NZ Energy & Global Trends

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Support by Energy Education Trust of NZ

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Introduction

- Fundamental significance of energy
  - Production e.g. dairy products for export, requires energy
  - Consumption e.g. Cell phone requires energy
- Economics:
  - Market design – deliver low cost, low carbon & reliable
  - Technology – more efficient use, impacts both supply & demand
  - External impacts - fossil fuels: SO_x, CO_2, development; location of wind farms: visual, claims about noise; dams for hydro: fish passage, lost recreation; geothermal: reinjection; solar: production of panels;
  - Policy – ultimate aim of economic analysis is to assist with formation of markets, regulation & strategic policy:
    - Market & policy design
      - Carbon tax or ETS?
      - RET such as 90% renewable electricity by 2025?
      - market regulation?
      - Access & property rights?; etc….

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Outline

- Global markets
  - Reserves
  - Prices
- New Zealand's energy market
  - background
  - NZ Economic indicators – how are we doing?
- Energy & Economic growth
- Markets: electricity, oil & gas
  - Demand & supply
- Energy Development
- Energy Policy

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Global markets

- Global energy markets are in transition
  - Growth, higher incomes have led to growth in energy demand, particularly developing economies within Asia as opposed to OECD
  - Drive towards improving energy efficiency
  - Share of renewables in energy supply increasing
  - Net result is that demand grew at ~ 1% over the last 3 years – 10 year average 1.8% pa
- Carbon emissions have been flat

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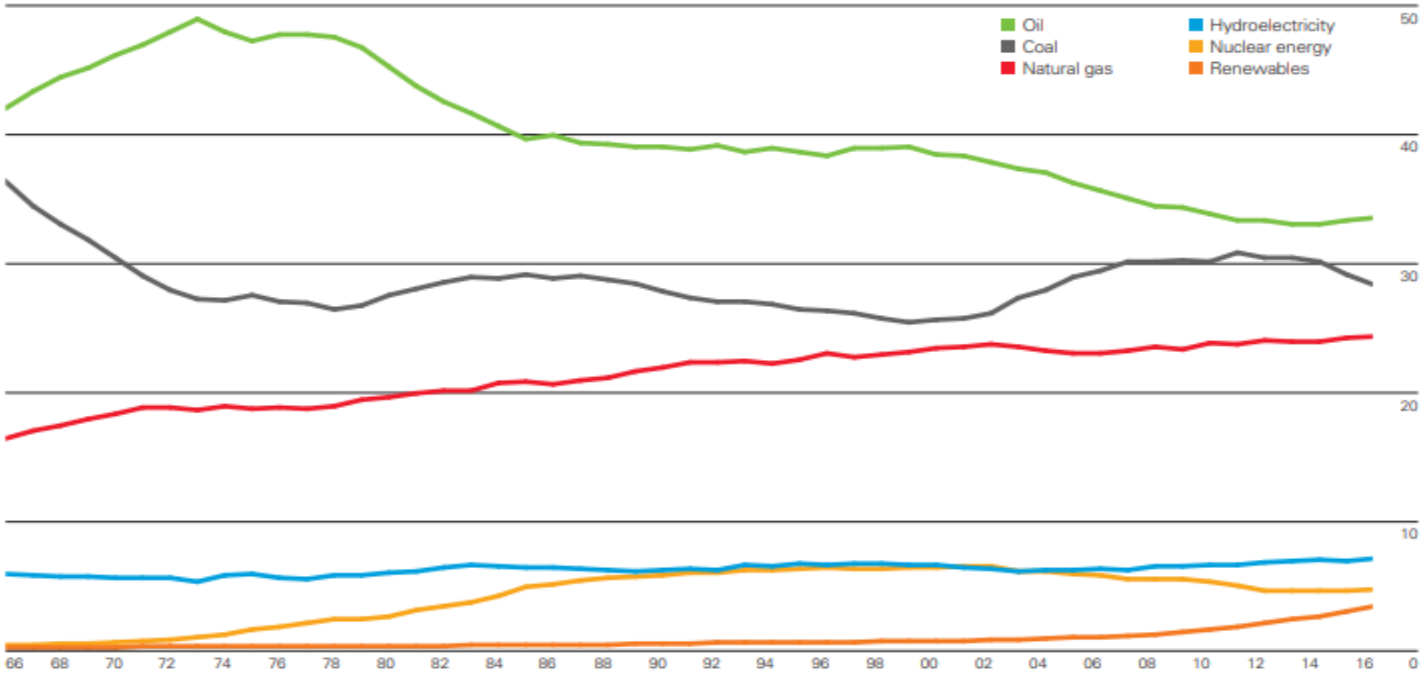
Primary energy consumption

Shares of global primary energy consumption

Percentage



Oil remains the world's dominant fuel, making up roughly a third of all energy consumed. In 2016 oil gained global market share for the second year in a row, following 15 years of declines from 1999 to 2014. Coal's market share fell to 28.1%, the lowest level since 2004. Renewables in power generation accounted for a record 3.2% of global primary energy consumption.

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Oil Markets

- World's leading fuel – market share increased following 15 years of decline
- Brent oil price averaged $43.73 per barrel in 2016, down from $52.39
- India & China largest increase in consumption
- Production in Middle East increased modestly, sharp decline in US, Nigeria

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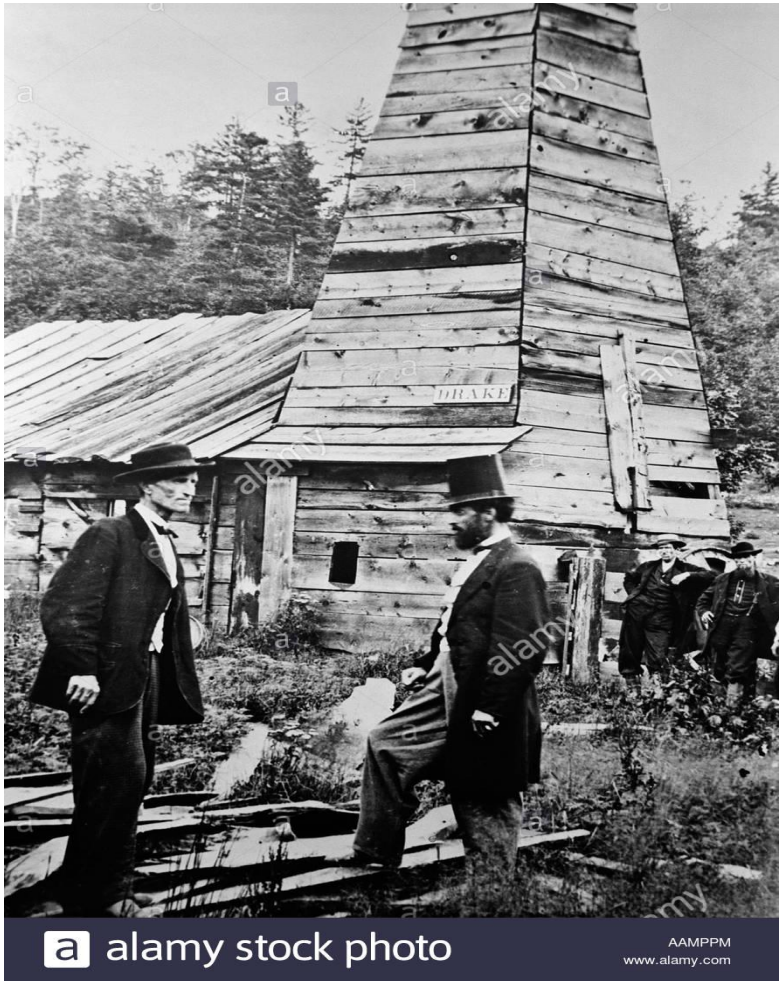
Drake's well 1859 & Huntington Beach



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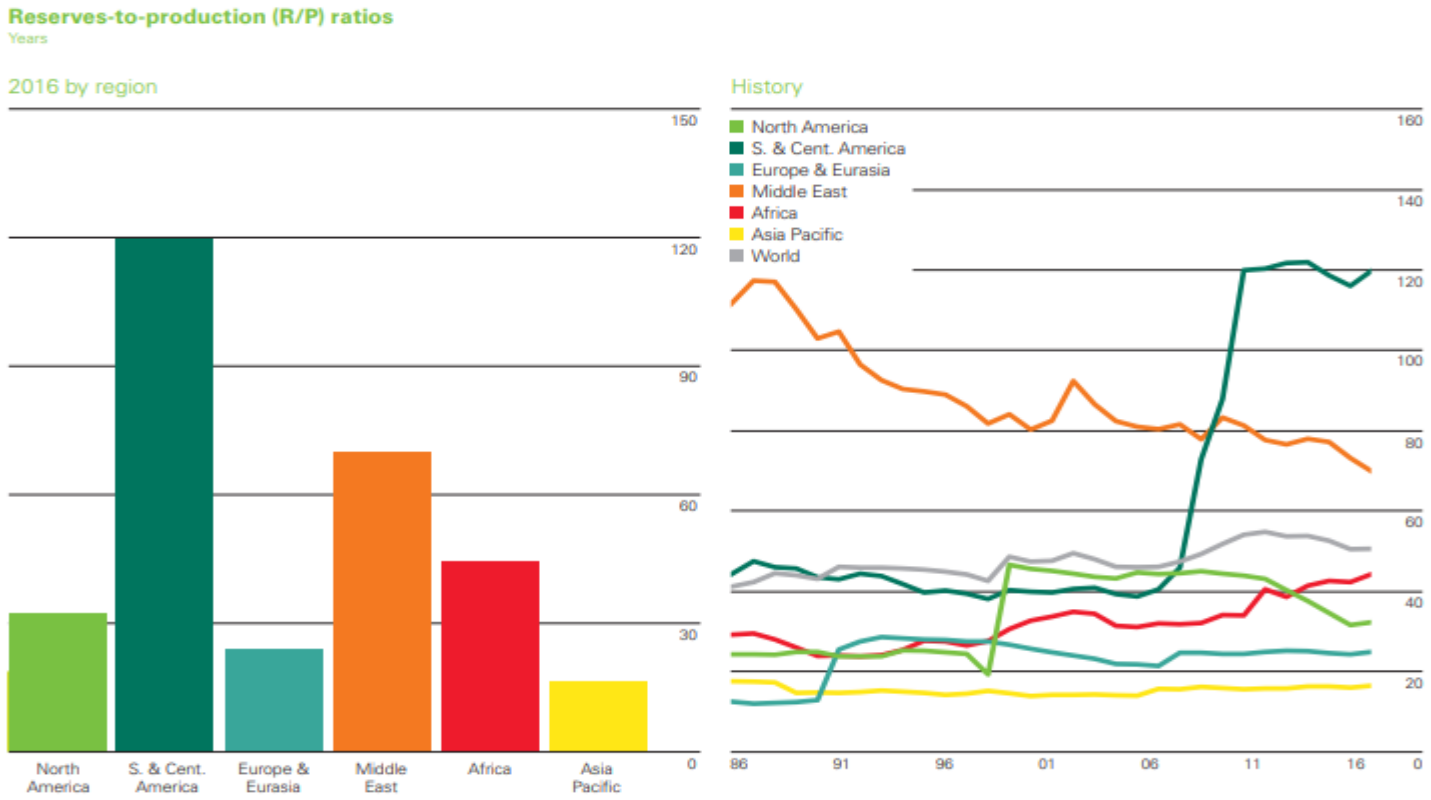
Oil Production



Global proved oil reserves in 2016 rose by 15 billion barrels (0.9%) to 1707 billion barrels, which would be sufficient to meet 50.6 years of global production at 2016 levels. The increase came largely from Iraq (10 billion barrels) and Russia (7 billion barrels), with small declines (<1 billion barrels) spread across a number of countries and regions. OPEC countries currently hold 71.5% of global proved reserves.

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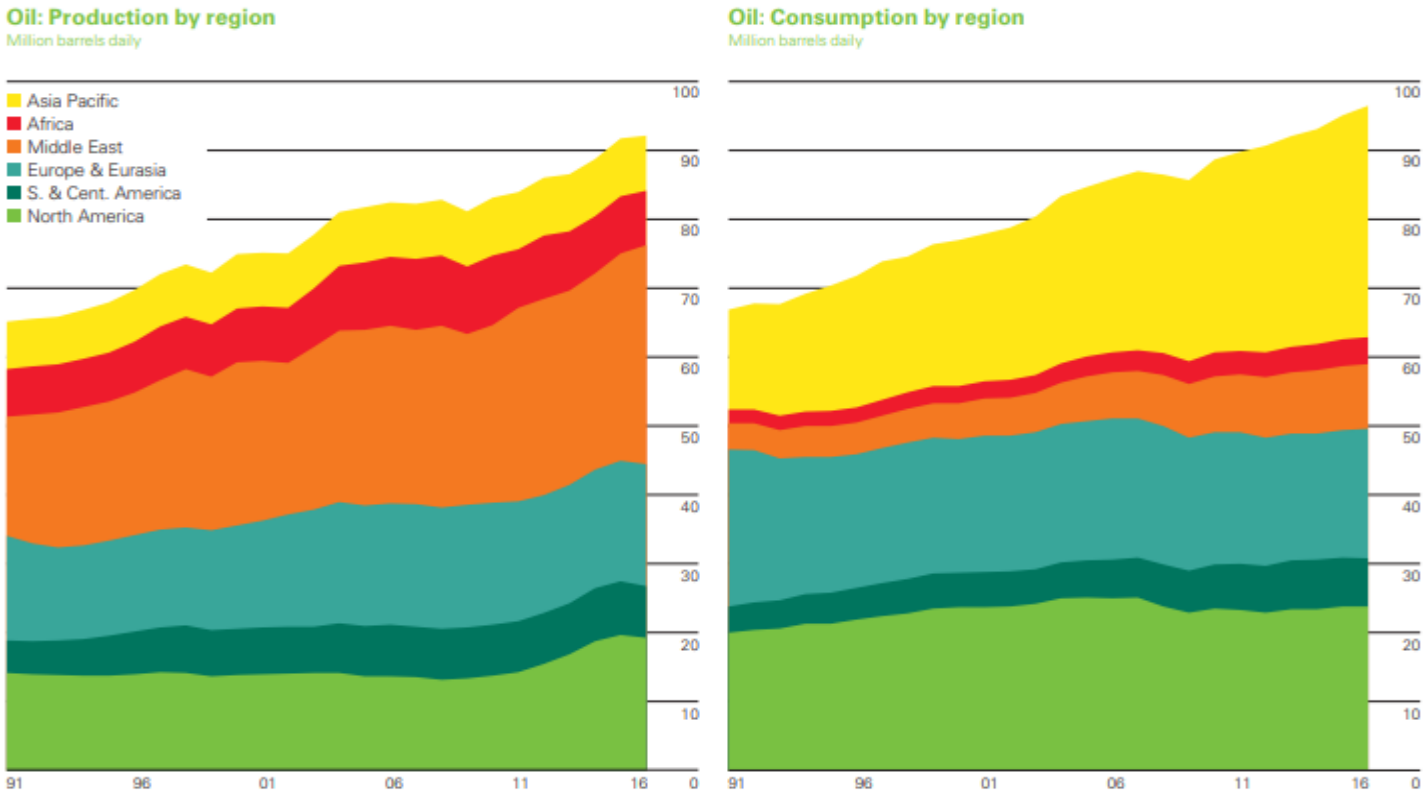
Oil production & consumption



World oil production grew by only 0.4 million b/d in 2016, the slowest growth since 2013. Production in the Middle East rose by 1.7 million b/d, driven by Iran, Iraq and Saudi Arabia, but this was largely offset by declines in North America, Africa, Asia Pacific and South & Central America. Global oil consumption growth averaged 1.6 million b/d, above the 10-year average of 1 million b/d for the second successive year as a result of stronger than usual growth in the OECD. However, China (400,000 b/d) and India (330,000 b/d) still provided the largest contributions to growth.

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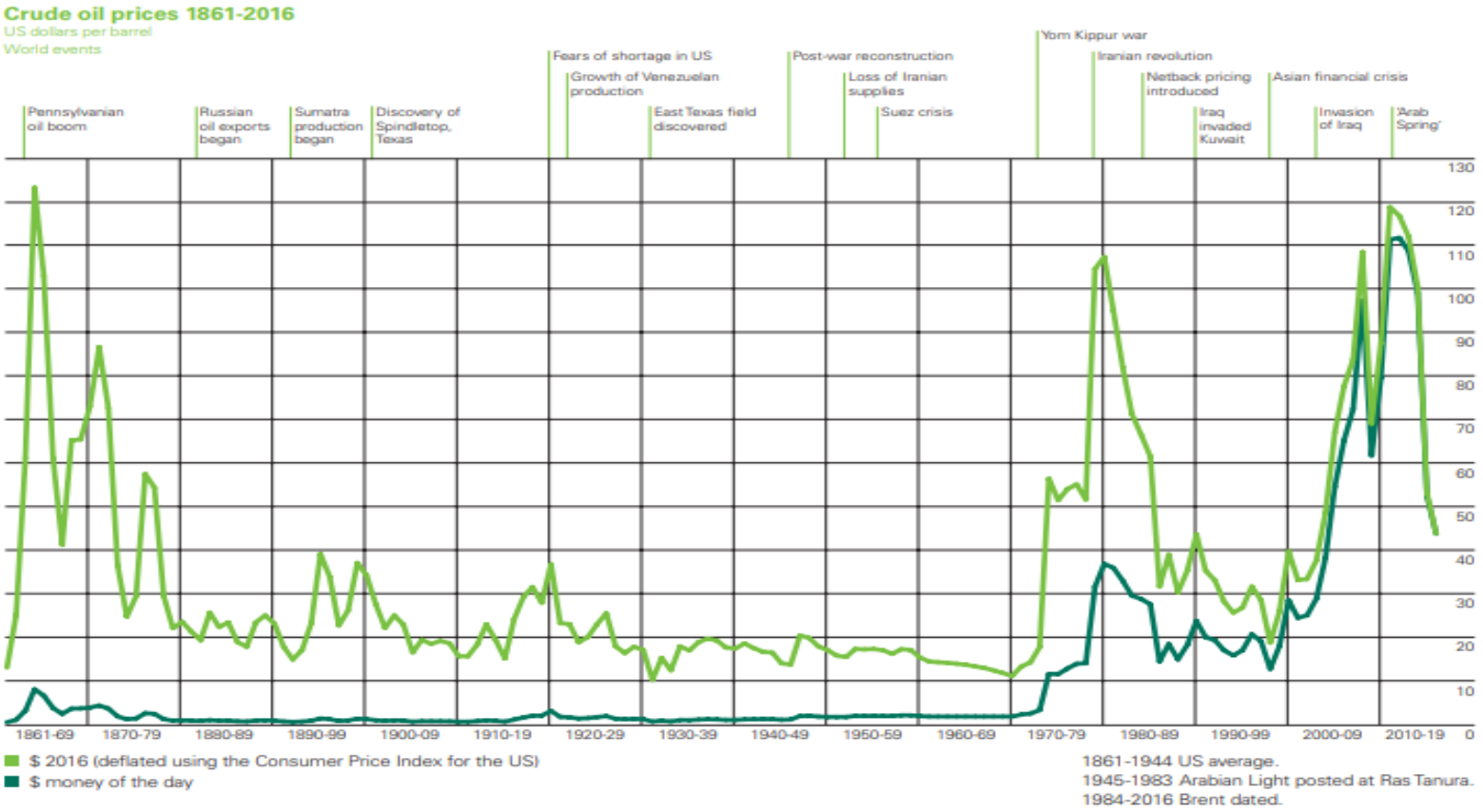
Oil prices



