SEM-REV Test Site for Marine Energy Converters

Le Croisic / France
West Atlantic Coast
www.semrev.fr

Christian Berhault

Ce projet est cofinancé par l'Union européenne. L'Europe s'engage en Pays-de-la-Loire avec le Fonds Européen de Développement Régional (FEDER).

Ecole Centrale de Nantes

- Graduate engineering programs, Masters and PhDs, to French and international students
- Mechanics, Materials, Energy, Cybernetics, Architecture
- 200 teaching and research staff, 38 partners countries
- Direct collaboration with : IRT, Labex, FEM,…

« Widespread recognition of the institute by firms and R&D organizations has enabled graduates to assume positions of responsibility in every sector... »

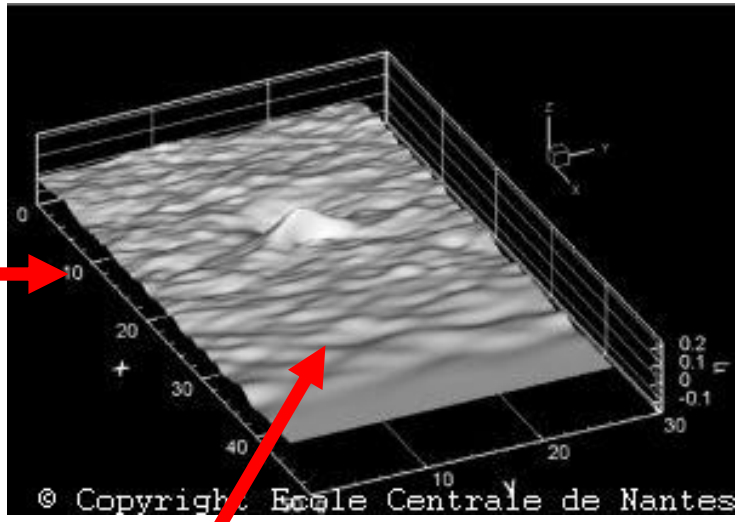
ECN - LHEEA
Fields of Expertise

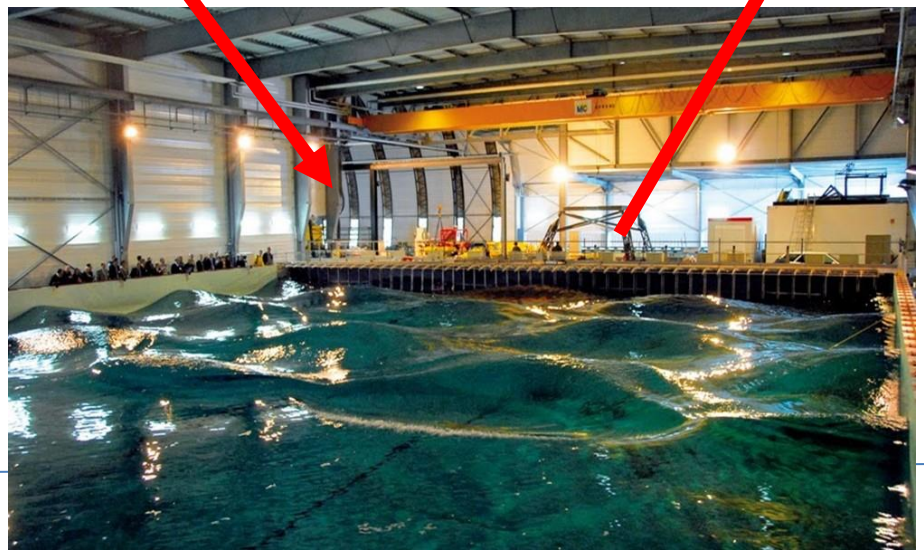
Environmental Conditions, Hydrodynamic, Ocean Engineering, Marine Renewable Energy

- Numerical modelling
- Wave tank model tests
- In-situ tests and measurements
- Assistance to MRE design
  - From feasibility study…
  - To validation in real conditions
- Participation to R&D projects :
  - MARINET, MARINA, R&D with Industry
  - Spin-off in marine engineering :

