Overview of Real Scale Activities of New Uses of Ocean Space:

Renewable Energy … and beyond.

Frank Neumann
(Director Adjunto - Associate Director WavEC)
Scope: “Opean Ocean” Demo Projects

Validation Model  Scale 1:25-100
Fundamental testing in regular waves: optimisation of the geometry and validation with numerical results.

Design Model  Scale 1:10-25
Testing in realistic sea conditions: investigation of several parameters with more accurate PTO, including survival options and mooring systems.

Process Model  Scale 1:3-10
Testing in conditions representative of deployment site: initiation of sea trials; scale effects of overall performance.

Prototype  Scale 1:1-3
Large scale pilot project at sea: all components are scaled from the final project; verification of electrical quality, grid supply, performance, survival, etc.

Demonstration  Escala 1:1
Pre-production prototype: optimisation of performance, grid connection, maintenance strategies, economics.

“Projects that prove technical viability of exploring the vast potential of the open ocean”
Ocean space utilization

Wave Energy

Fishery

...priorities?
...safety distances
...co-existence?
...common aspects,
shared infrastructures & equipment?

Offshore wind

Military

Offshore Aquaculture

Marine Biomass

Oil & Gas

Tidal & other marine RE

Navigation
Open Ocean (Fish) Aquaculture

- Large-scale Open Ocean Aquaculture starts to gain significant attention (Needs > industrial fishery yielding its physical limits; onshore aquaculture complex)
- Credible commercial projects exist; proposal to built cageless farming or self-propelling cages (e.g. Ocean Drifter) – moved by marine energy??

SeaStation (Ocean Spar Technologies), USA: over 50 installations (600 to 6,000 m³; > 25m water; high current, extreme conditions)

AquaPod (Ocean Farm Technologies, USA): Modular; 400 to 11,000 m³; symmetric shape allows rotation for maintenance, etc.

HOARP Demo Projekt
Source: NOAA

OceanGlobe Konzept; Source: Byks
The Ocean: a huge energy resource

Waves

Tidal stream: energy in fast flowing tidal currents

Tidal range: energy from the difference between high and low tides

Salinity gradient: pressure differential between salt and fresh water (osmotic energy)

Ocean thermal energy conversion (OTEC): temperature differential between cold water from the deep ocean and warm surface water

Wind offshore: typically a Wind Resource, but in fact it is also a Marine Energy Resource

Hydrothermal vents

Marine Biomass: micro-algae cultures to produce bio-fuel

Frank Neumann (Associate Director WavEC)
Marine Biomass / Macro Algae (Seaweed)

- Biomass
- CO₂ mitigation
- High-value added products
- Pharmaceuticals / cosmetics
- Waste water treatment
- Genes with high utility
- Could be located outside EEZ
- Synergy potential when used together with other "new" uses (moorings, control, O&M)
- Possible by-use of wave/wind parks for seaweed cultivation → large-scale biomass harvest

South Korea: creation of 86,000 acres of offshore seaweed forests to produce up to replace up to 13 percent of petroleum consumption.

Venice/Italy: 200 M€ project announced to capture seaweed for 40 MW biofuel plant. Up to half of city’s power...

Chile: announced investment of 7 M$US for seaweed-based bio-ethanol project (BAL, Universidad de Los Lagos and ENAP) 2010/11; goal: annually 165 million litres of bio-fuel, equivalent to 5% of Chile’s petrol consumption.

Sunrise Project – "Ethanol farm " in coastal zone (left) and offshore (right); Source: Aizawa et al.

Seaweed Carrier (Seaweed Energy Solutions)

Chile: announced investment of 7 M$US for seaweed-based bio-ethanol project (BAL, Universidad de Los Lagos and ENAP) 2010/11; goal: annually 165 million litres of bio-fuel, equivalent to 5% of Chile’s petrol consumption.

South Korea: creation of 86,000 acres of offshore seaweed forests to produce up to replace up to 13 percent of petroleum consumption.

Venice/Italy: 200 M€ project announced to capture seaweed for 40 MW biofuel plant. Up to half of city’s power…
OTEC (Ocean Thermal Energy Conversion)

Western India | since 2005, for desalination purposes

Reunión: DCNS DOT P1 - 1.5MW to be built

Japan | Experimental OTEC system (30 kW)

10MW plans
Floating Offshore Wind: “unlocking” deeper waters

Hywind (Statoil Hydro, NO): 2MW Spar: operational since 2009, performance above expected

Wectop Blue H (NL) 80kW; 2MW being developed

2MW Demo plant Portugal (2011)

WindFloat Principle Power (USA)
Tidal Current | Sea Testing

- **Voith Hydro**: 110 kW in Korea; EMEC
- **Tocardo (NL)**: Commercially available.
- Rolls Royce acquired Tidal Generation Limited (TGL) in 2009. 500 kW at EMEC
- The Blue Concept (300 kW)
  Hammerfest Strom (Norway);
  1 MW device to be installed at EMEC

- **Free Flow Turbine** (6 x 30 kW)
  Verdant Power (USA)

Frank Neumann (Associate Director WavEC)
Wave Energy – Technological Diversity

- Characteristics: VARIETY (reg. conversion mechanism, moorings, …)

OWC

Oscillating Bodies

Overtopping

Foto: Ocean Energy

Foto: OPT

Quelle: Pelamis

Quelle: Wavedragon

Frank Neumann (Associate Director WavEC)
Wave Energy: ‘close to where the challenge is’

Matters: Spray / Direct wave impacts / Number of dynamic load cycles / Relationship design load / survival load...

3 different examples with common concerns! ➔
(Offshore oil&gas equipment often for different exposure AND different budgets)

OWC: vapour/droplets, high speed, turbine & auxiliaries

Source: Wave Dragon

Source: Pelamiswave
Wave Energy | Recent/Actual Sea Testing

2011: P2 750kW device in Orkney (Ocean Power Technologies; 150kW)

2011: installing 800kW Oyster2 after 300kW Oyster1 testing

WaveRoller 300kW demo unit to be installed in Peniche/Portugal

CETO (AU): 1:2 tests under way

2011: Wello 500kW in EMEC

August 2011: a “First” in Orkney - 3 wave devices ready to deploy
Wave Energy – Why look so far if the good is nearby?

The Pico OWC (Azores, PT): old project, new spirit

First EC-funded wave power plant; difficulties in implementation (1996 – 2002)

Proof of Technology | Sept-Dec. 2010 autonomous (2010: > 1400h operational)

Actual Developments | 2011 stabilisation of operation; open test bed creation

Structural damage – needs repair

O&M annual 50~100k€

Thank you.