UKERC Marine (Wave and Tidal Current) Renewable Energy Technology Roadmap

UK Energy Research Centre
University of Edinburgh

Contact Details:
Dr. Markus Mueller: Email: Markus.Mueller@ed.ac.uk
Henry Jeffrey: Email: Henry.Jeffrey@ed.ac.uk
School of Engineering & Electronics
University of Edinburgh
The King’s Buildings
Edinburgh
EH9 3JL

Executive Summary

This document is a technology roadmap: it provides a guide for mobilising the wave and tidal energy community in the UK down a single deployment pathway towards a target of achieving 2GW installed capacity by 2020.

The roadmap is aimed at providing a focused and coherent approach to technology development in the marine sector, whilst taking into account the needs of other stakeholders. The successful implementation of the technology roadmap depends upon a number of complex interactions between commercial and technical aspects and all aspirations being achieved. These will also depend upon external factors.

Although this roadmap is technically focused it also considers policy, environmental and commercialisation aspects of the marine energy sector, in order to display and put in context the influences of these externalities.

The roadmap is aimed at *technology developers, project developers, policy makers, government bodies, investors (public and private), the supply chain, consultants, and academics in order to aid coherence to the sectors progression.*

Even though the roadmap has been written with the UK community in mind, we hope that its core technical aspects will be applicable to any country if modifications for the country's policy, regulation and infrastructure changes are taken into consideration.

It should be stressed that the roadmap is a living document: it will evolve and be maintained with time according to technology advances, changes in policy, an understanding of the environment and that of the overall landscape of the sector.

The roadmap has been arrived at as a result of consultation with the community at 4 workshops held since April 2005, as well as over 40 one to one interviews. Overall a Battelle methodology has been used in the construction of the roadmap, with Delphi method used in the one to one interviews. The final roadmap document builds upon a number of UKERC documents and the UKERC marine landscape document, all of which can be found on the UKERC website. Finally although the UKERC hosts this roadmap, its ownership lies with sector who have fed into it during the consultation process.

1 Document structure and Roadmap methodology

This document builds upon information raised during the expert consultations Although it is not the purpose of this roadmap to provide a definitive statement on the ultimate cost route forward for this nascent sector, this document will show how certain deployment scenarios can be applied in the marine energy sector. It also details the requirements and timescales involved in achieving them.

The consultation process included 4 community workshops held between April 2005 and February 2007 and over 40 one to one over 40 stakeholder interviews. A Battelle methodology has been used in the construction of the roadmap, with Delphi method used in the one to one interviews.

The Battelle approach is underpinned by 4 main criteria for consideration in forming roadmap for a sector that are as follows:

1. **Vision Statement**: The Vision statement defines the major target for 2020, which will be achieved through the various stages of the Deployment Strategy.
2. **Deployment Strategy**: The deployment strategy defines one scenario for deployment of marine devices up to 2020, with the final deployment target defined in the vision statement.
3. **Commercial Strategy:** The commercial strategy defines the paths required to achieve the various stages in the Deployment Strategy.
4. **Technical Strategy:** The technical strategy provides underpinning technical knowledge and breakthroughs to facilitate the achievement of the commercial and deployment strategies.

During the consultation process the following vision statement was agreed upon as a suitable and challenging target for the sector:

Vision Statement.

The UKERC Marine Renewable Technology Roadmap aims to assist the UK marine and renewable energy community with the following[1]:

- **To exploit energy from waves and tidal currents in an environmentally and socially responsible way aiming for an installed capacity of 2GW by 2020.**
- **To stimulate policy and funding instruments to overcome barriers to deployment.**
- **To establish a commercially viable industry supported by an extensive supply chain and thereby build skills capacity at all levels.**
- **To become competitive with other energy sources by 2020.**

The remainder of this document will provide the detail of the roadmap with chapter 2 detailing the deployment, chapter 3 detailing the associated commercial strategy. Chapter 4 is main section of the document where the underpinning technical requirements and timelines are detailed and qualified for the roadmap. Finally, chapters 5 and 6 summarise the challenges and conclude the overall findings.

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[1] In order to provide guidance to forming the vision statement it is worth comparing the respective current positions of the marine energy industry with the wind industry. It is estimated that marine renewables is 15-20 years behind wind, so that the target of 2GW installed capacity by 2020 reflects the development in wind in the UK.

The target is also in line with estimates in the Carbon Trust Marine Energy Challenge, which proposes 2-5GW of both wave and tidal current energy across Europe.

2 Deployment Strategy

The deployment strategy displayed in Figure 1 describes one scenario (or pathway) in graphical form showing how 2GW of installed capacity will be installed by 2020. This goal will only be achieved through device deployment and principally device arrays. The interconnections between the deployment strategy and the commercial and technical strategies are highlighted later in the document.

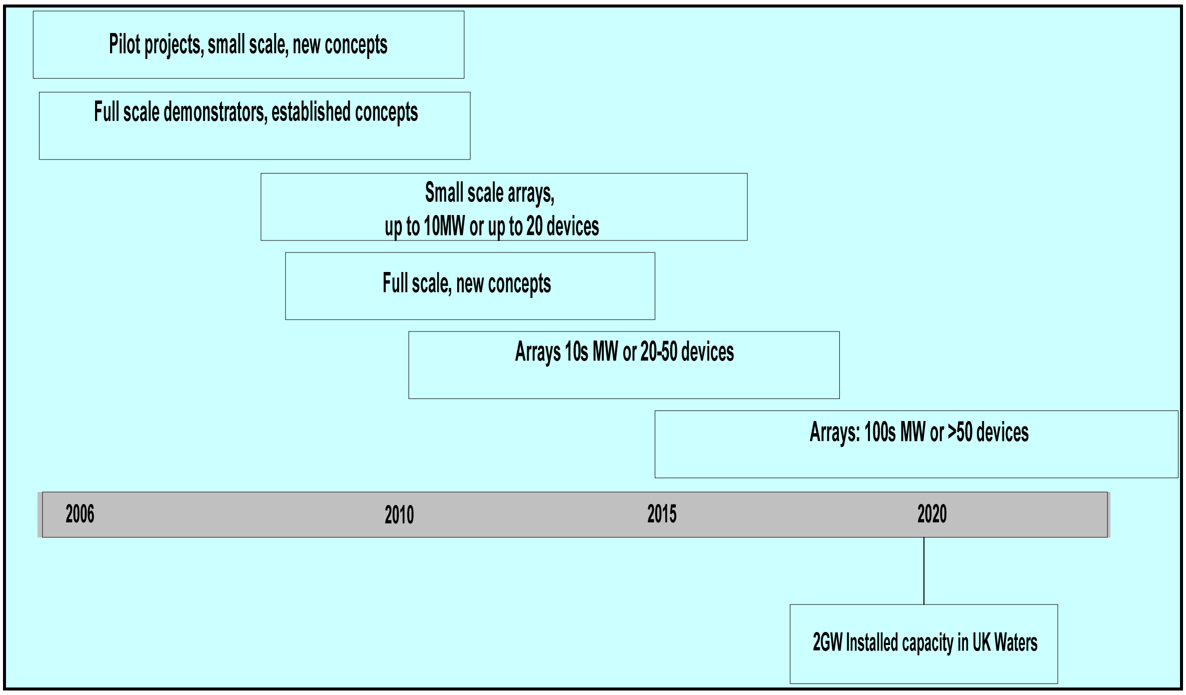

Figure 1: Deployment Scenario up to 2020[2]

Figure 1A displays the current funding policy landscape in the UK to facilitate and support the deployment of devices. To add context to this, Figure 1B displays a timeline of the current deployment situation.

