

Morecambe Bay Tidal Barrage



Professor George Aggidis

FIMechE, FIMarEST, FEI, FIET

g.aggidis@lancaster.ac.uk

**Head of Energy Engineering
Lancaster University**

**Thursday 25th March 2021
Brampton Cafe Scientifique**

1. Introduction
2. Resource
3. Past
4. Present
5. Next Steps
6. Conclusions



1. Introduction
2. Resource
3. Past
4. Present
5. Next Steps
6. Conclusions



UK Energy & Environment

Recent Politics: PM turned green



Boris Johnson's pledge:

“Offshore wind farms will produce enough electricity to power all UK homes within a decade”

It is reported in the news in Oct 2020

“Nearly a third of UK land would be protected for nature”

Boris Johnson, UN Summit on Biodiversity 30 Sept 2020



Beatrice, Scotland (588 MW)
Powers ~ 450,000 properties

Delivering up to 40 gigawatts of power on the grid by 2030 requires action **in this Parliament**

The question now is to find the right catalyst for the **PM to put finance and targets** to these ideas



For firm power, we need look no further than our coast. The UK is blessed with some of the world’s best tidal range resources. Tidal range projects, with barrages and impoundments proposed along much of the UK’s west coast, will deliver totally reliable, industrial scale low-carbon power generation and help maintain grid security and stability and protect coastal communities from storm surges and rising sea levels and provide thousands of jobs in places where employment is hard to find.

With an operating life of over 120 years, at least double that of a nuclear plant and three to four times the life of wind and solar farms, and many whole-system benefits, tidal range energy generation is cost competitive and should have a significant role to play in the UK’s Green Recovery.



Henry Dixon,
Chair, 2020

6 Oct 2020



HRH Prince William said he aimed to take up the environmental baton from his father HRH Prince Charles 8 Oct 2020



Professor George Aggidis and HRH Prince Philip The Duke of Edinburgh a great supporter of the Environment and Nature Conservation



Professor George Aggidis and HRH The Prince of Wales discuss Renewables & Sustainability

- The search is on for 50 solutions to the world's gravest environmental problems by 2030.
- With £50m to be awarded over a decade, the "Earthshot Prize" is the biggest environmental prize ever.
- The Earthshot Prize will make five awards of £1m each year for 10 years.
- These "Earthshots" are intended as "universal goals to repair our planet by 2030" and will go to the best and most innovative ideas to help:
 1. Protect and restore nature
 2. Clean our air
 3. Revive our oceans
 4. Build a waste-free world
 5. Fix our climate



- HRH Prince William and Sir David Attenborough have joined forces to launch on 8 Oct 2020 what they hope will become the "Nobel Prize for environmentalism"
- "I think the dotty person now would be the person who doesn't believe in climate change," HRH Prince William
- The prize launched by Sir David and HRH Prince William is looking for "brilliant" projects to save the planet

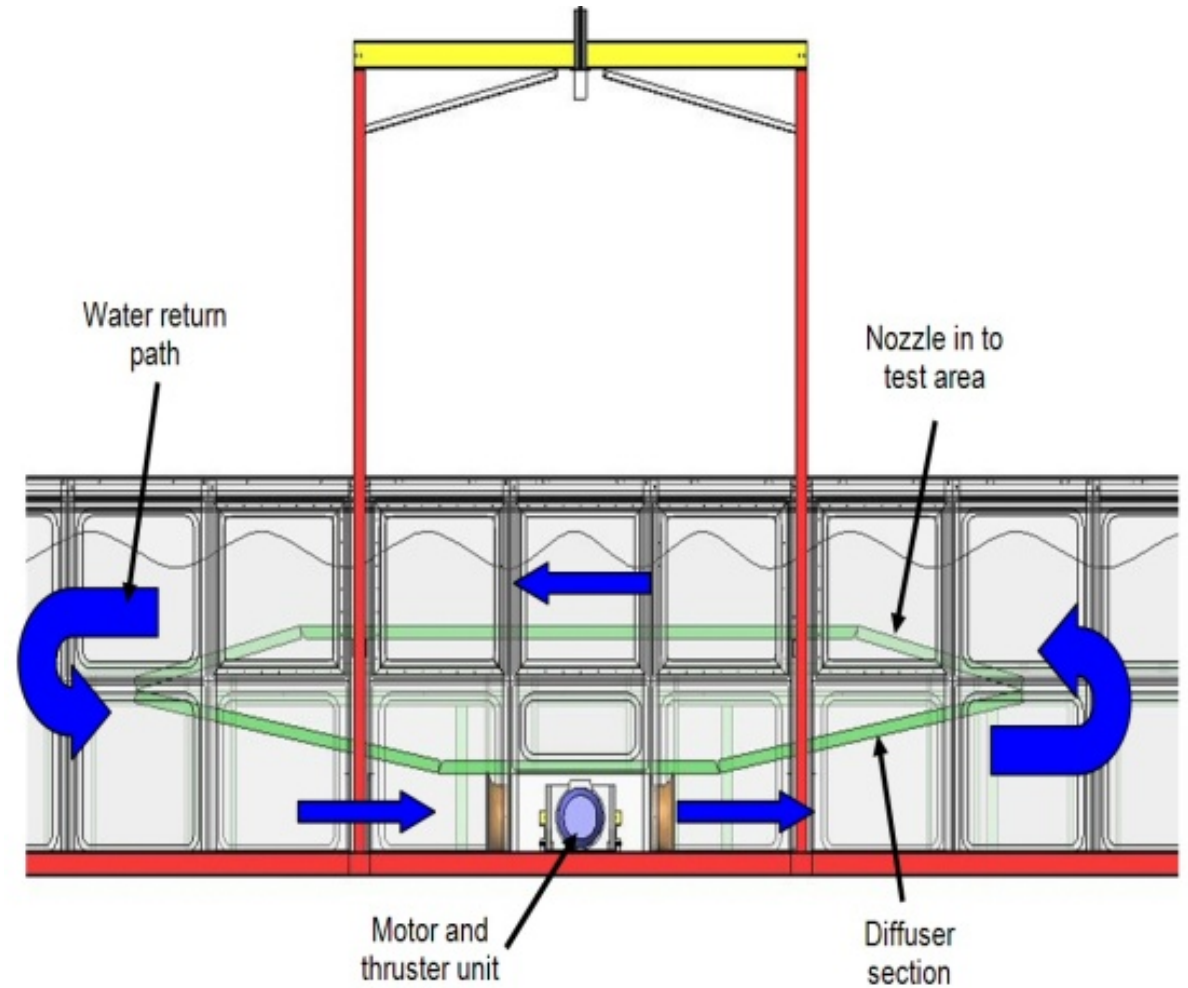
- Global pandemic
- One global community
- Most vulnerable in our society affected
- Exposed the serious weaknesses of our current systems
- We need to rebuild a society
- Sustainable, green jobs
- An end to fuel poverty
- Safeguard our planet and the health of all

Morecambe Bay Tidal Barrage is a vital step in getting us closer to a greener, safer, fairer future

- **Research on Renewable Energy & Fluid Machinery**
 - Generic & Applied
- **Energy & Renewables**
 - Computational & Experimental Modelling
 - Device Development & Power take off
 - Computational Fluid Dynamics & Control
 - Economics, Resource & Condition Monitoring
- **Novel Topology Fluid Machinery & Turbines**
 - Computational Fluid Dynamics, Turbine Design & Analysis
 - Direct Drive & In Line Turbines
 - Siphonic Low Head & Low Cost Turbine Research
 - Fluid Machinery reliability & Energy Efficiency
- **Funded by EPSRC, Carbon Trust, EU, RDAs, Utilities and Industry**

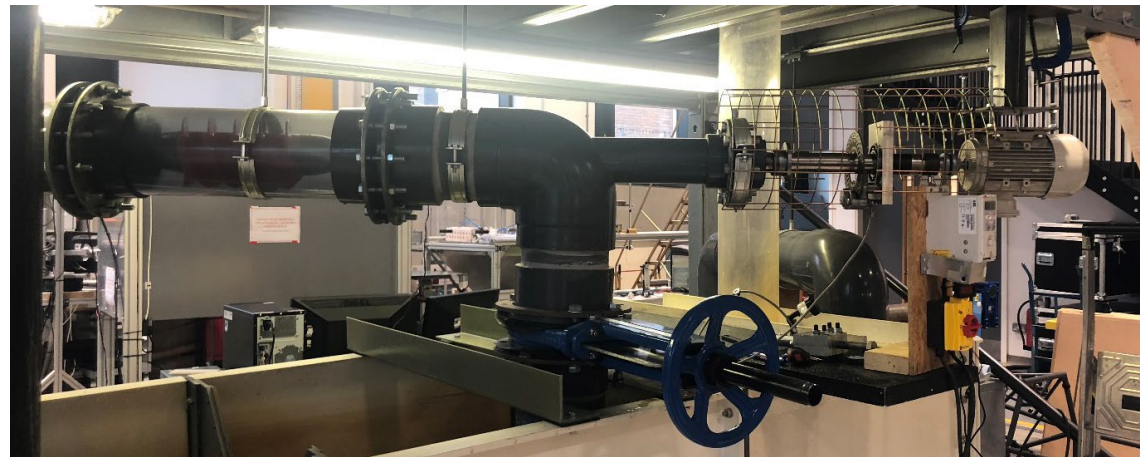
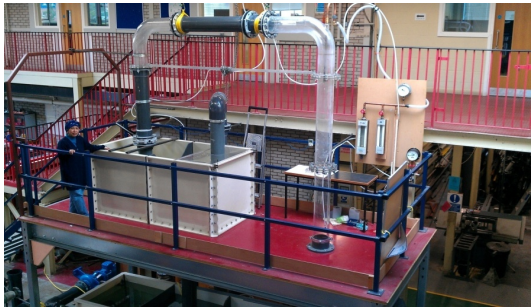


Lancaster University Engineering Building

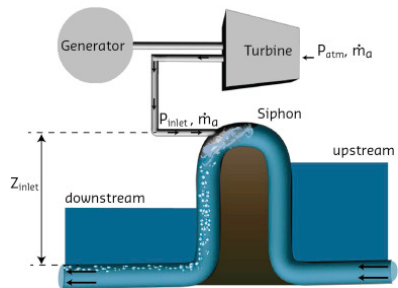


Waters, S. and Aggidis, G., 2016. Tidal range technologies and state of the art in review. *Renewable and Sustainable Energy Reviews*, 59, pp.514-529.

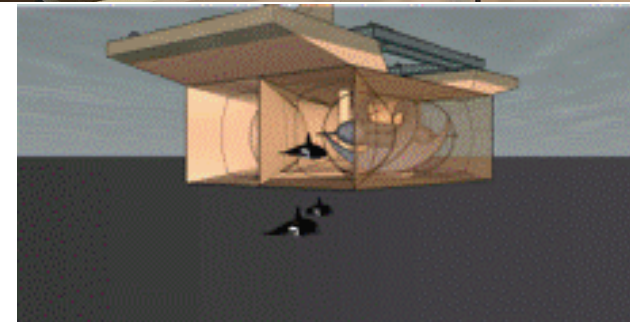
Waters, S. and Aggidis, G.A., 2015. Over 2000 years in review: Revival of the Archimedes screw from pump to turbine. *Renewable and Sustainable Energy Reviews*, 51, pp.497-505.



