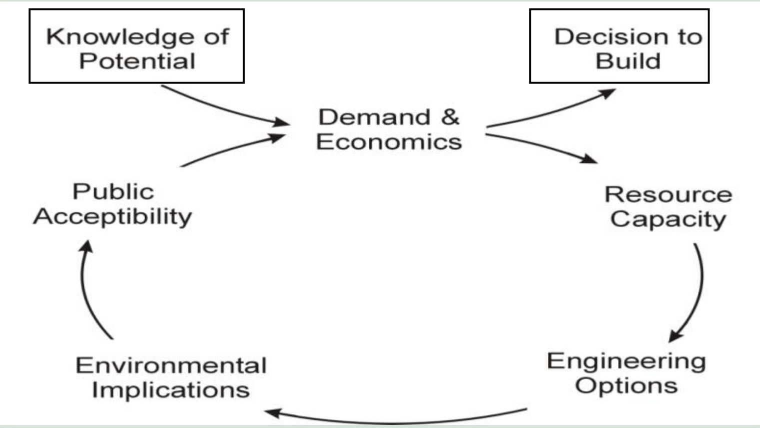
# Hydro Resource Model

*Low Head Kaplan Turbine and Draft Tube*

*Heron Corn Mill*

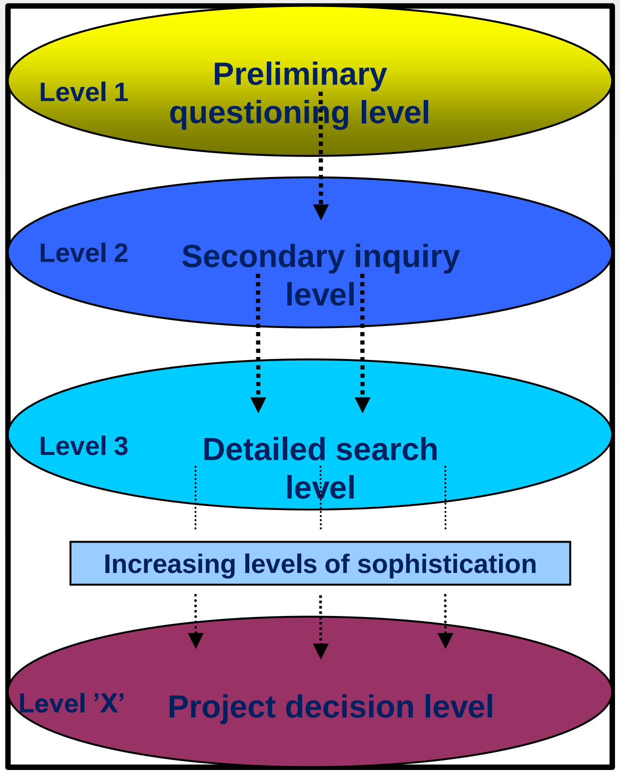
*The Completed Hydro Plant*




**Sequential decision making process**

*Before the Low Head Hydro Plant*

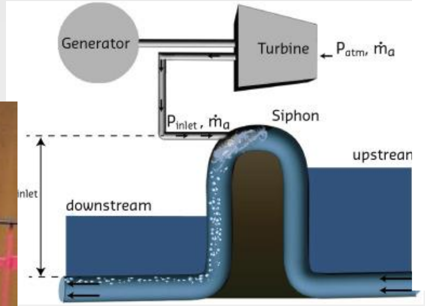
*After the completion of the Low Head Hydro Plant*

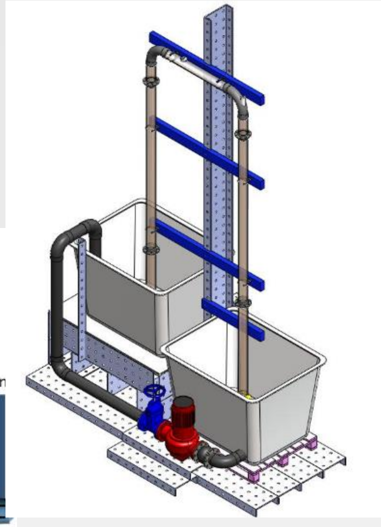



**Multi-level sequential decision making process**


- Aggidis, G.A., Luchinskaya, E., Rothschild, R. and Howard, D.C., 2010. The costs of small-scale hydro power production: Impact on the development of existing potential. *Renewable Energy*, *35*(12), pp.2632-2638.

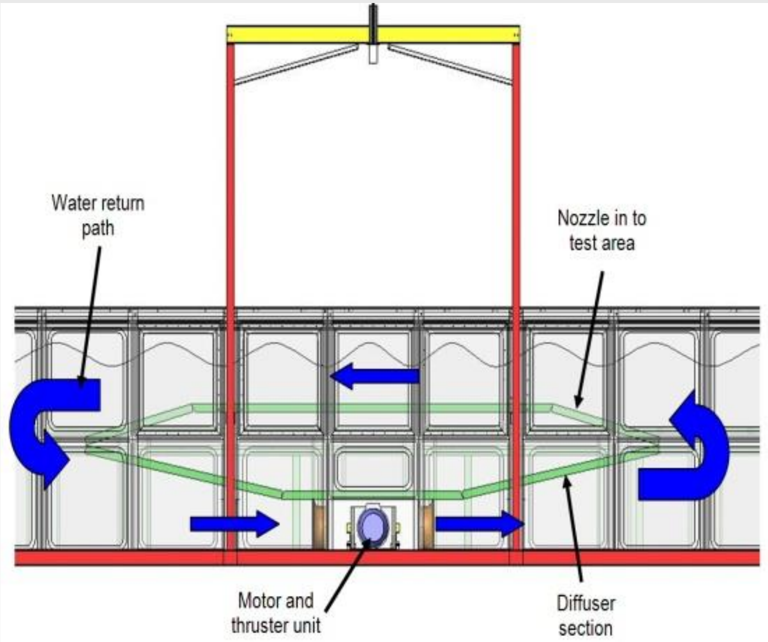
# Siphonic Low Head Hydro

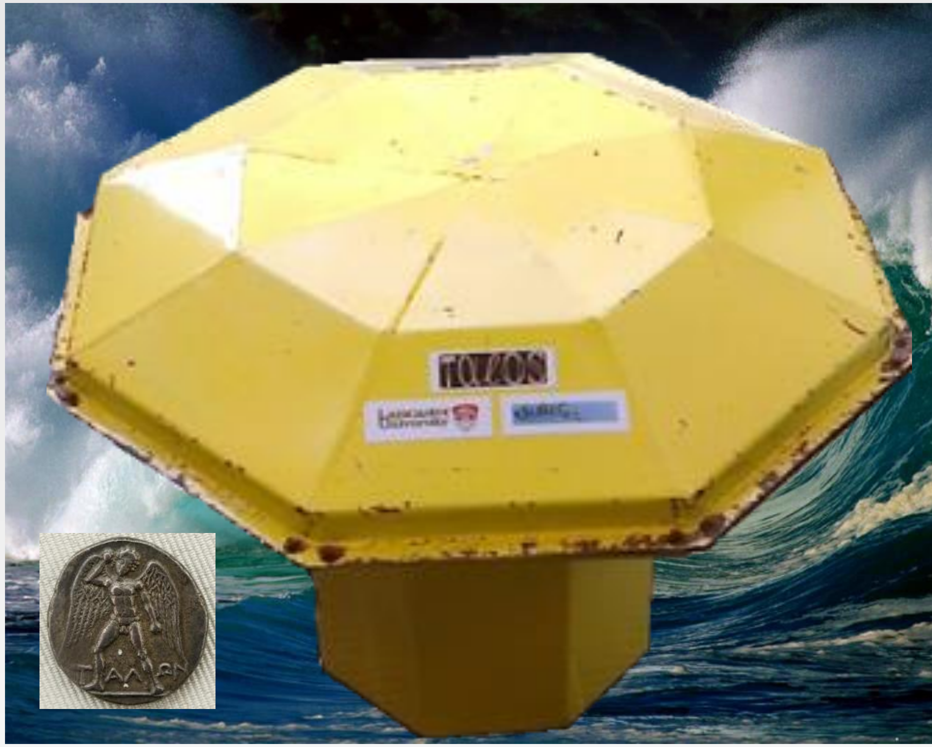


- Widden, M.B., French, M.J. and Aggidis, G.A., 2004. Economic energy from low-head water by conversion to air pressure. *Hydropower Developments: New Projects, Rehabilitation, and Power Recovery*, (6), p.41.

