ANDRITZ HYDRO

ADVANCED TECHNOLOGIES TO CONVERT THE POWER OF OCEANS INTO ELECTRIC ENERGY

MANILA 16.06.2023

ANDRITZ

ENGINEERED SUCCESS

FROM THE HISTORIC PIONEERS OF TECHNOLOGY TO A

MODERN MARKET LEADER

THE PIONEERS CREATED THE FOUNDATION

OUR PIONEERS (ALPHABETICAL ORDER):

AFI ANDRITZ Andritz VA TECH HYDRO Ateliers des Charmilles Ateliers de Constructions Mécaniques de Vevey (ACMV) Baldwin-Lima-Hamilton Bell Bouvier Boving C.E.G.B. Dominion Engineering ELIN English Electric Escher Wyss Finnshyttan GE Hydro GE Hydro Inepar General Electric Hammerfest Strom Hemi Controls HMI Construction Hydro Vevey I.P.Morris KAMEWA KMW Kvaerner Møller NOHAB Pelton Water Wheel Pichlerwerke Precision Machines Ritz Pumpenfabrik SAT Sulzer Hydro Tampella VA TECH HYDRO VOEST Voest MCE Waplans

2021 Largest rehabilitation project (Mexico)

2021 Co-located energy plant (Kidston, Australia; PSP, Solar, Wind)

2016 **First commercial tidal current array unit (Meygen, Scotland)**

2012 World largest Hydromatrix plant (Ashta, Albania)

2011 World largest Bulb turbine (Jirau and St. Antonio, Brazil)

2008 **World largest tidal power plant (Sihwa, South Korea)**

2008 770 MW Francis turbine (Simon Bolivar, Venezuela)

2002 First var speed motor-generator outside Japan (Goldisthal, Germany)

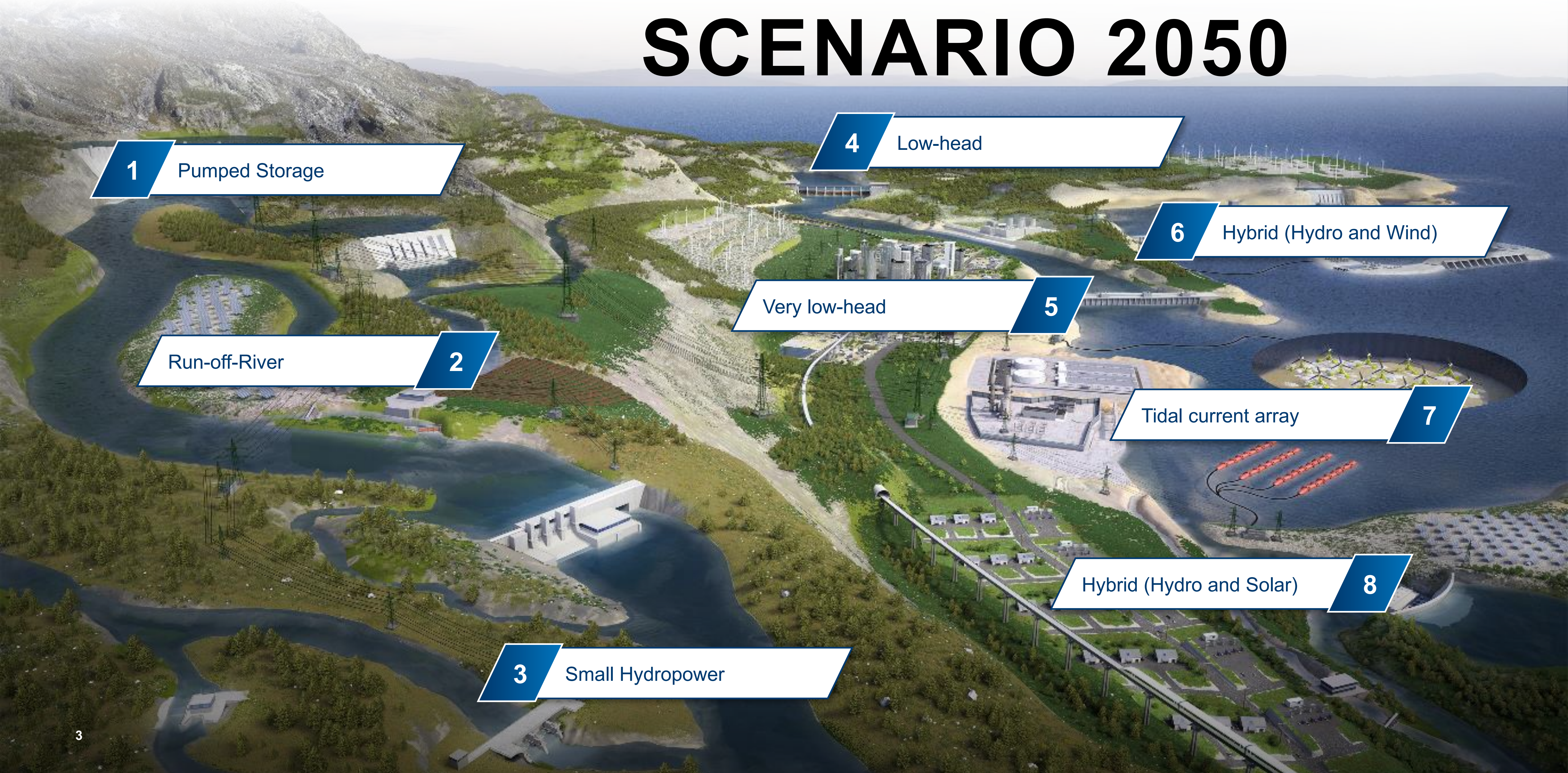
1991 World largest manifold (Tarbela, Pakistan; World Record)