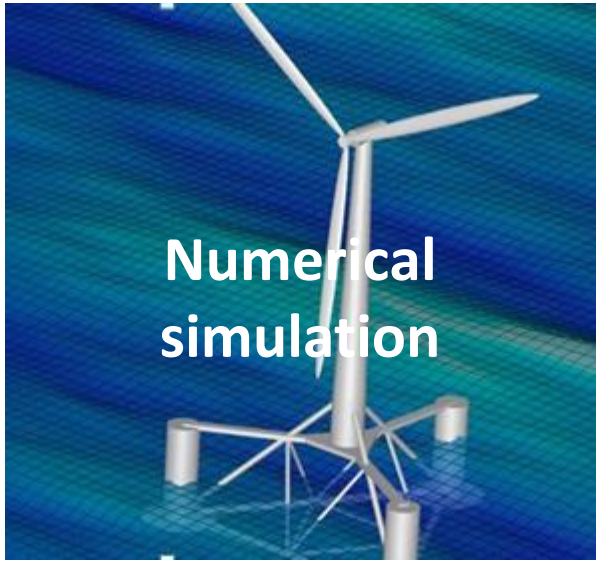
LHEAA = close to 100, with 35 PhD

ECN - LHEEA
Field of Expertise

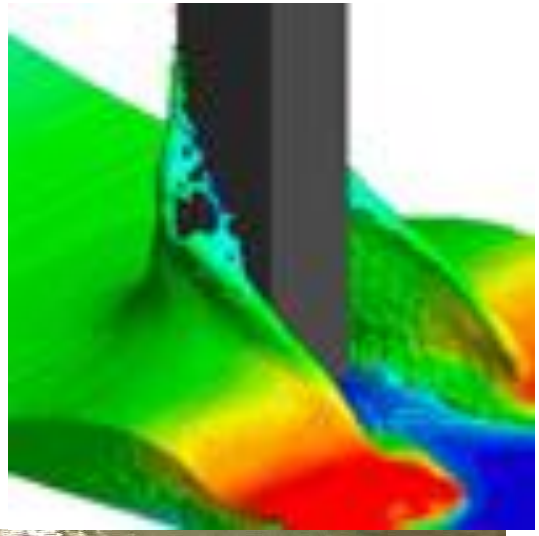


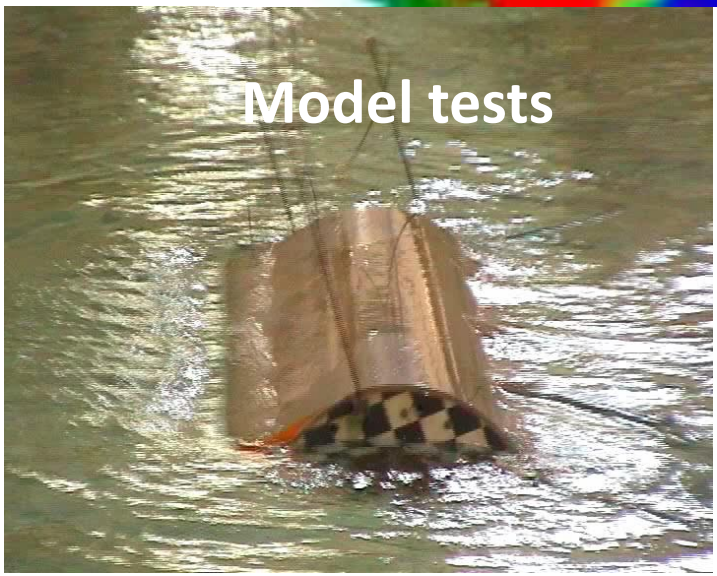


ECN - LHEEA
Field of Expertise



Complex system
with Floaters,
Mooring system
and Umbilical

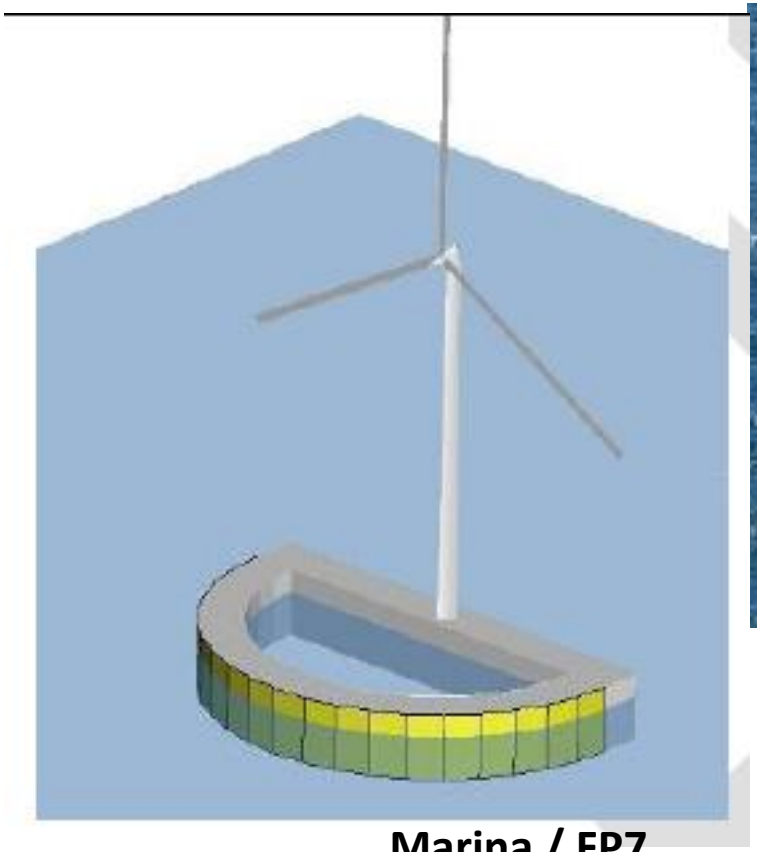




Floating Wind Turbine (HAWT, VAWT)

R&D Partnership, Examples :
HYSMAR / IRT Jules Verne
VALEF / France Energies Marines

Hybrid FWT / WEC



Marina / FP7

Poseidon FPP

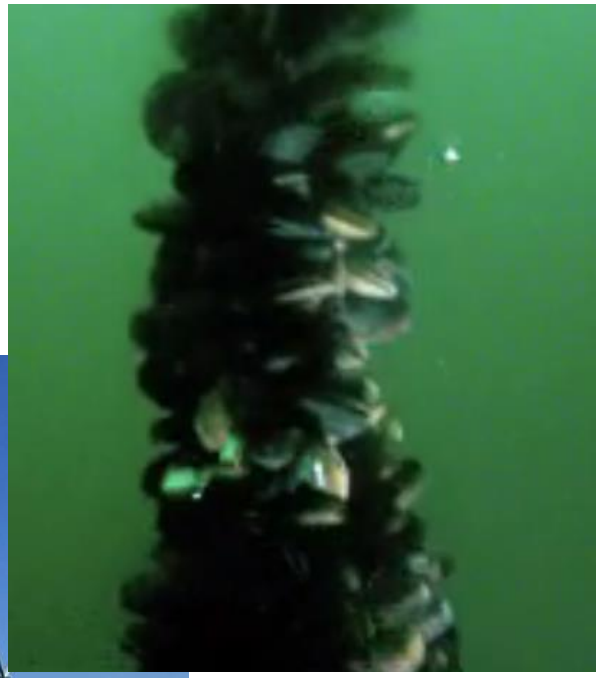
ECN - LHEEA
Field of Expertise

With other Research Teams and Industrial partners :

Monitoring and data processing

Structural analysis and Materials behaviour

Marine growth and Corrosion, …

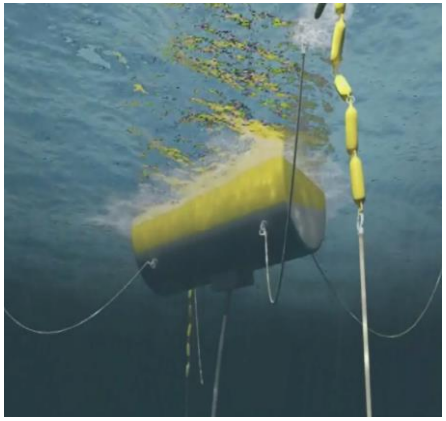


Installation, Operation Survey, Maintenance Extreme and Damaged conditions

SEM-REV
Sea Test Site

- Ocean test facility owned by Centrale Nantes
- Investment of 19 M€ (VAT included) - Public funding
- Managed by the LHEEA Research Laboratory
- SEM-REV dedicated team based in Le Croisic (Pen Avel)
- Direct collaboration with R&D teams from LHEEA
  - Numerical modelling and Simulation
  - Wave & Wind tank and model testing
- Direct collaboration with :
  - France Energie Marine : R&D program, energy system tests
  - IRT Jules Verne : R&D program

SEM-REV
Support to MRE technology



Facilities, services and support to MRE developers:

- Wave Energy Converters,
- Offshore Floating Wind Turbines
- Components of fixed wind turbine to confirm reliability
- Others systems depending on SEM-REV capabilities

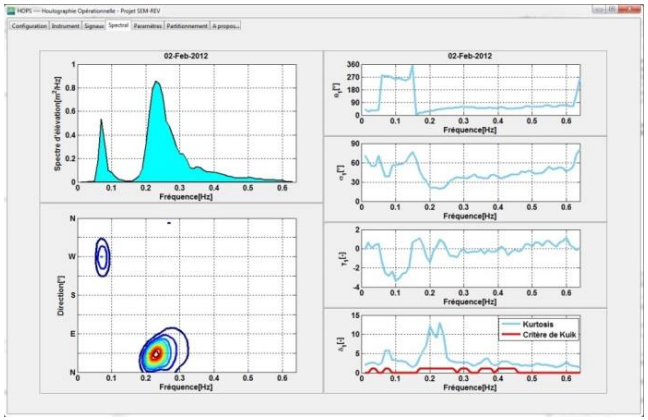
And also to test MRE components, specific JIPs :

- Subsea connection systems
- Materials and Structure reliability
- Monitoring and control systems
- Monitoring and of environmental impacts

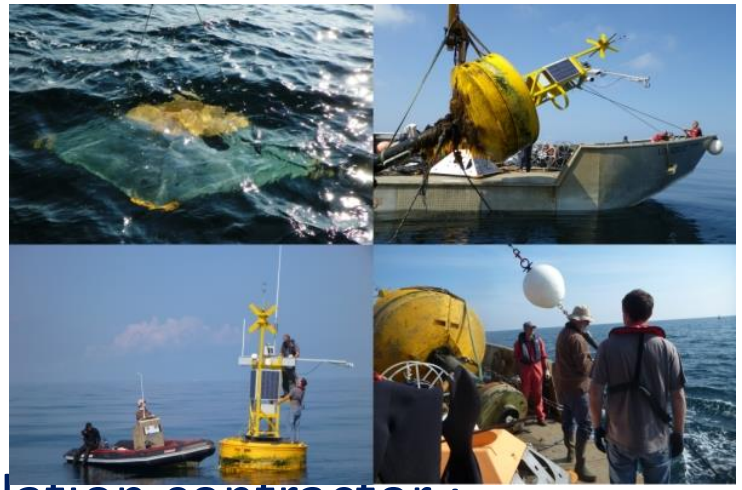
SEM-REV
Support to MRE technology

Support to technology developers:

- Evaluation of environmental conditions
- Energy and resource assessment
- Evaluation / optimization of global prototypes performance in term of energy production and cost (CAPEX and OPEX)
- Reliability assessment of global systems and their equipment (extreme, fatigue life)
- Materials and structures vs sea conditions (loads, corrosion, marine growth, …)
- Risk analysis assessment



