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APRIL 10, 2013 | CROMWELL, CT

The Role of Hydropower in ISO New England Operations

Connecticut Power & Energy Society Meeting

The Role of Hydropower in Connecticut's Energy Future

Stephen J. Rourke

ISO NEW ENGLAND, VICE PRESIDENT, SYSTEM PLANNING

PRESENTATION OVERVIEW

- About ISO New England
- New England's Electric Power Grid at a Glance
- Highlights of Hydropower in New England
- New England Hydropower at a Glance
- Existing Hydro Capacity and Energy Production
- Outlook for New Resources
- Appendix: Examples of New England's Hydroelectric Fleet

About ISO New England

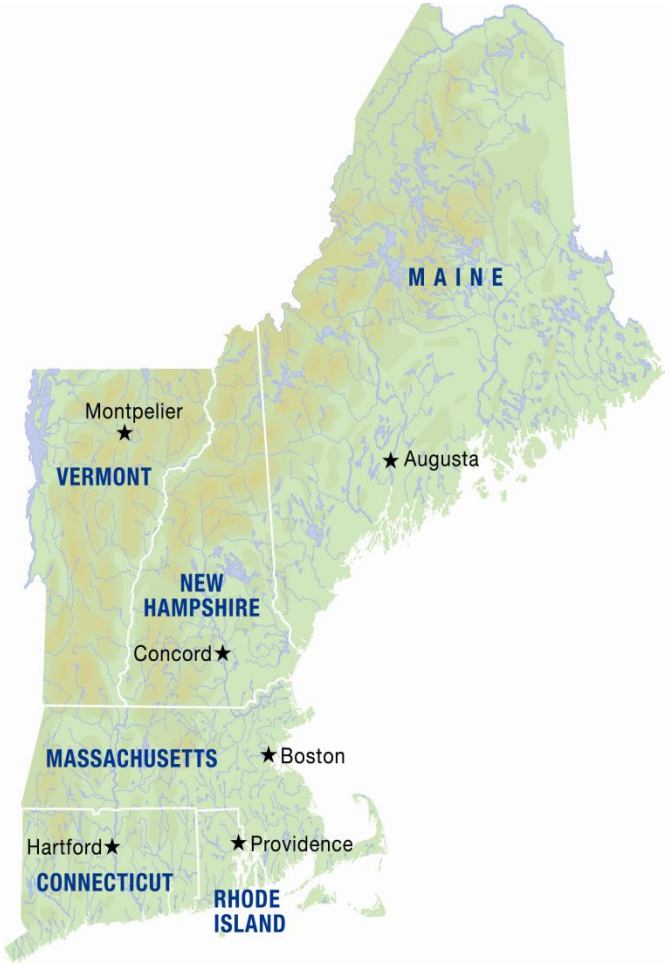
- **Not-for-profit corporation created in 1997 to oversee New England's restructured electric power system**
  - Regulated by the Federal Energy Regulatory Commission (FERC)

- **Independent System Operator**
  - Independent of companies doing business in the market
  - No financial interest in companies participating in the market
  - Neutral as to resource fuel type

- **Major Responsibilities**
  - Operating the Regional Power System
  - Administering Wholesale Electricity Markets
  - Managing Regional Power System Planning

New England's Electric Power Grid at a Glance

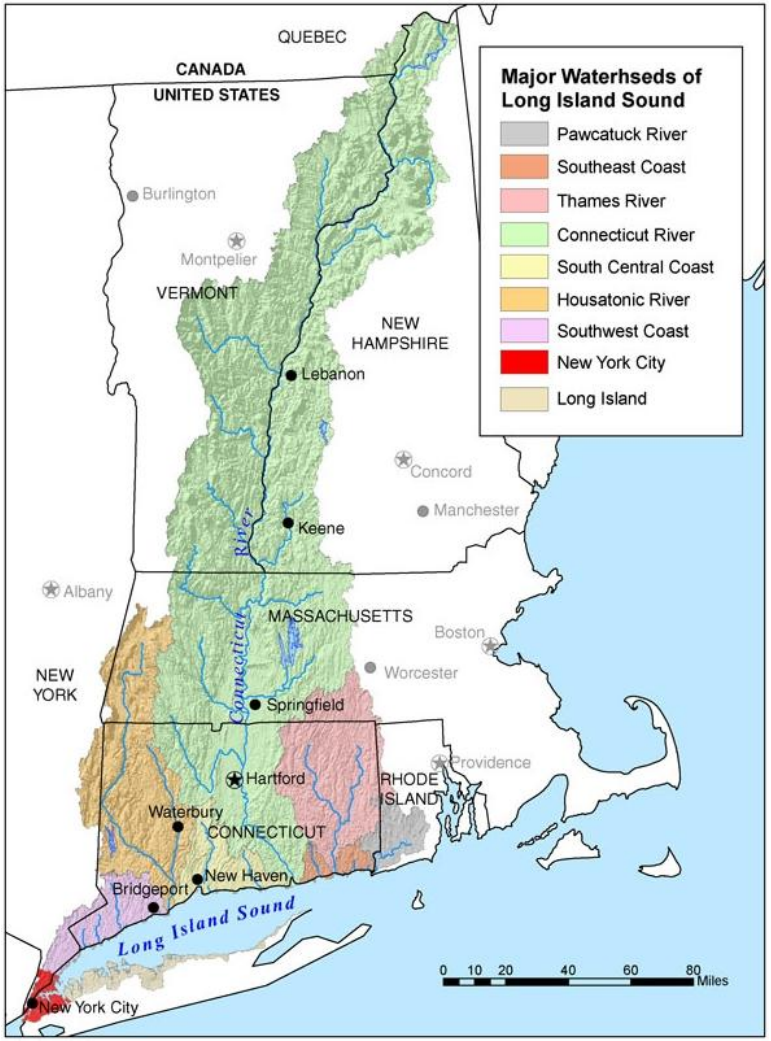
- 6.5 million households and businesses; population 14 million
- More than 350 generators
- More than 8,000 miles of high-voltage transmission lines (115 kV and above)
- 13 interconnections to electricity systems in New York and Canada
- 32,000+ megawatts (MW) of total supply and 2,000+ MW of demand resources
- All-time peak demand of 28,130 MW set on August 2, 2006
- More than 450 participants in the marketplace
- $5.2 billion energy market value in 2012

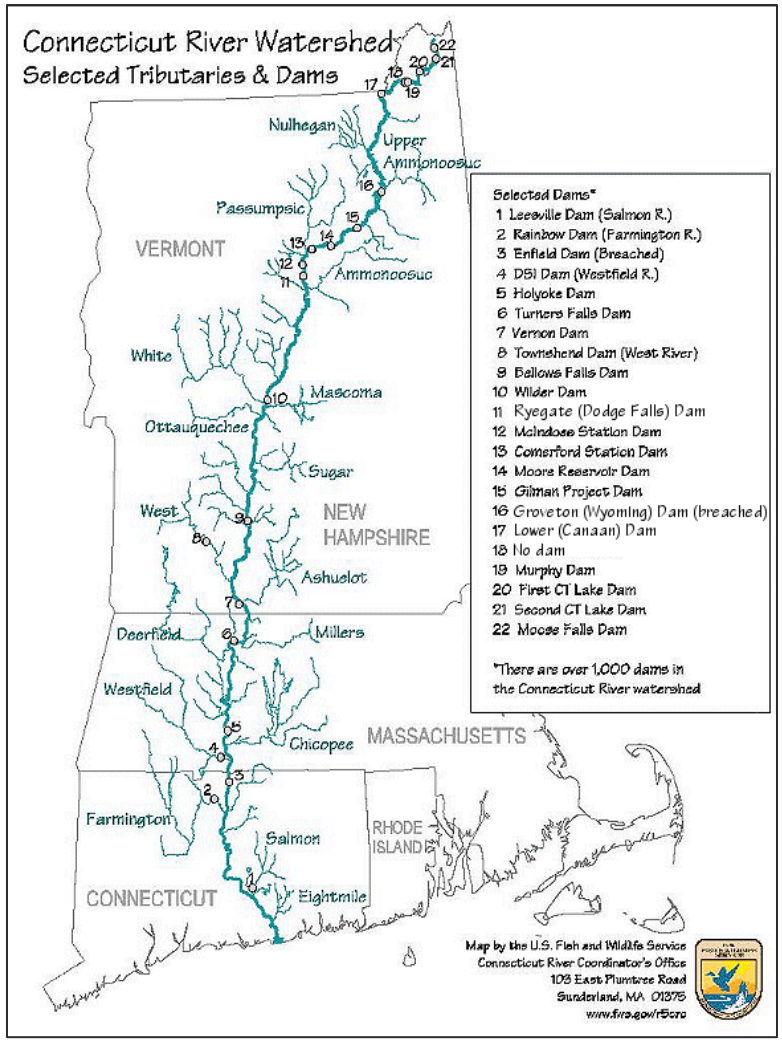


Highlights of Hydropower in New England

- Region has a well-developed system of hydroelectric facilities
  - 1,698 MW of pumped storage hydro capacity
  - 1,483 MW of conventional hydro capacity (run of river and pondage)
- Pumped storage facilities developed to provide fast-start capability to system operators (initially developed to cover sudden loss of nuclear generation) and to take advantage of lower cost off-peak energy
- Pumped storage is a fast-responding, but limited-energy resource
  - The ISO postures pumped storage facilities often to preserve energy and operating reserves for system peak
- Hydropower can provide black-start services during system restoration
- Hydropower is a form of energy storage for the region
- Hydropower can help balance variable resources on the system (e.g., wind)

