CANADA'S ALLIANCE FOR DECENTRALIZED ENERGY

DE Economic Analysis
Two Canadian Case Studies 2006

A Multi-Client Study Coordinated by NewERA

5TH ANNUAL
DECENTRALISED ENERGY
CONFERENCE
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Two Canadian Case Studies

- City of Calgary – One of the fastest growing population centres in Canada, with a need to address generation capacity options and transmission upgrade requirements (growth rate of ~2.6% annually)
- Province of Ontario - The combination of demand growth (0.9% annually, peak growth at 1.3%) and generation retirements (coal and nuclear) could create a demand/supply gap of roughly 24,000 MW by 2025, equivalent to about 80% of Ontario's current capacity.

WADE Economic Model

- Comparison of the performance of Central Generation (CG) and Decentralized Energy (DE) in meeting future electricity demand growth
- Outputs
  - Total capital costs
  - Delivered electricity costs
  - Environmental impact
- The WADE model has been applied in the UK, Ireland, Portugal, the European Union, China, Nigeria, Australia and the United States

Project Overview

- Calgary and Ontario
- Significant amount of data from many sources:
  - Electricity supply demand trends
  - Capital and operating costs
  - Transmission and distribution costs and line losses
  - Fuel costs
  - Heat rates
  - Air emissions and GHG factors
- Modifications to the computer model

DE Economic Analysis
Calgary Case Study

Alberta Internal Load - Technology

2005	Maximum Capacity (MW)	Percent	Generation (GWh)	Percent
Coal	5,840.0	51.2%	43,905.7	66.3%
Gas Cogen	3,214.0	28.2%	14,249.5	21.5%
Gas & Oil	794.0	7.0%	3,520.3	5.3%
CCGT	250.0	2.2%	1,108.4	1.7%
Hydro	869.0	7.6%	2,323.4	3.5%
Wind	255.0	2.2%	764.0	1.2%
Biomass	177.5	1.6%	373.1	0.6%
Others	8.5	0.1%	21.7	0.0%
TOTAL	11,408.0	100.0%	66,266.0	100.0%

Decentralized Energy Technologies

- 100 kW to 10 MW CHP gas turbines and internal combustion engines in local manufacturing plants and industrial locations
- Small CHP systems in the 30 to 100 kW range (microturbines, etc) for institutions such as hospitals, apartment buildings and grocery stores
- 1 to 30 kW units for residential buildings
- Substation peaker plants to provide peak power

Transmission

- Transmission losses: : 5%
- Transmission costs:
  - New line between Edmonton and Calgary: $488/kW
  - New line between Alberta and Montana: $400/kW
  - IEA/WADE average for U.S. and Canada: $384/kW
  - Average used in the study: $436/kW

Distribution

- Distribution losses: 3%
- Distribution costs:
  - Average of ENMAX 2005 and 2006 capital expenditures for new distribution: $1,885/kW

Modelling Results

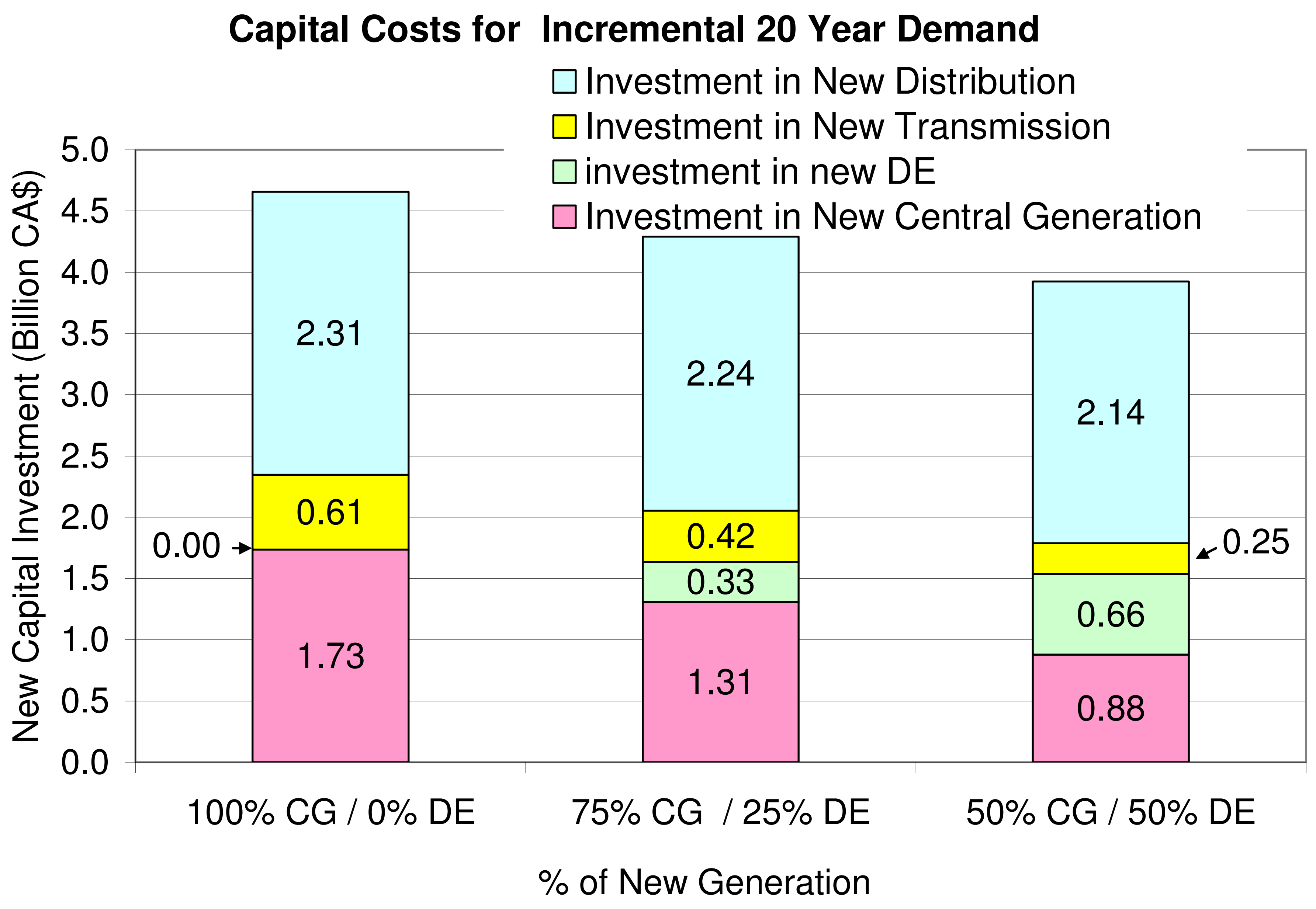
- Electricity demand increases from 8,286 GWh per year to 12,973 GWh in year 20 (2025) on the basis of an annual growth rate of 2.3% per year
- Peak capacity in 2025 is calculated to be 2,710 MW based on a peak growth rate of 2.6% per year
- Using 100% CG: 1,392 MW of new generation capacity is required
- Using 100% DE: 1,302 MW of new capacity is needed

