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Energy Security Improvements: Market Solutions for New England

Federal Energy Regulatory Commission Staff-Led Public Meeting

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New England Is Working Steadily to Meet The Commission’s Directive on Energy Security

- In July 2018, the Commission directed ISO New England “to develop **longer-term market solutions**” to the region’s energy security challenges*
- This presentation summarizes these challenges, the ISO’s proposed solution directions, and the region’s work ahead
- The ISO will file Tariff changes as directed on October 15, 2019

**ISO New England Inc.*, 164 FERC ¶ 61,003 at PP 54 (2018)

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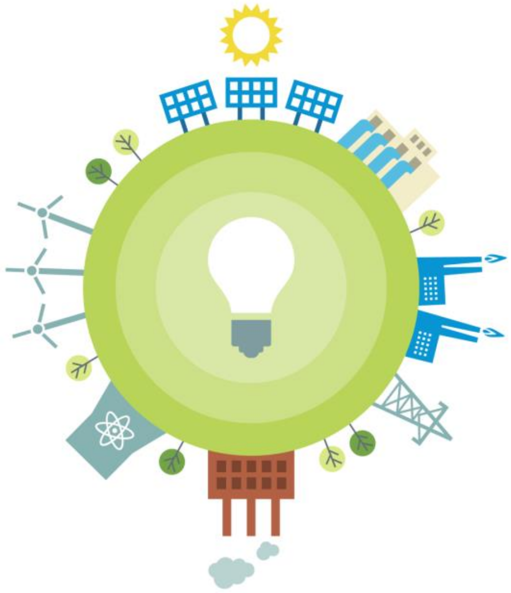
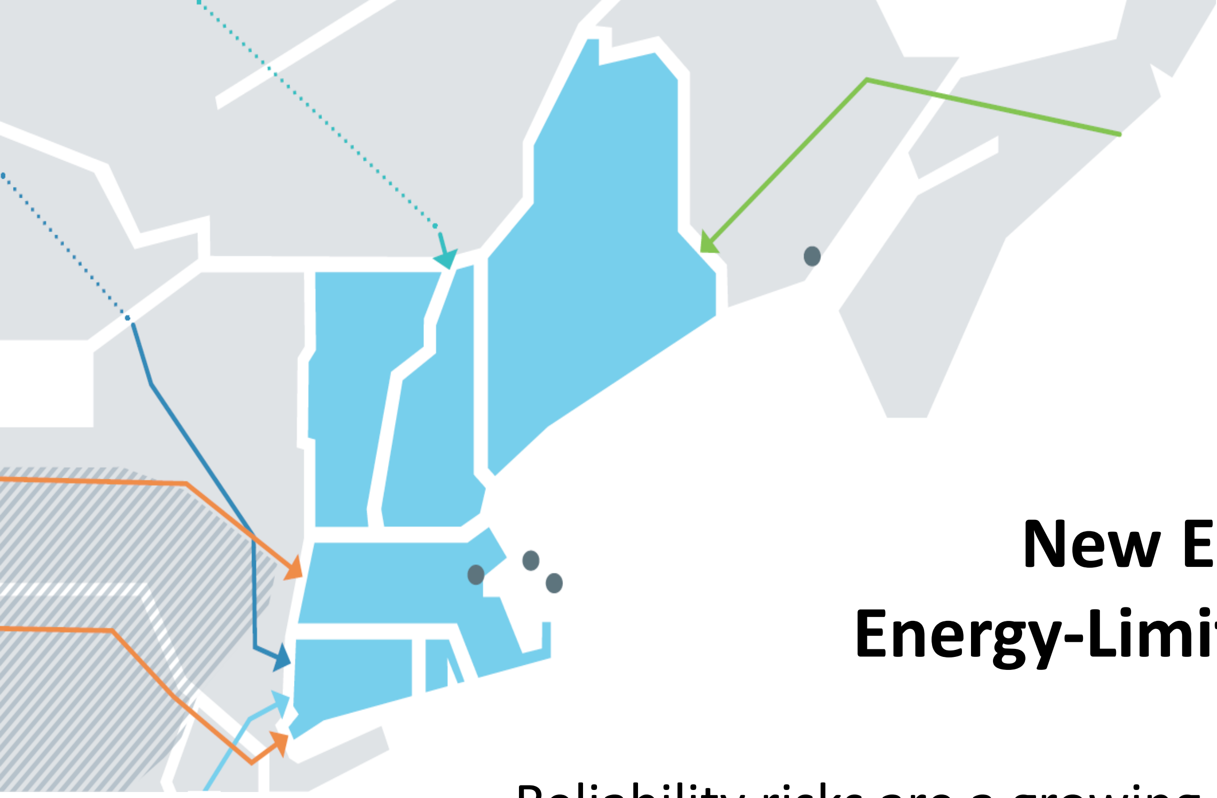


REGIONAL CHALLENGES & SOLUTION PRINCIPLES

Nexus of Renewables Growth and Fuel Infrastructure Limits



Key Points

New England is an Energy-Limited Power System

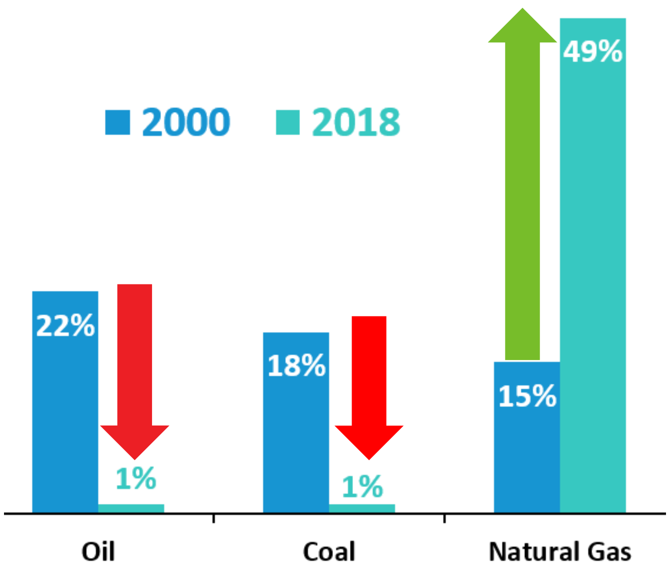
Reliability risks are a growing concern when

- Fuel delivery infrastructure is constrained, and/or
- Renewable resources experience adverse weather

Longer-term market solutions require innovative ideas

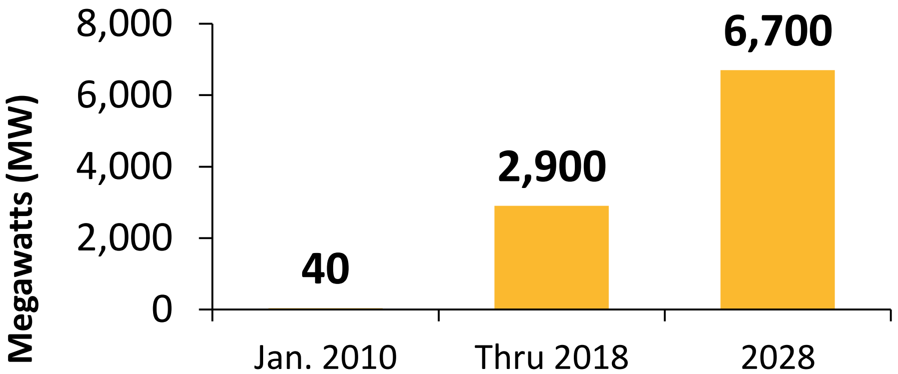
New England's Energy Mix Is Changing Dramatically