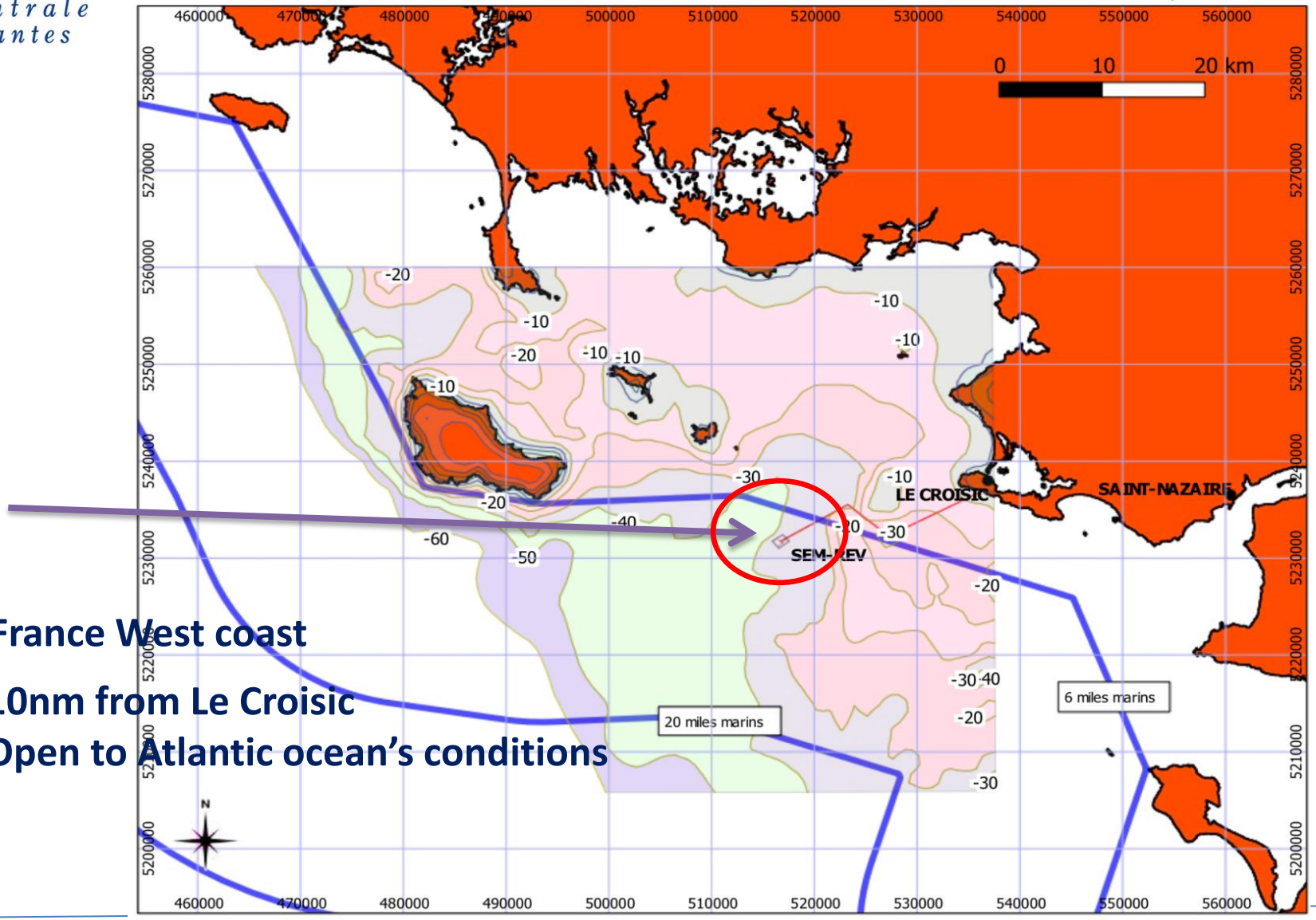
Support to MRE technology



Operational Support :

- Definition / Validation of procedures
  - Installation and decommissioning
- Inspection/Maintenance/Repair
  - Training for exploitation. Risk analysis
- Long-term contract with marine installation contractor :
  - Multi-cat barges, crane barges, 42m supply vessel, ROV, diving staff,…
- Standards and Guidelines
  - Development of a certification process

Test site location



France West coast

10nm from Le Croisic

Open to Atlantic ocean's conditions

Eolien posé

Maturité, R&D sur les composants

Exemple :

