Grid-Level Energy Systems and Management

Tuesday, 03/17

10:30am – 11:45am

NOTIFICATION OF RECORDING

This meeting will be recorded. MAPC may choose to retain and distribute the video, still images, audio, and/or the chat transcript. By continuing with this virtual meeting, you are consenting to participate in a recorded event. The recordings and chat transcript will be considered a public record. If you do not feel comfortable being recorded, please turn off your camera and/or mute your microphone, or leave the meeting.

Grid-Level Energy Systems and Management

Tuesday, 03/17

10:30am – 11:45am

Today's Lesson

Lesson Question

- How is electricity produced, delivered, and regulated? And what are you paying for in your electric bill?

Learning Objectives

- Introduce the three major electricity cost components – generation, transmission, and distribution.
- Review key market and regulatory constructs.
- Explain how electric sector costs are recovered from customers and related climate and affordability considerations.

Introductory Polls

Rate your level of agreement with the following statements:

- I understand major electricity cost components including generation, transmission, and distribution
- I can explain how electric sector costs are recovered from customers and related climate and affordability considerations

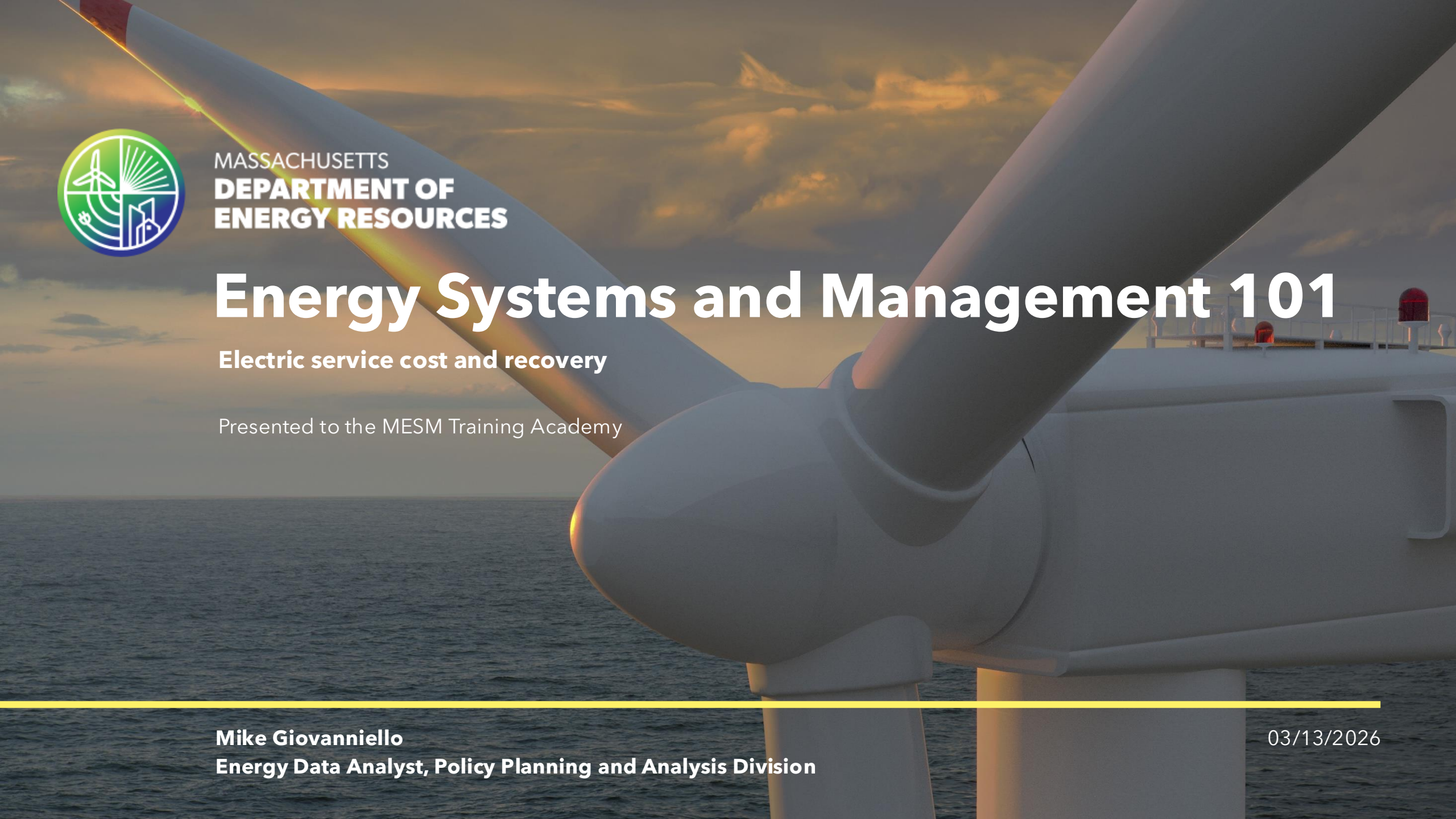
1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

Meet the Instructor

Mike Giovanniello

Energy Data Analyst

Massachusetts Department of Energy Resources



MASSACHUSETTS
DEPARTMENT OF
ENERGY RESOURCES

Energy Systems and Management 101

Electric service cost and recovery

Presented to the MESM Training Academy

Mike Giovanniello
Energy Data Analyst, Policy Planning and Analysis Division

03/13/2026

Roadmap

1. **Electric Costs:** Supply, transmission, and distribution

2. **Cost recover:** Deciding who pays for what via electric rates

3. **Managing Emissions and Energy Costs:** Policies, programs, and the future of electric rates

Electric Costs

Supply, Transmission, and Distribution

Your Electric Bill

What are you paying for?

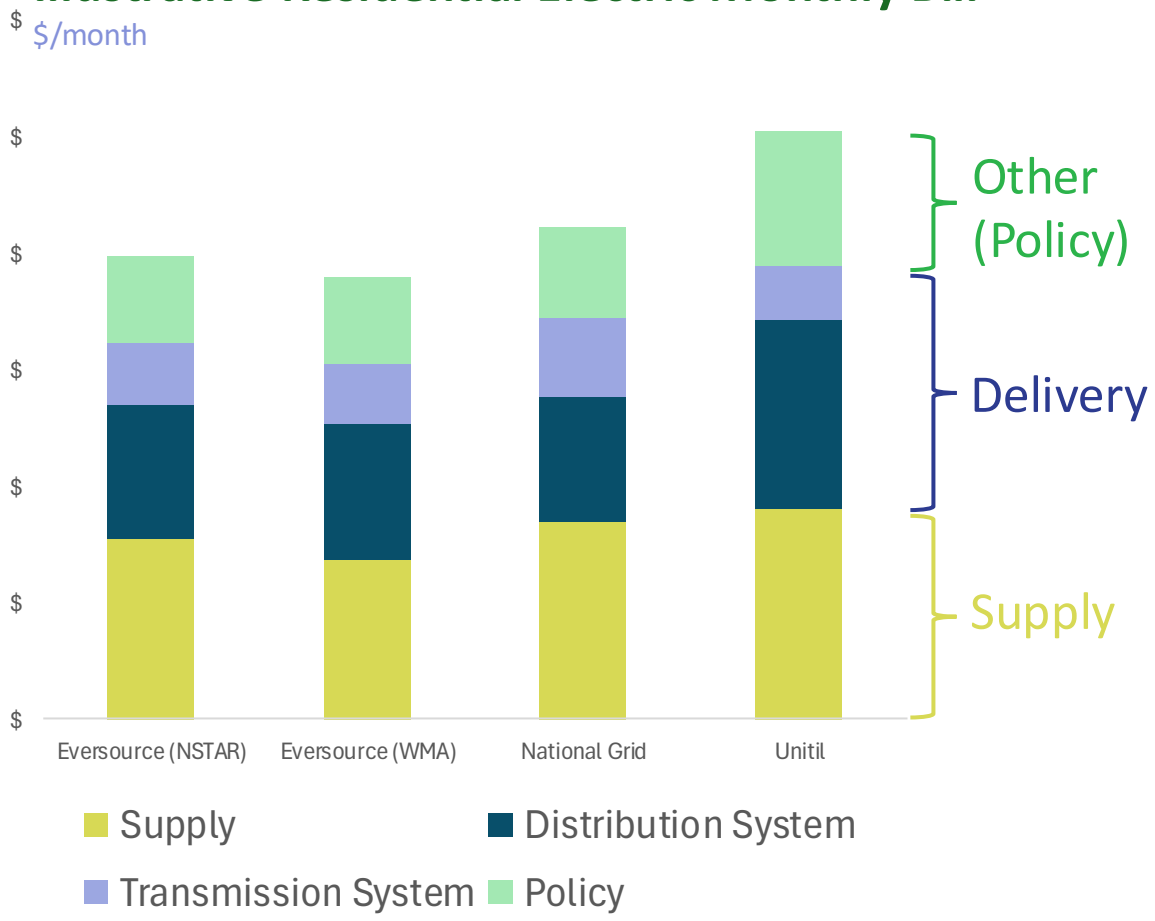
Electric bills primarily reflect the cost to **supply** (generate) and **deliver** electricity.

Supply: cost associated with generating electricity.

Delivery: cost associated with building and maintaining the infrastructure that brings the electricity produced by generators to end users. Includes:

- **Transmission** (e.g., high-voltage wires, bulk power substations, etc.)
- **Distribution** (e.g., poles, low-voltage wires, line transformers, etc.)

