Tar Sands Analysis Data Sources, Assumptions And Methodology Document -

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Analysis	Data Sources	Assumptions	Methodology
Scenario1: Potential Portland-Montreal Pipe Line (PMPL) crude oil based refined products by sector.	Pipeline crude oil capacity in barrels per day –Sierra Club Report[1] Crude oil byproducts percentage yield: EIA[2] Historical fuel consumption in northeast states by sector: EIA SEDS[3] Refined products as percentage of existing consumption: Propane – 4.76% Gasoline - 4.41% Jet Fuel – 6.38% Kerosene – 2.05% Distillate Fuel – 6.36% Residual Fuel – 5.73%		Pipeline crude oil capacity in barrels per day is used to derive total barrels of oil to be transported from the pipeline annually. Crude oil byproducts percentage yield is used to derive amount of byproducts to be produced from the total barrels of pipeline crude oil annually. The byproducts are further divided into transportation, residential and commercial sector usage based on historical consumption distribution. The amount of crude oil products used in electric power and industrial sector are distributed back into transportation, residential and commercial sectors based on the ratio of their consumption.
Scenario 2: Tar sand refined products as 15% of the existing consumption	Historical fuel consumption in northeast states by sector: EIA SEDS[3]		The refined products are further divided into transportation, residential and commercial sector usage based on historical consumption distribution. The amount of products used in electric power and industrial sector are distributed back into transportation, residential

			and commercial sectors based on the ratio of their consumption.
Figure 1: Cost and Emissions Associated with Cleaner Alternatives to reduce oil demand by 15% in 2022		It assumes reductions in the heating sector come from efficiency (50%) and air source heat pumps (50%) and in the transportation sector from switching light duty vehicles to electric vehicles and heavy duty vehicles to natural gas.	The cost and emissions numbers presented for all sectors for the year 2022 are calculated as described below.
Heating Sector - Combined Residential and Commercial Sector			
Figure 2: Fuel/Power, Equipment and Infrastructure Cost for Alternative Heating Options versus Heating Oil from 2013-2022 (2013$)	Fossil fuel prices: EIA AEO[3] Cord wood and wood pellets prices: Maine Government Home Energy Calculator.[4]	Oil efficiency total resource cost: 7.21 $/MMBTU Oil efficiency savings: 1% incremental efficiency of 2011 oil products sales in northeastern states with a 15 years measure life. Heating equipment average efficiency:- Electricity Heat Pump (Air Source): 250% Electricity Heat Pump (Ground Source): 250% Natural Gas: 77% Wood Pellet Boiler:80% Wood Pellets Stove:78% Wood Chips Boiler:75% Heating Oil: 72% Heating equipment's average cost:- Electricity Heat Pump (Air Source): $4000 Electricity Heat Pump (Ground Source): $23000 including 30% federal incentives until year 2016.[5]. Natural Gas: $7500	Total annual oil heating thermal need (sum of residential and commercial sector) in billion BTU to be met by pipeline oil products was calculated by multiplying average oil equipment efficiency with the total annual pipeline heating oil products in billion BTU. Then total annual heating need is divided by the equipment efficiency of alternative technology types to derive annual alternative fuel demand in billion BTU. Fuel prices are multiplied by the total annual alternative fuel demand to derive annual fuel expenditure for each technology type. Heating oil expenditure is evaluated based on multiplying its demand and price. Alternative fuels and oil equipment cost was divided by per house alternative fuel and oil demand in billion BTU and equipment age to derive equipment cost in dollar per billion BTU. Then equipment cost in dollar per billion BTU is multiplied with the annual alternative fuel and oil demand to derive total alternative and oil equipment expenditure.

		Cord Wood: $3500 Wood Pellets:$3500 Heating Oil: $7500 Heating equipment's average life:- Electricity Heat Pump (Air Based): 15 Electricity Heat Pump (Geothermal): 25 Natural Gas: 20 Cord Wood: 20 Wood Pellets:20 Distillate: 20 Amortization rate: 5% Other installation cost:- Natural Gas Service Hook Up: $4283 Natural Gas Main Extension Cost: $6300 3% of the heating oil homes are assumed to need only installation. 27% of the homes are assumed to need installation and service hookup. 70% of the oil homes are assumed to need installation, service hookup and main extension cost Per household annual oil consumption: 700 Gallons Discount rate: 3% Fuel switching and efficiency is assumed to happen in the year 2013.	Equipment cost was further amortized annually over the equipment life. Total expenditure for each technology type was derived as the sum of net present value of 10 years of fuel and amortized equipment expenditure.

