# Leveraging renewal of existing hydropower: implications for environmental assessment

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# The Challenge

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# The Challenge

- Reduce economy-wide GHG emissions **80% by 2050**
- Efficient electrification will play a key role
  - Improved end-use efficiency
  - **Low-carbon electricity development**
  - Electricity use in transportation, industry, and buildings
- Intermittent wind and solar will be increasingly deployed, but…

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# The (Bigger) Challenge: Electrical Capacity

- We also need electrical capacity that is:
  - Dependable (there to be called upon)
  - Reliable (always delivers once called)
  - Dispatchable (integrates variable renewables)
  - Storable (daily, weekly, seasonal)
  - Low carbon
- Low impact (esp. land use, habitat and biodiversity)
- Developed quickly (< 10 years)

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# How much electrical energy?

| | CANADA | | US |
|---|---|---|---|
| **Parameter** | **TEFP** | **DDPP** | **EPRI** |
| Δ 2015 to 2050 electricity (TWh/y) | 1550 | 800 | -- |
| Δ 2015 to 2050 CO2e | **-70%** | **-90%** | **-70%** |
| Δ 2015 to 2050 electricity (%) | **+220%** | **+135%** | **+50%** |
| Δ 2015 to 2050 hydroelectric (TWh/y) | 460 | 440 | (~200) |
| **Δ Site C or Muskrat Falls** | **90** | **85** | **(~40)** |

- Studies did not consider **hydroelectric renewal**

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# Storage Hydro: Solution?

- Typically 20 years from conception to operations
- Weak alternatives assessments
  - Inadequate assessment of economic risks
  - Large cost overruns (25% to 105%)
- Significant  adverse environmental effects
- Long-term aquatic management issues

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# The Opportunity

# The Opportunity: Hydro Renewal

- 75% of existing facilities now over 50 years old
- Substantial renewal potential:
  - > 5,000 MW additions and upgrades
  - > 5,000 MW pumped storage
  - Additional MW from operational changes

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# The Opportunity: Hydro Renewal

- **Costs**: vary with the nature of the renewal
- **Electrical capacity**: meets all criteria
- **Environmental effects**: low, with uncertainties
- **Time to develop**: < 10 years

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# 1. Capacity Addition: Revelstoke 6

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# Revelstoke 6: Design Issues

- Addition of 500 MW unit into empty turbine bay
- Increased maximum discharge (~20%)
- Upstream reservoir operating range unchanged
- Downstream reservoir elevation range unchanged

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# Revelstoke 6: Aquatic Issues

| Issue | Details |
|---|---|
| Baseline | ▪ Hydrological and geomorphological baseline essential<br>▪ After and before initial flow regulation |
| Hydrology | ▪ Predicted more frequent extreme flows<br>▪ Predicted higher ramping flow rates |
| Morphology | ▪ Still evolving due to initial regulation<br>▪ Few models available for post-regulation conditions |
| Climate (2050) | ▪ 13% increase in inflow<br>▪ Earlier snow melt, with higher freshet flows<br>▪ Lower late-summer flows |

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# Revelstoke 6: EA Issues

- Only provincial EA, no federal EA triggered
- Complex hydrological changes
- EA determined no residual aquatic effects
- EA determined no cumulative aquatic effects

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# 2. Capacity Upgrade: Lower Mattagami

https://www.opg.com/generating-power/hydro/northeast-ontario/Pages/smoky-falls-station.aspx

# Lower Mattagami: Design Issues

- Four dam cascade with undersized facilities
- Increased installed capacity of all facilities
  - Before: 52 + 136 + 140 +156 = 484 MW
  - After: 264 +200 +235 +235 =  934 MW
- Operate all facilities as peaking plants
- Synchronize operations

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# Lower Mattagami: Aquatic Issues

| Issue | Details |
|---|---|
| Baseline | ▪ Hydrological and geomorphological baseline essential<br>▪ After and before initial flow regulation |
| Hydrology | ▪ Predicted increased ramping in upper reservoir<br>▪ Predicted reduced fluctuations in lower reservoirs<br>▪ Predicted increased fluctuations below lowest station |
| Morphology | ▪ Still evolving due to initial regulation<br>▪ Severe erosion, particularly in the diversion channel<br>▪ Predicted reduced erosion in lower three reservoirs<br>▪ Predicted increased erosion below lowest station |
| Climate | ▪ No assessment |

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# Lower Mattagami: EA Issues

- Provincial EA approved 15 years earlier
- Federal comprehensive study (CEAA, 1992)
- Minimum in-stream flow established
- EA determined no residual aquatic effects
- EA determined no cumulative aquatic effects

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# 3. Pumped Storage: Brazeau

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# Brazeau: Issues

- Increase installed capacity by up to 900 MW
- Utilize existing upstream reservoir
- Utilize lower river as downstream reservoir
- Baseline and feasibility studies underway
- Triggers both federal and provincial EA
- Awaiting renewable energy contract

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# 4. Operational Changes: Hydro Quebec Coordination

- U.S Northeast and Hydro Québec Coordination
  - 2018 study by HQ, SDSN, Evolved Energy Research
  - Increase Quebec – US Northeast transmission interconnection to 13,000 MW from 4,000 MW
  - Increase Quebec wind or hydro by 30 TWh/year
  - **<u>Substantially alter the operation of Hydro Québec's existing reservoirs</u>**