Banc de Guérande

80 éoliennes, 480MW,

15m à 25m d'eau

78 km2

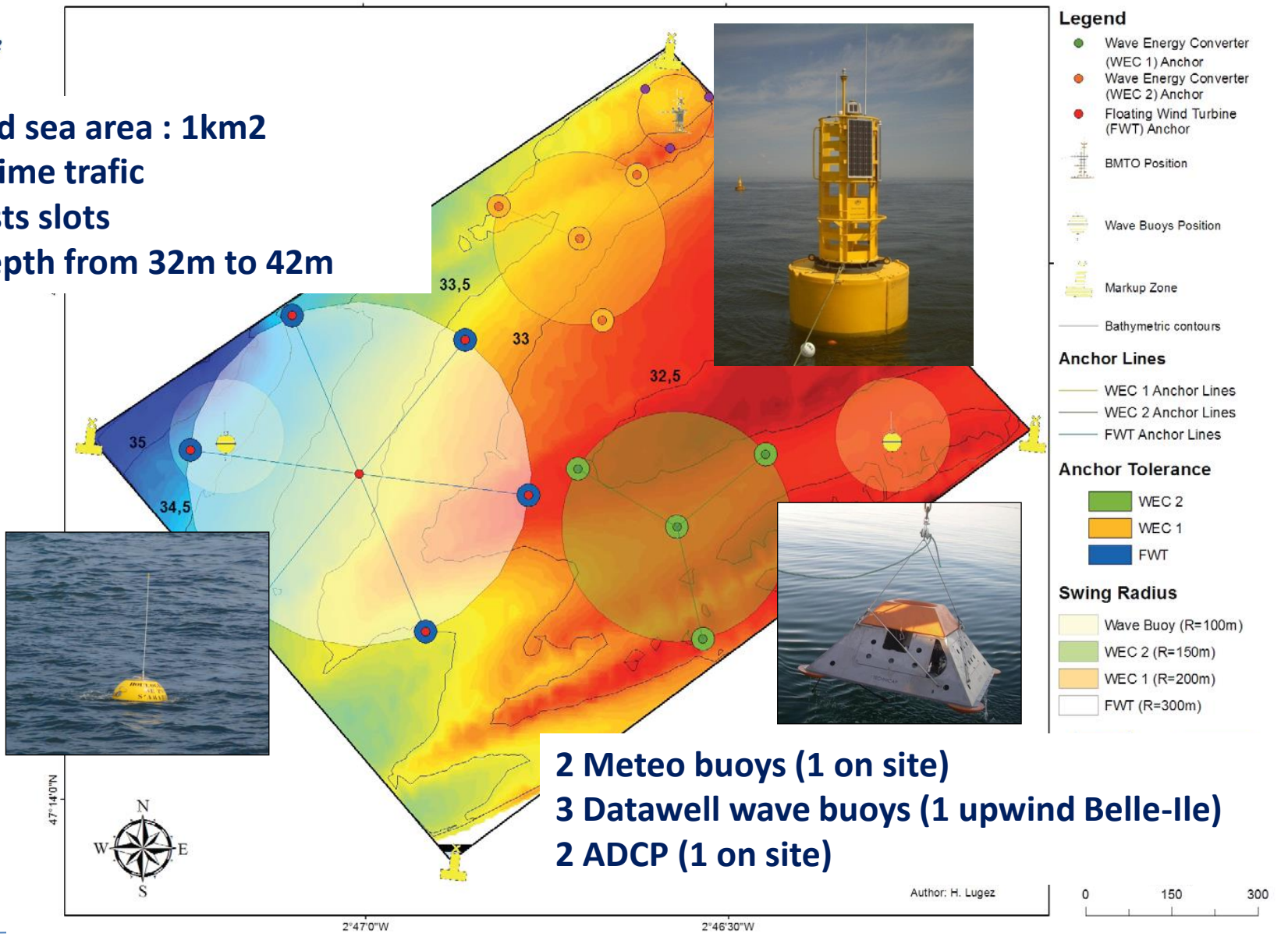
Installation : 2015 à 2018

EDF EN, Alstom Power,

Dong Energy, Nass&Wind

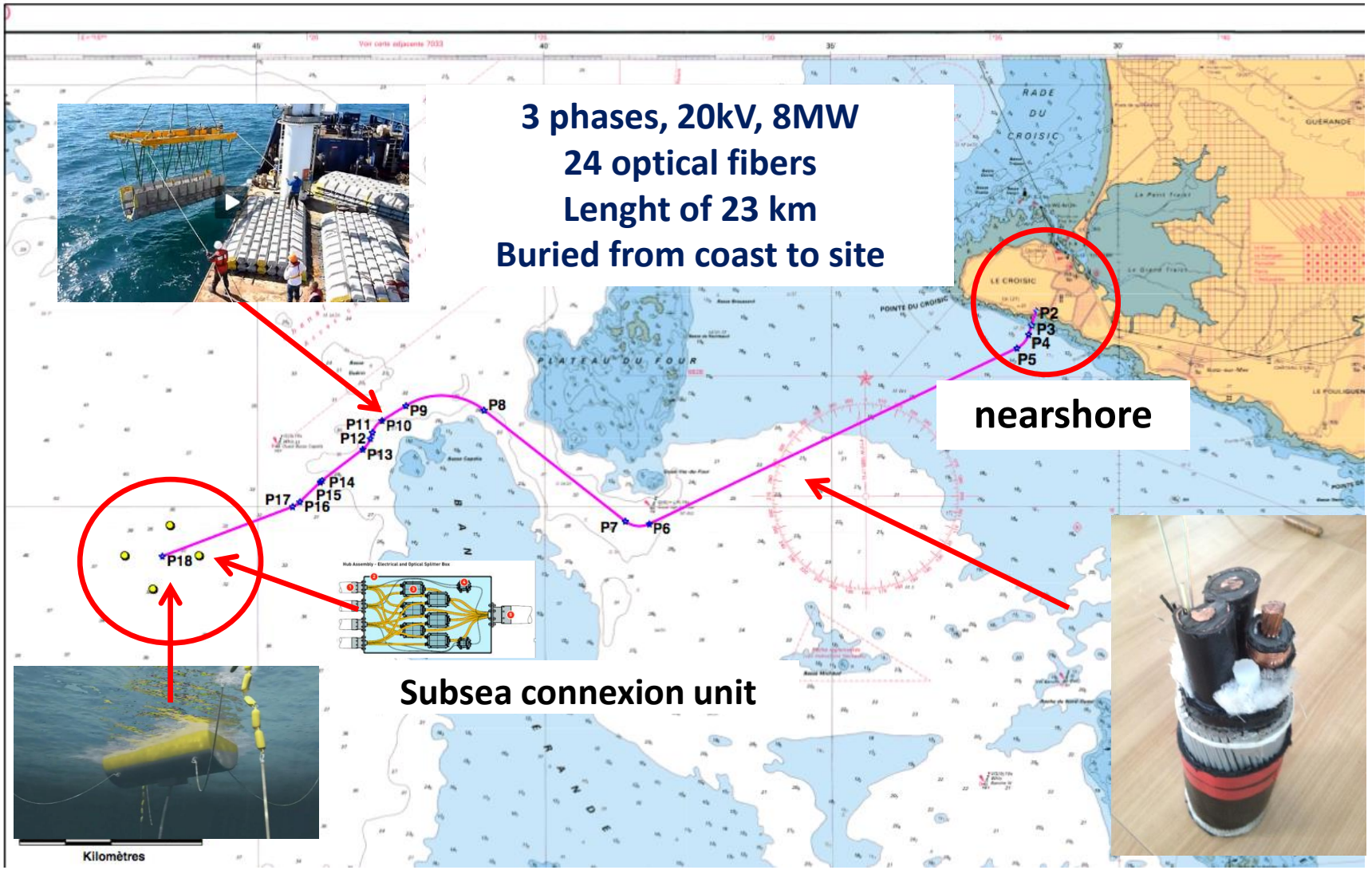
Offshore Area (DPM)

Restricted sea area : 1km2
No maritime trafic
2 to 4 tests slots
Water depth from 32m to 42m

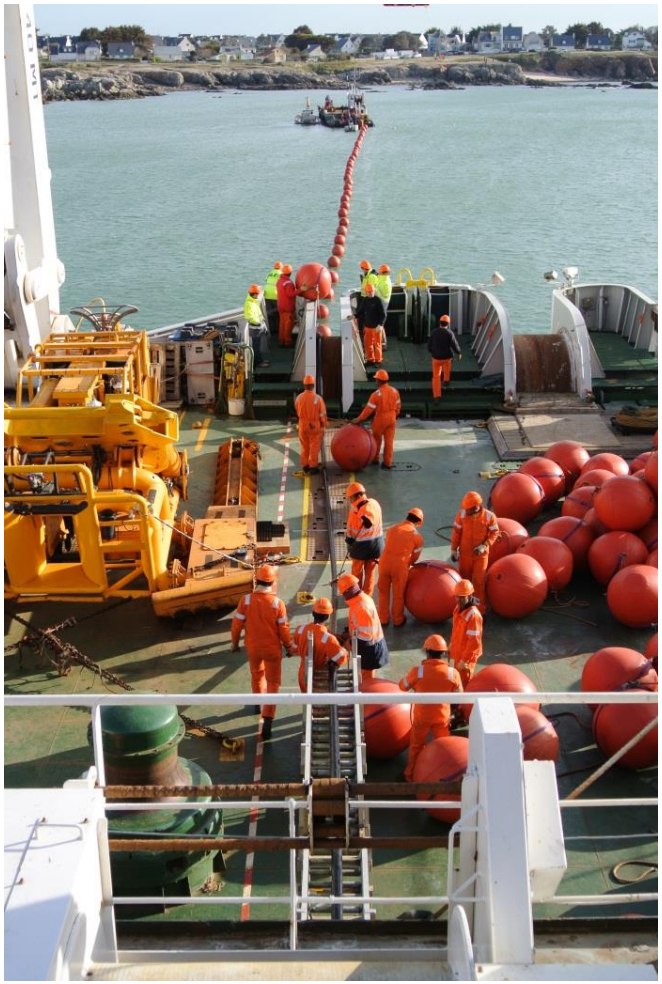


2 Meteo buoys (1 on site)
3 Datawell wave buoys (1 upwind Belle-Ile)
2 ADCP (1 on site)

Existing Grid Connection

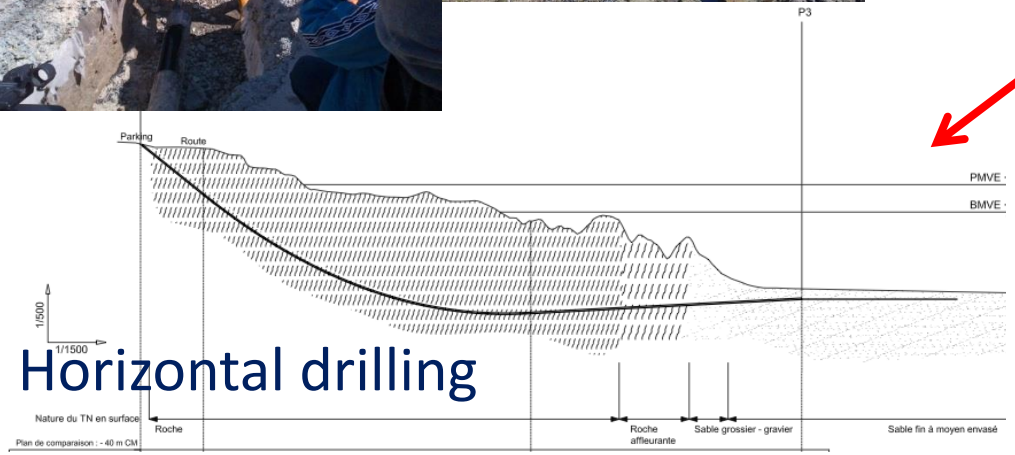


Cable installation
June to August 2012



Near-shore cable installation

Electrical substation (Le Croisic)



