

Marine Roadmap to 2020

All Energy 2010: Industrialising New
Power Technologies

Introduction to Marine Roadmap

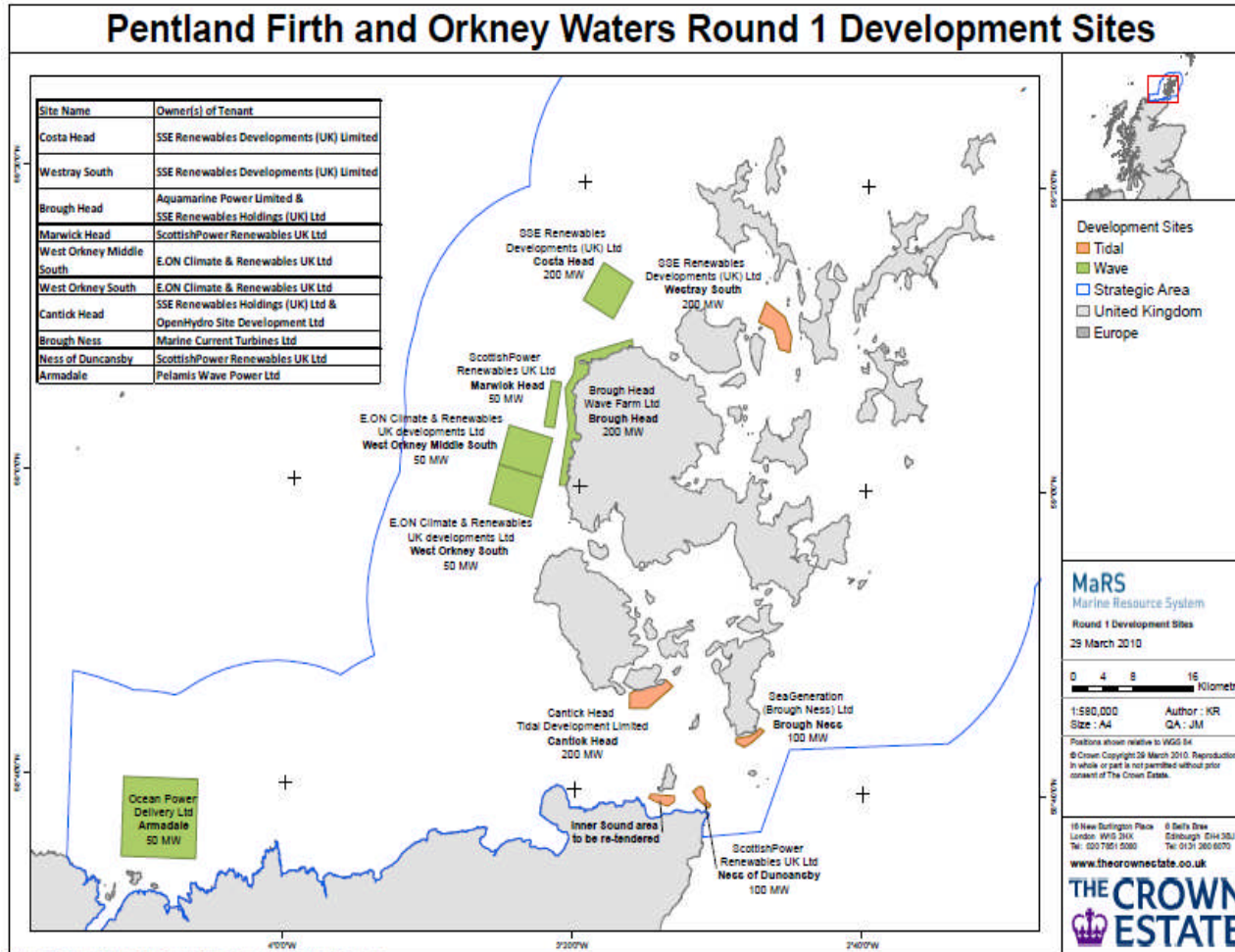
Technology Developer's Perspective

Marine Roadmap: Introduction

- Forum for Renewable Energy Development in Scotland (FREDS)
 - Marine Energy Group published August 2009
- Topics:
 - Finance
 - Grid
 - Supply Chain
 - Planning

