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# Nuclear Electricity and Canada's Domestic Response to the Kyoto Protocol

## Modeling the Economics of Alternative Scenarios

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# Contents

- Introduction
- The nuclear constraints
- Revising the constraints
- Reduced cost NG CANDU
- The AMG reference case
- The nuclear sensitivity “cases”
- Additional modeling considerations
- Detailed results
- Summarizing the results
- Conclusion


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# Introduction

- Electricity table modeling
  - Some modeling included future cost reduction (coal, solar, wind)
  - Not nuclear?
  - Only 1 or 2 product cycles development?
  - Why not? Substantial scope for reduction
- Subsequent AMG analysis
  - Nuclear electricity output invariant regardless of input variations
  - Why?

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# Introduction

- **Consultation with Technology Table and AMG**
  - Suggested nuclear sensitivity modeling
  - Based on AMG tools
- **CNA proceeded with supplemental modeling**
  - Establish reasons for constant nuclear electricity
  - Remove constraints
  - Introduce new lower cost CANDU technology

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# The Nuclear Constraints

- Review of ET and AMG modeling basis revealed:
  - A “start” time for new plants of 2013
  - A construction or “lag” time of 10 years
  - Both based on a historical review, consideration of utility plans, complexities of regulation and public ambivalence
- Thus no new nuclear plants to 2020

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# Revising the Constraints

- Decision or “start” time
  - Current CANDU or NG CANDU
  - 2002 or 2005 instead of 2013 – real fear of warming
- Construction or “lag” time
  - AECL experience basis
  - CANDU nuclear plants in Korea and china
  - About 5 years to build a plant instead of 10
- The possible rather than the probable
- NG CANDU cost 30% less than CANDU

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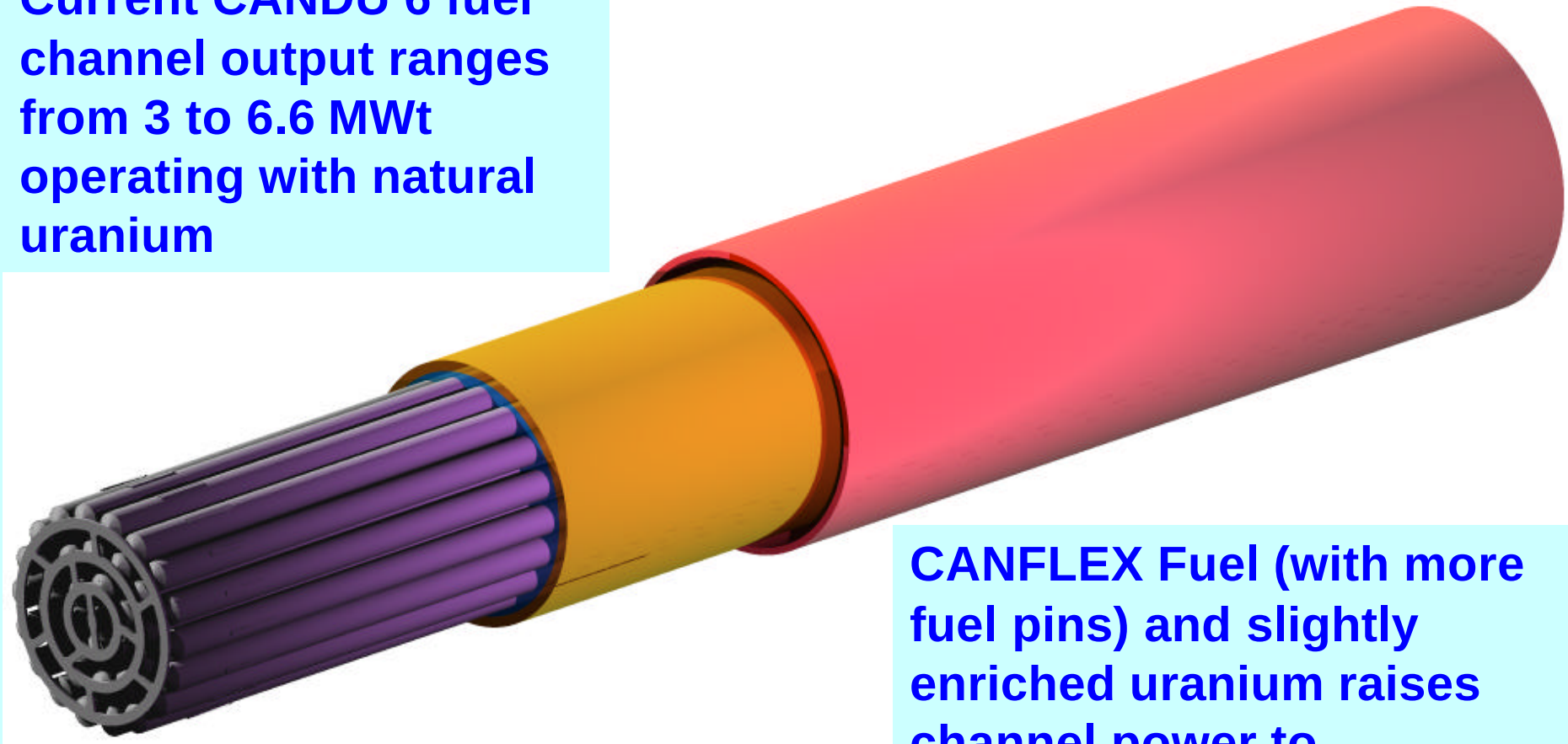
# Physical Basis for Cost Reduction

