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1. Introduce DTOceanPlus tools
2. Using DTOceanPlus and results
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5. Conclusions
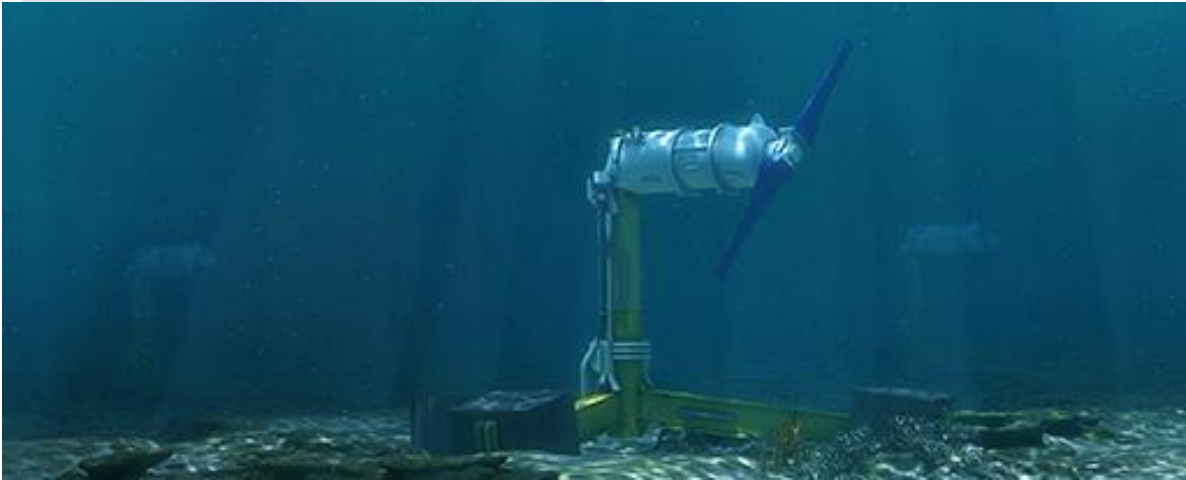
THE UNIVERSITY *of* EDINBURGH
School of Engineering

Policy and Innovation Group

- Techno- and Socio-Economic Assessment
- Life Cycle Evaluation
- Technology Roadmaps
- Array Optimisation Analysis
- Strategy Planning
- Consultancy