Source	Capacity (GW)	Location	Notes
<i>Future Marine Energy. The Carbon Trust. (2006)</i>	3 GW	UK	Installed
<i>Path to Power. BWEA (2006)</i>	3 GW	UK	Installed
<i>Harnessing Scotland's Marine Energy Potential. FREDS Marine Energy Group (2004)</i>	1.3	Scotland	Installed
<i>Strategic Objective. Scottish Renewables Forum (2008)</i>	1.3	Scotland	Consented by 2017
<i>Marine Energy Road Mapping for Scotland. Aquaret (2008)</i>	1	Pentland Firth	Operational in 2020
<i>UKERC Marine Renewable Energy Technology Roadmap. UKERC (2008)</i>	2	UK	Installed capacity. Estimated breakdown for Scotland – 1GW.
<i>Saltire Prize. Scottish Government</i>	<0.030	Scotland	Installed by 2017
<i>The Crown Estate – Pentland Firth Strategic Area</i>	0.7	Pentland Firth	Installed

Crown Estate Round 1 Development Sites



Wave sites

- 2x 200MW
- 4x 50MW

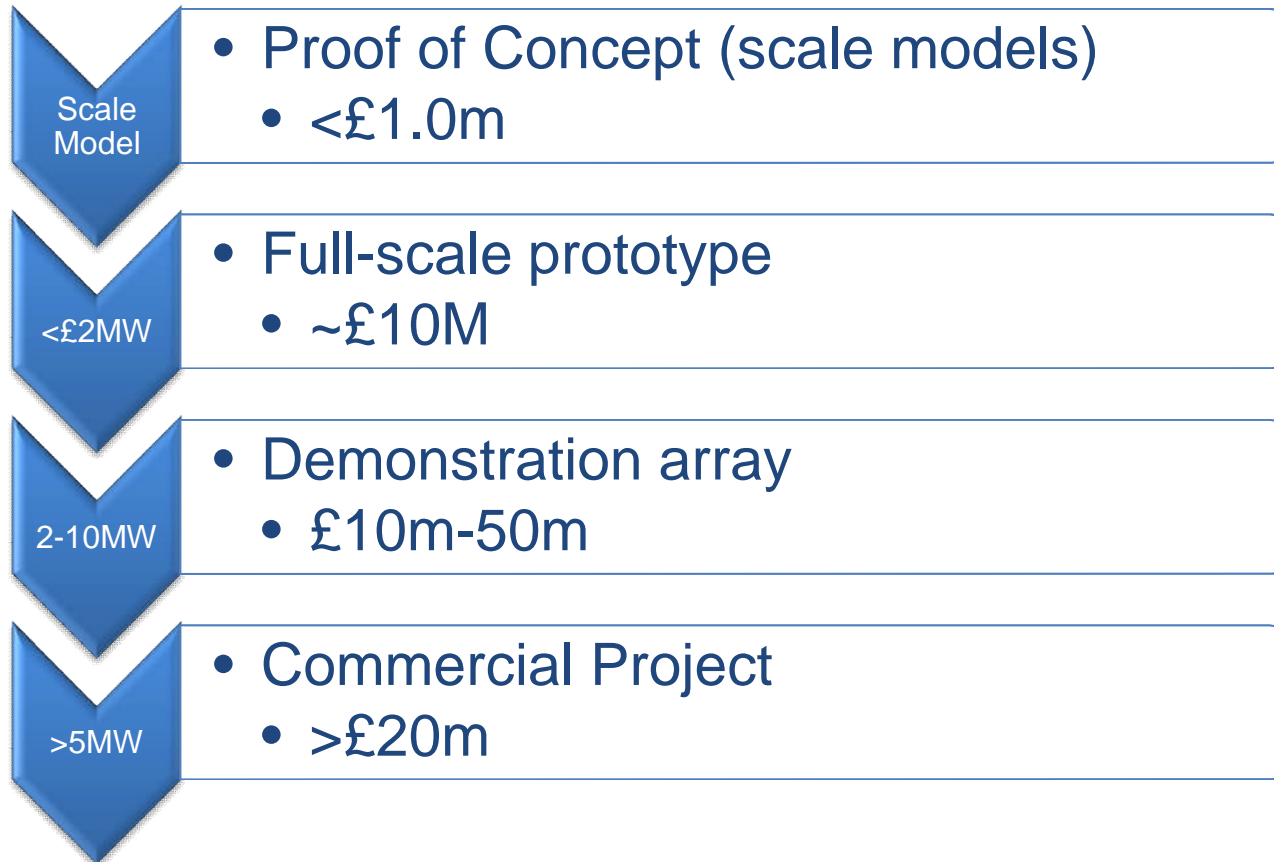
Tidal site

- 2x 200MW
- 2x 100MW

Total

- 1,200MW by 2020

Device development stages



Finance

Selection of available funding:

	Energy Technologies Institute	Carbon Trust	Scottish Government	Renewable Obligation Certificates*
Proof of Concept	Yes			
Full-scale prototype	Yes	MRPF	WATES	Multipliers Wave: 5x Tidal: 3x
Demonstration array		MRDF	WATES	Multipliers Wave: 5x Tidal: 3x
Commercial Project				Multipliers Wave: 5x Tidal: 3x

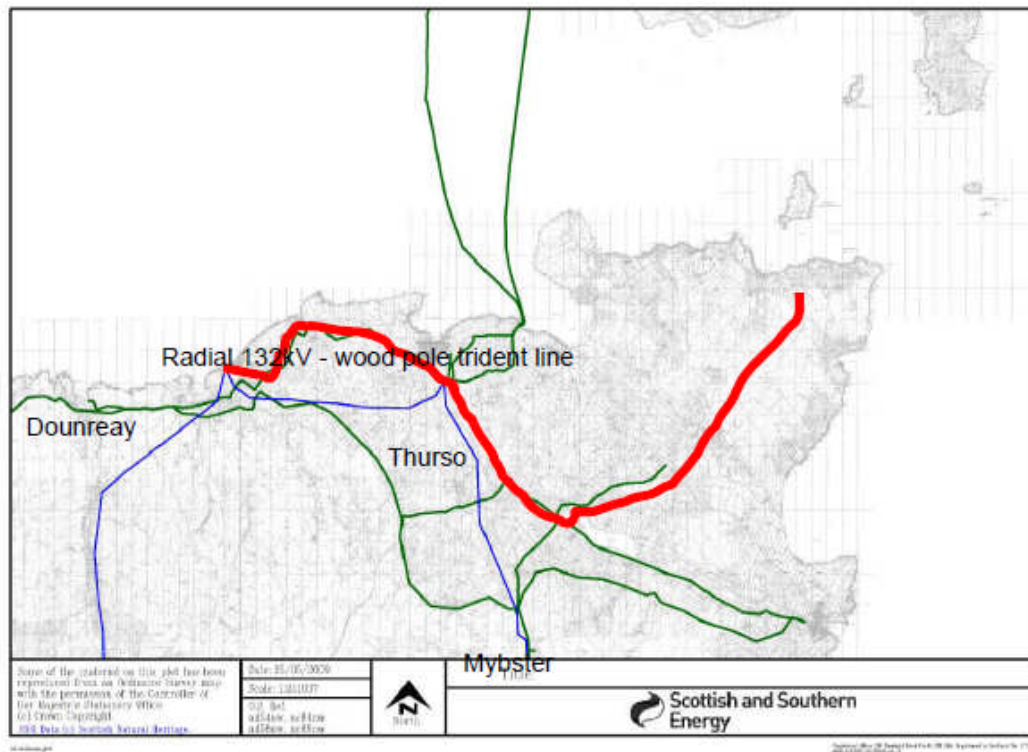
* Current ROC value at auction around £50 per MWh (e-roc.co.uk)

Finance

- Selection of private investors linked to current projects
 - Statoil New Energy
 - Scottish Power Renewables
 - Siemens Energy
 - Rolls Royce
 - Morgan Stanley
 - EDF Energy
 - Npower Renewables

Grid

- Best sites far from centres of population, and grid infrastructure
- Commercial array developments at Pentland Firth will require upgrades



- 132kV route from NE Caithness to Dounreay
- 132kV route from Orkney to Dounreay

Supply Chain

- Marine Energy can take advantage of existing Oil & Gas supply chain
- 1GW installed by 2020 will require spend of £2.4bn ^{*}
 - 53% Scotland (2,600 direct jobs)
 - 83% UK
 - 99% EU (5,000 jobs)
 - In addition
 - Indirect O&M, R&D expenditure in addition
 - Export opportunities

