

# Offshore Wind Farms

## Distance to shore calculation made easy

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GIS/CAD Specialist  
Offshore Centre of Excellence



**MAINSTREAM**  
RENEWABLE  
POWER

# Introduction to Company

- Founded by Dr. Eddie O'Connor in 2008
- Our business is the **development, financing, construction and operation of wind (offshore and onshore) and solar energy plants**



# Mainstream's Active Offshore Projects



# Outline

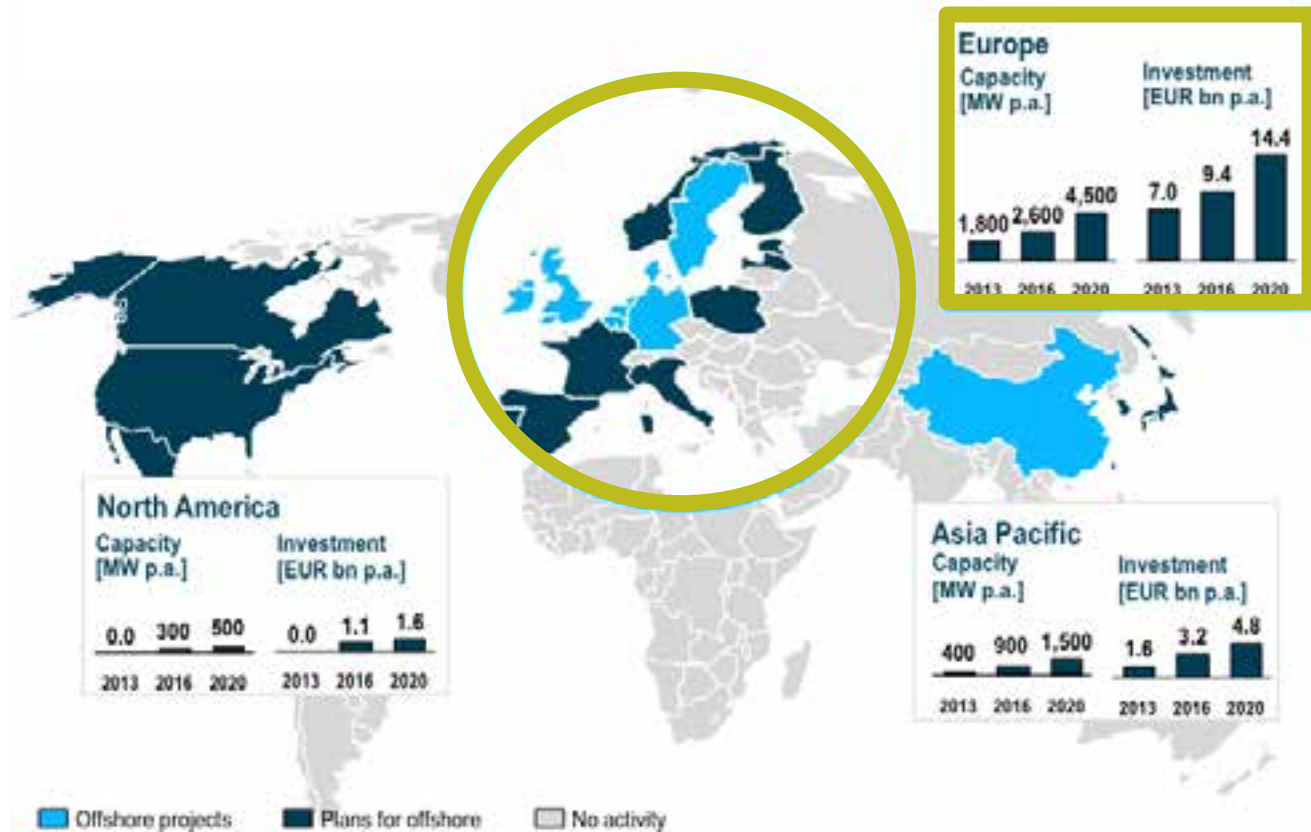
- Offshore Wind Industry
- Development Trend
- Capital expenditure (CAPEX)
- Distance to Shore : Impacts
- Developer's perspective
- Challenges in Calculation
- Role of GIS
- Case Study
- Observation
- Summary

# Offshore Wind

- The possibility of locating wind turbines on the sea bed has opened up a new frontier for wind power – the offshore wind industry
- First large-scale offshore wind farm at **Horns Rev 1** in 2002
  - Distance to shore ~18km
  - Avg. water depth ~10m