Gas has displaced oil and coal for electric generation …



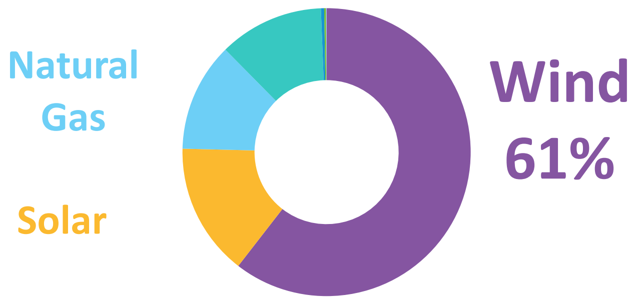
Source: *ISO-NE Net Energy and Peak Load by Source*
Electric generation within New England; excludes imports and behind-the-meter (BTM) resources, such as BTM solar.

… as solar grows steadily …



Source: *Final 2019 PV Forecast (March 2019); MW values are AC nameplate*

… and wind dominates the queue …

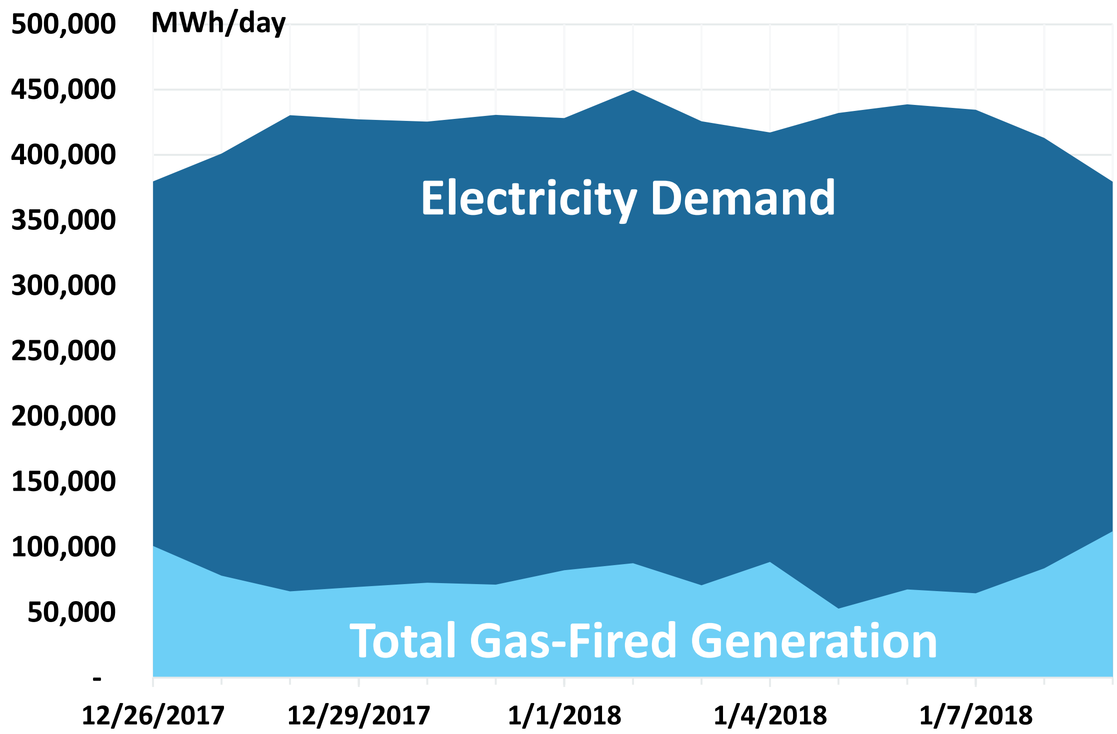


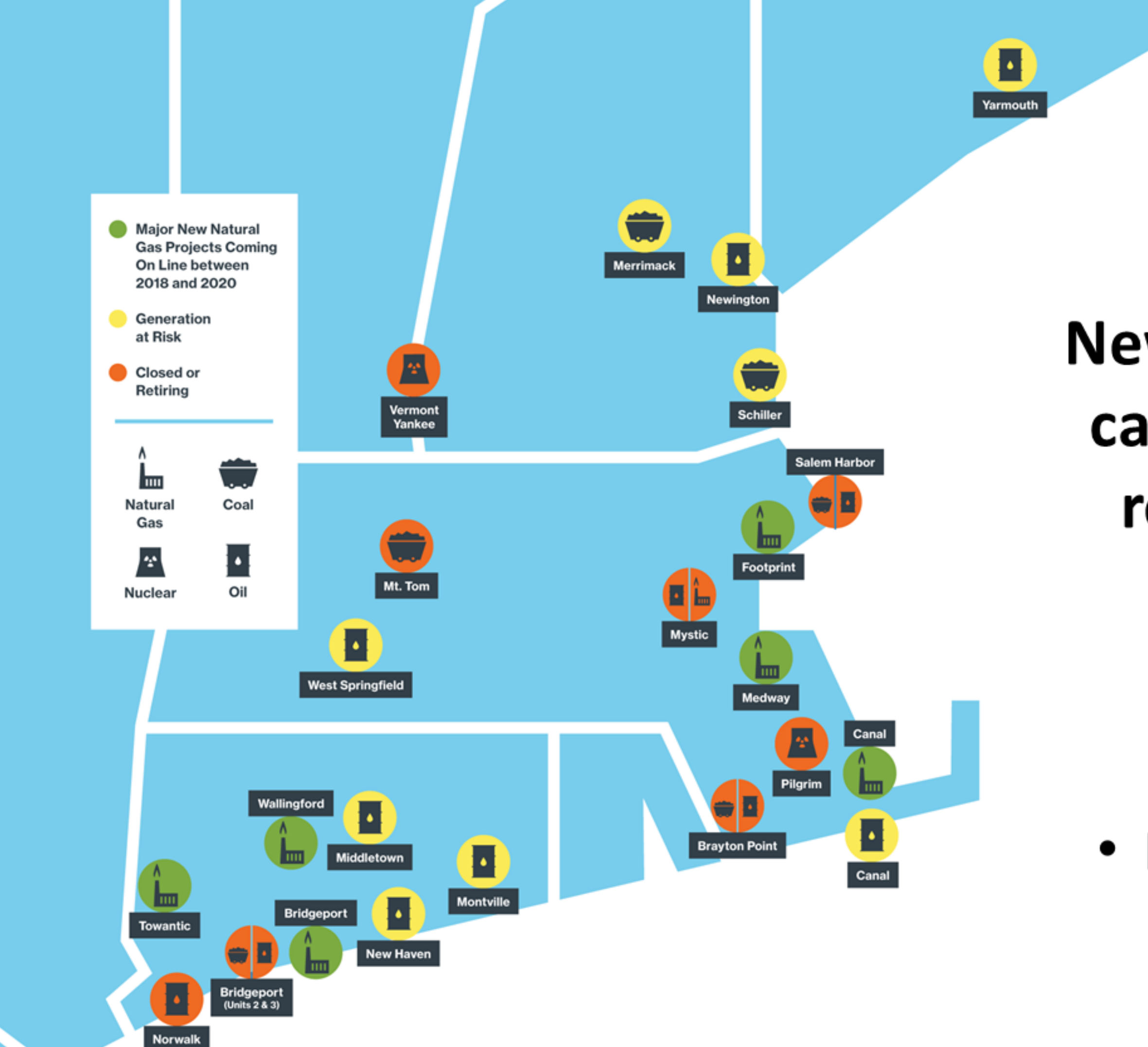
Source: ISO-NE Generator Interconnection Queue (June 2019)

