1.6 Human energy consumption and supply patterns: global and NZ

L 4 —

As engineers we are particularly interested in patterns of *human energy consumption*, both worldwide and NZ. Here we consider some general facts and figures and do some basic calculations to help interpret the data.

1.6.1 Global consumption patterns

Consider the Figures 6-8, obtained from `https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html`.

Example questions

21) Global energy use has steadily increased over the last 15 years, except for the last two years. This is surprising, given the continued increase in the world's population. What is the main cause of this 'plateau' in global energy consumption? **(1 mark)**

Answer:_____

22) Worldwide energy consumption in 2005 was 488 EJ (exa=10^{18}). In class we estimated 2015 worldwide energy consumption to be 13,000 Mtoe (1 toe = 42 x 10^9 J). What has been the percentage increase in worldwide energy consumption in the last 10 years?

(2 marks)

Percentage Increase: _____

23) Which of the following sectors is mainly responsible for the growth in NZ energy consumption over the last 15 years? **(1 mark)**

A. Industrial
B. Residential
C. Transport
D. Commercial and Public Services
E. Agriculture, Forestry, and Fishing

Answer:_____

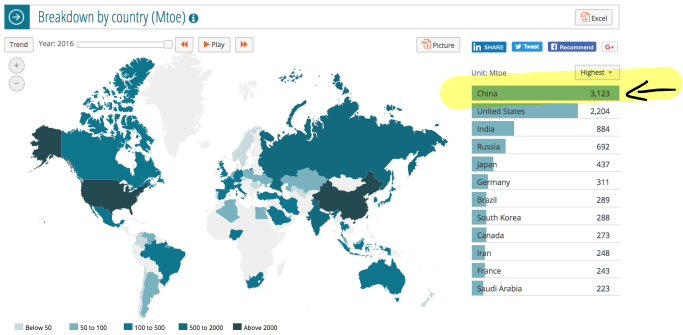


Figure 6: Global energy consumption (2016 data).

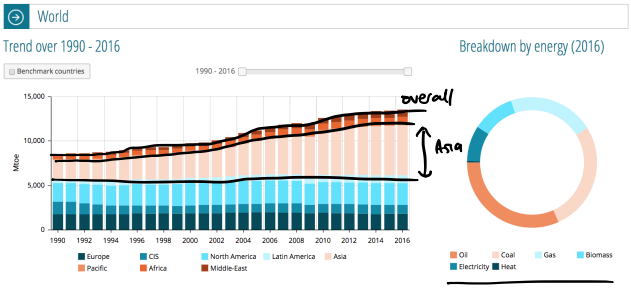


Figure 7: Global energy consumption trends 1990-2016.

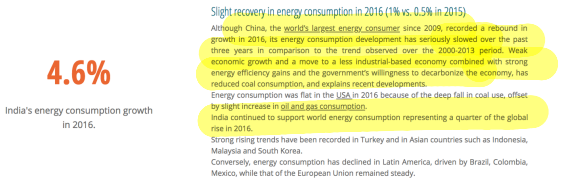


Figure 8: Global energy consumption: key drivers.

Let's look at the who, what, where, why etc! To help us, we'll also include some data on population growth - see Figure 9.

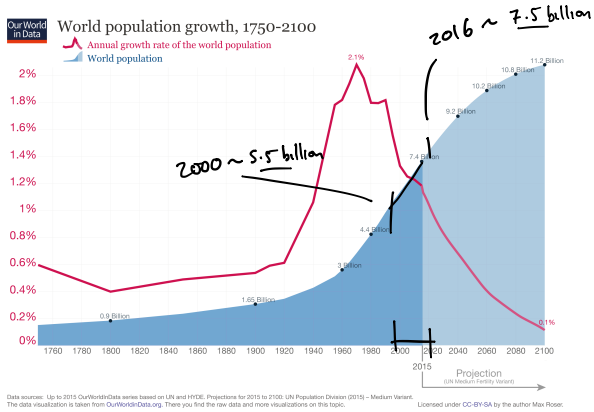


Figure 9: Worldwide population growth.