Illustrative Residential Electric Monthly Bill



MASSACHUSETTS DEPARTMENT OF ENERGY RESOURCES

Generating Electricity in New England

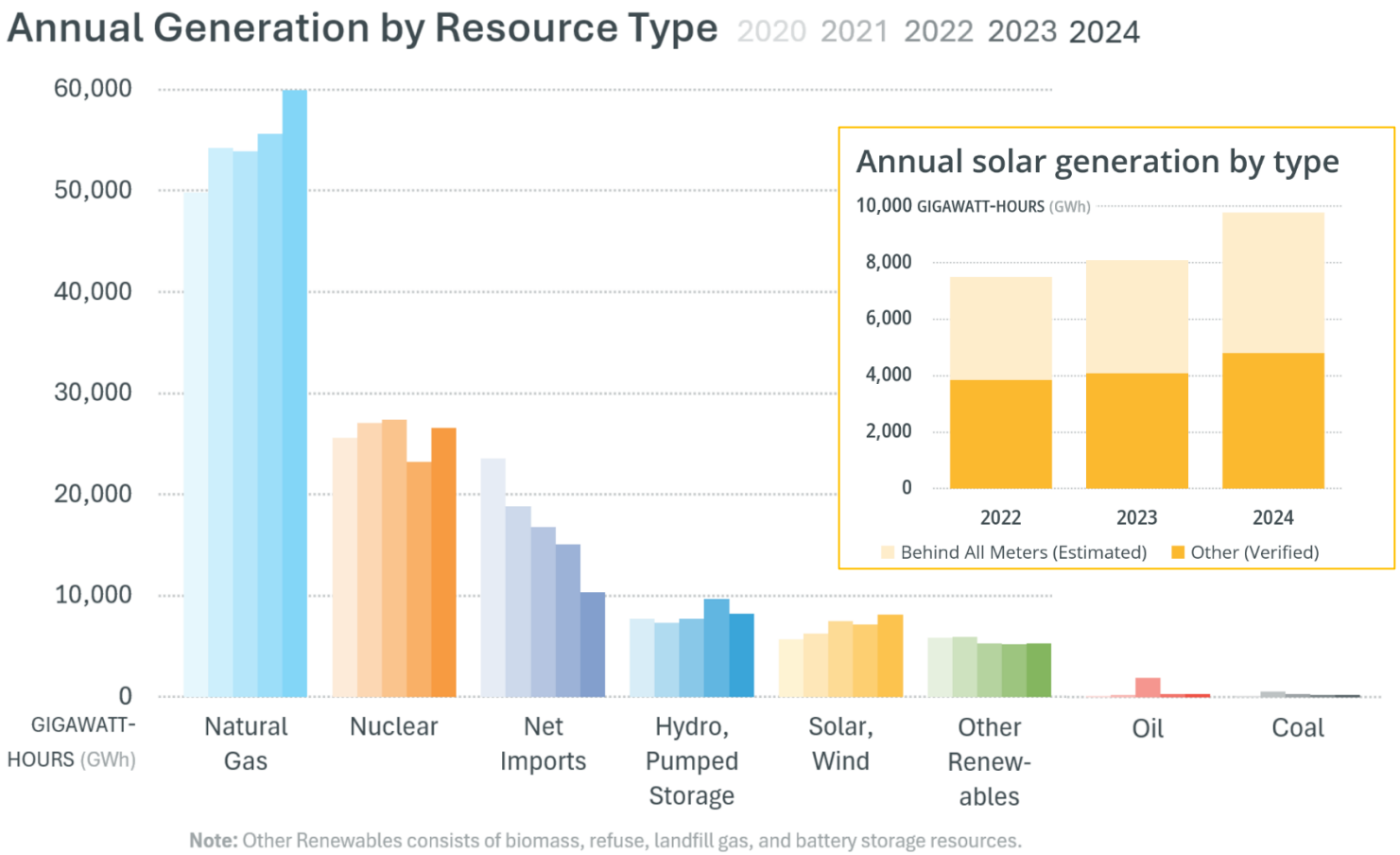


Figure 1-1: ISO New England annual generation by resource

Types of generators

Fossil: burn fuel to heat water to spin a turbine. The source of C02 emissions

Nuclear: nuclear fuel heats water, but no emissions

Hydro: water from river or dam spins a turbine

Renewables: solar and wind energy

Other renewables: biomass or landfill gas used as fuel. Arguably net-zero emissions

Imports: mainly hydro from Canada

ISO-NE Orchestrates Supply in the Region

Independent System Operator for New England (ISO-NE)

About

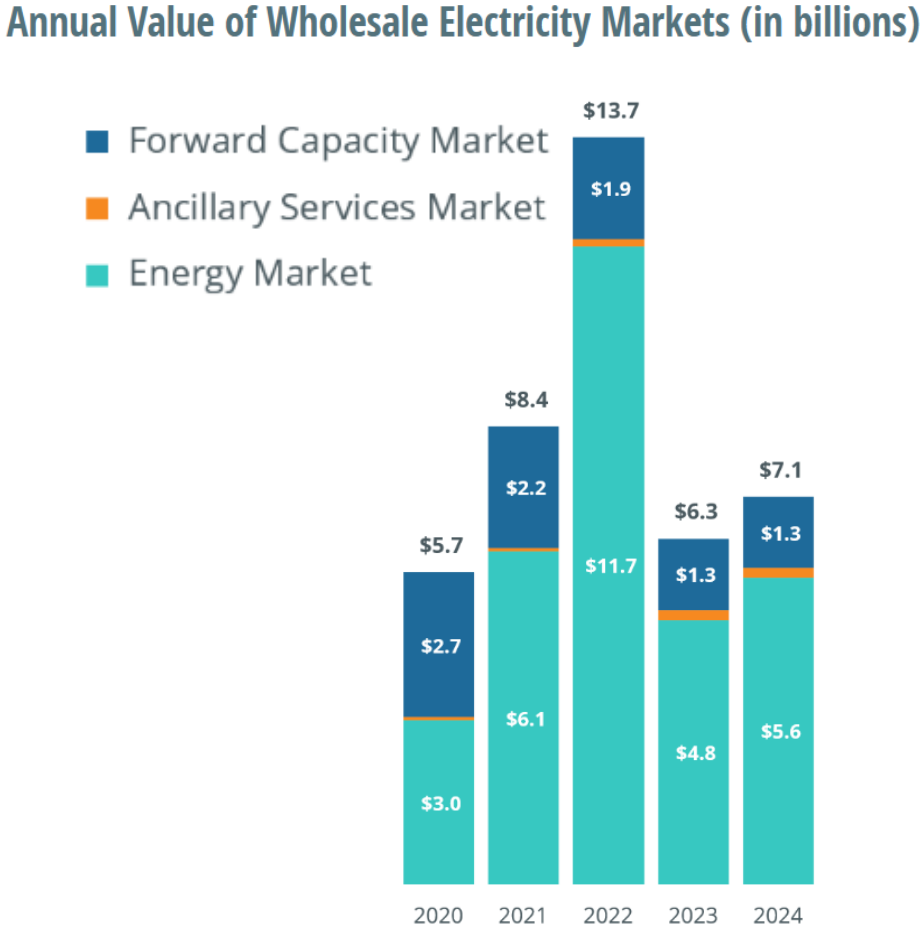
- A nonprofit, FERC-regulated entity
- Operates the grid for all New England States (~15 million people)
- Does NOT own any infrastructure, just acts as a neutral coordinator
- Publishes real-time grid data

Core responsibilities

- **Dispatch:** decides which power plants run at any given moment (least-cost dispatch)
- **Reliability:** ensures enough power is always available, including reserves
- **Markets:** administers wholesale energy, capacity, and ancillary services markets
- **Planning:** long-term transmission and resource adequacy studies

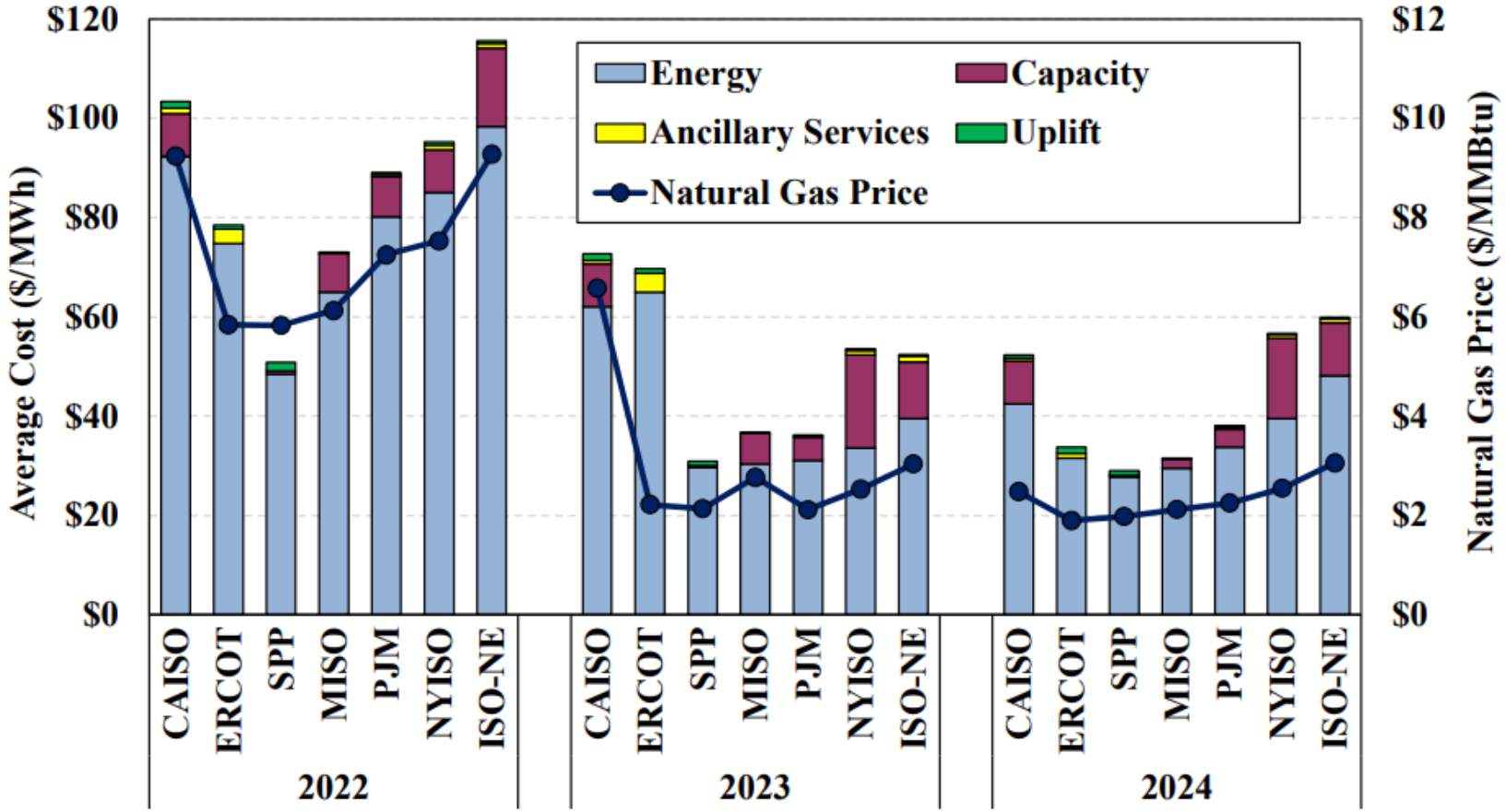
Wholesale Supply Markets

- **Energy market**
  - day-ahead and real-time markets
  - prices vary by time (e.g., hour) and location
  - generators bid a price to produce electricity
  - the marginal (most expensive) unit needed sets the clearing price for everyone
- **Capacity market**
  - Forward Capacity Market
  - secure generation to meet expected system peak demand 3 years out
  - generators are paid to be available, not just when running
- **Ancillary Services market**
  - reserves and frequency regulation to keep the grid stable second-to-second
- *Wholesale market costs flow through to consumers via the supply portion of their bill*