During Cold Weather, Natural Gas-Fired Generation Supplies a Small Fraction of the Region's Electricity

- Gas-fired generation plummets during **extended cold** weather
- Remaining oil-fired and coal units presently cover that '**energy supply gap**'
- This may not be feasible in future years

Electricity Demand and Total Gas-Fired Generation
Dec. 26, 2017 – Jan 9, 2018





Nearly 25% of New England's generating capacity has announced retirement since 2013

- Predominantly coal, oil, and nuclear
- **More at risk of retirement**

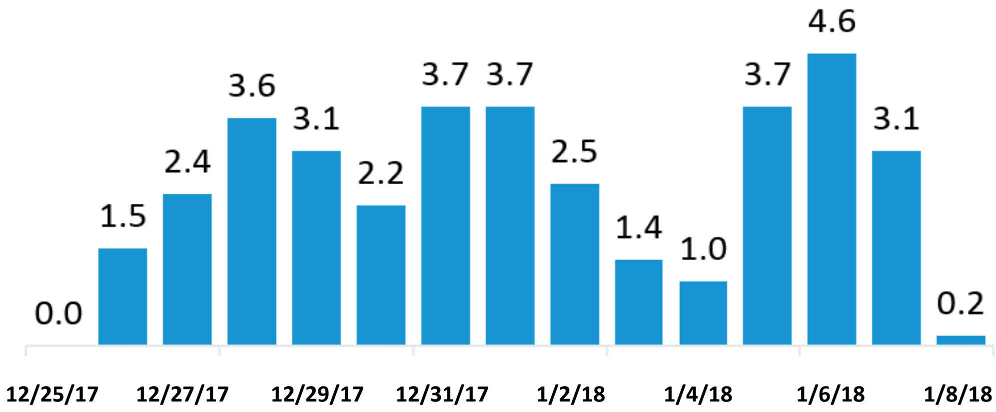
These have provided a key "margin" of stored energy in the past during cold winter conditions

Source: ISO New England 2019 Regional Electricity Outlook (March 2019)

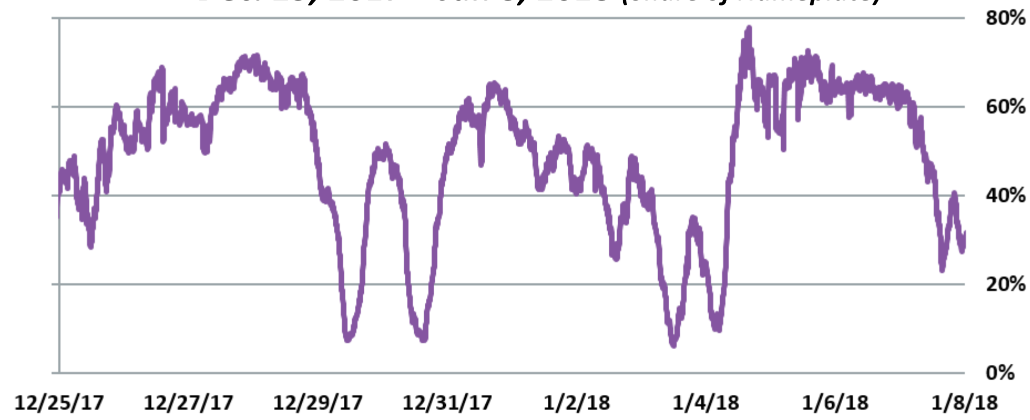
Cold Weather Exposes New Reliability Risks

- Natural gas generation is **severely limited** due to infrastructure constraints
- During **extended cold** weather, renewable energy output can be highly variable
- Both technologies rely on **just-in-time delivery** of their energy sources

Estimated Unavailable Natural Gas Generation Capacity (GW)
Dec. 25, 2017 – Jan 8, 2018



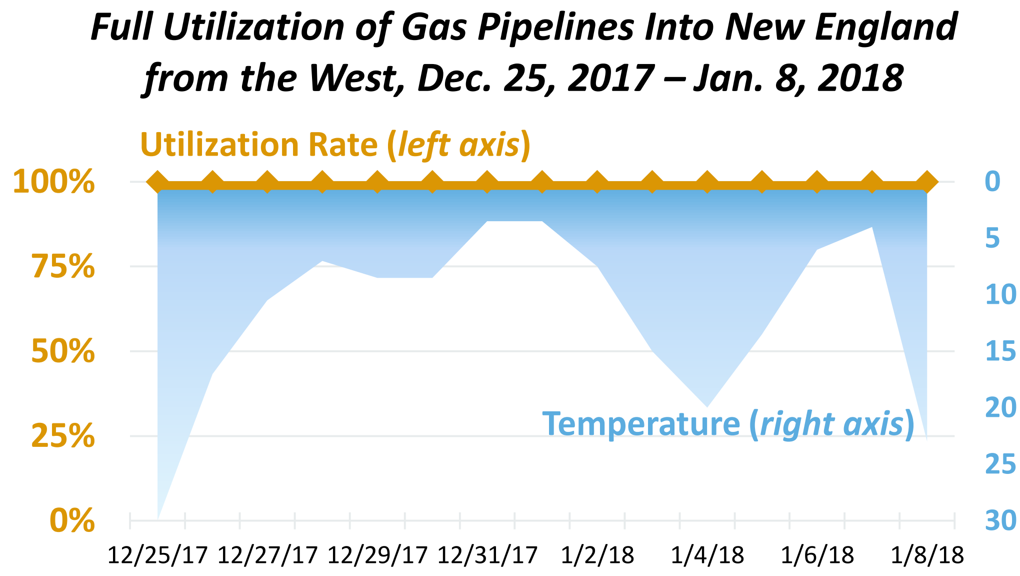
Output from Wind Fleet Generation –
Dec. 25, 2017 – Jan 8, 2018 (Share of Nameplate)