* MEG Supply Chain Report (Sgurr Energy and IPA Energy & Water Economics)

Planning

Selection of necessary Consents/Licences:

- Environmental Impact Assessment
- Marine Scotland
 - Application for Marine Works
- Fisheries Research Services
 - Application for Marine Construction Works
- Scottish Executive
 - European Protected Species Licence

Introduction to Marine Roadmap

Technology Developer's Perspective

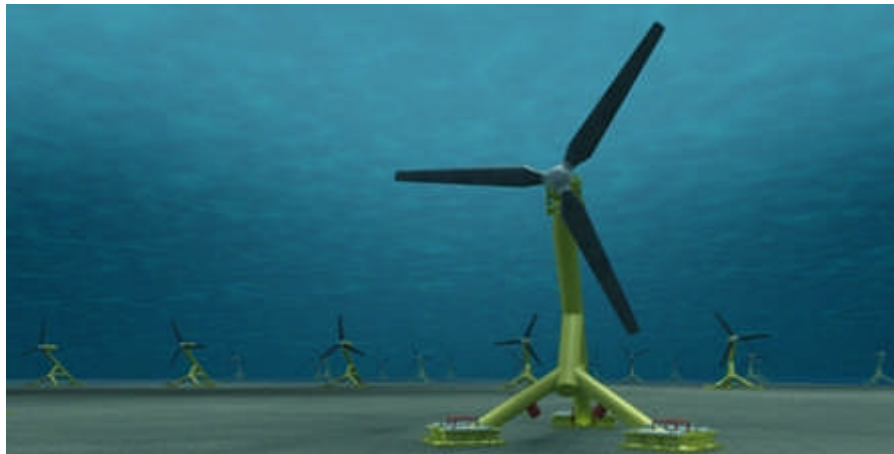
Hammerfest Strøm

- HSAS
 - Hammerfest
 - Formed 1997
 - Develop the HS300
- HSUK
 - Glasgow
 - Formed 2008
 - Develop the HS1000



Hammerfest Strøm technology

- HS300
 - 300kW
 - 2003 Installed
 - 2007 Removed
 - 2009 Reinstalled
- HS1000
 - 1MW
 - Manufacturing Underway
 - 2011 Installed



Hammerfest Strøm sites

- Kvalsundet (300kW)
- EMEC (1MW)
- Sound of Islay (10MW)
- Ness of Duncansby (~100MW)

