Atlantic Energy Snapshot

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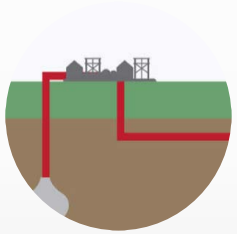
Basin & Reservoir Lab

K.Rutledge

Overview



1. Introduction
2. Offshore Oil and Gas
3. Onshore
4. Renewables
5. Carbon Storage
6. Hydraulic Fracturing (“Fracking”)
7. Conclusions

Oil & Gas Volume Measurements

Natural Gas

Abbreviation	Description
Bcf	billion cubic feet
Bcf/d	billion cubic feet per day
Btu/cf	British thermal units per cubic foot
cf	cubic feet
m^3	cubic metre
m^3/d	cubic metres per day
Mcf	thousand cubic feet
MMBtu	million British thermal units
MMcf	million cubic feet
MMcf/d	million cubic feet per day
Tcf	trillion cubic feet
t	tonne (1000 kilograms) equivalent to metric ton
MMt	Million Metric tons
MMt/y	Million Metric tons per year

Oil & Gas Volume Measurements

Bcf (Billion Cubic Feet)

Gas measurement approximately equal to one trillion (1,000,000,000,000) Btu's

Tcf (Trillion Cubic Feet)

A trillion cubic feet (1,000,000,000,000 cubic feet) is a volume measurement of natural gas that is equivalent to approximately one Quad. A Quad is an abbreviation for a quadrillion (1,000,000,000,000,000) Btu's.

MMscf/d = One Million Standard cubic feet per day

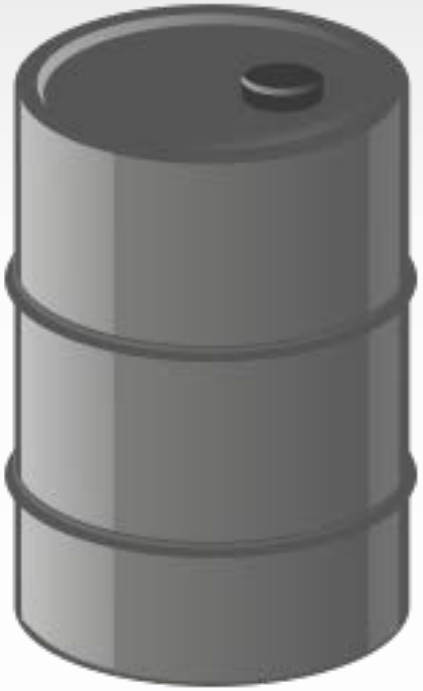
E3m3 = a thousand cubic meters

E6m3 = a million cubic meters

Heat Energy per unit of Measure for Natural Gas:

Unit of Measure	Approx. Heat Energy
1 cubic foot	1,000 BTU's
100 cubic feet (1 therm)	100,000 BTU's
1,000 cubic feet (1 mcf)	1,000,000 BTU's

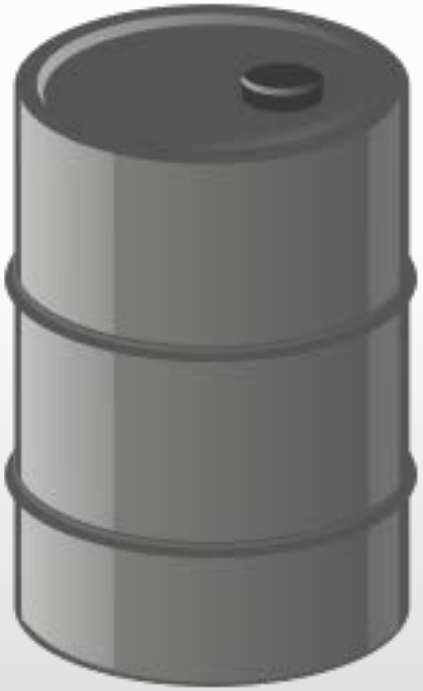
Oil & Gas Volume Measurements



Crude Oil and Natural Gas Liquids

Abbreviation	Description
b/d	barrels per day
bbl	barrels
m^3	cubic metre
m^3/d	cubic metres per day
$10*3m^3$	thousand cubic metres
Mb/d	thousand barrels per day
MMb	million barrels
MMb/d	million barrels per day

Oil & Gas Volume Measurements



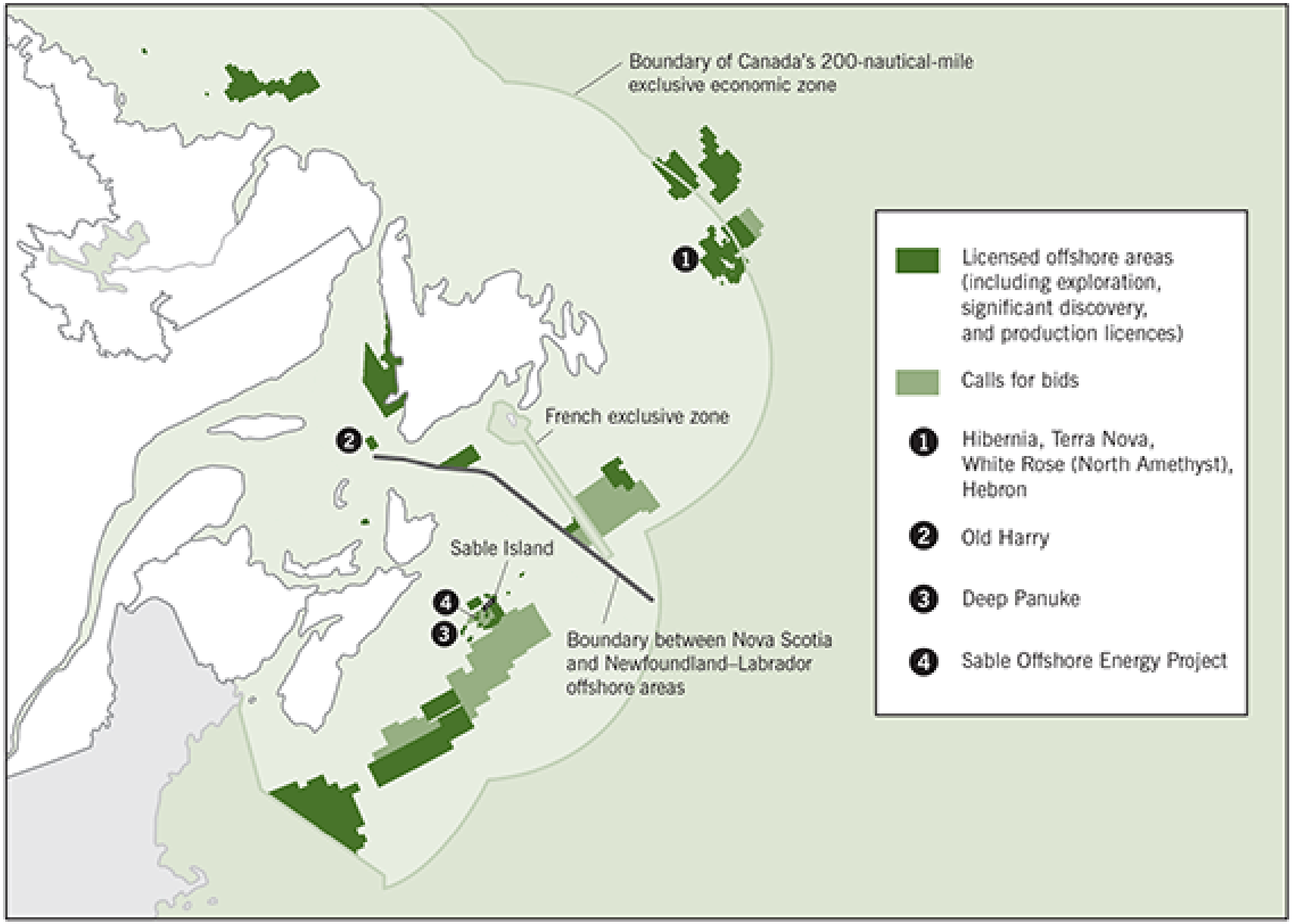
1 Barrel of Crude Oil (average gravity)

1 barrel = 42 US gallons
1 barrel = 158.98 litres
1 tonne = 7.33 Barrels
1 short ton= 6.65 Barrels
1.0 Cubic metres (m^3) = 6.2898 Barrels (bbl)

The amount of energy released by burning one barrel of crude oil:

1 barrel of oil equivalent = 1.6282 MWh

Offshore Oil & Gas



(Canada, Office of the Auditor General of Canada, adapted from publications of the Canada–Newfoundland and Labrador Offshore Petroleum Board and the Canada–Nova Scotia Offshore Petroleum Board, 2012)

NS Offshore Oil & Gas

Activity and Production

Cohasset-Panuke Project (1992 – 1999)

7,066,810.30 m^3 Total oil production

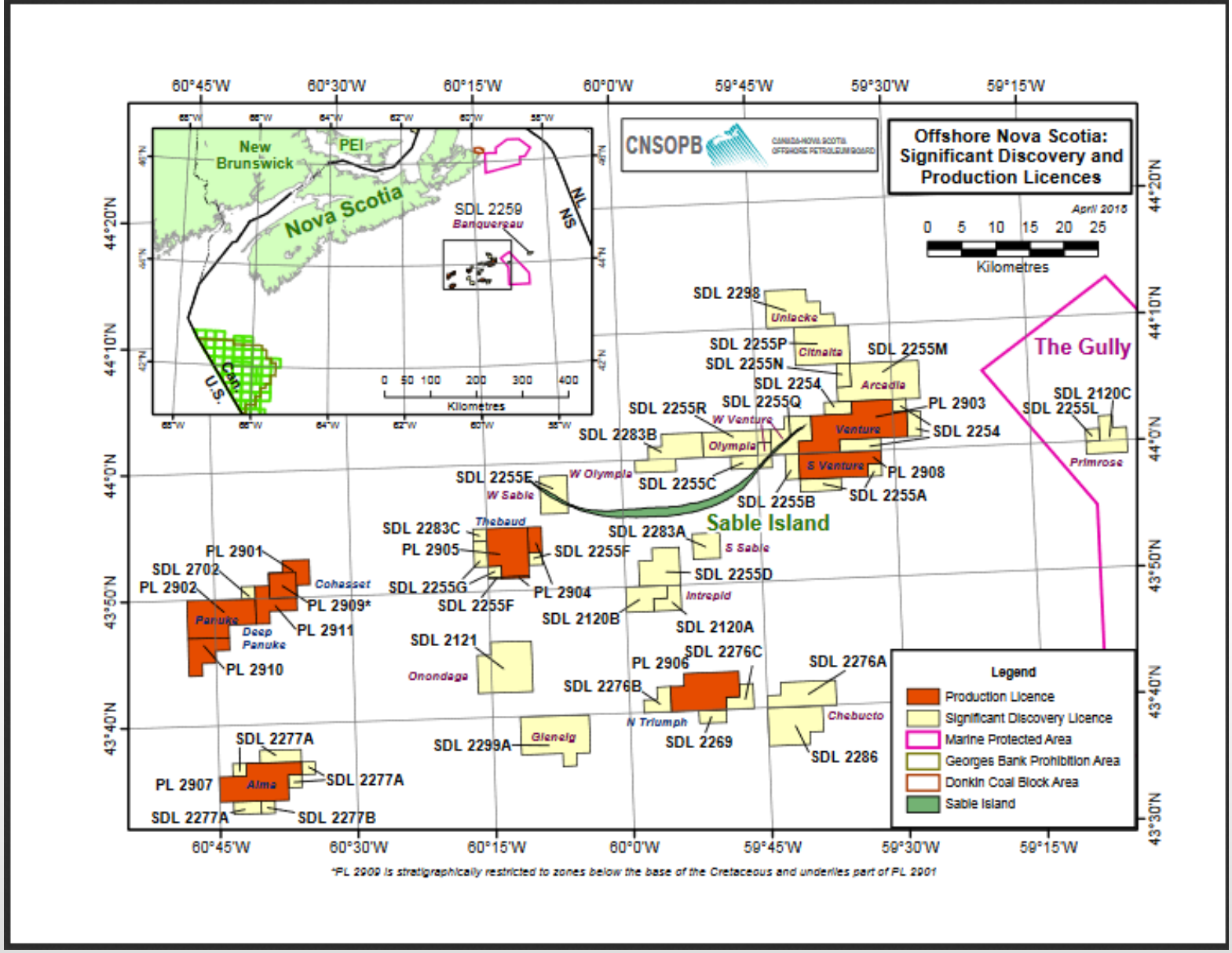
Deep Panuke Offshore Gas Project (2013- May 2018)

3,767,042.3 (10^3m^3) Total gas production since 2013

Sable Offshore Energy Project (1999 – December 2018)

59,966,565.73 (10^3m^3) Total gas production since 1999

(CNSOPB, 2018)

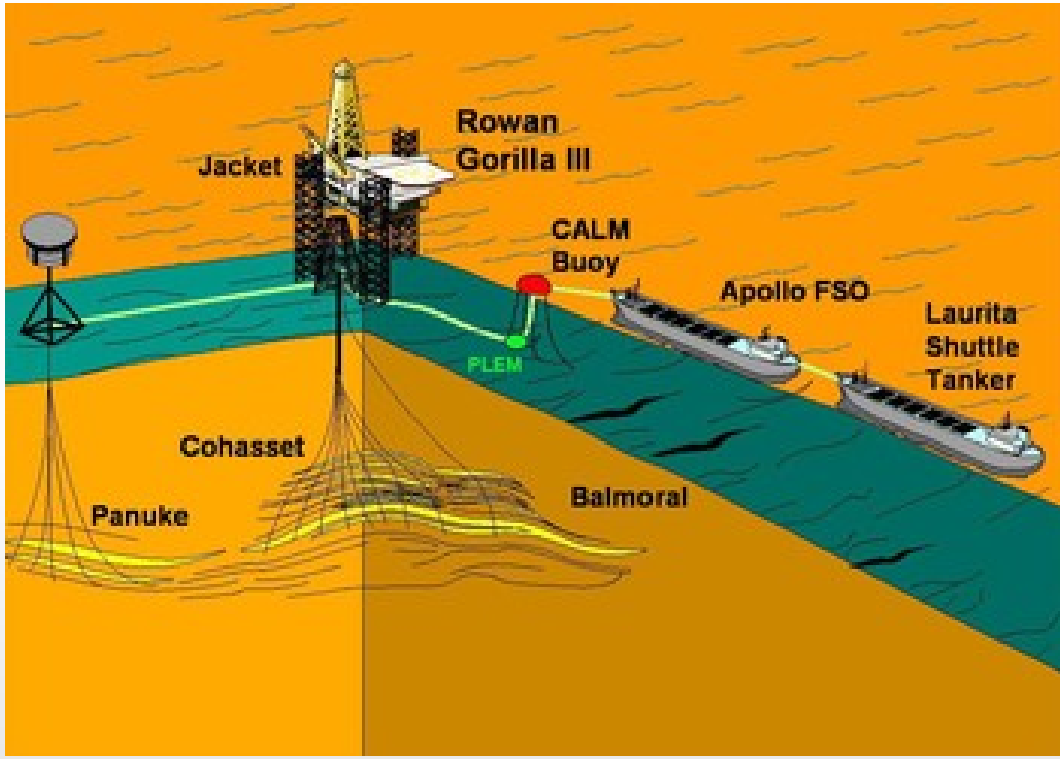


(CNSOPB, 2020)

Nova Scotia

NS Offshore Oil & Gas:
Cohasset-Panuke Project (1992 – 1999)

- Canada's first offshore oil project
- Production began in 1992, ended in 1999, and is now decommissioned
- 7,066,810.30 m^3 Total oil production

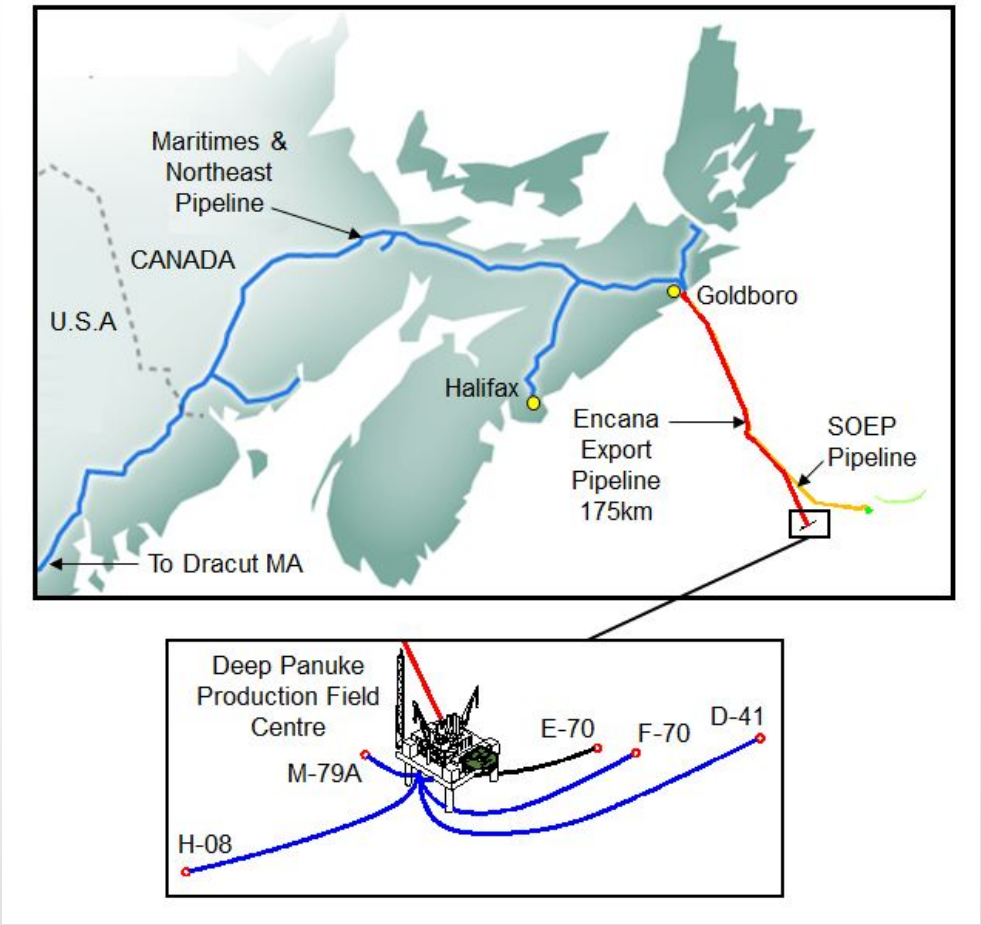


(CNSOPB, 1992)

NS Offshore Oil & Gas:

Deep Panuke Offshore Gas Project

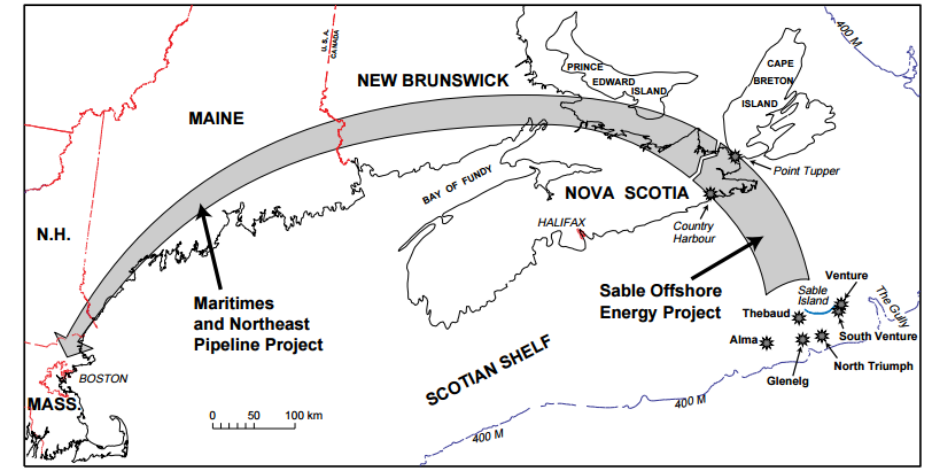
- 250 km southeast of Halifax
- Production began in 2013 and ended in 2018
- 892 Bcf of natural gas was estimated to be produced through a facility sized for a peak gas rate of 8498.4 ($10^3m^{3)}$ over a period of an estimated 13 years
- 147.2 Bcf Total production from 2013 to 2018



(CNSOPB, 2007).

NS Offshore Oil & Gas:
Sable Offshore Energy Project

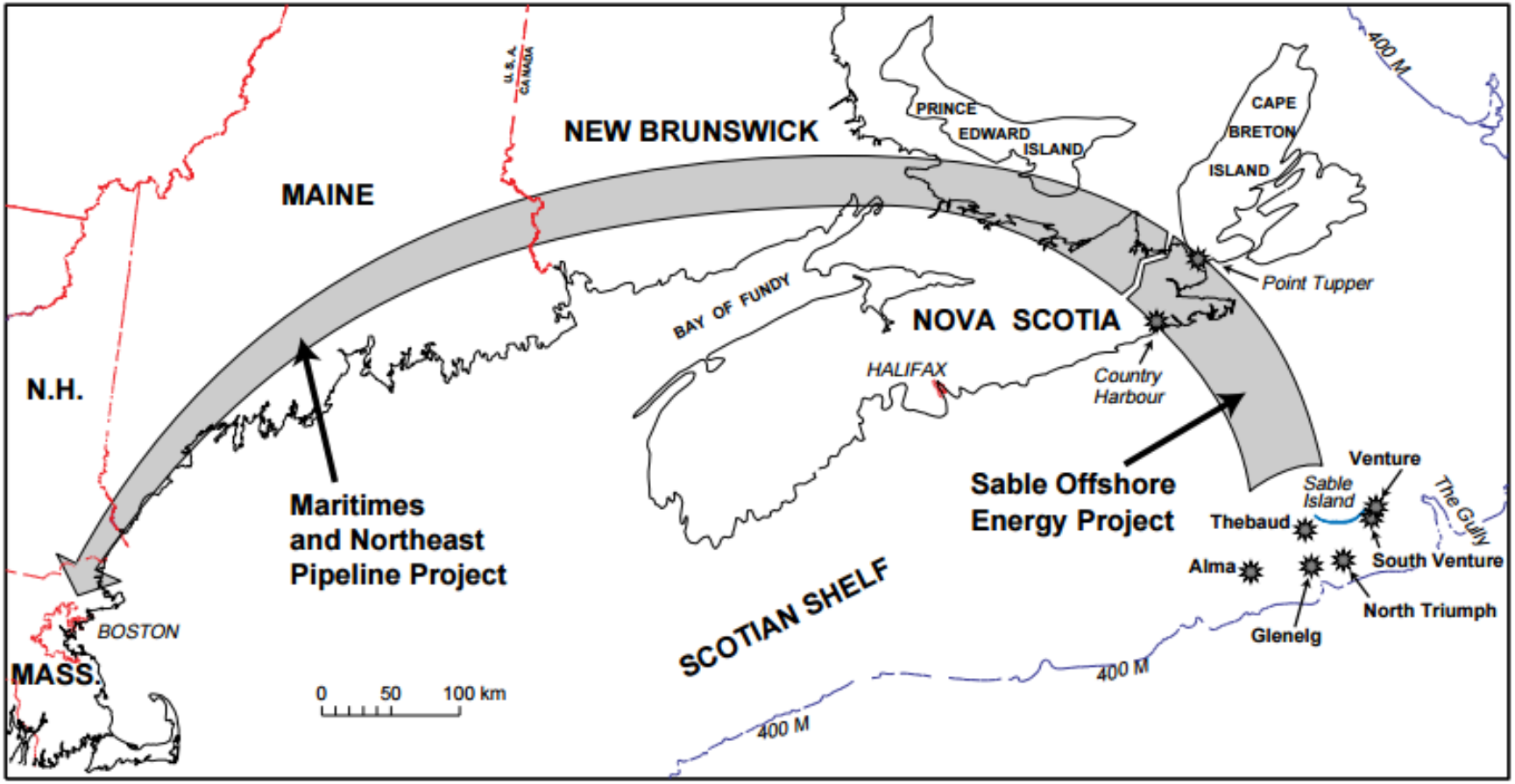
- Production began in 1999 with an estimated project life of 25 years
- Project design rate is 14,000.4 $10^3m^3/d$ of raw gas (510 MMscf/d) production yielding 13,000 $10^3m^3/d$ of sales gas. This production rate could be increased if market conditions and gas supplies warrant.
- Closed in 2018



(CNSOPB, 2007)

Offshore Oil & Gas:

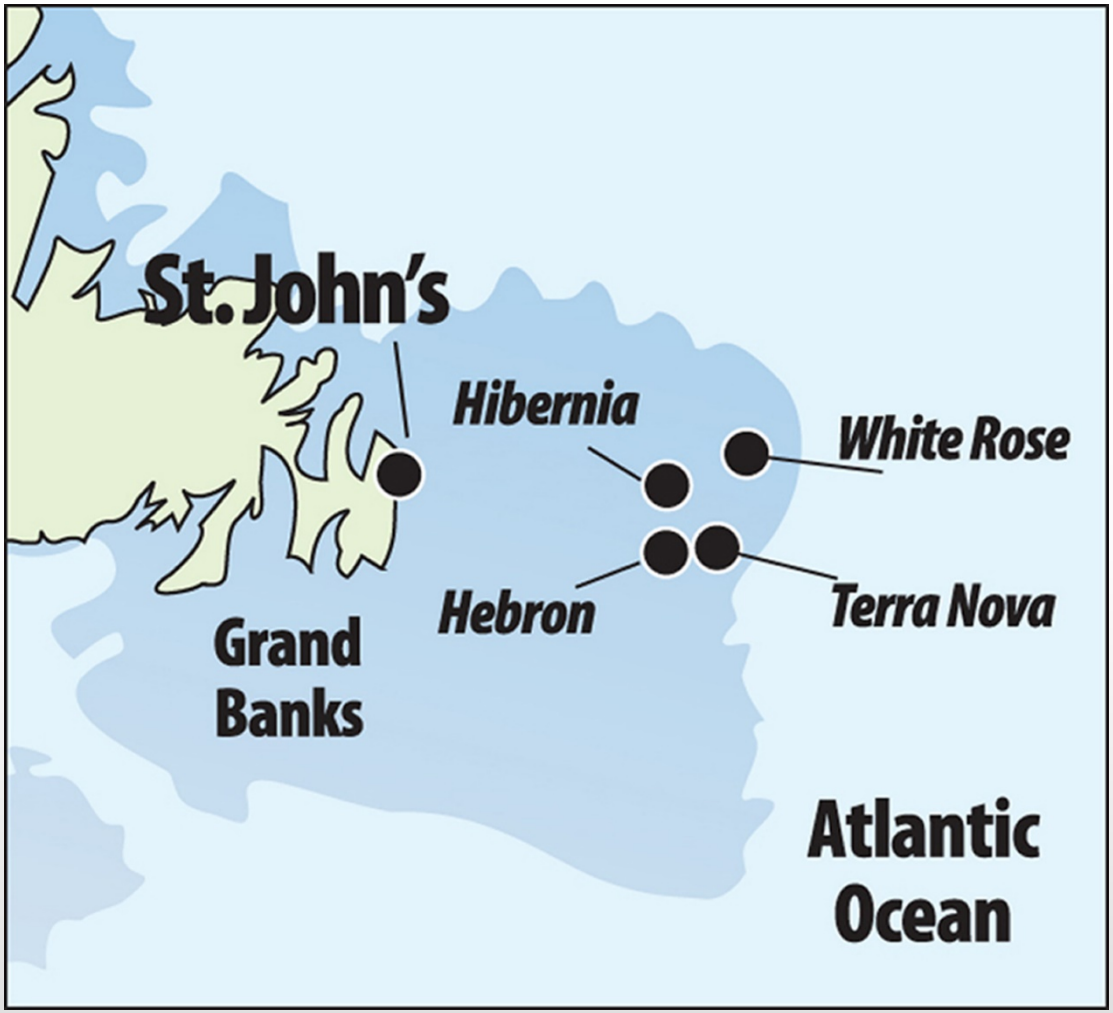
Sable Offshore Energy Project



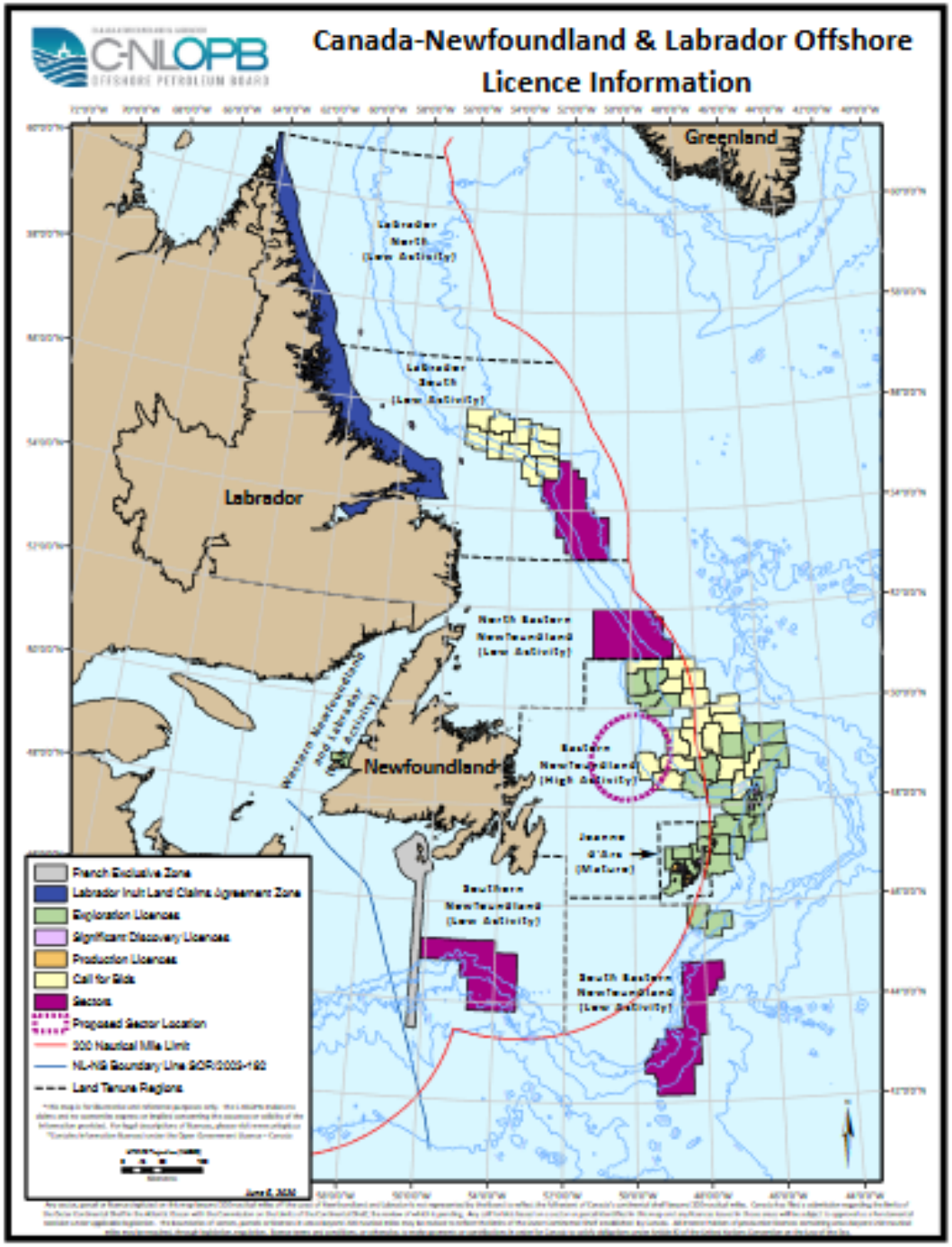
(CNSOPB, 2007)

Nova Scotia

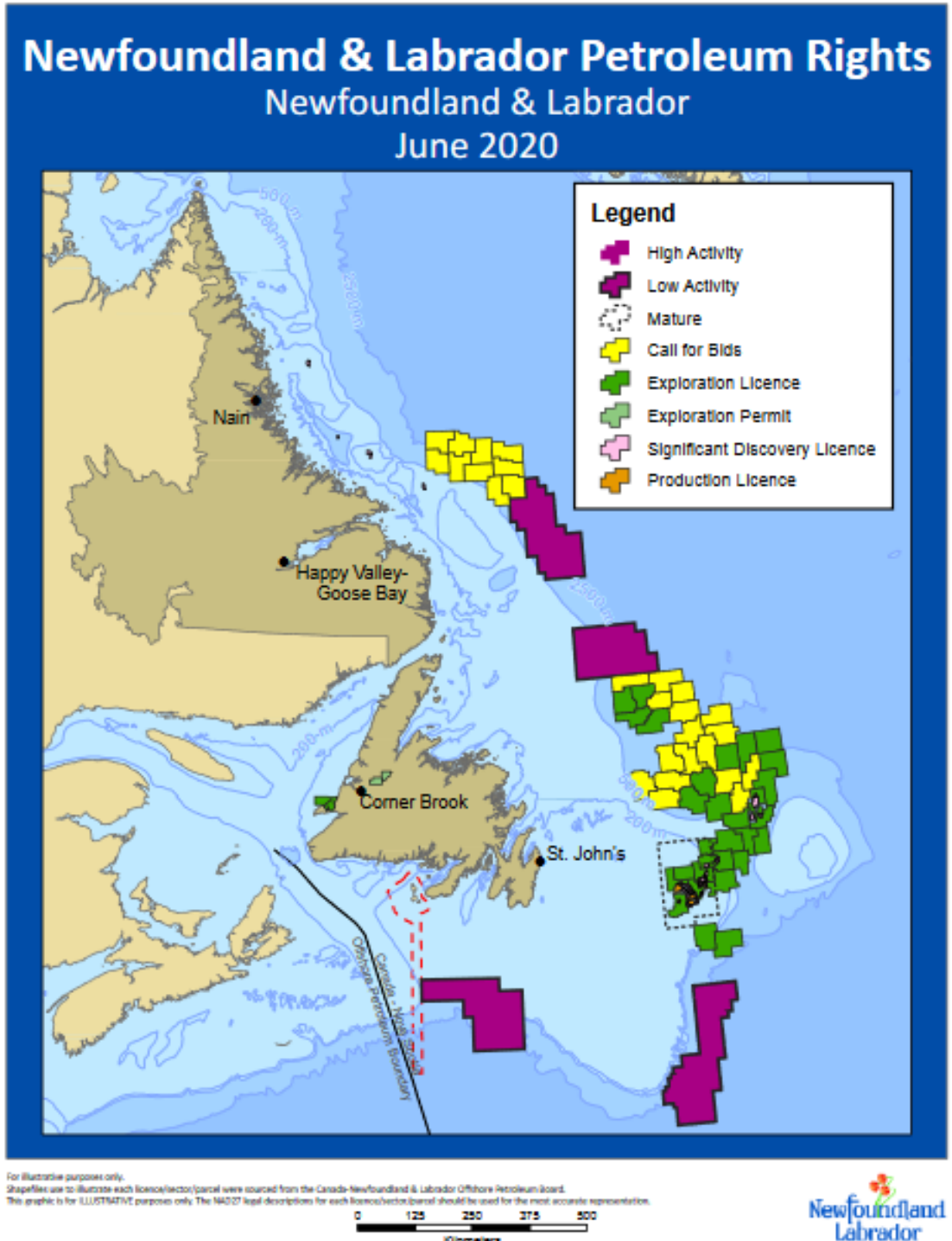
NL Offshore Oil & Gas



Newfoundland & Labrador


C-NLOPB
Canada-Newfoundland & Labrador Offshore
Licence Information
Greenland
Labrador
Newfoundland
Labrador North (Low Activity)
Labrador South (Low Activity)
North Eastern Newfoundland (Low Activity)
Eastern Newfoundland (High Activity)
Jeanne d'Arc (Mature)
Southern Newfoundland (Low Activity)
South Eastern Newfoundland (Low Activity)
Western Newfoundland and Labrador Activity
French Exclusive Zone
Labrador Inuit Land Claims Agreement Zone
Exploration Licences
Significant Discovery Licences
Production Licences
Call for Bids
Sectors
Proposed Sector Location
200 Nautical Mile Limit
NL-NS Boundary Line SOR/2009-160
Land Tenure Regions

(CNLOPB, 2020)



(Department of Natural Resources Newfoundland and Labrador, 2020)

NL Offshore Oil & Gas

Activity and Production (Cumulative to June 30, 2020)

Hibernia Field (1997-)

183 736 268 m^3 Total oil production

54 983 265 $10^3 m^3$ Total gas production

Terra Nova Field (2002 -)

67 575 481 m^3 Total oil production

23 732 $10^3 m^3$ Total gas production

White Rose Field (2005 –)

39 777 867 m^3 Total oil production

8 915 195 10^3 m^3 Total gas production

North Amethyst (White Rose Tieback 2010 -)

8 772 363 m^3 Total oil production

1 324 397 10^3 m^3 Total gas production

Hebron (2017-)

14 341 707 m^3 Total oil production

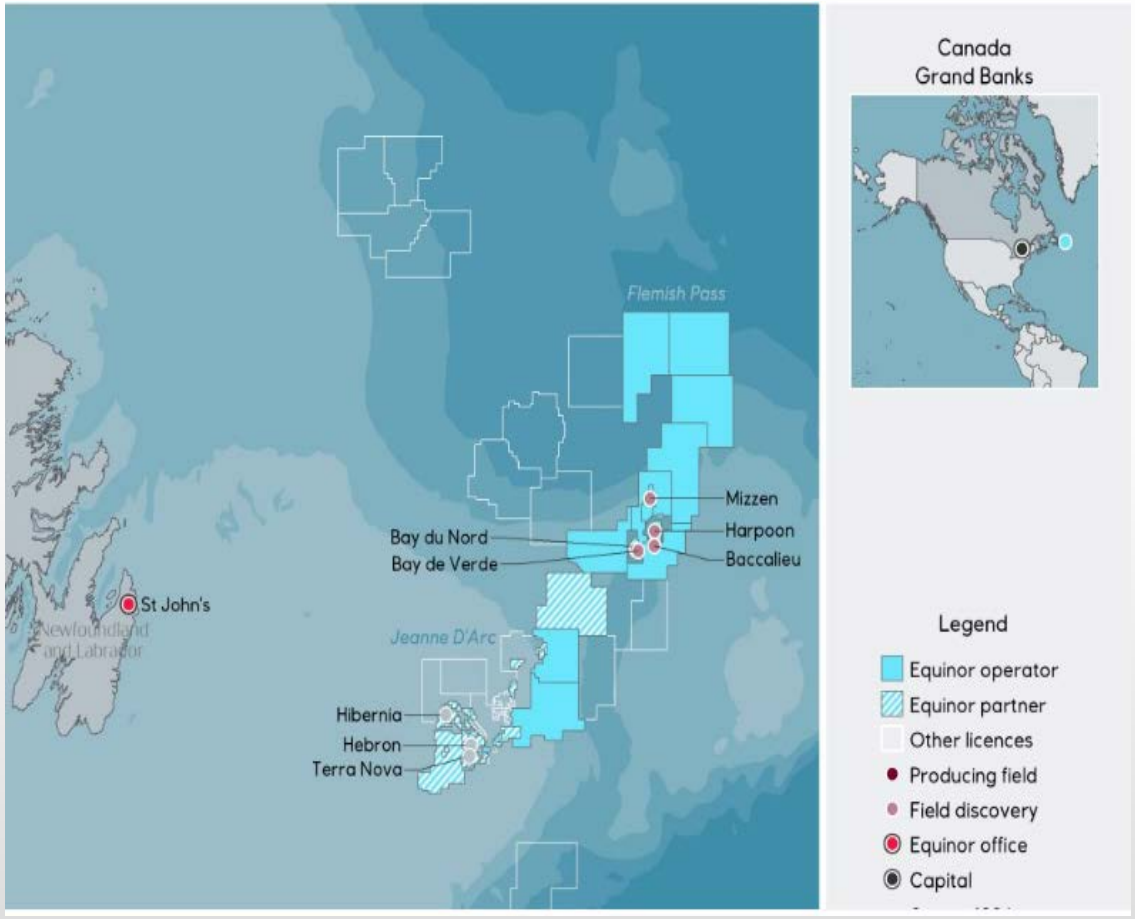
1133 818 10^3 m^3 Total gas production

(CNLOPB, 2020)

NL Offshore Oil & Gas

Activity and Production

- Bay du Nord
  - Discovered in 2013
  - Estimated recovery of 300 million barrels of oil
  - First oil anticipated in 2025



(Equinor, 2020; Department of Natural Resources Newfoundland and Labrador, 2019)

NL Offshore Oil & Gas

Hibernia Field (1997-)

(Cumulative to June 30, 2020)

- Production began in 1997
- Discovered in 1979, the Hibernia oil field is located 315 km east southeast of St. John's, Newfoundland and Labrador, in 80 metres of water
- It is the fifth largest field ever discovered in Canada
- When it was initially proposed for development, the field had an area of about 223 km^2 and the proponent estimated that it contained 520 million barrels of recoverable oil in two separate reservoirs named Hibernia and Avalon.
- 183 736 268 m^3 Total oil production since 1997
- 54 983 265 10^3m^3 Total gas production since 1997

(C-NLOPB, 2020)

NL Offshore Oil & Gas

Terra Nova (2002 -)

- Discovered in 1984, the Terra Nova field is located 350 kilometres east-southeast of St. John's, Newfoundland and Labrador
- The field, located in the Jeanne d'Arc Basin consists of one reservoir: the Jeanne d'Arc
- 128 km^2 with an estimated 400 Million barrels of recoverable oil
- Production began in 2002 via a Floating Production Storage and Offloading (FPSO) vessel

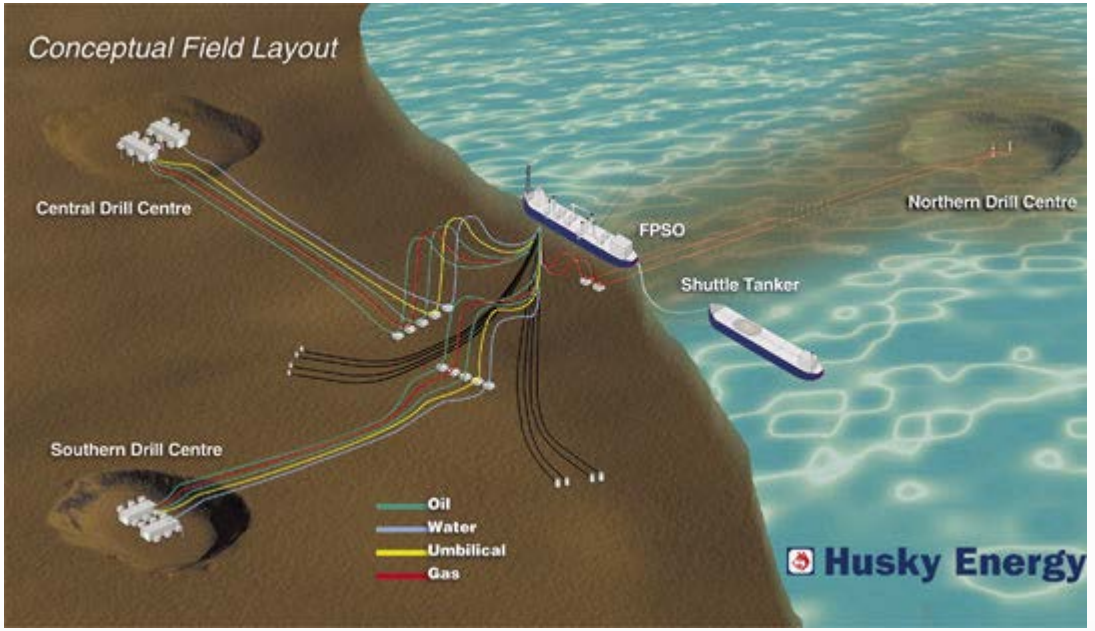
(Department of Natural Resources Newfoundland and Labrador, 2020)

(Suncor, 2016)

NL Offshore Oil & Gas

White Rose (2005 -)

- Discovered in 1984, the White Rose field is located 350 kilometres east of St. John's, Newfoundland and Labrador.
- One principal reservoir: the Ben Nevis-Avalon
- Covers approximately 40 km^2 and contains an estimated 300 million barrels (48 MM m^3) of recoverable oil
- Production began in 2005 via a Floating Production Storage and Offloading (FPSO) vessel, the SeaRose

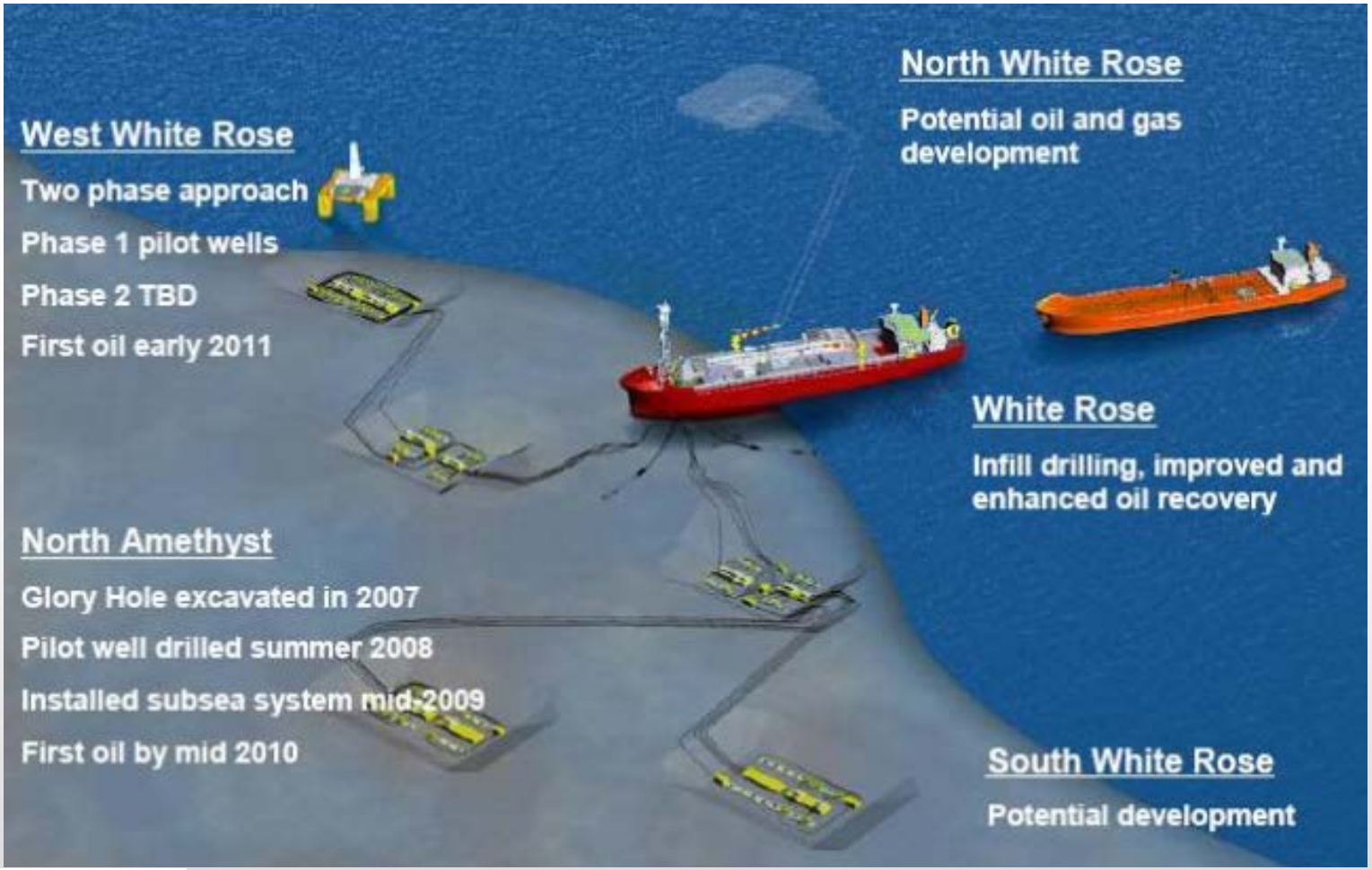


(Offshore Technology, 2020)

(Husky Energy, n.d.)

NL Offshore Oil & Gas

White Rose Expansion



NL Offshore Oil & Gas

White Rose Expansion

North Amethyst

- The North Amethyst field represents the first satellite expansion to the White Rose project
- Estimated to hold 68 million barrels of oil
- Cumulative to June 30, 2020:
  - 8 772 363 m3 Total oil production
  - 1 324 397103 m3 Total gas production

(Department of Natural Resources Newfoundland and Labrador, 2020)

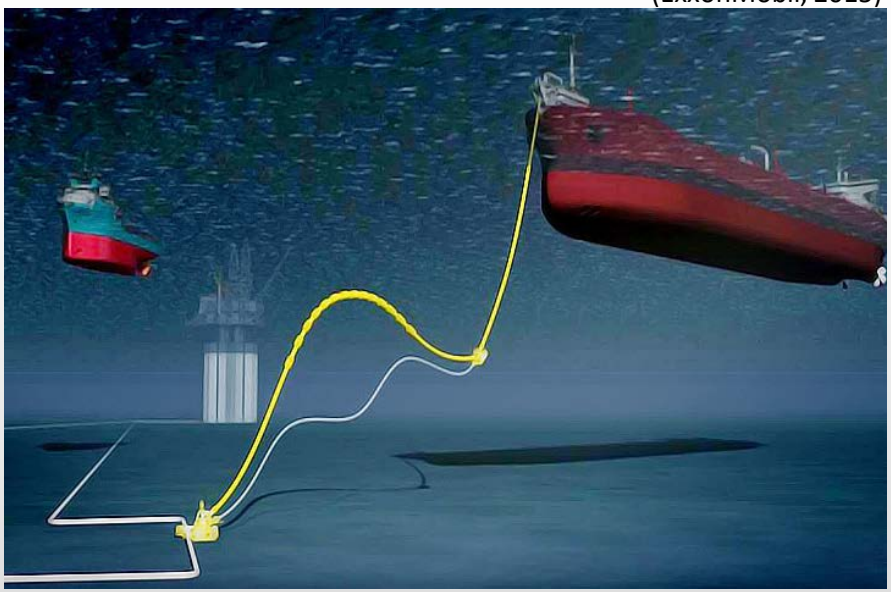
NL Offshore Oil & Gas

Hebron

- Located offshore Newfoundland and Labrador in the Jeanne d'Arc Basin, 350 kilometres southeast of St. John's
- The field was first discovered in 1980, estimated to contain 660-1055 million barrels of recoverable crude oil
- Construction began in 2011 and production began in 2017
- Expected to produce 150,000 barrels/day (at peak) of crude oil
- Expected production rates 215-300 m^3 of gas per day

(Hebron, 2015)

(ExxonMobil, 2015)

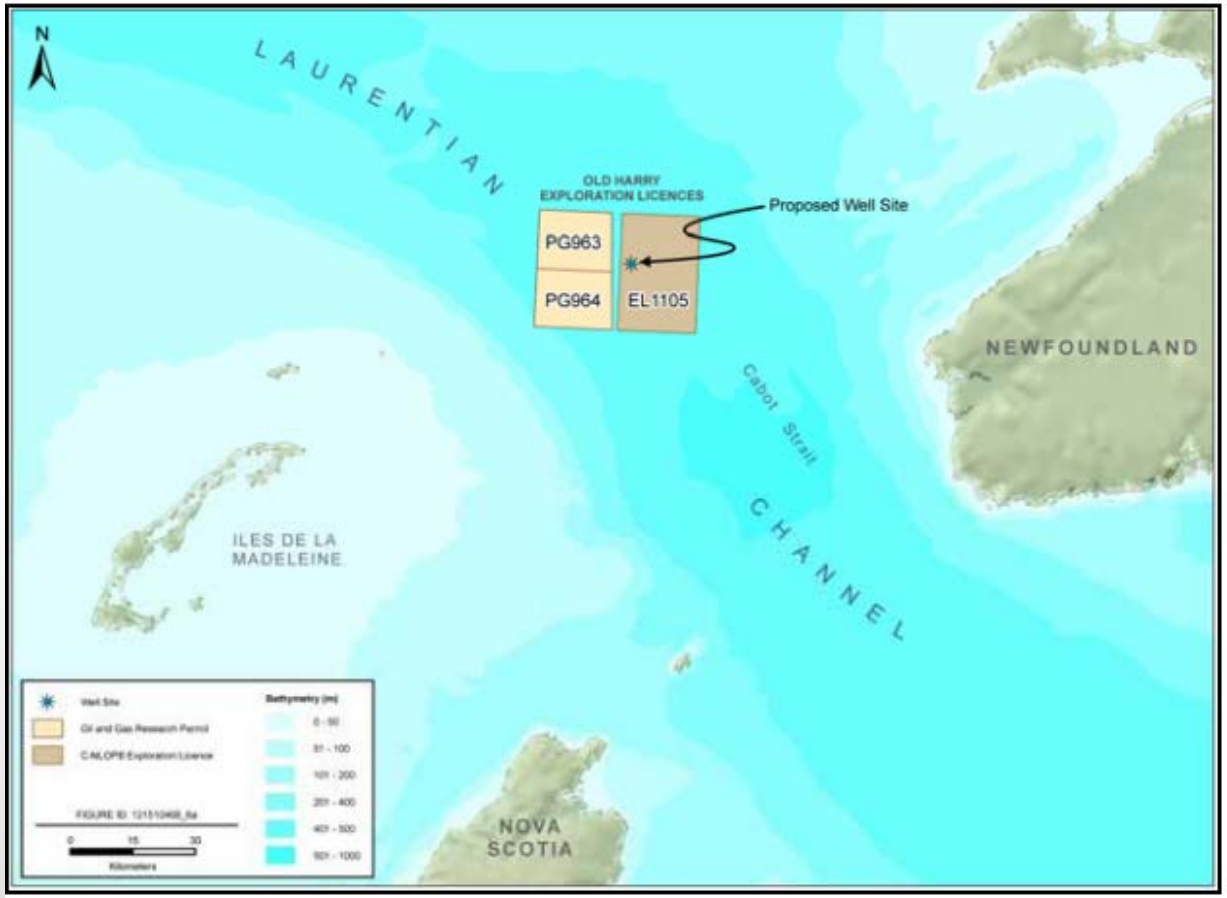


(ExxonMobil, 2015)