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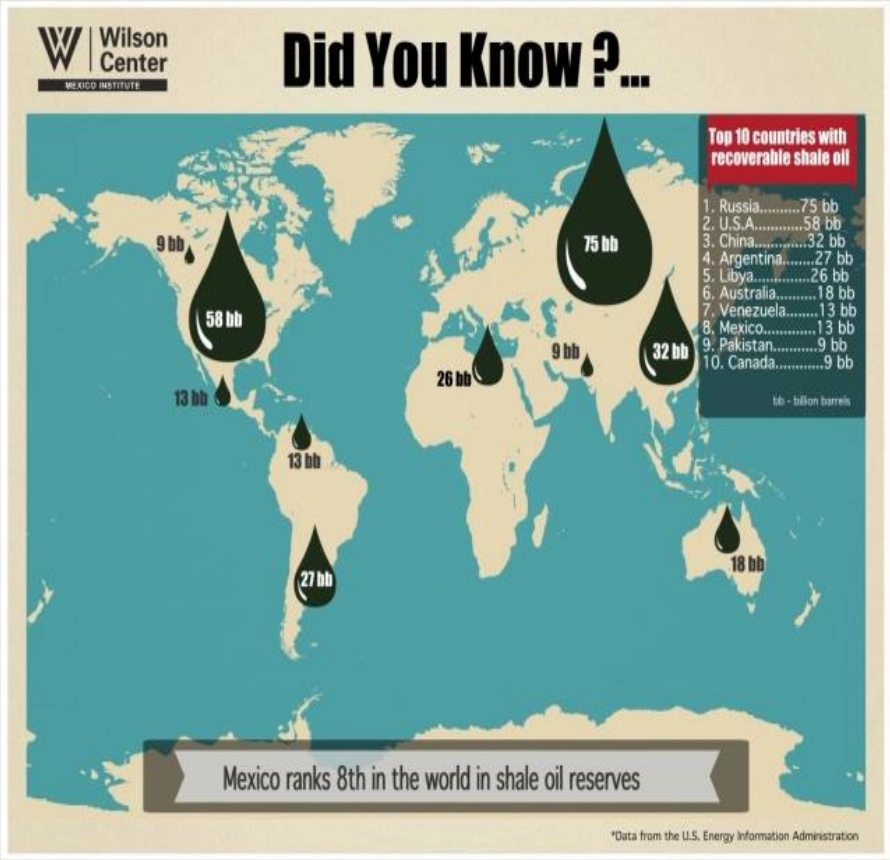
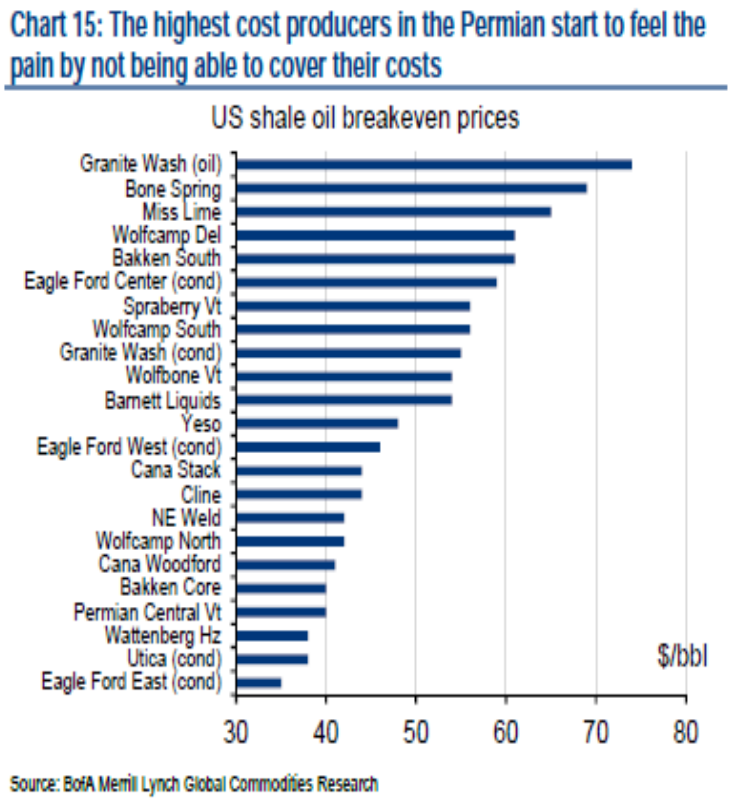
Shale oil





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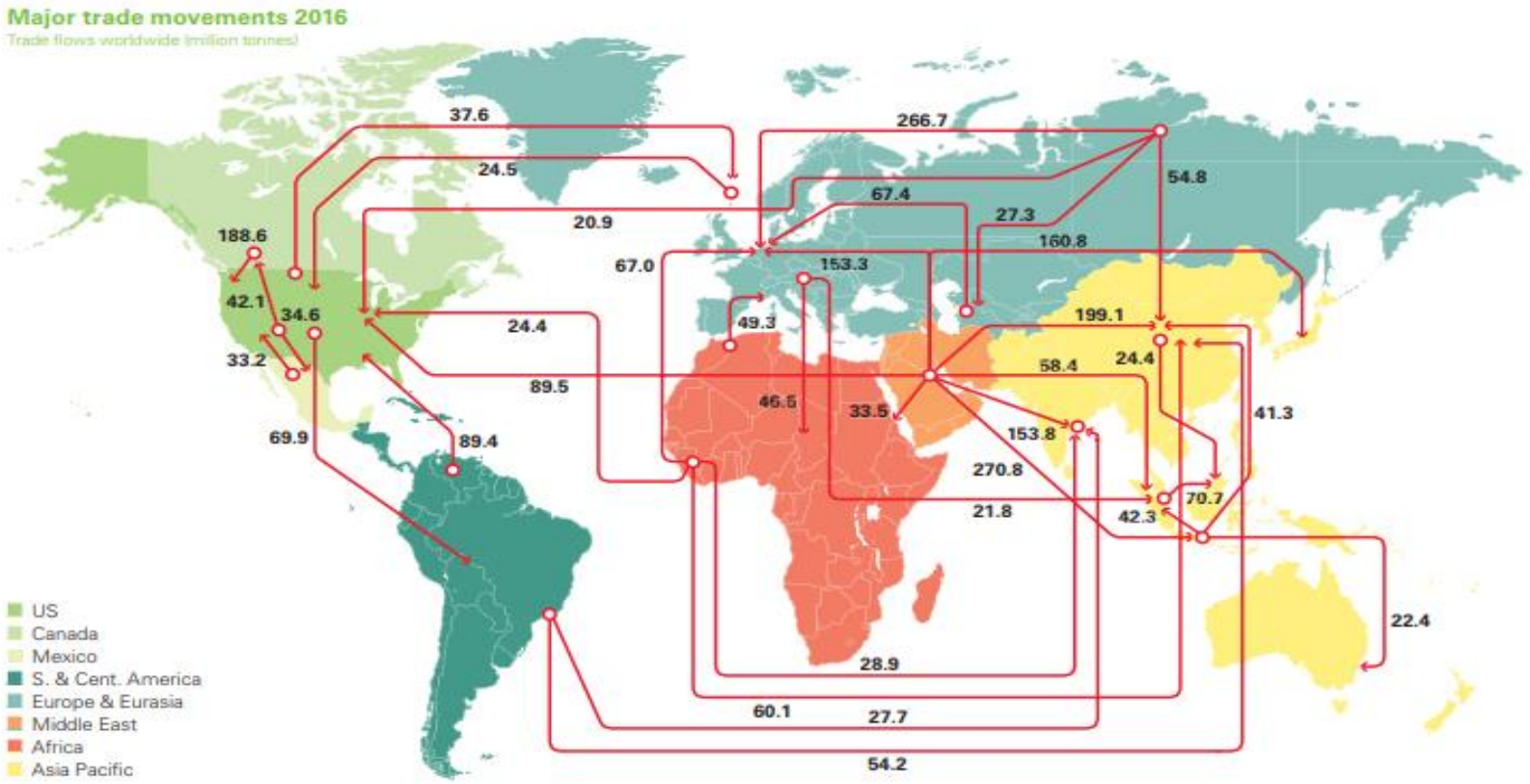
Oil trade



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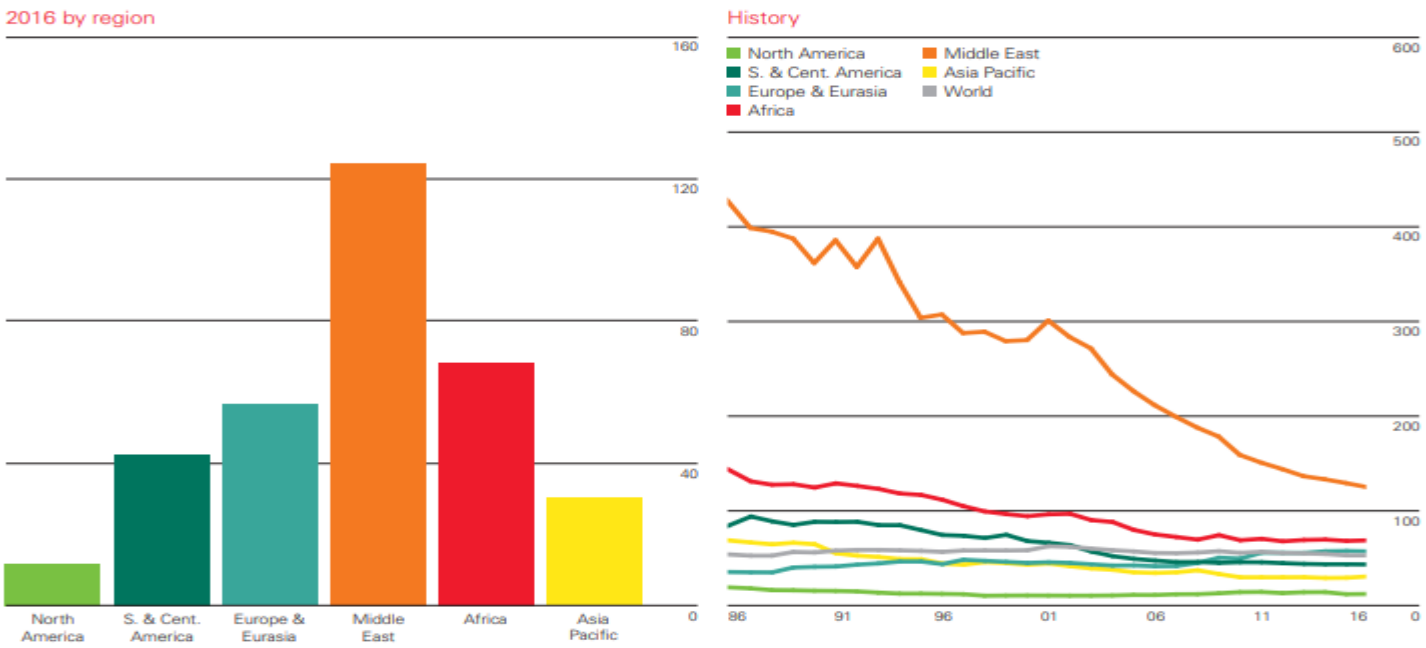
Gas

Reserves-to-production (R/P) ratios
Years



Global proved gas reserves in 2016 rose slightly by 1.2 trillion cubic metres (tcm) or 0.6% to 186.6 tcm. As with oil, this is sufficient to meet more than 50 years of current production (52.5 years). Myanmar (+0.7 tcm) and China (+0.6 tcm) were the main contributors to growth. By region, the Middle East holds the largest proved reserves (79.4 tcm, 42.5% of the global total), while by country, Iran is the largest reserve holder (33.5 tcm, 18% of total).
N.B. Lags in reporting official data mean that 2016 figures for many countries are not yet available.

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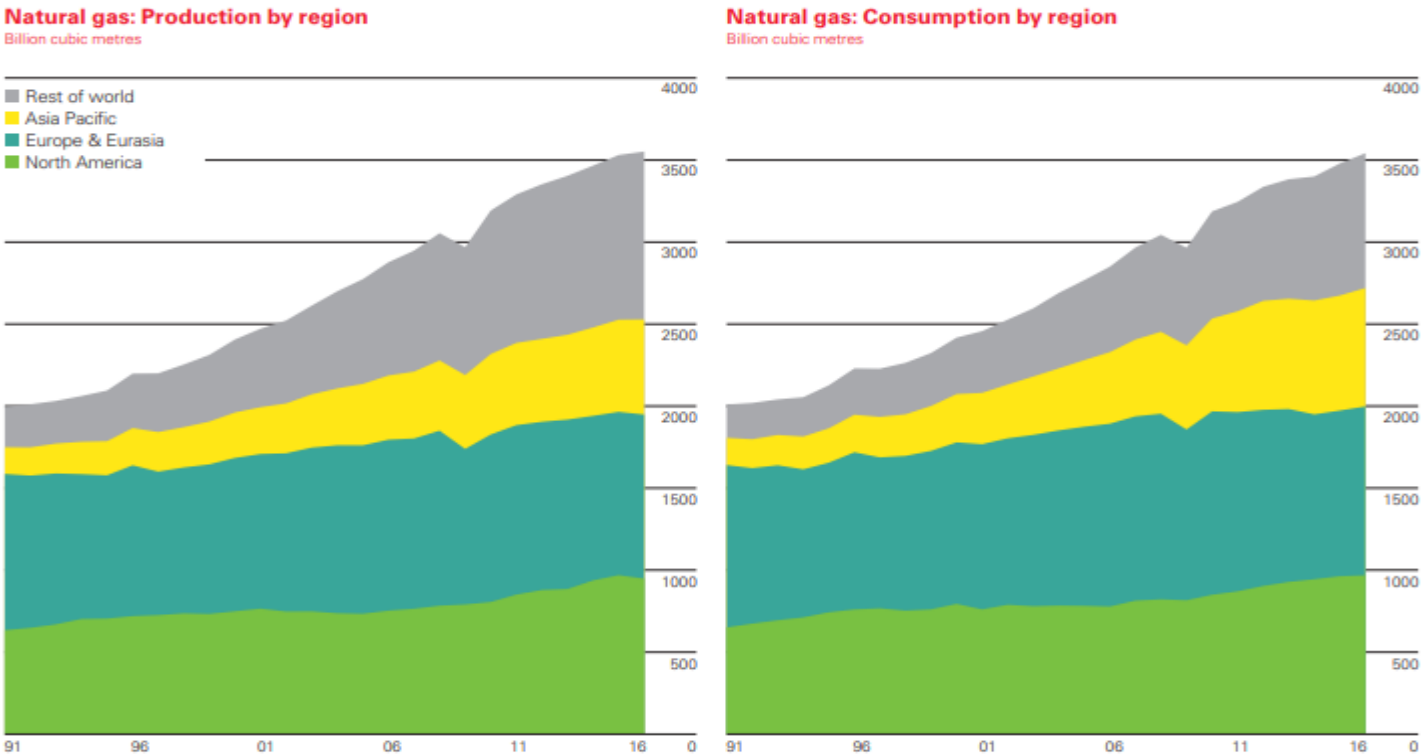
Gas production, consumption



Global natural gas production increased by only 0.3%, or 21 billion cubic metres (bcm) to 3552 bcm. Declining production in North America (-21 bcm) partially offset strong growth from Australia (19 bcm) and Iran (13 bcm). Gas consumption increased by 63 bcm or 1.5% – slower than the 10 year average (2.3%). EU gas consumption rose sharply by 30 bcm, or 7.1% – the fastest growth since 2010. Russia saw the largest drop in consumption of any country (-12 bcm).

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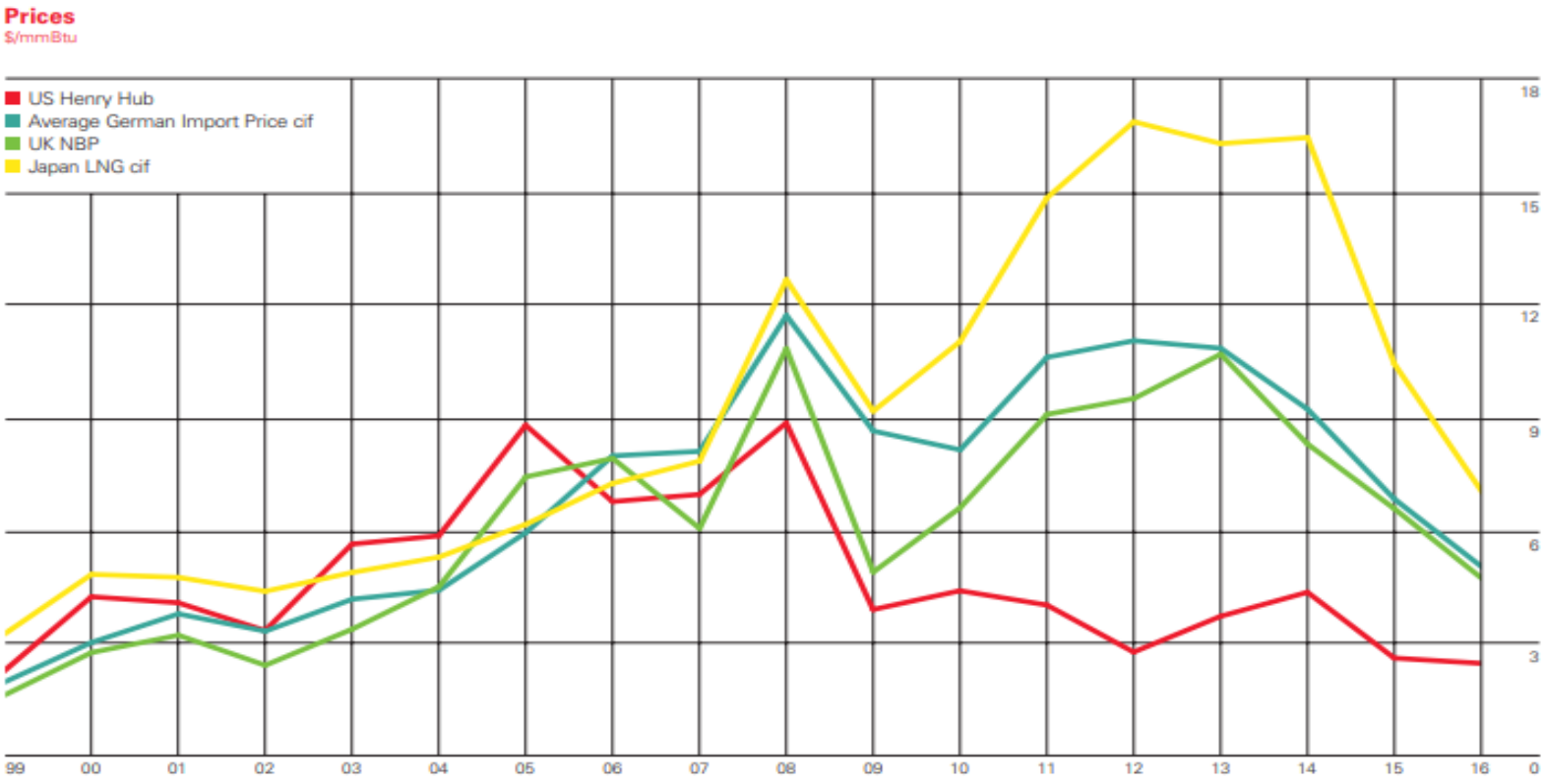
Gas prices



