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Paying the Price

NS Energy R&D Conf 21 May 2014

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Some Questions?

- What is the price?
- Why are they going to do it?
- What other options do they have?
- Who are they?
- Where are they?
- What do we need to do to them on board?
- What is so good about Tidal Energy

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What is The Price?

- CAPEX? CAN $ 8M? $10M? $15M? per MW
- COE? 44c/kWh? 74c/kWh?

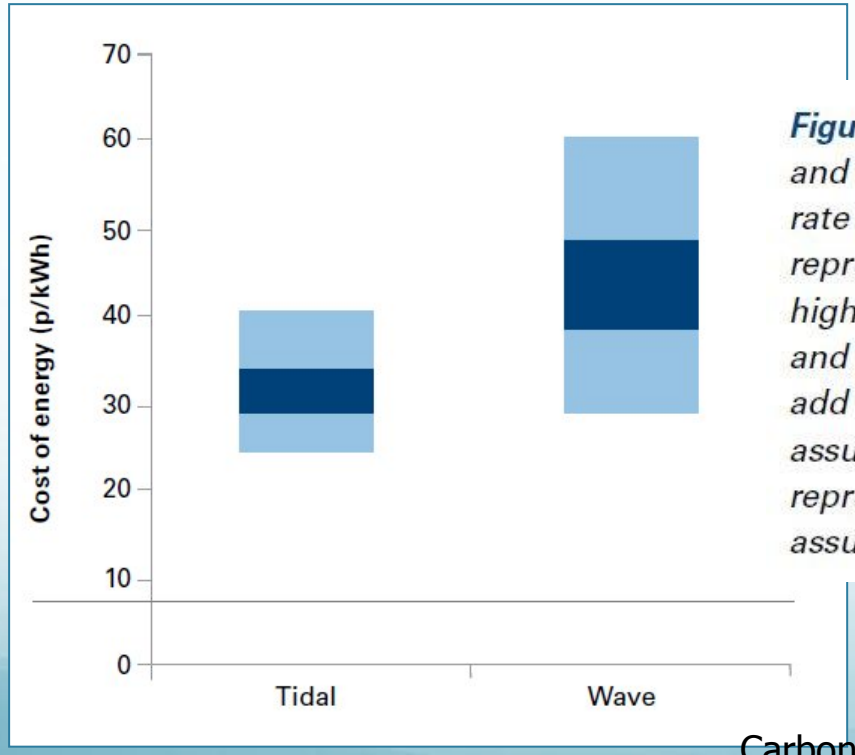

Figure 8 *Baseline costs for benchmark first farm wave and tidal devices. These costs assume a discount rate of 15% and a lifetime of 20 years. The dark bars represent CoE at medium energy (upper bound) and high energy (lower bound) sites, using base case cost and performance assumptions; while the outer bars add optimistic and pessimistic cost and technical assumptions to these limits. Thus the lowest costs represent optimistic case cost and performance assumptions for devices sited in energetic locations*

