Technology Theme Webinar

Developing and Implementing Optimisation tools

29 January 2018

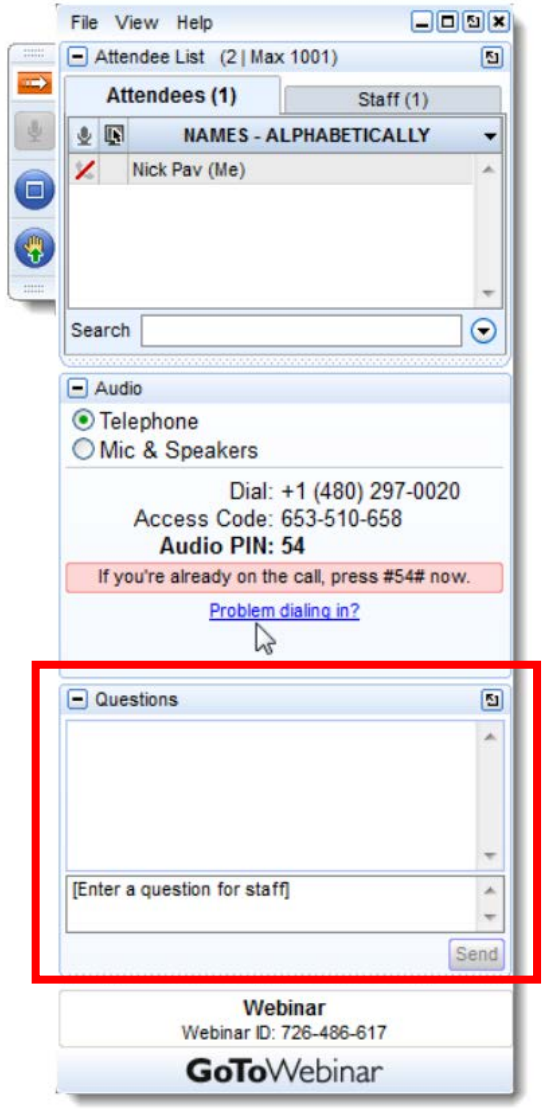
Agenda

Moderator		Speakers	
Leonore van Velzen		**Dr. Raymond Alcorn**	**Dr. Encarni Medina-Lopez**
The University of Edinburgh		Exceedence Ltd.	The University of Edinburgh

Questions and comments from the audience

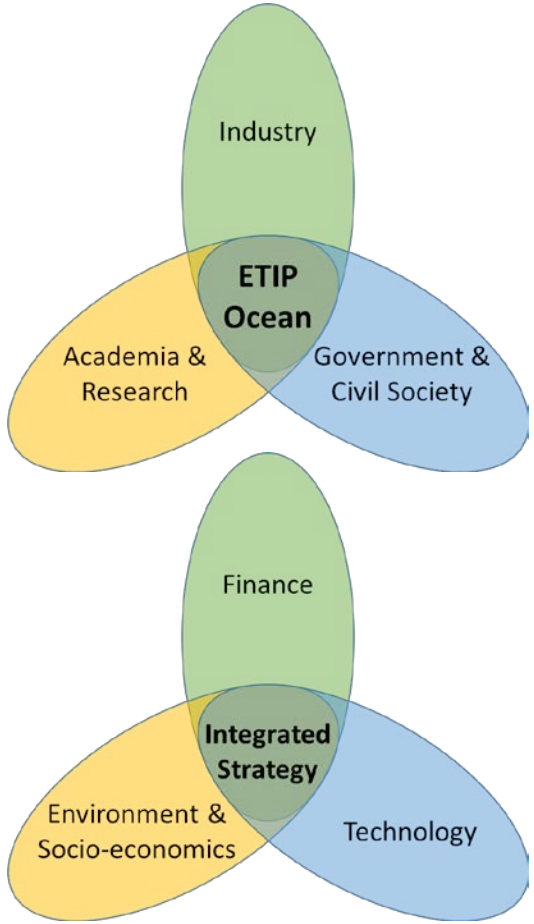
Technical details

- All attendees have microphones muted
- Feel free to send questions or commments by text at any time



The European Technology and Innovation Platform for Ocean Energy

- A hub for knowledge sharing and collaboration in the ocean energy sector
- Identify methods of overcoming barriers to sector commercialisation
- Define a common vision for the accelerated development of the sector
- Public engagement and education



Consortium

Ocean Energy Europe

- **ETIP Ocean Coordinator**
- Europe's ocean energy trade association
- 115 member organisations
- Represents the interests of the European ocean energy sector

THE UNIVERSITY of EDINBURGH

- **ETIP Ocean Partner**
- Policy and Innovation Group at the Institute for Energy Systems
- Leading research institution in the ocean energy sector

EERA
European Energy Research Alliance

- **ETIP Ocean Partner**
- EERA Ocean Energy Joint Programme
- A network of the 12 foremost research institutions in the European ocean energy sector
- Coordinated by the University of Edinburgh

Technology Theme Webinar

Developing and Implementing Optimisation tools

29 January 2018

wood.

EXCEEDENCE

OptiWave

January 2018


$300Bn p.a. new Renewables need finance. $85T will be under management by 2050. ALL need robust
DECISIONS
ALBATERN
ALBATERN

What is OptiWave?

- Financial & engineering optimisation platform for wave energy systems
  - Exceedence Finance: Techno-financial modelling tool
  - Flexcom Wave: Offshore marine engineering simulator
- Coupling of 2 COMMERCIAL packages to provide a better end-to-end service for the industry

OptiWave

wood. EXCEEDENCE

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

TEAM

EXCEEDENCE

- Domain experts in renewables
- Software team with 30 years experience
- Expertise in corporate finance including financing renewables

oceanlinx

First Active

OCEAN ENERGY

Dr Ray Alcorn,
Founder & CEO
25 year
Domain Expert

John Keating
Co-Founder COO
25 years Corporate
Finance

VATTENFALL

EIRCOM

fit The ICT Talent Pipeline

Snap-on

Annicka Wänn
Senior Projects
Engineer

Chris O'Donoghue
Principal Software
Engineer

Anthony
Sherlock
Software
Development

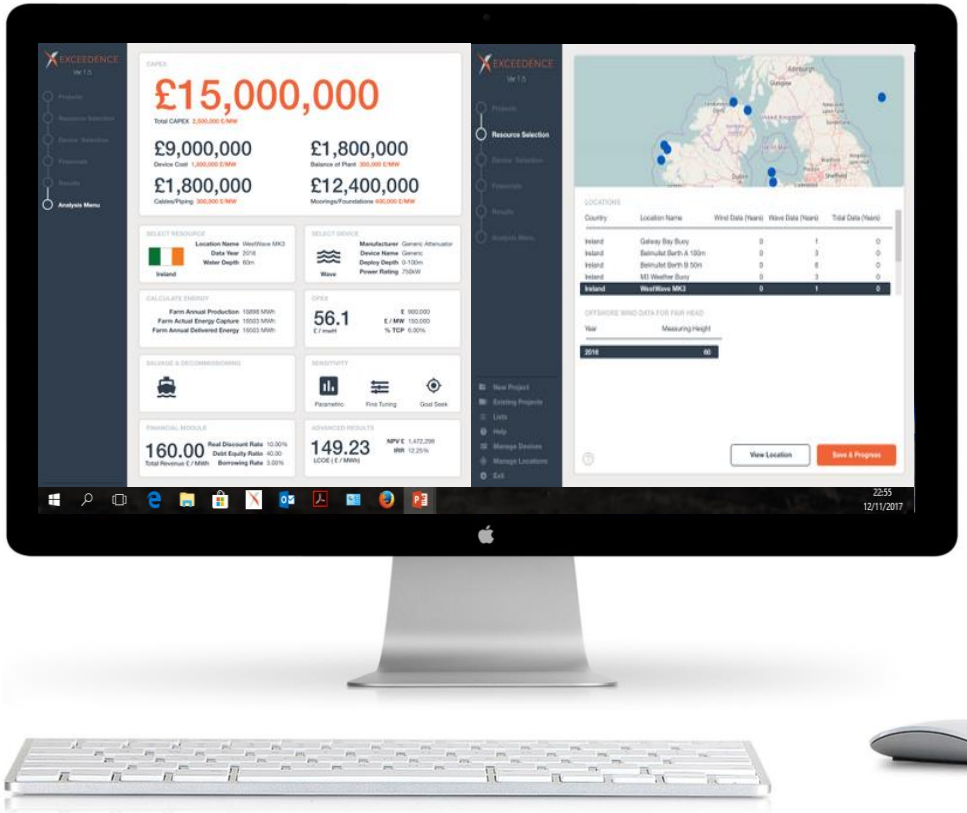
David
Sheehan
Software
Development

COMPANY OVERVIEW

EXCEEDENCE

- Sell B2B financial decision support software for renewable energy
- Started in Cork, Ireland in 2015
- Spun out from a world class research centre with desktop software
- Proprietary world class knowledge & expertise
- Have developed and about to launch cloud based software and tiered subscription model

ExceedenceFINANCE
A B2B SaaS Platform



+ Focus on Analytics. 80% Use time, 20% build. This is where value derives.

+ Transparent and shareable across VALUE chain.

+ Standardised process

+ Like-for-Like Comparison

+ Identify and Reduce Risk

BETTER
Decisions FASTER

facts… Wood PLC

A new global leader in technical, engineering and project services

$11BN
over $11bn revenue

WG.100
FTSE 100 listed

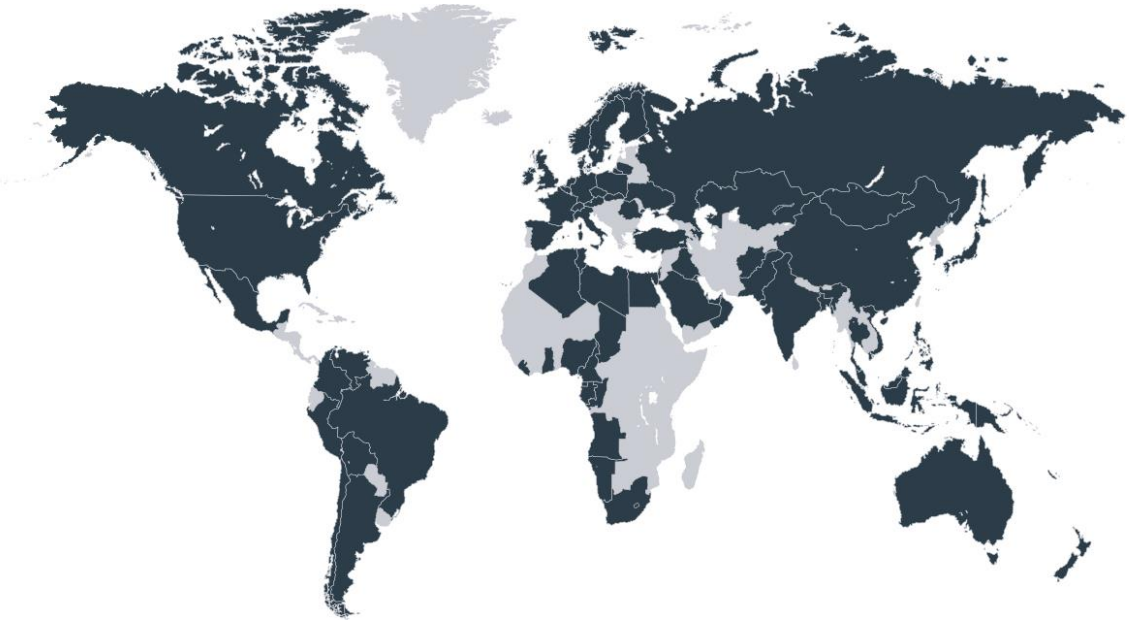
60+
Operating in more than 60 countries

160
Over 160 years experience

footprint…

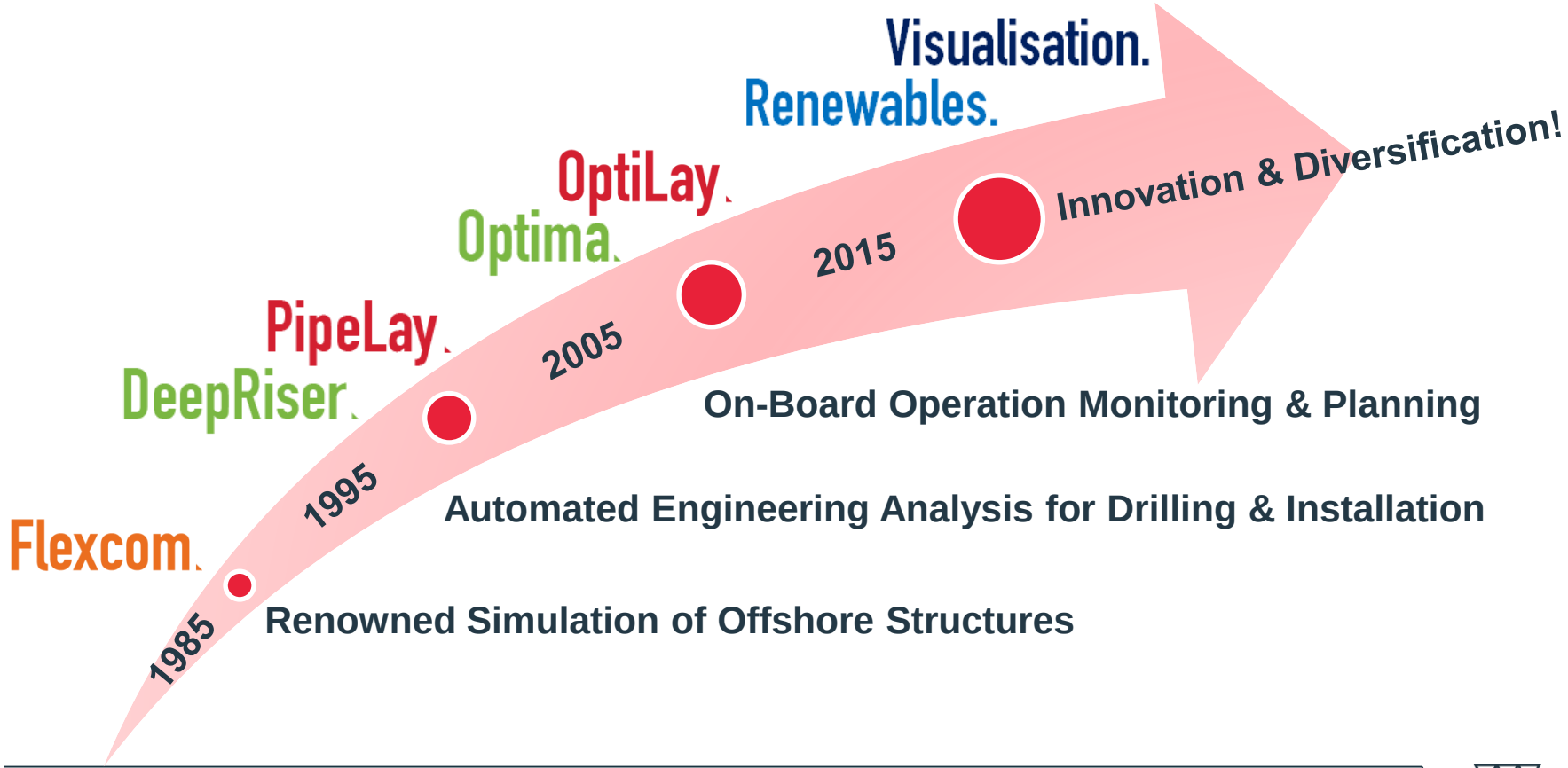
we are everywhere you need us

- We have an unmatched global footprint
- We’re accelerating and expanding in new sectors and geographies
- Unlocking our technology across an incredible sector spread



