Managing the Dry Year Problem in New Zealand

Analyzing the Potential Alternatives to Hydro Power

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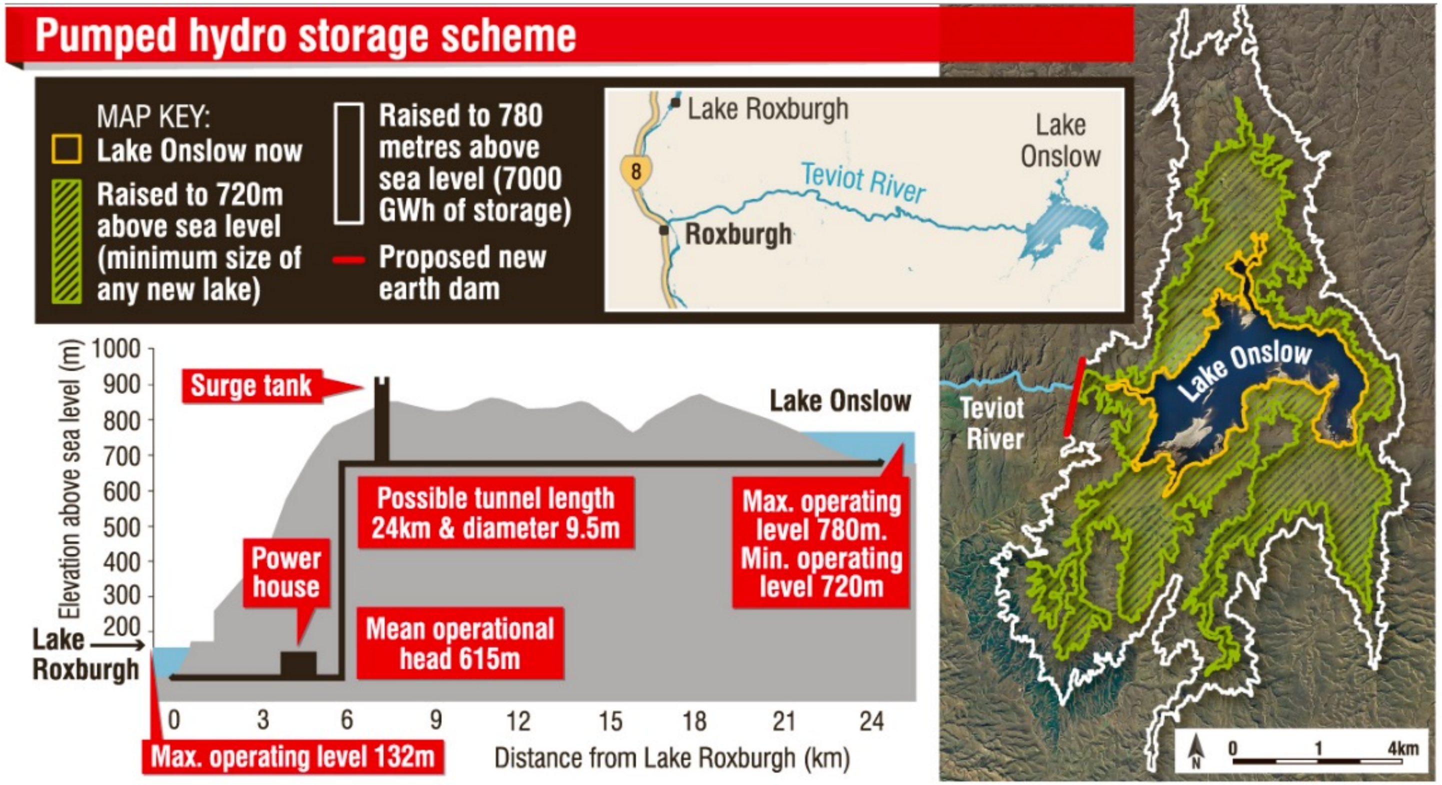
What is the "Dry Year" Problem?

