Energy Transitions

Basil Sharp
Professor, Director of the Energy Centre
University of Auckland, New Zealand
Questions

- Do we consume energy?
- What factors have influenced energy transitions?
Lighting

Candles

Lamps
Lighting

A tale of two energy sources

Whale oil was on the way out well before petroleum became society’s fuel of choice.

Coal entered the picture. Scientists discovered how to make kerosene for lighting and whale oil was priced out of the market.

Sources:
Beginnings of electricity

- Electricity exists in nature & was not invented, discovered and understood by many scientists
- Benjamin Franklin is given the credit for discovering electricity in 1752: experimented using a kite and key on a rainy day. He wanted to demonstrate the relationship between lightning and electricity
- Michael Faraday 1831 invented electromagnetic induction, the principle behind the electric transformer and DC generator
- Thomas Edison invented the light bulb in 1878. Replaced gas lighting. In the late 1800s, Tesla invented alternating current (AC) and the induction motor
Electricity generation

• World's first hydroelectric power plant began operation on the Fox River in Appleton, Wisconsin, 1882.
• 1888, Reefton power station supplied electricity to the gold mining town of Reefton, first to supply municipal electricity in Southern Hemisphere
• May 1901 the New Zealand government built its first hydro plant – a small 100kW generator at Okere Falls near Rotorua.
• Challenge: electric power distribution became necessary when electricity started being generated at power stations.
Getting electricity to consumers

• Roadblock: transmitting electricity a long distance at high voltage and then reducing it to a lower voltage for lighting
• Breakthrough: mid-1880s the development of functional transformers that allowed the AC voltage to be "stepped up" to much higher transmission voltages and then dropped down to a lower end user voltage
Land Transport

• Walking

• Horses thousands of years ago

• Wheel invented ~3500BC – greatly improved transport of material & people
Horse power

Single passenger  Buggy multiple passengers  Public transport
Externality associated with horse powered transport

Manure crisis

**LATE 1800s**
Roads became congested and pollution from horses became a problem.

Manure was sold to farmers, but they couldn’t keep up with supply.

20,000 deaths in NY attributed to manure crisis.
Coal powered trains & ships

Coal - a wonderful resource

- Energy conveniently packed in readily accessible deposits
- Gas was available for cooking...
- Coal powered trains
- Coal combined with science and engineering catapulted society into the industrial age
- ...and street lighting improved

Ships no longer had to rely on wind

6 week journey from the UK to US reduced to 7-10 days in a steamship
Electric vehicles

Around 1832, Robert Anderson developed the first crude electric vehicle, but it wasn't until the 1870s that electric cars become practical.

William Morrison, created the first successful electric vehicle in the U.S. His car was little more than an electrified wagon, but it sparked an interest in electric vehicles. Many early electric vehicles were not much different than carriages.
EVs gain in popularity

By late 1800s electric cars gained popularity - considered quiet, easy to drive and didn't emit smelly pollutants. Quickly became popular with urban residents, especially women.
Further innovation

Innovators took note of the electric car’s high demand & explored ways to improve the technology. Thomas Edison thought electric vehicles were a superior mode of transportation and worked to build a better battery.
Hybrid EV!

In 1901 Ferdinand Porsche invented the world’s first hybrid electric car. The vehicle was powered by electricity stored in a battery and a gas engine.
Internal combustion engine

In 1872, American George Brayton invented the first commercial liquid-fueled ICE.

In 1876, Nicolaus Otto, working with Gottlieb Daimler and Wilhelm Maybach, patented the compressed charge, four-stroke cycle engine.

In 1879, Karl Benz patented a reliable two-stroke gas engine.
Along comes the model T!

1908-12, model T dealt a blow to electric vehicles by making ICE cars affordable. In 1912, the electric starter was introduced, helping to increase vehicle sales. Pictured is Henry Ford with the first Model T and the 1 millionth.
Decline of EVs 1920-35

Better roads and discovery of cheap Texas crude oil contributed to the decline in electric vehicles. By 1935, they had all but disappeared.