CG or DE Outcomes

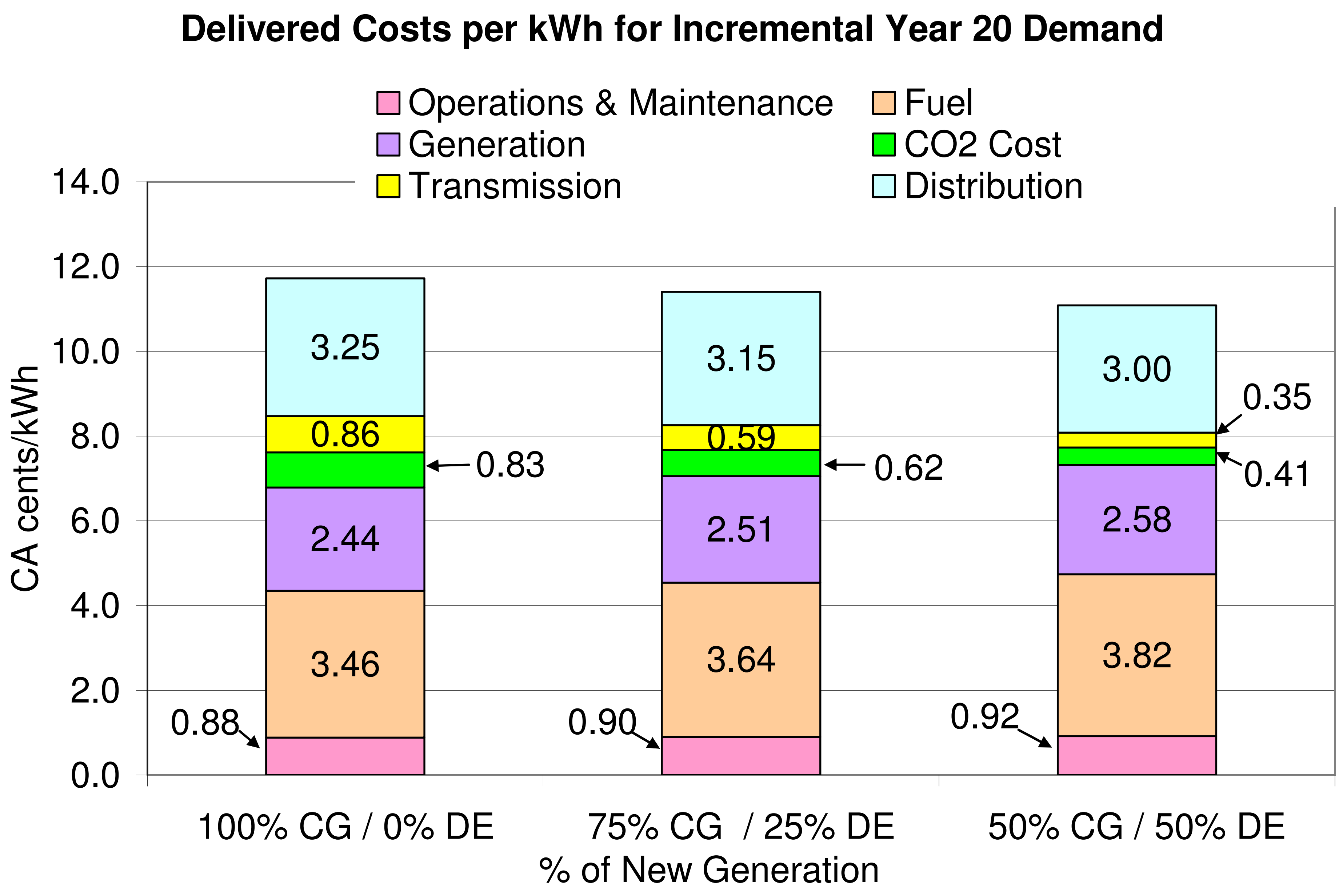
	100% CG	75%CG 25%DE	50%CG 50%DE	25%CG 75%DE	100% DE	Max DE Savings
Capital Cost (CA$ billion)	4.7	4.3	3.9	3.6	3.6	22%
Cost (CA¢ / kWh)	11.7	11.4	11.1	10.8	11.1	8%
NO_x (kT)	2.82	2.56	2.29	2.04	1.79	37%
SO_2 (kT)	2.08	1.56	1.05	0.55	0.02	99%
PM10 (kT)	0.38	0.30	0.23	0.16	0.08	79%
CO_2 (MT)	3.53	3.03	2.53	2.04	1.52	57%

Cost Analysis

- DE has higher unit capital costs than CG, but less DE capacity is required than CG because of the avoidance of line losses.
- However this is balanced by the higher cost of capital for DE.
- DE has less T&D costs than CG because DE is located closer to the load.
- DE has higher fuel costs because natural gas is more costly than coal.
- If DE requires 10% of the distribution infrastructure, the cost of delivered electricity could be reduced by $0.033/kw or 28%.



Capital Costs for Incremental 20 Year Demand
Investment in New Distribution
Investment in New Transmission
investment in new DE
Investment in New Central Generation
New Capital Investment (Billion CA$)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2.31
0.61
0.00
1.73
2.24
0.42
0.33
1.31
2.14
0.25
0.66
0.88
100% CG / 0% DE
75% CG / 25% DE
50% CG / 50% DE
% of New Generation



Delivered Costs per kWh for Incremental Year 20 Demand
Operations & Maintenance
Fuel
Generation
CO2 Cost
Transmission
Distribution
CA cents/kWh
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
3.25
0.86
0.83
2.44
3.46
0.88
3.15
0.59
0.62
2.51
3.64
0.90
3.00
0.35
0.41
2.58
3.82
0.92
100% CG / 0% DE
75% CG / 25% DE
50% CG / 50% DE
% of New Generation

Emissions

- In this study, DE is primarily based on natural gas and displaces CG that has an important coal component.
- Therefore, increased DE use results in reduced emissions of NO_x, SO_x, PM10 and CO_2.

Conclusions

- DE technologies could reduce capital and delivered costs of electricity while reducing emissions.
- Most of the cost savings arise from less transmission and distribution infrastructure.
- Further studies should focus on:
  - Quantifying benefits of the best DE applications
  - Capturing the thermal side of CHP technologies
  - The potential for additional distribution capital cost savings.

DE Economic Analysis
Ontario Case Study

Mark Tinkler
Emerging Energy Options

Ontario Case Study: Objectives

- Test the performance of the WADE Economic Model against the thorough Central Generation (CG) analysis provided by the Ontario Power Authority's (OPA) Supply Mix Advice Report
  - "calibrate" the WADE Model against detailed modeling work done specifically for the Ontario situation
- Utilize the WADE Model to extend the OPA analysis to consider in greater detail the potential benefits of an energy supply scenario with significant amounts of DE

Ontario Case Study: Methodology

1. Input the current (2005) energy supply mix in Ontario: capacity (MW), energy (TWh), associated Load Factors.
2. Select an energy supply Portfolio from the OPA Report and adjust CG growth characteristics (Input data for the Model) until the generation supply mix for 2025 (Output data) resembles that of the selected Portfolio.
3. Incorporate all relevant assumptions of the OPA study, eg: load growth rates, capacity retirements, operating costs for new generation, financing assumptions, fuel costs, generation emissions characteristics.
4. Run the Model and compare the resulting CG output characteristics (eg capital costs, emissions) against similar Supply Mix results for the Portfolio selected.

Ontario Case Study: Methodology (2)

5. Develop a “DE Future” scenario that envisions a reasonable mix of distributed generation supply. Adjust the Model’s DE growth characteristics (Input data for the Model) until the generation supply mix for 2025 (Output data) resembles that of the proposed DE scenario.

6. Obtain from appropriate sources other needed information eg: typical T&D costs, average and peak T&D losses, as well as small-scale (DE) generation capital/operating costs and emissions characteristics.

