INVESTMENT IN HYDROPOWER GENERATION: NEW ZEALAND & PERU

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Photo Credit: [1]

BASICS OF HYDROPOWER

Hydropower → power that comes from the energy of falling or fast moving water

Used since ancient times as renewable energy source

Previous uses: irrigation, sawmills, textile miles, ore mills

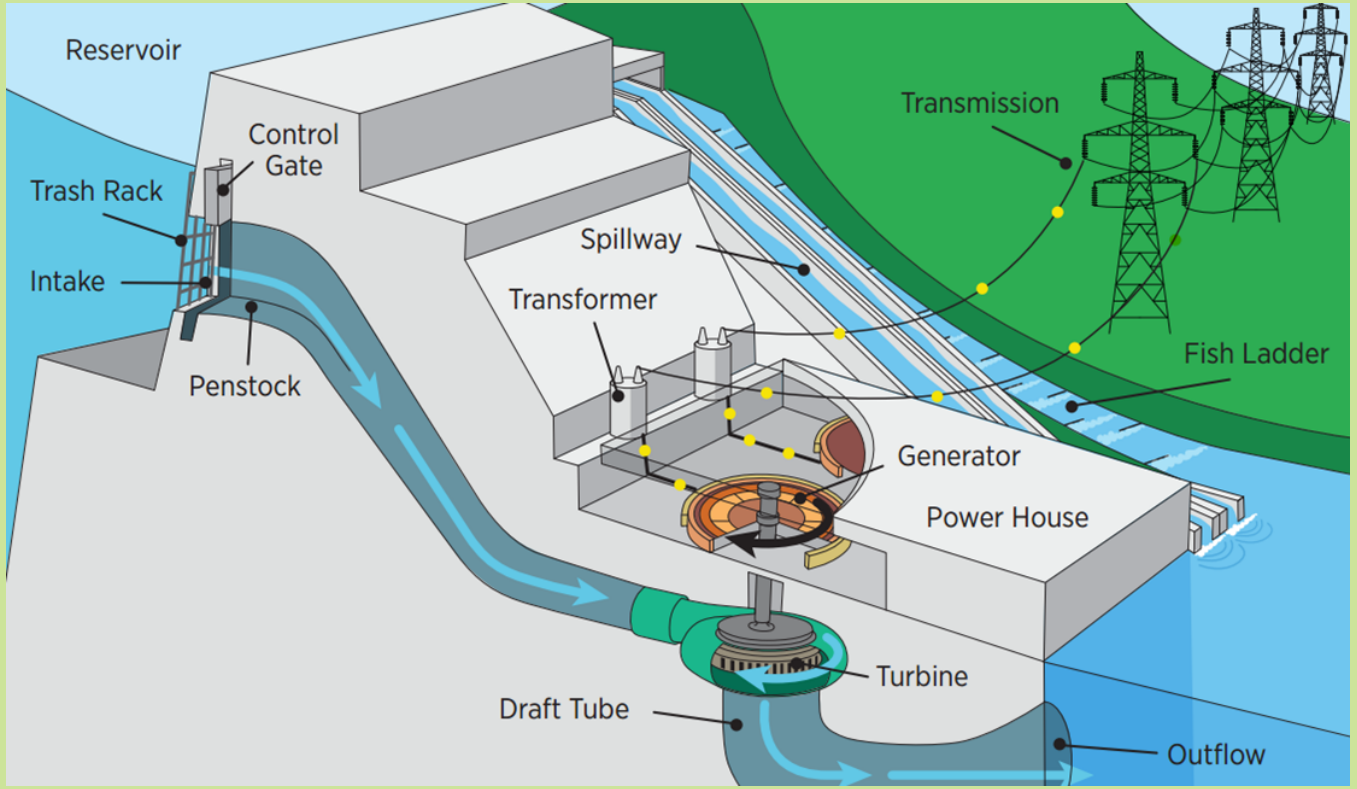
Now: generating electricity since the late 19th century

First house powered by hydroelectricity: 1878 in Northumberland, England

First commercial plant: 1879 at Niagara Falls in border of Ontario, Canada and New York, USA

Means of economic development for countries

Controversies: social and environmental impacts



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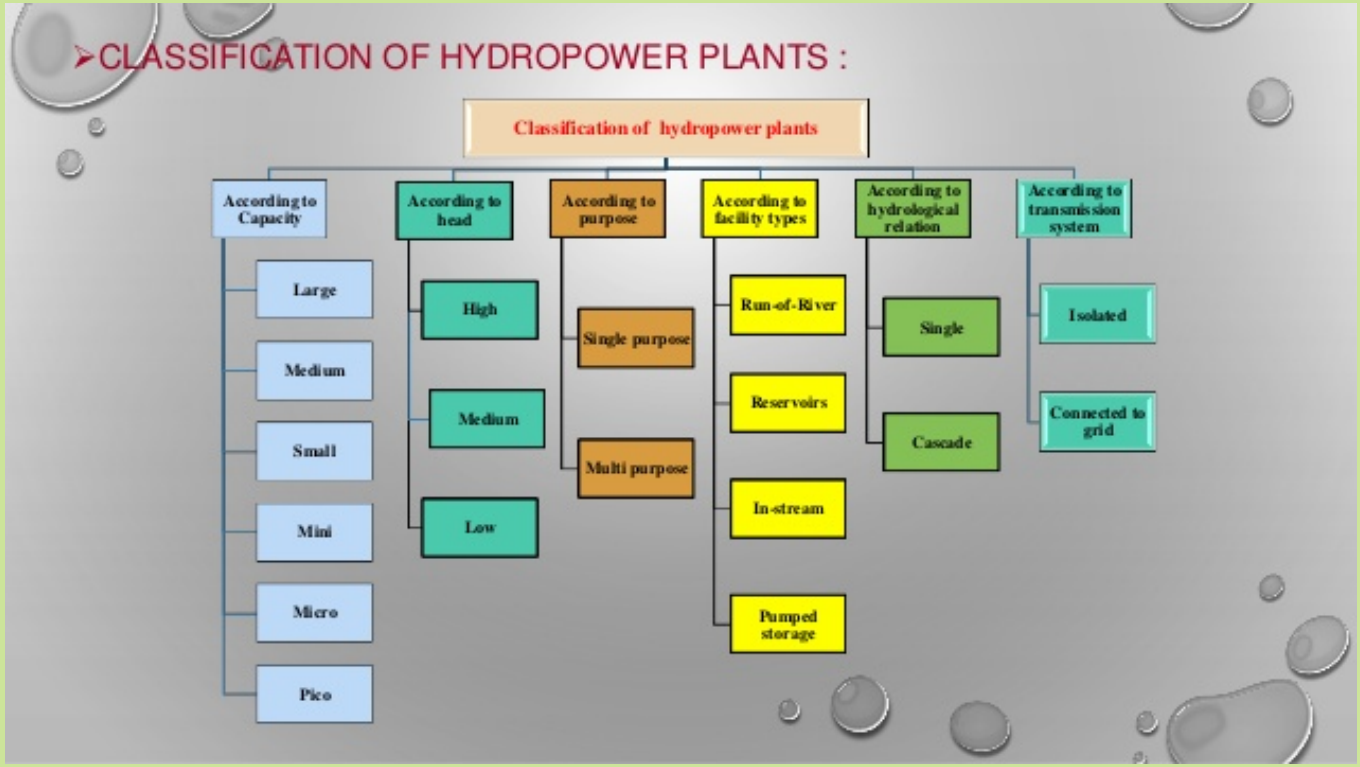
BASICS OF HYDROPOWER CONT.

