Floating Tidal Instream Energy

Jason Hayman, Dr. Ralf Starzmann
Sustainable Marine Energy & SCHOTTEL HYDRO

Manila, June 2018

Hydrokinetic Energy

SCHOTTEL HYDRO

SUSTAINABLE MARINE ENERGY LTD

BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

Global Market Opportunity

NORTH AMERICA

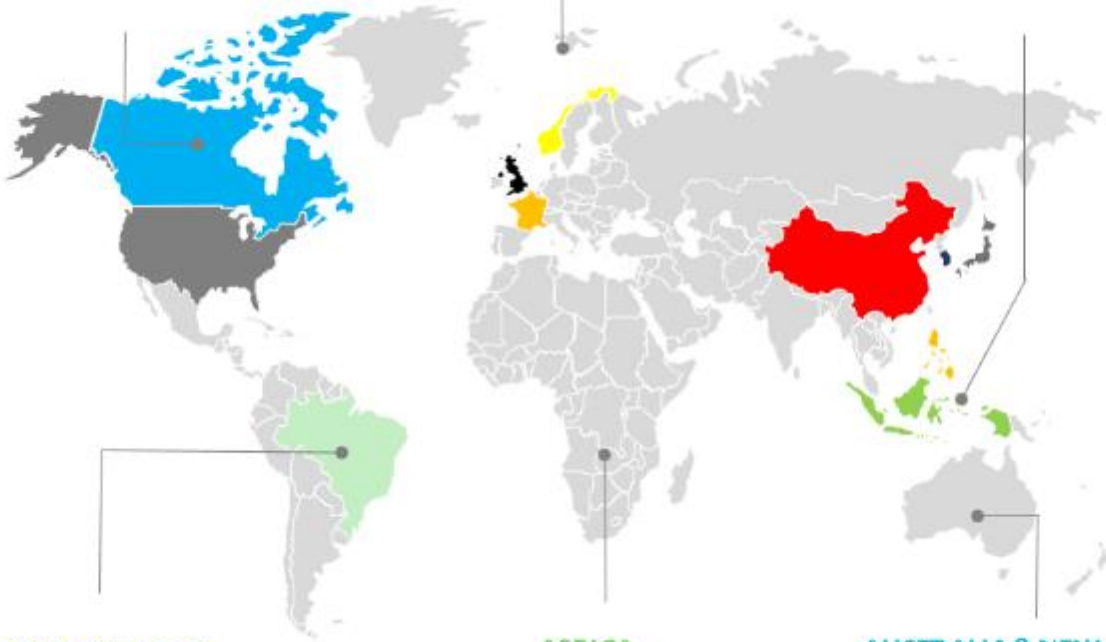
Strong tidal and river resources. Political support on national & regional levels. Grid-tied and off-grid potential

EUROPE

Traditional leader in Ocean Energy sector. Primary markets for tidal are UK & France.

ASIA

Most exciting market in global terms. Manifold opportunities to compete directly with fossil-fuels in Philippines & Indonesia



SOUTH AMERICA

World's strongest river resources. Individual projects 100MW+ . World-class tidal sites in Chile & Argentina

AFRICA

Limited tidal energy potential. Large but unknown river energy potential. Huge & growing off-grid market.

AUSTRALIA & NEW ZEALAND

Significant tidal resource in Australia & NZ. Run of River downstream of dams in N.Z.

SCHOTTEL HYDRO

SUSTAINABLE MARINE ENERGY LTD

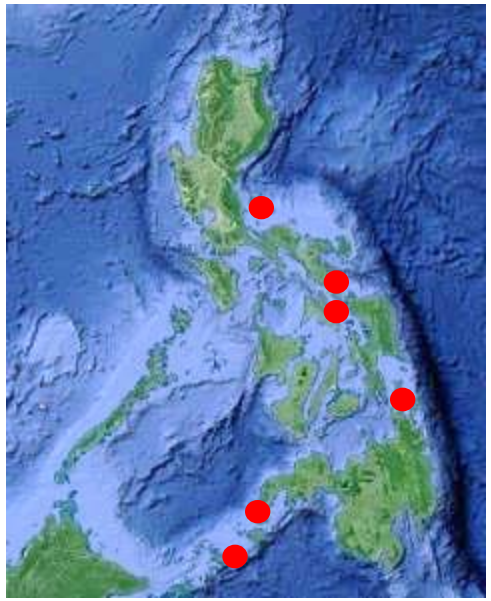
BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

The Philippines

KEY MARKET FACTS

- 20th largest sea area in the world - ~7,100 islands, ~2,000 inhabited
- Ministry of Energy estimates 40GW – 60GW tidal energy potential



PROJECT OPPORTUNITIES

- Tidal opportunities between the islands
- First project locations are being actively progressed by project developers
- Scope for follow-on projects <5MW – 100MW+
- **First projects directly competing with diesel for off-grid applications**

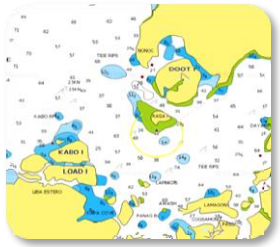
SCHOTTEL HYDRO
SUSTAINABLE MARINE ENERGY LTD
BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