# Global Scenario



Source: EER, BTM, Global data, Roland Berger

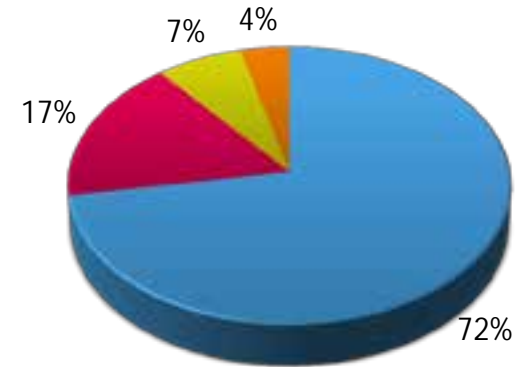
- By 2020, Offshore Wind Industry will become €130 Billion annual market

# Scenario in Europe

- In Europe, the largest share of installations is in **UK**
- UK has **3.6 GW** of operational wind capacity offshore



Source: London Array Limited



■ UK ■ Belgium ■ Germany ■ Denmark

## SHARE OF ANNUAL OFFSHORE WIND CAPACITY INSTALLATIONS PER COUNTRY IN EUROPE

Source: *The European offshore wind industry – key trends and statistics 2012*

### 1st largest offshore wind farm London Array Phase 1

- Distance to shore ~20km
- Max. water depth ~25m

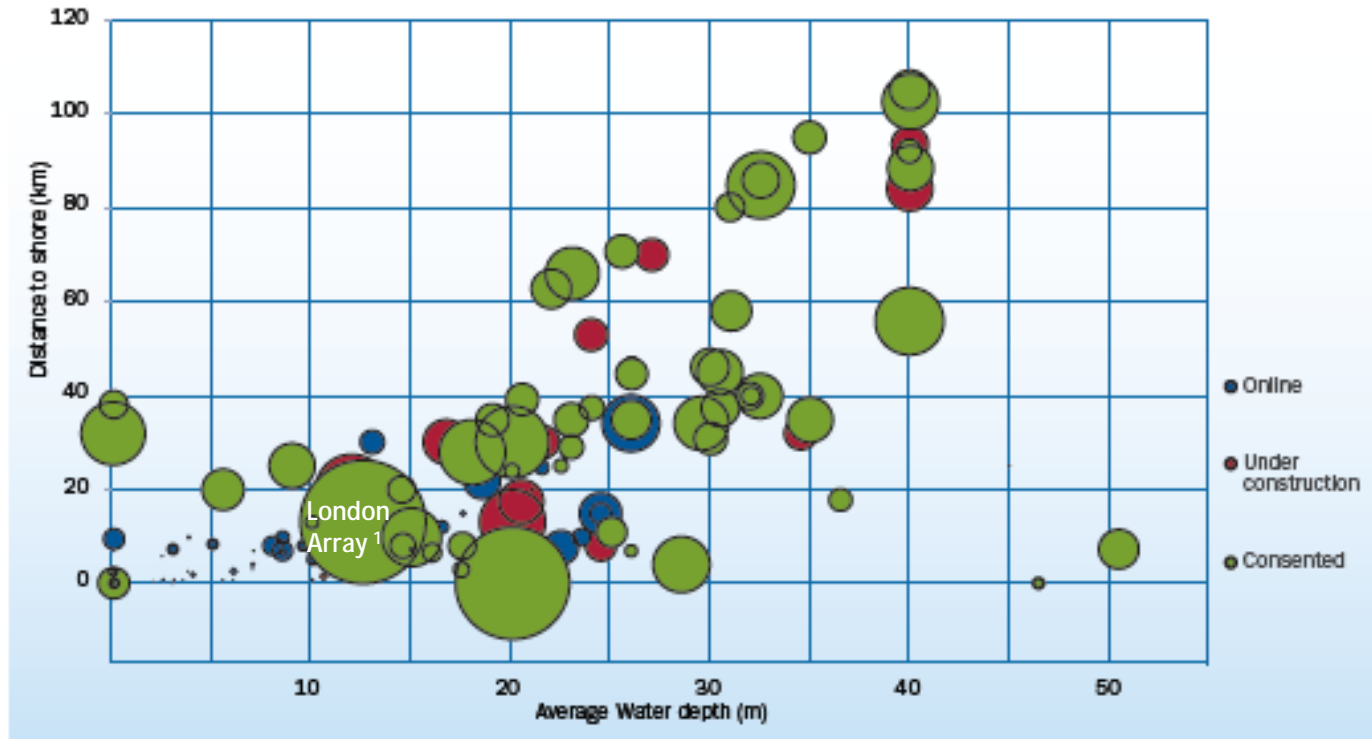
### 2nd largest offshore wind farm Greater Gabbard

