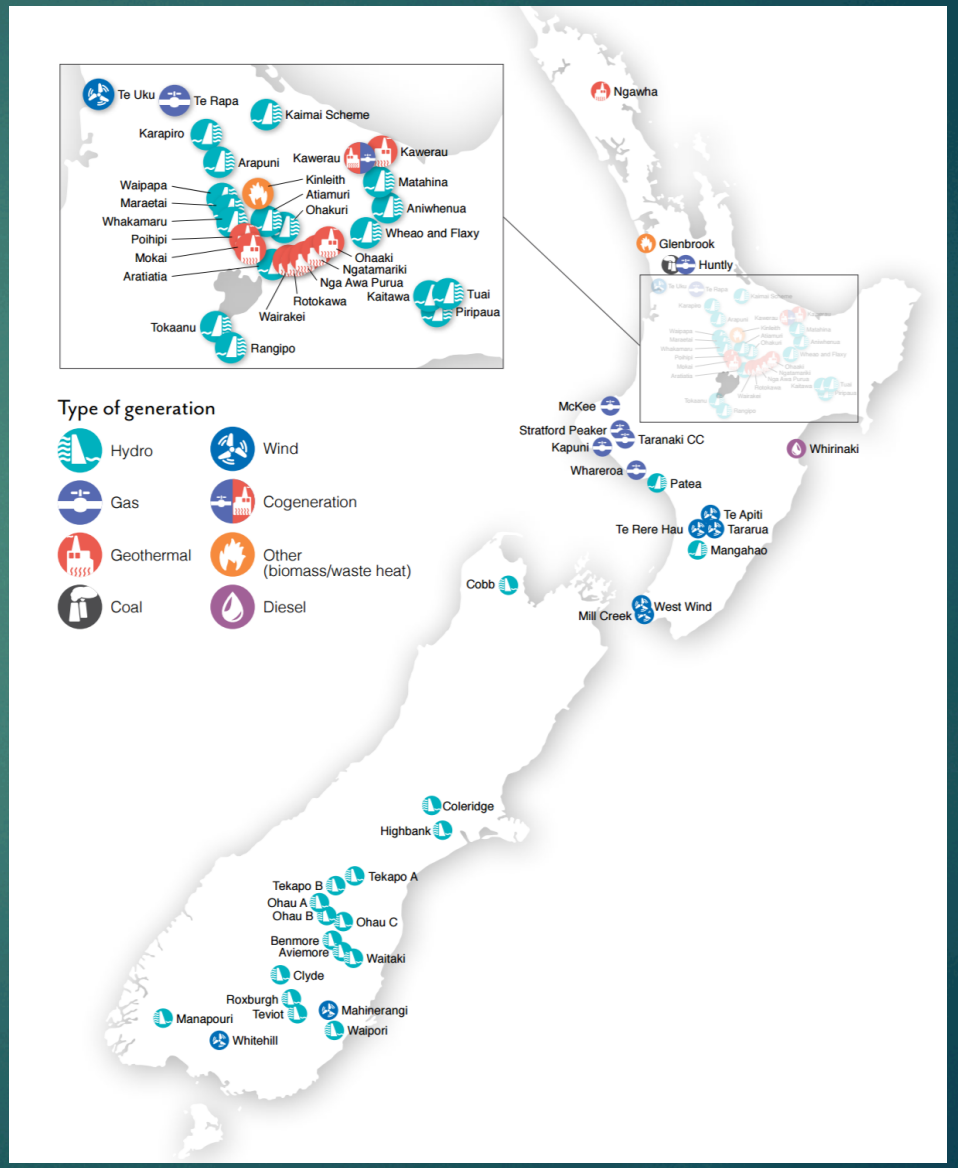
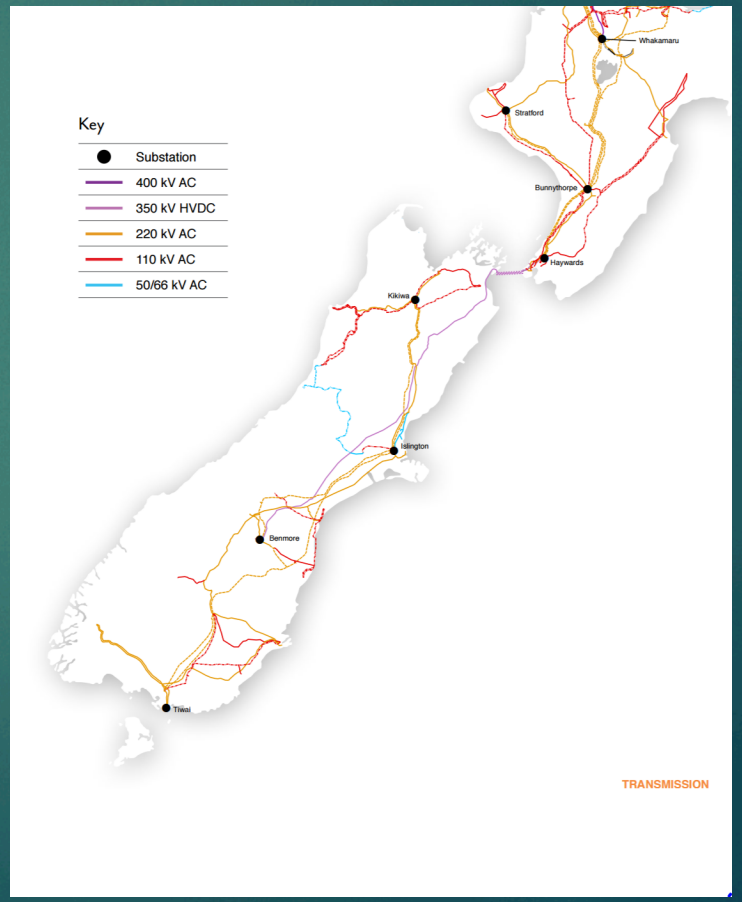
Hydrogen Production using Wind and Hydro in New Zealand