**Current CANDU 6 fuel channel output ranges from 3 to 6.6 MWt operating with natural uranium**



**CANFLEX Fuel (with more fuel pins) and slightly enriched uranium raises channel power to 6.2 to 8.2 MWt**

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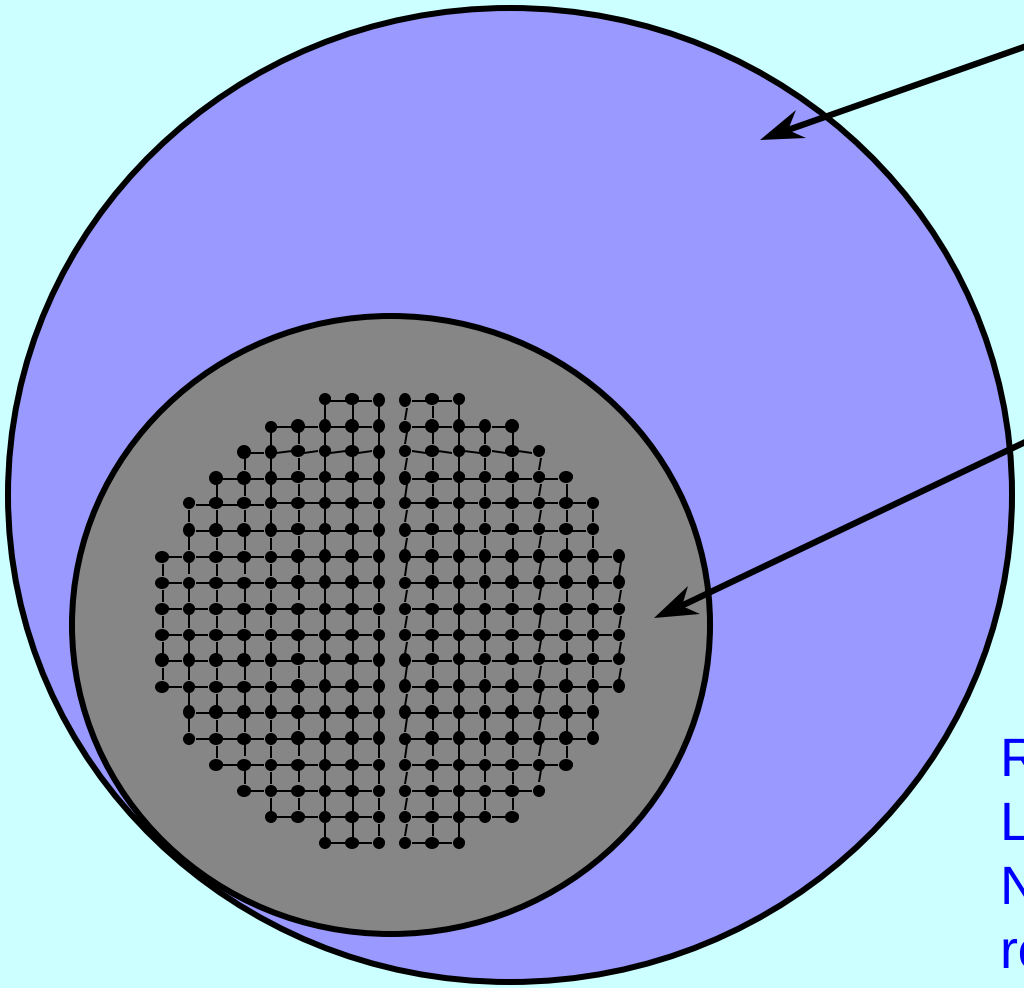
# Core Size Reduction