- Distance to shore ~36km
- Max. water depth ~32m



# Development Trend

- Bigger, deeper and further



**AVERAGE WATER DEPTH AND DISTANCE TO SHORE OF OPERATIONAL (ONLINE), UNDER CONSTRUCTION AND CONSENTED WINDFARMS**

*Source: The European offshore wind industry - key trends and statistics 2012*

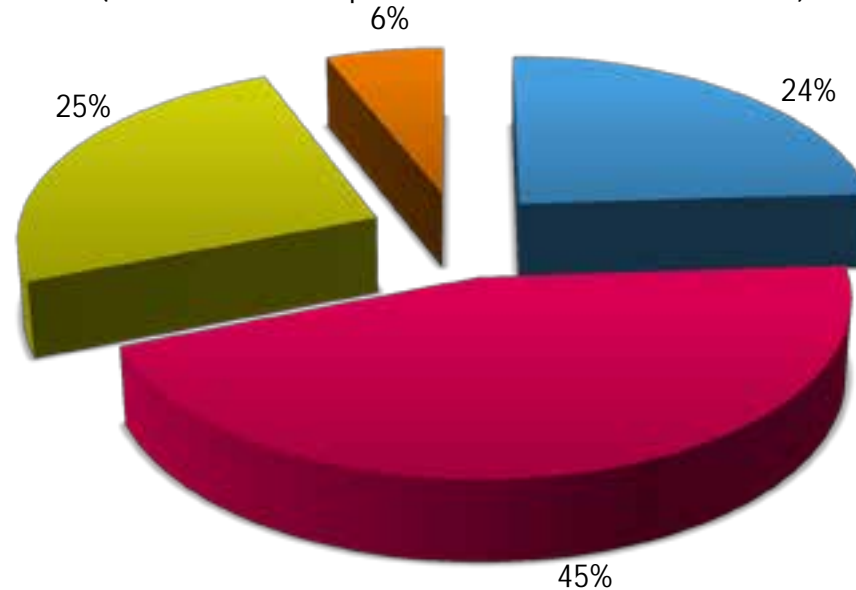
○ Bubble size ~ 200 MW



# Capital Expenditure (CAPEX)

## BREAKDOWN OF CAPEX FOR AN OFFSHORE WIND FARM

(Based on water depth 45m & distance to shore 50km)



■ Foundation Fabrication & Installation  
■ Electrical System Supply & Installation

■ Turbine Supply & Installation  
■ Project Management, Insurance etc

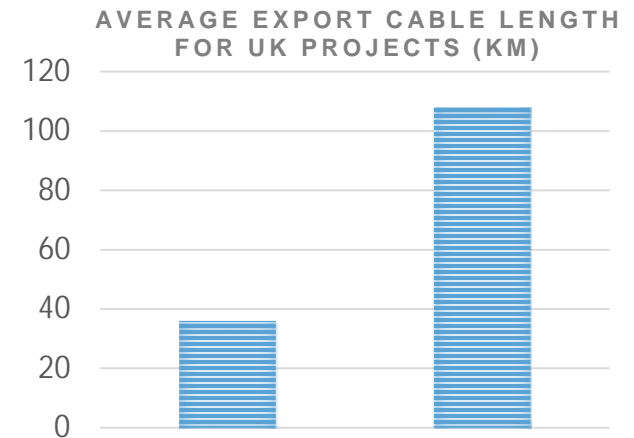
Source: Internal Studies, MRP, 2013

- Offshore development trend – “**further**” to access greater wind resources
- The cost of electrical system and installation increases with **distance to shore**.

# Distance to Shore : Impacts

## A. Cost of export cable (Supply & Installation)

- Export cables link the wind farm to the shore
- Cable length increases with distance to shore
- Export cable cost adds up to £875,000 per km (~€1.0 million)



Source : Renewable UK Report, 2011

Cross Sectional Area (mm <sup>2</sup> )	Cost per metre	
	150kV	320kV
1200	200 - 400	300 - 450
1500	250 - 400	300 - 450
1800	300 - 450	300 - 450

Costs are in British Pounds



Installation Type	Cost per km
Single cable, single trench	0.3 – 0.7
Twin cable, single trench	0.5 – 0.9
2 single cables, 2 trenches, 10m apart	0.6 – 1.2

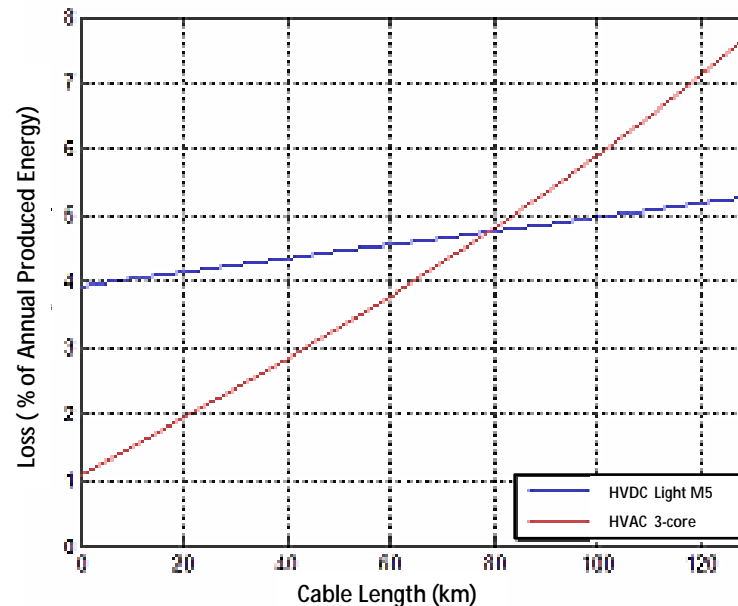
Costs are in millions of British Pounds

Source: 2011 Offshore Development Information Statement

# Distance to Shore : Impacts

## B. Transmission losses

- Use of High Voltage Alternating Current (HVAC) / High Voltage Direct Current (HVDC) systems



