Low Carbon Futures in Canada

Ralph Torrie, TEFP Managing Director

Sept. 17, 2012 ◆ University of Oxford,UK

rtorrie@trottierenergyfutures.ca

A partnership between the Canadian Academy of Engineering and the David Suzuki Foundation:

PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

1. **To identify energy strategies for Canada to be implemented between now and 2050 that would**
   - **Reduce Canada's emissions of greenhouse gases from all aspects of the energy sector with the target of 80% below 1990 levels by 2050**
   - **Make Canada a global role model in the sustainable generation, distribution and use of energy**
   - **Ensure that all Canadians have access to the energy they need to enjoy a high quality of life**
2. To recommend the optimal strategy, from amongst those identified, for implementation
3. To persuade the Canadian public, industry and governments that implementing the optimal energy strategy is in the best interest of Canada
4. To ensure that implementation of the optimal strategy has begun within the terms of this project.

Conceptual Framework for Reducing Energy-Related GHGs

Three broad levers available to lower emissions:

Consumption Per Unit of Activity	Decarbonization/ Fuel Switching	Activity Level
• The efficiency with which fuel, electricity are used to deliver energy services	• No- and low-carbon fuels • Carbon capture	• The level and pattern of activity in the economy that generates demand for energy services

* Carbon management (CCS) considered final lever due to cost/tonne

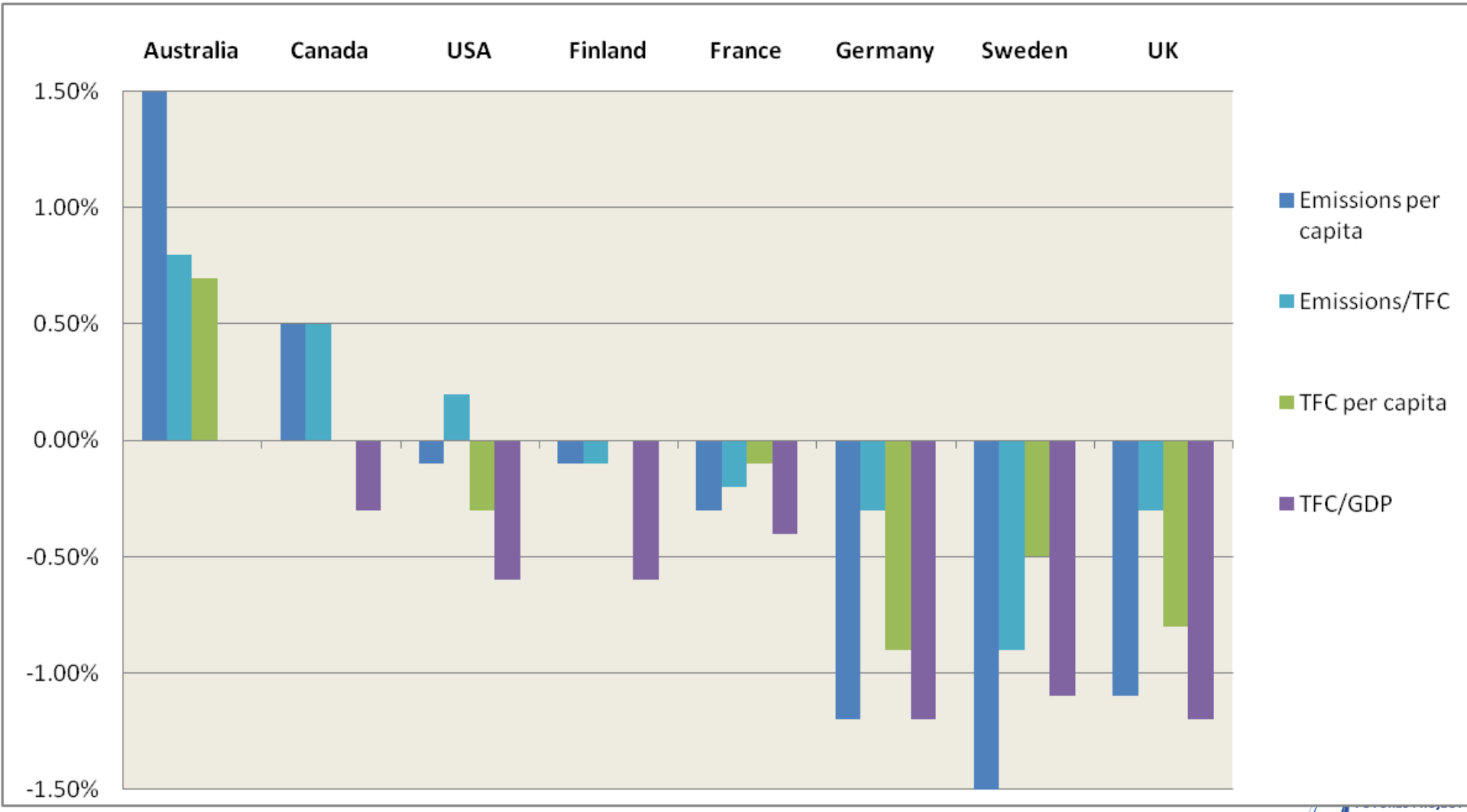
PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Selected Indicators from Illustrative Low Carbon Scenarios

	AUSI 2002 (Australia)	EREC 2010 (Canada)	RMI 2011 (USA)	PMO 2009 (Finland)	MIES 2004 (France)	BMU 2008 (Germany)	IVL 2010 (Sweden)	EKERC 2009 (UK)
Per capita end use of energy, GJ								
In 2009	140	216	181	180	96	103	137	84
In 2050	129	96	111	115	91	78	125	58
% Reduction	8%	56%	39%	36%	5%	24%	9%	31%
End use energy per GDP, GJ								
in 2009	5.8	8.6	4.9	6.8	4.2	4.2	4.4	3.1
In 2050	3.9	0.7	1.8	1.2	0.5	0.3	1.1	1.6
Energy Productivity Improvement	33%	92%	63%	82%	88%	93%	75%	48%
Carbon intensity of end use of energy, kg CO2e/GJ								
In 2009	127.7	71.5	93.1	57.1	57.0	88.9	32.8	89.7
In 2050	30	7	16	11	6	4	9	27
Reduction in Carbon Intensity of Energy	77%	90%	83%	81%	89%	96%	73%	70%
Emissions intensity of GDP, kg CO2e per thousand USD								
In 2009	738	615	457	390	241	375	146	278
In 2050	77	17	26	24	11	7	17	32
Reduction Emissions Intensity of GDP	90%	97%	94%	94%	95%	98%	88%	88%
Per capita greenhouse gas emissions, tonnes CO2e								
In 2009	17.9	15.4	16.9	10.3	5.5	9.2	4.5	7.5
In 2050	3.9	0.7	1.8	1.2	0.5	0.3	1.1	1.6
Reduction per capita GHG emissions	78%	95%	89%	88%	91%	97%	76%	79%

Selected Annual Growth Indicators, 1990-2009

Selected Country Indicators (Annual Growth Rates 1990-2009)



PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

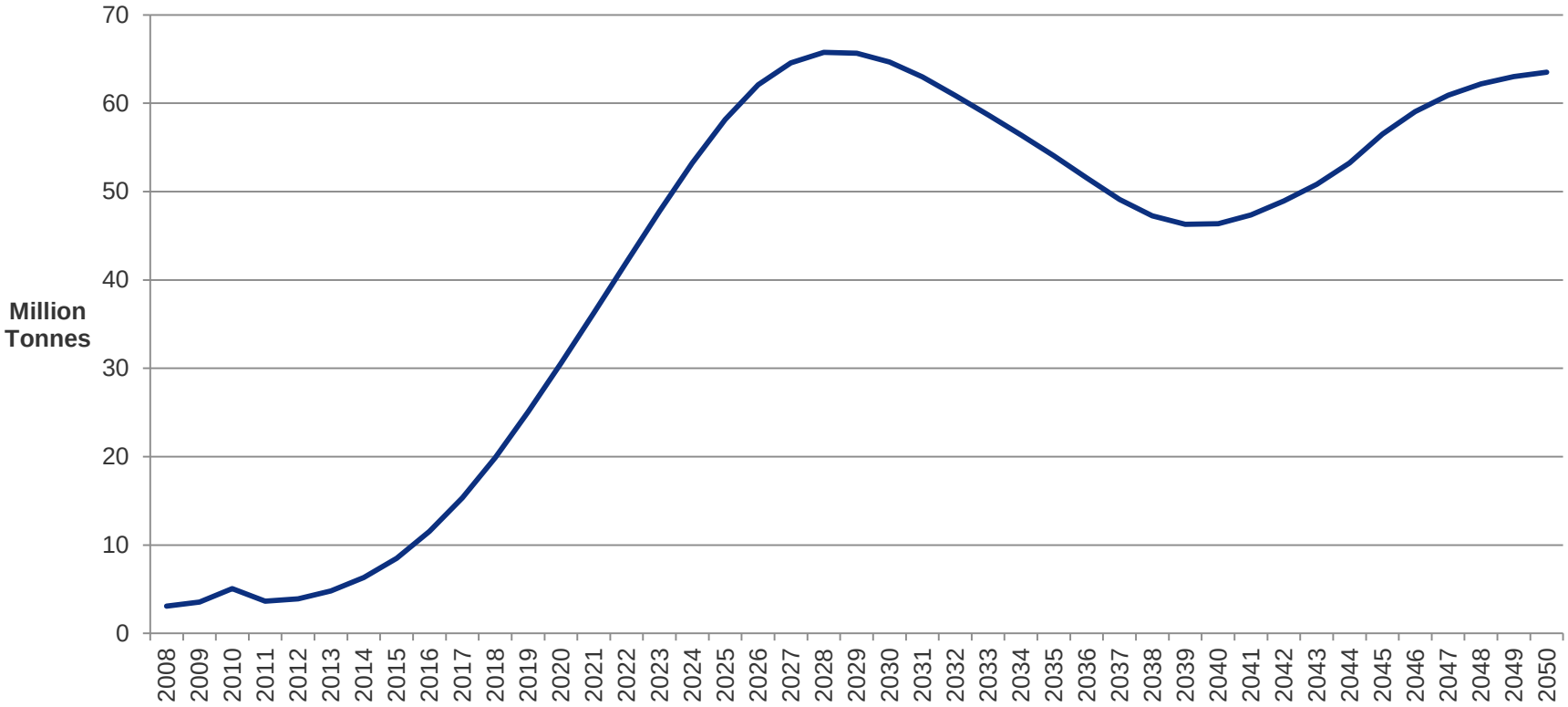
Decarbonization of Fuel and Electricity in Low Carbon Futures

In 2009	Australia	Canada	USA	Finland	France	Germany	Sweden	UK
Percent of end use energy provided by electricity								
In 2009	24%	21%	21%	27%	23%	19%	33%	21%
In 2050	25%	45%	24%	43%	51%	27%	38%	41%
Percent of all energy end use provided by renewable								
In 2009	2%	13%	2%	8%	3%	3%	19%	1%
In 2050	48%	76%	>80%	67%	49%	52%	93%	31%
Percent of electricity system powered by fossil fuels								
In 2009	93%	23%	70%	37%	11%	61%	4%	74%
In 2050	26%	5%	10%	0%	23%	18%	0%	26%

2050 Electricity Supply in Low Carbon Scenarios (PJ)

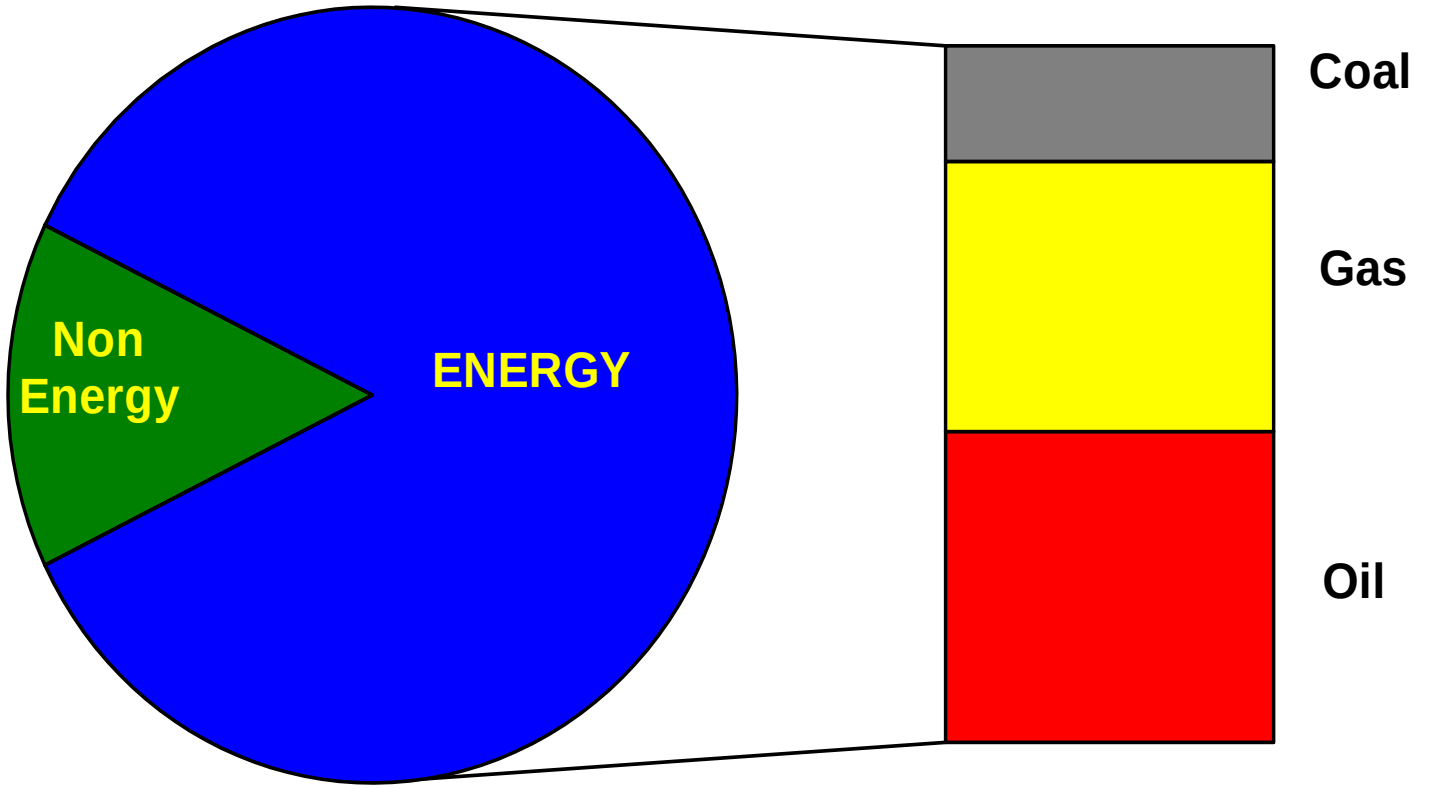
Petajoules	AUSI 2002 (Australia)	EREC 2010 (Canada)	RMI 2011 (USA)	FPMO 2009 (Finland)	MIES 2004 (France)	BMU 2008 (Germany)	IVL 2010 (Sweden)	UKERC 2009 (UK)
Hydro electricity	0	1,572	995	55		89	245	31
Wind electricity	500	396	5,897	67		672		188
Solar photovoltaics	100	43	5,163	0		100		0
Concentrated solar power	0	0	920	0		327		0
Electricity from Biomass	157	7	192	14		194	59	38
Geothermal	91	0	228	0		128		387
Wave or tidal energy	0	50	0	0				64
Unspecified caarbon-free electricity	0	0	0	0	924	190	263	0
Nuclear	0	0	0	150	1710	0	Included above	769
Total carbon-free electricity	847	2,041	13,395	286	2,634	1,699	566	1,477
Carbon-free as percent of electricity supply	74%	95%	90%	100%	77%	82%	100%	74%

Primary Biomass Feedstock in an Illustrative Low Carbon Future for Canada:

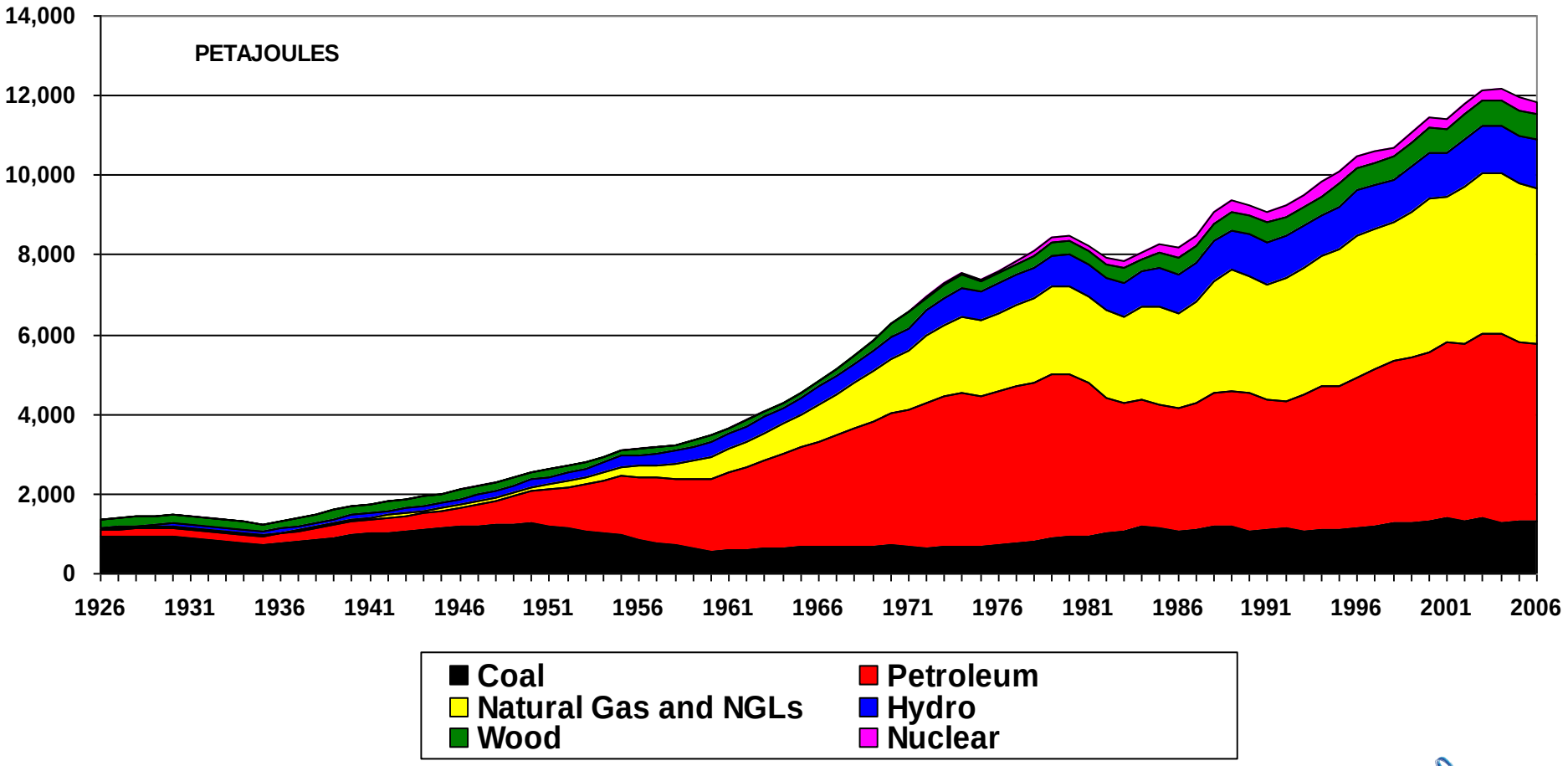


PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Fossil fuel production and consumption account for 82% of Canada's greenhouse gas emissions:

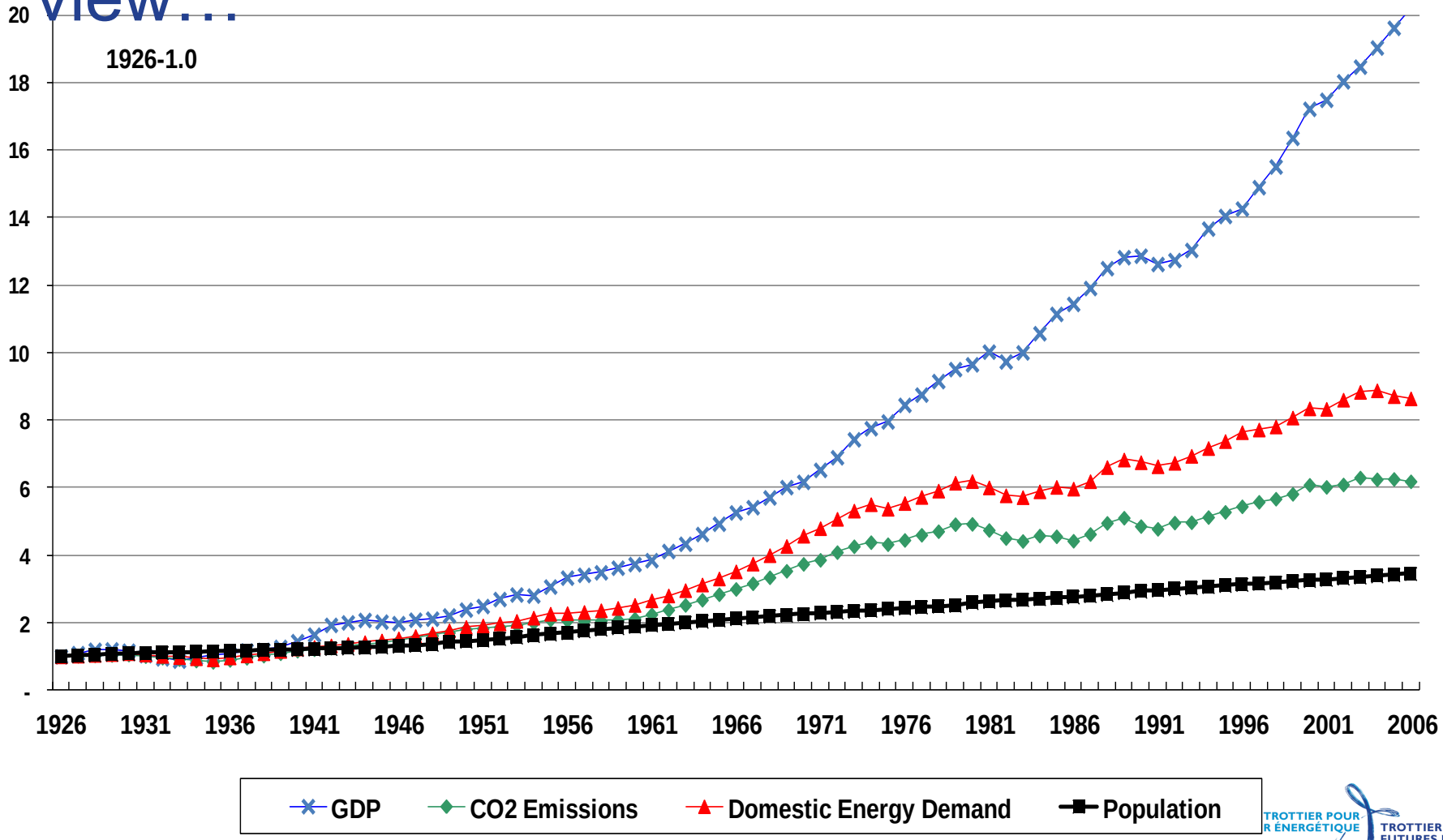


Canadian Domestic Demand for Primary Energy, 1926-2006



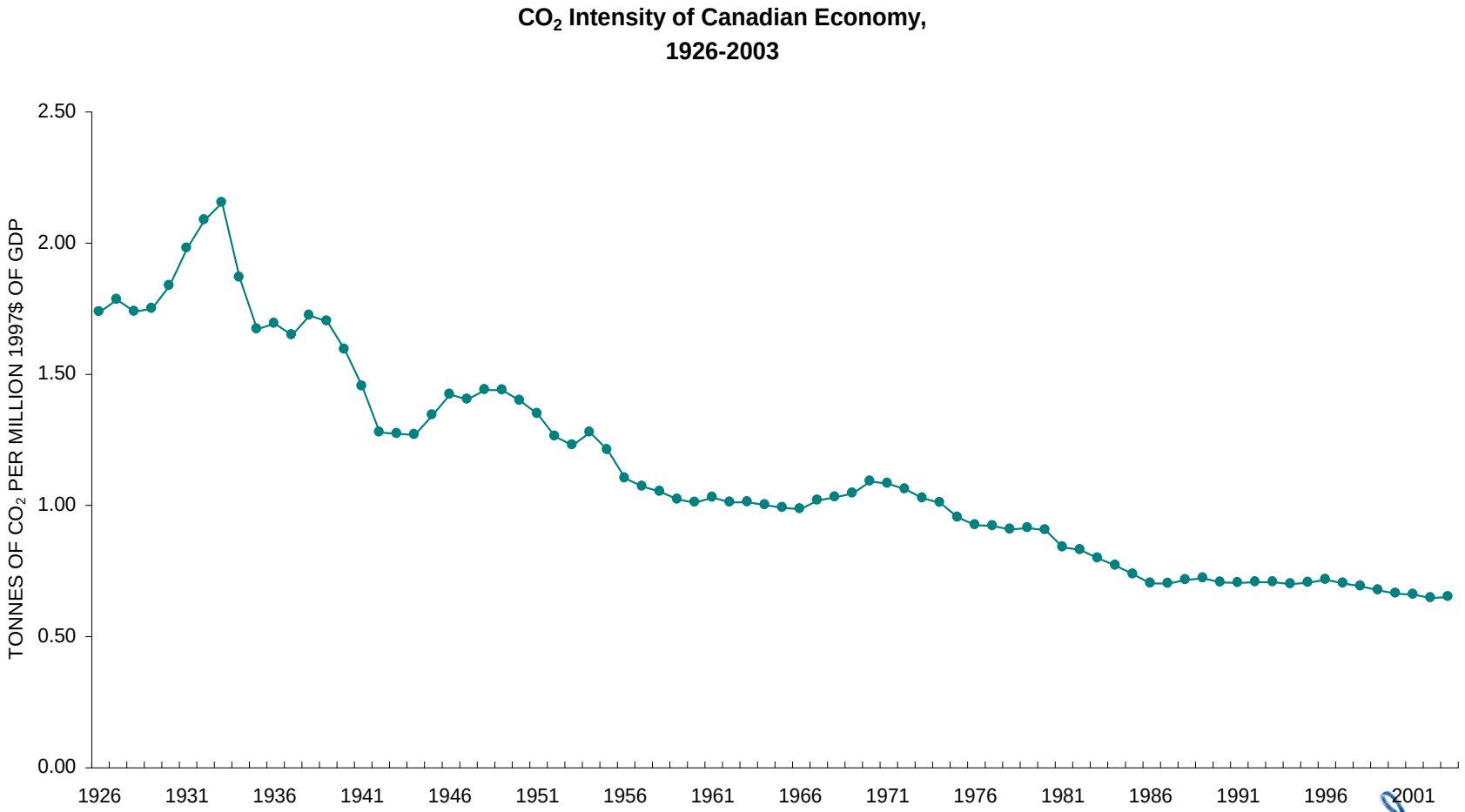
PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Relative growth of population, energy, CO2 emissions and GDP – the long view…



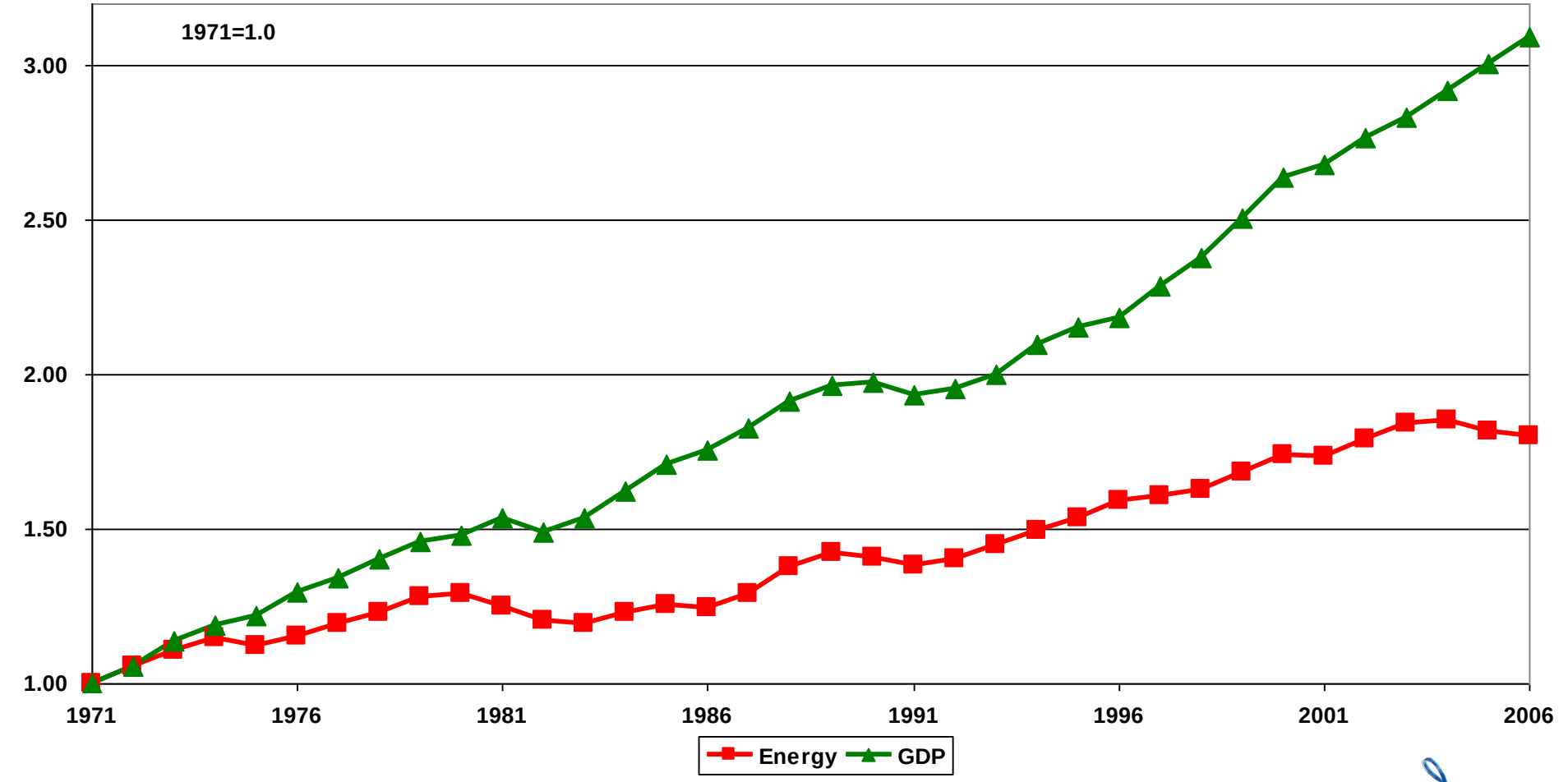
TROTTIER POUR R ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Energy productivity improvement and progressive shifts to less carbon intensive energy have resulted in a long term and persistent decline in the CO2 intensity of the Canadian economy:



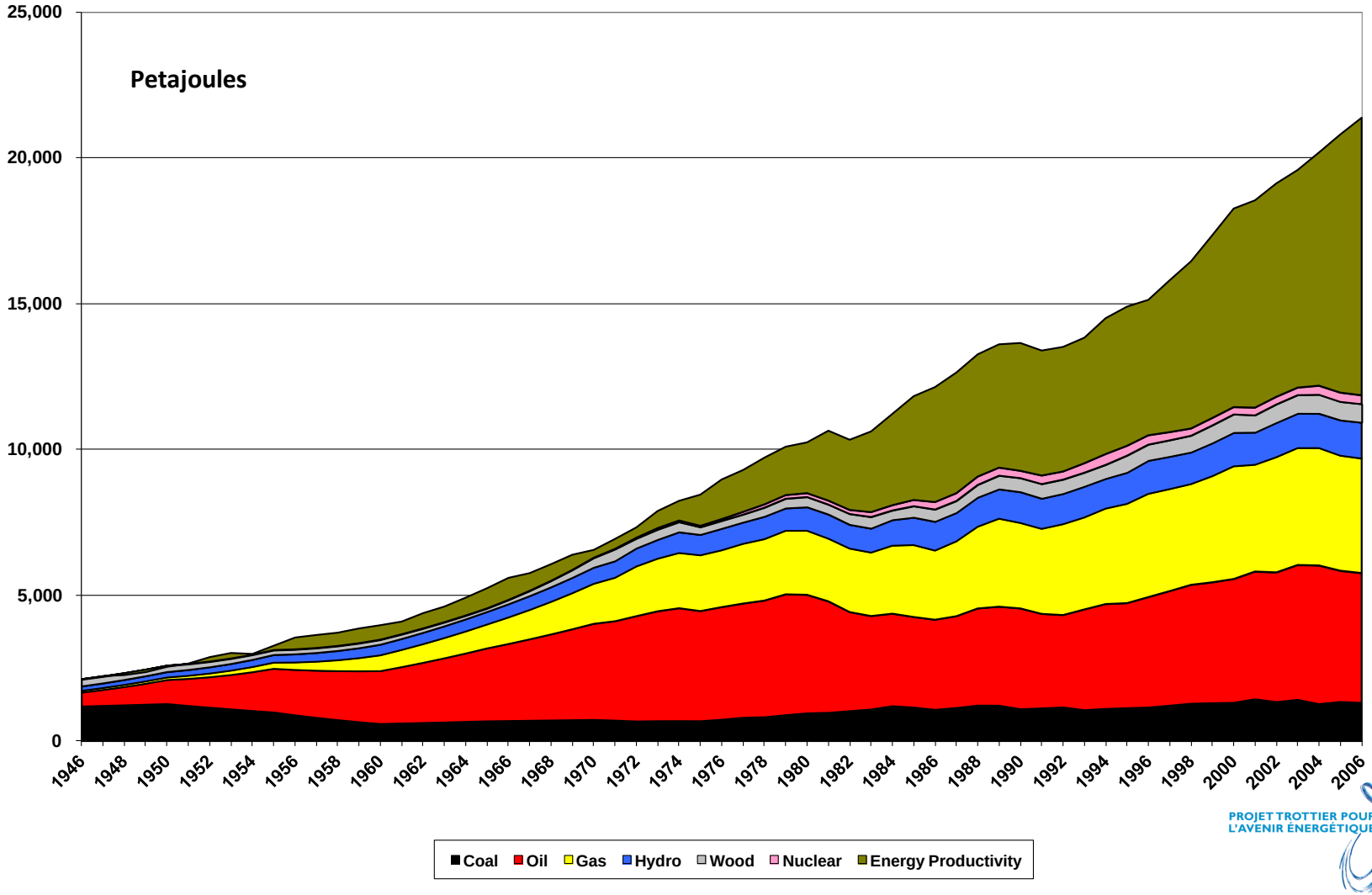
PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

GDP and energy commodity consumption “decoupled” in the early 1970’s, and energy productivity growth has outstripped growth in new supply since then:



PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

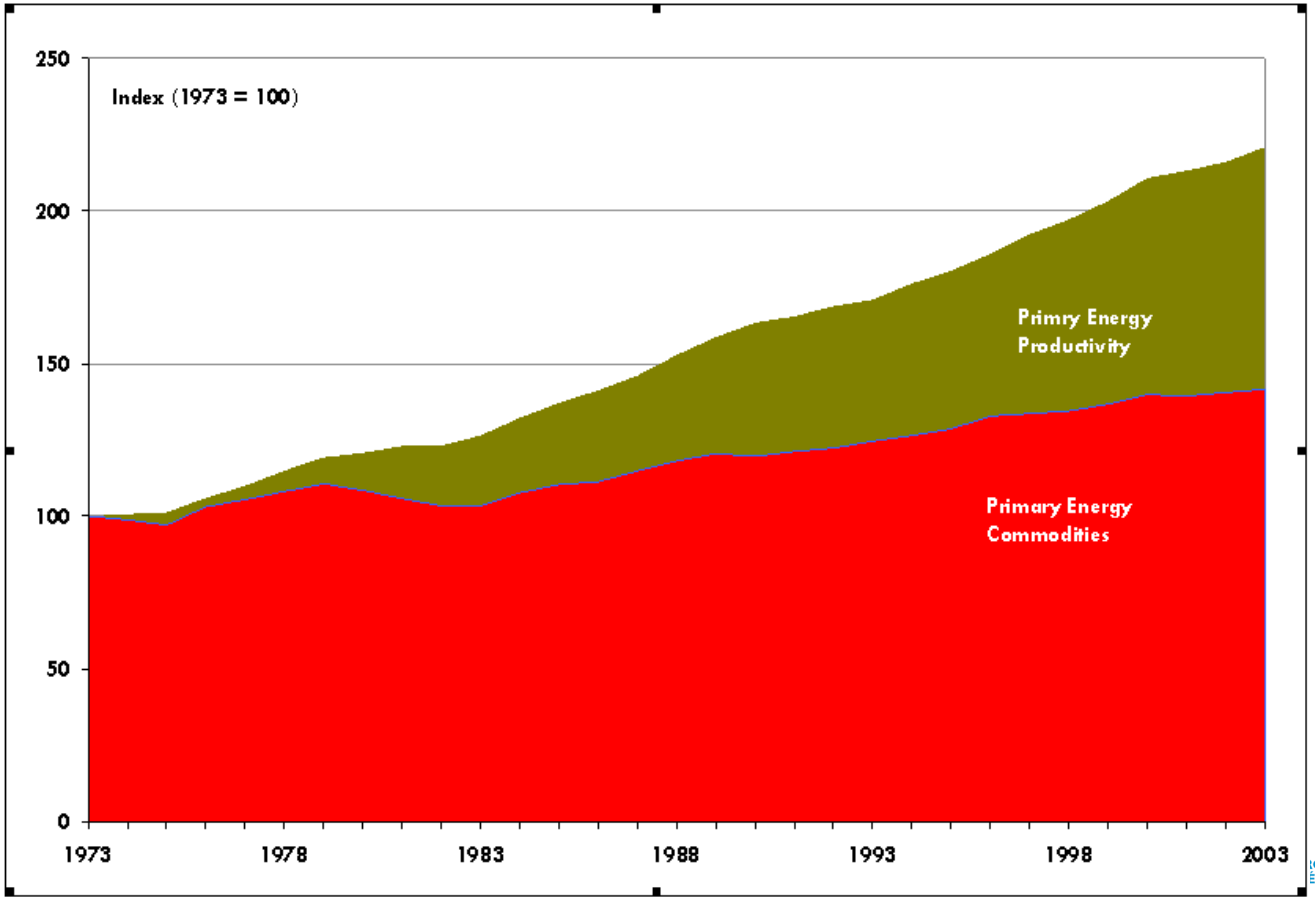
Two eras of post-War energy: from 1946 to early 1970's, fuel and electricity grew with economic output, starting in the 1970's energy productivity improvements have outstripped fuel and electricity growth.



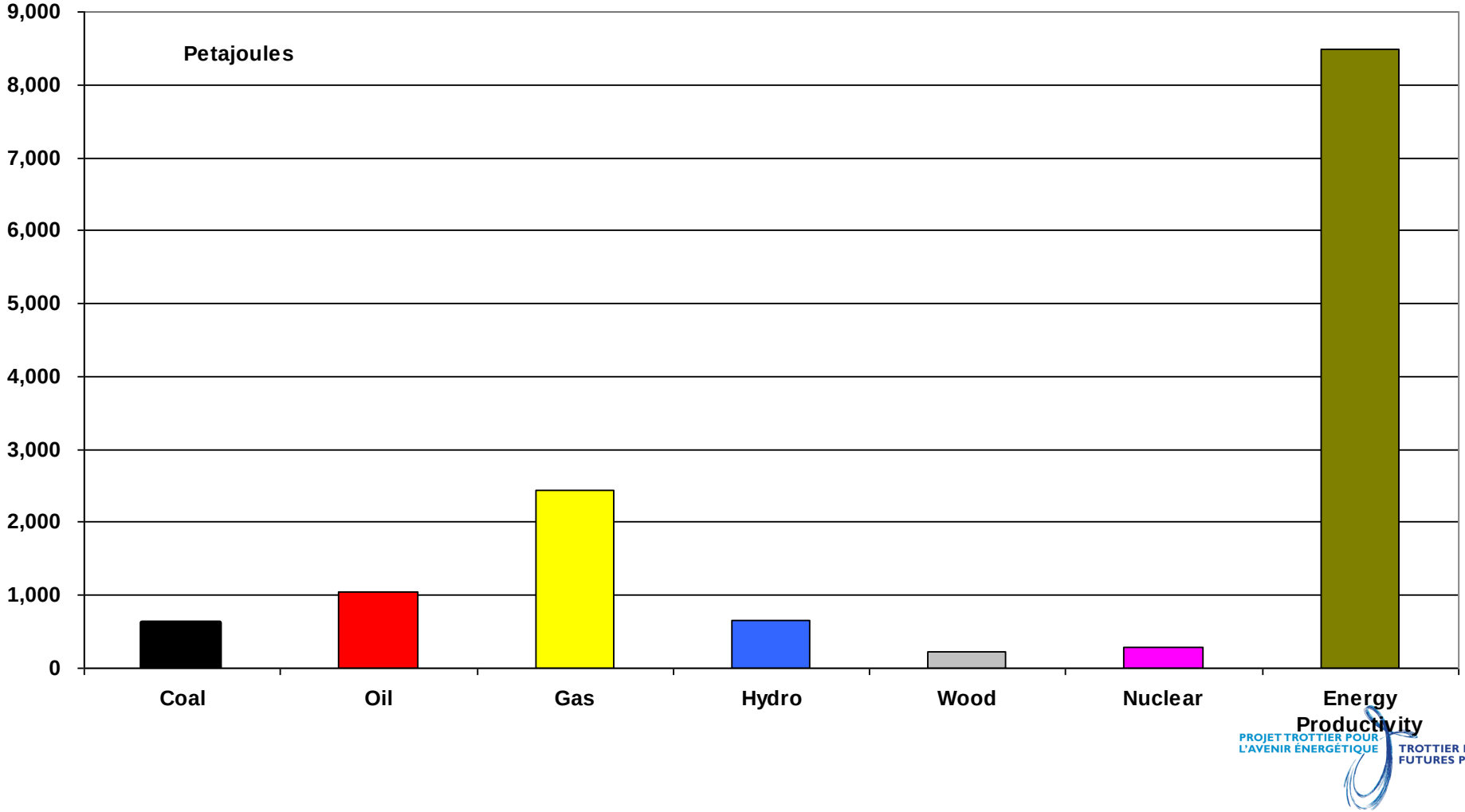
PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Energy productivity, measured as the ratio of GDP to energy consumption, has improved throughout the OECD, including with countries that already had much lower energy/GDP ratios than Canada at the outset:

Primary energy demand vs. energy productivity in the OECD

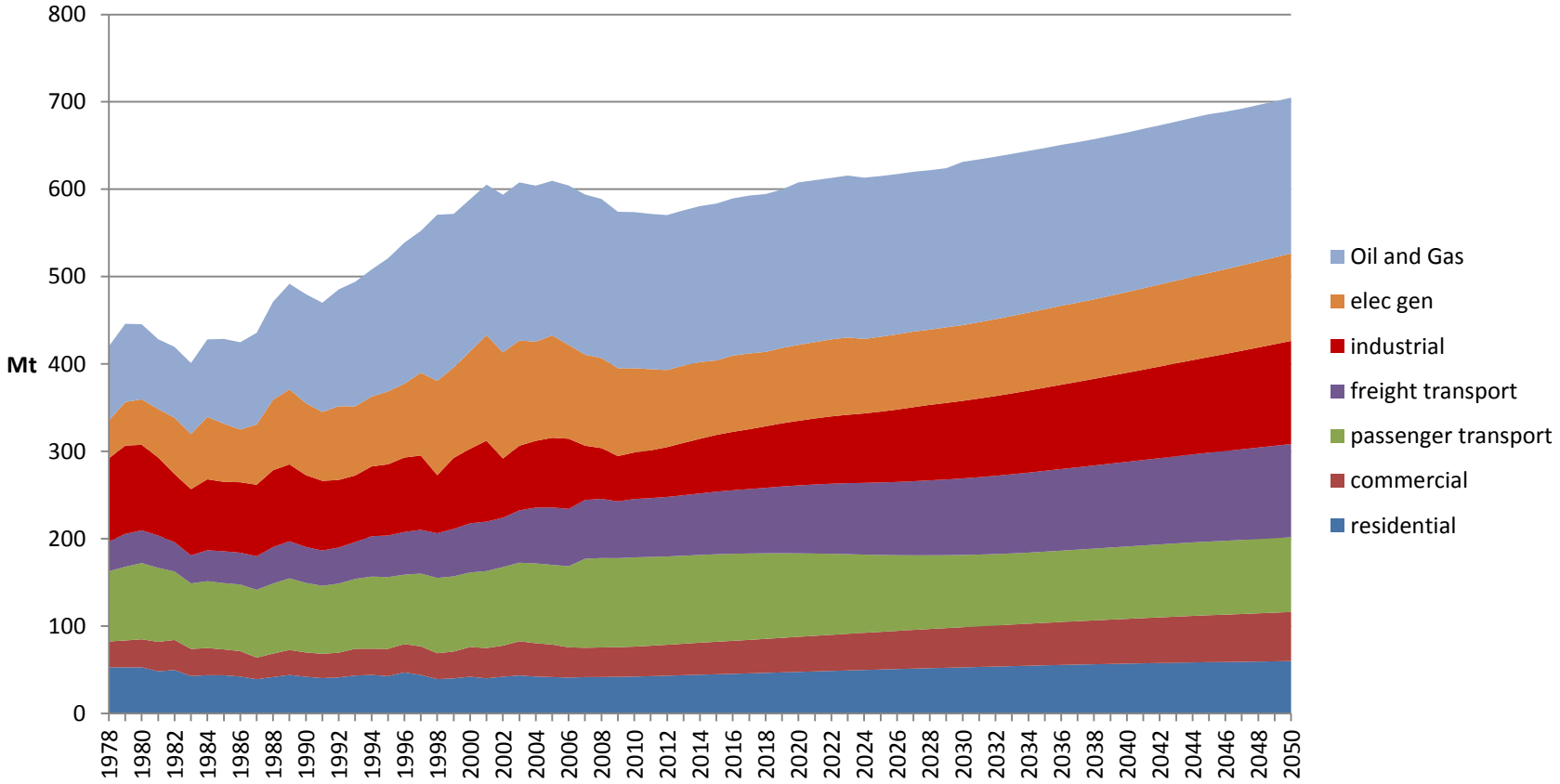


New supply from 1971-2006 compared to energy productivity growth over the same period:

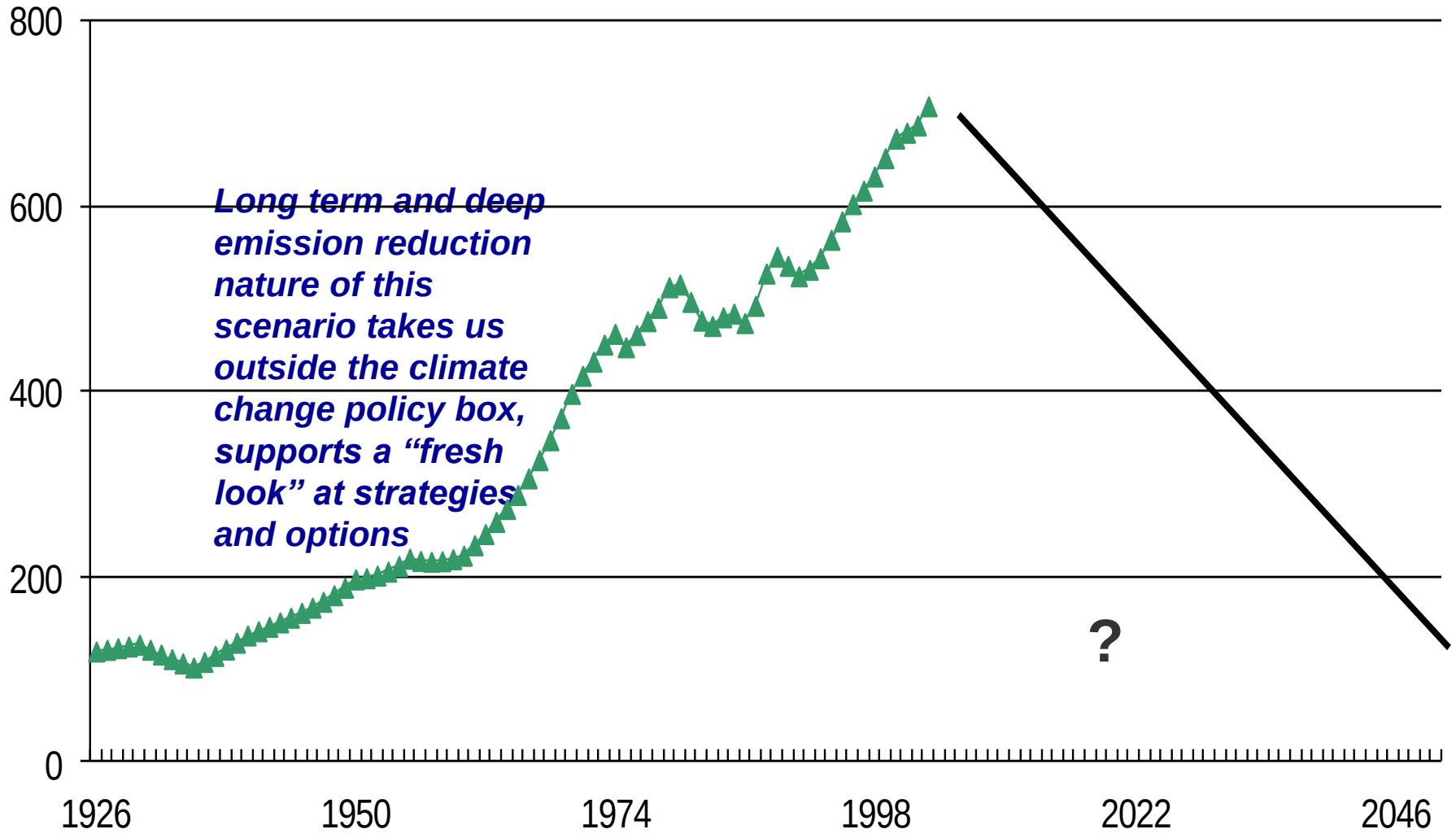


PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Reference Case Emissions by Sector

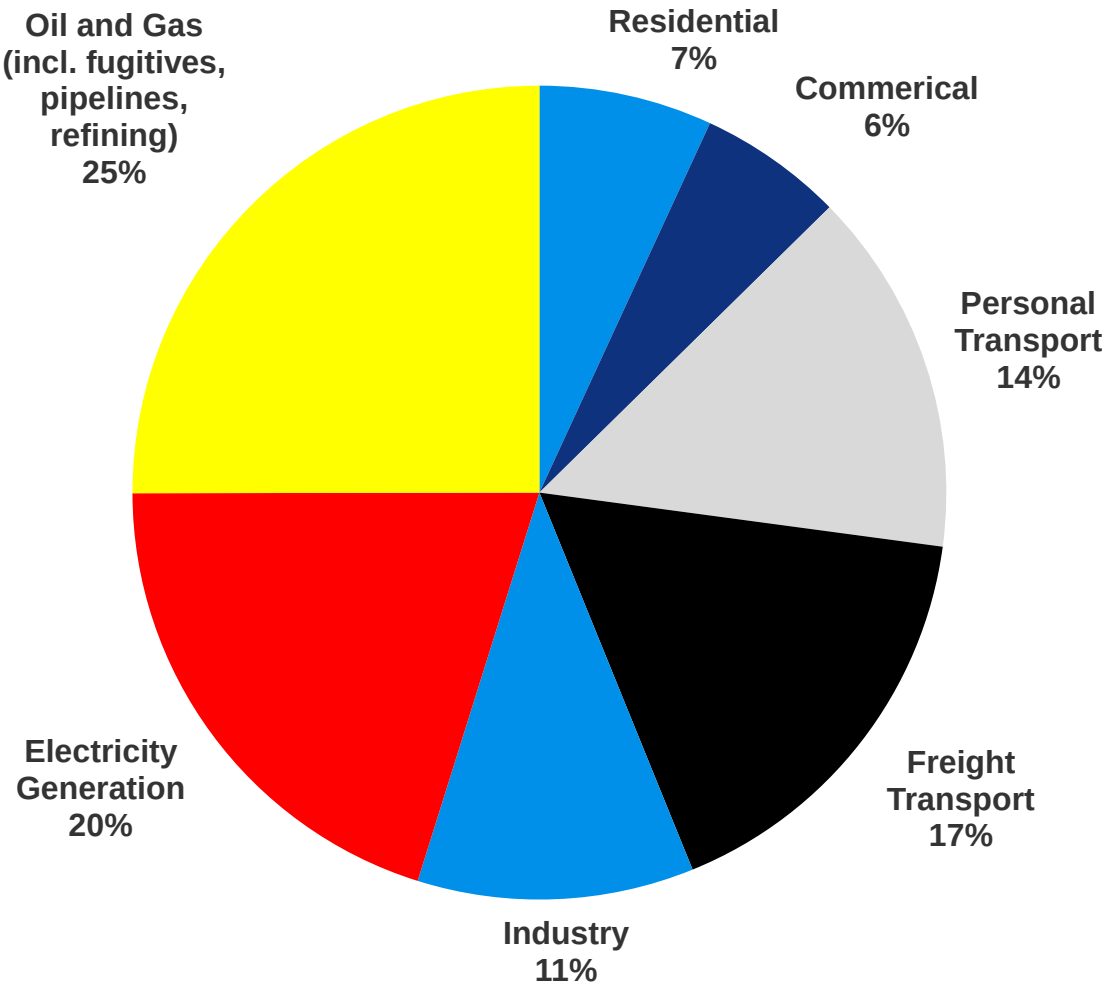


PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT



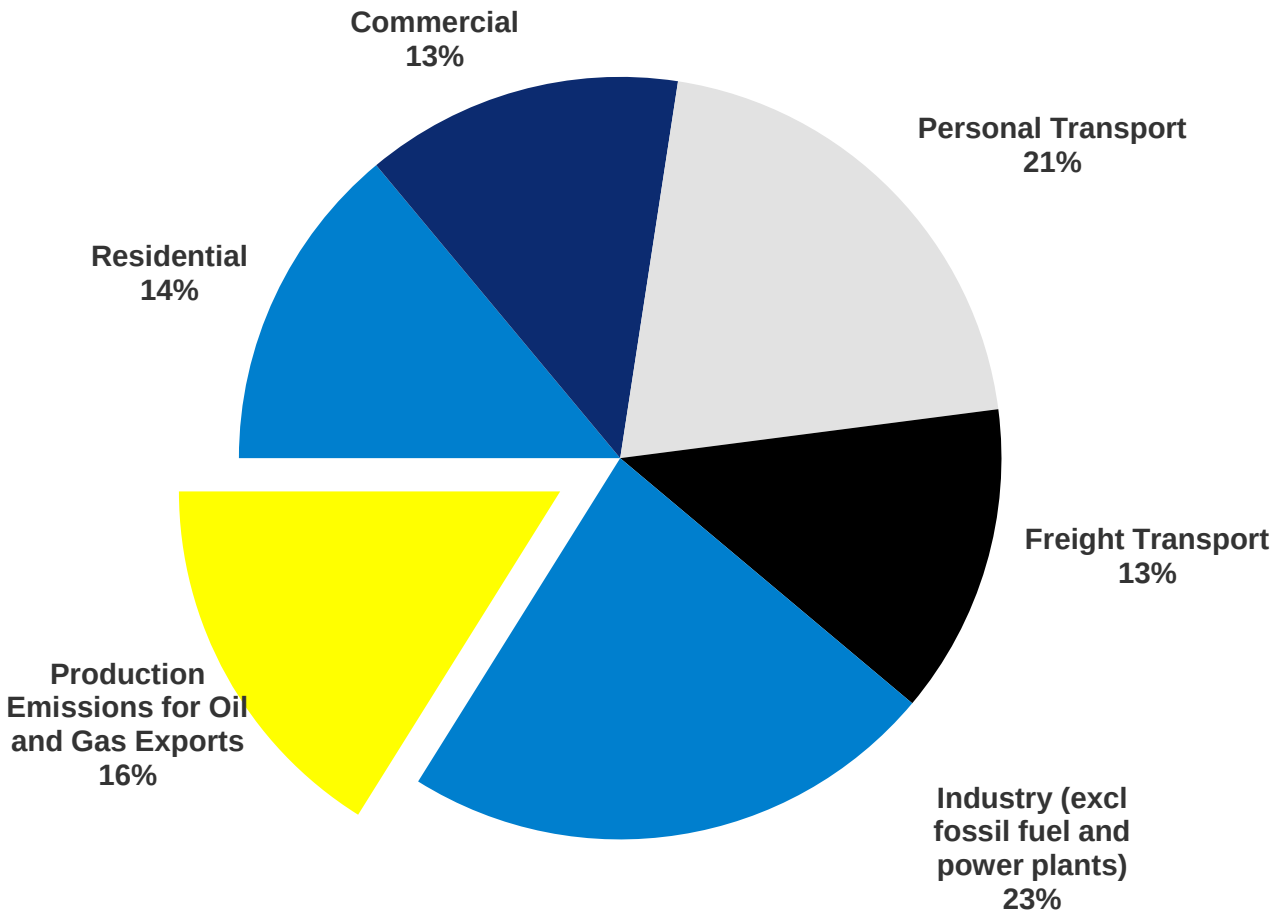
PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

