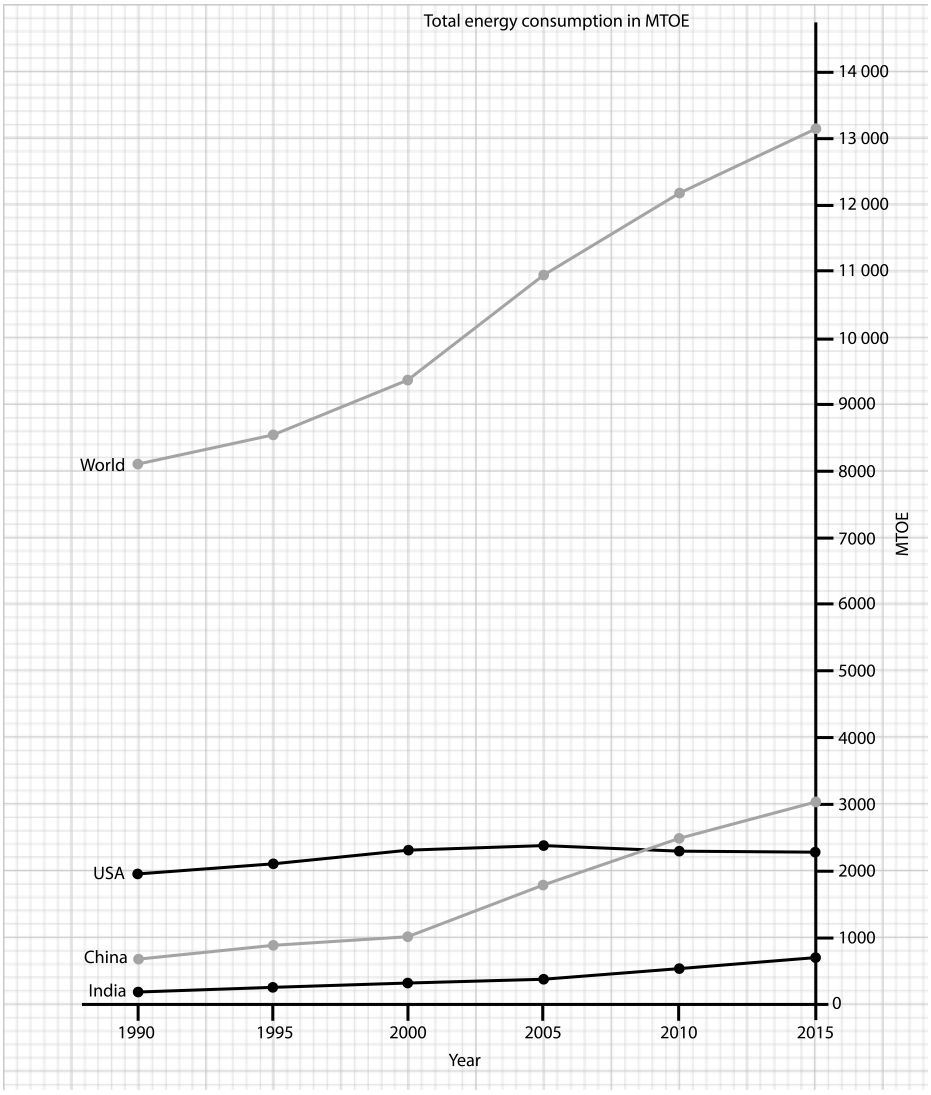
## Answers to data response and decision making exercises

1. The data below shows total energy consumption for three countries between 1990 and 2015, as well as global energy consumption.

| | **Total energy consumption in MTOE** (million tonnes oil equivalent – a unit of energy defined as the amount of energy released by burning one million tonnes of crude oil) | | | |
|---|---|---|---|---|
| **Year** | **USA** | **China** | **India** | **World** |
| 1990 | 1967 | 681 | 195 | 8136 |
| 1995 | 2121 | 885 | 252 | 8589 |
| 2000 | 2312 | 1003 | 316 | 9388 |
| 2005 | 2350 | 1794 | 394 | 10 940 |
| 2010 | 2285 | 2487 | 541 | 12 181 |
| 2015 | 2281 | 3014 | 700 | 13 147 |

a) Plot this data as a line graph on the grid below.



b) Describe the trend in world energy consumption from 1990 to 2015. Ensure you use statistics in your response.
World energy consumption has risen significantly since 1990 from 8136 million tonnes oil equivalent (Mtoe) to 13 147 Mtoe in 2015. The fastest rise was between 2000 and 2005 – a rise in consumption of over 1500 Mtoe.