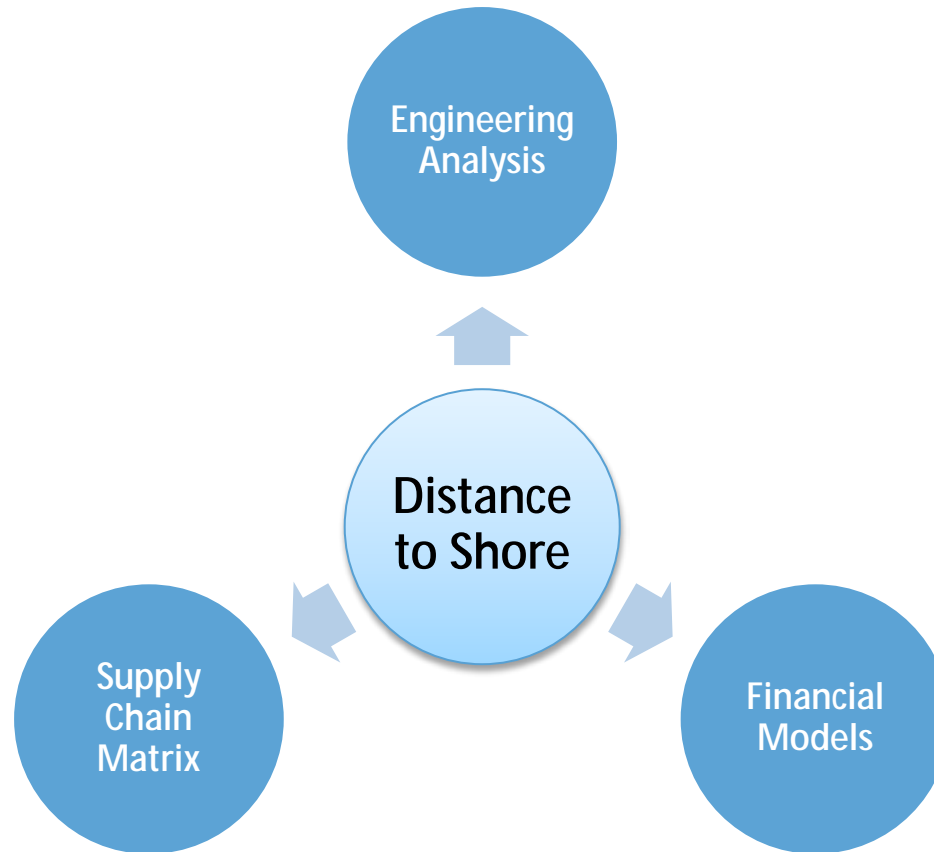
LOSS PERCENTAGE FOR VSC HVDC AND HVAC AS FUNCTION OF CABLE LENGTH (Capacity = 300 MW)

Source: Eeckhout B.V, Masters Thesis, 2008

- Transmission losses increase further offshore

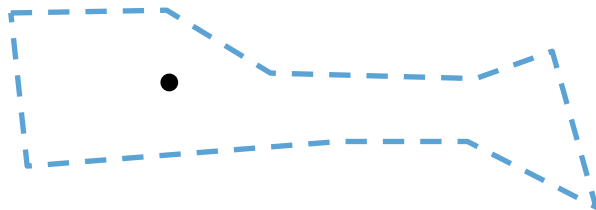
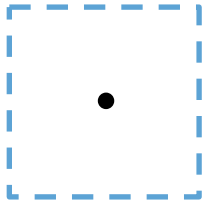
# Developer's Perspective