Lancaster University
Research on Low Head Hydro and Archimedes Screw Turbines for Tidal Applications



Holland Estuaries

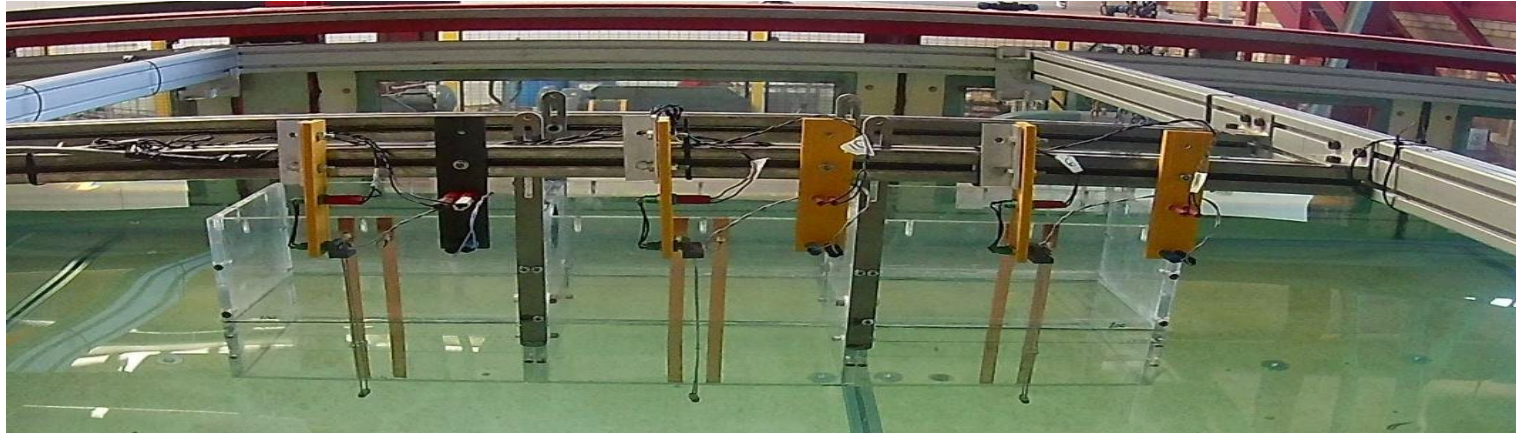


Indonesia

<https://www.tidalbridge.com/>

Lancaster University Research on Environmentally Friendly Solutions using Tidal movements

Widden, M.B., French, M.J. and Aggidis, G.A., 2004. Economic energy from low head water by conversion to air pressure. In *IMechE Conference Transactions* (Vol. 6, pp. 41-49).



waves2watts

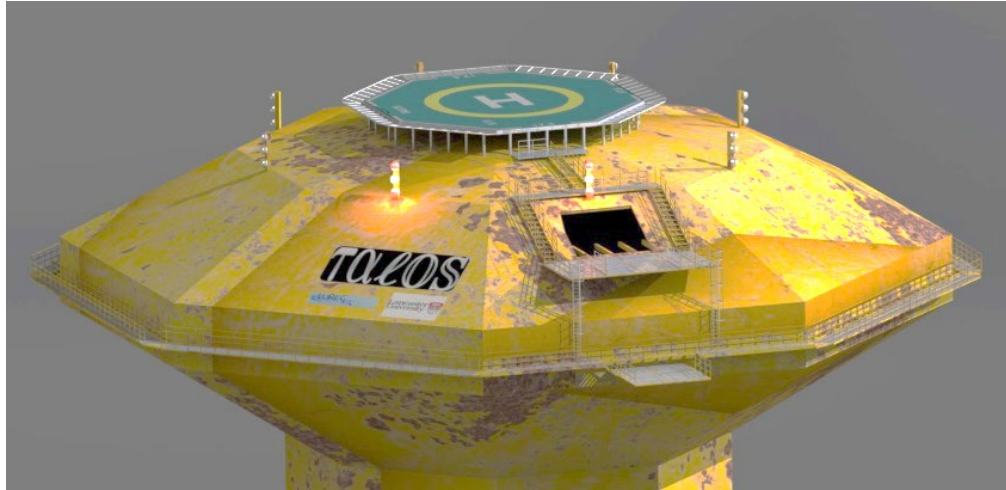
Lancaster University Research on W2W

Multi Oscillating Water Column

Wave Energy Converter and

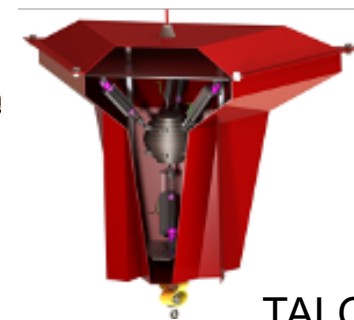
Floating Breakwater.

Doyle, S. and Aggidis, G.A., 2019. Development of multi-oscillating water columns as wave energy converters. *Renewable and Sustainable Energy Reviews*, 107, pp.75-86.

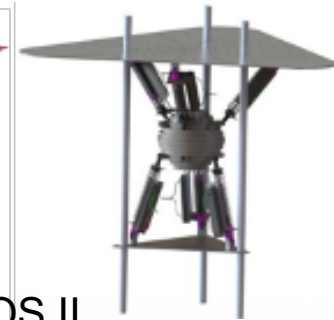


TALOS I

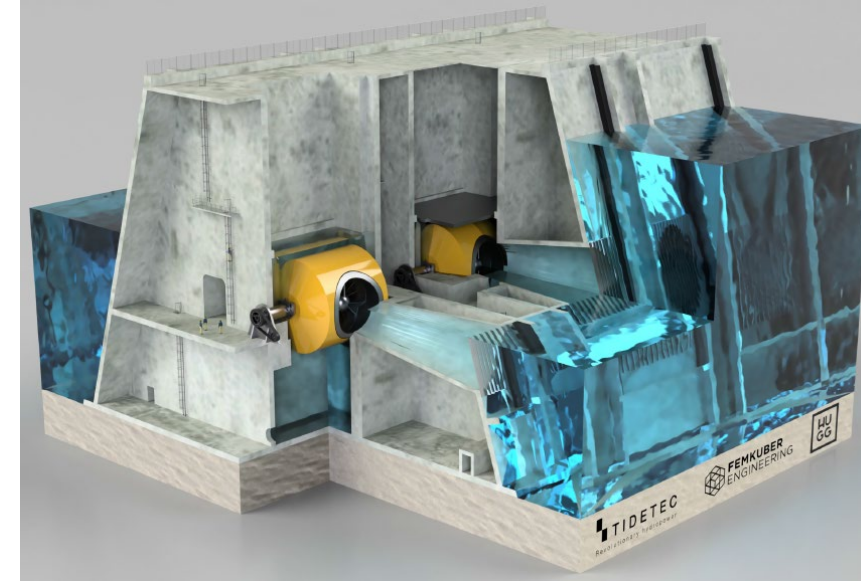
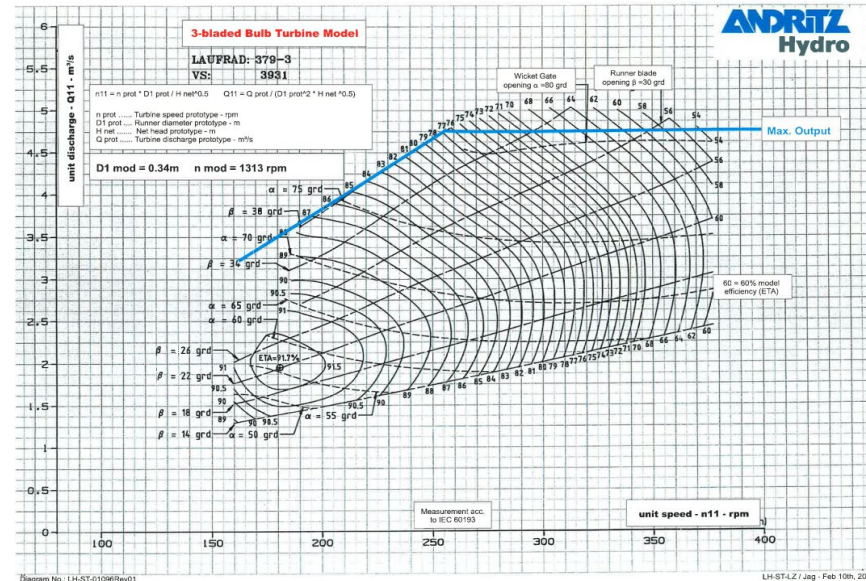
TALOS Multi Axis Wave Energy Converter System



TALOS II



Aggidis, G.A. and Taylor, C.J., 2017. Overview of wave energy converter devices and the development of a new multi-axis laboratory prototype. *IFAC-PapersOnLine*, 50(1), pp.15651-15656.



*Lancaster University
Research with Infinities
Global on Tidal Current
and Hydrogen Storage
Technology*



*Smart sea water
storage to provide
flexibility services to
the energy network*

Petley, S. and Aggidis, G., 2016. Swansea Bay tidal lagoon annual energy estimation. *Ocean Engineering*, 111, pp.348-357.



Before the Low Head Hydro Plant

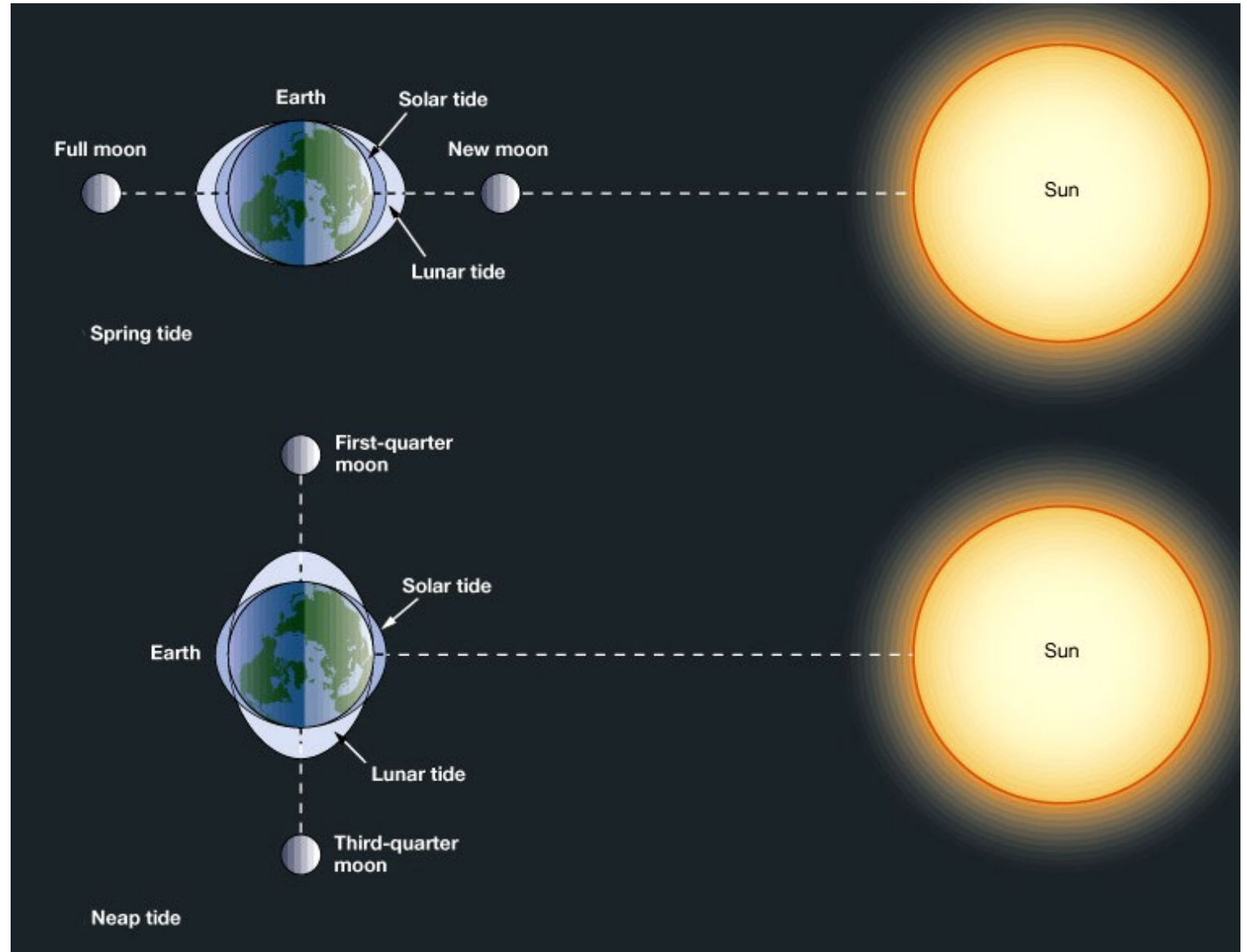


After the completion of the Low Head Hydro Plant

1. Introduction
2. Resource
3. Past
4. Present
5. Next Steps
6. Conclusions



Tidal energy exploits the **natural ebb and flow** of coastal tidal waters caused principally by the interaction of the **gravitational fields of the earth, moon and sun.**



The flows due to flood and ebb currents creates **KINETIC ENERGY**.



