Utilizing Wave Energy

potential, challenges and status

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Publication date:
2012

Document Version
Accepted author manuscript, peer reviewed version

Utilizing wave energy
- Potential, challenges and status

by

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Department of Civil Engineering
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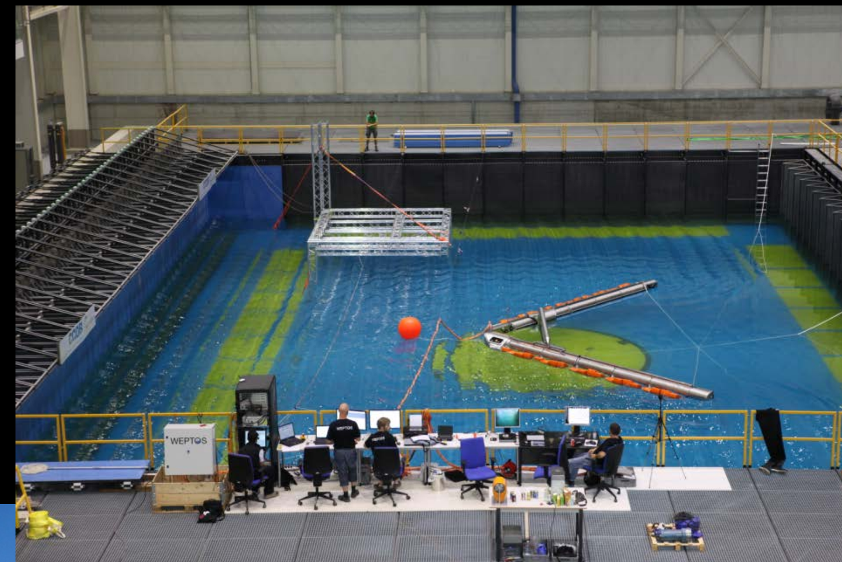
PhD Master Class
CoastLab 2012
16.09.2012

A little bit about me!

- M.Sc. in civil eng., specializing in coastal/offshore, from Aalborg University i 1997
- Have been working at Aalborg University, Dept. of Civil Eng. since then, but also at Rambøll (Aalborg, Ports)
- Ph. D., jan. 2003
- Participation in numerous WE projects both on wave lab. and field tests (Wave Dragon, SSG, DEXA, LEANCON, Wave Star, Weptos …)
- Head of the Wave Energy Research Group



Wave Energy Research Group

At Aalborg University,
  Department of Civil Engineering,
  Division of Water & Soil

- Staff: 10-15
- Profile:
  - Waves, Mechanics,
  - Hydro Dynamics, Control
- Experimentiel testing in lab. and at sea
- 2x 3-D wave tanks, wave and current flumes
- Key operator in Nissum Bredning
- Instrumentation for measuring “anything” ☺
- Numerical modelling

Wave Energy Research Group

- Have been involved in more than 40+ concepts/projects over the past 12-14 years
- Partner in 4 ongoing EU financed projects
- Involved in all primary Danish, and numerous international, concept developments within the sector
- National and international standardization efforts
- Teaching, courses (Ph.D./external)

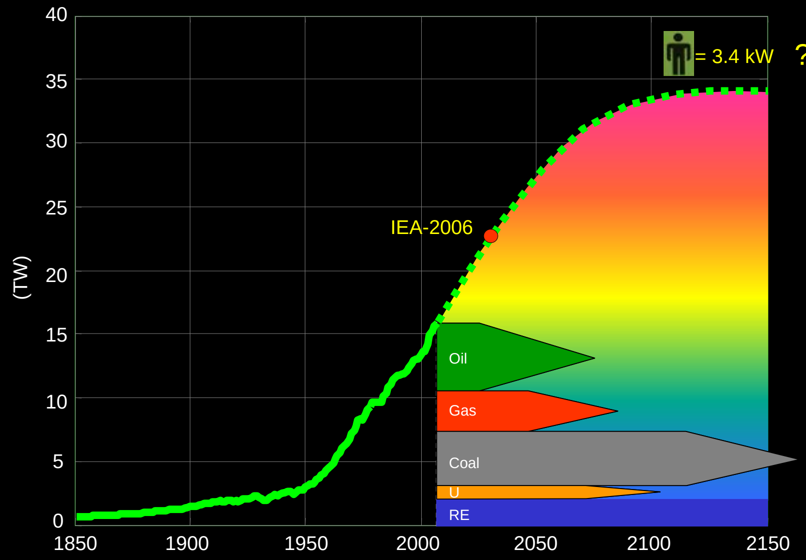
Subjects

- Why wave energy?
- Potential
- International cooperation
- Technologies
- What’s ”hot” right now?

Why wave energy?

As with other renewable energy sources:

- Climate change (CO_2 problem)
- The finite ressource of fussil fuels (oil, coal, gas, uranium)
- Security of supply – political stability
- Jobs



Never say never

1974, Risø report:

"Vindenergi vil aldrig kunne bidrage væsentligt til elproduktionen i Danmark"

"Vindenergi vil aldrig blive rentabelt"

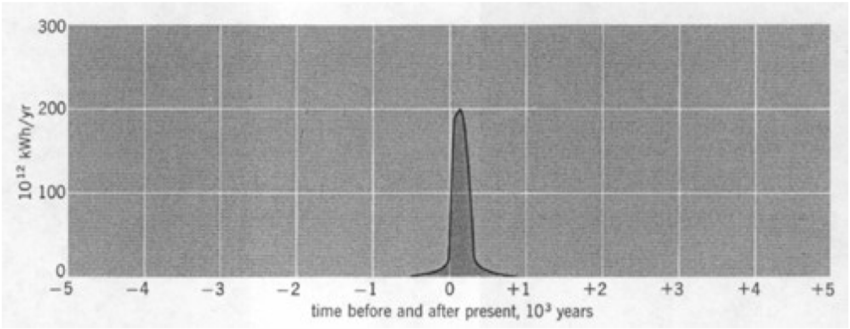
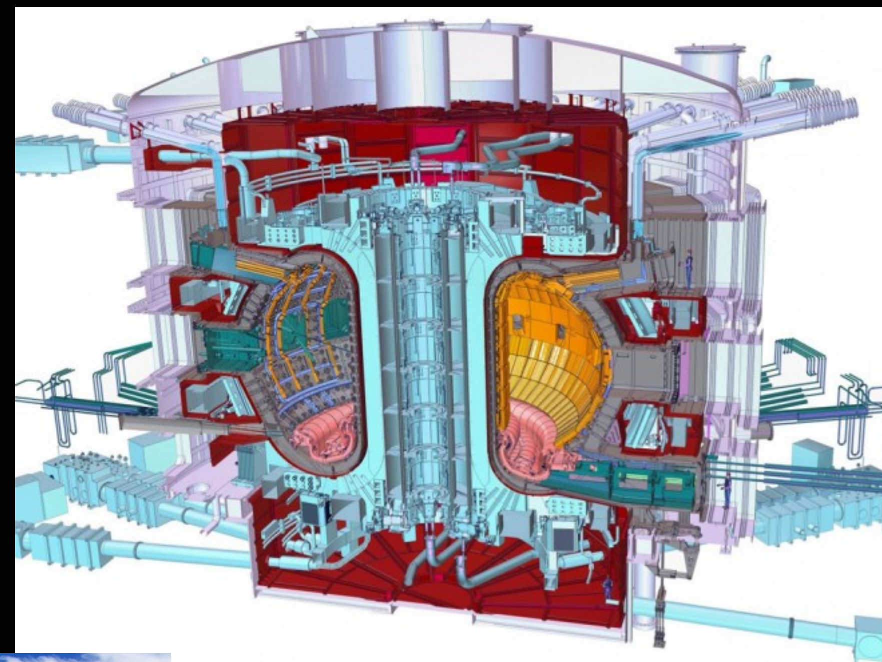


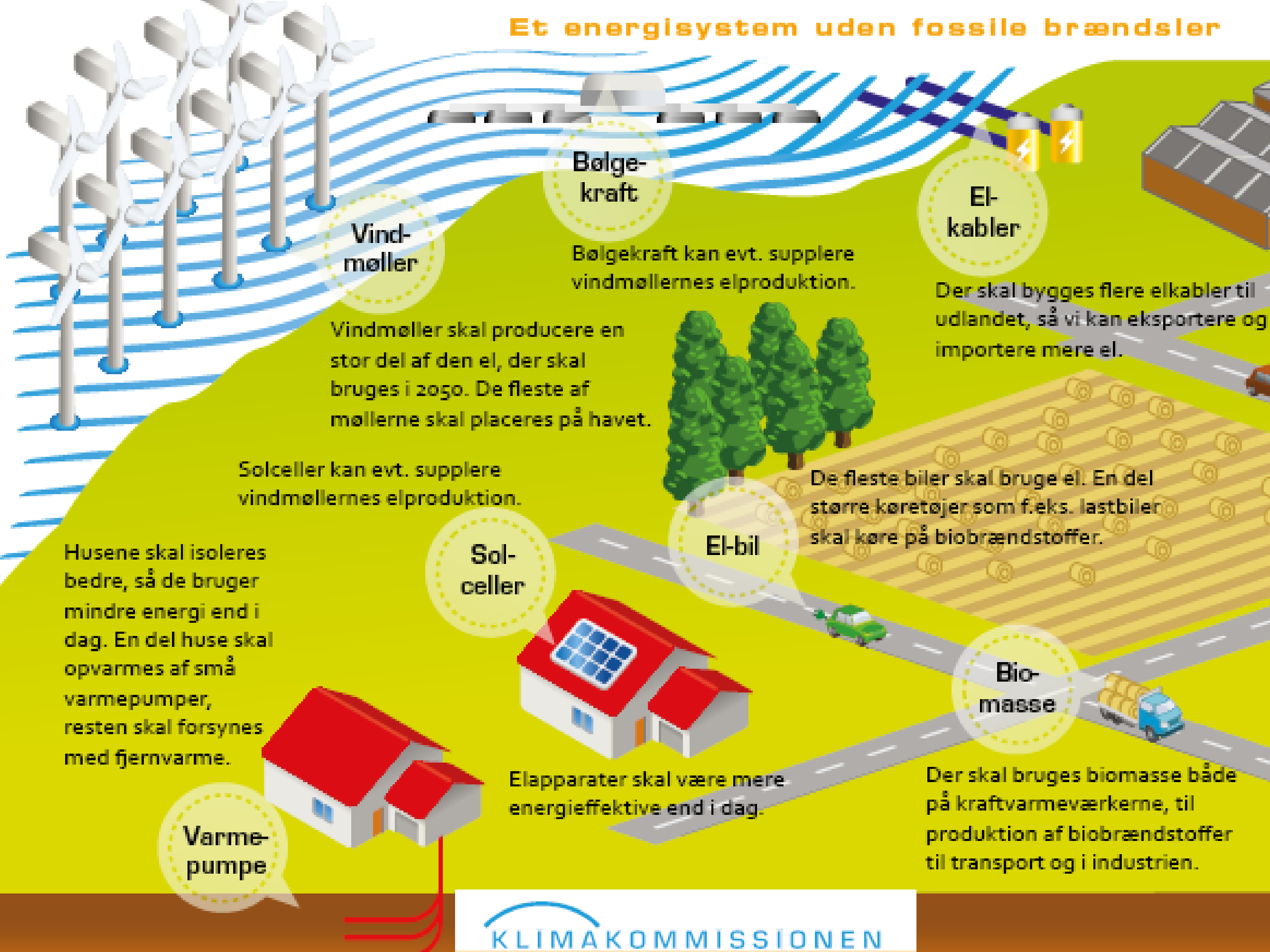
Fig. 19: The epoch of fossil-fuel exploitation as it appears on a time scale of human history ranging from 5000 years ago to 5000 years into the future. (From Hubbert, op. cit., 1974)

What are the options?