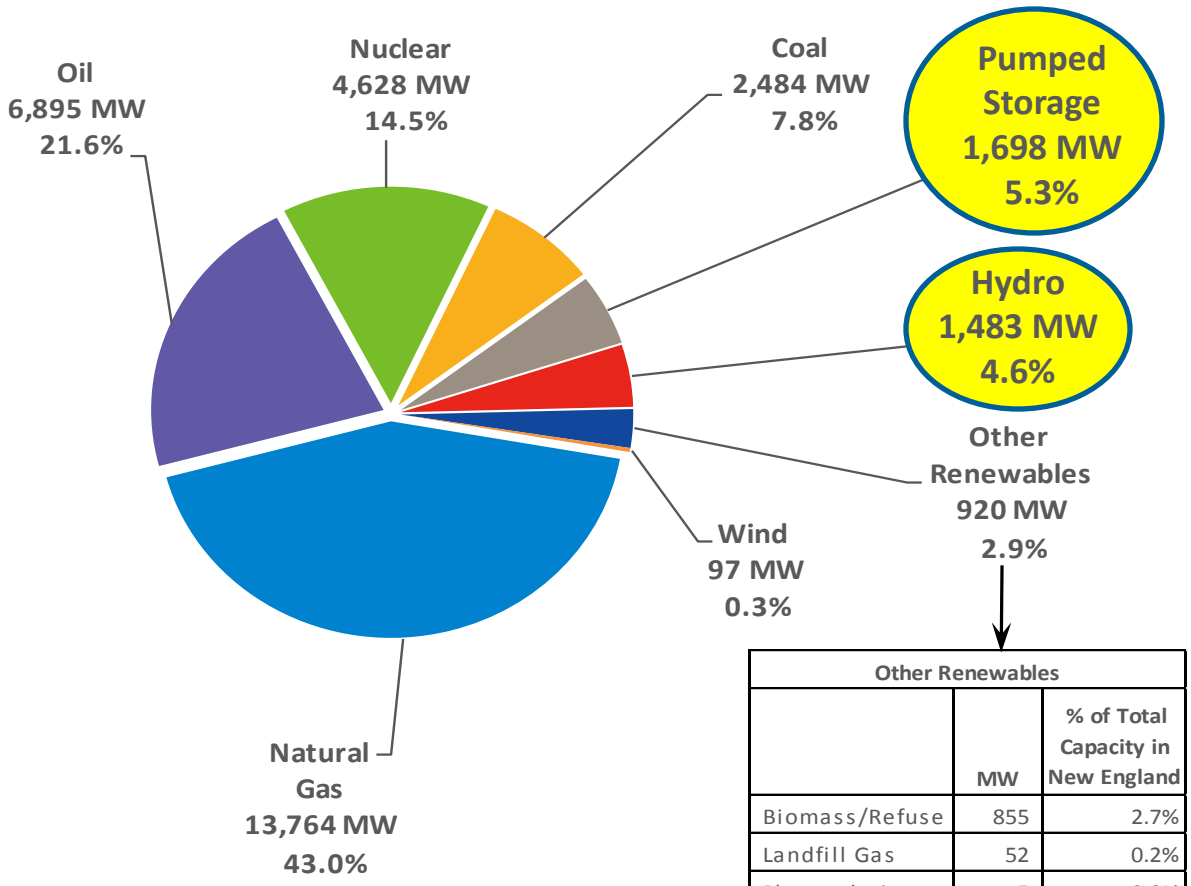
New England Hydropower at a Glance





New England's Generating Capacity by Fuel Type

Total 2012 installed summer capacity in megawatts (MW)

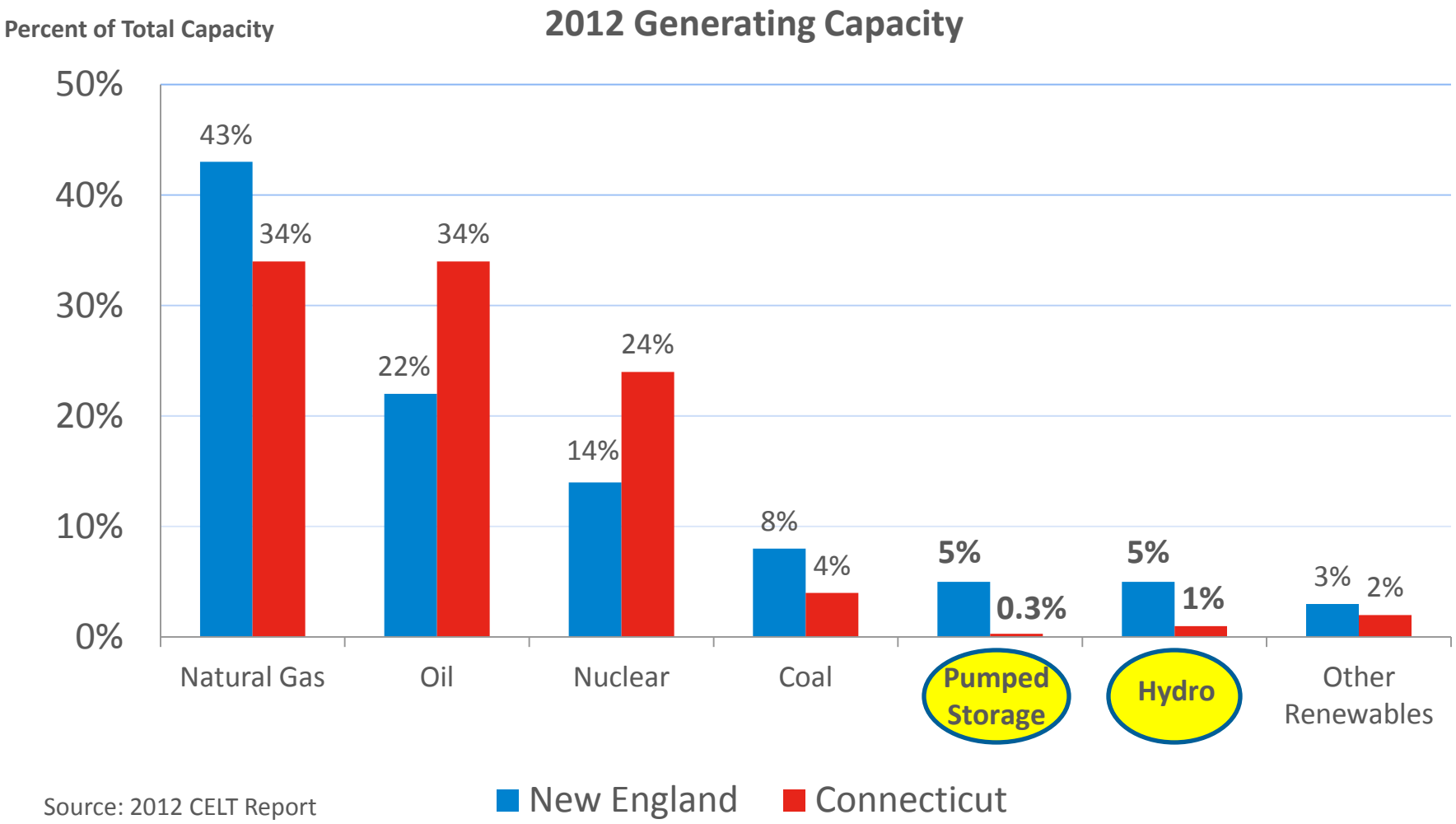


Other Renewables		
	MW	% of Total Capacity in New England
Biomass/Refuse	855	2.7%
Landfill Gas	52	0.2%
Photovoltaic	5	0.0%
Fuel Cell	8	0.0%

Source: 2012 Regional System Plan, Figure 7-1

New England and Connecticut Generating Capacity

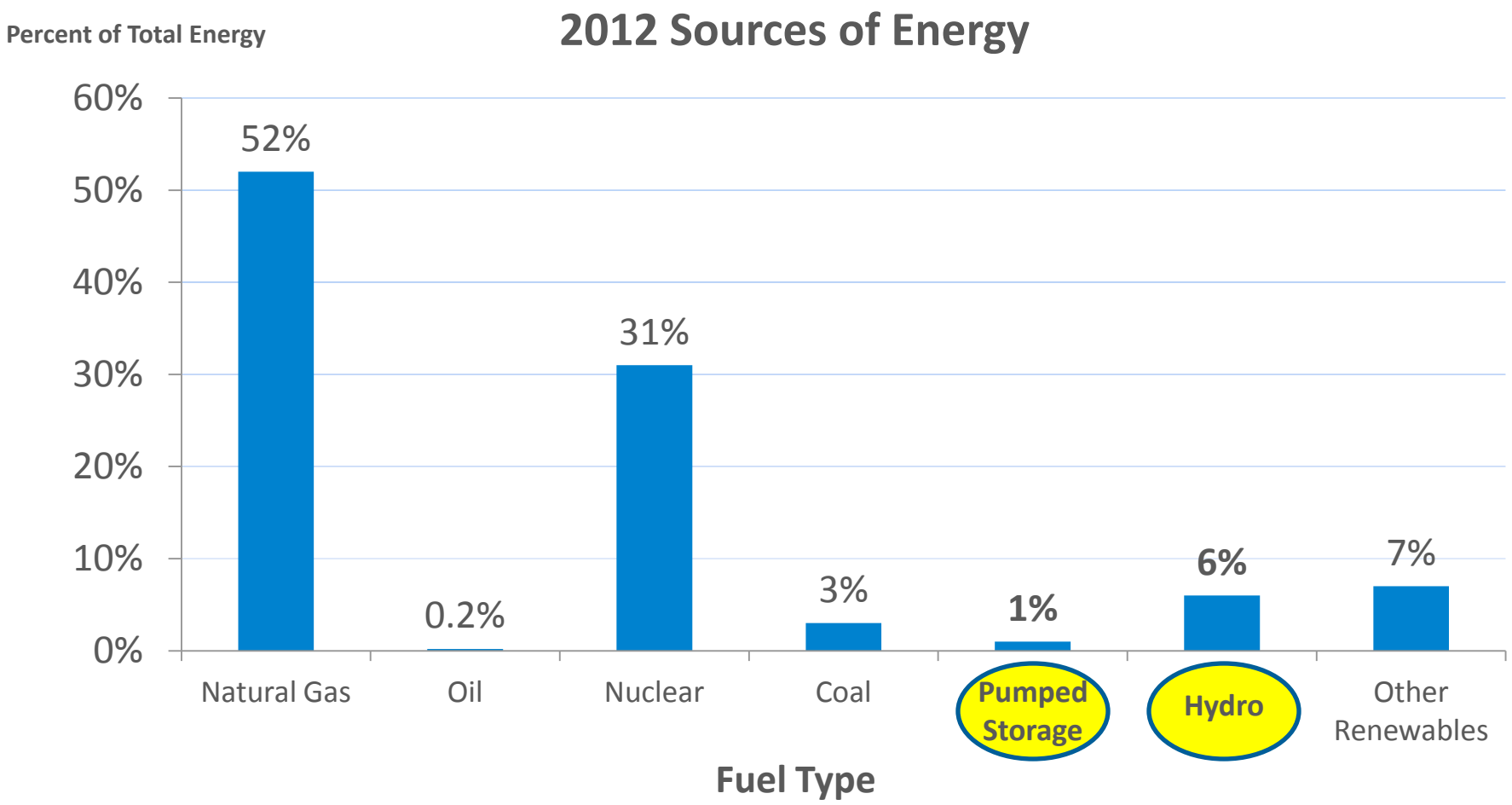
Percent of total capacity in 2012 by fuel type