Figure 3: GHG Emissions for Alternative Heating Options versus Tar-Sands-Derived and Conventional Heating Oil (2013-2022)	Direct emission factors: EPA[6] Production emission factors: Natural Gas – World Resource Institute[7] Tar Sand Crude Oil – Congressional Service Report[8]	Electricity indirect emission factor – Natural Gas Combines Cycle Factor of about 108 KG CO2/MMBTU	Direct annual emissions for each alternative technology type and heating oil except those using electricity as fuel source were calculated by multiplying their direct emission factors with the total annual alternative fuel and oil demand in billion BTU. Indirect annual emissions for each alternative technology type using electricity as fuel source were calculated by multiplying electricity emission factor with the total annual alternative fuel need in billion BTU. Production emissions for each alternative technology type and heating oil from tar sands were calculated by multiplying their production emission factors with the total annual alternative fuel and oil need in billion BTU. Total emissions were presented as the sum total of emissions over 10 years.
Table 2: Number of Homes and Businesses Treated to Offset Tar-Sands-Derived Heating Fuel under Scenarios 1 and 2		Oil with efficiency houses and businesses are defined as those with an average 30% of heating oil needs reduced by efficiency measures in both residential and commercial sector. Electric heat pumps (air source), cord wood and wood pellet based houses are those with 50% of their heating need supplied by these technology types in the residential sector. For the commercial sector these technology types cover 100% of need. Electric heat pumps (ground source) and natural gas based houses and businesses are those with 100% of the heating need	Total annual heating need was divided by per house and business heating need and percentage of supplemental heat provided by the alternative technology type to derive number of houses and businesses to be retrofitted respectively.

		supplied by these sources for both residential and commercial sector. Commercial establishment consumption is assumed to be 4000 gallons.	
Home heating fuel bills and savings for different residential house types.		Oil with efficiency houses are defined as those with 30% of oil need reduced by efficiency measures and rest supplied by oil based heat. Electricity heat pumps (air source), cord wood and wood pellets based houses are those with 50% of the heating need supplied by alternative fuel and rest by heating oil. Electricity heat pumps (geothermal) and natural gas based houses are those with 100% of the heating need supplied by alternative fuel.	Different house type annual fuel bills were calculated by multiplying respected house fuel need in billion BTU with the fuel price.
Transportation Sector			
New fuel efficiency and GHG emission program for medium and heavy-duty vehicles, model year 2016-2018 impact.[9]	Baseline and proposed fuel economy for heavy duty vehicles.[9]	Average annual heavy duty vehicle fuel need: 11500 gallons.[10]	The increase in annual fuel economy was calculated by subtracting each year's proposed fuel economy from the baseline fuel economy. Then average annual miles travelled for heavy duty vehicles were calculated by multiplying baseline fuel economy with the fuel need of the vehicles. Further, total transportation fuel saved due to the increase in fuel economy was calculated by dividing average annual miles travelled with change in fuel economy for the vehicles.

			Finally, total transportation energy need in billion BTU was derived by subtracting pipeline transportation oil products in billion BTU with the above calculated savings achieved by standards for heavy duty vehicles in each year.
Figure 4: Light Duty Vehicle Fuel/Power and Incremental Vehicle and Infrastructure Costs for Alternative Transportation Options versus Oil Products from 2013-2022 (2013$) Figure 5: Heavy Duty Vehicle Fuel and Incremental Vehicle and Infrastructure Costs for Alternative Transportation Options versus Oil Products from 2013-2022 (2013$)	Fossil fuel prices and Gasoline demand forecast: EIA AEO[3] Biodiesel and Hydrogen Prices: Argonne National Laboratory VISION Model[11]	Light duty vehicles (LDV) equipment efficiency ratio (alternative vehicle efficiency/traditional vehicle efficiency):- Electric Vehicles (EV)- 3 Hydrogen- 2.3 Natural Gas- 1 E85- 1 Heavy duty vehicles (HDV) equipment efficiency ratio (alternative vehicle efficiency/traditional vehicle efficiency):- Biofuels- 1 Natural Gas- 0.9 Light duty vehicle equipment's incremental cost: - See the table 1 below. Heavy duty vehicle incremental cost:- CNG truck incremental cost (short haul) – 1623 dollars per BTU with life of 15 years. LNG truck incremental cost (long haul) - 1507 dollars per BTU with life of 30 years. Alternative vehicle replacement for natural gas is 50% CNG as for short haul trucks and 50% LNG as for long haul trucks.	Above derived total annual transportation energy need including fuel economy standards and gasoline demand forecast impacts was phased over the period of first 10 years (2013-2022) uniformly to establish phased replacement of technology. Then the phased annual need was divided by the equipment efficiency ratio of alternative vehicles types to derive phased annual alternative fuel demand in billion BTU. Fuel prices were multiplied by the total phased annual alternative fuel and oil demand to derive annual fuel expenditure for each alternative fuel and oil vehicle type. Alternative vehicle's incremental cost was divided by per vehicle annual fuel demand in billion BTU and equipment age to derive cost in dollar per billion BTU. Then incremental cost in dollar per BTU was multiplied by the annual alternative fuel demand to calculate total alternative equipment expenditure. Total transportation fuel need was divided by per vehicle fuel need for both LDVs and HDVs to derive number of vehicles required each year. Number of vehicles was multiplied by chargers and public station cost to derive infrastructure cost for each alternative fuel based vehicle type. Finally net present value of sum of fuel, alternative