[2] The scenario as presented is in line with the growth shown in the Path to Power deployment scenario (BWEA), leading to gradual growth of up to 200-300MW by 2012-2015 with rapid growth thereafter to 2020

Funding Policy and Deployment

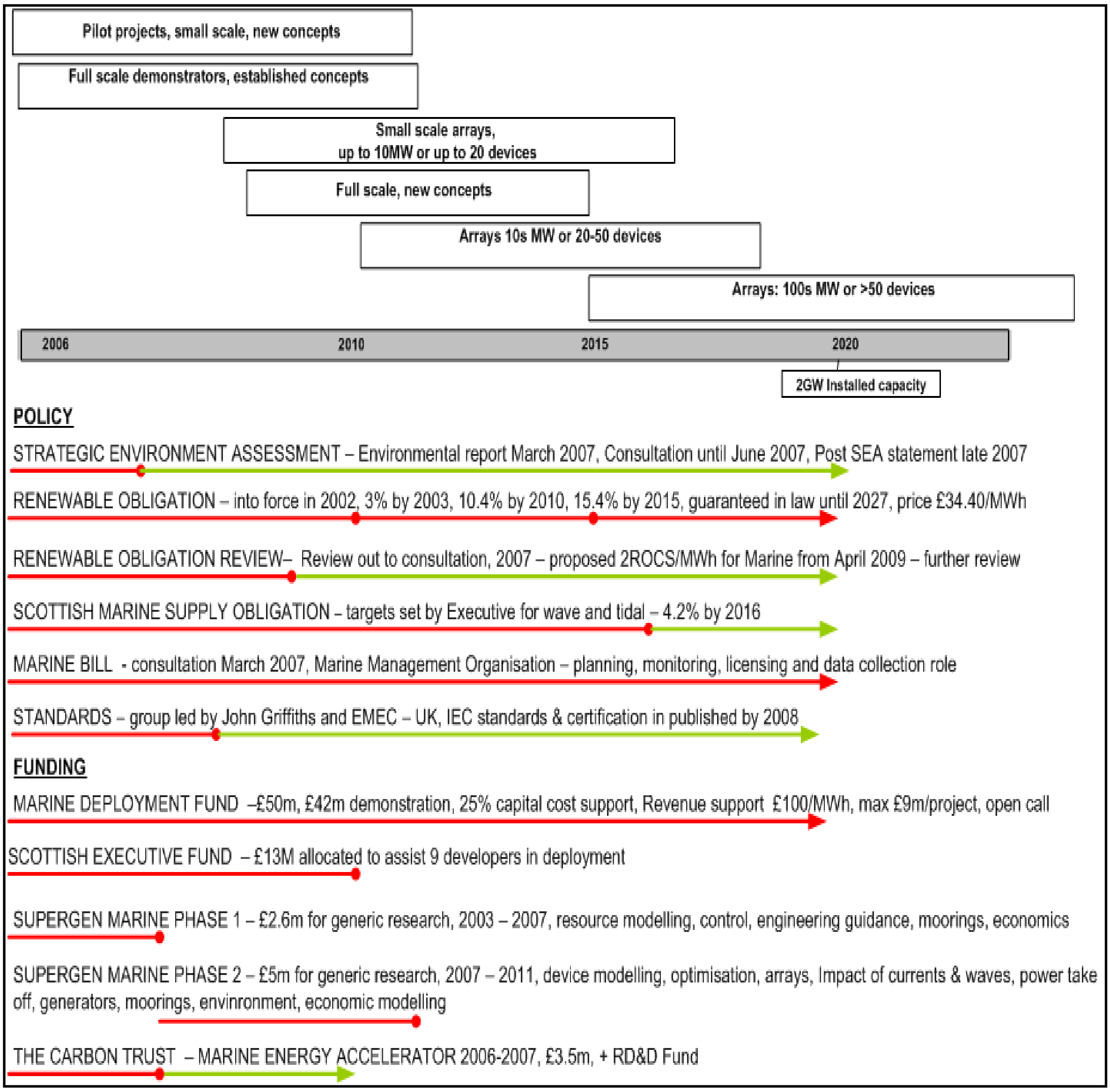

Figure1A: Current policy and funding landscape in the UK

Key:

In figure and all the remaining deployment figures, the red line indicates a primary activity, milestones are indicated by a red dot, and the green line indicates a review period.

Clearly, the status (primary or review) of each of these themes and their relationship with the deployment strategy will be under regular review depending upon changes in the technology or policy.