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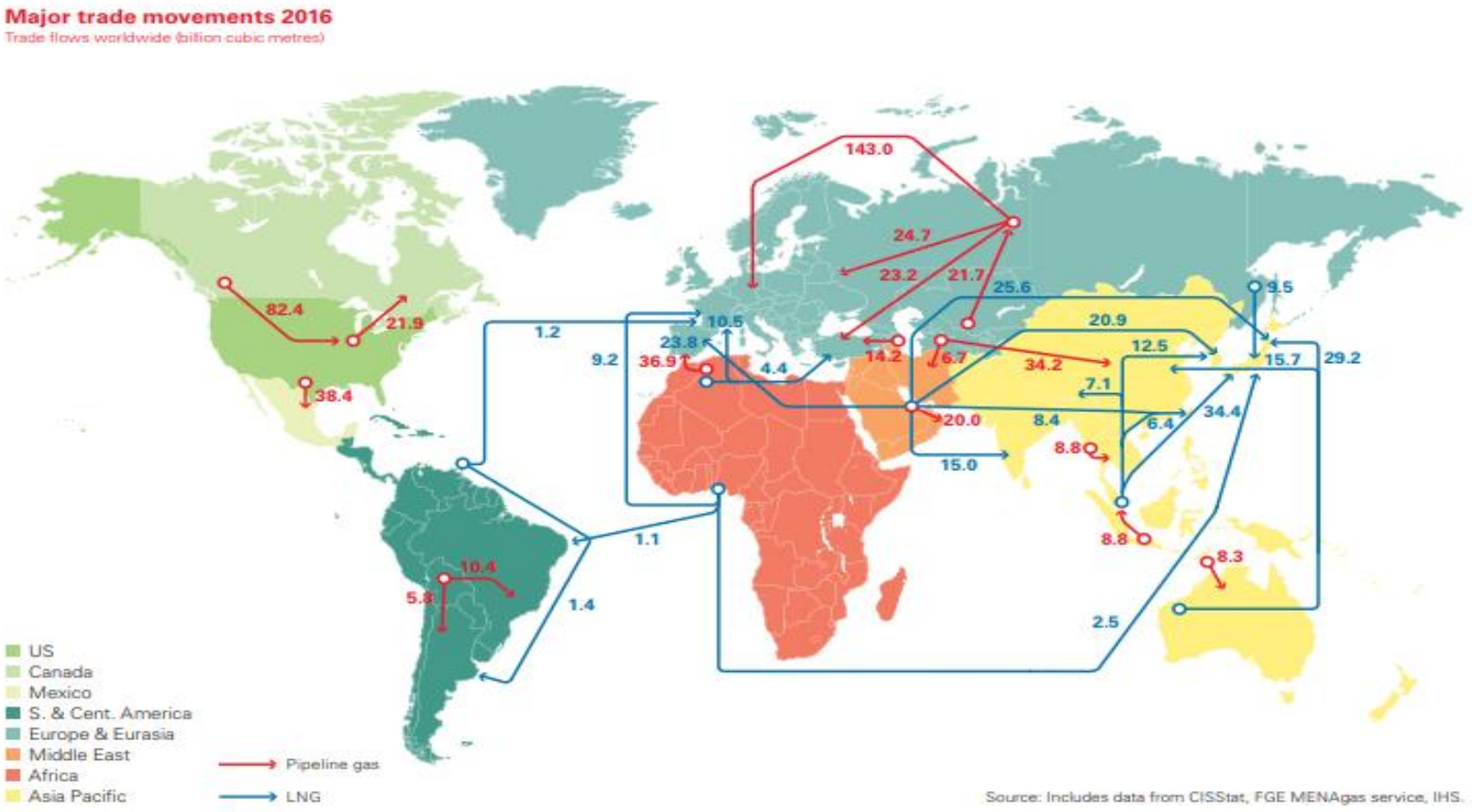
Gas trade



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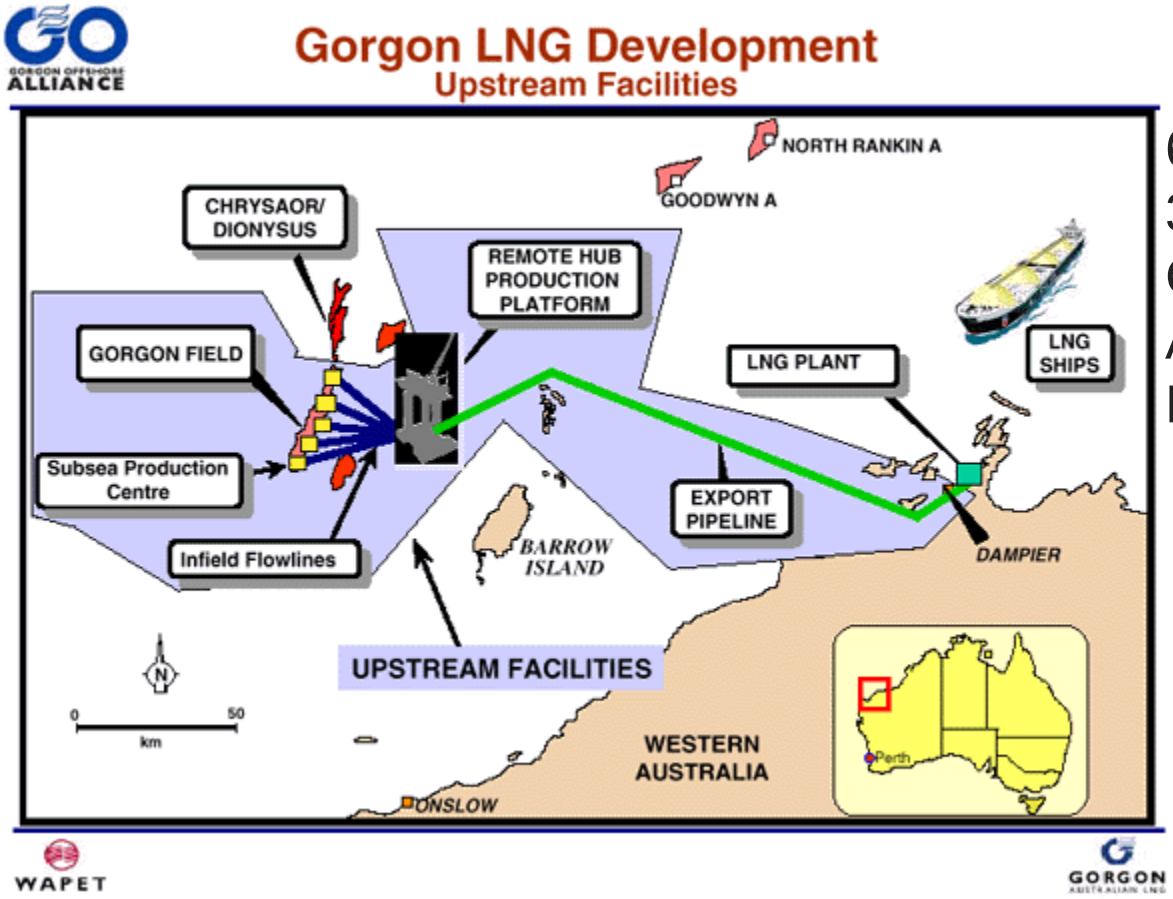
Gas development – Gorgon field



6000 construction jobs
350 operation
Cost ~A$60 b
Asset specific
Long term contracts

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LNG Terminal Japan

Asset specific investment - cost?
Power production
Long term contracts

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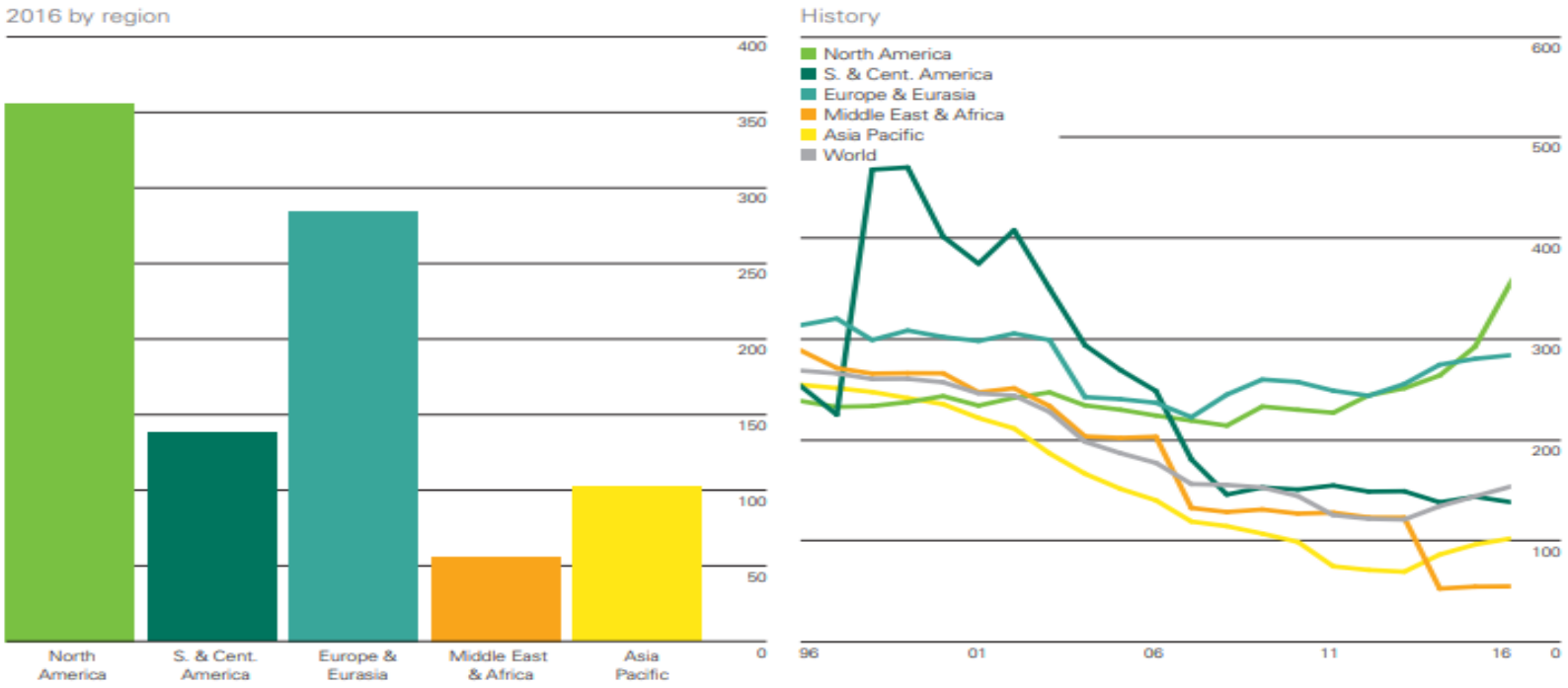
Coal

Reserves-to-production (R/P) ratios
Years



World proved coal reserves are currently sufficient to meet 153 years of global production, roughly three times the R/P ratio for oil and gas. By region, Asia Pacific holds the most proved reserves (46.5% of total), with China accounting for 21.4% of the global total. The US remains the largest reserve holder (22.1% of total).

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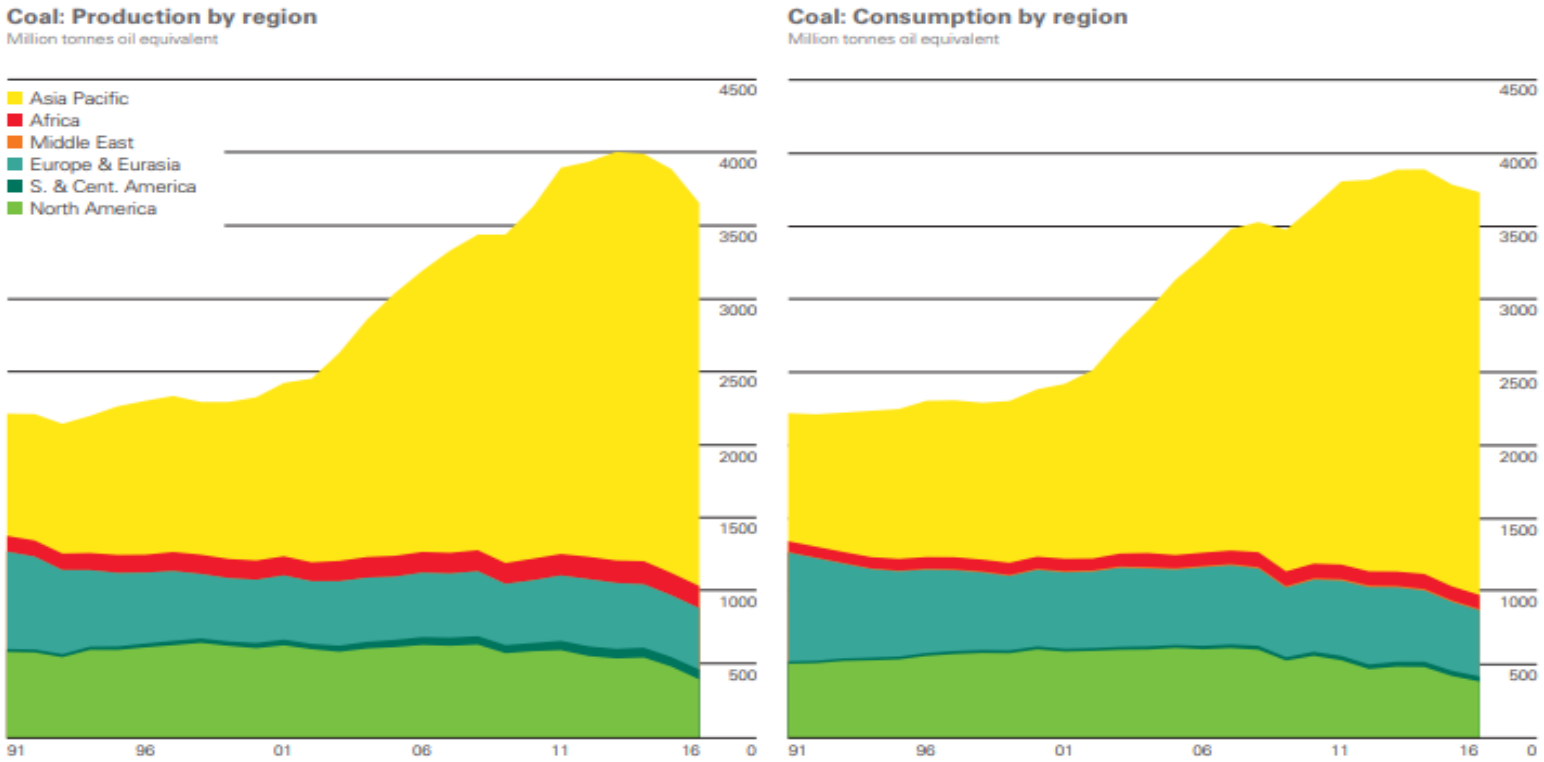
Coal



World coal production fell by 6.2%, or 231 million tonnes of oil equivalent (mtoe) in 2016, the largest decline on record. China's production fell by 7.9% or 140 mtoe – also a record decline – while US production fell by 19% or 85 mtoe. Global coal consumption fell by 1.7%, the second successive decline. The largest decreases were seen in the US (-33 mtoe, an 8.8% fall), China (-26 mtoe, -1.6%) and the United Kingdom (-12 mtoe, -52.5%).