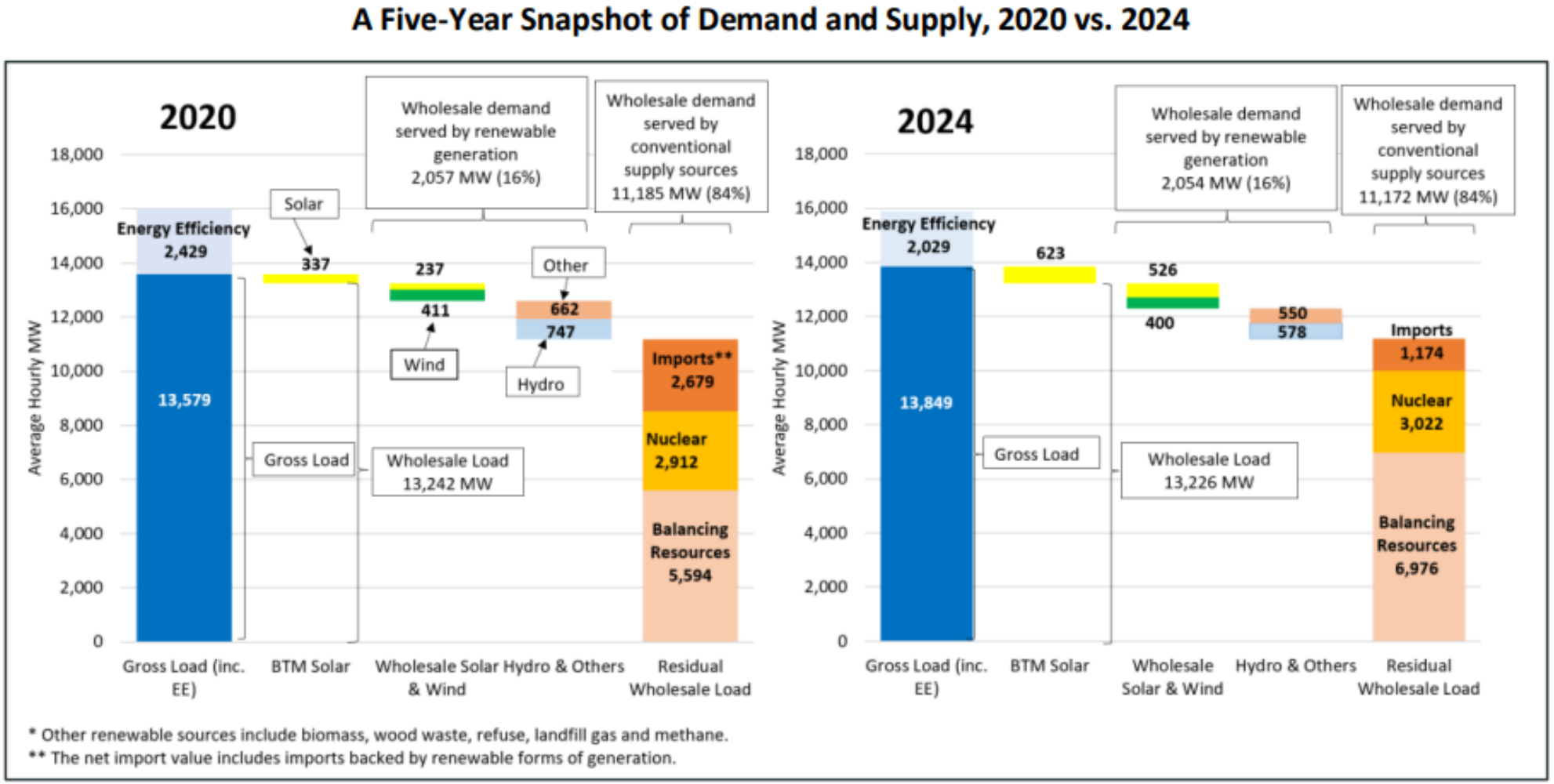
Natural Gas Prices Drive Electricity Prices

Figure 1: All-In Prices in RTO Markets[8]
2022 – 2024



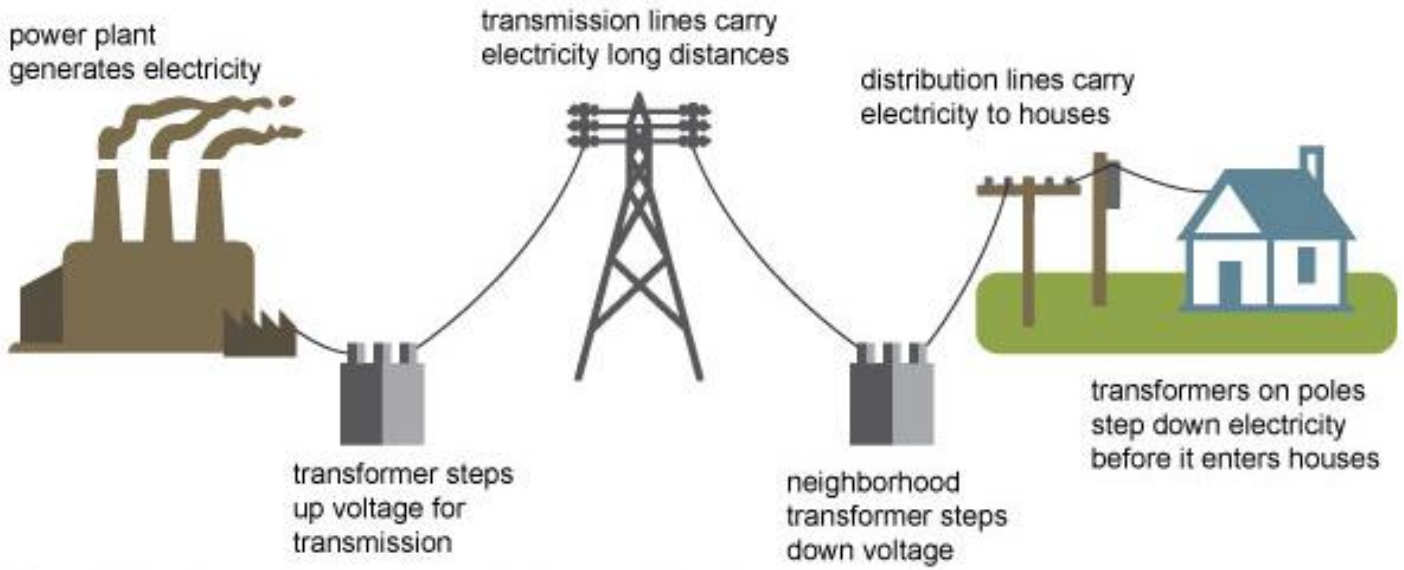
MASSACHUSETTS DEPARTMENT OF ENERGY RESOURCES

Energy Efficiency and BTM Solar Reduce System Load



Delivering Electricity – The Grid

The grid (transmission and distribution systems) bring power from generators to users



Source: Adapted from National Energy Education Development Project (public domain)

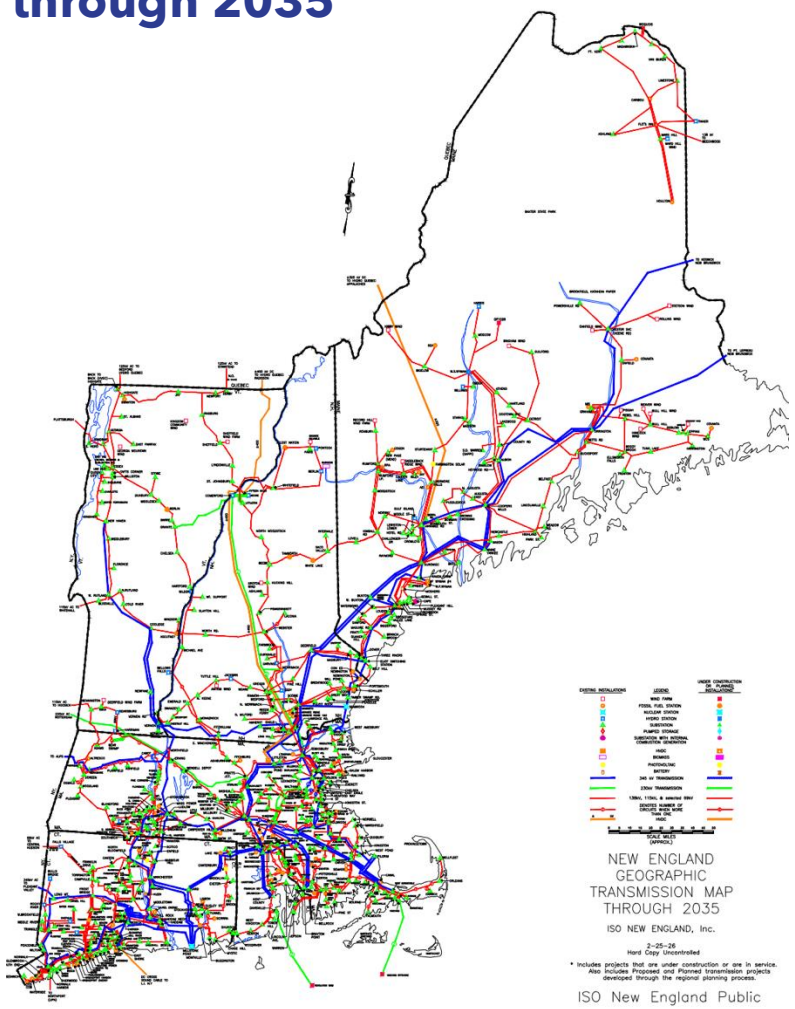
Transmission: High voltage infrastructure the transport electricity over long distances

Distribution: Lower voltage infrastructure that distributes electricity to you (what the "utilities" own and operate)