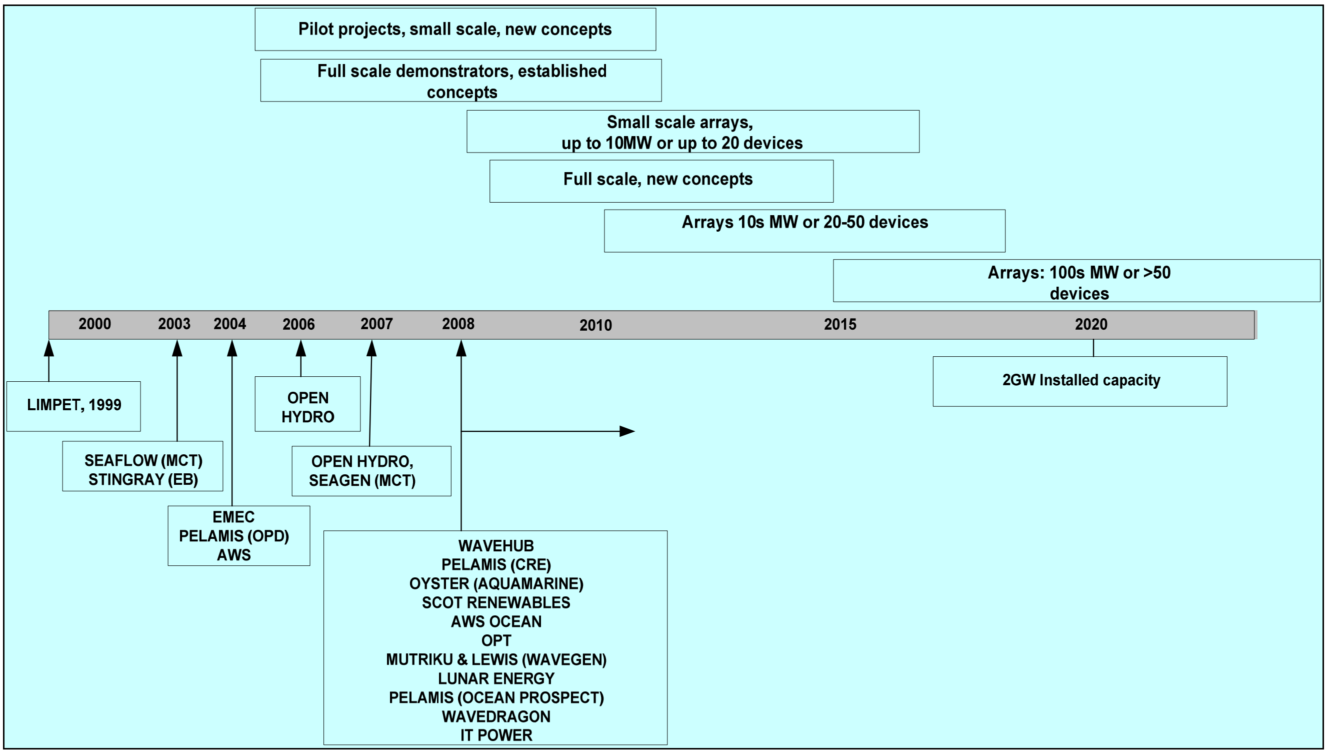

Figure1B: Present deployment landscape

The deployment strategy describes one scenario (or pathway) in graphical form showing how 2GW of installed capacity will be installed by 2020. This goal will only be achieved through device deployment and principally the deployment of device arrays. In order to ensure effective learning, deployment must be a gradual process, which is reflected in the scenario.

Currently, new devices are still being developed at small scales and more established devices are being demonstrated in the sea at or close to full scale. New concepts will continue to be developed throughout the scenario period, probably beyond 2015 as implied in Figure 1B.

As with any scenario there are always associated assumptions, which cover all aspects of the sector, including infrastructure, policy, economics and technical:

1. Manufacturing infrastructure is in place to meet low volume manufacture for small arrays ramping up to high volume manufacture by 2015.
2. Resource, electrical grid and environmental assessments at all the most promising sites have been completed before 2015.

3. Planning legislation is in place to enable all sites to be exploited to meet the 2020 target.
4. Individual device developers have finalised design on their respective technologies allowing high volume manufacture and deployments by 2015.
5. Policies are in place to ensure a smooth transition from low volume to high volume deployment.
6. Manpower skills and capacity is available to service the rapid expansion required beyond 2015.
7. Electrical regulatory and infrastructure aspects are in place to enable large volume deployments of arrays.
8. Cost effective installation and O&M strategies have been established before 2015.

3 Commercial Strategy

Figure 2 shows the relationship between the commercial and deployment strategies. The main headings of the commercial strategy are in upper case, and a brief description of the main issues is provided. A more detailed description of each commercial theme is provided later in this section.

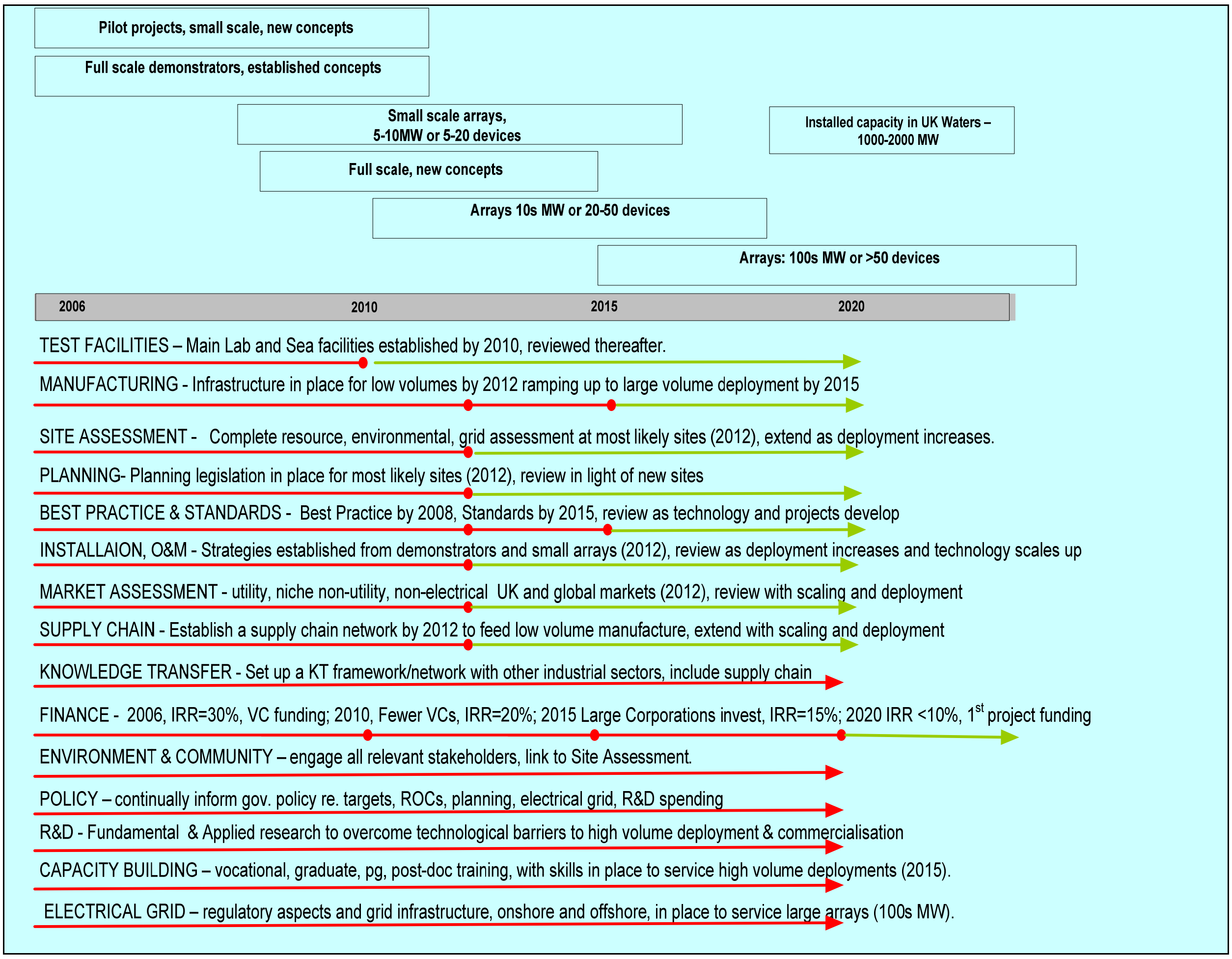

Figure 2: Time dependency between the Commercial Strategy and the Deployment Strategy