- Nuclear Fission/Fusion
- Renewable energy



http://www.ted.com/talks/amory_lovins_a_50_year_plan_for_energy.html

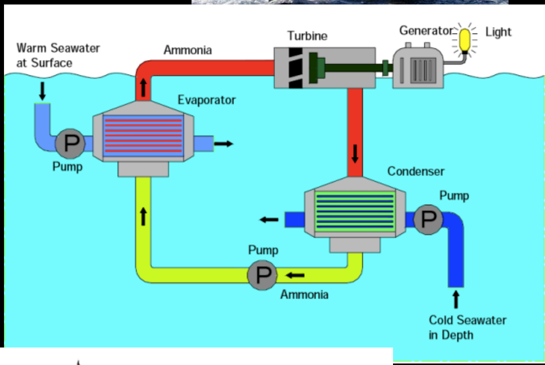

Et energisystem uden fossile brændsler
Vind-møller
Vindmøller skal producere en stor del af den el, der skal bruges i 2050. De fleste af møllerne skal placeres på havet.
Bølge-kraft
Bølgekraft kan evt. supplere vindmøllernes elproduktion.
El-kabler
Der skal bygges flere elkabler til udlandet, så vi kan eksportere og importere mere el.
Solceller kan evt. supplere vindmøllernes elproduktion.
Sol-celler
El-bil
De fleste biler skal bruge el. En del større køretøjer som f.eks. lastbiler skal køre på biobrændstoffer.
Husene skal isoleres bedre, så de bruger mindre energi end i dag. En del huse skal opvarmes af små varmepumper, resten skal forsynes med fjernvarme.
Bio-masse
Elapparater skal være mere energieffektive end i dag.
Der skal bruges biomasse både på kraftvarmeværkerne, til produktion af biobrændstoffer til transport og i industrien.
Varme-pumpe
KLIMAKOMMISSIONEN

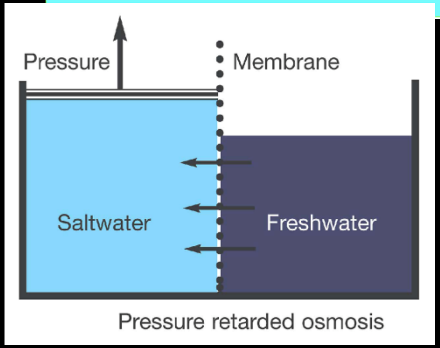
Potential ocean energy worldwide

Wave – 3 (1-10) TW (3×10^{12} W)
Ocean currents – 0,05 TW
Tidal currents – 0,2 TW
Temperature gradient – 3,8 TW
Osmose / salinity – 2,3 TW

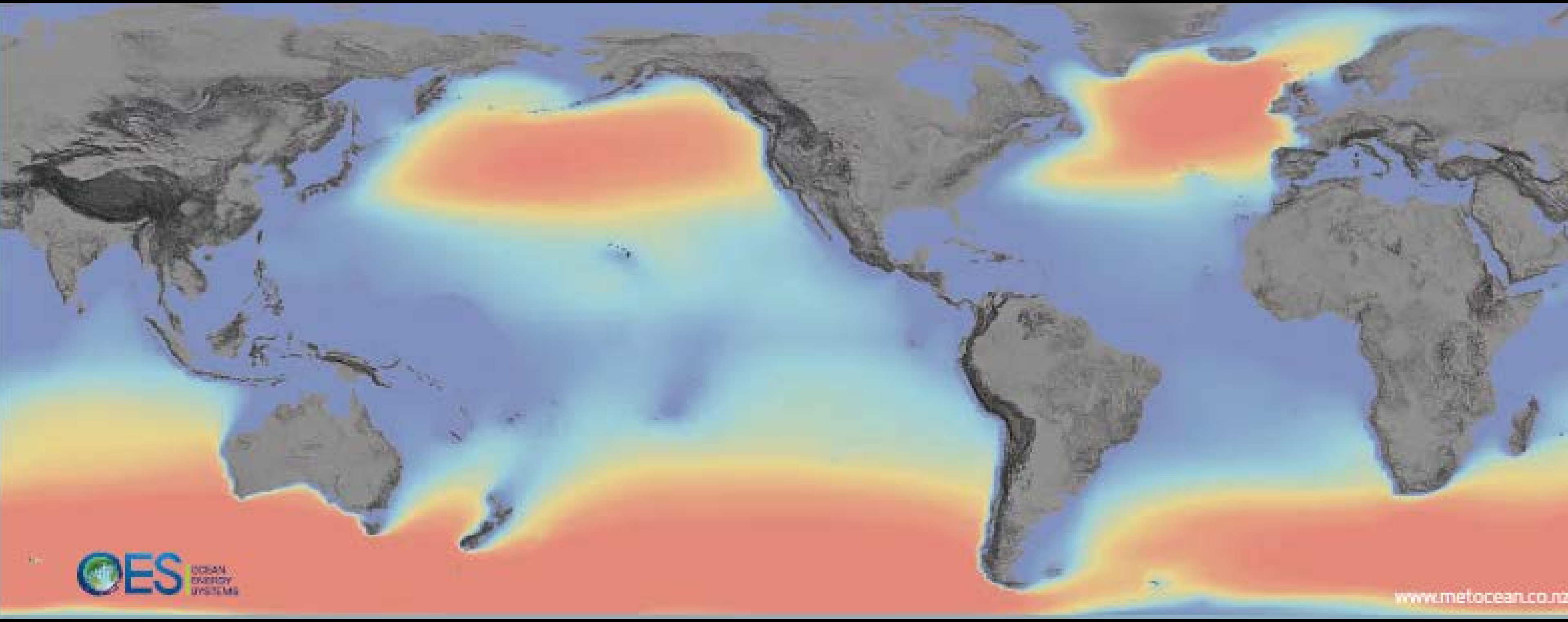
Global energy needs~ 15 TW
(140×10^{12} kWh/year)
(2005)

Note: Global solar energy: 120.000 TW
- ca. 8.000 times world consumption!

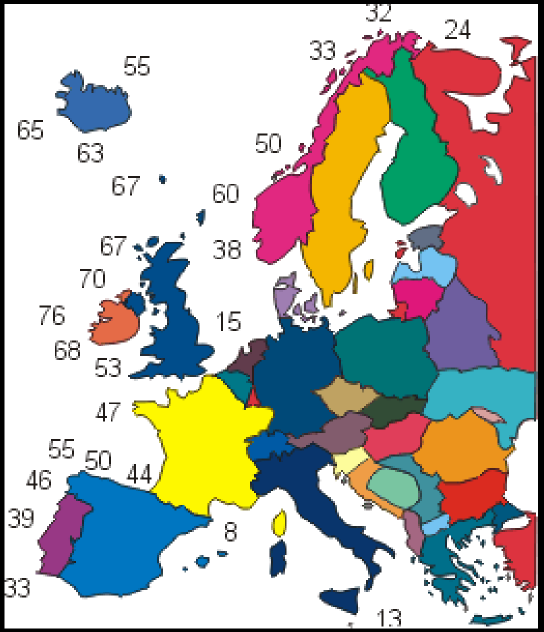




Wave energy worldwide



Potential wave energy in Europe



Denmark's electricity consumption: 3,7 GW

Danish West coast (offshore):

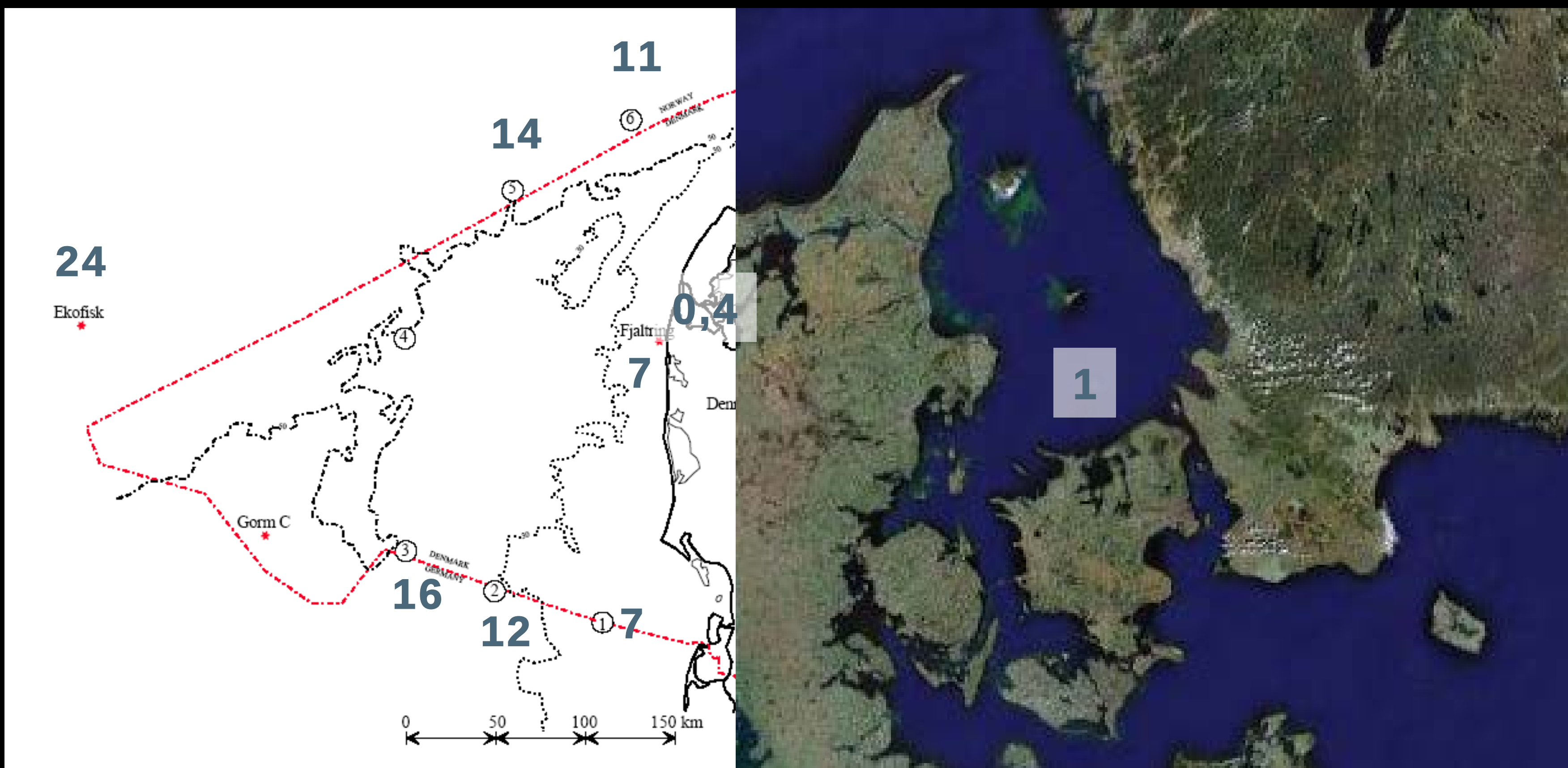
- Up to 25 MW/km
- averagely 16 MW/km
- Around 150 km from the coast
  ~ 2,4 GW

In the European Atlantic/North Sea coasts:
25 - 75 MW/km

Mediterranean sea: 4 - 11 MW/km

Total potential on European coasts: ca. 320 GW

Potential wave energy in Denmark



An example


Ressourceopgørelse for bølgekraft i Danmark

J. P. Kofoed

Carried out under contract for:

Klimakommissionen
Sekretariatet
Energistyrelsen
Amaliegade 44
1256 København K

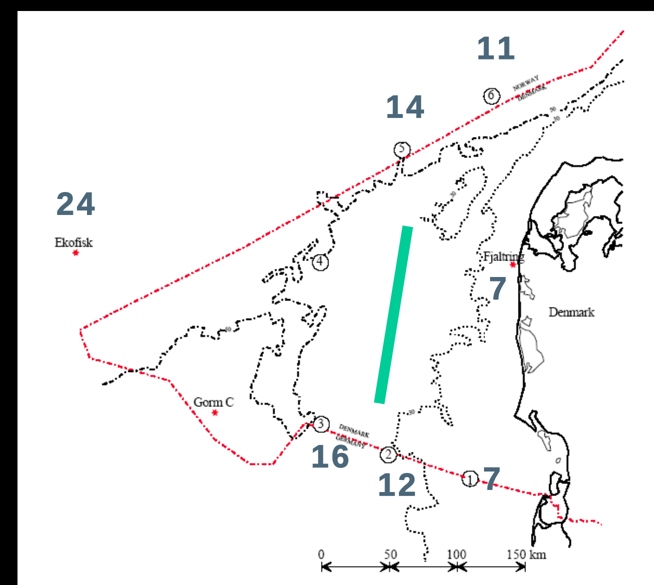
KLIMAKOMMISSIONEN

AALBORG UNIVERSITY
Department of Civil Engineering

DCE Contract Report No. XX

IDA2030:

- Wave power delivers 5 % of DK electricity consumption (35 TWh/y) through 500 MW installed WEC capacity.
- Assumptions:
  - 40 % load factor
  - 10 % overall efficiency (farm layout)
  - 15 MW/km average available wave power
- Result:
  - Use of 133 km



The Danish Wave Energy Program 1998 - 2002

A quite ”wide” development strategy

Projects carried out during a 4 years period:

- 40 – 50 inital phase, simple model testing (Phase 1)
- ~10 further R&D (Phase 2)
- 1 real sea testing (Phase 3)

Roughly half of all of the projects were carried at DCE, AAU

Total budget for the program was €5.4 mill

Staged development

Classification into 4 phases:

- Each phase should provide specific valuable information to inventor and investors, before going to the next step
- Avoid spending too much resources before having a reliable estimate on the concepts potential

Definition of phases:

- Phase 1: Proof of Concept
- Phase 2: Detailed investigations
- Phase 3: Real sea testing, at smaller scale
- Phase 4: Demonstration in half to full scale

IEA-OES http://www.ocean-energy-systems.org/

OES Collaborative Research Projects

Task 1
Review, Exchange and Dissemination of Information on Ocean Energy Systems - ACTIVE
Operating Agent: Wave Energy Centre - Portugal
Duration: From 2001

Task 2
Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems - CONCLUDED
Operating Agent: Ramboll - Denmark
Duration: 2002-2009

Task 3
Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids - CONCLUDED
Operating Agent: Powertech Labs - Canada
Duration:2007 - 2010

Task 4
Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems - ACTIVE
Operating Agent: Department of Energy - USA Duration: 2009 - 2011

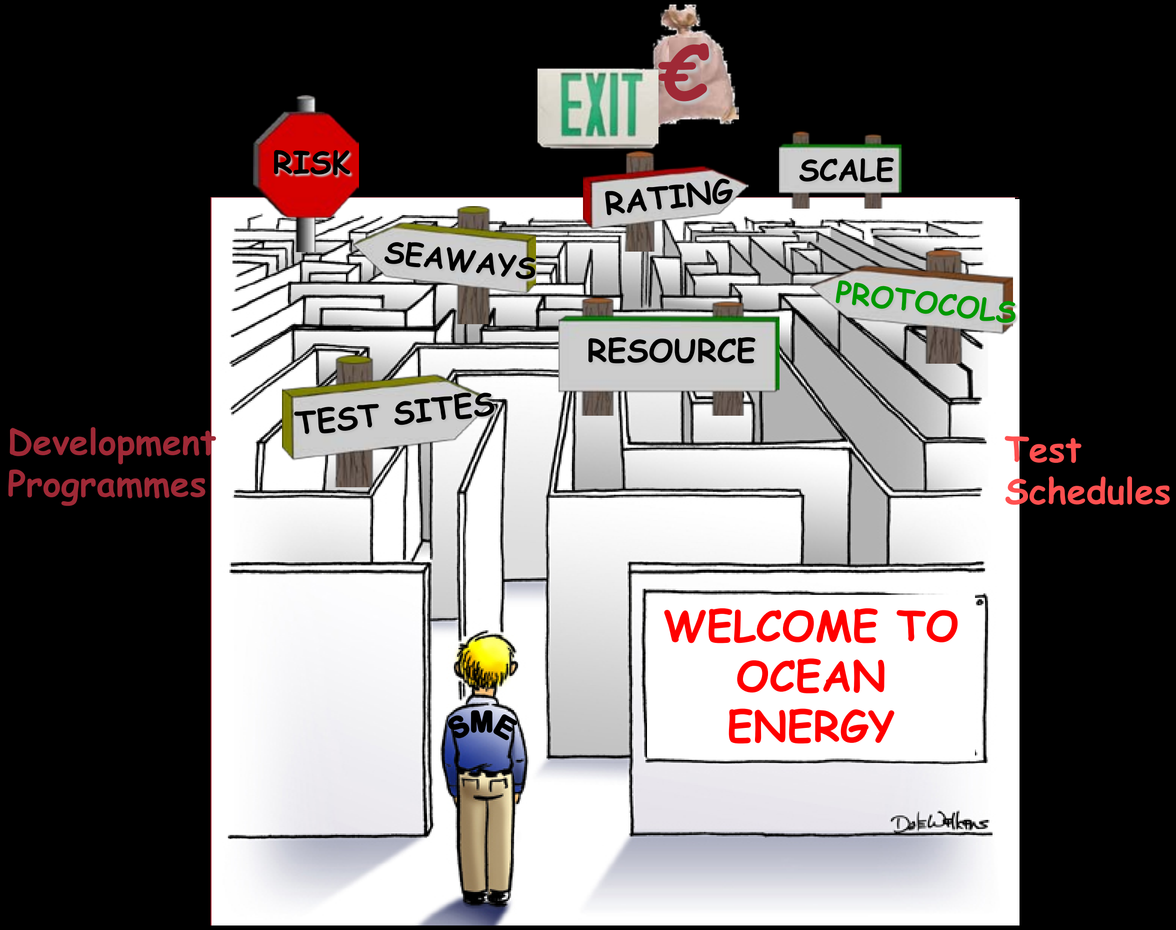
Task 5
The Exchange and Assessment of Ocean Energy Device Project Information and Experience - NEW
Operating Agent: Department of Energy - USA Duration: 2012 - 2014

OES Members

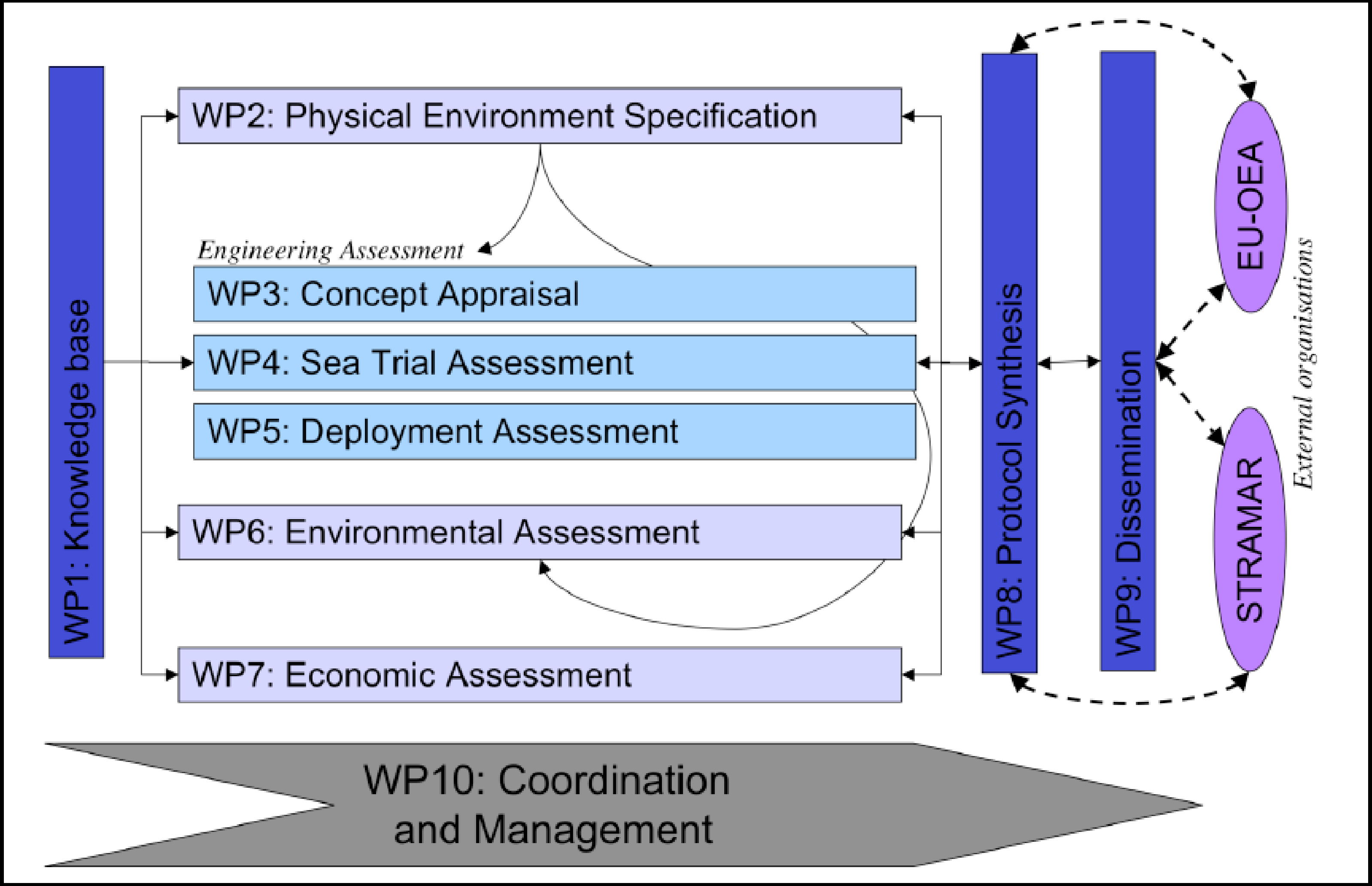
2001	Denmark
	Portugal
	United Kingdom
2002	Ireland
	Japan
2003	Canada
2005	USA
2006	Belgium
2007	Germany
	Mexico
	Norway
2008	Spain
	Italy
	New Zealand
	Sweden
2009	Australia
2010	Korea
	South Africa
2011	China