- Power extracted from kinetic energy of flowing water:

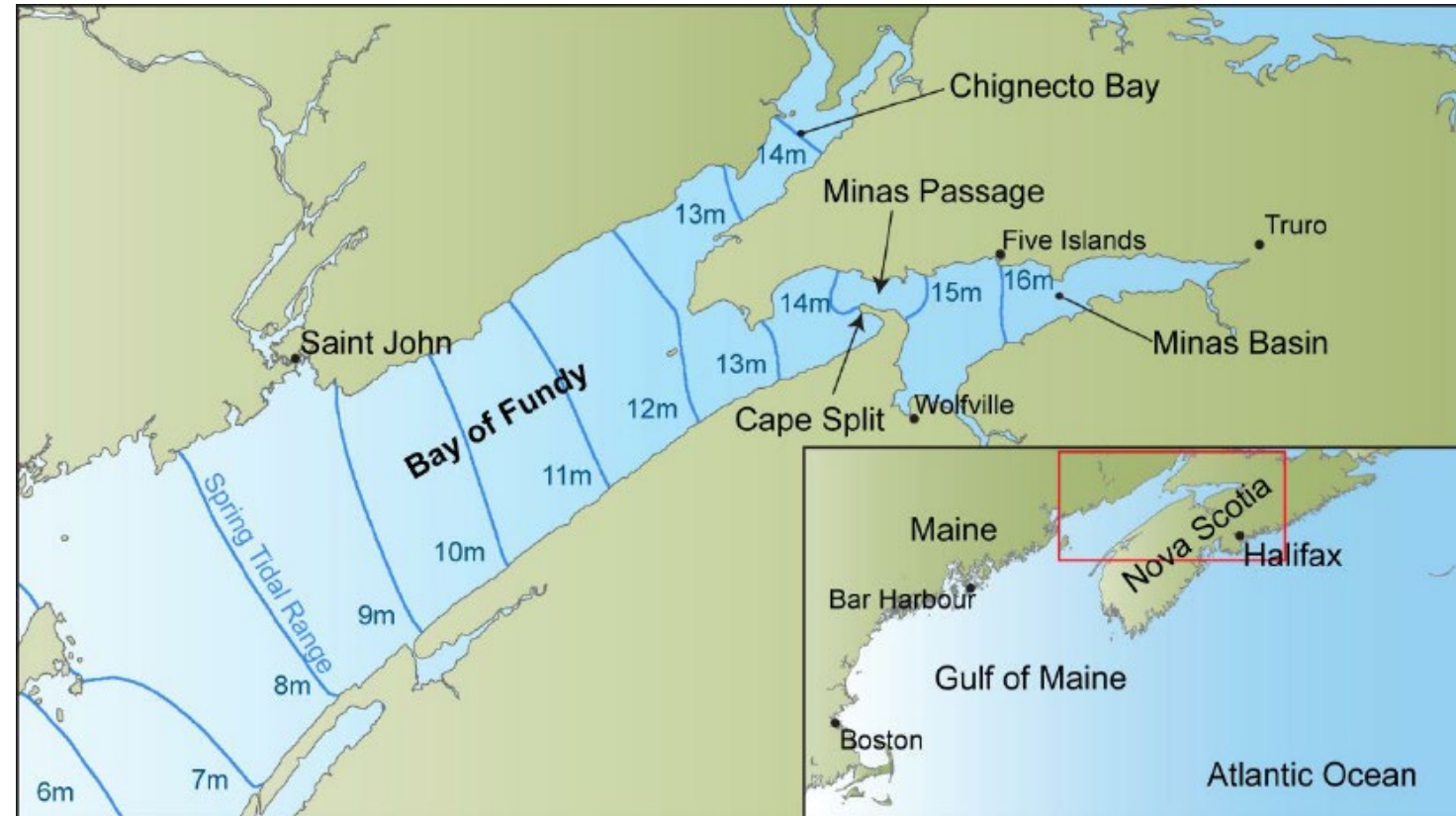
$$P = \frac{1}{2} \rho A U^3$$

- Water 800 times denser than air.
- Turbines similar to wind turbines, but:
 - the blades are smaller
 - turn more slowly and
 - withstand greater forces and movements



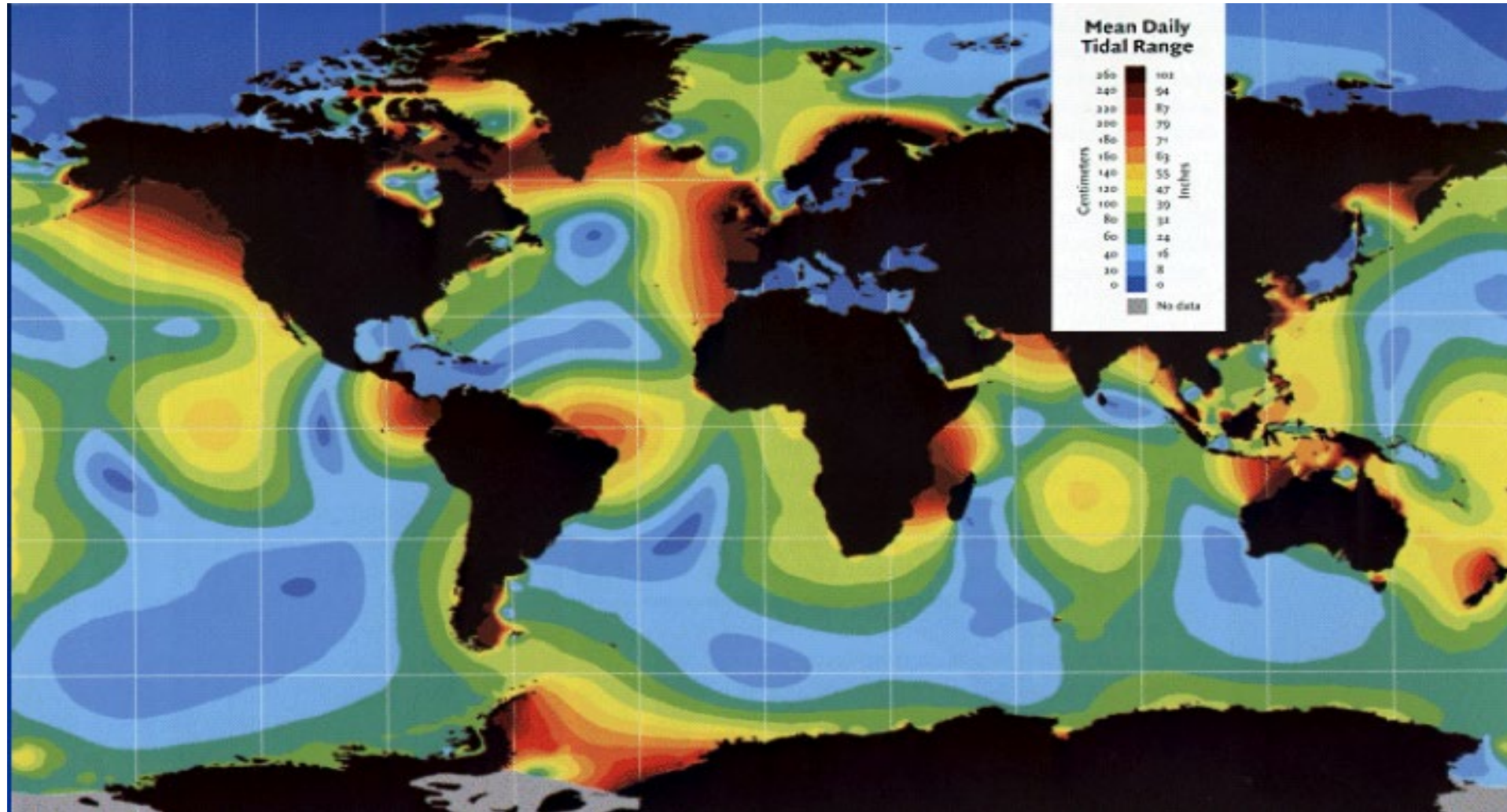
The rise and fall of the tides up to 16 m creates **POTENTIAL ENERGY**.

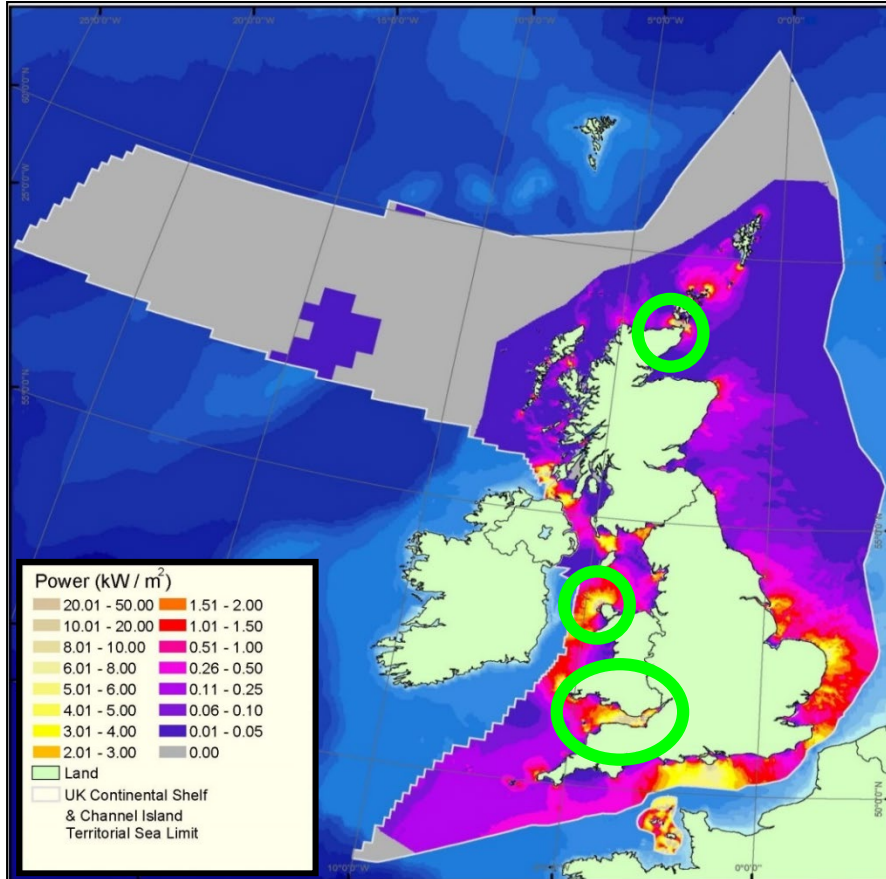
- Tidal energy is **focused** by **shape and shallowness** of bay.
- The Bay of Fundy in Canada has the **greatest tidal range on the planet**.
- Maximum spring tidal range in **Minas Basin 16.2 m**.