Old Harry

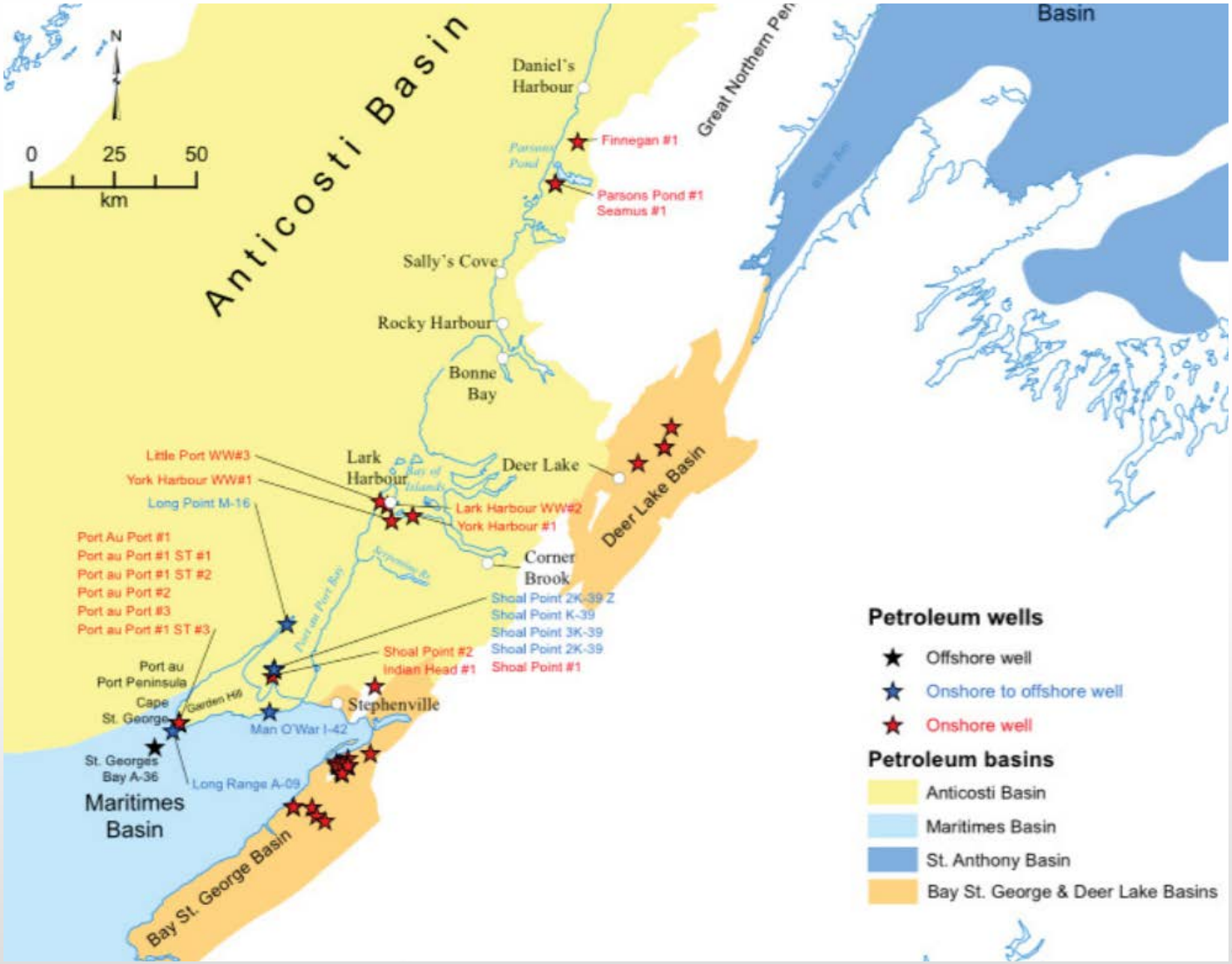
- Located in the Gulf of St. Lawrence with the centre of the prospect approximately 80 km west-northwest of Cape Anguille, Newfoundland and Labrador
- Borders Quebec
- Economic potential of two billion barrels of recoverable oil or up to five TCF (trillion cubic feet) of natural gas

Drilling Area and Proposed Drilling Site



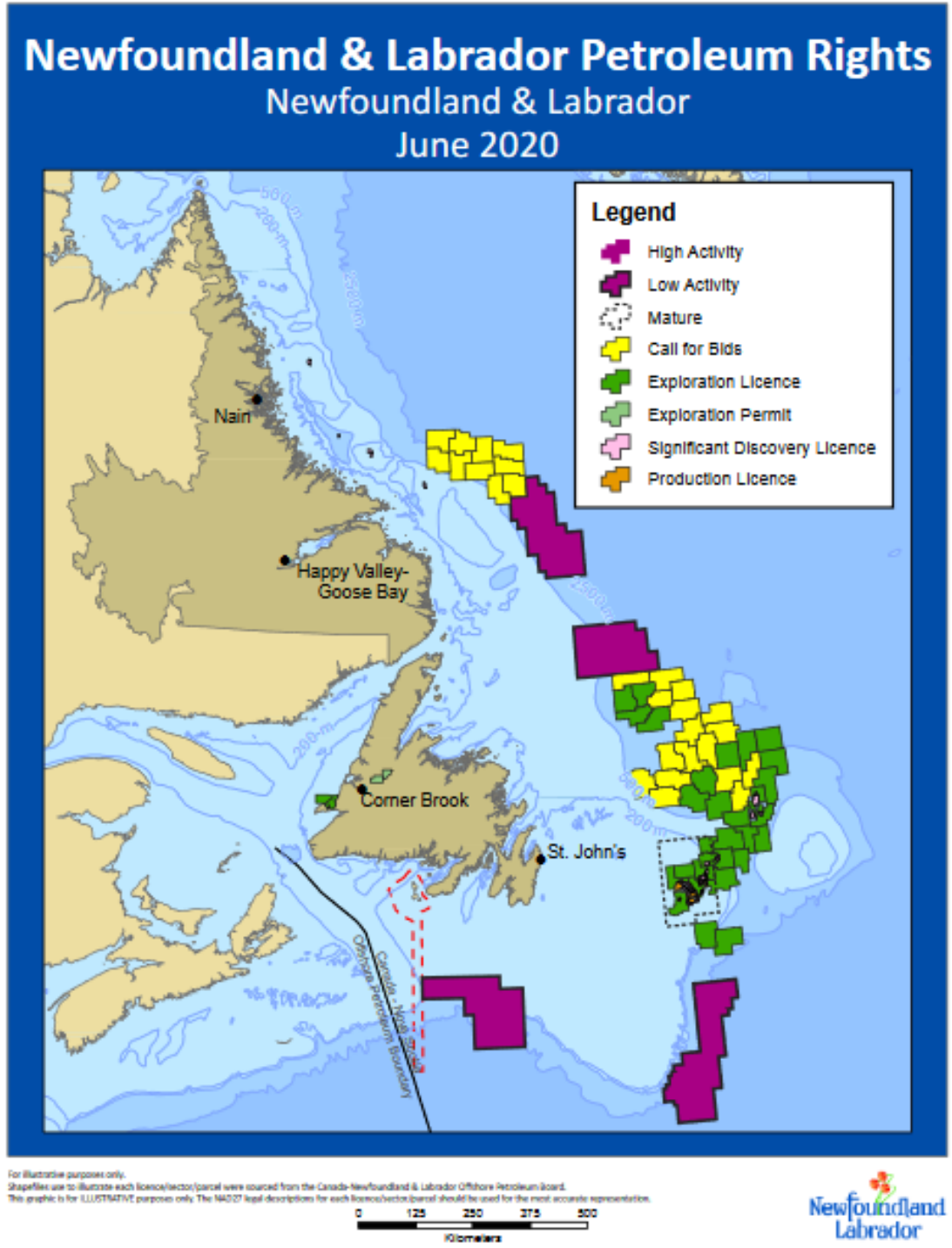
(Corridor Resources, 2011)

Locations of petroleum wells in Western Newfoundland



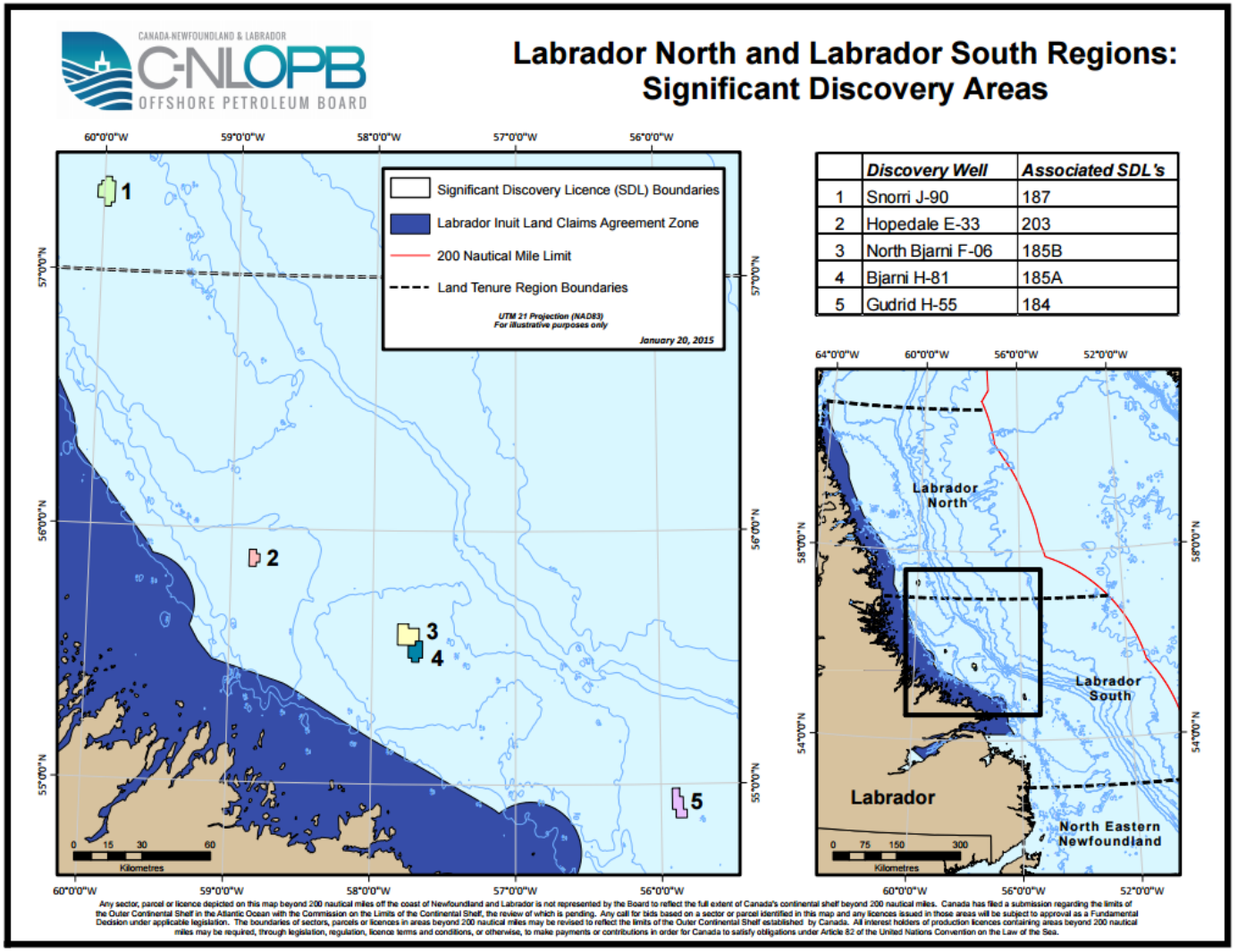
(Hinchey et al, 2014)

Newfoundland & Labrador

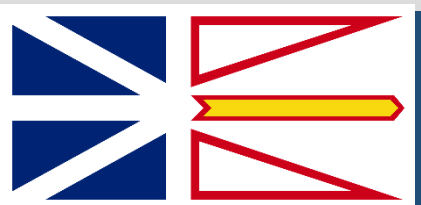


(Department of Natural Resources Newfoundland and Labrador, 2020)

Labrador Shelf



(CNLOPB, 2015)



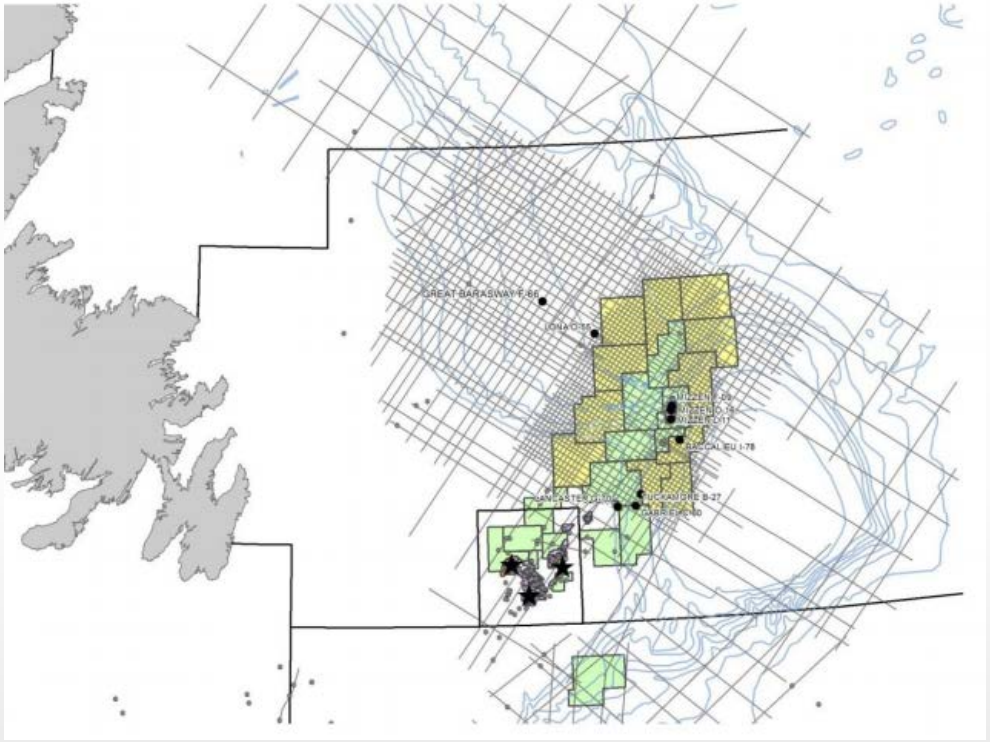
Newfoundland & Labrador

NL Offshore Oil & Gas

Exploration

- Flemish Pass

The world's largest offshore liquids discovery of 2013 was made in the Flemish Pass in the Newfoundland and Labrador offshore region

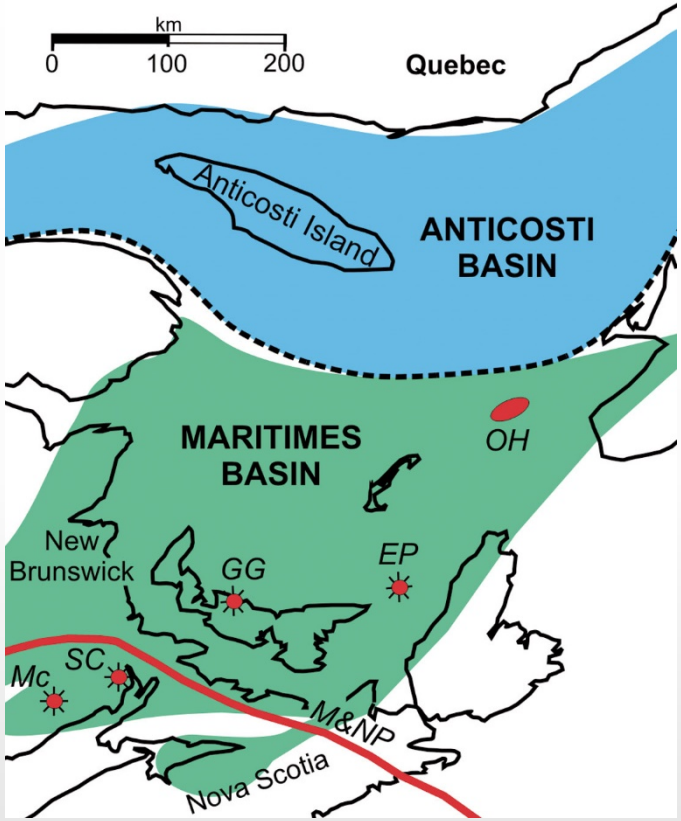


(Nalcor Energy, 2015)

PEI Offshore Oil & Gas

Activity and Production

- Exploration activities have identified the existence of potential reservoirs of natural gas, including a significant discovery made offshore in East Point, PEI
- However, Prince Edward Island's hydrocarbon potential has yet to be fully assessed as, to date, only twenty exploratory wells and one re-entry well have been drilled on and around the province.

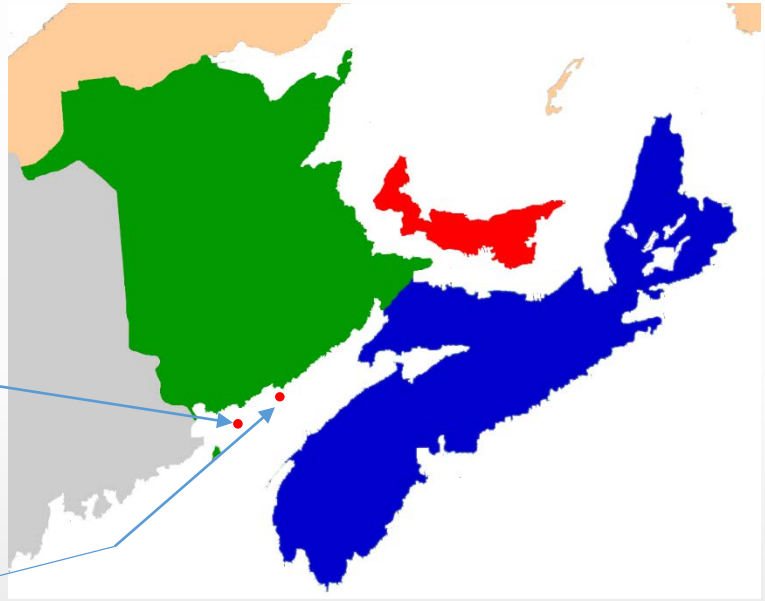


(Durling & Martel, 2004)

NB Offshore Oil & Gas

Activity and Production

- Bay of Fundy – no exploration or activity since 1987
  - 1975 Chinampas (Mobil-Gulf)
  - 1983 Cape Spencer (Irving/Chevron)



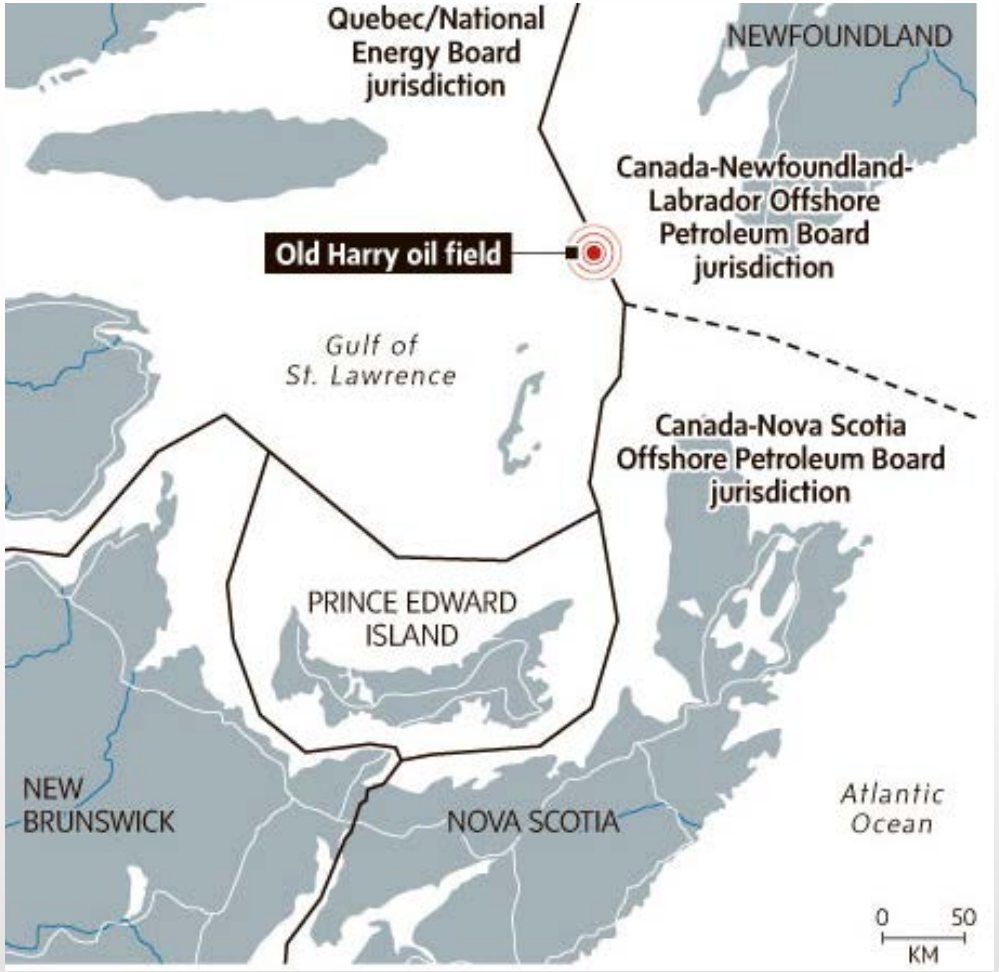
(Blogspot, 2018)

QC Offshore Oil & Gas

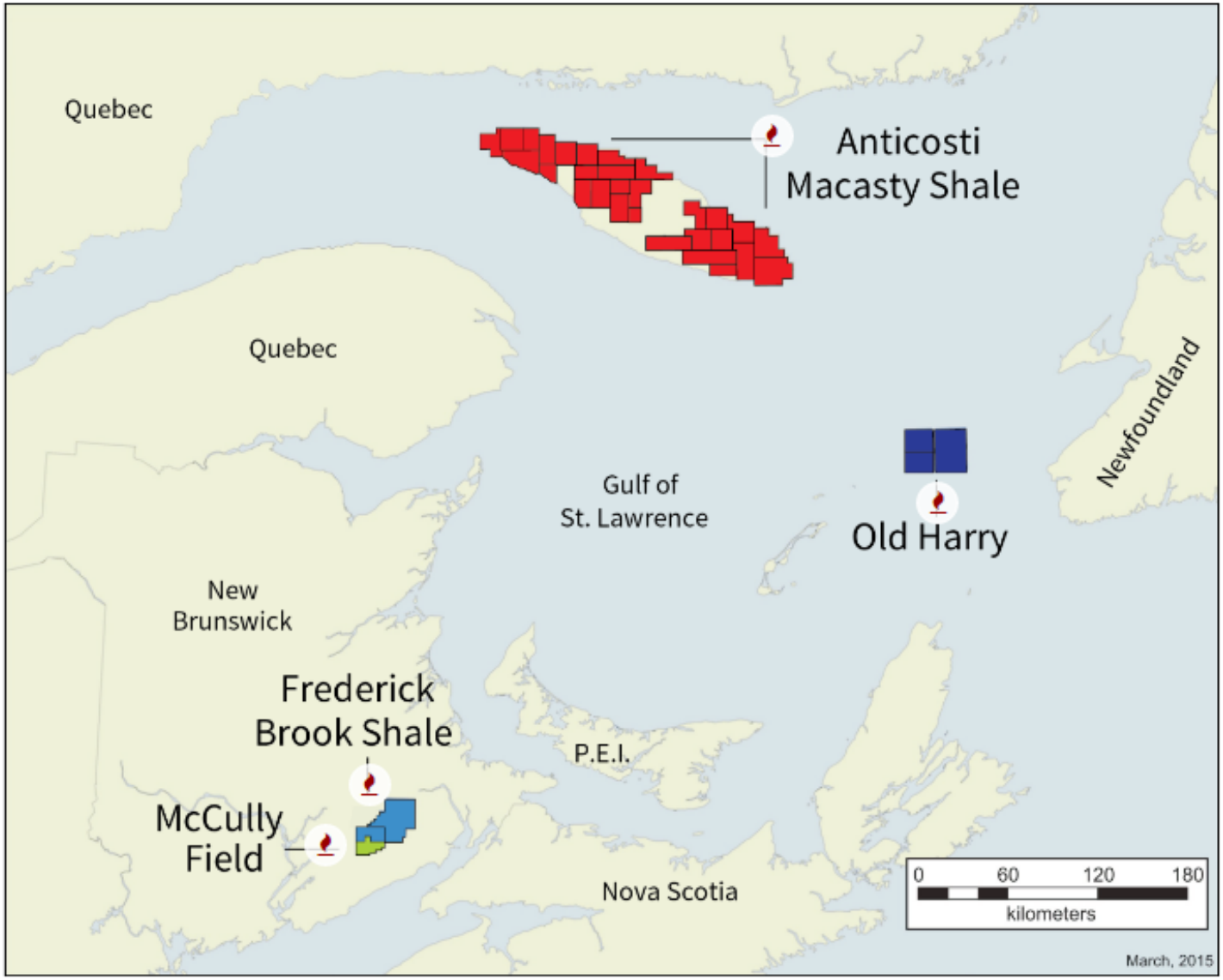
Activity and Production

Old Harry

- Gulf of St. Lawrence
- Economic potential of two billion barrels of recoverable oil or up to five TCF (trillion cubic feet) of natural gas
- Exploration indefinitely suspended in 2018.



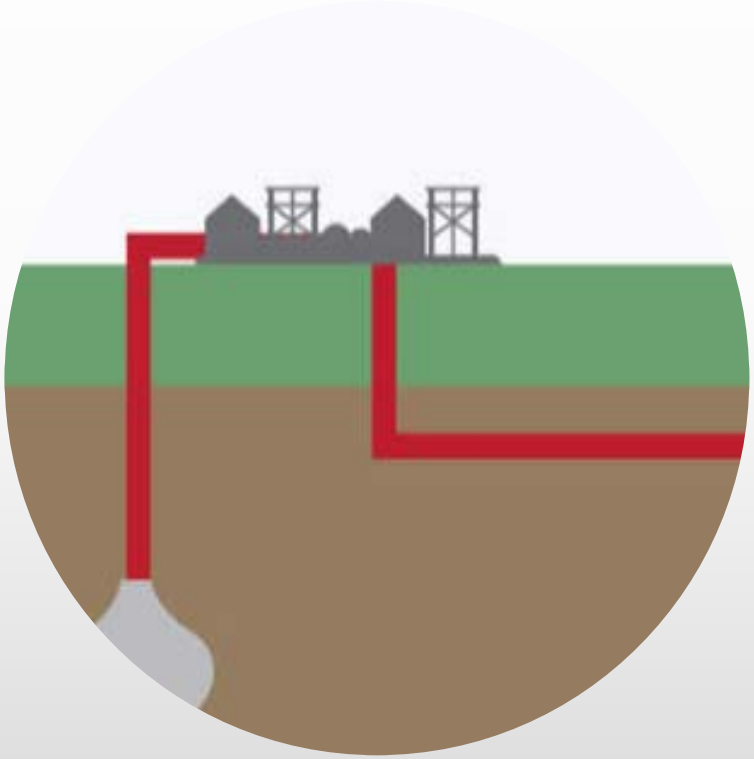
(Corridor Resources, n.d.)



(Corridor Resources, n.d.)

