

RENEWABLE ENERGY SYSTEMS

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Outline

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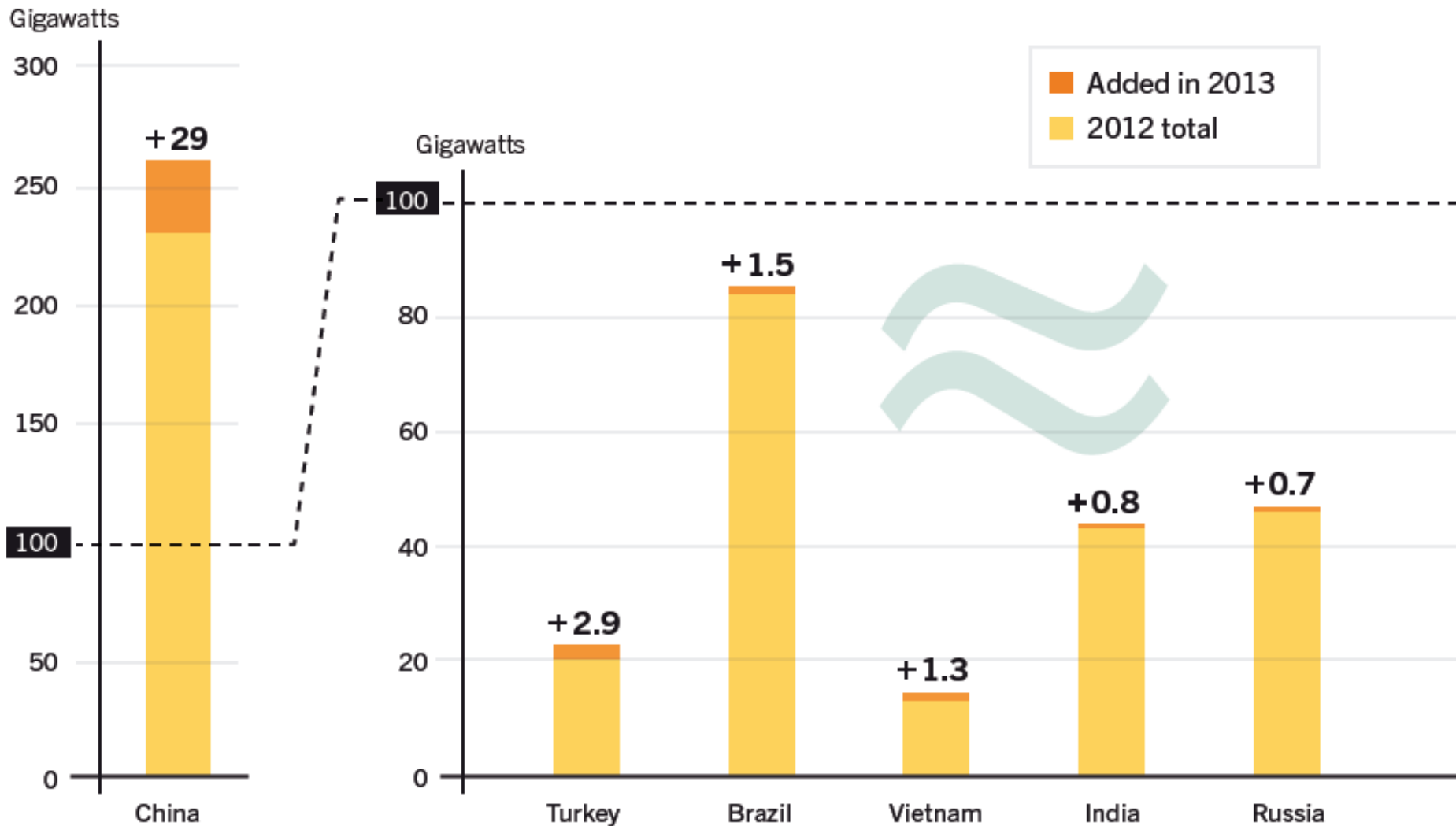
- Hydro Energy
- Ocean Energy (waves, currents and tides)
- Biomass
- Geothermal Energy

Hydroenergy

- Hydropower generating plants capture the kinetic energy of falling water, such as from a river and waterfalls, to generate electricity.
- A turbine converts the kinetic energy from water, first to mechanical energy and then to electrical energy using a generator.
- Hydropower is considered a renewable energy source since the water cycle is a continuous cycle.