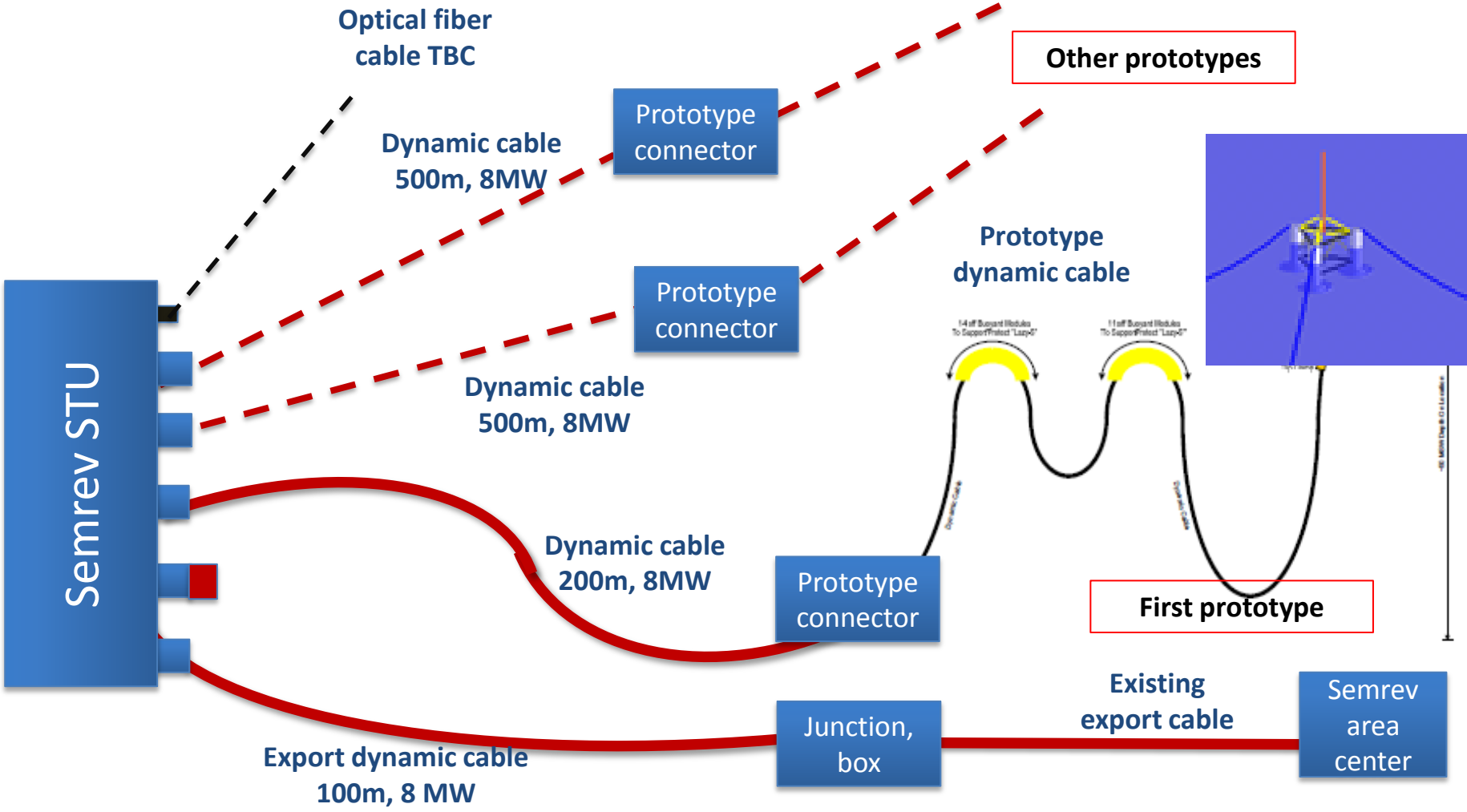
Horizontal drilling

Onshore substation

- Distribution grid regulations
- Specifications according to :
  - Power fluctuation, Voltage variations
  - Flicker, Harmonics
  - Reactive power

Subsea Termination Unit

Final arrangement



Onshore Base (Le Croisic)

Pen Avel

- 350m2
- Team: 6 technicians / engineers covering required competences
- Working platform in St-Nazaire

Offshore Exploitation

Long-term contract with marine installation contractor : multi-cat barges, crane barges, 42m supply vessel, ROV, diving staff, …

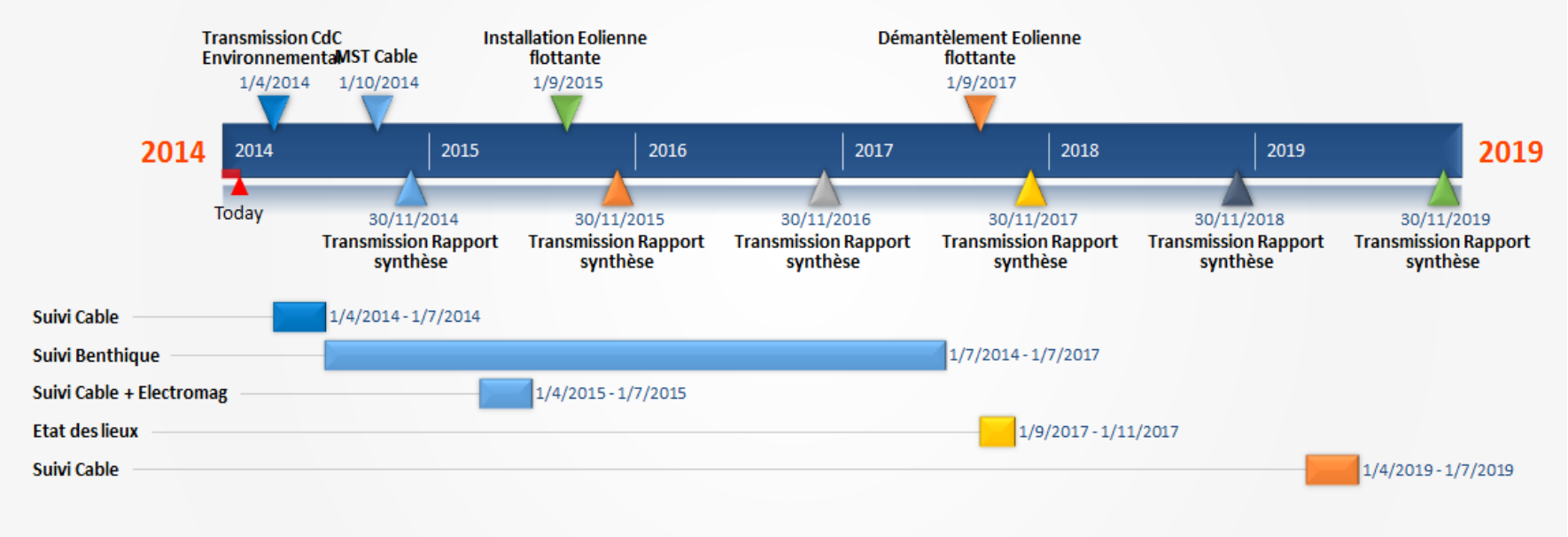
Permitting process

Public Maritime Domain consent for WEC, July 2011
Environmental impact studies
Water act consent, July 2011
Test site marling consent, July 2011
Construction license for electrical substation, Jan 2012
Grid connection agreement, 2012
Electricity purchase agreement, 2013
Permitting for Floating Wind Turbine, January 2014
Subsea connection: end of 2014 (1st) to end of 2015 (full system)

Prototype testing process

Regulatory Framework :

- Maritime Public Domain consent: Compulsory surveys of the environmental data supposed to be modified by the test site (protocols specified in N°2013_BPUP_099)
- Water Act Authorization: protocols established by ECN for these surveys will be transmitted to the appropriate services the 31/12 every year.