EquiMar

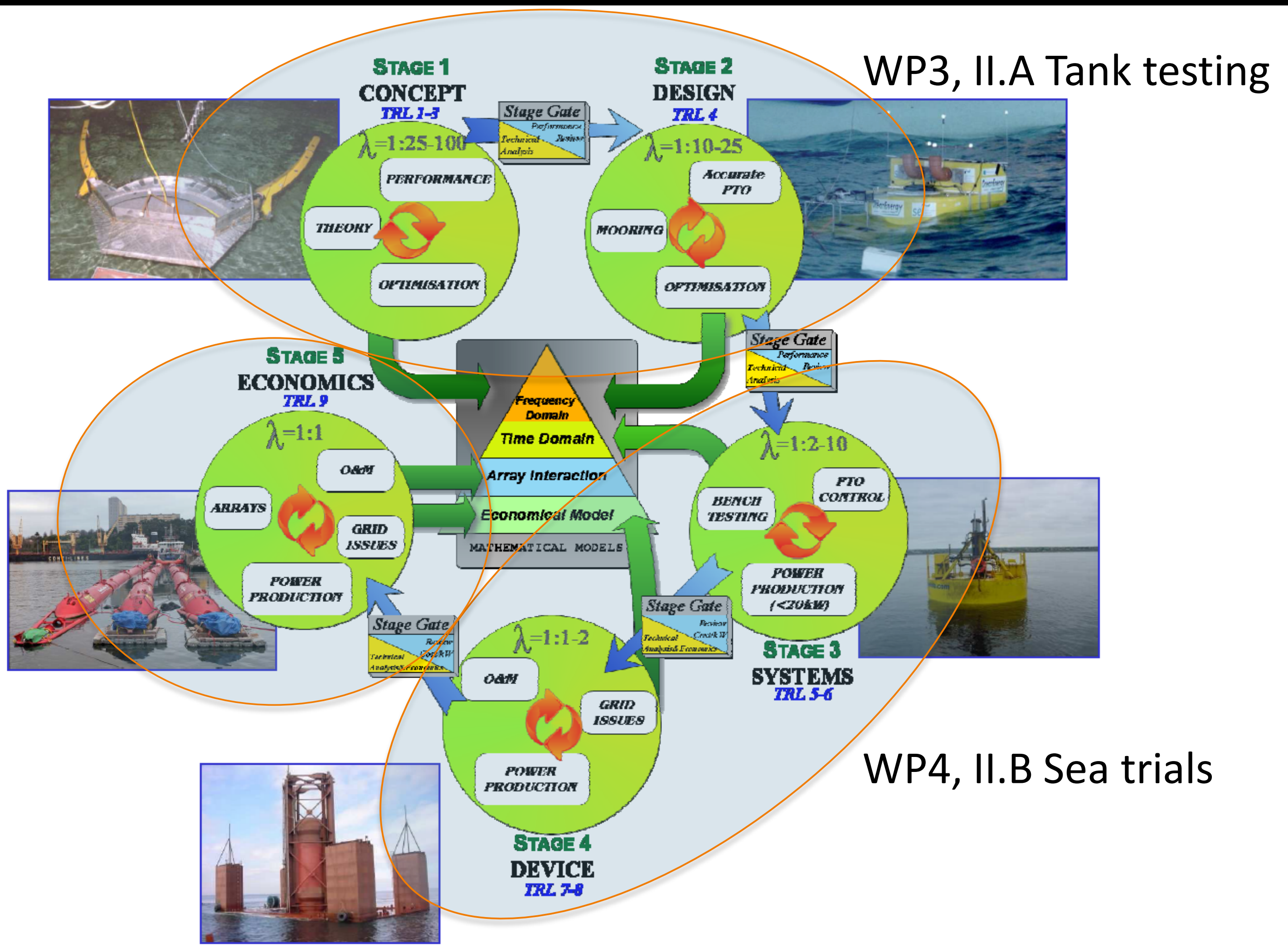
Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact



EquiMar – Work packages



EquiMar – Staged development



EquiMar – Co-operation

Connecting other documents and ***filling in*** the details

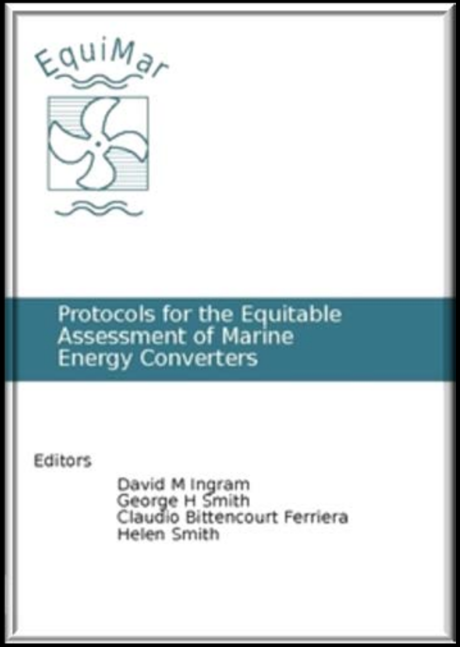
U.S. DEPARTMENT OF ENERGY

Waveplam

SUPERGEN MARINE

EquiMar –
Online resources

Project website: www.equimar.org
Project wiki (download af PDF’er): www.wiki.ed.ac.uk/display/EquiMarwiki/EquiMar
Print-to-order hardcopy of Final protocols: http://www.lulu.com/product/paperback/protocols-for-the-equitable-assessment-of-marine-energy-converters/15675151
Youtube videos: www.youtube.com/user/EquimarVid



IEC TC 114 – Marine energy
- Wave, tidal and other water current converters

http://www.iec.ch/dyn/www/f?p=103:7:0::::FSP_ORG_ID:1316

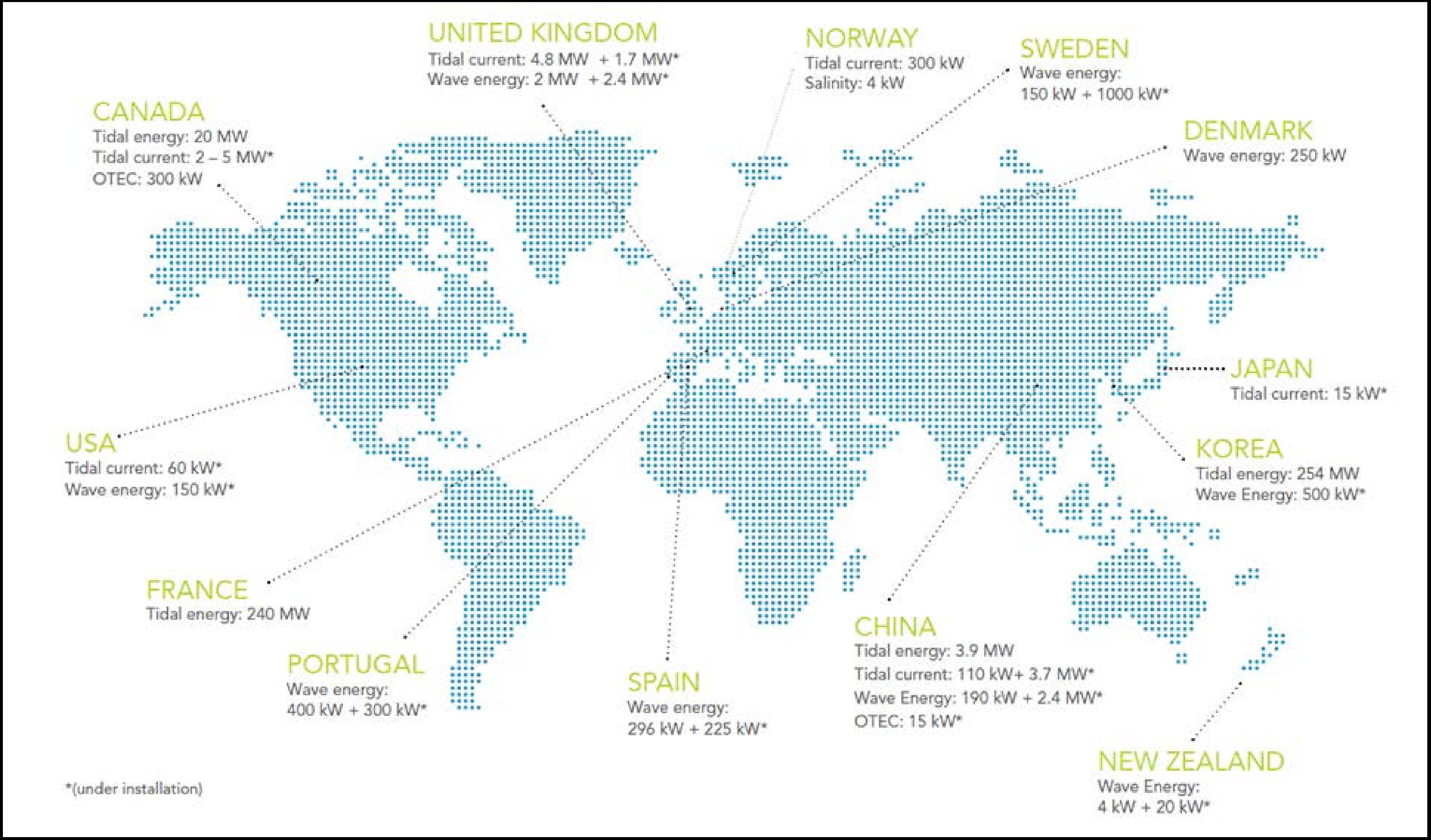
Project Team	Title	Convener
PT62600-1	Terminology	Mr. Ghanashyam Ranjitkar (CA)
PT62600-2	Design requirements for marine energy systems	Dr Robert Paasch (Interim) (US)
PT62600-10	Assessment of mooring system for marine energy converters	Mr. Mann-Eung Kim (KR)
PT62600-20	Guideline for design assessment of Ocean Thermal Energy Conversion (OTEC) system	Mr. Mann-Eung Kim (KR)
PT62600-30	Electrical power quality requirements for wave, tidal and other water current energy converters	Mr. Mohamed E. El-Hawary (CA)
PT62600-100	Power performance assessment of electricity producing wave energy converters	Mr. Emil David Tietje, III, P.E. (US)
PT62600-101	Wave energy resource assessment and characterization	Mr. Matt Folley (GB)
PT62600-102	Wave energy converter power performance assessment at a second location using measured assessment data	Mr. Kim Nielsen (DK)
PT62600-200	Power performance assessment of electricity producing tidal energy converters	Mr. Henry Jeffrey (GB)
PT62600-201	Tidal energy resource assessment and characterization	Mr. Andy Baldock (GB)

National 'mirror' committee DS S-614

Member based:

- **DONG Energy Power A/S**
- **Aalborg Universitet**
- **Wave Star Energy A/S**
- **Bølgekraftforeningen**
- **Sterndorff Engineering**

Ocean energy – Installed capacity 2011



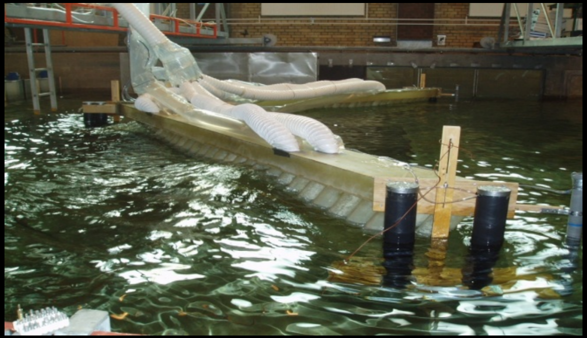
In Europe

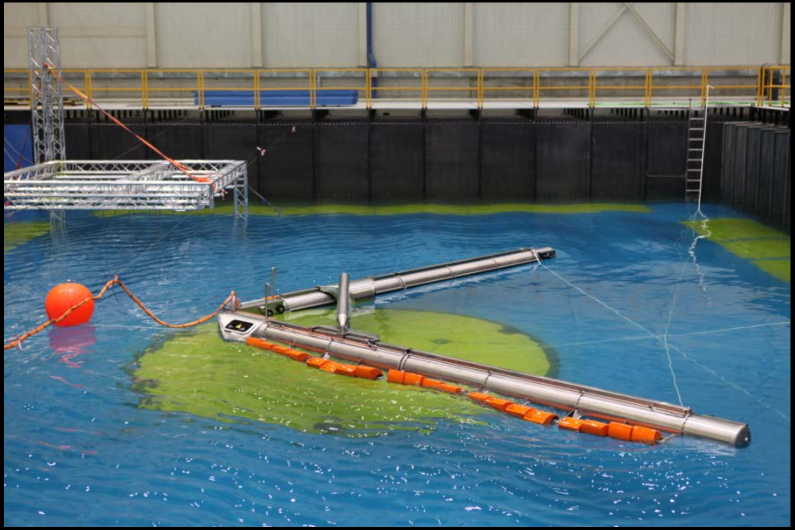


	Wave Power	
2011	Status kW	Target 2020 MW
UK	2000	
Ireland		500
France		200
Portugal	400	300
Spain	300	100
Sweden	150	
Denmark	250	