Quebec

Onshore



NS Onshore Activity:

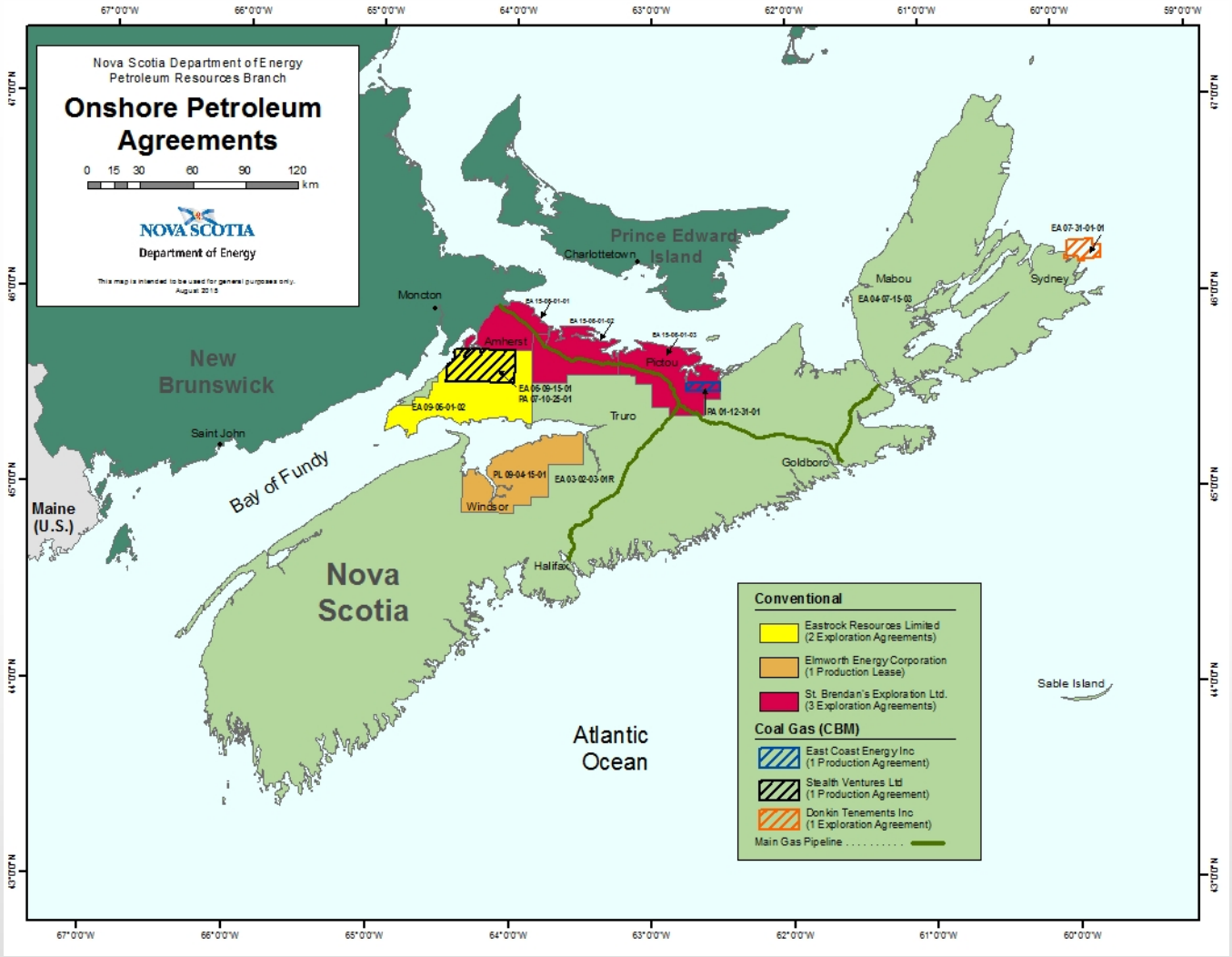
- Oil & Gas infrastructure
  - Pipelines

- Oil & Gas Exploration
  - Conventional oil
    - 7 conventional oil and gas exploration agreements
  - Coal gas
    - 1 exploration coal gas agreement
    - 2 production agreements for coal gas
  - Shale gas
    - 1 production lease for shale gas

(Department of Energy, 2016.)

Nova Scotia

NS Onshore:

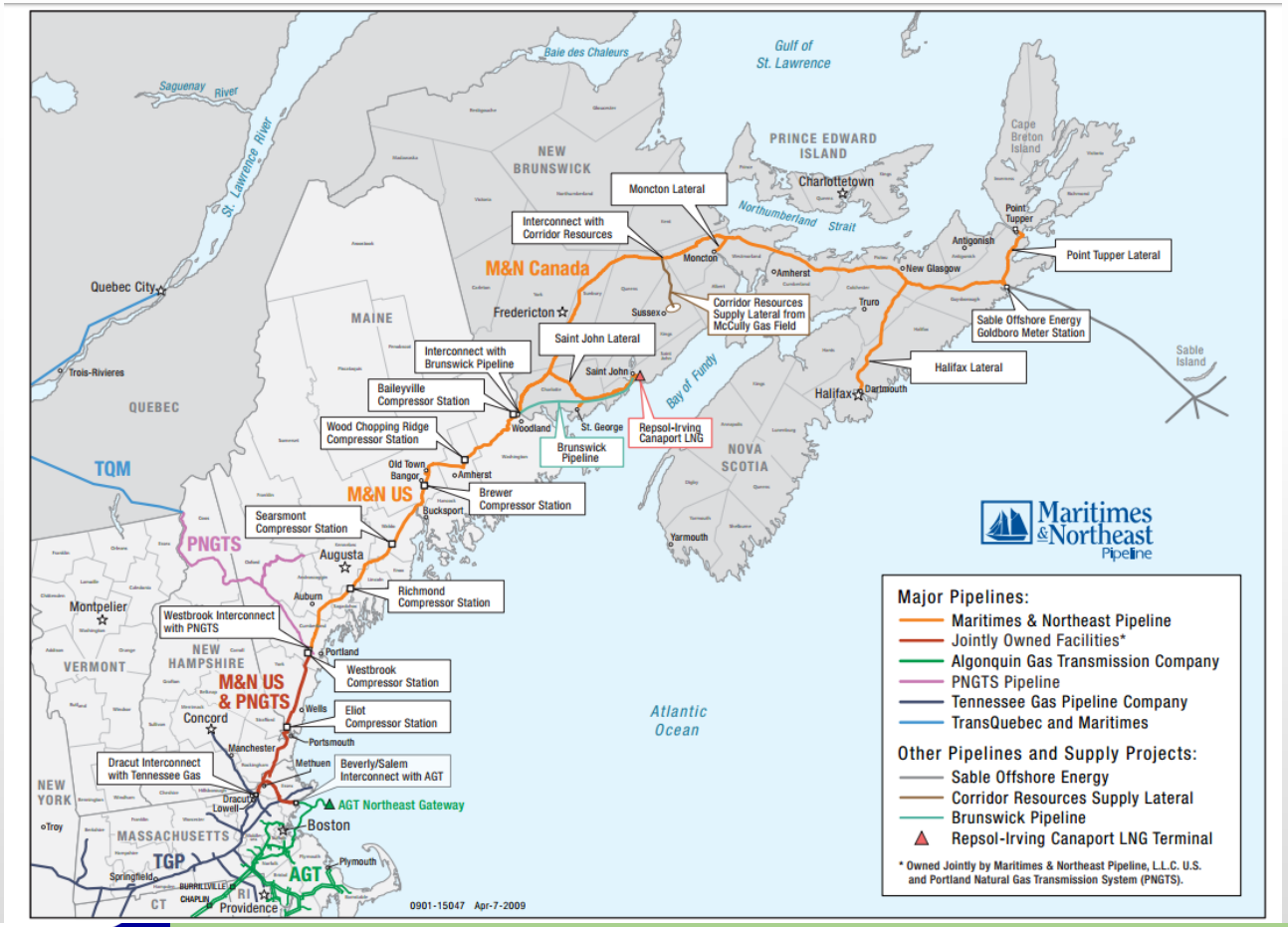


(NS Department of Energy, 2015.)

Nova Scotia

Maritimes & Northeast Pipeline

- Connects Goldsboro gas plant to distribute in Nova Scotia, New Brunswick, and Maine-New Brunswick border



(Maritimes & Northeast Pipeline, 2009)

Nova Scotia

Thermal Electricity

Coal - 4 coal-fired power plants

Lingan Generating Station, Cape Breton Island	620 MW
Point Aconi Generating Station, Cape Breton Island	171 MW
Point Tupper Generating Station, Cape Breton Island	154 MW
Trenton Generating Station, Trenton	307 MW

Natural Gas – Tufts Cove Generating Station, Dartmouth, 500 MW

Waste Heat Recovery - The Tufts Cove Waste Heat Recovery project added a sixth generator to the plant in 2011 that produces up to 50 MW of electricity, enough to power up to 35,000 homes.

(NS Power, 2020)

Nova Scotia

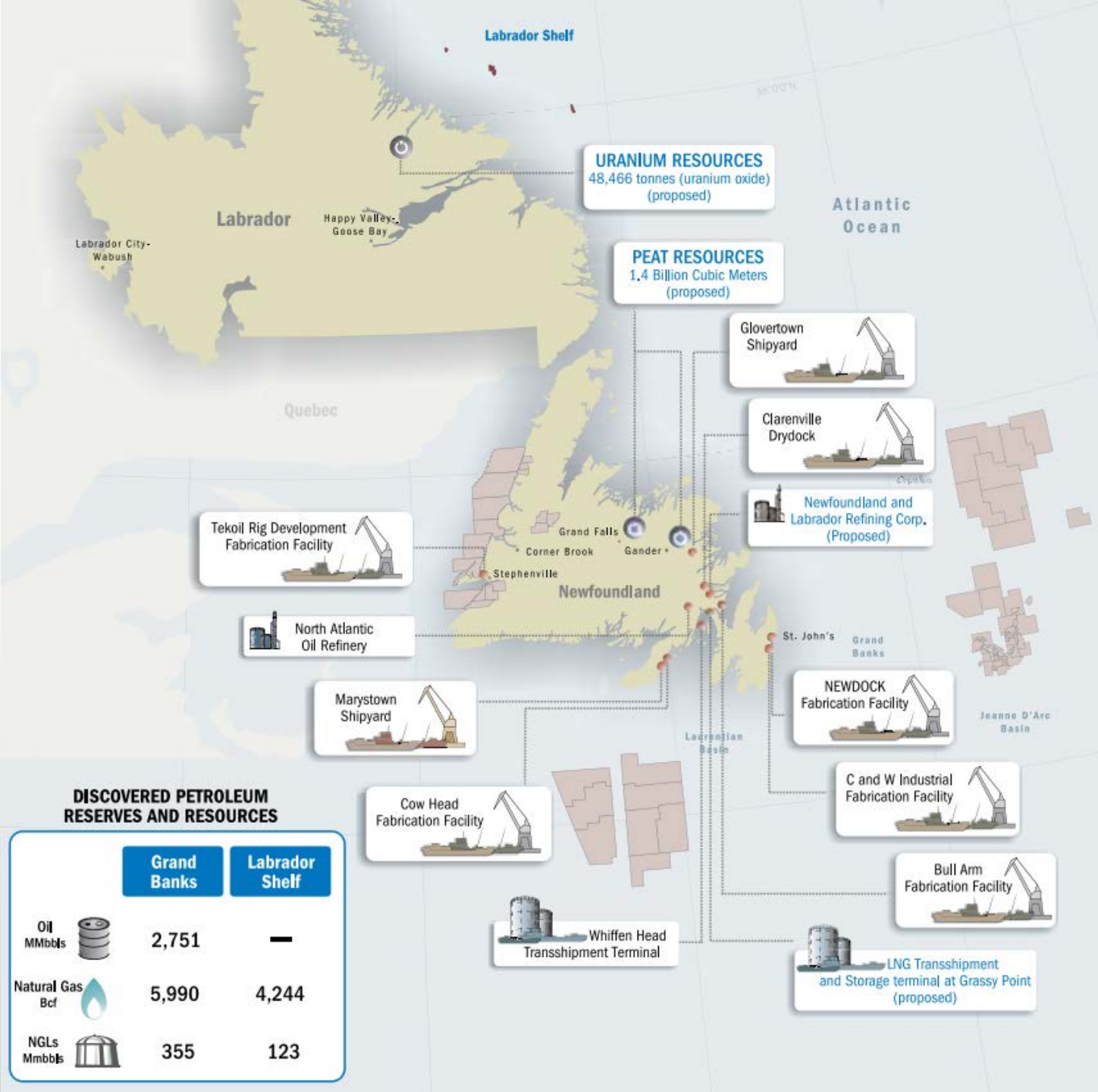
Thermal Electricity

Oil – 3 oil-fired combustion turbine units (totalling 222 MW)

Burnside Combustion Turbine, Dartmouth	132 MW
Victoria Junction Combustion Turbine, Cape Breton Island	66 MW
Tusket Combustion Turbine, Southwestern NS	24 MW

(NS Power, 2020)

NL Onshore Activity:



DISCOVERED PETROLEUM RESERVES AND RESOURCES

	Grand Banks	Labrador Shelf
Oil MMbbls	2,751	—
Natural Gas Bcf	5,990	4,244
NGLs Mmbbls	355	123

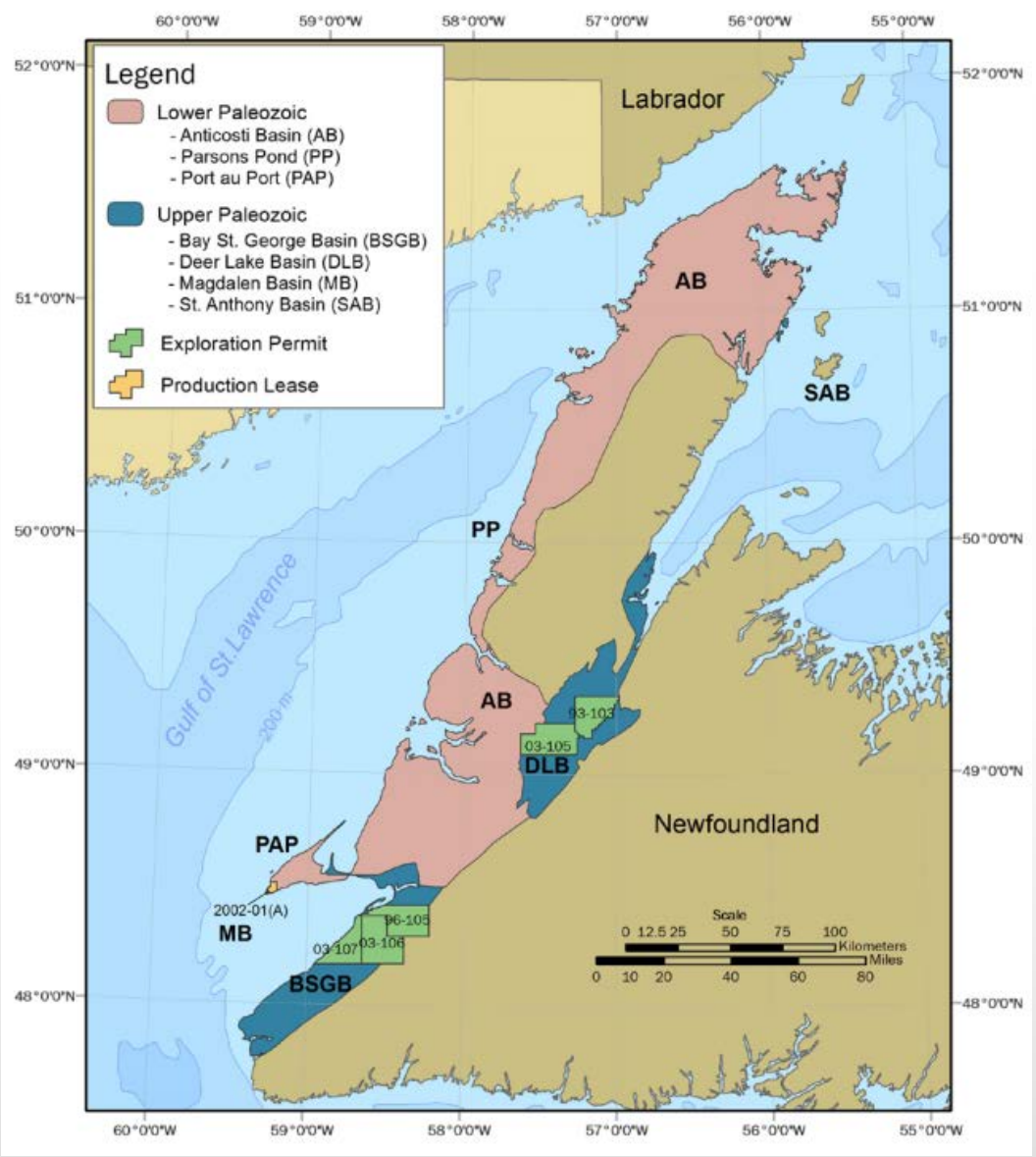
NL Onshore Activity:

Oil & Gas Exploration

- Conventional oil:
  - 6 conventional oil and gas exploration agreements
  - 3 oil companies with onshore Land interests in Western Newfoundland & Labrador

(CNLOPB, 2020)

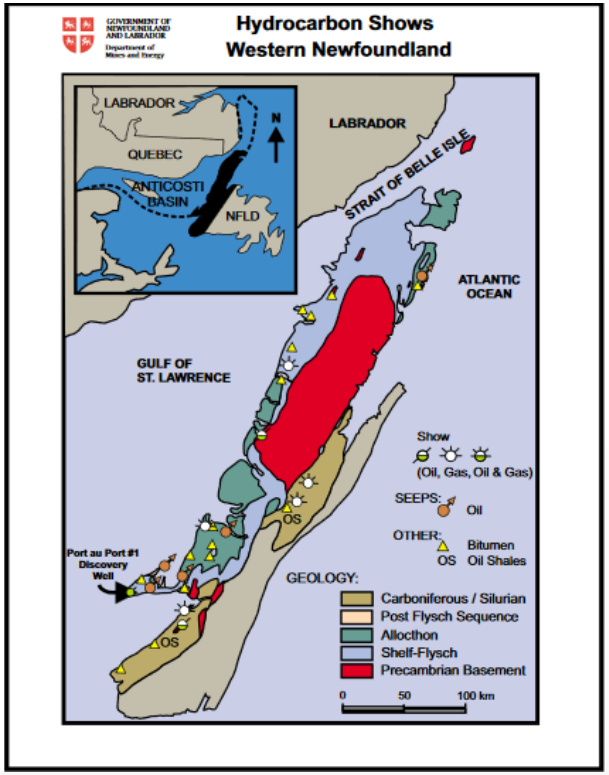
- Anticosti Basin
- Deer Lake Basin
- Bay St. George Basin
- St. Anthony Basin



(Hogg, Enachescu et al., 2015)

Newfoundland & Labrador

Anticosti Basin



Wells:

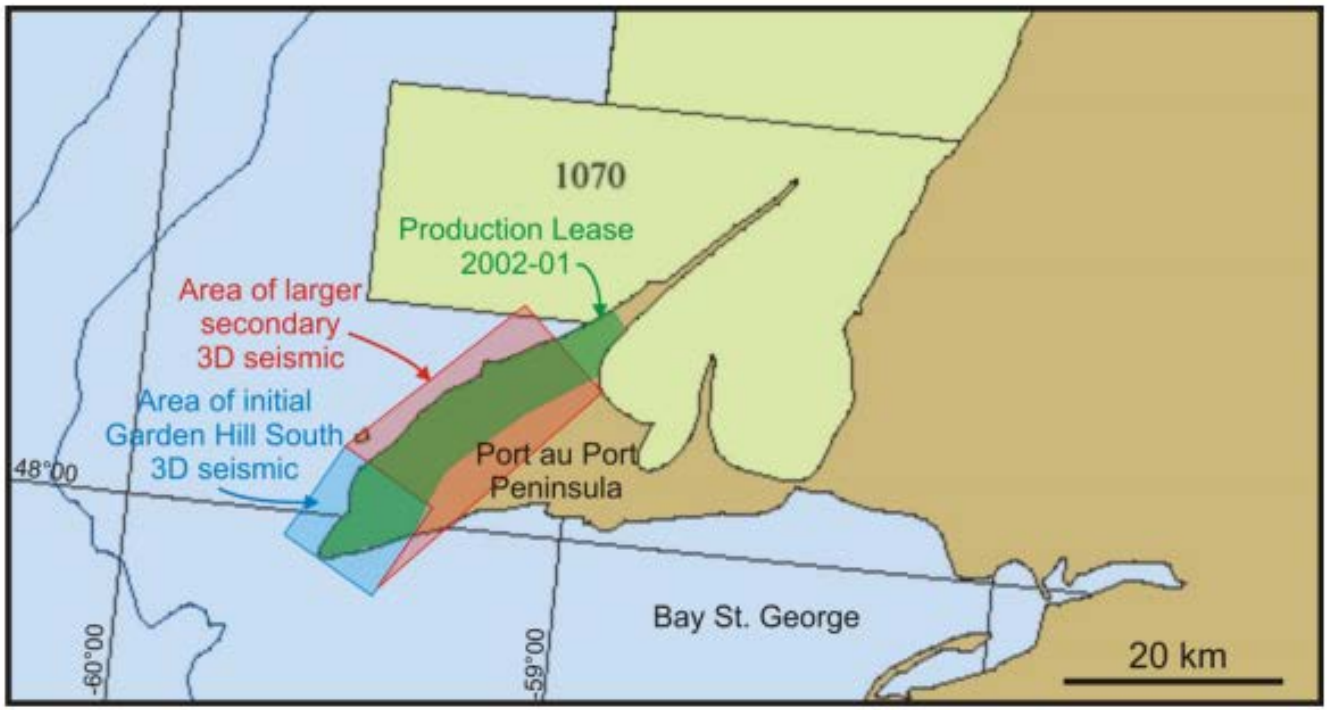
- 48 pre-1994
- 14 recent
- 11 stratigraphic

Oil & Gas Discovery: Garden Hill South on the Port au Port Peninsula

Production to date: Approximately 35,000 barrels of oil through pre-production testing at Garden Hill South and unknown quantities (up to 5,000 barrels of oil) from historic (pre-1994) wells at Parson's Pond and Shoal Point

(Department of Natural Resources Newfoundland and Labrador via ArcGIS, 2012)

Garden Hill South on the Port au Port Peninsula

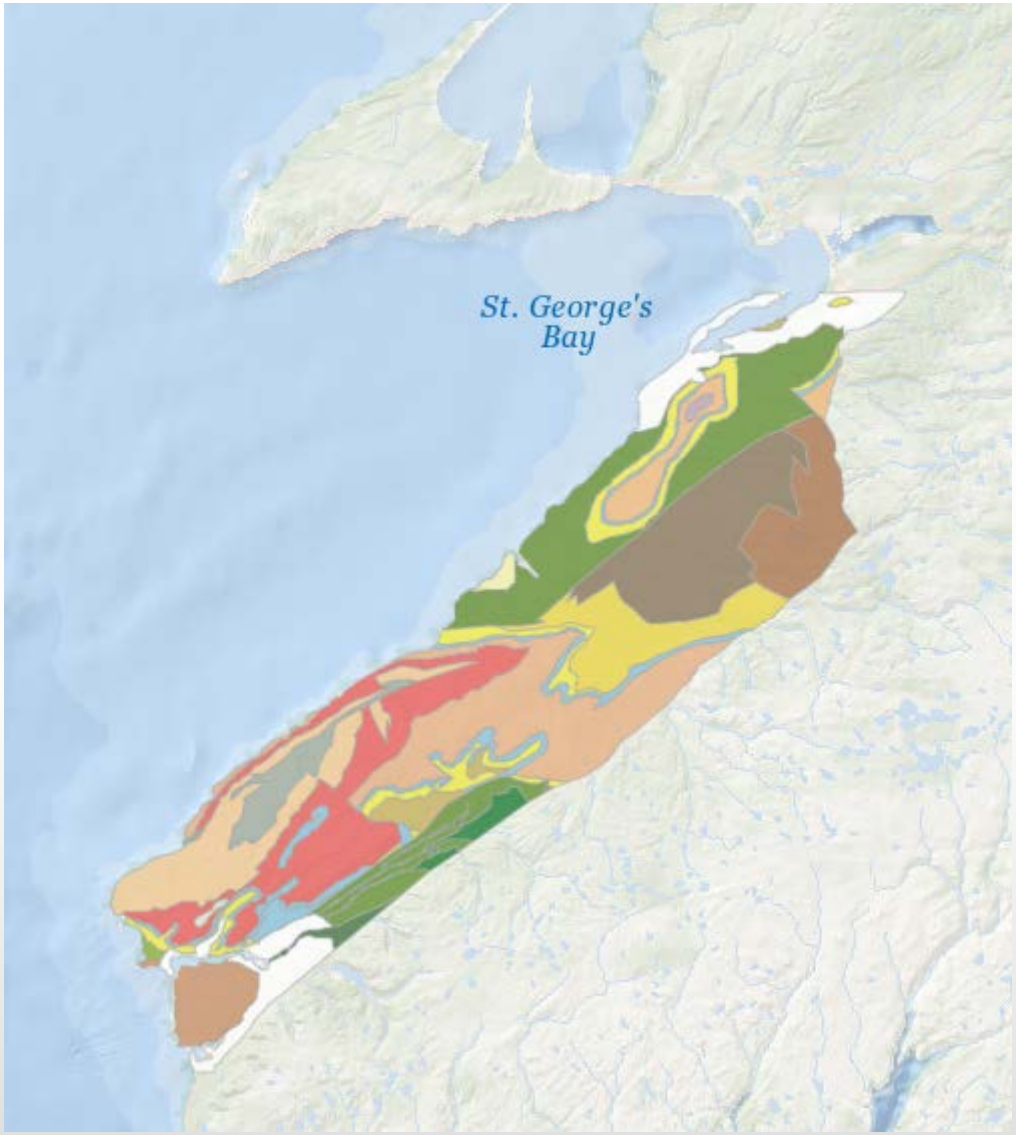


(PDI Production Inc., 2007)

Bay St. George Basin

Wells

- 1 (pre-1994);
- 12 (recent);
- 9 (stratigraphic tests).

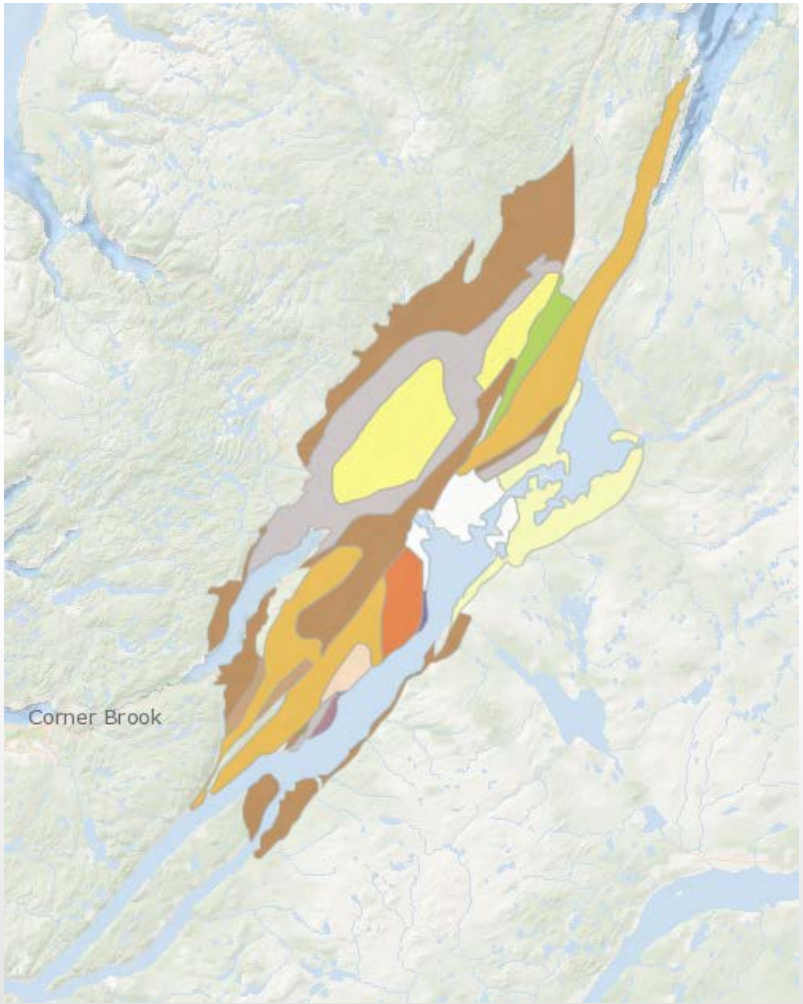


(Department of Natural Resources Newfoundland and Labrador via ArcGIS, 2012)

Deer Lake Basin

Wells

- 9 historic
- 3 (recent)



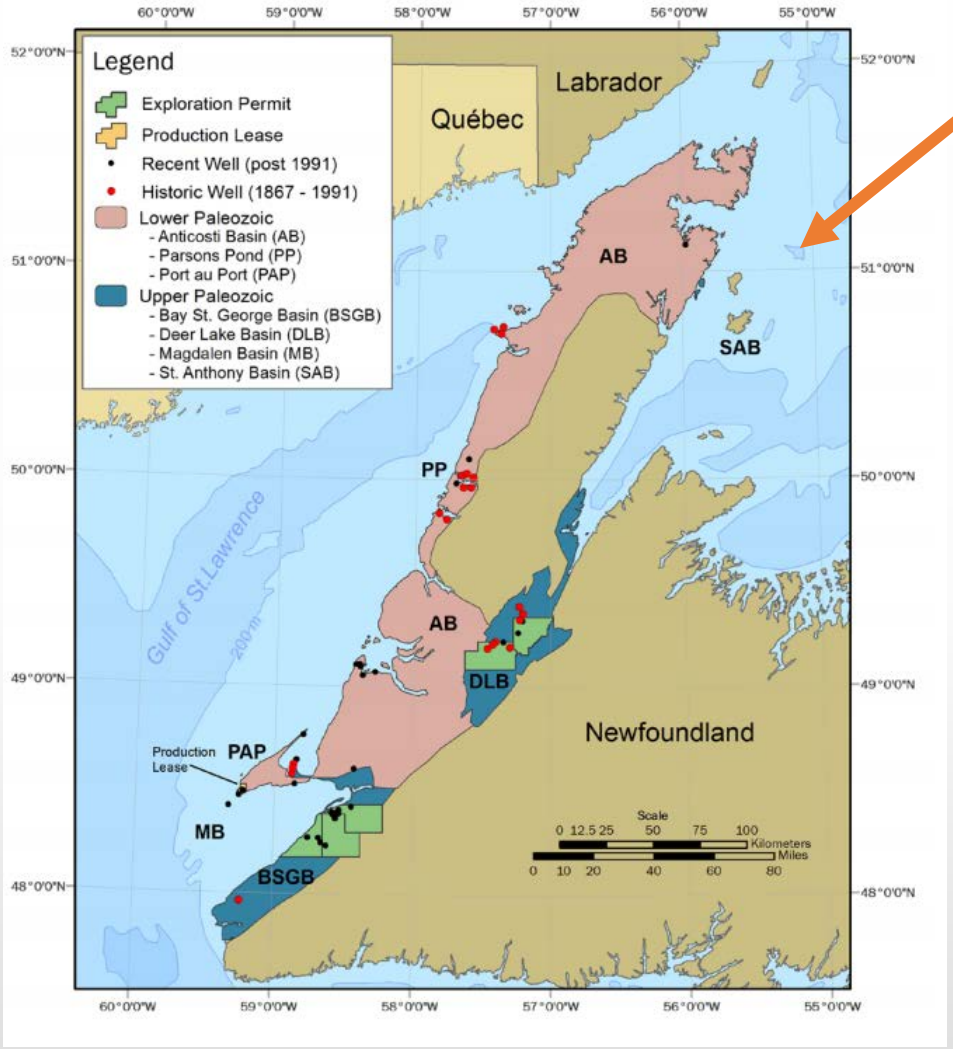
(Department of Natural Resources Newfoundland and Labrador via ArcGIS, 2012)

St. Anthony Basin

- Two small peninsulas on the eastern side of the Northern Peninsula
- Juxtaposed against the Lower Paleozoic Anticosti Basin
- No onshore drilling in the basin

Photo credit: Michael Enachescu.