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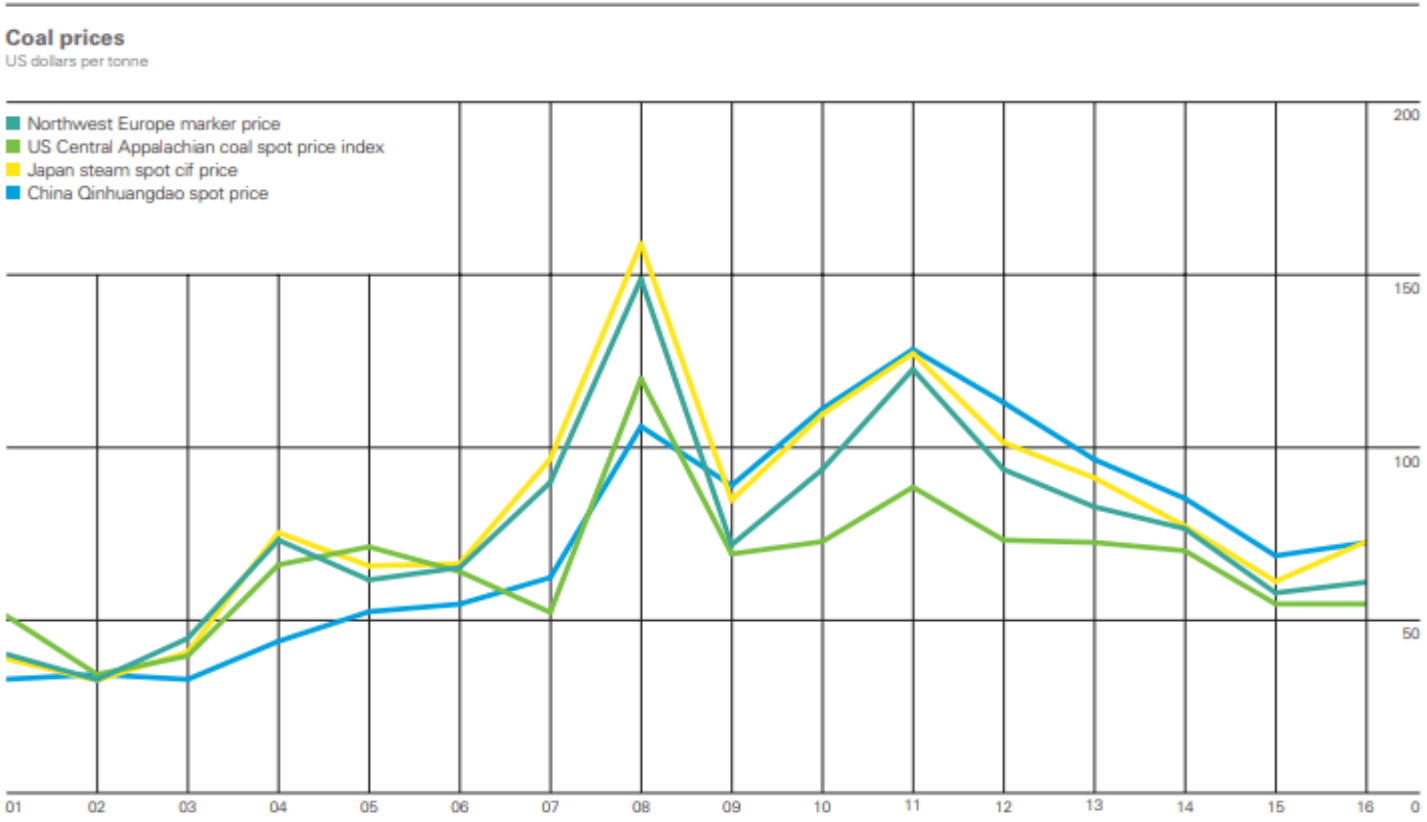
Coal prices



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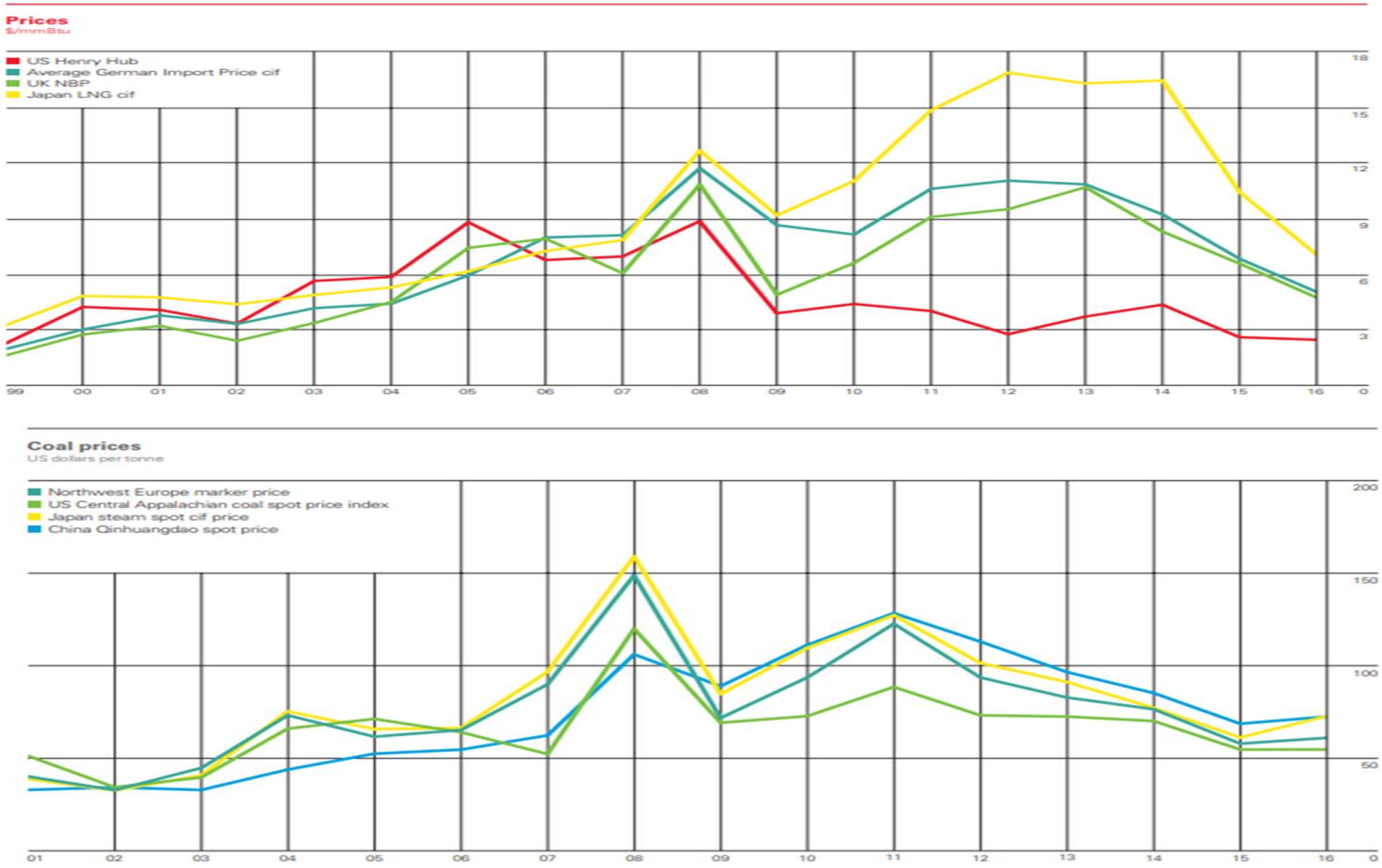
Are gas & coal prices correlated?



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Open cut mining Hunter region

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Fossil fuel emissions

FOSSIL FUELS

COMBUSTION

Carbon
Hydrogen
Nitrogen
Sulfur
Oxygen

Primary Pollutants

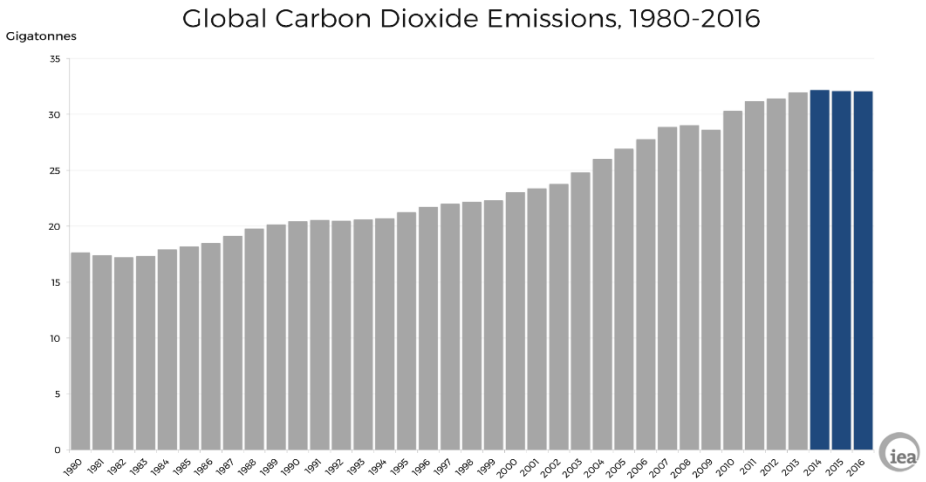
CO - Carbon Monoxide
CO_2 - Carbon Dioxide
SO_2 - Sulfur
NO_x - Nitrogen Dioxide
N_2O - Nitric Oxide

VOCs - Volatile Organic Compounds
or
HCs - Hydrocarbons

Particulate Matter

PM_{10} - Course Particles - less than 10 microns
$PM_{2.5}$ - Fine Particles - less than 2 microns

NH_3 - Ammonia



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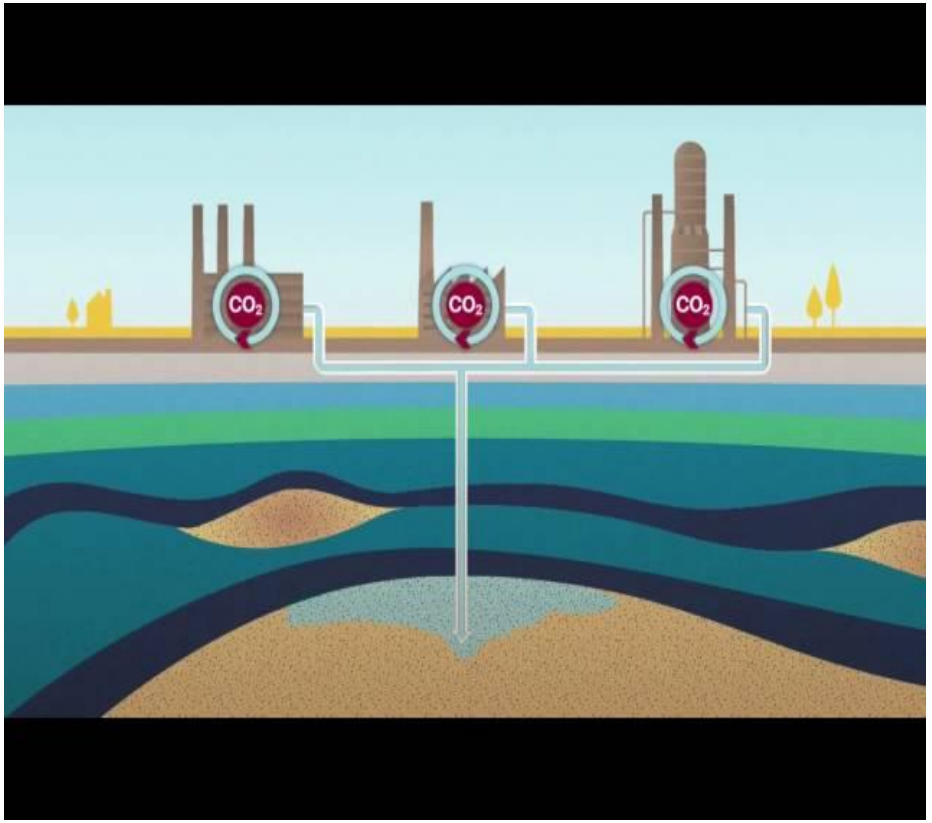
Clean coal

- CCS (carbon capture and storage) aimed at preventing carbon dioxide (CO_2) exhaust from entering the atmosphere.
- Kemper Project 582 MW (MI) planned for 2014 @ US $2.4 b; 2017 cost US $7.5 b. Switched to running on gas.



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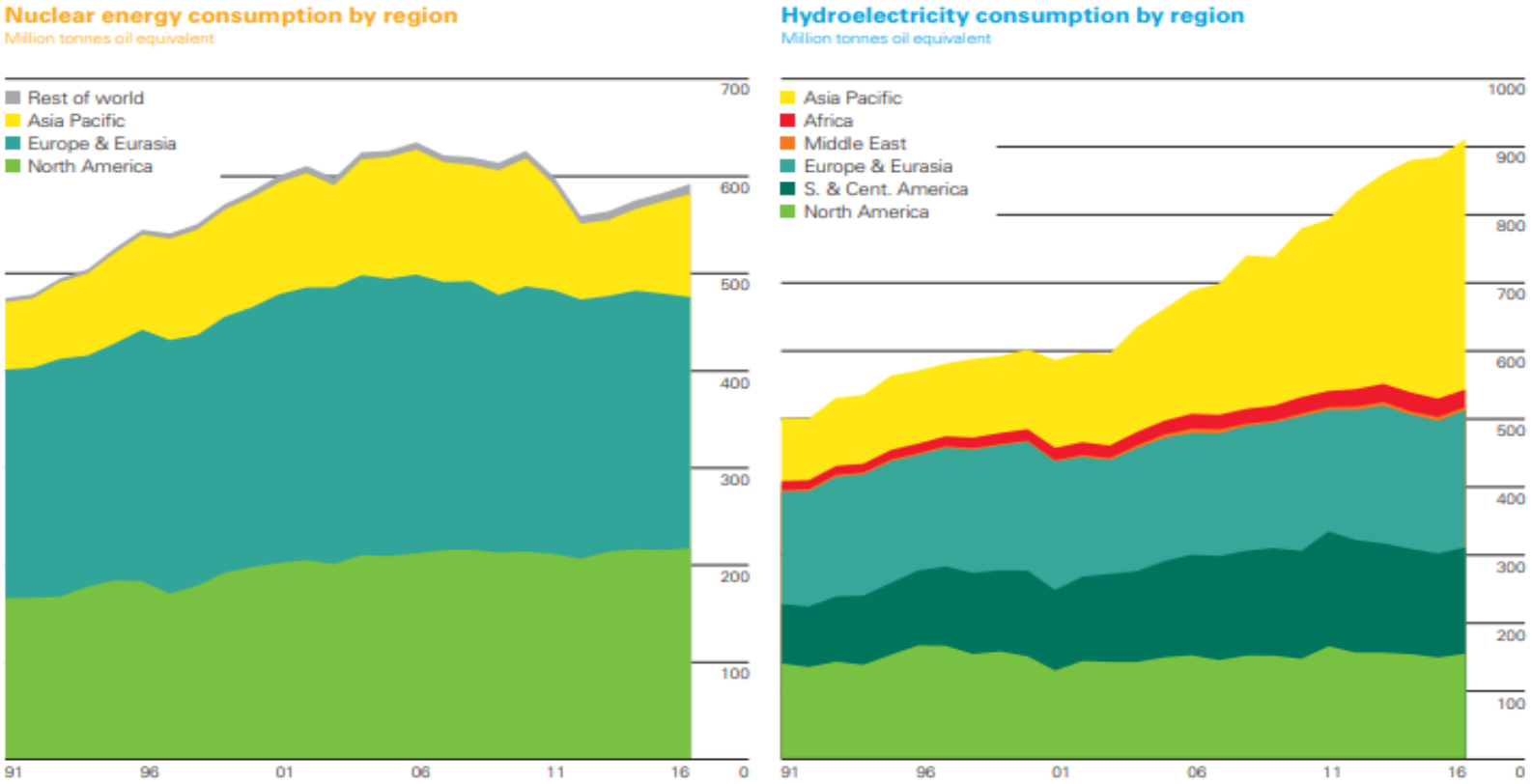
Nuclear & hydroelectricity



Global nuclear power generation increased by 1.3% in 2016, or 9.3 million tonnes of oil equivalent (mtoe). China accounted for all of the net growth, expanding by 24.5% (9.6 mtoe). Generation in Japan and Belgium also grew strongly, while France saw a sharp decline (-8.1%, -7.7 mtoe). Hydroelectric power generation rose by 2.8% (27.1 mtoe), slightly below the 10-year average of 2.9%. China (4%, 10.9 mtoe) and Brazil (6.5%, 5.5 mtoe) were the largest contributors to growth.

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Hydro technology – 1882 Wisconsin

- Technical potential for growth – development limited by politics & poorly developed transmission networks in Asia.
- Lake Benmore; run of river system

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Fukushima diachi power plant

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Fukushima diachi after earthquake

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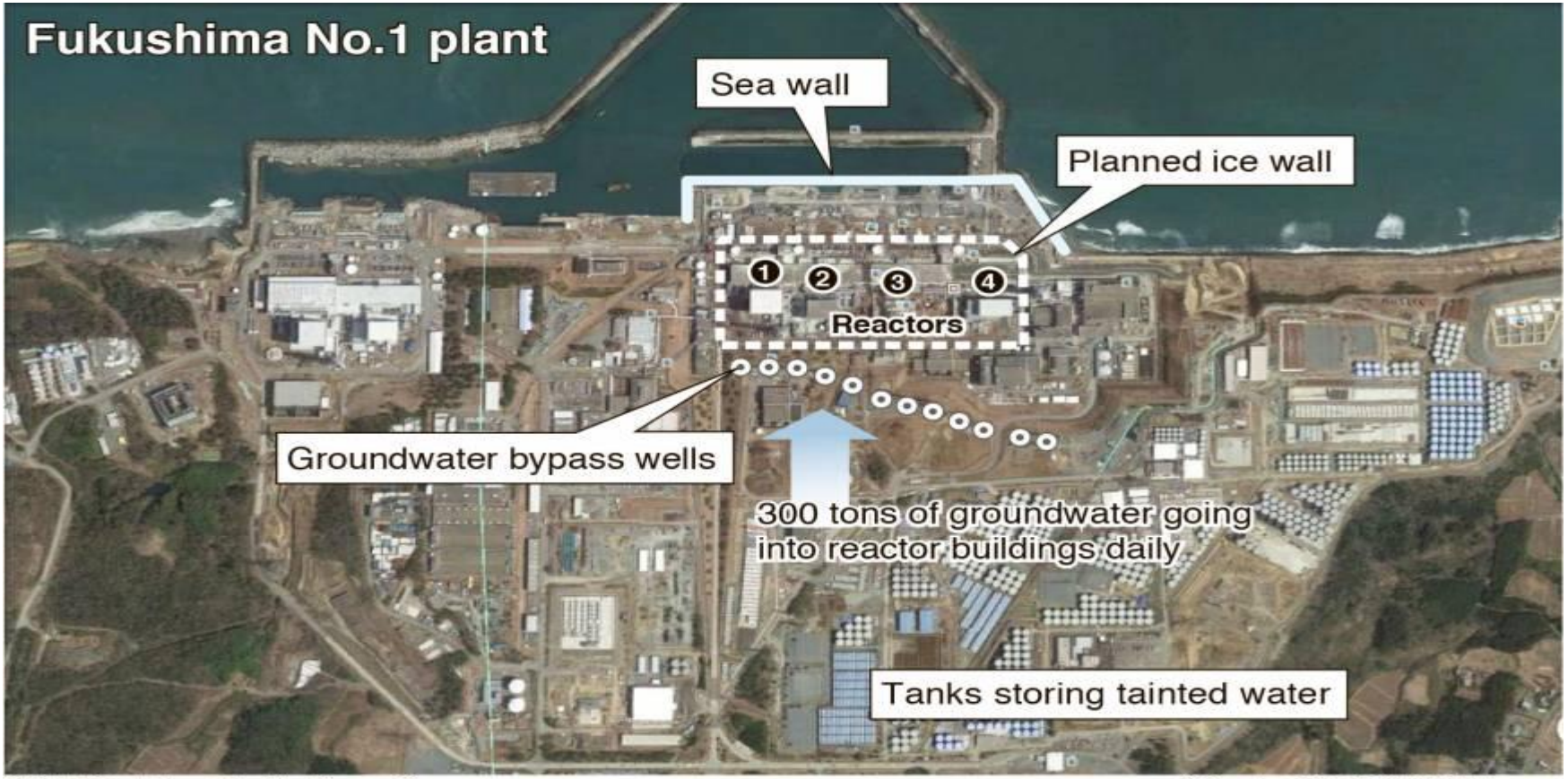
Fukushima recovery



SOURCE: Tokyo Electric Power Co.