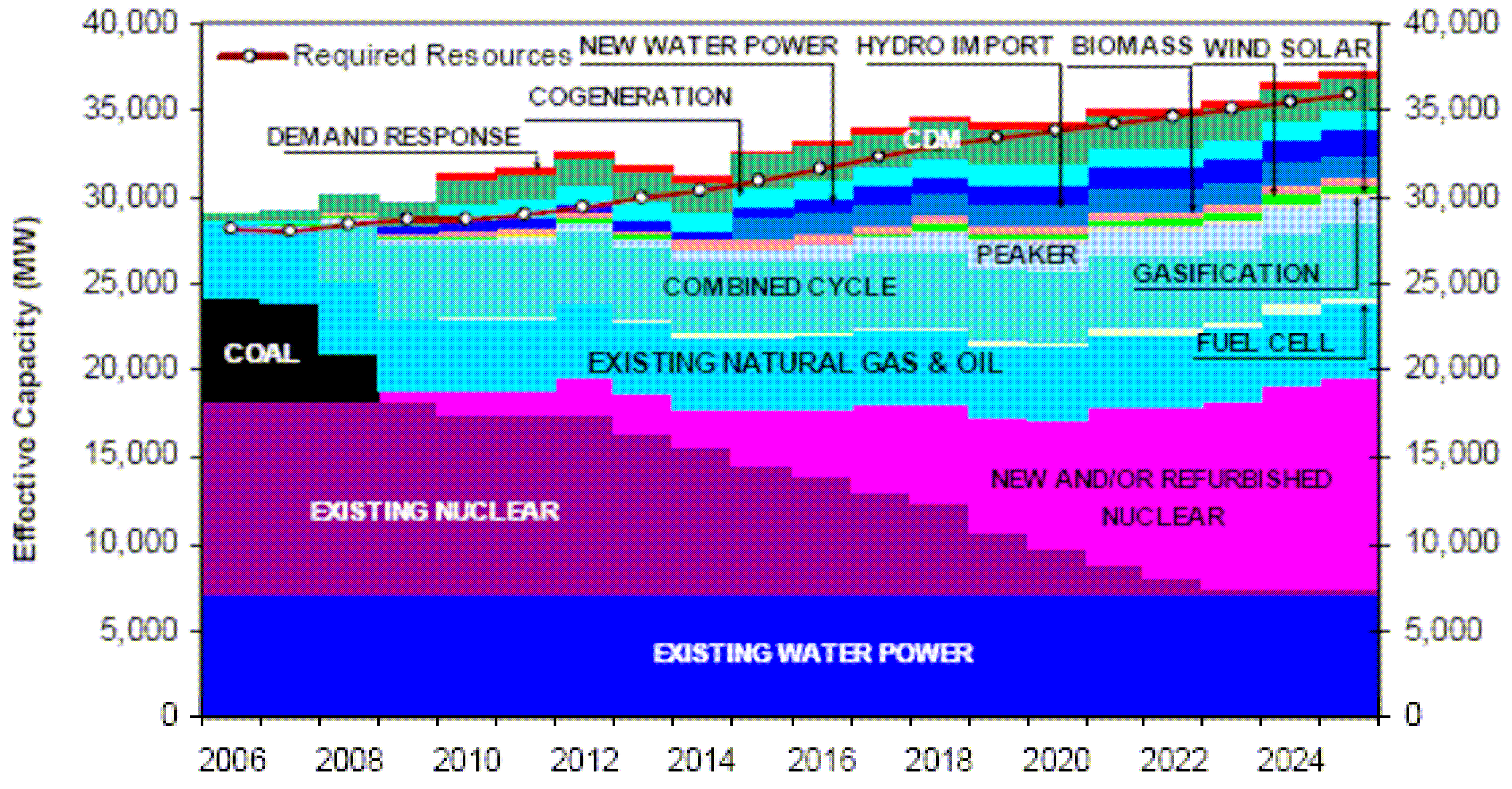
7. Assess the Model’s output results - a detailed comparison of capital costs (capacity and T&D), electricity retail cost (c/kWh), and emissions characteristics for various levels of CG vs DE to 2025.

Current Energy Supply Mix

Ontario Generation Supply Mix, 2005						
	Total Capacity (MW)	**Percent of Capacity (%)**	**Generation (TWh)**	**Percent of Generation (%)**	**Avg. Load Factor (calc.)**
Coal	6,434	21	30	19	53.2%
Nuclear	11,397	37	79	51	79.1%
Gas (& Oil)	4,976	17	12	7.5	27.5%
Hydroelectric	7,756	25	34	22	50.0%
Wind, Biomass	68	<<1	<1	<1	-
TOTAL	30,631	100	156	100	

Sources: IESO 18-Month Outlook, Dec 2005; IESO Press Release, Jan. 2006

Selected OPA Supply Mix Portfolio



Portfolio 1A – Default Scenario, Nuclear Growth

Source: OPA Supply Mix Advice Report, Nov 2005

Matching CG Growth Characteristics

Comparison of New CG Additions by 2025	
CG Type	**OPA Portfolio 1A** New Additions by 2025 (MW)
Gas CC CHP >50MW	1000
Gas CC (CCGT)	5000
Hydro Central	1200
Wind - Onshore	5000
Bioenergies	300
Nuclear	12382
Interconnector (Import)	1250
Coal Gasification	250
Gas CT (Peaker)	1520
Total New Additions	27902

Matching CG Growth Characteristics

Comparison of New CG Additions by 2025			
CG Type	**OPA Portfolio 1A** New Additions by 2025 (MW)	**WADE Model** New Additions by 2025 (MW)	**Differences** (MW)
Gas CC CHP >50MW	1000	1032	+ 32
Gas CC (CCGT)	5000	5053	+ 53
Hydro Central	1200	1216	+16
Wind - Onshore	5000	5140	+140
Bioenergies	300	335	+ 35
Nuclear	12382	12087	-295
Interconnector (Import)	1250	1288	+ 38
Coal Gasification	250	286	+ 36
Gas CT (Peaker)	1520	1549	+ 29
Total New Additions	27902	27986	**+ 84**

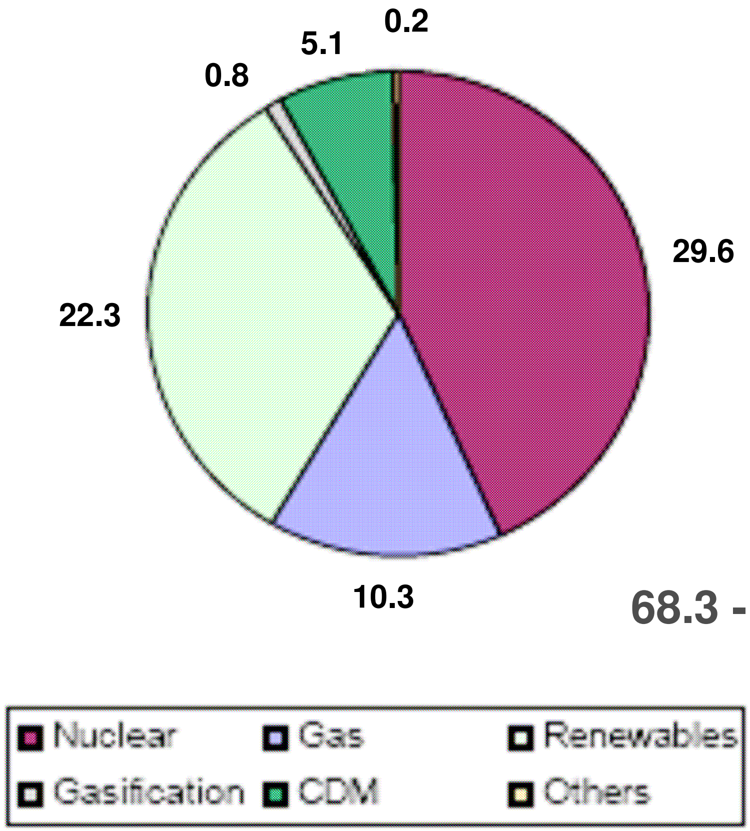
Comparing CG Output Characteristics

Comparison of CG Electricity Supply in 2025			
CG Category	**OPA Portfolio 1A** Electricity Supply in 2025 (TWh)	**WADE Model** Electricity Supply in 2025 (TWh)	**Differences** (TWh)
Nuclear	89	90.6	+ 1.6
Gas-Fired	11	26.1	+ 15.1
Renewables	77	60.9	- 16.1
Total	179*	179.4*	+ 0.4

* Includes ~ 2 TWh from coal gasification, excludes CDM contribution

Comparing CG Output Characteristics (2)