- Types of Hydropower:
  - Conventional hydroelectric (hydroelectric dams)
  - Run-Of-The-River Hydroelectricity (captures kinetic energy without using dams)
  - Small hydros (<10 mW)
  - Micro hydros (few-few hundred kW for isolated homes)
  - Conduit Hydroelectricity (use water that has been diverted for use elsewhere),
  - Pumped-Storage (stores power pumped uphill into reservoir)
  - Pressure-Buffing Hydropower (uses natural power for water pumping to turbines while exceeding water is pumped uphill into reservoirs)



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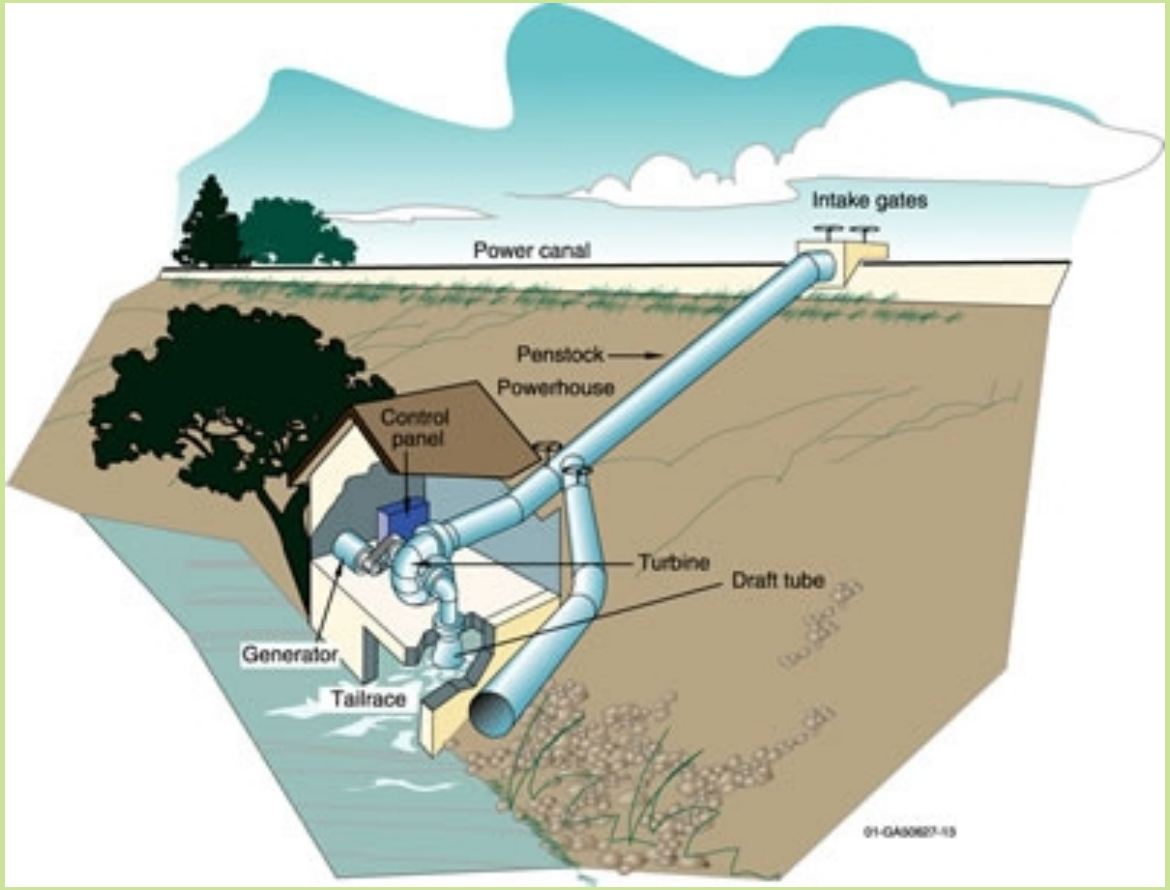
HYDROPOWER FAST FACTS

- Most commonly used renewable energy source in the world
- Largest hydroelectric plant is in Quebec, Canada
- Process produces no air pollution sources or toxic byproducts
- Don't need a dam to function- can have diversions of run-of-river facilities
- Economic costs to implement are less than other renewable energy systems
- Ideal source for meeting sudden changes in demand for electricity
- Can implement devices in dam hydropower plants help fish, aquatic wildlife to move safely around turbines
- Dams can also be used for irrigation, navigation, flood control, reservoirs