Site Assessment

DESKTOP

- Use Navionics and online sources to gather high-level info
- Assess potential in terms of flow speed, depth, bathymetry, exposure, access etc
- Determine tide times and tidal coefficients for initial scoping



VISUAL

- Site Visit - 'eyes on assessment'
- Visually assess onsite conditions - flow speed, slack water duration, exposure etc
- Assess logistical and project enabling / limiting factors
- Preliminary measurement of flow speed and depth and compare to desktop data

INITIAL

- High level assessment utilising local vessels e.g. bangka:
  - Flow speed e.g. drifter
  - Flow direction
  - Flow divergence
  - Depth
  - Bathymetry e.g. single beam
  - Bed steepness
  - Bed type
- Determine high-level viability and plan for detailed surveys

DETAILED

- For selected sites measure:
  - Flow speed e.g. ADCP
  - Flow direction
  - Flow divergence, turbulence
  - Depth
  - Bathymetry e.g. multi-beam or sonar
  - Bed steepness
  - Bed type
- Ready data for inclusion in detailed financial model

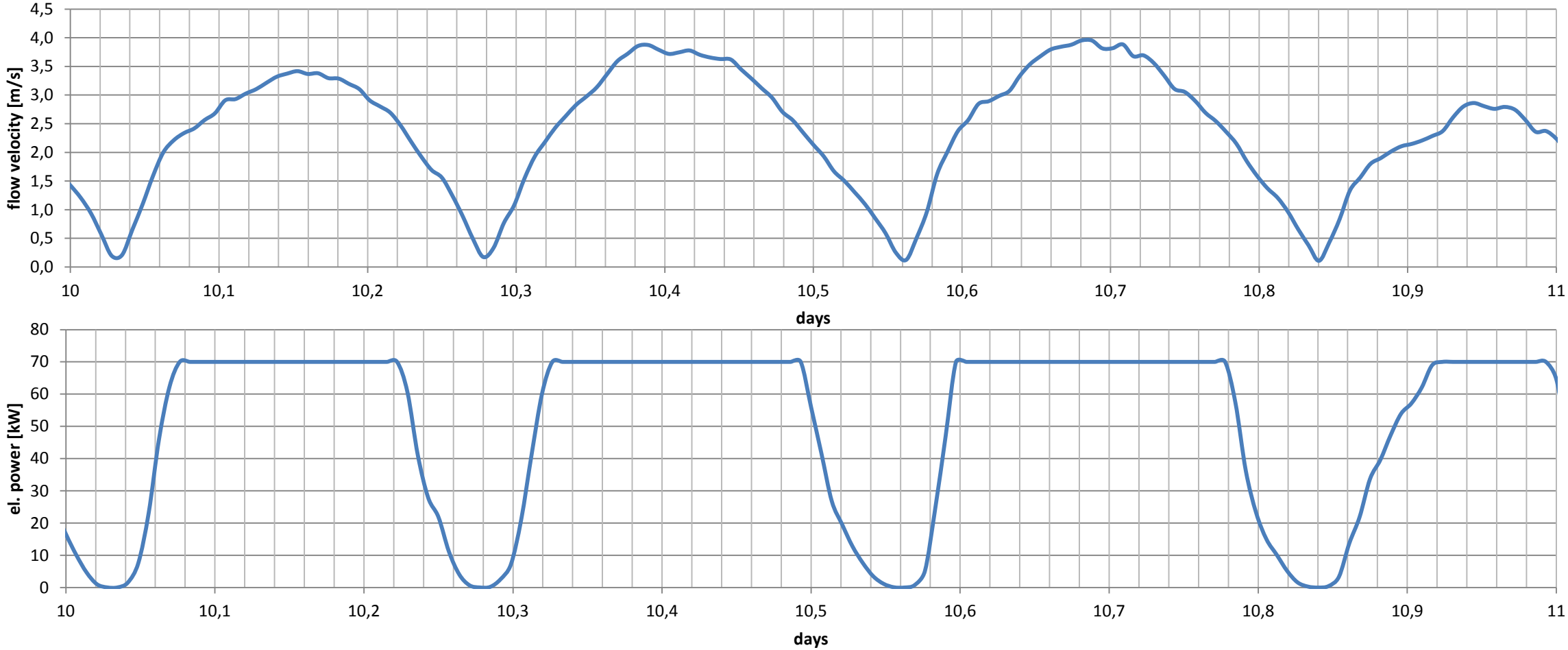
SCHOTTEL HYDRO

SUSTAINABLE MARINE ENERGY LTD

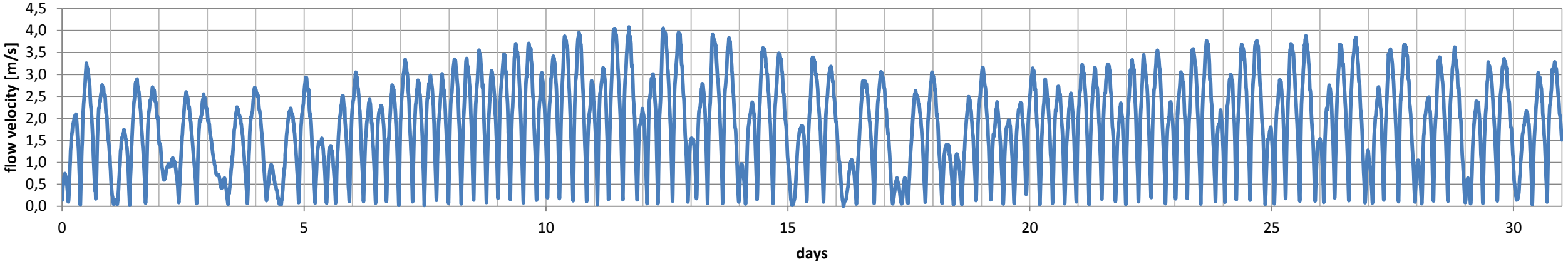
BLACK ROCK TIDAL POWER

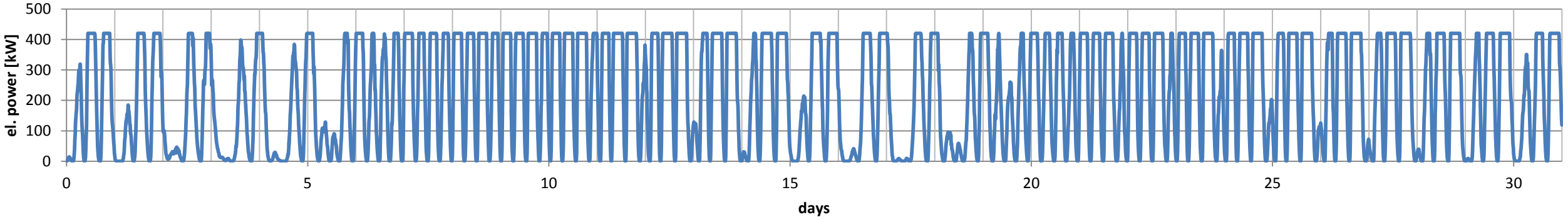
INTEGRATED TIDAL ENERGY

A Predictable Resource – One Day Time Series



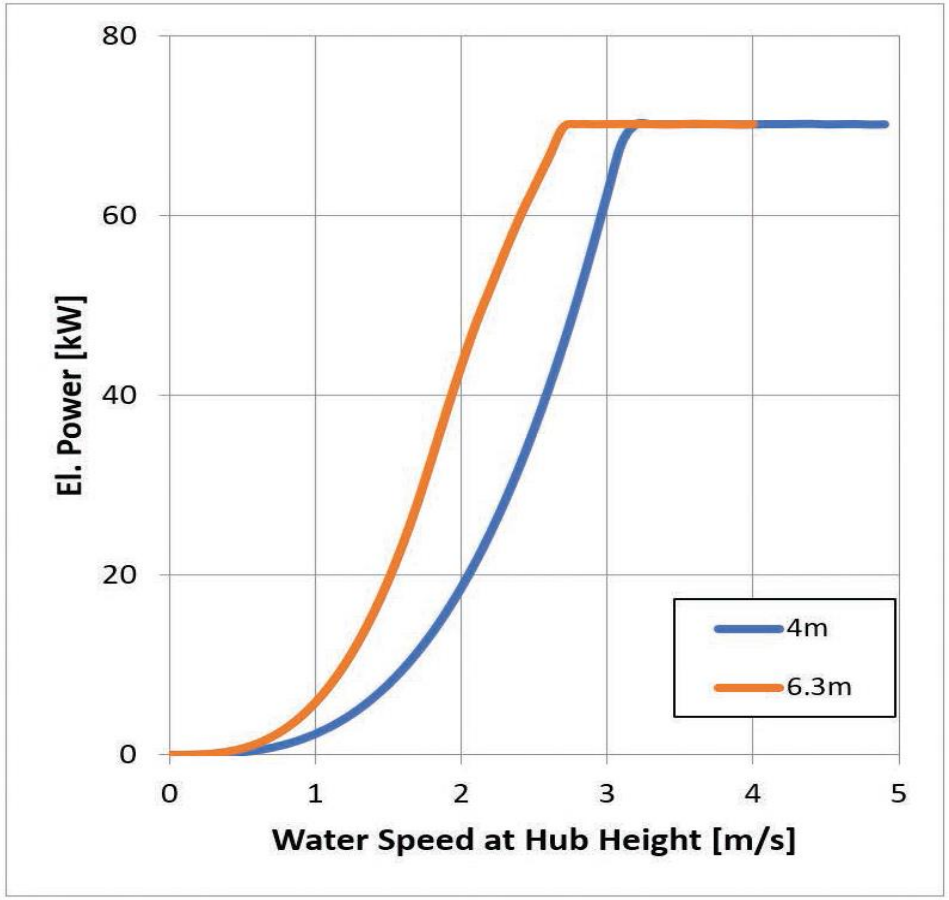
A Predictable Resource – One Day Time Series