Hydropower Capacity and Additions, Top Six Countries for Capacity Added, 2013

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Hydropower Global Capacity

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China
26%

Brazil
8.6%

United States
7.8%

Canada
7.6%

Russia
4.7%

Rest of the World
41%

India
4.4%

Global capacity reaches
1,000 GW

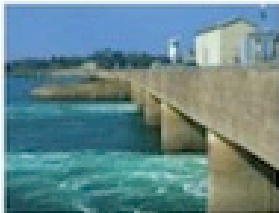

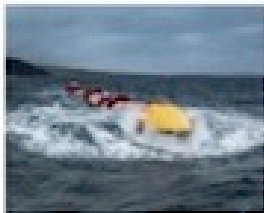

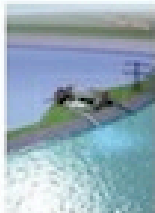
Ocean Energy (waves, currents and tides)

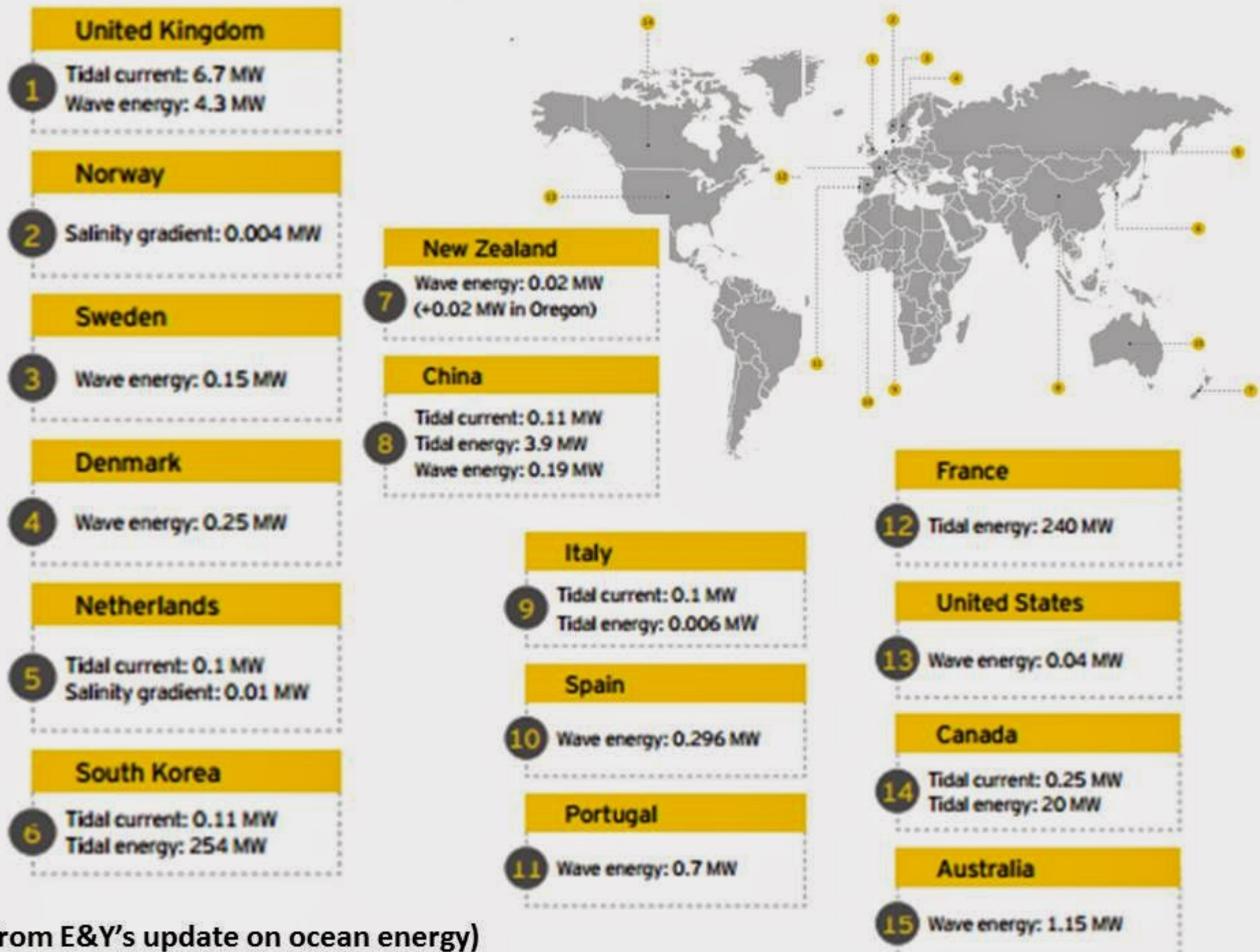
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- Generating technologies for deriving electrical power from the ocean include tidal power, wave power, ocean thermal energy conversion, ocean currents, ocean winds and salinity gradients.
- Of these, the three most well-developed technologies are tidal power, wave power and ocean thermal energy conversion.