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NEW ZEALAND GEOGRAPHY

- Two islands: north and south, number of smaller islands
- North island: volcanic plateau, less mountainous
- South island: southern alps, glaciers
- 1.6% of land area covered by water: rivers, lakes, ponds
- Largest lake by surface area: Lake Taupo, lies in a caldera
- Country is on the boundary of two tectonic plates
- Volcanism as a result of the subduction of the Pacific plate under the Indo-Australian plate- geothermal power source
- Maritime climate with temperatures ranging from 8-16 C
- Land uses: natural gas, iron ore, sand, coal, hydropower, gold, limestone, arable land, wheat, barley, sheep
- Total renewable water sources: 327 km^3

Photo Credit: [5]

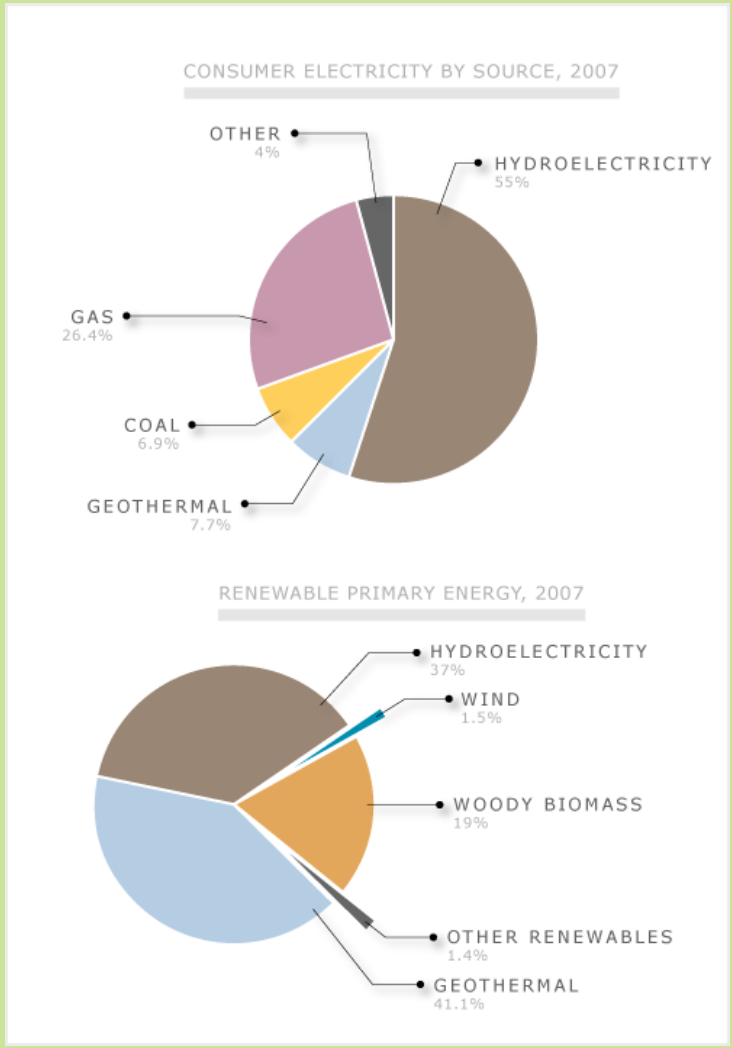
NEW ZEALAND ENERGY HISTORY

- Net importer of energy, mostly petroleum products
- 70% of energy supply comes from hydrocarbon fuels
- Non-renewable energy amounts vary depending on water flows into hydroelectricity lakes
- Energy consumption in 2007 was 120 GJ
- Does not operate any nuclear power stations

NZ primary energy supply 2014 (PJ)[1]

Oil	Gas	Geo-thermal	Hydro	Wood	Coal	Wind	Biogas	Waste heat	Solar	Biofuel	Total
280.1	204.4	200.1	87.6	58.3	55.6	8.0	3.2	0.9	0.4	0.1	898.7
31.2%	22.7%	22.3%	9.7%	6.5%	6.2%	0.9%	0.4%	0.1%	0.0%	0.0%	100%

Photo Credit: [7]



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HISTORY OF HYDROPOWER IN NEW ZEALAND

- Hydroelectric has been a part of the energy system for > 100 years
- Provides ½ of NZ's electricity needs
- Established with the forming of 1903 Waipori scheme, and 1914 Lake Coleridge power station
- 1960s: many hydro sites on north island, potential to implement on south island
- HVDC Inter-Island Link: 1965, possible to send electricity between islands
- Examples: 540 MW Benmore Power Station, 700 MW Manaouri Power Station, 848 MW Upper Waitaki River Scheme, 432 MW Clyde Dam
- Total production (2014): 24,094 GW, 57% of total electricity
- Hydropower is 11% of total energy usage in NZ