- To lower project CAPEX and Operational expenditure
- To reduce project risk



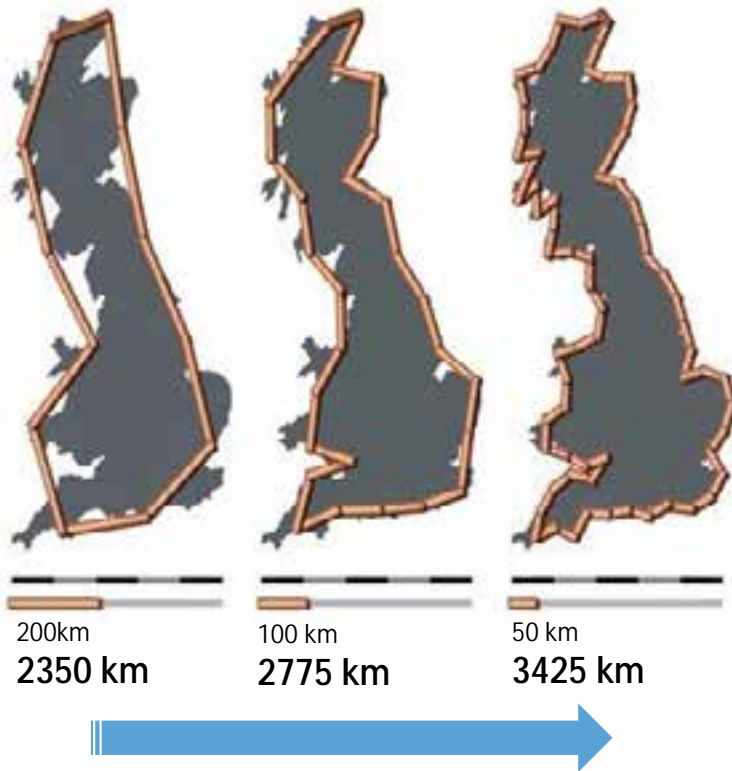
# Challenges in Calculation

- Geometrically, a **windfarm** is best represented by a **polygon**.
- Determination of polygon centroids



# Challenges in Calculation

- Coastline paradox



- Relates to cartographic generalisation

- Convoluted Coastline



Source: Wikipedia

# Role of GIS

- Geographic Information System (GIS)



- ESRI is the leader in the field of GIS



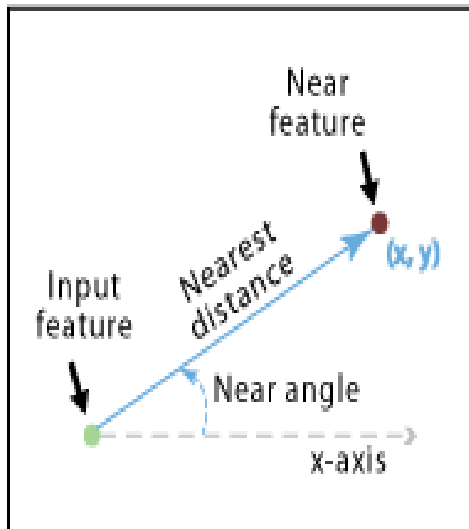
One of the Technology partners of Mainstream



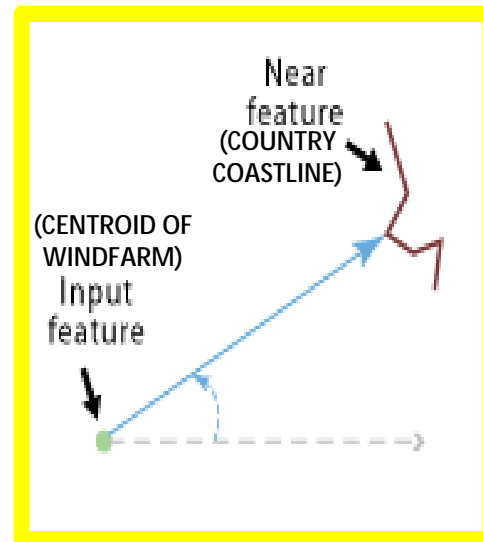
# The Solution

- Proximity Analysis
- Use of **Feature to Point** tool – for centroid generation
- Use of **Near** tool – to calculate distance to shore