Portfolio 1a Capital Expenditures, as Spent not Present Value ($billions, in 2006 dollars)



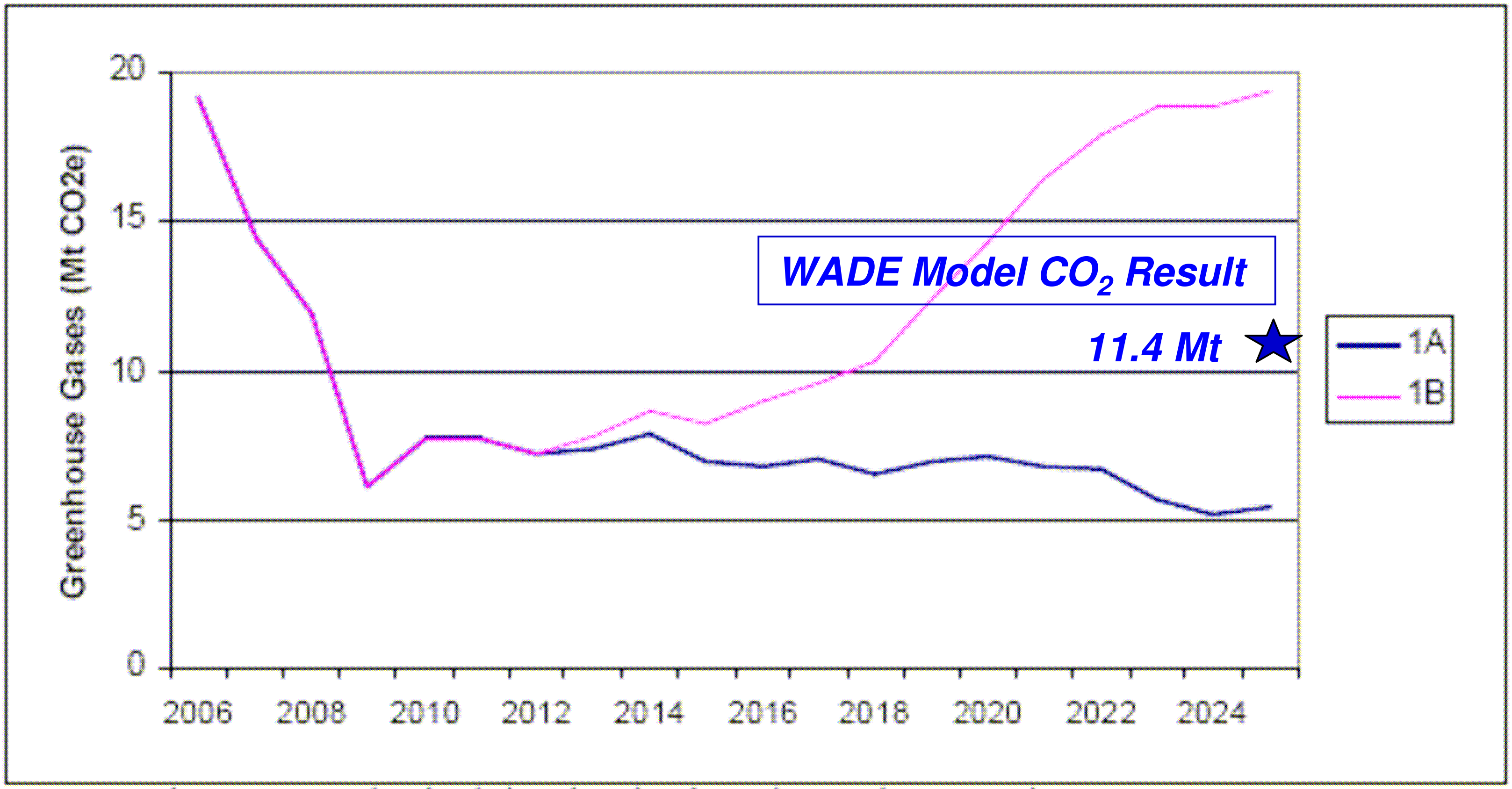
WADE Model Result: Capital Investment for New CG

$57.7 B

68.3 - 5.1 (CDM) = $63.2 B

Comparing CG Output Characteristics (3)

CO_2 Emissions for OPA Supply Mix Portfolios 1A and 1B



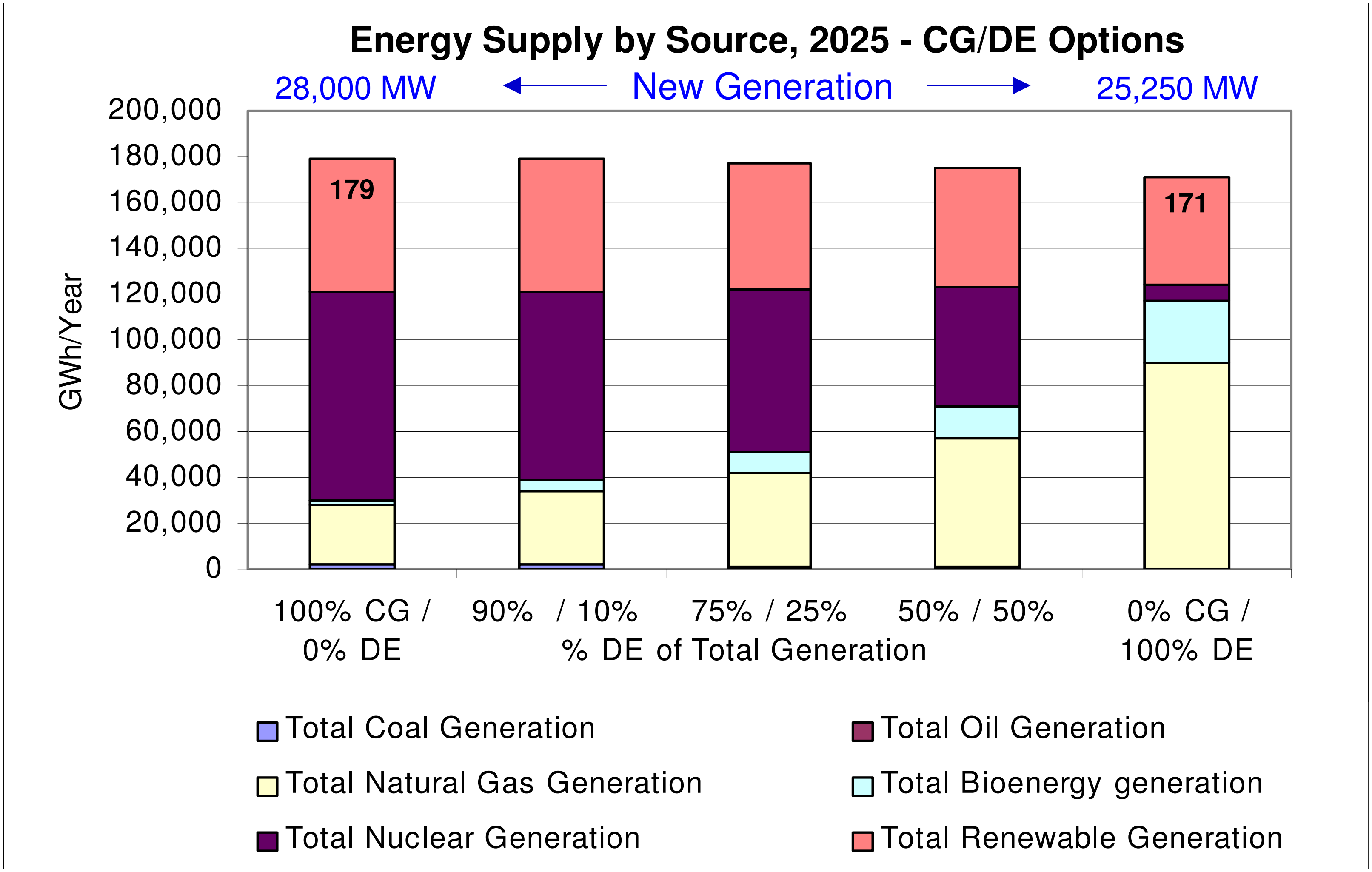
Note: Greenhouse gases analyzed include carbon dioxide, methane and nitrous oxide