Source: 2012 CELT Report

New England Annual Energy Production

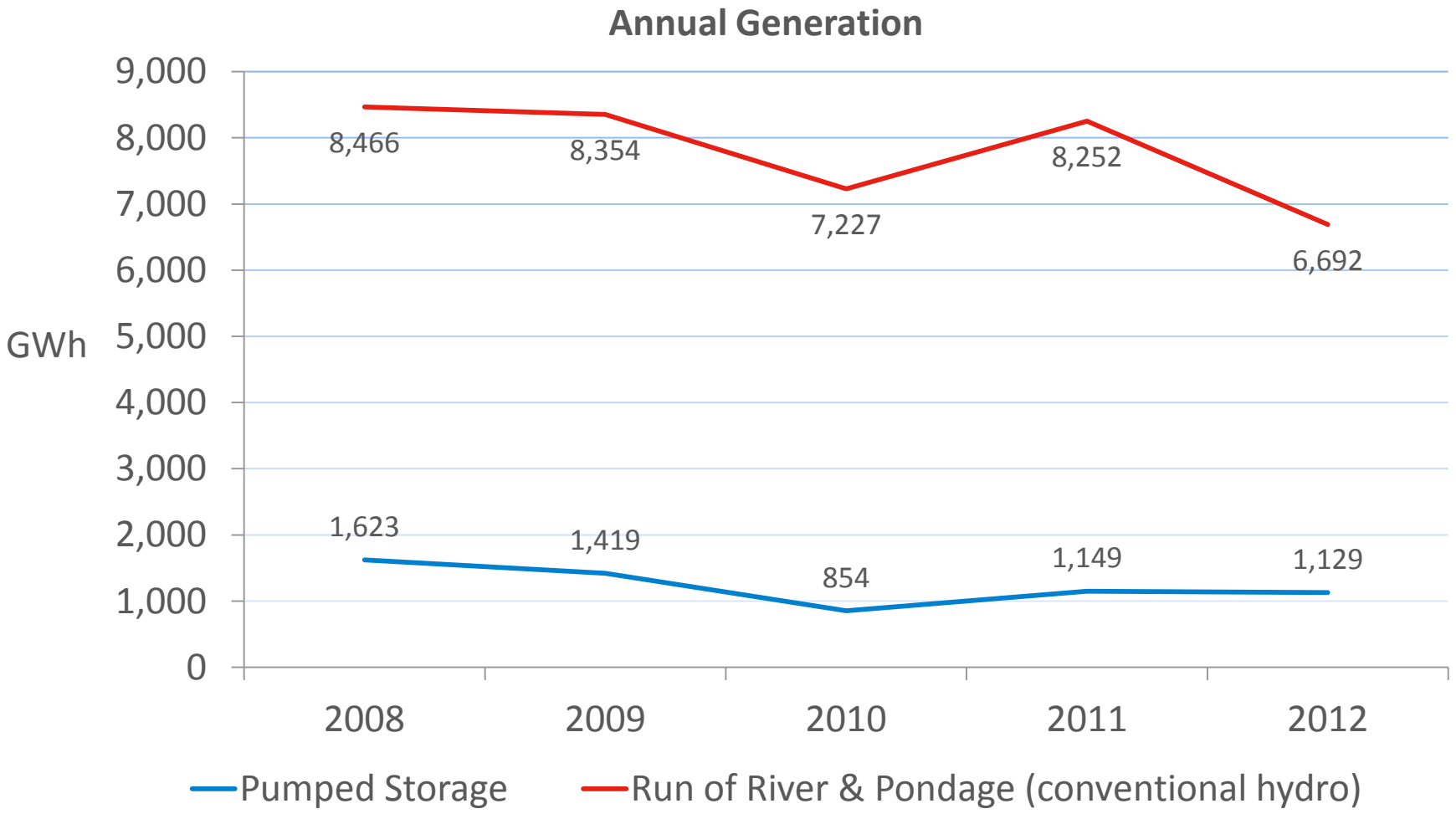
Percent of total electric energy production in 2012 by fuel type



Source: http://www.iso-ne.com/nwsiss/grid_mkts/enrgy_srcs/index.html

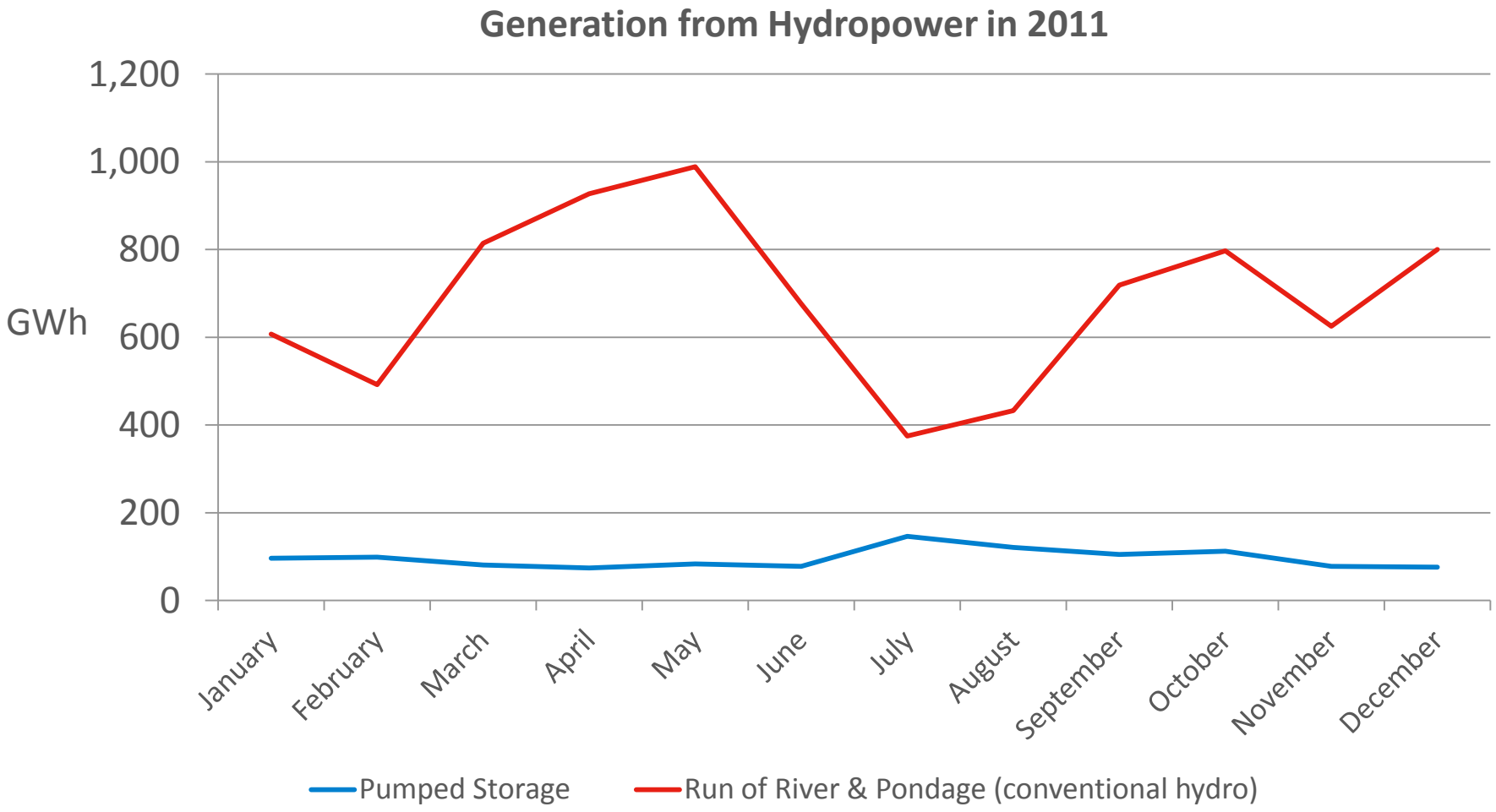
Historical Energy Generation from Hydropower

Conventional hydro varies year-to-year with changes in precipitation



ISO New England's Use of Hydropower throughout the Year

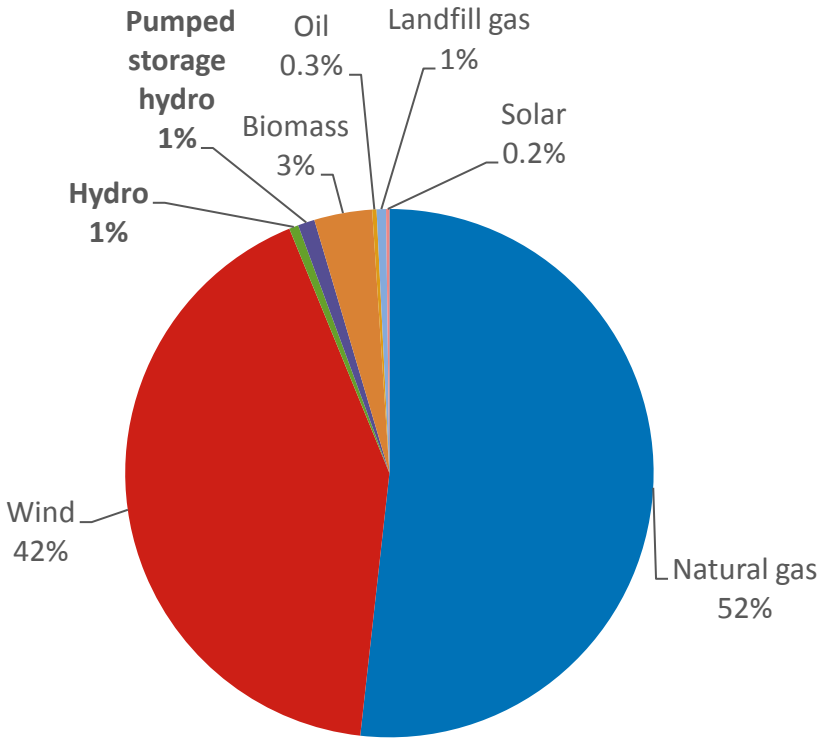
Conventional hydro use peaks in the spring due to snowmelt



