counterfactual 1	98%	1233%	208%	54%	482%	84%
Pcnt Change: Counterfactual 2	19%	541%	135%	22%	120%	26%
Pcnt Change: Counterfactual 3	121%	1448%	237%	65%	553%	110%
Pcnt Change: Counterfactual 4	121%	1448%	237%	65%	553%	110%

Note: Each state has multiple Classes or Tiers. For simplicity, we sum avoided costs for all non-Class I/New RPS policies together in the "all other classes" row. Levelization periods are 2018–2032 for AESC 2018 and 2021–2035 for AESC 2021. The real discount rate is 1.34 percent for AESC 2018 and 0.81 percent for AESC 2021. AESC 2018 values are from AESC 2018 Chapter 7, and have been converted into 2021 dollars. All values include a 9 percent loss factor.

2g. Non-embedded environmental costs

- AESC 2021 offers four different non-embedded GHG costs. These prices may be useful in different states according to different policy contexts.
- In addition, AESC 2021 establishes a non-embedded NOX emission cost of $14,700 per short ton, based on a review of findings in the literature, which translates into an avoided wholesale cost for NOX of $0.77 per MWh

ES-Table 13-14. Comparison of GHG costs under different calculation approaches

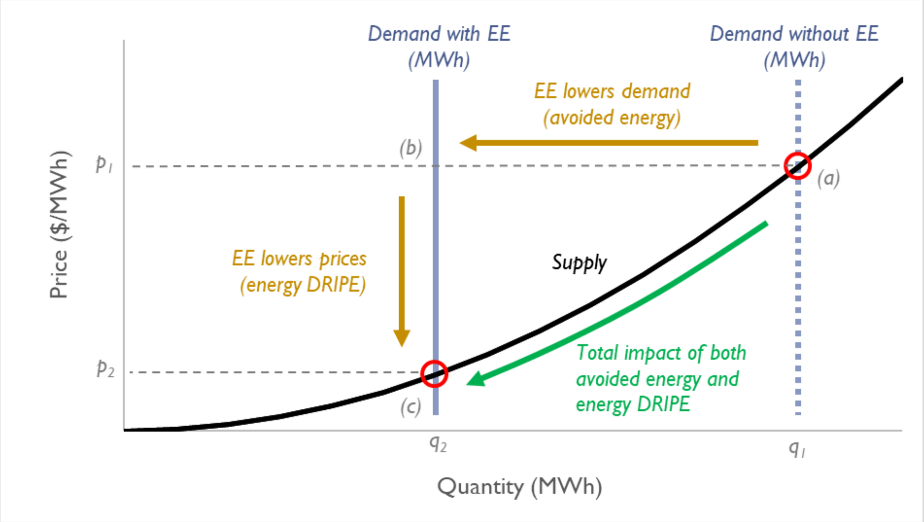
	2021 $ per short ton				2021 cents per kWh			
	AESC 2018	AESC 2021	Difference	% Difference	AESC 2018	AESC 2021	Difference	% Difference
Social cost of carbon (SCC or “damage cost”) at 2% discount rate	Not quantified	$128	-	-	Not quantified	4.87	-	-
Global marginal abatement cost	$105	$92	-$13	-12%	4.64	3.41	-1.23	-26%
New England-based marginal abatement cost, derived from the electric sector	$72	$125	$53	75%	2.83	4.74	1.91	67%
New England-based marginal abatement cost, derived from multiple sectors	Not calculated	$493	-	-	Not calculated	19.72	-	-

Notes: All values shown are levelized over 15 years. All AESC 2021 values except the SCC are levelized using a 0.81 percent discount rate (SCC uses a 2.0 percent discount rate). All AESC 2018 values are levelized using a 1.34 percent discount rate, then converted into 2021 dollars. In AESC 2018, damage costs were discussed, but not quantified. AESC 2018 did not discuss or estimate a New England-based marginal abatement cost derived from multiple sectors. All $-per-short-ton values are net of energy costs, but not net of embedded GHG costs. All cents-per-kWh values are net of energy costs, net of embedded GHG costs (including RGGI, and several MA-specific GHG regulations). All cents-per-kWh values are quoted using summer on-peak seasonal marginal emission rates, and also incorporate a 9 percent energy loss factor.