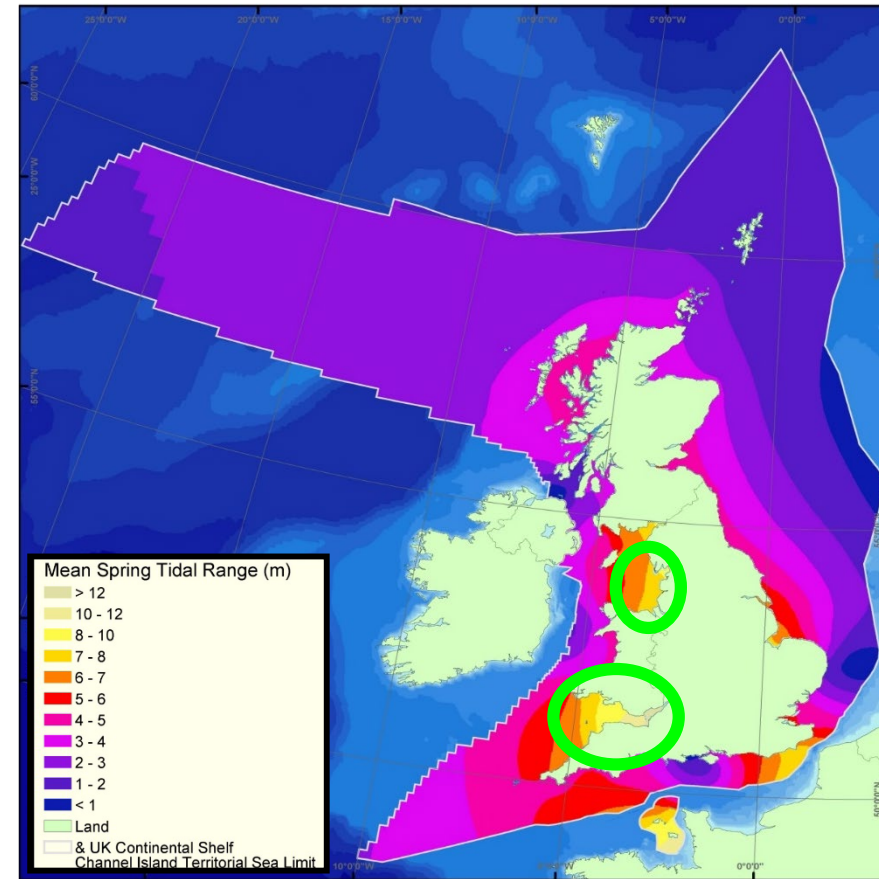
Global Distribution of Tidal Range

Electric Power Research Institute (EPRI).





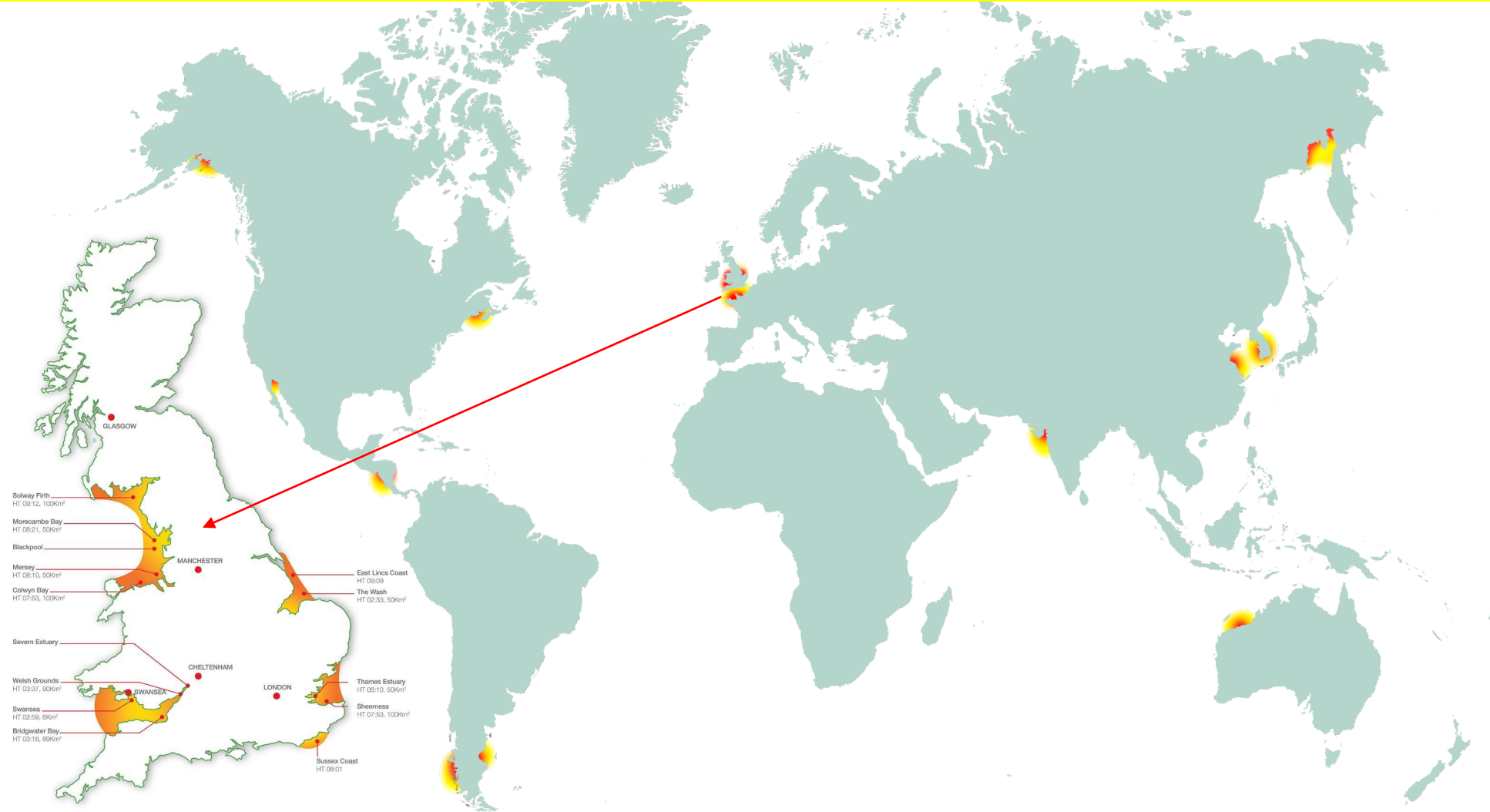
Tidal Stream



Tidal Range

Source – DTI Atlas of Marine Renewable Energy Resources

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.



1. Introduction
2. Resource
3. Past
4. Present
5. Next Steps
6. Conclusions



Dukes Lancaster, Theatrical Play "Keeping the Lights On, Morecambe Bay Tidal Barrage" Advisor Prof George Aggidis **2018**

Morecambe Bay

Mo Kelly Barrage, North West Tidal Energy Alliance **2015**

Alan Torevell, Prof George Aggidis & NWBLT, NWE² Model **2014**

Nigel Catterson & Peter Roberts Gateway & VETT Technology **2010**

NWTEG Launch Prof George Aggidis founding Chairman **2008**

David Brockbank, Hazel Broach, Martin Widden & Prof George Aggidis Blue Energy Tidal Fence **2004**

2004 David Brockbank, Hazel Broach & Prof George Aggidis Bridge Across the Bay

2004 David Brockbank, Hazel Broach, Prof Stephen Salter & Prof George Aggidis Theta Islands

2002 John Handley, Westmorland Gazette Barrage

1960s Ernest Leeming Barrage

1857 Lancaster to Grange over Sands Railway Bridge across Morecambe Bay

1837 George Stephenson West Coast Railway over Morecambe Bay

Existing tidal references world wide include:

- **La Rance, France, 1967**

 - Alstom Hydro
 - 5.4 m Dia. 24 Turbines x 10 MW
 - 240 MW total capacity
- **Kislaya Guba, Russia, 1968**

 - 1 Turbine x 0.2 MW
 - 1 Turbine x 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 x 500KW
 - 1 Turbine x 600KW
 - 3 Turbines x 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



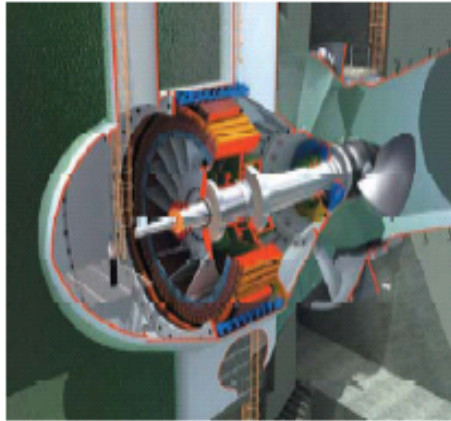
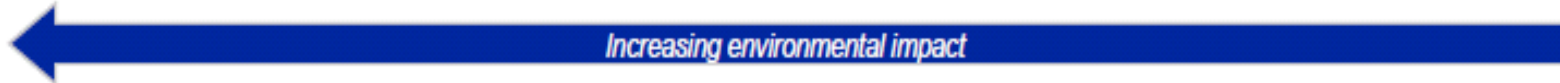
Sihwa, South Korea tidal power plant 2011

*Markus Schneeberger
ANDRITZ Hydro &
Prof George Aggidis*

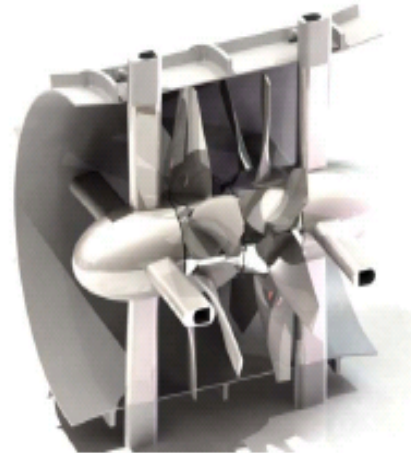
1. Introduction
2. Resource
3. Past
4. Present
5. Next Steps
6. Conclusions



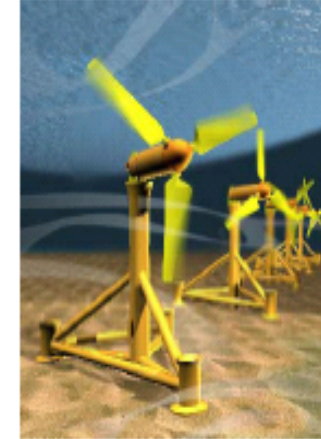
Both forms of energy (potential & kinetic) can be harvested by tidal energy technologies as renewable energy.