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Tomioka township

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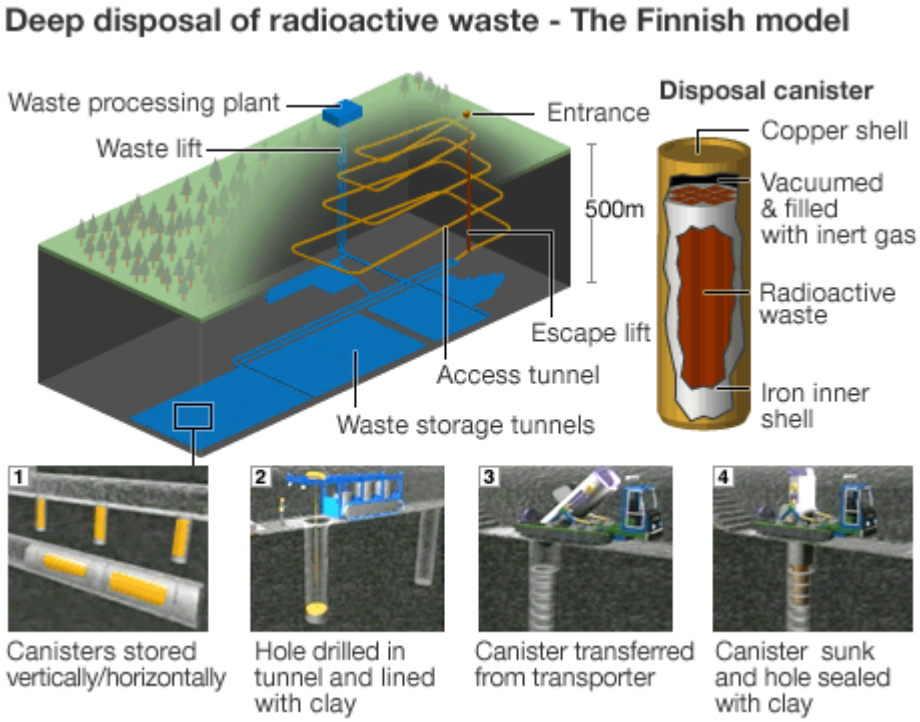
High level radioactive waste



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Low level radioactive waste

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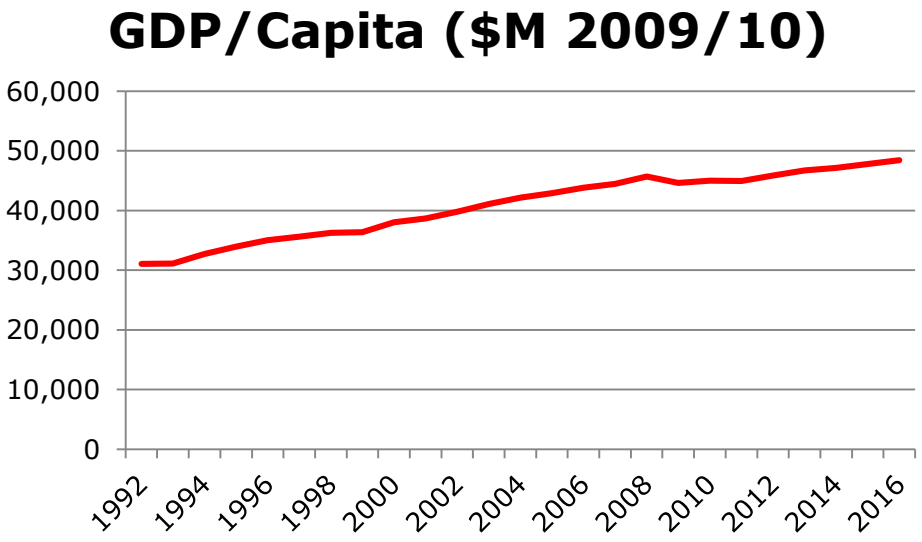
Economy-Energy New Zealand

- Macroeconomic measure
  - GDP, imports/exports
  - Structure of economy
  - Energy per unit output
- Energy supply/demand
  - Sector demand
  - Transport
- Energy resources
  - Hydro, geothermal, gas, oil, wind, solar

Gross Domestic Product



$$GDP = C + I + G + (X\text{-}M)$$

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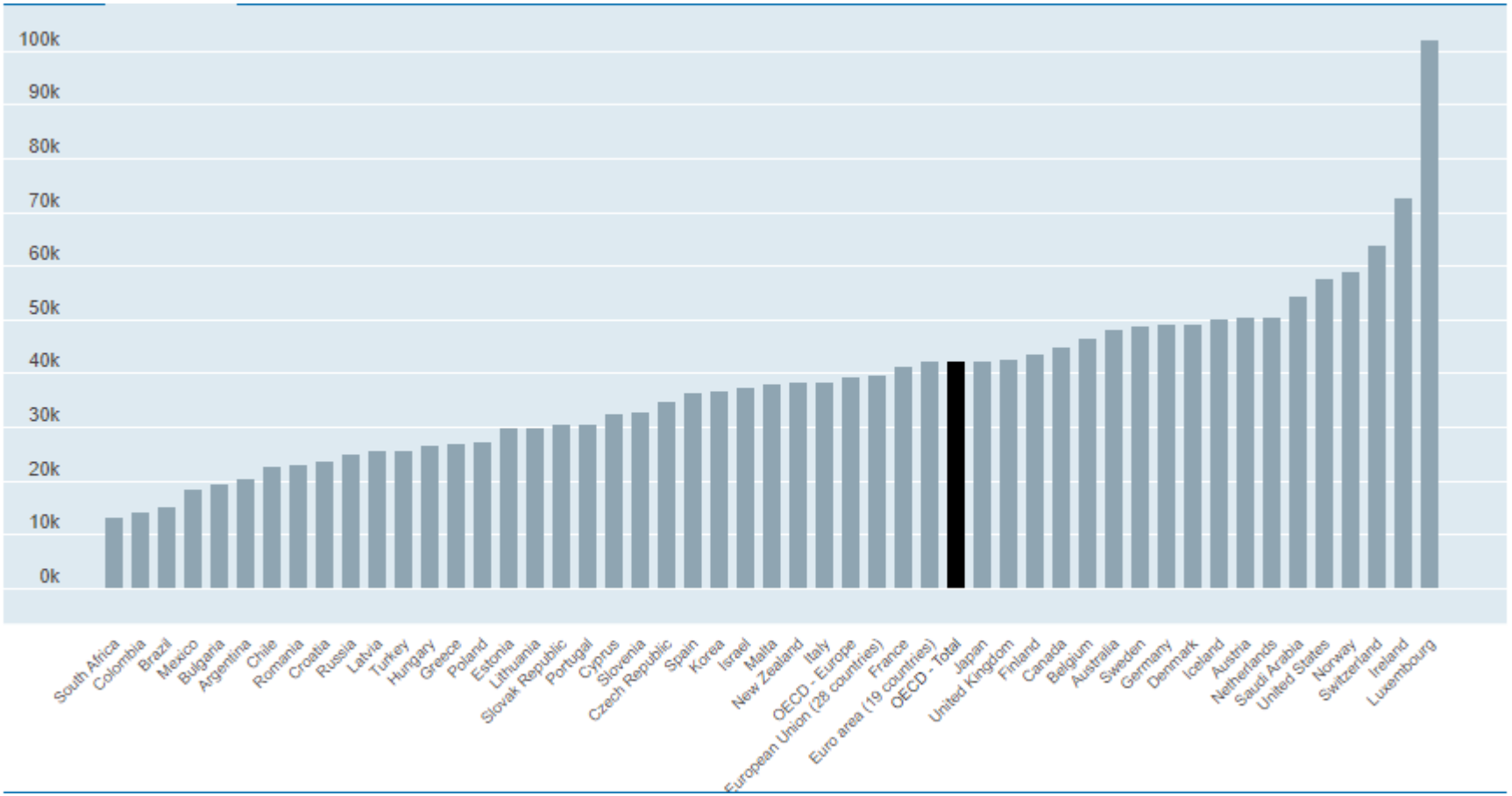
US$ GDP per capita 2016



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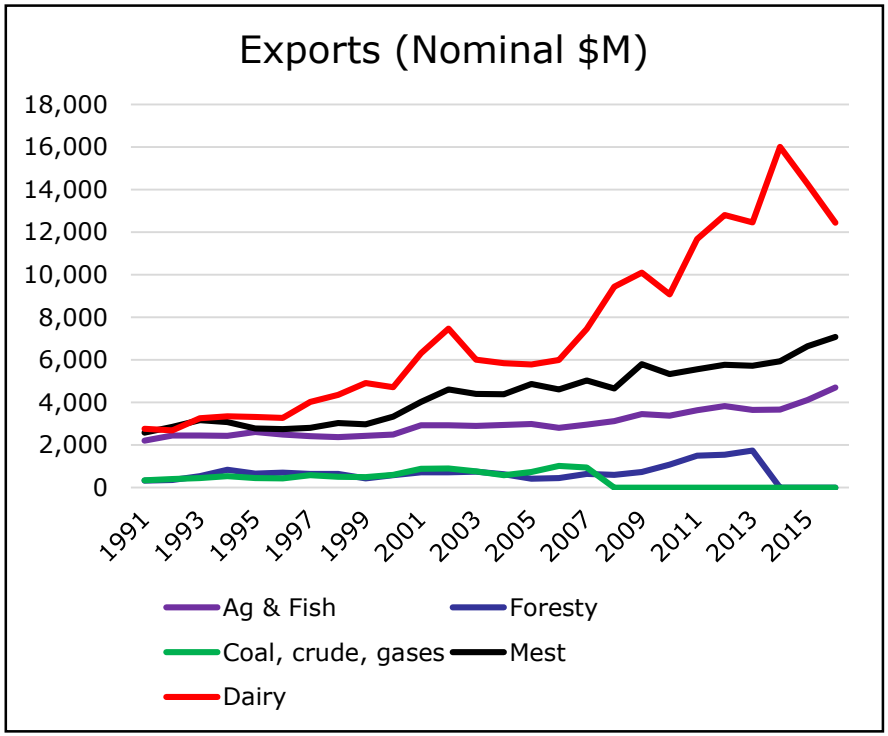
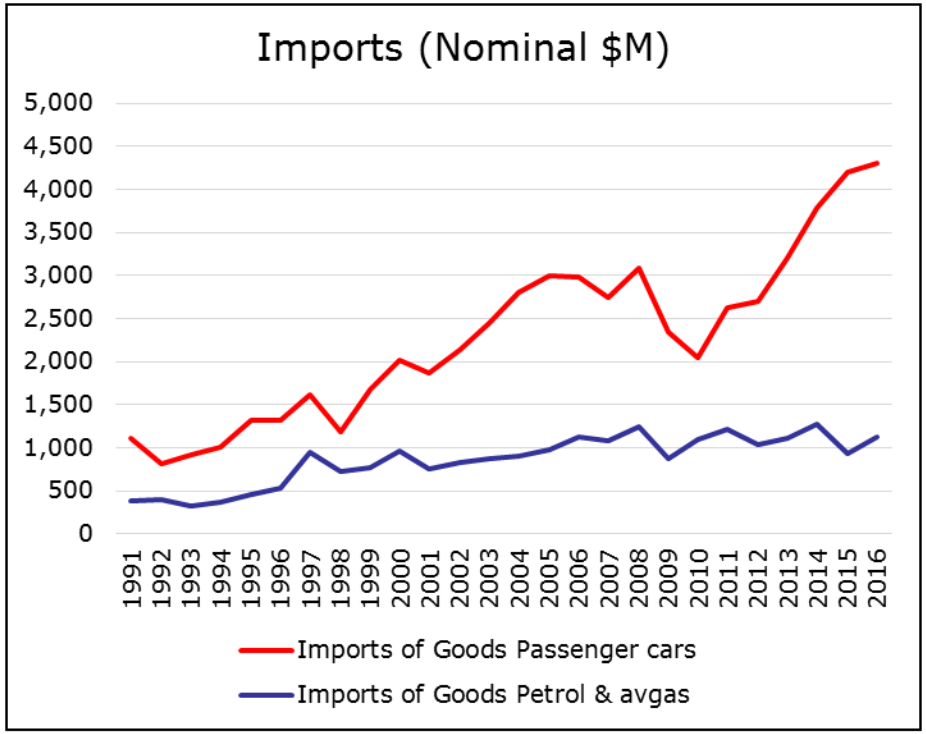
Value of Exports & Imports





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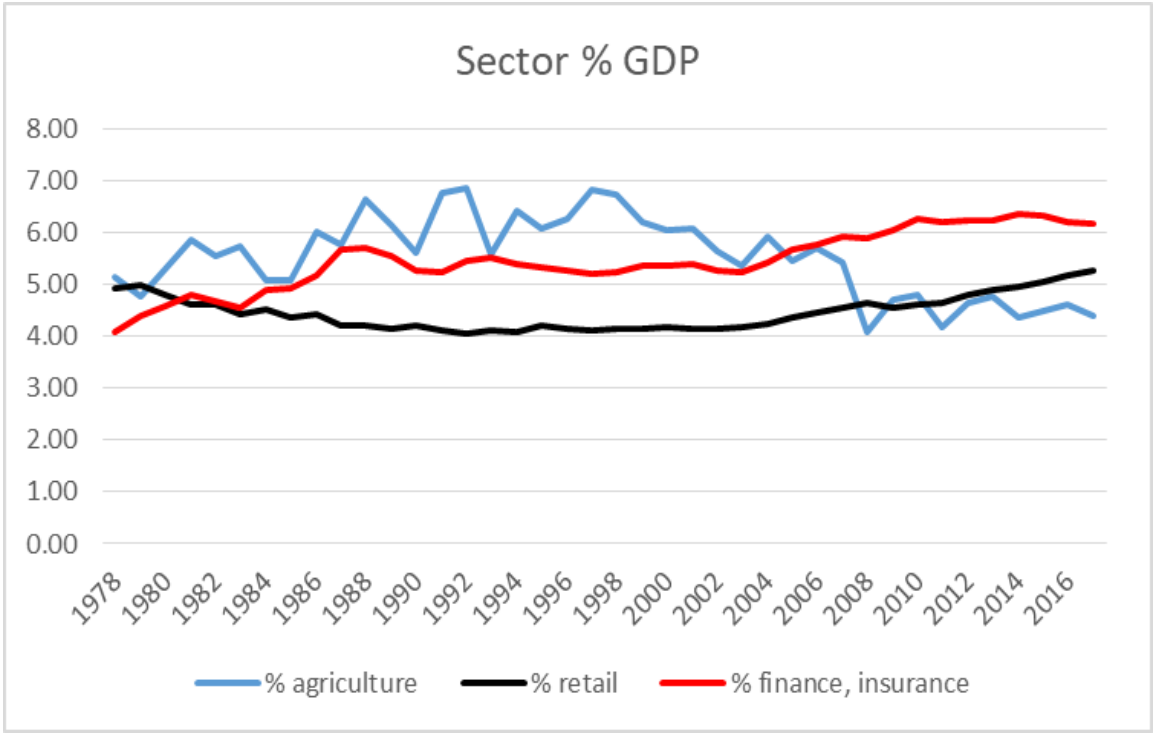
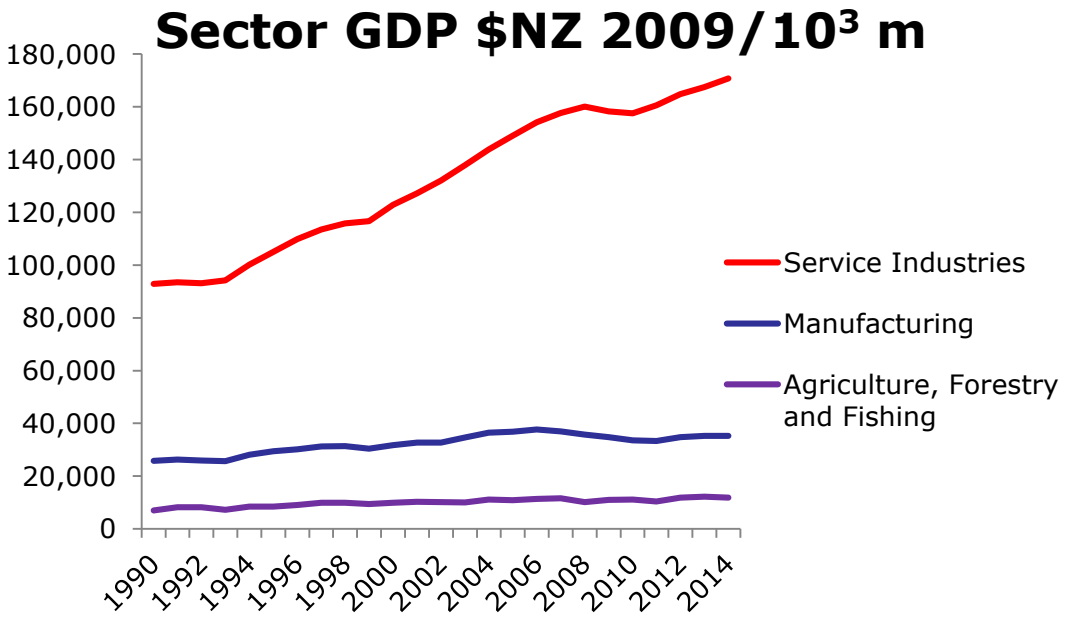
Economy in transition



Sector Level Contributions to GDP



Composition 2014

Primary ind.	7%
Goods producing ind.	20%
Service sector	65%

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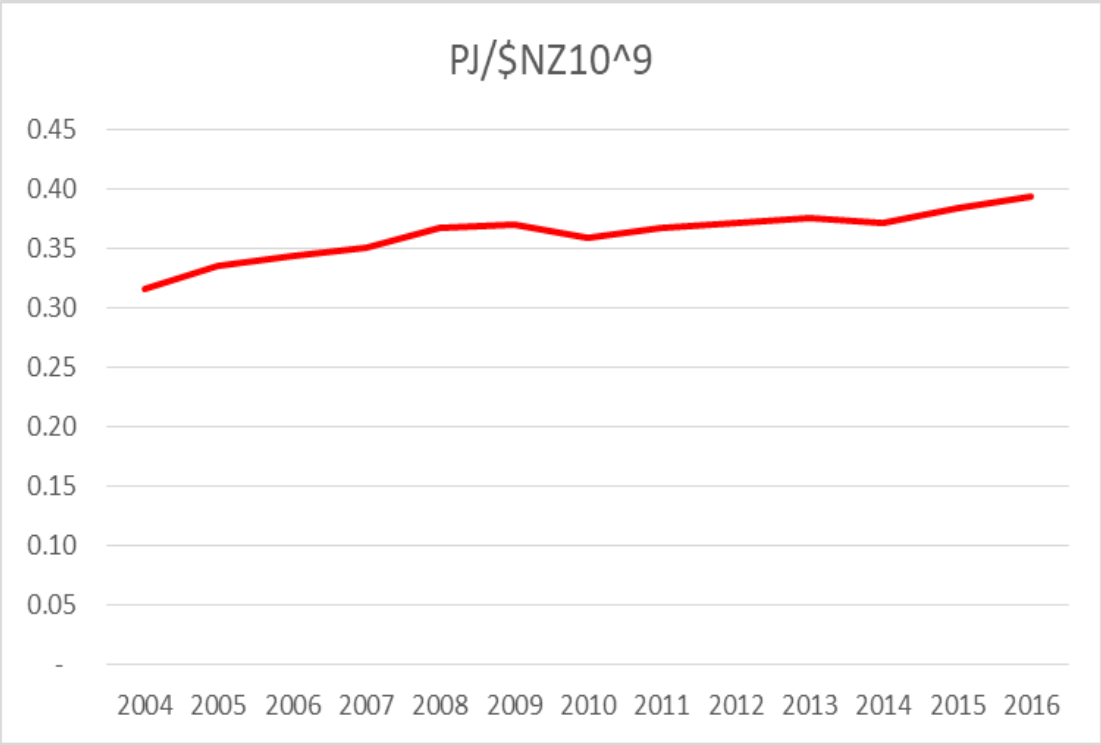
Energy consumption per unit GDP