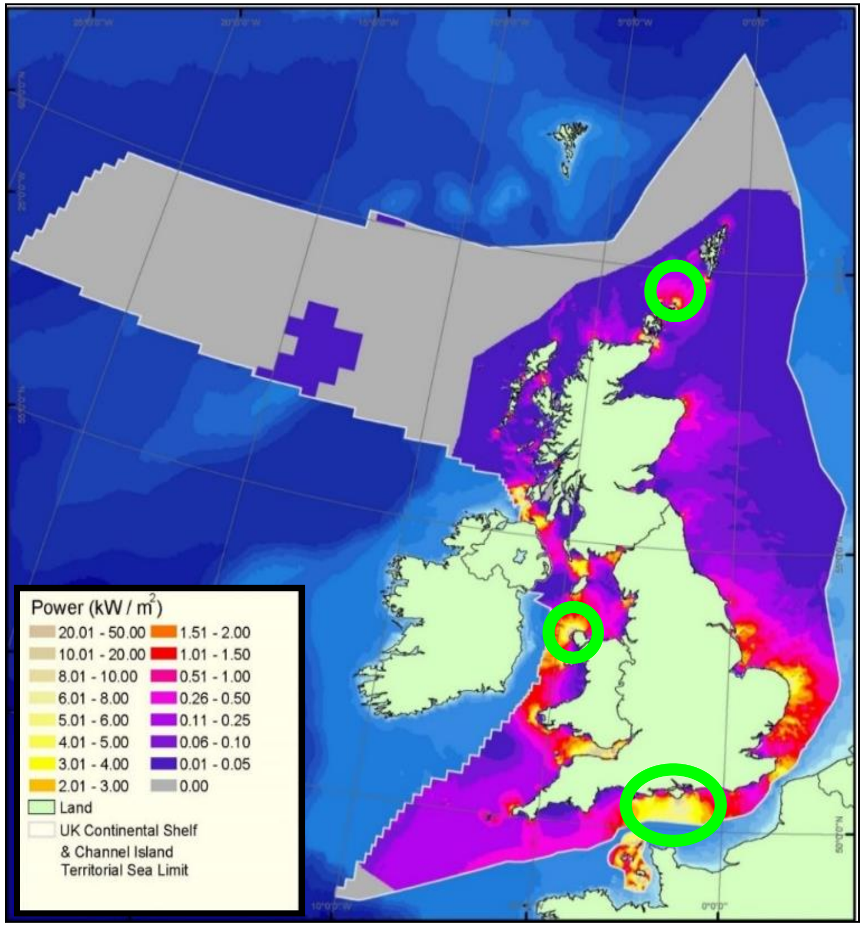
# Waves Tides Hydrokinetics Testing Facility



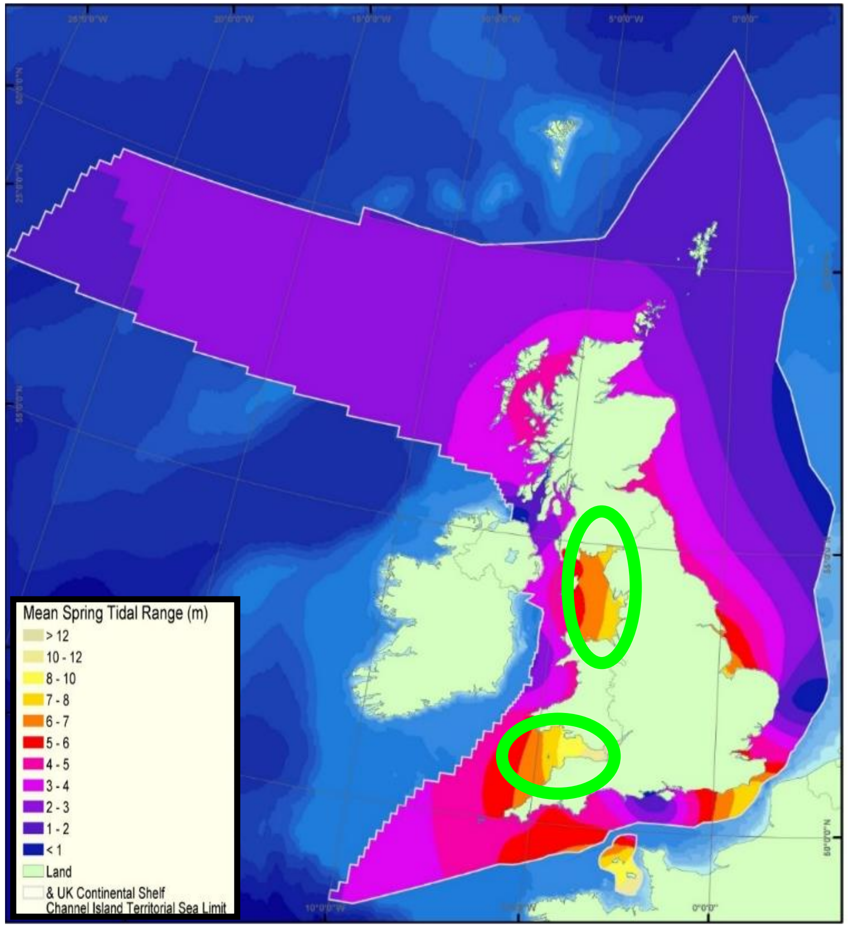



**TALOS Wave Energy Converter**
Multi-Axis, Omni-Directional Point Absorber Style WEC completely enclosed with internal inertial mass using Hydraulic Cylinders or Linear Generators PTO

# U.K. Tidal Resource



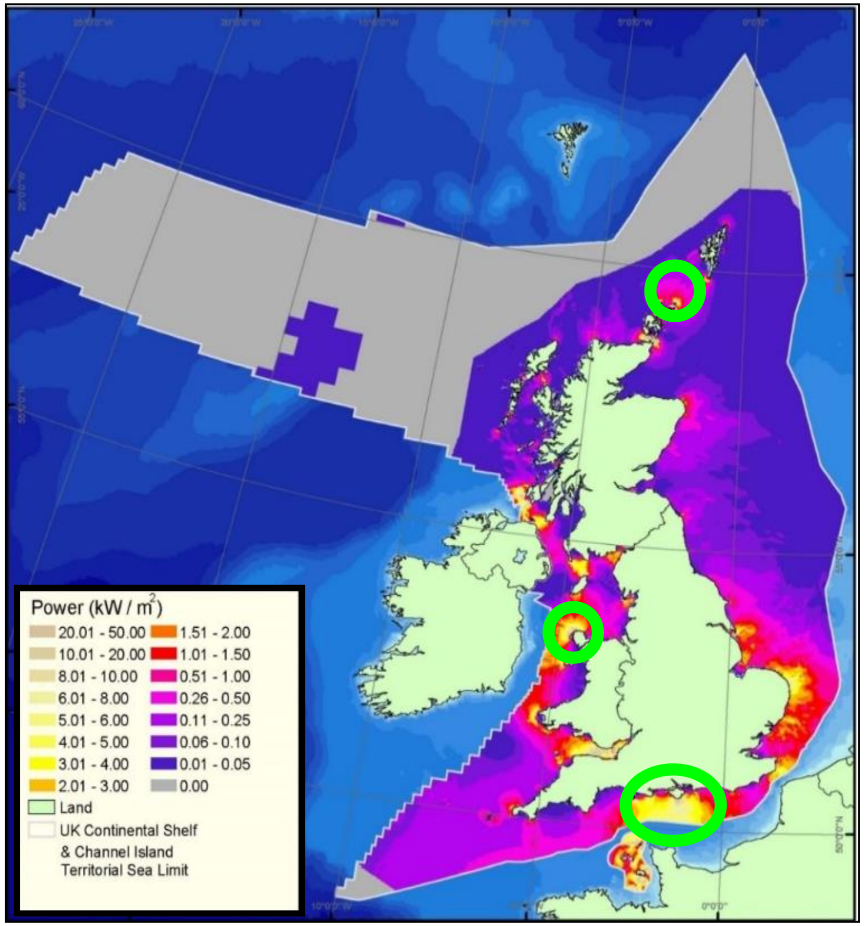

Tidal Stream




Tidal Range

Source – DTI Atlas of Marine Renewable Energy Resources

# Tidal Current Technologies - UK Resource




Tidal Stream

Source – DTI Atlas of Marine Renewable Energy Resources

Main types of Tidal Stream Energy Convertors:

- **Horizontal Axis**
  - Rigidly mounted
  - Floating and Semi-Submerged
- **Vertical Axis**
- **Hydrofoil**
  - Oscillating
  - Translating
- **Venturi Systems**
- **Archimedes Screw**
- **Tidal Kite**
- **Other**

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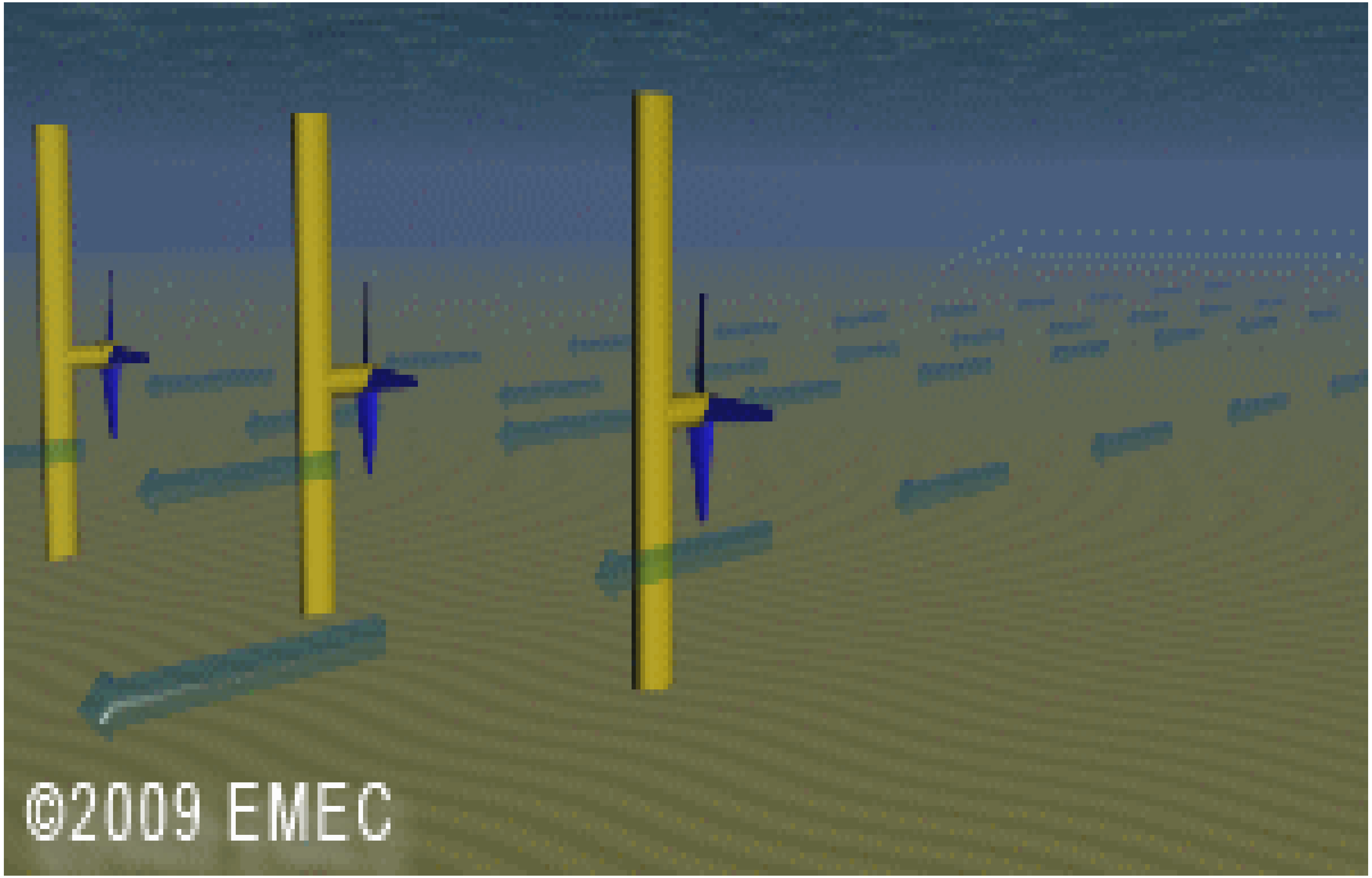
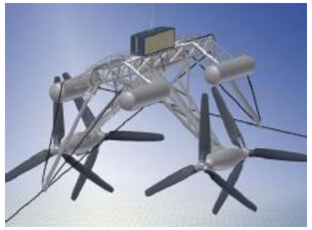
U.S. DEPARTMENT OF ENERGY