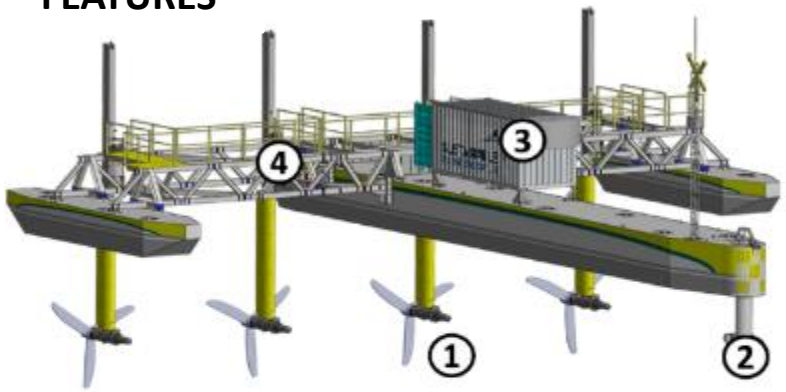
SCHOTTEL Instream Turbine

- SHY is a part of the SCHOTTEL Group, a market leader in azimuthing ship propulsion, founded in 1921 with approximately 1200 employees worldwide
- The SIT 250 consists of a fixed pitch horizontal axis turbine with a high power to weight ratio
- SHY has also developed a modular power conversion system which is produced by SCHOTTEL Group company HW Elektrotechnik



PLAT-I Inshore Tidal Energy Platform

FEATURES



1. SIT 250 tidal turbine generators
2. Turret mooring to allow 360^{o} rotation
3. Containerised control and power conversion system
4. Turbine deployment module for turbine access

SCHOTTEL HYDRO

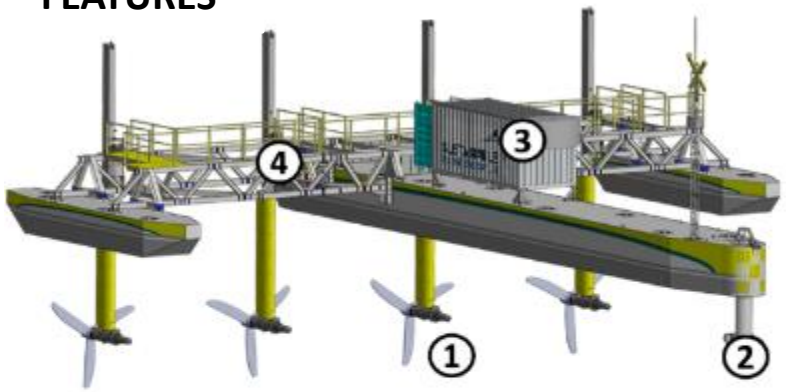
SUSTAINABLE MARINE ENERGY LTD

BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

PLAT-I Inshore Tidal Energy Platform

FEATURES



1. SIT 250 tidal turbine generators
2. Turret mooring to allow 360^{o} rotation
3. Containerised control and power conversion system
4. Turbine deployment module for turbine access

SCHOTTEL HYDRO

SUSTAINABLE MARINE ENERGY LTD

BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

Anchors & Mooring Systems

- SME has developed innovative direct embedment anchoring systems for both rock and soft seabed
- These anchors have advantages over traditional anchoring technologies such as gravity bases or drag embedment anchors. These include:
  - Extremely high holding power on rock seabed
  - Highly accurate placement on rock and soft seabed
  - Far lower material and logistical cost for installation
- In tandem installation tools have been built and demonstrated to install anchors sub-sea and in energetic environments
- SME's innovative mooring technology is also available for other marine solutions

SCHOTTEL HYDRO

SUSTAINABLE MARINE ENERGY LTD

BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

PLAT-I Inshore Tidal Energy Platform

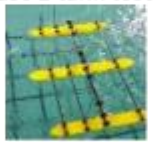
DEVELOPMENT HISTORY

Q3 2016
PLAT-I concept process begins

Comprehensive market study performed; establish key design criteria

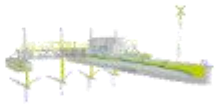
Q4 2016
Concept designs evaluated

Phase 1 tank testing



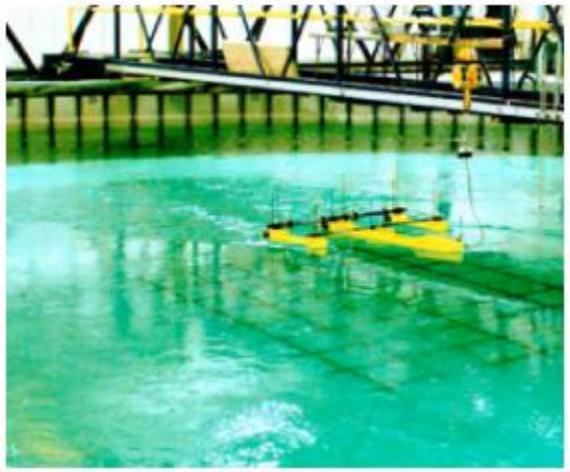
Q1 2017
Phase 2 tank testing at FloWave Edinburgh

