Impact of the TransCanada pipeline on the oil and gas industry in Newfoundland and Labrador

Kathleen Vaillancourt, ESMIA Consultants
Yuri Alcocer, Lead Economist, North Atlantic Refinery

With the support of

Wade Locke, Professor, CARE, MUN
Olivier Bahn, Professor, HEC Montreal

CARE - St-Johns, February 13th, 2015

ESMIA
Energy Super Modelers and International Analysts

Outline

- Introduction to ESMIA activities
- MARKAL/TIMES family of models
- The North American TIMES Energy Model - NATEM
- Case study on the impact of new pipelines
  - Methodological aspects
  - Preliminary results
    - Canada
    - Newfoundland & Labrador

Introduction to ESMIA activities

Introduction to ESMIA activities

- Optimization E3 model development
  - USA
    - System for the Analysis of Global Energy Markets (SAGE) for the IEO
    - Framework for Analysis of Climate-Energy-Technology Systems model (FACETS)
  - European Commission
    - Pan European TIMES model (PET)
  - World
    - The Integrated TIMES Energy model (IEA-ETSAP)
    - Building incremental DEMO models for users of TIMES model (IEA-ETSAP)
  - Mexico:
    - The national optimization energy model for Mexico
- Optimization E3 model applications
  - Vermont: Ambitious GHG (-80%) and Renewable Energy (90%) Goals for 2050
  - Canada : Optimal strategies for reducing GHG emissions by 80% in Canada by 2050
  - Newfoundland & Labrador: Impact of pipeline projects on the oil & gas industry
- Research and development
  - Collaboration with Olivier Bahn (HEC, GERAD)
    - Modeling biorefineries in details
  - Collaboration with Pierre-Olivier Pineau (HEC)
    - Electricity markets integration (QC-ON)

MARKAL/TIMES family of models

3E model classification

- **Bottom-up**: a **techno-economic** approach that leads to **disaggregated** models representing the energy sector with great details
- **Top-down**: a **macro-economic** approach that leads to **aggregate** models in the sense that they use aggregate economic variables
- **Hybrid models** incorporate within the same framework **both** modeling **approaches**

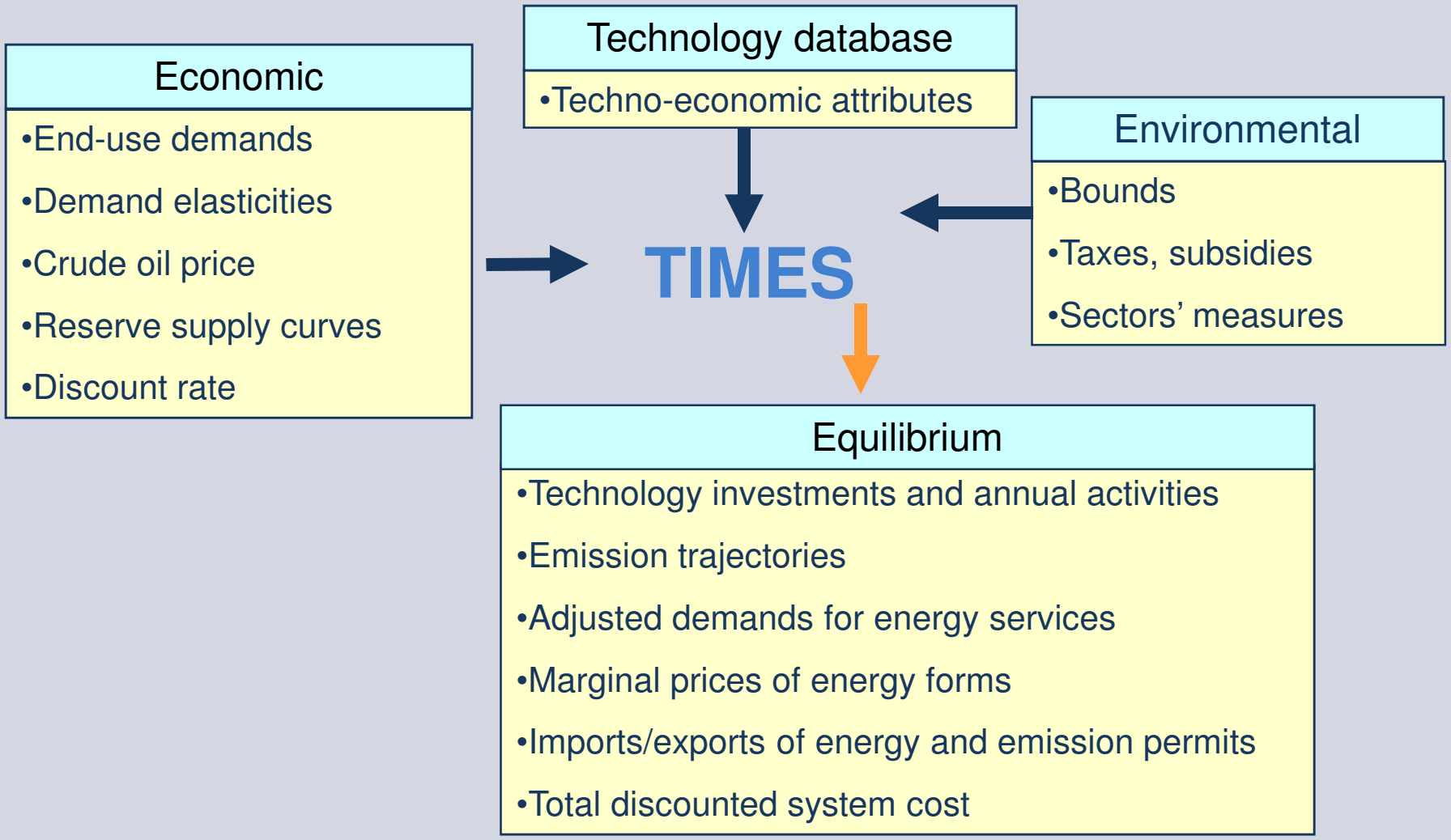
MARKAL / TIMES: History

- Developed within the **Energy Technology Systems Analysis Programme (ETSAP)** of the International Energy Agency (**IEA**)
- Long and rich history of methodological developments and applications to energy and environmental issues in nearly **70 countries** around the world
- **Canadian** researchers are among the prime developers of MARKAL/TIMES models

The Integrated MARKAL-EFOM System (TIMES)

- Combine advanced versions of MARKAL models
- Linear programming hybrid bottom-up energy models
- Integrated modeling of the entire energy system
- Prospective analysis on a long term horizon (50-100 yrs)
  - Demand driven (exogenous) in physical units
  - Price-elasticities for end-use demands
- Partial and dynamic equilibrium (perfect market)
- Optimal technology selection
- Objective-function: Minimize the total cost of the system
- Environmental constraints (GHG emission limits)
- Energy and emission permits trading

In summary


Technology database
•Techno-economic attributes
Economic
•End-use demands
•Demand elasticities
•Crude oil price
•Reserve supply curves
•Discount rate
TIMES
Environmental
•Bounds
•Taxes, subsidies
•Sectors' measures
Equilibrium
•Technology investments and annual activities
•Emission trajectories
•Adjusted demands for energy services
•Marginal prices of energy forms
•Imports/exports of energy and emission permits
•Total discounted system cost

LP formulation

$$\begin{cases} \min EC = c^T x \\ \text{s.t.} \\ Dx \geq d \\ Sx \leq s \\ x \geq 0 \end{cases}$$

Energy costs

Investment, **capacity**, **activity** (technology), **import** & **export** (energy)

Demand constraints: energy demands ***d*** must be satisfied

Constraints describing functioning of the **energy sector**

The TIMES Objective-Function

$$NPV = \sum_{r=1}^{R} \sum_{y \in YEARS} (1 + d_{r,y})^{REFYR-y} \bullet ANNCOST(r, y)$$

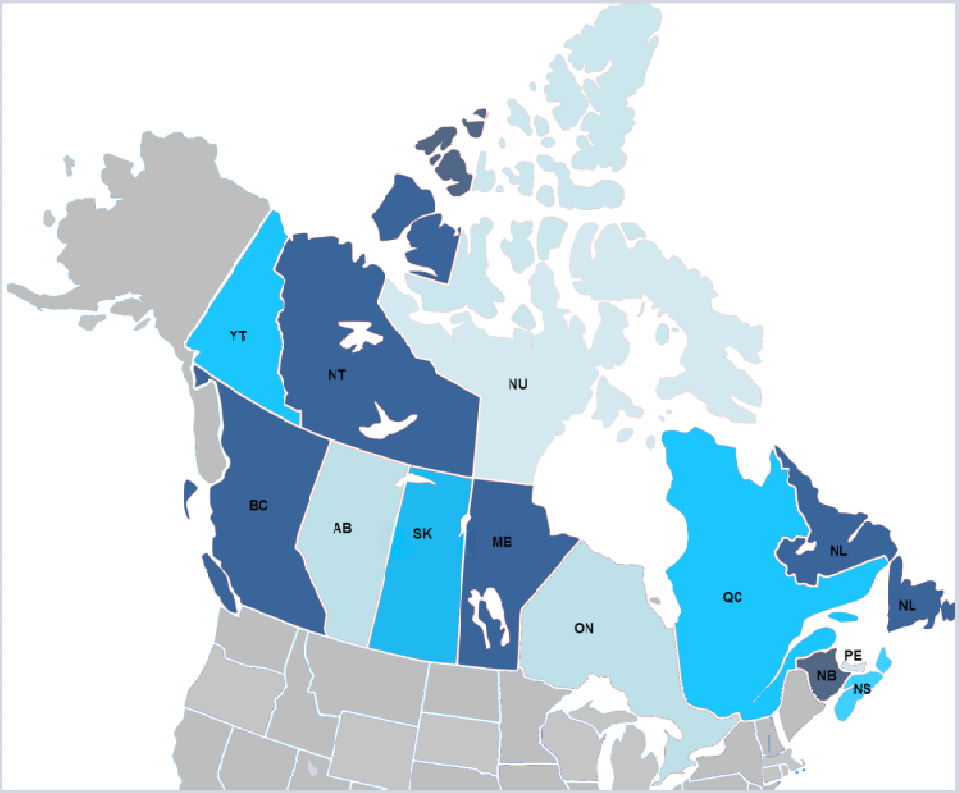
where:

NPV	is the net present value of the total cost for all regions (the OBJ);
ANNCOST(r,y)	is the total annual cost in region r and year y;
$d_{r,y}$	is the general discount rate;
REFYR	is the reference year for discounting;
YEARS	is the set of years for which there are costs (in the horizon, plus past and before years EOH;
R	is the set of regions in the area of study

- Investment and dismantling costs are transformed into annual payments;
- A salvage value of all investments still active at the end of the horizon (EOH) is calculated and its value is assigned to the (single) year following the EOH;
- All other annual costs are added (ANNCOST);
- For each region, a total NPV of the stream of annual costs is computed and discounted to a selected reference year.
- Regional discounted costs are aggregated into a single total cost (OBJ to be minimized by the model in its equilibrium computation.