Transmission – Electricity Highways

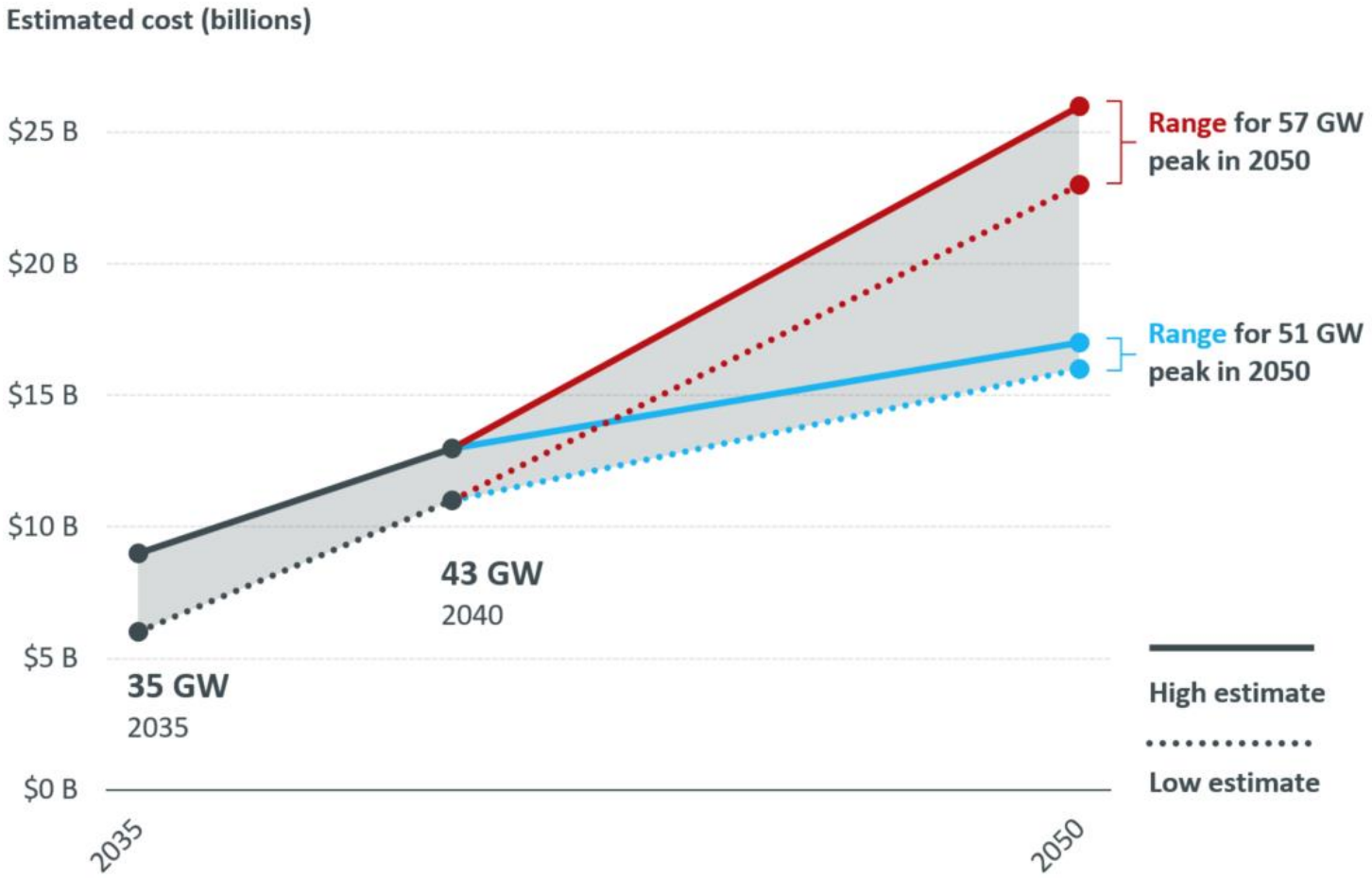
- High-voltage infrastructure for transporting electricity over long distances. Higher voltage = lower losses
- The transmission system is built out to handle peak demand – e.g., the maximum need to transport energy to users
- Owned and maintained by transmission companies, which are distinct from distribution companies (but may have same parent company)

ISO-NE transmission system through 2035



Transmission – Looking Forward

Increasing the peak demand necessitates expensive new infrastructure investments



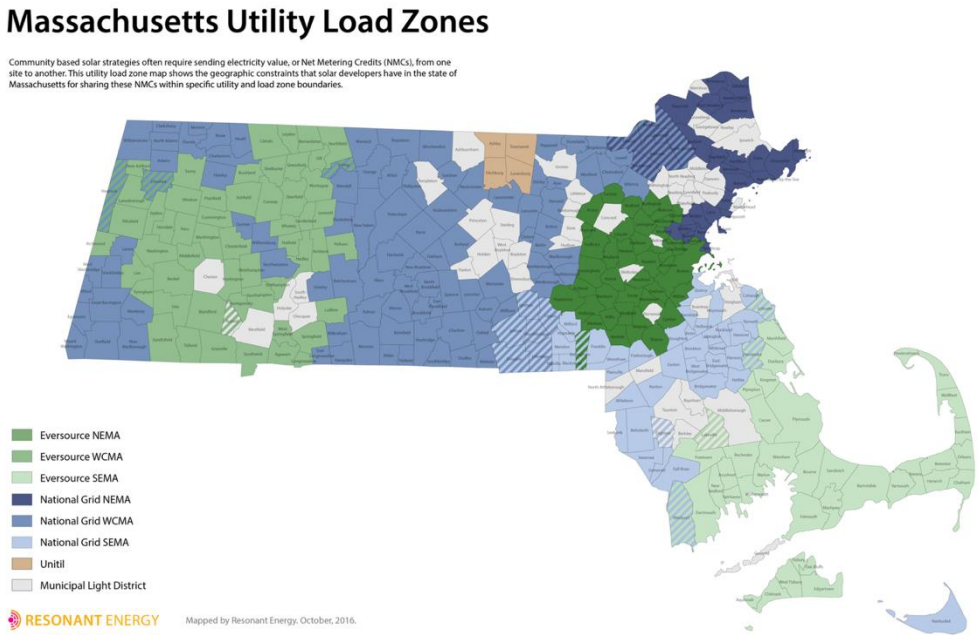
ISO-NE estimates that unmanaged load growth will require **$7-9 billion in new transmission costs**

Source: Charles Dawson, DOER. Expert Presentation Session on Performance Mechanisms (Nov. 2025), p. 52.

Source: ISO-NE, 2050 Transmission Study (Feb. 2024), Figure 2-1, p. 16

Distribution – The Last Mile

- Steps voltage down from transmission levels to usable levels.
  - substations, transformers, poles, wires, and meters
- Owned an operated by electric distribution companies (EDCs).
  - three investor-owned EDCs in MA: Eversource, National Grid, and Unitil
  - some towns have their own small utilities, called municipal light plants (MLPs)
- Distribution is where most outages occur and where most grid modernization is happening
- Rooftop solar and batteries push power back onto distribution lines



Any Questions?

Cost Recovery

Ratemaking determines who pays for what

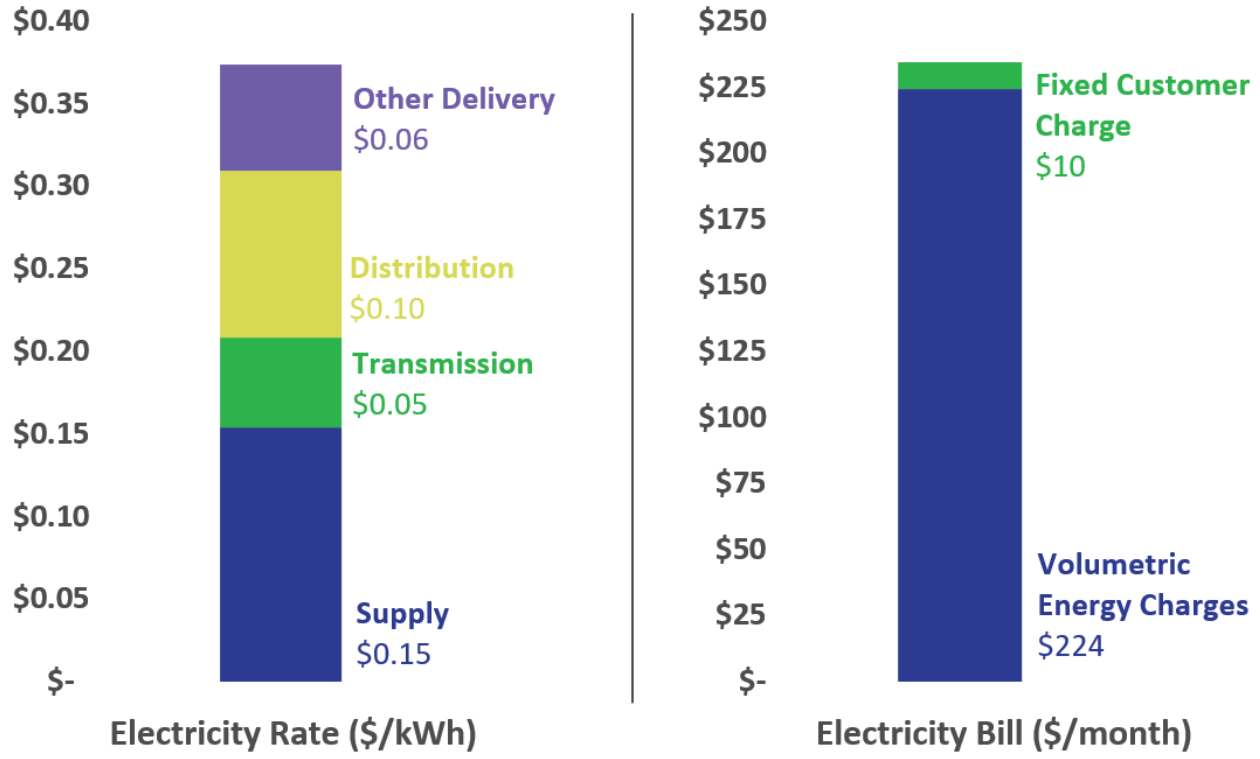
Rate Design

Rate design is an exercise in deciding how we recover the costs associated with supplying and delivering electricity, traditionally through a combination of **volumetric** and **fixed** charges

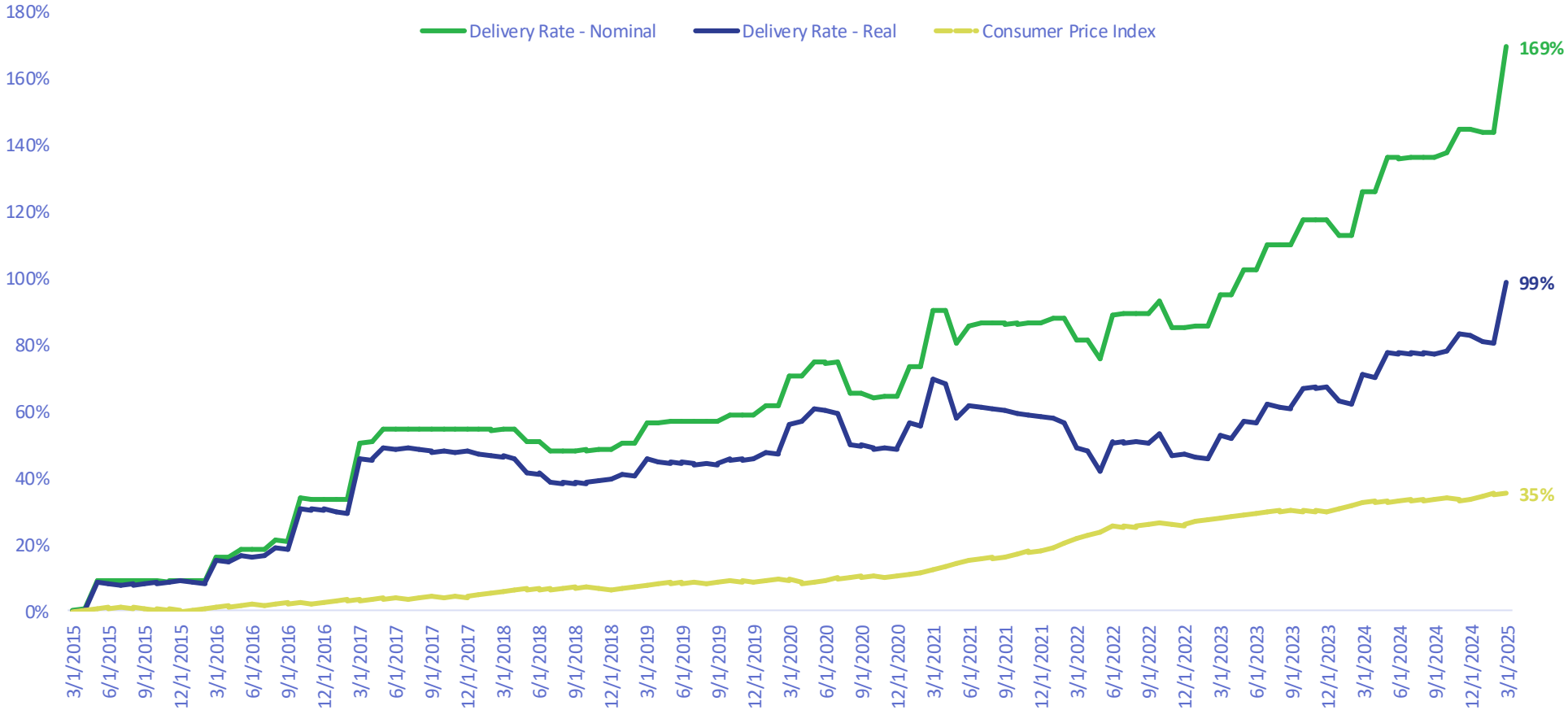
- **Volumetric charges** scale with how much electricity a customer uses. For example, a customer who consumes 300 kWh will pay half as much in volumetric charges as a customer who consumes 600 kWh
- **Fixed/customer charges** are paid by customers regardless of how much they consume. For example, the 300kWh and 600 kWh customers will pay the same fixed charge