Introduction



Current Grid

- Nominal Cost of the Inter-Island Link Transmission Lines
  - 795 million Dollars
  - 75 GWh per week Northward
- Adding transmission to Picton
  - ~800 km transmission Line



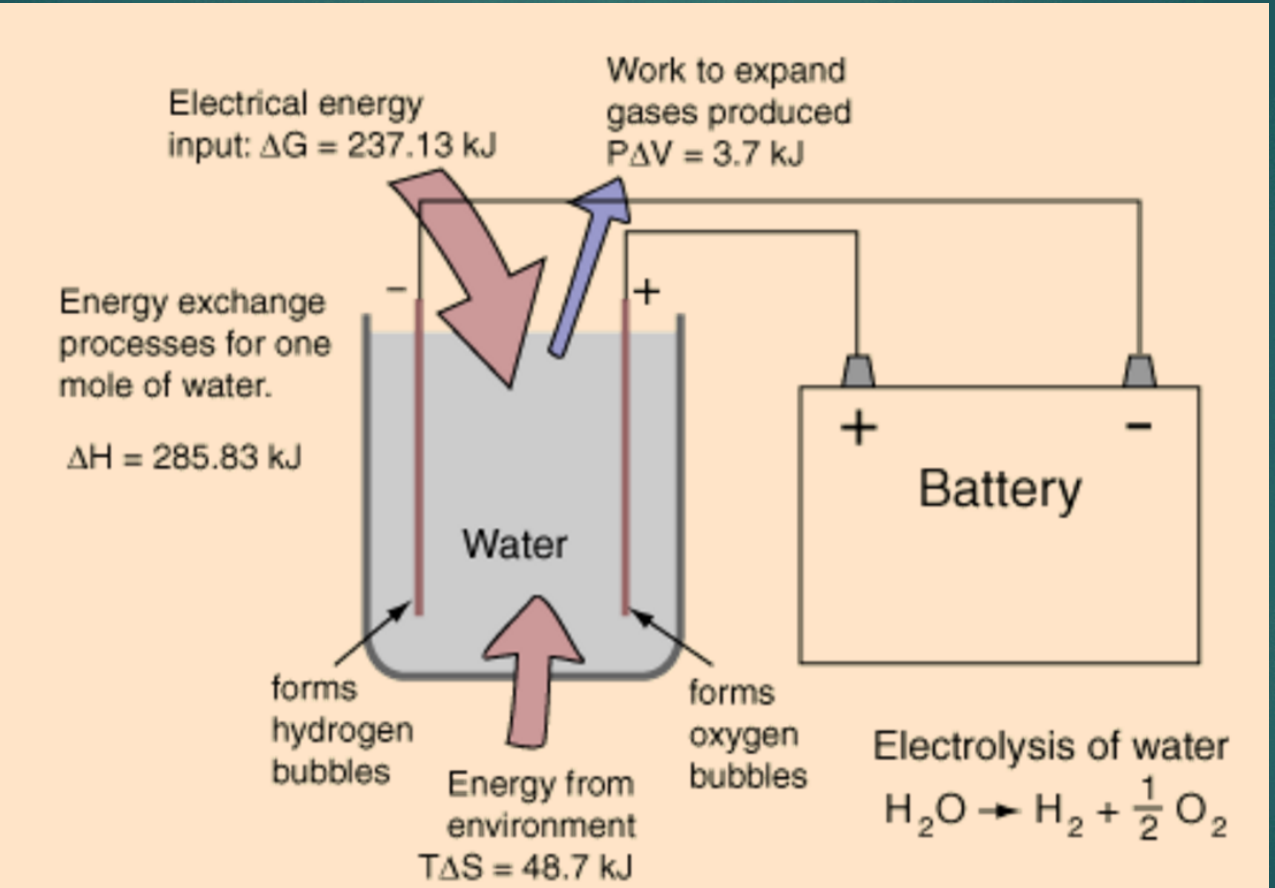
Role of Wind and Hydro in NZ

- 19 Wind Farms of Power currently Operating and Under Construction
  - Currently 690MW (over 1,930 GWh)
    - 3,000 MW consented or looking for consention
  - 5% of NZ annual Energy Generation
  - Wind potential is 3x its energy demand.
- Hydroelectric (Over 5000 MW, 24,094 GWh)
  - 11% Primary Energy Usage, 57% total Generation
  - Over 100 Current stations, around 13 proposed

NZ Energy Strategy (2011-2021)

- Goals
  - 90% renewable plan by 2025, Wind to consist of 30%
  - 50% reduction green house gases by 2050
- Objective on how:
  - Businesses
  - Individuals
  - Public Sector
  - Market Participants

Electrolysis



Quantity	H_2O	H_2	0.5 O_2	Change
Enthalpy	-285.83 kJ	0	0	ΔH = 285.83 kJ
Entropy	69.91 J/K	130.68 J/K	0.5 x 205.14 J/K	TΔS = 48.7 kJ