Q2 2017
Design and costings finalised
Production begins



Q3 2017
Fabrication at JBS
SCHOTTEL delivers SITs

Q4 2017
Assembly, commissioning, and installation at Connel



Innovate UK

Scottish Enterprise

FloWave

LMC
LONDON MARINE CONSULTANTS

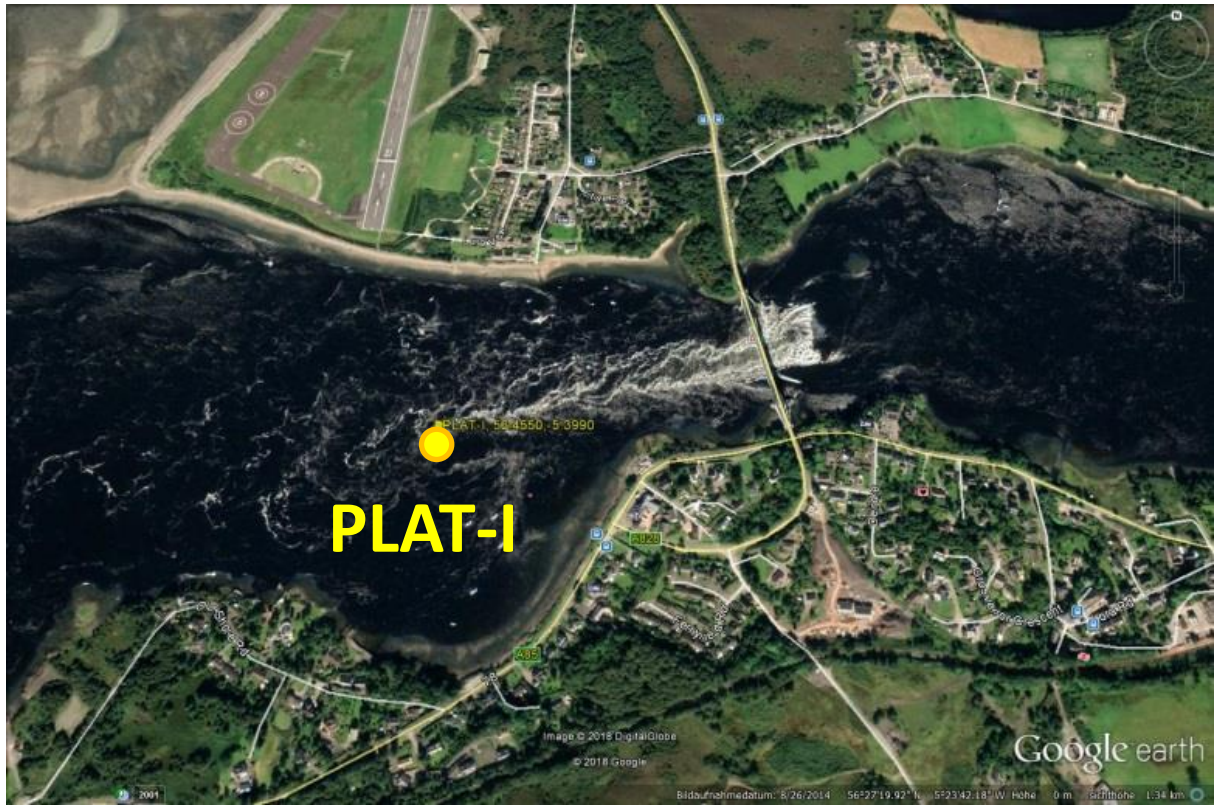
SCHOTTEL HYDRO

SUSTAINABLE MARINE ENERGY LTD

BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

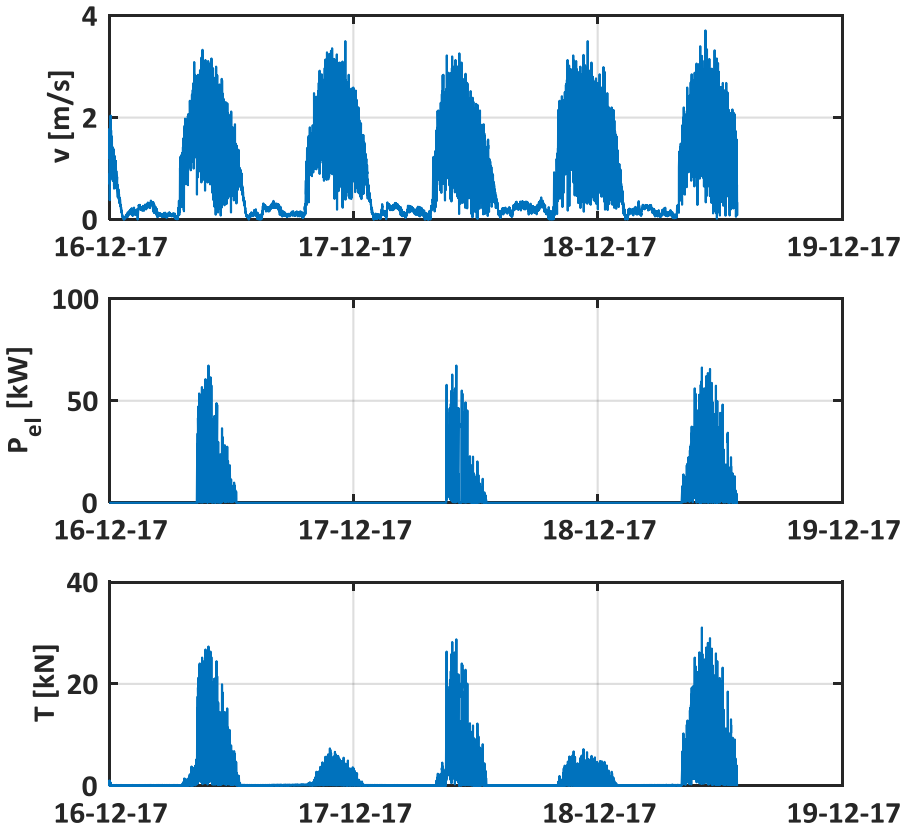
PLAT-I at Connel, Argyll & Bute, Scotland