1896 First large commercial hydropower plant

1839 **First turbine supplied**

1805 Foundation of Escher Wyss & Cie, Switzerland

SCENARIO 2050



OCEAN ENERGY

Three-quarters of the Earth‘s surface is covered by water.
Of this water, 97% is Ocean.

The opportunities for generating energy at sea are varied, tidal stream, tidal range, wave, solar and wind amongst others.

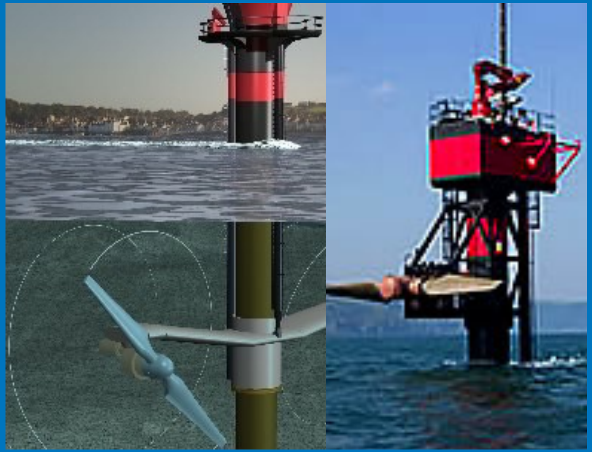
ANDRITZ Hydro is aware of the role which Ocean Energy can play in the energy mix, and thus is actively developing innovative solutions to harness this predictable, renewable and low carbon energy source

ENERGY FROM TIDAL CURRENT

Rotating devices

Open Centre Turbine (Irland)

Tocardo (Netherlands)



Seaflow (UK) & Seagen (UK)

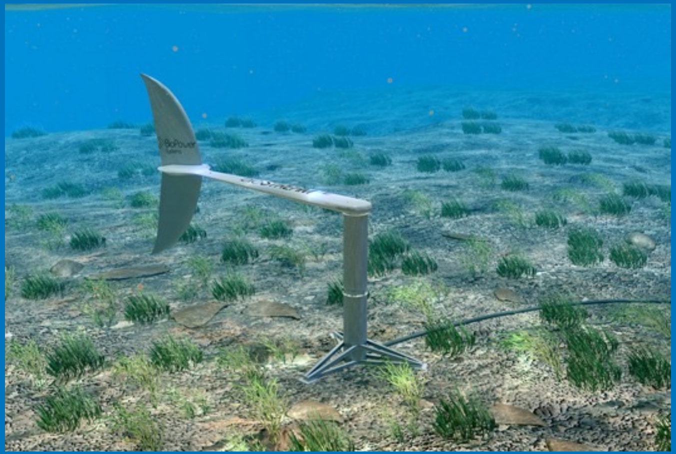
Evopod (UK)