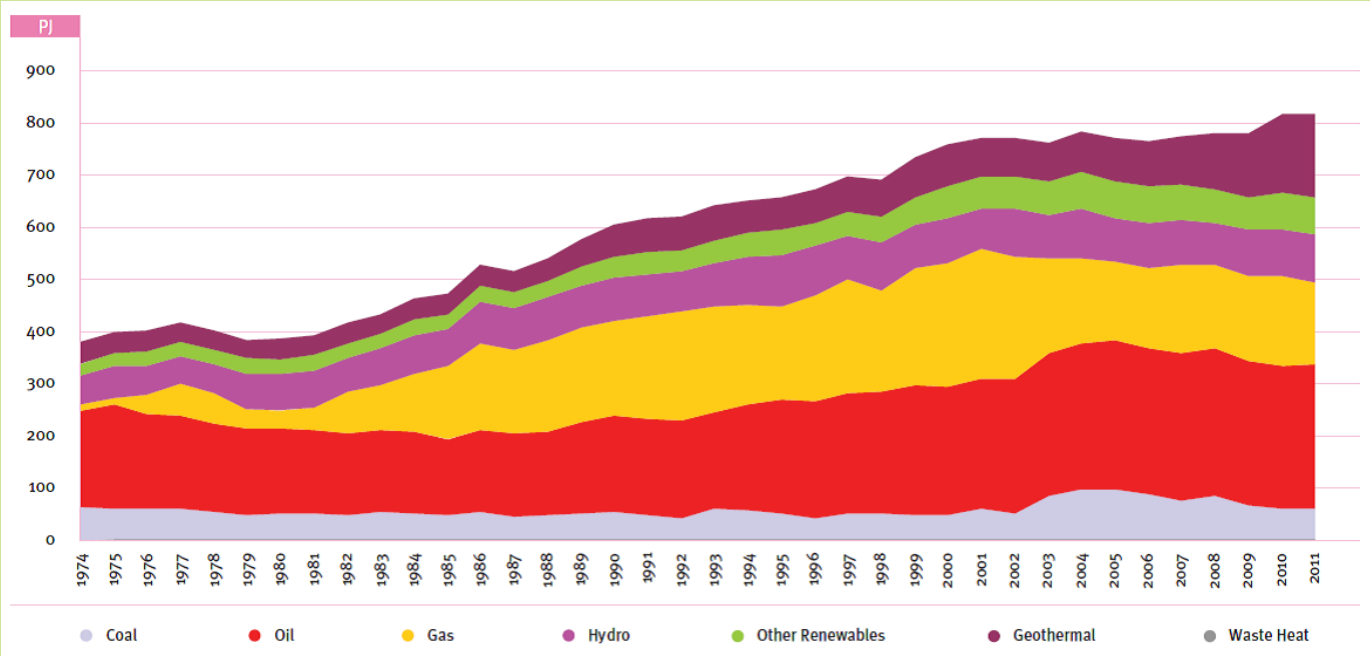


Photo Credit: [8]

EXAMPLE OF NEW ZEALAND HYDROPOWER

The Upper Waitaki Hydro Development Scheme at Lake Benmore on the South Island of New Zealand provides one third of New Zealand's hydro electricity.

Photo Credit: [9]

FUTURE PROPOSED PROJECTS IN NEW ZEALAND

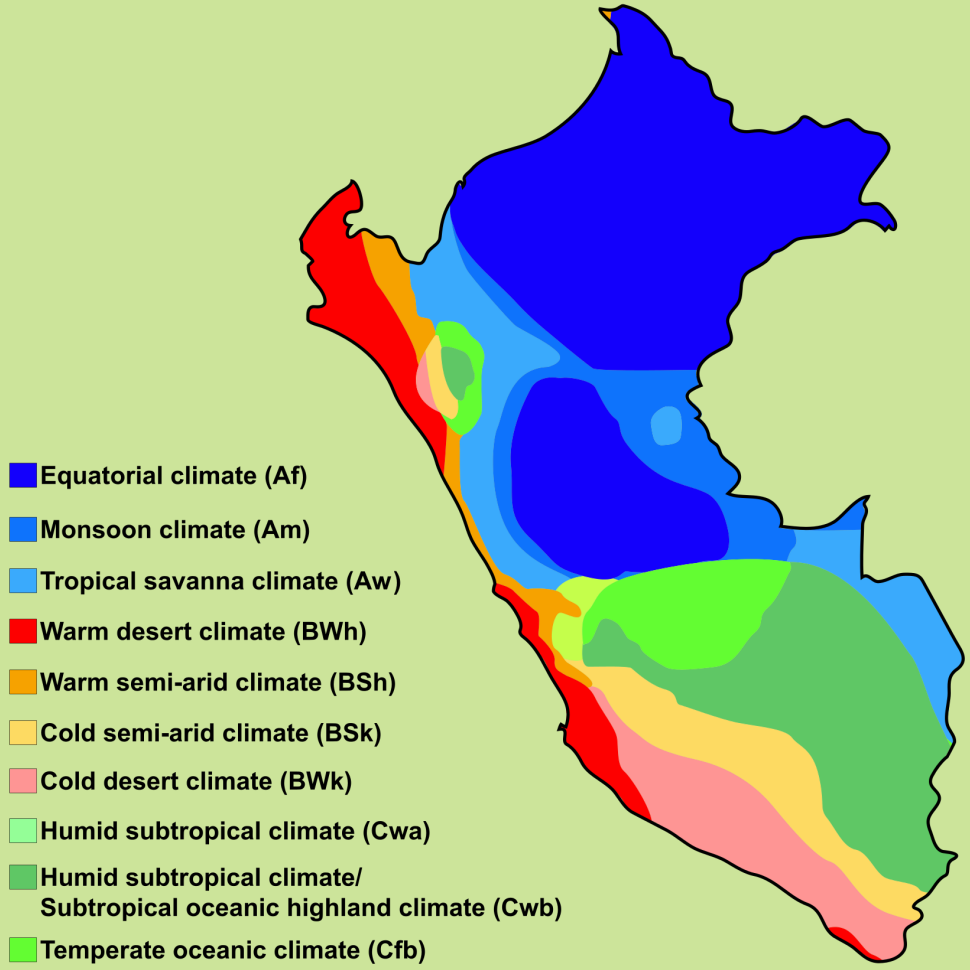
- Project Aqua- lower Waitaki River, dropped
- North Bank Tunnel- Waitaki River, Meridian Energy
- Wairau Hydro Scheme- Waitaki River, Trust Power
- Arnold Power Station- Trust Power, extension

Photo Credit: [10]

PERU GEOGRAPHY

- Has 11 ecological regions and a wide range of natural resources
- 3 main regions: coast, mountains, jungle
- Amazon Rainforest: 59% of the national territory, plains covered by vegetation in the Amazon River Basin
- Highlands: 30% of the national territory, mountainous regions with varying altitudes
- Coast: 11% of the national territory, section of fertile valleys along the Pacific Ocean
- Rivers include: Apurimac, Maranon, Napo, Ucayali
- Lakes: more than 12,000 in total
- Also home to hot springs, geysers, and waterfalls