Consider the following questions:

Example Problems 5: Global energy

1. Who is using the most energy?
2. What trends do you notice in energy consumption?
3. Given the growth in our population over the last 16 years, why are we not seeing this growth in energy consumption?

Answers

1. Who? China 3,123 Mtoe

(Figure 6).

Mega tonnes of oil equivalent

energy released by burning one tonne of crude oil.

2. Trends?

Overall → see Fig.

→ Increasing 2000 – 2014

→ Flattening last few years? 2014–2016? Eg China slowing?

→ or maybe stepwise growth?

?

Other? Europe & N. A. pretty stable

Biggest growth: Asia.

↳ China biggest but slowing

↳ India still growing.

3. Population continues to grow, though rate declining.

↳ still quite large increase.

↳ seems to be slower increase in energy

one explanation: efficiency increase.

eg Total = $\frac{\text{energy}}{\text{person}}$ × person

($\downarrow$) ($\uparrow$)

(more efficient = less energy/person).

1. Mega tonnes of oil equivalent

Need/given $1\ \text{toe} = 42\ \text{GJ} = 42 \times 10^9\ \text{J}$

So $1\ \text{Mtoe} = 1 \times 10^6\ \text{toe}$

$$= 1 \times 10^6\ \cancel{\text{toe}} \times \frac{42 \times 10^9\ \text{J}}{1\ \cancel{\text{toe}}}$$

$$= 42 \times 10^{15}\ \text{J}$$

$(= 42\ \text{PJ}$, 'peta' $= 10^{15}$

Eg China: $3{,}000\ \text{Mtoe} = 3{,}000\ \cancel{\text{Mtoe}} \times \frac{42 \times 10^{15}}{1\ \cancel{\text{Mtoe}}}$

$\approx 126{,}000\ \text{PJ}$)

Example Problems 6: More on global energy

1. What does Mtoe stand for? Convert Mtoe to J.
2. Convert worldwide energy consumption in 2016 to TW (tera $= 10^{12}$). What type of quantity is this?
3. Convert China's energy consumption in 2016 to TW.

Answers

2. Worldwide energy consumption 2016 ~ 13,000 Mtoe.

Recall: $1\,W = 1\,J/s$. So convert energy to J first.

(a) Use: $1\ \text{Mtoe} = 42\times10^{15}\,J = 42\times10^{15}\,\frac{J}{s}\cdot s$

$= 42\times10^{15}\,J = 42\times10^{15}\,W\cdot s$ (want watts)

$\rightarrow$ let's convert to $TW\cdot h$ {energy = power x time ✓

$42\times10^{15}\,W\cdot s \times \frac{1\,h}{60\times60\,s} = 11.7\times10^{12}\,W\cdot h$

$= \boxed{11.7\ TW\cdot h}$

(b) Also $1\,\text{year} = \frac{24\,h}{\text{day}} \times 365\,\text{days}$

$= 8760\,h$

So:

$$\frac{13{,}000\ \text{Mtoe}}{1\ \text{year}} = \frac{13{,}000\ \text{Mtoe}}{1\ \text{year}} \times \left(\frac{1\ \text{year}}{8760\,h}\right) \times \left(\frac{11.7\,TW\cdot h}{1\ \text{Mtoe}}\right)$$

$$= \frac{13{,}000\times11.7}{8760}\ TW$$

$$\approx \boxed{17.26\ TW} \quad \left(\frac{\text{energy}}{\text{time}} = \text{power}\right).$$

$\rightarrow$

3. China : $\frac{3{,}000\ \text{Mtoe}}{1\ \text{year}} = 3{,}000\ \frac{\text{Mtoe}}{\text{year}} \times \left(\frac{11.7\ \text{TW·h}}{1\ \text{Mtoe}}\right) \times \frac{1\ \text{year}}{8760\ \text{h}}$

$= \frac{3{,}000 \times 11.7}{8760}\ \text{TW}$

$\simeq 4\ \text{TW}.$ (almost 1/4 of world!)

1.6.2 Energy consumption and supply sources

Here we are interested in questions like: where does the energy we consume come from? What forms of energy do we consume the most of? How is our electricity produced? Note: electricity is not the same as total energy!