Natural Uranium
676 MWe
380 channels
Diameter = 760 cm

Slightly Enriched Uranium NG CANDU concept
600 MWe
240 channels
Diameter = 484 cm

Reduced Calandria Volume
Light water coolant reduces NG CANDU heavy water requirement to 25% of the current CANDU

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# The AMG Reference Case

- Electricity Table and AMG set the stage
- MARKAL micro-modeling Path 2
  - Meets the Kyoto commitment
  - MARKAL free to choose least cost options
  - A major reduction of GHG from electricity
- Path 2 chosen as the single reference case for nuclear sensitivity studies

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# The Nuclear Sensitivity "Cases"

| Scenario | Start Time (Year) | Lag Time (Years) | Nuclear Technologies available | External Credit Trading |
|---|---|---|---|---|
| Reference Path 2 | 2013 | 10 | Existing + new CANDU | No (CA) |
| Case 1 | 2002 | 5 | Existing + new CANDU | No (CA) |
| Case 2 | 2005 | 5 | Existing + new NG CANDU | No (CA) |
| Case 3 | 2002 | 5 | Existing + new CANDU | Yes (KT) |
| Case 4 | 2005 | 5 | Existing + new NG CANDU | Yes (KT) |

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# Additional Modeling Considerations

- The KT scenario assumes external permit trading, but also different prices and volumes for all energy imports and exports
- MARKAL may allow investments in quantities that do not respect standard plant size
- Cases 2, 3, and 4 implies that the new nuclear investments may start in 2010, which is in the middle of a MARKAL period. We therefore restricted nuclear investments in that period to be at most 60% of the period's need for new capacity

# Result Overview

- CANDU (with decreased lag) penetrates marginally (Case 1) or not at all (Case 3)
- NG CANDU penetrates strongly in Cases 2 and 4 (replaces coal plants with CO2 sequestration, and some electricity trading)
- NG CANDU contributes significantly to the overall reduction of the cost of Kyoto, especially in Path 2-CA (-1.5 B$ NPV).
- NG CANDU does not change significantly the share of electricity sector emission reductions