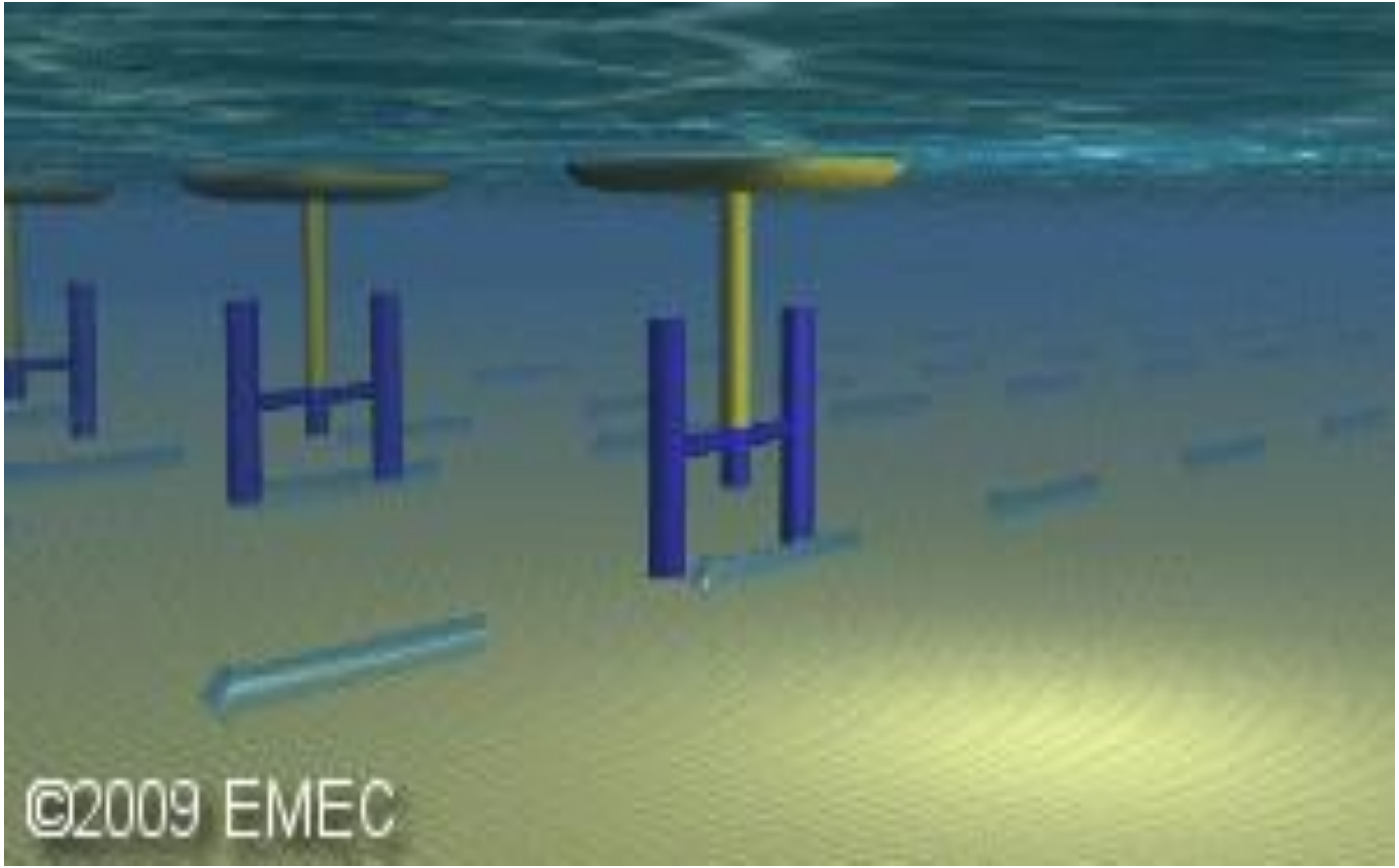
# Horizontal axis turbines




*Lancaster University Research with Infinities Global on Tidal Current Technology*