Most costs are charged volumetrically for residential customers

Illustrative Residential Electric Monthly Bill



Rates are going up faster than inflation



Supply – Three Options for Customers

Basic Service: EDC procures power on behalf of customers through periodic competitive solicitations

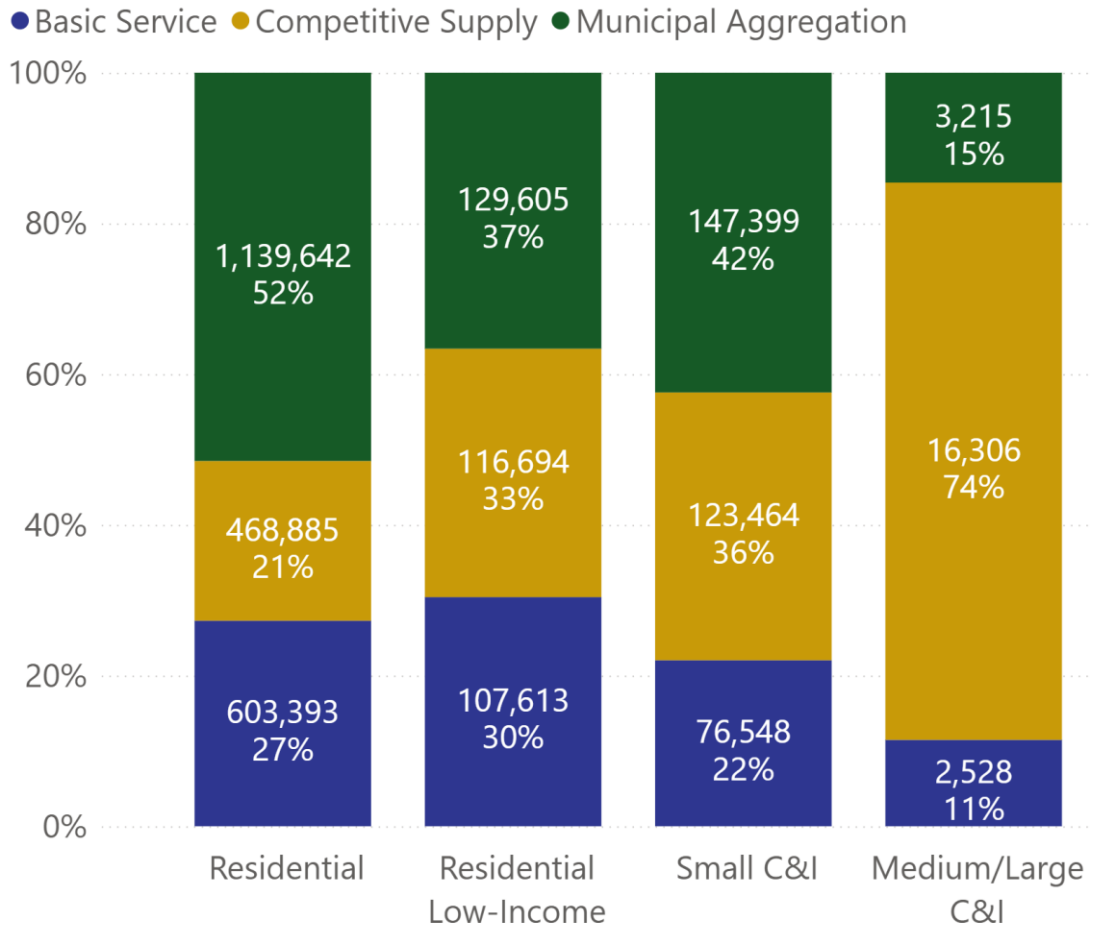
- price changes every 6 months for residential customers.
- DPU approves the rate

Municipal Aggregation: municipality contracts with a supplier on behalf of constituents

- Contracts of 1-3 years
- Price often slightly lower than Basic Service, but savings are not guaranteed
- DPU regulates muni aggs but does not dictate contracts

Competitive Supply: customer contracts directly with a third-party supplier

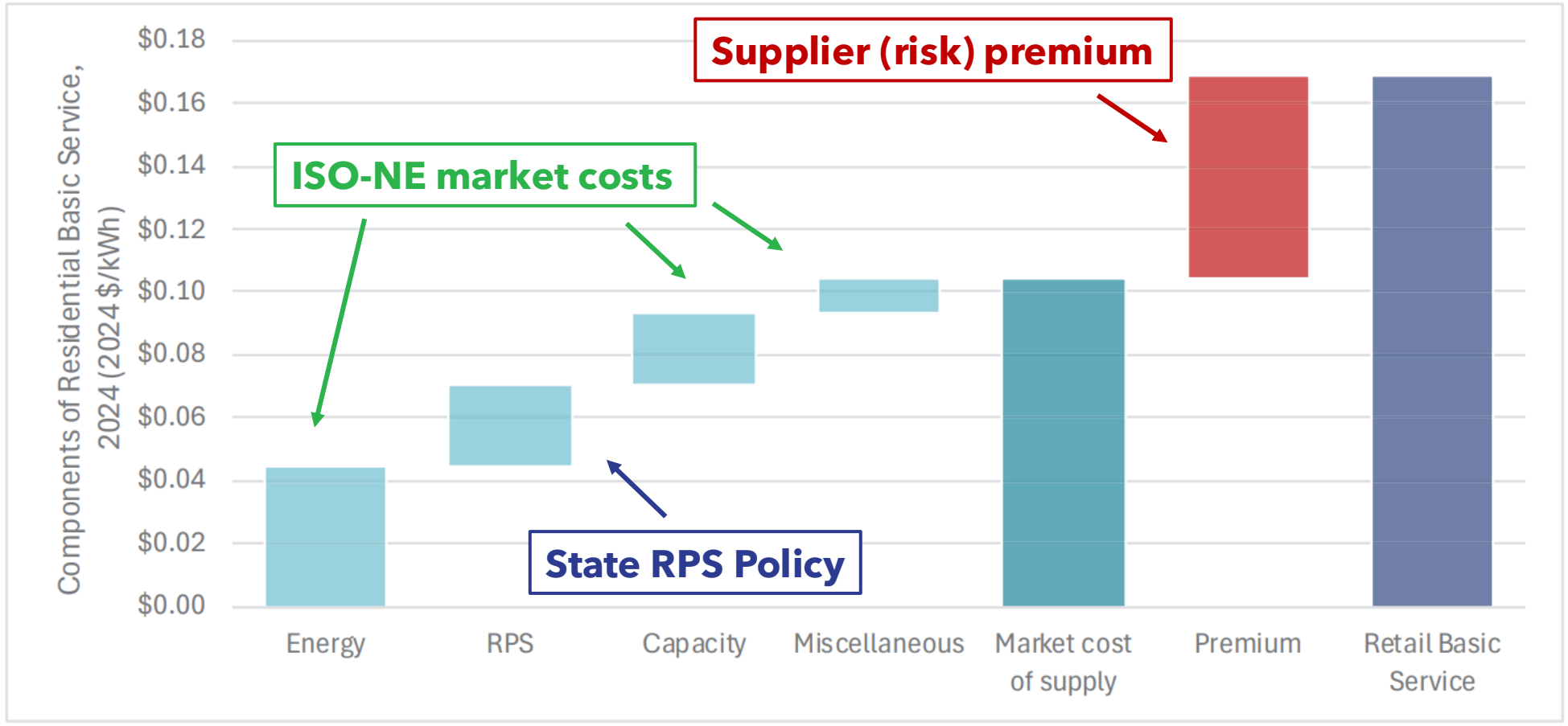
- Track record of exploiting customers – offer sweat deal upfront then quietly raise price



MASSACHUSETTS DEPARTMENT OF ENERGY RESOURCES

Supply Rate Breakdown

Figure 1. Average cost of supply and Basic Service rate components for residential customers, 2024



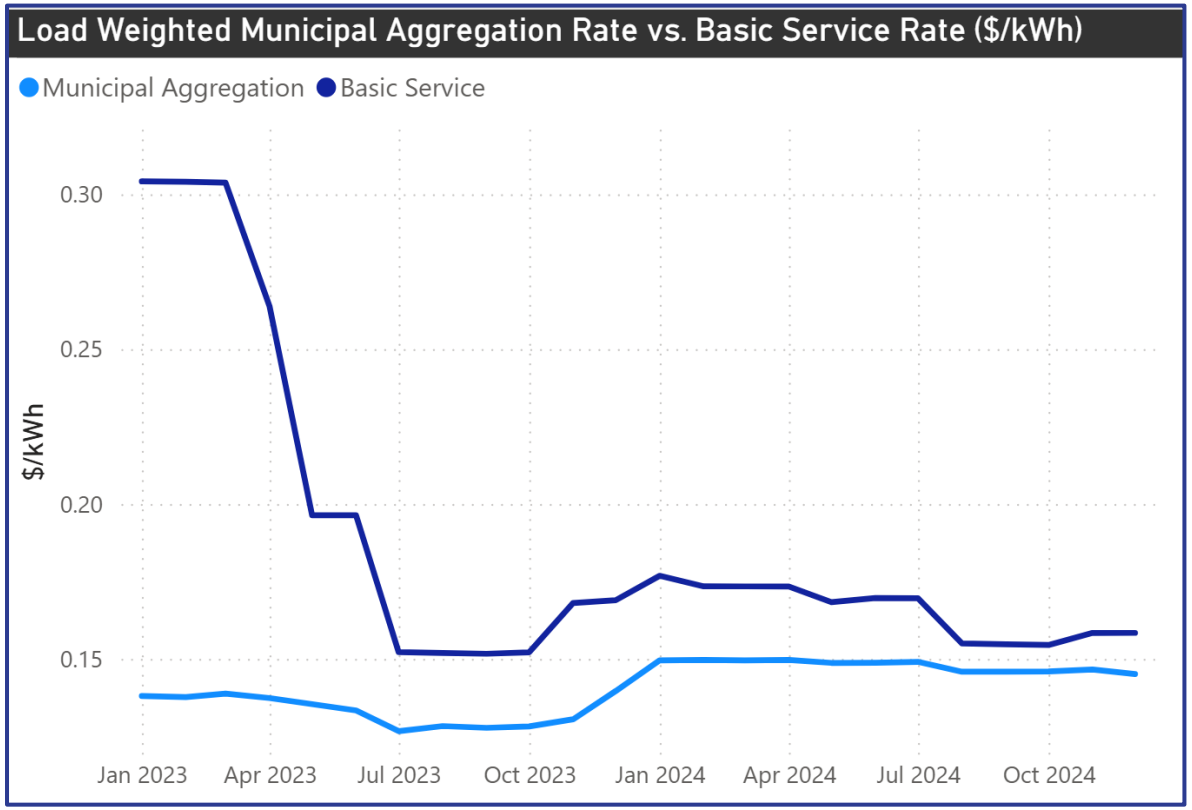
Source: Synapse Energy Economics, Overcharged Report (2026)