Examples of Danish wave energy concepts

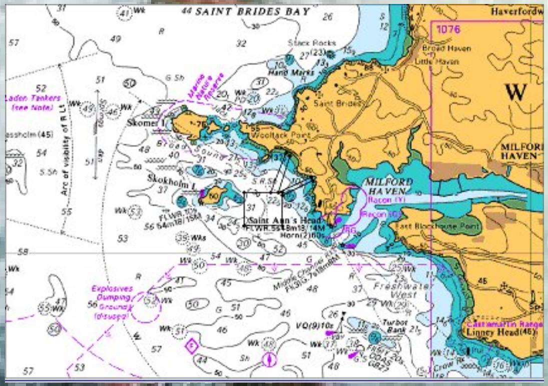




Wave Dragon

- a slack moored wave energy device of the overtopping type

Full production unit near Wales



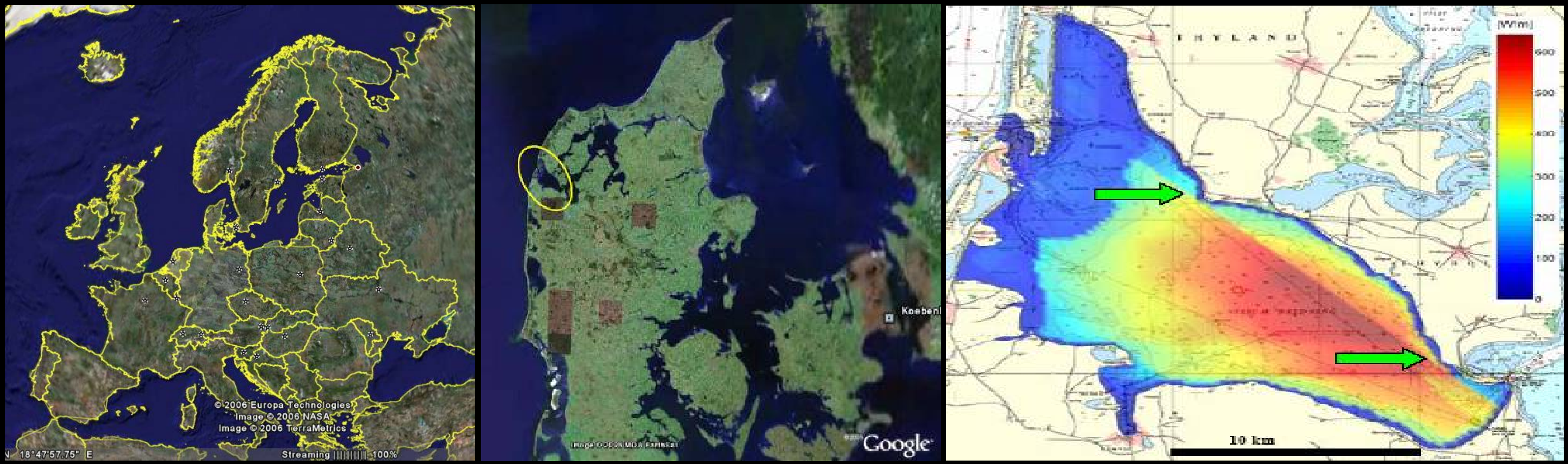
1:4.5 Protoype in Nissum Bredning

1:50 Model in Wave Tank

Prototype Test Location

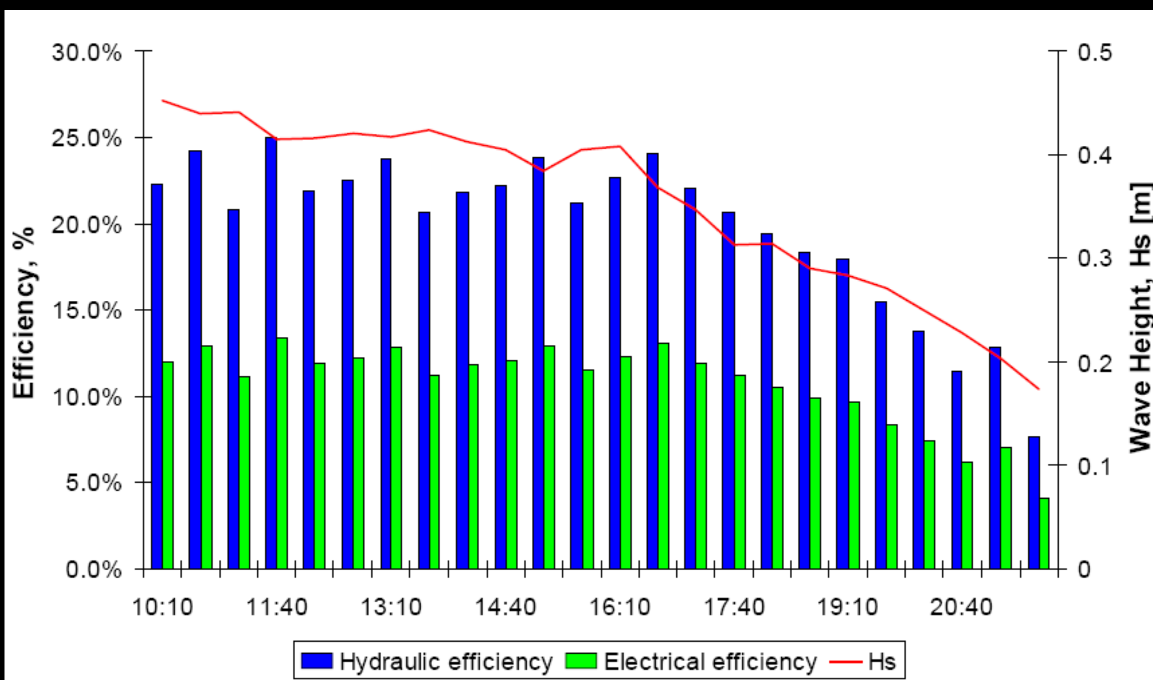
Nissum Bredning

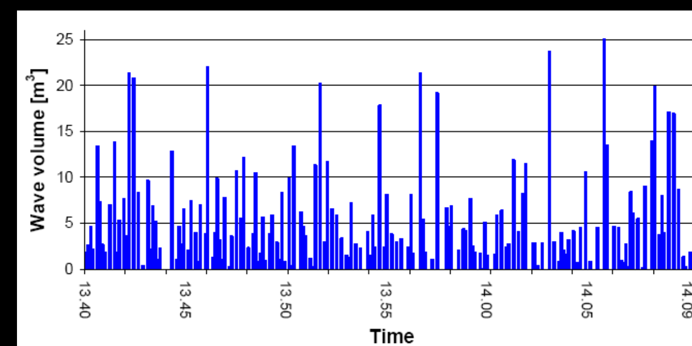
- A benign site in Northern Denmark

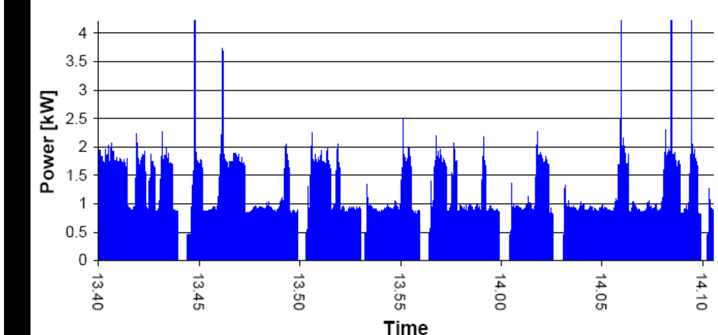


- 1:4.5 scale (compared DK North Sea) prototype in situ at Test Site 1, 2003 – 2005
- Grid connected, Full control system, Highly instrumented

Example of Time Series

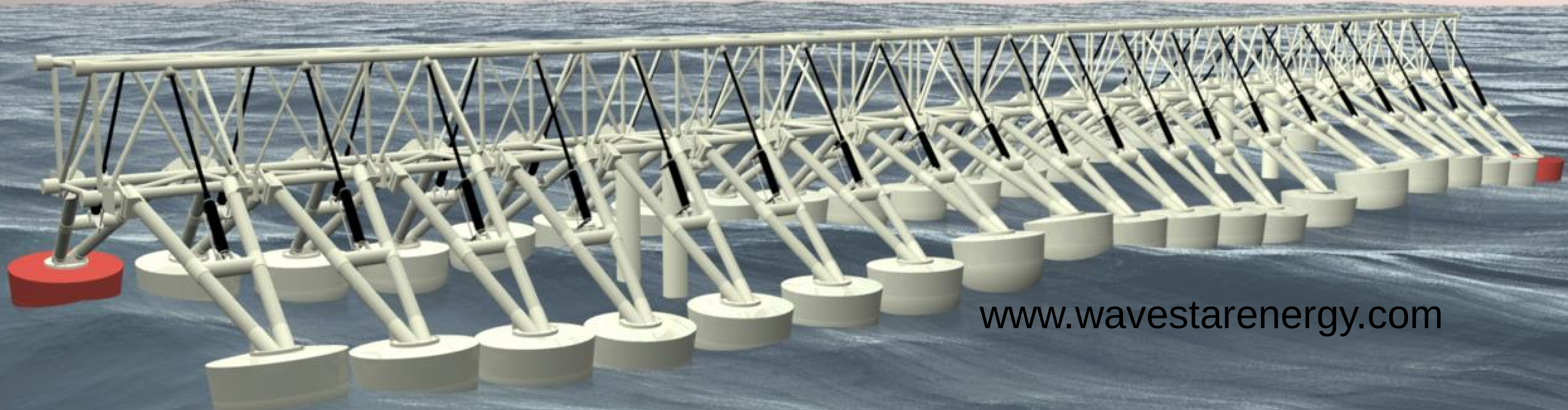






The wave energy converter *Wave Star*

A multi point absorber system

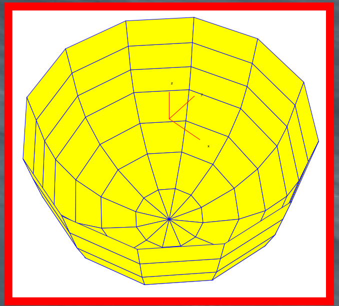


www.wavestarenergy.com

Scale 1:10 testing in Nissum Bredning

Scale 1:40 testing at AAU

Numerical modelling



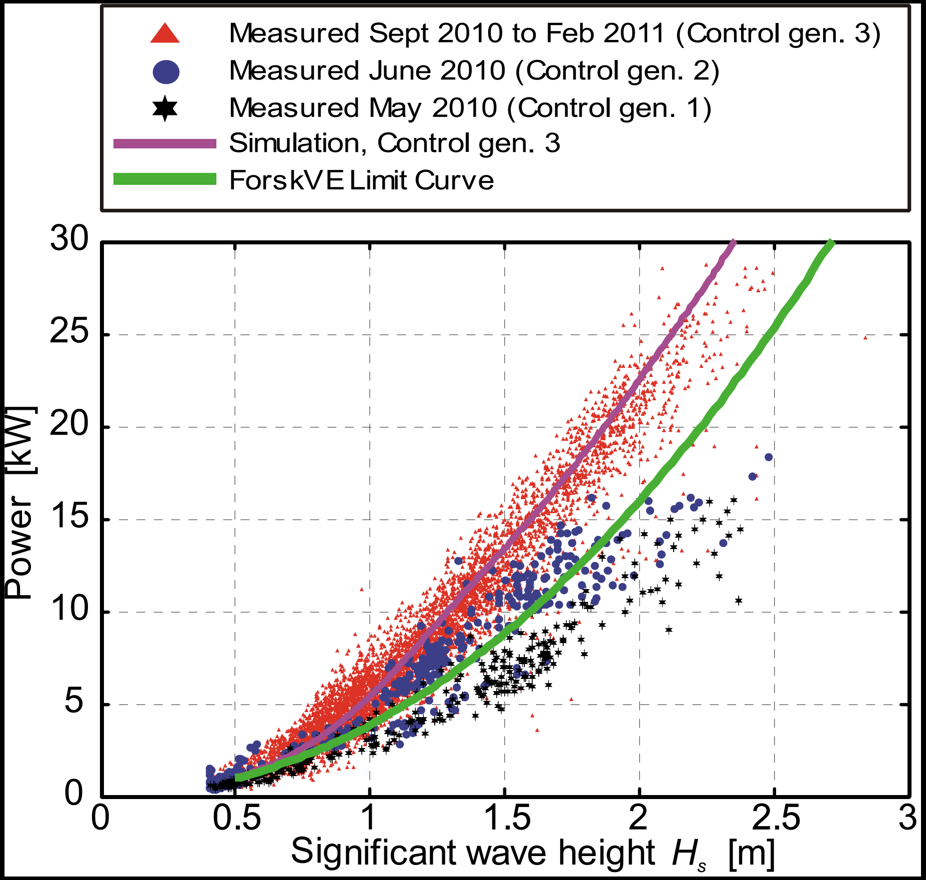
Scale 1:10 Real Sea Tests in Nissum Bredning