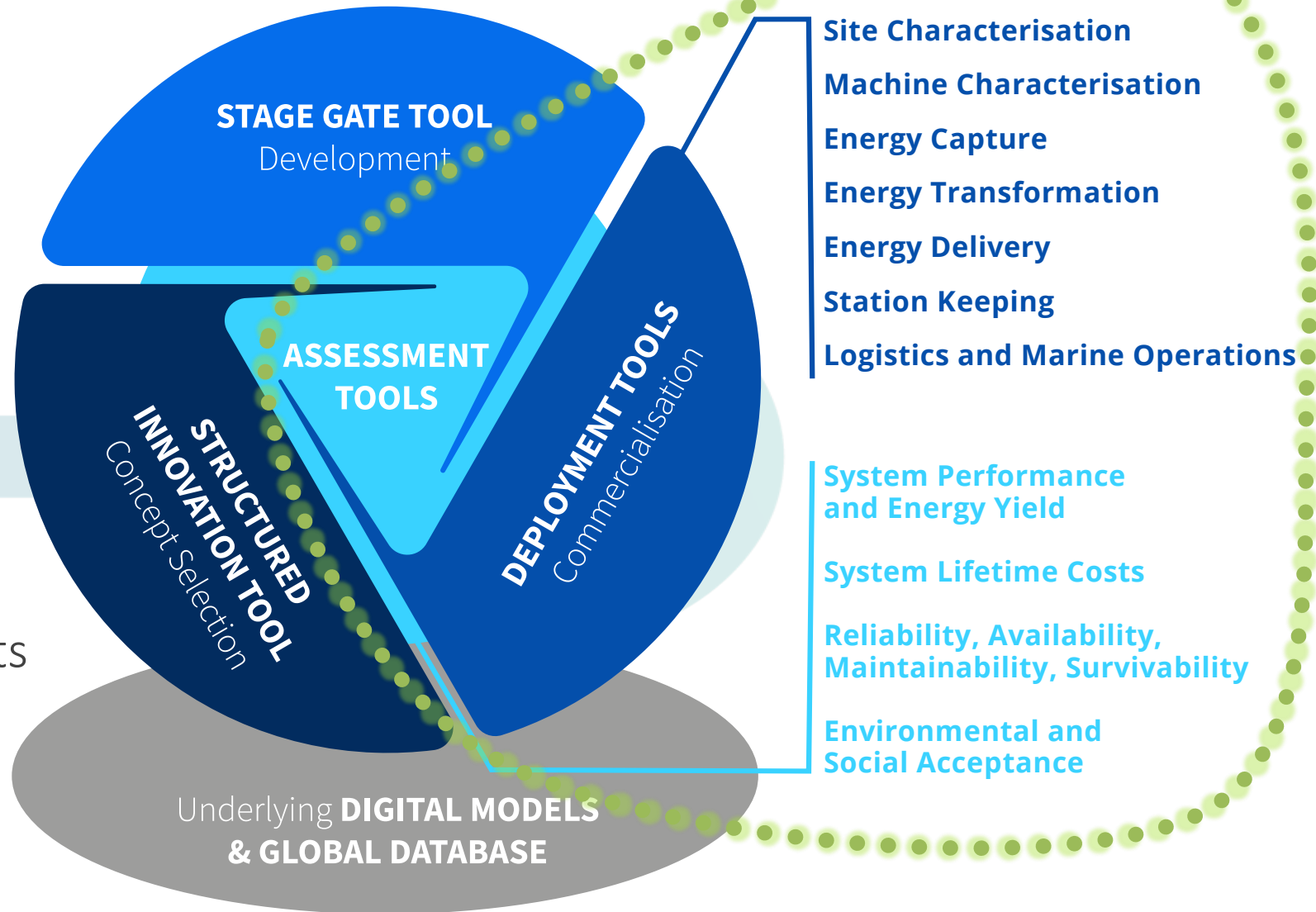policyandinnovationedinburgh.org

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ICOE
INTERNATIONAL CONFERENCE ON OCEAN ENERGY

OCEAN ENERGY EUROPE

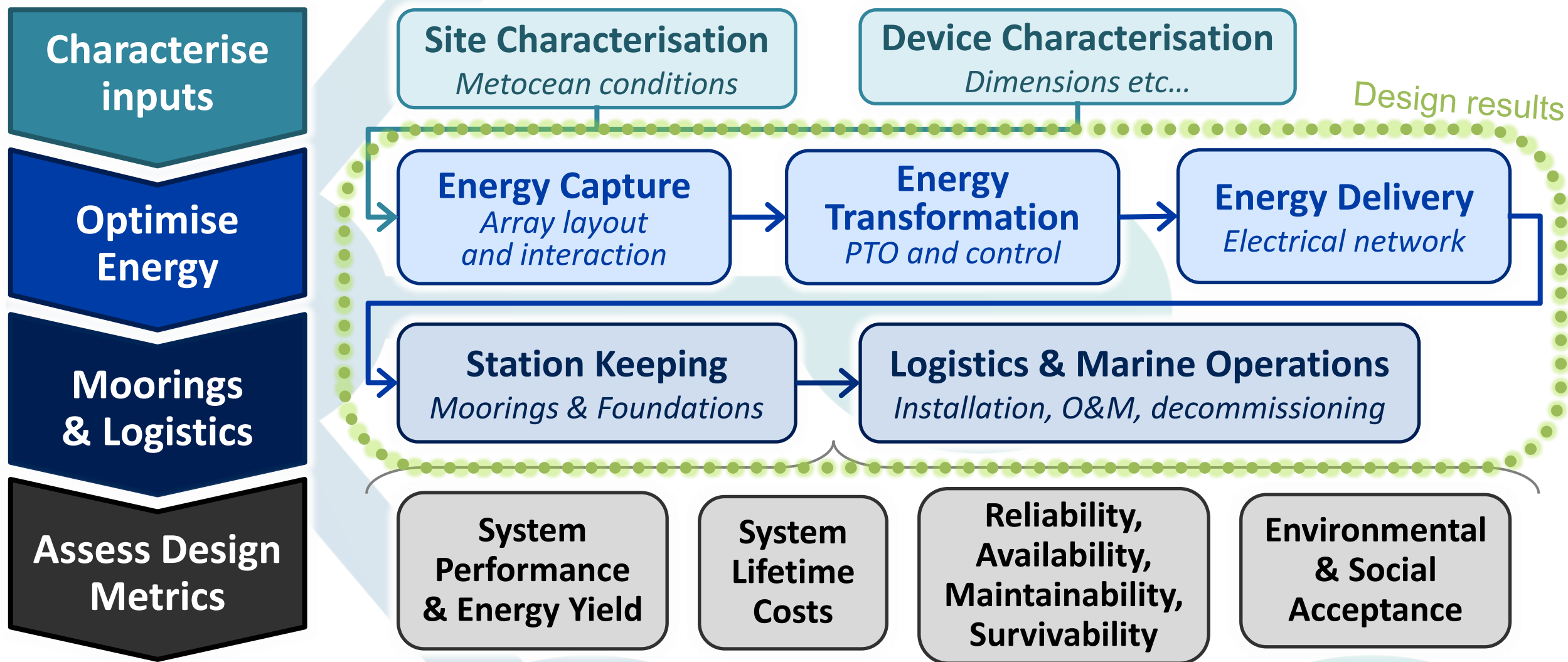Donostia / San Sebastián 2022

EnFAIT

The DTOceanPlus Tools

- Suite of modular tools →
  - Design and optimisation
  - Wave and tidal energy
  - Fixed and floating
  - Subsystem, device & arrays
- Holistic design of many, often conflicting, requirements
- Builds on and expands original DTOcean tools
- dtoceanplus.eu

STAGE GATE TOOL
Development

ASSESSMENT TOOLS

STRUCTURED INNOVATION TOOL
Concept Selection

DEPLOYMENT TOOLS
Commercialisation

Underlying **DIGITAL MODELS & GLOBAL DATABASE**

Site Characterisation

Machine Characterisation

Energy Capture

Energy Transformation

Energy Delivery

Station Keeping

Logistics and Marine Operations

System Performance and Energy Yield

System Lifetime Costs

Reliability, Availability, Maintainability, Survivability

Environmental and Social Acceptance

EnFAIT

Using the Deployment Design and Assessment tools

Characterise inputs