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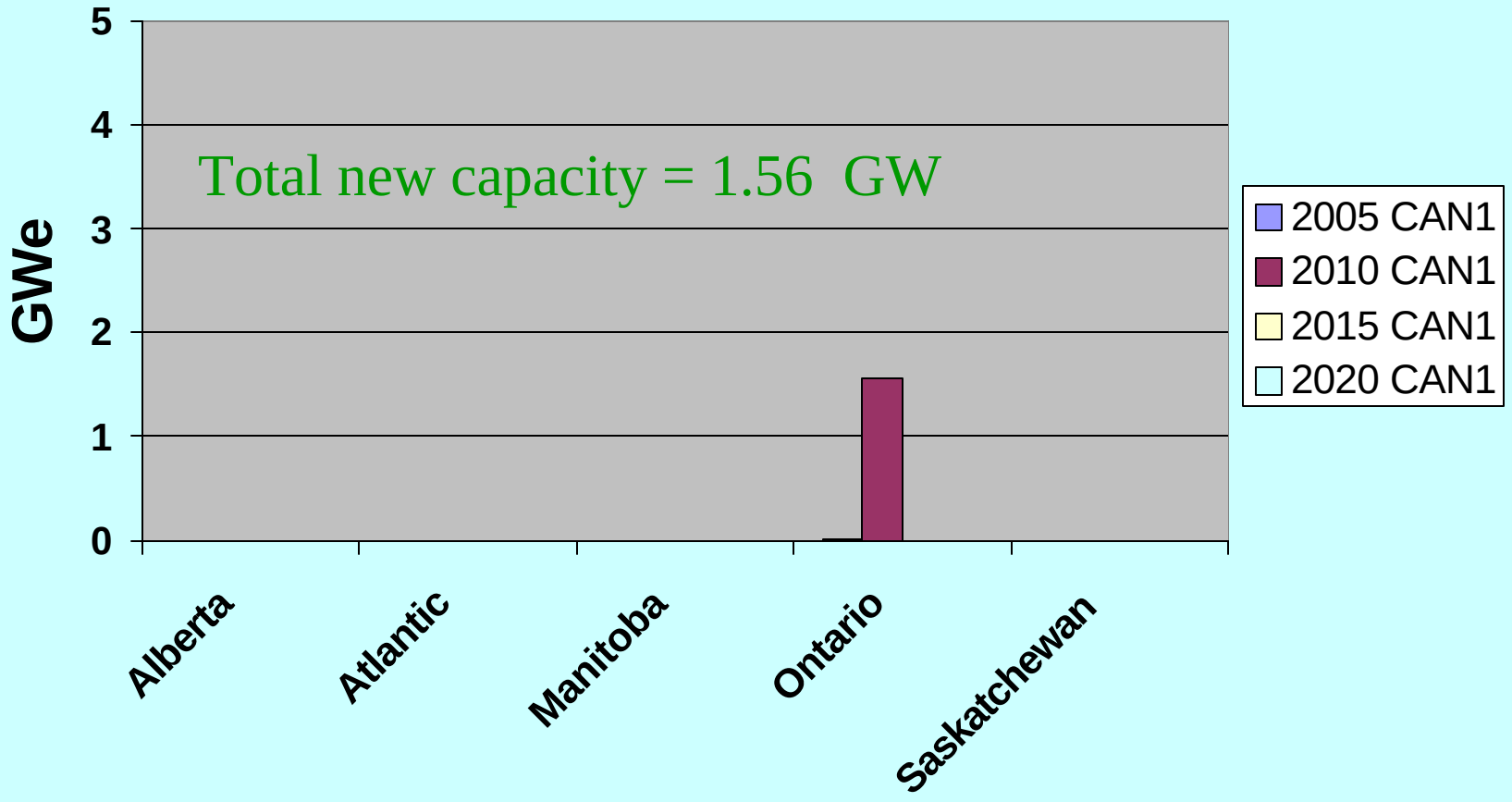
# Additional CANDU Capacity (Case 1)