WAVE STAR ENERGY
WAVE STAR ENERGY

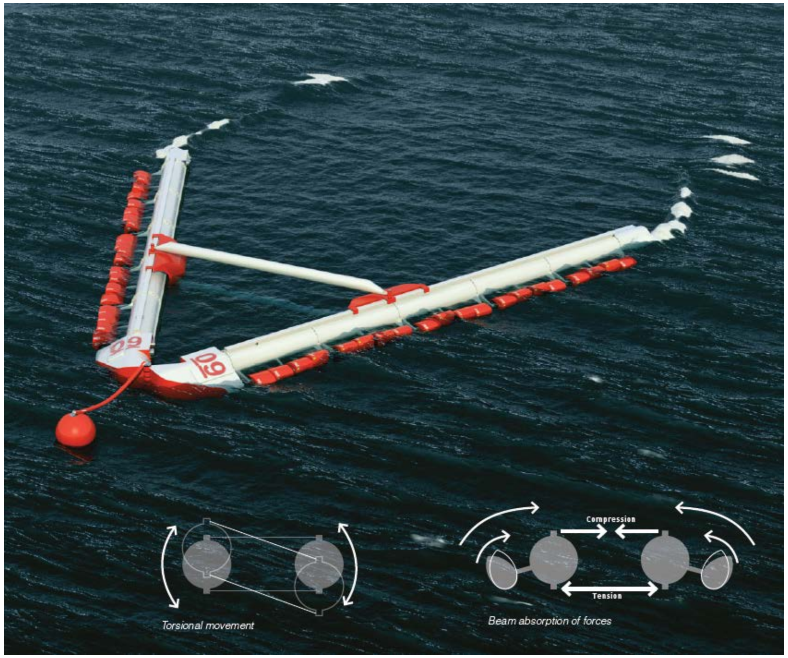
Power measurements from Roshage test unit

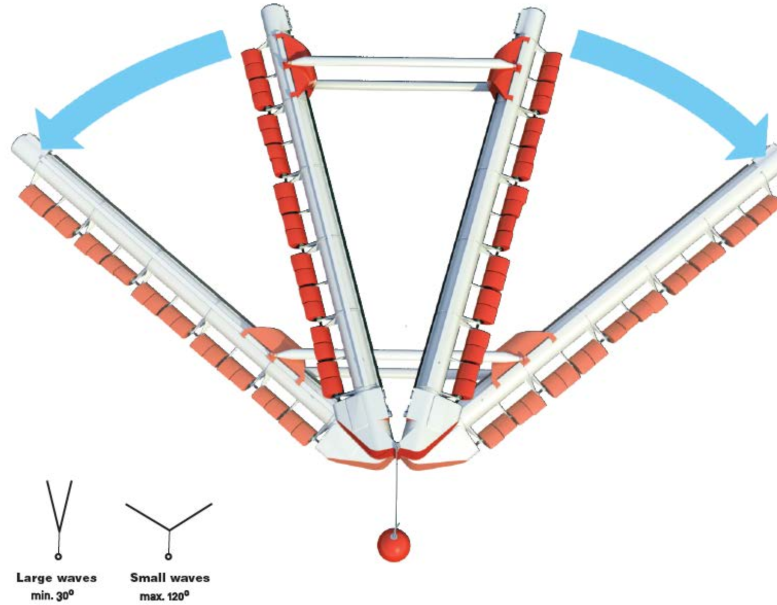
Notes:
• Power is 10 minute average values of harvested power from one float (hydraulic power leaving one cylinder)
•A typical wave period for the Roshage location is used for the simulated curve

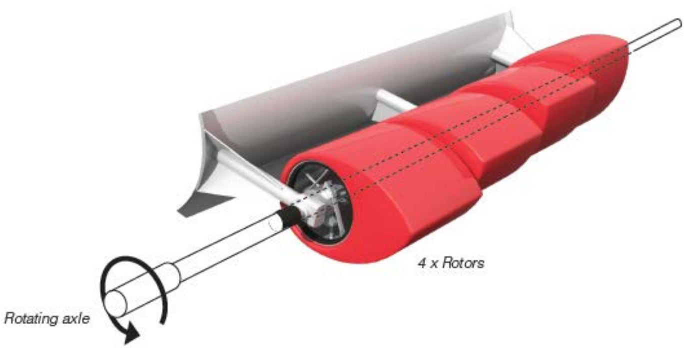
•Online data at http://wavestarenergy.com/concept

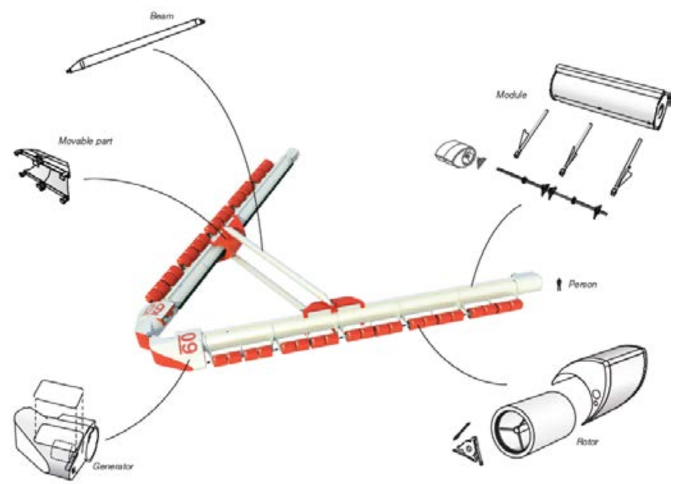



WEPTOS™
Innovating in Wave Energy


Compression
Tension
Torsional movement
Beam absorption of forces


Large waves
min. 30°
Small waves
max. 120°


4 x Rotors
Rotating axle

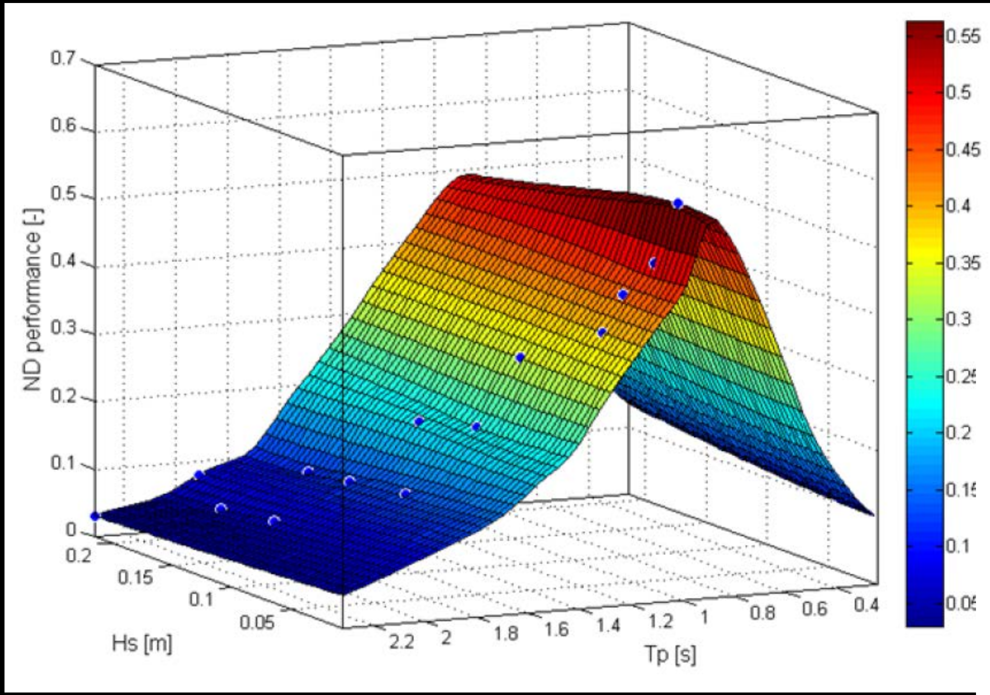

Beam
Module
Movable part
Person
Generator
Rotor

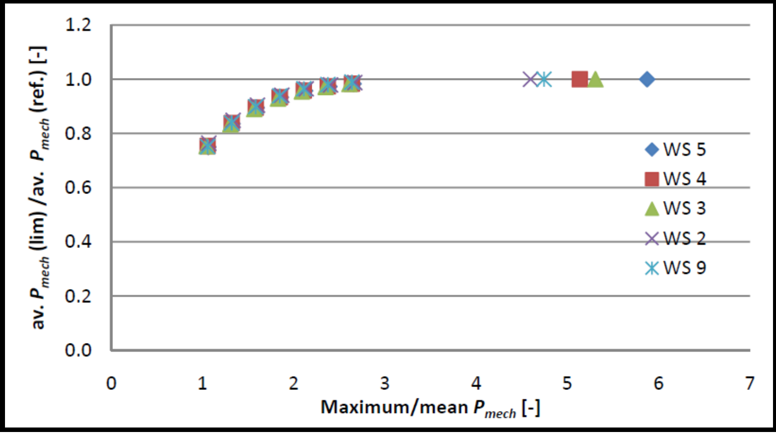

WEPTOS

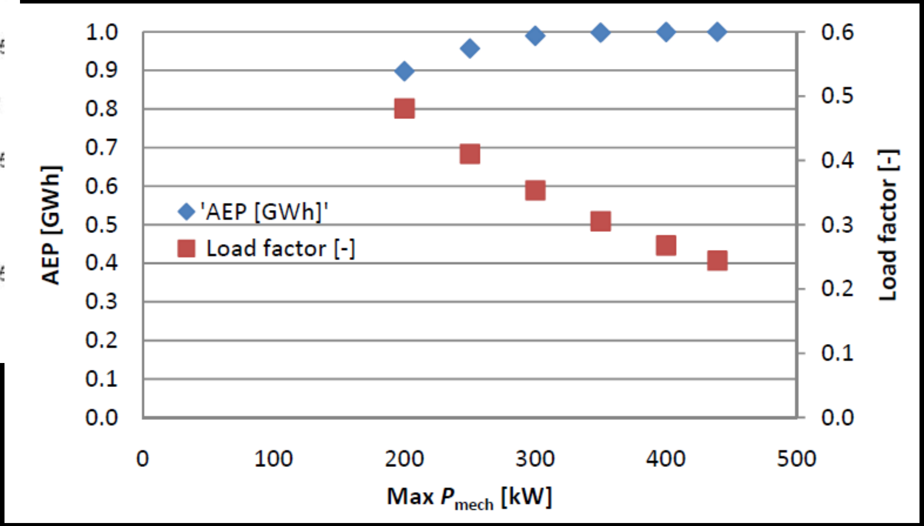

WEPTOS™

Power production measurements

$$\eta = \frac{P_{mech}}{P_{wave} \times 2 \times 20 \times 0.24}$$







Anholt

Scaling ratio: 1.Relative to prototype 2. relative to reference	**8.33**		1.00		**10**		1.20		**12**		1.44		**15**		1.80	
Leg: 1.absolute length [m] 2.active length [m] 3.diameter [m]	63	40	2.9		76	48	3.5		91	58	4.2		114	72	5.3	
Rotor: 1.weight [ton] 2.volume [m^3] 3.width [m] 4.chord [m]	2.3	4.3	2.0	2.7	4.1	7.4	2.4	3.3	7.0	12.8	2.9	3.9	13.7	25.0	3.6	4.9
Pwave [kW/m]	0.99				0.99				0.99				0.99			
Load factor* [-] (unlimited and limited)	**0.13**	**0.32**	**0.40**	**0.51**	**0.11**	**0.32**	**0.39**	**0.48**	**0.09**	**0.30**	**0.37**	**0.45**	**0.08**	**0.30**	**0.36**	**0.44**
Maximum Pmech. [kW]	107	42	32	21	194	64	48	32	335	93	70	47	629	151	114	76
Overall η [-]	0.18	0.17	0.16	0.14	0.22	0.21	0.20	0.16	0.27	0.25	0.23	0.19	0.35	0.32	0.28	0.23
Average Pmech [kW]	14.1	13.6	12.7	10.8	21.2	20.1	18.5	15.4	31.1	28.5	25.7	21.1	50.5	45.0	40.5	33.2
Annual Energy Production [GWh]	0.12	0.12	0.11	0.09	0.18	0.17	0.16	0.13	0.27	0.25	0.22	0.18	0.44	0.39	0.35	0.29
Relative AEP to unlimited load factor [-]	1.0	0.97	0.90	0.77	1.0	0.95	0.87	0.73	1.0	0.91	0.83	0.68	1.0	0.89	0.80	0.66
Relative AEP to reference [-]	1.00	0.97	0.90	0.77	1.51	1.43	1.31	1.09	2.21	2.02	1.83	1.50	3.59	3.20	2.88	2.36