Peru map of Köppen climate classification



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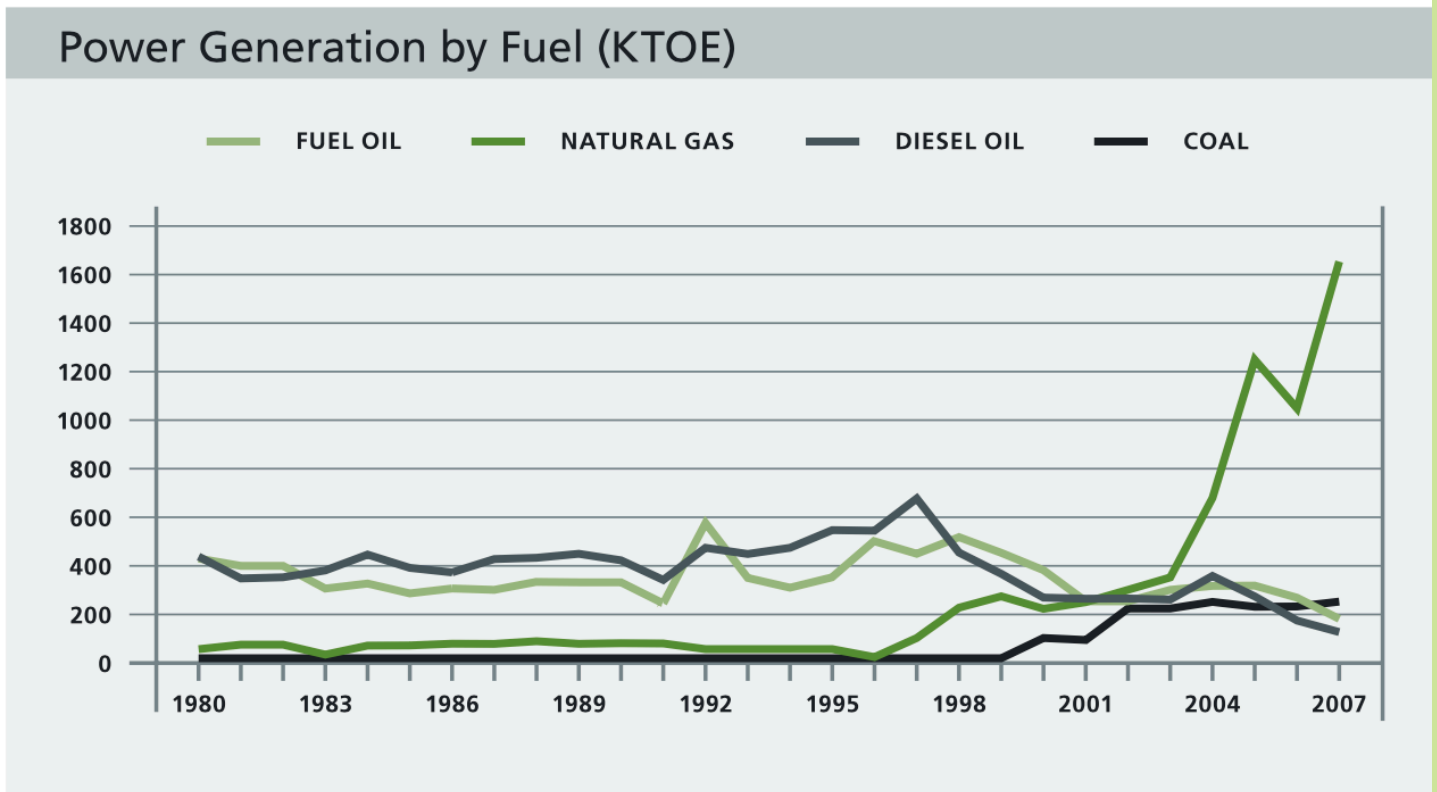
PERU ENERGY HISTORY

- Access to electricity has increased 40% in the past 15 years
- Electricity tariffs are a contentious problem
- Installed capacity: 6.7 GW
- Fossil fuels: 52% of total energy supply
- Inadequate regulatory framework has hold back projects in wind and solar
- Electricity split between thermal and hydroelectric sources
- National Interconnected System serves 85% of the total population
- Rural electricity supply comes from public sources



Source: APEC Energy Database

Photo Credit: [12]

HISTORY OF HYDROPOWER IN PERU

- Hydropower accounts for 48% of renewable energy
- Installed hydropower capacity: 3,820 MW (2014)
- Total hydropower generation: 23.76 TWh (2014)
- Estimated potential remaining: 70 GW, with 3.8 GW tapped so far
- Identified tributaries for hydropower start in the Peruvian Andes mountains
- Hydropower is only renewable resources used in Peru
- Accounts for 72% of electricity generated
- ElectroPeru is a state-owned energy company that operates the largest sites
- Law for the Promotion of Energy Efficient Law passed in 2000 to support efficient use of energy