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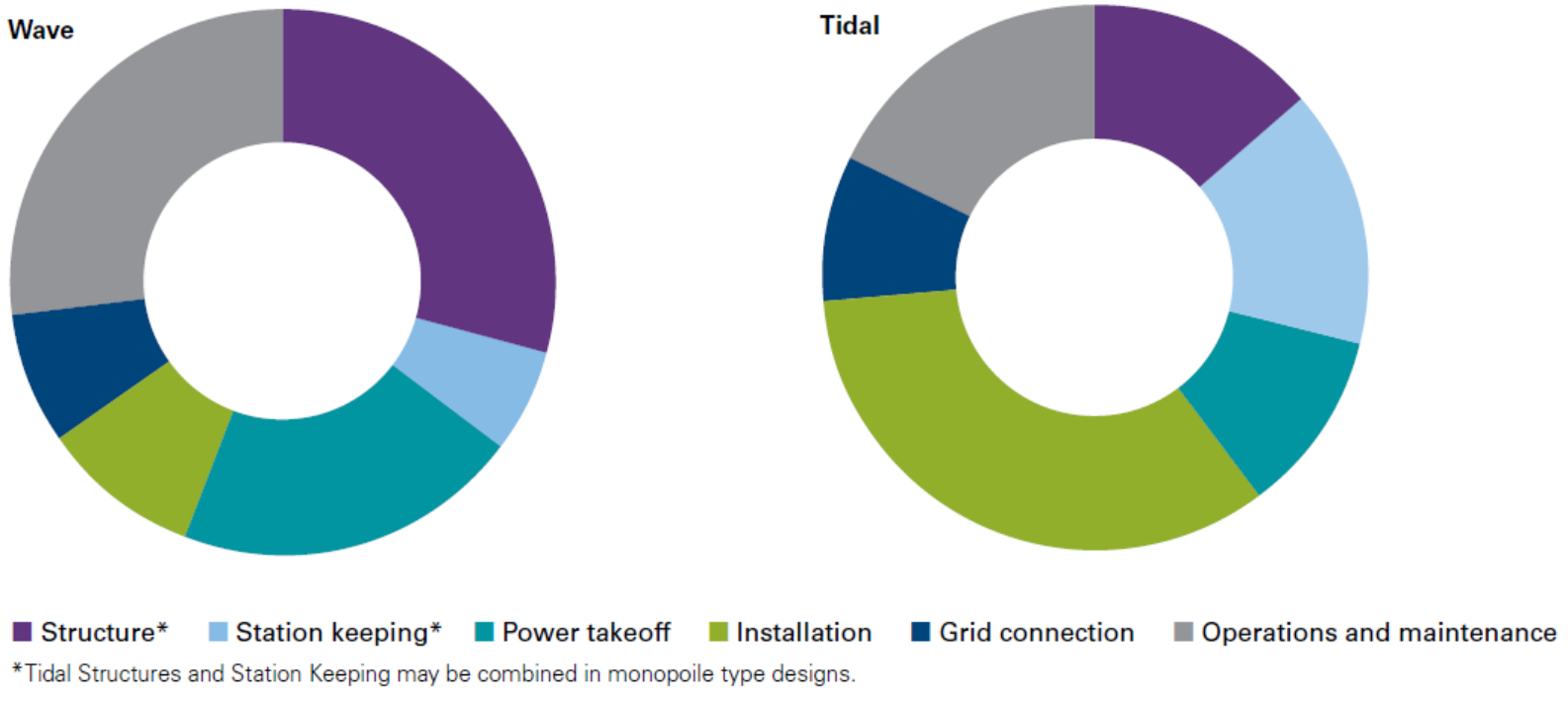
What is The Price?

Figure 7a and 7b *Indicative levelised cost of energy components for wave and tidal energy converters in an early commercial farm. The coloured segments are capital costs, while the grey segment represents O&M costs and includes all other spend including insurance and leases*



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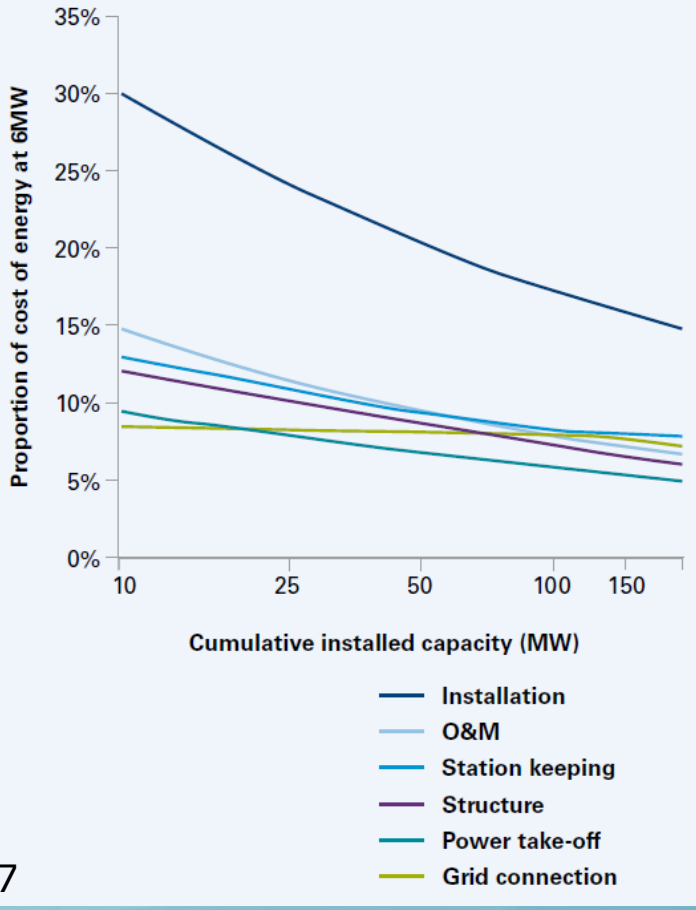
What is The Price?