The commercial strategy (displayed in Figure 2) required to fulfil the deployment strategy consists of 10 main themes (some have sub-themes leading to 15 items in Figure 2) covering all aspects of the RDD&D chain for an emerging technology such as marine renewables. An expansion of the 10 main and their sub-themes can be found in Appendix 1

4 Technical Strategy

Although dependent on both the deployment and commercial strategies the underpinning technical strategy is the focus of the roadmap. The technical strategy has been divided into 12 themes referred to as Technology Working Areas (TWA), which represent the technology development chain in marine renewable devices:

a) Resource Modelling
b) Device modelling
c) Experimental Testing
d) Moorings & Sea bed attachments
e) Electrical Infrastructure
f) Power Take Off and Control
g) Engineering Design
h) Lifecycle & Manufacturing
i) Installation, O&M
j) Environmental
k) Standards
l) System Simulation

The following section will display the overall timeline for the Technical Strategy in relation to the Deployment Strategy and detailed qualified timelines for each of the TWAs listed above will be presented.

Deployment Strategy and the Technical Strategy.

Figure 3 shows the overall relationship between the technical strategy and the deployment strategy, with the TWAs in upper case and a brief description of the main technical issues.

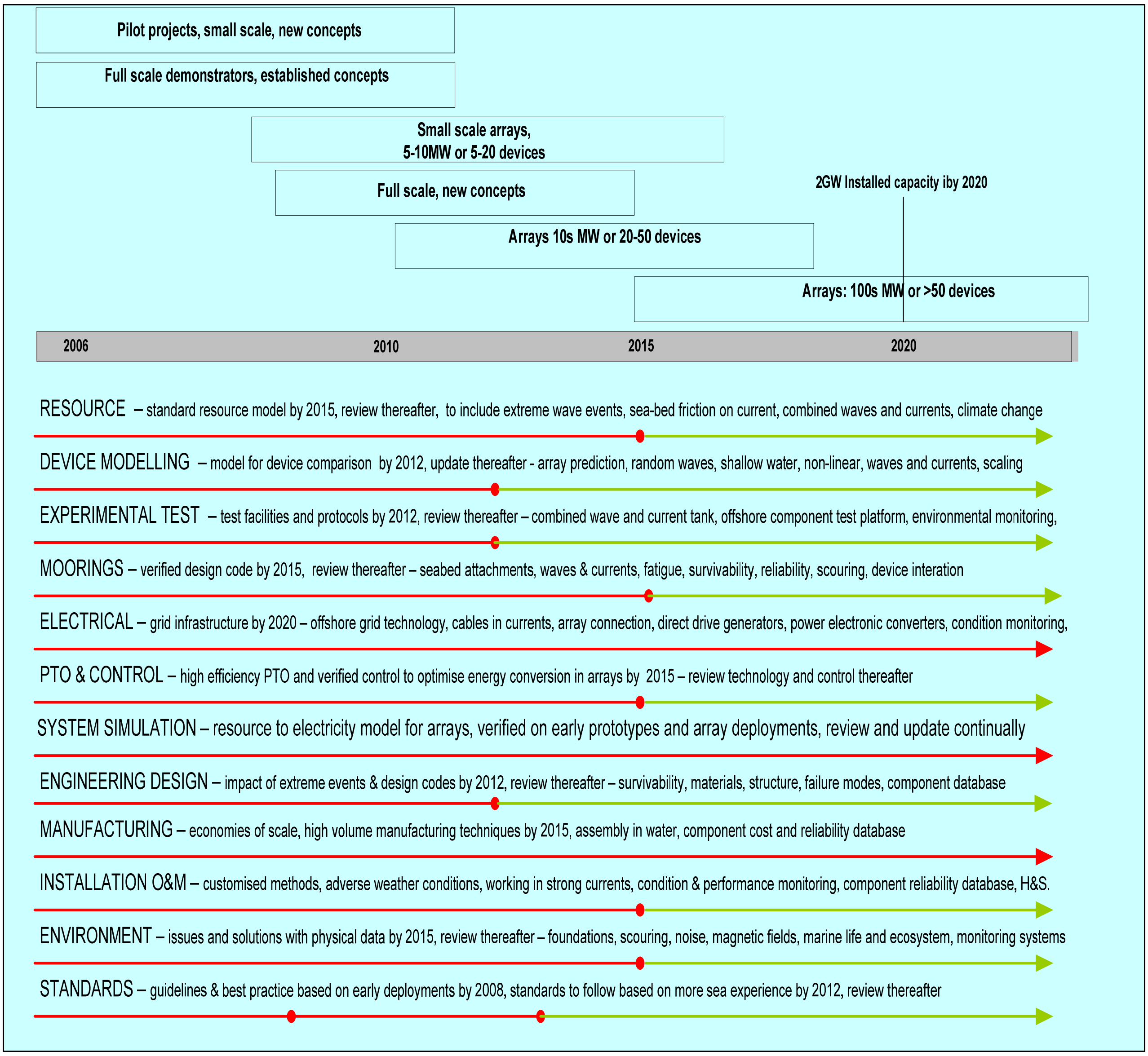

Figure 3: Time dependency between the Technical Strategy and the Deployment Strategy

The remaining figures 3A to 3I display the qualified detailed timelines for each of these TWAs

Technical Strategy: Resource Modelling Timeline

- Resource modelling is important for technical and economic reasons.
- Knowledge of extreme events will impact the engineering design of a device and its ability to survive, which in turn has economic implications.
- A better knowledge of the near shore resource will inform the design of devices and the economic exploitation of such sites.
- The size of the wave resource is reasonably well understood, but the impact of climate change on the resource will affect design and economics.
- The tidal current resource is probably less well understood, in particular the impact of seabed friction and the environmental impact on sediment flow.
- Knowledge of the combined impact of waves and currents on devices is very much an unknown.
- All modelling needs to be verified using tanks to provide confidence in the use of these models, and is thus closely linked to Experimental Testing.
- These issues need to be better understood by 2015 so that there are no technical barriers to large volume deployment.