More than 600 offices worldwide

30+ years of Building Simulation Software



Industry Needs

- Why Techno - Financial models?
  - Convince Investors, Government and EU Funders
  - Plan for cost reduction, measure and track progress
  - Make both Corporate and Technical Development decisions
  - Supply chain credibility
  - BE COMPETITIVE

- Industry needs
  - Reference models & data
  - Own Data Import and Output with full transparency
  - Variable granularity – Input and Output
  - Indicators – Yield, Capacity Factor, LCOE, IRR, NPV, NPV/MW
  - Built in Data Sets (e.g. WES, Belmullet) and Device Models
  - STANDARDISED
  - What-IF? Analysis and Optimisation

wave energy SCOTLAND

U.S. DEPARTMENT OF ENERGY

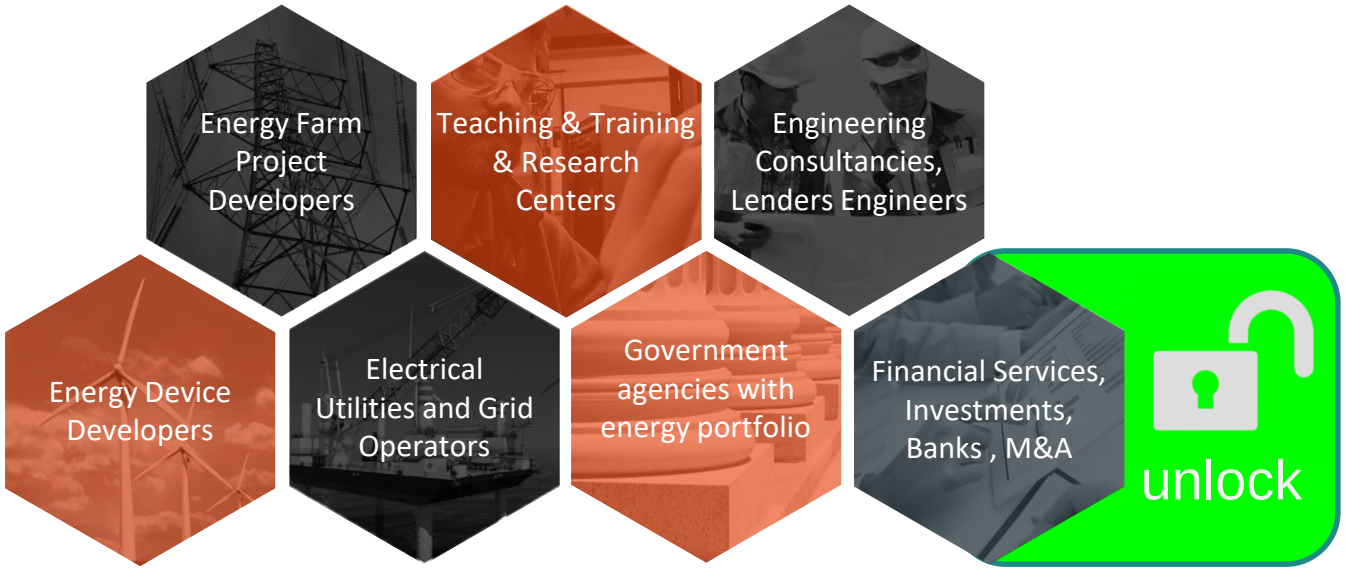
CATAPULT Offshore Renewable Energy

seai SUSTAINABLE ENERGY AUTHORITY OF IRELAND

HORIZON 2020

IEC

MRE Supply Chain



Technical & Financial Marriage

Key Benefits

- ✓ Accurate financial metrics: detailed engineering models and real-world wave resources
- ✓ Accelerated development: screen out weaker concepts earlier
- ✓ Design optimisation: explore advances in energy generation and opportunities for cost reduction
- ✓ Key insights: AEP, local power fluctuations, structural loads and fatigue life
- ✓ Clarity: Transparency of financial and engineering design processes
- ✓ Consistency: Suitable for concepts, prototypes, full scale versions
- ✓ Unlock investment: Increase investor confidence, de-risk projects
- ✓ Reliable: Validated via industry case studies

Why choose OptiWave?

- Complete Solution
  - Alternative products lack a techno-financial modelling capability – this is a unique selling point of OptiWave
- Flexibility
  - Multi-tiered pricing model which delivers cost efficiencies to smaller companies with limited budgets
- Support & Maintenance
  - Professionally supported product, which is often lacking in open source options

Industry Case Studies

Sea Power's Platform

Benson's ORLA

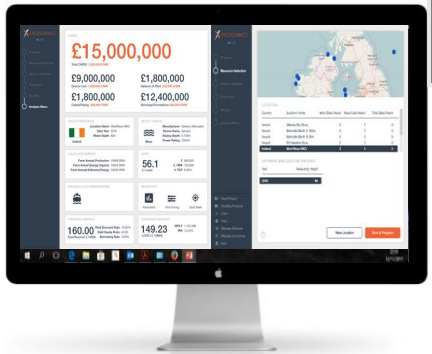
ESBI WestWave

Software demonstration

ROADMAP

DESKTOP Version

CLOUD Version



Enterprise

Standard

Lite

Future CLOUD

OptiWave

Enterprise Modules

Co Products

Data Sets

Solar PV

3RD PARTY
FUNCTIONALTY
FLEXCOM WAVE

wood.

OPEN DATA SETS

VALIDATION

EY Building a better working world

Proof of Concept
- Sales & consultancy Revenues

Tiered Offering
- Across value chain

New Products, Channels & Markets

How did we do it

- Originally both desktop packages
- Exceedence ground-up rebuild as Cloud Package
  - Many advantages for customer & company
- Linked a Desktop Package to web services
- Now providing an accessible TIERED offering to the industry on a subscription basis


OptiWave
Financial and engineering optimization platform for wave energy systems
Start Flexcom Wave
Start Exceedence Finance
Watch Tutorial
Open Website

Sample Project – RM3

- Dual-body floating point absorber
  - Designed by US DoE
  - Publicly available information
- Real-world design environment
  - Eureka site, California
- GOAL – optimise LCOE for the given Resource

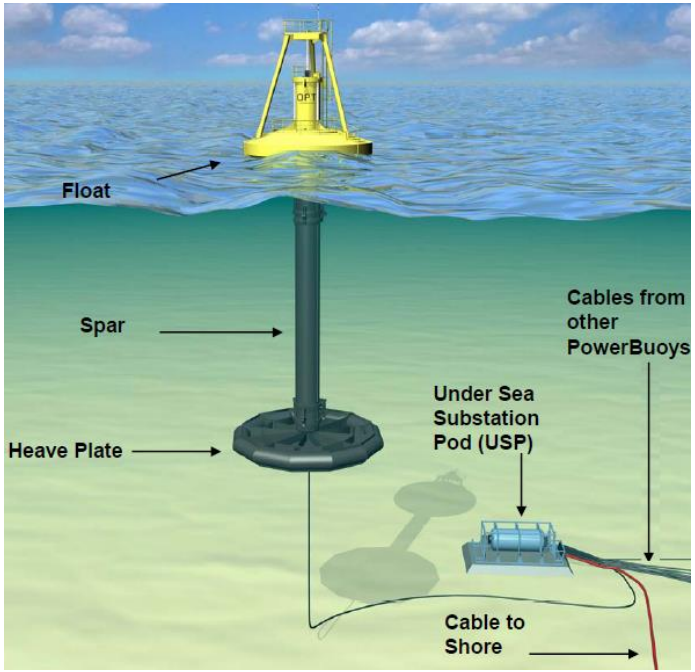


Image courtesy Ocean Power Technologies

SANDIA REPORT
SAND2014-9040
Unlimited Release
Printed March 2014

Methodology for Design and Economic Analysis of Marine Energy Conversion (MEC) Technologies

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Sandia National Laboratories

5 Reference Model 3 (RM3): Wave Point Absorber

5.1 RM3 Description

The RM3 wave point absorber, also referred to as a wave power buoy, was designed for a reference site located off the shore of Eureka in Humboldt County, California. The concept design for this device was inspired by the Ocean Power Technology's PowerBuoy (http://www.oceanpowertechnologies.com), which is a two-body floating point absorber (FPA) designed to convert ocean wave energy into electrical power. The design of the device consists of a surface float that translates (oscillates) with wave motion relative to a vertical column spar buoy, which connects to a subsurface reaction plate (Figure 5-1 and Figure 5-2). This two-body point absorber converts wave energy into electrical power predominately from the device's heave oscillation induced by incident waves; the float is designed to oscillate up and down the vertical shaft up to 4 m. The bottom of the reaction plate is about 35 m below the water surface. The device is targeted for deployment in water depths of 40 m to 100 m. The point absorber is also connected to a mooring system to keep the floating device in position. Our RM3 design assumed a hydraulic PCC system, which is placed inside the vertical column. The optimum energy capture of a wave point absorber occurs when the system is at resonance, in other words, when the oscillating body velocity is in-phase with the hydrodynamic wave excitation force.

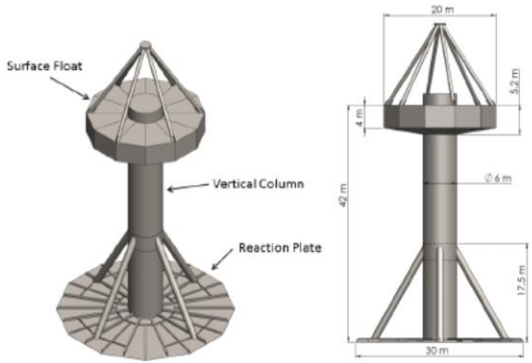
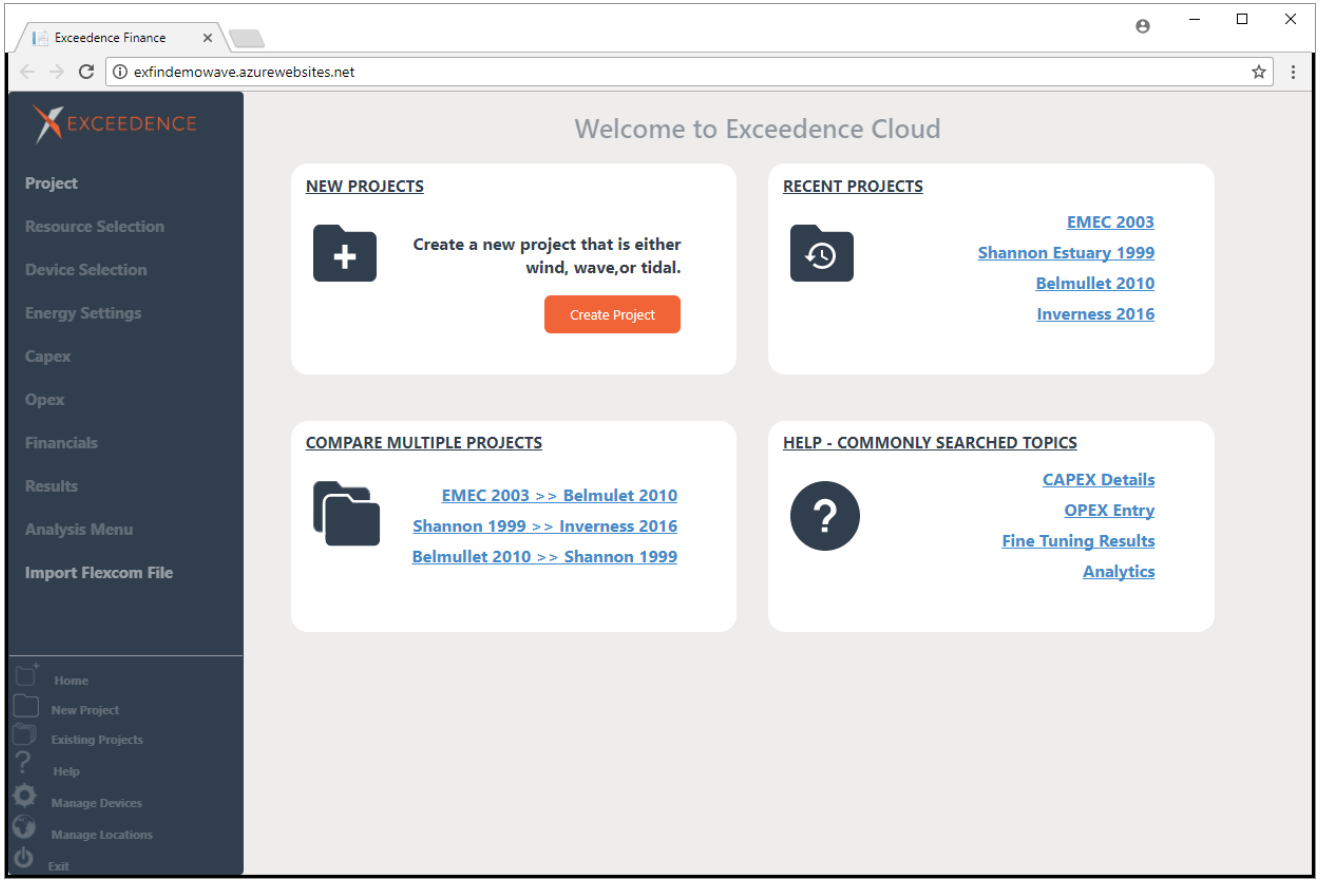
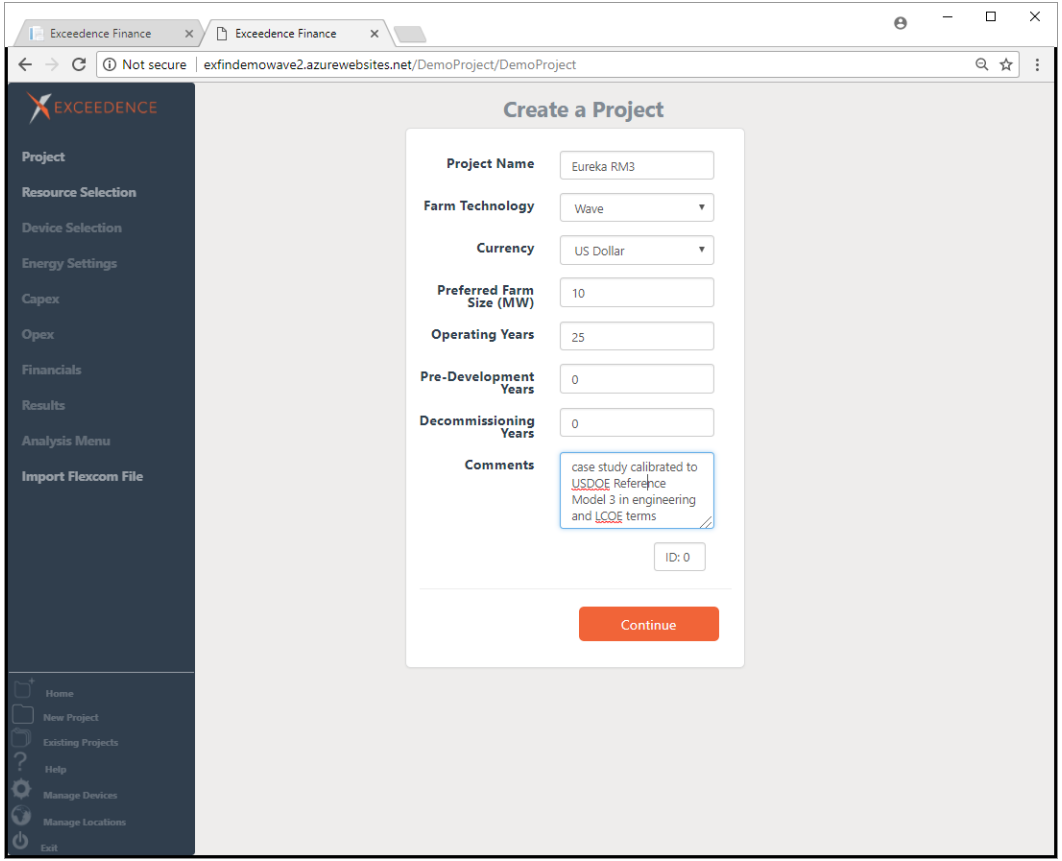