Correlation coefficient
GDP (2009/10$)
& PJ = 0.74

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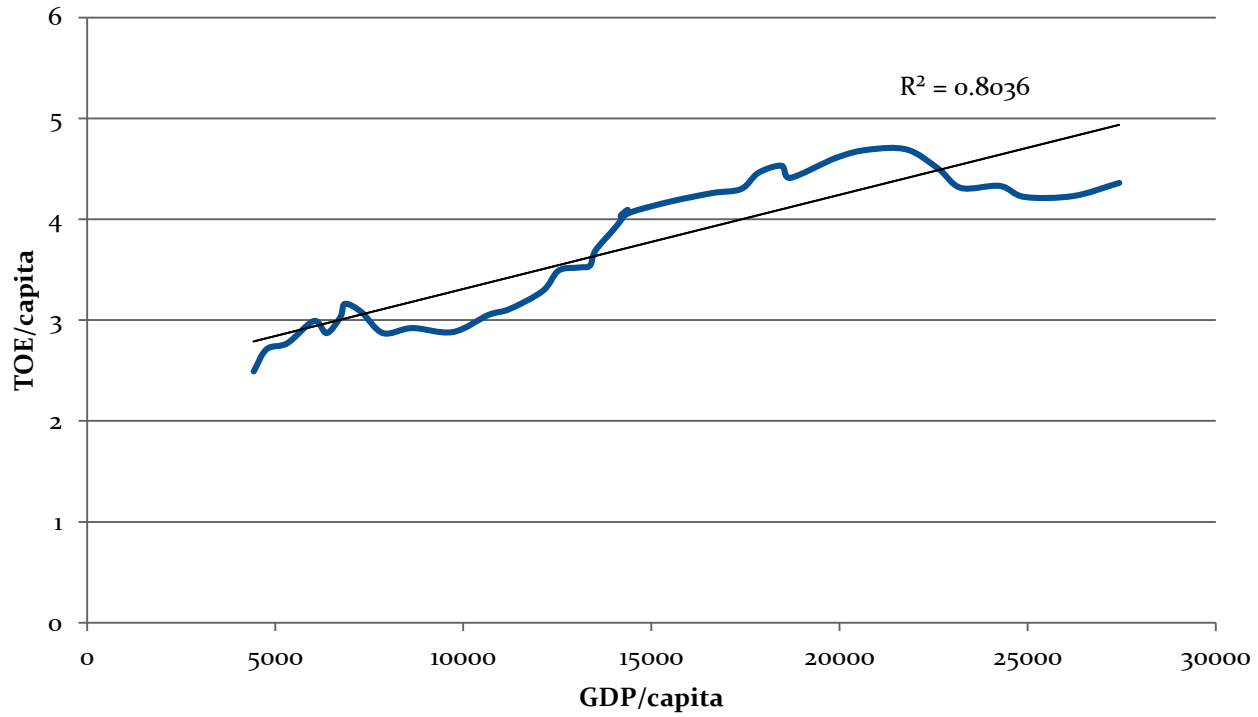
Energy & Economic Growth, NZ



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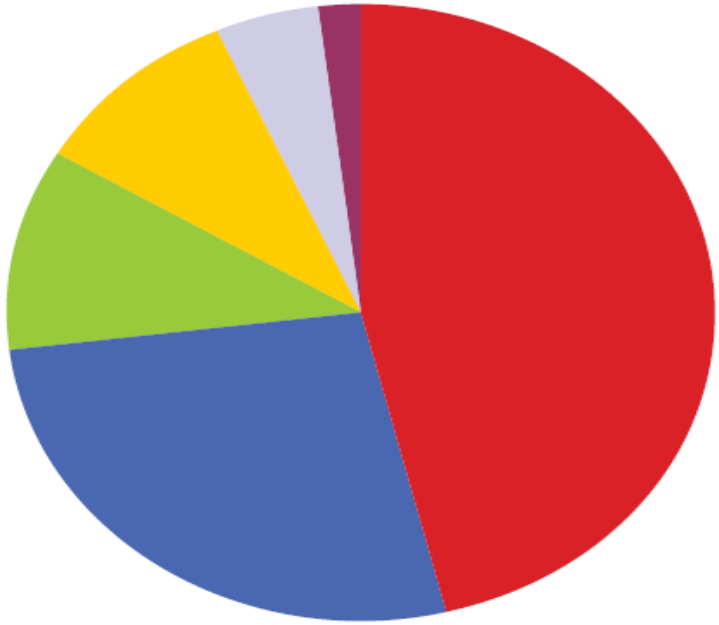
NZ Total Energy by Fuel



- Oil 46.0%
- Electricity 27.0%
- Other Renewables 10.3%
- Gas 10.2%
- Coal 4.8%
- Geothermal Direct Use 1.8%

Note:
Significance of oil & electricity
Link to: imports & transport

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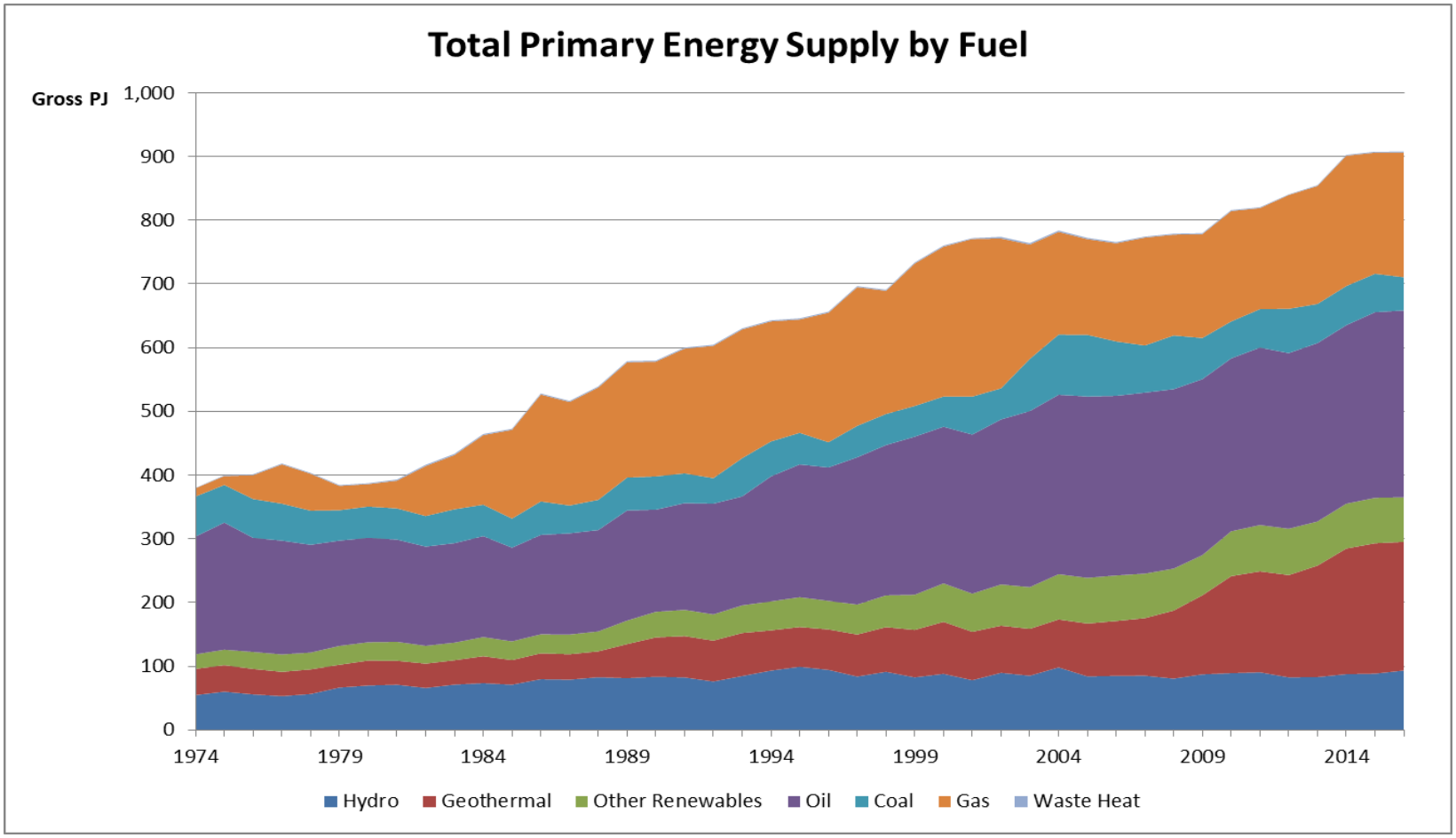
Oil > gas > geothermal>hydro



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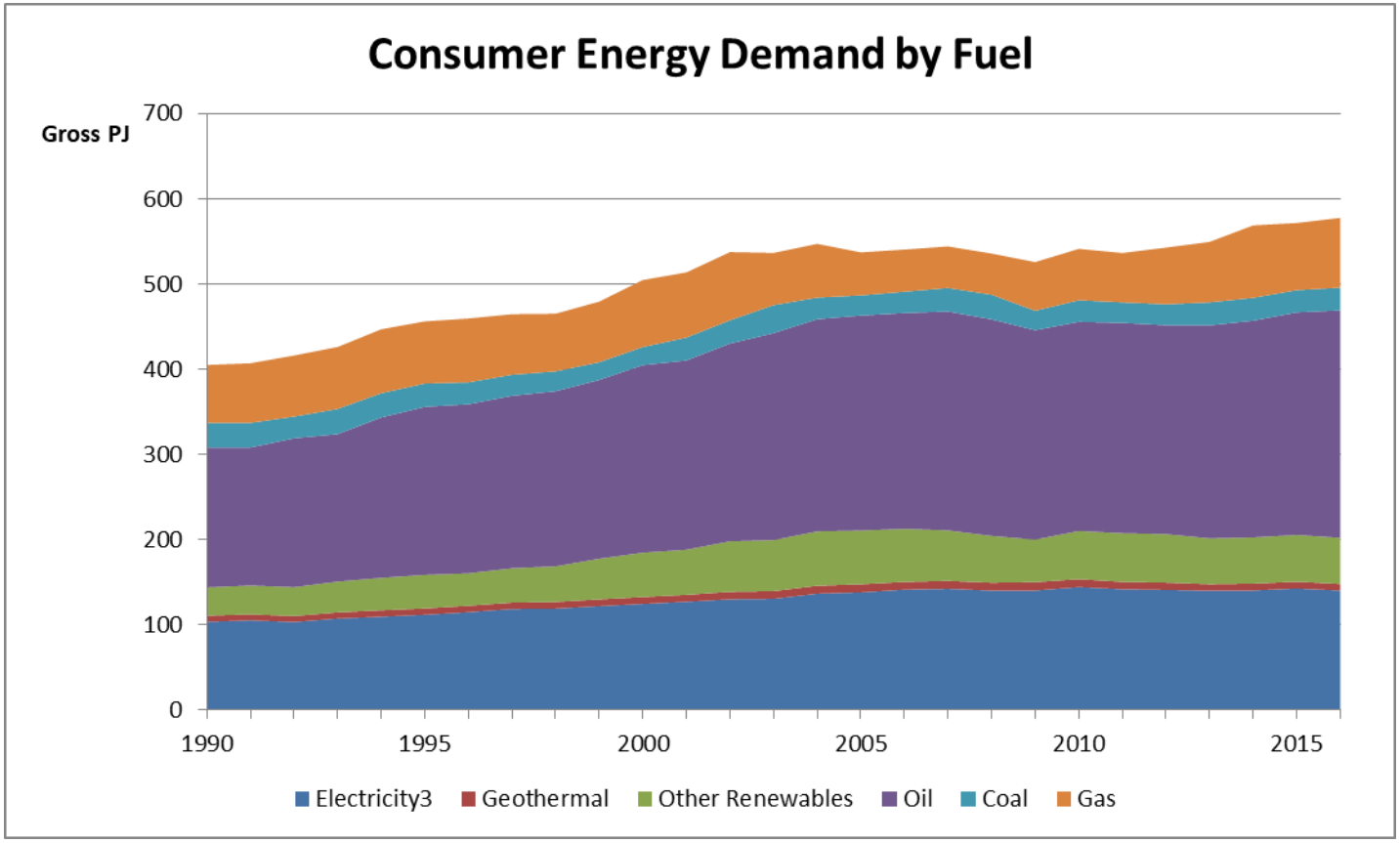
Oil>electricity>gas



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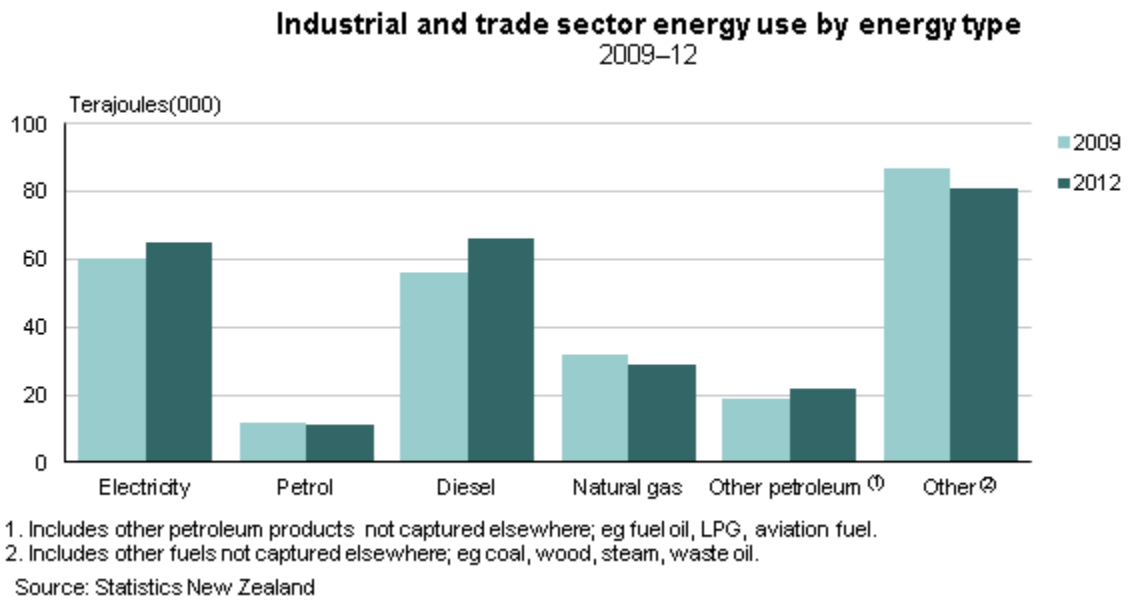
Energy Use Industrial & Trade Sector



1. Includes other petroleum products not captured elsewhere; eg fuel oil, LPG, aviation fuel.
2. Includes other fuels not captured elsewhere; eg coal, wood, steam, waste oil.

Source: Statistics New Zealand

~ 275,000 TJs in 2012
75% of NZ total demand
Electricity, diesel, coal
66% sector demand

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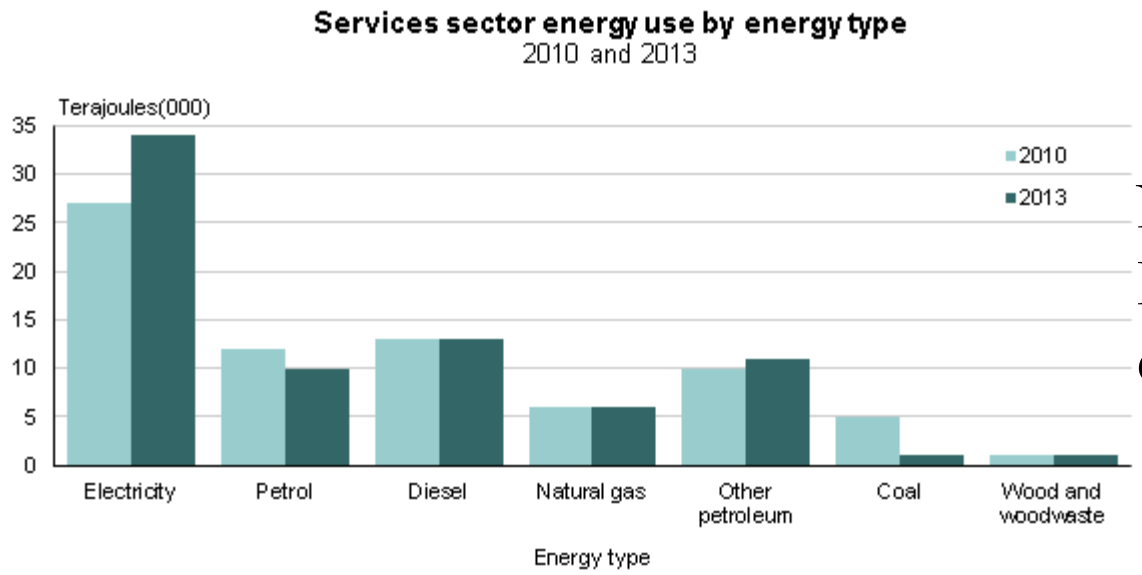
Energy Use Services Sector



Source: Statistics New Zealand

75,000 TJs ~ 20% NZ business demand

Electricity, petrol, & diesel > 75 % demand

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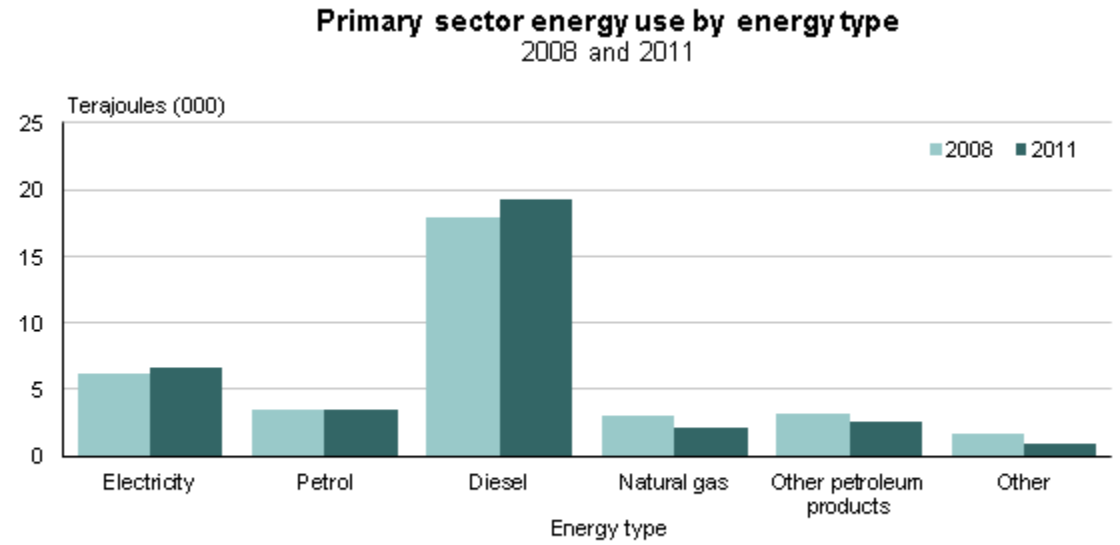
Energy Use Primary Sector