A TIMES model for Canada – Part of the NATEM model

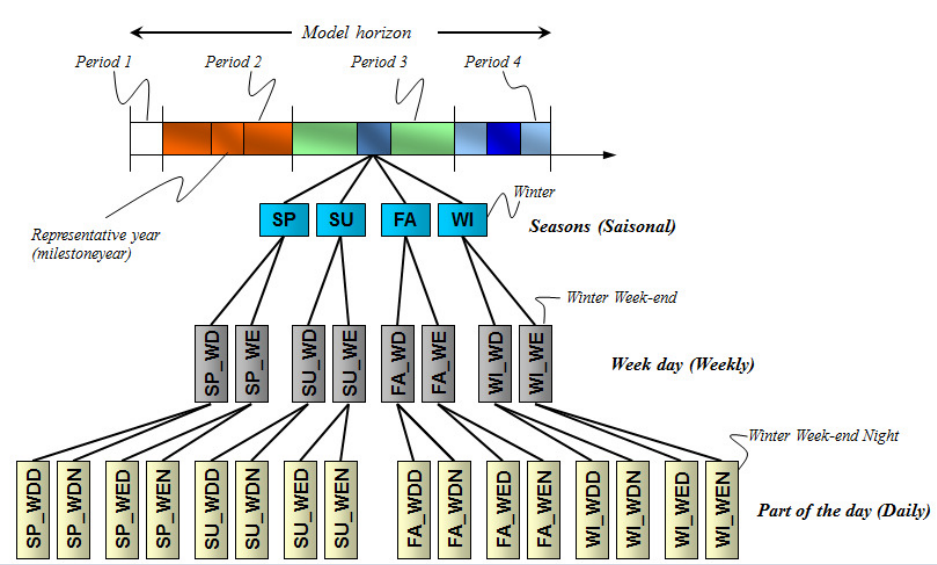
Provinces and Territories



Code	Province/Territory	Region
AB	Alberta	West
BC	British Colombia	West
MB	Manitoba	West
NB	New Brunswick	East
NL	Newfoundland	East
NS	Nova Scotia	East
NT	Northwest territories	North
NU	Nunavut	North
ON	Ontario	Central
PE	Prince Edward Island	East
QC	Quebec	Central
SK	Saskatchewan	West
YT	Yukon	North

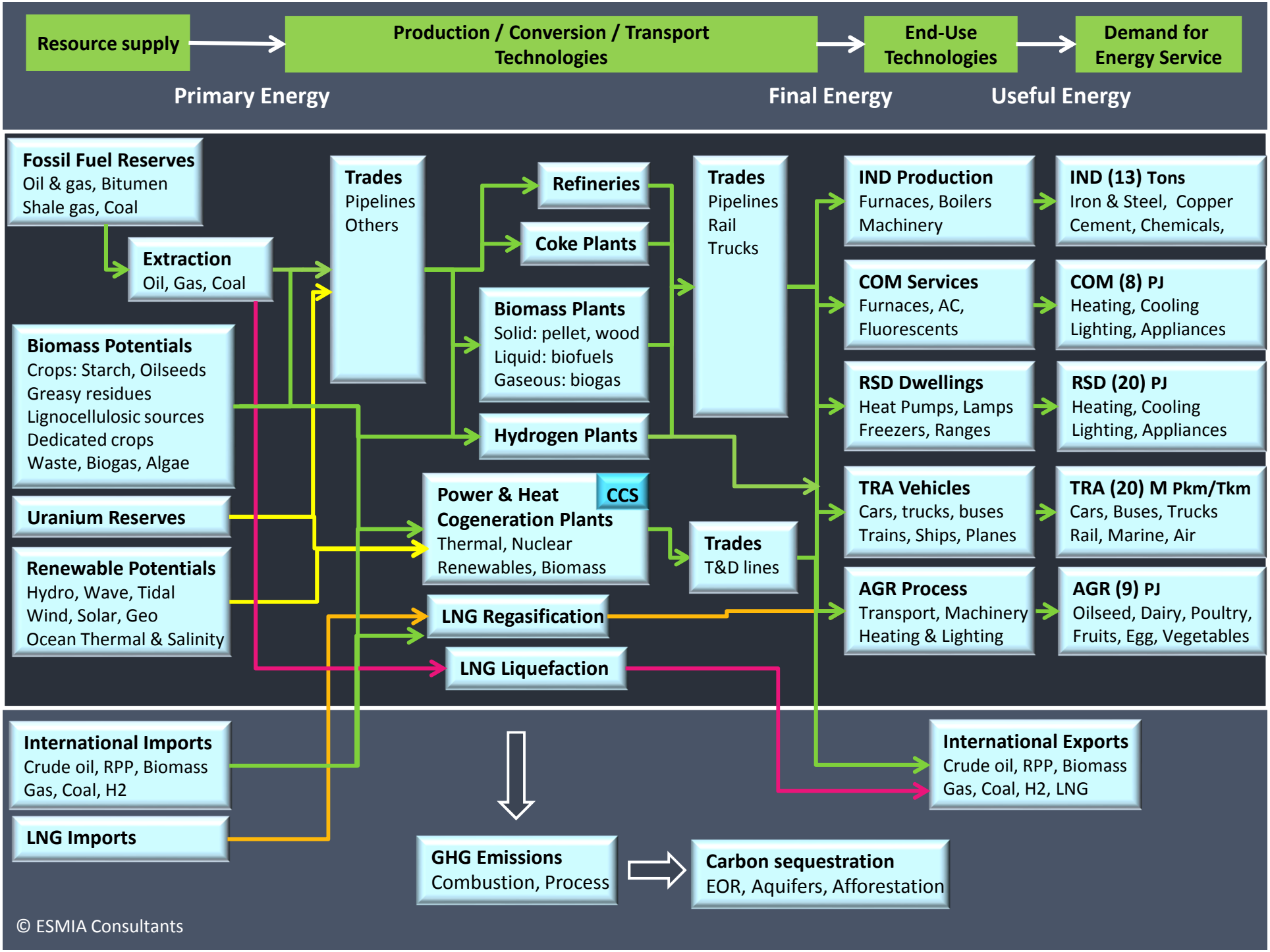
Time Periods and Time Slices

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Start	2011	2012	2015	2016	2025	2027	2034	2037	2044	2057	2064	2077	2084	2097
Mid	**2011**	**2013**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
End	2011	2014	2015	2024	2026	2033	2036	2043	2056	2063	2076	2083	2096	2103



Source: Loulou et al (2005)

Season	Definition	Period of day	Definition	Time slice
Spring	March 21st – June 20th	Morning Peak (P1)	6h - 7h59	RP1
		Day (D)	8h - 16h59	RD
		Evening Peak (P2)	17h-19h59	RP2
		Night (N)	20h - 5h59	RN
Summer	June 21st – September 20th	Morning Peak (P1)	6h - 7h59	SP1
		Day (D)	8h - 16h59	SD
		Evening Peak (P2)	17h-19h59	SP2
		Night (N)	20h - 5h59	SN
Fall	September 21st - December 20th	Morning Peak (P1)	6h - 7h59	FP1
		Day (D)	8h - 16h59	FD
		Evening Peak (P2)	17h-19h59	FP2
		Night (N)	20h - 5h59	FN
Winter	December 21st - March 20th	Morning Peak (P1)	6h - 7h59	WP1
		Day (D)	8h - 16h59	WD
		Evening Peak (P2)	17h-19h59	WP2
		Night (N)	20h - 5h59	WN