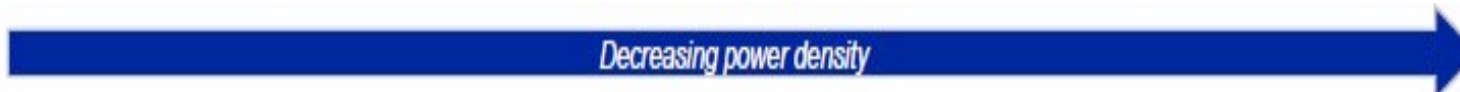
- Uni-directional operation.
- High axial flow speed.
- 50 metre downstream diffuser.
- High solidity rotor.
- Steady flow conditions.
- Deep cavitation submergence.



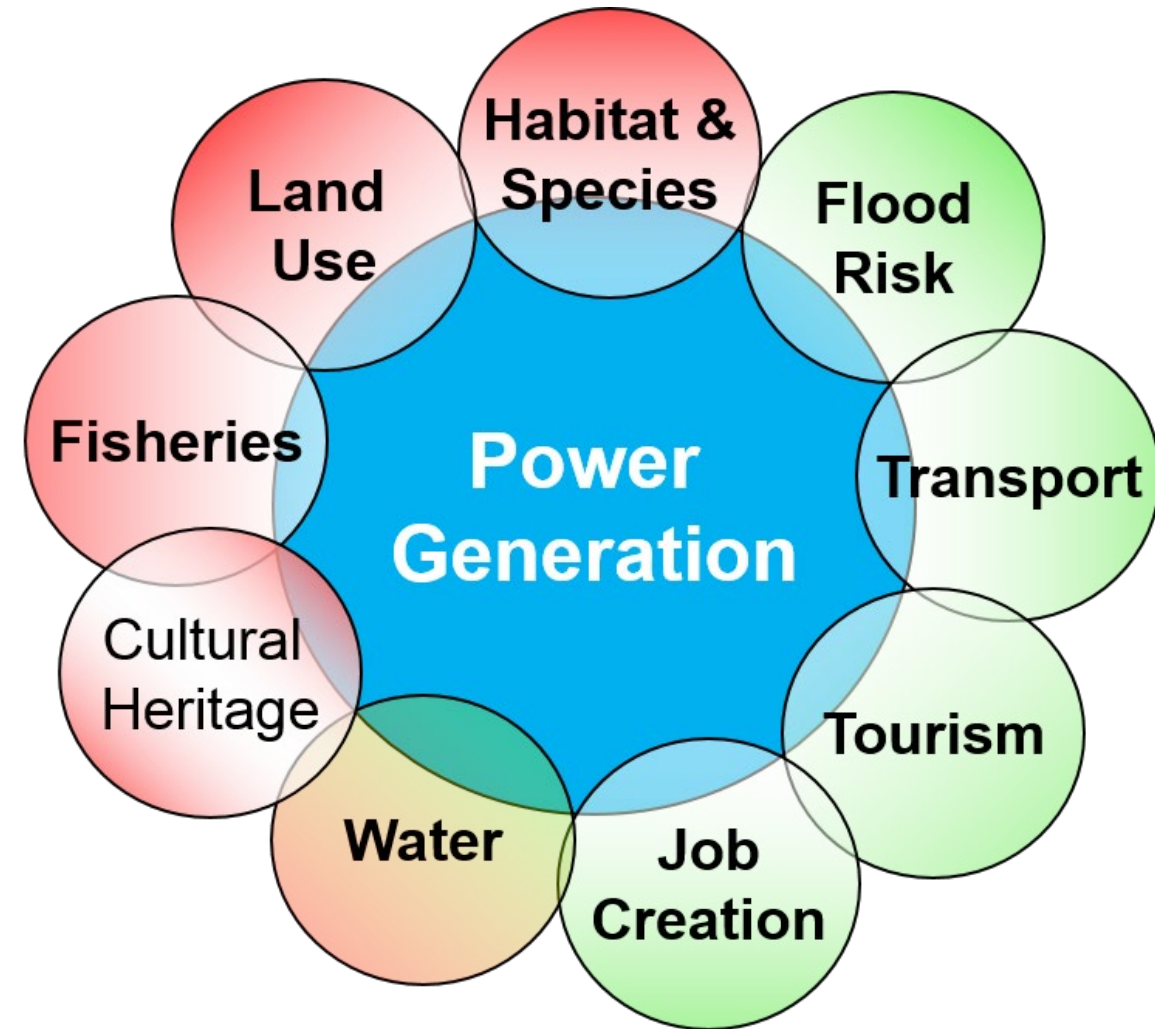
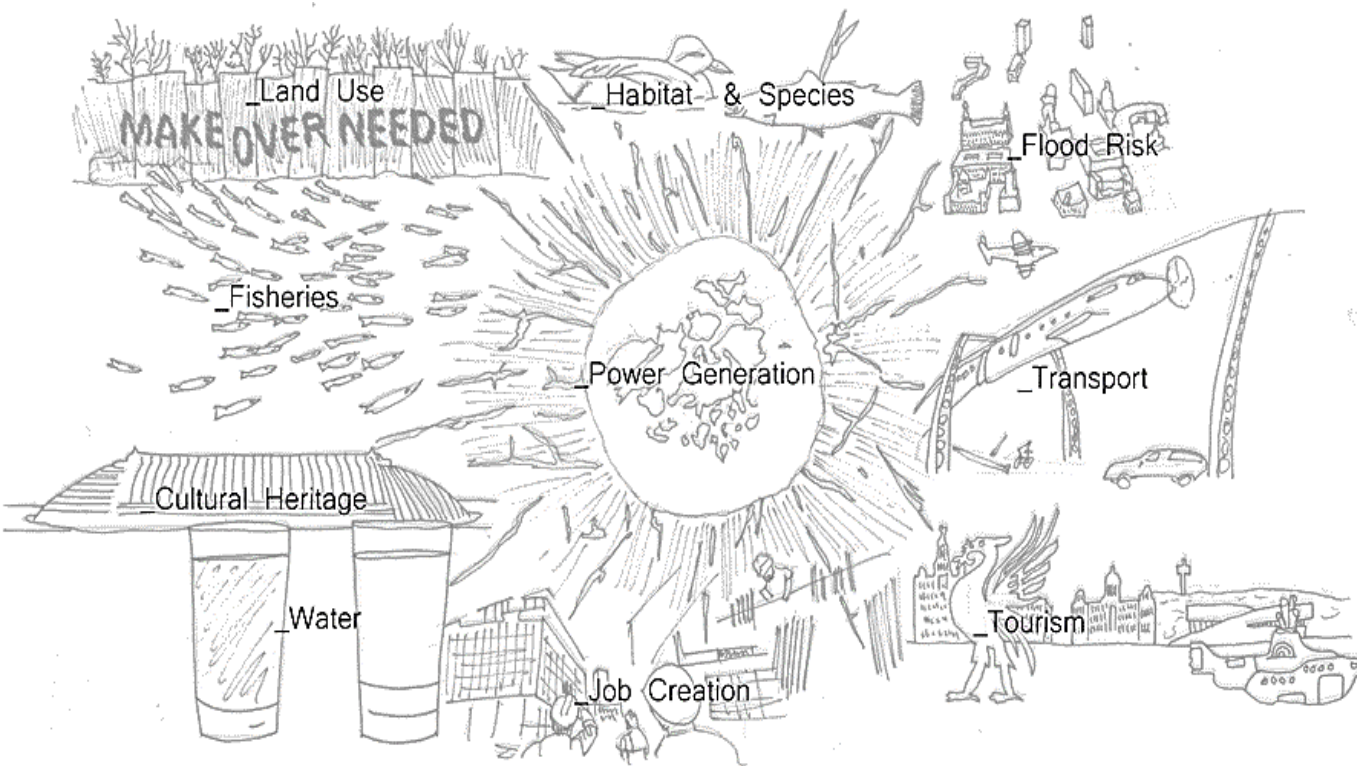
- Bi-directional operation.
- Low axial flow speed.
- Straight walled support structure.
- Twin low solidity rotors.
- Steady flow conditions.
- Modest cavitation submergence.



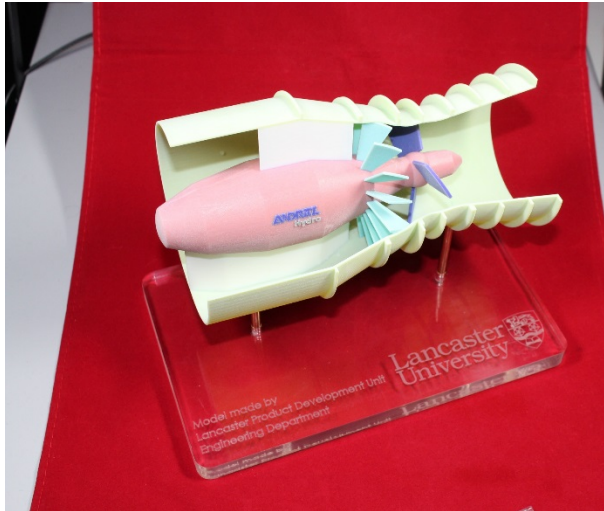
- Bi-directional operation.
- Low axial flow speed.
- No enclosing support structure.
- Low solidity rotor.
- Unsteady flow conditions.
- Modest cavitation submergence.