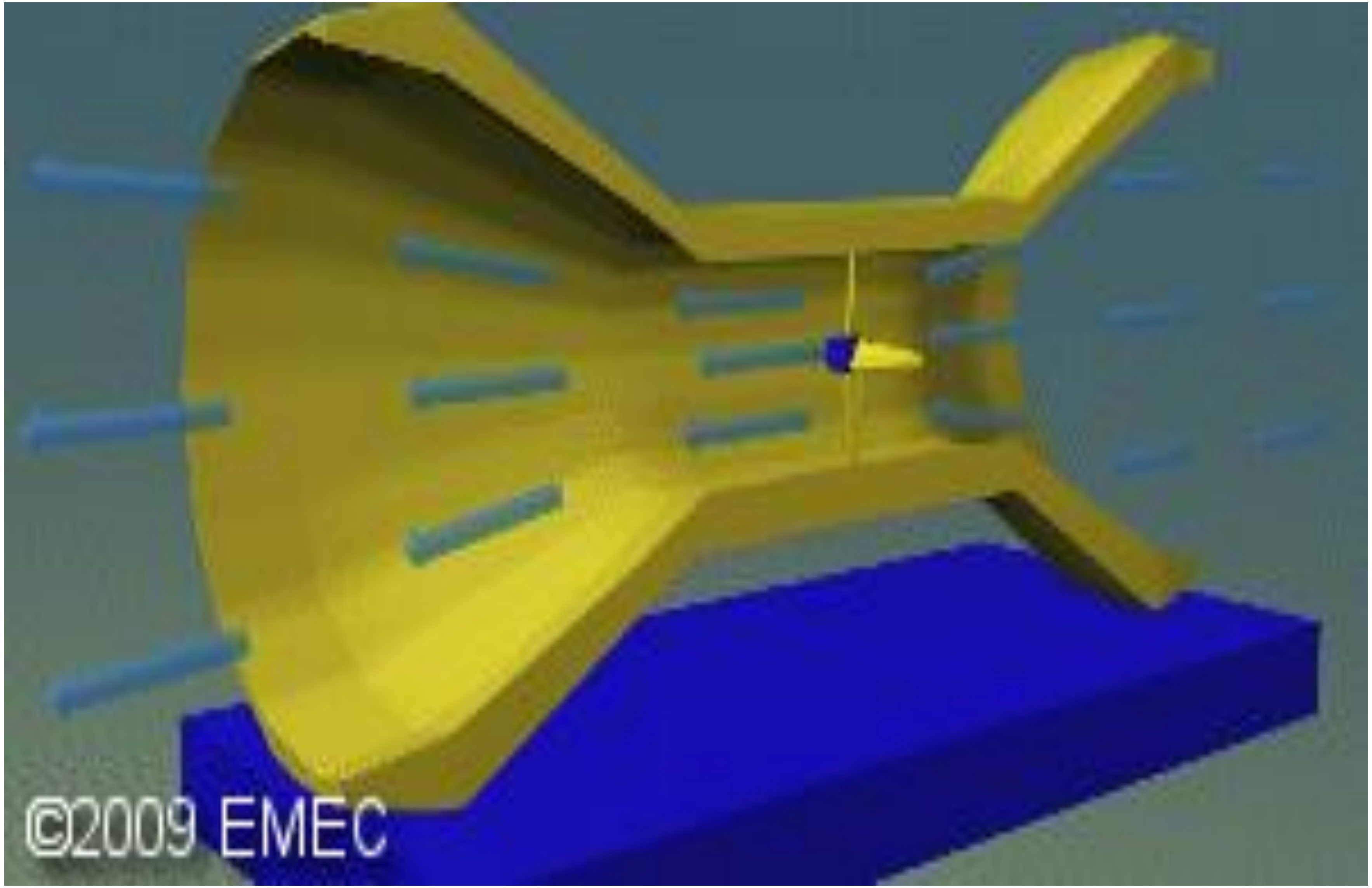


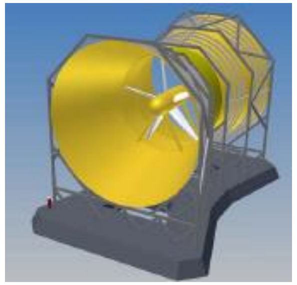
# Vertical axis turbines



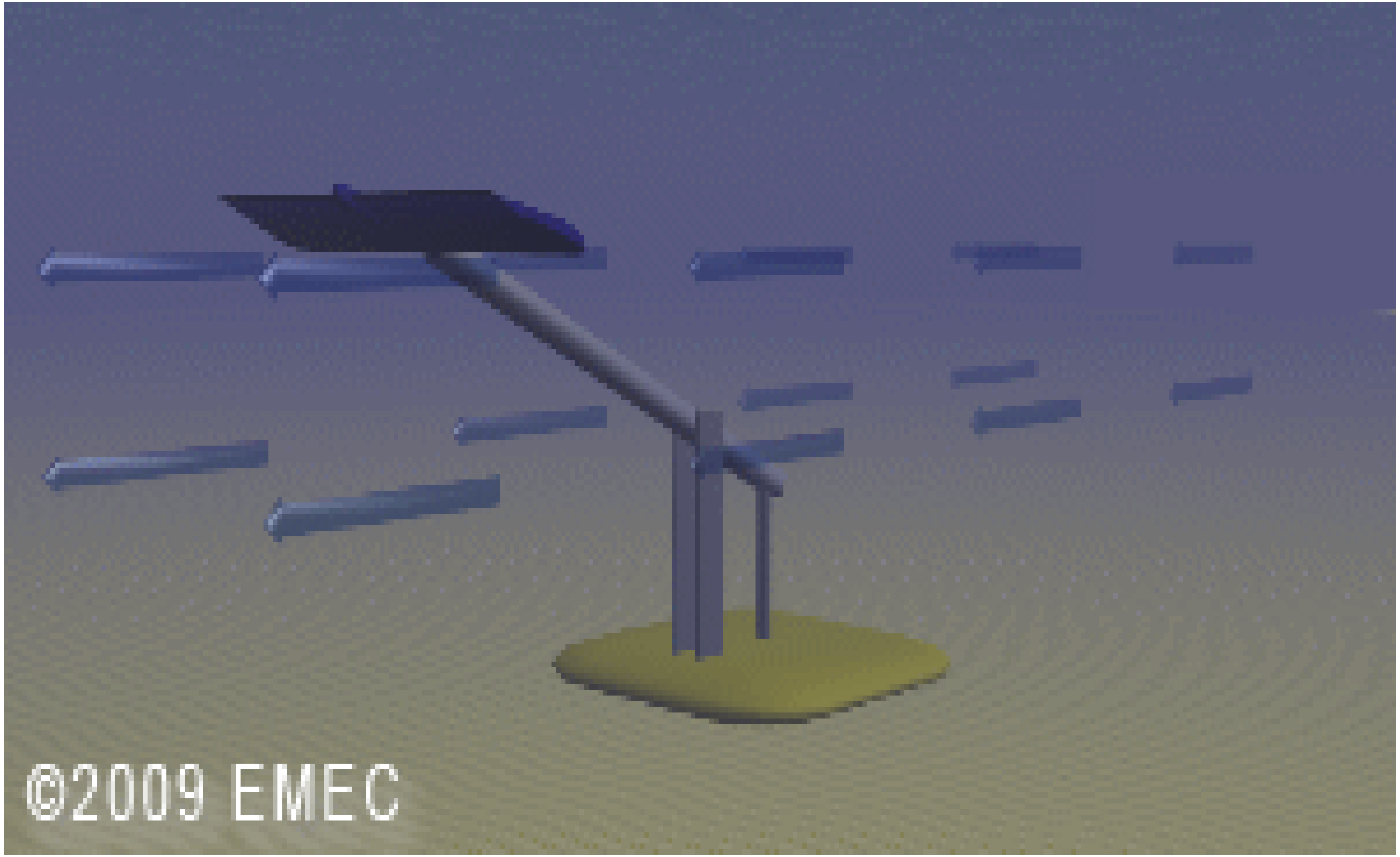


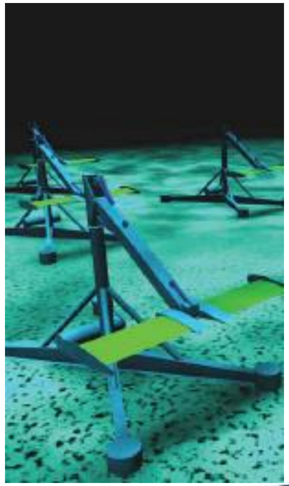
# Venturi Effect & Ducted turbines

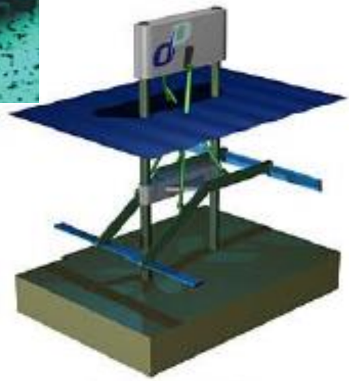


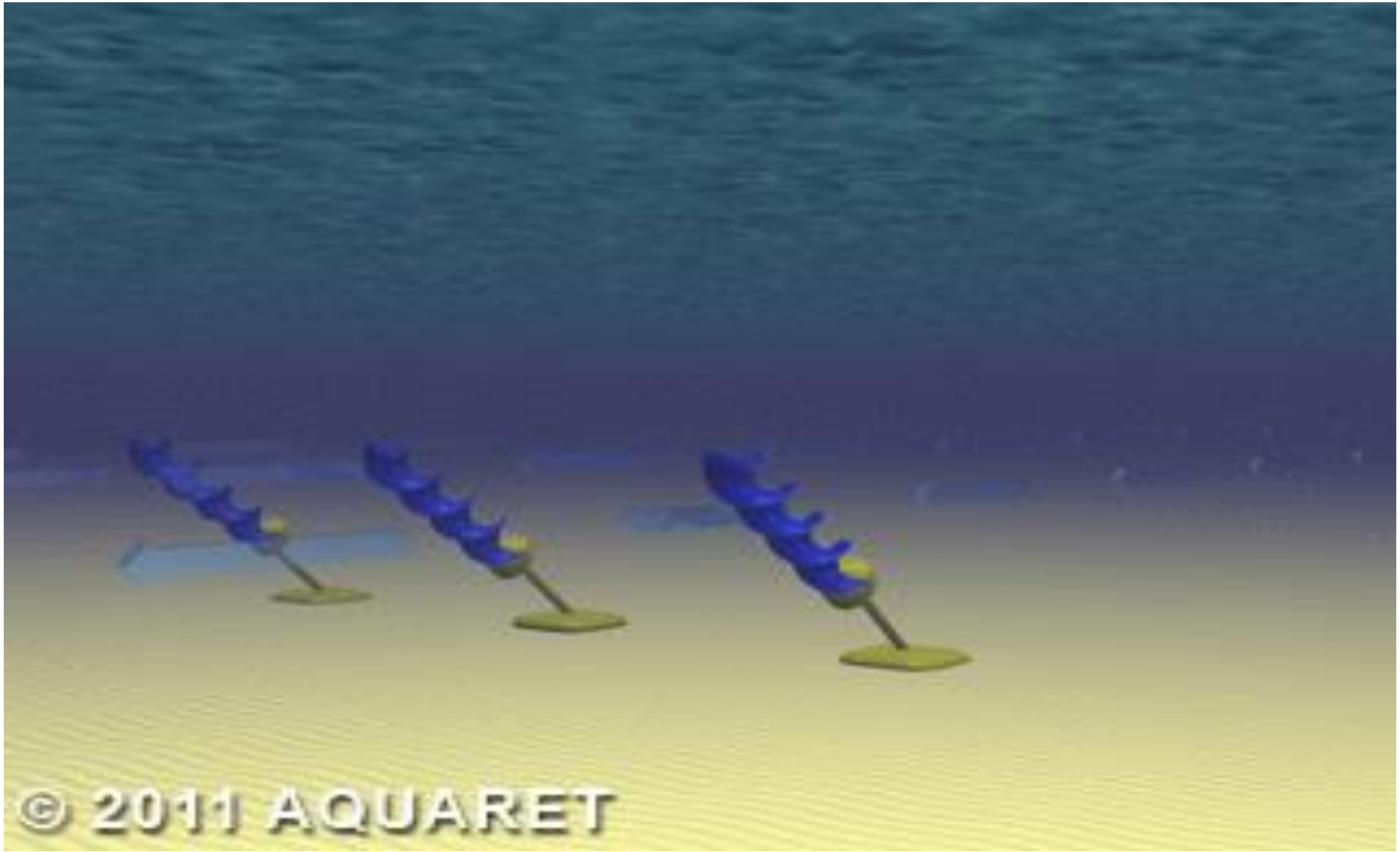
# Reciprocating Devices



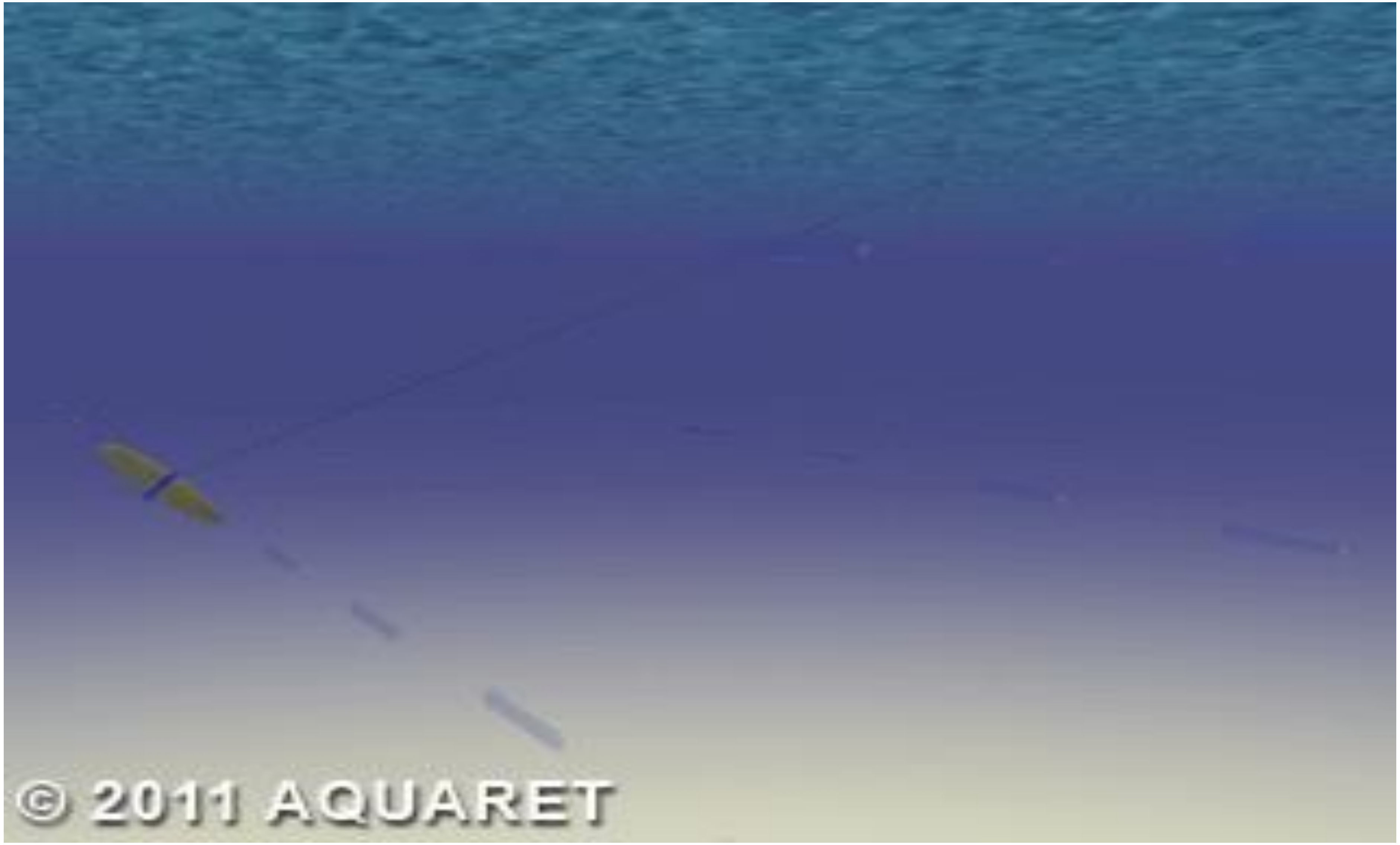





# Archimedes Screw

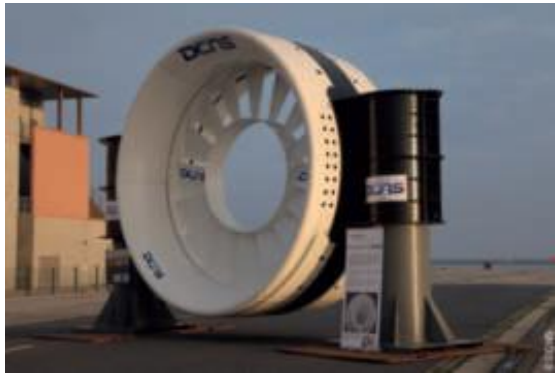



# Tidal Kite

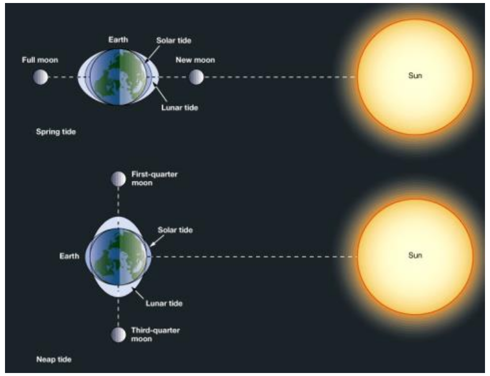




# Open Centre turbines

# Tidal Range Energy Resource




Earth-Moon-Sun Gravity

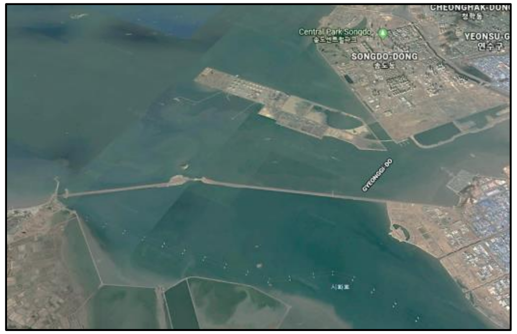

**Neill, S.P., Angeloudis, A., Robins, P.E., Walkington, I., Ward, S.L., Masters, I., Lewis, M.J., Piano, M., Avdis, A., Piggott, M.D. and Aggidis, G., 2018**. Tidal range energy resource and optimization–Past perspectives and future challenges. *Renewable energy*, *127*, pp.763-778.

# Global References (Tidal Range)

- Existing tidal references world wide include:
  - **La Rance, France, 1967**
    - Alstom Hydro
    - 5.4 m Dia. 24 Turbinesx10 MW
    - 240 MW total capacity
  - **Kislaya Guba, Russia, 1968**
    - 1 Turbine × 0.2 MW
    - 1 Turbine × 1.5 MW
    - 1.7 MW total capacity
  - **Annapolis, Canada, 1980**
    - Andritz VaTech Hydro
    - 7.6 m Dia. Straflo Turbine
    - 1 Turbine x 20 MW
    - 20 MW total capacity
  - **Jiangxia, China, 1980**
    - 1 Turbine × 500KW
    - 1 Turbine × 600KW
    - 3 Turbines × 700KW
    - 3,200 KW total capacity
  - **Sihwa, South Korea, 2011**
    - Andritz Hydro
    - 7.5 m Dia. 10 Turbines x 26 MW
    - 260 MW total capacity

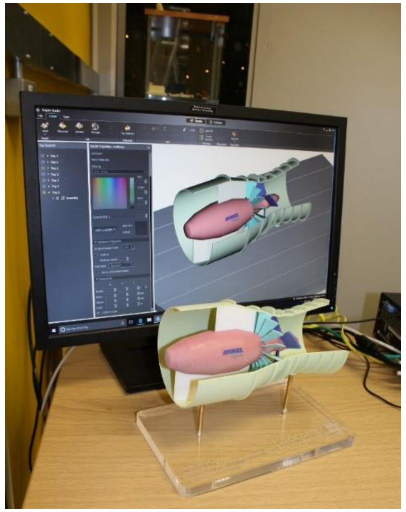

*Marcus Schneeberger ANDRITZ Hydro & Prof George Aggidis*

*Sihwa, South Korea Tidal Power Plant 2011*

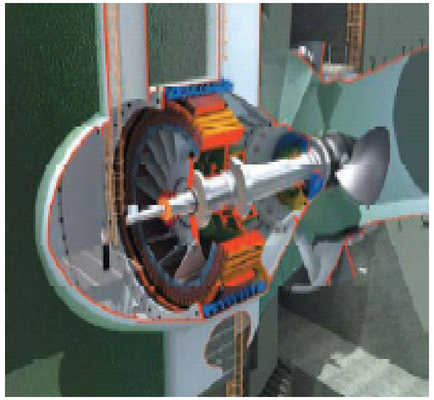



# Tidal Technologies

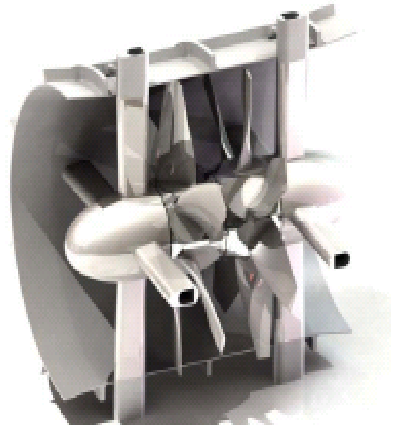
Both forms of energy (potential & kinetic) can be harvested by tidal energy technologies as renewable energy.