Figure 5-1. RM3 device design and dimensions.

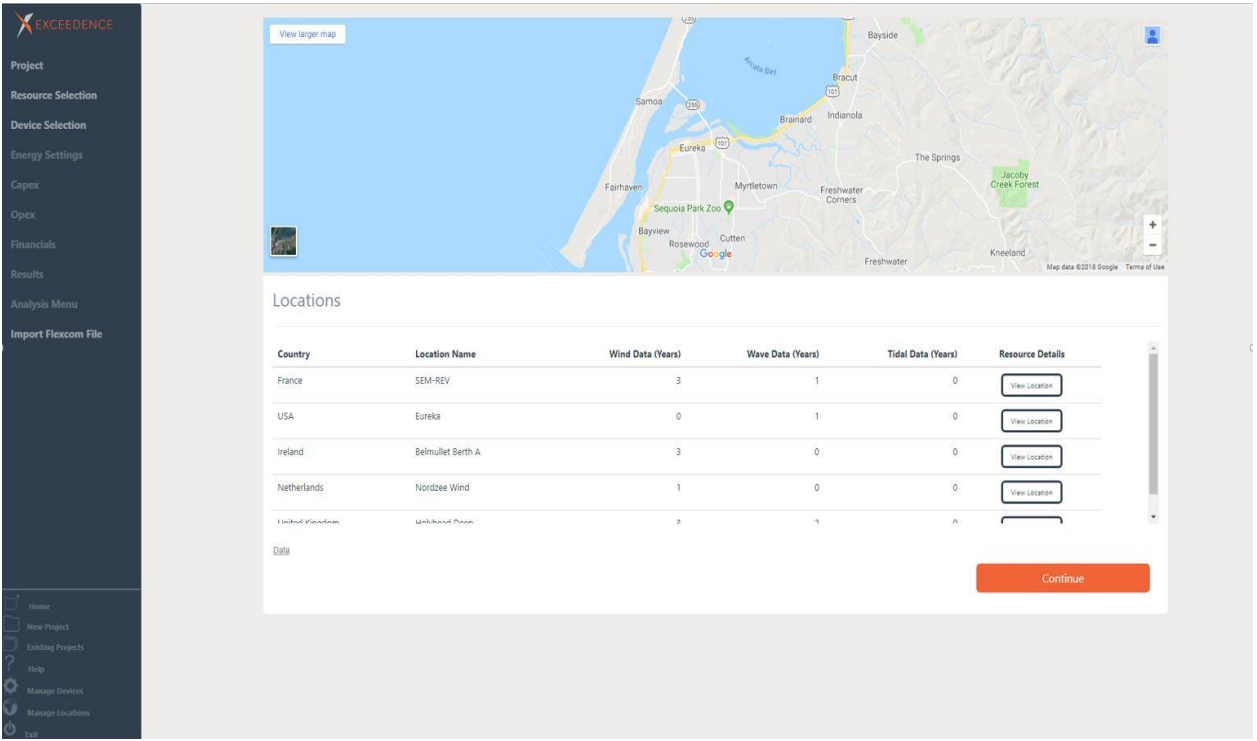
Getting Started

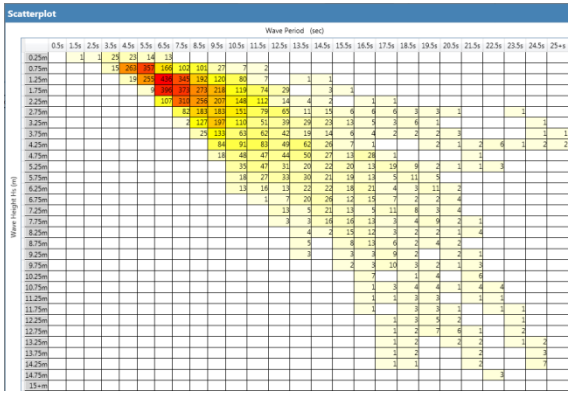


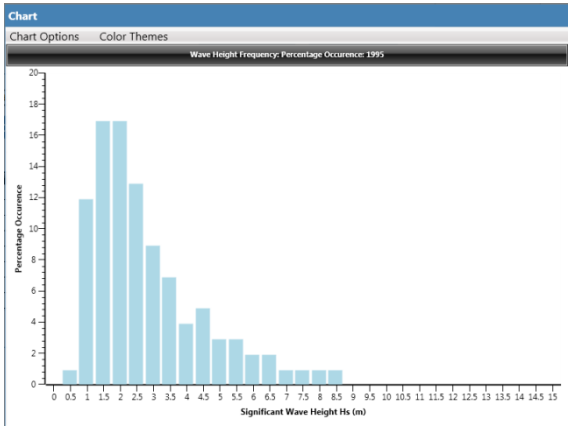
Define a Project



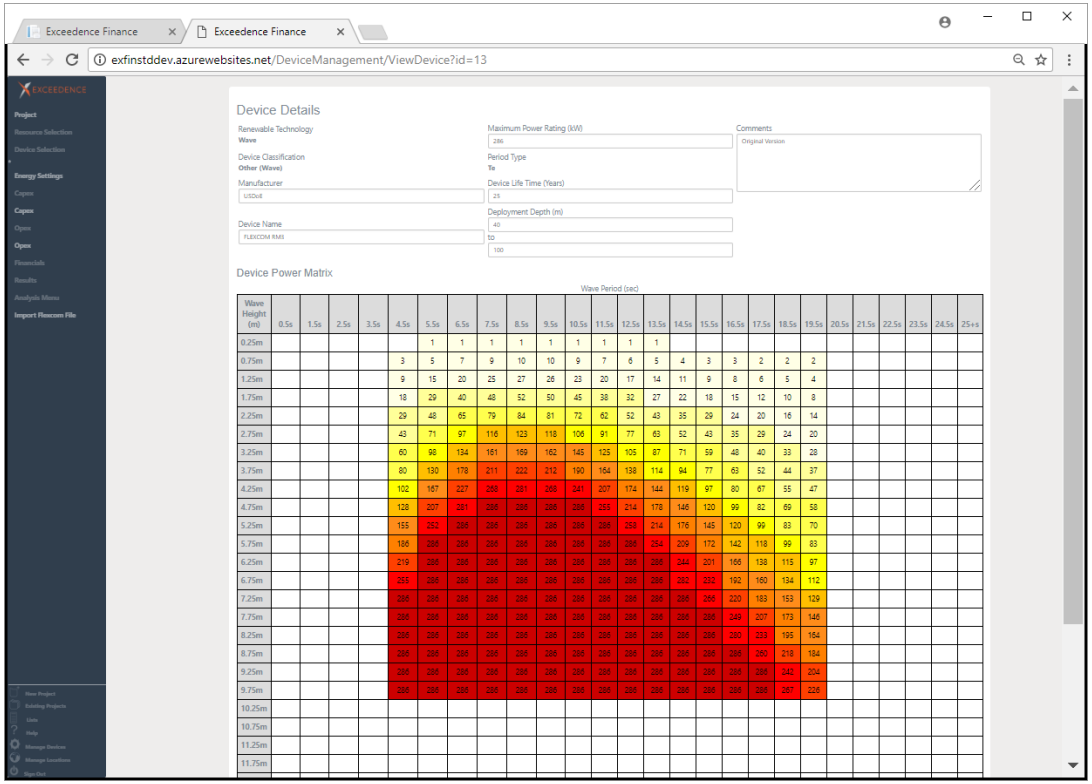
Resource Selection



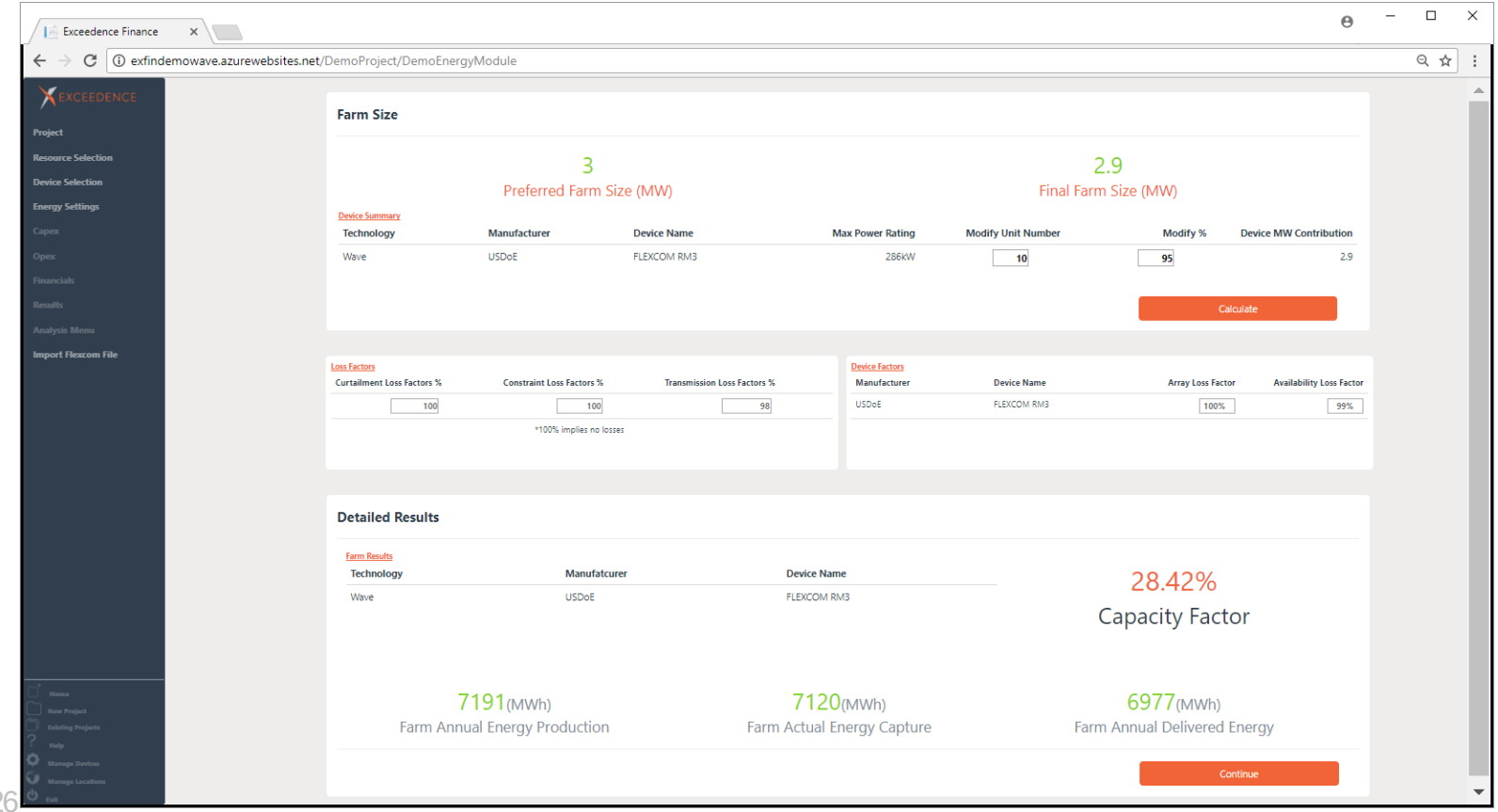




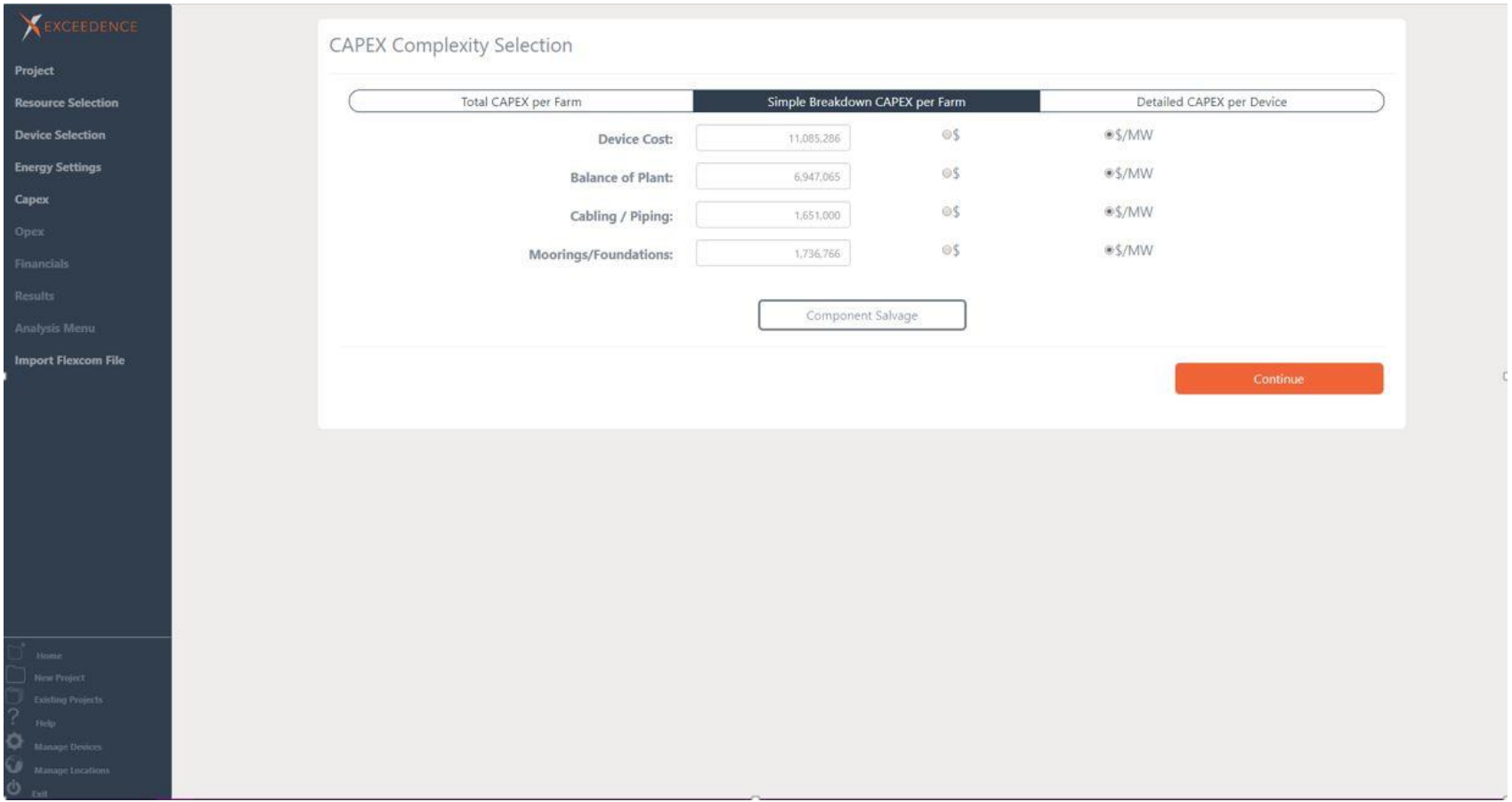
Choose a Device



Yield Calculation BEFORE



CapEx & OpEx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Project