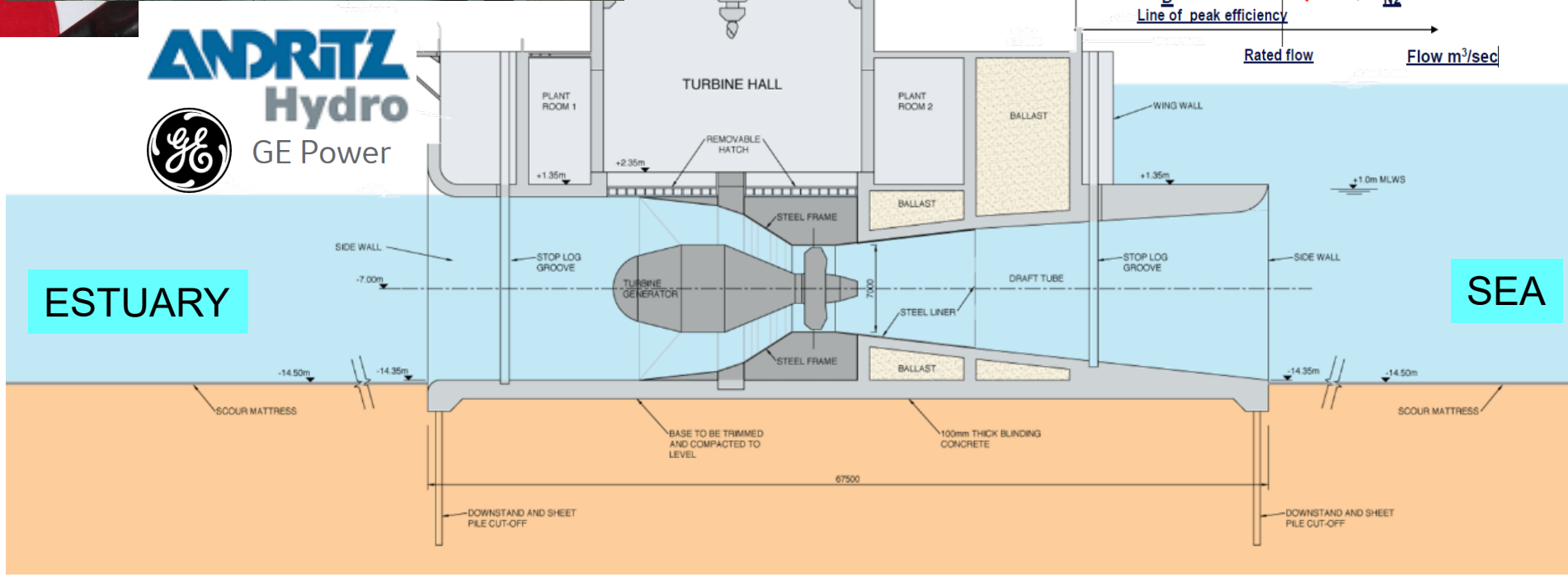
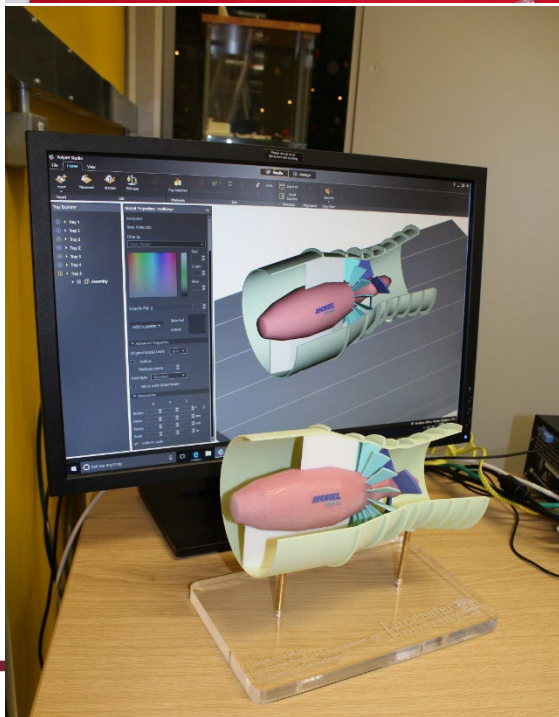
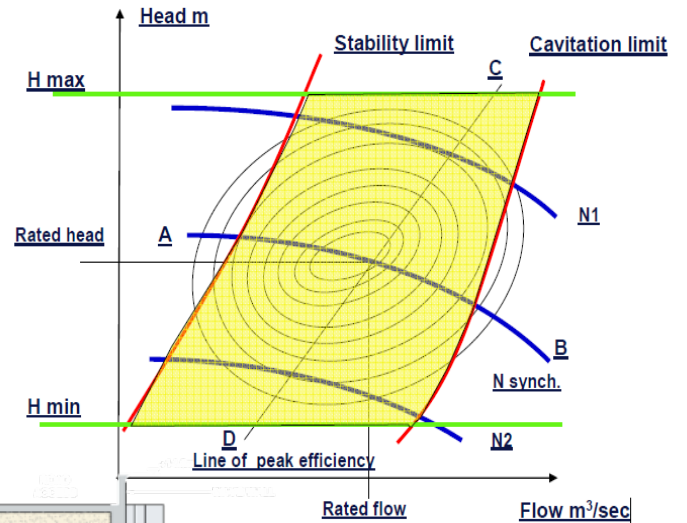
Multi Functional Infrastructure & Power Generation

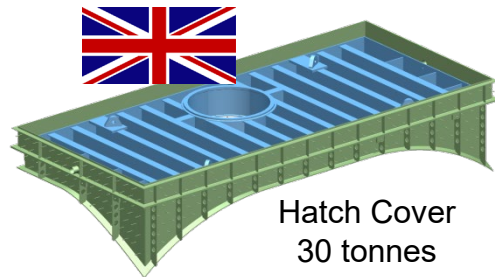


Triple Regulation Turbine (2017)

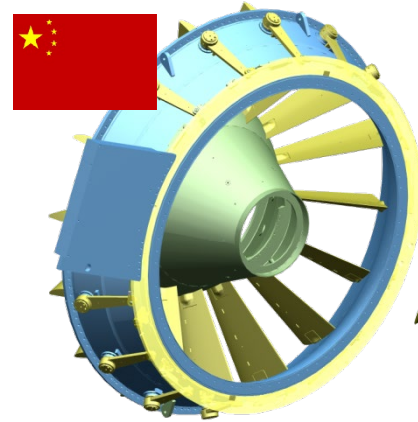


Prof George Aggidis & Bernd Hindelang
ANDRITZ Hydro





Hatch Cover
30 tonnes



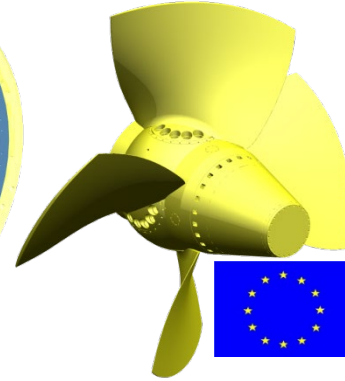
Distributor
90 tonnes



Runner blade
18 tonne



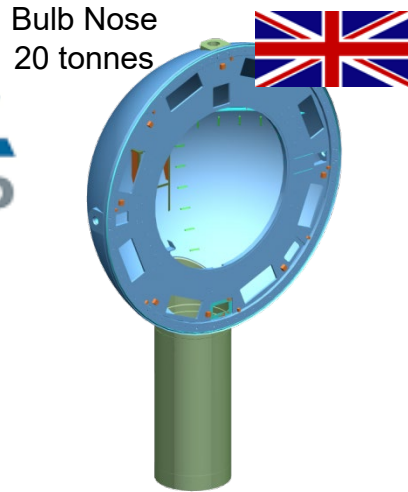
Runner hub
45 tonnes



Runner



Discharge ring

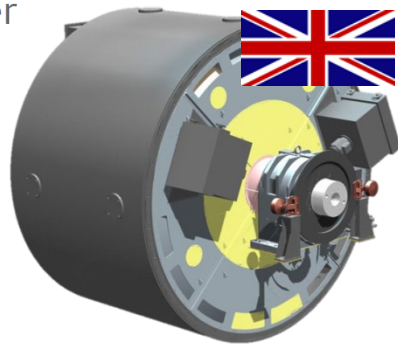


Bulb Nose
20 tonnes

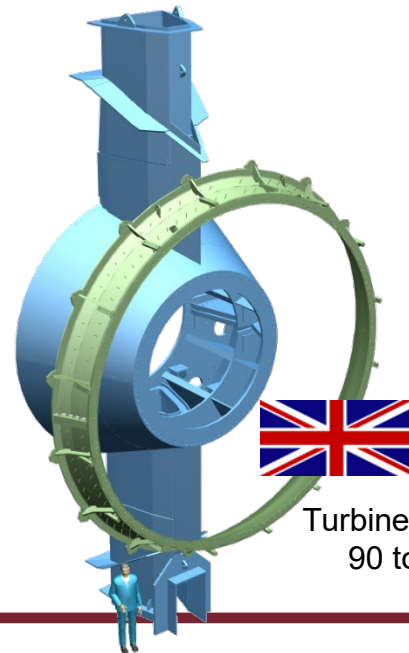
ANDRITZ
Hydro



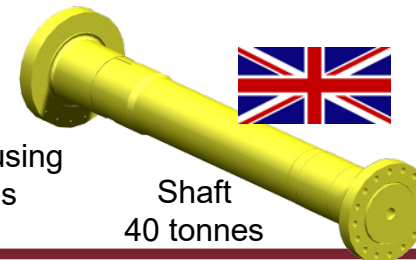
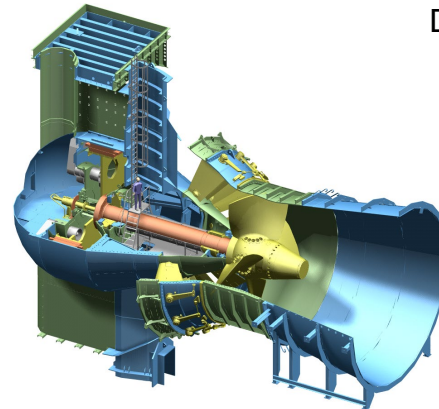
GE Power



