

# CO<sub>2</sub> INJECTION FOR GEOLOGICAL STORAGE: *Emissions from Fossil Fuels at the Global Scale*

1. Determine the total fossil fuel consumption in 2013 for the US, China, and Norway in MTOE\*. A good source of data is the BP Statistical Review of World Energy (<http://www.bp.com/statisticalreview>). You can download the data and do calculations on a spreadsheet. Or, use fossil fuel consumption summarized in Table 1 of this worksheet, and complete the calculations for natural gas and total fossil fuel consumption below.

Calculations:

U.S.

	831		MTOE oil +	
=			MTOE natural gas +	
	456		MTOE coal	
			MTOE fossil fuel total	

Calculations:

China

	507		MTOE oil +	
=			MTOE natural gas +	
	1925		MTOE coal	
			MTOE fossil fuel total	

Calculations:

Norway

	10.6		MTOE oil +	
=			MTOE natural gas +	
	0.7		MTOE coal	
			MTOE fossil fuel total	

\*MTOE, "million tons of oil equivalent", is a measure of energy content often used to compare fuel consumption. For example, the energy content of 39.2 BCF of natural gas is equivalent to the energy content of one million tons of oil.

Also, all references to "tons" mean metric tons, sometimes written as "tonnes". A metric ton is 1000 kg. A metric ton is 1.1023 "short tons". A short ton (the convention "ton" in the US) is 2000 lb.

Figure 1 shows oil consumption for the U.S., China, and Norway from 2000 to 2013. Figure 2 shows natural gas consumption, and Figure 3 shows coal consumption. Table 1 lists the data from the BP Statistical Review of World Energy, 2014.

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**CO<sub>2</sub> INJECTION FOR GEOLOGICAL STORAGE:**  
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2. Determine the total amount of CO<sub>2</sub> emissions from each country in 2013.

U.S.

<u>Oil</u> :
<u>Gas</u> :*
*Self-check: Emissions for natural gas should be 1491 Mt CO <sub>2</sub>
<u>Coal</u> :
<u>TOTAL</u> :

China

<u>Oil</u> :
<u>Gas</u> :
<u>Coal</u> :
<u>TOTAL</u> :

Norway

<u>Oil</u> :
<u>Gas</u> :
<u>Coal</u> :
<u>TOTAL</u> :

39.2 BCF (billion standard cubic feet) of natural gas = 1 MTOE

2 million tons of coal = 1 MTOE

1 Mt natural gas = 48 BCF gas

**Approximate CO<sub>2</sub> emitted by burning fossil fuel:**

2 ton CO<sub>2</sub>/ton coal

3 ton CO<sub>2</sub>/ton oil

2.75 ton CO<sub>2</sub>/ton natural gas

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3. Determine the CO<sub>2</sub> emissions per capita from each country in 2013. Your answer should be in tons CO<sub>2</sub>/person/year. (How would your answer be different if you gave it in tons of carbon/person/year?) The values listed below are from the U.S. Census Bureau International Database <http://www.census.gov/population/international/data/idb/informationGateway.php>

2010 Population of the United States: 316,438,601  
2010 Population of China: 1,349,585,838  
2010 Population of Norway: 5,148,000

CO <sub>2</sub> emissions per capita, U.S. (also give answer as C emitted per capita):
CO <sub>2</sub> emissions per capita, China (also give answer as C emitted per capita):
CO <sub>2</sub> emissions per capita, Norway (also give answer as C emitted per capita):

4. Determine the CO<sub>2</sub> emissions per U.S. dollar (USD) of gross domestic product (GDP) for each country. Your answer should be in kg CO<sub>2</sub>/USD. The CIA World Factbook is a good source of economic data. <https://www.cia.gov/library/publications/the-world-factbook/index.html> (note: numbers for 2013 are estimates and could change; data are in 2014 U.S. dollars)

2013 GDP of the United States: \$17.05 trillion (per capita income: \$53,900)  
2013 GDP of China: \$16.42 trillion (per capita income: \$12,100)  
2013 GDP of Norway: \$333.5 billion (per capita income: \$65,400)