Source: OPA

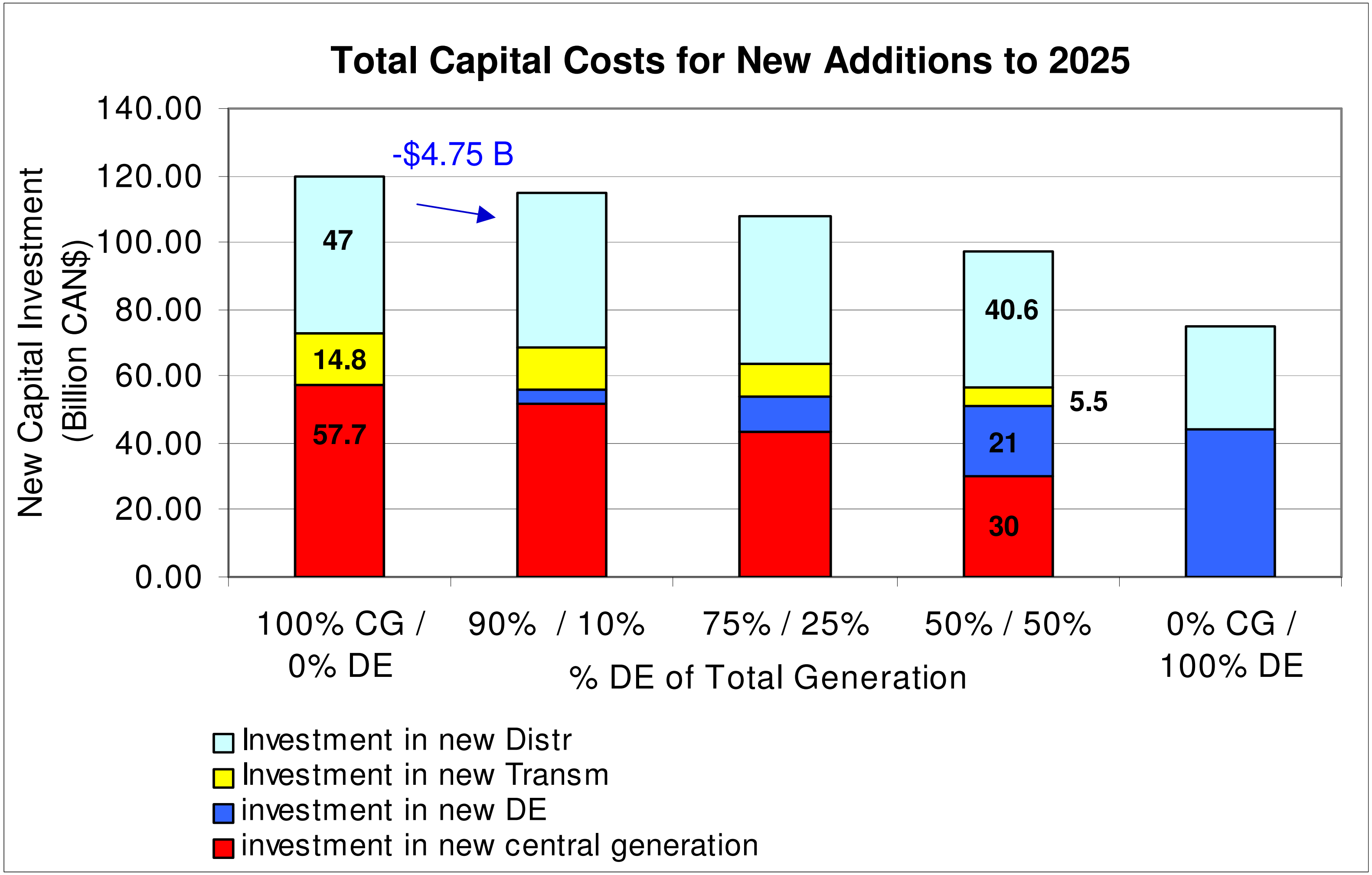
Develop a “DE Future” Scenario

“DE Future” Scenario for Ontario, 10% by 2025			
DE Type		**Total Capacity (MW)**	**Portion of DE Capacity (%)**
Landfill gas non-CHP		150	5.9
Hydro (Local)		175	6.8
Gas micro-CHP		150	5.9
Solar (Local)		80	3.1
Gas CHP (Indust. Cogen)		550	21.5
Biomass CHP		350	13.7
Other FF CHP: Fuel Cell		400	15.7
Gas CHP (Engine CHeP)		350	13.7
Substation Peakers		350	13.7
TOTALS		2555	100.0

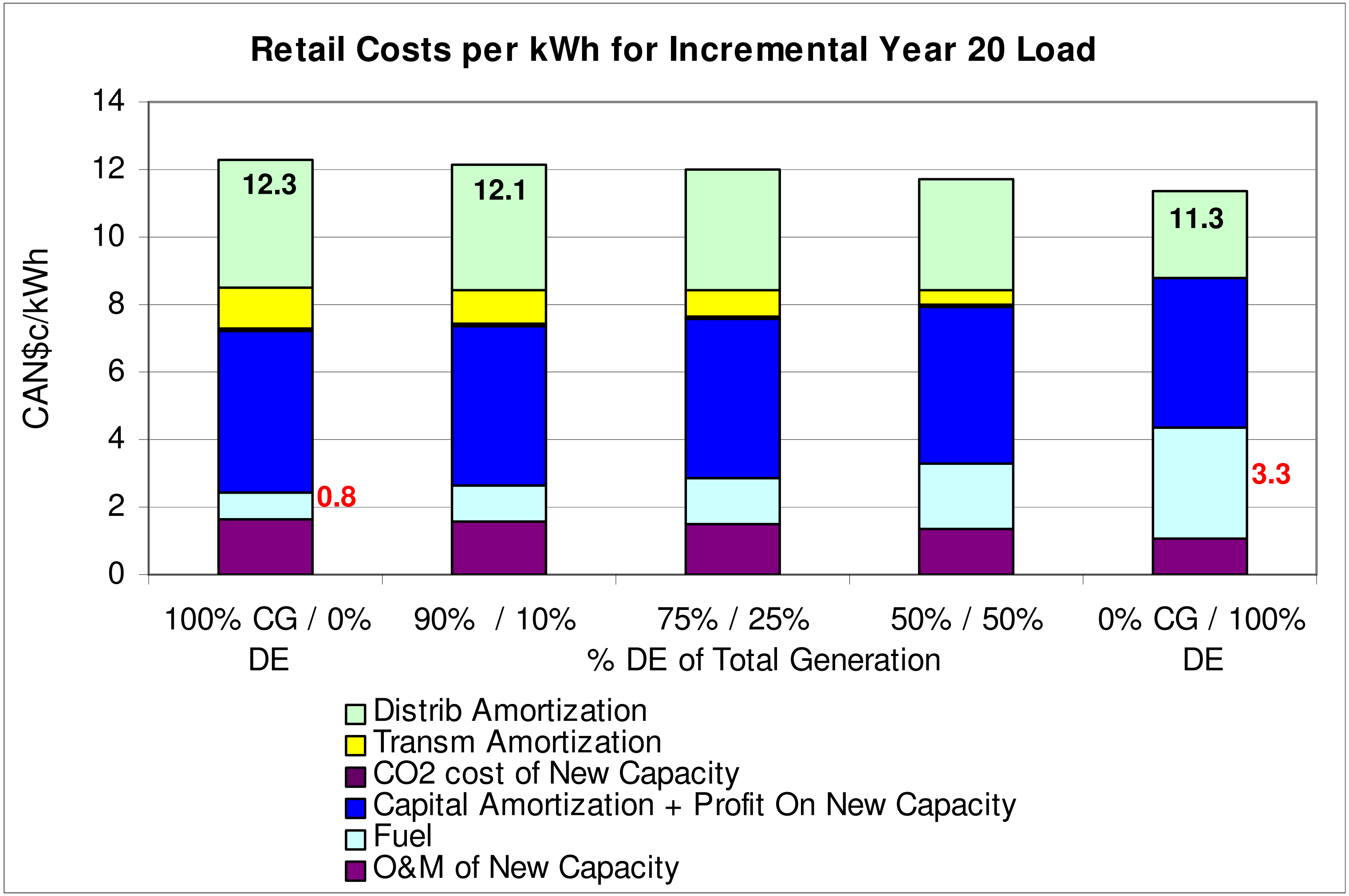
Ontario Model Results: Energy Supply, 2025