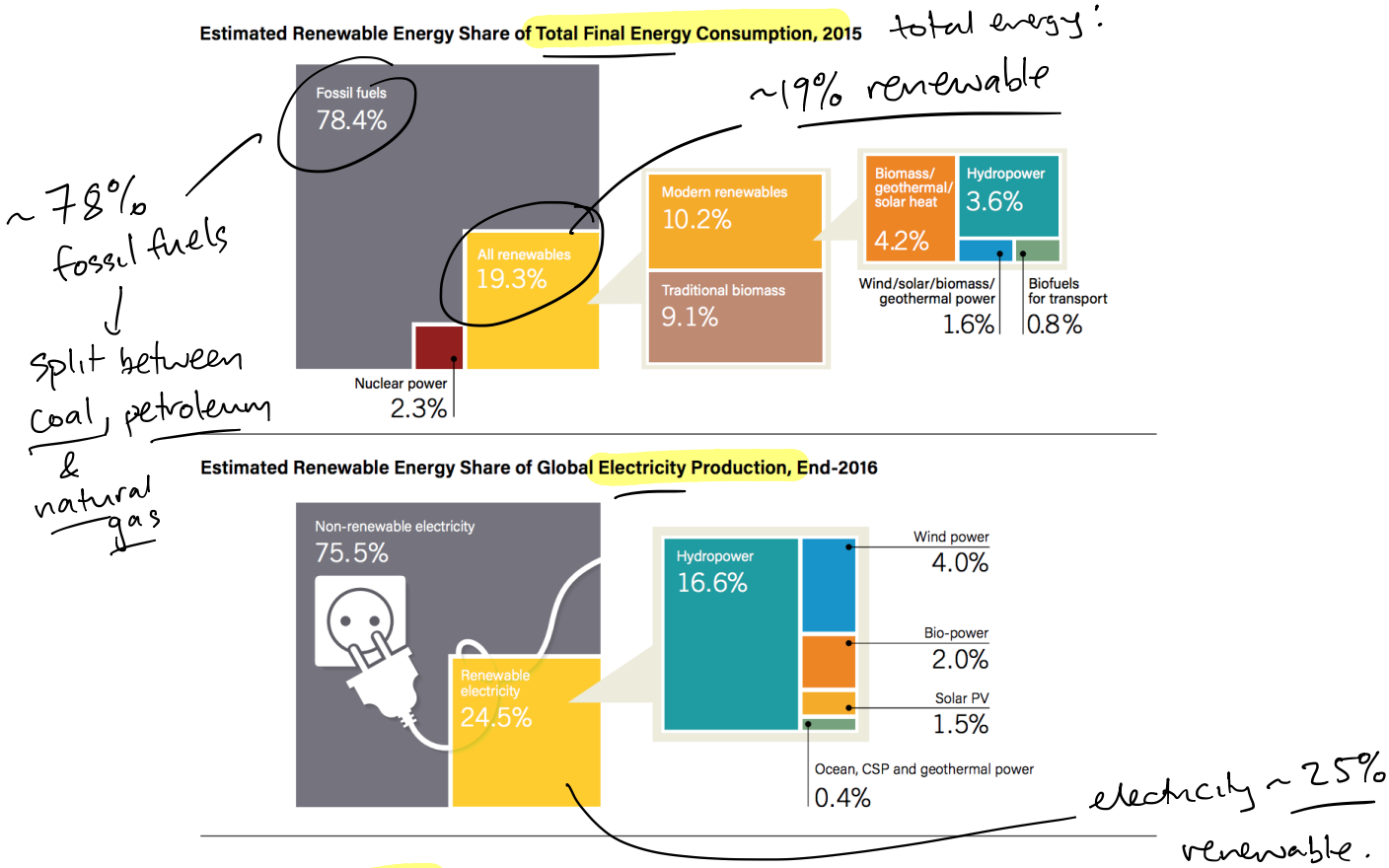
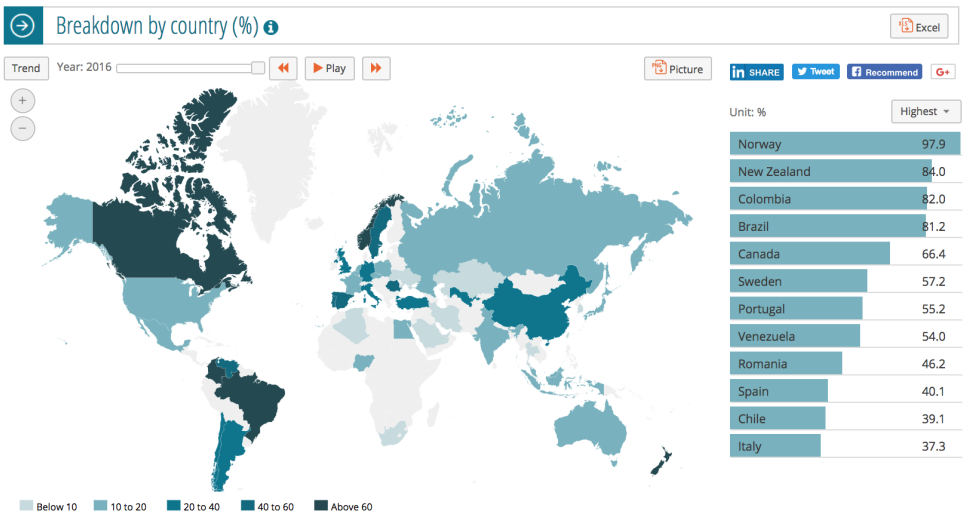