Municipal Aggregations

- Municipal Aggregations often offer a lower supply rate than basic service
  - Longer contracts
  - Less risk (basic service serves as last resort)

- DOER published a *Municipal Aggregation Manual & Best Practices Guide* (Guide) to help municipalities navigate aggregation

- The Guide identifies three options for supporting clean energy
  1. Fund a local clean energy project
  2. Purchase additional MA Class I Renewable Energy Certificates
  3. Fund an energy manager



Transmission Rates

All customers pay a transmission rate based on their "rate class" - e.g., residential, residential low-income, small C&I, large C&I, etc.

Setting transmission rates

1. The **Federal Energy Regulatory Commission Regulates (FERC)** regulates **transmission owners** and approves their costs
2. Costs are socialized across all New England customers. **ISO-NE** determines cost allocation
3. **EDCs** propose how to allocate transmission costs among rate classes, and develop rates accordingly
4. **DPU** approves the EDC's proposed transmission rates in annual transmission reconciling tariff filings

Transmission Costs and Rates, Eversource 2026

	Total (a)	R-1/R-2 (b)	G-1 (c)	G-2 (d)	G-3 (e)
Total Transmission Expense to be Recovered	$861,810,647				
Coincident Peak Allocator	100.00%	53.61%	8.92%	11.07%	26.03%
Allocated Total Transmission Expense	$861,810,647	$462,048,998	$76,884,619	$95,439,281	$224,348,616
2026 Optional Coincident Peak Transmission Expense Factor per kW					$21.91
Forecasted kWh Sales - March 2026 through February 2027	19,983,405,956	8,455,943,350	2,247,792,830	2,719,290,692	6,491,900,963
2026 Net Transmission Charge per kWh	$0.04312	$0.05464	$0.03420	$0.03509	$0.03455

Distribution Rates

All customers pay a distribution rate based on their rate class

- The **DPU** regulates **EDCs** and approves their investments in **rate cases,** which result in
  - **Rate base**: how much money the utilities are allowed to earn a profit on
  - **Rate of return**: how much profit they earn (% of rate base)
- EDCs propose and DPU approves how to allocate distribution costs to rate classes and develop rates accordingly
- Distribution costs recovered via volumetric ($/kWh) and fixed charge ($/month)

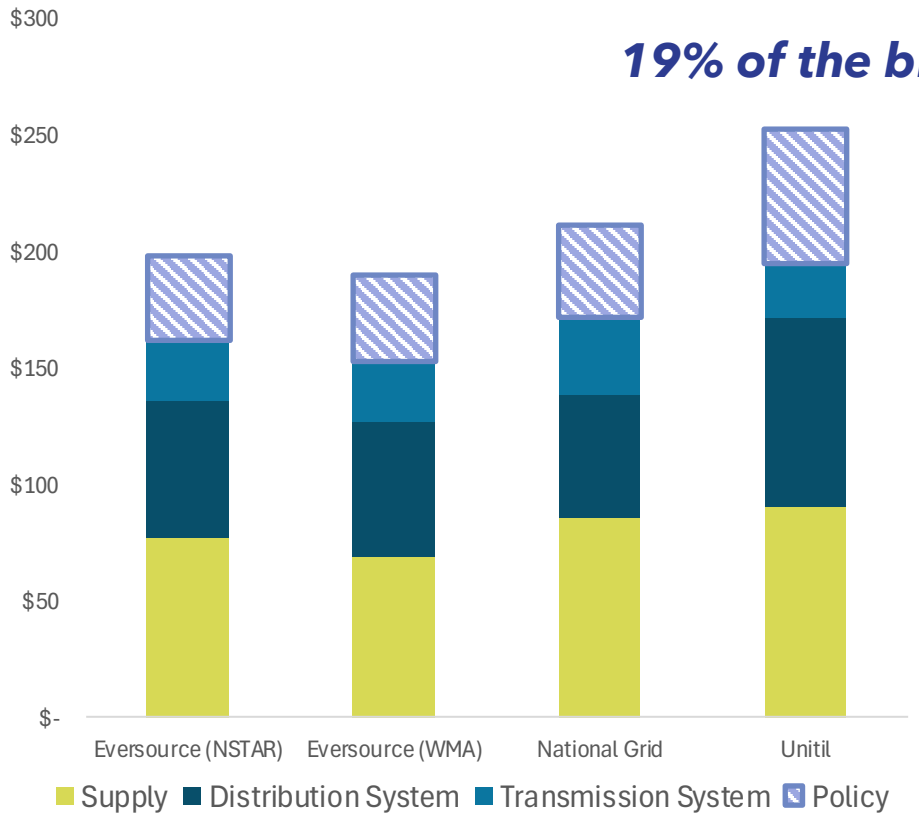
Rate Base and Rate of Return, Eversource

E. Schedule 4 – Rate Base and Return on Rate Base

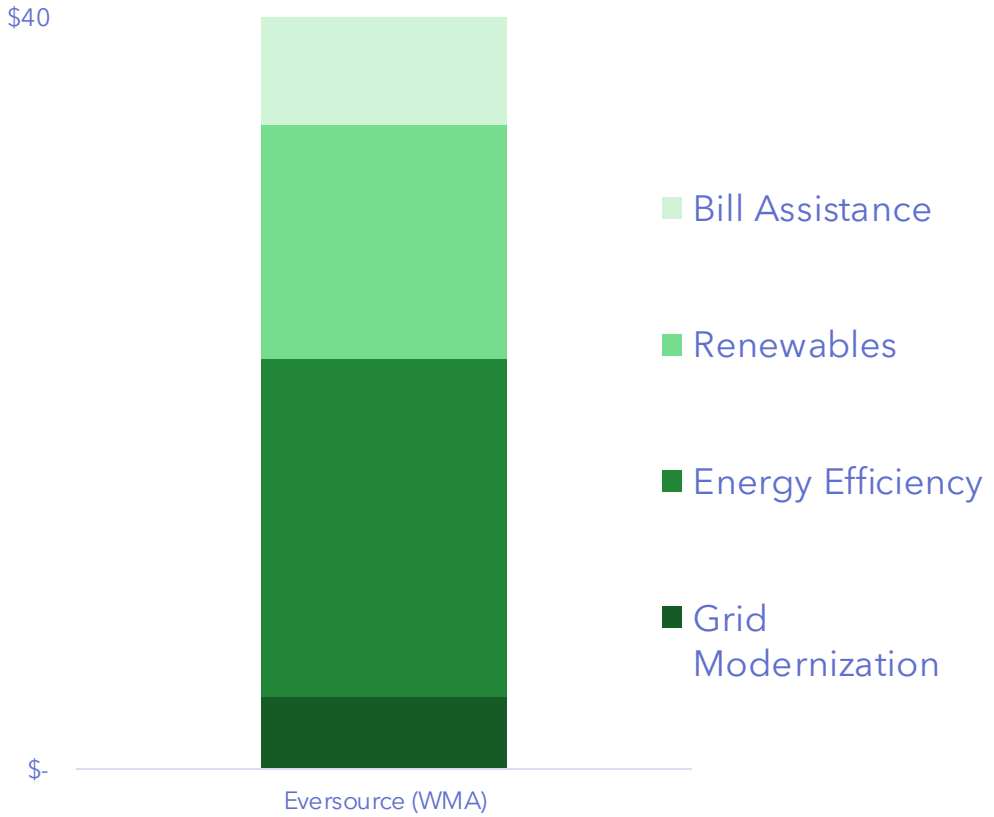
	PER COMPANY	COMPANY ADJUSTMENT	DPU ADJUSTMENT	PER ORDER
Utility Plant in Service	8,158,167,577	(257,233,638)	(328,863,241)	7,572,070,698
LESS:				
Reserve for Depreciation	2,611,720,164	(62,449,509)	(120,017,193)	2,429,253,462
Reserve for Amortization	49,613,183	(2,196,844)	0	47,416,339
Net Utility Plant in Service	5,496,834,230	(192,587,285)	(208,846,048)	5,095,400,897
ADDITIONS TO PLANT:				
Cash Working Capital	53,688,003	1,276,279	(3,616,840)	51,347,443
Materials and Supplies	52,956,389	4,165,283	0	57,121,672
Total Additions to Plant	106,644,392	5,441,562	(3,616,840)	108,469,115
DEDUCTIONS FROM PLANT:				
Reserve for Deferred Income Tax	733,301,500	11,030,397	(47,343,789)	696,988,108
FAS 109 Regulatory Liability (net)	560,994,216	(28,674,651)	0	532,319,565
Customer Deposits	5,032,962	(789,353)	0	4,243,609
Customer Advances	40,487,331	(237,788)	0	40,249,543
Total Deductions from Plant	1,339,816,009	(18,671,395)	(47,343,789)	1,273,800,825
RATE BASE	4,263,662,613	(168,474,328)	(165,119,099)	3,930,069,187
COST OF CAPITAL	7.32%	0.11%	-0.37%	7.06%
RETURN ON RATE BASE	**311,997,775**	**(7,753,952)**	**(26,938,141)**	**277,305,682**