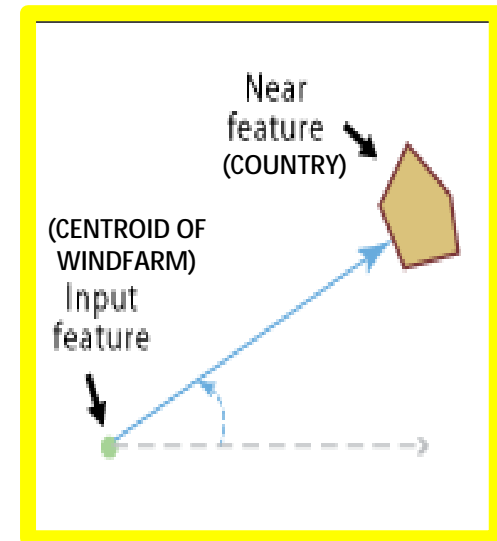
POINT TO POINT



POINT TO LINE



POINT TO POLYGON

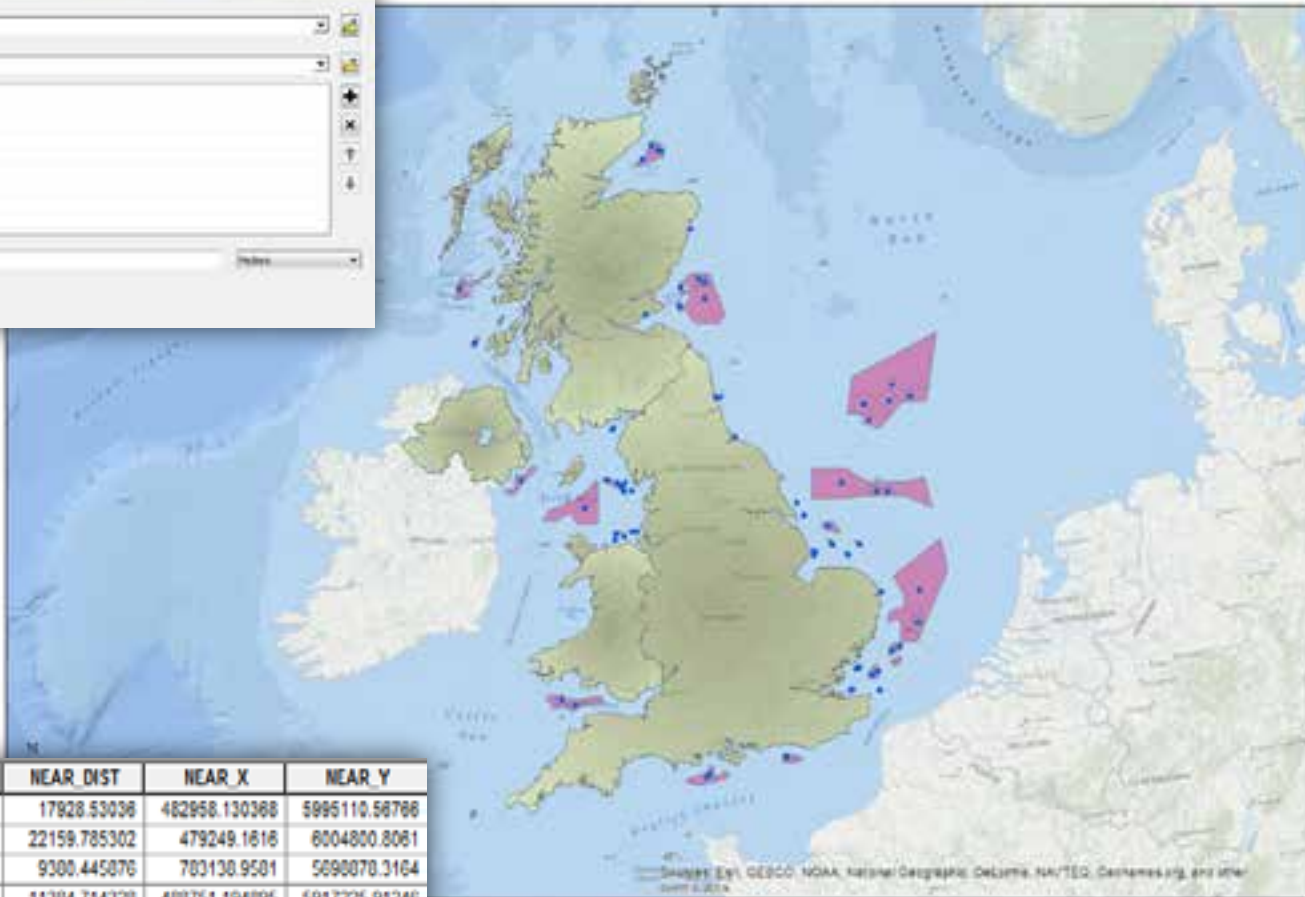


Source: ESRI

- Option to add coordinates of nearest feature considered



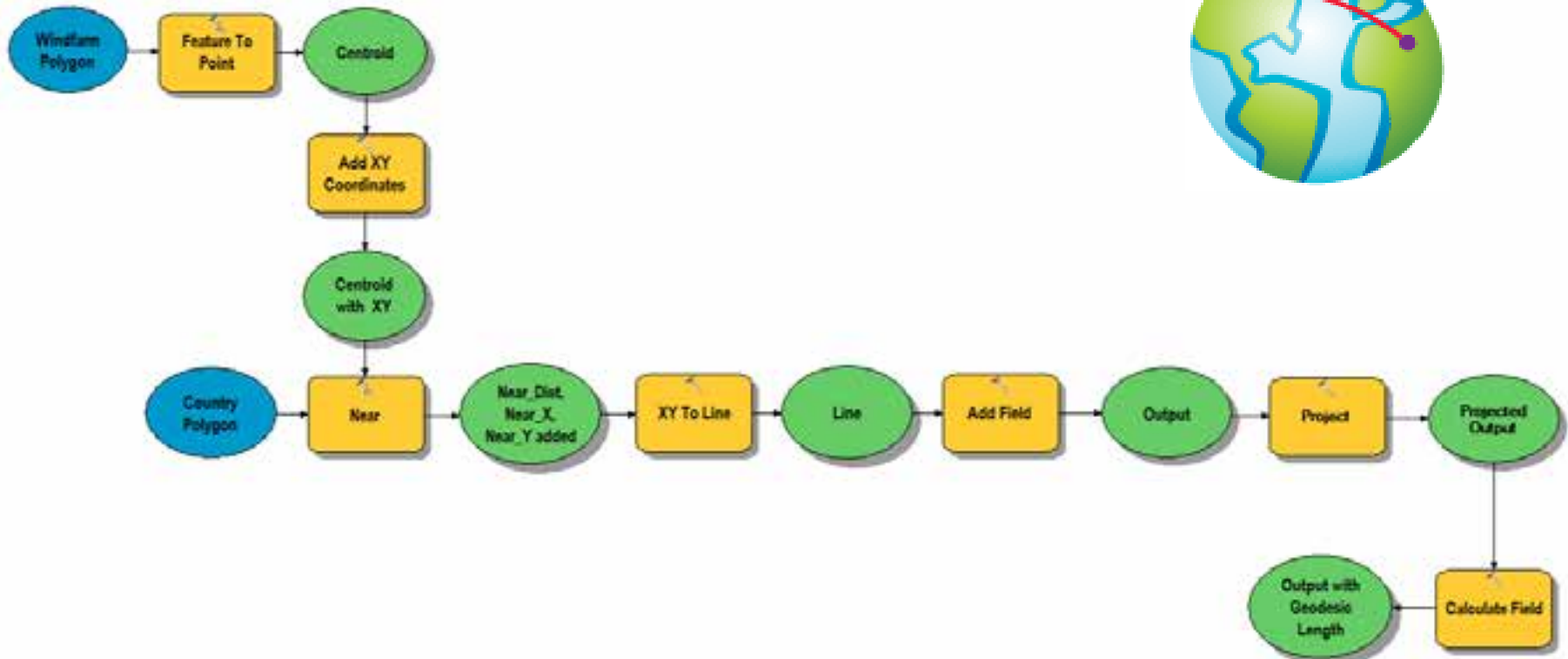
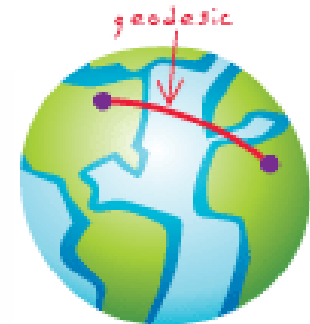