Development of network: filling stations increased availability of petrol, leading to the rise in popularity of ICE vehicles.
Drake’s well 1859 & Huntington Beach 1930s
Race to the pump house

Oil - a wonderful resource

Demand for oil exploded with the mass production of cars - the manure crisis was solved.

Huntington Beach, California 1926

Your cell phone uses the electricity equivalent of 2 modern refrigerators.

The global ICT ecosystem uses the combines annual electricity consumed by Japan and Germany.
Back to electric vehicles

7.2 Million Electric Cars Hit the Roads in 2019

Global stock of electric passenger cars, by region*

- China
- Europe
- United States
- Rest of the World

* including plug-in hybrids and light vehicles
Source: International Energy Agency

Electric vehicles per 1000 residents
Price of Batteries

According to Bloomberg, the cost of Lithium-ion battery packs has gone from an average of $1,160 USD per kilowatt hour in 2010 to just $176 in 2018. Expectations are for this to go under $100 in the next few years. However, the raw materials to create EV batteries may not come down in price.
The EV race is on

- Tesla produced 500,000 EVs in 2020
  - Stock market value of US$800bn
- Here comes Volkswagen
  - Stock market value $160bn
  - Vertical integrated production
  - Software development
Connection with digital technology – 5G
Back to electricity

• In 1905 Einstein explained how light could drive currents in some materials.

• Russell Ohl 1940: researcher at Bell Labs shone a bright light on a rod of silicon & a current flowed between electrodes attached to the rod’s ends.

• Ohl’s work led to the development of transistors, which replaced vacuum tubes, semiconductors & the silicon chip.
Road to commercialisation

• In 1954 Bell Labs claimed that its “photovoltaic” battery could power a house but at a cost of US$1.5m.
• Oil shocks in the 1970s saw governments taking more interest in the possibilities of solar energy.
• By 2000 there was about 1GW of photovoltaic capacity worldwide & cost was about 1/10th that of 1970.
• Social Democrats & pro-green government in Germany used a subsidy scheme encouraging solar panels.
Germany FIT for Roof Top Installations

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<th>&gt;=30kW</th>
<th>&gt;100kW</th>
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<td>FIT values*</td>
<td>0.3601 €/kWh</td>
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<td>0.3242 €/kWh</td>
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*RES Act that established FIT’s with a contract duration of 20 years and a constant remuneration for produced electricity. In 2004 could sell any amount at €457/mWh ~ 5 times cost of coal generation (price carbon? By 2012 the subsidy scheme had cost €200bn
What happened to nuclear?

- Civilian nuclear power introduced in 1954
- Considered at the time to have great potential
- However from 1970s nuclear has grown slowly
- Reasons:
  - Safety concerns
  - Prices have risen in contrast to solar
Fukushima diachi after earthquake
High level radioactive waste

Deep disposal of radioactive waste - The Finnish model

- Waste processing plant
- Waste lift
- Entrance
- Escape lift
- Access tunnel
- Waste storage tunnels

Disposal canister
- Copper shell
- Vacuumed & filled with inert gas
- Radioactive waste
- Iron inner shell

1. Canisters stored vertically/horizontally
2. Hole drilled in tunnel and lined with clay
3. Canister transformed from transporter
4. Canister sunk and hole sealed with clay
Low level radioactive waste
Given NZ’s Emission Profile & Recommended Reductions – what can we learn from history?
CCC proposals on transition?

- **Transport**
  - City transport planning, including cycleways, walkways
  - National transport network
  - Focus on EVs, low carbon fuels (biofuels & hydrogen for heavy vehicles)

- **Heat, industry & power**
  - Eliminate use of coal
  - Renewable electricity for EVs & process heat
  - Energy efficiency

- **Agriculture**
  - Biogenic methane (90% in 2018)
  - Reduce 1.2Mt CH₄ to 0.97MtCH₄: agricultural management