(Hogg, Enachescu et al., 2015)



(Hogg, Enachescu et al., 2015)

Newfoundland & Labrador

NL Onshore Activity:

Electricity

- 9 hydro electric plants
- 1 thermal plant
- 4 gas turbines
- 25 diesel plants

(Newfoundland Labrador Hydro, 2020)

Thermal Electricity

Holyrood Thermal Generating Station

- Only thermal generating station in NL
- Established in 1969
- Burns 0.7% sulphur fuel
- Generates an average of 15-25% of Newfoundland's electricity
- 490 MW generating capacity
- In peak production, the plant burns approximately 18,000 barrels of oil per day

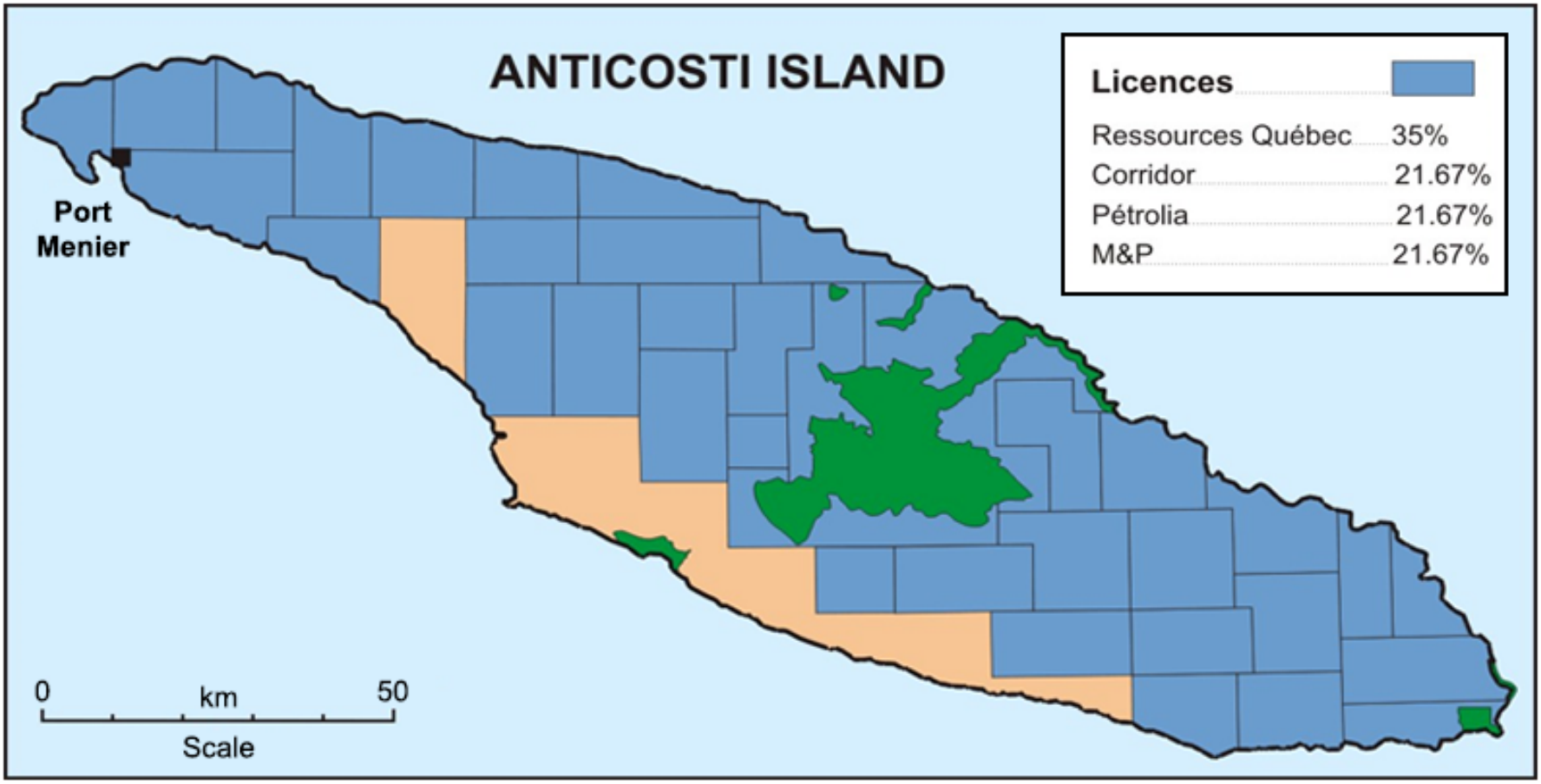
(Newfoundland Labrador Hydro, 2020)

QC Onshore

Oil & Gas Activity and Production

- Anticosti Island
- TransCanada's Energy East project
- Reverse flow of the Enbridge 9B oil pipeline

Anticosti Hydrocarbons JV Interest Owners & Licenses



Source: Corridor Resources

Quebec

Anticosti Island

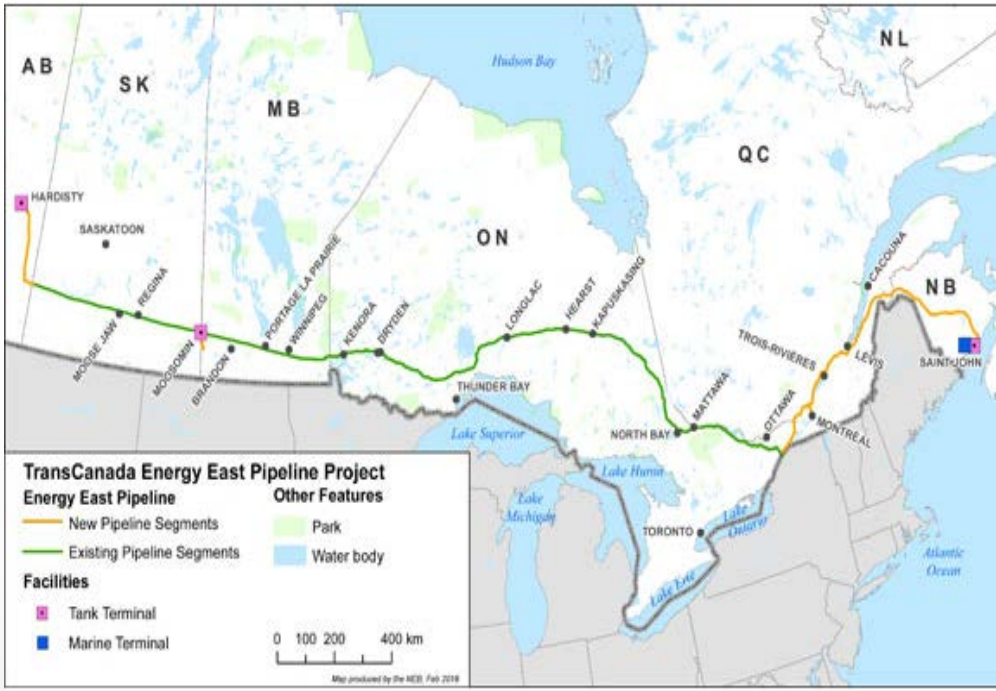
Macasty Shale, Macasty Formation source rock

- Could represent more than 40 billion barrels. However, this oil potential has never been confirmed.
- Estimated 30.7 bboe gross unrisked undiscovered petroleum initially-in-place (6.65 bboe net to Corridor) for the Macasty Shale within the Anticosti Joint Venture lands.
- The Macasty shale is a black, organic rich shale with similar geological characteristics to the Utica (Point Pleasant) shale in Ohio, where production from wells in the heart of the play have initial production rates up to 20 mmcf/d of gas and 1,300 bbls/d of liquids.
- All drilling banned in 2017 by Quebec's government.

(CBC, 2017; NRCAN, 2017)

TransCanada's Energy East project

- Convert a section of the gas pipeline into an oil pipeline and to build and operate a 4,600km oil pipeline from Alberta to New Brunswick that will cross Québec.
- The project also calls for the construction of an oil handling terminal and a tank farm in Cacouna for exporting crude oil.
- Transport up to 1.1 million barrels of crude oil a day, expected 2018
- Project terminated for the Energy East and Eastern Mainline in 2017.



(Canada Energy Regulator, 2020)

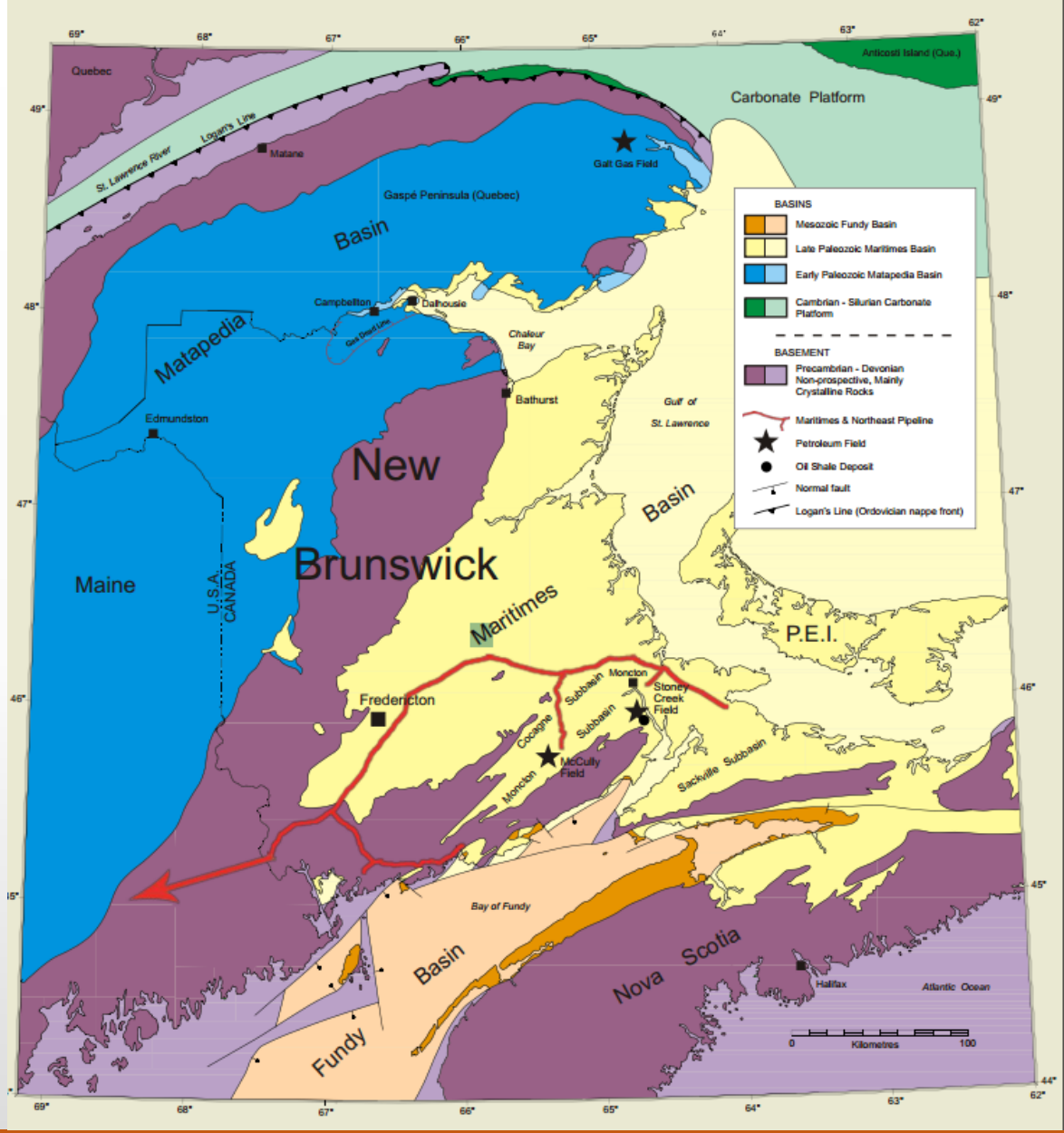
Reverse flow of the Enbridge 9B oil pipeline

- Reversing the direction of flow of crude oil in an existing pipeline
- Enbridge intends to supply refineries in Québec, mainly with light crude oil from Western Canada and the American West
- The Quebec government intends to establish a monitoring unit to promote information exchanges with Enbridge and with other stakeholders.

(Enbridge, 2020)

NB Onshore

- Matapedia Basin
- Maritimes Basin
- Fundy Basin

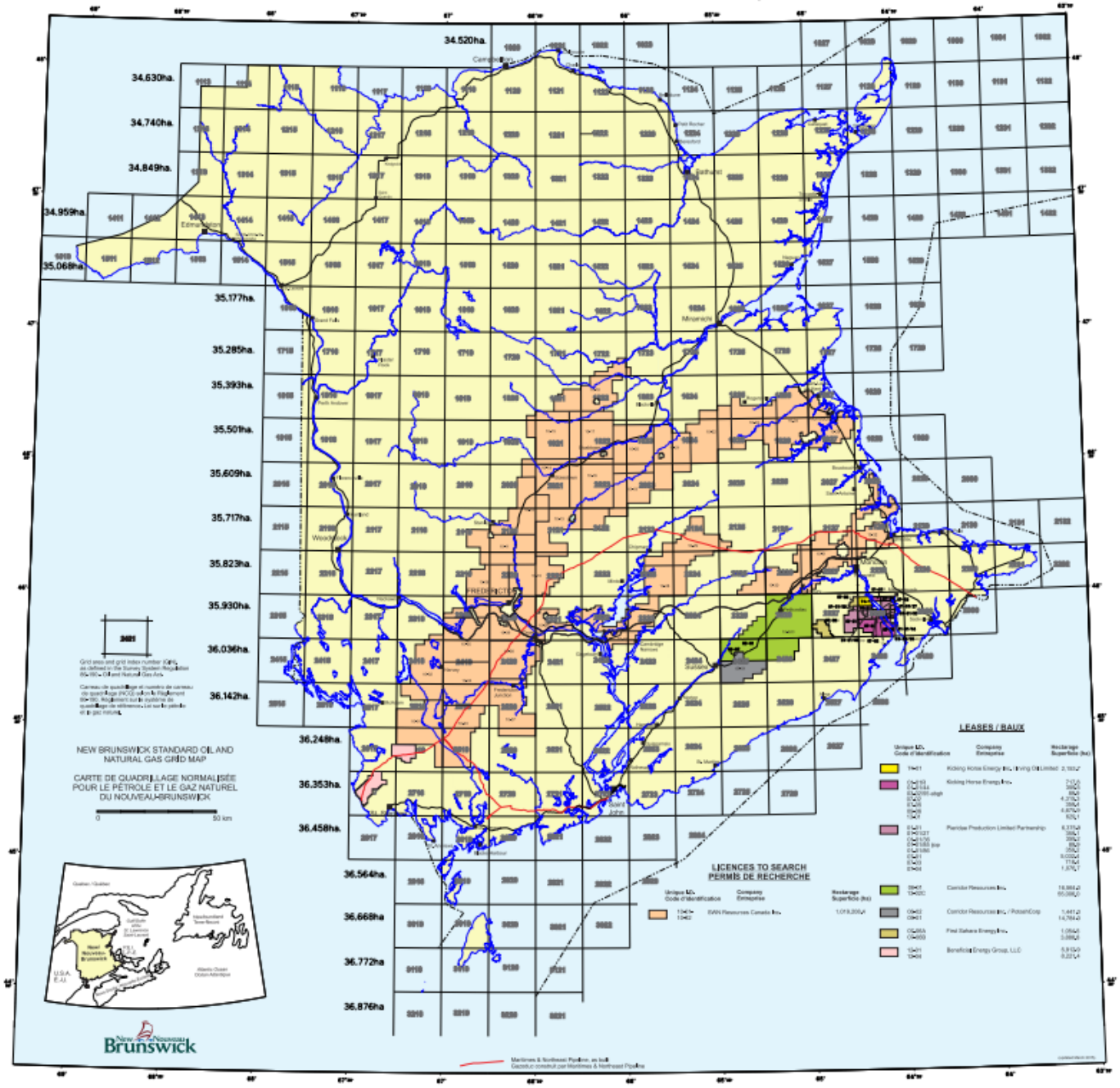


(Smith 2010, Modified by CERI.)

New Brunswick

OIL AND NATURAL GAS LICENCES/LEASES, NEW BRUNSWICK
PERMIS ET BAUX POUR LE PÉTROLE ET LE GAZ NATUREL, NOUVEAU-BRUNSWICK

Plate / Planche 2005-56



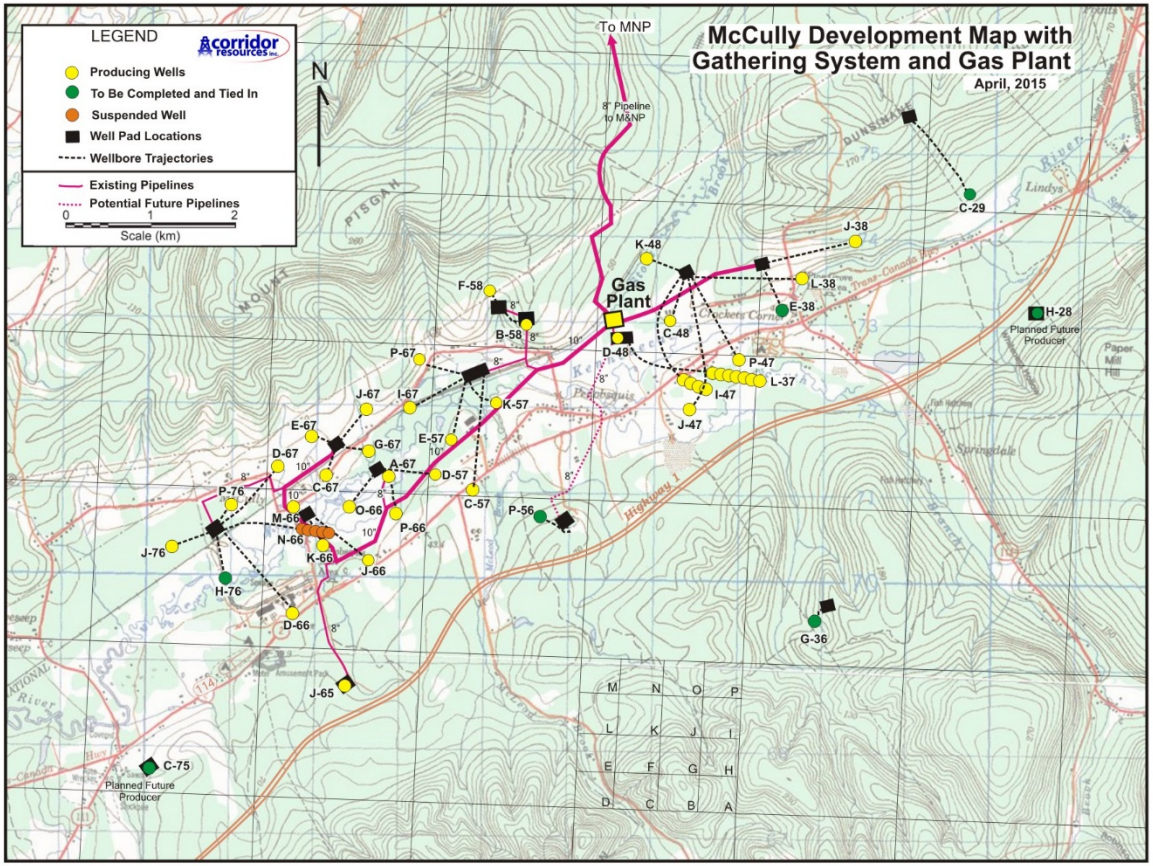
Maritimes Basin:
Stoney Creek

- 1909-1991: 804,000 barrels of oil and 850 10^6m^3 of sweet gas produced
- Renewed in 2005, began producing in 2007
- Estimated to contain proven and probable reserves of 30 million barrels of oil and 180 10^6m^3 of natural gas.

(NRCAN, 2017)

McCully Field

- Located approximately 10 km northeast of Sussex, New Brunswick in the farming community of Penobsquis.
- 39 wells have been drilled, all which have encountered gas
- Has produced 55 Bcf of natural gas as of the end of 2016

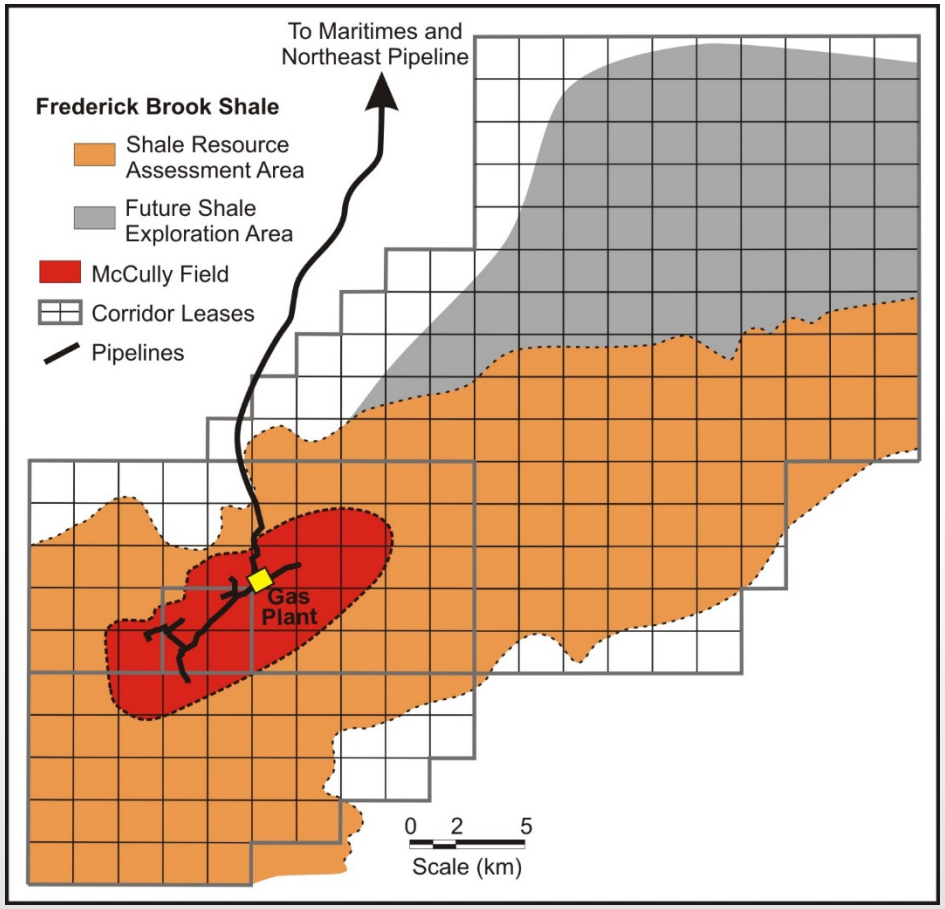


McCully Development Plan Update

(Corridor Resources Inc., 2015c; Canadian Energy Research Institute, 2017)

Frederick Brook Shale

- Located in the Elgin sub-basin in southern New Brunswick and underlies the tight sandstone rocks of the McCully Field
- 13 wells drilled to date
- Connected to Maritimes & Northeast Pipeline in 2007
- Estimated to contain approx. 67 TCF of natural gas with recovery factor estimated at 20%



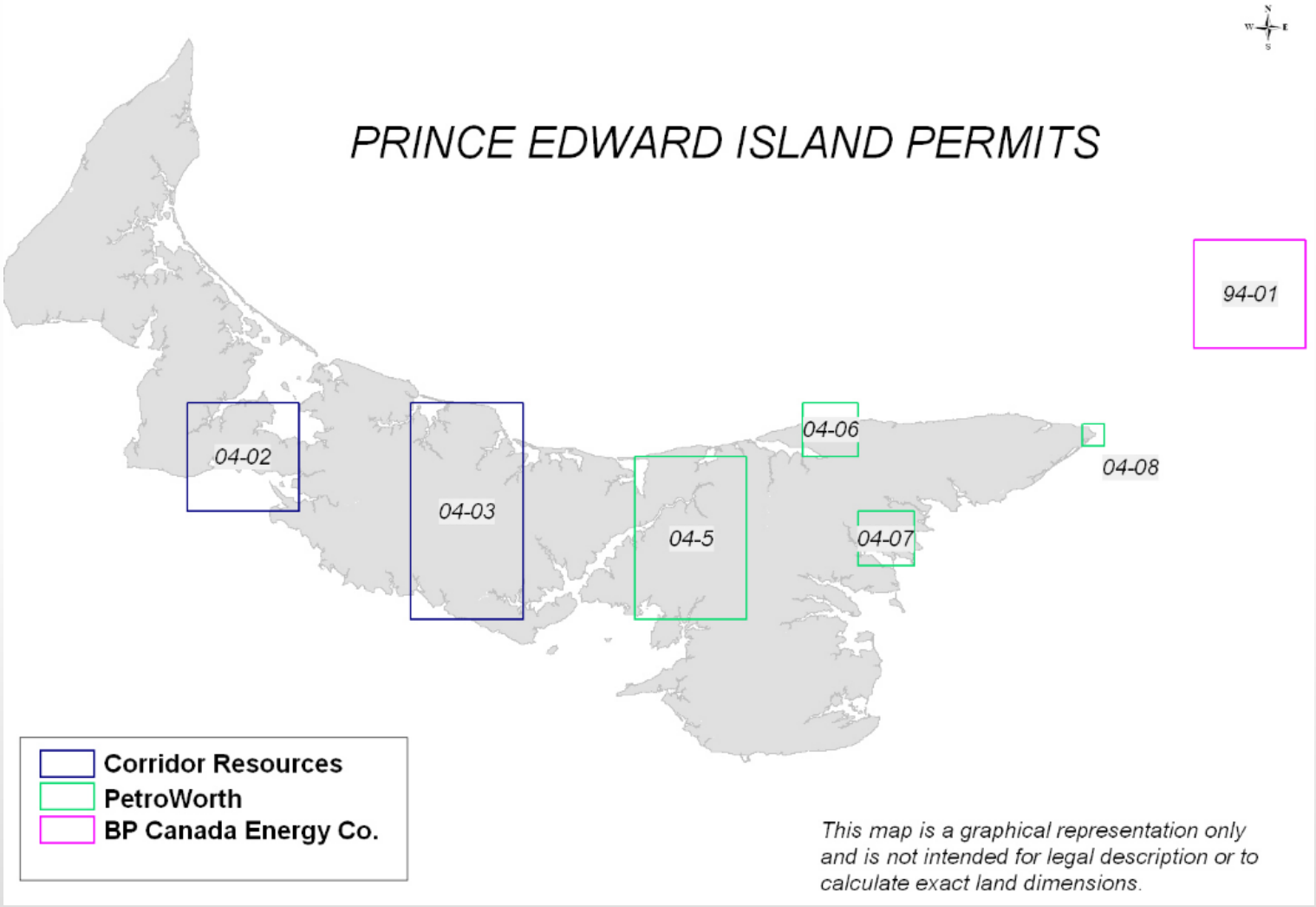
(Corridor Resources, 2019; CERI, 2017)

PEI Onshore

- There are currently no on-shore permits issued on Prince Edward Island.
- Since November 2002, there has been 7 on-shore permits that have utilized both vibroseis and shot-hole techniques for energy generation
- PetroWorth Resources ran Prince Edward Island's first 3D seismic program in the Souris area from August to October in 2004. This was also the largest 3D onshore seismic program in the Maritimes.