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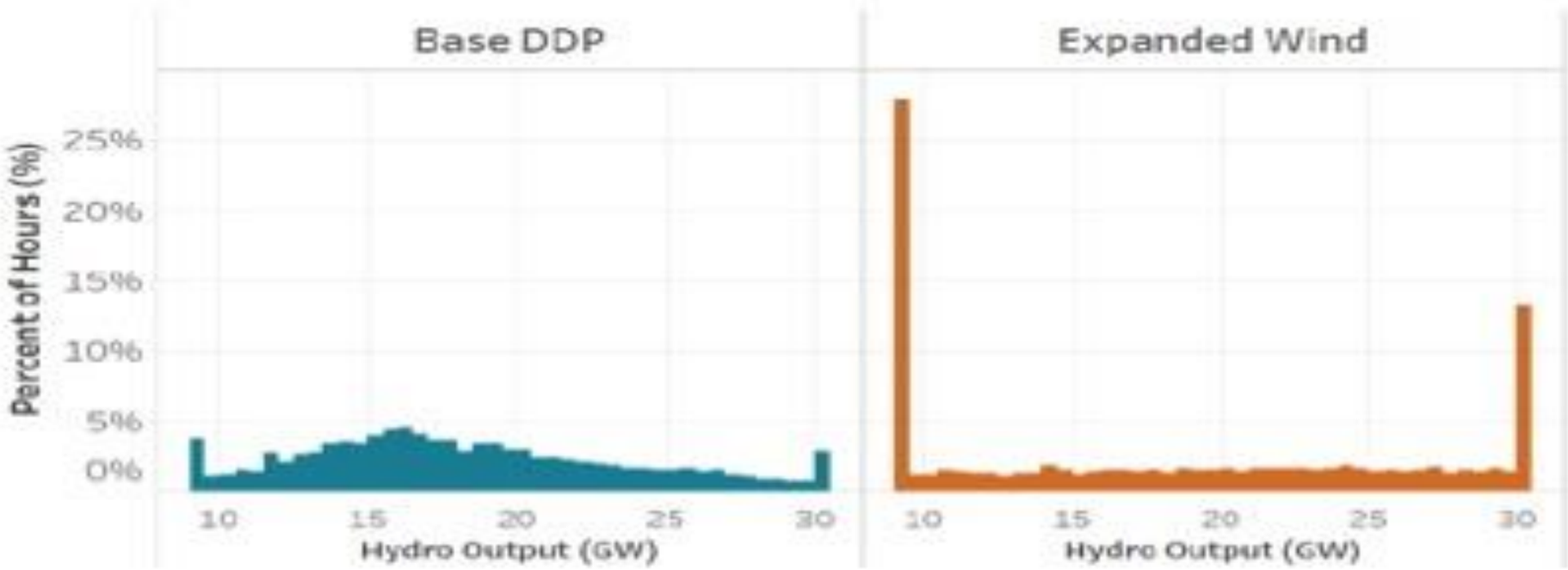
# Hydro Quebec Coordination (Caniapiscau à l'envers?)

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# Hydro Quebec Coordination

- Major changes in seasonal and diurnal timing
- Increased ramp rates for filling and emptying of reservoirs
- Requires extensive hydrological and hydro system operations modeling
- Need to also consider impacts of climate change on hydrologic flows

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# The Implications

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# Implications

- How can governments and utilities improve baseline knowledge of existing facilities?
- How can we improve geomorphological models?
- Can we improve cumulative effects assessment for large hydroelectric facilities?
- How prepared are regulators and regulations for hydroelectric renewal?

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# THE END

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# Appendices

# Hydroelectric EA Triggers

| Region | New | Modification |
|---|---|---|
| Canada | ≥ 200 MW | ↑ MW by ≥ 50% and by ≥ 200 MW |
| BC | ≥ 50 MW | ≥ 50 MW |
| Alberta | ≥ 100 MW | Not specifically addressed |
| Manitoba | Class 2: > 10 and ≤ 100 MW<br>Class 3: ≥ 100 MW | Class 2: Major operational changes or modifications |
| Ontario | Class EA: ≤ 200 MW<br>Designated: > 200 MW | Class EA: ↑ MW by ≥ 25% |
| Québec | ≥ 5 MW | ≥ 5 MW |

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# Storage Hydro: Costs

| Project | Capacity (MW) | Initial ($B) | Current ($B) | Overrun ($B) | Overrun (%) | On-line (year) |
|---|---|---|---|---|---|---|
| Wuskwatim | 200 | 0.9 | 1.6 | **0.7** | **80** | 2012 |
| Keeyask | 695 | 6.2 | 8.7 | **2.5** | **40** | 2021 |
| Muskrat Falls | 824 | 6.2 | 12.7 | **6.5** | **105** | 2020 |
| Site C | 1145 | 7.9 | 10.7 | **2.8** | **35** | 2025 |
| TOTAL | | 21.2 | 33.7 | **12.5** | **60** | |

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# Storage Hydro: Environmental

| Project | Adverse Effects |
|---|---|
| **Site C Project** | **20** |
| **Lower Churchill Project (inc. Muskrat Falls)** | **6** |
| New Prosperity Gold and Copper Mine Project | 5 |
| Jackpine (Oilsands) Mine Expansion Project | 5 |
| Pacific Northwest LNG | 3 |
| Cheviot Coal Project | 2 |
| Encana Shallow Gas Infill Development Project | 2 |
| Kemess North | 2 |
| LNG Canada | 1 |
| Northern Gateway Project | 1 |
| White Pines Quarry | 1 |

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- *Reviewable Projects Regulation*, BC Reg 370/2002
- *Environmental Assessment (Mandatory and Exempted Activities) Regulation*, Alta Reg 111/1993
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- *Regulation respecting the environmental impact assessment and review of certain projects,* CQLR c Q-2, r 23.1


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