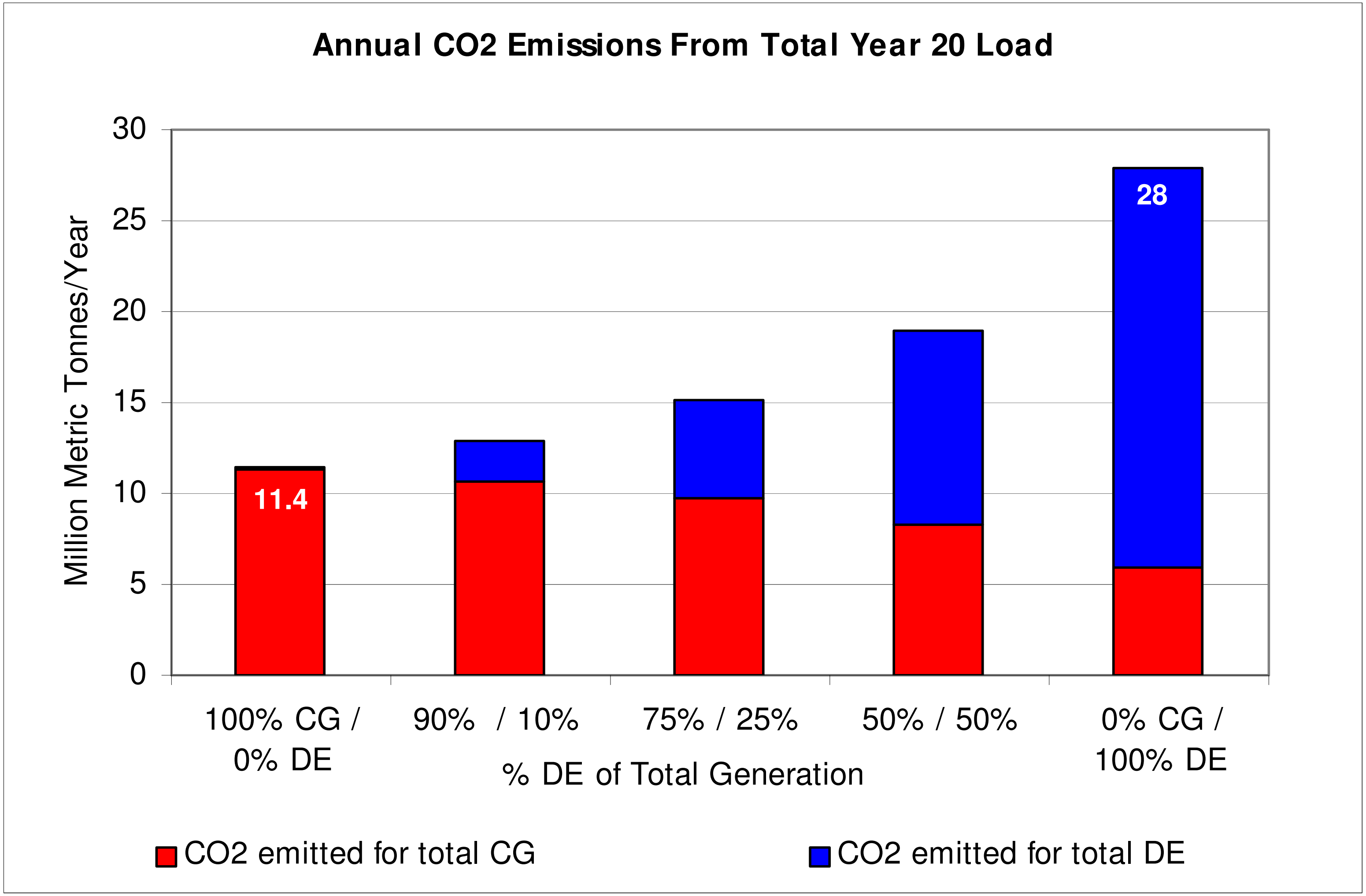
Ontario Model Results: Capital Costs to 2025



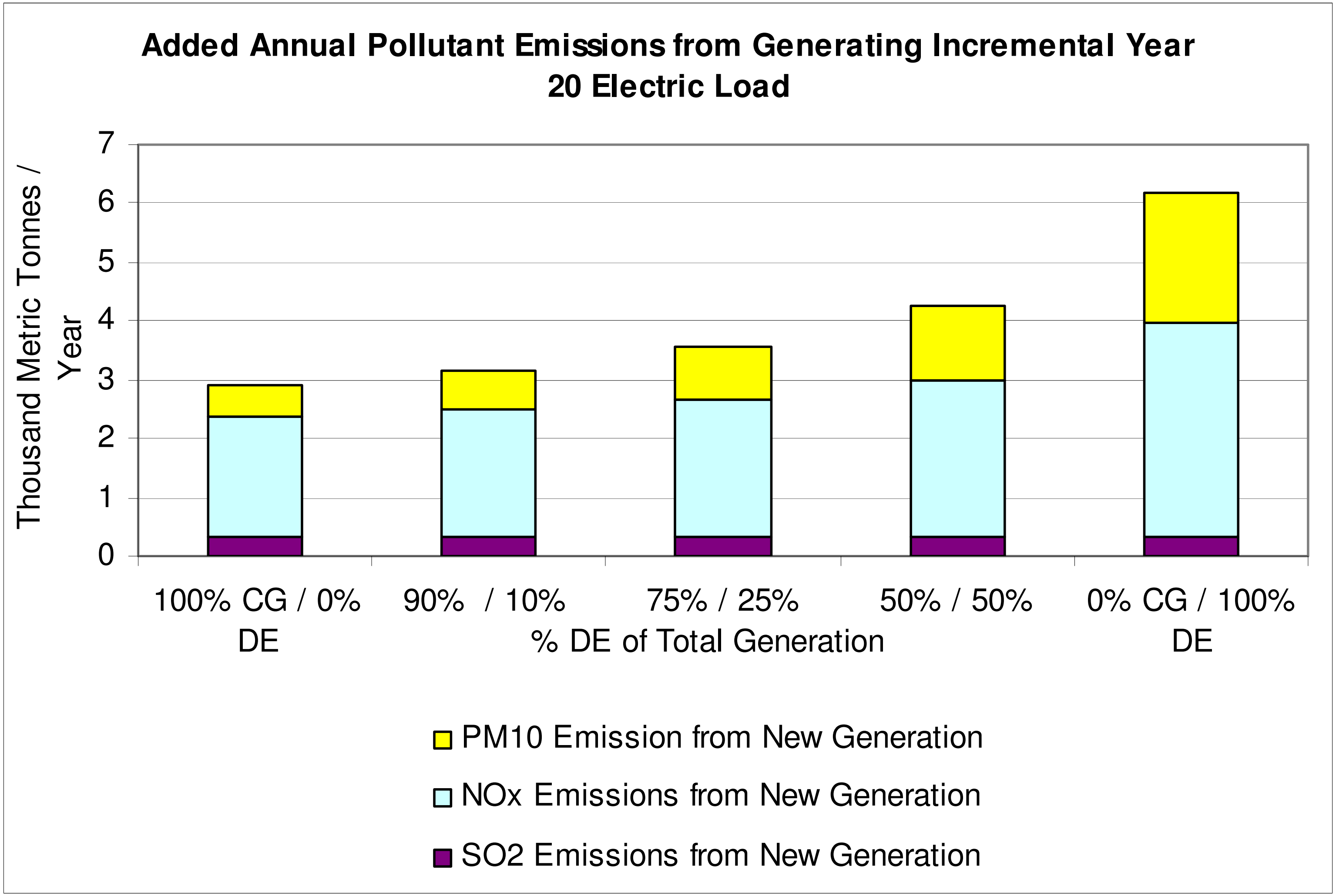
Ontario Model Results: Retail Costs, 2025