CO <sub>2</sub> emissions per USD, U.S.:
CO <sub>2</sub> emissions per USD, China:
CO <sub>2</sub> emissions per USD, Norway:

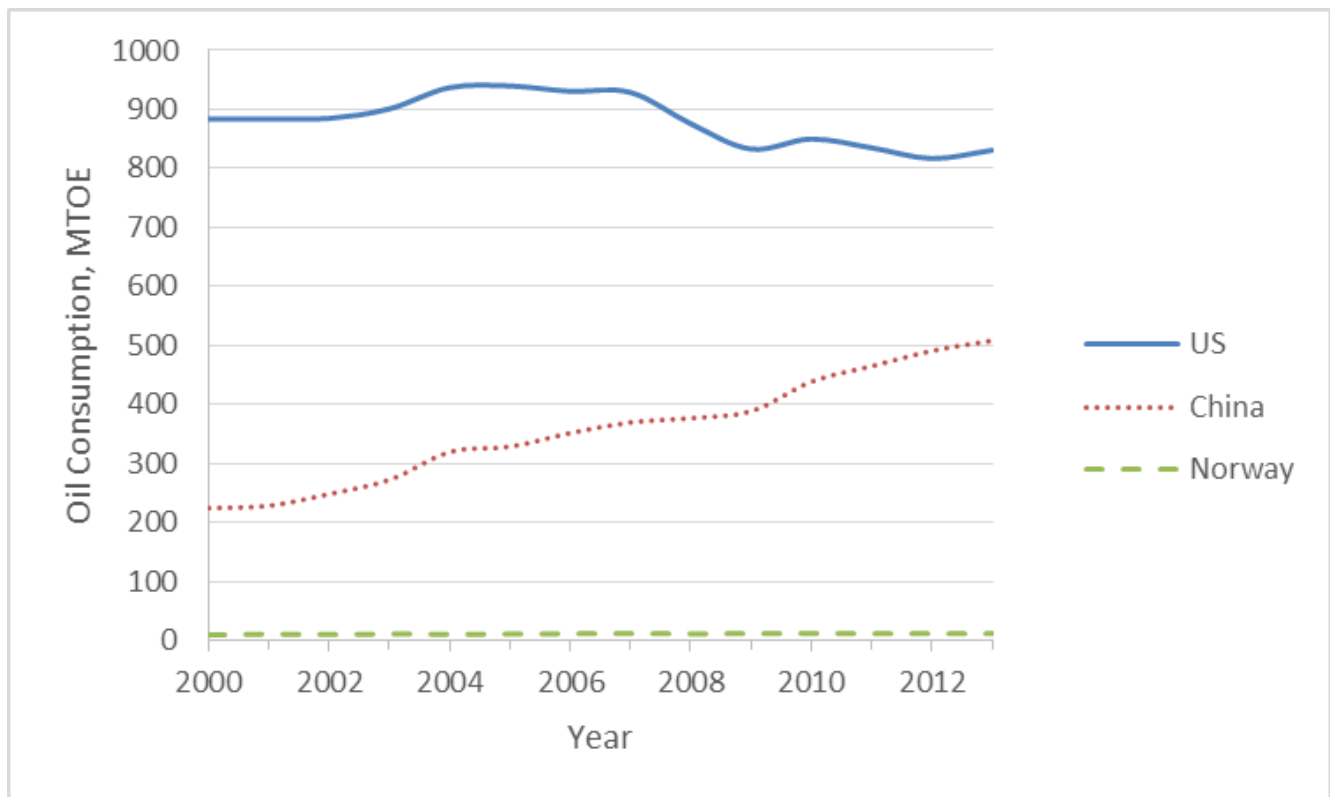
5. Which country
- Is the worst offender with respect to CO<sub>2</sub> emissions?
  - Has the most to gain from geologic sequestration?
  - Has the most to lose in a carbon-constrained world?