2h. DRIPE

- Demand Reduction Induced Price Effect (DRIPE), a/k/a price suppression
- AESC 2021 models:
  - Energy DRIPE
  - Capacity DRIPE
  - Natural gas DRIPE
  - Cross-DRIPE (which carry over dynamics between the gas and energy markets)
  - Oil DRIPE
- DRIPE results in AESC 2021 differ from those in AESC 2018 because of updated information changes in utility long-term energy purchases, updated market data, and new commodity forecasts.
- Generally speaking, we find (a) lower energy DRIPE and capacity DRIPE values, due to projections of flatter supply curves compared to AESC 2018, (b) lower natural gas DRIPE values due to lower commodity prices and flatter supply curves, and (c) lower oil DRIPE values, due to changes in the underlying projection of crude oil prices.

Example figure depicting separate and non-overlapping avoided energy and energy DRIPE effects



Note: This example figure depicts impacts in the energy market, but the principles are the same for all other DRIPE categories. This figure also uses "EE" as an example measure. DRIPE effects can be calculated for any measure (EE or otherwise), including measures that increase the demand of a commodity.

2i. Avoided T&D costs

- In AESC 2021, we present four separate threads for analysis of avoided transmission and distribution (T&D) costs, building on the foundation established in the 2018 AESC and updating or expanding the analysis presented. The four aspects are:

1. Updating the avoided costs for PTF facilities based on future costs (now $84 kW-year);
2. Reviewing utility approaches to generic avoided cost values for non-PTF transmission and distribution and evaluating these approaches on a common evaluation rubric to facilitate cross-comparison and learning;
3. Reviewing utility approaches to calculating geographically localized avoided costs, such as for non-wire alternatives (NWA); and
4. Developing an approach to the avoided cost of natural gas system transmission and distribution.

2j. Value of improved reliability

- Utilize the calculation of value of lost load (VoLL), the value a consumer derives from avoiding an outage.
  - AESC 2021 projects a value of $73 per kWh
  - This is almost 3 times higher than the VoLL estimated in AESC 2018 ($26 per kWh), which reflects updated information from literature reviews.

- VoLL is applied to two categories:
  - Generation Reliability
    - Effect of increasing reserve margins and improving on generation reliability.
    - In AESC 2021, we find 15-year levelized values of $0.47 per kW-year for cleared benefits and $8.45 per kW-year for uncleared benefits. These are 32 percent lower and 21 percent higher, respectively, than the same values estimated in AESC 2018, after adjusting for inflation.
    - For cleared reliability, despite a higher VoLL, overall benefits are lower as a result of flatter supply curve assumptions for the capacity market. Changes to the capacity market have less of an impact on uncleared resources, which exist outside the capacity market. As a result, an increase in the VoLL produces an increase in the uncleared reliability value.
  - T&D Reliability
    - New in AESC 2021, we provide an example methodology to estimate benefits related to T&D reliability This estimate is based on data for National Grid Massachusetts. This value would likely differ for each jurisdiction.
    - As a result, the methodology provided can be interpreted as guidance for calculating avoided cost.

2k. Sensitivities

- We modeled three sensitivities:
  - High Gas Price Sensitivity: Counterfactual #1 with higher gas prices.
  - No New EE Climate Policy Sensitivity: Counterfactual #3 (no EE) with increased levels of building electrification and transportation electrification. This sensitivity also includes a new policy that gets the New England electricity system to 90 percent non-fossil in 2035.
  - All-In Climate Policy Sensitivity: Counterfactual #2 (with EE) with increased levels of building electrification and transportation electrification. This sensitivity also includes a new policy that gets the New England electricity system to 90 percent non-fossil in 2035.
- High Gas Price Sensitivity assumes higher Henry Hub gas prices based on sensitivities in AEO 2021.
  - Higher gas prices lead to higher energy costs, lower RPS costs, and lower non-embedded costs.
- Climate policy sensitivities assume higher levels of electrification, flexible load, and an incremental regional clean energy policy (IRCEP), which causes New England's electricity supply to be at or near 90% non-fossil in 2035.
  - Climate policies tend to increase capacity costs and RPS compliance costs, and slightly reduce energy costs. Costs of IRCEP compliance tends to be small as many states are already approaching high levels of clean energy by 2035.
- Additional detail can be found in the AESC 2021 report.