(PetroWorth Resources, Inc., 2006)

Past Onshore Permits



(Department of Natural Resources Prince Edward Island, 2011)

Prince Edward Island

Thermal

Charlottetown Thermal Generating Station

- 60 MW total capacity
- Diesel fired combustion turbine and five heavy oil fired units
- Currently being decommissioned and demolished

Borden Generating Station

- Two diesel fired combustion turbines
- 40.56 MW

These generating stations are kept on standby for backup mode and put into operation when the energy supply from off-Island sources is interrupted, during times of peak loading such as in the winter months and July and August, and when more economical than external purchases.

(Wikipedia, 2019;Maritime Electric, 2012)

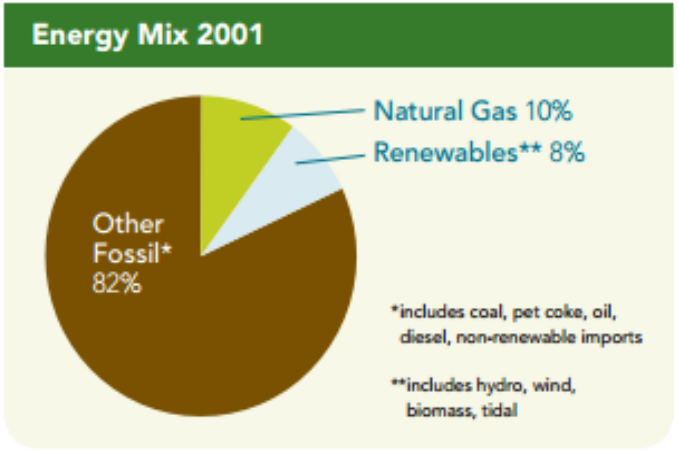
Renewables

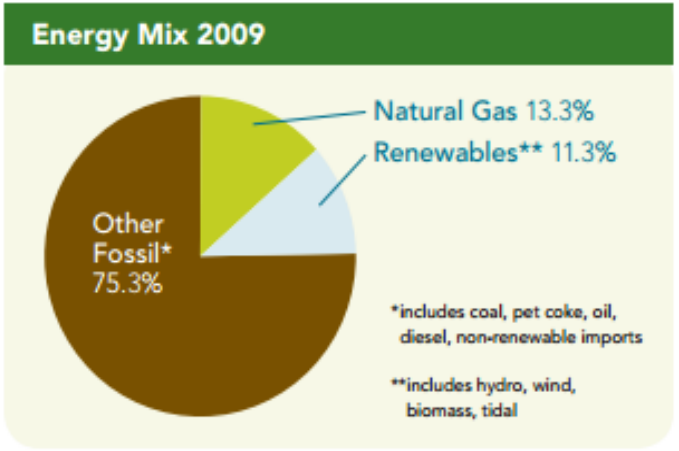
- Wind
- Hydro-electricity
- Geothermal
- Solar
- Bioenergy
- Marine Renewable (Tidal)

Note: *1 megawatt (MW) can power approx. 1,000 homes.*

Nova Scotia's Plan

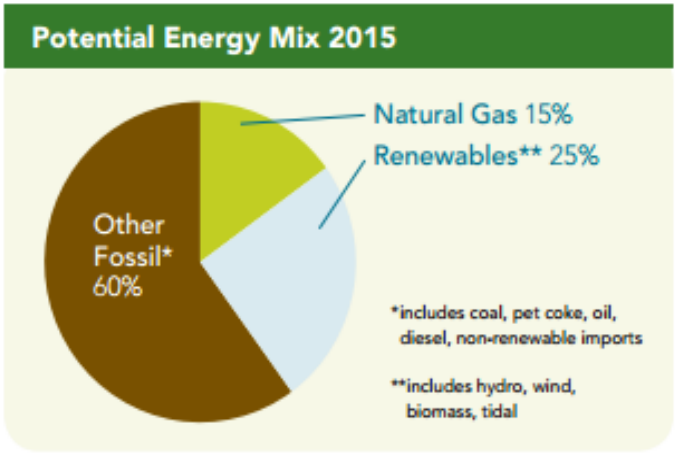
Past

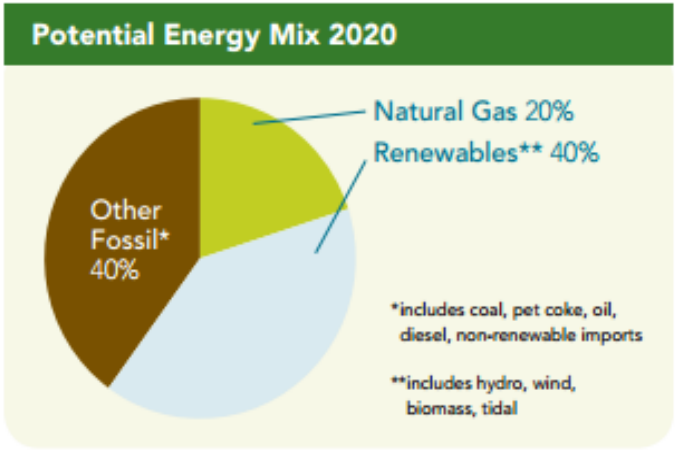




In the first decade, fossil fuels dominate but cleaner-burning natural gas begins to play a larger role.

Future





Coal and oil give way to increasing amounts of renewables (domestic and/or imported) and natural gas.

(COMFIT Program, 2011)

Wind Energy

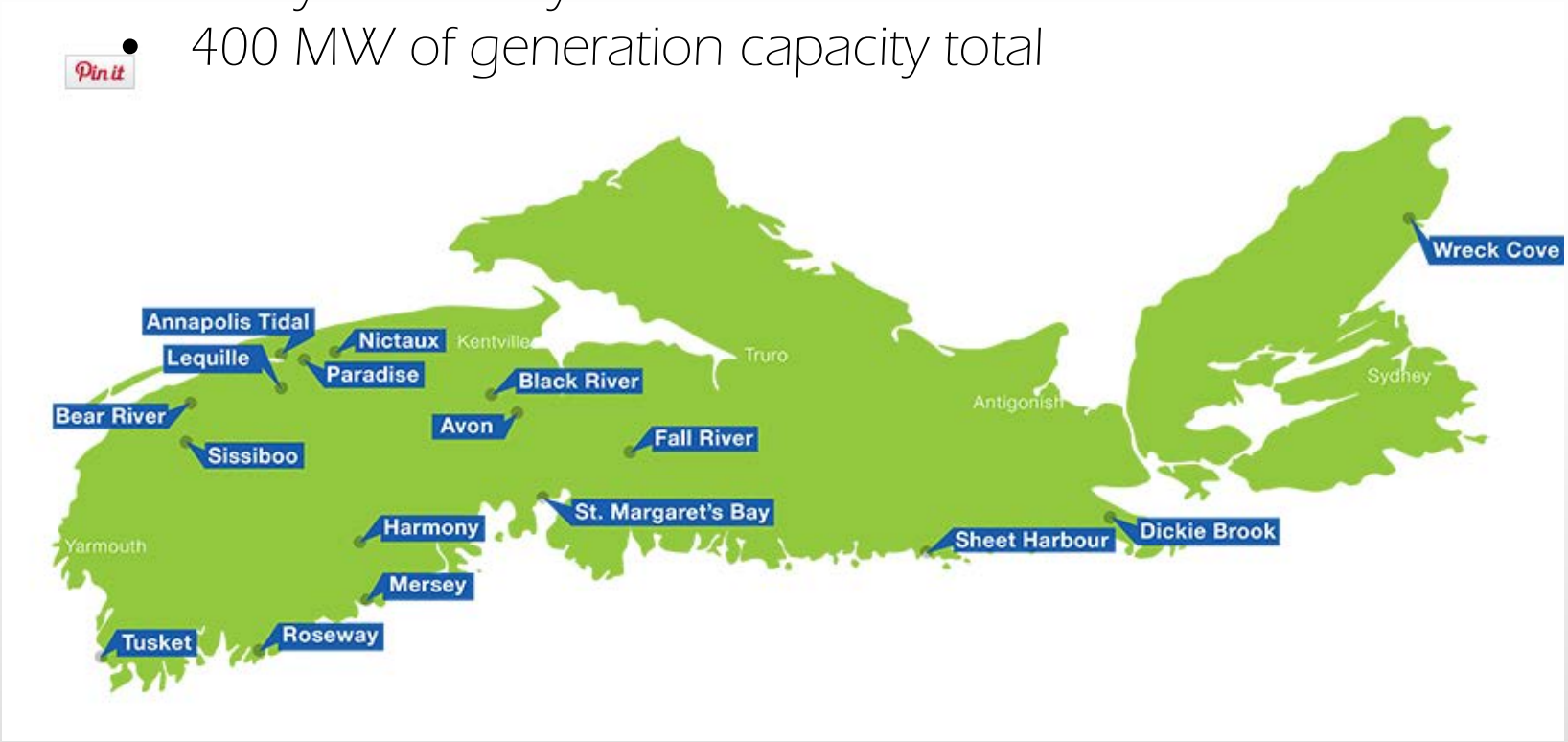
- Over 300 units in service across NS
- 14% of electricity used in NS

(Nova Scotia Power, 2020)

Nova Scotia

Hydroelectricity

- 33 hydro electric plants
- 17 hydro river systems
- 400 MW of generation capacity total



(Nova Scotia Power, 2020)

Nova Scotia

BioEnergy

BioMass

Port Hawkesbury Biomass Plant (60 MW)

- Wood with no other commercial use
- 3% of the province's electricity

BioGas

Former Sackville Regional Landfill site supplies 2 MW of electricity annually to the provincial power grid via biogas

(Nova Scotia Power, 2020)

Nova Scotia

Solar Energy

Incentive Programs

- Varying financing options are available through private and Property Assessed Clean Energy (PACE) financing programs.

- Enhanced Net Metering
  - get credit for any electricity you feed into the grid and are paid for it at the retail class rate
  - up to an overall limit of 1 MW

(Efficiency NS, 2018; Nova Scotia Power, 2020)

Nova Scotia

Geothermal Energy

Incentive Programs:

The Green Heating program offers rebates up to $1,900 or low interest financing (2%) up to $15,000 for five years to help cover the cost of new equipment and installation

Figure 1 – An Example of an Open-loop Ground Source Heat Pump System

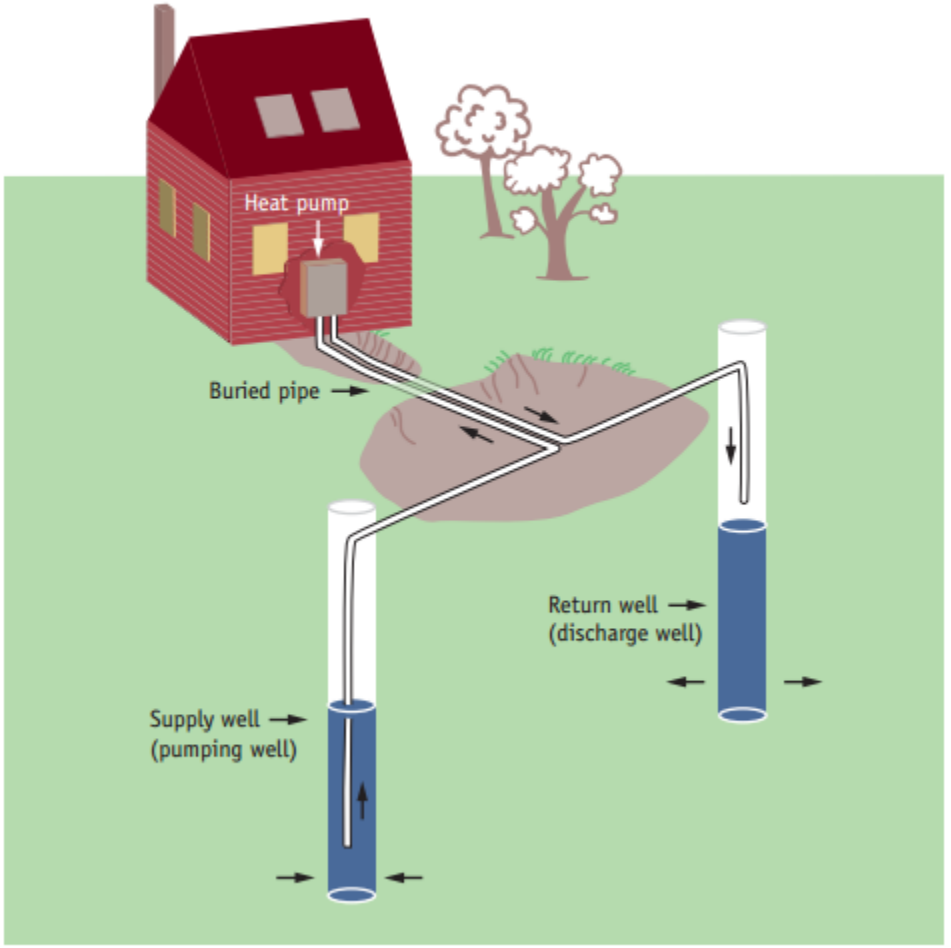


Diagram not to scale.

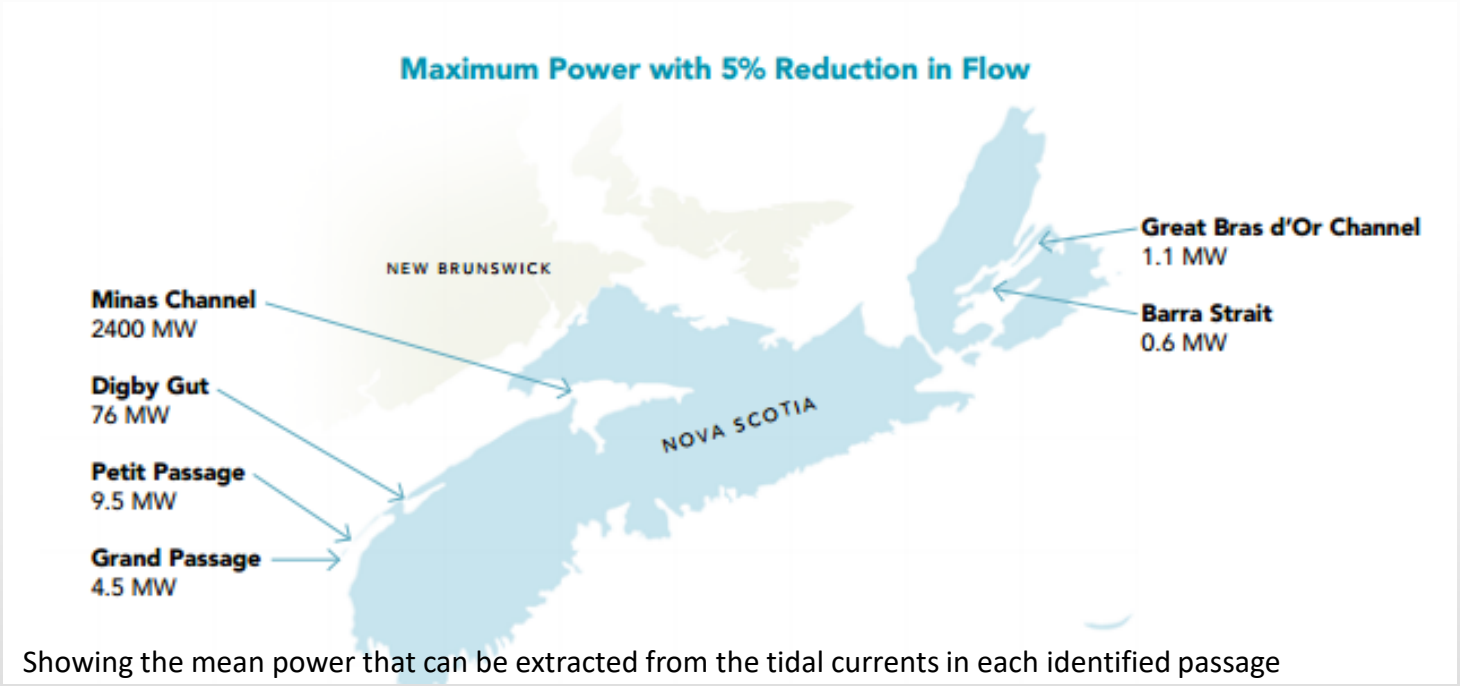
(Efficiency NS, 2018)

Marine Renewable (Tidal) Energy

Annapolis Royal Generating Station (1984 – present)

- Tidal Barrage Plant – extracting energy from the rise and fall of the tides

In-stream Tidal Energy Technology



Showing the mean power that can be extracted from the tidal currents in each identified passage

(NS Marine Renewable Energy Strategy, 2012.)

Marine Renewable (Tidal) Energy

Fundy Ocean Research Centre for Energy (FORCE)

- Bay of Fundy
- SME turbine deployed, Grand Passage in 2019
- Electric Power Research Institute estimates potential of ~300 MW, enough to power 100 00 homes.

(Canadian Press, 2016; FORCE, 2020; Canada Energy Regulator, 2020).

Nova Scotia

Energy Storage

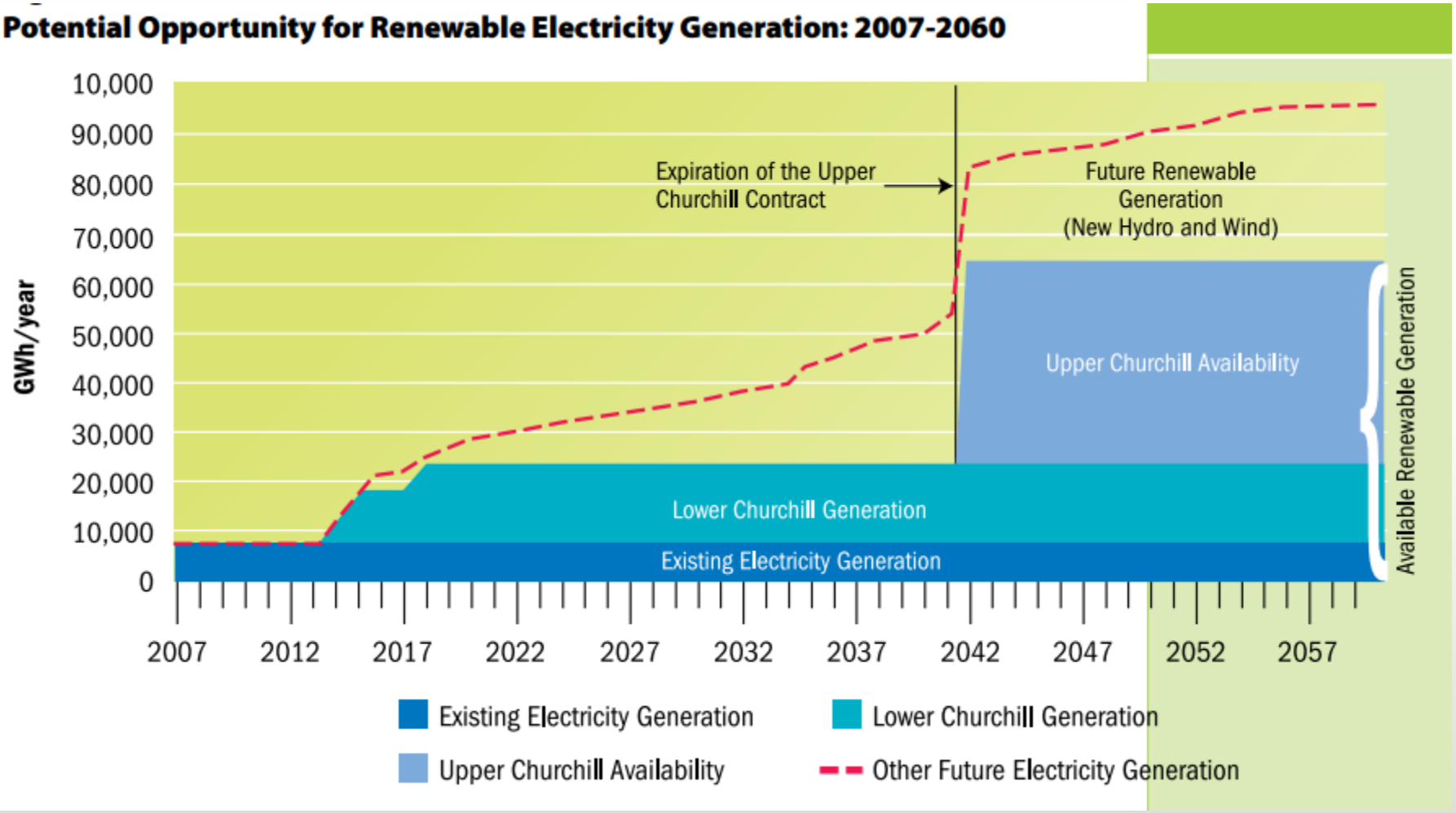
Alton Natural Gas Storage Project

- Alton, Nova Scotia
- Underground natural gas storage facility
- Stewiacke Salt Formation (Windsor Group)
- 60 km from Halifax
- Building a new facility to meet growing demand

Louisiana Department of Natural Resources

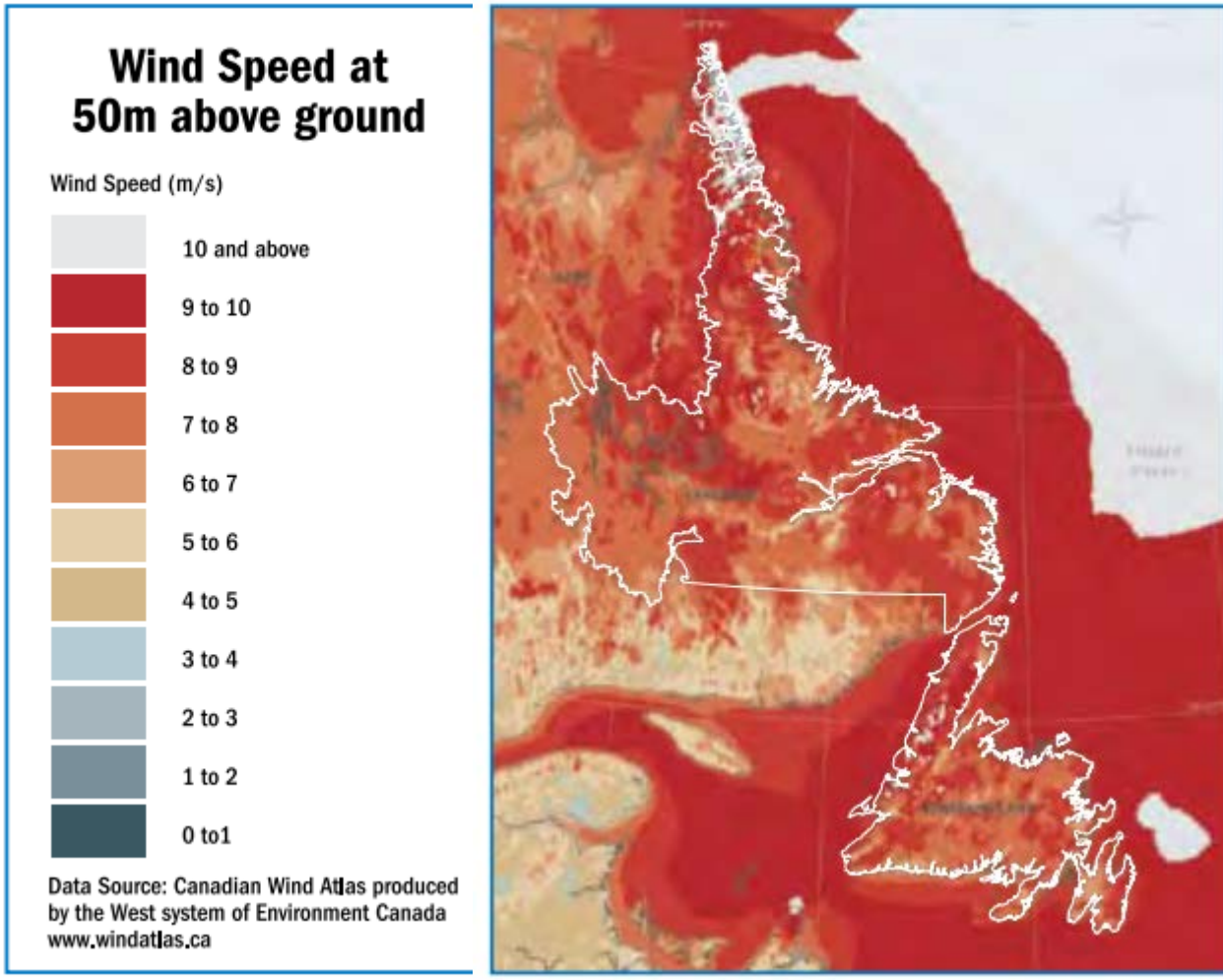
Alton Natural Gas Storage, L. P.

NL Energy Plan



Wind

Wind energy potential



Developed:

St. Lawrence 27MW
Fermeuse 24MW

Undeveloped:

> 5,000MW

(NL Dept of Natural Resources, 2007)

Newfoundland & Labrador

Wind

Wind-Hydrogen-Diesel Energy Project (Nalcor Energy)

- Ramea, Newfoundland
- Uses renewable energy to supplement the diesel requirements of an eclectically isolated island community
- 21 other similar existing NL Hydro isolated diesel systems on coast of Newfoundland & Labrador
- Significant potential for deployment in remote communities in Canada

(Natural Resources Canada, 2007)

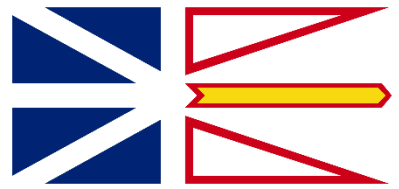
Hydroelectricity

Lower Churchill Project

- 3,000 MW
- 16.7 Terawatt hours (TWh) of electricity per year – enough to power 1.5 million homes

  - Gull Island
  - Muskrat Falls

(Department of Natural Resources Newfoundland and Labrador, n.d.)