SRTT (UK)

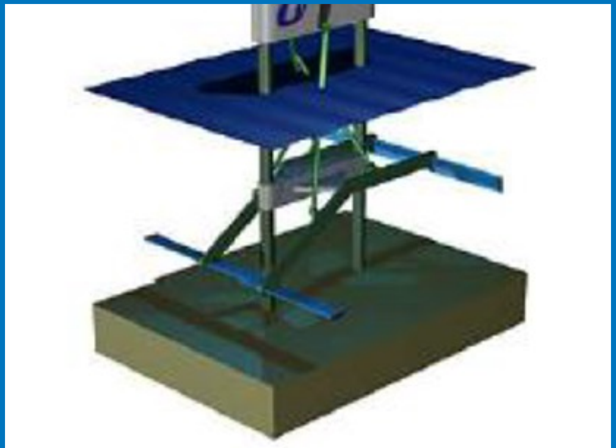
TidEL (UK)

ENERGY FROM TIDAL CURRENT

Oscillating devices



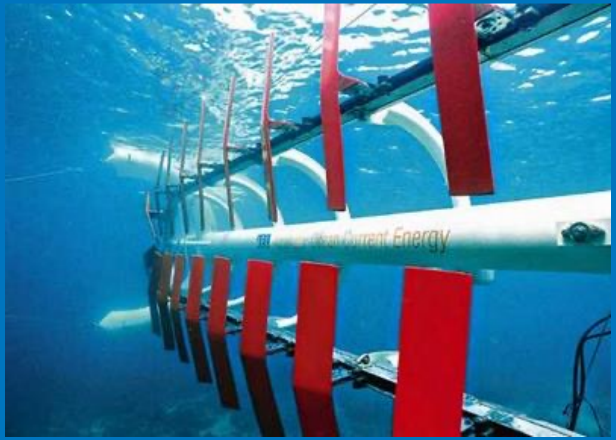
BioStream (Australia)



Pulse Generator (UK)

Stingray (UK)

Harmonica (Norway)



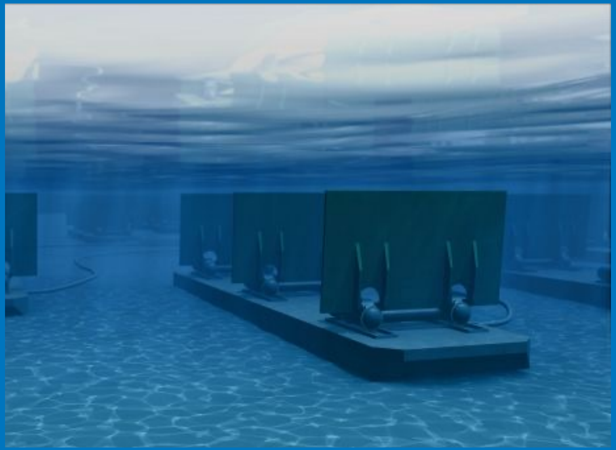
Aquanator

WAVE ENERGY

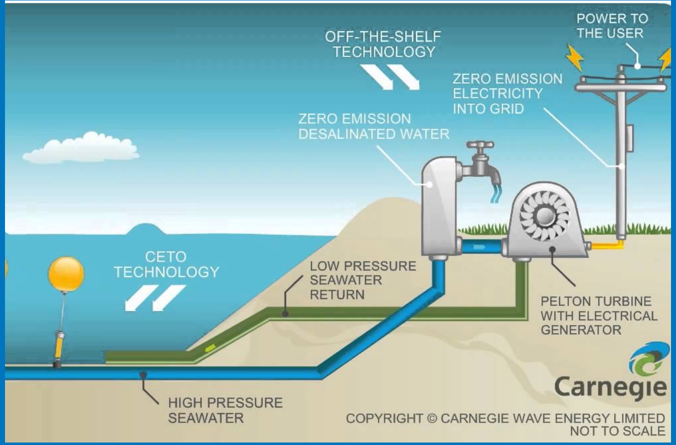
Prototypes

Pelamis Wave Power Ltd.