**CO<sub>2</sub> INJECTION FOR GEOLOGICAL STORAGE:  
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	Oil Million tonnes			Natural Gas Billion cubic feet per day			Coal Million tonnes oil equivalent		
	US	China	Norway	US	China	Norway	US	China	Norway
2000	884	224	9.4	63.8	2.4	0.39	569	710	0.99
2001	884	228	10.2	60.9	2.7	0.36	552	721	0.88
2002	885	248	9.8	63.1	2.8	0.39	552	760	0.77
2003	901	272	10.4	61	3.3	0.42	563	900	0.75
2004	937	319	10	61.2	3.8	0.44	566	1066	0.84
2005	940	328	10.2	60.3	4.5	0.43	574	1186	0.72
2006	931	351	10.5	59.4	5.4	0.43	566	1318	0.62
2007	929	369	10.7	63.3	6.8	0.41	573	1393	0.68
2008	876	376	10.4	63.6	7.8	0.42	564	1441	0.7
2009	833	388	10.6	62.8	8.7	0.4	496	1580	0.49
2010	850	438	10.8	65.1	10.4	0.4	526	1676	0.63
2011	835	464	10.6	67.1	12.6	0.4	495	1761	0.7
2012	817	490	10.5	69.8	14.1	0.4	437	1856	0.7
2013	831	507	10.6	71.3	15.6	0.4	456	1925	0.7

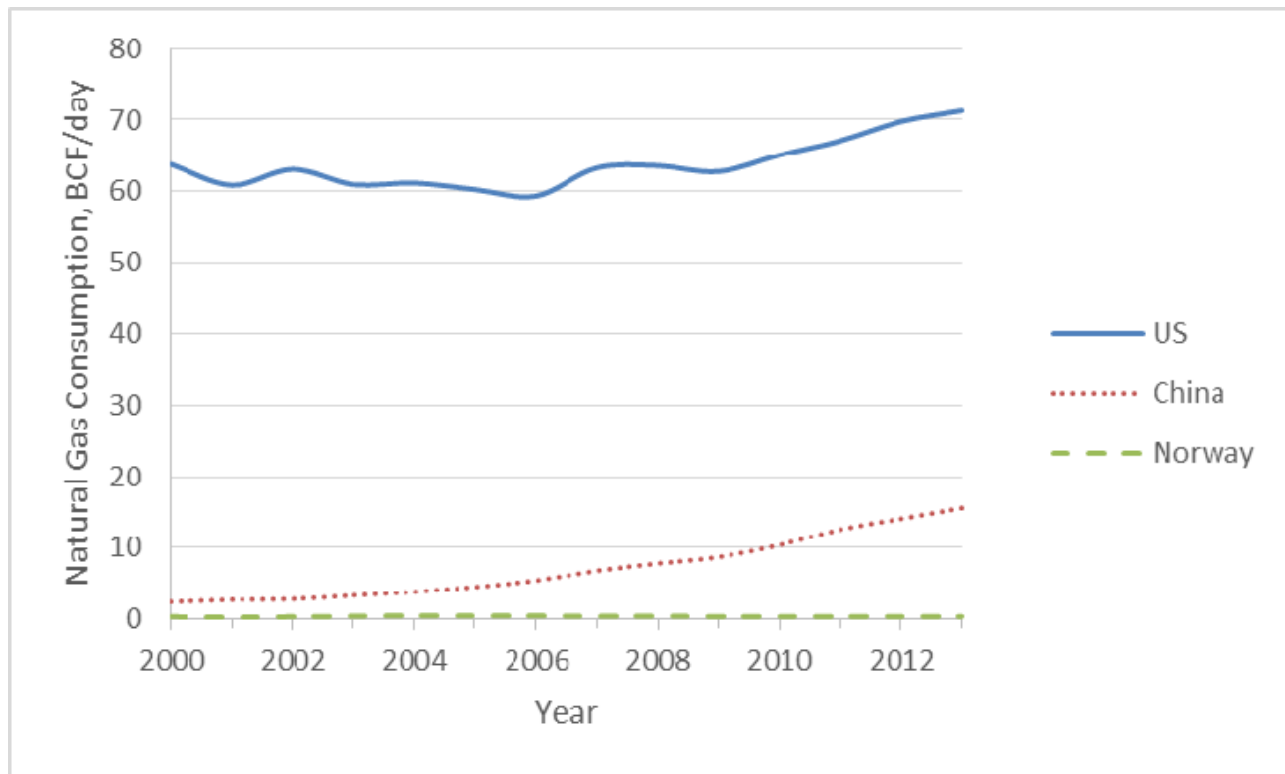
**Table 1:** Oil, natural gas, and coal consumption of the U.S., China, and Norway, 2000-2013

Source: BP Statistical Review of World Energy, 2014. These numbers presented here are rounded off, but you can download the numbers as presented at <http://www.bp.com/statisticalreview> to complete your calculations in a spreadsheet.