Resource supply
Production / Conversion / Transport Technologies
End-Use Technologies
Demand for Energy Service
Primary Energy
Final Energy
Useful Energy
Fossil Fuel Reserves
Oil & gas, Bitumen
Shale gas, Coal
Extraction
Oil, Gas, Coal
Biomass Potentials
Crops: Starch, Oilseeds
Greasy residues
Lignocellulosic sources
Dedicated crops
Waste, Biogas, Algae
Uranium Reserves
Renewable Potentials
Hydro, Wave, Tidal
Wind, Solar, Geo
Ocean Thermal & Salinity
Trades
Pipelines
Others
Refineries
Coke Plants
Biomass Plants
Solid: pellet, wood
Liquid: biofuels
Gaseous: biogas
Hydrogen Plants
Power & Heat Cogeneration Plants
CCS
Thermal, Nuclear
Renewables, Biomass
LNG Regasification
LNG Liquefaction
Trades
Pipelines
Rail
Trucks
Trades
T&D lines
IND Production
Furnaces, Boilers
Machinery
IND (13) Tons
Iron & Steel, Copper
Cement, Chemicals,
COM Services
Furnaces, AC,
Fluorescents
COM (8) PJ
Heating, Cooling
Lighting, Appliances
RSD Dwellings
Heat Pumps, Lamps
Freezers, Ranges
RSD (20) PJ
Heating, Cooling
Lighting, Appliances
TRA Vehicles
Cars, trucks, buses
Trains, Ships, Planes
TRA (20) M Pkm/Tkm
Cars, Buses, Trucks
Rail, Marine, Air
AGR Process
Transport, Machinery
Heating & Lighting
AGR (9) PJ
Oilseed, Dairy, Poultry,
Fruits, Egg, Vegetables
International Imports
Crude oil, RPP, Biomass
Gas, Coal, H2
LNG Imports
GHG Emissions
Combustion, Process
Carbon sequestration
EOR, Aquifers, Afforestation
International Exports
Crude oil, RPP, Biomass
Gas, Coal, H2, LNG
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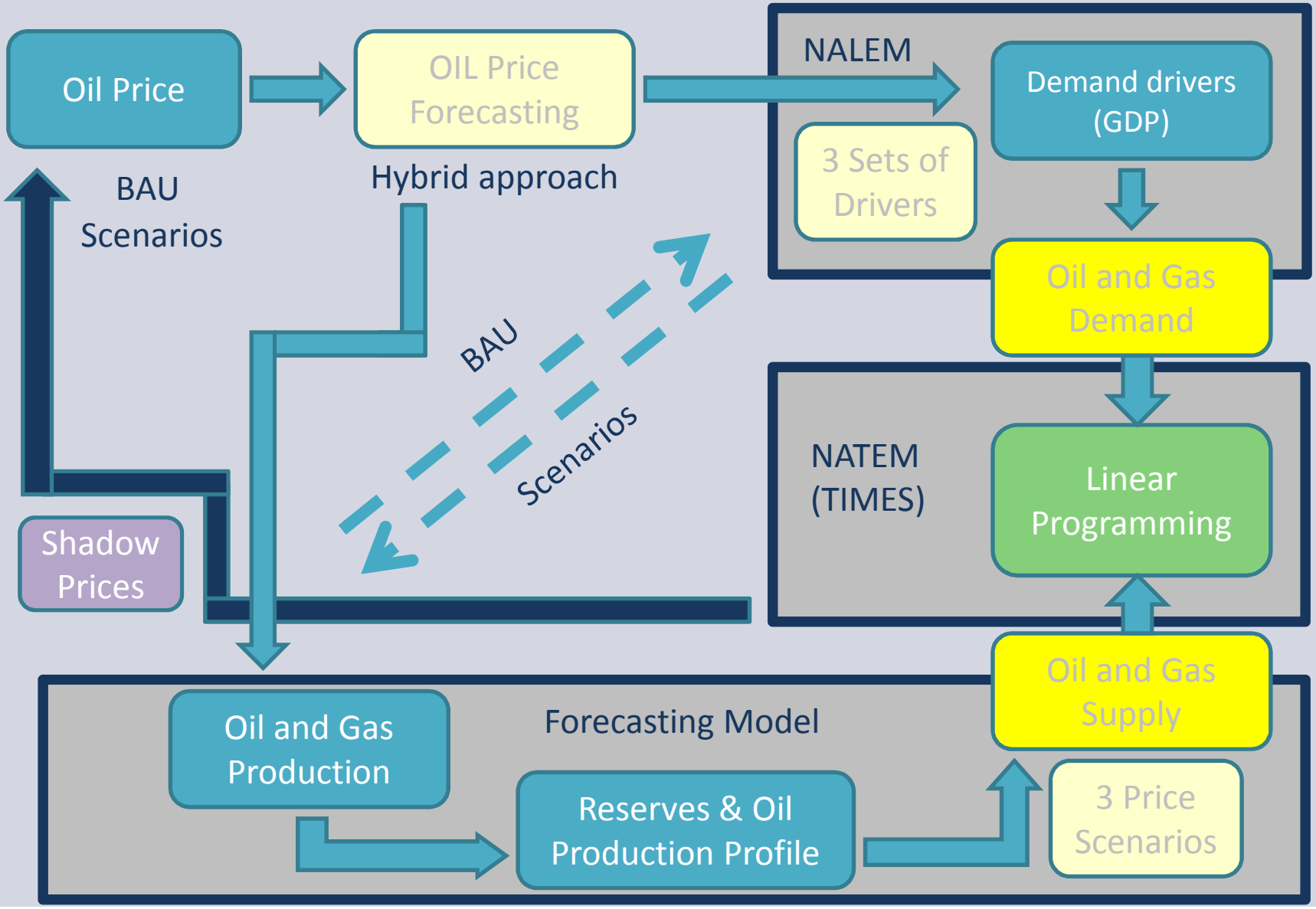
Analyzing the impact of pipeline projects on the Canadian energy system

Methodology

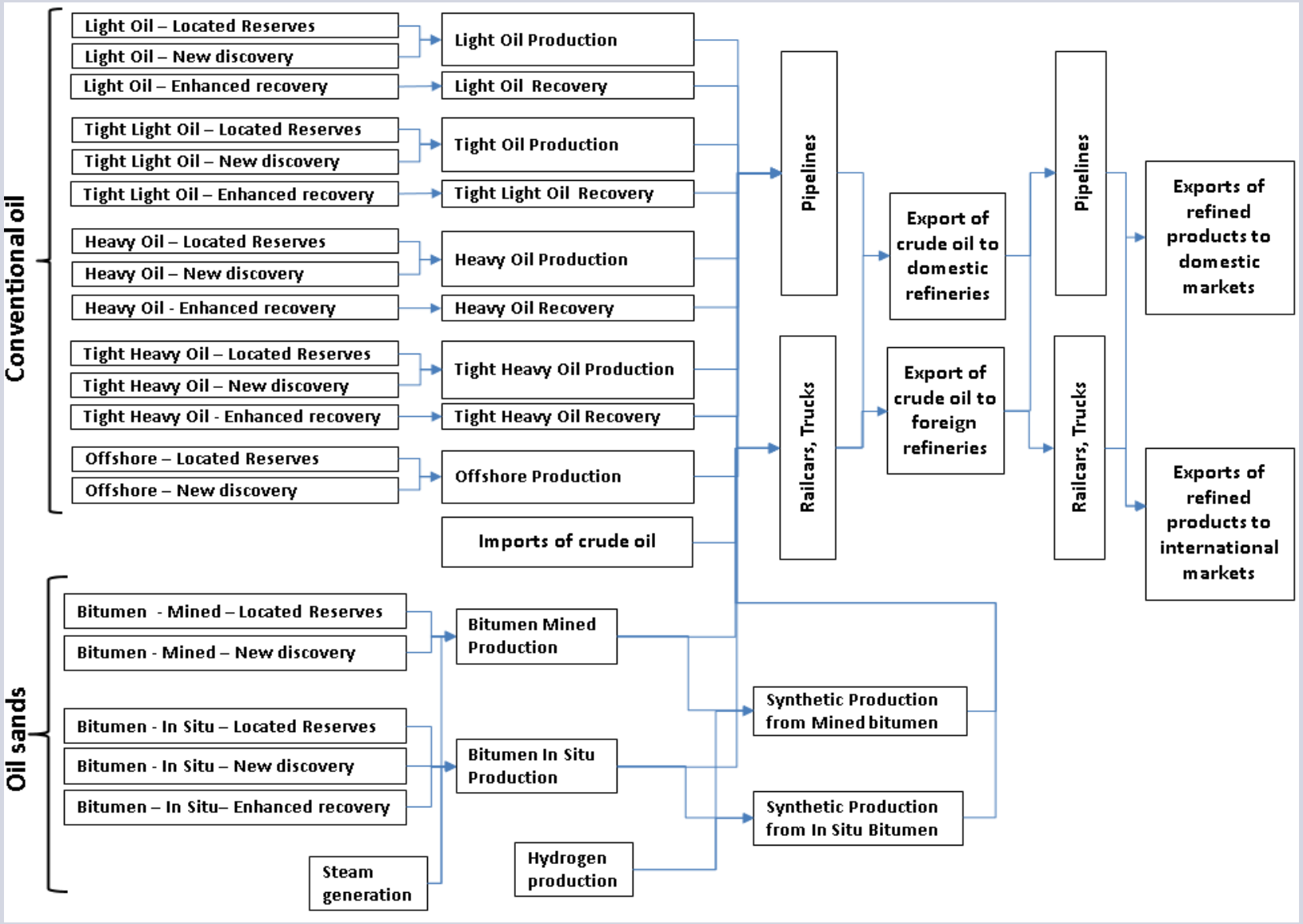
Three-model framework



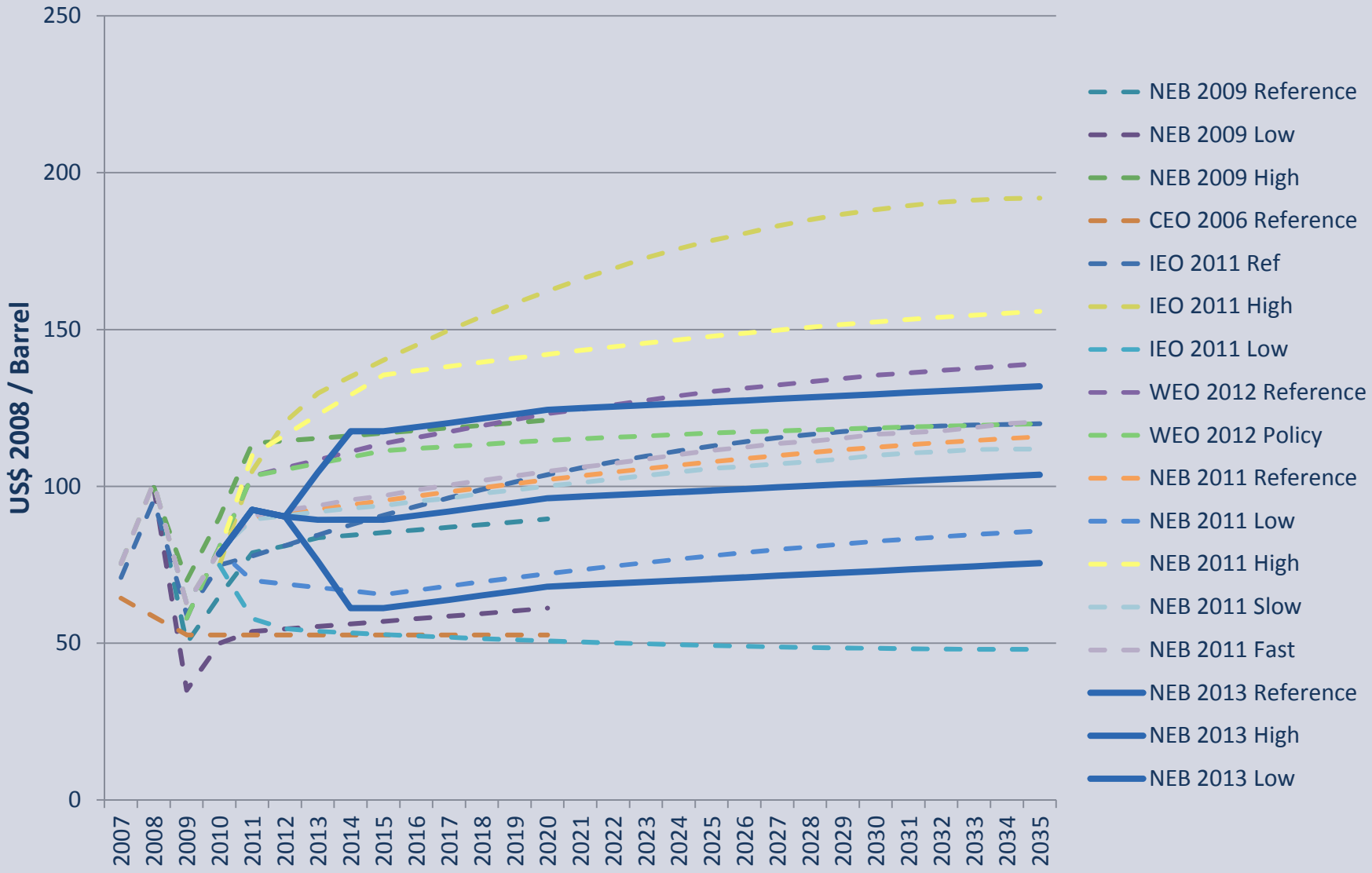
Analyzing the impact of pipeline projects on the Canadian energy system