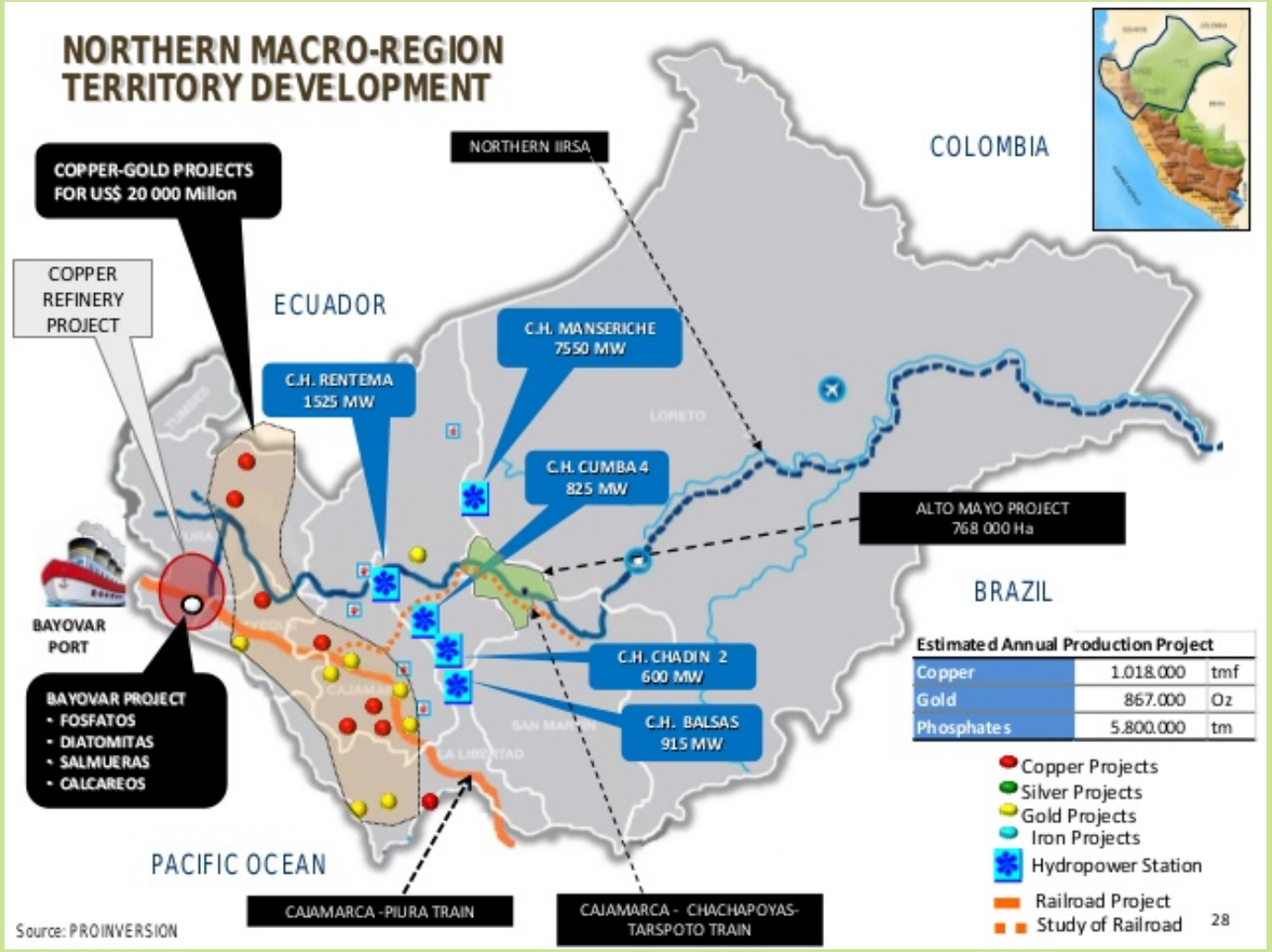


Photo Credit: [13]

FUTURE OF PROPOSED PROJECTS IN PERU

- Veracruz (730 MW) by Enersis
- Chadin 2 (600 MW) by Energia
- Over 20 projects currently in planning phases
- Recently completed: Huanza Project (92 MW), Chaglla Plant (406 MW)
- Challenges for future projects limited by access to modern water and energy services, especially in remote areas

Renewable Energy Generation Potential Projection from 2012 to 2020			
Renewable Energy Source	**Potential Cumulative Demand (MW)**	**Installed Investment Costs (Million US$/MW)**	**Total Investment Potential (Million US$)**
Photovoltaic	540	2.5 – 3.0	1.350 – 1.620
Wind	1,800	1.8 – 2.0	3.240 – 3.600
Hydropower	2,000	1.5 - 1.8	3.000 – 3.600
Biomass	1,800	1.8 – 2.5	3.240 – 4.500
Total	**6,140**	**7.6 – 9.3**	**10.830 – 13.320**

Source: CINYDE analysis

Photo Credit: [14]

HYDROPOWER ON THE GLOBAL SCALE

- Total worldwide consumption: 132,000 TWh
- Global use increased 5% from 2009-2010
- China is largest hydropower producer, 17% of domestic electricity
- Produced in 150+ countries
- 4 countries generate all of their electricity from hydropower: Albania, Bhutan, Lesotho, Paraguay
- Produced most hydropower per capita: Iceland, New Zealand, Norway