*Increasing environmental impact*



- Uni-directional operation.
- High axial flow speed.
- 50 metre downstream diffuser.
- High solidity rotor.
- Steady flow conditions.
- Deep cavitation submergence.

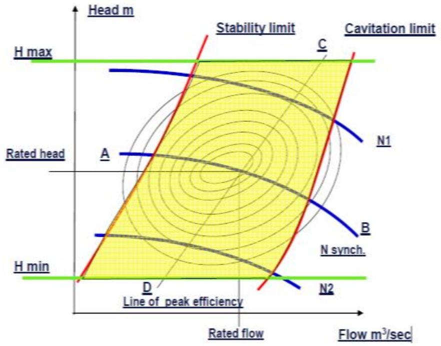


- Bi-directional operation.
- Low axial flow speed.
- Straight walled support structure.
- Twin low solidity rotors.
- Steady flow conditions.
- Modest cavitation submergence.

- Bi-directional operation.
- Low axial flow speed.
- No enclosing support structure.
- Low solidity rotor.
- Unsteady flow conditions.
- Modest cavitation submergence.

*Decreasing power density*

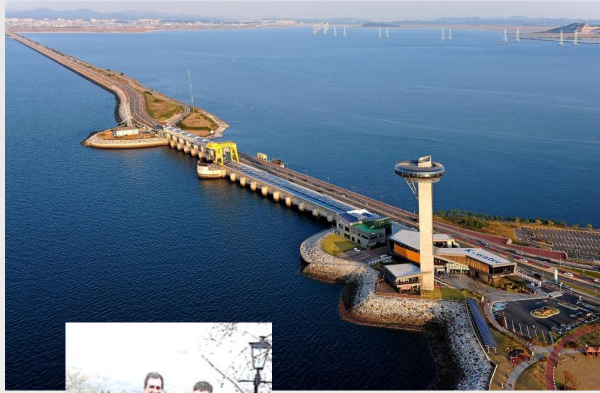
Bernd Hindelang
ANDRITZ Hydro &
Prof George Aggidis




Triple Regulation Turbine (2017)

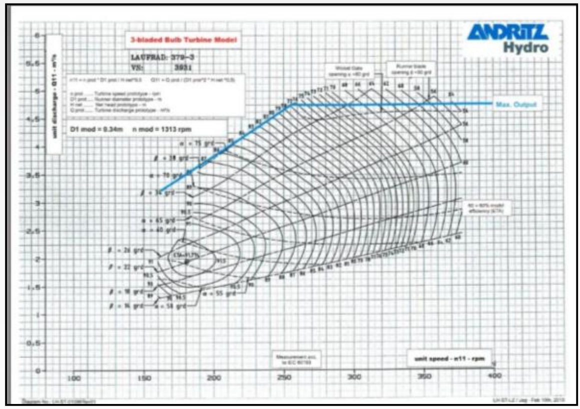
**Waters, S. and Aggidis, G., 2016**. Tidal range technologies and state of the art in review. *Renewable and Sustainable Energy Reviews*, *59*, pp.514-529.

# Tidal Range Hydro Turbines



Sihwa,
South Korea
Tidal Power
Plant 2011

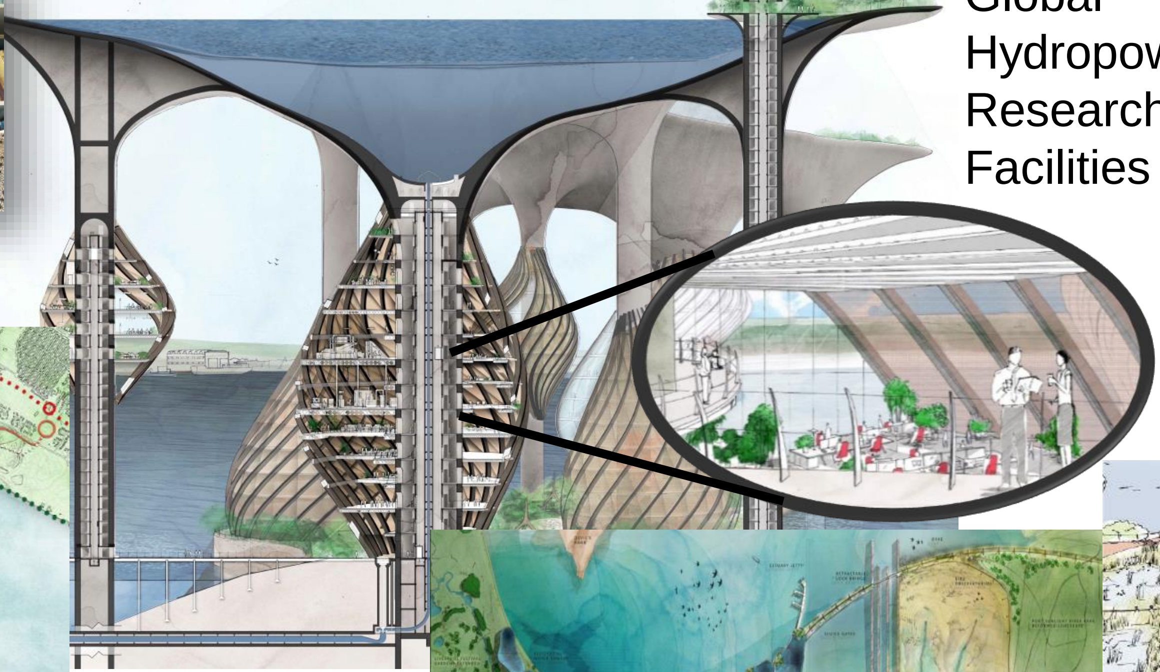

- Aggidis, G.A. and Feather, O., 2012. Tidal range turbines and generation on the Solway Firth. *Renewable energy*, *43*, pp.9-17.
- Aggidis, G.A. and Benzon, D.S., 2013. Operational optimisation of a tidal barrage across the Mersey estuary using 0-D modelling. *Ocean Engineering*, *66*, pp.69-81.
- Petley, S. and Aggidis, G., 2016. Swansea Bay tidal lagoon annual energy estimation. *Ocean Engineering*, *111*, pp.348-357.
- Waters, S. and Aggidis, G., 2016. Tidal range technologies and state of the art in review. *Renewable and Sustainable Energy Reviews*, *59*, pp.514-529.
- Waters, S. and Aggidis, G., 2016. A world first: Swansea Bay tidal lagoon in review. *Renewable and Sustainable Energy Reviews*, *56*, pp.916-921.
- Vandercruyssen, D., Baker, S., Howard, D. and Aggidis, G., 2023. Tidal range electricity generation into the twenty-second century. *Proceedings of the Institution of Civil Engineers-Energy*, pp.1-9.
- Vandercruyssen, D., Baker, S., Howard, D. and Aggidis, G., 2023. Tidal range generation: combining the Lancaster zero-dimension generation and cost models. *Proceedings of the Institution of Civil Engineers-Energy*, pp.1-14.
- Vandercruyssen, D., Howard, D. and Aggidis, G., 2022. A model of the costs for tidal range power generation schemes. *Proceedings of the Institution of Civil Engineers-Energy*, *176*(4), pp.177-186.
- Vandercruyssen, D., Baker, S., Howard, D. and Aggidis, G., 2022. Tidal range electricity generation: A comparison between estuarine barrages and coastal lagoons. *Heliyon*, *8*(11).
- Neill, S.P., Angeloudis, A., Robins, P.E., Walkington, I., Ward, S.L., Masters, I., Lewis, M.J., Piano, M., Avdis, A., Piggott, M.D. and Aggidis, G., 2018. Tidal range energy resource and optimization–Past perspectives and future challenges. *Renewable energy*, *127*, pp.763-778.