Testing Conditions

- SEMREV : research experimental tool owned and operated by ECN
- ECN has all permits and site operating contracts
- Collaborative projects including ECN as a partner
- Consortium agreement includes all required conditions (associated to permits, insurance, decommissioning, safety procedures)
- Direct co-funding via ANR (PIA) – under discussion, TBC
- Tests costs partially funded project partnership
- Benefit of electricity resale to ECN (CODOA)

MRE testing Schedule

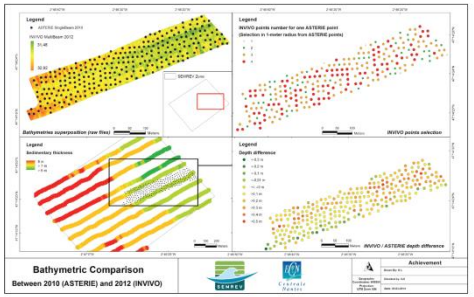
- Mid-2015 : installation of the subsea connection grid
- Mid-2015 : installation of the first FWT (2,5MW)
- End-2015 : installation of the first WEC
- 2016 to 2017 : tests of the first prototypes
- > 2106 : Tests others prototypes
- 2013 to 2019 : R&D projects
- *Projects context :*
  - FP7, Horizon 2020
  - AMI ADEME, ANR, FUI, Local funding
  - France Energies Marines, IRT Jules Verne, JIPs, …

Main R&D projects

- Modeling of Environmental conditions
  → wind, waves, current, soil mechanics, …
- Sea impact on MRE components:
  marine growth, corrosion,
- New materials reliability vs. sea conditions
- Monitoring and control systems
- Dynamic of umbilical behavior
- Dynamic of mooring line
- Risk assessment and safety procedures
- Impact on marine environment

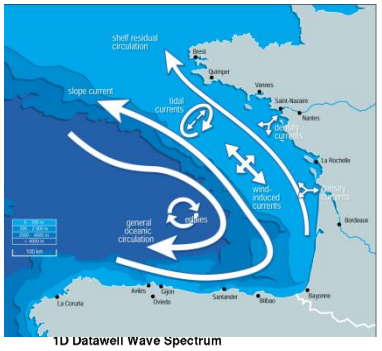
→ Marine Environment Surveillance System : SEAMON

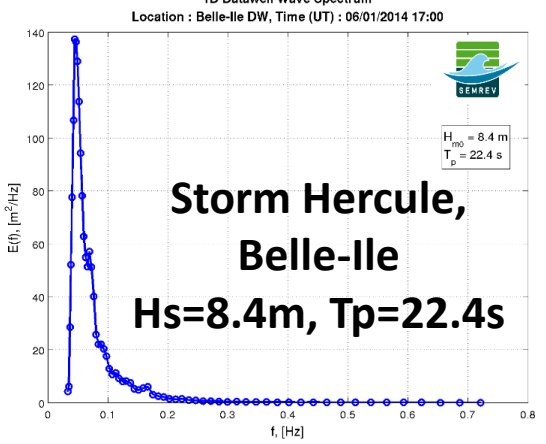
Environnement Monitoring



Understanding the marine environment

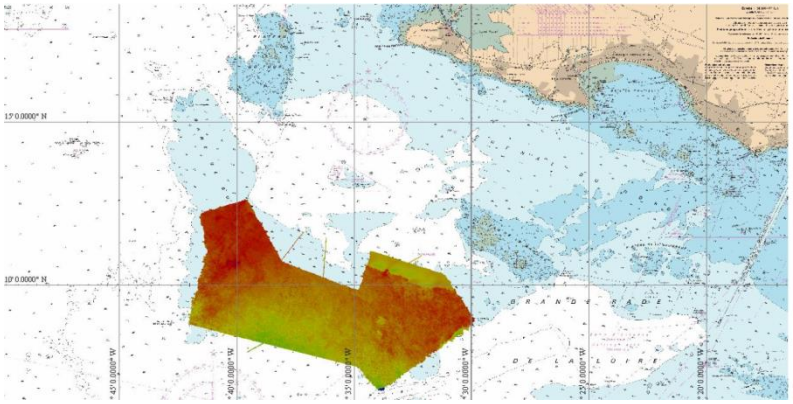
- Sea bottom:
  - Geophysics/Geotechnics/Bathy (consultation)
- Water Column:
  - Hydrodynamic/Sediments Transport (Internship)
  - Turbidity/Water Quality (Ifremer)
- Fauna/Flora
  - Benthos/Pelagos/Mammals/Birds (EDF-EN)
- Lack of reference data :
  - Initial State
  - Environmental observatory R&D project



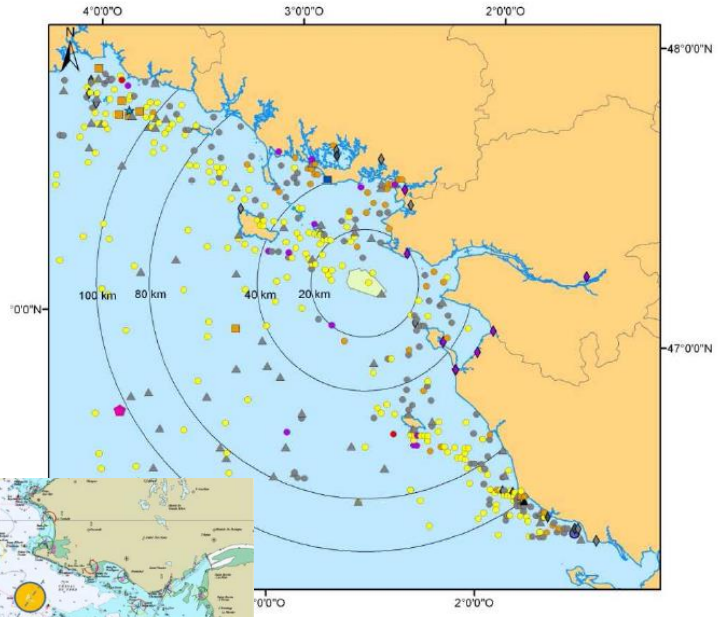


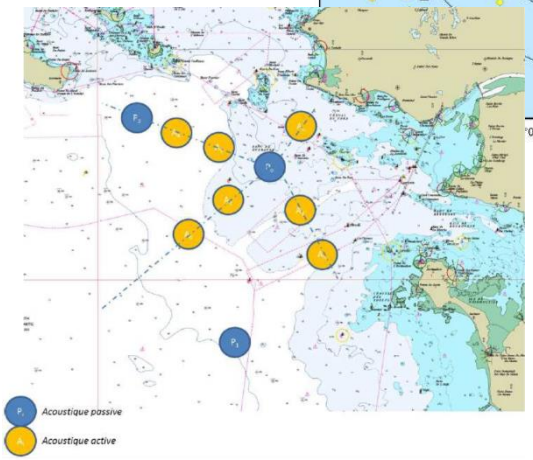
Environnement Monitoring

- Cumulative Impacts / Interactions / Synergies



3km away from a 480MW Wind Farm





80 Offshore Wind Turbine over 78km2 in 2018

Offshore Monitoring: Zone

- Marking & Lighting
  - Prototype
  - Offshore Zone

Night-time light rhythms:

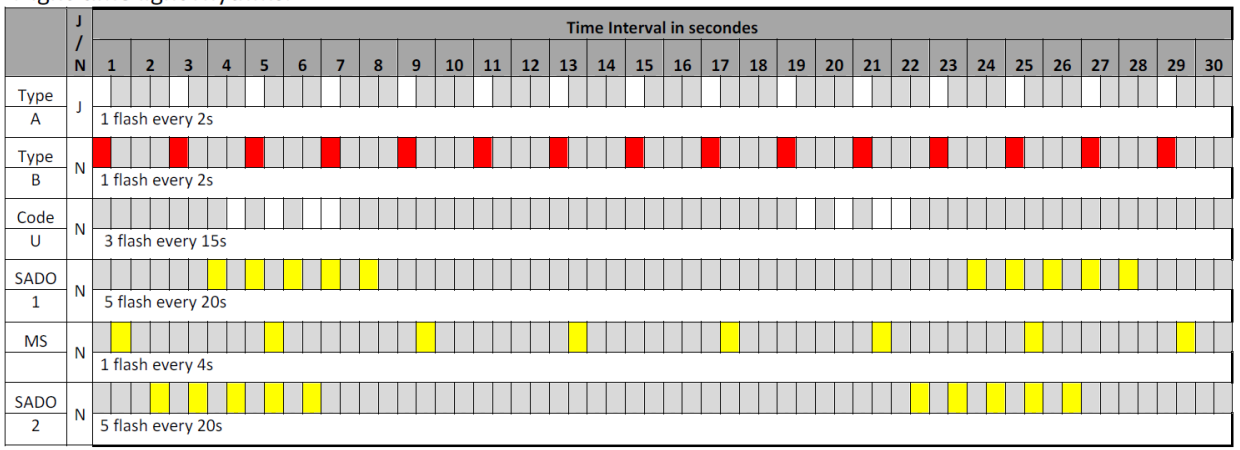
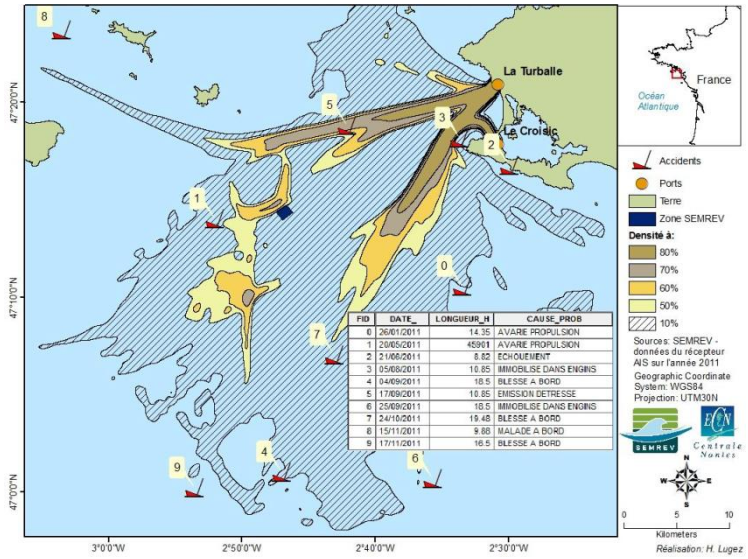


Figure 2: marking lights rhythms (updated recommendations)

- Marine Trafic (Surveillance)
  - Projects Interferences
  - Fishery, recreational, cabotage…
  - Insurances & responsability
  - Inputs for Risk Analysis
  - Exploitation guidance



FID	DATE_	LONGUEUR_H	CAUSE_PROB
0	26/01/2011	14.35	AVARIE PROPULSION
1	20/05/2011	45901	AVARIE PROPULSION
2	21/06/2011	8.82	ECHOUEMENT
3	05/08/2011	10.85	IMMOBILISE DANS ENGINS
4	04/09/2011	18.5	BLESSE A BORD
5	17/09/2011	10.85	EMISSION DETRESSE
6	25/09/2011	18.5	IMMOBILISE DANS ENGINS
7	24/10/2011	19.48	BLESSE A BORD
8	15/11/2011	9.88	MALADE A BORD
9	17/11/2011	16.5	BLESSE A BORD

Offshore Monitoring MEC & components

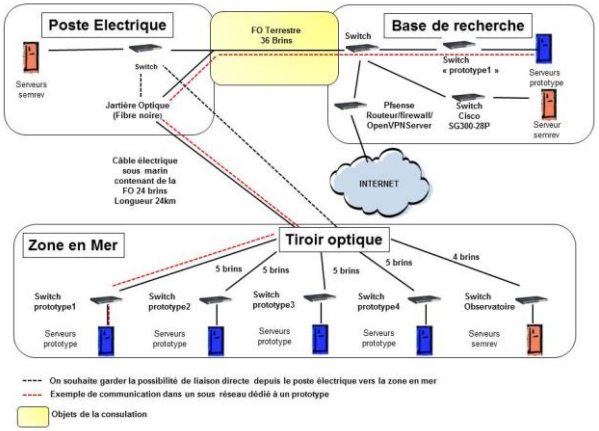
- Communication
  - Security Attributes

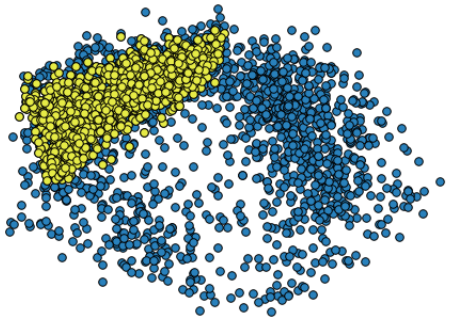
MEC GPS position (AIS), Communication Alert

  - Back-up Attributes

MEC state & position, Fire & Waterway Alerts

- Materials & Structure reliability
  - Float stability, loads measurements
- Mooring
  - Strain gages?
- PTO system
  - storage, use on-site, power supply



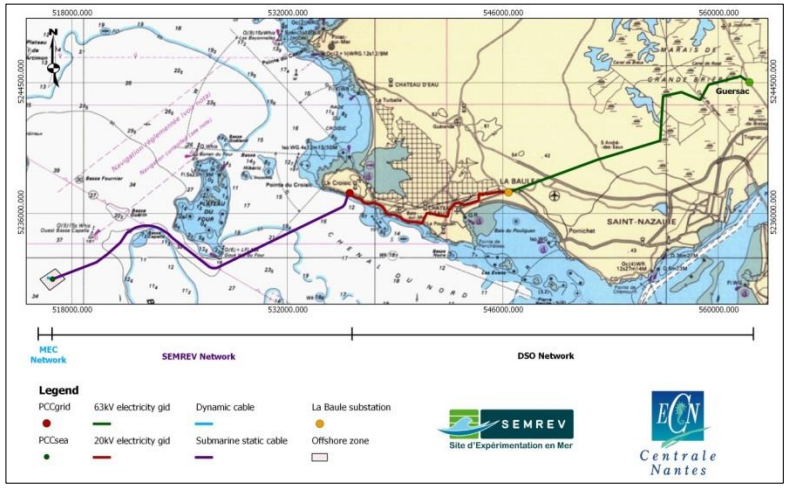


Offshore Monitoring Cables

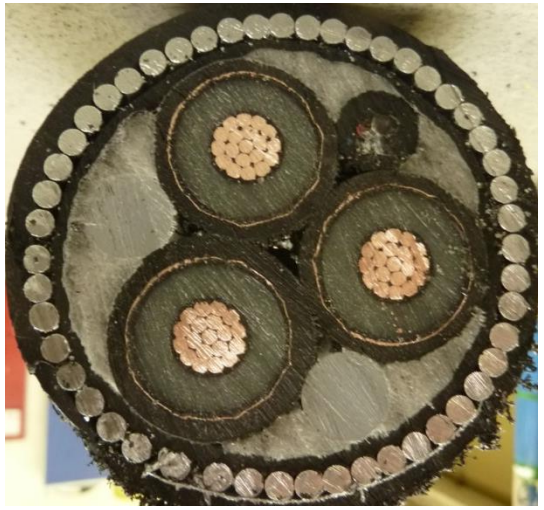
Electrical Connection

- Umbilical
  - Instrumented cable?

  Real-Time deformation?