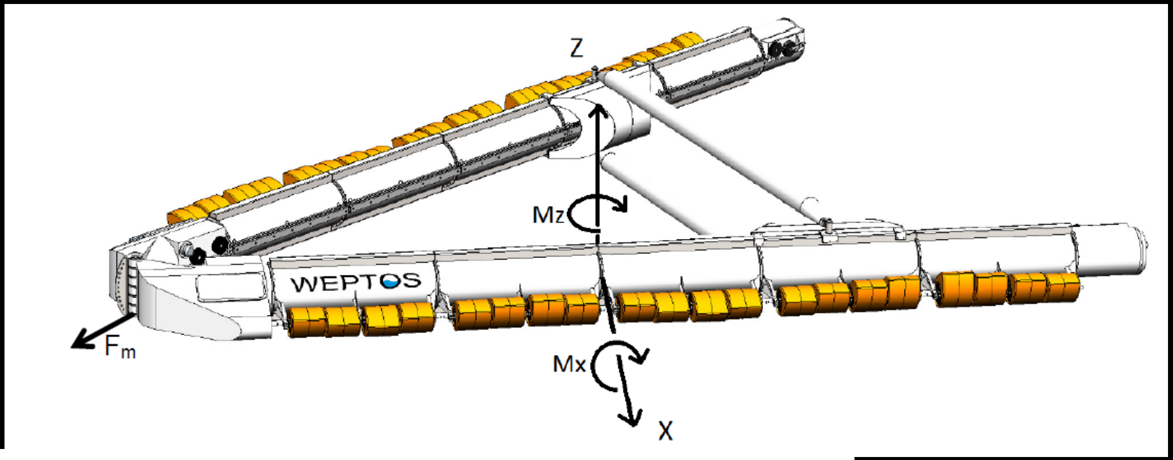
Hanstholm (DanWEC)

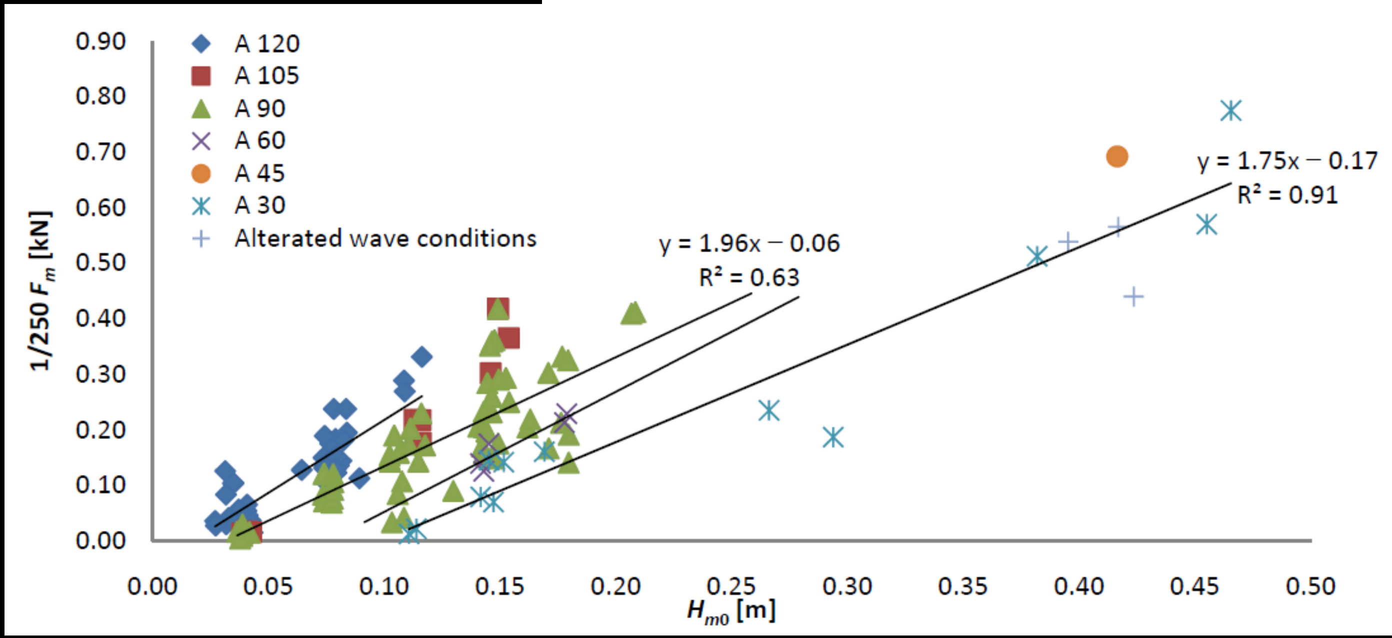
Scaling ratio: 1.Relative to prototype 2. relative to reference	**12**		1.0		**15**		1.25		**20**		1.67		**25**		2.08	
Leg: 1.absolute length [m] 2.active length [m] 3.diameter [m]	91	58	4.2		114	72	5.3		152	96	7.1		190	120	8.9	
Rotor: 1.weight [ton] 2.volume [m^3] 3.width [m] 4.chord [m]	7	13	2.9	3.9	14	25	3.6	4.9	32	59	4.8	6.5	63	115.7	6.0	8.2
Pwave [kW/m]	6.1				6.1				6.1				6.1			
Load factor* [-] (unlimited and limited)	**0.08**	**0.33**	**0.42**	**0.55**	**0.08**	**0.33**	**0.42**	**0.54**	**0.06**	**0.32**	**0.41**	**0.52**	**0.06**	**0.32**	**0.39**	**0.50**
Maximum Pmech. [kW]	757	176	132	88	1454	330	247	165	3656	699	524	349	6017	1166	875	583
Overall η [-]	0.08	0.08	0.08	0.07	0.12	0.12	0.12	0.10	0.20	0.19	0.18	0.15	0.26	0.25	0.23	0.20
Average Pmech [kW]	59	58	56	48	110	108	103	89	233	226	213	183	389	370	344	293
Annual Energy Production [GWh]	0.5	0.5	0.5	0.4	1.0	0.9	0.9	0.8	2.0	2.0	1.8	1.6	3.4	3.2	3.0	2.5
Relative AEP to unlimited load factor [-]	1.0	0.99	0.95	0.82	1.0	0.99	0.94	0.81	1.0	0.97	0.91	0.78	1.0	0.95	0.89	0.75
Relative AEP to reference [-]	1.0	0.99	0.95	0.82	1.87	1.85	1.76	1.52	3.97	3.86	3.63	3.11	6.63	6.31	5.87	4.99

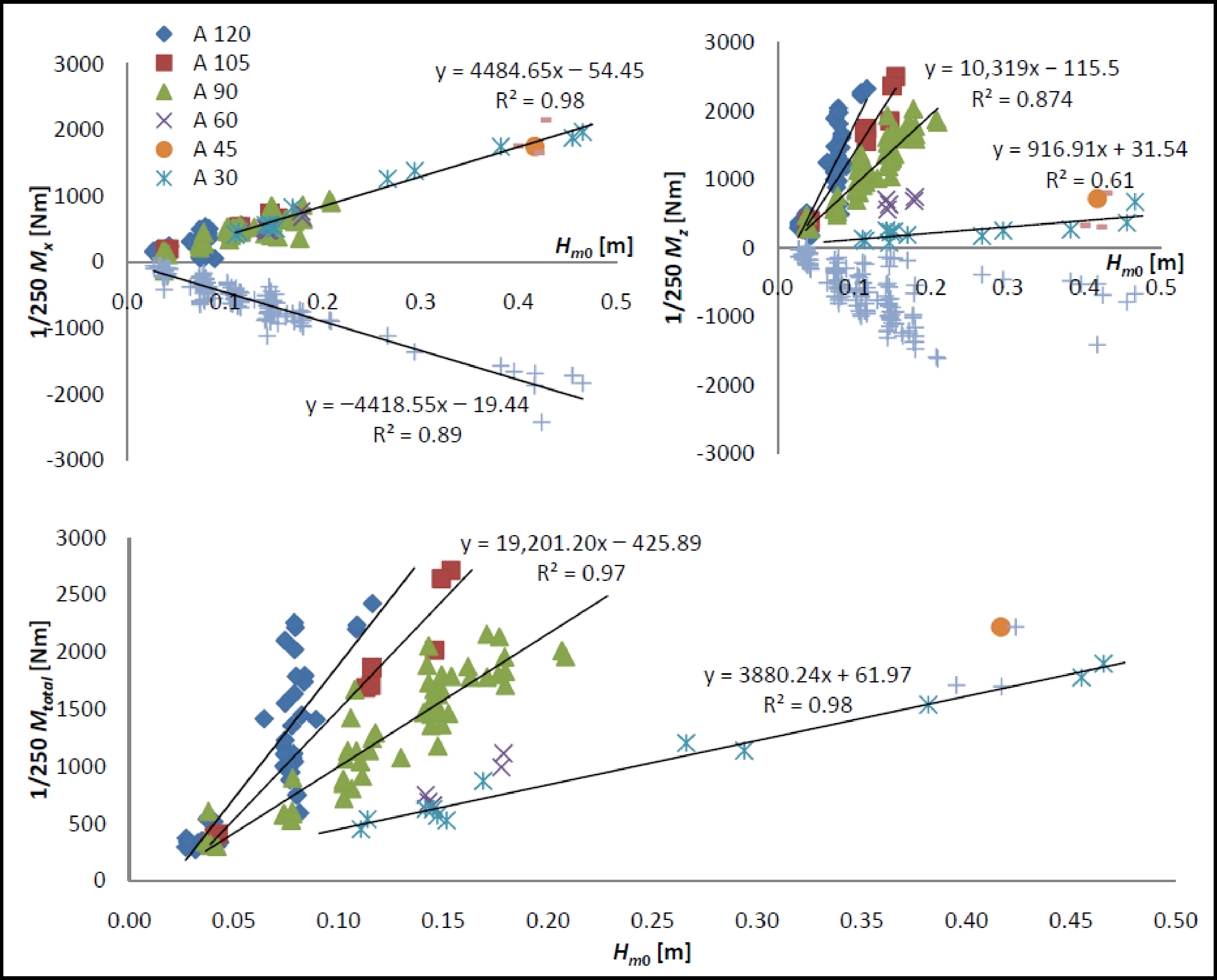
Danish part of the North Sea

Scaling ratio: 1.Relative to prototype 2. relative to reference	**23.4**				**25**				**30**				**35**			
Leg: 1.absolute length [m] 2.active length [m] 3.diameter [m]	178	112	8.3		190	120	8.9		228	144	10.6		266	168	12.4	
Rotor: 1.weight [ton] 2.volume [m^3] 3.width [m] 4.chord [m]	52	95	5.6	7.6	63	116	6.0	8.2	110	200	7.2	9.8	174	317.6	8.4	11.4
Pwave [kW/m]	16.3				16.3				16.3				16.3			
Load factor* [-] (unlimited and limited)	**0.18**	**0.33**	**0.42**	**0.55**	**0.19**	**0.33**	**0.42**	**0.54**	**0.18**	**0.33**	**0.41**	**0.52**	**0.16**	**0.32**	**0.39**	**0.49**
Maximum Pmech. [kW]	2080	1147	860	574	2422	1368	1026	684	4126	2196	1647	1098	6627	3152	2364	1576
Overall η [-]	0.10	0.10	0.10	0.09	0.12	0.12	0.11	0.09	0.16	0.15	0.14	0.12	0.19	0.19	0.17	0.14
Average Pmech [kW]	382	379	363	315	456	452	430	370	732	721	677	573	1051	1012	933	780
Annual Energy Production [GWh]	3.3	3.3	3.1	2.7	4.0	3.9	3.7	3.2	6.3	6.2	5.9	5.0	9.1	8.8	8.1	6.8
Relative AEP to unlimited load factor [-]	1.0	0.99	0.95	0.82	1.0	0.99	0.94	0.81	1.0	0.98	0.92	0.78	1.0	0.96	0.89	0.74
Relative AEP to reference [-]	1.00	0.99	0.95	0.82	1.19	1.18	1.12	0.97	1.91	1.89	1.77	1.50	2.75	2.65	2.44	2.04