Newfoundland & Labrador

(Nalcor Energy, n.d)

Newfoundland & Labrador

Hydroelectricity

Upper Churchill Project

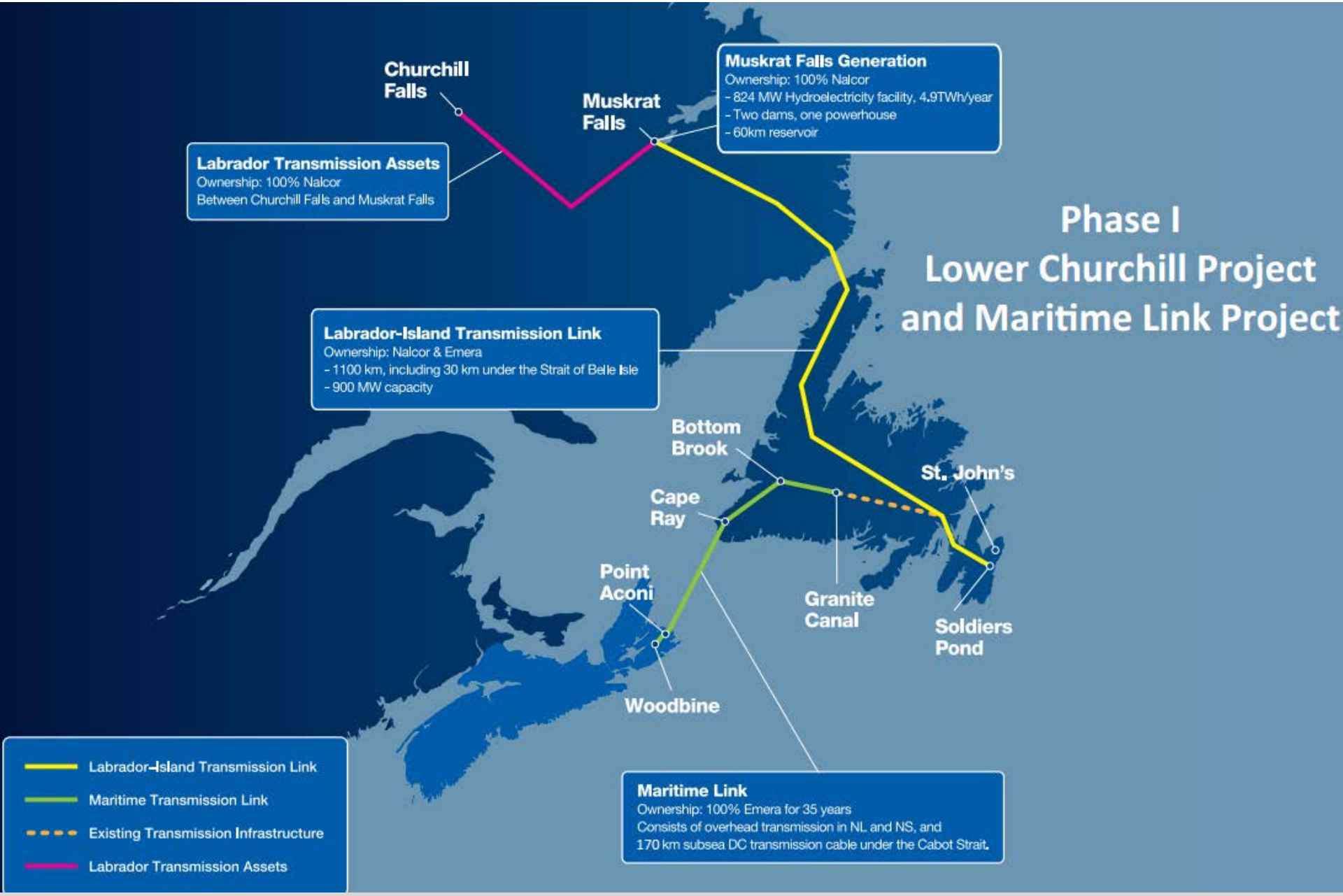
- 5,428 MW

(Department of Natural Resources Newfoundland and Labrador, n.d.; Clean Energy BC, 2010)

NL Hydroelectric Generating Stations

Hydroelectric Generating Stations	MW generation capacity
Bay d'Espoir Hydroelectric Generating Facility	604 MW
Cat Arm Hydroelectric Generating Station	127 MW
Granite Canal Hydroelectric Generating Station	41 MW
Hinds Lake Hydroelectric Generating Station	75 MW
Paradise River Hydroelectric Generating Station	8 MW
Roddickton Hydro Plant	0.4 MW (400kW)
Snooks Arm and Venams Bight	1 MW
Upper Salmon Hydroelectric Generating Station	84 MW

(NL Hydro, 2020)



(Emera Newfoundland and Labrador, 2020)

Labrador-Island Transmission Link

- Fixed annual cost fixed, resulting in long-term rate stability and certainty on the Island.
- Provides opportunity to increase the amount of electricity generated by clean, renewable hydropower, reduce fossil fuel reliance on the Island and provide rate certainty

Maritime Link

- Connects the island of Newfoundland to Nova Scotia and the North American transmission grid for the very first time
- The Maritime Link is owned and operated by NSP Maritime Link Inc., a wholly owned subsidiary of Emera Newfoundland & Labrador

(Nalcor Energy, n.d.)

BioEnergy

Biogas Electricity Generation Pilot Program

- Established in 2014/15
- Newfoundland and Labrador Hydro will purchase electricity from biogas projects up to a maximum of 2 megawatts (MW) per biogas project
- Burning biogas as an electricity fuel source reduces its greenhouse gas impact and creates economic value from landfill and agricultural waste

(Department of Natural Resources Newfoundland and Labrador, n.d.)

Net Metering

Newfoundland and Labrador's Net Metering Policy Framework

- Announced 2015
- Policy parameters for Newfoundland and Labrador Hydro, Newfoundland Power, and the Board of Commissioners of Public Utilities to develop and implement net metering programs for utility customers
- Eligibility is limited to small-scale renewable energy sources
- Individual renewable generation systems will be limited up to a maximum of 100kW and cannot be sized beyond a customer's load

(Department of Natural Resources Newfoundland and Labrador, n.d.)

TakeCHARGE - Energy Rebates

Instant Rebates - Save instantly on energy efficient products

Thermostat Rebate - purchase eligible electronic and programmable thermostat

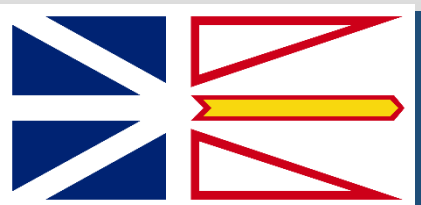
Insulation Rebate – Install insulation throughout your home including attic and basement

HRV Rebate – Install a Heat Recovery Ventilator

Appliance & Electronics Rebates – Purchase and install Energy Star Certified Appliances and TVs

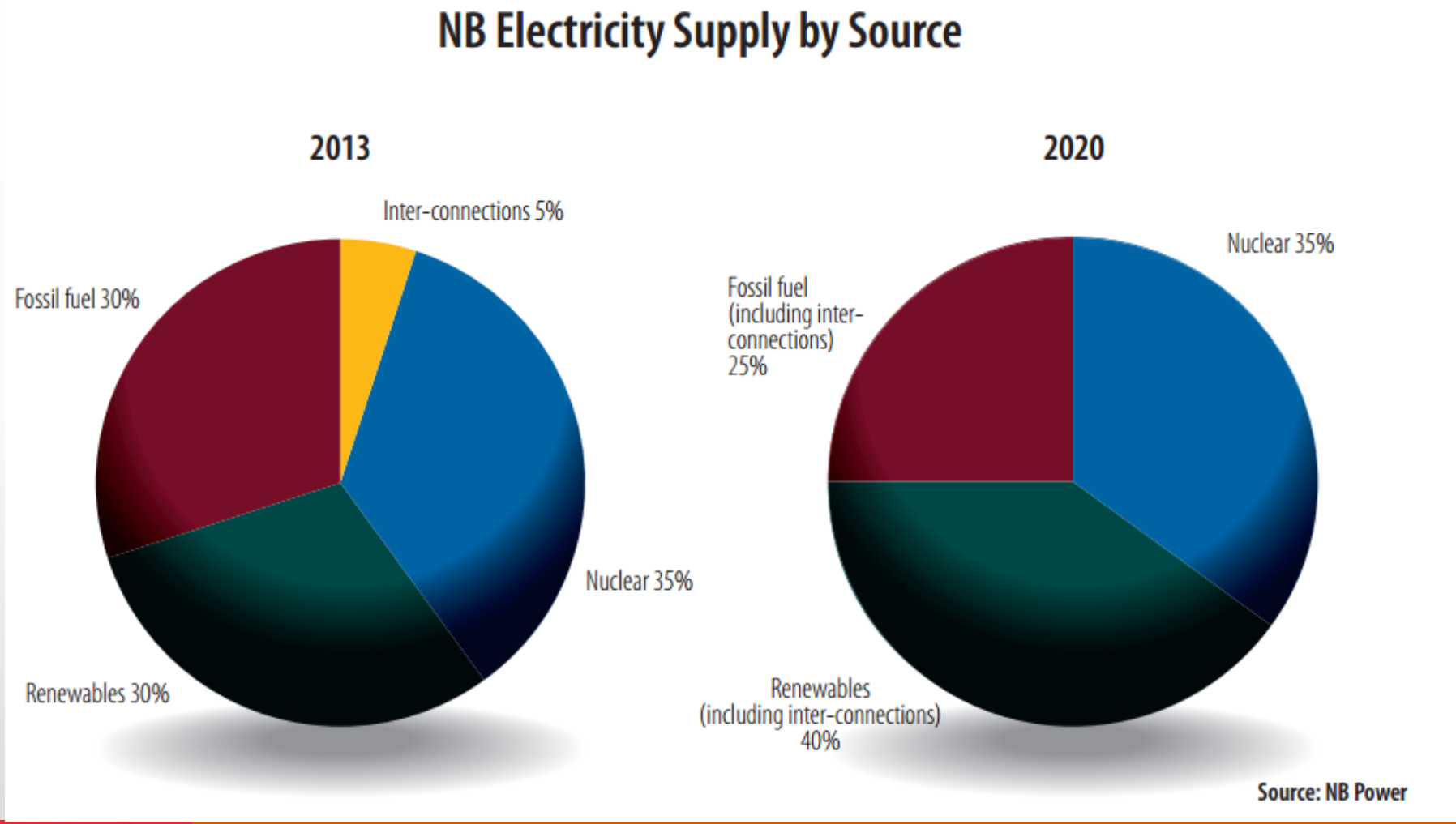
Business Rebates – Take part in the Business Efficiency Program for custom solutions, and you can could up to $50,000 back when you invest in energy saving upgrades

(TakeCHARGE Newfoundland, n.d.)



Newfoundland & Labrador

New Brunswick's Energy Plan



Wind

- 50% NB electricity needs met by wind
- 294 MW of wind generation capacity
- 28 Wind stations

Kent Hills Wind Farm

- 150 MW
- Southwest of Moncton, NB
- Since 2008

Lamèque Wind Power Project

- 45 MW
- Lamèque Island, Gulf of St. Lawrence
- Since 2011

(NB Power, 2020)

Bioenergy

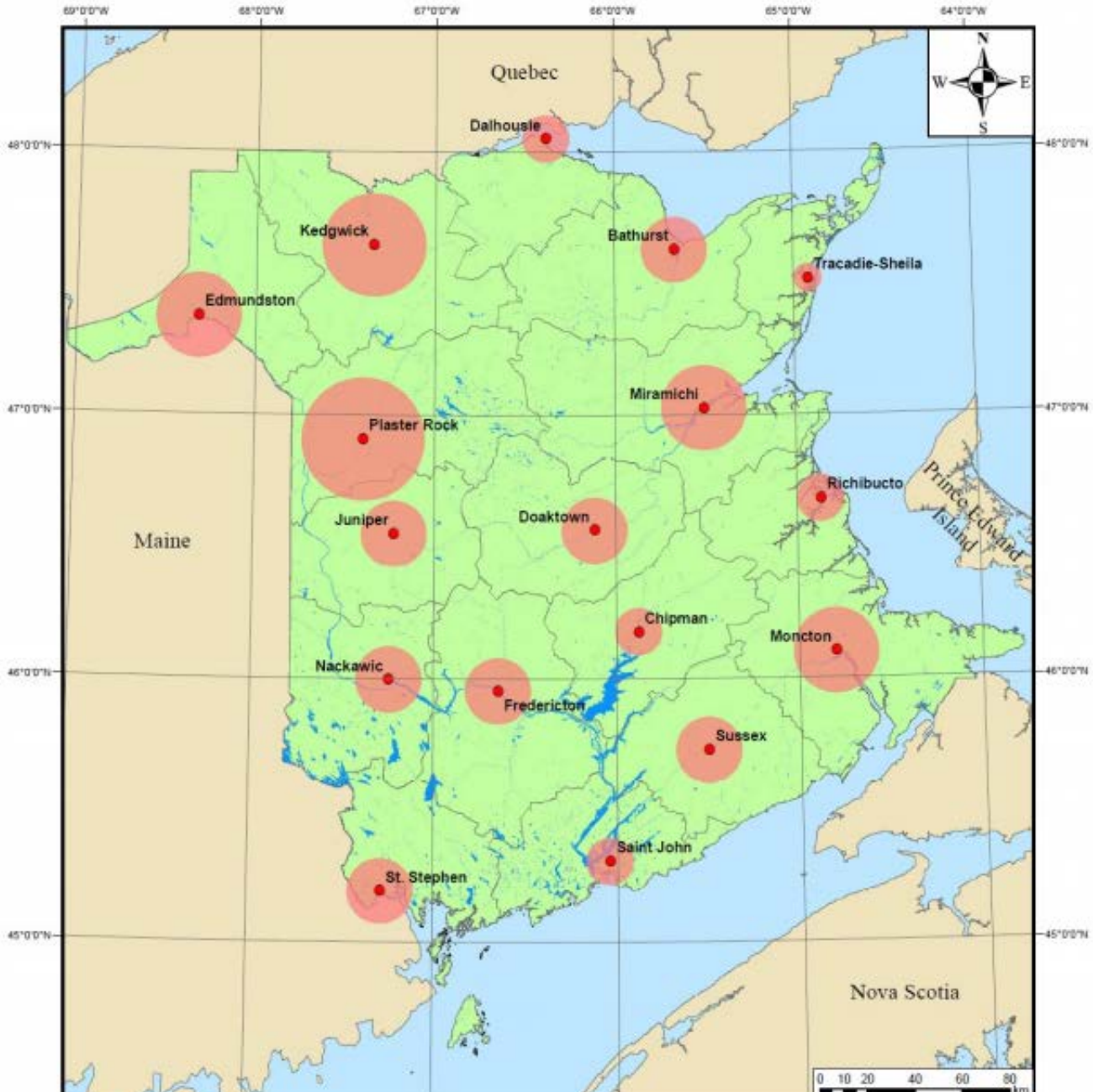
Biomass

- There are 4 large scale facilities in NB using woody based biomass to produce electricity:

Twin Rivers Paper	87 MW
Irving Pulp & Paper	30 MW
AV Cell Inc.	7.6 MW
AV Nackawic	25 MW

(NB Power, 2017)

Technical Power Potential Map of Forest Biomass in New Brunswick



Hydroelectric Energy

Mactaquac Hydroelectric Generating Station

- Expected to reach the end of its service life in 2068
- Saint John River
- Supplies 12% of NB electricity needs
- Requires repairs to reach 100-year life expectancy.

(NB Power, 2020)

Interconnection Upgrade Project

- Connects PEI to the mainland grid
- Imports electricity from New Brunswick
- Two new 180 MW submarine cables

PEI

NB

(Maritime Electric, 2020).

New Brunswick

NB Energy Efficiency Programs

- Energy Smart Commercial Buildings Retrofit Program
  - Up to $3,300 towards an evaluation to determine the potential for energy efficiency upgrades in a commercial building and a maximum of $100,000 towards the energy retrofitting project costs that result in measureable electricity savings
- Low Income Energy Savings Program
  - targets homes in need of major energy efficiency upgrades, especially those needing insulation, air sealing and possibly ductless heat pumps
- Home Insulation Energy Savings Program
  - provide information and incentives to homeowners to help reduce their energy consumption through targeted air sealing and insulation upgrades in electrically heated homes
- Ductless mini-split heat pump program
  - NB Energy offers a $500 point-of-sale rebate on ENERGY STAR certified, CEE Tier III rated Cold Climate (-20°C and lower) ductless mini-split heat pumps purchased through participating heating contractors

(Save Energy NB, 2020; NB Power, 2020)

NB Energy Efficiency Programs

- Water Saving Devices Program
  - NB Power will offer free or cost-shared water savings devices (e.g. low flow showerheads and faucet aerators) to customers who lease a new and more energy efficient domestic hot water heater through the provincial utility.
- Home Energy Report Program
  - After the initial pilot phase in 2015, in 2016 NB Power launched a program through which select customers will receive a personalized energy report. The report will help customers to better understand their energy usage, and to compare their consumption with that of their peers

(NB Power, 2020)

NB Renewable Energy Initiatives

- Net metering – NB Power has created policy to allow customers to produce their own renewable energy by connecting a small generation unit (under 100 kW) to NB Power's distribution system. Encourages decentralized generation and broad geographical distribution of renewable energy sources

- Embedded Generation Sales – NB Power is required by the Electricity Act to purchase electricity from the owners of small to medium size generators that supply their energy directly to the distribution grid (as opposed to the higher voltage transmission grid)

(NB Power, 2020)

Solar

- Individual consumers can utilize 'net metering' to connect their own environmentally sustainable generation unit to NB Power's distribution system

- The program allows customers to generate their own electricity to offset their consumption, while still remaining connected to NB Power's distribution system – so they can meet their electricity demands when their generation unit cannot.

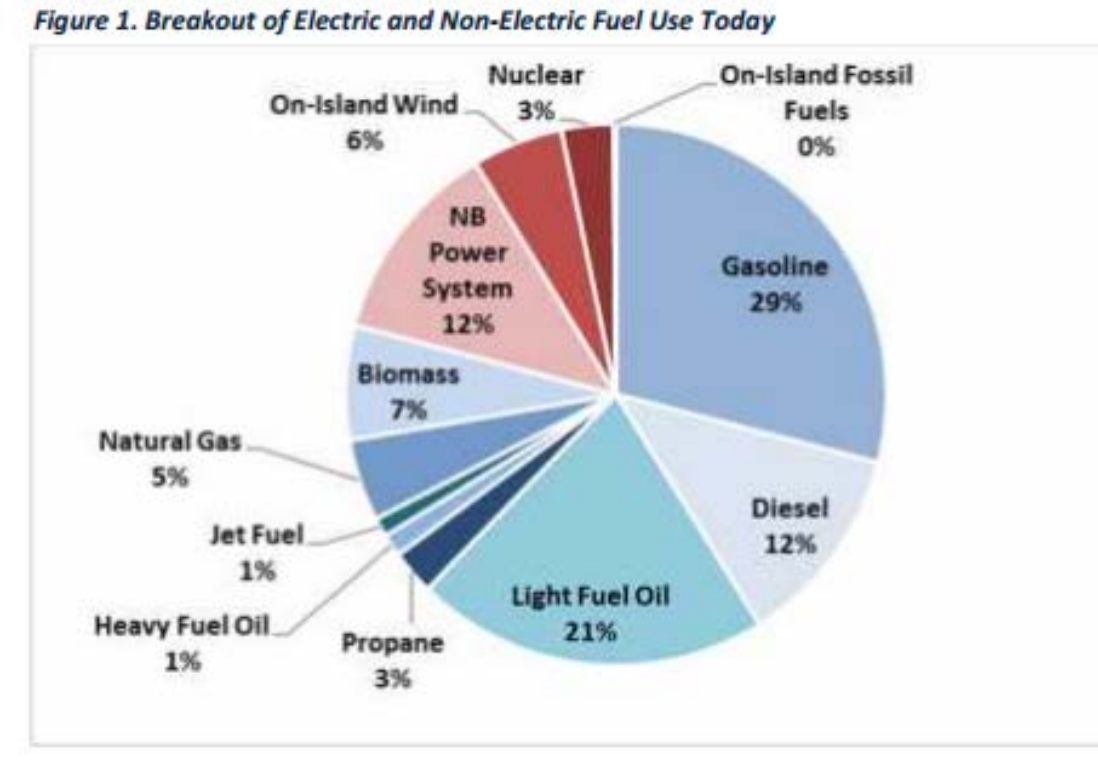
- Must not exceed 100kW

(NB Power, 2020)

PEI's Provincial Energy Strategy

Released May 2016

Figure 1. Breakout of Electric and Non-Electric Fuel Use Today



(PEI Energy Corporation, 2016)

Prince Edward Island

- PEI has a peak electricity load requirement of 285 MW (2018)
- PEI has the highest wind penetration of jurisdiction in North America, second in the world after Denmark
- Almost 60% of PEI's electricity supply is provided by NB Power in 2016

(PEI Energy Corp; University of Alberta Future Energy Systems, 2018.)

Prince Edward Island

Table 1. Comparison of PEI Peak Load to Existing Available Resources

Load Requirements	2016	2017	2018	2019	2020	2021	2022
Forecast Peak Load	264	266	271	276	281	286	294
Interruptible Load	-15	-15	-15	-15	-15	-15	-15
15% Planning Reserve	37	38	38	39	40	41	42
Total Load Requirements	**286**	**289**	**294**	**300**	**306**	**312**	**321**
Available Capacity							
Charlottetown Generating Station	55	55	55	0	0	0	0
Borden Plant	40	40	40	40	40	40	40
Combustion Turbine 3	49	49	49	49	49	49	49
Summerside Thermal	15	15	15	15	15	15	15
Total On-Island Thermal	**159**	**159**	**159**	**104**	**104**	**104**	**104**
Point Lepreau	29	29	29	29	29	29	29
Maximum Off-Island Purchases	110	110	110	110	110	110	110
Effective Capacity of On-Island Wind	31	31	31	31	31	31	31
Total Available Capacity (sum of Total On-Island Thermal and other sources)	**329**	**329**	**329**	**274**	**274**	**274**	**274**
Capacity Surplus/Deficit	**43**	**40**	**35**	**-26**	**-32**	**-38**	**-47**

(PEI Energy Corporation, 2016)

Prince Edward Island

Wind Energy

- 26% PEI electricity needs are met by wind
- 203 MW of wind generation capacity
- 7 wind facilities (6 provincial, 1 private)

Aeolus Wind Farm
- 3 MW

Eastern Point Wind Farm
- 40.56 MW

Norway Wind Farm
- 9 MW

Summerside Wind Farm
- 12 MW

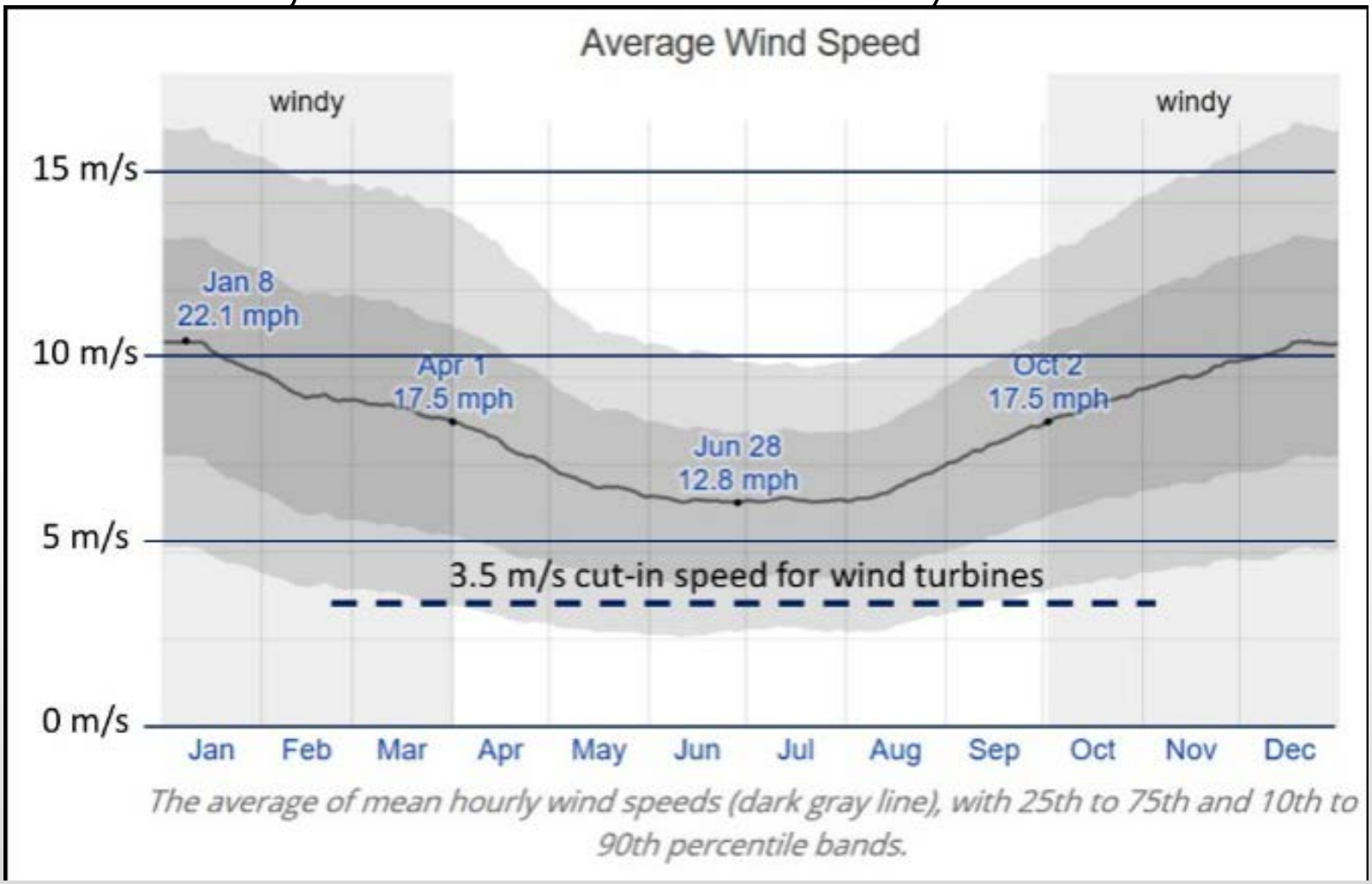
North Cape Wind Farm
- 10.56 MW

Eastern Kings Wind Farm
- 30 MW

West Cape Wind Farm
- 99 MW

(Maritime Electric, 2020)

Average of mean hourly winds

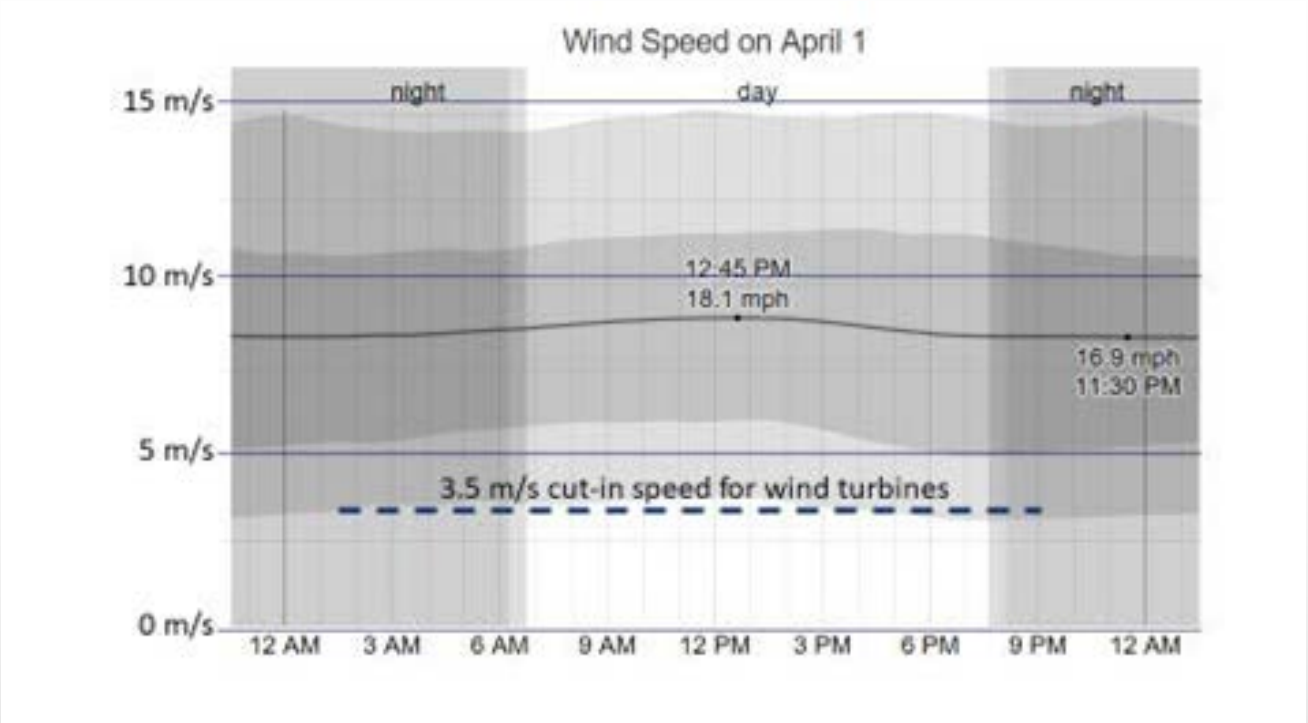


The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.