Preliminary results for Canada up to 2050 – Do not quote

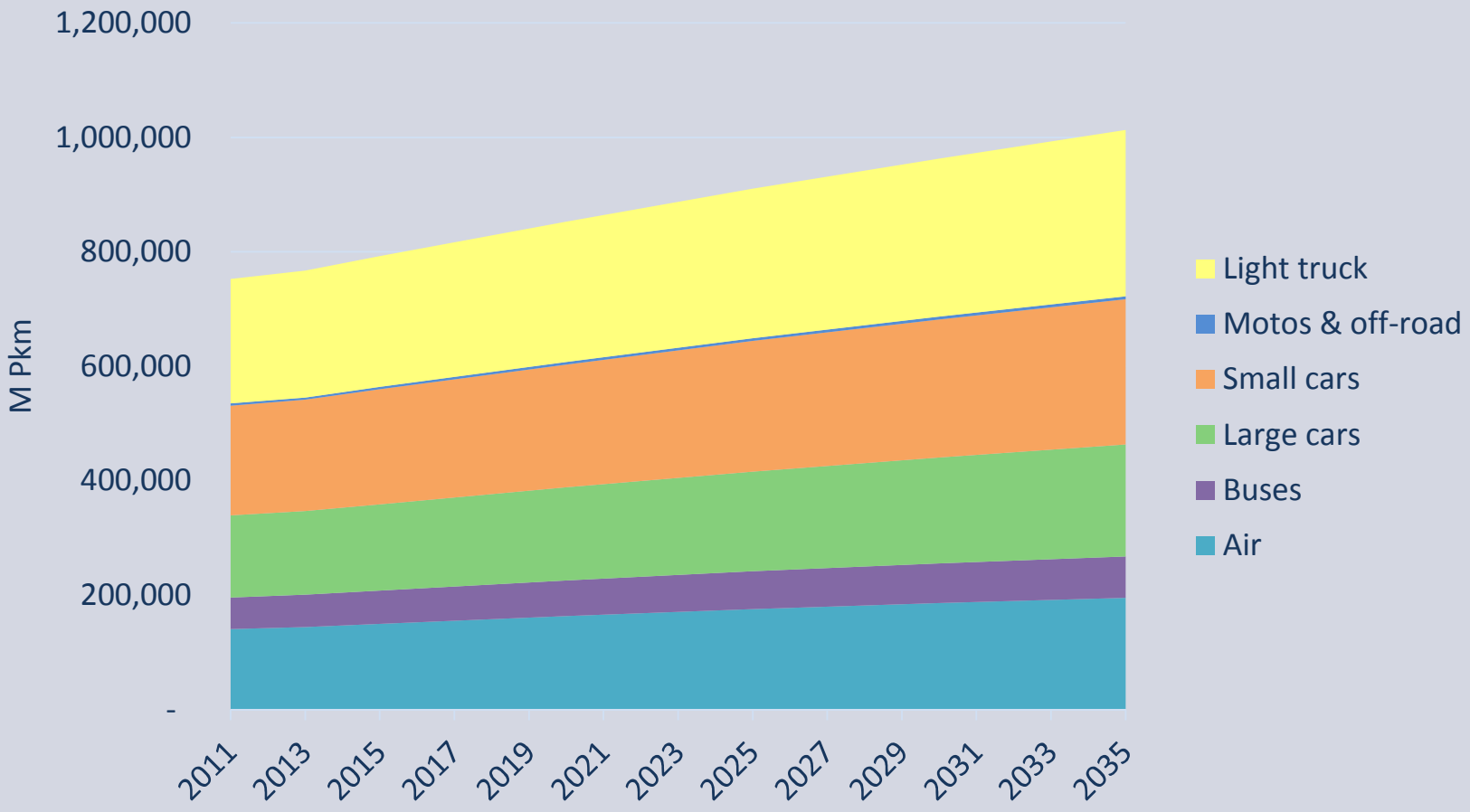
Representation of the oil sector



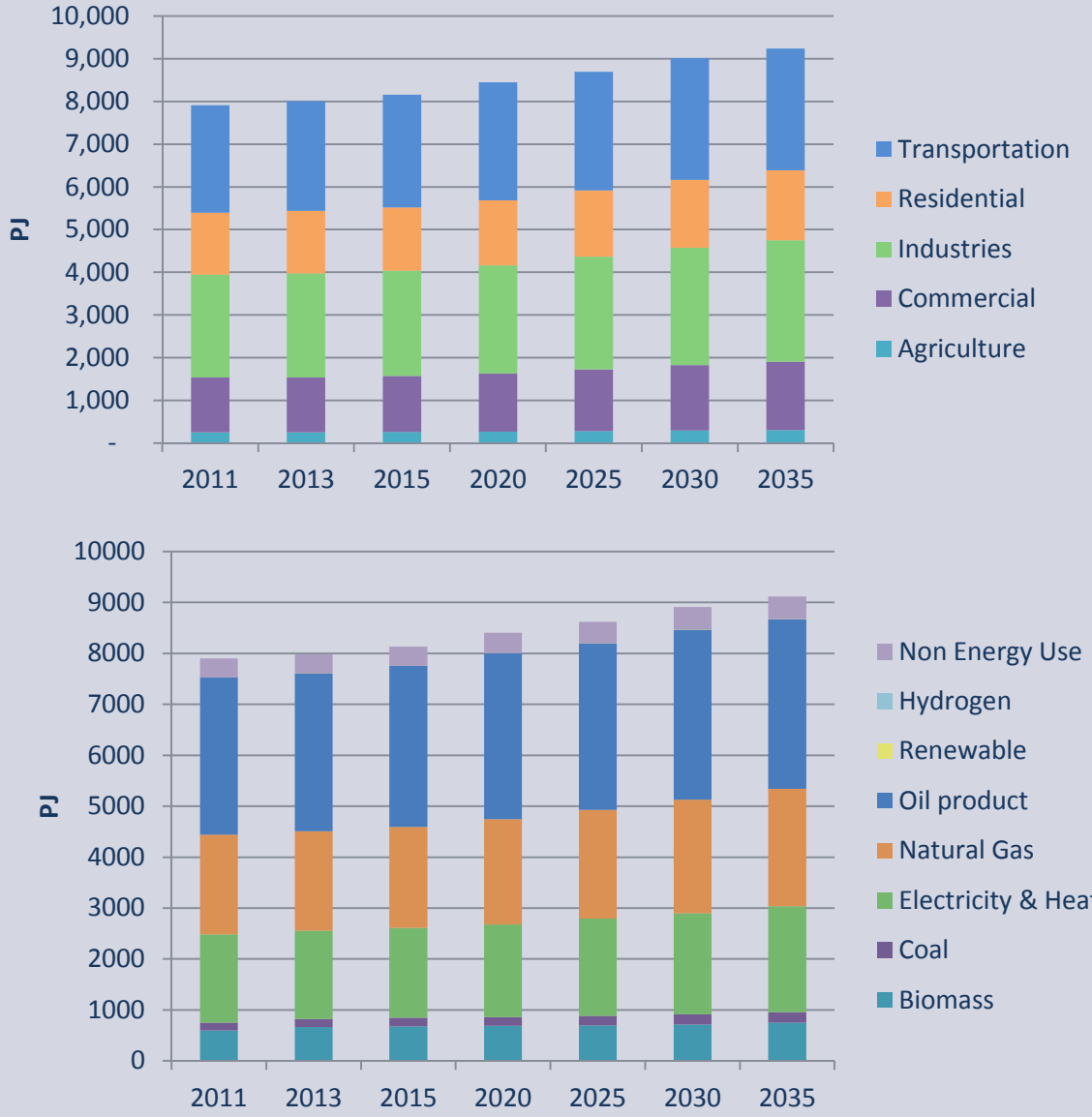
Oil prices in three baselines



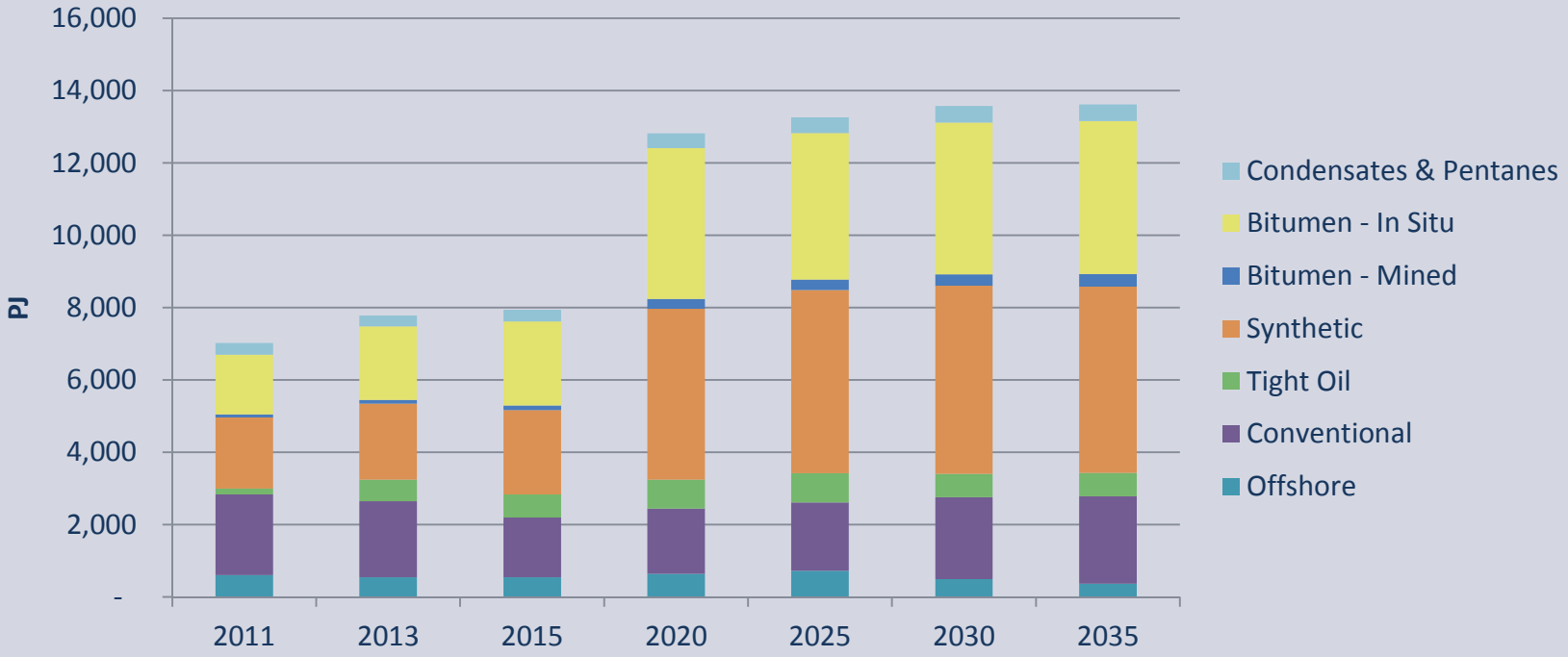
Demand for passenger transportation



Final energy consumption



Oil production



Impacts of pipeline projects

Exports to domestic markets

Pipeline	Target In-Service	Capacity (k bbl/day)
Enbridge Line 9 reverse	2015	300
TransCanada Energy East	2018	850
Total Capacity		1,150

Exports to international markets

Pipeline	Target In-Service	Capacity (k bbl/day)
Enbridge Mainline	1950	2500
Kinder Morgan Trans Mountain	1953	300
Spectra Express	1997	280