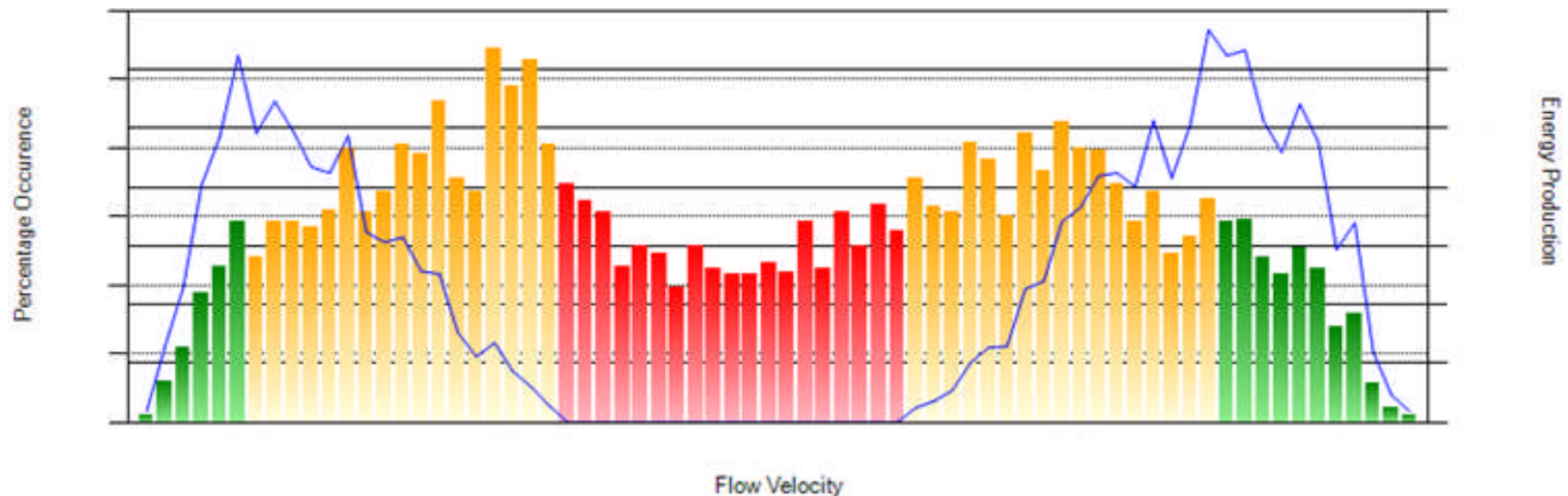


Site evaluation

- Predictable Resource allows optimisation
- Factors of primary interest:
 - Operational
 - Velocity occurrence
 - Wave height occurrence
 - Survivability
 - Maximum velocity
 - Maximum wave height

Site evaluation

- Thrust $\propto v^2$
 - Increased foundation size
- Power $\propto v^3$
 - Increased energy yield
- Rated capacity (1MW)
- Rated velocity (2.7m/s)

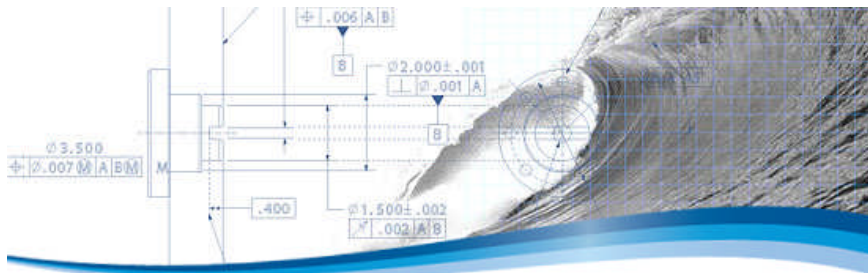


Site comparison

Site	Current Velocity	Wave Height
Kvalsundet	Medium	Small
Sound of Islay	High	Small
EMEC	High	High
Ness of Duncansby	Very High	High

HS1000: Finance

- HSUK primary sources of finance
 - Investors
 - Carbon Trust MRPF
 - Scottish Enterprise



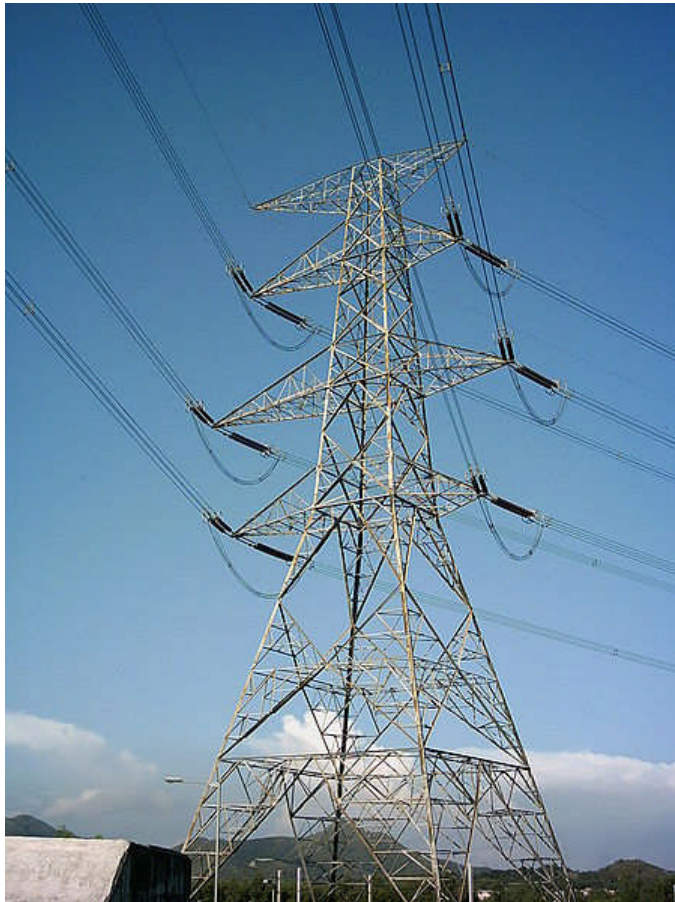
Marine Renewables Proving Fund



Scottish Enterprise



HS1000: Grid



- HS1000 due to connect to infrastructure put in place by EMEC
- Sound of Islay and Ness of Duncansby will require infrastructure upgrades