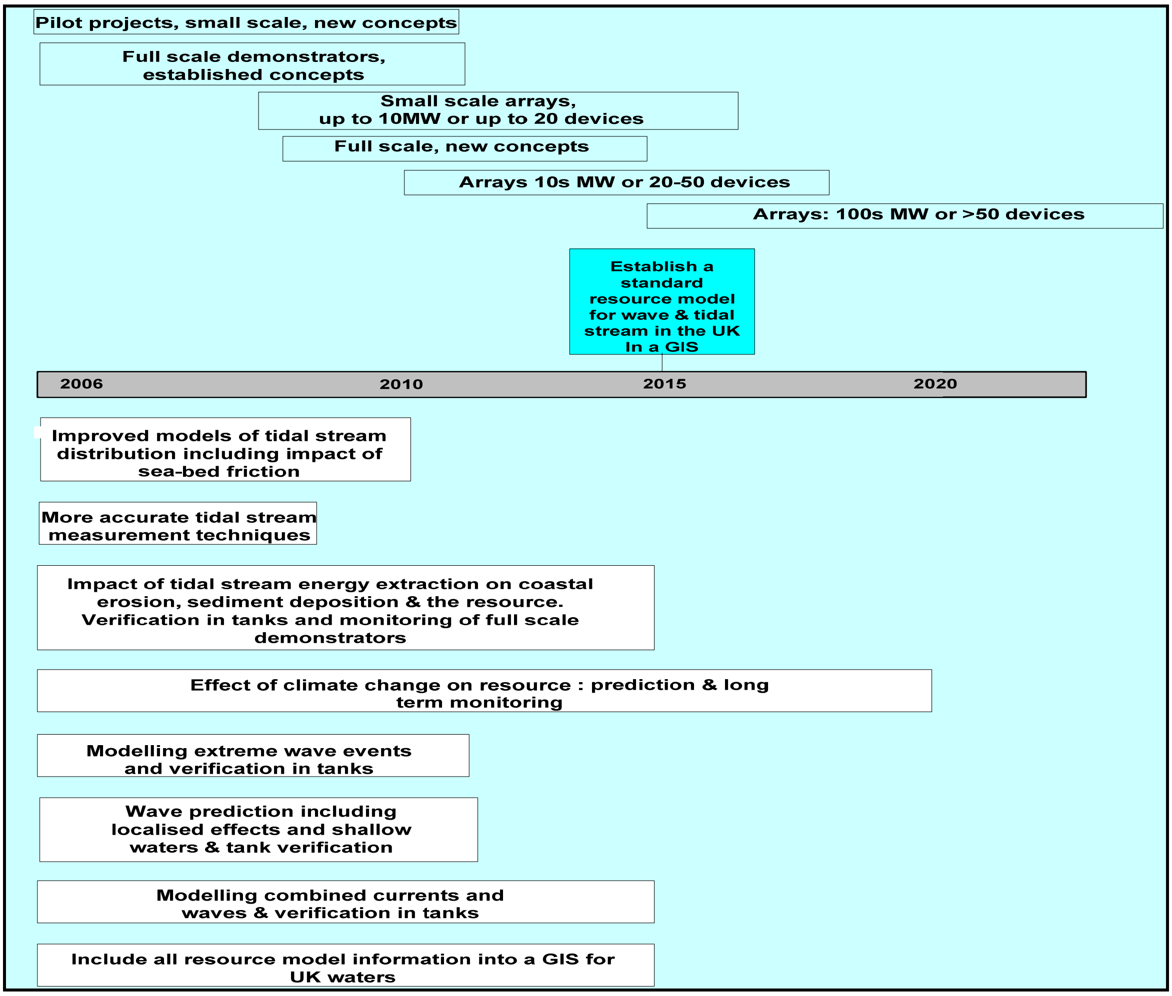

Figure 3A: Resource Modelling Timeline

Technical Strategy: Device Modelling Timeline

- Traditionally the development process involves a number of stages in wave tanks at different scales and can take between 7-10 years before reaching a scale suitable for sea trials.
- The number of development stages could be reduced by combining tank tests with more accurate device models that can be used with confidence.
- Modelling of devices in arrays is vital for large volume deployment of devices in arrays from 2015 onwards.
- Physical data from smaller arrays deployed from 2007 to 2012 should be used to verify array modelling work.
- There are close links with resource modelling, experimental testing, moorings, electrical infrastructure, PTO & control and system modelling.