- Lack of water filling lakes to generate hydropower
  - Rain or snow melt
- Impossible to predict when/how long it will occur
- Creates energy deficit of 10% annual energy needs
- Forced reliance on fossil fuels
- Need a power source that is always available to ramp up or ramp down

NZ Battery Project- Phase 1

- Focus on pumped hydro
  - Lake Onslow- South Island
  - Upper Moawhango- North Island
- Most developed alternative to fossil fuel peaker plants
- Large capital costs and environmental harm during construction
  - $15.7 billion Lake Onslow
- Power needed for pumping to upper reservoir



Projections for the spread of the expanded Lake Onslow. GRAPHIC: ODT/JOHN CULY CONSULTING

Bioenergy

- Currently used for heating
- Biogas and liquid biofuels not scalable
- Wood pellets or chips- most viable
    - Not sustainable
    - Can be ramped up or down (flexible power)
- Energy content of Bioenergy < coal or gas

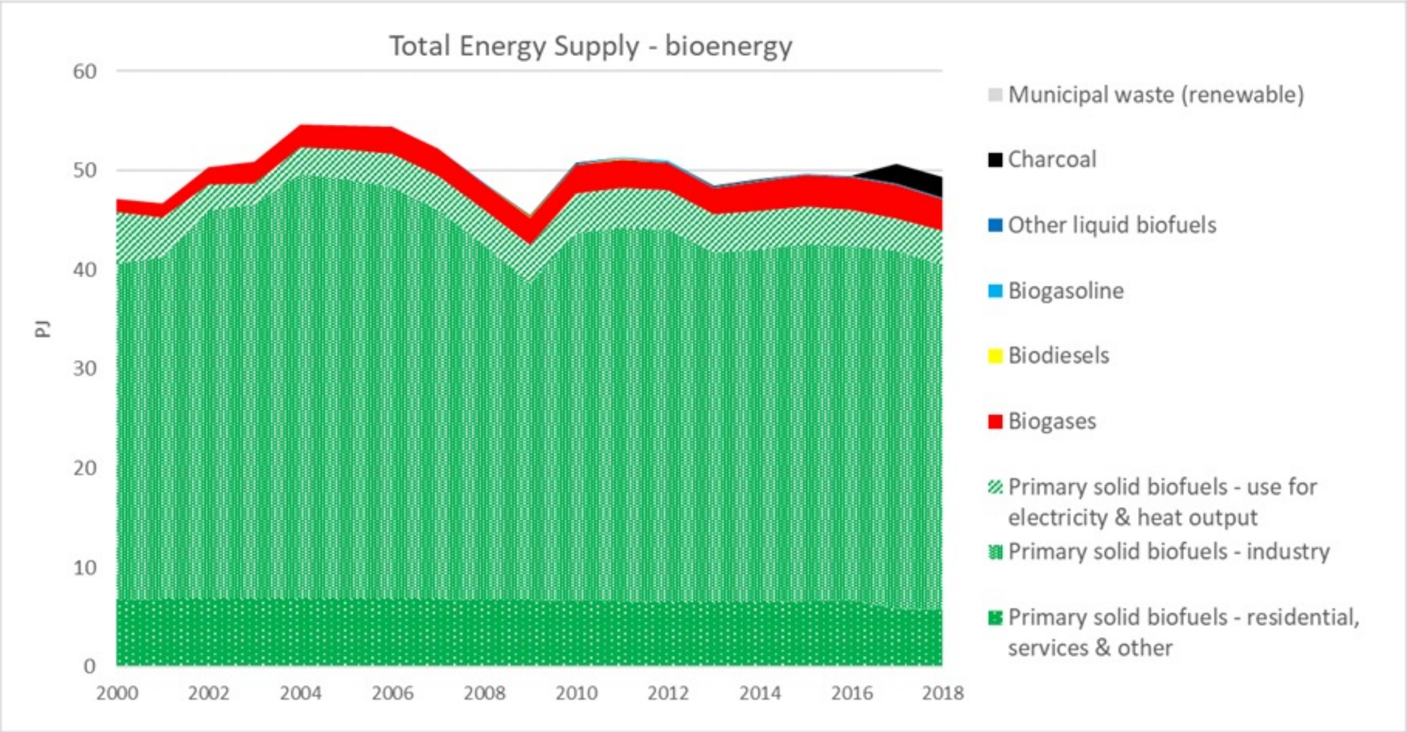
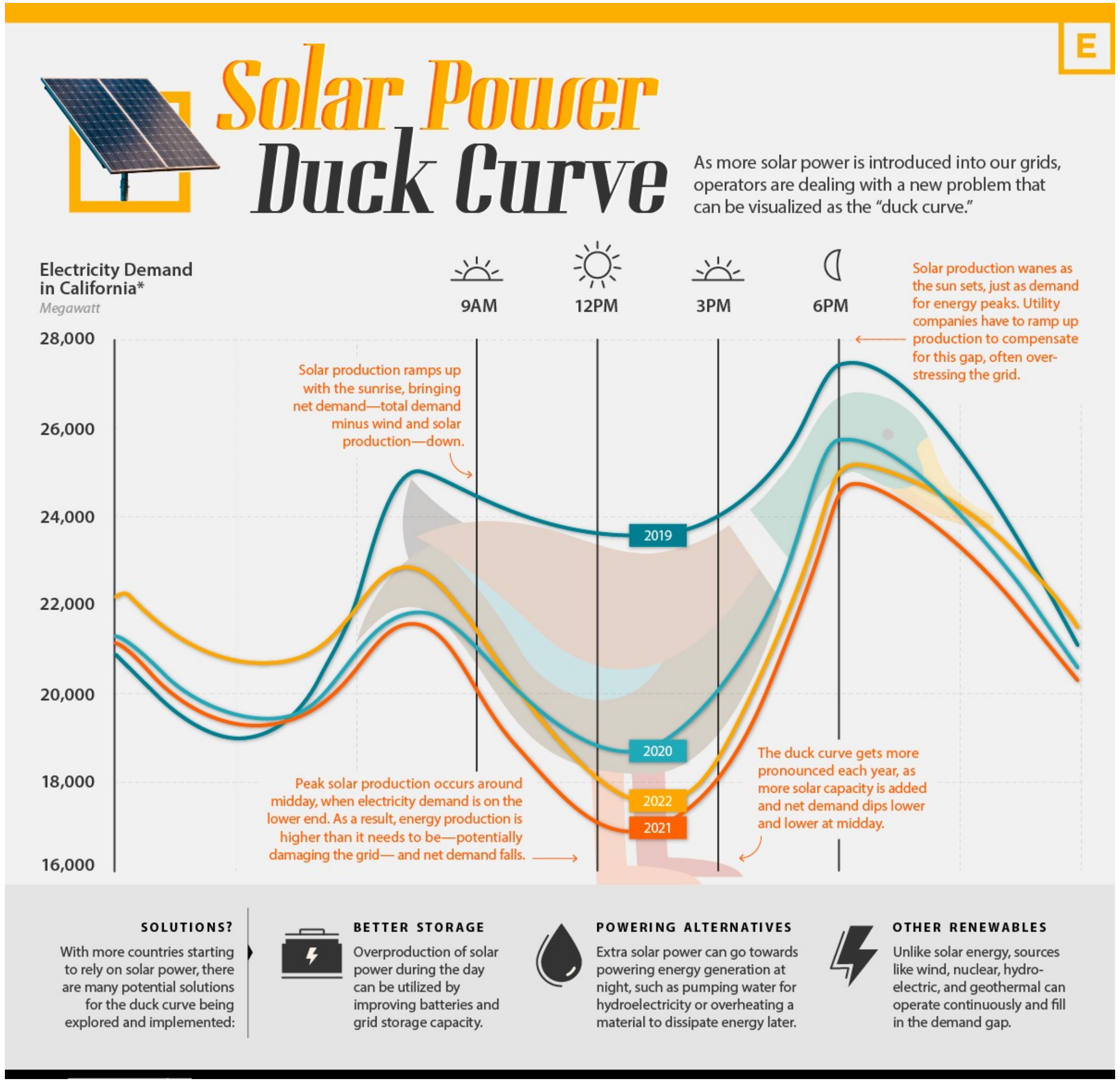