HS1000: Supply Chain

- HS1000 currently in Manufacturing Phase
 - Over 65 tenders from companies in more than 10 countries.
 - Cost, timescales and future capacity vary greatly



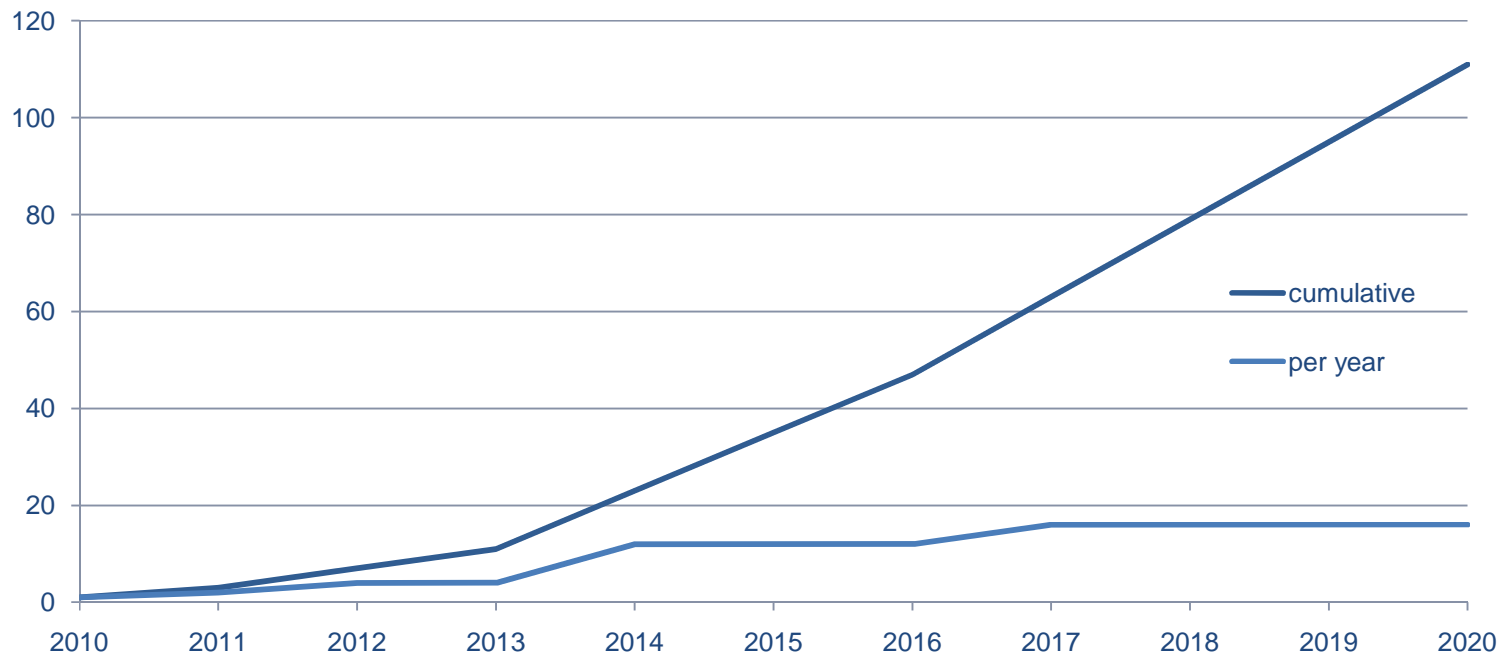
HS1000: Consents

- Consents and Licences underway for EMEC and Islay projects
 - Much repetition in process
 - Opportunity to simplify and expedite



HS1000: Next 10 years

HS1000 Units Produced



Thank you!

Please see our web site:

www.hammerfeststrom.com

By: Craig Love

Turbine Control Engineer

craig.love@hammerfeststrom.co.uk