(Maurice Dusseault, 2020)

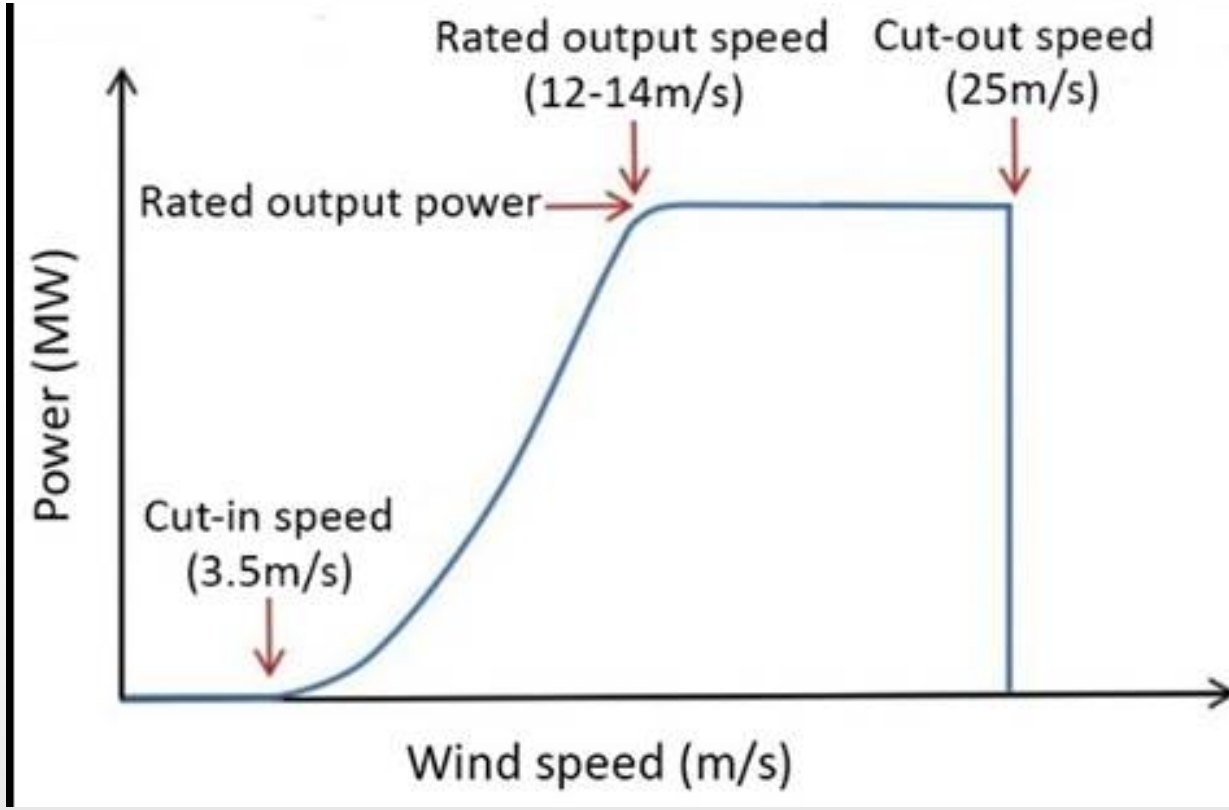
Close-up of *April 1*

- *Daily wind in PEI relatively consistent, unlike many other provinces.*



(Maurice Dusseault, 2020)

- Rated power output occurs (depending on the turbine) from 12-14 m/s and the cut out, when the blades are feathered to prevent damage, is 25 m/s velocity.



(Maurice Dusseault, 2020)

Hydroelectricity

- PEI is the only Canadian Province without an active hydroelectric station
- Last one ended commercial operation in 1950

(Maritime Electric, 2020)

Solar

- Modest solar resources
- "Utility-scale solar costs on the Island today are over twice those of wind, but costs are decreasing dramatically" (PEI Energy Corp, 2016).
- Net Metering up to 100kW
- 70 residential solar PV systems involved in net metering

(Maritime Electric, 2020)

Tidal Energy

- Currently no tidal initiatives in PEI
- Considerably more expensive than other renewable energy resources for the foreseeable future
- The magnitude of tides in the Bay of Fundy suggests that Atlantic Canada has an attractive in-stream tidal resource BUT Prince Edward Island's tidal resources are not as favourable as Nova Scotia's

(PEI Energy Corp., 2017)

Biomass

- 30% homes in 2014 used wood logs as supplementary heating source
- Additional 1.4% used wood pellets as primary heating source
- 22 facilities (i.e.. Schools) used wood pellets for heating

Table 2. Comparison of Current Costs Related to Wood and Oil Heating and Fuels in PEI

Cost Type	Wood	Heating Oil
Capital cost	Pellet furnace: up to $20,000	Oil furnace: <$10,000
Fuel cost	Pellets: $20+/GJ ($6-7 per 40 lb bag)	Heating oil: $21/GJ ($0.76/L)
Fuel cost	Firewood: $240/cord	Heating oil: $422 (560 L)
Heating cost	Wood chip heating (service model)	Equivalent to oil cost of $1/L

(PEI Energy Corp., 2017)

Biogas

- Digesters currently exist at Cavendish Farms and the Charlottetown wastewater treatment plant; however, the gas is only used to produce process heat and not electricity.

Argo-West starch plant (Souris, PEI)

- Only digester facility that produces electricity

Table 5. Potential Diesel Displacement from Locally Produced Biogas

Source	Amount per year	Biogas/methane yield	Total Annual Potential	Diesel Displaced[5]
Organic waste	20,000 tonnes[3]	60 m^3/CH_4 tonne[4]	1,200,000 m^3	1,249,000 l
Cattle	65,000 heads[1]	2.0 m^3/d each[2]	130,000 m^3	67,000 l
Hogs	60,000 heads[1]	1.9 m^3/d each[2]	114,000 m^3	59,000 l
Poultry	Unknown	0.85 m^3/d per 100[2]		

[1] 2012 StatsCan data, CANSIM Tables 003-0083, 003-0102
[2] Government of Alberta assumptions http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10945
[3] Annual amount received at Central Composting Site (2014 IWMC Annual Report)
[4] Harvest Power (MSW PROJECT OPPORTUNITY, Slide Presentation, 2013)
[5] Compared to diesel, based on energy content; assumes methane content of 50% in biogas

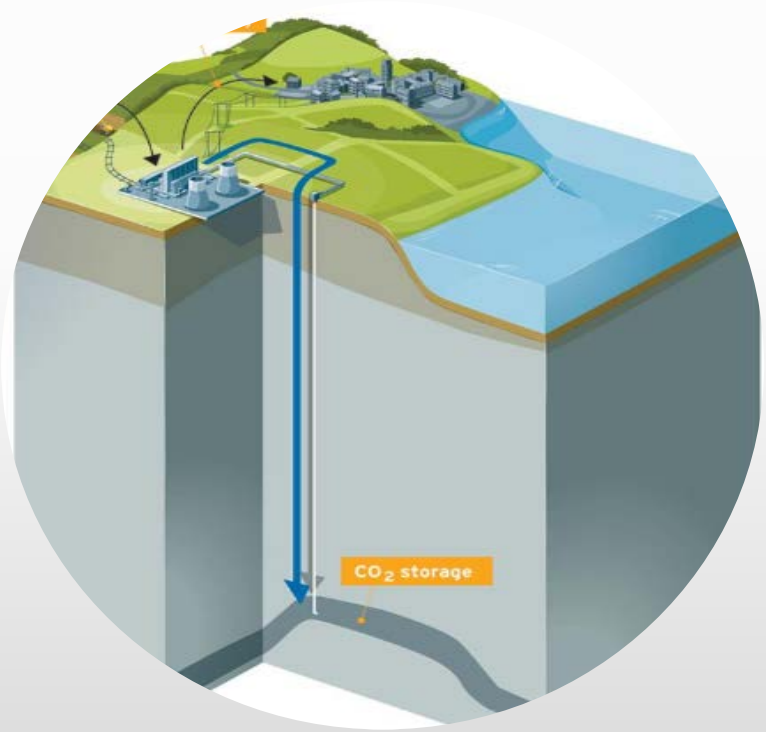
(PEI Energy Corp., 2017)

Energy Storage

- City of Summerside Thermal Energy Storage Program
- PowerShift Atlantic Program
- Battery Storage by Wind Energy Institute of Canada

(PEI Energy Corp, 2017.)

Carbon Capture & Storage



The process of capturing waste carbon dioxide (CO_2) from large point source such as fossil fuel power plants, transporting it to a storage site, and depositing it where it will not enter the atmosphere

Carbon Capture & Storage

- Canada produces 5% of its electrical energy using natural gas-fired power plants.
- These plants emit approximately 16 Mt of CO2 which is equivalent to the amount of carbon sequestered by 410 million seedlings over10 years (EPA, 2012 & Environment Canada, 2011).
- Options for Captured CO_2:
    - Geological storage
    - Enhanced Oil Recovery
    - Enhanced Coal Bed Methane Recovery
    - Hydraulic fracturing in arid regions

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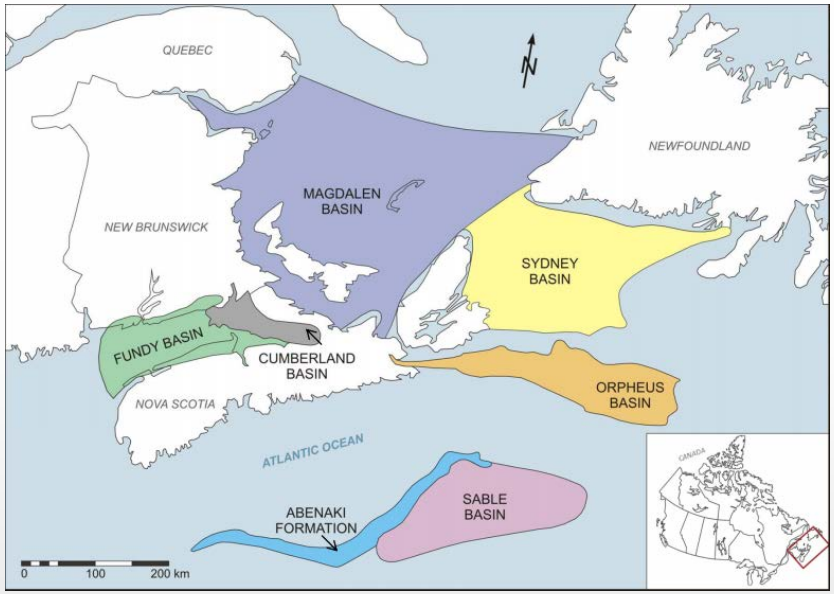
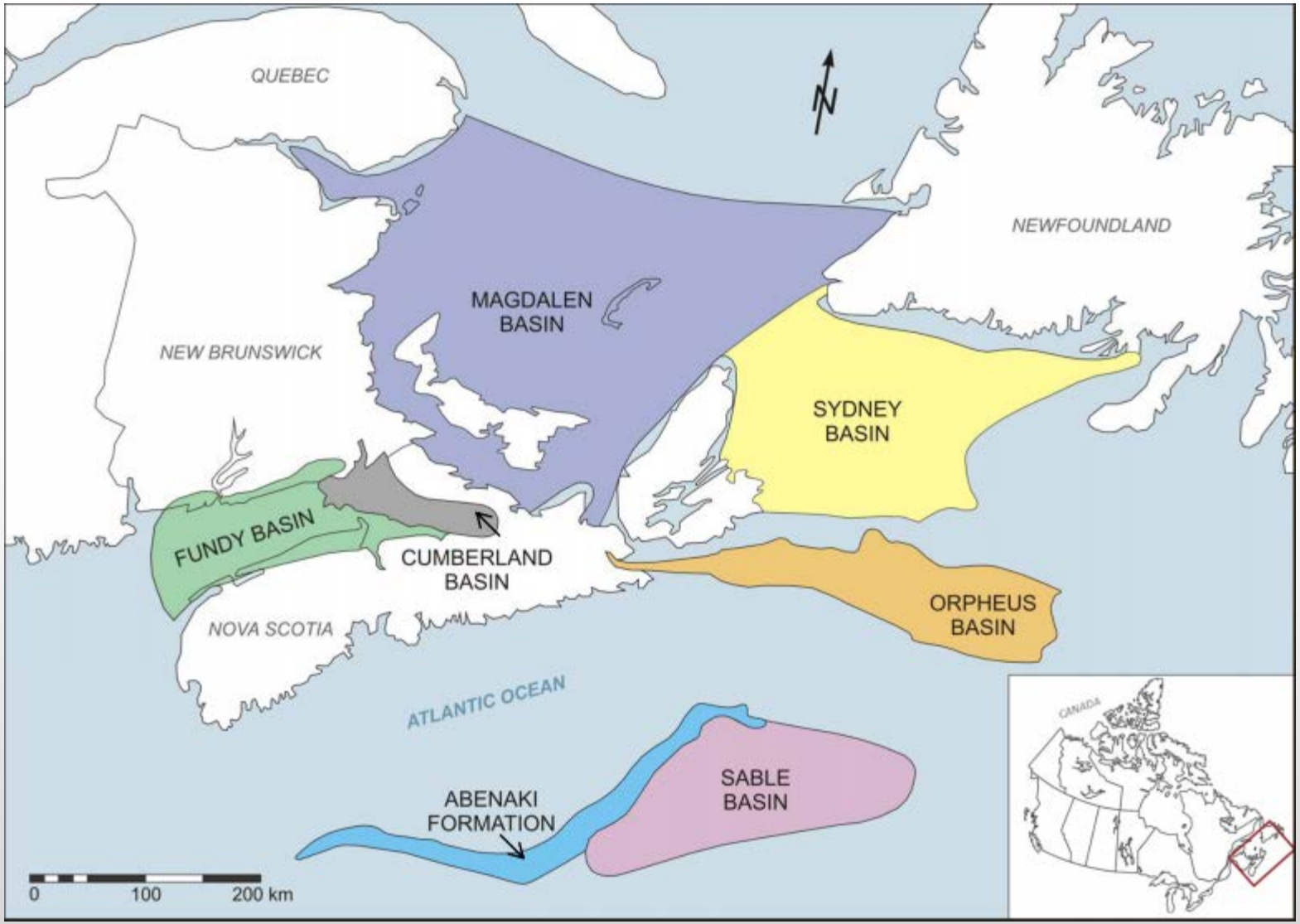
Geological Storage

- To be economically feasible, the CO_2 emission source must be close to the storage reservoir
- There are Paleozoic and Mesozoic basins for CO_2 storage near several major sources in Atlantic Canada
- Carbonate and clastic reservoirs have several pairs
- Capped by thick shale deposits or evaporate deposits which can form excellent seals



(Pothier, Wach & Zentilli, 2011)

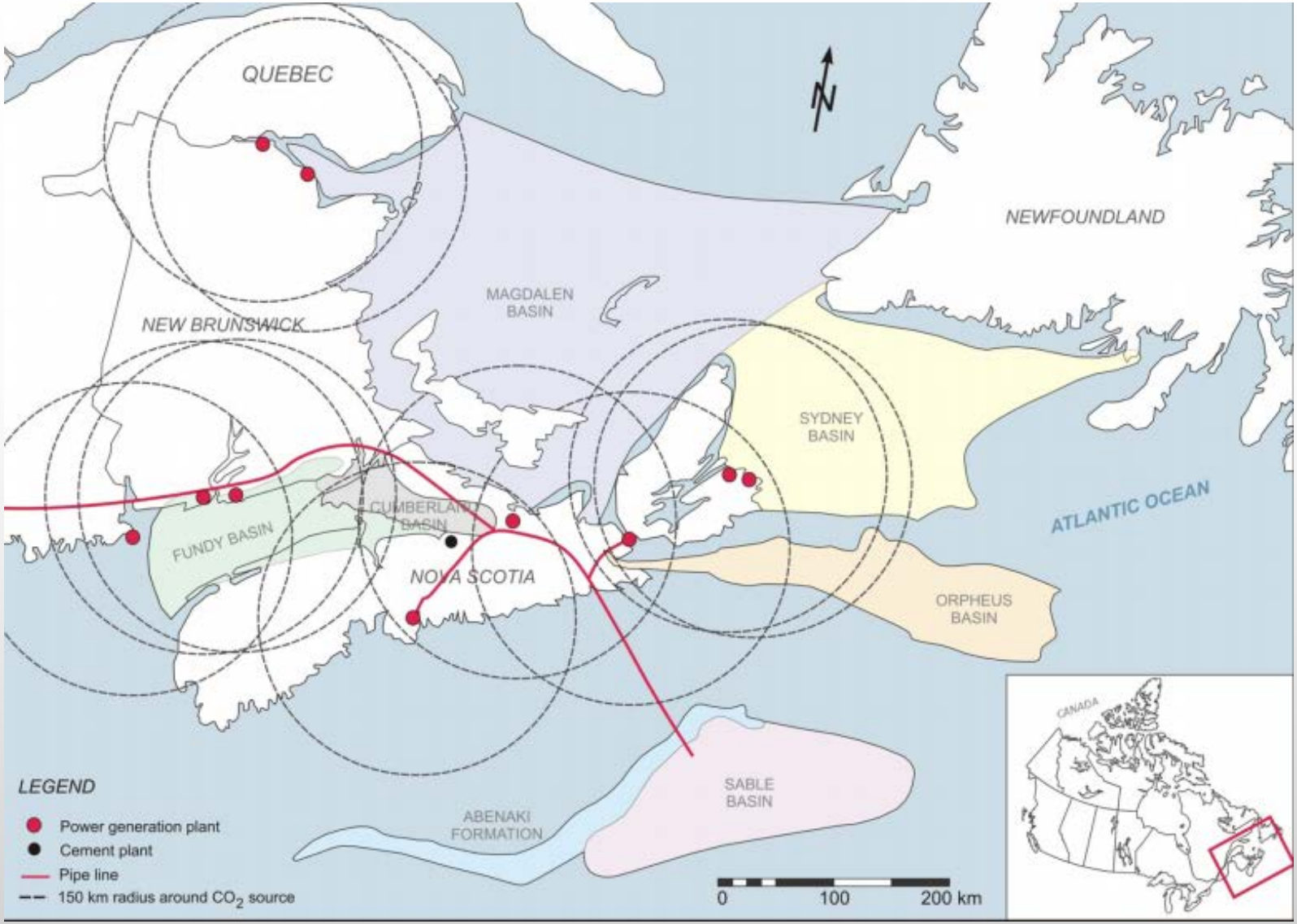
Geological Storage: *Atlantic Canada Sedimentary Basins*



(Pothier, Wach & Zentilli, 2011)

Sources of CO_2

Here we can see the proximity of emission sites to the surrounding Eastern Canadian basins and existing pipeline infrastructure.



(Pothier, Wach & Zentilli, 2011)

Basin Evaluation – possible storage sites

MARITIMES BASIN	
Cumberland	**Reservoir** - Pennsylvanian coarse clastics (Joggins and Polly Brook Fms.) **Seal** - evaporites **Pros** - Close proximity to emission site **Cons** - Low Porosity and Permeability
Magdalen	**Reservoir** - Devono-Carboniferous to Permian age coarse clastics **Seal** - Mississippian evaporites and salt **Pros** - Close proximity to emission site **Cons** - Low Porosity and Permeability
Sydney	**Reservoir** - Devono-Carboniferous to Permian age coarse clastics **Seal** - Mississippian evaporites and salt **Pros** - Close proximity to emission site **Cons** - Low Porosity and Permeability

(Pothier, Wach & Zentilli, 2011)

Basin Evaluation – possible storage sites

SCOTIAN BASIN	
Orpheus	**Reservoir** - fine grained to conglomeratic clastics (Eurydice Fm.) **Seal** - thick evaporites (Argo Fm.)
	Pros - Close proximity to emission site; potential for salt seal **Cons** - Offshore pipeline and monitoring survey needed
Sable	**Reservoir** - thick deltaic sands (Missisauga Fm.) **Seal** - thick transgressive prodelta shales
	Pros - Pipeline in place and good porosity **Cons** - Far from emission sites
Abenaki	**Reservoir** - carbonates with fracture and dolomitic porosity (Abenaki Fm.) **Seal** - thick transgressive prodelta shales
	Pros - Pipeline in 2010; planned H_2S injection site so some infrastructure **Cons** - Far from emission sites
Fundy	**Reservoir** - fine grained to conglomeratic clastics (Blomidon and Wolfville Fms.) **Seal** - Basalt
	Pros - Good Porosity **Cons** - Farther from emission sites

(Pothier, Wach & Zentilli, 2011)

Recommendations:

- As coal-fired power plants age, they should be replaced with efficient natural gas-fired plants.
- New and current natural gas-fired power plants should be designed or retrofitted to be carbon capture ready.
- Where geology allows, storage should be put in place. In places where geology is not suitable pipelines will be needed to transport CO_2
- Improvements in well completion technology needs to be reflected in regulations to ensure methane leakage is mitigated
- Government incentive/support should be provided to ensure CCS is implemented on a broad scale.

(A. Grant, 2013)

Hydraulic Fracturing

Or "Fracking", is a method of forcing natural gas or oil from rock layer deep below the Earth's surface

Hydraulic Fracturing

Concerns:

1. Water contamination
   - Well casing failure
   - Waste and produced water storage leakage
   - Dipping geological strata can cause surface connection
   - Unlikely fractures will connect with surface unless natural surface fault occurs

2. Water usage
   - Hydraulic fracturing uses 7 to 20 million liters of fluid per well.
   - Water can be used but alternatives are increasing (eg. liquid propane)

In Nova Scotia:

Geologic Potential:

Although no commercial discoveries have been made to date in Nova Scotia, the Carboniferous Supergroup shows similar characteristics to New Brunswick geology which has proven hydrocarbon reserves.

Infrastructure:

- Maritime & Northeast Pipeline
- proposed infrastructure (e.g.. LNG plant in Goldsboro)
- Salt cavern natural gas storage

Economic Benefits:

Hydraulic fracturing could lead to economic benefits through royalties and the use of locally sourced goods and services as outlined in the N.S. Petroleum Resource Regulations

Nova Scotia

Nova Scotia Legislation

Hydraulic Fracturing Act (2011)

- No person may engage in hydraulic fracturing in the Province without a permit

Wheeler Report (2013)

- In August 2013, the government of Nova Scotia commissioned an independent review of the socio-economic impacts of hydraulic fracturing, led by Dr. David Wheeler, President of Cape Breton University

Petroleum Resources Act (amended 2014)

- Prohibits high-volume hydraulic fracturing in shale unless exempted by regulation for the purpose of testing or research

Nova Scotia

New Brunswick Regulation

Indefinite moratorium on fracking lifted in 2019.

New Brunswick Energy Institute

- New Brunswick created an independent organization, the New Brunswick Energy Institute.
- The Institute's mandate is "to review and assess the environmental, social, economic and health issues relating to energy extraction, development or production" and thereby serve as an advisory body to the province.
- two separate lawsuits were launched against the province in June 2014

New Brunswick Commission on Hydraulic Fracturing (NBCHF)

- Commissioned in 2015

(CBC, 2019)

New Brunswick

NB Commission on Hydraulic Fracturing (NFBCF)

Geologic Potential:

As identified by the NBCHF, it is currently unknown definitively if shale gas and/or oil exist within held licences or if it can be extracted commercially, therefore it impossible to accurately predict production levels or a timeline for hydraulic fracturing in New Brunswick

Infrastructure:

- *Maritime & Northeast Pipeline*
- *Corridor*

Economic Benefits:

As identified by the NBCHF, investing in energy holds significant potential for economic grow for New Brunswick

(NBCHF, 2016)

NB Commission on Hydraulic Fracturing (NFBCF)

Findings:

1. A different approach is needed to address complex public issues such as hydraulic fracturing.
2. A broader community conversation about community risks and benefits is required.
3. An independent environment and energy research network is required.
4. An environment and energy strategy needs to be developed that helps transition to a new, value-added knowledge-based economy
5. An independent regulator should be created with a mandate to strengthen New Brunswick's monitoring and evaluation of shale gas development in terms of understanding cumulative effects, including impact on human health and the environment

NB Commission on Hydraulic Fracturing (NFBCF)

Findings:

6. Adequate resources must be assigned to properly plan for potential public infrastructure impacts.
7. Short-term and long-term solutions to hydraulically fractured wastewater should be determined before commercial production begins.
8. The Government of New Brunswick needs to work with Indigenous leadership in New Brunswick to adopt a nation-to-nation consultation process for hydraulic fracturing.
9. The Government should determine a royalty structure that encourages responsible development and promotes specific government priorities.

Newfoundland & Labrador Regulation

- In 2013, a moratorium on fracking was put in place to temporarily prohibit hydraulic fracturing in Newfoundland and Labrador
- In 2014, the Minister of Natural Resources appointed an independent panel (NLHFRP) to review of the socio-economic and environmental implications of hydraulic fracturing in Western Newfoundland
- The Newfoundland and Labrador Hydraulic Fracturing Review Panel (NLHFRP)'s report was published on May 31st, 2016

Newfoundland & Labrador Hydraulic Fracturing Review Panel (NFLHFRP) (May 31st, 2016)

RECOMMENDATIONS

"The Panel unanimously recommends that a number of gaps and deficiencies must be addressed before the necessary conditions could exist that would allow for hydraulic fracturing, as an all-inclusive industrial process, to proceed reasonably and responsibly in Western Newfoundland" ....

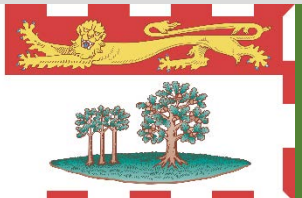
.....The Panel believes that, at this point, the "pause" in accepting applications involving hydraulic fracturing in Western Newfoundland should remain in effect while some of the supplementary recommendations are implemented".

PEI Regulation

- Fracking a "non-issue" in PEI according to Environment Minister, since no applications for hydraulic fracturing have come before the department.

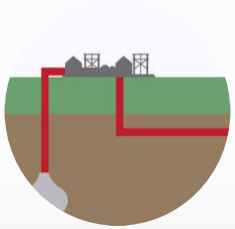
- Currently, there isn't a moratorium in place to prohibit hydraulic fracturing in PEI. However, interest groups argue in its favor.

- There has been discussion to address hydraulic fracturing in the proposed PEI Water Act



Prince Edward Island

Review



1. Offshore Oil and Gas
2. Onshore
3. Renewables
4. Carbon Storage
5. Hydraulic Fracturing (“Fracking”)

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