Generator



Turbine Housing
90 tonnes



Shaft
40 tonnes



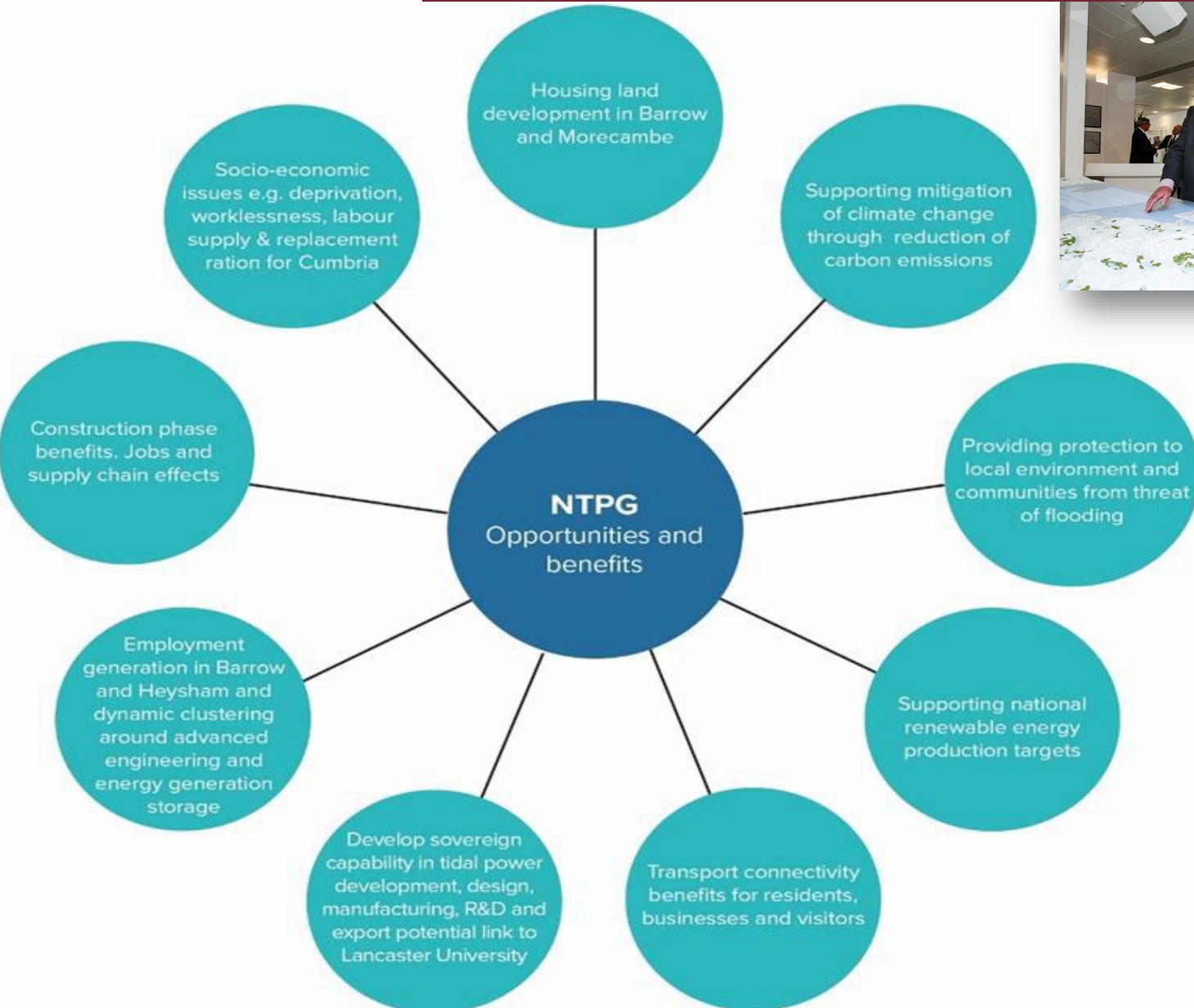
Draft Tube
40 tonnes



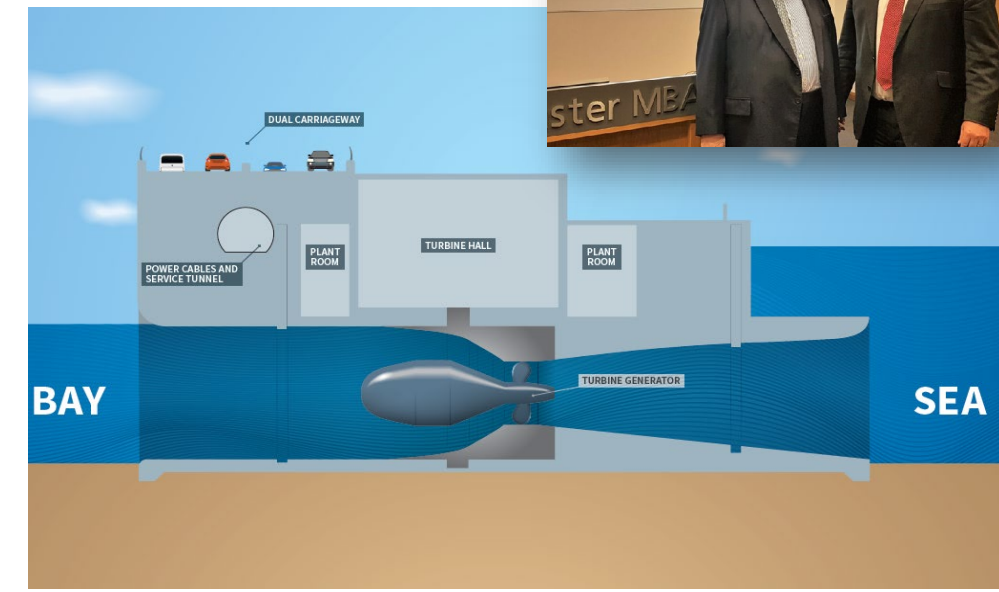
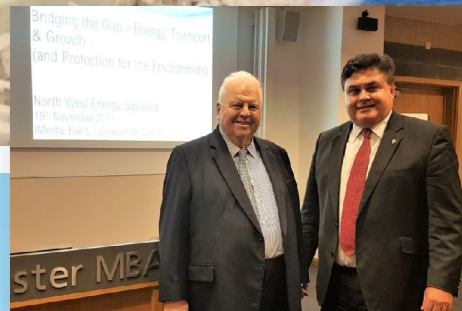
Prof George Aggidis
& Bernd Hindelang, John Epps
ANDRITZ Hydro



Bernd Hindelang
ANDRITZ Hydro &
Prof George Aggidis



Alan Torevell & Prof George Aggidis



- **PAST** - Historically and up to date:
 - All proposals for the various schemes proposed for Morecambe Bay **have not progressed**
 - **Despite greater power output forecasts** (due to mainly 0-D modelling) technological developments, multi functional infrastructure and strong transport links
 - Because they have **not been able to achieve appropriate financial targets for government funding** and the profit to cost ratio required to attract investors
- **FUTURE** - From now on and looking into the future:
 - We have to address the climate emergency
 - Including potential sea level rising
(IMechE Report "Rising Seas: the Engineering Challenge", 12 Nov 2019)

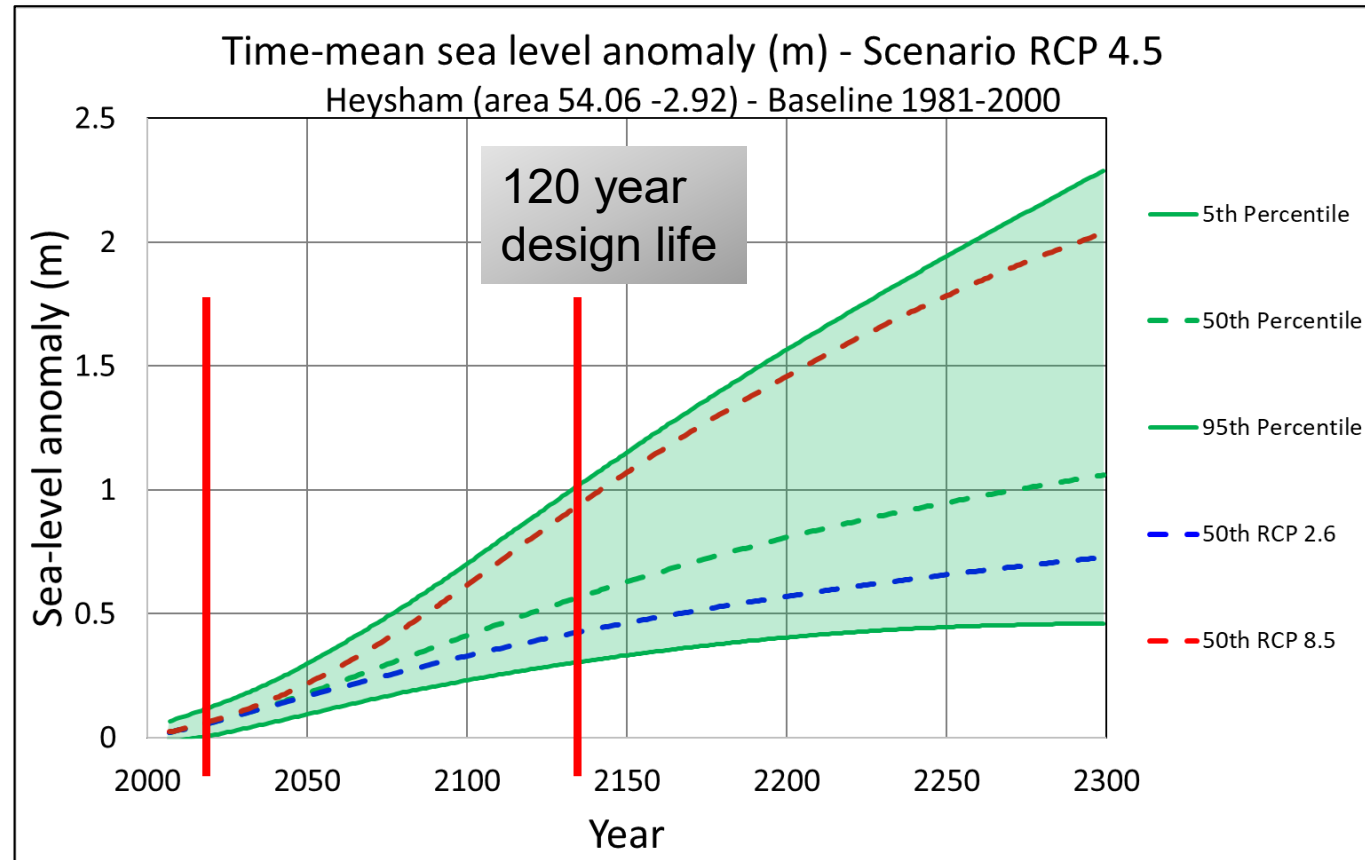
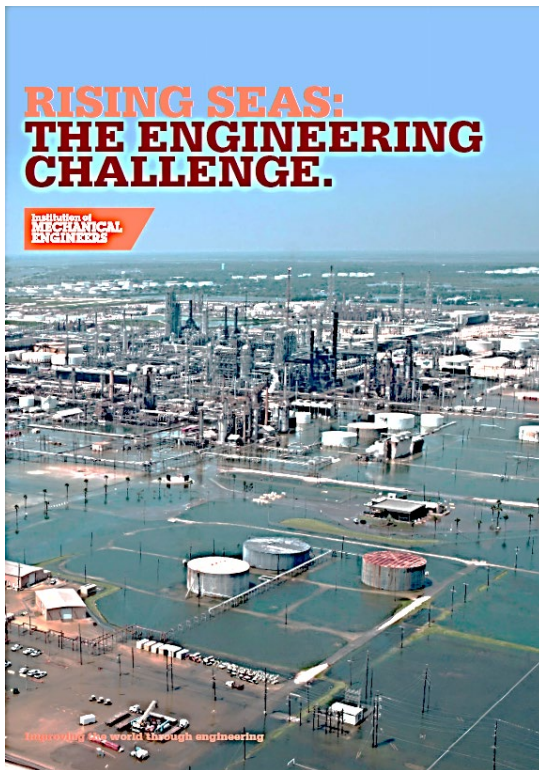
1. Introduction
2. Resource
3. Past
4. Present
5. Next Steps
6. Conclusions



- The **UK government** have announced a climate emergency with targets to **decarbonise by 2050**.
- We need to reach "net zero" far **sooner than 2050** – we're already seeing the **catastrophic effects** of climate breakdown both across the globe and here in the UK.
- We have just a **short window of opportunity** left to **avoid irreversible damage**.
- We need to **live greener** and more **sustainable lives**.
- We need to **reduce UK dependence on imports** of dirty fuels like coal, oil and gas.
- The UK should be powered by a **home-grown renewables sector**, providing **jobs** and **clean energy** at **affordable prices** for homes, heating, transport and industry.

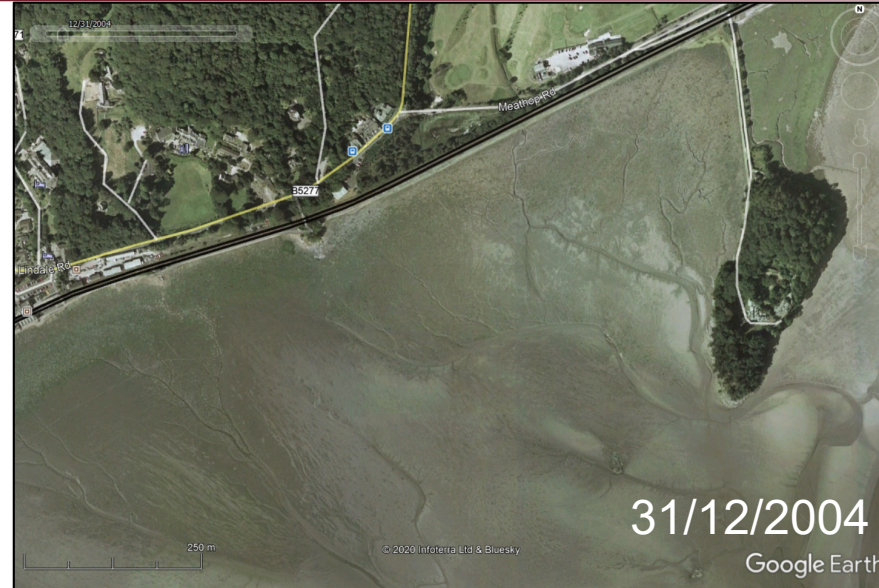
A **Representative Concentration Pathway (RCP)** is a greenhouse gas concentration (not emissions) trajectory adopted by the IPCC for its fifth Assessment Report (AR5) in 2014. Emissions in RCP 4.5 peak around 2040, then decline.