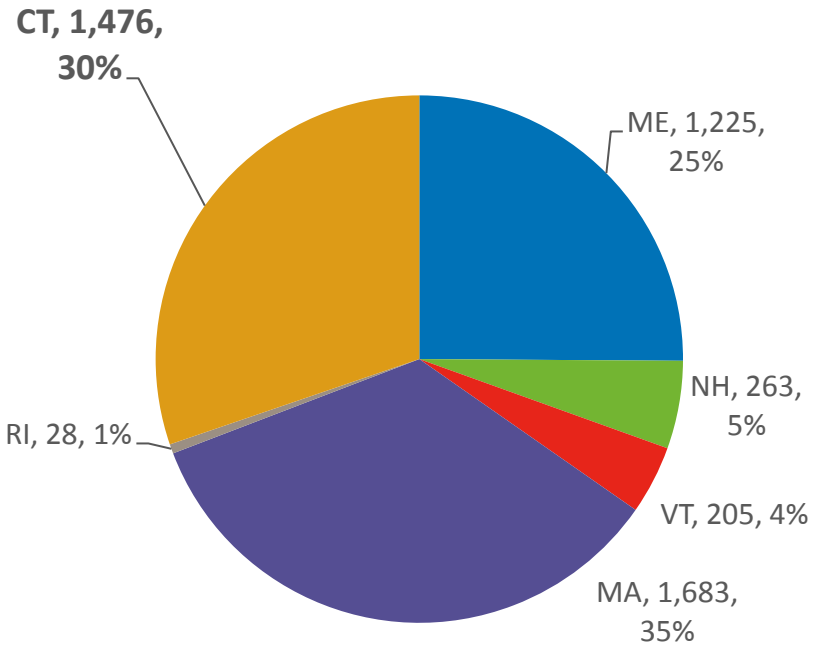
Generator Proposals in the ISO Queue

Approximately 5,000 MW

By Type

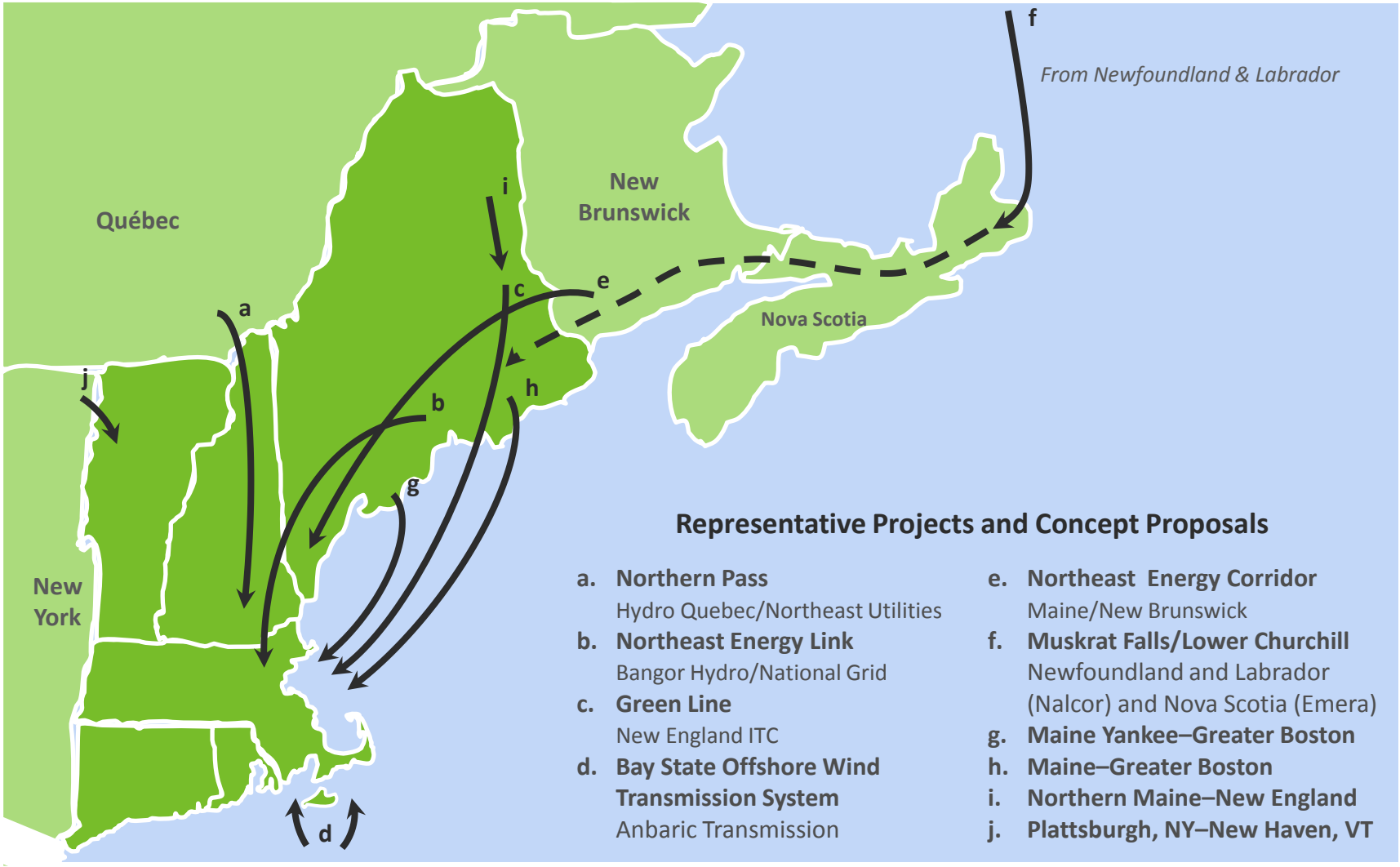


By State



January 2013

On- and Off-shore Transmission Proposals Vying to Move Renewable Energy to New England Load Centers



Representative Projects and Concept Proposals

a. **Northern Pass**
Hydro Quebec/Northeast Utilities

b. **Northeast Energy Link**
Bangor Hydro/National Grid

c. **Green Line**
New England ITC

d. **Bay State Offshore Wind Transmission System**
Anbaric Transmission

e. **Northeast Energy Corridor**
Maine/New Brunswick

f. **Muskrat Falls/Lower Churchill**
Newfoundland and Labrador (Nalcor) and Nova Scotia (Emera)

g. **Maine Yankee–Greater Boston**

h. **Maine–Greater Boston**

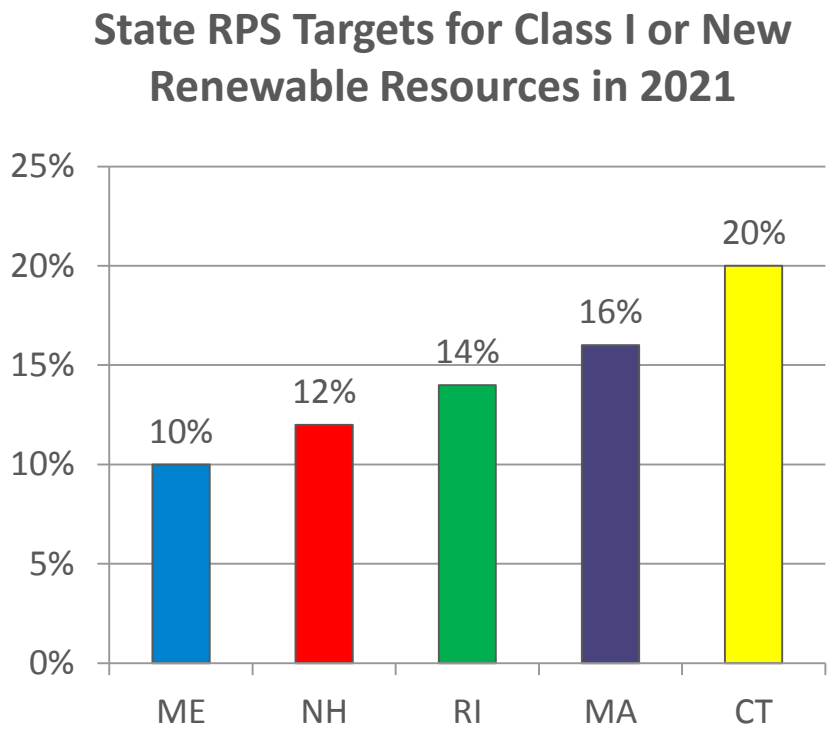
i. **Northern Maine–New England**

j. **Plattsburgh, NY–New Haven, VT**

Note: These projects are NOT reliability projects, but ISO New England' s role is to ensure the reliable interconnection of these types of projects.

State Renewable Standards and Goals Serve as Inputs to the ISO's Regional System Planning Process

- Five out of six New England states have Renewable Portfolio Standards
  - Vermont has other incentives for the development of renewable resources
- State targets have led to the development and integration of a variety of renewable resources, including wind, solar, hydro and biomass



Questions

APPENDIX:

Examples of New England's Hydroelectric Fleet

New England's Hydroelectric Fleet

Pumped Storage

Northfield Mountain

- Units 1 – 4 went into commercial operation on November 30, 1972
- The underground powerhouse contains four reversible pumps/turbines operating at gross heads ranging from 753 to 824.5 feet
- The station's total nameplate capacity is 1,119.2 MW
- The total station capacity was 1,080 MW (270 MW/unit); however, Units 2 and 3 recently underwent efficiency improvements with the replacement of the turbine runner and rewind of the motor-generator

Northfield, Massachusetts

Owner

FirstLight Power Resources, subsidiary of GDF SUEZ

Nameplate Capacities

Unit 1 – 267.9 MW
Unit 2 – 291.7 MW
Unit 3 – 291.7 MW
Unit 4 – 267.9 MW

New England's Hydroelectric Fleet

Pumped Storage

Bear Swamp

- Units 1 and 2 began commercial operation on September 1, 1974 and October 1, 1974, respectively
- Bear Swamp's two underground hydroelectric generating units have a nameplate capacity of 300 MW a piece
- Bear Swamp's generating units participate in ISO New England's energy, capacity and ancillary services markets
- In 2007, Bear Swamp signed a long-term power purchase agreement with the Long Island Power Authority (LIPA) for a significant portion of its output

Rowe and Florida, Massachusetts

Owner

Brookfield Power (50%) and Emera Energy (50%)

Nameplate Capacities

Unit 1 – 300 MW

Unit 2 – 300 MW

New England's Hydroelectric Fleet

Pumped Storage

Rocky River

- Located on the Housatonic River in New Milford, Connecticut
- Completed in 1929, Rocky River was the first pumped storage facility to be built in the United States
- Rocky River's three generating units can produce a total of 29 MW

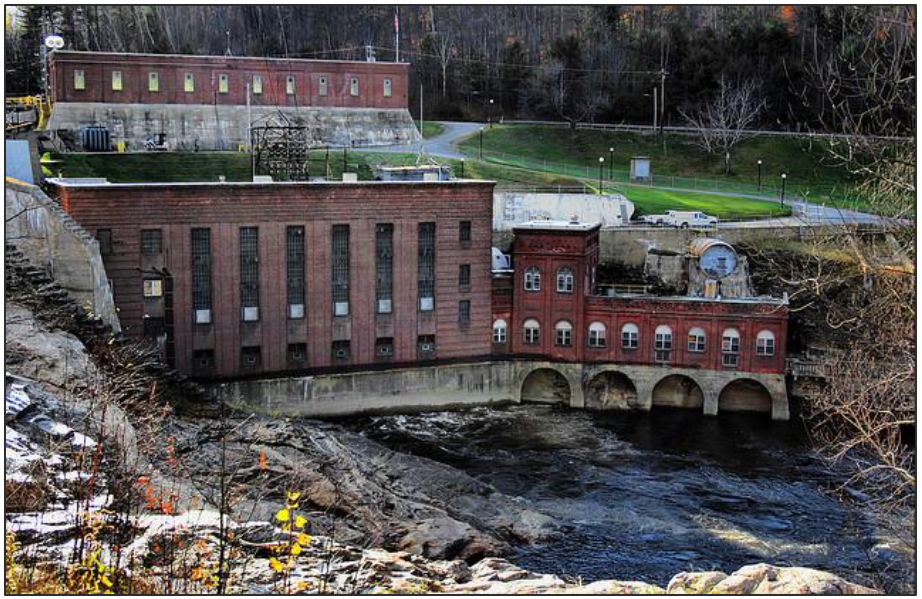
Owner
FirstLight Power Resources, a subsidiary of GDF SUEZ

New England's Hydroelectric Fleet

Conventional Hydro Run of River – Daily Cycle

Rumford Falls

- Located on the Androscoggin River in Rumford, Maine
- Rumford Falls' two generating units have a total nameplate capacity of 39.35 MW
- Maximum hydraulic capacity is 7,300 cubic feet per second and the average annual generation is roughly 270,302 MWh



Owner
Brookfield Power

New England's Hydroelectric Fleet

Conventional Hydro - Weekly Cycle

Stevenson

- Located on the Housatonic River connecting Monroe and Oxford, Connecticut
- Stevenson's four generating units have a total capacity of 28.9 MW
- Previously owned by Northeast Utilities, the dam and its power station were sold to FirstLight Power Resources in late 2006
- Stevenson is typically used by ISO New England during periods of high electricity demand