c) By how many MTOE did China's total energy consumption change between 1990 and 2015?
China's energy consumption increased by 2333 Mtoe between 1990 and 2015.

d) Compare energy consumption in the USA with that in China over time.
Between 1990 and 2015, the energy consumed by the USA has slowly increased from 1967 to 2281 Mtoe, with fluctuations over this time. In comparison, China has seen a rapid rise in energy consumption.

e) The energy consumption of China and India has increased rapidly over time. Suggest reasons for this increase.
Both China and India have rapidly growing and industrialising economies. The growth of industry – particularly manufacturing – has rapidly increased energy consumption in both countries, with China witnessing the greatest increase. A developing manufacturing economy will increase energy consumption as more electricity and fuel oil is needed to run factories and machines. Furthermore, the manufactured goods require raw materials and transportation – all of which increase energy demand. In addition, both countries have large, and in India's case, rapidly growing populations. The increasing population, coupled with rising incomes, will lead to greater consumption of energy. People who have access to electricity will aspire to own more manufactured goods such as refrigerators and washing machines. These will increase the consumption of energy.

f) Identify two possible environmental management challenges caused by this increase in consumption. For each, suggest a possible solution.
One environmental management challenge created by an increase in energy consumption in China and India would be air pollution. The rapid industrialisation means that the demand for cheap energy would increase. It is highly likely that this demand will be met with fossil fuels – particularly coal. This would increase the likelihood of air pollution in areas around power stations. One possible solution to this would be to invest in cleaner, more renewable energy solutions such as solar or wind.

A further environmental management challenge could be the increased risks of oil spills in both countries. As demand for oil increases in both countries, there will be an increase in the shipping and transportation of crude oil or petroleum into the countries. With an increased number of ships and pipelines being used, there is an associated increase in the possibility of oils spills. The risk of these could be reduced by ensuring that shipping is properly regulated and that there are well-practised plans in place in the event of a spill. This would reduce the impact of any spills.

2. This graph shows global energy use by source over time. It is a compound line graph, so the total amount of energy used is shown by the top line, but each proportion underneath is representative of the energy source.

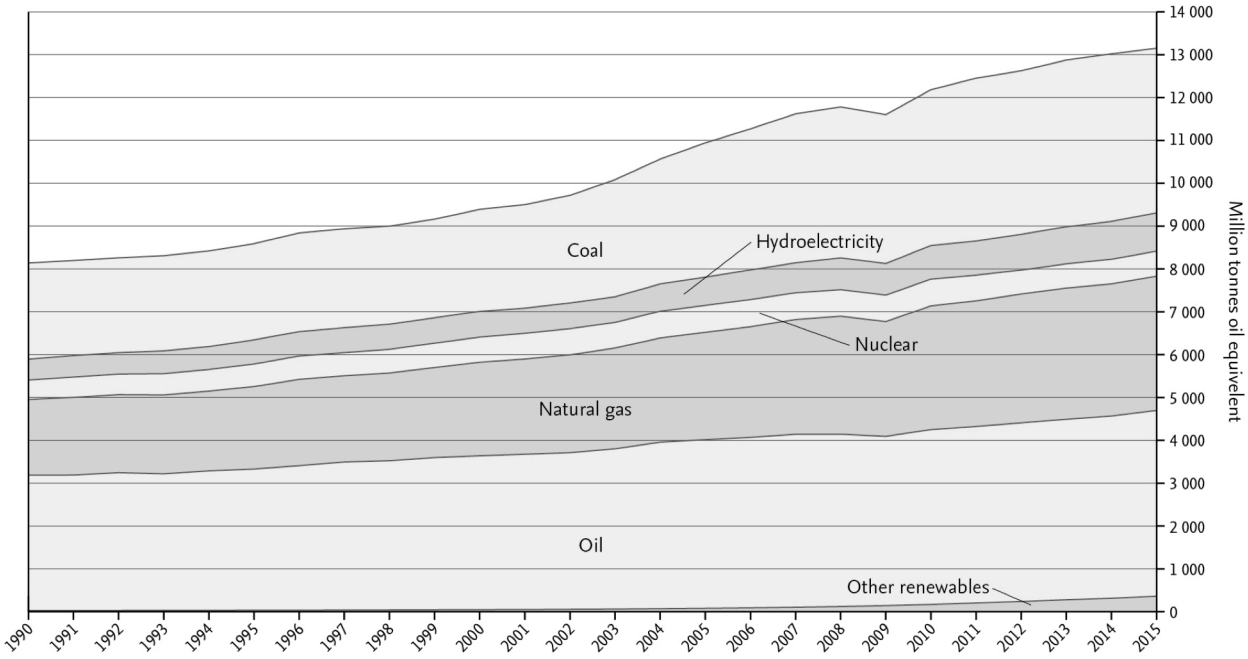



Fig. 2.12 World consumption of different energy sources.