Ontario Model Results: Annual CO_2 Emissions



Ontario Model Results: Other Emissions



Ontario Case Study: Summary

1) The WADE Model appears to calibrate well against the Central Generation (CG) analysis provided by the OPA's Supply Mix Advice Report
2) The Model can effectively be used to consider in greater detail the potential benefits of an energy supply scenario with significant amounts of DE
3) First-run results confirm significant potential economic benefit with increasing DE, because of avoided T&D losses and reduced T&D requirements
4) Because of the nature of Ontario's CG supply mix, increased DE is likely to result in somewhat higher emissions

Conclusions

- DE technologies could reduce capital and delivered costs of electricity and may reduce emissions.
- Most of the cost savings arise from less transmission and distribution infrastructure.
- Further studies should focus on:
  - Best DE applications
  - Thermal side of CHP technologies
  - Additional distribution capital cost savings.

Questions ?

CANADA'S ALLIANCE FOR DECENTRALIZED ENERGY

Thank You

- Natural Resources Canada
- Ontario Power Generation
- Alberta Economic Development
- Government of the Northwest Territories
- Enbridge
- Fortis Alberta
- Alberta Electric System Operator
- Enmax
- Renewable Energy Solutions

Project Team:

- Bert Dreyer
- Marc Godin
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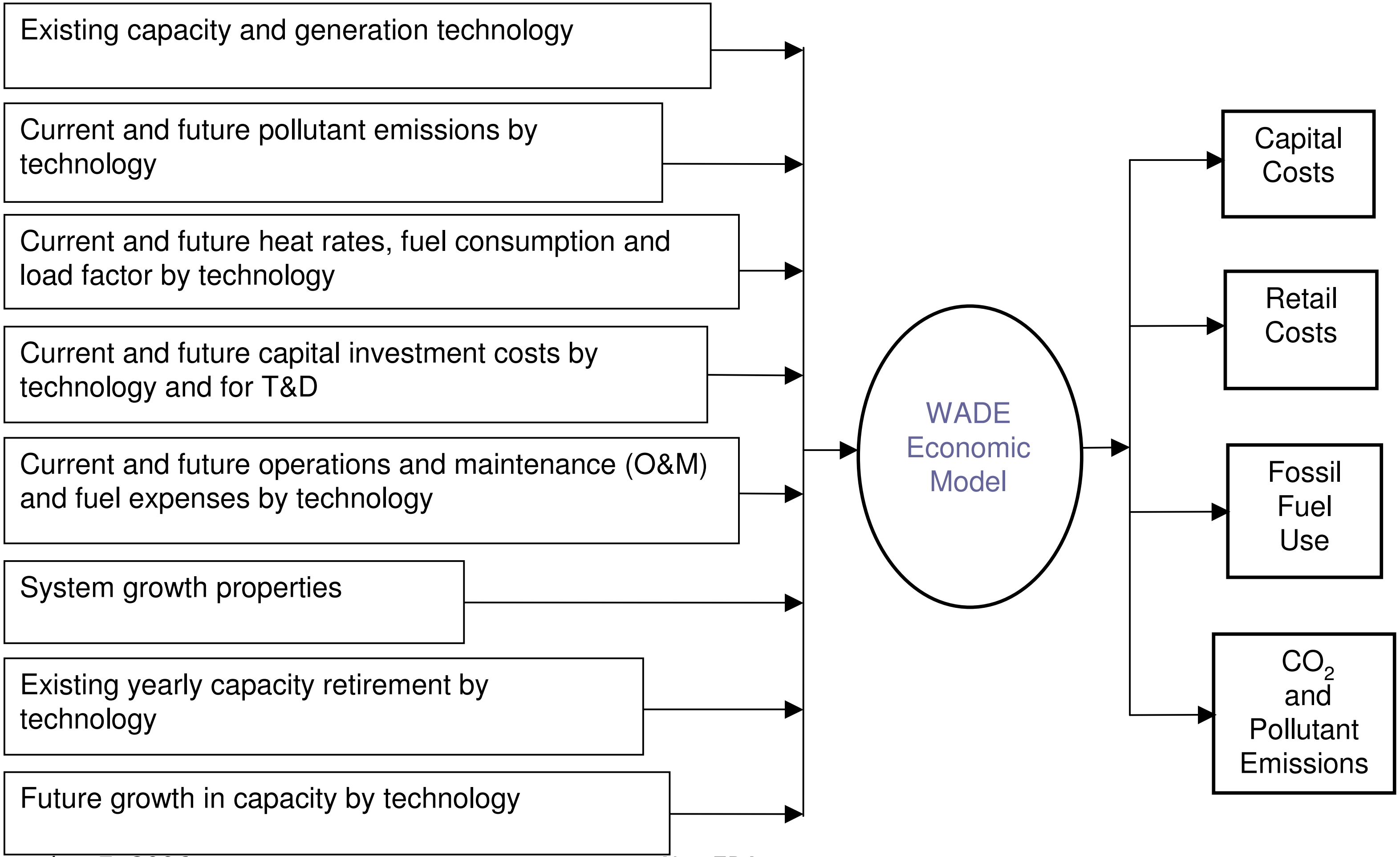
Additional Slides

WADE Economic Model:
Inputs & Outputs



Alberta Internal Load Growth

Year	Energy Consumption (GWh)	Peak Demand (MW)
2000	54,052	8,185
2002	59,428	8,570
2004	65,259	9,236
2006	*69,453*	*9,974*
2008	*74,468*	*10,597*
2010	*77,136*	*11,002*
2012	*81,324*	*11,493*
2014	*84,059*	*11,946*
Growth	*3.4 %*	*2.9 %*