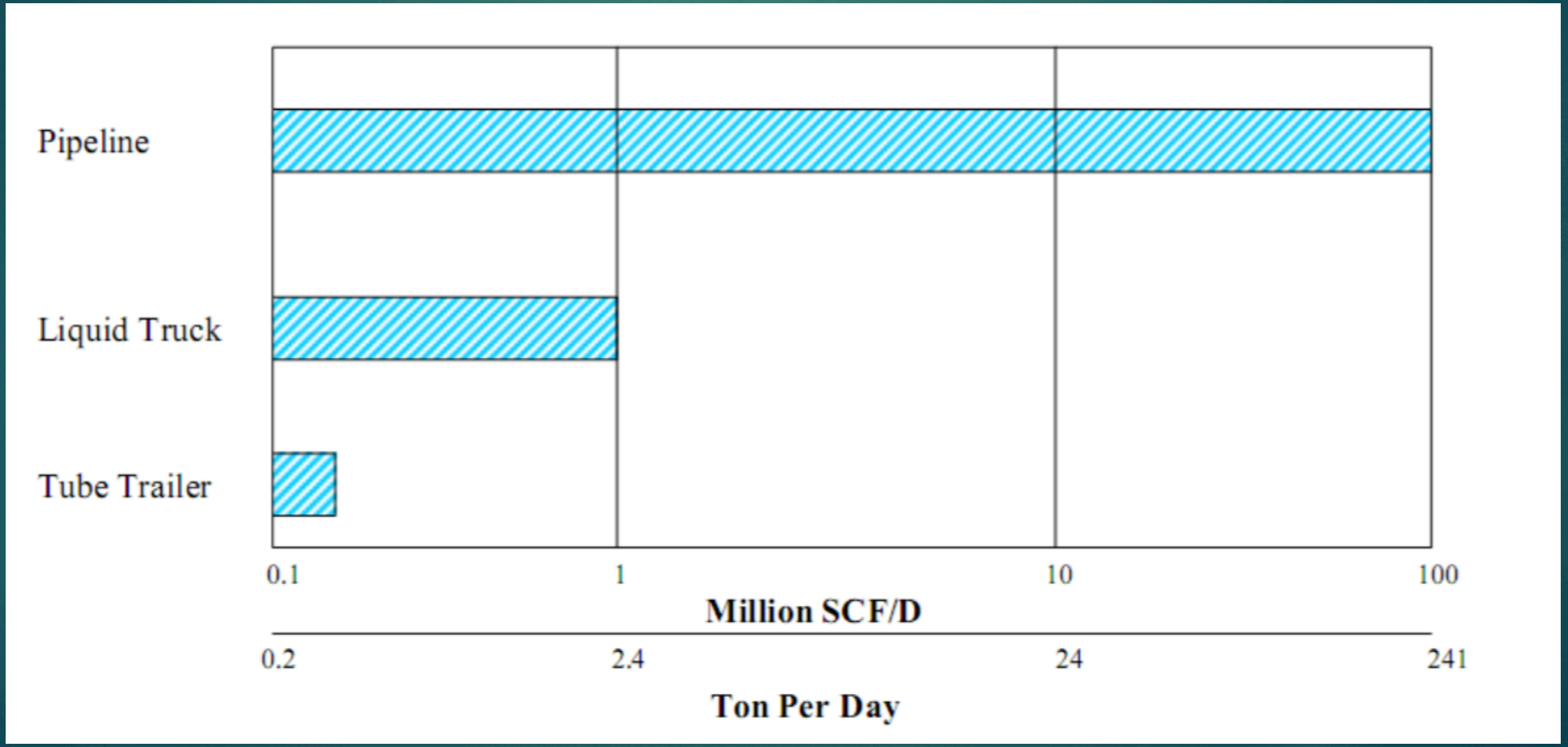
Cost of Electrolysis

- $2 USD per kg of Hydrogen ($1.6 USD without electricity costs)
- Example: 1000 kg of Hydrogen/day
  - Capital Investment
    - $2,241,141
  - Electricity
    - $4,962,527
  - Operation and Maintentance
    - $800,407