a) Describe how the proportion of oil used has changed since 1990.
Since 1990, world energy consumption has increased rapidly from around 8000 Mtoe to over 13 000 in 2015. In 1990, oil consumption accounted for over 3000 Mtoe – 39% of the total. The use of oil has grown over time to 4331 Mtoe in 2015. This is now just over 32% of the total energy consumed.

b) Which energy source has seen the greatest growth since 1990? Use statistics in your answer.
Since 1990 the energy source that has seen the greatest growth in use is coal. Coal use has risen from just over 2000 Mtoe in 1990 to approximately 3800 Mtoe in 2015.

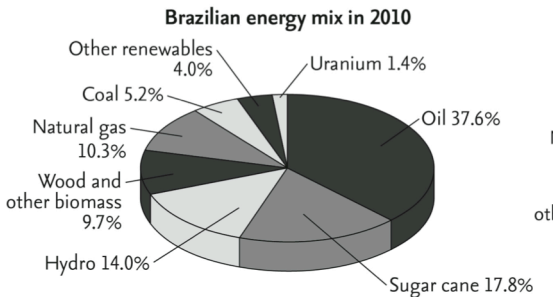
c) Which types of fuel dominate the global energy mix in 2015?
In 2015, the three fuels that account for the greatest consumption worldwide are oil, coal and natural gas. These are all non-renewable fossil fuels.

d) In your view, is the world likely to move away from the use of fossil fuels in the next 10 years? Use the graph, plus your own knowledge and understanding to justify your conclusion.
It is highly unlikely that the world will be able to move away from fossil fuels significantly in the next 10 years. In 2015, fossil fuels account for just under 90% of all the fuel sources consumed around the world. Whilst the use of nuclear power, hydro power and other renewables continues to grow, they are not yet able to meet the global demand for energy. Put simply, the world could not switch to renewable energy overnight and maintain the same level of energy consumption. The main advantage of fossil fuels is that they are relatively abundant and a cheap source of energy. Renewables require more investment

and nuclear power needs a long lead in time from approval to being built. In simple economic terms, this makes fossil fuels cheaper to use. However, the cost of coal, for example, does not reflect the true price of coal in terms of the environmental impact of mining, air pollution and climate change. Until these costs are factored in, it makes renewable energy less affordable, so many countries are more likely to stay with fossil fuels – particularly if they have access to them in large quantities.

Whilst there will be a shift toward renewable energy in the next 10 years – a necessary outcome to reduce greenhouse gas emissions – it is unlikely that they will overtake the use of fossil fuels. However, with technological improvements, it is possible that the rate of renewable energy growth will increase at the same time as improvements in energy efficiency will cause a reduction in the total amount of energy consumed.

3. The pie charts below show the energy mix of Brazil.

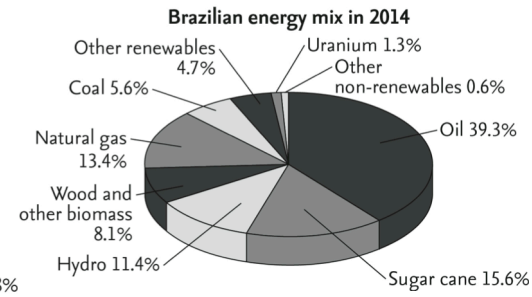




Fig. 2.13 Location of Brazil. Fig. 2.14a and 2.14b Brazilian energy mix 2010 and 2014.

a) Define the key terms ‘energy mix’ and ‘energy security’.
Energy mix is defined as the energy consumption by source of a household, region or country. It would be made up of both renewable and non-renewable energy sources. Energy security is a measure of how secure a country is in its energy supply. A country that is energy secure has enough sources of power to meet its own energy needs.

b) Describe the changes in Brazil’s energy mix between 2010 and 2015.
In 2010, the majority of Brazil’s energy came from oil, sugar cane, HEP, wood and natural gas, with oil making up 37.6% of all energy consumed. By 2015, oil had increased to 39.3% of all energy consumed. Natural gas had also increased. Wood, hydropower and sugar cane use have decreased in this 5-year period.

c) What proportion of Brazil’s energy comes from non-renewable sources? Has this changed over time?
In 2010, over 54% of Brazil’s energy mix came from non-renewable energy sources such as uranium and fossil fuels. By 2015, this had increased to over 60% with oil and gas showing the largest increases.

d) Major HEP projects require construction of large scale dams across rivers. Describe and explain two advantages and two disadvantages of these projects.