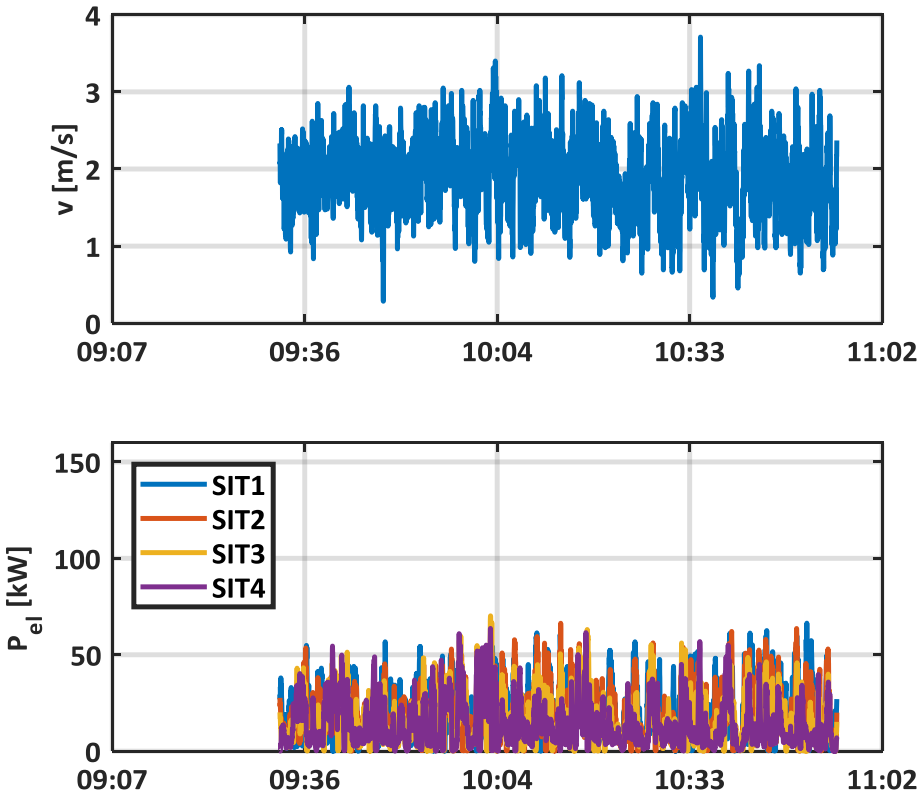
- High spatial variation
- High temporal variation (TI= 40% @ 2m/s)
- Strong ebb – weak flood

Time Series Data

Raw data (SIT 2 only)

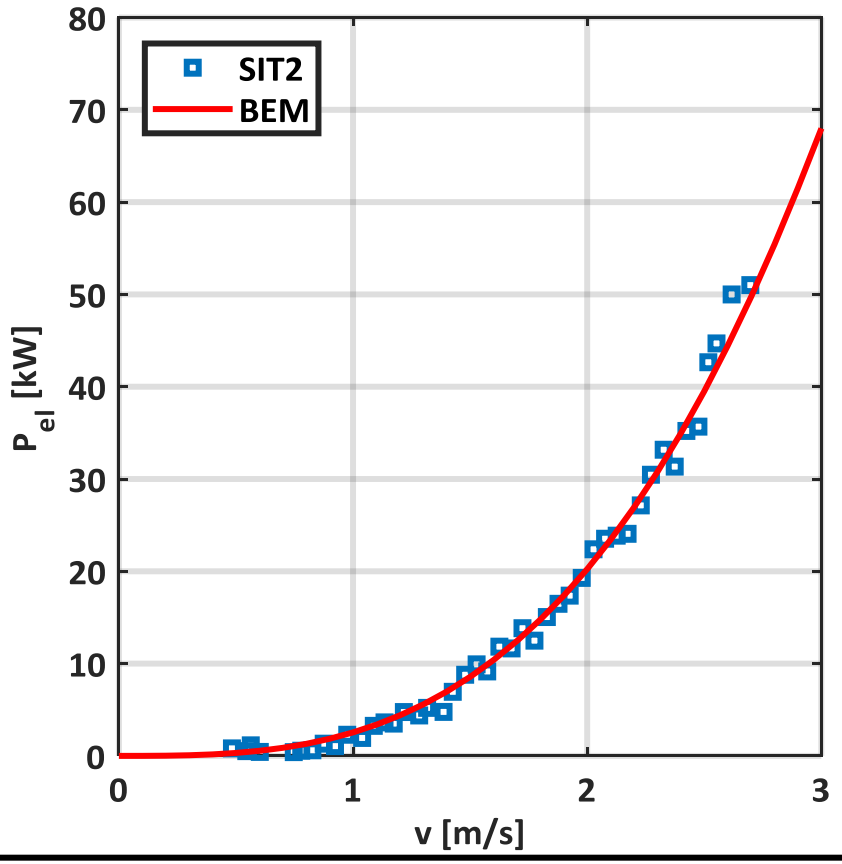


Raw data (all turbines; 19/12/2017)