Daily Motion (Brazil)



AW-Energy's (Finland)



Carnegie Wave Energy

Wave Dragon (Denmark)

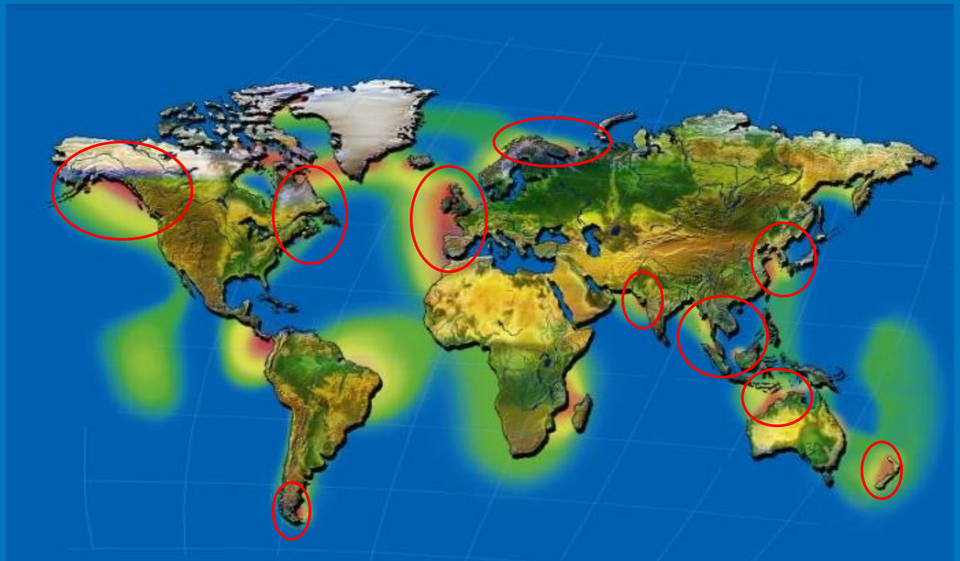
TIDAL POWER – ENERGY POTENTIAL

Potential & Advantages

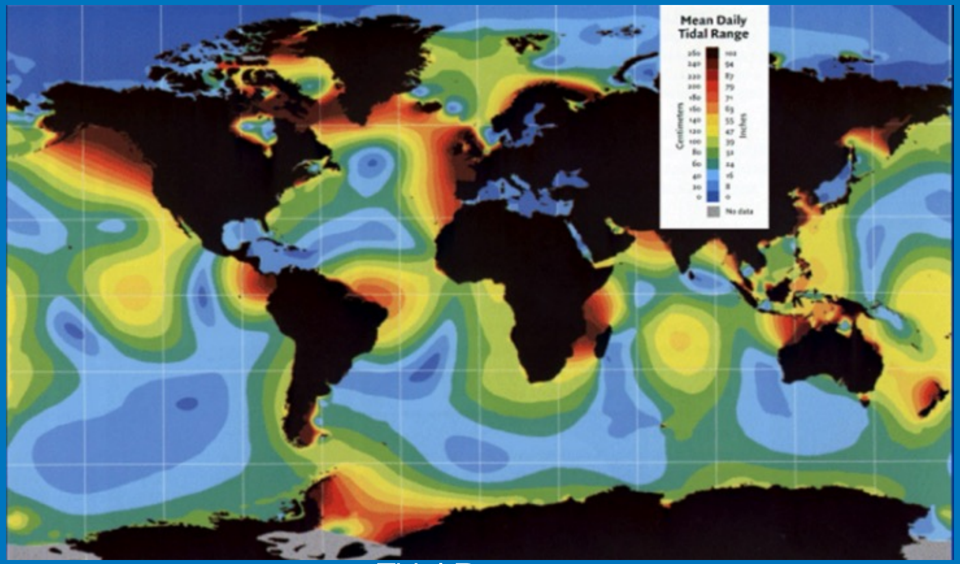
- ❖ Could be a very promising future for energy source
- ❖ **Estimated Potential**
  - ❖ > 15,300 TWh/yr. theoretical
  - ❖ **> 3,060 TWh/yr. technical**
  - ❖ Compared to 4,370 TWh global installed hydropower (2020)
- ❖ **Clean, reliable, PREDICTABLE**
- ❖ not influenced by weather conditions