2I. Appendices

- Appendix A: Usage instructions
- Appendix B: Detailed Electric Outputs
  - Contains text describing how to use energy avoided costs
  - Also available within the User Interface and in a standalone Excel workbook
- Appendix C: Detailed Natural Gas Outputs
  - Also available in a standalone Excel workbook
  - DRIPE components calculated dynamically within the User Interface
- Appendix D: Detailed Oil and Other Fuels Outputs
- Appendix E: Common Financial Parameters
- Appendix F: User Interface
- Appendix G: Marginal Emission Rates and Non-embedded Environmental Cost Detail
- Appendix H: DRIPE Derivation
- Appendix I: Matrix of Reliability Sources
- Appendix J: Guide to Calculating Avoided Costs for Cleared and Uncleared Resources
  - This has been rewritten as a simplified guide to cleared vs. uncleared resources
- Appendix K: Scaling Factor for Uncleared Resources
  - This was previously a standalone supplemental report to AESC 2018

2m. User Interface

- Excel workbook containing hourly load and price data for 2021-2035 for each region; extrapolates values through 2035
- Four different versions, one for each counterfactual
- Dynamically provides avoided costs for different regions and counterfactuals
- Dynamically calculates DRIPE values based on DRIPE vintage
- Users can view avoided costs according to the traditional AESC costing periods (summer onpeak, etc.), or set up their own costing periods where they focus on peak prices or peak loads
- Training available upon request

ES-Table 1 notes

1. *Values are shown for the WCMA reporting zone, summer on-peak, on a 15-year levelized basis; all values are in 2021 dollars unless otherwise stated.*
2. *AESC 2018 data is from ES-Table 1 in AESC 2018. AESC 2018 values levelized (2018-2032) escalated with a factor of 1.05 to convert 2018 dollars to 2021 dollars. We observe that the total cost in AESC 2018 was 16.05 cents per kWh in 2018 dollars or 16.91 cents per kWh in 2021 dollars.*
3. *Assumes load factor of 55%*
4. *Avoided cost of capacity purchases:*
   - *AESC 2018 cost (2018 $/kW-year) of $83/kW-year*
   - *AESC 2021 cost (2021 $/kW-year) of $49/kW-year*
5. *Includes T&D loss adjustments of:*
   - *9.0% for energy*
   - *16.0% for peak demand*
   - *These same adjustments have been applied to AESC 2018 values in that study's ES-Table 1, some of which used a T&D loss factor of 8%.*
6. *This table assumes that 100% of capacity, capacity DRIPE, and reliability values are cleared or bid into the capacity market*
7. *Includes wholesale risk premium adjustment of 8.0%*
8. *Avoided wholesale energy cost (2021 $/MWh) of $33/MWh*
9. *Avoided RPS compliance cost of $12/MWh*
10. *Assumes non-embedded GHG cost based on New England MAC (electric sector)*
11. *Assumes PTF cost (2021 $/kW-year) of $84/kW-year*
12. *Assumes reliability value (2021 $/kW-year) of $0.47/kW-year, and a VOLL of $73/kWh*
13. *"Electric energy and cross-DRIPE" is the sum of electric energy, G-E cross-DRIPE and E-G-E cross-DRIPE. In both AESC 2018 and AESC 2021, these DRIPE values represent the Massachusetts-wide (zone-on-zone) value, but not the Rest-of-Pool amount.*

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