When GHG emissions are allocated according to where they take place, the picture looks like this; just over half (55%) of Canada's energy-related greenhouse gas emissions are emitted from tailpipes, chimneys and smokestacks where fossil fuels are burned – the other 45% are emitted by the energy commodity industry itself (power plants and fossil fuel industry):



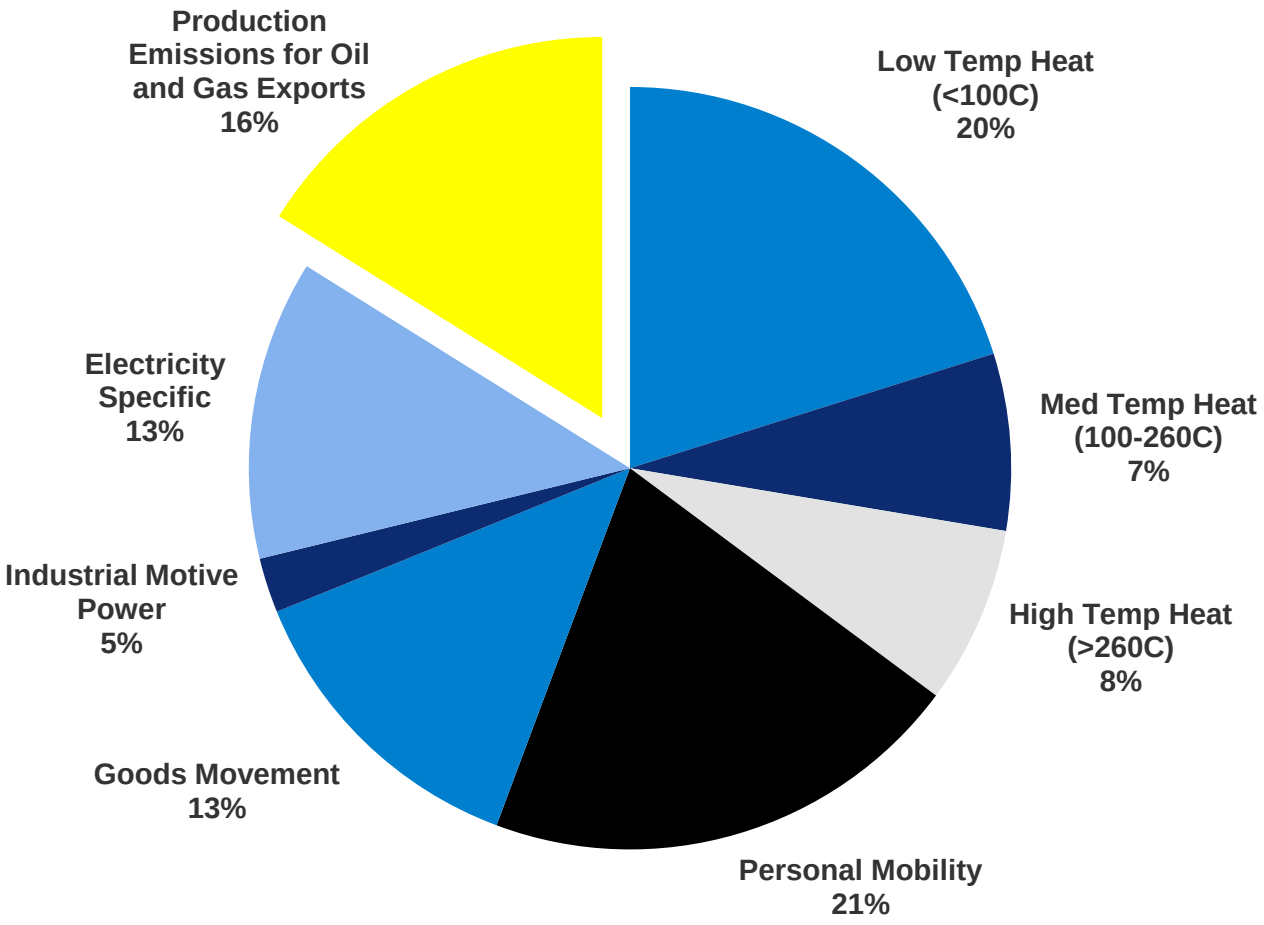
PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

When the emissions of power plants and the oil and gas industry are pro-rated to the end use sectors, the emission source takes on a different look:



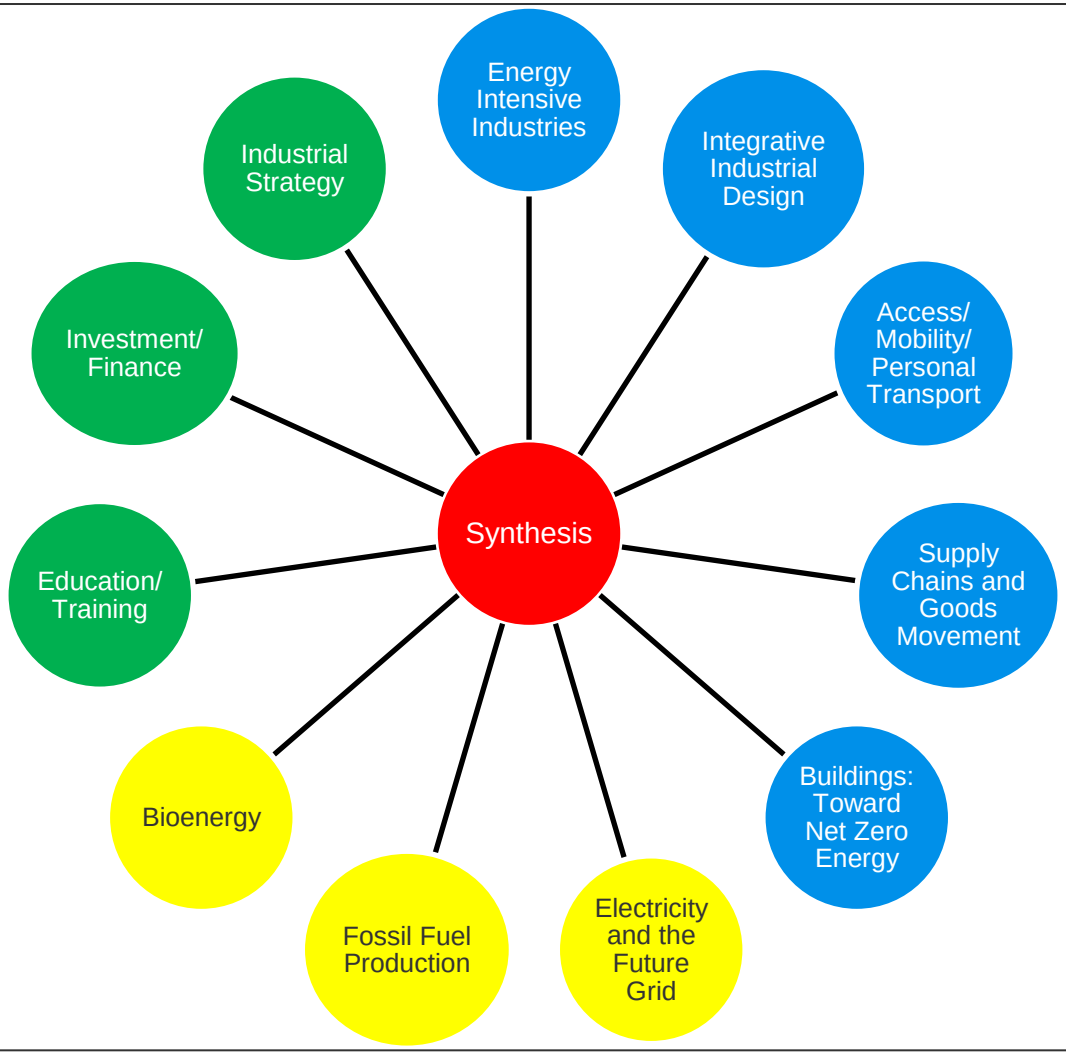
PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Connecting greenhouse gas emissions to the energy service demands that drive them provides yet another perspective…



PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT

Trottier Energy Futures Project – Research and Strategy Development Framework



PROJET TROTTIER POUR L'AVENIR ÉNERGÉTIQUE
TROTTIER ENERGY FUTURES PROJECT