Source: Statistics New Zealand

35,000 TJs
~ 66% diesel

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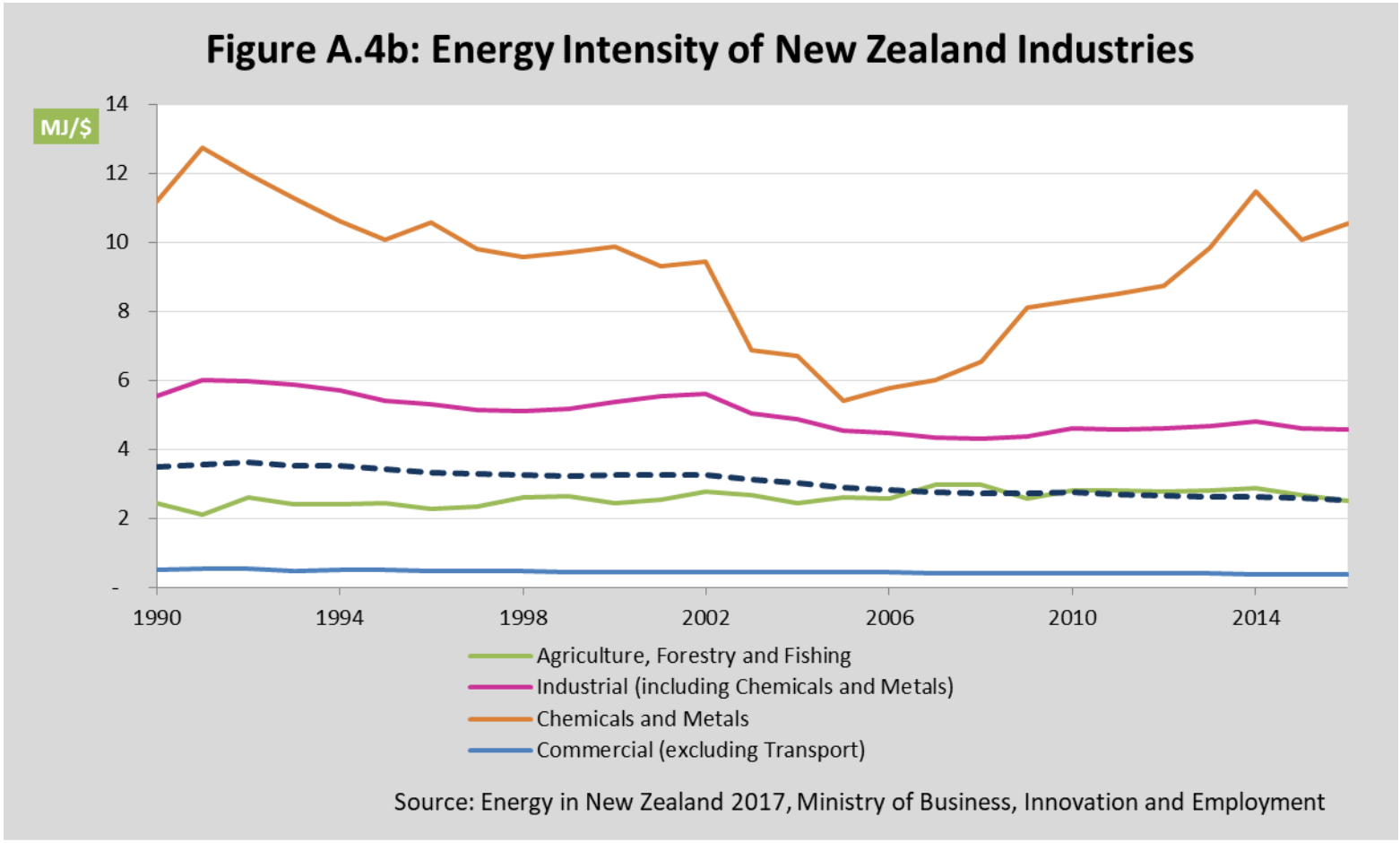
Energy intensity per $ output



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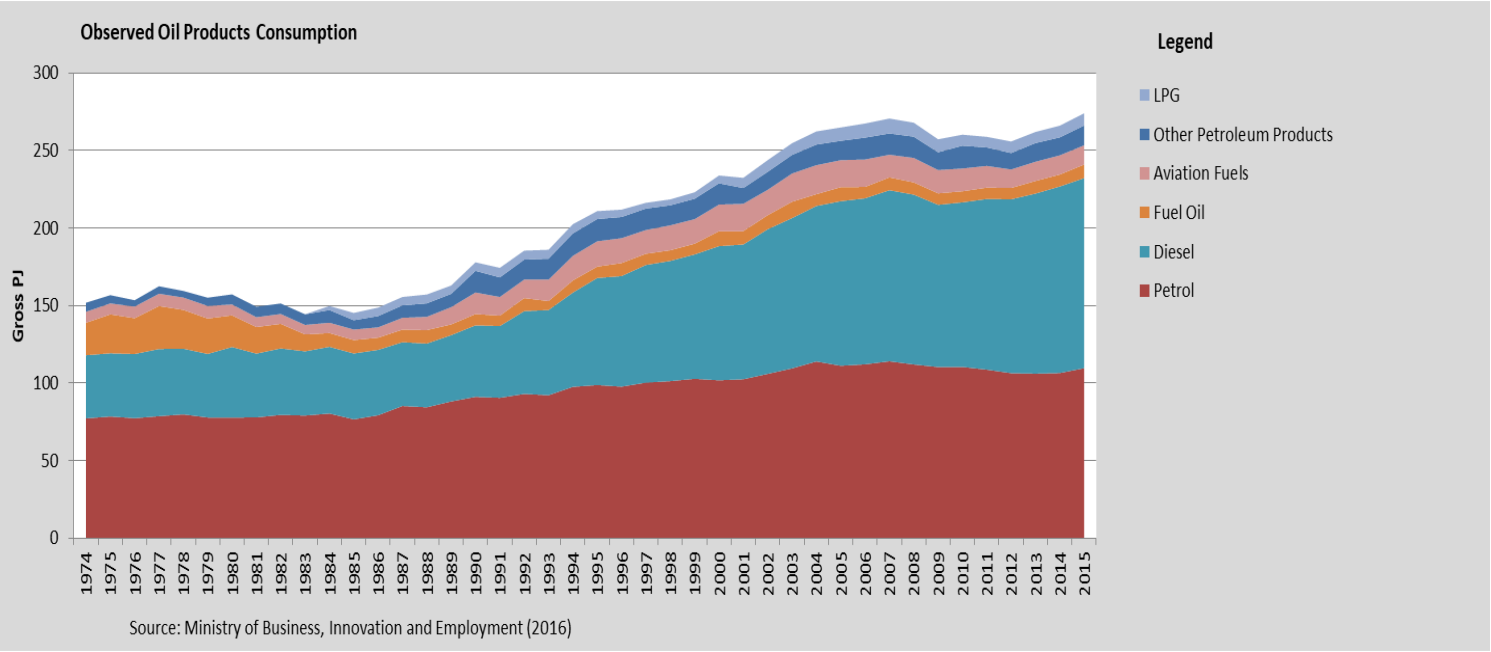
NZ consumption of oil products



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Fleet composition & emisssions

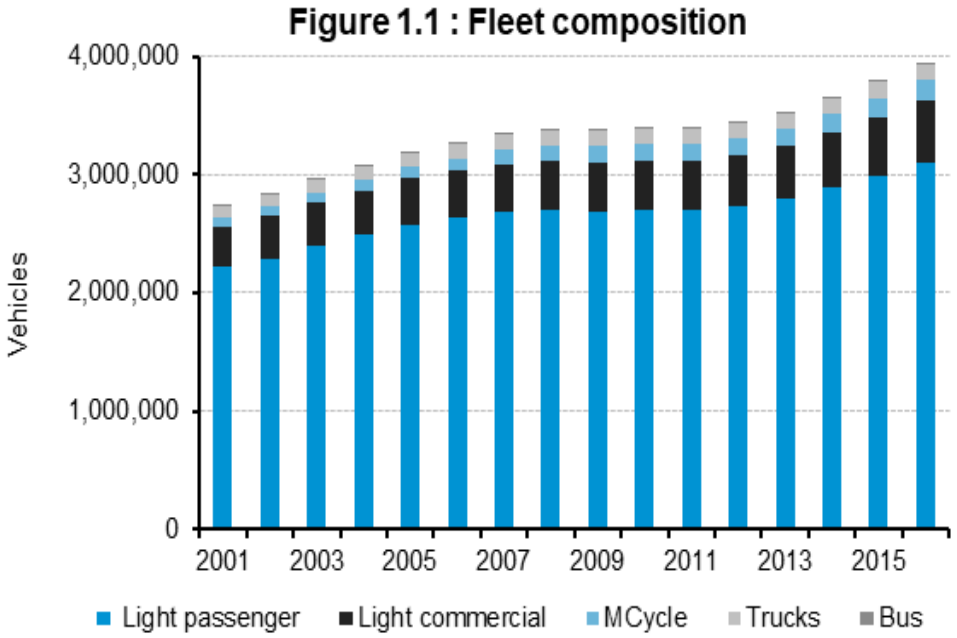
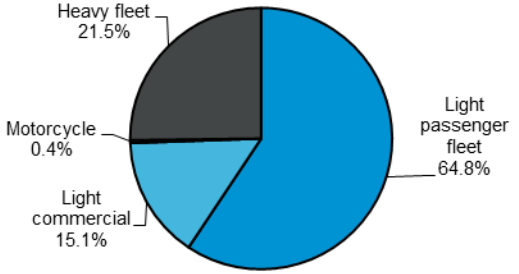
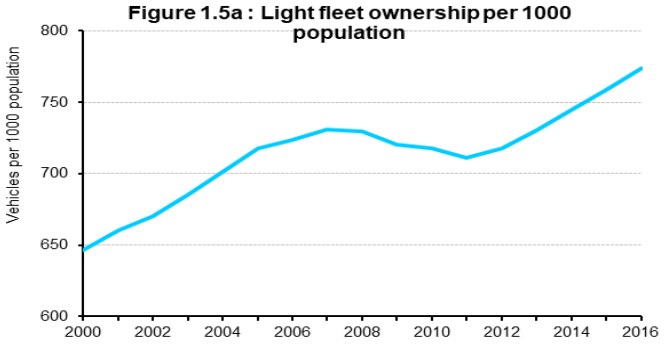


Figure 1.10 : 2015 CO_2 emissions



Source : VFEM (Vehicle Fleet Emissions Model) 2



http://www.transport.govt.nz/research/newzealandvehiclefleetstatistics/#annual

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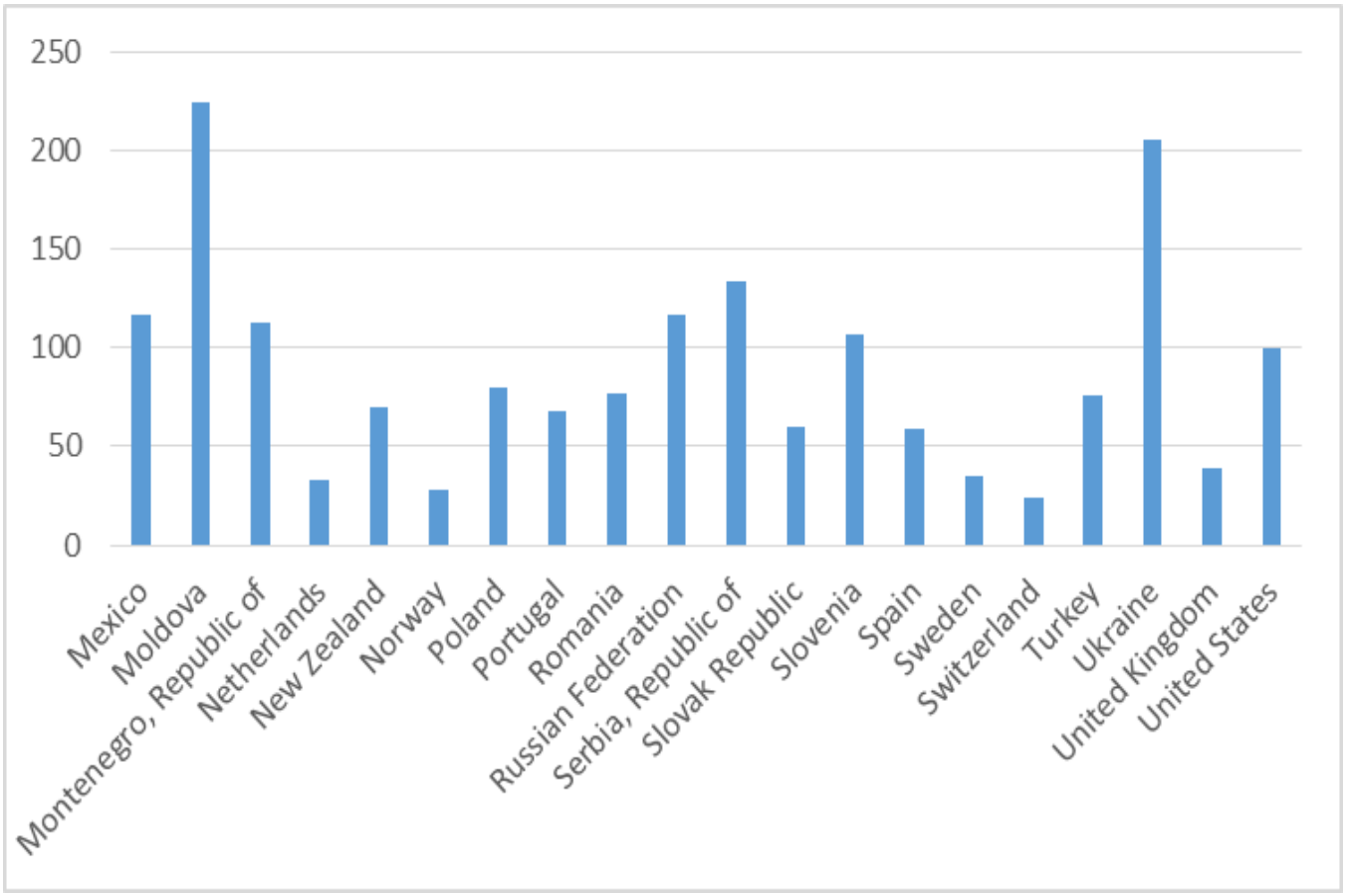
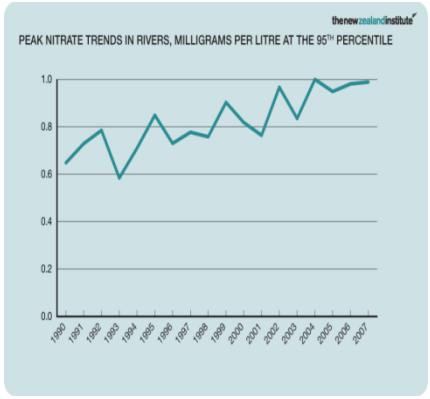
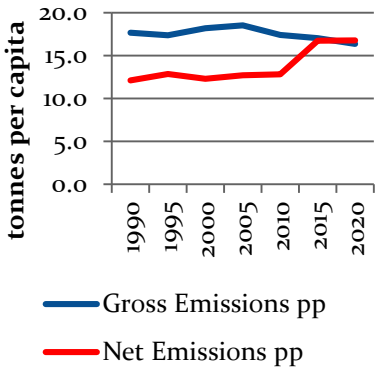
Tonnes of CO_2 from transport per US10^6

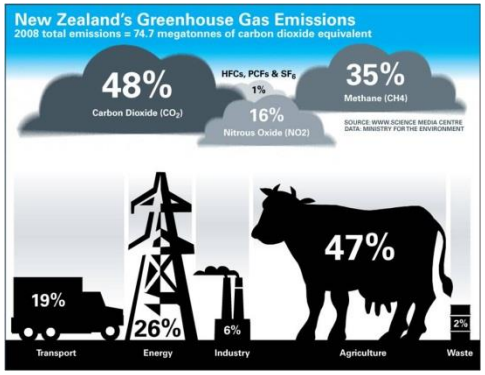


Green Growth

- What GDP does not measure
  - Environmental degradation
  - Depletion of natural resources
  - Equity
- Origins: Bruntland's *Our Common Future* (1987) and earlier
  - A green economy maintains/improves wellbeing, within ecological constraints, more than just low GHG emissions
  - OECD, UNEP, World Bank







Economic Reforms: Light handed regulation

- NZ transitioned from economy dominated by large government departments to an economy in which markets play a key role in resource allocation subject to regulations & government over sight.
- In the case of electricity: progression was from centralised production and price setting to a more competitive framework within a regulatory framework.