		Electric vehicles infrastructure cost: Level 1 Charger: $500 (1 charger per vehicle) Level 2 Charger: $9000 (1.3 stations per 1000 vehicles) Hydrogen, E85 and natural gas vehicles infrastructure cost: $1014000 (1.3 stations per 1000 vehicles) Biodiesel vehicles infrastructure upgrade cost: $172000 (1.3 stations per 1000 vehicles) Average annual light duty vehicle fuel consumption: 529 gallons.[10] Average annual heavy duty vehicle fuel consumption: 11500 gallons.[10]	vehicle increment and infrastructure expenditure for 10 years was calculated to derive total expenditures.
Figure 6: GHG Emissions for Alternative Transportation Options (LDVs) versus Tar-Sands-Derived and Conventional Oil Products (2013-2022) Figure 7: GHG Emissions for Alternative Transportation Options (HDVs) versus Tar-Sands-	Direct emission factors: EPA.[6] Production emission factors: Natural Gas – World Resource Institute[7] Tar Sand Crude Oil – Congressional Service Report[8] E85, Biodiesel and Hydrogen Emission Factors - California Air Resource Board carbon intensity factors.[12]	Electricity indirect emission factor – Natural Gas Combines Cycle Factor of about 108 KG CO2/MMBTU	Direct annual emissions for each alternative fuel and traditional vehicle, except electric vehicles, were calculated by multiplying their direct emission factors with the total annual phased alternative fuel and petroleum demand in billion BTU. Indirect annual emissions from electric vehicles were calculated by multiplying electricity emission factor with the total annual phased alternative fuel demand in billion BTU. Production emissions for each alternative fuel and tar sand oil products based vehicles were calculated by multiplying their production emission factors with the total annual phased alternative fuel and oil need in billion BTU.

Derived and Conventional Oil Products (2013-2022)			Total emissions were presented as the sum total of emissions over 10 years.

Table1: Transportation Light Duty Vehicle Cost

Vehicle Cost ($/billion btu)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
EV	10,414	10,245	10,079	6,765	6,603	6,445	6,289	6,136	5,985	5,837	5,691	6,931	6,579
E-85	298	322	348	375	405	438	473	510	551	595	642	649	656
Diesel	1,758	1,750	1,743	1,736	1,729	1,722	1,715	1,708	1,701	1,694	1,687	1,689	1,691
CNG	7,047	7,077	7,107	7,138	7,169	7,200	7,231	7,262	7,293	7,325	7,356	7,363	7,371
Diesel HEV	9,301	8,632	8,011	7,434	6,900	6,403	5,943	5,515	5,119	4,750	4,409	4,481	4,555
Hydrogen (Fuel Cell)	54,658	53,791	52,938	47,058	46,232	50,460	49,660	48,873	48,098	47,335	46,585	45,138	43,736

For Further Information:

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End Notes:

[1] http://www.sierraclub.org/dirtyfuels/tar-sands/field-maine.pdf
[2] http://www.eia.gov/petroleum/data.cfm
[3] http://www.eia.gov/forecasts/aeo/index.cfm
[4] http://maine.gov/energy/fuel_prices/heating-calculator.php
[5] http://energy.gov/savings/residential-renewable-energy-tax-credit
[6] http://www.epa.gov/climateleadership/documents/emission-factors.pdf
[7] http://pdf.wri.org/clearing_the_air_full.pdf
[8] http://www.fas.org/sgp/crs/misc/R42537.pdf
[9] http://www.nhtsa.gov/fuel-economy/
[10] http://www.afdc.energy.gov/data/tab/all/data_set/10308
[11] http://www.transportation.anl.gov/modeling_simulation/VISION/
[12] http://www.arb.ca.gov/fuels/lcfs/lu_tables_11282012.pdf