***Figure 3**: Development of total energy supply from bioenergy in New Zealand 2000 - 2019 (Source: IEA (2021) World Energy Balances and Renewables Information)*

Geothermal

- Always available
    - Continuous baseline power
    - Can still be affected by dry year
- Some emissions need capture
    - 1/6 CO_2 from natural gas plant
- Ramp down if needed
    - Reinject unused hot fluids
    - Ormat Puna Geothermal Plant in Hawaii
    - May damage reservoir
    - Loss of profit



Hydrogen (for power generation)

- Using hydrogen generated from other electricity
  - Convert to liquid ammonia
  - Transformed back to hydrogen when needed
- Cofiring of coal with ammonia reduces emissions
  - 20% blending
- Hydrogen fired gas turbines to increase flexibility
  - By 2030
- Hydrogen fuel cells
  - Shorter lifetime than gas turbines
- Expensive technology when load is low

	Current role	Demand perspectives	Future deployment	
			Opportunities	Challenges
Co-firing ammonia in coal power plants	No deployment so far; co-firing has been demonstrated in a commercial coal power plant in Japan	20% co-firing share in global coal power plant fleet could by 2030 lead to an ammonia demand of up to 670 Mt ammonia or a corresponding hydrogen demand of 120 MtH_2	Reducing the carbon impact of existing coal-fired power plants in the near term	CO_2 mitigation costs can be low, but rely on low-cost ammonia supply. Attention has to be paid to NO_x emissions; further NO_x treatment may be needed. Only a transitional measure – still significant remaining CO_2 emissions
Flexible power generation	Few commercial gas turbines using hydrogen-rich gases. 363 000 fuel cell units (1 600 MW) installed	Assuming 1% of global gas-fired power capacity would run on hydrogen by 2030, this would result in a capacity of 25 GW, generating 90 TWh of electricity and consuming 4.5 MtH_2	Supporting the integration of VRE in the power system. Some gas turbine designs already able to run on high hydrogen shares	Availability of low-cost and low-carbon hydrogen and ammonia. Competition with other flexible generation options as well as other flexibility options (e.g. demand response, storage)
Back-up and off-grid power supply	Demonstration projects for electrification of villages. Fuel cell systems in combination with storage	With increasing growth of telecommunications, also growing need for reliable power supply	Fuel cell systems in combination with storage as a cost-effective and less polluting alternative to diesel generators. More robust than battery systems	Often higher initial investment needs compared with diesel generators
Long-term and large-scale energy storage	Three salt cavern storage sites for hydrogen in the United States; another three in the United Kingdom	In the long term, with very high VRE shares, need for large-scale and long-term storage for seasonal imbalances or longer periods with no VRE generation. In combination with long-distance trade, scope to take advantage of seasonal differences in global VRE supply	Due to high energy content of hydrogen, relatively low CAPEX cost for storage itself. Few alternative technologies for long-term and large-scale storage. Conversion losses can be reduced if stored hydrogen or ammonia can be directly used in end-use applications	High conversion losses. Geological availability of salt caverns for hydrogen storage region-specific. Little experience with depleted oil and gas fields or water aquifers for hydrogen storage (e.g. contamination issues)

Implementation

- Or lack of?

New Zealand's Future Plans

- Definitely not nuclear
  - 1987 New Zealand Nuclear Free Zone
  - Not enough demand
- A Vision for Hydrogen in New Zealand
- Increasing biogas and solid biomass combustion
- Plans for geothermal

Sources

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