TransCanada Keystone	2010	591
Total Existing Capacity		3,671
Enbridge Alberta Clipper Expansion	2014	120
Enbridge Alberta Clipper Expansion	2016	230
TransCanada Keystone XL	2020	830
Trans Mountain Expansion	2017	590
Enbridge Northern Gateway	2017	525
Total Proposed Capacity		2,295

Source: CAPP (2014)

BAU: All projects

No South: Constraint to reach South and Central USA markets.

No West: Constraint to reach West Coast and Asian markets.

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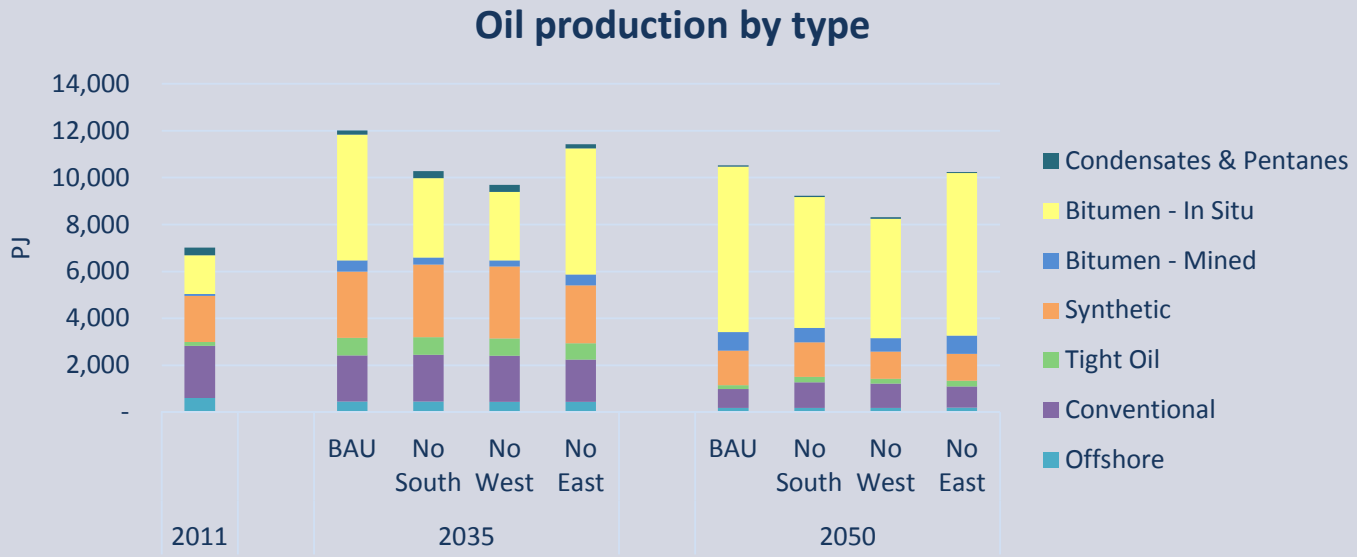
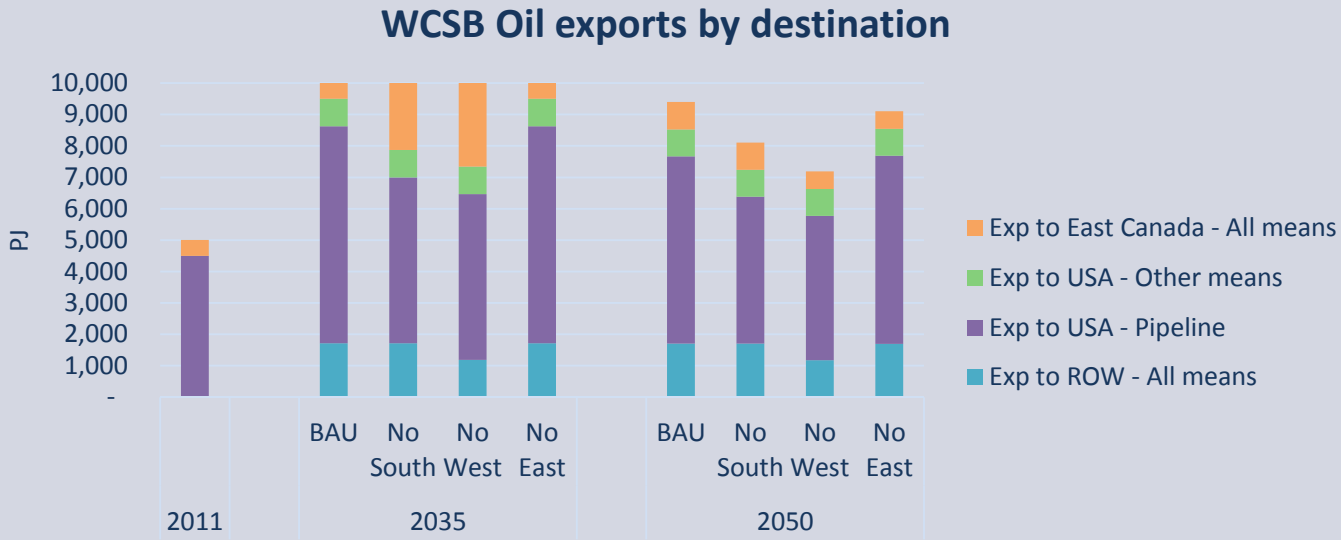
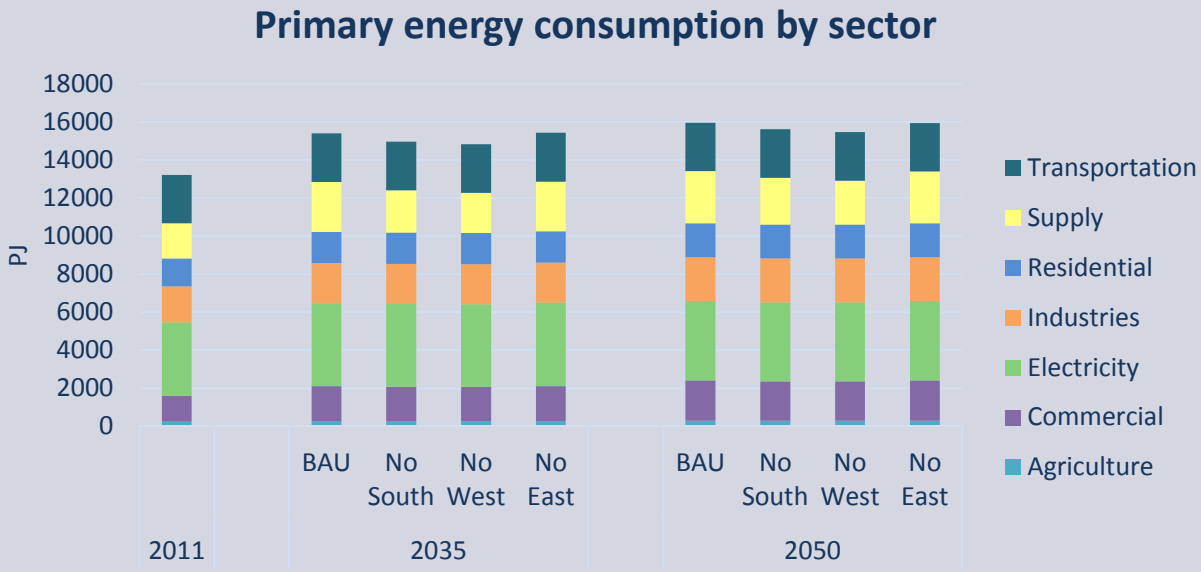
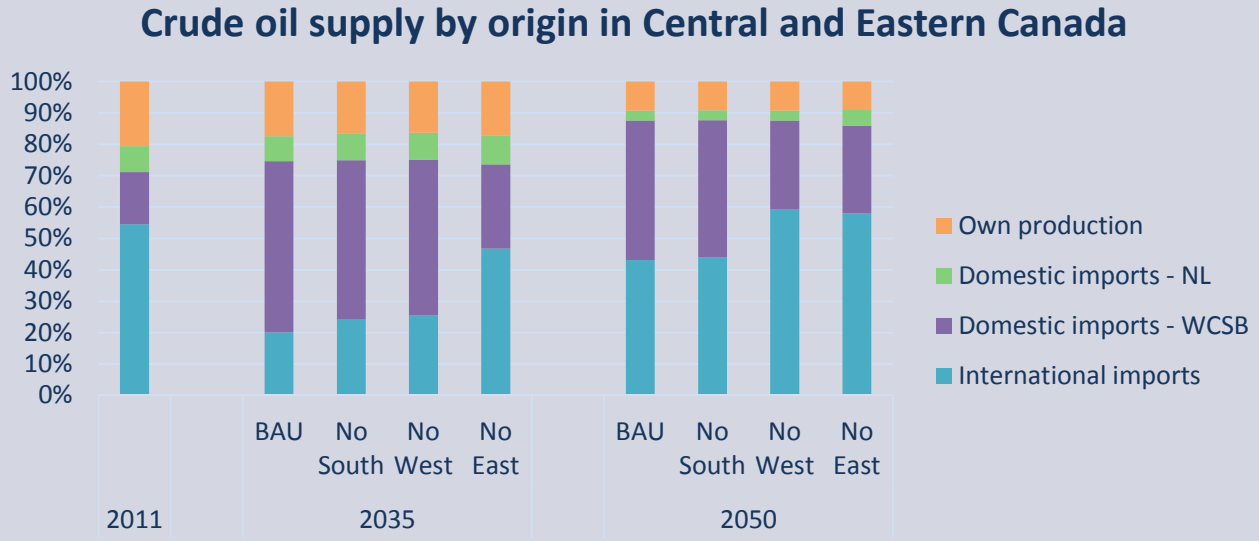
Impacts on the Canadian oil sector