Two options for exploitation:

1) Kinetic energy from currents close to shore
2) Potential energy from tidal ranges



Tidal Currents



Tidal Ranges

TIDAL POWER – POWER BASED ON TIDES

Technology Overview

ANDRITZ HYDRO: Decision to invest in both technologies

Instream Tidal Turbines
„Tidal Kinetics“ / „Tidal Stream“

Tidal Power Stations
„Tidal Barrage“ / „Tidal Lagoon“

ANDRITZ TIDAL TECHNOLOGY

REALIZED PROJECTS

- Three generations of instream turbines
  - 0.3 MW, Norway
  - 1 MW, EMEC, Scotland
  - 3x 1.5 MW, MeyGen, Scotland

- ANDRITZ Hydro delivered turbines & equipment for
  - Sihwa Lake (10x 25.4 MW)
  - La Rance (24x 10 MW)
  - Annapolis Royal (1x 17.6 MW)

Tidal Turbines – Projects and Technologies

TIDAL CURRENT TURBINES

Kinetic Energy

Tidal currents near shore: up to 3.5 m/s

Tidal current technology - based on wind technology

$$P(t) = \eta * A * \rho * v^3 / 2$$

TIDAL CURRENT TURBINES

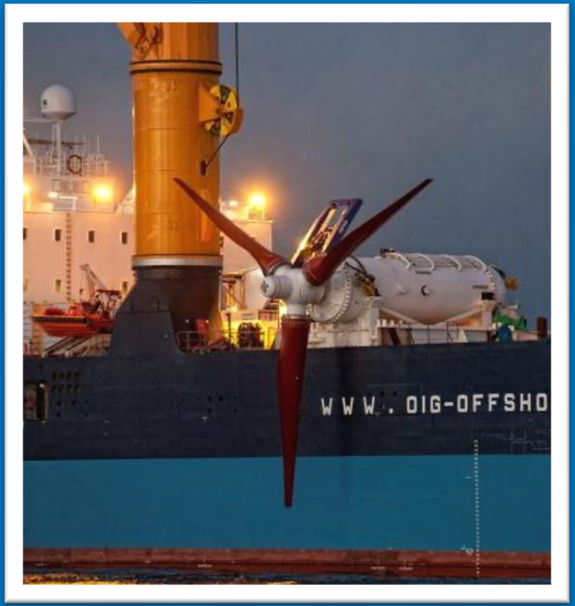
Four Generations

HS300

0.3 MW

1 GWh

HS1000



1 MW

1.3 GWh

Mk1

1.5 MW

52 GWh
(to date)

Mk2

~2 MW

First operation
TBC

TIDAL CURRENT TURBINES

Summary

- **Selection of locations**
  - Water depth between 35 m and 100 m
  - Current speed >1 m/s
  - Condition of seabed
  - Distance to the grid
- **Advantages**
  - 24 hours operation possible (average 20 hours)
  - No impact on marine life (slow rotation 15 rpm, monitoring devices, quick stop)
  - Fast implementation (pre-assembled units) ~24 months
  - Ideal in combination with energy storage systems, i.e. pump storage power plants, batteries
  - Proofen technology, maintenance free
- **Obstacles**
  - Receiving permits could take long (environmental issues)
  - Commercialisation (due to few installed units)
  - Still to less assessment studies in countries with potential source