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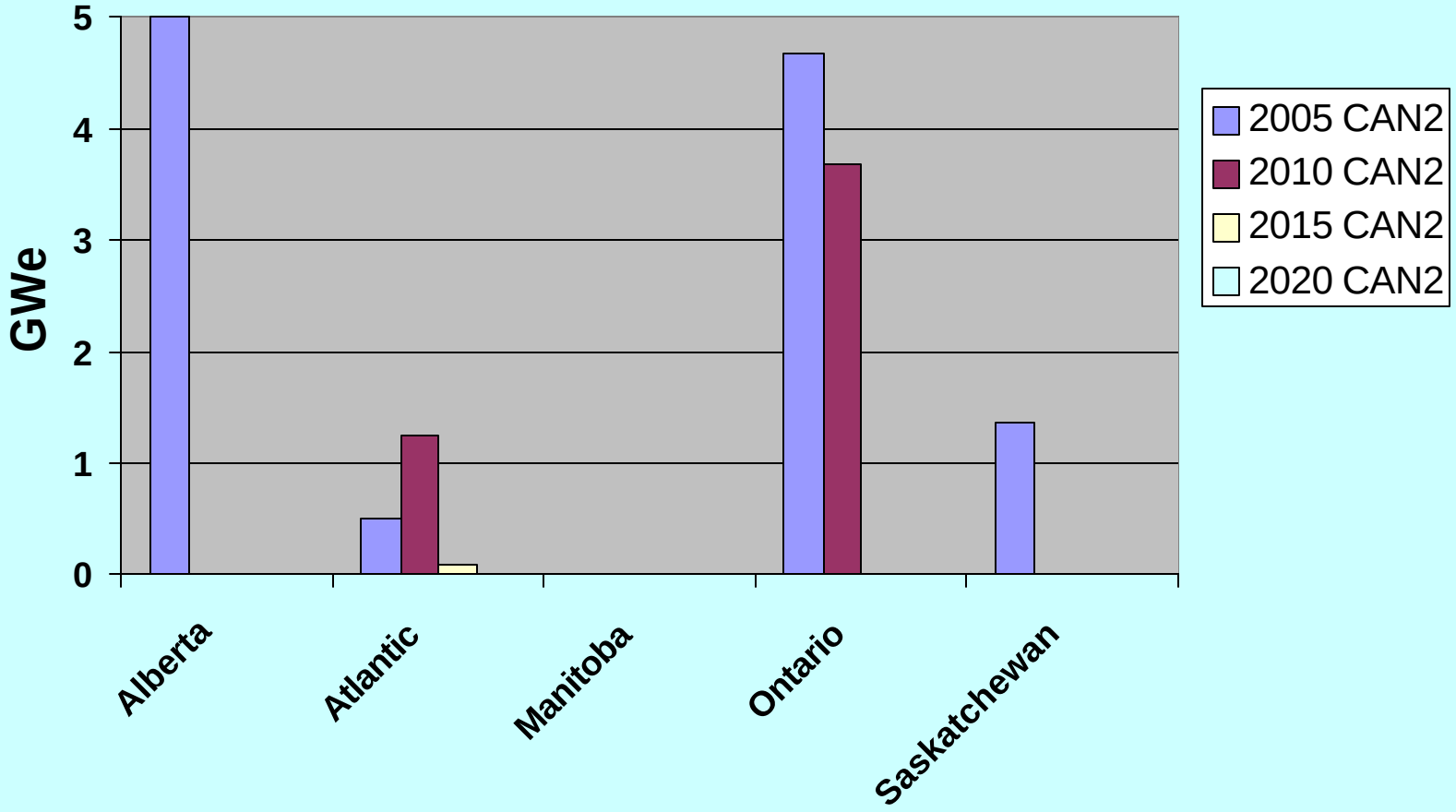
# Additional NG CANDU Capacity (Case 2)