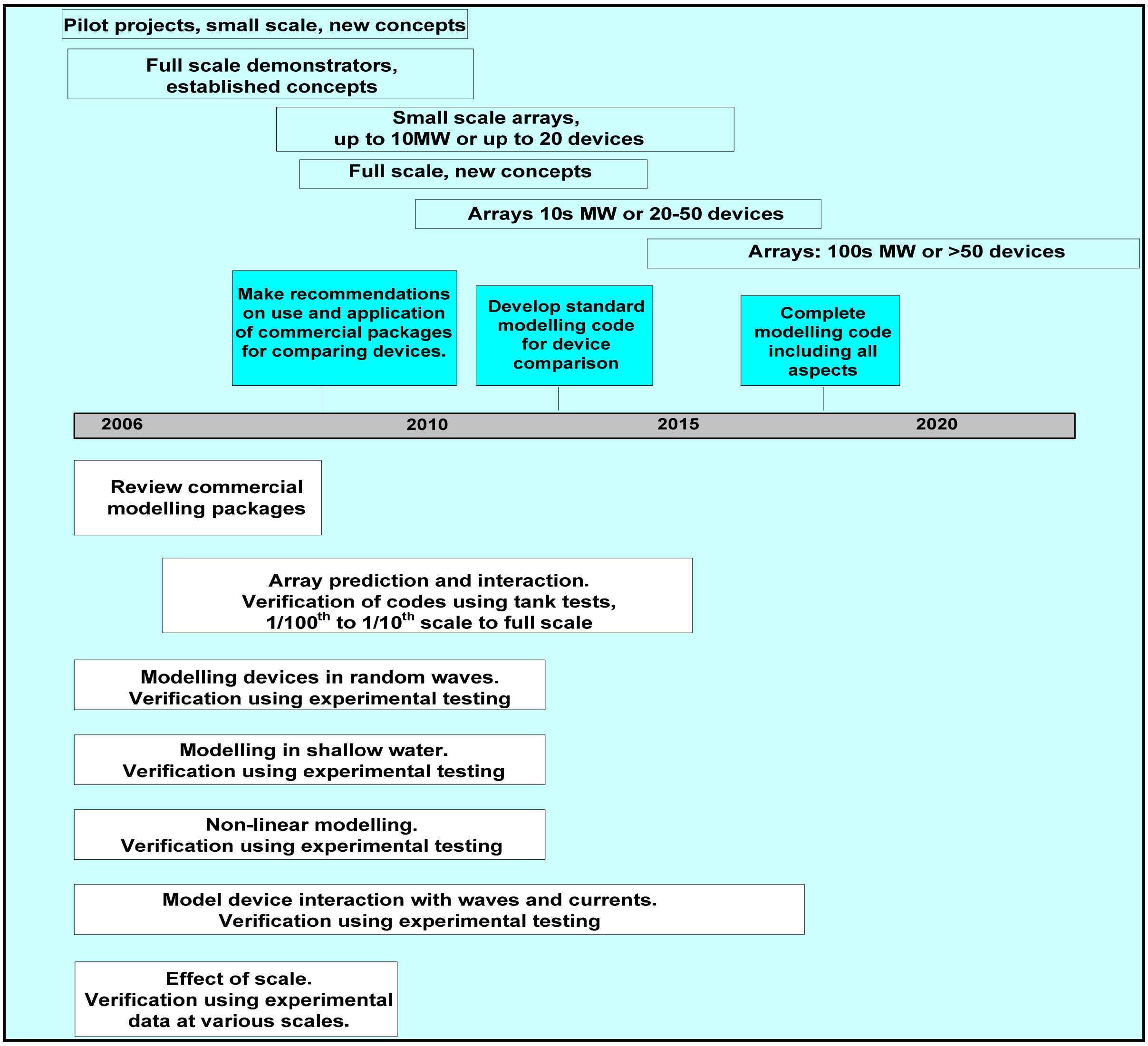

Figure 3B: Device Modelling Timeline

Technical Strategy: Experimental Testing Timeline

- Access to scale test tanks provides an economic method of assessing new concepts, which when combined with accurate device models has the potential to reduce the number of development stages.
- Tank test facilities provide a controlled and repeatable environment for device development.
- Sea test sites are already available at EMEC, and WAVEHUB is due to come online in August 2008.
- Test facilities are important for the verification of resource and device models.
- The major gap in controllable and repeatable wet test facilities is for tidal current systems. At present developers tend to use river sites for scale testing at say 1/15th scale and then jump to full scale for sea-trials, which has considerable risk associated with it.
- Towing tanks have been used in the past, but these do not adequately represent the interaction of a stationary energy extraction device in moving water.
- There is currently no facility for investigating the combination of current and waves – if all sites are to be exploited there will be a need for such a facility.
- Component testing will contribute to a better understanding of reliability, but must be performed under realistic conditions.
- Testing standards are required to ensure consistency between test facilities.
- Alongside resource and device modelling, experimental testing is integral to the engineering design and deployment of devices at all levels from new concepts to large arrays.

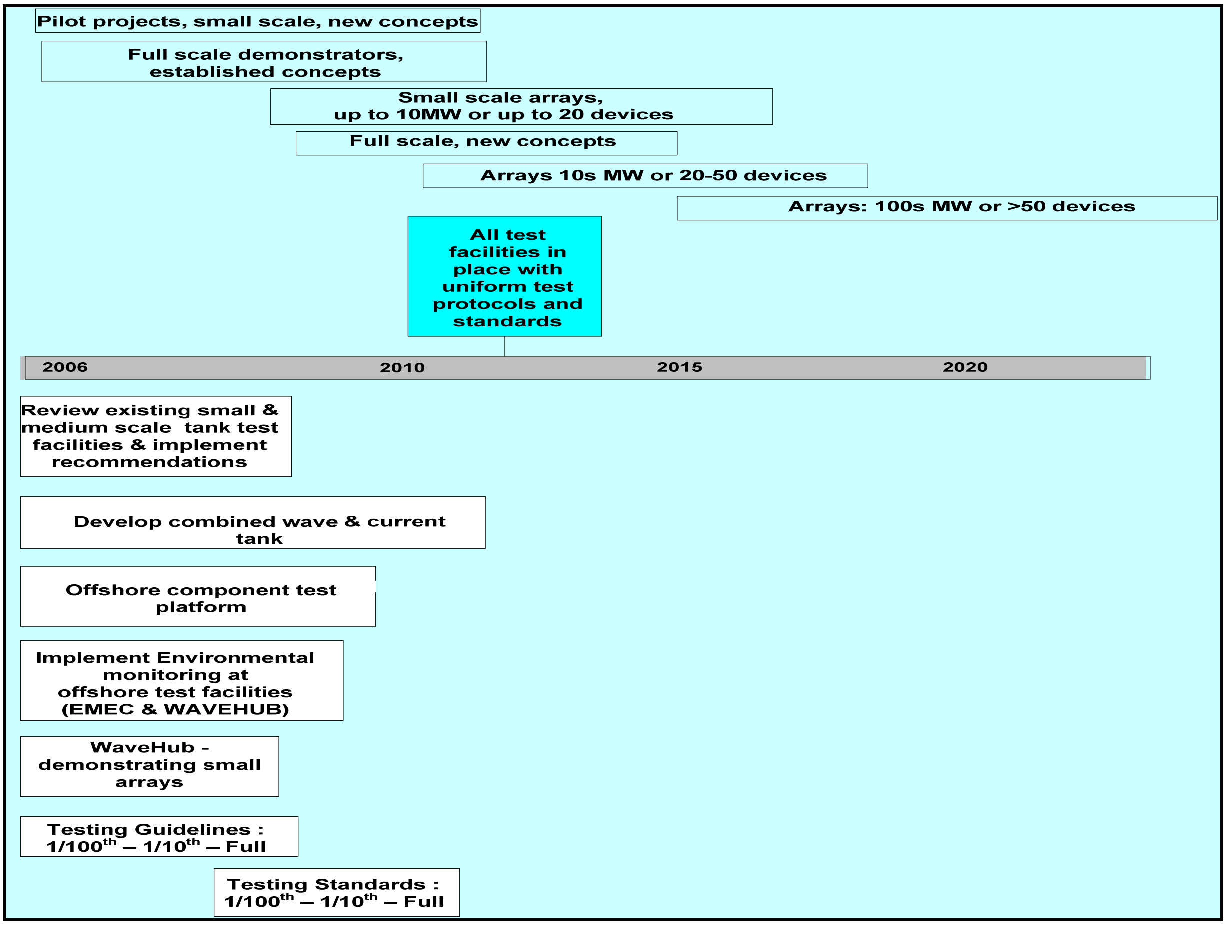

Figure 3C: Experimental Timeline

Technical Strategy: Moorings and Seabed Attachments Timeline

- Moorings and seabed attachments were identified as a potential gap in expertise and investment in the funding landscape analysis in section 2.
- They are integral to the successful deployment and operation of floating wave and tidal current devices.
- Knowledge gained from deployments between 2008 and 2012 must be used to finalise design tools for large volume deployment from 2015.
- Testing should take place in both scale test facilities and at sea, EMEC and WAVEHUB. Physical data from deployments at sea needs to be shared with research groups to validate design tools.
- There will be close interaction with resource, device modelling, experimental testing, engineering design, environment, and installation O&M.