Technologies to Generate Power from the Ocean

Ocean energy overview

	Tidal Barrage	Tidal Stream	Wave	Thermal Gradient	Salinity Gradient
					
Energy source	<ul style="list-style-type: none"> Tidal range (using conventional hydro technology) 	<ul style="list-style-type: none"> Tidal currents Ocean currents 	<ul style="list-style-type: none"> Ocean waves 	<ul style="list-style-type: none"> Temperature gradient between the sea surface and deepwater 	<ul style="list-style-type: none"> Difference in salt concentration at fresh-water/ sea-water interface
Example technologies	<ul style="list-style-type: none"> Ebb generation Flood generation 	<ul style="list-style-type: none"> Horizontal Axis Ducted Rotor Vertical Axis Hydrofoil 	<ul style="list-style-type: none"> Attenuator Oscillating Water Column (OWC) Point Absorber Overtopping 	<ul style="list-style-type: none"> Different Ocean Thermal Energy Conversion (OTEC) processes 	<ul style="list-style-type: none"> Pressure-retarded reverse osmosis and associated conversion technologies
Maturity of installed devices	<ul style="list-style-type: none"> Mature: plants in operation 	<ul style="list-style-type: none"> Pre-commercial: full-scale prototypes (~1MW) 	<ul style="list-style-type: none"> Testing: part-scale prototypes (<1MW)¹⁾ 	<ul style="list-style-type: none"> Demonstration: first small-scale devices (<250kW) 	<ul style="list-style-type: none"> Concept: first pilot device (<5kW)
Exploitation potential	<ul style="list-style-type: none"> Environmental concerns limit further exploitation (~300 TWh/a²⁾) 	<ul style="list-style-type: none"> Emerging exploitation, sites under development (~800 TWh/a) 	<ul style="list-style-type: none"> Mid-term potential (~8,000 TWh/a, economically viable) 	<ul style="list-style-type: none"> Long-term potential (~10,000 TWh/a²⁾) 	<ul style="list-style-type: none"> Long-term potential (~1,600 TWh/a²⁾)



(from E&Y's update on ocean energy)

Wave energy

- Wave energy conversion takes advantage of the ocean waves caused primarily by interaction of winds with the ocean surface. Wave energy is an irregular and oscillating low-frequency energy source that must be converted to a 50 or 60-Hertz frequency before it can be added to the electric utility grid.
- Although many wave energy devices have been invented, only a small proportion have been tested and evaluated. Furthermore, only a few have been tested at sea, in ocean waves, rather than in artificial wave tanks.

Tidal Energy

- nother form of ocean energy is called tidal energy. When tides comes into the shore, they can be trapped in reservoirs behind dams. Then when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric power plant.
- Tidal energy has been used since about the 11th Century, when small dams were built along ocean estuaries and small streams. the tidal water behind these dams was used to turn water wheels to mill grains.
- In order for tidal energy to work well, you need relateivel large increases in tides. An increase of at least 16 feet between low tide to high tide is generally needed. There are only a few places where this tide change occurs around the earth. Some power plants are already operating using this idea.