Figure 14 *Cost reduction potential for tidal devices by cost centre*

Tidal stream: Modelled cost centre cost reductions between first and later commercial farms of currently leading tidal devices. The y-axis shows the proportion of first farm levelised CoE accounted for by each cost centre. The change between 10MW and 200MW cumulative installed capacity takes into account both experience and volume effects (the farm at 200MW is assumed to have 50MW capacity, while the 10MW farm is 10MW capacity).



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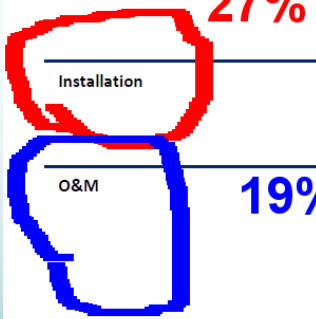
What is The Price?

Summary of opportunities –tidal

	Capex reduction	Yield improvement	Opex reduction
Structure & prime mover	Material optimisation Upscaling of devices Batch and serial production Reduced over-engineering Multiple rotor platforms Regional manufacturing	Optimisation of siting to maximise yield Micro-siting techniques Improved yaw and pitch mechanisms Hydrodynamically optimised structures Upscaling length of blades	Multiple rotor platforms
Power take-off	New drive train configurations Alternative and improved PTOs	Direct drive Improved hydraulic actuation systems Improved control systems and algorithms Array yield optimisation	Modular subsystems
Foundations & moorings	Improved subsea/seabed drilling Specialist vessels Improved piling and fixing techniques Improved mooring techniques (floating devices)	Floating or neutrally buoyant devices accessing high energy flows Hydrodynamically optimised foundations/platforms	Specialist vessels
Connection	Off-shore umbilical / Wet-mate connectors Subsea hubs Array electrical system optimisation (transformers etc.)		Improved connection and disconnection techniques
Installation	Specialist vessels Improvements in metocean forecasting Modularisation of components Improved ROV and autonomous vehicles		
O&M		Improved availability through: Intelligent predictive maintenance Techniques to reduce weather dependency	Intelligent predictive maintenance Increased reliability Modular components. Simpler access Specialist vessels Intelligent predictive maintenance Improved ROV and autonomous vehicles



SI Ocean CoE Report 2013

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Why are they going to do it?

- Capital working
- Payback
- Rate of Return (IRR Hurdle Rate)
- Ethical
- Portfolio Balance
- Fuel Risk
- Market Share and Capacity

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What other Options...?

- ...Onshore Wind
- ...Solar
- Offshore Wind
- Hydro
- ...Geothermal
- ...Biomass
- ...Wave

OR

- Non renewable

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What other Options...?

Table 1. Updated estimates of power plant capital and operating costs

	Plant Characteristics		Plant Costs (2012$)			
	Nominal Capacity (MW)	Heat Rate (Btu/kWh)	Overnight Capital Cost ($/kW)	Fixed O&M Cost ($/kW-yr)	Variable O&M Cost ($/MWh)	NEMS Input
Biomass						
Biomass CC	20	12,350	$8,180	$356.07	$17.49	N
Biomass BFB	50	13,500	$4,114	$105.63	$5.26	Y
Wind						
Onshore Wind	100	N/A	$2,213	$39.55	$0.00	Y
Offshore Wind	400	N/A	$6,230	$74.00	$0.00	Y
Solar						
Solar Thermal	100	N/A	$5,067	$67.26	$0.00	Y
Photovoltaic	20	N/A	$4,183	$27.75	$0.00	N
Photovoltaic	150	N/A	$3,873	$24.69	$0.00	Y
Geothermal						
Geothermal – Dual Flash	50	N/A	$6,243	$132.00	$0.00	N
Geothermal – Binary	50	N/A	$4,362	$100.00	$0.00	N

-13%

-22%

DoE US Energy Information Administration April 2013

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What other Options?

TABLE 0.1: Cost structure of a typical 2 MW wind turbine installed in Europe (€ 2006)

	INVESTMENT (€1,000/MW)	SHARE OF TOTAL COST %
Turbine (ex works)	928	75.6
Grid connection	109	8.9
Foundation	80	6.5
Land rent	48	3.9
Electric installation	18	1.5
Consultancy	15	1.2
Financial costs	15	1.2
Road construction	11	0.9
Control systems	4	0.3
TOTAL	**1,227**	**100**

Note: Calculated by the author based on selected data for European wind turbine installations

European Wind Energy Association Econ of Wind 2009

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What other Options...?