Figure 10: Global renewable energy consumption and electricity production.

Note: what is a fossil fuel? (via Wikipedia!):

A fossil fuel is a fuel formed by natural processes, such as anaerobic decomposition of buried dead organisms, containing energy originating in ancient photosynthesis.



NZ ~ 84%!

(MBIE ~ 81%)

Figure 11: Global electricity production: percentage from renewable sources.

Example Problems 7: Worldwide energy consumption sources

1. Approximately what percentage of worldwide energy supply is met by fossil fuels? ~ 78%
2. Approximately what percentage of worldwide *electricity* production is from renewable sources? ~25%
3. Which countries produce the highest percentage of electricity from renewable sources? Norway, NZ!, Columbia, Brazil...
4. Is electricity the main form of energy consumed worldwide?

Answers

↳ Back to fig 7! No! Oil, coal, gas...

1.6.3 Energy consumption and supply sources: NZ in particular

Let's focus some more on NZ energy consumption and supply. Some key facts and figures are shown in Figures 12-15.

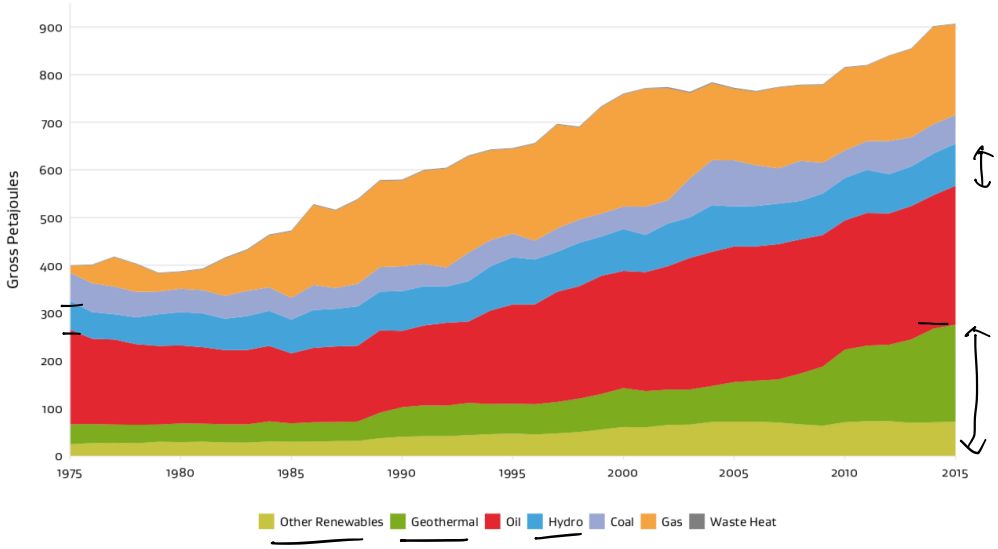
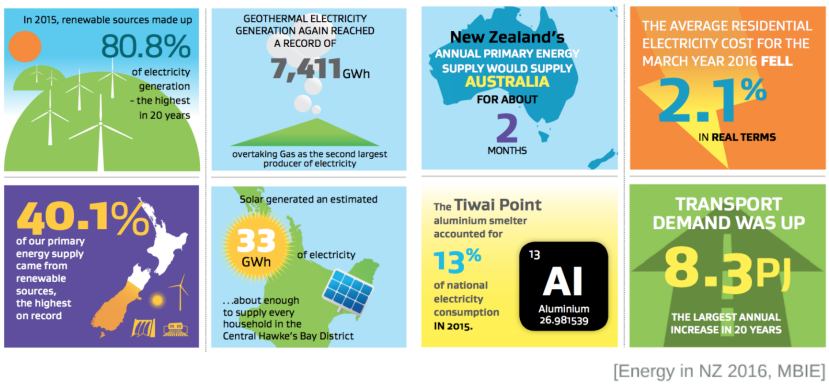