UK Open Government Licence for Public Sector Information v3.0 UKCP18



Projected sea-level rise for various IPCC RCP scenarios

- With no Barrage and no intervention Nature will take it's course



- Is the Environment better protected with a Barrage?





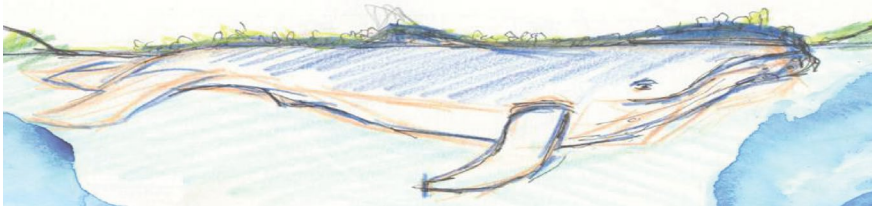


The volume of floodwater combined with the restriction caused by the high tide, resulted in overtopping of the right bank of the River Kent in the area around Levens Hall and Levens Moss.

This vital conversation is now set across the backdrop of the **coronavirus pandemic**.

- Now more than ever we must **prioritise health and wellbeing** of everyone by investing in infrastructure which improves our quality of life.
- We must **put green jobs at the heart of the recovery**.
- We must **fix our broken economy** so it works for everyone and looks after our planet.
- We must **co-operate globally and act responsibly** - as per climate breakdown, the pandemic has disproportionately impacted the poorest and most vulnerable in society.
- As one of the richest countries in the world, **the UK has a duty to lead the way** to protect the health of both people and planet.

Opportunities for tidal range projects beyond energy generation: Using Mersey barrage as a case study.



THE GREEN WHALE (2017)



Dr David Howard CEH
& Prof George Aggidis

...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.

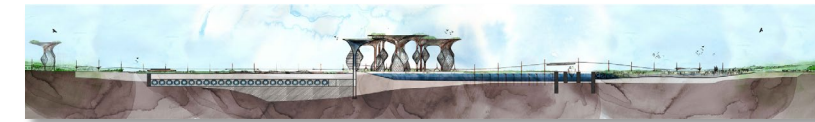
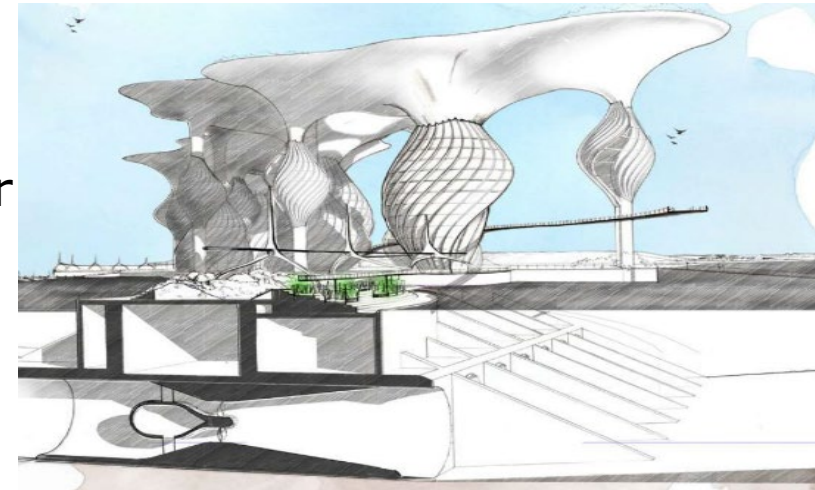
Dragon Energy Island

Proposed by Swansea Bay City Region (2019)



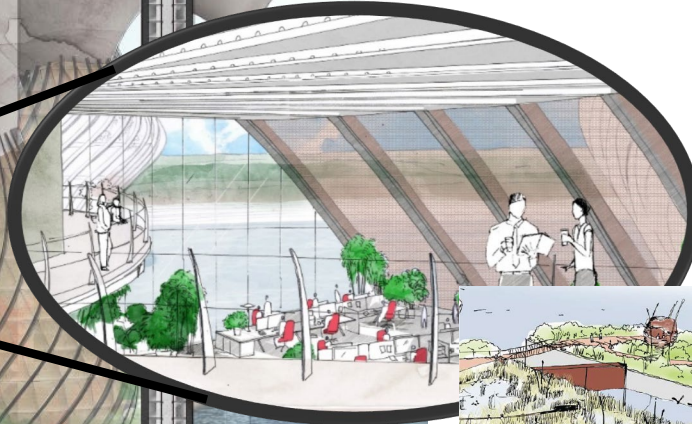
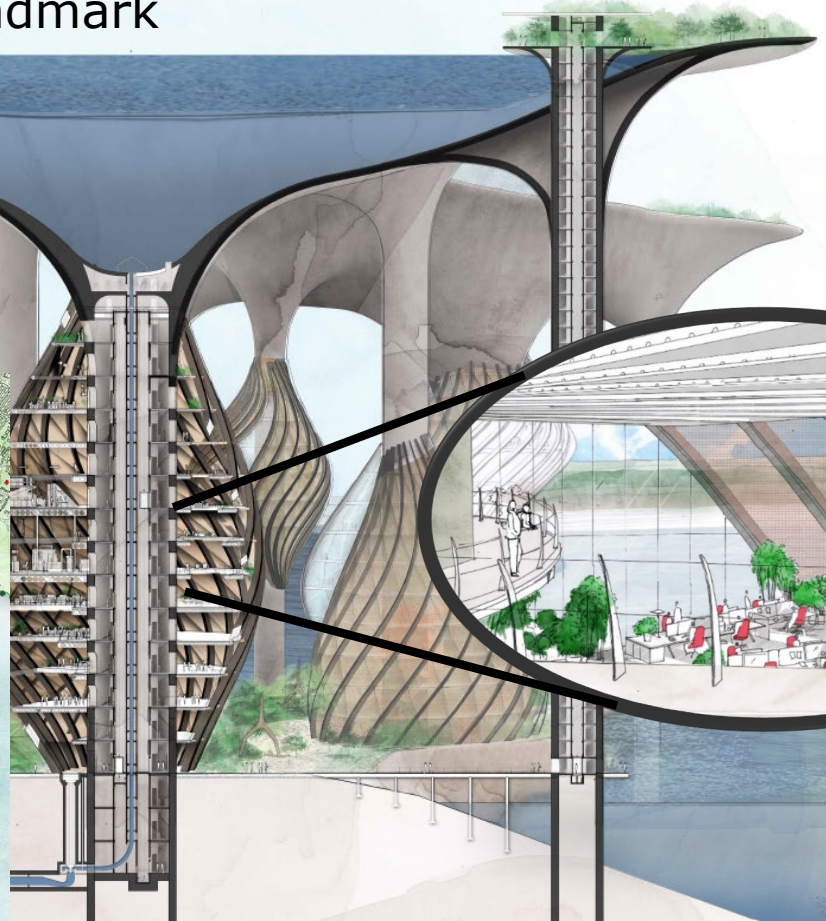
International Landmark

Global Hydropower Research Facilities



Connecting Communities

Integrating Wildlife



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.

- Hydropower
- Compressed Air
- Batteries
- Flywheel
- Hydrogen
- Gravitational Mass
- Etc.



- Lancaster University's work suggests:
 - **Further research and modelling** needed to optimise and balance the requirements of climate change, environment & energy generation, energy storage & grid supply against energy demand. In addition to **triple regulation & modelling accuracy** (0D, 2D & 3D).
 - **More pumps** are required to successfully maintain the environmental status sea level rise and mitigate serious flooding.

- Due to the proposed recommendation by the Benyon Report 2019 and its status as a Highly Protected Marine Area, Morecambe Bay is now an unlikely location in NW England for a **power only project**.

- **We welcome this report** which has helped further development of the **holistic benefits** of Morecambe Bay Tidal Barrage project.

- **Establish links** with the Lancaster University **Eden North Project**. A unique and ambitious project that seeks to reimagine the seaside resort for the twenty-first century. The project has far-reaching environmental, social and economic ambitions.



Professor Robert Barratt
Eden North Project Chair of
Education & Engagement



1. Introduction
2. Resource
3. Past
4. Present
5. Next Steps
6. Conclusions



- Global pandemic
- One global community
- Most vulnerable in our society affected
- Exposed the serious weaknesses of our current systems
- We need to rebuild a society
- Sustainable, green jobs
- An end to fuel poverty
- Safeguard our planet and the health of all

Morecambe Bay Tidal Barrage is a vital step in getting us closer to a greener, safer, fairer future

Tidal Energy (unlike wind & solar) does not suffer from intermittency and is unaffected by the weather being highly predictable for future generations generated both day and night and build for 120 years

1. Primary Focus

Health, Wellbeing, Green Jobs & Environment - Climate Emergency

- This is why we need to build a Morecambe Bay Tidal Barrage
- All UK estuaries will be seeing same pressures from **rising sea level**
- **Therefore a Barrage across the Bay is now essential**

2. Secondary Focus

Energy, Storage and Grid

JFK : “We choose to go to the moon.

We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win.”

This speech would go on to become one of the most quoted and celebrated speeches of all time, and **JFK’s “Moonshot” would become synonymous with the idea of challenging the impossible.**

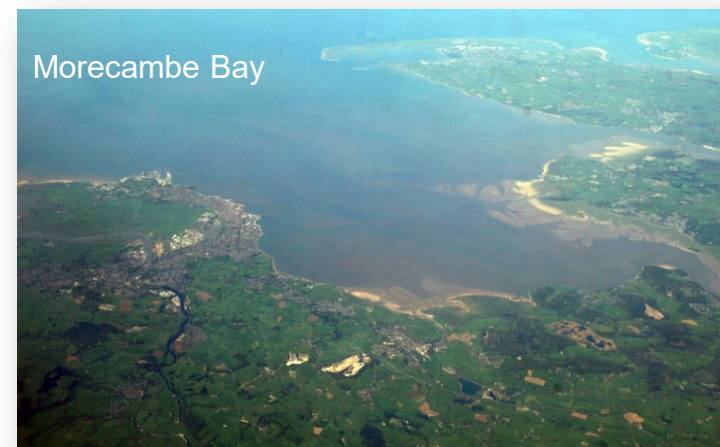


President John Fitzgerald Kennedy gave his now famous “Moonshot” speech at Rice University on 12 Sept 1962 in which he outlined his audacious plans to put a man on the moon.

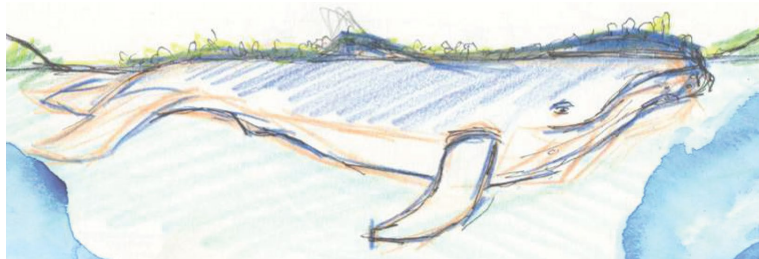


HRH Prince William and Sir David Attenborough launch Earthshot Prize on 8 Oct 2020

THE
EARTHSHOT
PRIZE



Morecambe Bay Shot ?



Professor George Aggidis

FIMechE, FIMarEST, FEI, FIET

g.aggidis@lancaster.ac.uk