Owner
FirstLight Power Resources, a subsidiary of GDF SUEZ

FirstLight™
Power Enterprises

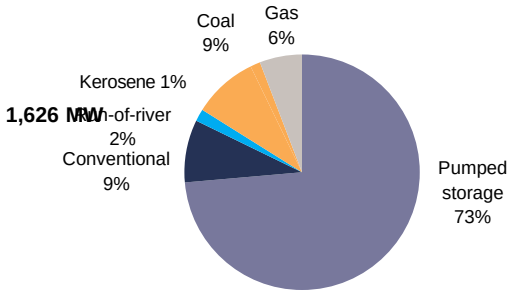


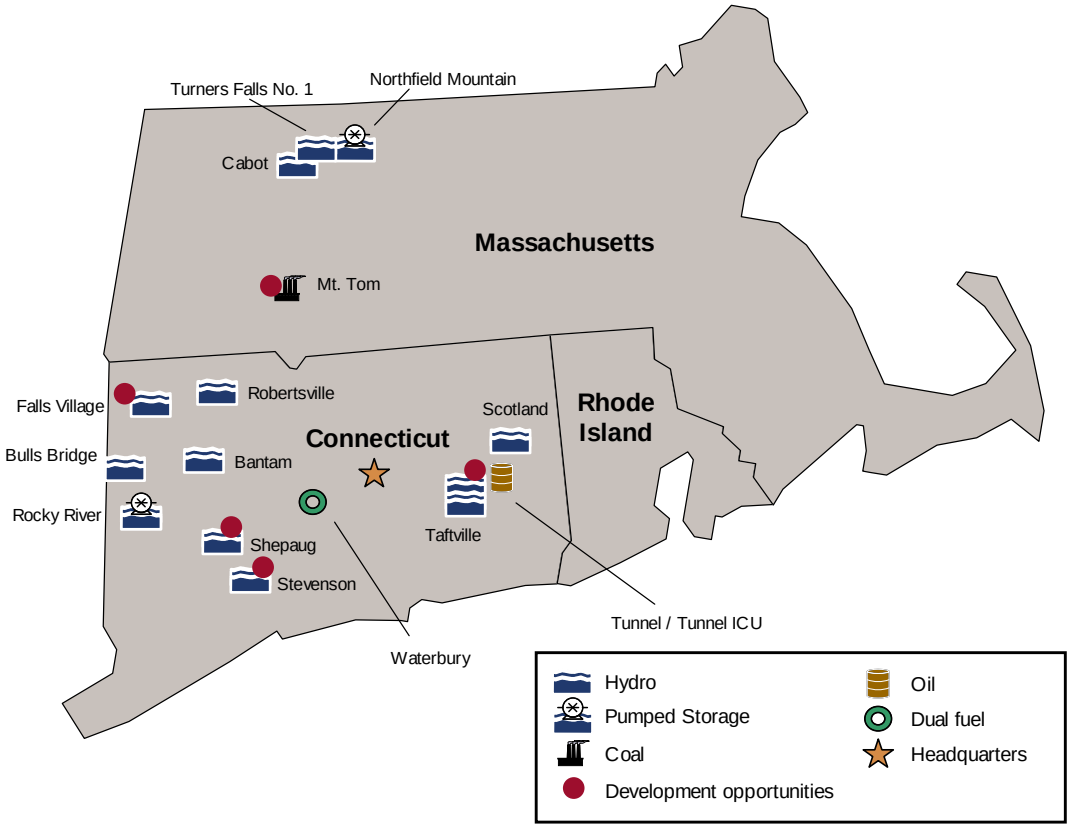
Overview of Hydropower in Connecticut

Connecticut Power and Energy Society
April 10, 2013

FirstLight Overview

Generation capacity by fuel type





(1) Includes the 96 MW Waterbury simple-cycle project and the 88 MW Northfield Mountain efficiency improvement project.
(2) Ultra-low sulfur diesel.

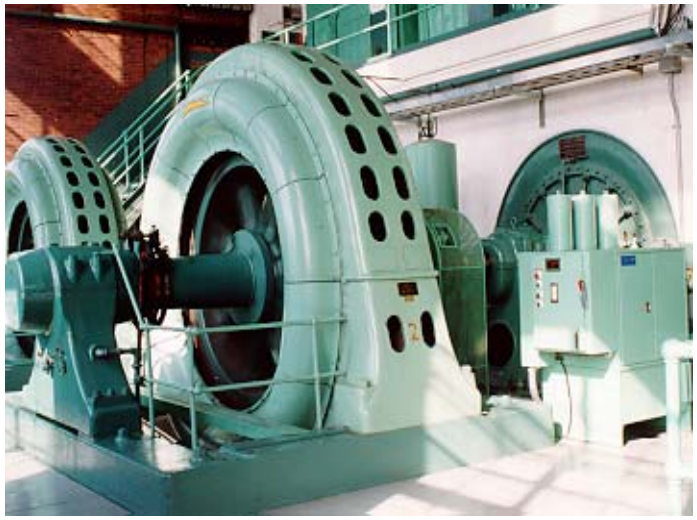
In-State CT Hydro: A Distinctive Resource

- Over 130 MW of non-greenhouse gas emitting generation
- Strict Environmental Licensing Requirements from United States FERC
- Hundreds of acres of open space for public recreation on land and on water
- Unique Habitat for Wildlife including one of best bald eagle viewing sites in New England
- Over 50 Connecticut employees at its facilities and offices
- One of largest taxpayers in CT municipalities where our plants are located

CT Hydro in the ISO-NE Market

- Units operate predominantly in Day Ahead, Real-time, LFRM, and Capacity Markets in ISO-NE
- Currently have no long term contracting provisions with utilities
  - Units are paid clearing price
  - No above market costs to customers
- Only two units currently qualify as Class I "renewable" in CT – Tunnel and Taftville
  - Upgrade to Class I planned for Scotland
  - New RPS standards being debated in Hartford
- Additional Expansion Opportunities at Bulls Bridge, Shepaug, and Stevenson

FirstLight Power Resources, Inc.
Falls Village Hydro



- Located in Falls Village, CT/Housatonic River
- COD: 1913
- Capacity: 10.5 MW, 3 Allis Chalmers
- Instantaneous run-of-river
- Great Falls overlook
- Two trail systems. Canoe/kayak and picnic area
- Trout management area downstream

FirstLight Power Resources, Inc.
Bulls Bridge Hydro

- Located in New Milford, CT/Housatonic River
- COD: 1903
- 8.4 MW, 6 GE (1.4 MW each)
- First large hydroelectric station in Connecticut
- Operations: Instantaneous run-of-river
- High difficulty whitewater area
- Trout management area
- Trail systems
- Wildlife management area

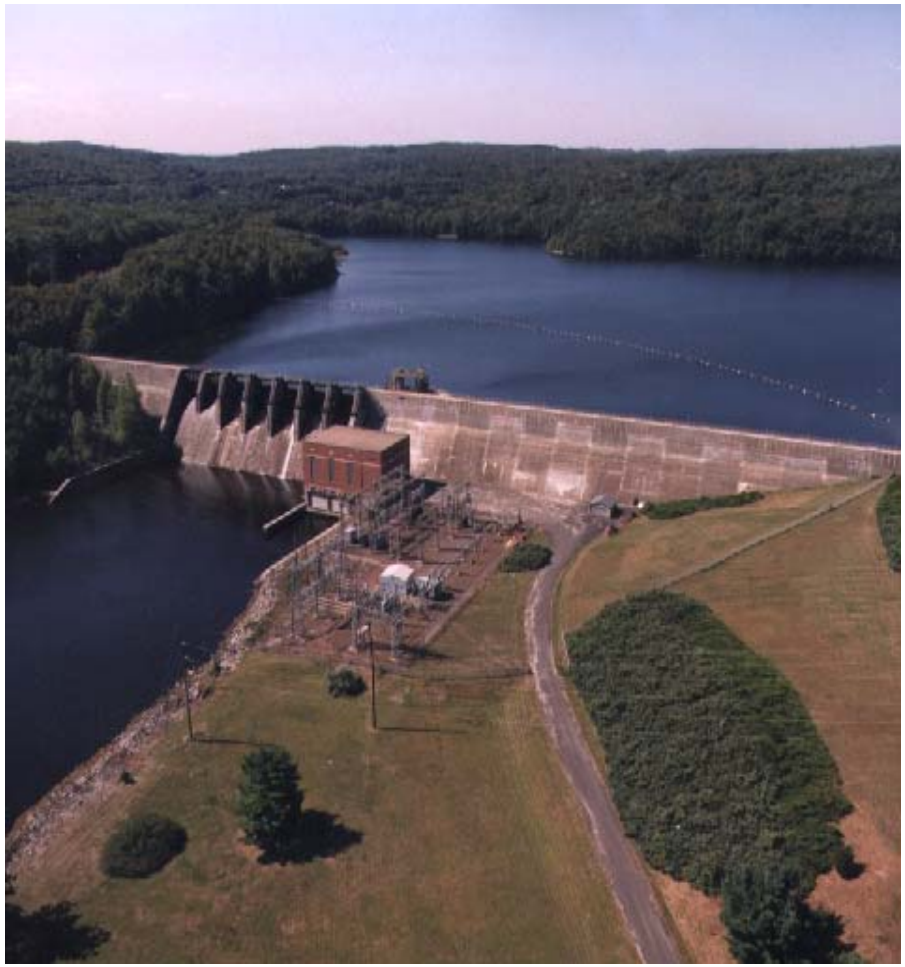
FirstLight Power Resources, Inc.
Rocky River Hydro

- **Located in New Milford, CT on Housatonic River**
- **First pumped-storage station in this country**
- **COD: 1929**
- **Capacity: 29.0 MW, 3 units: 2 GE (3.5 MW); 1 GE (23 MW)32,000 kilowatts of capacity**
- **Operations:**

  -Pumping during high water periods

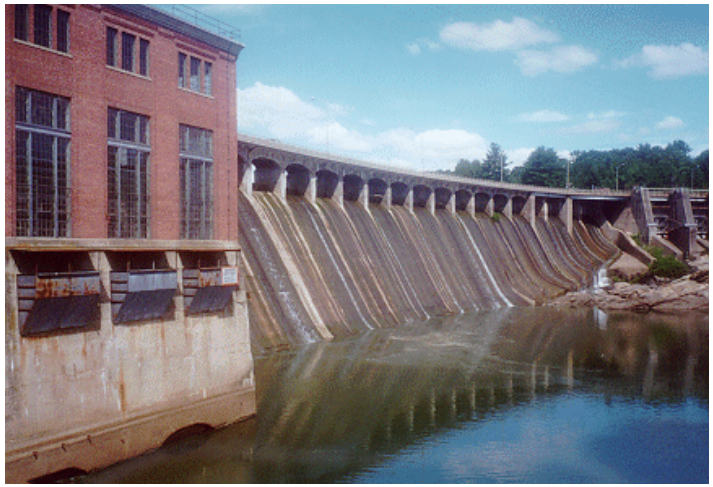
  -Releases water to be used by downstream facilities
- **Centralized dispatch center for all of CT Hydro**
- **Dam and dikes create Candlewood Lake – state's largest**
- **15,000 people visit our Dikes Point Recreation Area at Candlewood Lake each year**