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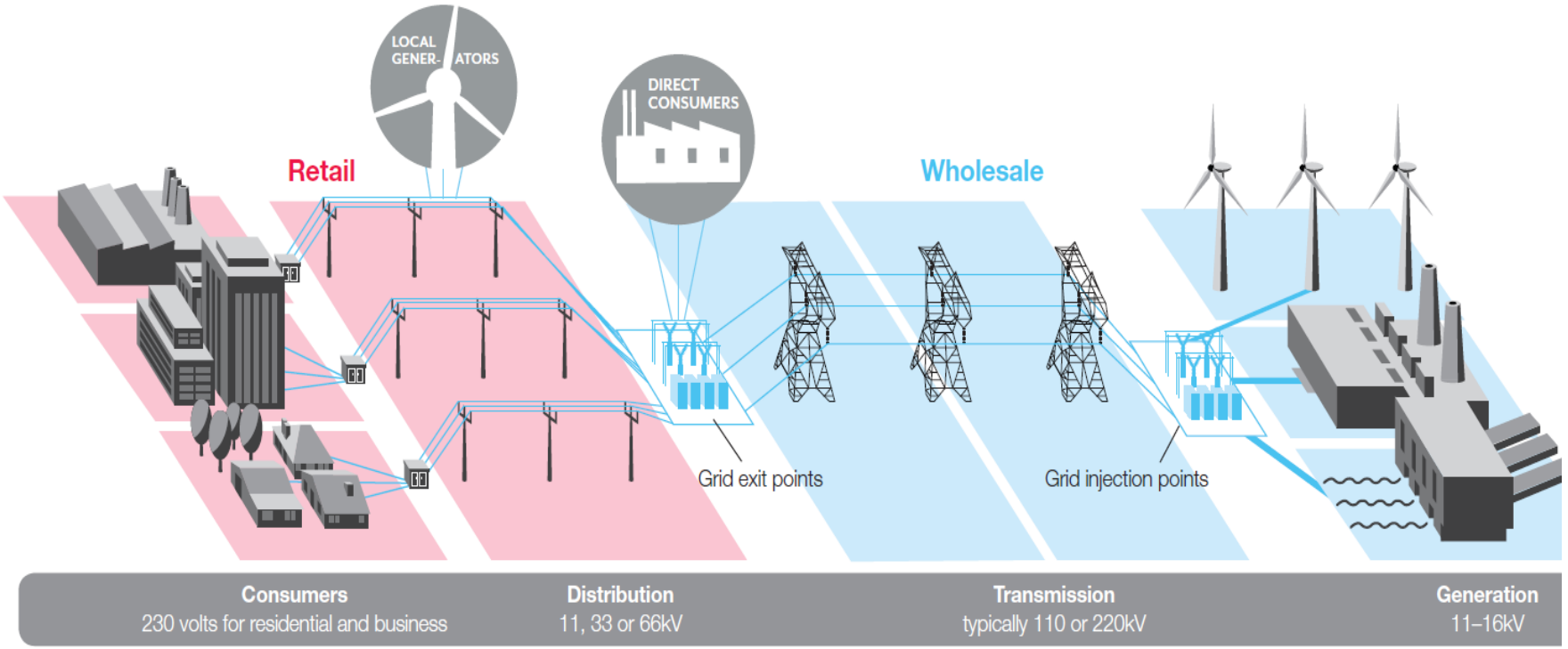
New Zealand Electricity Market



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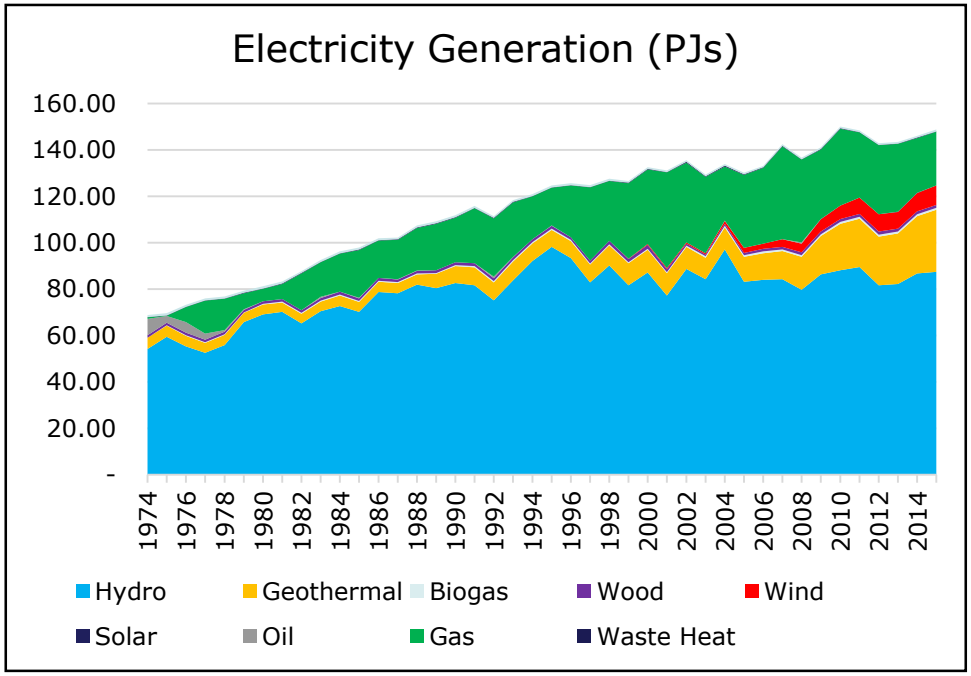
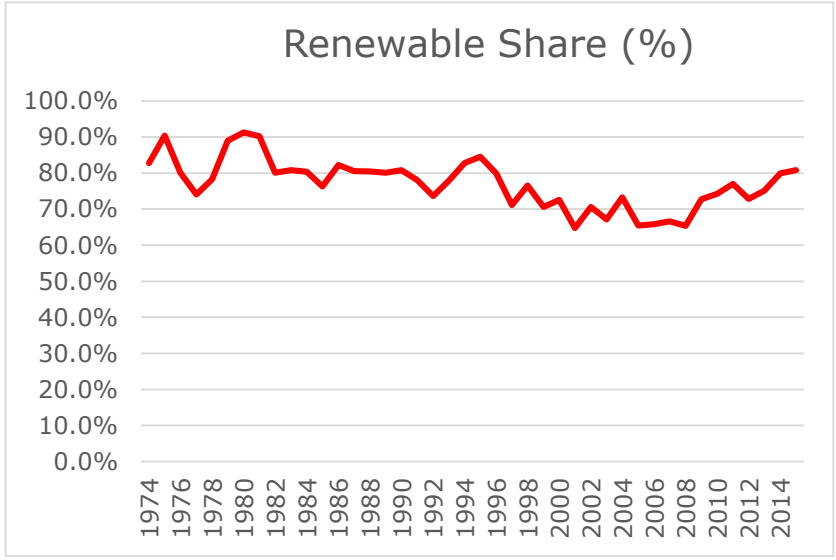
NZ Electricity



Renewable share



Price elasticity: electricity

$$\frac{\%\Delta Q}{\%\Delta P}$$

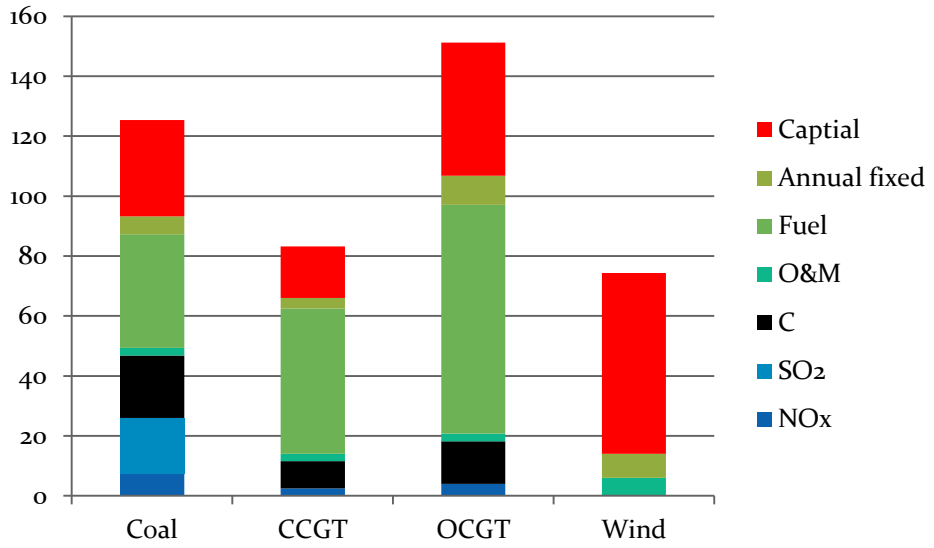
	Proportion	Short-run	Long-run
Industrial	45%	-0.06	-0.28
Commercial	22%	-0.06	-0.28
Residential	33%	-0.08	-0.21
Weighted Av.		-0.07	-0.26

Source: MED

Demand is price inelastic:

In short run, increase price to residential by 10%, demand falls by 0.8%

External Cost of Electricity Generation



Source: COVEC (2006)

Assumption: new plant under high cost scenario

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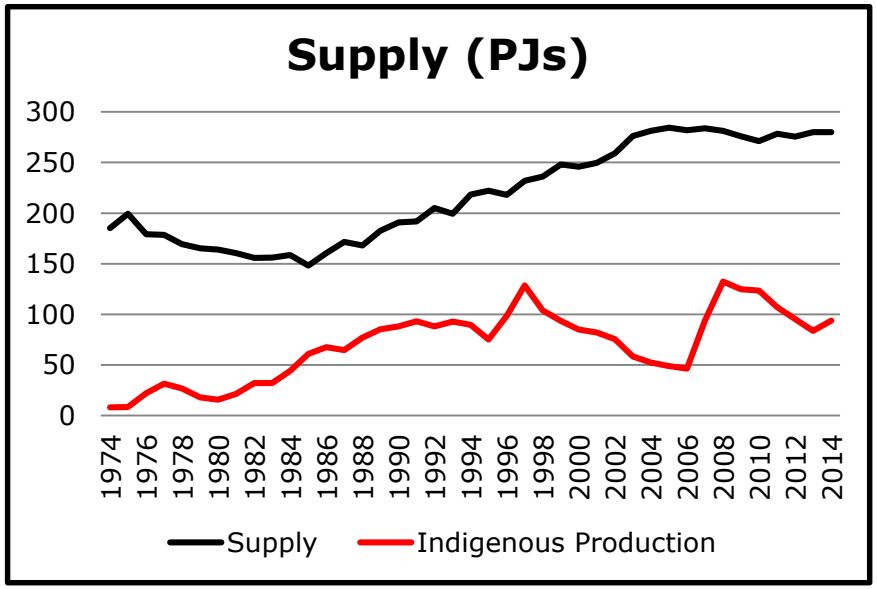
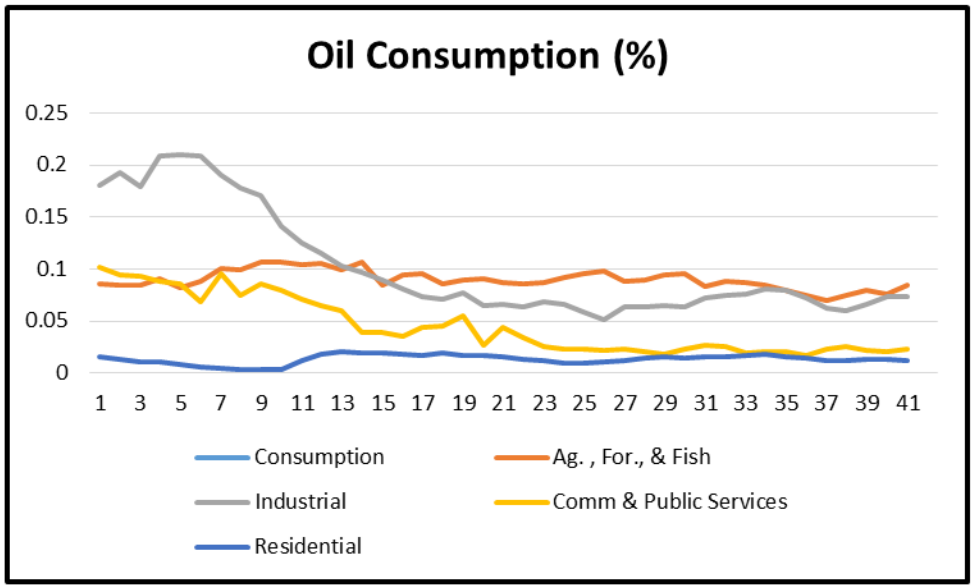
Oil Supply & Demand





Price elasticity of demand: in range of [-0.1 to -0.4]

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External cost of transport fuels

	Share of Emissions	Effects
CO	70%	Health, global warming
Hydrocarbons	38%	Health, acid rain
SO2	5%	Health & acid rain
NOx	41%	Smog, global warming
CO2	30%	Global warming, health
Air Toxins	23%	Health

Development of renwables: Hydro resources

Existing ~5,300MW
30% in DOC estate
Av. Load factor ~ 56%

Storage:
Measured in days (~60)

Potential:
<$3,500/kW ~ 1,845MW
~90% s.t. RMA

$3,500-$7,000/kW ~ 4,729MW
~ 75% s.t. RMA

Resource Management Act 1991
- First-come-first-served

- Attenuated property rights
  - Limited ability to trade
  - Maximum duration 35 years

Outcomes
- Over allocation
- Existing uses likely to be inefficient
- Cross sector competition *viz.* hydro & agriculture

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Geothermal: economic features

- Existing capacity ~ 1000MW
- Potential: ~ additional 1,000MW
- 129 geothermal areas classified as High temperature > 220^0 C
- Drilling costs: Non-linear ~ $3,000/m, up front risk
- Costs:
  - Reasonably robust governance
  - Negotiating with land owners
  - $2,500 – 4,000/kW, temperature dependent
  - Modular design
  - Economies of scale
  - Significant operating and maintenance costs
  - High load factor ~ 90%

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Cascading use

Unsustainable use

- Rotorua New Zealand
  - Open access 1970s-1980s
  - Home heating, relatively inexpensive
  - Pressure dropped, subsidence & damage to tourist attractions
  - Entry closed
- Ohaaki plant
  - Commissioned capacity of 114MW
  - Production reduced to 30MW, now ~ 45MW
  - Subsidence & flooding

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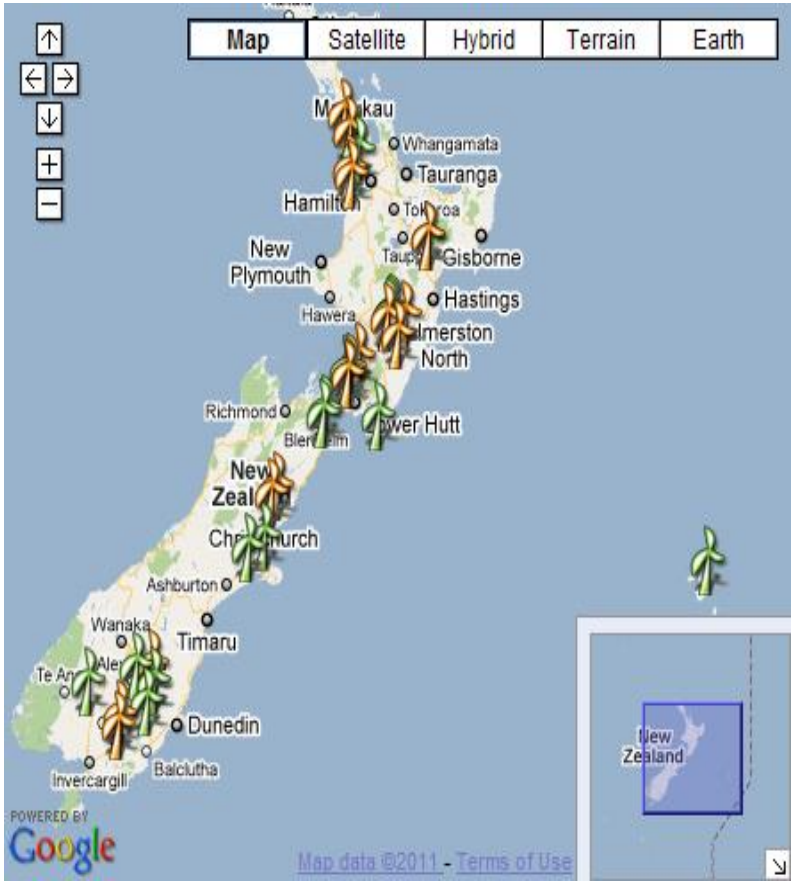
Wind Generation Sites



First wind farm 1993 – 225kW
2014: 19 wind farms
623 MW installed
Load factor: ~30-50%

External impact of Wind Farms

Project Hayes:
630MW 176 turbines
Electricity for 278,000 homes
Estimated cost $2b
Carbon savings
Environment Court & over turned in High Court

- Non-market impacts: aesthetics and noise
- No evidence (to date) in New Zealand

Environmental Protection

- Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
  - September 2012
  - Extends coverage beyond RMA (12 nautical miles)
  - Interim voluntary measures in place until 2013
- Capital investment
- Does NZ have the capacity to handle a major oil spill
  - Deep Water Horizon US$38 b
  - Cost of Christchurch rebuild NZ$30 b

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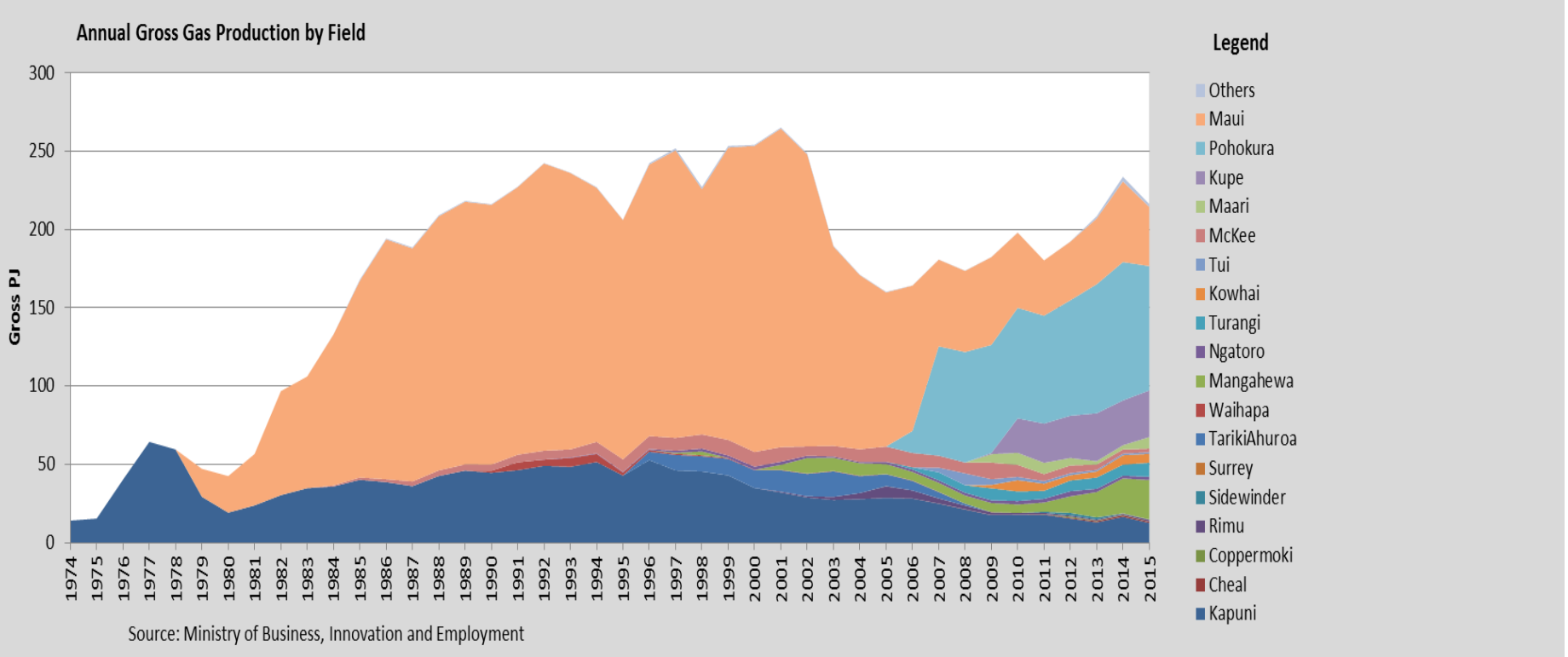
Gas Production



Solar

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Auckland: application using LiDAR data

LiDAR (Light Detection And Ranging) uses laser light to sample the surface of the earth

<1% electricity supply
Potential
Pricing
Network integration

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Govt. Draft Policy Statement 2017-2022

Priority areas:

1. Renewable and efficient use of process heat Target: Decrease in industrial emissions intensity of one per cent per annum on average between 2017 and 2022.

2. Efficient and low emissions transport Target: Electric vehicles make up two per cent of the vehicle fleet by the end of 2021.

3. Innovative and efficient use of electricity We already have a target to increase the level of renewable electricity to 90 per cent by 2025.