Site Characterisation
Metocean conditions

Device Characterisation
Dimensions etc...

Design results

Optimise Energy

Energy Capture
Array layout and interaction

Energy Transformation
PTO and control

Energy Delivery
Electrical network

Moorings & Logistics

Station Keeping
Moorings & Foundations

Logistics & Marine Operations
Installation, O&M, decommissioning

Assess Design Metrics

System Performance & Energy Yield

System Lifetime Costs

Reliability, Availability, Maintainability, Survivability

Environmental & Social Acceptance

EnFAIT

Example Results from DTOceanPlus

- **Energy Capture**: array layout plan, AEP for devices & array, interaction factor, ...

- **Energy Transformation:** Design of PTO, power/energy lost at each step, ...

- **Energy Delivery**: array electrical network, power delivered to shore & losses, ...

- **Station Keeping**: design of foundation (or mooring) for devices and substations, ...

- **Logistics & Marine Operations**: vessel/port selection, timing of operations, ...

Array layout plan

Vessel & port selection
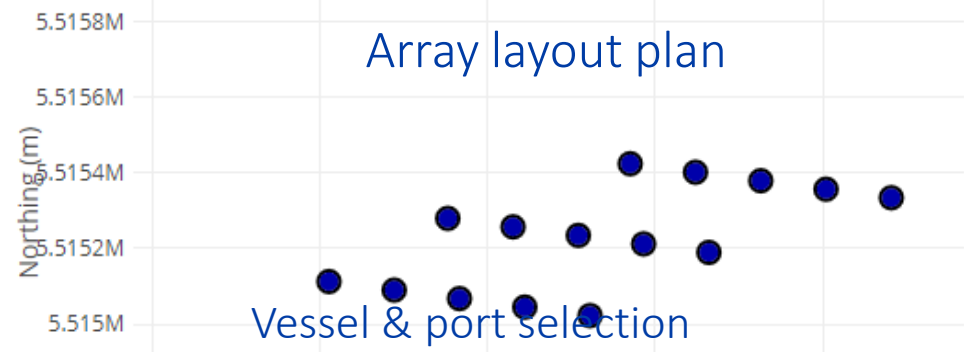
Installation solution:

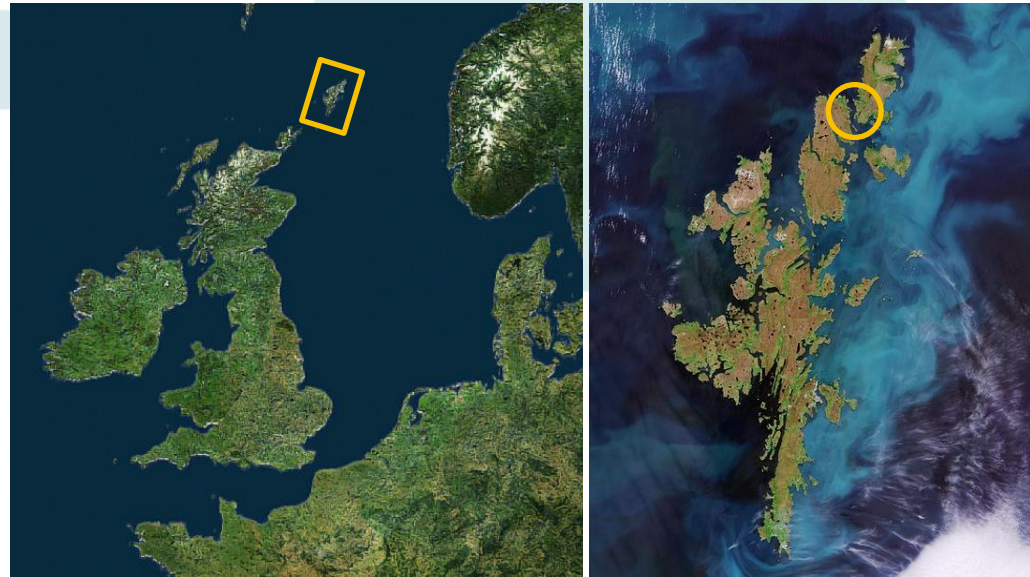| minal costs (€)	Vessel costs (€)	Equipment costs (€)	Total costs (€)	Terminal	Vessels	Equipment
3,409.0	616,533.0	65,240.0	685,182.0	Agotnes - Kai 11s	Propelled Crane Vessel	ROV inspection
3,016.0	545,515.0	57,700.0	606,231.0	Agotnes - Kai 11s	Propelled Crane Vessel	ROV inspection
2,872.0	510,712.0	63,774.0	577,359.0	Agotnes - Kai 11s	Cable Laying Vessel (CLV)	ROV inspection, burial plough

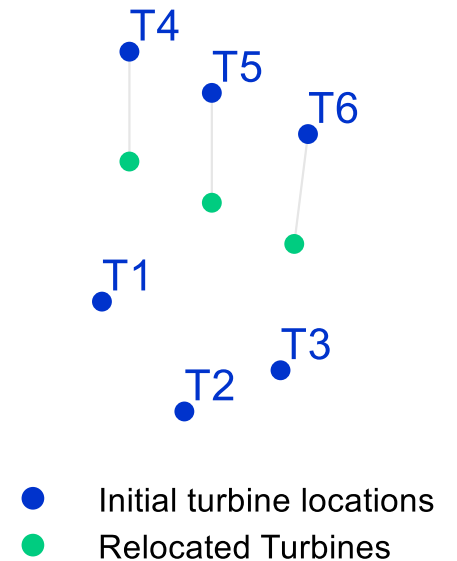| Operation name	Start date	End date	Duration (d)	2021-Mar	2021-Apr
foundation installation	2021/04/01	2021-04-09	8		
device installation	2021/04/09	2021-04-16	7		
cable installation	2021/04/16	2021-04-21	5		