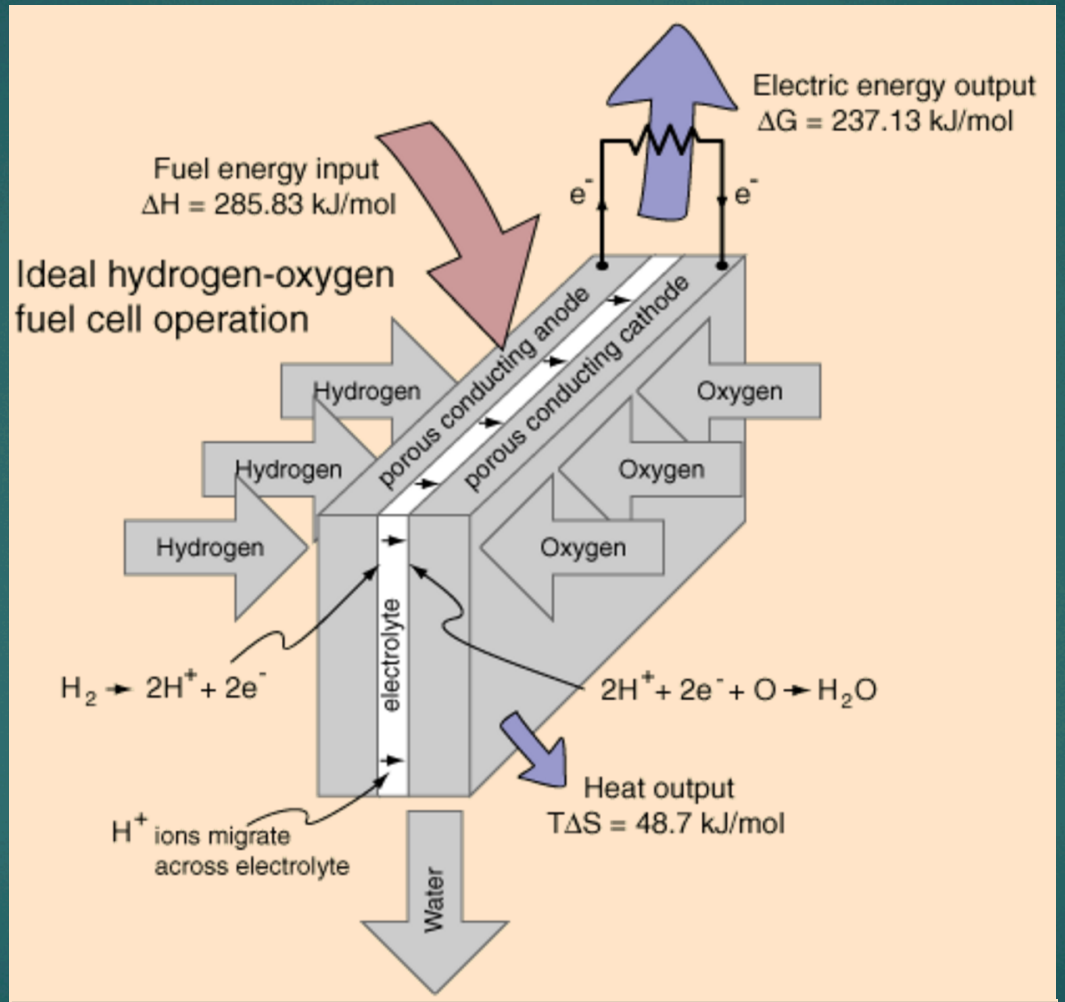
Distribution

- Pipeline
  - $0.5-1.5 million USD per mile to make
  - In US, 241 Tons per Day
  - North Africa to Central Europe
    - Around $1 USD per kg
    - Over 3000 km
- High-Pressure Tube Trailers
  - $2.09/kg of Hydrogen
  - Range used: ≤200 miles
  - In the US, less than 0.5 Ton per day
- Liquefied Hydrogen Tankers
  - $0.18/kg of Hydrogen
  - In US, 2.4 Tons per Day

Hydrogen Distribution in the United States



Fuel Cell



Quantity	H_2	0.5 O_2	H_2O	Change
Enthalpy	0	0	-285.83 kJ	ΔH = -285.83 kJ
Entropy	130.68 J/K	0.5 x 205.14 J/K	69.91 J/K	TΔS = -48.7 kJ

Pros of Fuel Cells

- Higher Efficiency than Diesel and Gas
- Silent and 100% Clean, especially if renewable energy used for electrolysis
- Not dependent on oil
- Portability
- More stable decentralized power grid
- Low Temperature Fuel Cells have Low heat transmission
- Higher Temperature Fuel Cells produce high-grade process heat and electricity (cogeneration)
- No ‘‘memory effect’’
- Maintenance is Simple!

South Island (over 10 MW)

Power Station	Power Rating (MW)	Year Generation (GWh)
HYDRO		
Cobb	32	190
Coleridge	39	270
Highbank	29	98
Tekapo A	25.5	160
Tekapo B	160	833
Ohau A	264	1,140
Ohau B	212	958
Ohau C	212	958
Benmore	540	2215
Aviemore	220	942
Waitaki	105	496
Clyde	464	2100
Roxburgh	320	1650
Paerau and Paetearoa	12	62
Waipori	84	400
Manapouri	850	5100
WIND		
Whitehill	58	81.3244
Mahineragni	36	105
TOTAL	**3,662.50**	**17,758**

CALUCLATIONS

Interesting Projects

- Inter-Island Pipeline for Hydrogen ($0.5 -$1.5 million USD per Mile)
- Hydrogen Stations for Hydrogen Fuel-Cell Electric Car