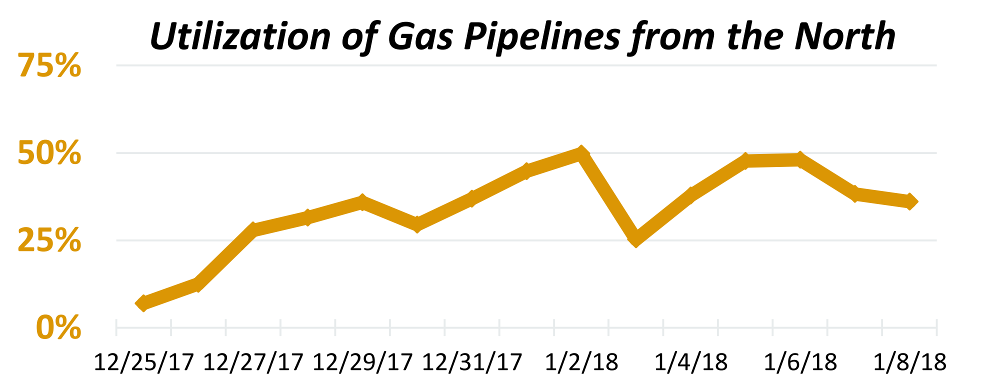


Sources: ISO-NE Cold Weather Operations (2/2018, p. 50); ISO-NE Seven Day Capacity Forecast, Anticipated Cold Weather Outages (12/25/17-1/8/18)

Key Fuel Delivery Infrastructure Operates at its Limits

- Gas pipelines reaching New England from the West are **fully utilized** in cold weather
- **Incremental energy supply** must come from other sources: LNG, oil, and/or (over time) more renewables
- There is **import capability** on LNG-served pipelines from the North and via LNG terminals





Sources: ISO-NE calculations and Genscape.
Notes: Imports from the west are totals for AGT, TGP, and IRQ pipelines into New England; imports from the north are for M&N from Canaport

Just-in-Time Technologies Present New Challenges

- ***Risk***: Ensuring the grid has sufficient energy "on demand" to power New England….

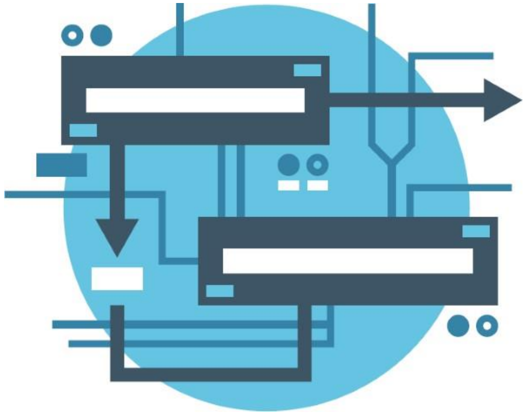
  … *when* much of our "just-in-time" gas-fired and renewable technologies may be unavailable ***simultaneously***

- ***Today***: No loss-of-load in New England attributable to insufficient energy supplies to date

- ***Looking forward:*** Industry trends will increase this risk over time, unless solutions are developed proactively

Sound Solutions Require Clear Objectives

Goal: Create a proactive, long-term solution that enhances



- ✓ **Reliability**
  Reduce the heightened risk of unserved electricity demand
- ✓ **Cost-effectiveness**
  Leverage established markets and efficiently use the region's infrastructure
- ✓ **Sustainability**
  Facilitate innovation that can reduce this risk as technology continues to evolve

Design Principles for Longer-Term Market Solutions

1. **Product definitions should be specific, simple, and uniform,** regardless of the technology that provides it
2. **Transparently price the desired service**
3. **Reward outputs, do not specify the inputs,** to foster competition as technology evolves
4. **Sound forward markets require sound spot markets** for the same underlying service
5. **Similarly compensate all resources** that provide the desired service

ISO New England is Actively Pursuing Market Solutions

- **New Energy Option "Reserve" Services**
  - ✓ Provides sufficient on-demand energy in reserve *before* each operating day
- **Multi-Day Markets for Energy**
  - ✓ Increases the market's forward-looking horizon for energy schedules, and compensates for preserving limited energy
- **Seasonal Forward Markets**
  - ✓ Competitively compensate for seasonal energy supply commitments

*These provide a '**margin for uncertainty**' in our increasingly energy-limited grid*

CREATING MARGINS FOR UNCERTAINTY: MARKET SOLUTIONS (I)

Risks, Root Causes, and Energy Option Products

Summary Points

- ISO proposes new "on call" energy option products within a co-optimized, day-ahead market
- Addresses two inter-related shortcomings of the region's existing energy market design:

  a) **Insufficient market incentives** for additional energy supply arrangements; and

  b) There are many GW of resources that do not receive day-ahead energy awards, *yet* the ISO **relies upon those resources** to meet the system's next-day operating plan requirements

These resources are not presently compensated for the ***"option value"*** *they provide to a reliable power system each day*

Insufficient Market Incentives Have Three Root Causes

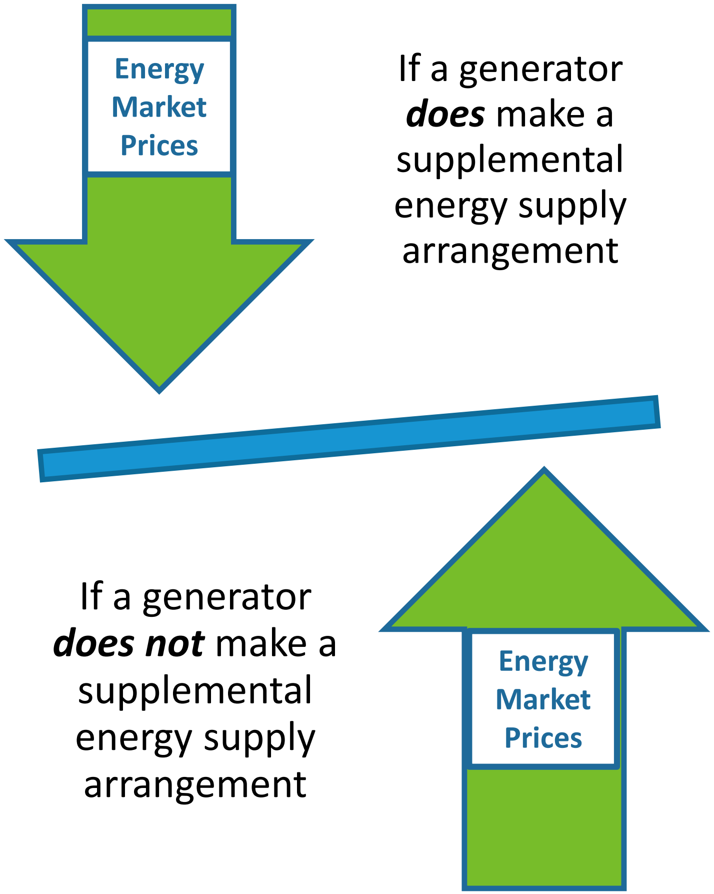
1. **Misalignment problem** between the high price society *avoids* and the lower energy price a supplier *receives*
2. **Uncertainty** facing many suppliers over whether their resources will be in demand or not (especially during winter)
3. **Fixed costs** of advance arrangements for fuel