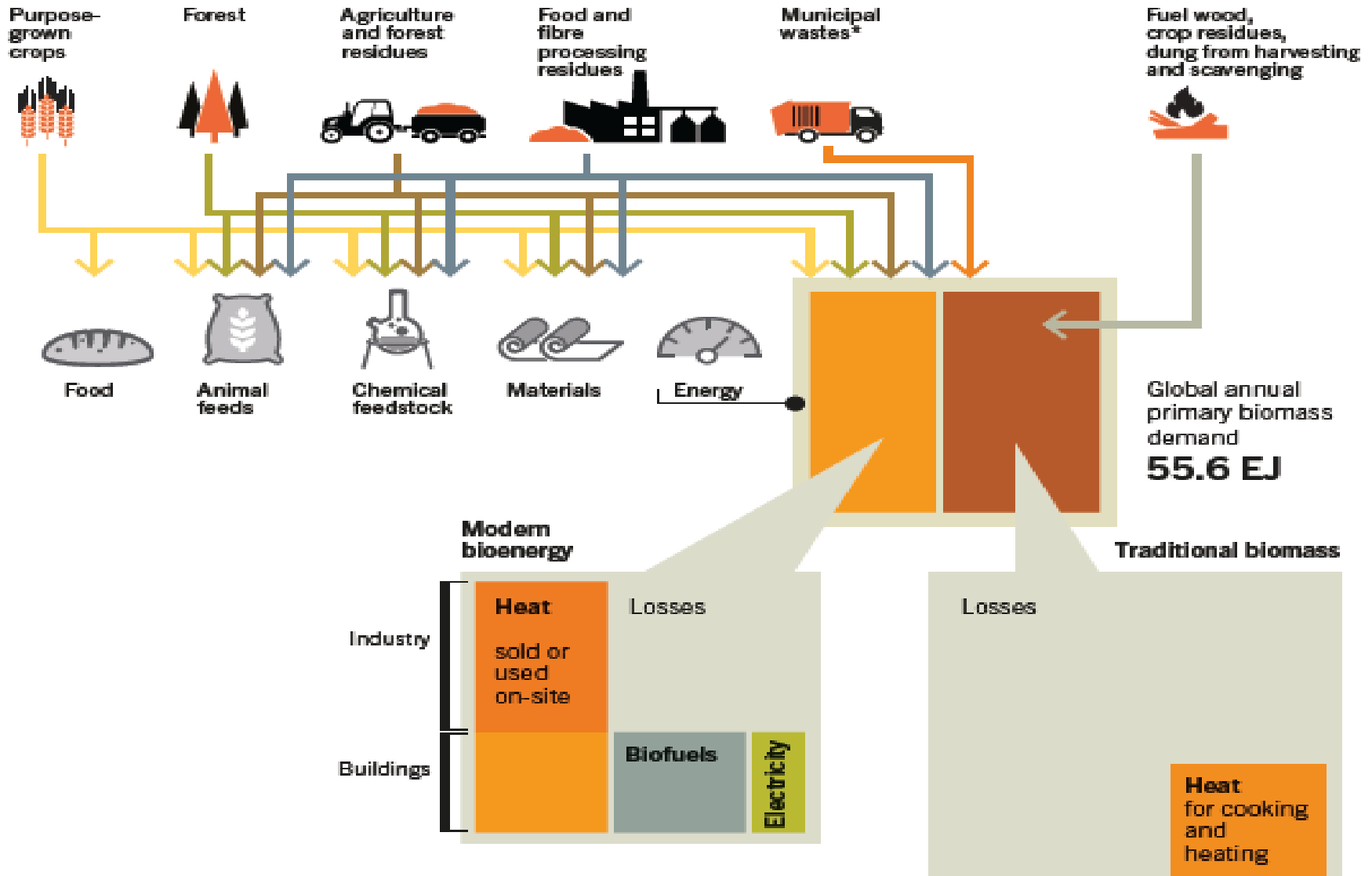
Ocean Thermal Energy Conversion (OTEC)

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- The idea of using the temperature of water to make energy actually dates back to 1881 when a French Engineer thought of OTEC. The final ocean energy idea uses temperature differences in the ocean.
- If you ever went swimming in the ocean and dove deep below the surface, you would have noticed that the water gets colder the deeper you go. It's warmer on the surface because sunlight warms the water.
- But below the surface, the ocean gets very cold. That's why scuba divers wear wet suits when they dive down deep. Their wet suits trapped their body heat to keep them warm.