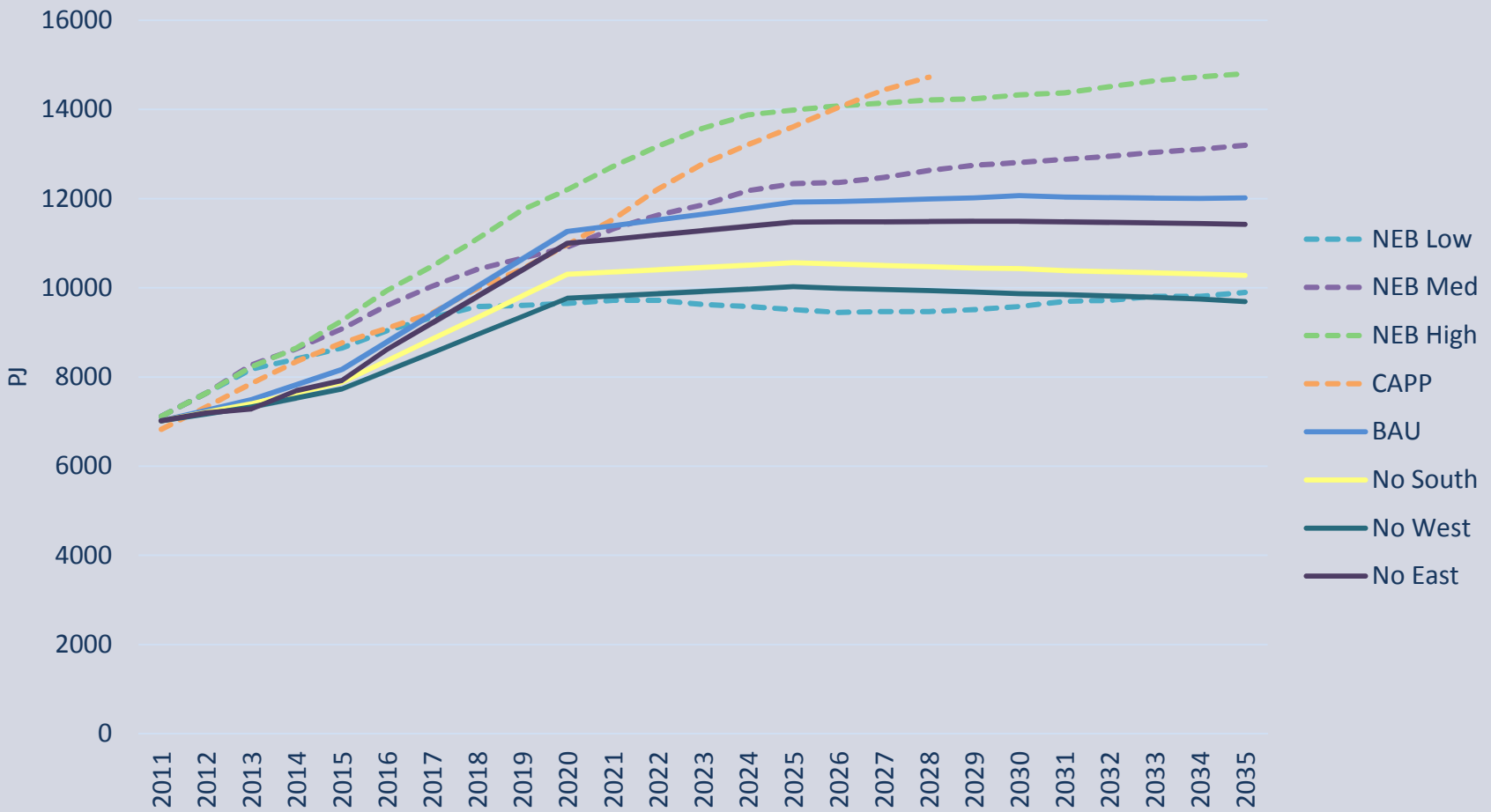


Impacts on the Canadian energy system





Oil exports from WCSB



Analyzing the impact of pipeline projects on the Canadian energy system

Preliminary results for Newfoundland & Labrador up to 2035

– Do not quote

Impacts of pipeline projects

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Impacts of pipeline projects

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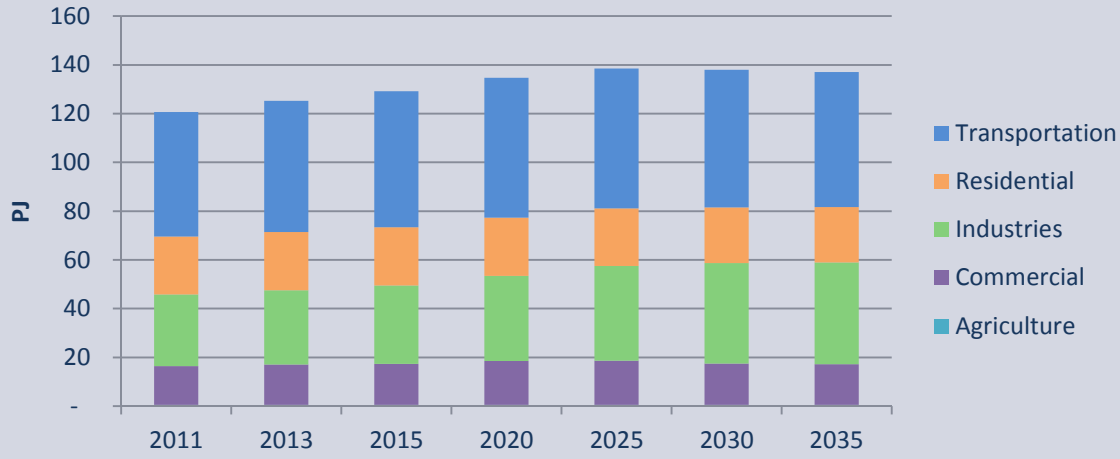
TransCanada Pipeline