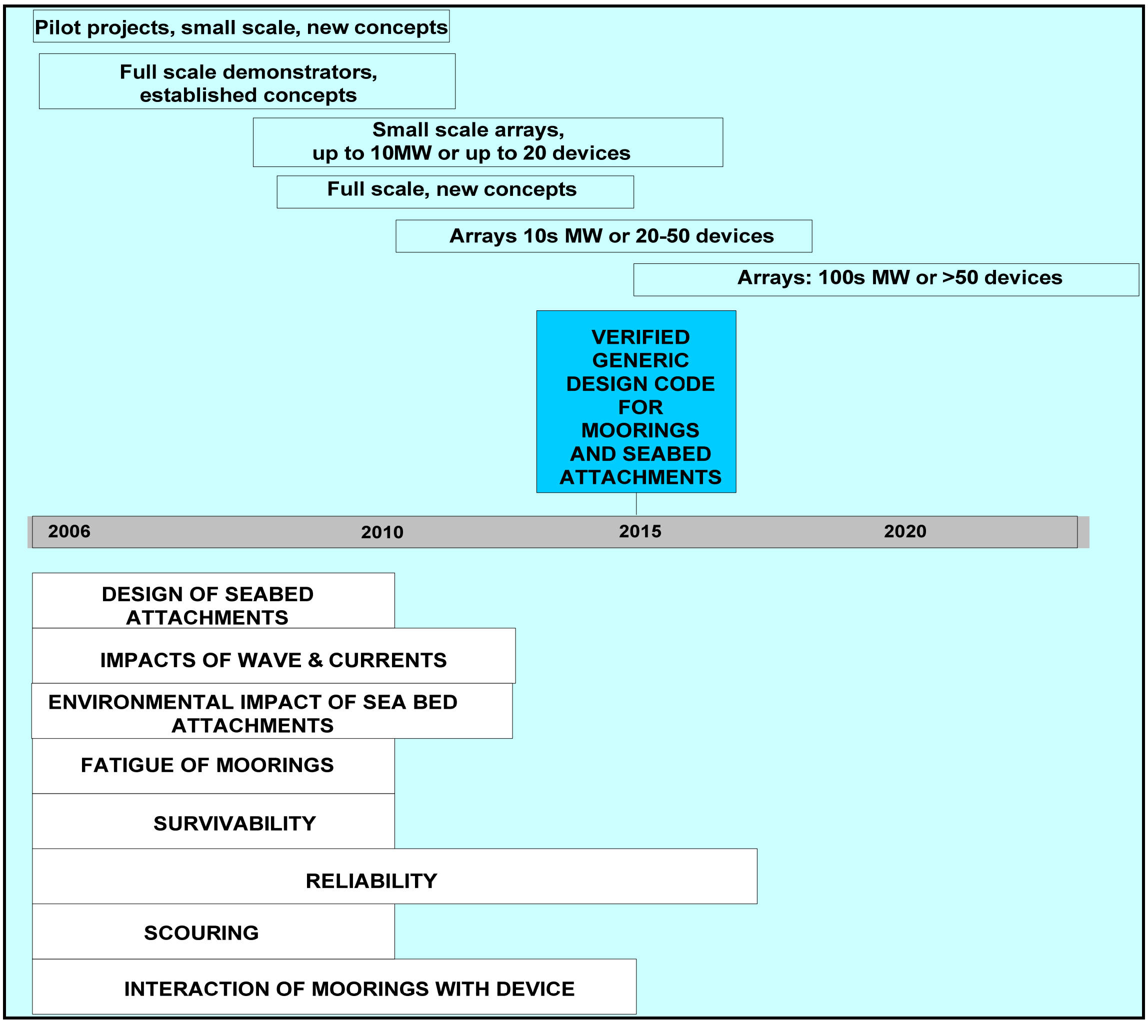

Figure 3D: Moorings & Seabed Attachments Timeline

Technical Strategy: Electrical Infrastructure Timeline

- In the UK, upgrading of the electrical grid infrastructure is critical to meeting the 2020 target.
- Upgrading is likely to be both onshore and offshore – the two have to be combined in such a way to minimise potential delays brought on by planning and environmental issues. A strategy needs to be in place by 2010.
- Electrical connection of devices, cable laying, and connection within and between arrays link in with installation and O&M.
- Conversion of the mechanical energy into electrical energy using direct drive provides a potentially more robust and efficient solution compared to say hydraulics or gearboxes driving a conventional rotary generator, but deployments are required to demonstrate the potential advantages if direct drive is to make a significant contribution to large volume deployment from 2015 onwards.
- Power electronic converters are required to interface to the electrical grid, but once again, deployments are required to gain more knowledge of performance and reliability in particular.
- Condition monitoring systems will play a role in O&M of devices, and should be intelligent such that the PTO can be controlled to modify performance ensuring continued operation even during a fault condition.
- Physical data collected from small scale deployments should be used to modify designs for large volume array deployments