Solution implications:

- Suppliers currently face **inefficiently low incentives** for additional energy supply arrangements
- Market solutions must **solve #1,** given reality of #2 and #3

New England's Power System Has Evolved in a Way That Puts Generators in an Economic *Catch-22*

- **Supplemental energy supply arrangements** can help many generators to perform during energy-constrained periods
- **Because of misaligned incentives,** more robust energy supply arrangements may be beneficial and cost-effective for the **system**, but not for **individual generators**



Solution: Energy Options in the Day-Ahead Market

- **Solution concept.** Procure two product types in an expanded, co-optimized day-ahead market:

  A. **Forward energy** for RT delivery (same as today); and

  B. **Options on RT energy** delivery (new), acquired from *additional* (physical-only) resources

- An **energy option award** in the day-ahead market provides:
  - An up-front, market-determined option price that lowers uncertainty over revenue for sellers
  - Incentives for resources to be able to "cover the call" (*e.g.,* have fuel)

Logic: Energy Options Strengthen Incentives

- **Options change behavior,** including a generator's willingness to make advance energy supply arrangements
- **This works generally because:**
  - The option price ("premium") offsets the upfront cost of acquiring fuel
  - A generator's settlement charge if it does *not* acquire fuel – *i.e.*, if it cannot "cover the call" – reflects the RT energy cost to replace it
  - The RT energy cost to replace it equals the price society would be able to *avoid* if the generator made advance energy supply arrangements
  - This replacement cost is a correct market consequence if the generator is not able to deliver after selling the option
- **A market solution to the misalignment problem**

Examples Show Options Are a Practical Solution

In the Appendix, we provide a simple numerical **example** that **shows how and why**:

- Under the current rules, the energy market design provides **inefficiently low incentives** to arrange fuel; and
- Introducing day-ahead energy options **solves this problem**, re-aligning the generator's commercial and society's interests
- This approach satisfies **all five design principles** (p. 13)

Option designs are practical, market-based solution to insufficient incentives problems when sellers face up-front fixed costs (to arrange fuel) and uncertainty over demand

Energy Option Design Elements

Product Definition

- A call option on a resource's energy during the operating day
- DA option awards depend on a resource's physical ("flexibility") parameters (*e.g.*, generator ramp rates or start-up times)

Participation and Demand

- Resources submit energy and voluntary option supply offers
- Required quantities (demand) for products in the DA market are not static; they are inherently dynamic and will vary day-to-day

Co-Optimized Day-Ahead Market Clearing

- Procurement will be co-optimized with all participants' energy supply and demand awards in the day-ahead market
- All cleared offers (awards) create financially binding settlements

Pricing and Compensation

- Clearing prices will vary over time as supply and demand dictate
- Clearing prices of each day-ahead product will reflect resources' offer prices and (inter-product) opportunity costs

Energy Options Follow Universal Option Settlement Rules

Option Strike Price	▪ Published *prior to* each day-ahead market (at an index)
Day-Ahead	▪ The market-clearing option price (or "premium") is paid day-ahead
Real-Time Settlement: Supplying Energy	▪ A credit, at RT LMP *or* the strike price, whichever is less
Real-Time Settlement: Not Supplying Energy	▪ A charge, of RT LMP *less* the strike price, if positive

Options settlements accords well with the ISO's existing DA-RT two-settlement energy market design

Three New Co-Optimized Day-Ahead Energy Option Products

1. **Generation contingency reserves,** the (existing) fast-response reserve products that address sudden supply loss situations

2. **Replacement-energy reserves,** to ensure "on call" energy within 1.5-to-4 hours to restore contingency reserves and for uncertainty in the load forecast and resources' performance

3. **Load-balance (or 'energy imbalance') reserves,** to supply the difference if forecast next-day energy demand exceeds the physical supply cleared in the Day-Ahead Market

*These products provide a greater "**margin for uncertainty**" in our increasingly energy-limited grid*

Practicalities: What Resources Are Impacted Most?

- **ISO relies on four resource groups for these capabilities** today (but does not compensate for them in the DA market):
  a) Off-line fast-start generators (hydro, ICUs, and CTs)
  b) Higher-cost blocks of CCGTs above their DA energy schedules
  c) Higher heat-rate CCGTs that do not normally clear day ahead
  d) Long lead-time oil-steam units, in some situations (*e.g.,* cold weather)
- **Looking forward:** As group (d) retires, (b) and (c) are likely to become predominant resources for replacement energy and load-balancing reserves. They are:
  – Gas-only or dual-fuel, and face production uncertainty during winter
  – Can respond to greater incentives to arrange advance fuel (*next)*

What Do We Expect Resources To Do As a Result?

- **Near term:** They are expected to be able to "cover the call" if awarded a day-ahead energy option, by (*e.g.*):
  - Making 'backup' gas-from-LNG supply arrangements with terminals
  - Acquiring and timely replenishing fuel oil inventories
  - (Potential) DA gas scheduling with brokers for intra-day notice service
  - Greater demand response arrangements
- **Long term:** Incremental capex for backup supply arrangements, *if* risks and price signals are supportive:
  - Additional dual-fuel capability, where able to permit
  - Longer-duration (daily/weekly cycle) energy storage technologies
  - (Potential) Satellite LNG facilities for winter peak gas generation

Two Key Energy Market Implications

- Day-ahead market co-optimization of energy and ancillary services will **impact day-ahead energy compensation**
  - Day-ahead energy compensation will reflect (new) opportunity costs of providing energy versus ancillary services
  - These opportunity costs will be compensated through transparent prices for each product/service (not unit-specific opportunity cost payments)
- Real-time dispatch/commitment will remain based on resources' latest real-time energy supply (re-)offers
  - Resources are not "called" based on day-ahead strike prices
  - Using current offers is essential for efficient real-time dispatch

Design FAQ: Options Versus Traditional Reserves

- Day-ahead reserves are sometimes co-optimized with energy, but settled against a real-time reserve (*not* energy) price
- Energy options procured day-ahead settle against the real-time energy price, and **provide stronger financial incentives** (*i.e.,* to have fuel)
  - Real-time energy prices can be high even when real-time reserve prices are low (or even zero)
- Economically, day-ahead reserve designs that settle against real-time reserve prices do not (fully) solve the ***misaligned incentives,*** or *Catch-22,* problem (p. 17-18)

Key Properties and Implications (1 of 2)

- **Improves fuel security** for ~3-6 GW of (presently extra-marginal) generators each day that provide energy options
- Co-optimization of energy and options ensures the value of options **are properly reflected in energy prices,** and paid to all resources that clear energy in the day-ahead market
- Options' incentives reflect the **market price to replace the seller's energy in real-time,** a sound economic consequence
  - This design element resolves the *misalignment problem*
- **There are limits.** A generator won't incur costs so unlikely to be 'used or useful' they exceed the real-time price to replace it
  - This is central to the cost-effectiveness logic of energy options

Key Properties and Implications (2 of 2)