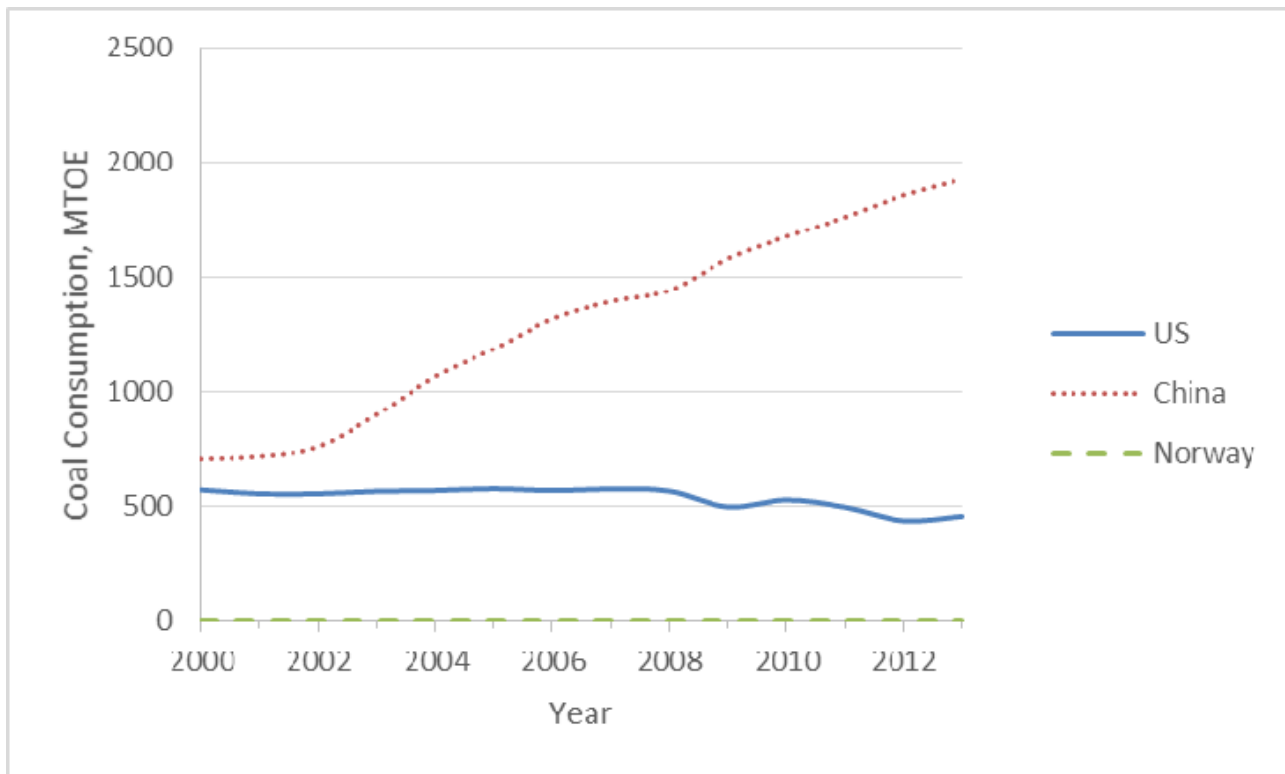


*Figure 1. Oil Consumption of the U.S., China and Norway, 2000-2013*

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*Figure 2. Natural Gas Consumption of the U.S., China and Norway, 2000-2013*



*Figure 3. Coal Consumption of the U.S., China and Norway, 2000-2013*