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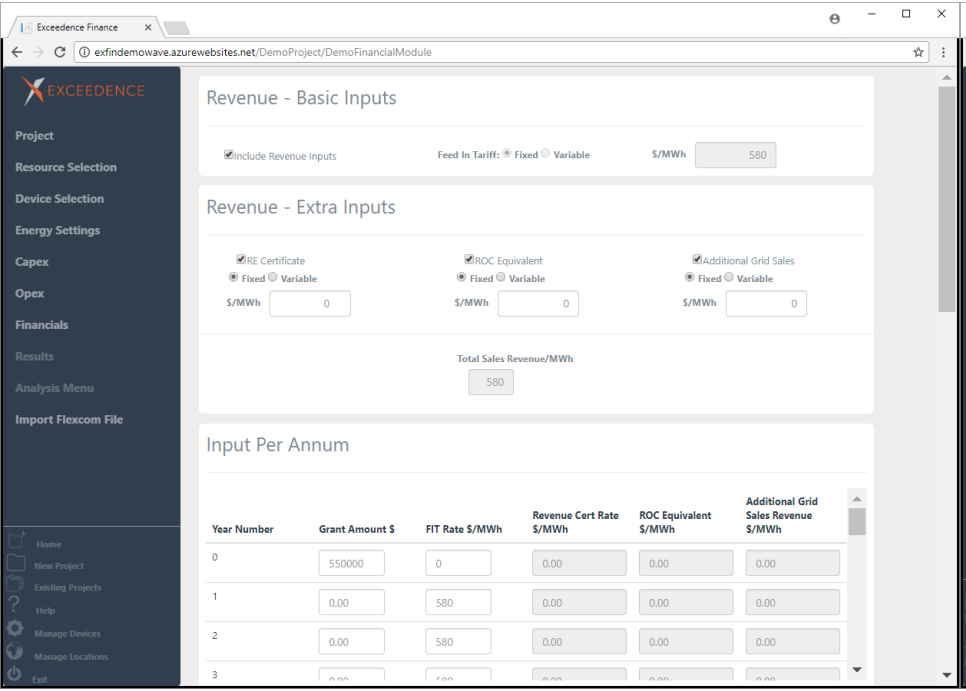
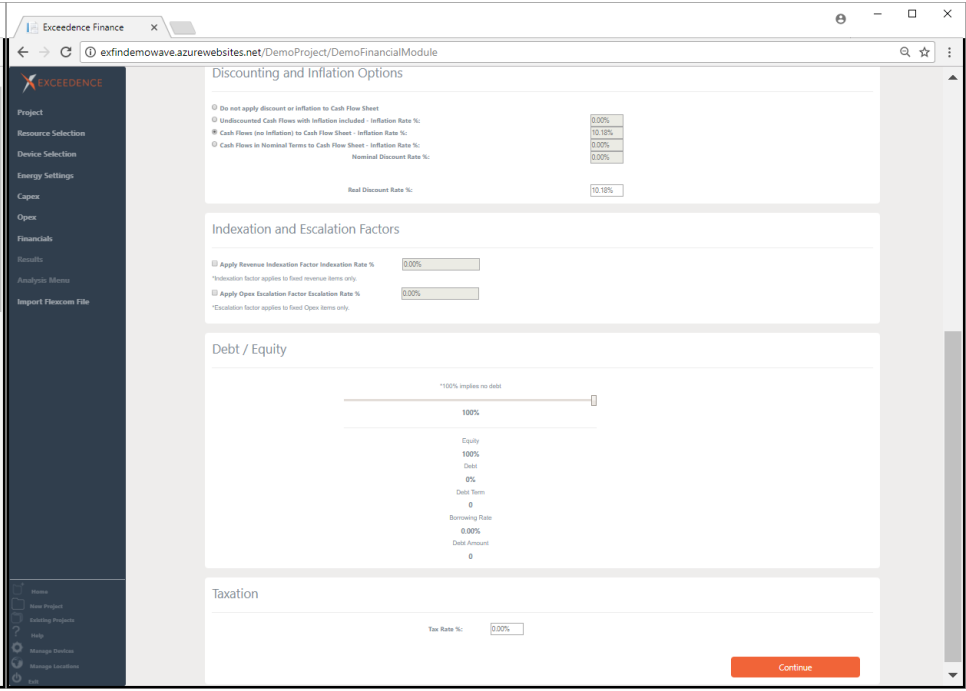
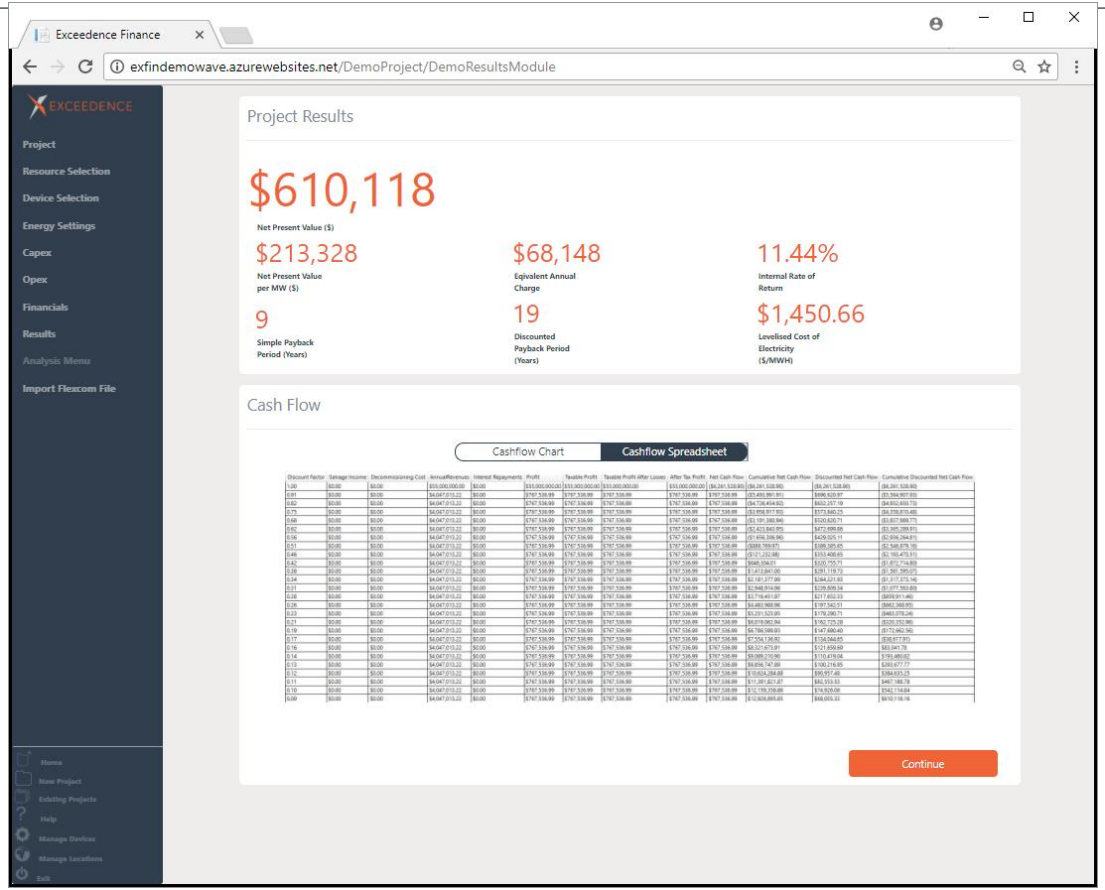
Results
Analysis Menu
Import Flexcom File
Home
New Project
Existing Projects
Help
Manage Devices
Manage Locations
Exit
CAPEX Complexity Selection
Total CAPEX per Farm
Simple Breakdown CAPEX per Farm
Detailed CAPEX per Device
Device Cost:
11,085,286
$
$/MW
Balance of Plant:
6,947,065
$
$/MW
Cabling / Piping:
1,651,000
$
$/MW
Moorings/Foundations:
1,736,766
$
$/MW
Component Salvage
Continue