The cost breakdown for a commercial PV system:

- 50-60% for PV modules (TF and c-Si, respectively),
- 10% for the inverter,
- 23-32% for installation of BoS
- 7% for engineering & procurement

EPIA 2011

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Who are they?

- OEMs
- Major Energy Industrials
- Utilities
- Pension and Insurance Funds
- Private Equity
- Private or Town Electricity Companies
- Commercial Banks
- Public – Crowd Funding?

Where are they?

- Major OEMs Siemens etc
  - Carrying risk on technology and early arrays
- Smaller Technology Providers
  - Also carrying some risk with equity investors
- Utilities
  - Some minor plays but likely to be coming
  - Scot Power/Iberdrola Sound of Islay
- Private Equity
  - Largely in smaller technology providers

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Where are they?

- Pension and Insurance
- Commercial Banks
  - Conservative - waiting for Warranties, Insurances, Demonstration of Operation
- Major Energy Industrials
  - Interest but need MW capacity and Warranties
- Private & Town Electricity Companies
- Public Crowd Funding
  - Entry costs high for level of risk

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What do we need to do...?

- Whatever Price it is - its too much
  - More energy capture per base
    - MW per base(as wind!)
  - Energy from rotor
    - Bigger swept area (as wind!)
  - Installation and O&M Strategies
    - Cheaper vessel – not Oil & Gas
    - Quicker deployment - weather
  - Balance of Plant - ditto

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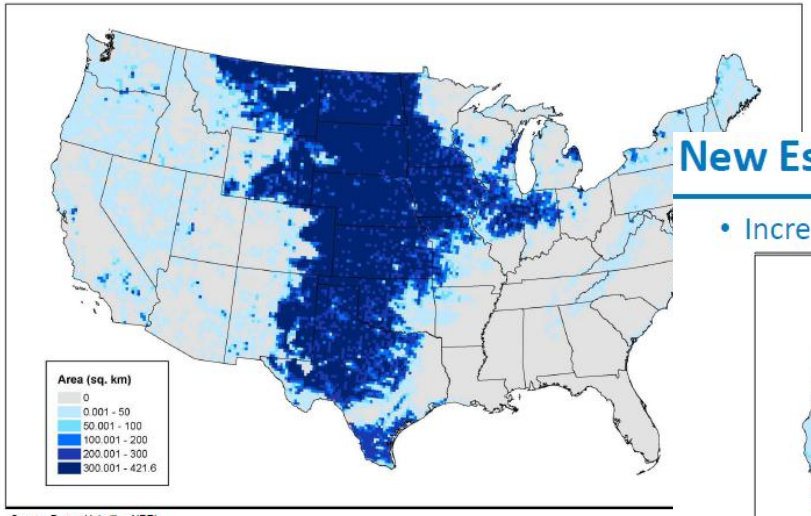
What do we need to do...?

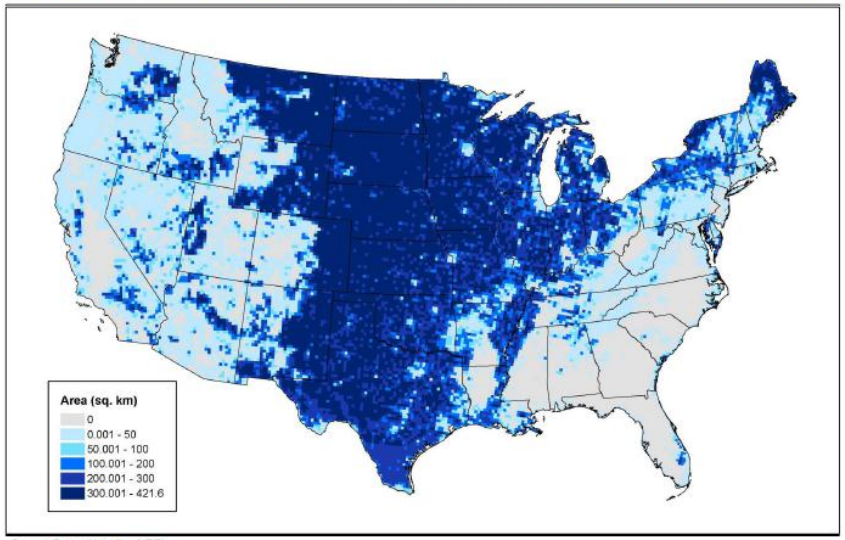
Past Estimates (GCF>30% IEC Class 2 turbine 80m HH)



Source: Donna Heimiller, NREL.