Tidal Power Stations – Projects and Technology

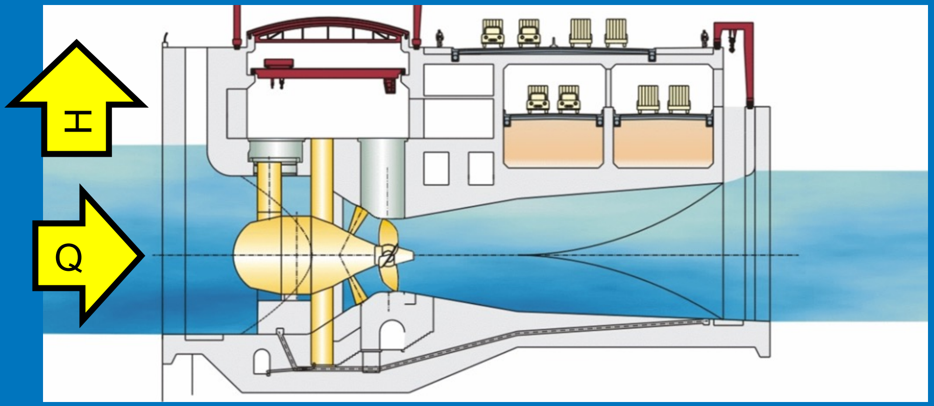
TIDAL POWER STATIONS

Potential Energy

Tidal range = from 0.5 to >10 m

Tidal Power Plants – construction based on run-of-river plants

$$P\ (t) = \eta * Q * H * \rho * g$$



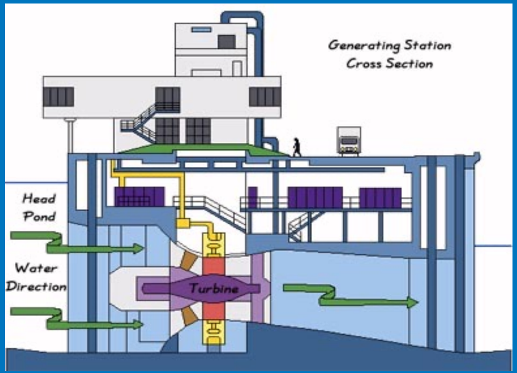
TIDAL POWER STATIONS

La Rance – France

- 24x 10 MW
- Built 1961 - 1967
- Multiple mode operation
- Pump turbines for both flow directions
- Successful operation since 40 years