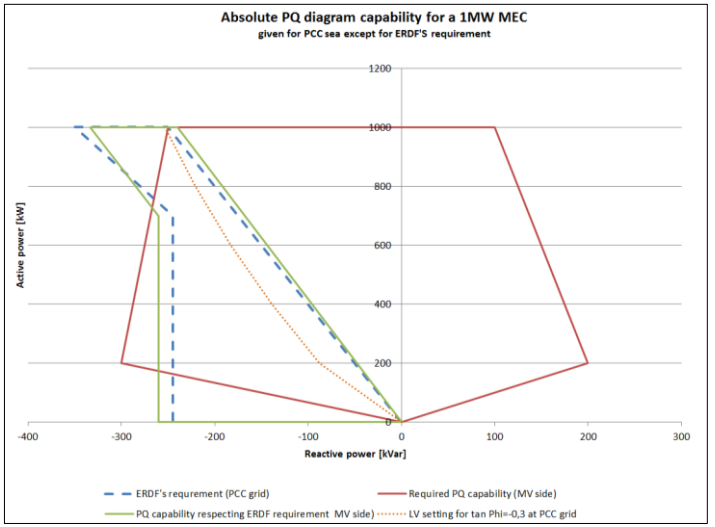
- Subsea Termination Unit + Connector
  - Tension at the connection point???

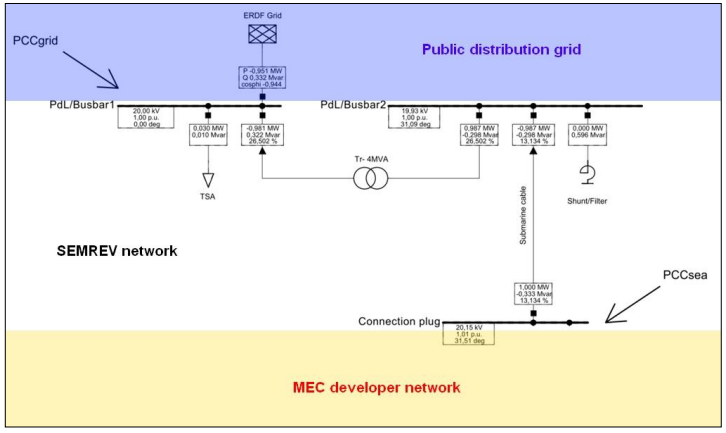


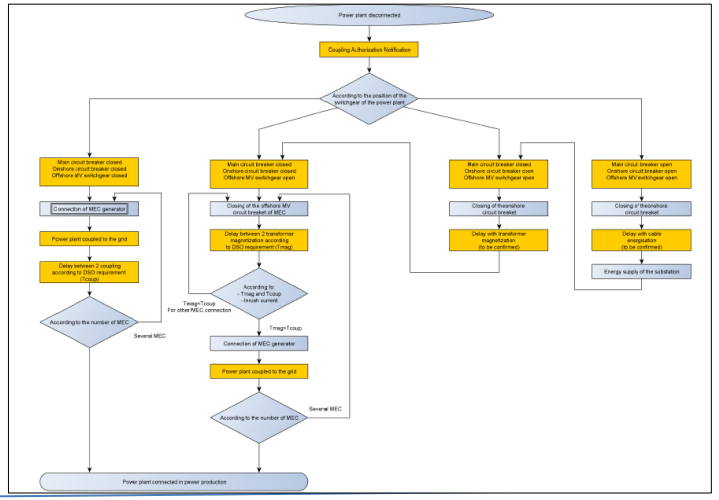
- Export Cable distant testing
  - Electrical testing
  - Fiber Optics testing (reflectometry)

Onshore Monitoring Electrical Substation

- Production
  - Power Quality (Grid Requirements)
  - Interferences (Troubleshooting)
  - Commissioning tests
- Exploitation
  - DEIE/PLCs/SCADA/…



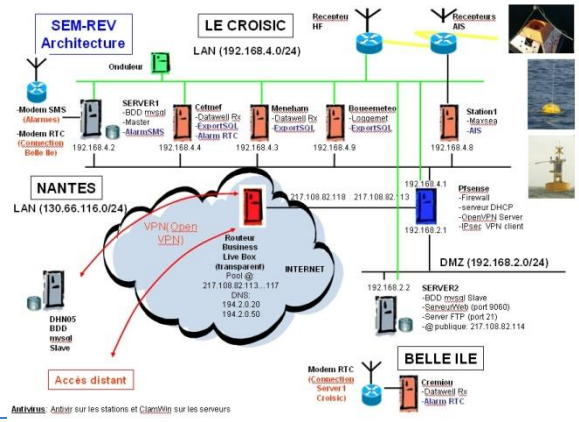




Onshore Monitoring Research Centre

- Building Security
  - Presence on site, Video
- Secured Informatics
  - Storage Management & Alerts
  - Confidentiality & Accessibility
- Meteo information, Antennae

bmto	ServicesWindows	CRITICAL	1h 51m CRITICAL: BMTO_MySQLExport: stopped (critical)	
		UP	1h 52m PING OK - Packet loss = 0%, RTA = 0.12 ms	0.125ms
	AisDdispatcher	OK	1h 50m OK: aisdispatcher.exe: running	1
	AisDecoder	OK	1h 22m OK: aisdecoder.exe: running	1
	CPU	OK	1h 51m OK CPU Load ok.	17%
	Disk	OK	1h 50m OK: All drives within bounds.	477499G
	Memory	OK	1h 50m OK: physical memory: Total: 1.95G - Used: 1.14G (58%) - Free: 828M (42%), virtual memory: Total: 2G	58%
borne-wifi		UP	1h 52m PING OK - Packet loss = 0%, RTA = 0.79 ms	0.79ms
houlobelleile		UP	1h 51m PING OK - Packet loss = 0%, RTA = 63.87 ms	63.865002ms
	CPU	OK	1h 50m OK CPU Load ok.	9%
	Disk	OK	1h 49m OK: All drives within bounds.	45%
	Memory	OK	1h 48m OK: physical memory: Total: 894M - Used: 312M (34%) - Free: 583M (66%), virtual memory: Total: 2G -	18%
	ServicesWindows	OK	1h 30m OK: All services are in their appropriate state.	
	VagueDir	OK	1h 30m OK: vaguedirmkiii_v2.exe: running	1
houloest		UP	1h 53m PING OK - Packet loss = 0%, RTA = 0.16 ms	0.163ms
	CPU	OK	1h 50m OK CPU Load ok.	7%
	Disk	OK	1h 48m OK: All drives within bounds.	60%
	Memory	OK	1h 51m OK: physical memory: Total: 1.25G - Used: 581M (45%) - Free: 699M (55%), virtual memory: Total: 2G -	29%
	ServicesWindows	OK	1h 46m OK: All services are in their appropriate state.	
	VagueDir	OK	1h 46m OK: vaguedirmkiii_v2.exe: running	1
houlooouest		UP	1h 51m PING OK - Packet loss = 0%, RTA = 0.15 ms	0.154ms
	CPU	OK	1h 48m OK CPU Load ok.	6%
	Disk	OK	1h 50m OK: All drives within bounds.	59%
	Memory	OK	1h 44m OK: physical memory: Total: 1.25G - Used: 559M (43%) - Free: 721M (57%), virtual memory: Total: 2G -	29%
	ServicesWindows	OK	1h 48m OK: All services are in their appropriate state.	
	VagueDir	OK	1h 40m OK: vaguedirmkiii_v2.exe: running	1
livebox		UP	1h 50m PING OK - Packet loss = 0%, RTA = 1.10 ms	1.101ms
onduleur-croisic		UP	1h 48m PING OK - Packet loss = 0%, RTA = 0.03 ms	0.028ms
	ApcBatteryCharge	OK	1h 49m OK - Battery Charge: 100.0%	100%
	ApcLoad	OK	1h 50m OK - Load: 18.2%	18.2%



Test site possible extensions

- Production
  - Increase grid power capability between Le Croisic and La Baule (onshore cable, electric equipments in the onshore substation)
- Tests capabilities
  - Fixed wind turbine up to 6MW or 8MW
  - Sea test area (from 1km2 to 2 or 3km2)
  - New permitting process required (modifications of both environmental impact and DPM).

SEM-REV Test Site

- Almost operational multi-functions testing equipment
- Test site integrated in an environment of competences and means
- A regulatory & contractual framework with Ecole Centrale de Nantes
- First feedback in France from the harsh field for the future projects


www.semrev.fr
Thank you
Christian.berhault@ec-nantes.fr