Total new capacity = 16.56 GW



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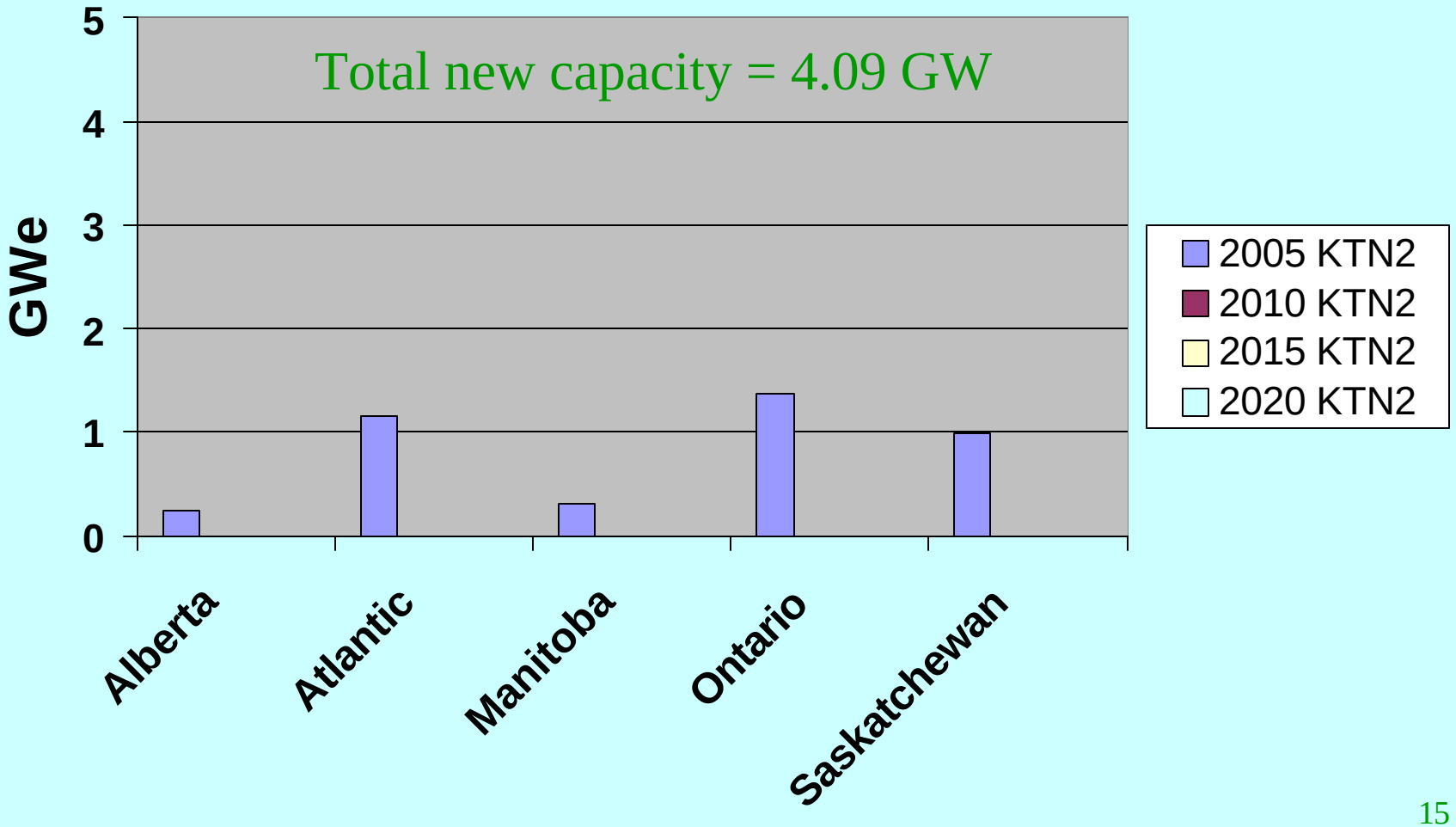
# Additional NG CANDU Capacity (Case 4)



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# Electricity Production by Type (2010) TWh

| 2010 | | BAU | CA Path 2 | CA Path 2 with NG |
|---|---|---|---|---|
| **Gas** | | 65.5 | 41.5 | 42.4 |
| **Coal** | | 97.5 | 64 | 17.6 |
| **Other** | | 14 | 8.2 | 8.5 |
| **Hydro** | | 376 | 393.5 | 382.6 |
| **Nuclear** | | 71.4 | 73.6 | 159.2 |
| **Wind** | | 8 | 18.2 | 12.9 |
| ***TOTAL*** | | ***632.4*** | ***599*** | ***623.2*** |