- Design satisfies all **five core design principles** (p. 13)
- A sensible **long-term market framework** for managing a system with increasing **renewables and just-in-time resources**
  – Day-ahead market will now achieve (most) functions of ISO's non-market Reserve Adequacy Assessment (RAA) process
- **Risk-responsive design.** If energy security risks are reduced through other (*e.g.,* state) policies or changes in market conditions, the total cost of the energy options should be low
  – The design helps avoid locking consumers into long-term, high-cost obligations that may turn out to be unneeded with time

MULTI-DAY AHEAD MARKETS: MARKET SOLUTIONS (II)

Using Existing Infrastructure More Efficiently

Multi-Day Ahead Markets (M-DAM): Summary

- **Issue:** Existing one-day ahead markets may not efficiently coordinate production over *multiple* days
  – ISO currently forecasts the power system **six days forward**, but the markets operate only **one day forward**
  – Concerns over **premature** depletion of stored energy (*e.g.,* oil in tanks) during winter cold spells

- **Benefits:**
  – **Transparently** signals future system conditions up to a week in advance
  – Compensates resources **today** for **efficiently preserving energy inventory** to a later day, and reduces their (financial) risk of doing so

M-DAM: Concept and Mechanics

- Extends the ISO's 24-hour day-ahead energy market up to a **six-day (144-hour) energy market horizon**
  - **Optimizes supply and demand** over that entire horizon, accounting for limited energy (principally oil) inventories of generators
- **Re-cleared each day** on a rolling basis, incorporating updated offer prices, bid-in demand changes, inventory changes, etc.
- Produces **LMPs and financially binding awards** for (cleared) bids/offers for each future delivery hour
- Participation beyond one-day forward is **voluntary,** for both supply and demand
  - A one-day-ahead, must-offer requirement applies to capacity suppliers

M-DAM: Concept and Mechanics *(continued)*

- **Energy** is cleared for full horizon (prompt day and out-days)
- **Day-ahead ancillary services** (energy options) will be cleared only one-day ahead
  - ***Energy imbalance reserves:*** Clearing one-day ahead allows participants every opportunity to align bid-in demand with expected RT demand
  - ***Other day-ahead reserves***. Clearing only one-day ahead achieves the design objectives and simplifies the initial implementation
- ISO's next-day operating plan requirements will be achieved by procuring these services on a one-day ahead basis

M-DAM: Settlement Concepts

- Rolling, daily re-cleared multi-day markets extend the **standard settlement logic** of *deviations* from forward positions
  - Each day, a participant can re-offer for the same future delivery hour
  - Each day, it is credited (or charged) for its cleared *incremental* MWh sales (or purchases) for the *same* future delivery hour.
- Incremental sales/purchases are credited/charged at the prevailing multi-day ahead LMP for the delivery hour
  - **A multi-day, multi-settlement system**: Successive awards are settled based on successive *deviations*, at the then-prevailing LMP
- Same multi-settlement design used in commodity markets generally

ISO Continues to Evaluate M-DAM Approach

- Stakeholders have posed several **practical questions**:
  - Will ISO's new opportunity cost methodology for oil and dual-fuel generators (started 12/1/2018) deliver much of a M-DAM's benefits?
  - Would a shorter (*e.g.,* 2 or 3 day) M-DAM deliver much of the benefit of a longer (*e.g.,* 6-day) M-DAM?
- ISO is **continuing to assess** these questions and stakeholders' feedback
- Our assessment will include information from the **impact analysis**, which is not completed (*next*)
- The ISO will discuss with stakeholders and finalize how to proceed before the ISO's October 15th filing

M-DAM: Summary of Key Points

- M-DAM provides **forward price signals reflecting expected system conditions** over multiple operating days
- This **better aligns with current operational planning horizon** than existing one-day ahead energy market
- M-DAM **efficiently allocates stored energy** to future periods
  - Limited energy resources are compensated for being "pushed out"
  - System is run more efficiently, with lower production costs
  - Reduces need for out-of-market posturing
- ISO anticipates addressing stakeholder questions on the relative benefits of M-DAM with quantitative analysis

IMPACT ANALYSIS EFFORTS

Facilitating regional understanding through market modeling

Analysis of Proposed Design Informs How It Performs

- **Objective:** Help stakeholders understand the market and reliability impacts of the proposed solutions
- **Quantitative analysis** will provide specific information on market and reliability impacts across a range of potential future system conditions, for the two proposed energy security improvements (ESI):
  - Energy options in the day-ahead market; and
  - Multi-day ahead energy markets
- **Qualitative analysis** will provide context to stakeholder in regards to how the proposed solutions may impact the capacity market
- October filing will include a detailed report on the analysis

Quantitative Analysis Will Be Accomplished Through a Production Cost Model

- Production cost model (PCM) estimates the market and reliability impacts of the proposed ESI solutions on energy and reserve market outcomes
  - ISO has retained the Analysis Group to build and run this model
- Model simulates the day-ahead and real-time markets for a range of future possible market conditions and resource mixes
- Model does not include all "real-life" energy market constraints – for example:
  - Does not include transmission constraints
  - Uses simplified commitment logic to handle unit "lumpiness" and intertemporal parameters
- Model studies winter months, when the proposed solutions are expected to have largest impact on market and reliability outcomes

Comparison of Current Design and Proposed Design Will Demonstrate Impacts

- To estimate the impact of the proposed solutions, the model will be run with the same set of resources and load for:
  - **Current design**: No market design changes
  - **Proposed design**: New ancillary services in the day-ahead market (and the multi-day-ahead construct)
- Evaluate market participants' potential responses in arranging additional energy supply when that may increase their expected profit
  - **Oil resources**: Procure additional oil prior to the winter period or increase in-period replenishments
  - **Gas resources**: Procure forward contracts/firm transportation or schedule gas prior to the delivery day

Scenarios Will Be Responsive to Stakeholder Requests

- Based on discussions to date, ISO expects to run distinct scenarios where demand patterns are based upon three recent winters:
  - **Severe:** 2013/14
  - **Moderate:** 2017/18
  - **Mild:** 2016/17
- Scenarios will also include variations on the resource mix – and other assumptions – to examine:
  - Retirement of existing resources
  - Entry of new resources
  - Adjustments to fuel availability for gas and oil resources
  - Additional contingencies or changes to weather/electricity demand
- Model is not intended to show all potential proposal impacts (*e.g.,* does not consider resource entry and exit responses)
- ISO is working to provide as many representative cases requested by stakeholders as possible in the time available

Model Informs Stakeholders About a Range of Potential Market and Reliability Impacts

- Not a probabilistic model that estimates impacts across all possible future scenarios; rather, it evaluates distinct scenarios deterministically
- Stakeholders can use their private expectations about scenario likelihoods and future resource mixes analyzed in considering the solutions' impacts on market and reliability outcomes
- Developing a probabilistic model would require probabilities to be determined on the likelihood of all possible future resource mixes and load conditions

Results Will Show the Market and Reliability Outcomes under the Current and Proposed Design