Financial Parameters

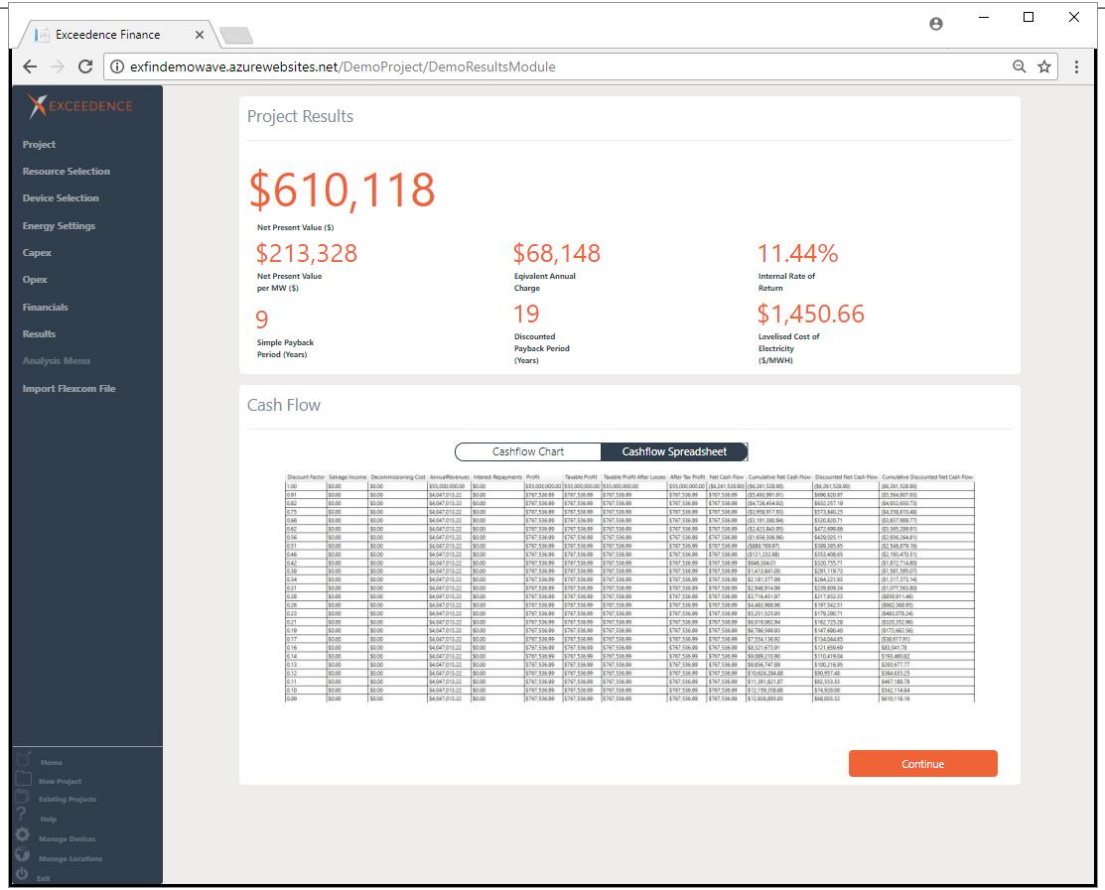




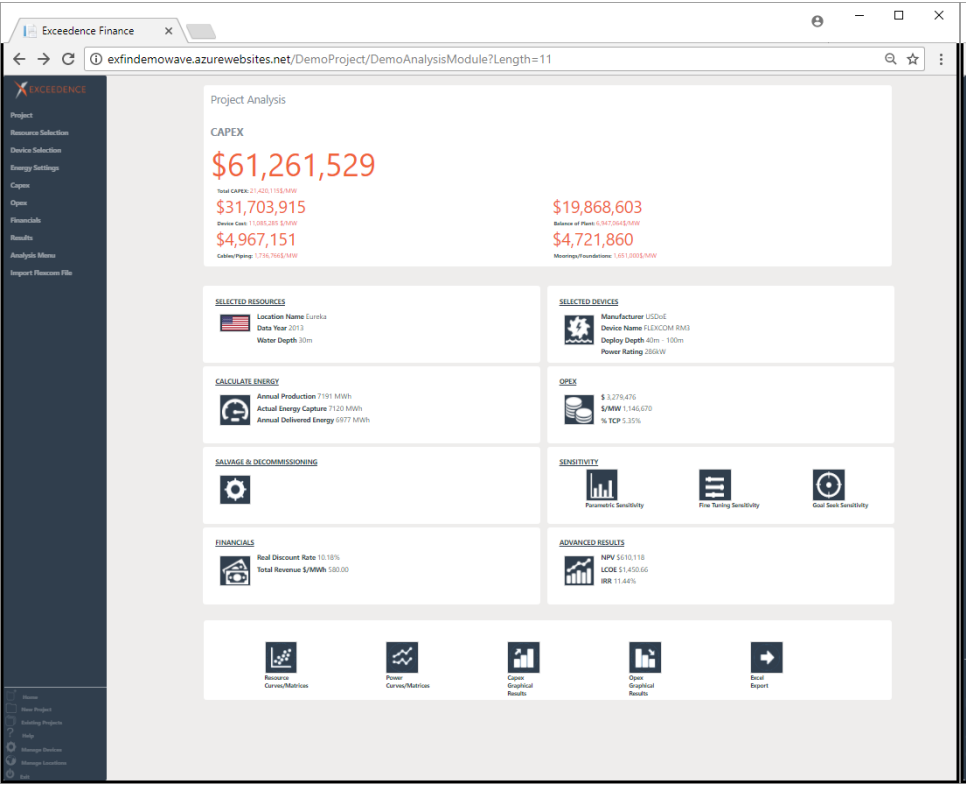
Results Before



Results Before CF



Analytics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Results
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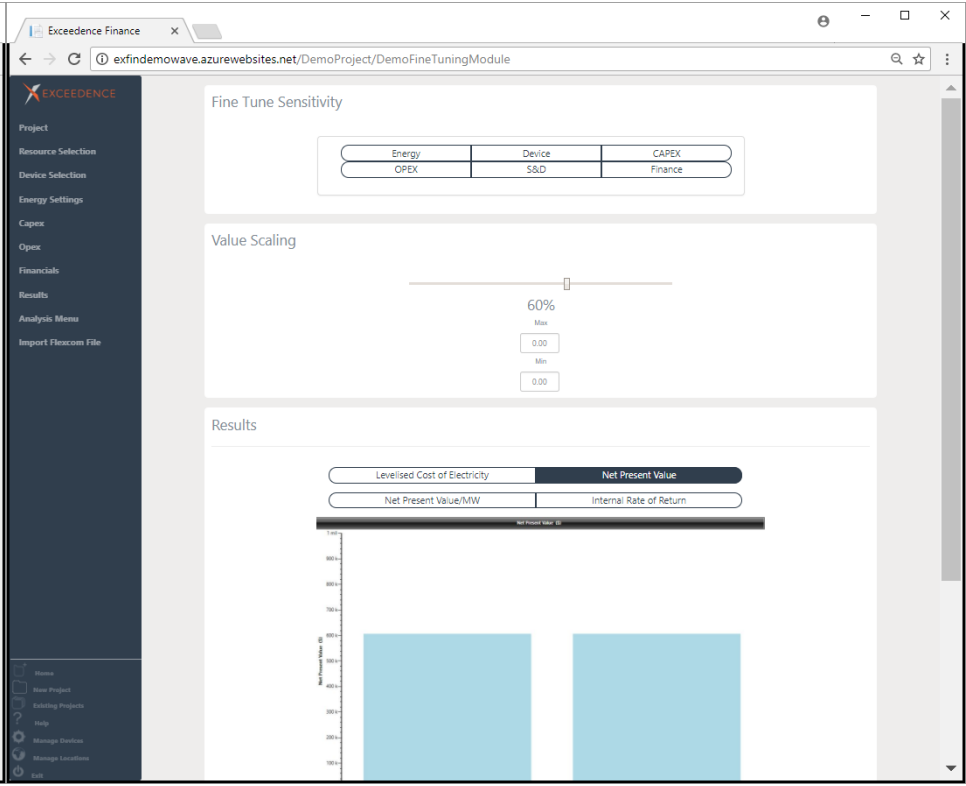
Import Flexcom File
Project Analysis
CAPEX
$61,261,529
$31,703,915
$19,868,603
$4,967,151
$4,721,860
SELECTED RESOURCES
Location Name Eureka
Data Year 2013
Water Depth 30m
SELECTED DEVICES
Manufacturer USDoE
Device Name FLEXCOM RM3
Deploy Depth 40m - 100m
Power Rating 28GkW
CALCULATE ENERGY
Annual Production 7191 MWh
Actual Energy Capture 7120 MWh
Annual Delivered Energy 6977 MWh
OPEX
$ 3,279,476
$/MW 1,146,670
% TCP 5.35%
SALVAGE & DECOMMISSIONING
SENSITIVITY
Parametric Sensitivity
Fine Tuning Sensitivity
Goal Seek Sensitivity
FINANCIALS
Real Discount Rate 10.18%
Total Revenue $/MWh 580.00
ADVANCED RESULTS
NPV $610,118
LCOE $1,450.66
IRR 11.44%
Resource Curves/Matrices
Power Curves/Matrices
Capex Graphical Results
Opex Graphical Results
Excel Export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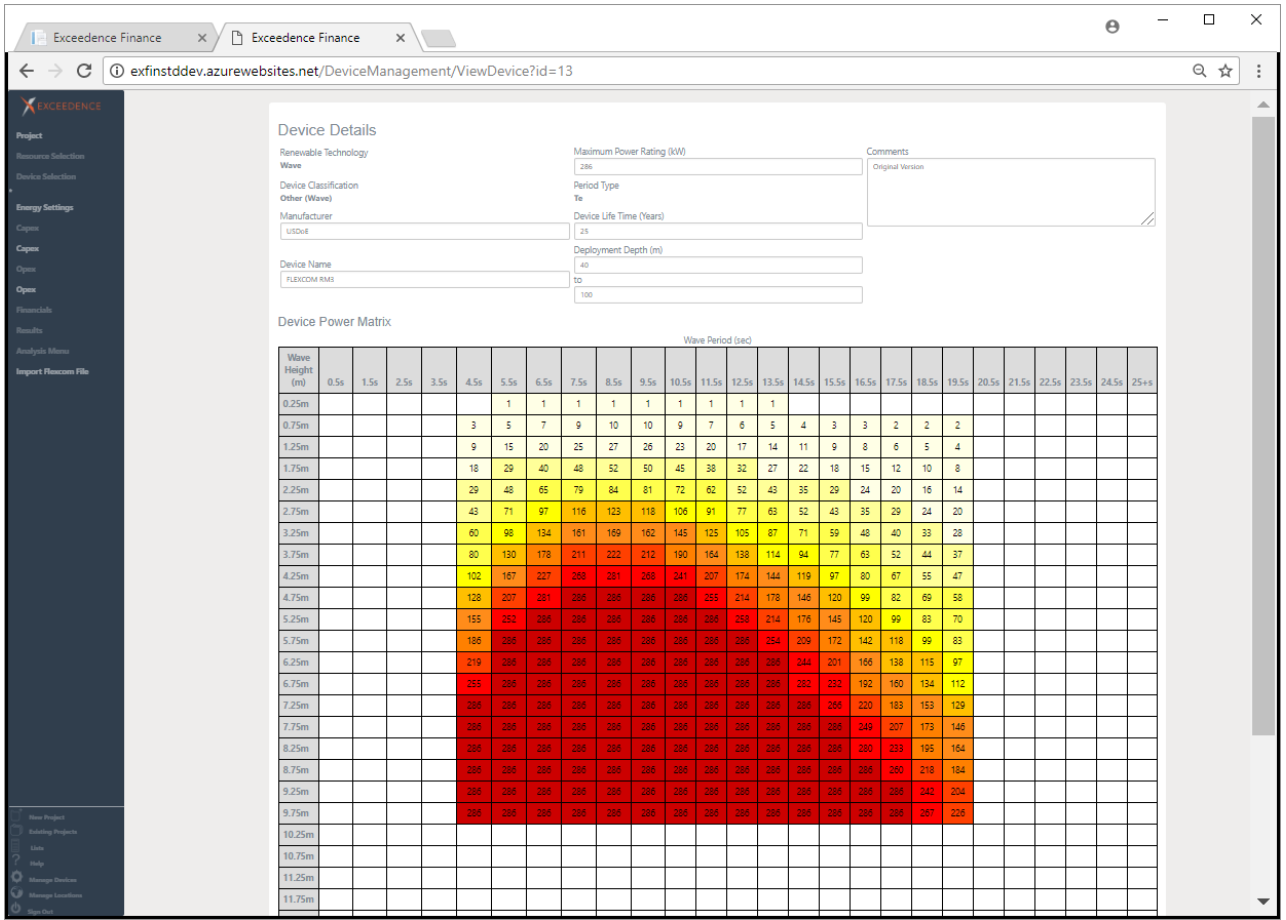
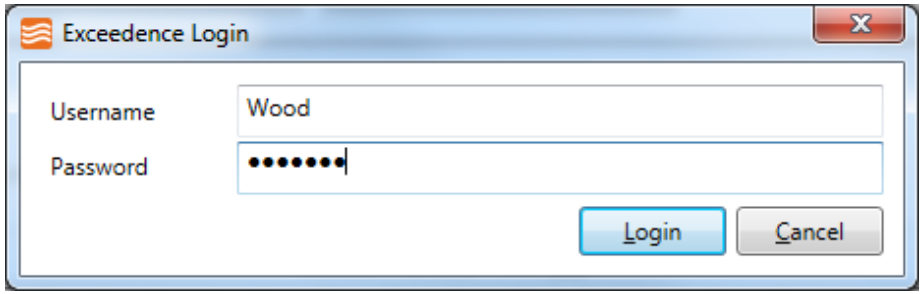
Import Flexcom File
Fine Tune Sensitivity
Energy
Device
CAPEX
OPEX
S&D
Finance
Value Scaling
60%
Max
0.00
Min
0.00
Results
Levelised Cost of Electricity
Net Present Value
Net Present Value/MW
Internal Rate of Return

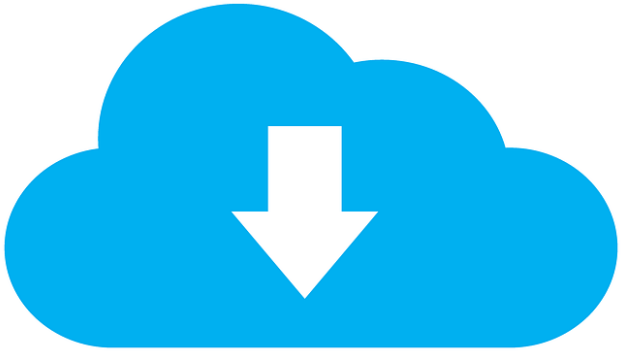
Revise the Device

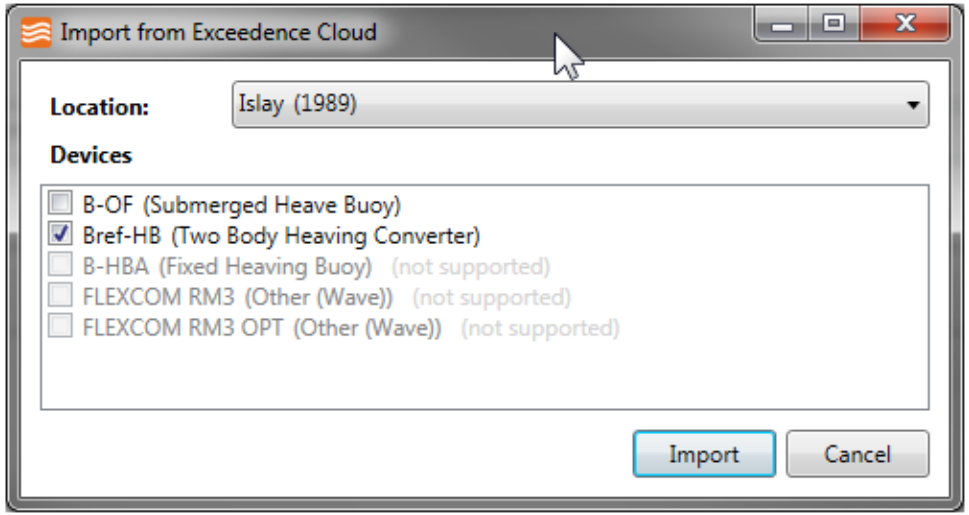


Wave Height (m)	0.5s	1.5s	2.5s	3.5s	4.5s	5.5s	6.5s	7.5s	8.5s	9.5s	10.5s	11.5s	12.5s	13.5s	14.5s	15.5s	16.5s	17.5s	18.5s	19.5s	20.5s	21.5s	22.5s	23.5s	24.5s	25+s
0.25m						1	1	1	1	1	1	1	1	1												
0.75m					3	5	7	9	10	10	9	7	6	5	4	3	3	2	2	2						
1.25m					9	15	20	25	27	26	23	20	17	14	11	9	8	6	5	4						
1.75m					18	29	40	48	52	50	45	38	32	27	22	18	15	12	10	8						
2.25m					29	48	65	79	84	81	72	62	52	43	35	29	24	20	16	14						
2.75m					43	71	97	116	123	118	106	91	77	63	52	43	35	29	24	20						
3.25m					60	98	134	161	169	162	145	125	105	87	71	59	48	40	33	28						
3.75m					80	130	178	211	222	212	190	164	138	114	94	77	63	52	44	37						
4.25m					102	167	227	268	281	268	241	207	174	144	119	97	80	67	55	47						
4.75m					128	207	281	286	286	286	286	255	214	178	146	120	99	82	69	58						
5.25m					155	252	286	286	286	286	286	286	258	214	176	145	120	99	83	70						
5.75m					186	286	286	286	286	286	286	286	286	254	209	172	142	118	99	83						
6.25m					219	286	286	286	286	286	286	286	286	286	244	201	166	138	115	97						
6.75m					255	286	286	286	286	286	286	286	286	286	282	232	192	160	134	112						
7.25m					286	286	286	286	286	286	286	286	286	286	286	266	220	183	153	129						
7.75m					286	286	286	286	286	286	286	286	286	286	286	286	249	207	173	146						
8.25m					286	286	286	286	286	286	286	286	286	286	286	286	280	233	195	164						
8.75m					286	286	286	286	286	286	286	286	286	286	286	286	286	260	218	184						
9.25m					286	286	286	286	286	286	286	286	286	286	286	286	286	286	242	204						
9.75m					286	286	286	286	286	286	286	286	286	286	286	286	286	286	267	226						
10.25m																										
10.75m																										
11.25m																										
11.75m																										