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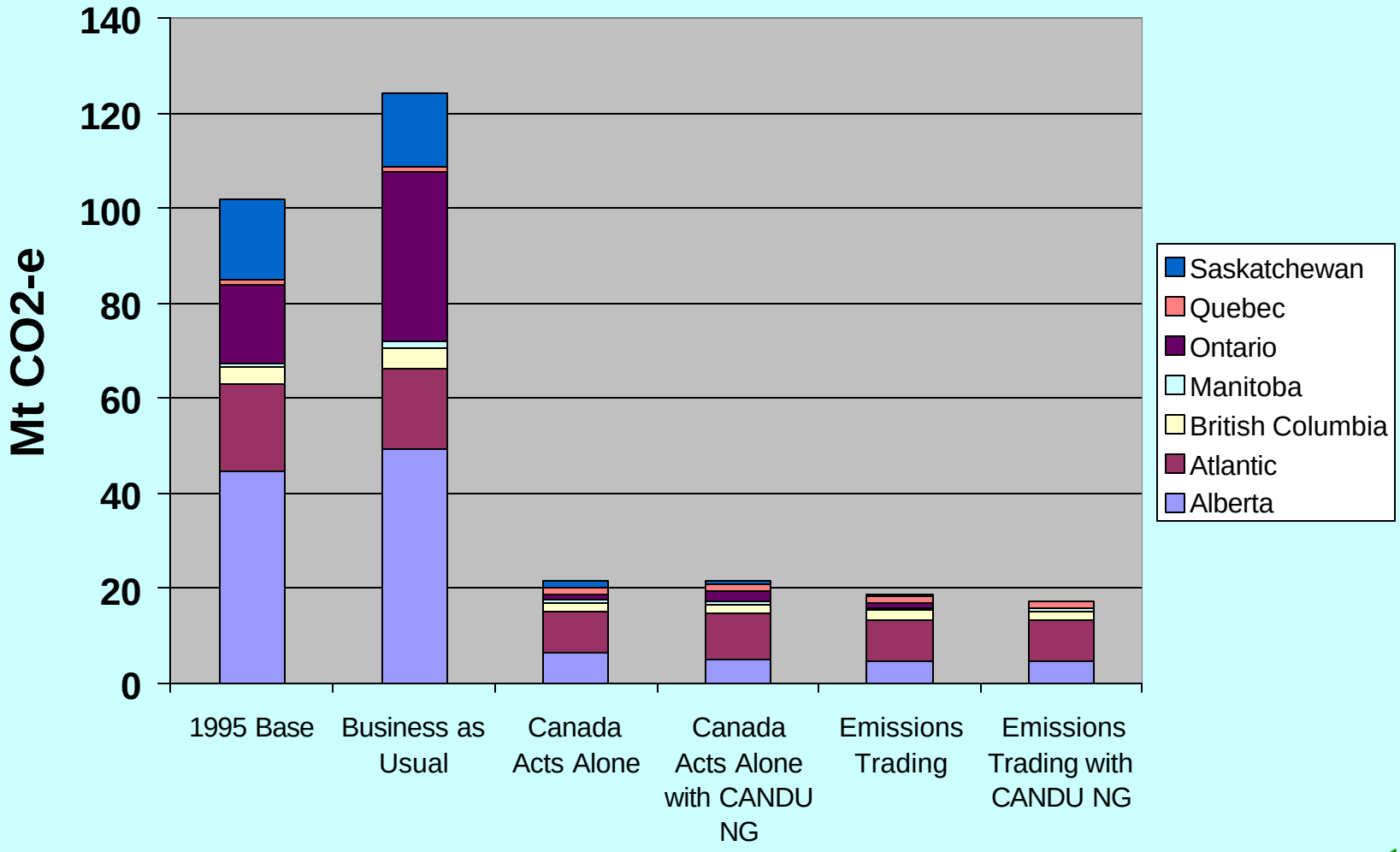
# Emissions from Electricity in 2010