- Market outcomes
  - Prices (energy, operating reserves, energy imbalance reserves)
  - Total payments (revenues to supply, costs to load)
- Reliability outcomes
  - Energy, operating reserve and other reserve shortages
  - Energy inventory profiles over winter
- Air emissions impacts
- Technology-type revenues and output

CAPACITY MARKET IMPLICATIONS

Solutions Will Ultimately Impact the Capacity Market

- Resources' expected net revenues may change through various mechanisms:
  - Sale of new ancillary service products
  - Impact on energy market prices
  - Additional costs incurred to provide energy security
- As net revenues increase, the 'missing money' that resources will need to recover via the capacity market decreases
- Resources that receive greater net revenues from the proposed solutions can be expected to lower their FCM bids and offers, relative to those that receive less net revenues
- This 'reshuffling' of the supply curve will generally award Capacity Supply Obligations to resources that provide more energy security

Solutions Will Potentially Change Resources' Capacity Revenue

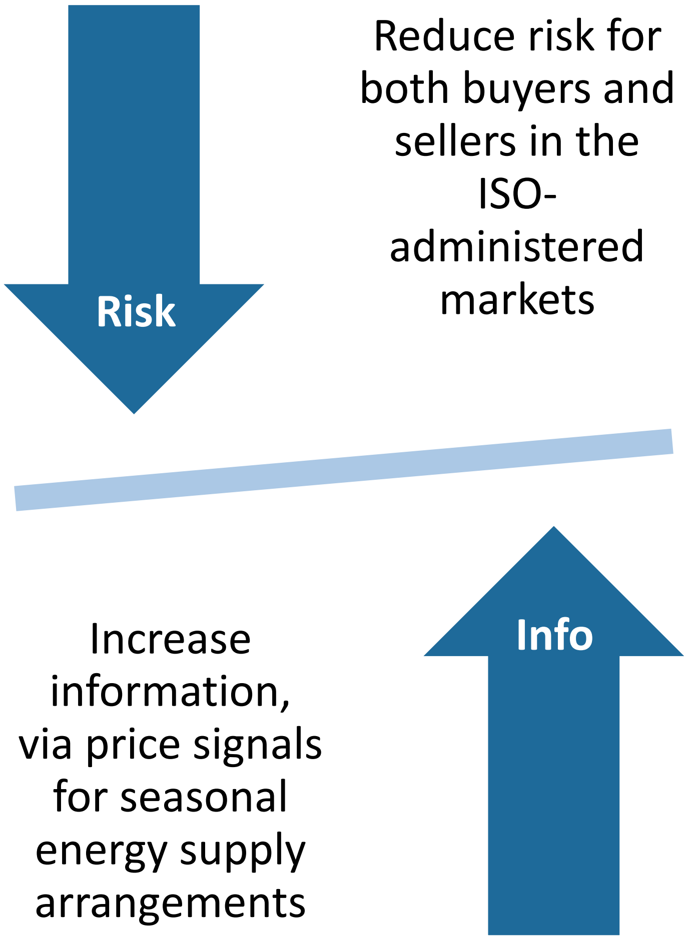
- ISO will provide aggregated information on how revenues and costs may change for different "proxy" units, to provide stakeholders with context for the implications
  - ISO will discuss how changes to revenues and costs may impact capacity market bidding behavior
- In 2020, the ISO will be evaluating the implications of the proposed solutions on the Net CONE and Offer Review Trigger Prices (ORTP) applicable to Forward Capacity Auction (FCA) 16
  - FCA 16 is for delivery year 2025-2026

NEXT STEPS

Future Work and October 2019 Filing

Seasonal Forward Market Development: Concept

- Seeks to facilitate investments in **costly supplemental energy supply** arrangements well in advance of winter
- The ISO remains in **early, conceptual stages** of evaluating designs for such a forward market



Seasonal Forward Market Development: Process

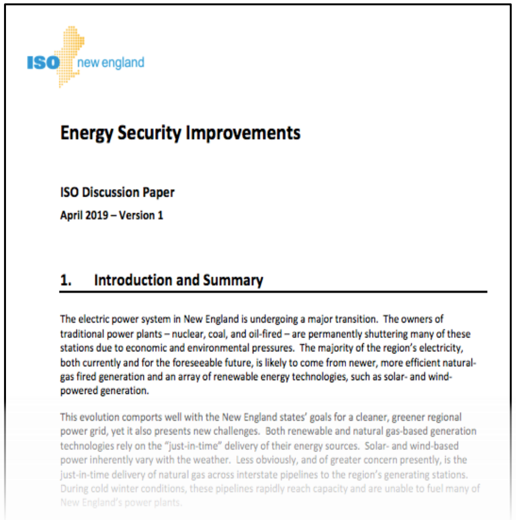
- ISO will **discuss design ideas** with NEPOOL in August
- There are a range of designs to consider, and the ISO looks forward to stakeholders' concepts and design objectives
- The seasonal forward market component will not be developed for "core" long-term market solution filing on October 15th to the Commission
- ISO plans to further review with stakeholders and refine options in the first half of 2020, informed by the outcome of this proceeding

Solving Energy Security is a Multi-Year Effort

- As with any major market design initiatives, there will be follow-on market rule development during the implementation phase for, *e.g.:*
  - Mitigation rules for the new ancillary services offers
  - Net Commitment Period Compensation (uplift) revisions (if needed)
  - Season forward market design
- This detailed design work is dependent upon the Commission's determination on the core long-term market solution design to be filed October 15, 2019
- We anticipate undertaking that work beginning in 2020, subject to the Commission's determinations on the October filing

Market Solutions Filing for October 15

- **ISO's April 2019** [Discussion Paper]() provides detailed explanations of energy security problems and root causes
- **Stakeholders** discussions have been underway throughout 2019 at the NEPOOL Markets Committee
- **Core design to be filed** with the Commission on October 15, 2019


ISO new england

Energy Security Improvements

ISO Discussion Paper

April 2019 – Version 1

1. Introduction and Summary

The electric power system in New England is undergoing a major transition. The owners of traditional power plants – nuclear, coal, and oil-fired – are permanently shuttering many of these stations due to economic and environmental pressures. The majority of the region's electricity, both currently and for the foreseeable future, is likely to come from newer, more efficient natural-gas fired generation and an array of renewable energy technologies, such as solar- and wind-powered generation.