Figure 12: NZ total primary energy supply by fuel (2016 MBIE report).



[Energy in NZ 2016, MBIE]

Figure 13: NZ energy: various facts (2016 MBIE report).

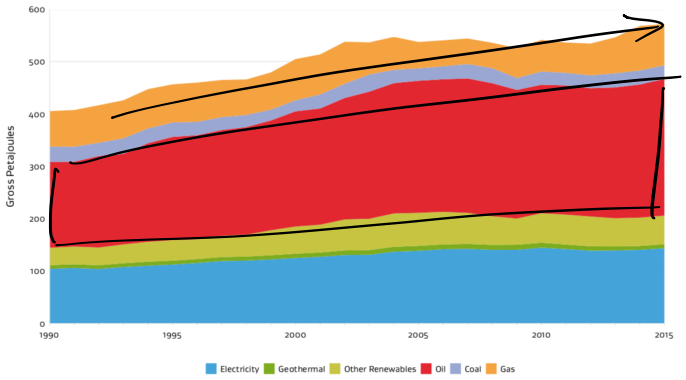


Figure 14: NZ consumer energy demand by fuel (2016 MBIE report).

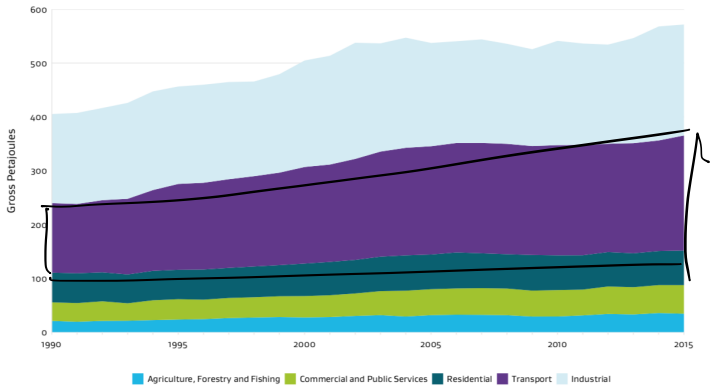


Figure 15: NZ consumer energy demand by sector (2016 MBIE report).

Example Problems 8: NZ energy consumption and supply

1. What was NZ's total primary energy supply in 2015?
2. What percentage of NZ's total primary energy supply in 2015 is from renewable sources?
3. Which energy source has experienced the most growth in the last 10 years in NZ?
4. What energy source continues to dominate NZ's primary energy supply?
5. What is the main source (fuel type) of the rise in NZ consumer demand of energy?
6. What sector is causing this growth?
7. What could consumers do to alter these figures in the coming decades?

Answers

1. ~ 900 PJ.
2. Renewable ~300–400 PJ

   So ~ $\frac{300}{900}$ – $\frac{400}{900}$ ≈ 30–45% of total.
3. Geothermal!
4. Oil.
5. Oil.
6. Transport
7. Shift to renewable electric transport
   - already using ~80–85% renewable electricity.

Let's just do electricity for this one.