Annapolis - Canada

- 1x 18 MW
- Commissioned in 1984
- Single operation mode



TIDAL POWER STATIONS

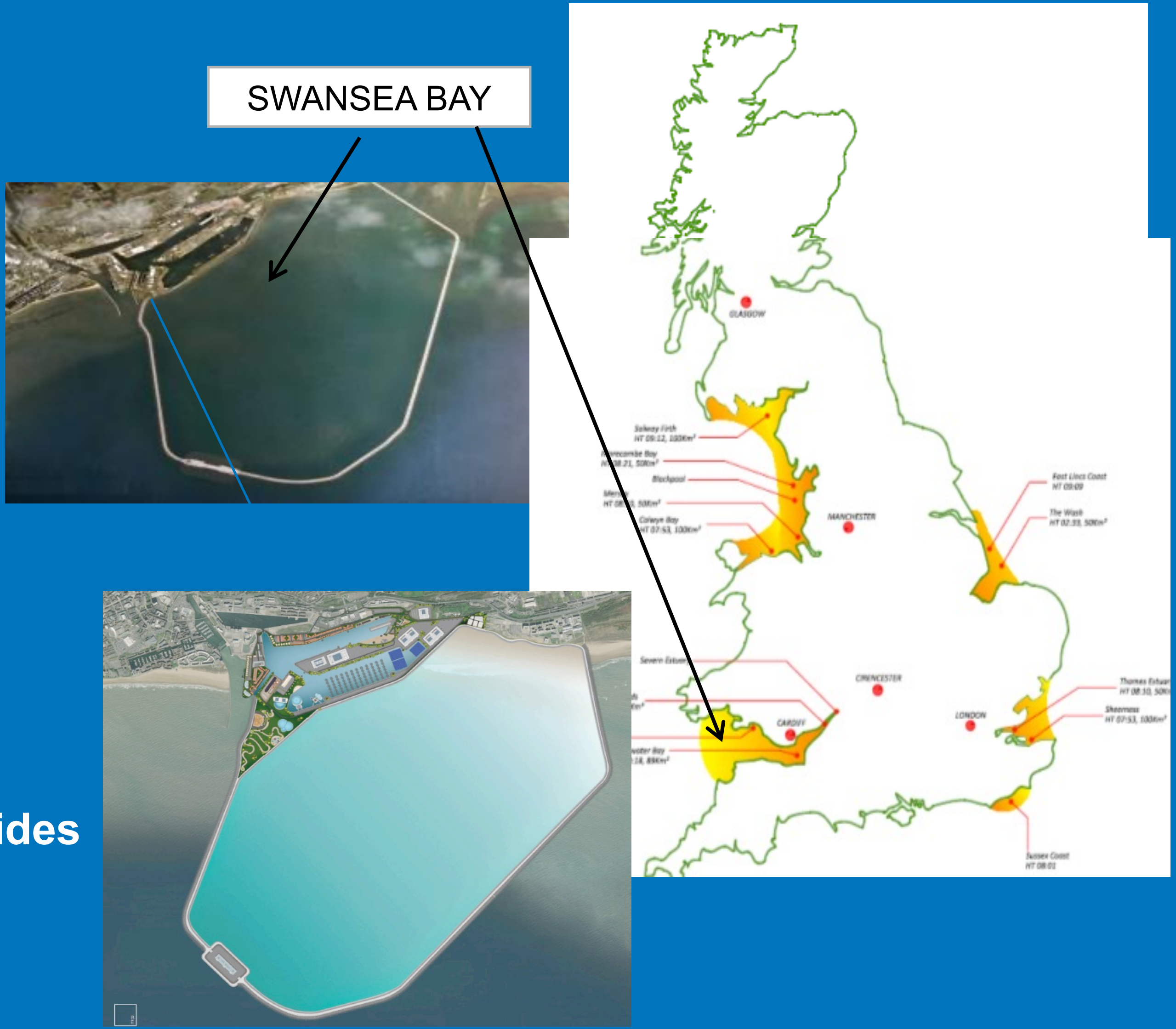
Sihwa Tidal – South Korea

- ❖ Largest Tidal Power Plant in the world: 260 MW (10 units)
- ❖ Rated head 5.8 m, rated discharge 482 m^3/s
- ❖ An existing dam built in 1994 (agriculture, reclamation of land)
- ❖ Industrial and biological pollution
  → return to natural exchange of water
- ❖ Korea is committed to carbon neutrality by 2050

TIDAL POWER STATIONS

Tidal Lagoon Swansea Bay - Wales

- **Location: Coast of Swansea, Wales**
- **Large tidal range**
  - Maximum tidal range of 10.52 m
  - Average tidal range during spring tides of 8.5 m
- **Shallow seabed gradient**
  - Low seawall height required
  - Reduced construction costs
  - Area 11.5 km^2
- **Bi-directional tidal bulb pump turbine**
  - 352 MW (16 units)
- **Power generation for incoming & outgoing tides**
- **Pumping for additional AEP**



TIDAL POWER STATIONS

Summary

- **Location Selection**
  - Bays, Lagoons
  - Max. tidal range ~10 m
  - Average tidal range during spring tides not less than 8 m
- **Advantages**
  - Power generation for incoming and outgoing tides
  - Low seawall height required = reduced construction costs
  - High installed capacity due to large number of turbines
  - Ideal in combination with i.e. floating PV, batteries
  - Proofen technology, maintenance free
  - Substantial creation of value for the local industry
- **Obstacles**
  - Permits
  - Energy tariff
  - Funding of projects

THANK YOU

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