This evolution comports well with the New England states' goals for a cleaner, greener regional power grid, yet it also presents new challenges. Both renewable and natural gas-based generation technologies rely on the "just-in-time" delivery of their energy sources. Solar- and wind-based power inherently vary with the weather. Less obviously, and of greater concern presently, is the just-in-time delivery of natural gas across interstate pipelines to the region's generating stations. During cold winter conditions, these pipelines rapidly reach capacity and are unable to fuel many of New England's power plants.

https://www.iso-ne.com/committees/key-projects/energy-security-improvements/

Conclusion

- New England is an **energy limited** power system
- Long-term market solutions require innovative design ideas now, to value and price services that were **once treated as free**
- **ISO's proposed suite of changes** provide stronger incentives and appropriate compensation for **advance** fuel arrangements, energy **storage,** and resource **flexibility**
- These are practical solutions and satisfy **sound market design principles**

APPENDIX

How Energy Options Change Fuel Incentives: An Example

Day-Ahead Energy Options: An Example

- **A simple numerical example** where a generator must incur an up-front cost to arrange fuel in advance of the operating day
- That would be a good thing: The up-front cost is less than society's expected cost savings from arranging fuel (and, in extreme cases, it would improve reliability)
- **We first show:** Under the current energy market design, the generator has **inefficiently low incentives** to arrange fuel – arranging fuel is not in its private commercial interest
- **We then show:** Introducing a **day-ahead energy option** product **solves this** problem, aligning its private commercial interest and society's interest in cost-effective solutions

Example: Setting the Stage

- **Uncertainty.** A generator without a DA energy award faces uncertainty over whether it will be in demand during the (next) operating day
- **Decisions.** It must decide whether or not to arrange fuel in advance of the operating day
- **Salience.** If it decides not to arrange fuel in advance, then it will not be able to operate the next day (even if in demand)
  - To simplify, we'll assume no fuel would be available intra-day
  - The same conclusions hold in more realistic cases, where intra-day fuel is limited and will be (more) expensive than arranging it day-ahead

Example: Cost and Uncertainty Assumptions

- Assume a 1 MW generator, and a time period of 1 hour
- Arranging fuel in advance has an **up-front (fixed) cost** of **$40**
  – This is an 'unavoidable' cost to arrange fuel, whether it runs or not
- If it operates, the **variable fuel cost** is an additional **$70**/MWh
  – This 'avoidable' cost would not be incurred if it does not run
- There is only a **20% chance** the generator will be in demand the next day, so it is unlikely it will be instructed to run
  – The generator knows this, and accounts for it in its decision-making

Example: Market Outcomes and Prices

With advance arrangements for fuel:

- If demand is high (20% chance), the LMP will be **$120**/MWh
- The generator would incur the $40 up-front cost, then earn a gross margin of $120 - $70 = $50 in the RT energy market
- If demand is low (80% chance), it would not run, and would incur a total $40 loss for arranging fuel in advance

Without advance arrangements for fuel:

- If demand is high (20%), the LMP will be set by a more expensive resource at **$400**/MWh
- The generator cannot run regardless, so earns $0

The Generator’s Decision

- Expected profit if it **does** arrange fuel is a $30 loss:
  - Expected (value of its) gross margin is **$10** / MWh:

    20% run chance x ($120 LMP - $70 var. cost) = **$10** / MWh
  - Cost of arranging fuel: **$40 for sure**
  - Expected (value of its) profit is therefore $10 - $40, a **$30 loss**
- Expected profit if it **does not** arr. fuel: **$0**. No revenue or cost
- **Conclusion:** The up-front cost is too unlikely to be recovered in the energy market for the generator to profitably incur it
- **Problem:** Arranging fuel in advance is not financially prudent for the generator… *under the current energy market design*

Society's Preferred Outcome

- **Efficiency:** When demand is high, advance fuel arrangements mean running a generator with a marginal cost of $70/MWh, *instead of* a more expensive one at a cost of $400/MWh
- **Benefit:** In this example, the expected cost savings (*i.e.*, the benefit) to the system is $66:

  20% x ($400 - $70) = **$66**

- **Cost:** This exceeds the cost of arranging fuel of $40
- **Net Gain:** From society's standpoint, the expected benefit/cost comparison is worthwhile:

  $66 – $40 = **$26**

Implications for the Current Energy Market Design

- Advance fuel arrangements lowered the system's expected total cost to achieve equally (or more) reliable outcomes
  - In more extreme cases, such as if there would be a reserve (or energy) shortage if the generator has no fuel to run, society's benefit becomes even greater – but the generator's incentives remain *unchanged*
- However, making such advance fuel arrangements is not in the generator's commercial interest: ***misaligned incentives!***
- This misalignment problem **will not solve itself** – the *current energy market design* cannot produce efficient outcomes in such situations

A Reality Check: What Drives This Conclusion?

- Though this is a (highly) simplified example, it rests on three quite broadly applicable market conditions:
  1. **Fixed costs.** There are up-front costs of arranging fuel in advance
  2. **Uncertainty.** The generator is uncertain whether it will have the opportunity to use the fuel or not
  3. **Materiality.** The generator's fuel arrangement decision impacts the costs of running the system
- These are fairly ubiquitous in practice, although smaller generators might not always impact #3, and some efficient larger ones face little uncertainty in #2 (*e.g.*, newer CCGTs)

Day-Ahead Energy Option Awards

A day-ahead energy call option has three elements:

- A day-ahead **option price** Assume: **$50** here.
  - Generally: A uniform market-clearing price set in a co-optimized day-ahead market, determined by sellers' option *offer* prices.
- The option **strike price** Assume: **$120** here
- The **underlying product price**: **RT LMP** for energy

A seller with an energy option award is paid the option price

It then settles in real time based on the strike, the RT LMP, and whether or not it delivers energy *(as noted next)*

With Energy Options: The Generator's Decision

- Expected profit if it **does** arrange fuel in advance is **$20:**
  - It receives the day-ahead option price of **$50**
  - Cost of arranging fuel: **$40 for sure**
  - It is paid the **$120 strike price** if RT demand is high (and zero if not)
  - Expected (value of its) gross margin is therefore **$10:**

    20% run chance x ($120 strike - $70 var. cost) = **$10**
  - Expected profit is therefore **$20** = $50 - $40 + $10.
- Expected profit if it **does not** arrange fuel is a $6 loss:
  - It still receives the day-ahead option price of **$50**
  - If RT demand is high, it is **charged the RT LMP *less* $120 strike price,** an *expected* cost of:

    20% run chance x ($400 LMP - $120 strike price) = **$56 charge**
  - Expected profit is therefore $50 - $56 = – $6, a net loss
- **Conclusion.** If it sells the option, it is profitable to arrange fuel

Is The Generator Better Off Now?

- Would the generator **willingly sell (accept) the call option** obligation at the day-ahead market price of $50?
- Yes! Without the option, its expected profit is: **$0**
  With the option, its expected profit is: **$20**
  - In fact, its *offer price* to sell the option to the ISO in the day-ahead market would be (a little above) $30, though it receives a market-clearing option price of $50 (in this example)
- ***Note:*** **This is a "real" option design:** The generator's (minimum) option offer price depends on its own cost of arranging fuel, not (just) the option settlement
  - The cost of arranging fuel is its best way to "cover the call" position

Example Summary: Energy Options

- **Conclusion.** Real options change behavior – in this case, the generator's willingness to undertake a costly investment in advance fuel arrangements
  - Even though it may not be used by the generator
- **This works generally because:**
  - The option price ("premium") offsets the upfront cost of acquiring fuel
  - The generator's settlement charge if it does *not* acquire fuel – *i.e.*, if it cannot "cover the call" – reflects the RT energy cost to replace it
  - That RT 'replacement' cost is the high price society is able to avoid if the generator makes the investment in fuel arrangements – the correct economic "liquidated damages" for RT non-performance
- ***Incentives are now aligned!***

Questions