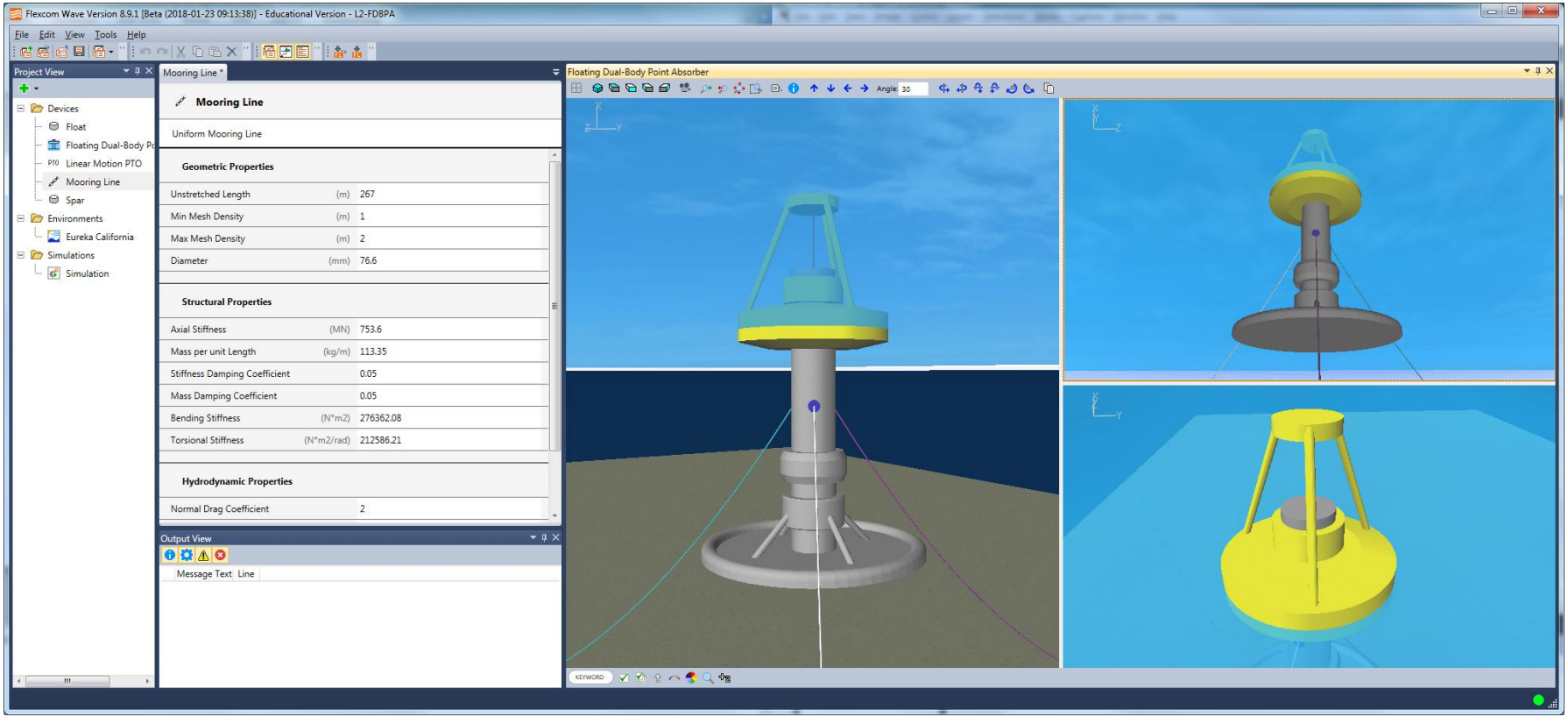
Import Data into Flexcom Wave



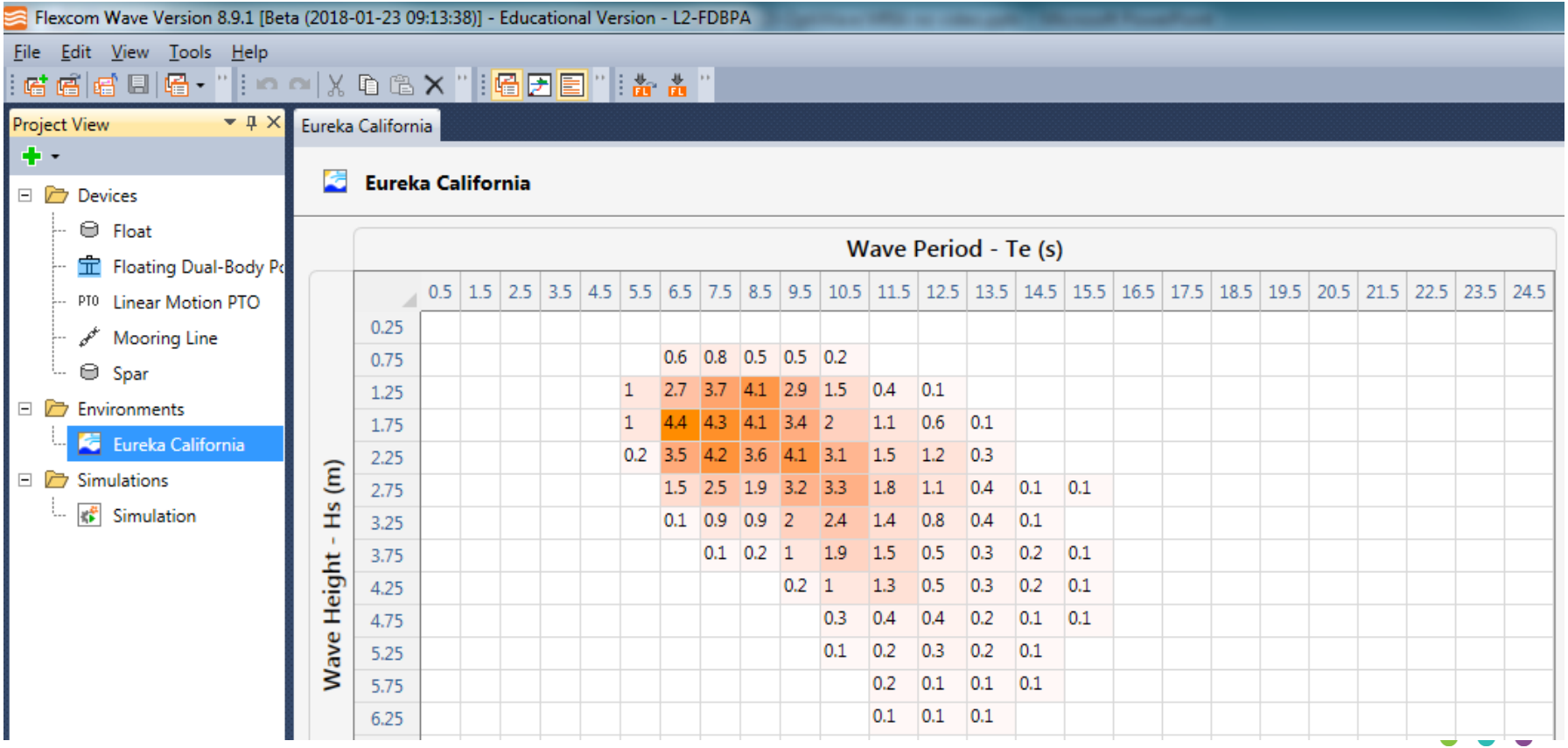




Engineering Model

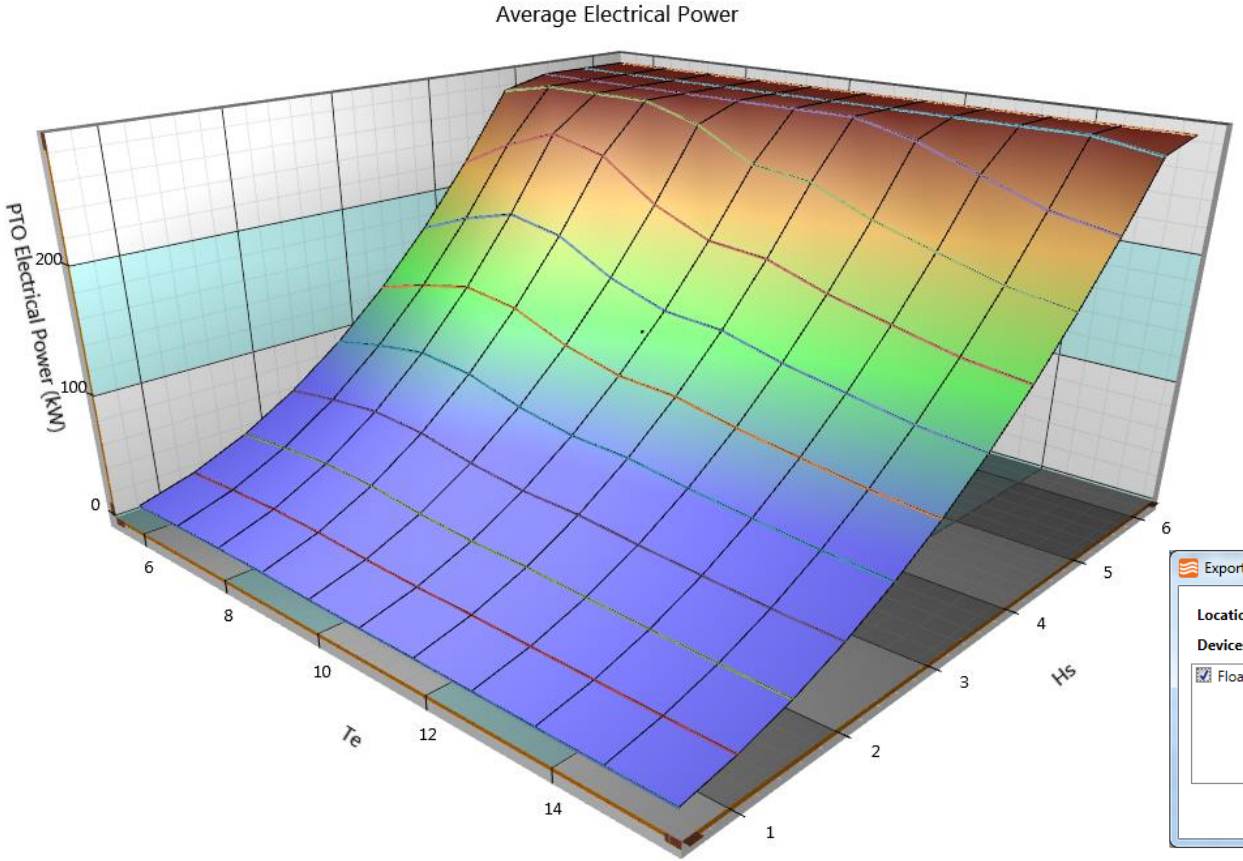


Wave Scatter Diagram

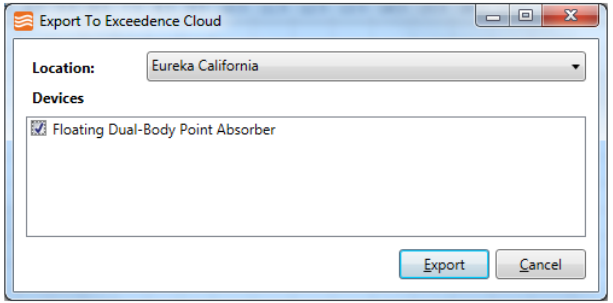


Hs (m) \ Te (s)	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5
0.25																									
0.75							0.6	0.8	0.5	0.5	0.2														
1.25						1	2.7	3.7	4.1	2.9	1.5	0.4	0.1												
1.75						1	4.4	4.3	4.1	3.4	2	1.1	0.6	0.1											
2.25						0.2	3.5	4.2	3.6	4.1	3.1	1.5	1.2	0.3											
2.75							1.5	2.5	1.9	3.2	3.3	1.8	1.1	0.4	0.1	0.1									
3.25							0.1	0.9	0.9	2	2.4	1.4	0.8	0.4	0.1										
3.75								0.1	0.2	1	1.9	1.5	0.5	0.3	0.2	0.1									
4.25										0.2	1	1.3	0.5	0.3	0.2	0.1									
4.75											0.3	0.4	0.4	0.2	0.1	0.1									
5.25											0.1	0.2	0.3	0.2	0.1										
5.75												0.2	0.1	0.1	0.1										
6.25												0.1	0.1	0.1											