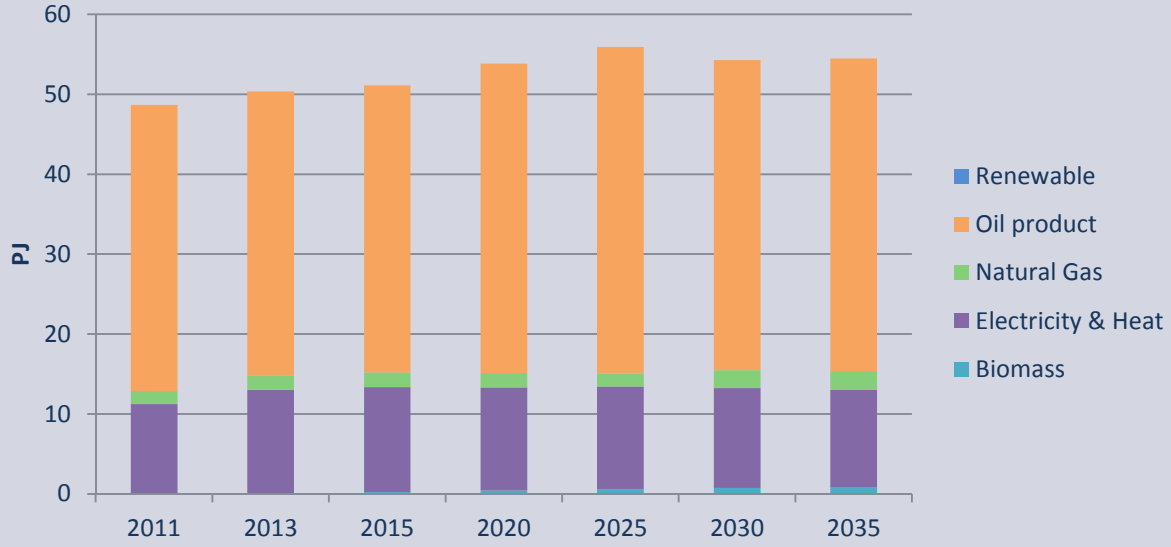
S1: Access to QC, NB, NL

S2: No access for NL

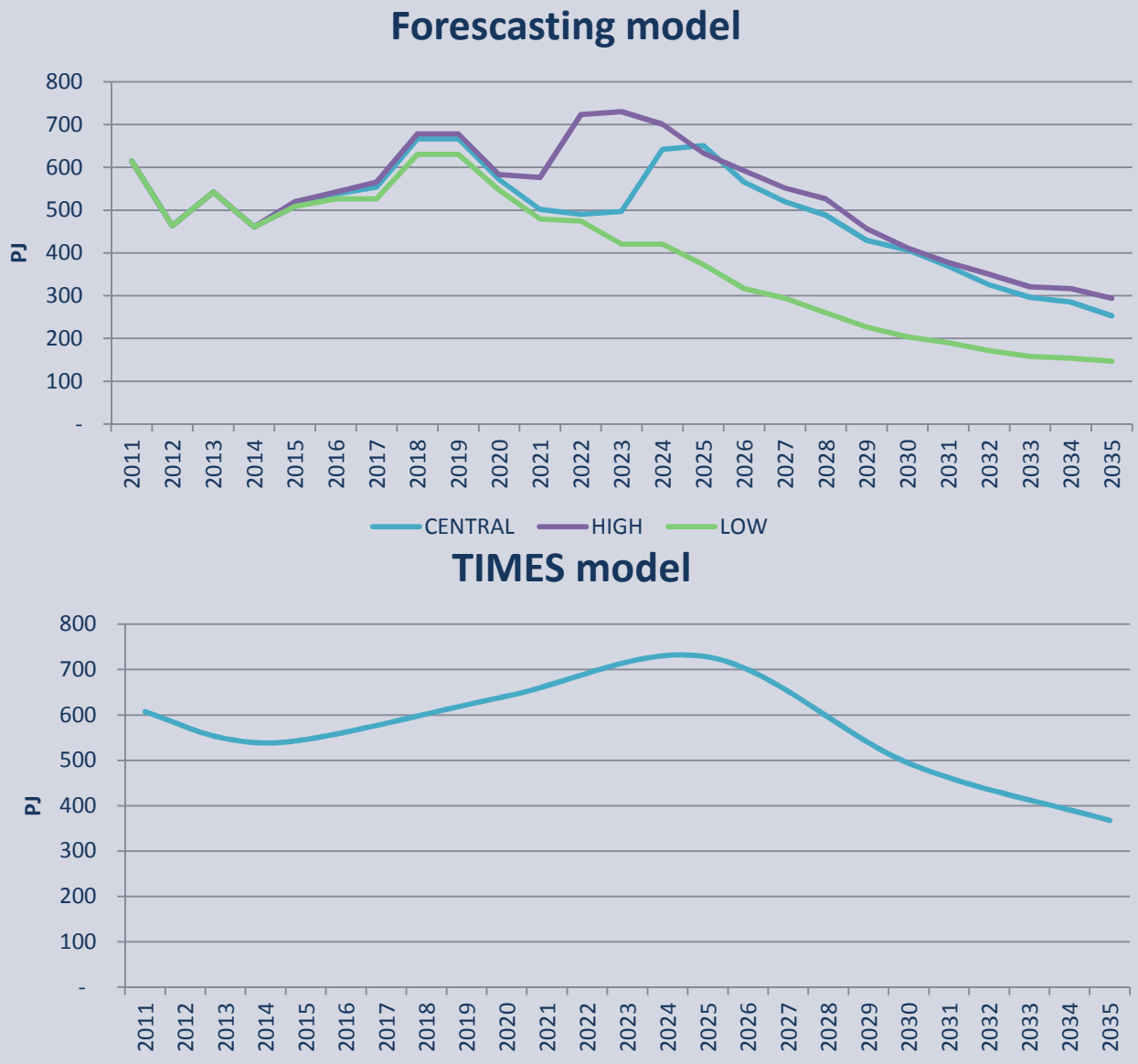
S3: More access for NL

Final energy consumption

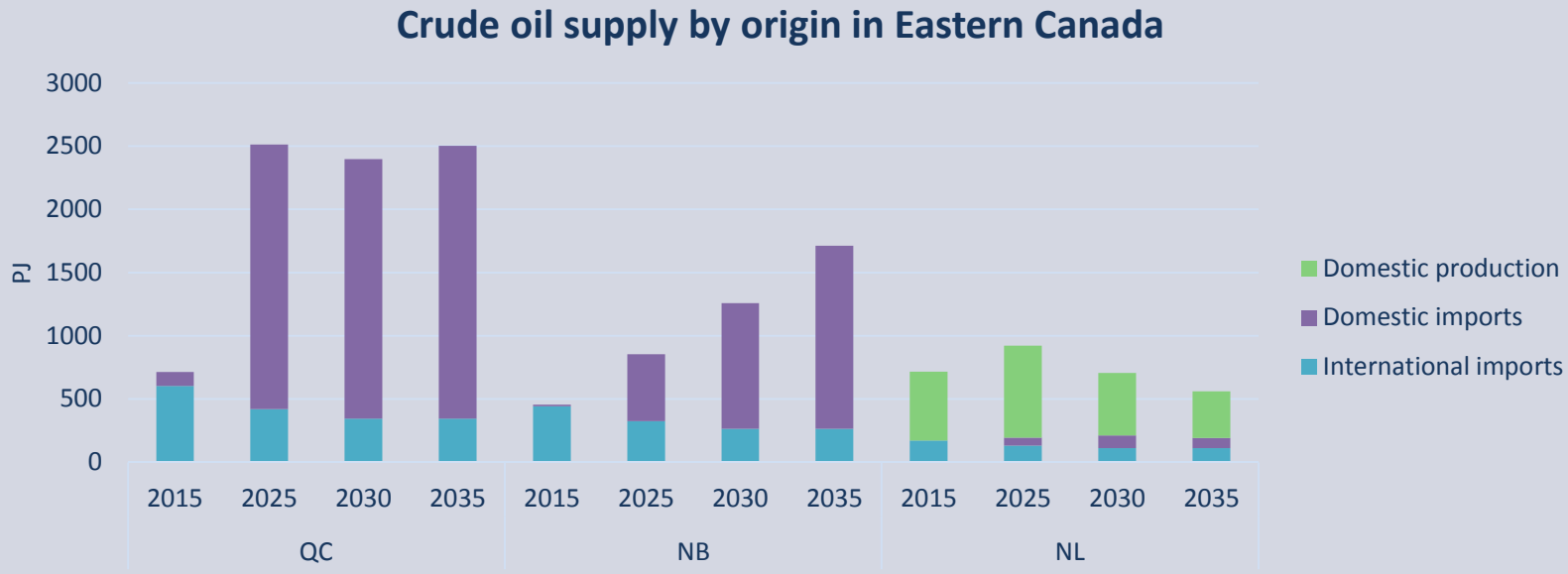


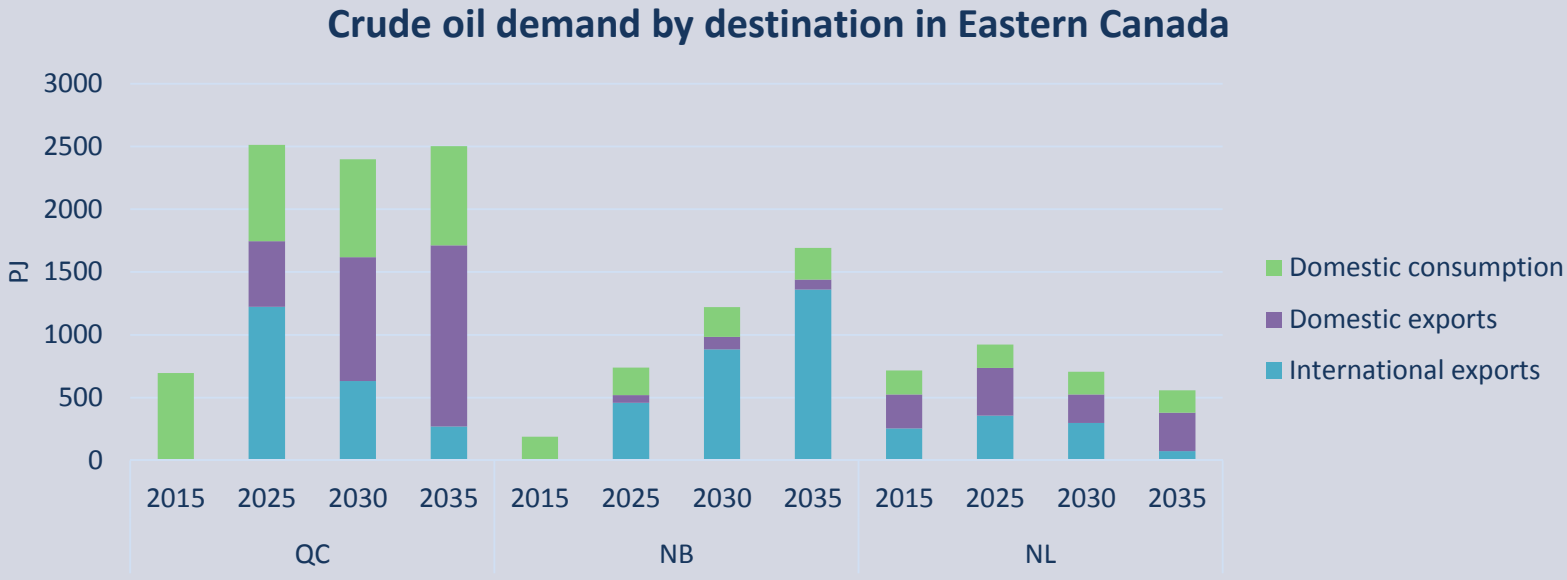


Oil production

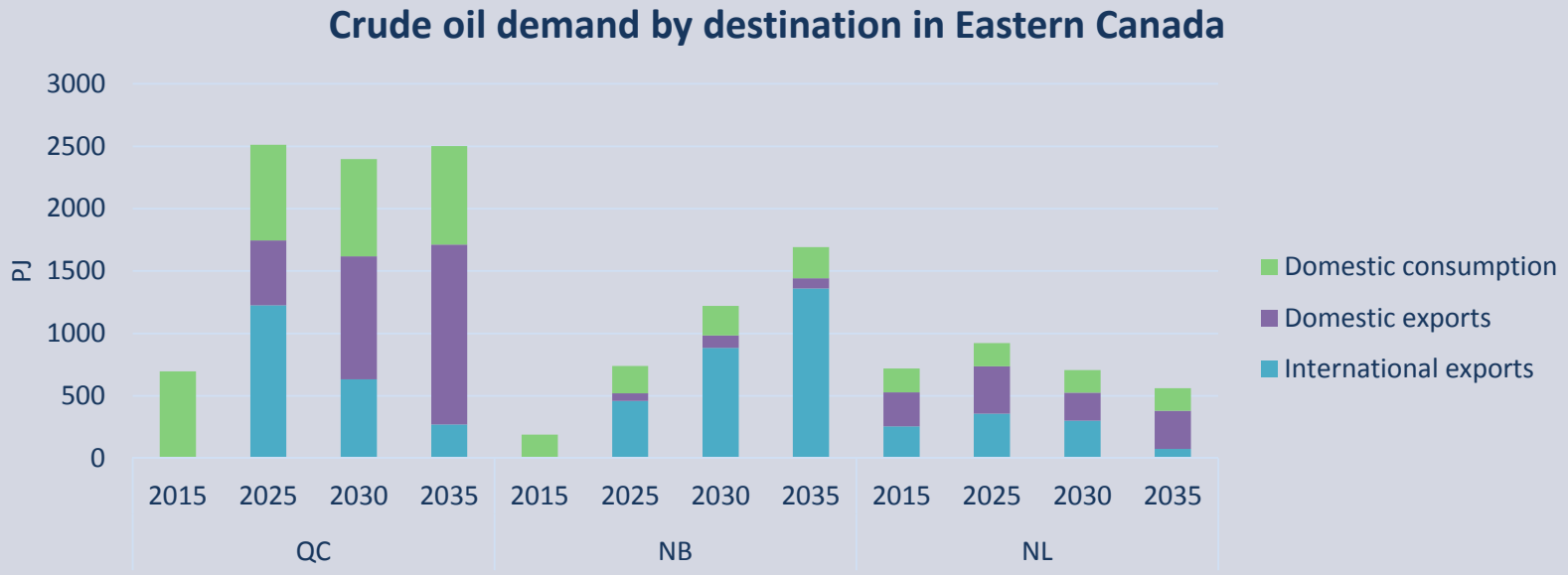


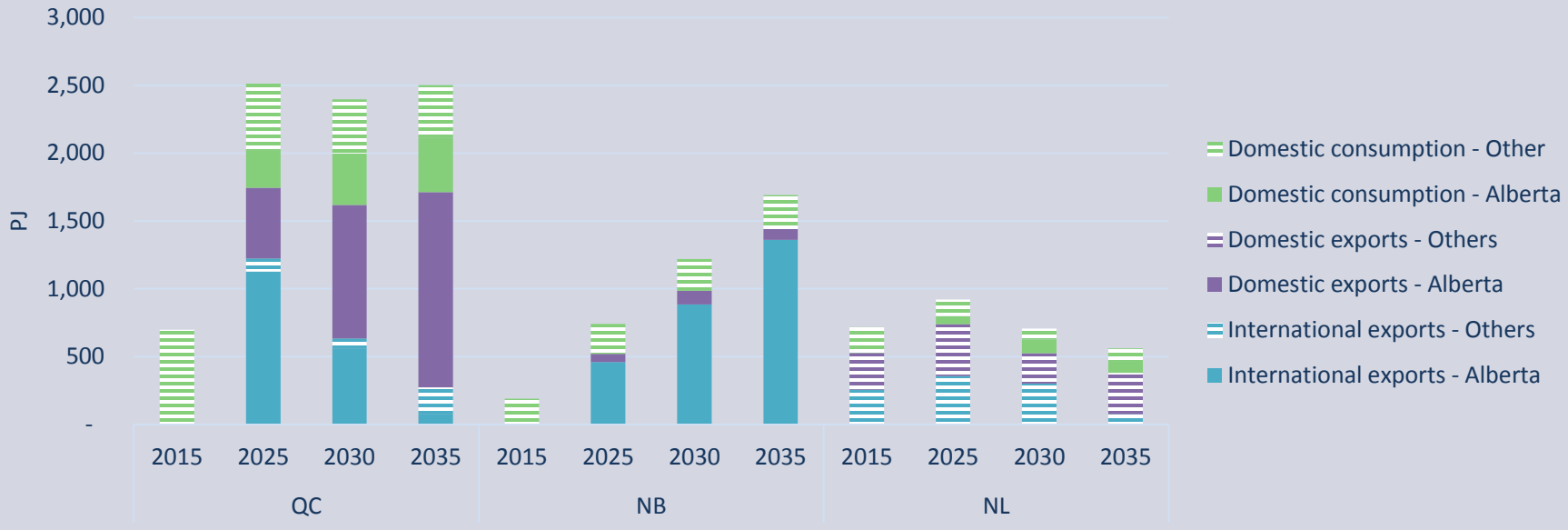
Oil disposition in Eastern Canada



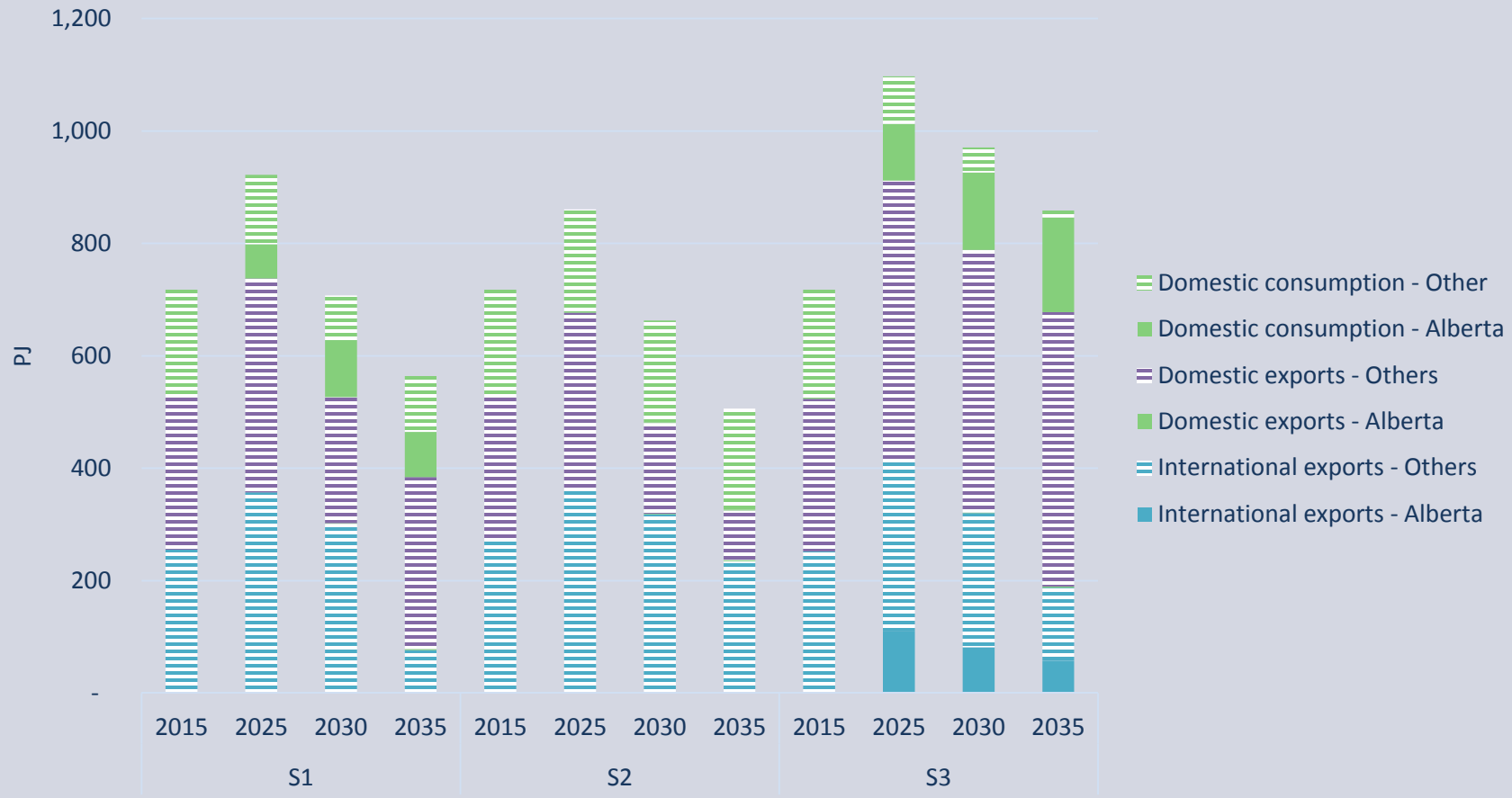


Oil disposition in Eastern Canada



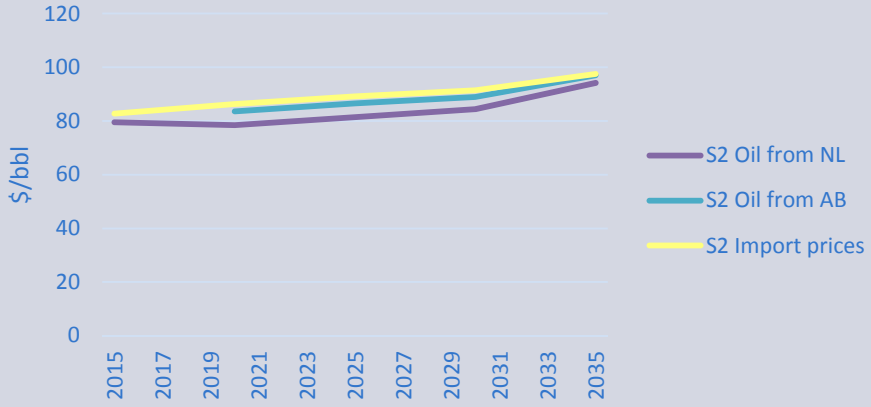


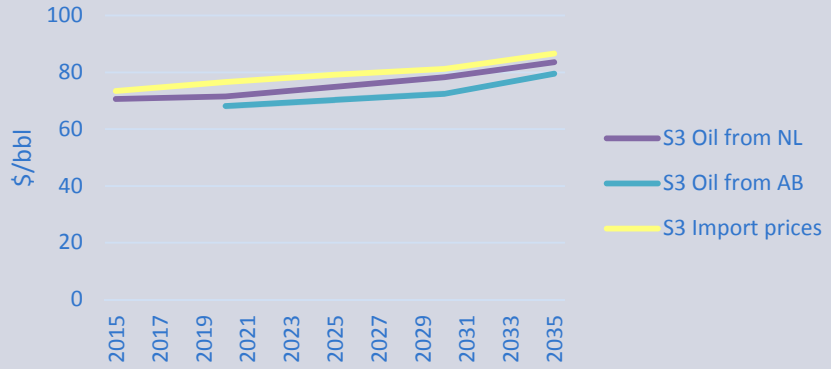
Oil disposition in NL



Oil prices


120
100
80
60
40
20
0
$/bbl
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
S2 Oil from NL
S3 Oil from NL
S2 Oil from AB
S3 Oil from AB


120
100
80
60
40
20
0
$/bbl
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
S2 Oil from NL
S2 Oil from AB
S2 Import prices


100
80
60
40
20
0
$/bbl
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
S3 Oil from NL
S3 Oil from AB
S3 Import prices

Future works

Test other scenarios

- Socio-economic growth – NALEM
- Oil reserves – Oil forecasting model
- Pipeline projects

Allow more flexibility in the model

- Upgrading activities (on-site or at refineries)
- Transportation options and their capacity
- International imports of crude oil and refined products

Make sensitivity analysis on key factors

- Production costs by type of oil commodity
- Transportation costs – pipelines and others
- Crude mix as input to refineries
- Pipeline capacity

Thank you for your attention

kathleen@esmia.ca

yuri-ernesto.alcocer-morales@hec.ca

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