New Estimates (GCF>30% GE 1.62-100 80m HH)

- Increase in raw area available ~**50.6% over previous estimate**



Source: Donna Heimiller, NREL.

Donna Heimiller NREL2009

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What do we need to do...?

- Confidence in Technology
  - Warranties
  - More Energy
  - Cheaper
- Confidence in Pipeline
  - De-risked Commercial Scale Projects
  - Market Certainty

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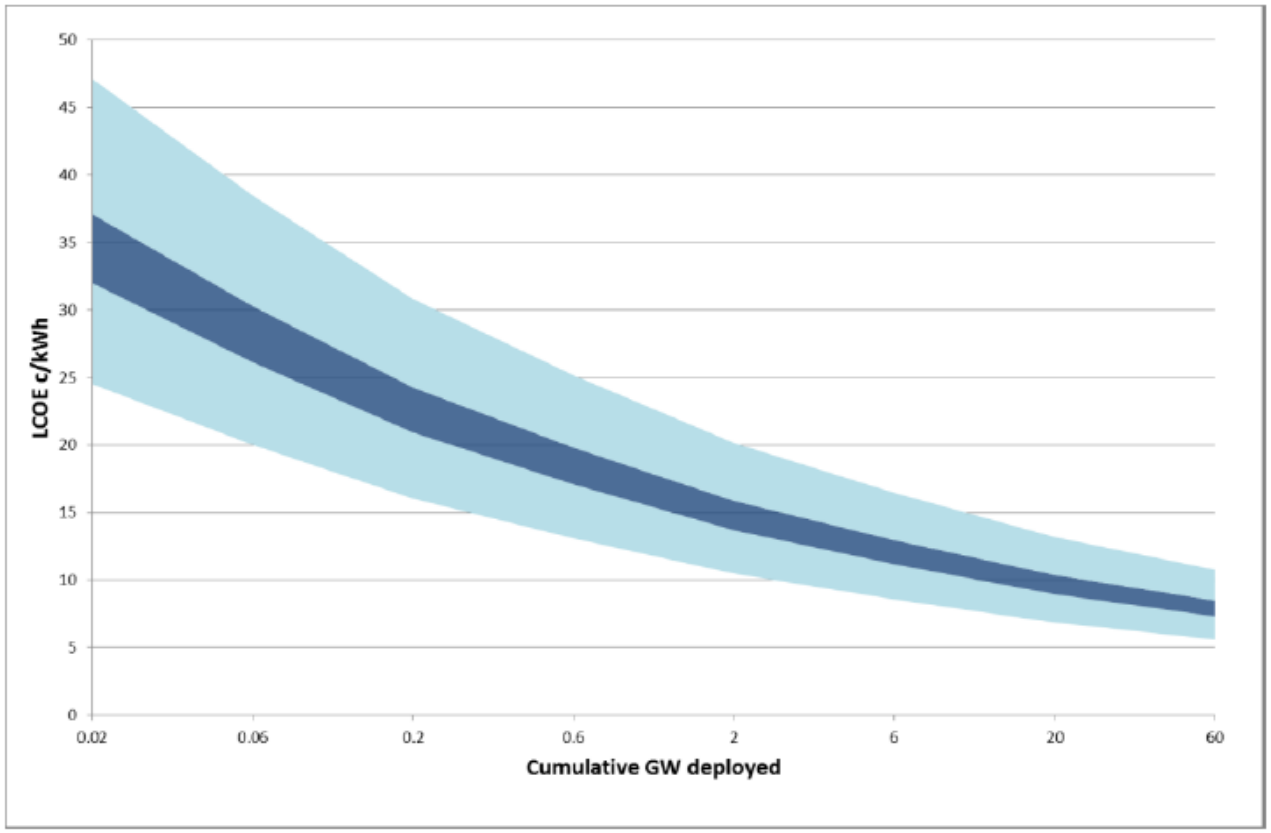
What do we need to do...?

Figure 6 Tidal LCOE ranges (deployment on a logarithmic scale)



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What is so Good about Tidal?

- Tidal is completely predictable
- There is no significant weather effect (ish)
- P50=P90. There are no ‘bad years’
- There is no risk of Global Warming Impact
- Potential for extremely high Capacity Factors
- Environmentally benign if done correctly
- Widely socially acceptable

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Tidal Power

Challenging but almost there

Simon De Pietro
simon.depietro@dpenergy.com
+353 87 9722399
+1 508 971 2608

www.dpenergy.com