FirstLight Power Resources, Inc.
Shepaug Hydro



- **Located in Southbury, CT**
- **COD: 1955**
- **Capacity: 42.6 MW, 1 Allis Chalmers unit**
- **Operations:**
  - **Weekly pond and release**
  - **Remotely operated from Rocky River**
  - **Maximum station discharge of 6,200 cfs**
- **Environment provides unique habitat for wildlife, including bald eagles**
- **9,500 people visit annually for recreation**

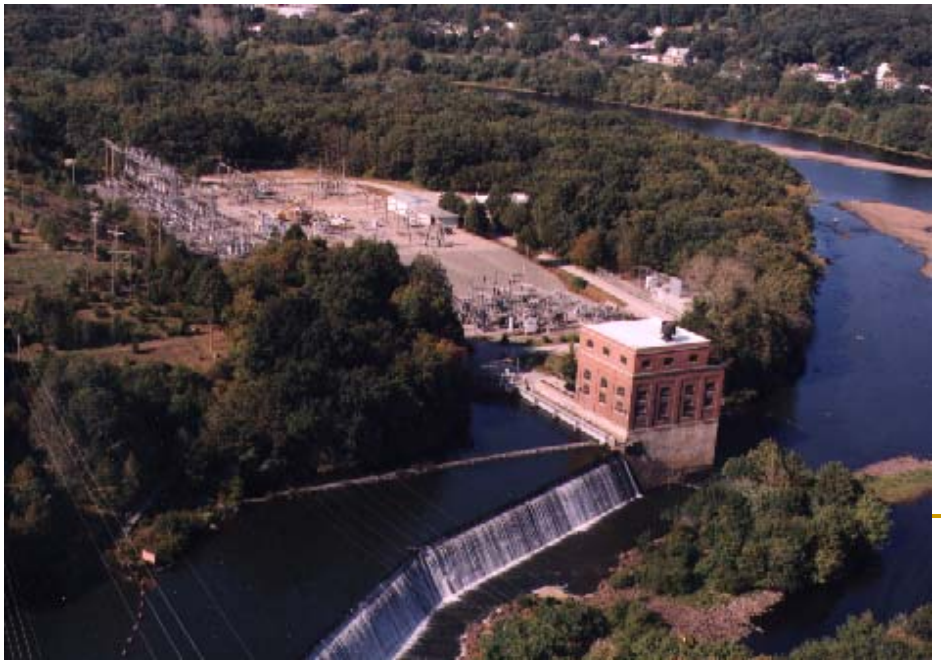
FirstLight Power Resources, Inc.
Stevenson Hydro



- **Located in Monroe, CT/Housatonic River**
- **COD: 1919**
- **Capacity: 28.9 MW, 4 Westinghouse units**
- **Operations:**

  -Remotely operated from Rocky River

  -In response to Shepaug's schedule
- **Stevenson Dam created Lake Zoar, used for water related recreation**



Eastern Connecticut

Scotland (1937), Taftville (1906) & Tunnel (1919) – 6 MW total

Shetucket and Quinebaug Rivers

Northwestern Connecticut

Bantam (1905) & Robertsville (1923) - 0.9 MW total

Bantam and Still Rivers

The Role of Hydro-Québec in New England Electric Markets

Connecticut Power & Energy Society Meeting
The Role of Hydropower in Connecticut's Energy Future

April 10, 2013

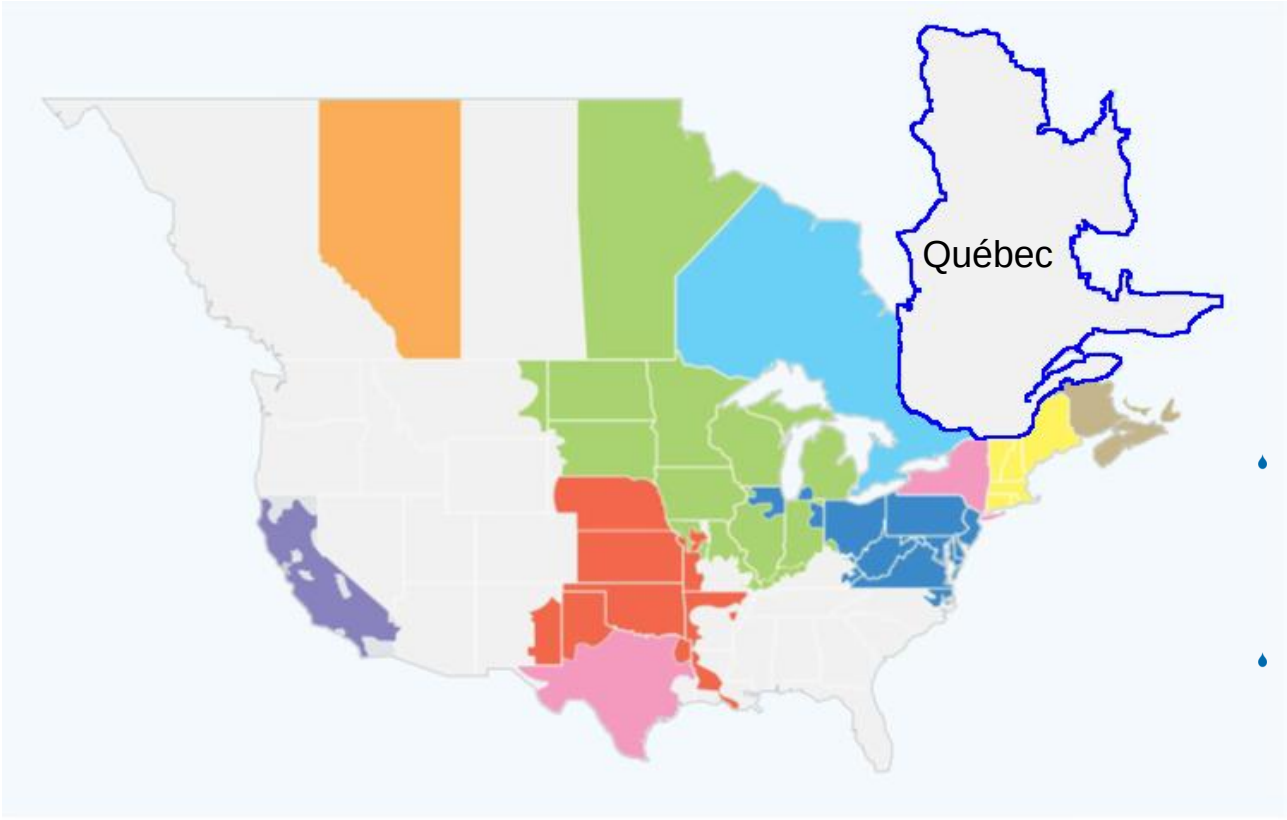
Stephen Molodetz
Vice President, Business Development, HQUS

Summary

- Overview of Quebec and Hydro Quebec
- New Hydro Generation Projects
- New Transmission Projects
- New England Electric Markets

HQUS

The Province of Québec



- Size, geography and climate present a unique opportunity for development of large hydropower
  - 645,000 square miles
  - 12% is water
  - Over 4500 rivers and 500,000 lakes
- Major reservoirs located in “boreal” regions (cold temperatures)
- Hydro Québec acted on this opportunity beginning 50 years ago to develop a clean and reliable electricity supply