Electric bills include climate and affordability policies

Monthly Bill by Utility



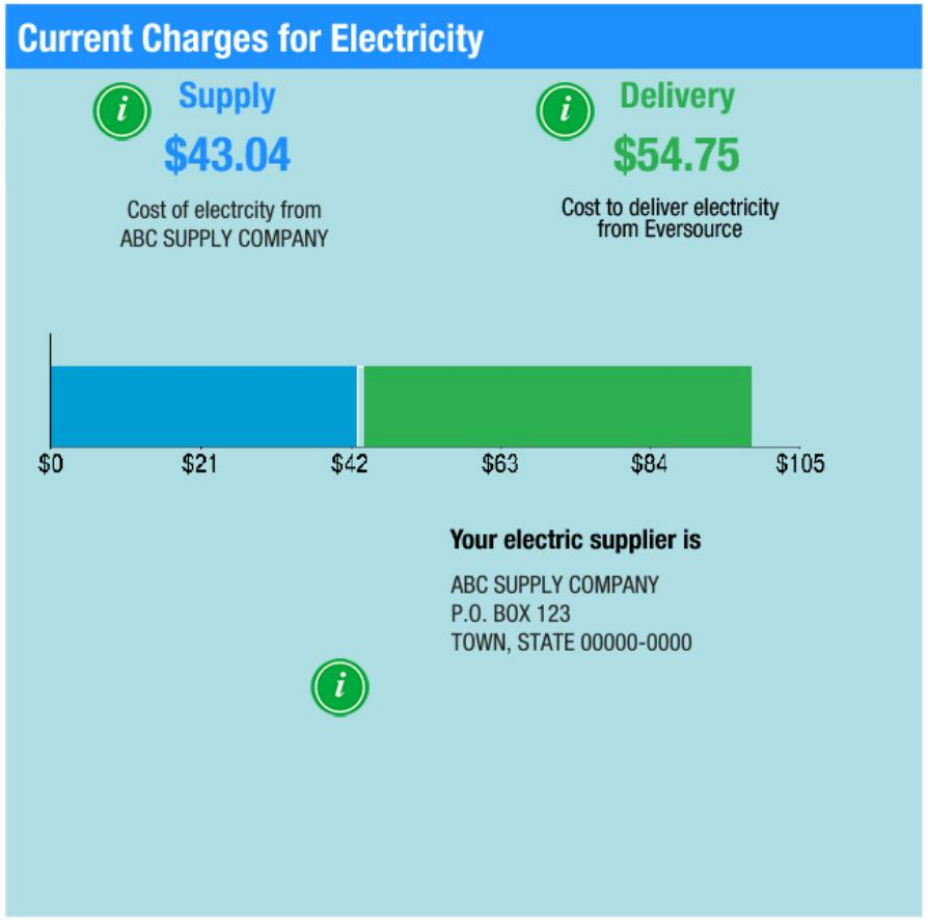
Breakdown of Policy Costs on Monthly Bill



MASSACHUSETTS DEPARTMENT OF ENERGY RESOURCES

Learning Check – Unpacking a Bill

Illustrative Residential Customer Bill, Eversource



Total Charges for Electricity

Supplier (ABC SUPPLY COMPANY)
Meter 000000000

Generation Service Charge	422 kWh X .10200	$43.04
Subtotal Supplier Services		$43.04

Delivery
(Rate 06 G1 SMALL GENERAL SERV NONDMD)
Meter 000000000

Customer Charge		$15.00
Distribution Charge	422 kWh X .05020	$21.18
Transition Charge	422 kWh X -.00411	-$1.73
Transmission Charge	422 kWh X .03149	$13.29
Revenue Decoupling Charge	422 kWh X .00212	$0.89
Distributed Solar Charge	422 kWh X .00327	$1.38
Renewable Energy Charge	422 kWh X .00050	$0.21
Energy Efficiency	422 kWh X .01073	$4.53
Subtotal Delivery Services		$54.75
Total Cost of Electricity		**$97.79**

Other Charges or Credits

SALES TAX	$2.69
Subtotal Other Charges or Credits	$2.69

EM 230220.TXT

Supply

Distribution

Transmission

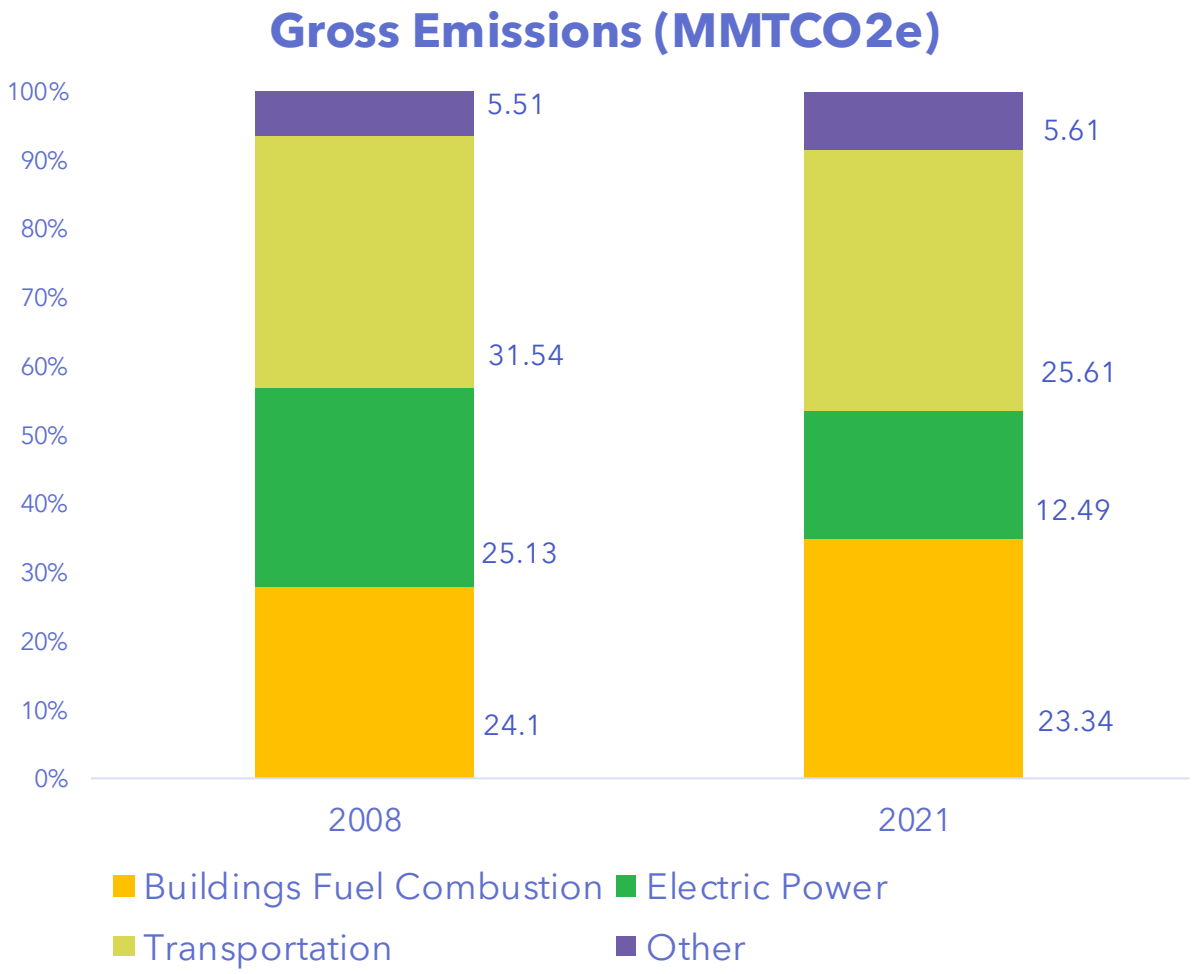
Policy

Any Questions?

Managing Emissions and Energy Bills

Policies, Programs, and the Future of Electric Rates

Emissions Sources in MA



- Electric power emissions have more than halved since 2008
- The bulk of emissions currently come from heating and transportation
- Electrifying fossil heating and transportation is the most cost-effective climate pathway, even with the current generation mix

Electrification is the Most Cost-Effective Climate Pathway

Scenario	Upfront Total Cost	Net Change in Emissions	Upfront Ratepayer Cost	Ratepayer Cost of Emission Reductions
Baseline (Gas Heating)	-	-		-
Solar (6kW)	$18,000	(2.07) MT CO2	-	$783 /MT CO2
Energy Efficiency	$2,267	(0.82) MT CO2	$2,267 (Mass Save)	$444 /MT CO2
Energy Efficiency & Heating Electrification	$22,267	(1.7) MT CO2	$12,267 (Mass Save)	$409 /MT CO2
All-of-the-Above (11kW)	$90,267	(9.42) MT CO2	$15,767	$360 /MT CO2
Heating Electrification	$20,000	(1.11) MT CO2	$10,000 (MassSave)	**$149 /MT CO2**
Vehicle Electrification	$35,000	(3.53) MT CO2	$3,500 (MOR-EV)	**($56) /MT CO2**
Vehicle and Building Electrification	$55,000	(4.64) MT CO2	$13,500	**($7) /MT CO2**

Notable Policies and Programs

For Energy Managers+

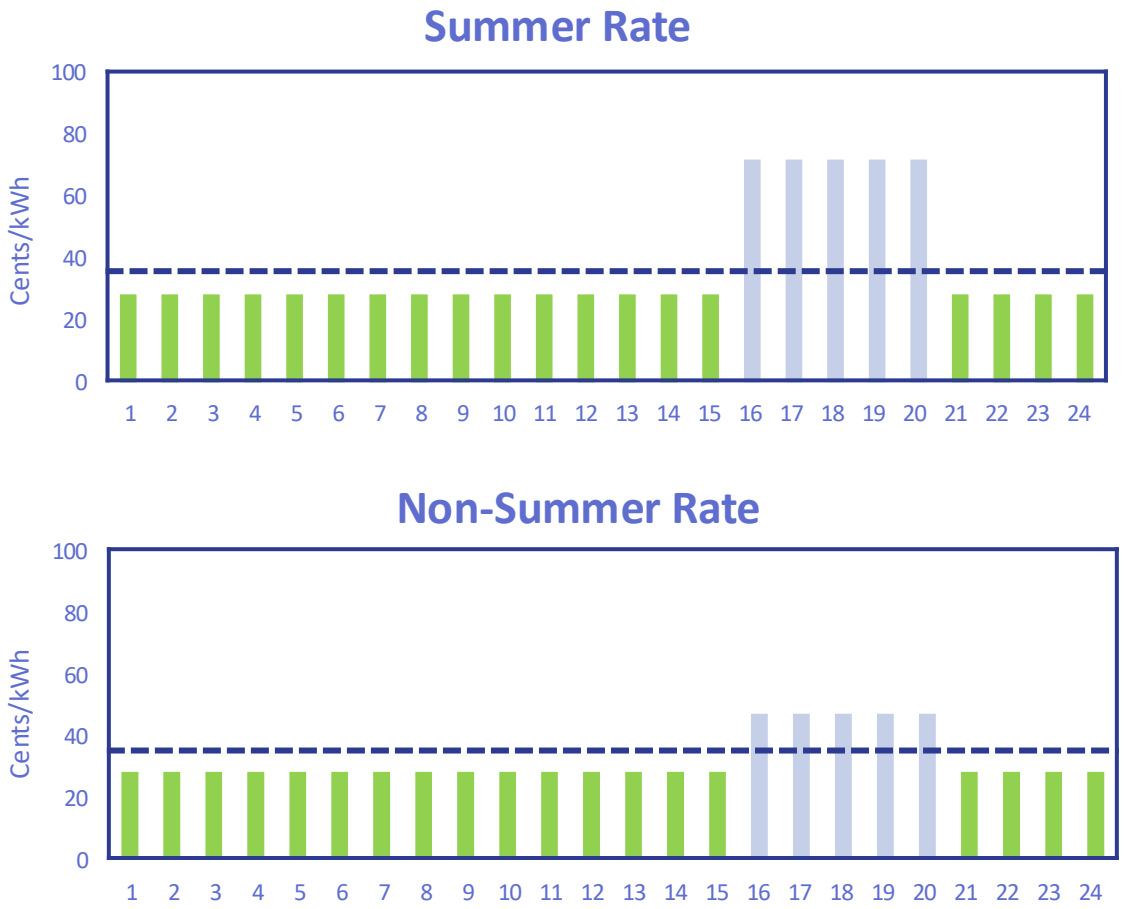
- **Energy Efficiency**
  - **Mass Save:** rebates, audits, technical support, and incentives to reduce energy use through efficiency upgrades and get heat pumps
- **Distributed Energy Resources (DER) Incentives**
  - **Solar:** SMART, net metering
  - **Batteries:** ConnectedSolutions
- **Green Communities:** grants and technical support for energy efficiency and renewables projects
- **Leading by Example:** standards and guidance, including building codes, for being a climate leader
- **Municipal Aggregation** to reduce supply rate