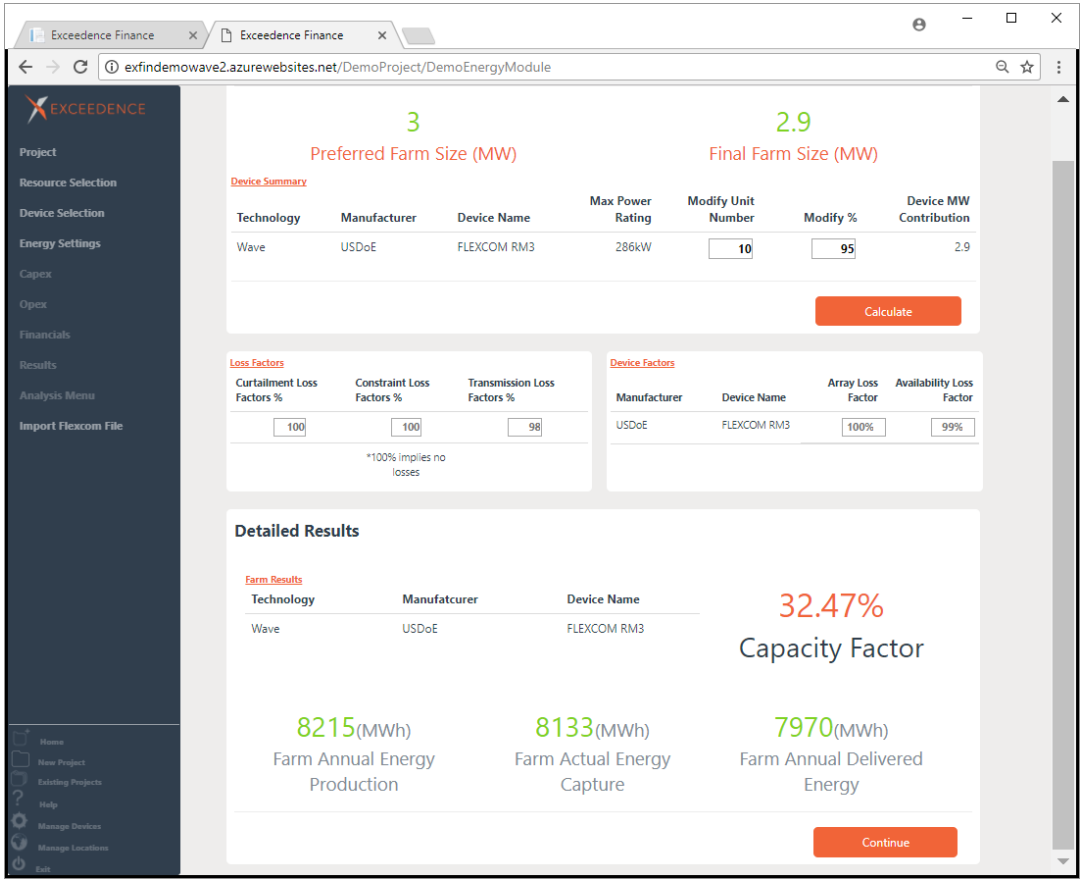
Power Output



Export to Exceedence

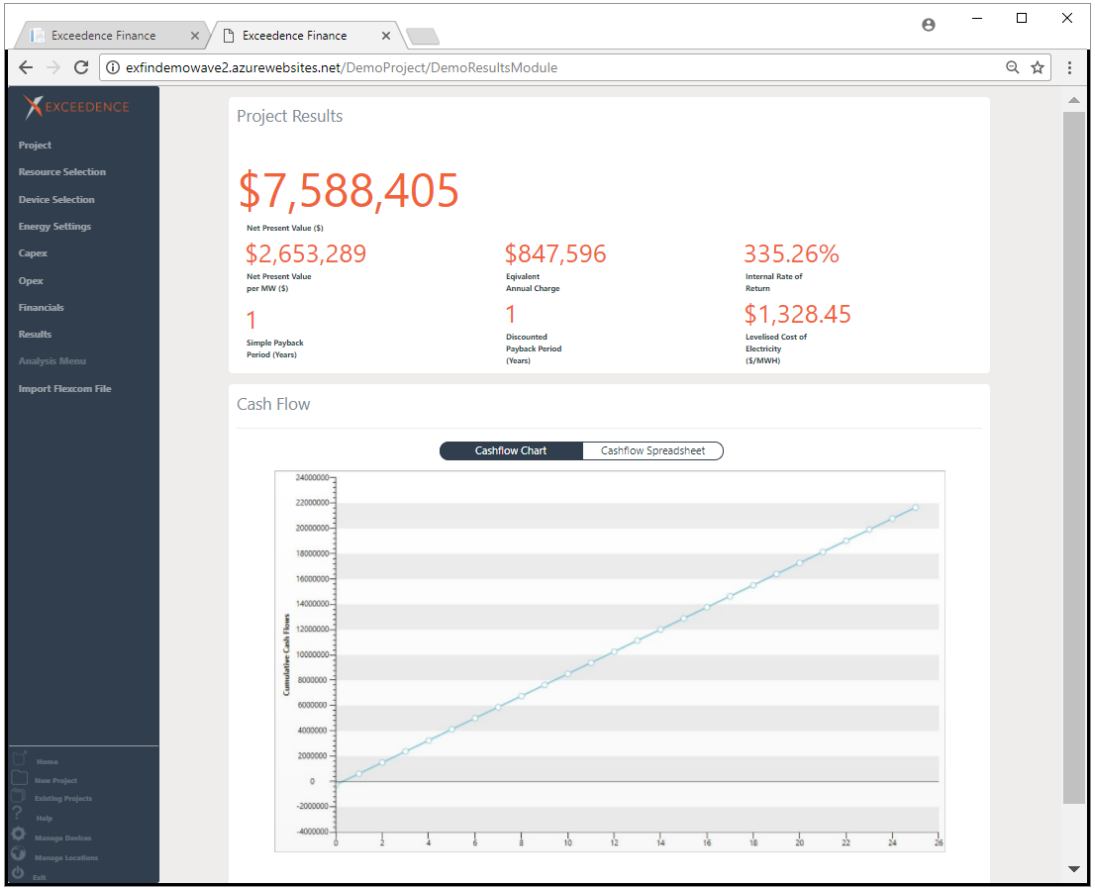


Yield After



- 14% Increase in Yield

Results After



- 9% reduction in LCOE

OptiWave

Financial and engineering optimization platform for wave energy systems

- Greater understanding for wave energy developers
- Better confidence for funders and investors
- Validated against real world case studies
- Fully supported commercial package
- Tiered subscription offering
- 1st in a line of products

Further Information

OptiWave

- OptiWave@woodgroup.com
- https://www.woodgroup.com/optiwave *(coming soon)*

Exceedence

- http://exceedence.com

Flexcom

- https://www.woodgroup.com/flexcom

Thank you

EnFAIT

DTOcean

THE UNIVERSITY of EDINBURGH

POLICY AND INNOVATION GROUP

DTOcean

Optimisation design tools applied to the **EnFAIT** project

Dr Encarni Medina-Lopez

29th January 2018 – ETIP Webinar

DTOcean (Optimal Design Tools for Ocean Energy Arrays). ENERGY 2013-1, EC.

Objectives:

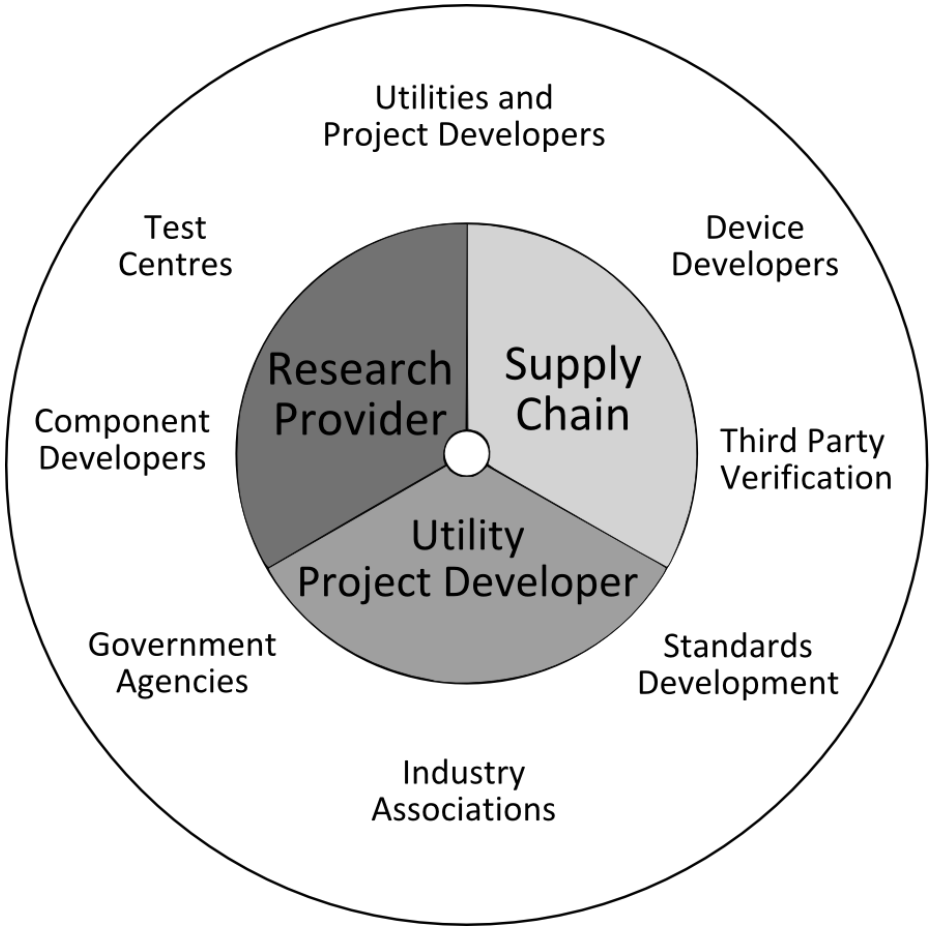
1. Full suite of whole-system software design tools.

2. Identification of enabling technologies to reduce deployment costs and increase the performance of ocean energy arrays.

3. Guidelines for accelerating decisions by reducing risks and uncertainties.

18 partners from 11 countries under the coordination of the University of Edinburgh

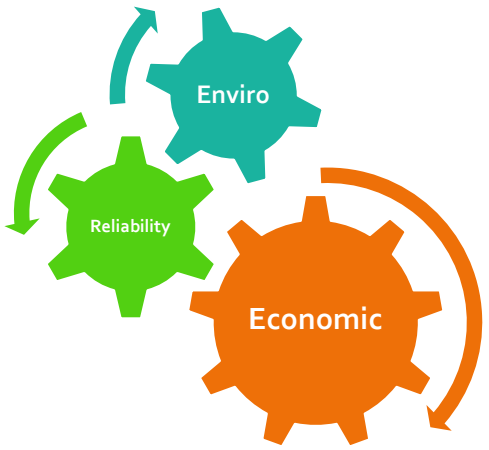
Structure of the consortium



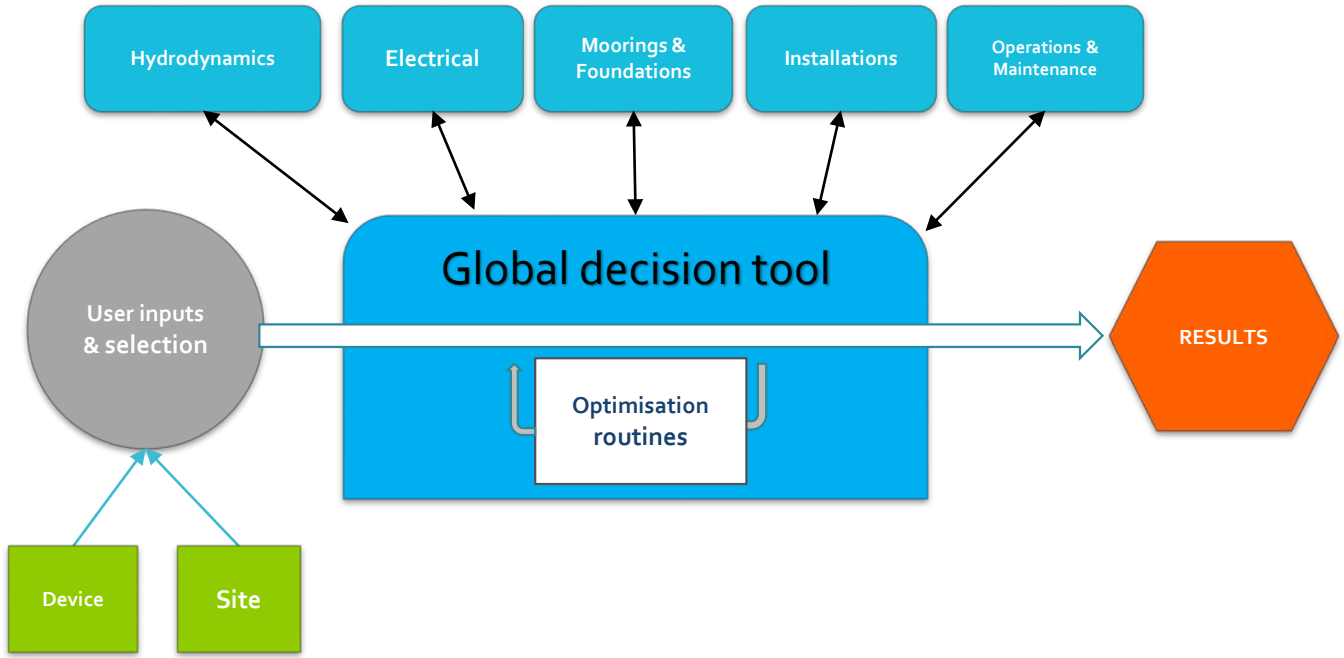
- Advisory Board
- Research Providers (Universities and Applied Research Centres)
- Utilities and Project Developers
- Supply Chain

DTOcean structure

- Modules
  - Hydrodynamics
  - Electrical systems
  - Moorings & Foundations
  - Installation
  - Operations & Maintenance



- Assessments
  - Economics
  - Environmental
  - Reliability



Software

- Python 2.7: the programming language of the software
- PostgreSQL 9.4: Database manager
- Qt4: graphical interface

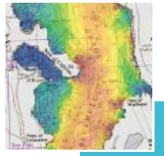
Typical mid-range Windows system

Data requirements

- Tidal
- Wave
- Fixed or floating device?