HQUS

Hydro-Québec and HQUS

Hydro Québec

23,600 employees

Hydro Québec Production

Hydro Québec TransÉnergie

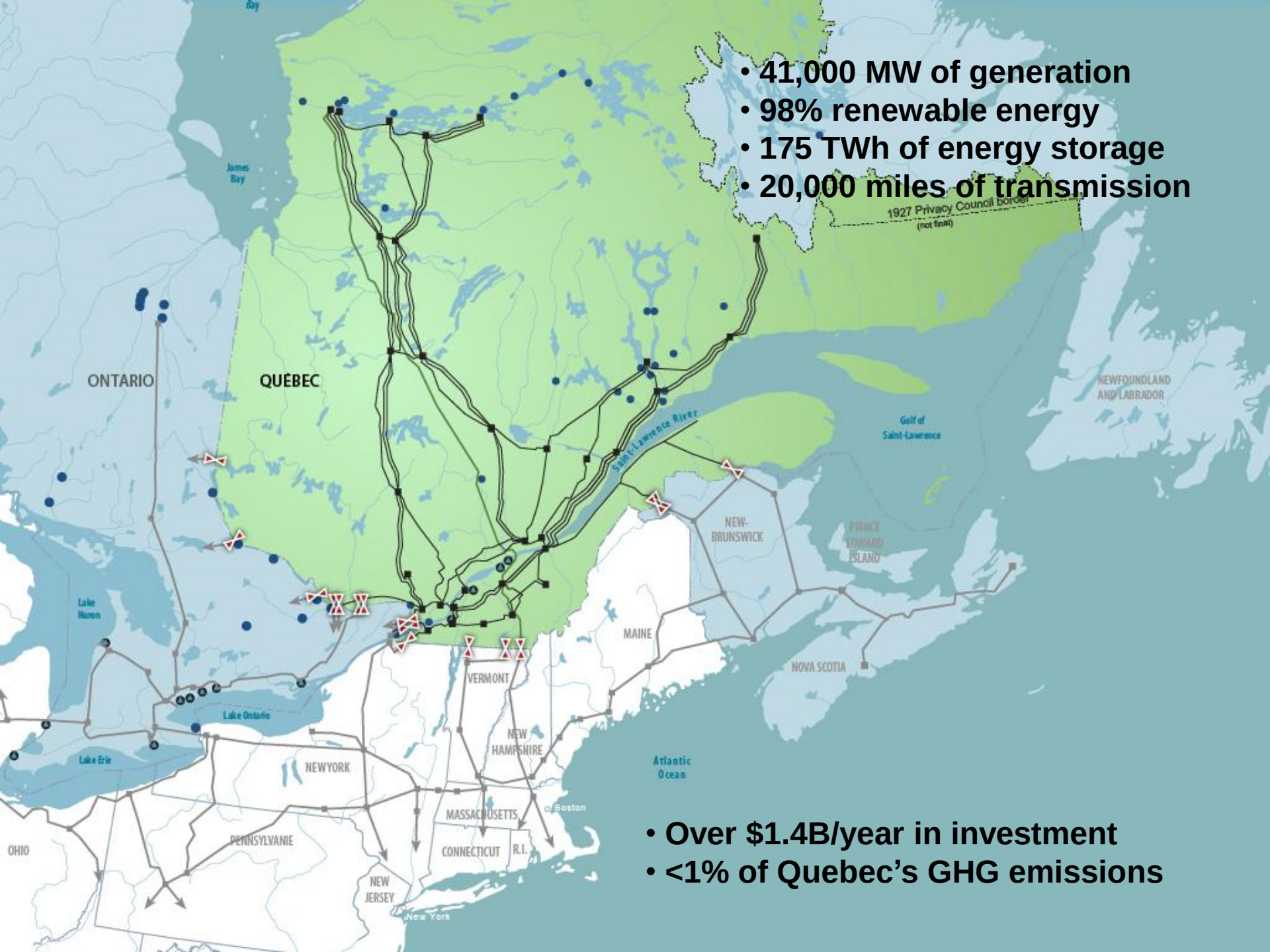
Hydro Québec Distribution

Hydro Québec Équipement

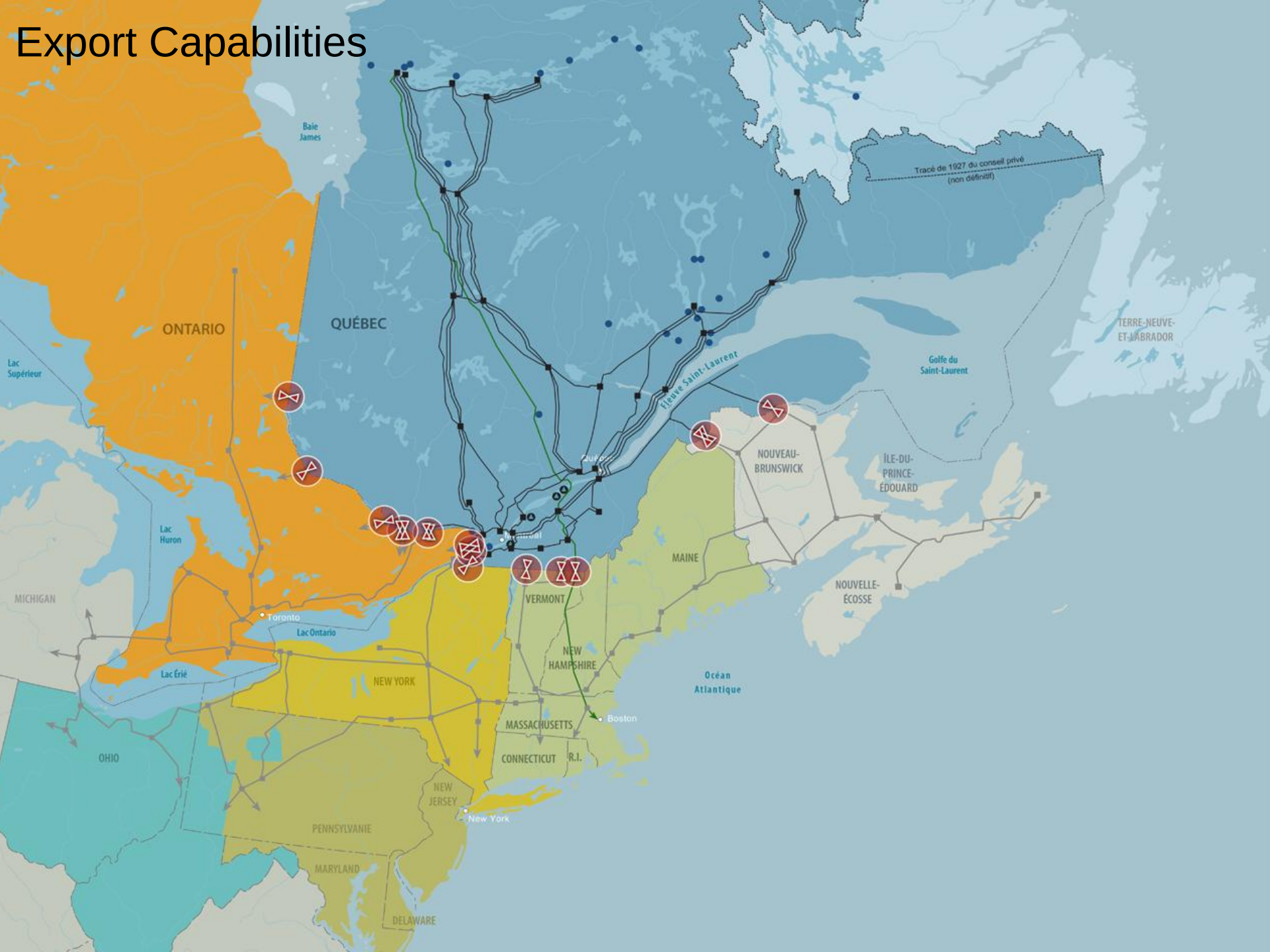
HQUS

Headquartered in Hartford, CT

HQUS


• 41,000 MW of generation
• 98% renewable energy
• 175 TWh of energy storage
• 20,000 miles of transmission
1927 Privacy Council border
(not final)
James Bay
ONTARIO
QUÉBEC
Saint-Lawrence River
Gulf of Saint-Lawrence
NEWFOUNDLAND AND LABRADOR
NEW-BRUNSWICK
PRINCE EDWARD ISLAND
NOVA SCOTIA
MAINE
VERMONT
NEW HAMPSHIRE
Lake Huron
Lake Ontario
Lake Erie
NEW YORK
MASSACHUSETTS
Boston
CONNECTICUT
R.I.
PENNSYLVANIE
OHIO
NEW JERSEY
New York
Atlantic Ocean
• Over $1.4B/year in investment
• <1% of Quebec's GHG emissions

Export Capabilities



Export Levels

Net Electricity Exports by Hydro-Québec Production						
Year	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Volume (TWh)	10.7	15.2	18.5	12.6*	20.8	30.1

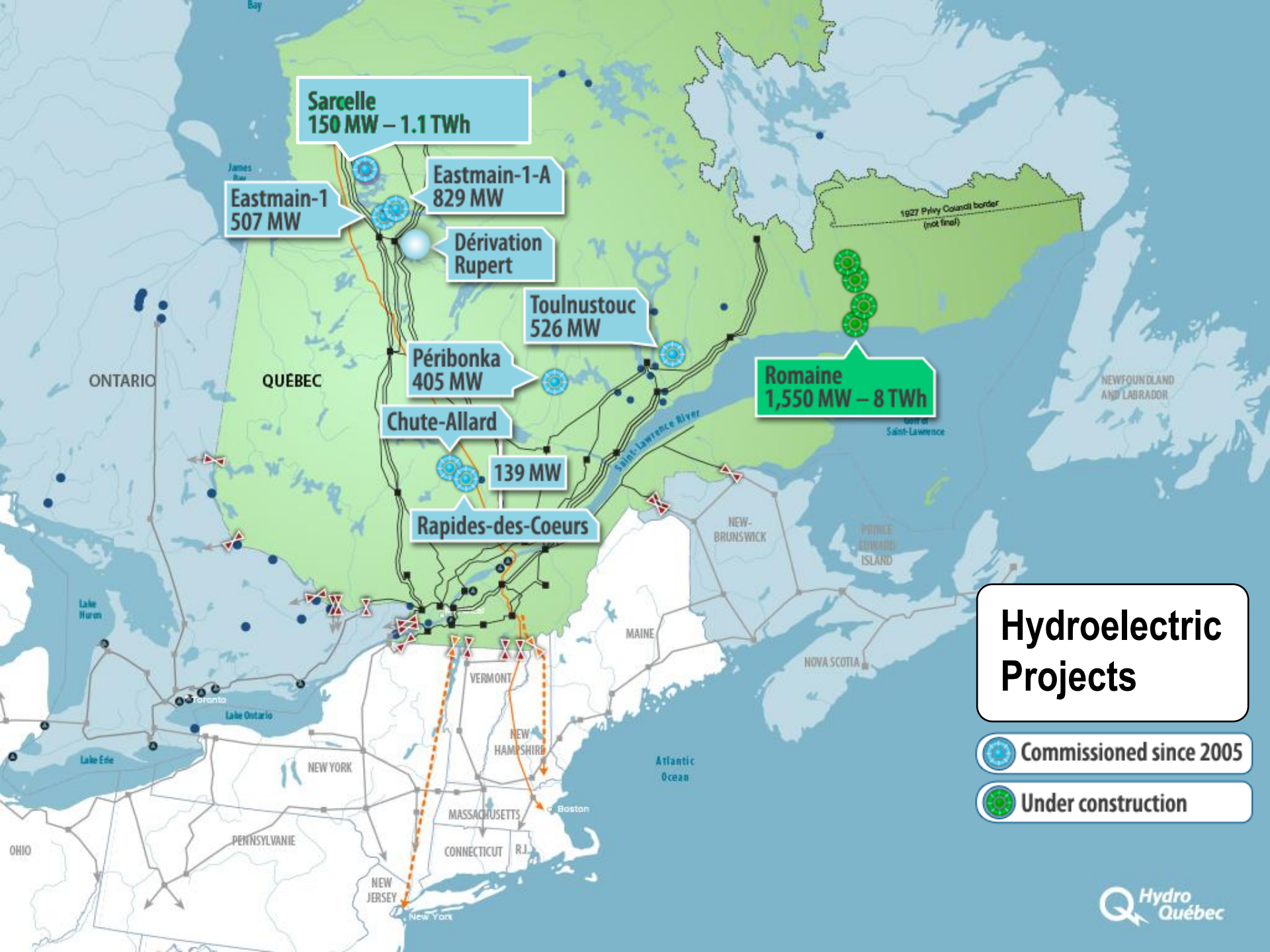
* 2010 suffered from very low hydraulicity

- Future years export projections are on par with recent years

Generation Developments

- Three criteria must be met for Hydro Quebec to pursue construction of a new generating project.

- Projects are required to be:
  - Profitable
  - Environmentally acceptable
  - Well-received by local communities