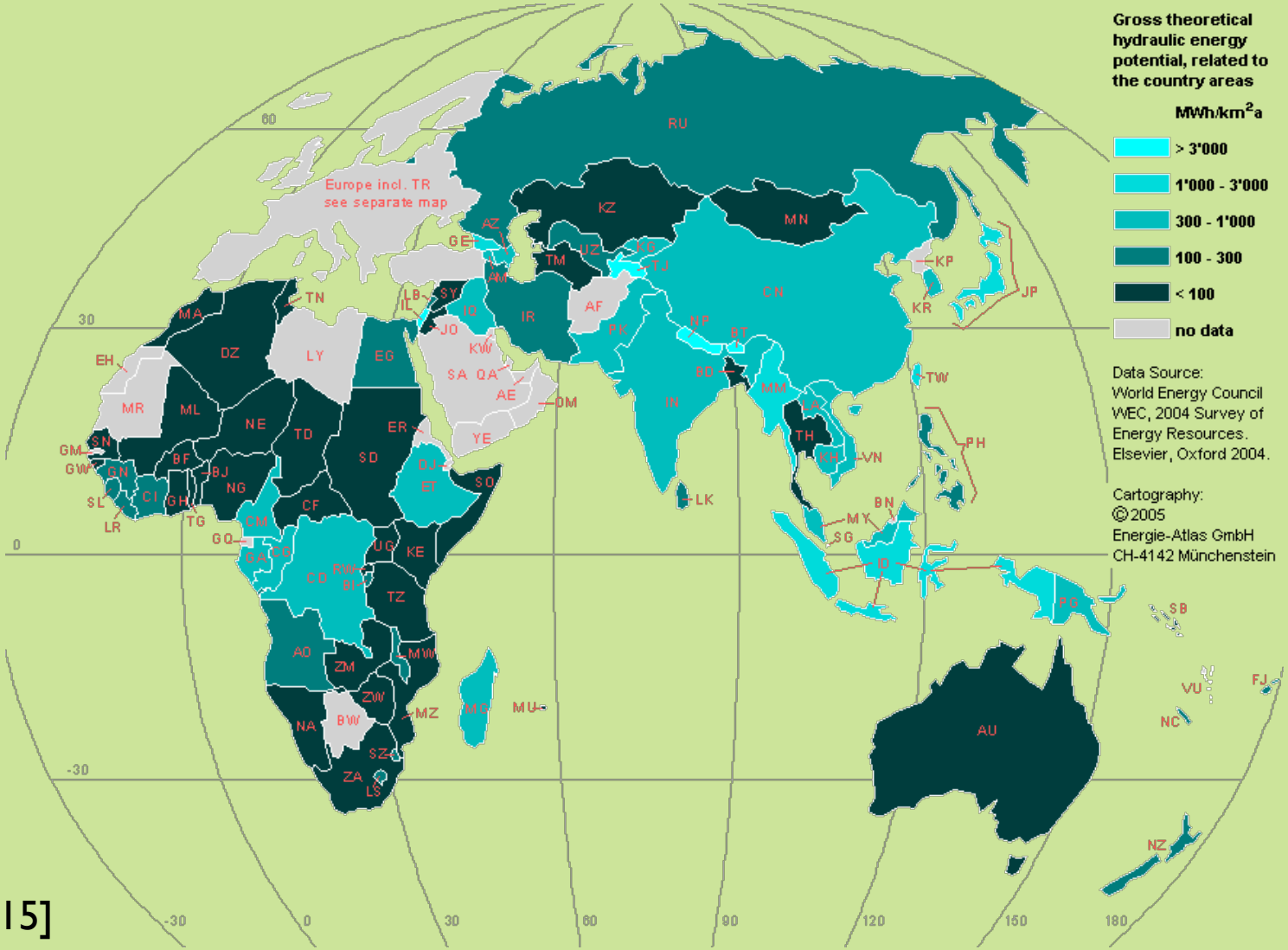


Photo Credit: [15]

ECONOMICS OF HYDROPOWER

- $40–45 billion was invested in large hydropower projects worldwide in 2010
- Operational costs are low compared to other renewable energies
- Long time to develop and construct plants
- Two major cost components: infrastructure development and electro-mechanical equipment
- Total investment costs depend on sit design, cost of labor, cost of materials
- Smaller projects have higher average costs
- Lower costs by designing plants with higher installed capacity

Table 1. Ten of the largest hydroelectric producers as at 2009

Country	Annual hydroelectric production (TWh)	Installed capacity (GWh)	% of total capacity
China	652	197	22
Canada	370	89	61
Brazil	364	69	86
United States	251	80	6
Russia	167	45	18
Norway	141	28	98
India	116	34	16
Venezuela	86	15	69
Japan	69	27	7
Sweden	66	16	44

Source: Wikipedia: electricity

Photo Credit: [16]

ENVIRONMENTAL IMPACTS

- Damming interrupts the flow of rivers and can harm local ecosystems
- Construction large dams and reservoirs often involves displacing people and wildlife and requires significant amounts of carbon-intensive cement
- Reservoir and dam can also change natural water temperatures, water chemistry, river flow characteristics, and silt loads
- Reservoirs may cover important natural areas, agricultural land, or archeological sites.
- A reservoir and the operation of the dam may also result in the relocation of people