Loadings


Z
Mz
WEPTOS
F_m
Mx
X


A 120
A 105
A 90
A 60
A 45
A 30
Alterated wave conditions
y = 1.96x – 0.06
R² = 0.63
y = 1.75x – 0.17
R² = 0.91
1/250 F_m [kN]
H_{m0} [m]
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
0.05
0.15
0.25
0.35
0.45


A 120
A 105
A 90
A 60
A 45
A 30
y = 4484.65x − 54.45
R² = 0.98
y = −4418.55x − 19.44
R² = 0.89
1/250 M_x [Nm]
H_m0 [m]
y = 10,319x − 115.5
R² = 0.874
y = 916.91x + 31.54
R² = 0.61
1/250 M_z [Nm]
H_m0 [m]
y = 19,201.20x − 425.89
R² = 0.97
y = 3880.24x + 61.97
R² = 0.98
1/250 M_total [Nm]
H_m0 [m]

Very large numbers of ideas….

- Hundreds of concepts for utilization of wave energy – and even more patents!
- Still new concepts coming and being tested
- Some promising concepts, but the race is still open!
- No convergence so far…

Important items to remember in design…

Energy contents at open sea much larger than closer to shore

- Ratio can easily be 3 – 5x

Ratio between forces in production and extreme conditions are far greater at open sea than close to shore

- open sea: 30 – 50x
- close to shore: 5 – 10x

Utilization has to be:

- efficient in smaller, but frequent waves
- but inefficient in larger, but rare waves

Accept minor loss in yearly power production to gain reasonable load factor (0.3 – 0.4 desirable)

Efficient conversion from slow oscillating motion to fast rotational motion is a challenge

Adaption to reduce extreme loads is key to get an economic structure

In summary…

There are ready Wave Energy Technologies out there.

In spite of the very high expectations on Wave Energy, present costs are high and limited operational experience is available today.

- Today a realistic guess on cost is 2-5 dkr/kWh for initial open sea deployments
- Wind industry cut prices from 3 dkr/kWh to 0.3-0.6 dkr/kWh in 10-20 years.

Incentives to create investments are needed. Market development is essential and the subsidised tariff is the most important mean to finance the development

- The timescale for development is estimated to be large

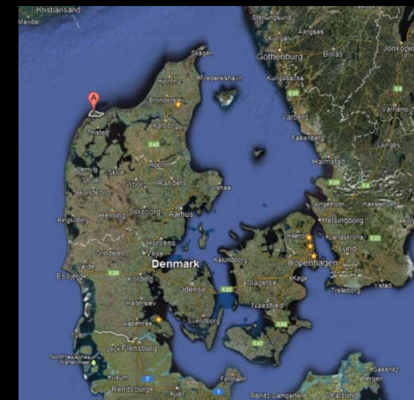
Various of reasons exist for development of a Wave Energy sector. In the long run Wave Energy seems even to become economical competitive

What's "hot" right now (seen from WERG)?

- Device development
  – going from lab testing to real sea testing
  - Weptos, Wavestar ...
- Demonstration – Centers
  - DanWEC / Partnership for WE
- Standardization / common approach
  - EquiMar/Marinet
  - IEC
  - EERA
- DSF Research Alliance
  - Structural Design of Wave Energy Devices

DanWEC, Hanstholm

- Test and develop precommercial WEC's
- Provide basic design data, wave measuremens and surveillance of installations
- Cable connection to mono pile on 25 m water depth
- Marked site at sea
- 3 – 4 prototype test beds



Hanstholm test history

- DWP
- Waveplane
- Wavestar
- Dexa

Expected:

- Crestwing
- Resen Wave
- Weptos
- …

Partnership for Wave Energy (DK)

Wave energy developers and network organisations

- Wavestar
- Floating Power Plant
- Wave Dragon
- WavePlane
- Dexawave
- CrestWing WaveEnergyFyn
- Leancon Wave Energy
- Resen Energy
- Rolling cylinder
- WavePiston
- Weptos

Public authorities and energy companies

- Energinet.dk
- DONG Energy A/S

Universities, technological service institutions and test centres

- Aalborg University
- DHI
- DanWEC

Wave energy association

- The Alliance for Offshore Renewables
- Esbjerg Erhvervsudvikling
- Lindø Offshore Renewable Center (LORC)
- Hanstholm Havneforum
- Offshore Center Danmark

Advisers and service

- Rambøll
- Innovayt
- Sandroos (lawyer)

Wave Energy Technology.
Strategy for Research, Development and Demonstration 2012

Partnership for Wave Energy

EUDP
Energiteknologisk udvikling og demonstration

Purpose:
- Work for the development of wave energy through industrial partnerships.
- Work for the greatest possible coordination of various networking activities for wave energy development in terms of joint meetings, conferences etc.

SDWED - The Research Alliance: Structural Design of Wave Energy Devices

SDWED
STRUCTURAL DESIGN OF WAVE ENERGY DEVICES

Objective of the project:

Strengthen and consolidate Denmark's position as one of the leaders in wave energy research, through the formation of a strategic international research alliance focusing on the structural design of Wave Energy Devices

- Project granted by the Danish Council for Strategic Research
- Call: Strategic Research in Sustainable Energy and Environment
- Theme: Energy Systems of the Future
- 5 years (2010-2014)
- 12 Partner organizations - 6 Danish (73 %), 6 International (27 %)
- Budget: 25 mil. dkr. (19.6 DSF, 5.4 Co-fin.)

Funded by
Danish Agency for Science Technology and Innovation
Ministry of Science Technology and Innovation

SDWED - Organisation

PROJECT STEERING COMMITTEE

MANAGEMENT

Project Coordinator:
Jens Peter Kofoed, AAU-C

Exploitation and Dissemination Manager:
Kim Nielsen, Rambøll

Research Training Coordinator:
John Dalsgaard Sørensen, AAU-C (Leader, WP5)

Harry Bingham, DTU (Leader, WP1)

Barbara Zanuttigh, UniBo (Leader, WP2)

Jochen Bard, FRAU (Leader, WP3)

Peter Frigaard,AAU-C (Leader, WP4)

Jacob Tornfeldt Sørensen, DHI

⇔

INTERNATIONAL ADVISORY BOARD

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Jon Kringelum	**DONGenergy**
Chris Retzler	**Pelamis**
Laurent Marquis	**Wave Star Energy**
Monika Bakke	**WaveEnergy**

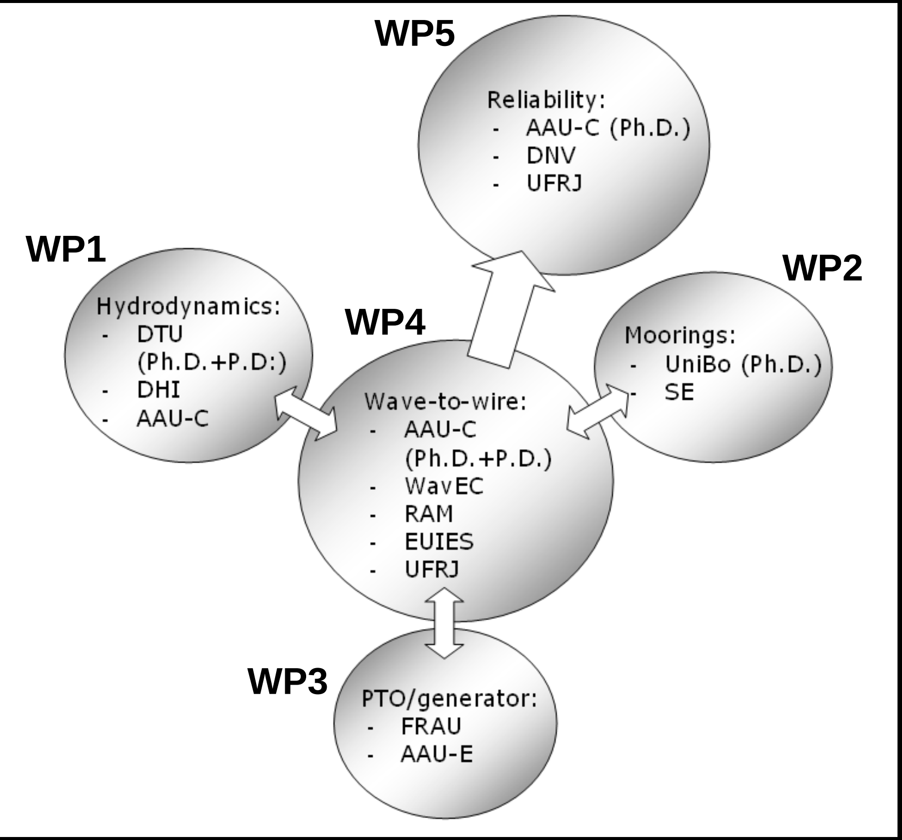
Main management units:

- Project Steering Commitee (PSC)
- Consortium Management (CM)
- Exploitation & Dissemination Manager (EDM)
- Work Package Leaders (WPL)
- Research Training Coordinator (RTC)
- International Advisory Board (IAB)

SDWED – Anticipated results

A **novel advanced wave-to-wire model** synthesized from the following results related to wave energy devices to be generated in the project:

Advanced knowledge on **wave loadings**
Advanced knowledge on loads from and behaviour of **mooring systems**
Advanced knowledge on loads from and behaviour of **PTO systems**
New advanced knowledge on the **interaction** of the mentioned elements
Advanced knowledge on the structural **reliability** of the devices



SDWED – More info…

- Web site: www.sdwed.civil.aau.dk
- Newsletter: www.sdwed.civil.aau.dk/News/
- LinkedIn group: www.linkedin.com/groups?gid=2842052

- PhD Courses: www.waveenergy.civil.aau.dk/PhDcourses/Individual+Courses/
  - Generation and Analysis of Waves in Physical Models, September 24-28, 2012
  - Experimental Testing for Wave Energy Utilization, November 19-23, 2012
  - Advanced Control Theory for Wave Energy Utilization, November 26-30, 2012
  - Reliability and Risk Analysis of Wind Turbines and Wave Energy Devices, December 3-5, 2012

Marine
Renewables
Infrastructure
Network for
Emerging Energy
Technologies

SEVENTH FRAMEWORK PROGRAMME

MaRINET – Towards a Network of Marine Renewables Testing Facilities

www.fp7-marinet.eu

Transnational Access & Networking

- EC-funded consortium of 29 partners
- 42 marine renewable energy testing facilities
- offers access to these facilities at no cost to research groups and companies

What MaRINET Offers

- EU-funded access to 42 state-of-the-art wave, tidal, wind and environmental testing facilities
- 700 weeks of access for 300 projects and 800 users available
- Open to all – researchers, commercial users, SMEs etc.
- Allowance paid towards travel and subsistence for users
- Personnel training to share and standardise testing techniques to enhance expertise in this growing industry

Closing remark!

We are often asked
”Now you have been testing so many different devices – which one is the best?”

Not easy to answer! We can give reasonably good answers to what each of the tested devices is expected to produce, but the big question is ”at what price?”

We need a lot of devices in the real sea for a long period of time to get closer to answering that question!

AALBORG UNIVERSITET

If you have been …

Thank you for listening ;-)