Just for Residents

- **Heat Pump Rate:** lower rate during winter to reduce uneconomic cost-shift and make competitive with fossil heating
- **Low-Income Discount Rate:** discounts electricity and gas bills for income-eligible households to reduce energy costs

Looking Forward – Time-of-Use (TOU) Rates

Illustrative TOU rate based on National Grid (2025)



Empower customers to manage their electric bills

Short-term savings from shifting load away from peak

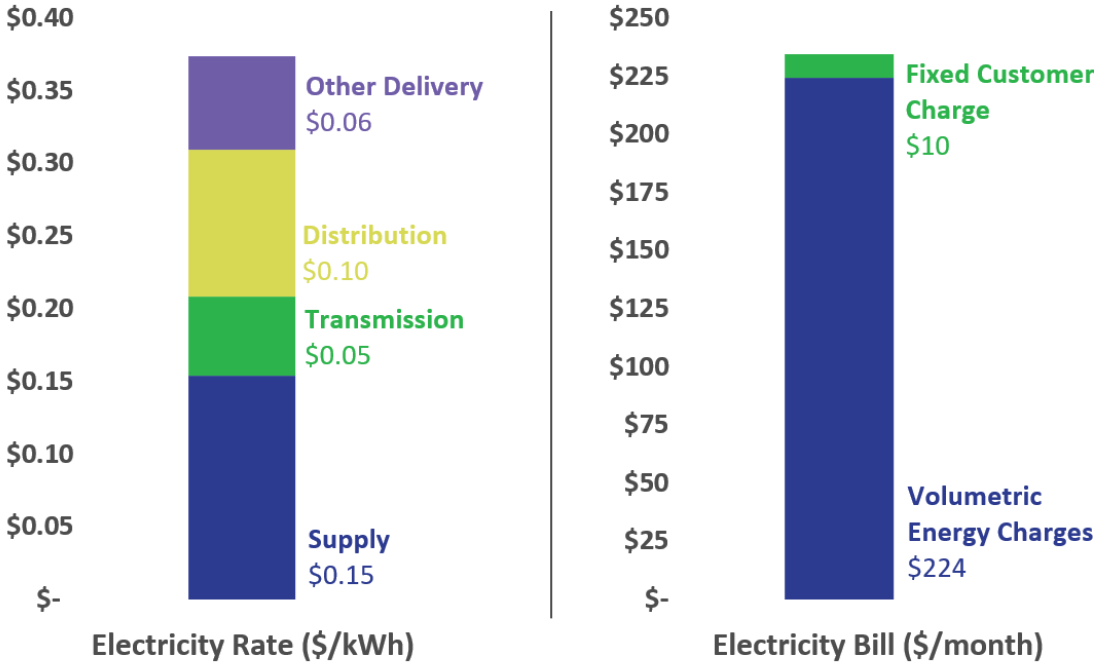
- Reduces wholesale market energy costs
- Reduces allocation of capacity and transmission costs to MA customers

Long-term saving from avoiding the need for new infrastructure to accommodate load growth, including transmission, capacity, and distribution

*This illustrative example has a 1:1.5 peak ratio for distribution costs. In practice, this differential can be identified via a marginal cost of service study

Summary – Costs and Cost Recovery

Illustrative Residential Electric Monthly Bill



Core Electric Costs

- **Supply:** ISO-NE wholesale markets for energy and capacity
- **Transmission:** high voltage, regional system to transport electricity over long distances
- **Distribution:** low-voltage, local system to distribute electricity to users

Cost Recovery

- *Mainly recovered via **volumetric** charges*
- **Supply:** Wholesale market costs flow through to consumers. Choice of Basic Service, municipal aggregation, or competitive supplier
- **Transmission:** Federal government regulates costs; ISO-NE allocates them; and DPU approves rates
- **Distribution:** DPU regulates costs and rates; EDCs own, operate, and profit from infrastructure

Summary - Reducing Bills and Emissions

Decarbonizing and Managing Energy Costs

- Electrification and energy efficiency are key to accomplishing our climate goals
- Massachusetts offers numerous programs to support electrification, energy efficiency, and DERs while realizing savings
  - Mass Save, Green Communities, SMART, Net metering, ConnectedSolutions, Leading by Example
- Advances in design (e.g., TOU rates) will empower customers to manage their own bills and reduce total system costs

Resources

- Mass Save: resources for *energy saving opportunities*
- Mass Save: training on *energy modeling* for compliance with the stretch code
- Eversource: webinars and tools to understand *electric bills* and *natural gas* bills.
- *ISO-NE 101*: self-paced training on electricity markets
- DOER *Ratemaking Straw Proposal* on the future of rate design
- DOER *Municipal Aggregation Guide*

Questions?

MASSACHUSETTS
DEPARTMENT OF
ENERGY RESOURCES

Thank You

Municipal Energy and Sustainability Managers ACADEMY

Supplemental Slides

Recap

Generation

- **ISO-NE** administers the markets
- **Generators** operate power plants and bid into markets
- **Suppliers** provide contracts for supply service to users
  - **EDCs** procure Basic Service, the default supply offering
  - **Municipal aggregations** may work with a supplier to contracts for their customers
  - **Third-party suppliers** contract with individual customers

Transmission

- The **Federal Energy Regulatory Commission (FERC)** regulates transmission owners
- **ISO-NE** allocates the cost of transmission system across the region
- The **Department of Public Utilities** approves EDC proposal for how to recover those costs from MA customers via rates

Distribution

- **Electric distribution companies** (EDCs) own and operate the distribution system
- **DPU** regulates the EDCs, including how much money they spend and their profits, and approves rates

Cost Recovery Recap

Component	Underlying Cost	Regulator	Cost Recovery
Supply	Wholesale market costs associated with electricity generation and capacity	• FERC/NERC regulate powerplants • ISO-NE administers markets and dispatch	• Through supply contracts • DPU oversees Basic Service
Transmission	Regional, high-voltage transmission infrastructure	FERC	• ISO-NE allocates costs across region • EDCs propose allocation and rate by rate class; DPU approves.
Distribution	Poles, wires, etc. to deliver electricity from the transmission system to end users	DPU regulates EDCs and approves distribution cost in a rate case	• EDCs propose allocation and rate by rate class; DPU approves
Other/Policy	Climate, affordability, and other programs	DPU, sometimes dictated by law	• Costs allocates and rates set by rate class

Next Steps

- Please take 3-5 mins to please complete the anonymous evaluation form (link in chat)

Upcoming Events:

- **Office Hours:** 3/25 (1-2pm)
- **Optional In-Person Heat Pump Training at Daikin Training Center:** 3/30 (9-12pm)
- **MassEnergize Conference:** 4/08
- **PLN: Clean Energy Tax Credits (w/ Undaunted K12):** 4/15

Municipal Energy and Sustainability Managers ACADEMY

Thank you!

Municipal Energy and Sustainability Managers ACADEMY

Q&A Notes

Q&A Notes

- Q: One of the municipalities' Community Choice Aggregation rates went up, will you help me make sense of that?
  - Through CCAs, municipalities decide to contract on behalf of their residents for the products that the utilities offer. The prices are a reflection of the market prices. Municipalities can time the market to enter contracts to secure electricity at comparable rates. They can also sign longer contracts.
  - *Did the rate go up mid –contract?*
    - The price increased recently before the contract was signed. Although the prices were fixed, there have been some that have increased, it is a rare thing to happen.
    - This could be a Day-Ahead Services Initiative (DASI) true up – an adjustment that corrects the difference between estimated costs charged and the actual costs of purchasing the services
  - CCA contracts can save munis money. In 2023, a lot of town saved on energy bill because the energy costs went up due to the war on Ukraine, but contracts had secured the prices

Q&A Notes Contd.

- Q: Municipal Light Plants (MLPs) seem to have lower electricity prices than investor-owned utilities, is it due to the differences in their goals, such as not taking profits?
  - MLPs do have advantages in keeping prices lower, as their primary goal is to provide affordable electricity rather than generate profit. Basic service procurement for investor-owned utilities can be inefficient, with some contracts priced relatively high
  - Is it a function of their supply sources and commitments to supporting energy efficiency and renewable energy?
    - Yes, but to a lesser degree
  - IOU basic contracts gets out roughly 6 months, there are not many bidders. For ISO-NE, there are 25 sophisticated bidders which allows for lower premiums and cost lock-ins.
  - IOUs also pay into climate and energy affordability programs, which can account for 25% of all supply costs. MLPs do not pay into the same state programs
  - IOUs have to generate shareholder profits to secure a good rate of return. MLPs have a much lower rate of return (3-4%), not from shareholders but from municipal bonds.

Q&A Notes Contd.

- Q: Will the time of use rates be useful for tenants? How can affordability arguments be made for energy programs?
  - DOER is actively trying to communicate
  - Energy efficiency programs have reduced the load, without needing to build new infrastructure. When you consider things like carbon cost – these programs pencil out.
  - The question is how costs are paid, not so much whether the dollars are delivering the benefits. Currently, the costs are recovered volumetrically (based on sales), which is regressive, those who use less still pay proportionally more.
  - Cost recovery methods could be rethought; charges can be made more progressive and target assistance to those who need it most. For example, there could be fixed charges and tiered discount rates, when you apply tiered discount rates of 0 going upto 40% discount – we can get to progressive charges
  - Through DPU 25-200, DOER is saying we can rethink these recovery costs. The investigation will examine the causes of bill volatility and promote a greater understanding of rates for customers.

Q&A Notes Contd.

- Q: You mentioned a newer program for electricity rate – is that through utility or national grid. Do customers get automatically signed up?
  - A: There is verification that happens for households to quality for the lower income discount rate. Historically, it was you were low income or not, now NationalGrid has moved towards tiered brackets based on income.
- Q: Are there any resources similar to the cost saving table in slide 34 that shows financial impact/benefits for adopting specialized energy code?
  - A: Would have to check.
  - MAPC is developing some of these resources for a separate project, will distribute among MEMs when ready.