Device data

- Geometry
- Performance
- Maintenance
- Installation
- …



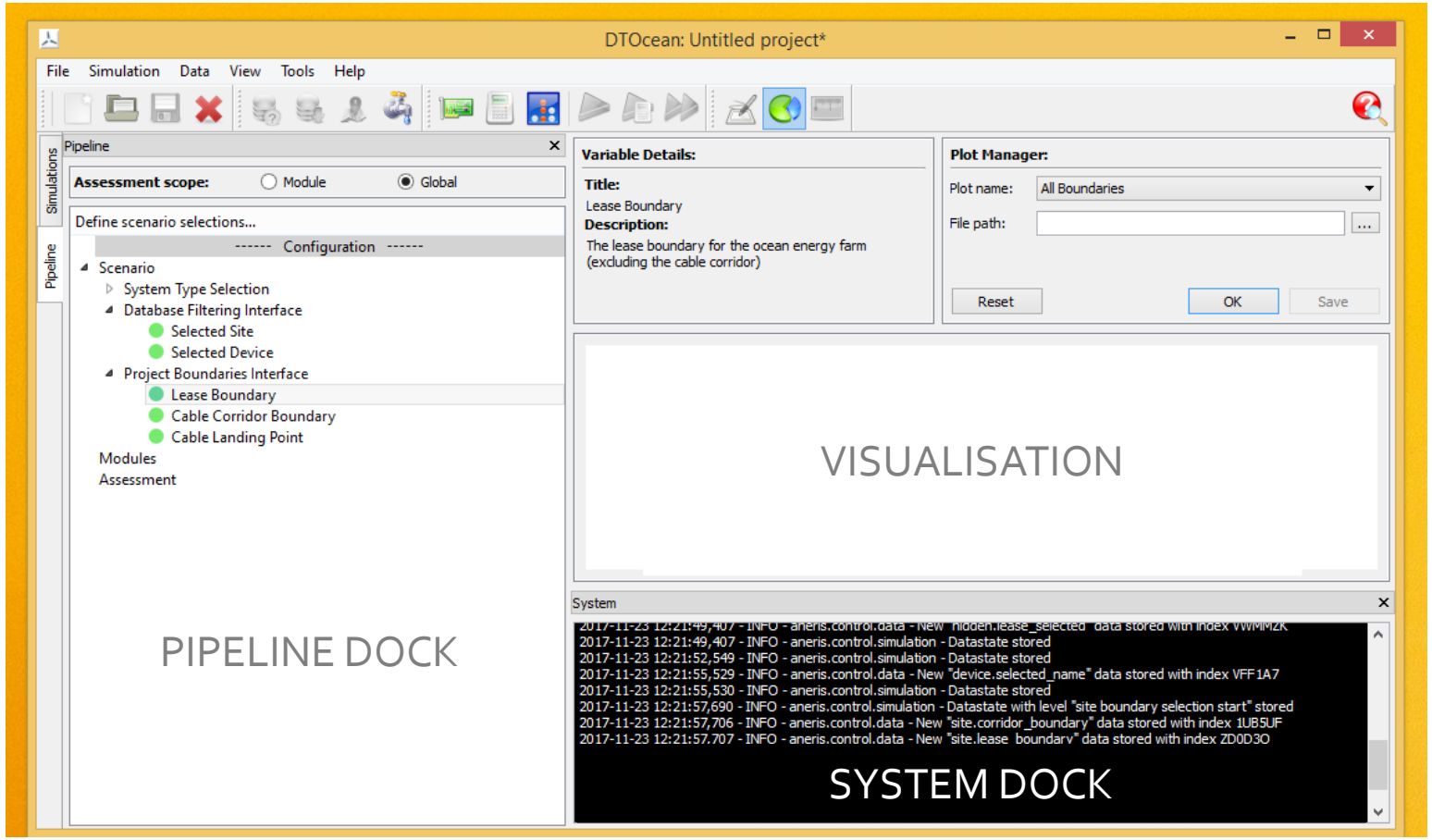
Site data

- Bathymetry
- Metocean
- Soil features
- …

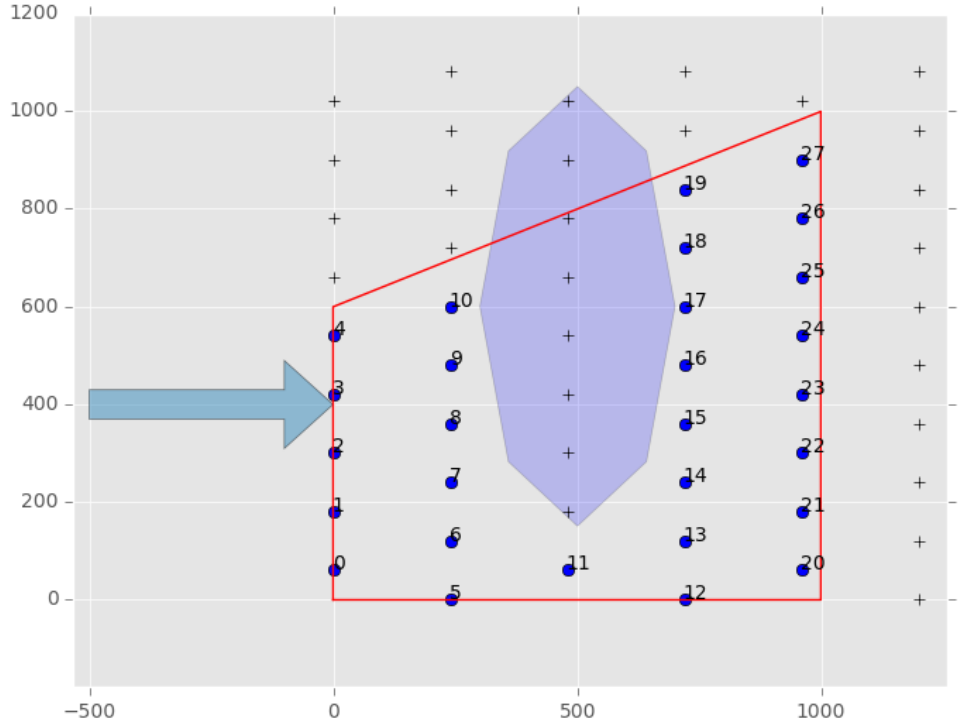
Project data

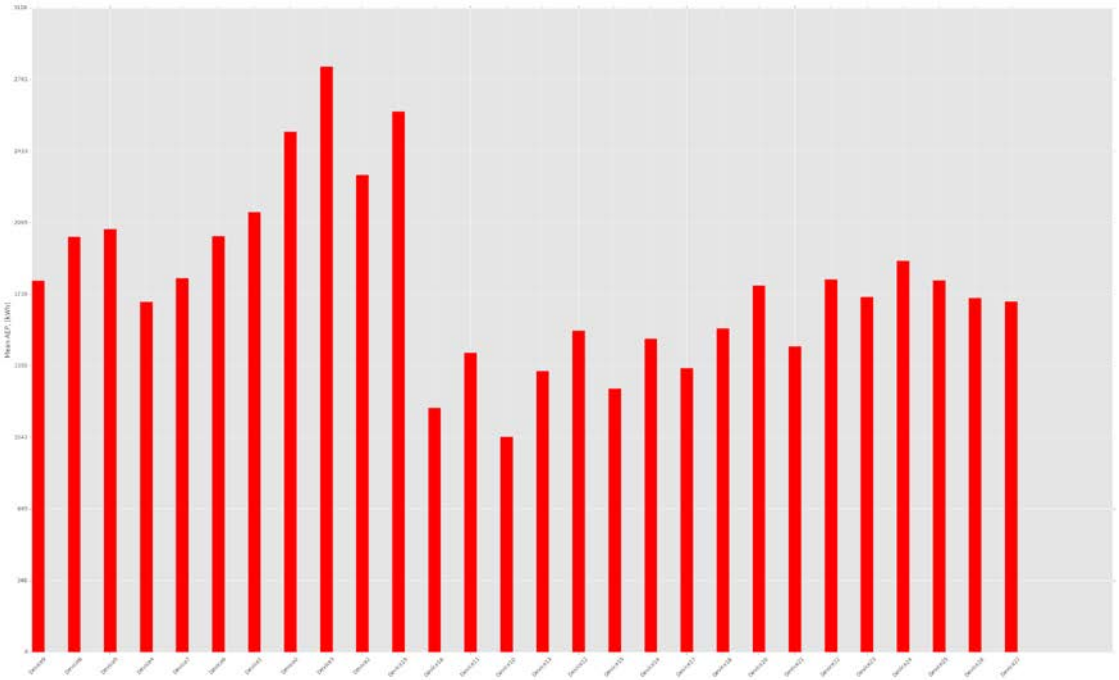
- Array power
- Ports nearby
- Vessels
- Installation rates
- Basic costs
- …

DTOcean interface



Expected outputs





The EnFAIT project

DTOcean

EnFAIT www.enfait.eu

- Enabling Future Arrays in Tidal
- 5 years project (start July 2017).
- 9 partners around Europe.

https://youtu.be/jLuOueRuIEk

NOVA INNOVATION

elsa GROUPE IDETA

CATAPULT Offshore Renewable Energy

SKF

THE UNIVERSITY of EDINBURGH

mojomaritime wind · tide · wave

HMK Mechanical Drives

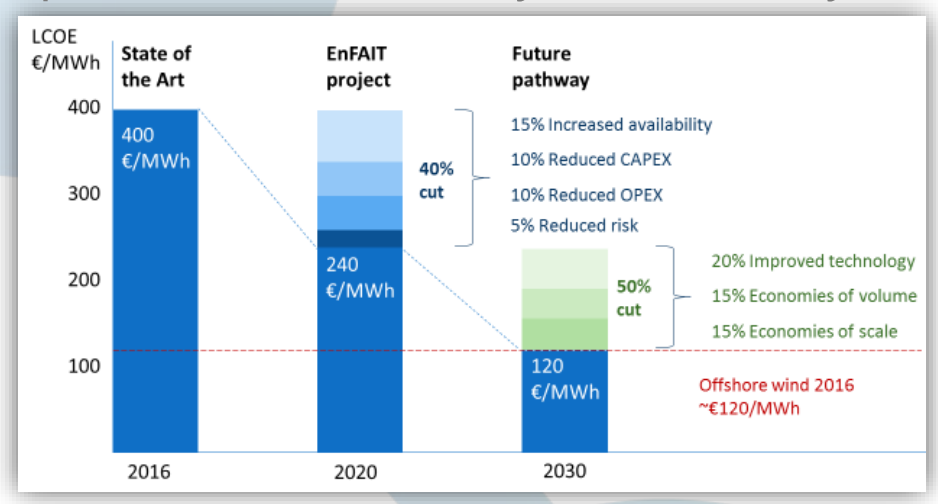
WOOD GROUP

RSK

- Present: 0.3 MW array. Upgrade to 0.6MW (100kW turbines).

GOALS

- Reduce LCOE
- Prove high reliability and availability
- Disseminate learning in ocean energy
- Step towards bankability of tidal arrays



Buemull Sound
Shetland Islands
Scotland

DTOcean – EnFAIT: goals

- Validate tool
- Validate 3-turbines array
- Optimal placing of 6-turbine array
- Estimation of metrics to be used

Thank you

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Technology Theme Webinar

Developing and Implementing Optimisation tools

29 January 2018

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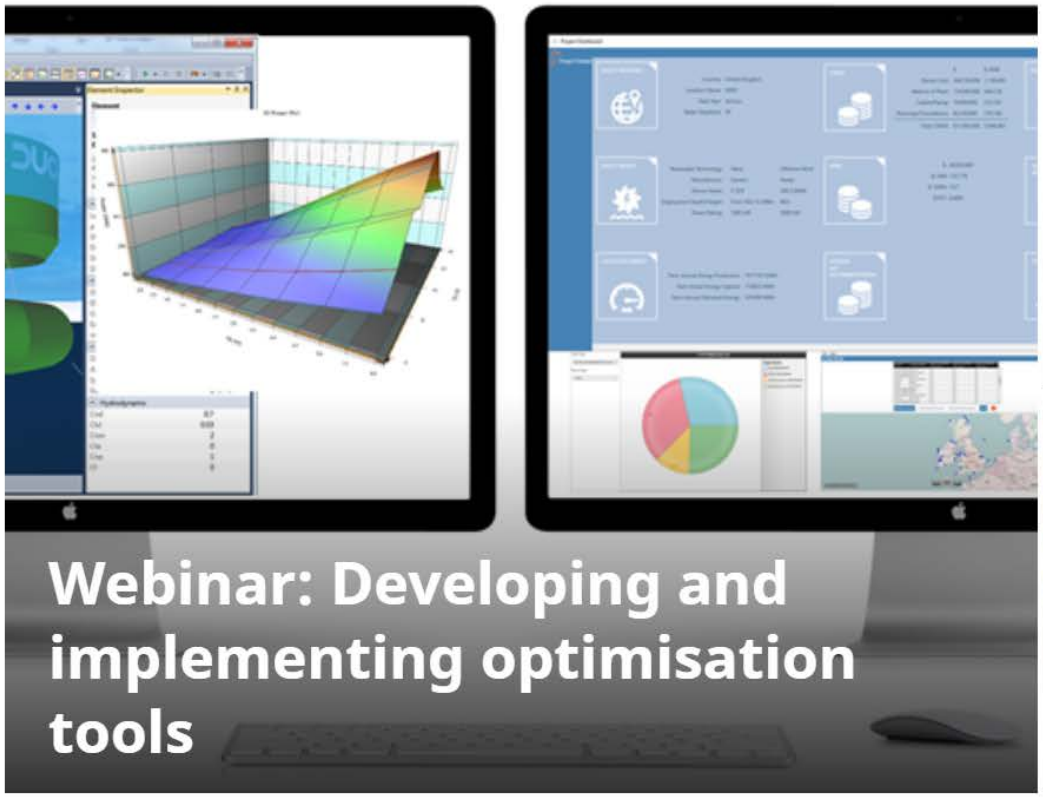

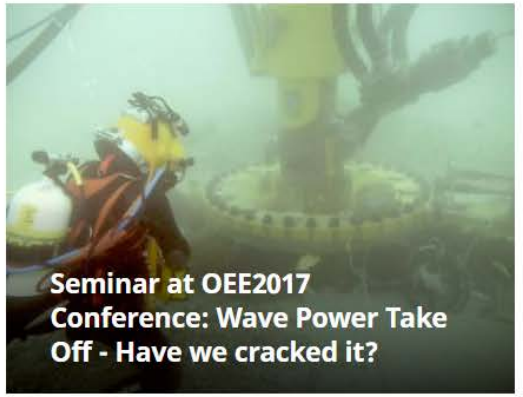

Staying in Touch

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