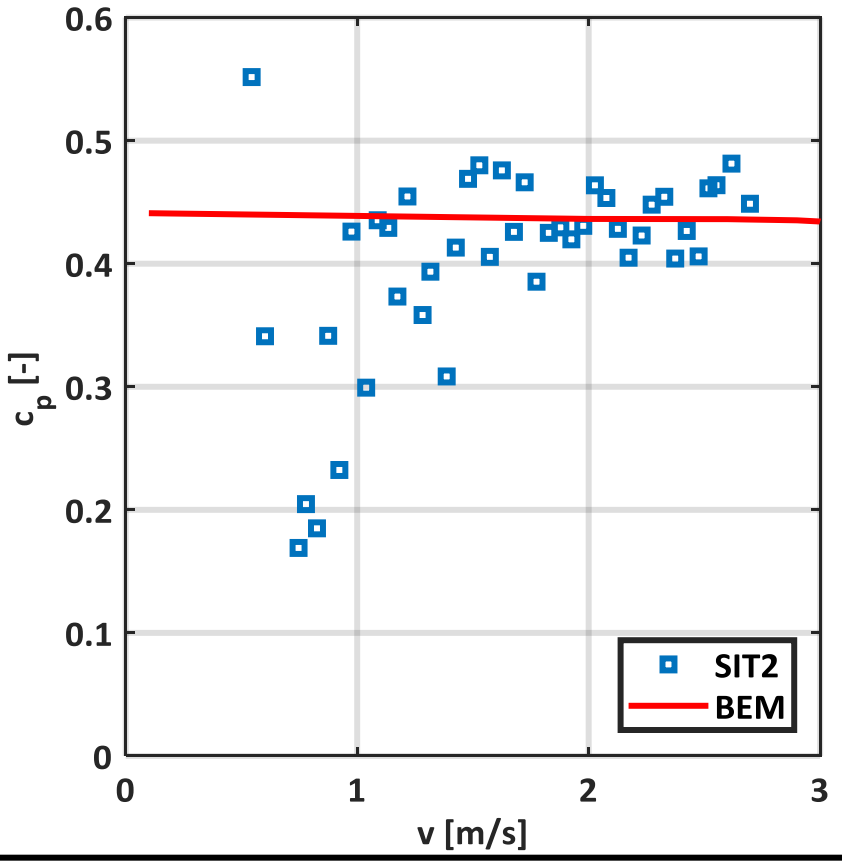


Performance Assessment – Design Validation

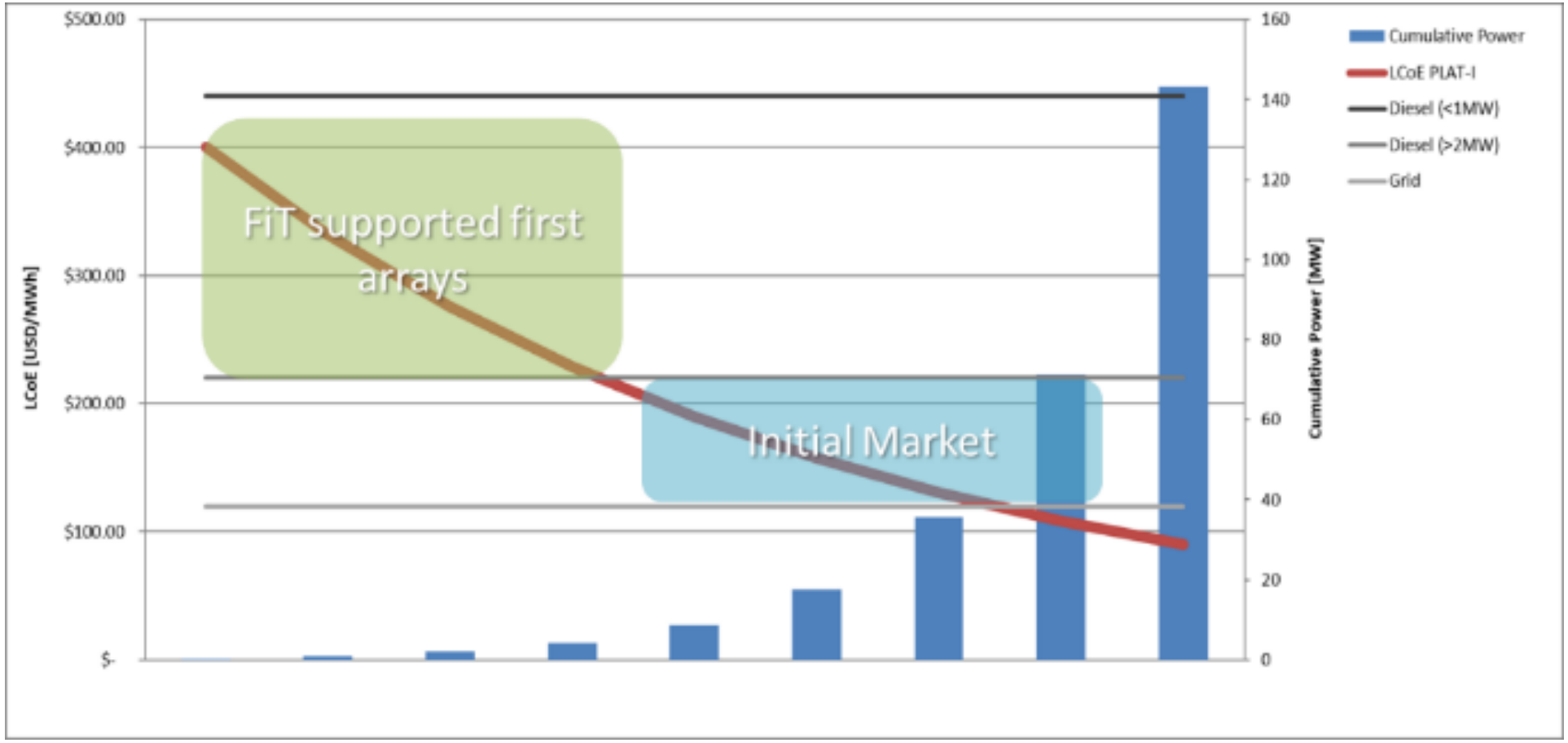
Power Curve - Comparison with Prediction