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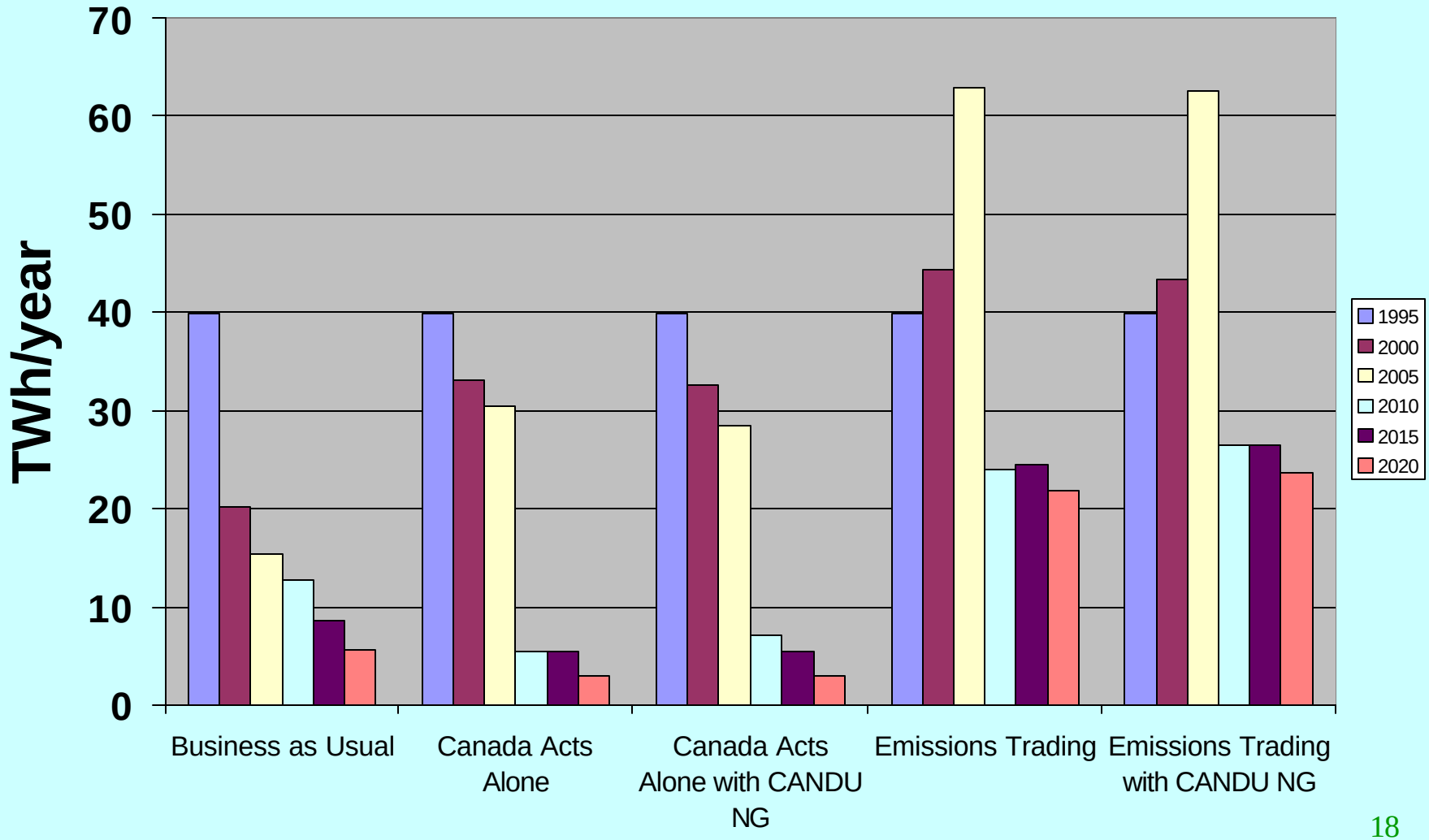
# Canada's Exports of Electricity



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# Conclusion

- This sensitivity analysis shows that

  NG CANDU should not be ignored in evaluating strategies to reach Kyoto target
- The contribution of NG CANDU could be as significant as that of CO2 sequestration or electricity trading, or other actions
- Further analysis and confirmation of

  NG CANDU cost and availability would be useful next steps to this work