Sarcelle
150 MW – 1.1 TWh
Eastmain-1-A
829 MW
Eastmain-1
507 MW
Dérivation
Rupert
Toulnustouc
526 MW
Péribonka
405 MW
Chute-Allard
139 MW
Rapides-des-Coeurs
Romaine
1,550 MW – 8 TWh
1927 Privy Council border
(not final)
ONTARIO
QUÉBEC
NEWFOUNDLAND
AND LABRADOR
Saint-Lawrence River
Gulf of
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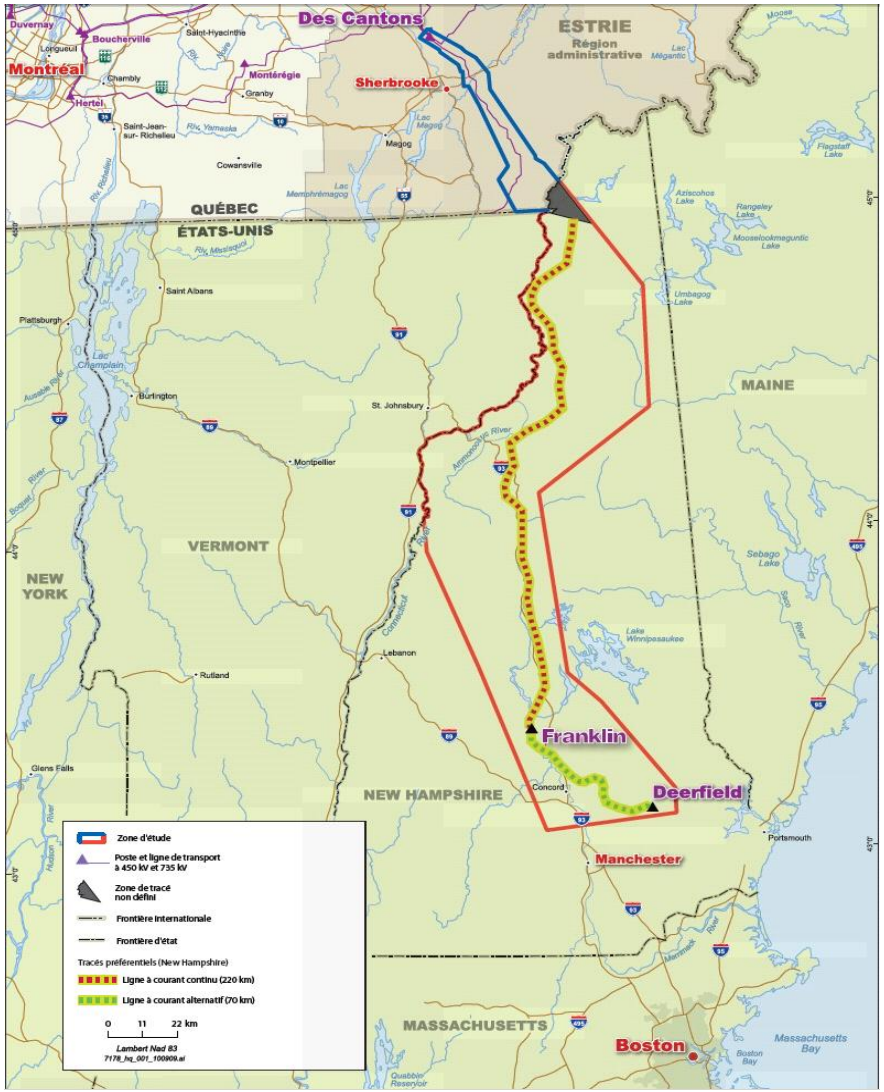
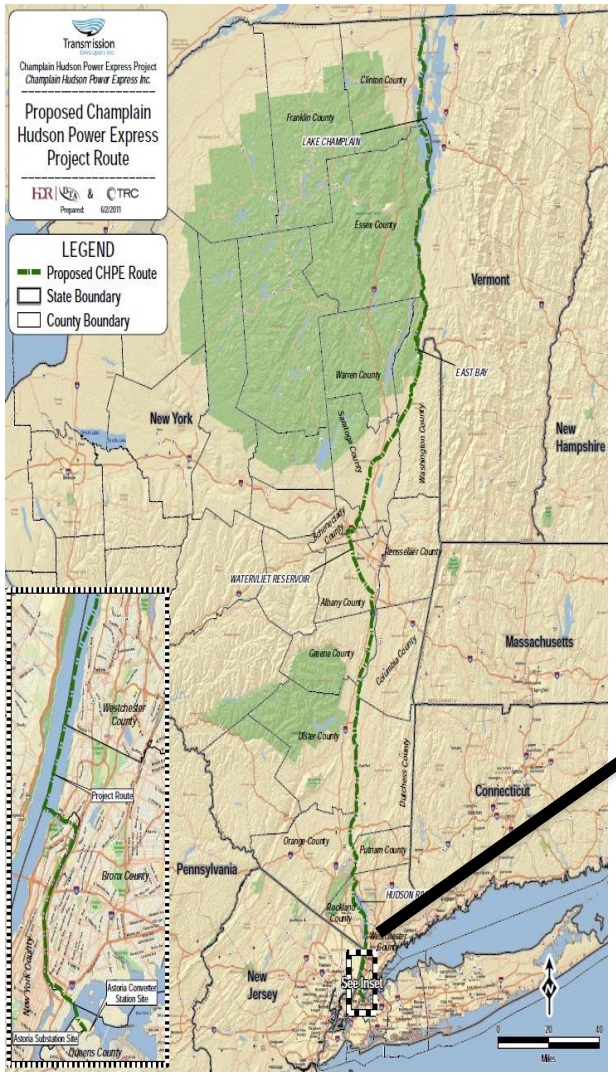
BRUNSWICK
PRINCE
EDWARD
ISLAND
NOVA SCOTIA
MAINE
VERMONT
NEW
HAMPSHIRE
NEW YORK
MASSACHUSETTS
CONNECTICUT
R.I.
PENNSYLVANIE
OHIO
NEW
JERSEY
Boston
New York
Toronto
Lake Huron
Lake Ontario
Lake Erie
Atlantic
Ocean
Hydroelectric
Projects
Commissioned since 2005
Under construction
Hydro
Québec

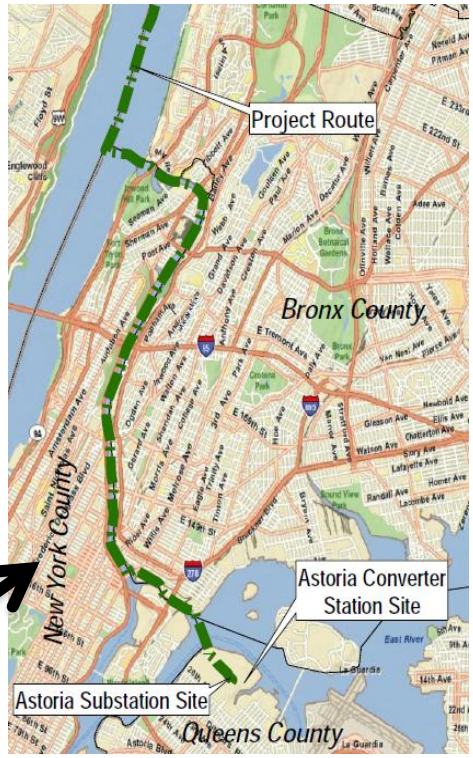
Transmission Developments: Northern Pass Transmission Project



- 1200 MW HVDC link between Quebec and Deerfield, NH
- Cost-based, participant funded project
- Target in-service date 2017
- NU is the US developer
  - Revised route to be announced shortly
- TransÉnergie is the Québec developer

Champlain Hudson Power Express Project



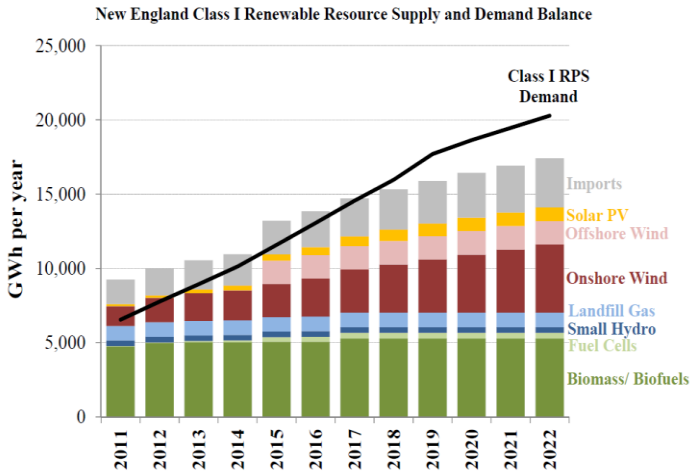


- 1 000 MW HVDC line between Quebec and New York City
- Merchant project
  - HQ in negotiations to be the “anchor tenant” for 75% of the capacity
  - Open season solicitation for remaining 25%
- Siting approval expected this month
- Target in-service date 2017
- TDI is the US developer

HQUS

HQUS Outlook for New England Market: Value of Hydro-Québec Power Increasing

Regional Class I RPS Shortage Projected After 2017



Northeast increasingly reliant on natural gas for power generation

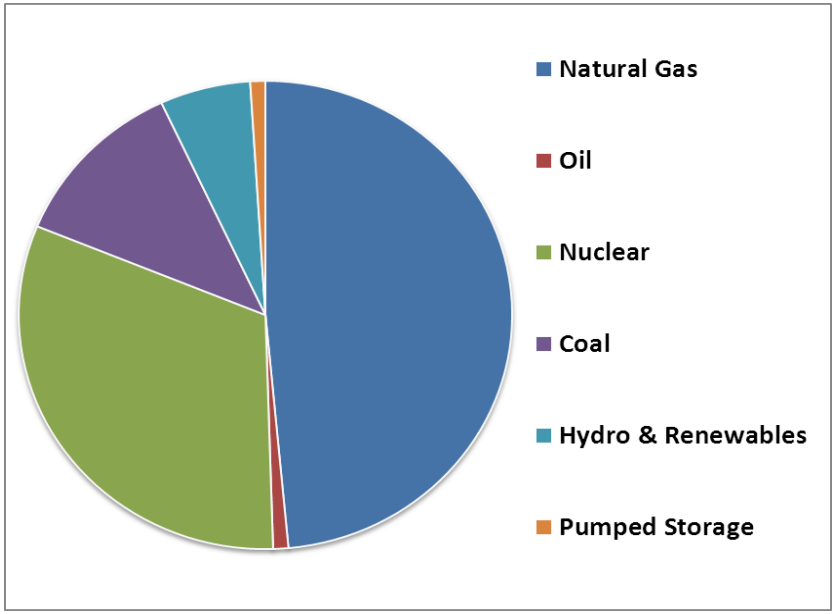
Lack of gas transmission causing power system reliability issues

Older generating plants lack flexibility, uneconomic

States unlikely to meet RPS requirements, ratepayer exposure significant

Canadian hydropower available to contribute to compliance at a lower cost

Can also assist to integrate higher levels of wind to help meet RPS



Market Conditions Challenge Greater Integration

- Low natural gas prices diminish the economics of major new transmission projects for Hydro-Québec
- Mechanisms to promote the numerous benefits of Hydro-Québec power that could improve the economics of new transmission do not exist
  - Large hydro facilities are unable to participate in state renewable programs
  - A federal renewable program continues to be an uncertainty in the US
  - Incentives to promote increased fuel diversity/reliability are not available
  - To date, efforts to fund the cost of transmission for economic or public policy purposes have not been successful in New York or New England

HQUS

States Consider Options For Increasing Reliance on Hydropower…

- To lower RPS compliance costs
  - Connecticut has proposed a “contracted tier” for the RPS in which large hydropower and Class 1 renewables compete to meet a limited amount of the compliance requirement
  - Maine Governor LePage proposing to remove the 100 MW size limit on eligible hydropower resources
- To contribute to reducing CO2 emissions
  - Massachusetts is considering how a “Clean Energy Standard” might be designed to attract large hydropower to contribute to the targets of the Global Warming Solutions Act
- NESCOE’s coordinated procurement could result in the procurement of large hydropower as a balancing/firming resource for greater wind and solar integration

In Closing….

- HQUS will continue to be a valued energy partner for Northeast energy markets and to pursue mutually beneficial projects
- Despite market and regulatory challenges, HQUS is optimistic about activities underway to recognize the value of hydropower to ensure, and increase, deliveries into the region.
- HQUS comments on the Draft Comprehensive Energy Strategy can be found at http://www.dpuc.state.ct.us/DEEPEnergy.nsf/$EnergyView?OpenForm&Start=1&Count=30&Expand=4.3&Seq=2.
- HQUS comments on SB 1138 An Act Concerning Connecticut's Clean Energy Goals can be found at http://www.cga.ct.gov/asp/menu/CommDocTmyBill.asp?comm_code=ET&bill=SB-01138&doc_year=2013.

Save-the-Date!

- Visit www.isoenergyconference.com for more details