Power Coefficient Rotor



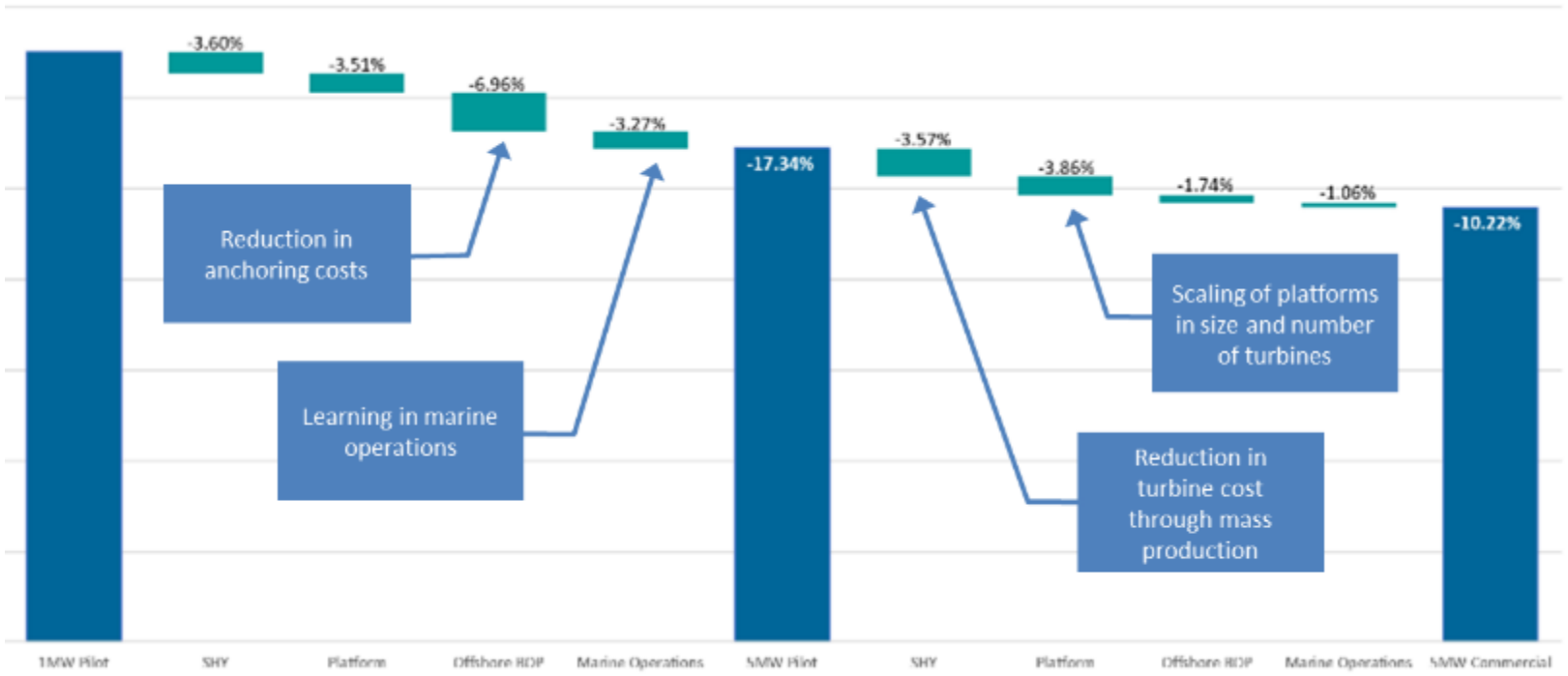
Driving down costs



- Modular systems
- Stepwise build out

- Start by addressing market for island and coastal communities
- Only incremental reductions assumed here
- Technology can compete in Off-Grid markets (2-10 MW capacity) after 10 MW had been installed

Incremental Cost Reduction



Cost reductions are incremental and achieved through learning; both in physical technology and processes, and then scaling up; in number of units produced and deployed.

SCHOTTEL HYDRO
SUSTAINABLE MARINE ENERGY LTD
BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY

Summary and Conclusions

- First demonstration projects have been crucial in creating awareness of the potential of tidal energy in the region
- Small scale and modular floating concept ideally suited to address island grid market
- Cost reduction potential while competing with diesel (below 10 MW)
- Yield and reasonable PPA crucial for first projects in SEA (in the 1 MW range)

SCHOTTEL HYDRO

SUSTAINABLE MARINE ENERGY LTD

BLACK ROCK TIDAL POWER

INTEGRATED TIDAL ENERGY