# Case Study



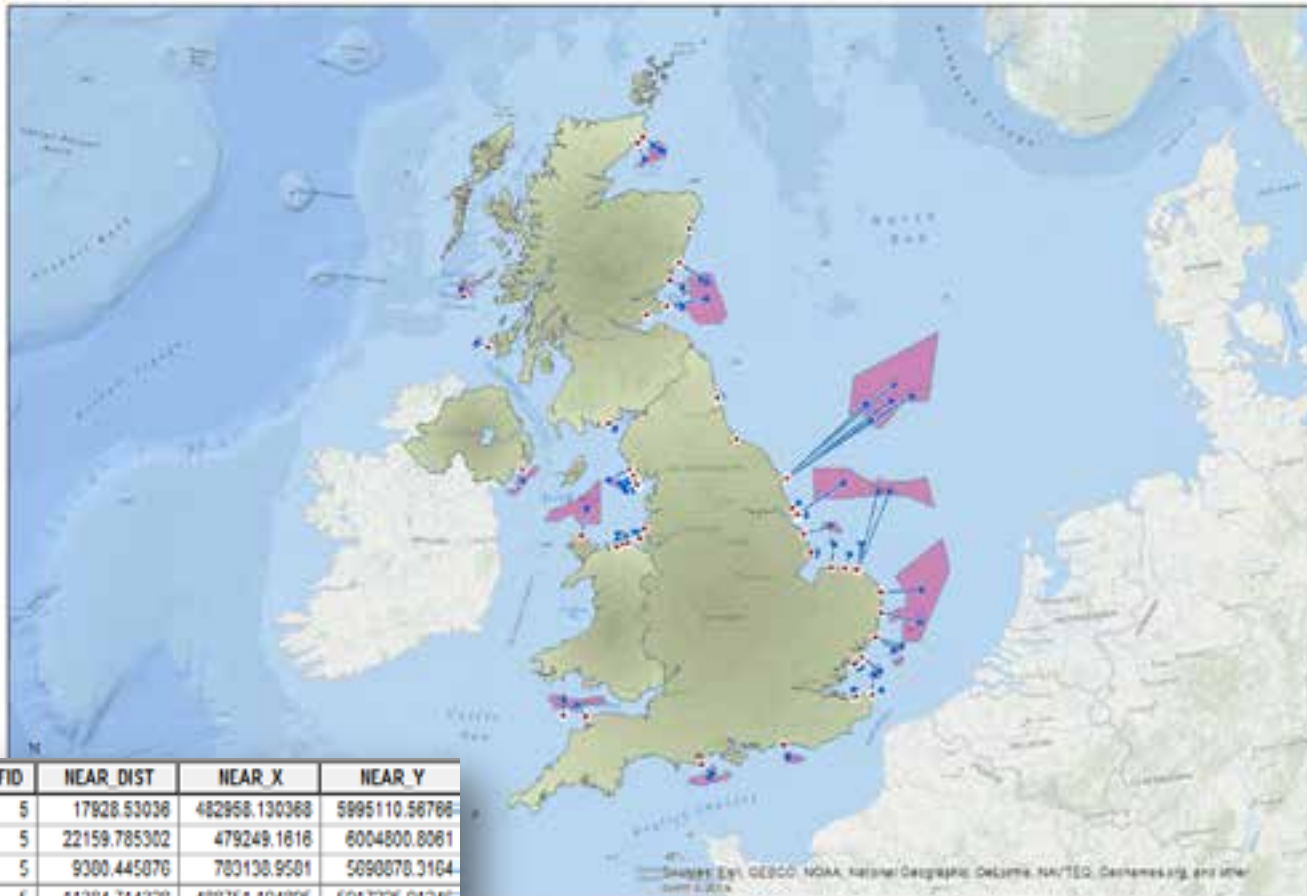
ORIG_FID	NEAR_FID	NEAR_DIST	NEAR_X	NEAR_Y
0	5	17928.53038	482958.130368	5995110.58788
1	5	22159.785302	479249.1818	6004800.8061
2	5	9300.445876	703130.9501	5690070.3164
3	5	11304.714328	400751.194895	5917225.91246
4	5	26695.358389	807692.4576	5702505.4616