One advantage of major HEP projects is a supply of renewable energy. The dams create large man-made reservoirs behind them. Water can be slowly released downwards, turning the potential energy of the stored water into kinetic energy. The water turns turbine blades in a generating station, which in turn generates electricity. The energy is cheap to produce (once the dam is paid for!) and reduces greenhouse gas emissions. This is a renewable form of energy.

A second advantage of large-scale dams would be flood control. Large dams stop the flow of water downstream. This can be damaging to downstream communities, so water is slowly released to maintain river flows. During heavy rainfall events, the dam is able to completely close and to reduce the channel flow downstream. These large stores of water are highly effective at reducing the risk of flooding downstream. The Three Gorges Dam in China has drastically reduced the amount of flooding downstream on the Yangtze River.

However, large-scale dams can also have a number of disadvantages. Dams are very expensive to build and are highly disruptive to river systems. The construction of large dams requires huge investment in terms of capital and labour. They are massive engineering challenges, so take a long time to plan and construct. The construction can be damaging to the local environment and cause pollution to enter rivers.

A further disadvantage is the significant social disruption to those residents living alongside the river behind the dam. As the dam is completed, the land behind will begin to flood. Residents will need to be compensated and will need to relocate homes and businesses. In some dam projects, people have been forced from their homes with little consultation or compensation. This often leads to migration away from the area – breaking up the communities that once existed.

4. Read the following extract from a news report from June 2016:

*The Brazilian government has suspended a major HEP project in the Amazon rainforest whilst it investigates the impact on indigenous people in the region. The project would include 40 dams (5 major and 35 smaller projects) in the Tapajós river basin. This is part of a wider plan to develop 24 gigawatts of hydropower by 2024 to ease the electricity shortages that affect some places frequently. The largest dam – the 8000 MW São Luiz do Tapajós (SLT) dam – would be 7.6 km wide and flood hundreds of square kilometres of rainforest. The project would also be used to create an industrial waterway to allow soybeans produced inland to be shipped easily to North America and Europe. If built, the dams on the Tapajós would flood an area the size of greater London, Paris and Amsterdam combined. There is significant environmental opposition to the project from around the world, but Brazil argues such a project is needed to meet demand shortages from renewables.*

Fig. 2.15 A traditional fishing village on the Rio Tapajos that would be flooded under the new plans.

Fig. 2.16 Aerial view of a hydroelectric power plant in northeastern Brazil.

a) Using your own research and the information here, outline the arguments for and against building the São Luiz do Tapajós dam in the Amazon rainforest.

| For | Against |
|---|---|
| A renewable source of energy. The largest dam will generate 8000 MW of electricity.<br><br>The dam will help ease electricity shortages.<br><br>No pollution/or greenhouse gases are emitted from HEP electricity generation.<br><br>A dam is often a multipurpose scheme: it helps flood-control, water supplies and irrigation, and creates leisure, recreation and tourism opportunities.<br><br>Water can be stored and used to generate power when demand is high.<br><br>HEP schemes are long lasting, so can be relied upon for decades.<br><br>The project would also be used to create an industrial waterway to allow soybeans produced inland to be shipped easily to North America and Europe. | The 40 dams (5 major and 35 smaller projects) in the Tapajós river basin will flood an area larger than greater London, Paris and Amsterdam combined.<br><br>The largest dam would be 7.6 km wide and flood hundreds of square kilometres of rainforest.<br><br>The indigenous people in the region would be forced from their homes. There are over 10 000 Munduruku people living near the river. They are protected under the constitution of Brazil.<br><br>The cost of the project planning will be huge. The developers will need to carry out expensive impact assessments and fight legal challenges. |

In recent years, Brazil has found an estimated 50 billion barrels of oil in deep water (2000 m) 300 km off the coast. These finds are the most significant of the 21st century and have the potential to lift millions of Brazilians out of poverty and increase energy security. The oil fields are in water deeper than the Gulf of Mexico (where the Deepwater Horizon disaster occurred)

and occur in complex geology with the reservoirs reported to contain toxic gases. Accessing this oil presents major engineering challenges, as well as causing environmental concerns over possible spills and the carbon dioxide emissions caused by accessing and consuming the oil. Each well is estimated to cost US$300 million – four times the cost of drilling a shallow water well. Currently, a low oil price means that exploiting these wells is not a cost-effective solution to an energy shortage at this time. One answer would be to develop more renewable projects, but these have also been plagued with difficulties. Prolonged drought has reduced river levels and stopped HEP projects from functioning. The projects are often located a long way from urban centres. Furthermore, HEP projects that flood tropical forests often face acidic water conditions that reduce the efficiency of large-scale dams as turbine blades have to be replaced more frequently.