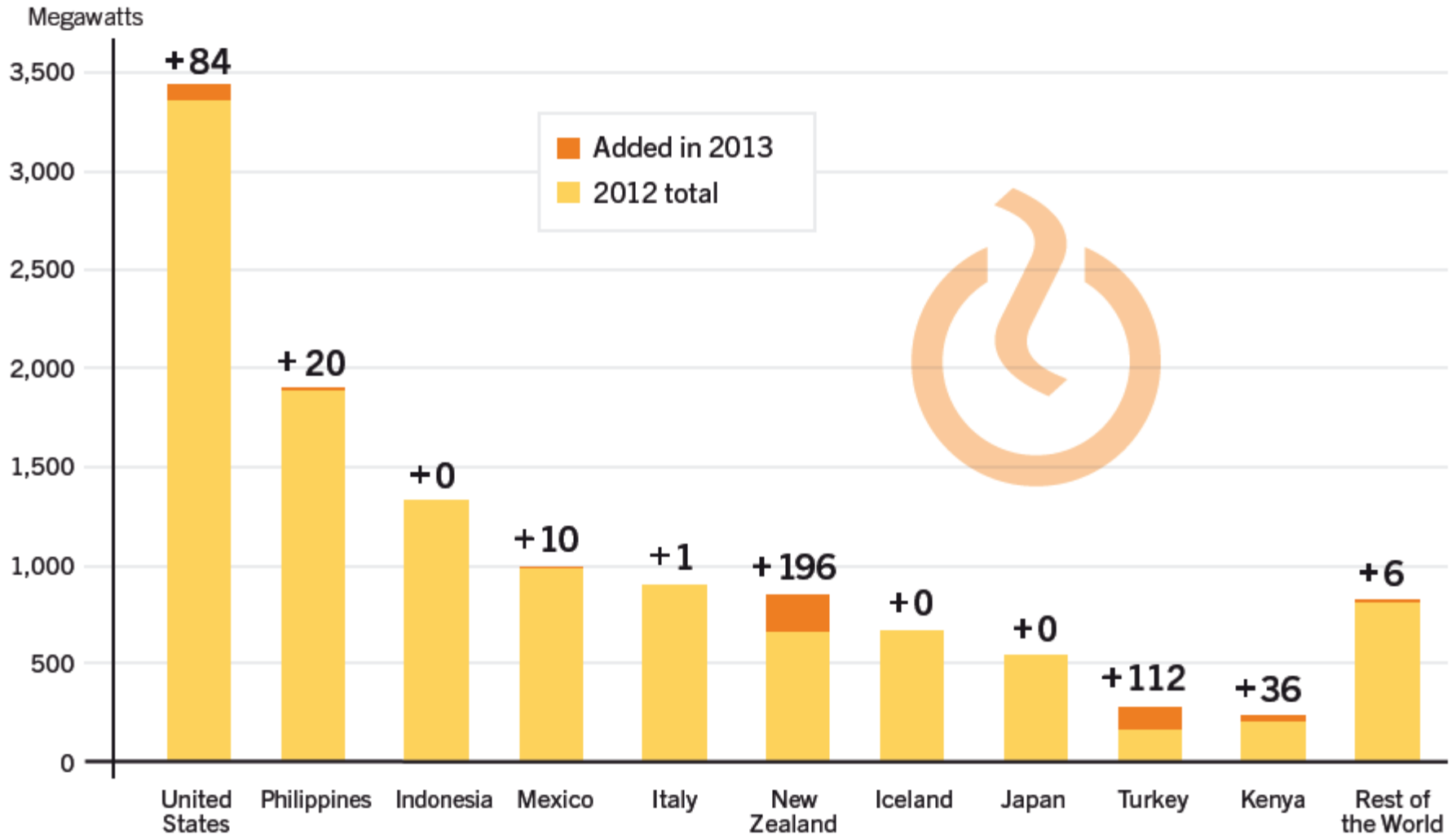
Biomass

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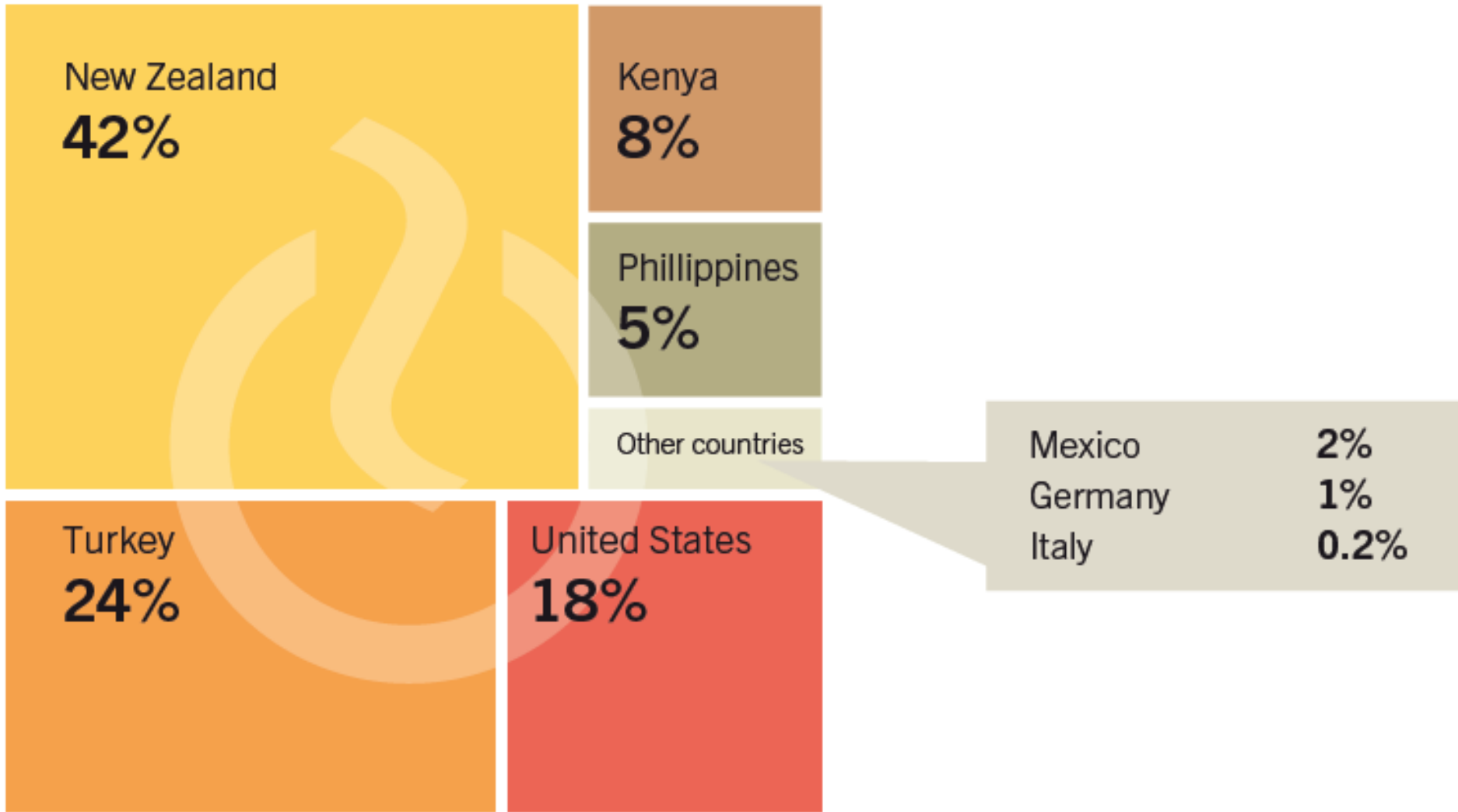
Geothermal Power Capacity and Additions, Top 10 Countries and Rest of World

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Geothermal Power Capacity Additions, Share of Additions

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Any Questions...
Just Ask!