# Refining the Calculation

- Near tool calculates Euclidean distance in projected coordinate system
- Geodesic distance is calculated using ModelBuilder



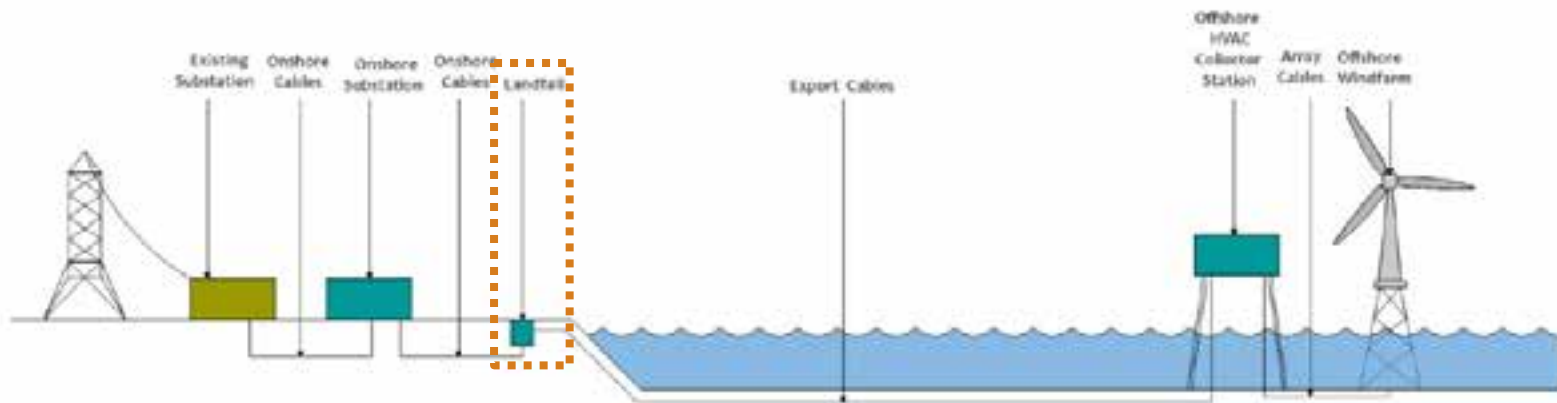
# Observation



ORIG_FID	NEAR_FID	NEAR_DIST	NEAR_X	NEAR_Y
0	5	17928.53038	482958.130368	5995110.58766
1	5	22159.785302	479249.1818	6004800.8081
2	5	9300.445076	703138.9581	5690878.3164
3	5	11304.714320	480751.194895	5917225.91246
4	5	26695.358389	807692.4576	5702505.4616

# Insight

- Identification of possible **landfall** location



- Identification of the **shortest path** for the export cable corridor

# Summary

- Distance to shore is a significant parameter in offshore windfarms
- Calculated using Proximity analysis in ArcGIS
- Initiates the optimization process related to the identification of export cable corridor
- Identifies possible landfall location
- Leads to informed decision-making



**Thank you**