Timing of operations

The EnFAIT Project

- Led by Nova Innovation (2017–2023)
- Array of 100kW turbines – Bluemull Sound, Shetland
- Currently 4 installed, T5 & T6 later this year
- Plan to relocate 3 turbines to study array interaction
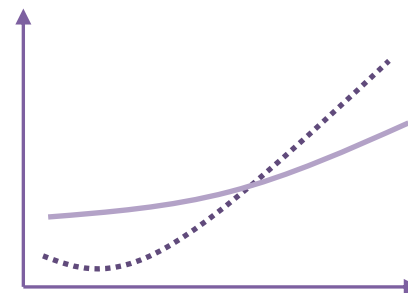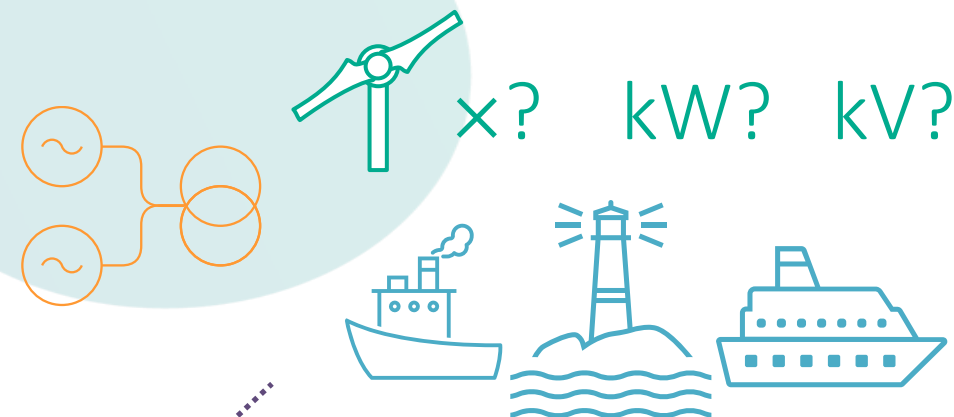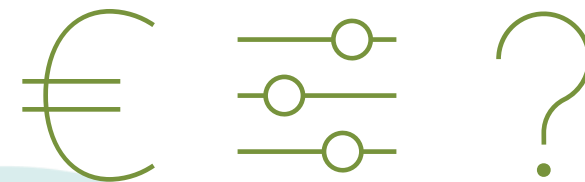

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T4
T5
T6
T1
T2
T3

● Initial turbine locations
● Relocated Turbines

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EnFAIT

Use of **DTOceanPlus** and Comparison with the **EnFAIT** Array

- Within EnFAIT – using DTOcean(Plus) design tools to model the array
    1. Understand how well these tool work
    2. Identify areas to improve DTOceanPlus
    3. Give feedback to plan/improve future arrays

- Can model most aspects of EnFAIT array in DTOceanPlus
    ◦ Some default assumptions and costs could be refined for small arrays

- Numerous improvements identified – many now implemented
    ◦ Bugs & limitations – ongoing work to resolve