Calgary Electricity Demand Statistics

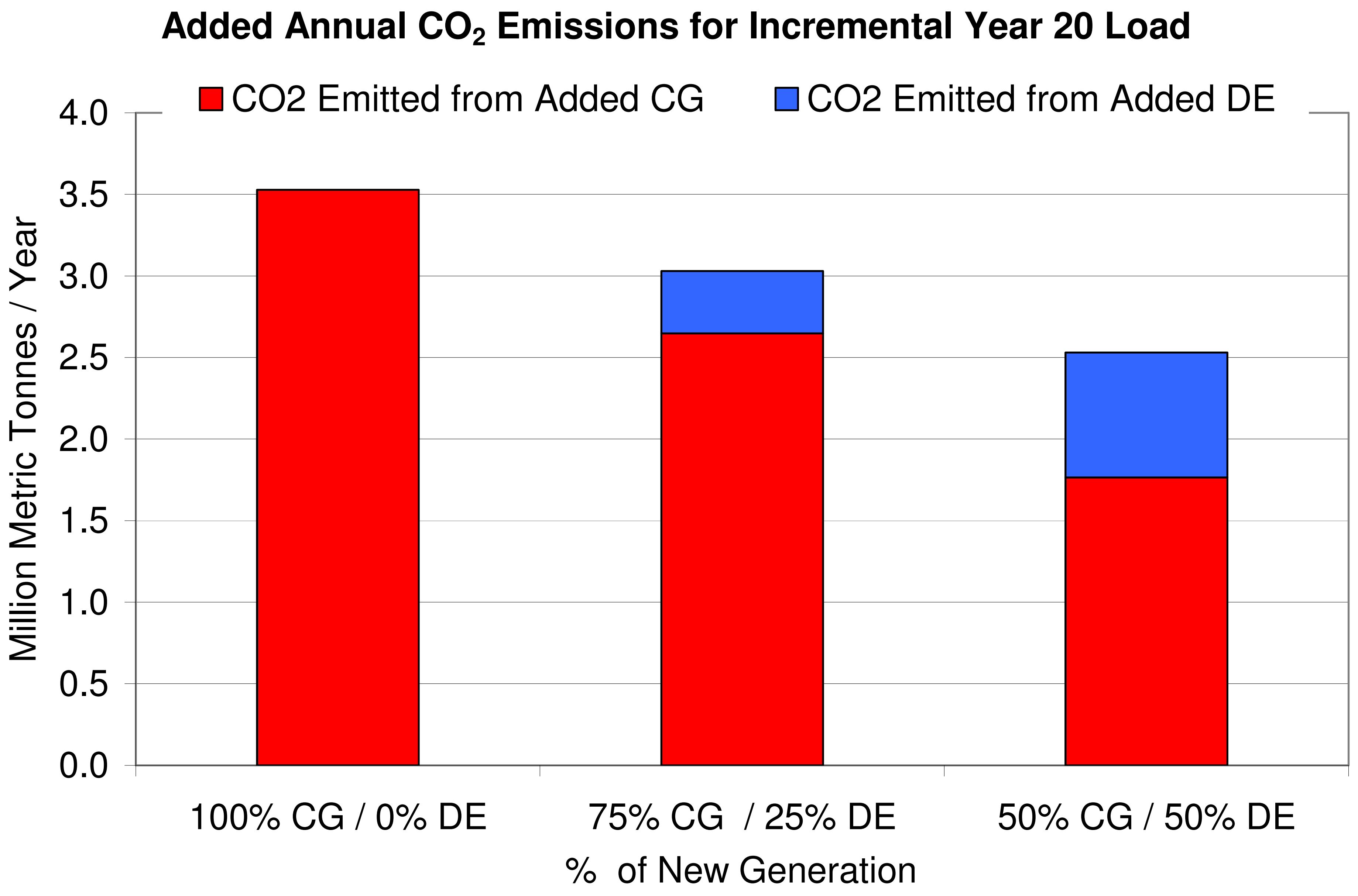
Year	Energy Delivered (GWh)	Peak Demand (MW)
2002	7,747	
2004	8,044	
2006	*8,479*	*1,527*
2008		*1,612*
2010		*1,700*
2012		*1,788*
2014		*1,868*
Growth	*2.3 %*	*2.6 %*

Transmission and Distribution

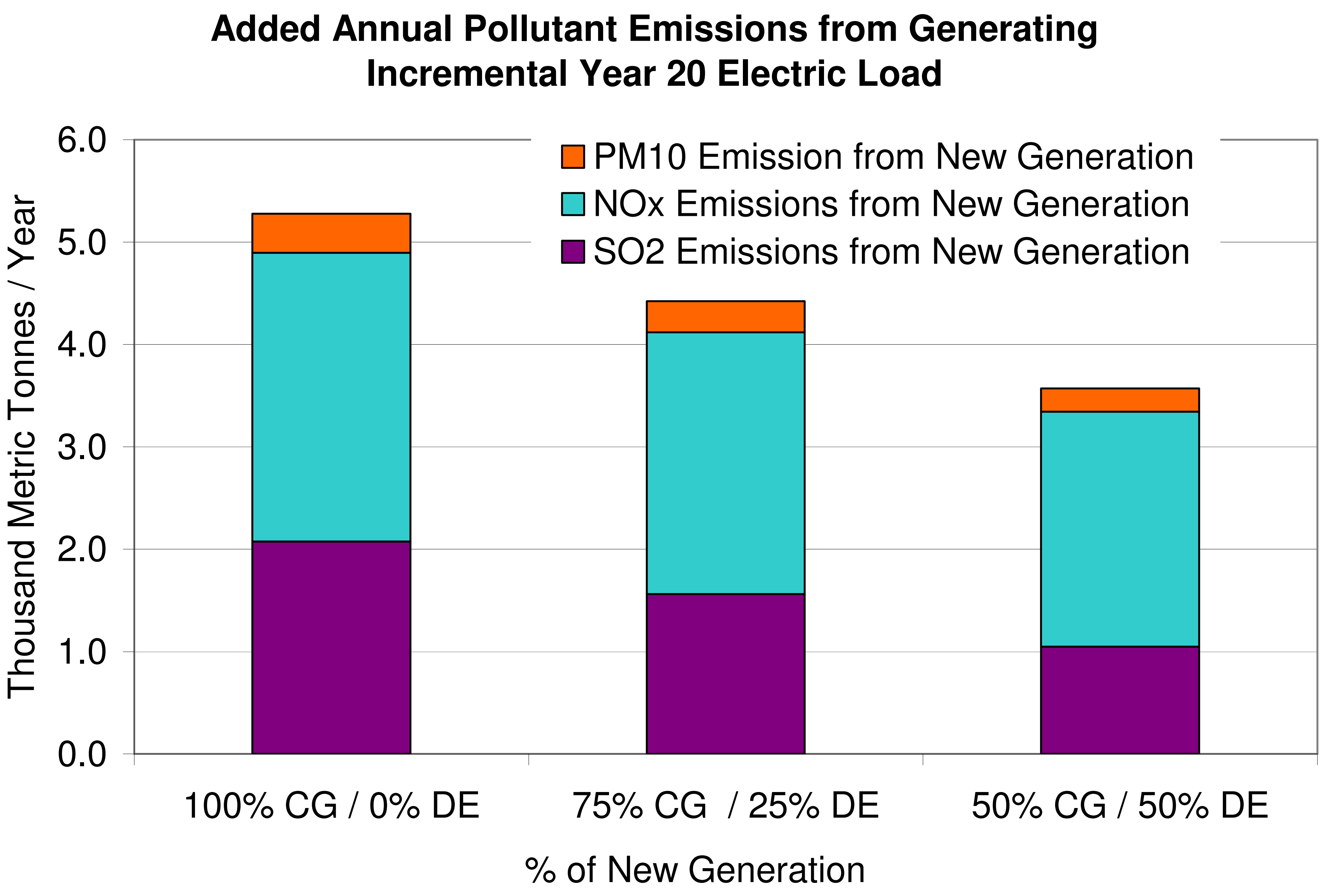
- Full transmission costs were attributed to CG but none to DE.
- Full distribution costs were attributed to CG and DE.
- The likelihood that DE would have lower distribution costs than CG was explored, but facts were not available to perform a definite analysis.

Central Generation Technologies

- Three new 450 MW coal generation plants by 2015, similar to Genesee 3
- A total of 3,151 MW of oil sands related cogeneration facilities by 2015, of which 750 MW would be available for exports to the Alberta grid
- Increases in wind power, but at a slower pace; 400 MW of new capacity by 2015
- Balance of power requirement provided by natural gas simple and combined cycle turbines



Added Annual CO_2 Emissions for Incremental Year 20 Load
CO2 Emitted from Added CG
CO2 Emitted from Added DE
Million Metric Tonnes / Year
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
100% CG / 0% DE
75% CG / 25% DE
50% CG / 50% DE
% of New Generation



Added Annual Pollutant Emissions from Generating Incremental Year 20 Electric Load
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Thousand Metric Tonnes / Year
PM10 Emission from New Generation
NOx Emissions from New Generation
SO2 Emissions from New Generation
100% CG / 0% DE
75% CG / 25% DE
50% CG / 50% DE
% of New Generation