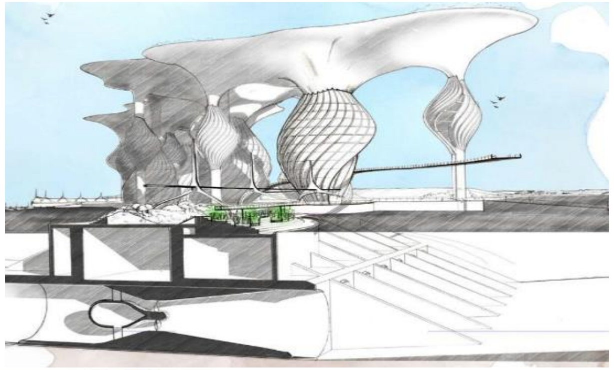

# Multi Functional Infrastructure
# Multidisciplinary Research

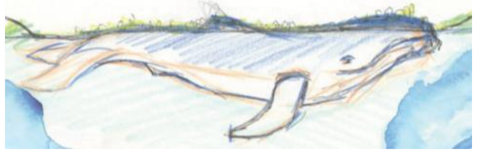
Dr David Howard CEH
& Prof George Aggidis

International Landmark



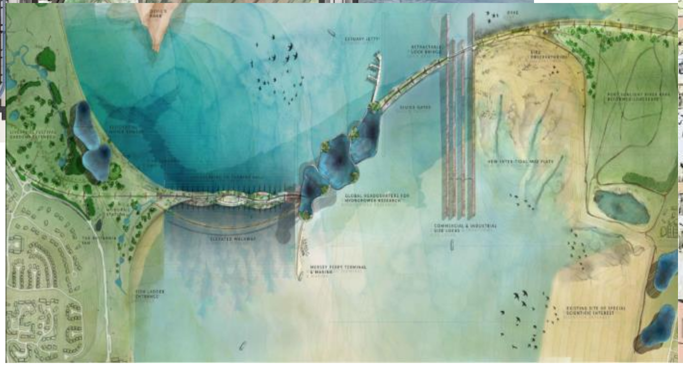
Global
Hydropower
Research
Facilities

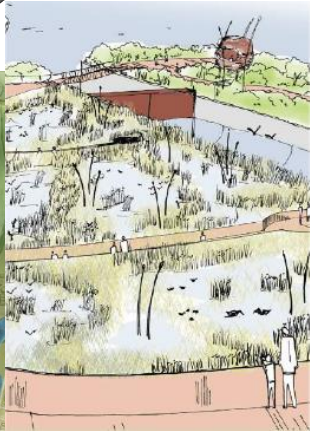


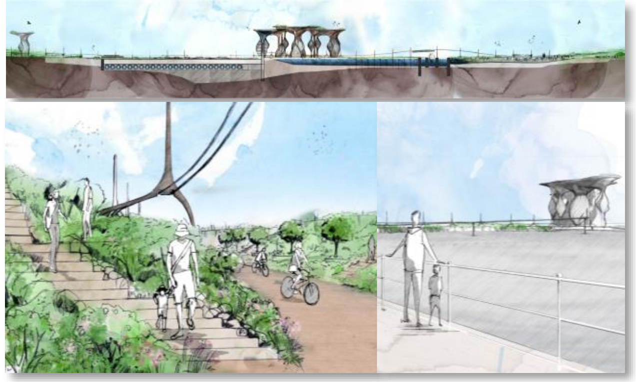


THE GREEN
WHALE (2017)

Connecting
Communities







Integrating Wildlife

…This paper contributes in part to a fully holistic treatment of **tidal barrages**, recognising that apart from **energy generation,** other **environmental, societal and economic opportunities** arise and must be fully investigated for robust decision-making…

**Petley, S., Starr, D., Parish, L., Underwood, Z. and Aggidis, G.A., 2019**. Opportunities for tidal range projects beyond energy generation: Using Mersey barrage as a case study. *Frontiers of Architectural Research*, *8*(4), pp.620-633.

# Latest relevant research at Lancaster

1. Vandercruyssen, D., Howard, D. and Aggidis, G., **2022. A model of the costs for tidal range power generation schemes**. Proceedings of the Institution of Civil Engineers-Energy, 176(4), pp.177-186. - https://doi.org/10.1680/jener.22.00058

2. Vandercruyssen, D., Baker, S., Howard, D. and Aggidis, G., **2022. Tidal range electricity generation: A comparison between estuarine barrages and coastal lagoons**. Heliyon, 8(11). - https://www.cell.com/heliyon/pdf/S2405-8440(22)02669-X.pdf

3. Vandercruyssen, D., Baker, S., Howard, D. and Aggidis, G., **2023. Tidal range power generation: case studies combining the Lancaster 0-D generation and cost models**. Proceedings of the Institution of Civil Engineers-Energy, pp.1-25. - https://www.icevirtuallibrary.com/doi/10.1680/jener.22.00077

4. Vandercruyssen, D., Baker, S., Howard, D. and Aggidis, G., **2023. Tidal range electricity generation into the 22nd century**. Proceedings of the Institution of Civil Engineers-Energy, pp.1-19. - https://doi.org/10.1680/jener.23.00031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Science News from research organizations
How tidal range electricity generation can protect coastal areas from flooding
Date: January 13, 2024
Source: Lancaster University
Summary: Tidal range schemes can protect estuaries and coastal areas from the effects of sea level rise, according to researchers who say that tidal range schemes are vital to protect habitats, housing and businesses from a rising sea level estimated to be over one metre within 80 years. High tides can be limited to existing levels simply by closing sluices and turbines and existing low tide levels can be maintained by pumping. Development of estuarine barrages has been hampered by misconceptions about their operation and fears of disturbance of the ecologically sensitive intertidal areas.
Share:


How tidal range electricity generation can protect coastal areas from flooding
11 Jan 2024 1:21pm
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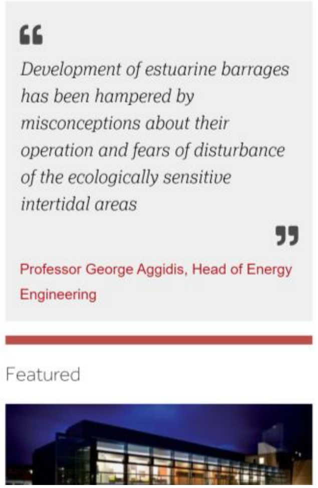
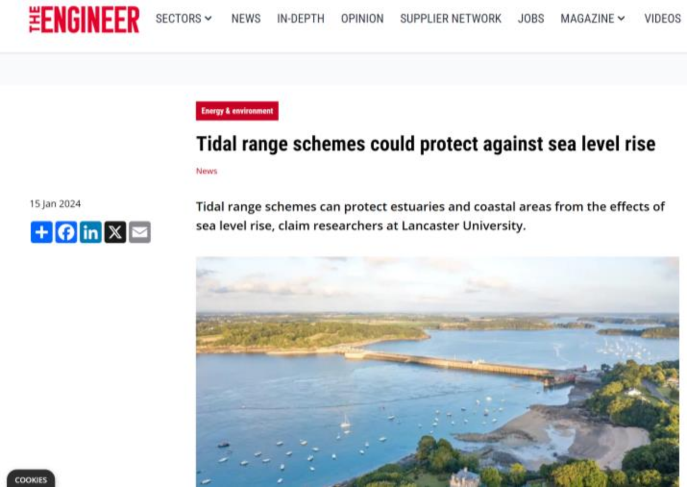
*Tidal range schemes can protect estuaries and coastal areas from the effects of sea level rise according to Lancaster researchers.*


*Development of estuarine barrages has been hampered by misconceptions about their operation and fears of disturbance of the ecologically sensitive intertidal areas*
Professor George Aggidis, Head of Energy Engineering
Featured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Energy & environment
Tidal range schemes could protect against sea level rise
News
15 Jan 2024
Tidal range schemes can protect estuaries and coastal areas from the effects of sea level rise, claim researchers at Lancaster University.
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