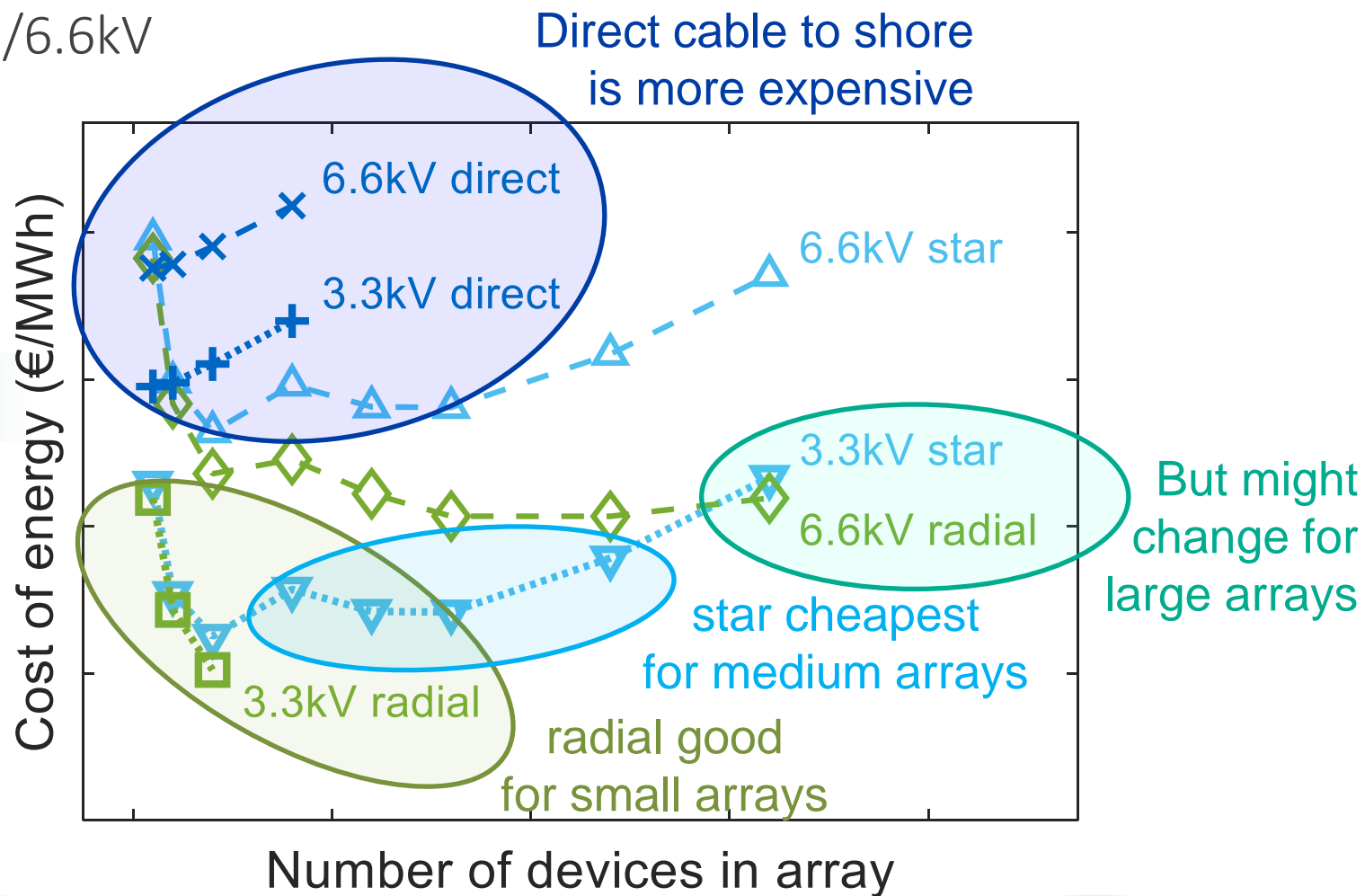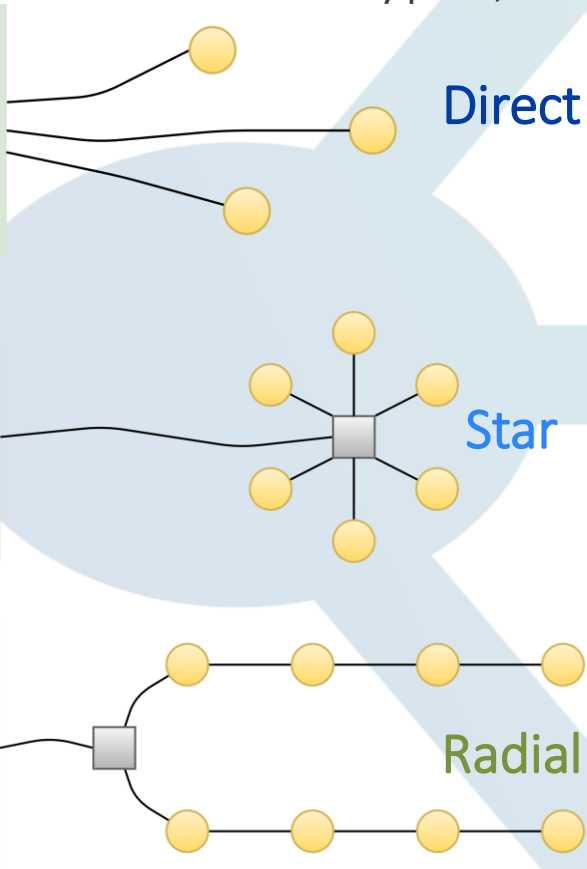- Work ongoing for recommendations on future arrays…

Analysis of Electrical Networks for Ocean Energy

- Techno-economic analysis of parameter space

- Considering things like:
  - Number of devices, rated power, voltage, …
  - Network configuration – with hub/substation?
  - Installation method & vessels used, …
  - CAPEX vs OPEX considerations, etc.

- Try identify trends and transition points
  - Noting that every project is unique

Initial Results of Analysis of Electrical Networks

- 3 network types, 2 voltages: 3.3/6.6kV

Direct

Star

Radial

Direct cable to shore is more expensive

Cost of energy (€/MWh)

6.6kV direct

3.3kV direct

6.6kV star

3.3kV star

6.6kV radial

But might change for large arrays

star cheapest for medium arrays

3.3kV radial

radial good for small arrays

Number of devices in array

Conclusions

- Dedicated tools might offer more detail and accuracy for one aspect
- Value of **DTOceanPlus** is combined suite with a **multi-faceted assessment**
  - Noting tools still in development

- Use at planning stage for future arrays, to optimise design
  - Opportunity for upcoming array calls?

- DTOceanPlus tools to help with planning and decision making
  - What changes between an array of 6 turbines and 66 turbines?