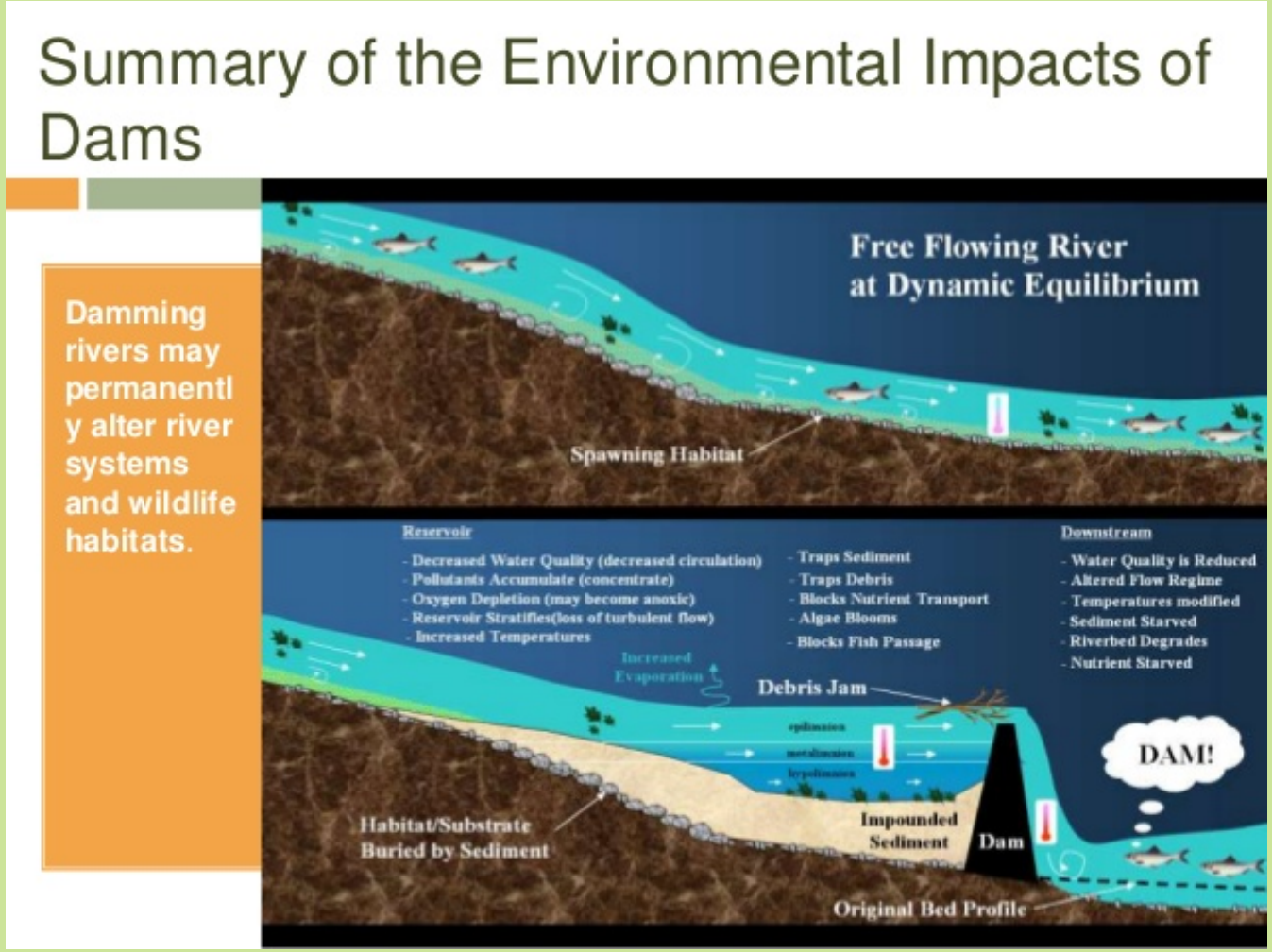


Photo Credit: [17]

FINAL THOUGHTS ON HYDROPOWER

- Five countries—China, Brazil, the United States, Canada, and Russia—accounted for approximately 52 percent of the world's installed hydropower capacity in 2010.
- Hydropower is also a flexible source of electricity since plants can be ramped up and down very quickly to adapt to changing energy demands.

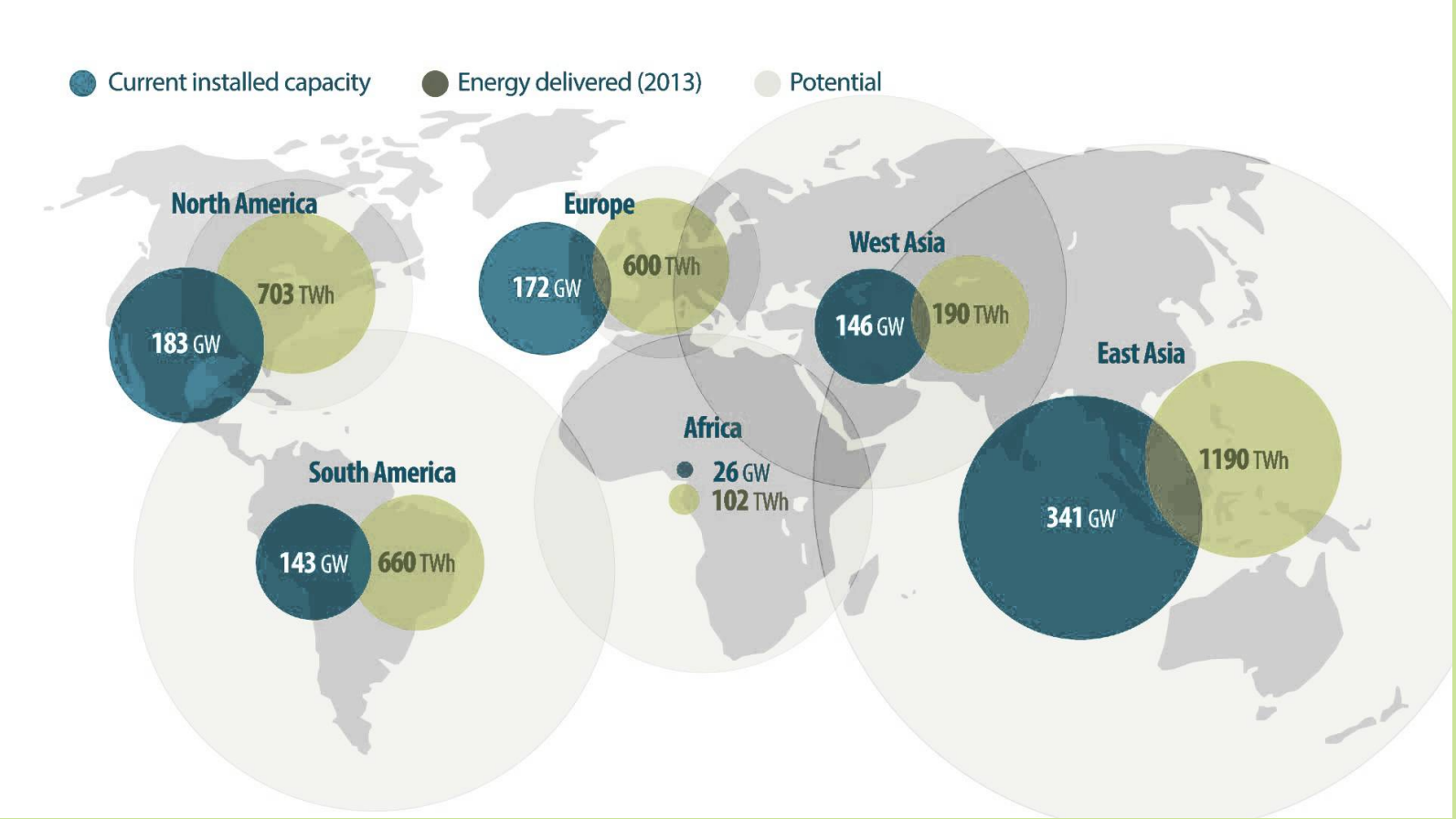


Photo Credit: [18]

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IMAGE SOURCES

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