1. pop ~ 4.5 million ~ 4.5×10^6 people

tot. electricity use ~ 160 PJ = 160×10^{15} J

1 kW·h = 3.6×10^6 J

(a) Total use: $160 \text{ PJ} = 160 \times 10^{15} \text{ J} \times \frac{1 \text{ kW·h}}{3.6 \times 10^6 \text{ J}}$

$\approx \frac{160}{3.6} \times 10^9$ kW·h

(b) $\frac{\text{Total use}}{\text{person}} = \left(\frac{160}{3.6} \times 10^9 \text{ kW·h}\right)\left(\frac{1}{4.5 \times 10^6 \text{ people}}\right)$

$\approx$ 9900 kW·h/person

Example Problems 9: More on NZ ~~energy~~ electricity consumption

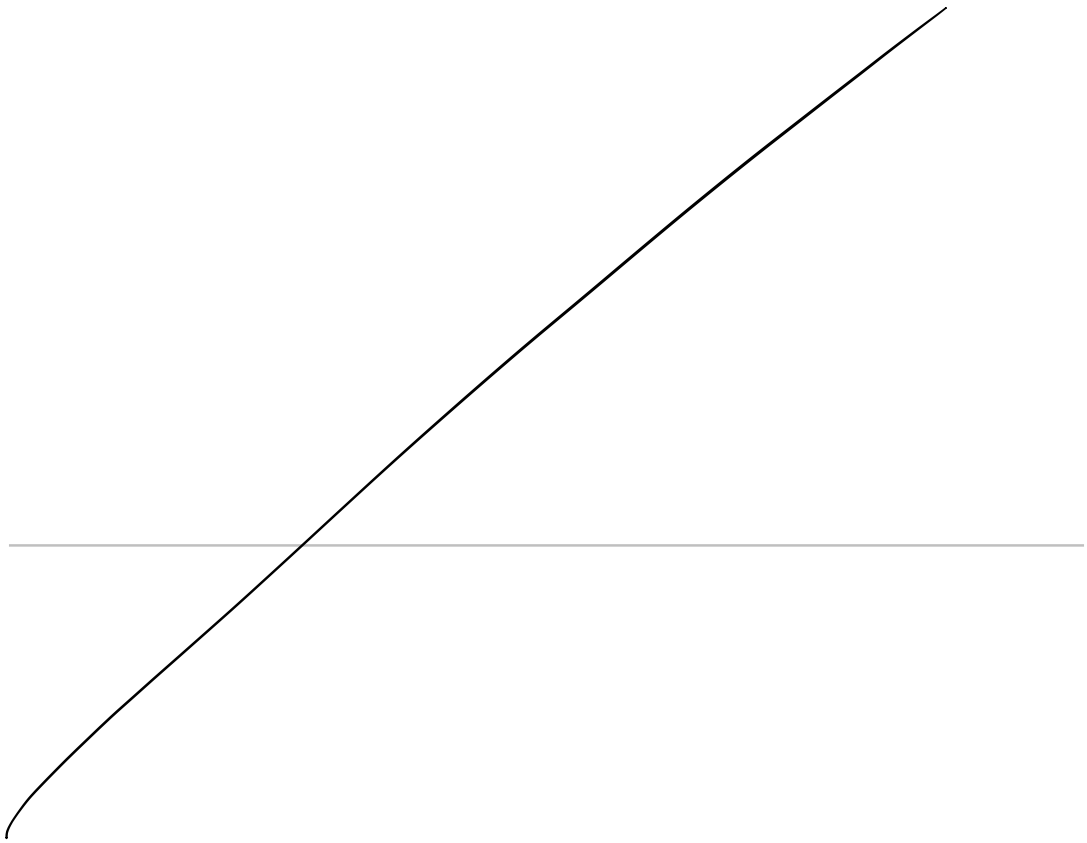
1. Estimate NZ's ~~energy~~ electricity consumption per capita.
2. Look up data on some other countries and compare NZ's per capita consumption to them.

Answers

2. Comparison: USA ~ 14,000 kWh/person

Mexico ~ 2,500 kWh/person

Norway ~ 25,000 kW·h/person } high because lot's of electricity use (cf other sources).



End L4.