Meeting energy demand for a growing urban population is a challenge for the Brazilian government – especially at a time of low oil prices, a shrinking economy and rising public debt. An estimated 11 million people live in shanty towns known as favelas, and perhaps here people have a solution: small-scale household-based renewable solar projects. There has been a recent growth in these projects in favelas, and local councils and mayors are taking an interest in smaller-scale projects as a short-term solution to keep the lights on.

b) Why is it necessary to change the current energy mix in Brazil? Think about local, national and global issues.

Brazil's current energy mix is dominated by non-renewable fossil fuels, which accounted for over 60% of all energy consumption in 2015. The discovery of vast oilfields off the coast of Brazil provides the potential to meet future demand for energy. Demand for energy is increasing due to a growing population that is becoming wealthier. However, the oil has significant costs attached which make it uneconomical at this time to develop. A low global oil price means it is not currently worth the investments in overcoming the deep water challenges. This presents Brazil with a significant challenge – how to meet the growing energy needs of the population at a time when there is global pressure to reduce greenhouse gas emissions.

If exploiting new oil and gas fields is not the way forward for the short term due to economic and environmental factors, then Brazil needs to shift its energy mix towards more renewable resources. The tropical climate provides high levels of rainfall, which can be harnessed in large HEP projects. Brazil has a number of these already and there are plans for many more (the government plan to develop 24 gigawatts of hydropower by 2024). However, prolonged drought and environmental concerns about the impact of these expensive projects on the rainforest ecosystem mean that HEP alone cannot meet the needs of people facing electricity shortages in the short term.

At the local scale, in many Brazilian cities there are favelas that have developed over many years. These are improving in many cities and are now demanding more electricity. These densely packed urban areas are the most prone to electricity shortages and unreliable supplies. Shifting towards a local approach to energy generation from renewable sources such as solar would be beneficial from both an environmental and economic perspective. Building more dams and exploiting offshore wells will not meet the needs of people in the short term. As Brazil's cities grow and demand for electricity increases further, the need for

a sustainable solution will accelerate, so Brazil will need to consider changes in the energy mix.

The Brazilian government has a range of approaches to consider when dealing with decisions about future energy supply.

i. **Business as usual** – continue to use fossil fuels (some of which are imported) and current renewables whilst exploiting offshore gas and oil finds as soon as possible.
ii. **A multi-energy solution** – diversify the energy sources to make best use of what is available in the country. This could include:

- developing small scale energy projects
- developing new renewable energy sources such as solar and wave energy – both of which have high potential in the country
- increasing biofuel production to reduce dependence on oil imports
- building nuclear power stations – Brazil has large deposits of uranium
- building new HEP projects
- developing refining capacity to reduce imports of oil products and natural gas, whilst building oil and gas thermal power stations
- developing the use of carbon capture and storage in power stations

iii. **Energy conservation** – reducing the amount of energy consumed.

c) Using your own research, the information here and the Student Book, consider the options available to Brazil. If you were advisor to the Minister of Energy in Brazil, what suggestions would you make on how to meet demand for energy in Brazilian cities – both now and in the future?

In order to meet electricity demand and to ensure Brazilian energy security, it is important that Brazil examines and begins to shift its energy mix. A business as usual approach is the least environmentally sustainable model and will lead to short-term energy insecurity, as it relies upon foreign imports to meet a shortfall whilst the new oil and gas fields are developed. The business as usual approach will increase the carbon emissions of Brazil at a time when global agreements on reducing carbon emissions are coming into force.

The most effective, secure and sustainable way forward for Brazil would be to develop a multi energy solution alongside introducing a range of conservation measures. The conservation measures would allow demand to be reduced in some areas. However, overall demand is going to increase as rising levels of wealth will lead to greater numbers of household appliances which will in turn increase demand for electricity. A multi-energy solution would include development of both small- and large-scale renewable projects alongside the development of efficient gas turbine power stations. Money earned from selling fossil fuel reserves could be invested in small-scale household solar energy schemes as well as offshore wind and wave power. Brazil has huge untapped renewable energy potential so it is vital to develop this in the future. Increasing fossil fuel use to meet the immediate needs would be a short-term fix, but can only be a viable option if renewables are developed and then scaled up alongside these. Once renewable energy sources at both large and small scales are meeting demand, Brazil would then be able to reduce the reliance on fossil fuels.