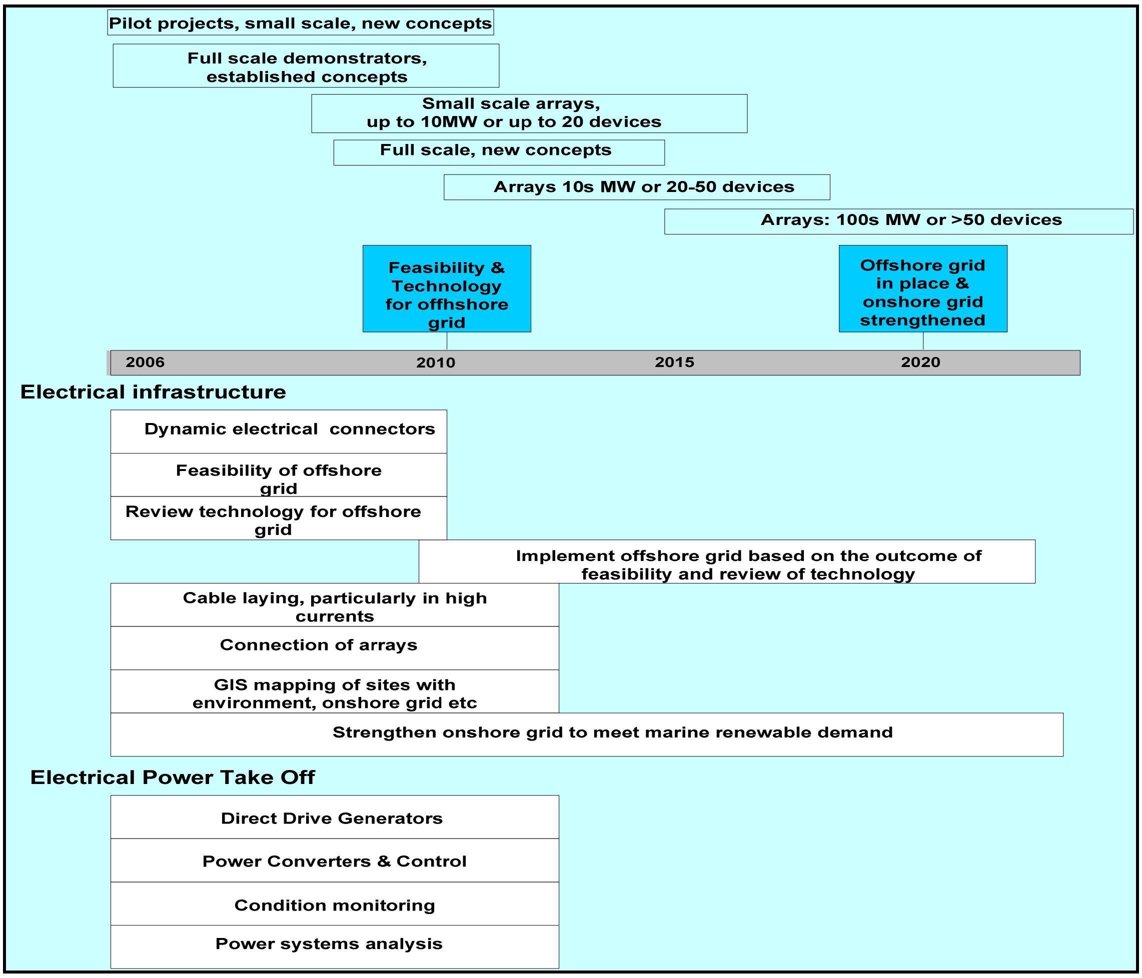

Figure 3E: Electrical Infrastructure Timeline

Technical Strategy: Power Take Off and Control Systems Timeline

- High part load efficiency and effective control systems in power take off mechanisms such as hydraulics or air-turbines affect the technical performance and the economics of the system.
- Control strategies between devices in arrays need to be developed and tested in small array deployments for implementation in large arrays beyond 2015.
- Energy storage systems and alternative energy vectors is a long term issue, but needs to be investigated for non-electricity markets and further developments beyond 2020.
- There will be close links with resource and device modelling, electrical infrastructure, experimental testing, moorings, engineering design, markets and economics.

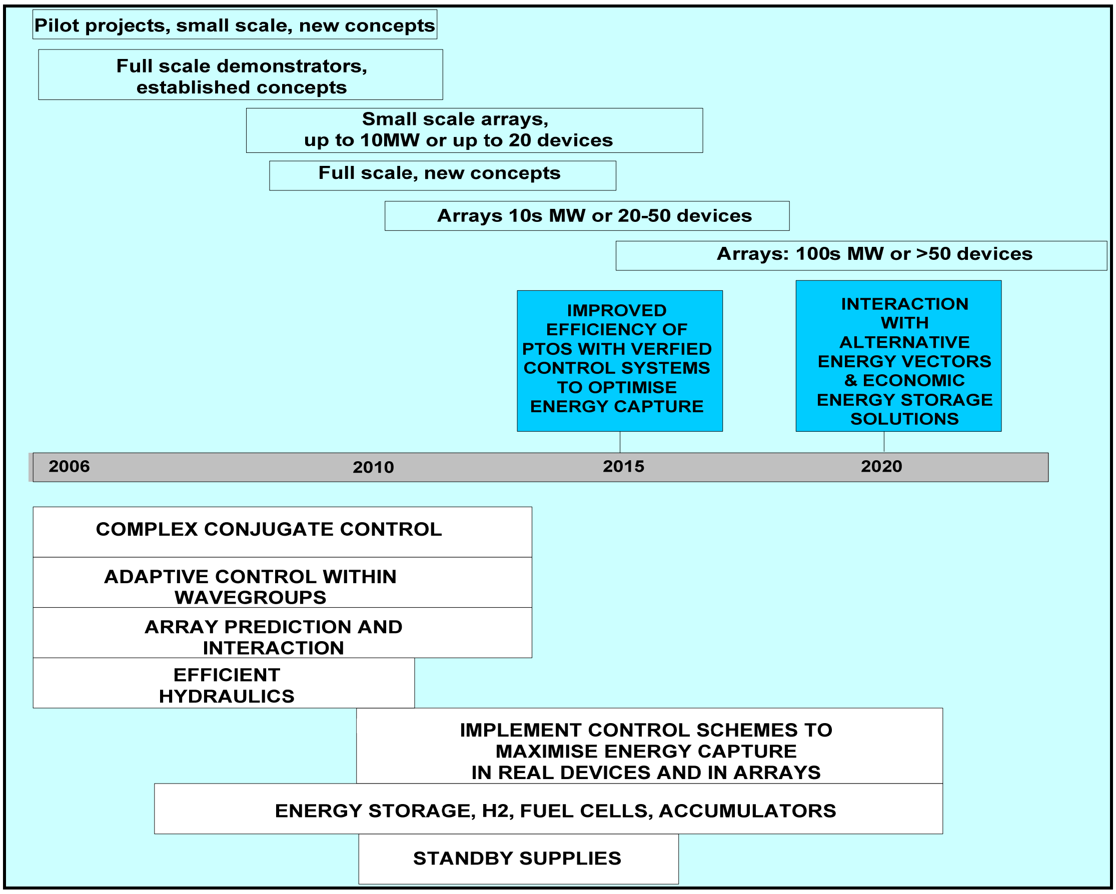

Figure 3F: Power Take Off & Control Systems Timeline

Technical Strategy: Engineering Design Timeline

- Engineering design is critical to successful large volume deployment.
- Survivability is the most important aspect of the development of any new device, which requires advances in new structural materials, a better understanding of failure modes and component reliability, and the ability to forecast extreme events.
- There are close links with resource modelling in terms of extreme events, device modelling, moorings, electrical infrastructure, PTO and control, manufacturing and environment.
- Standard design codes should be developed so that they can be applied to any new concept to reduce the development stages and reduce cost.

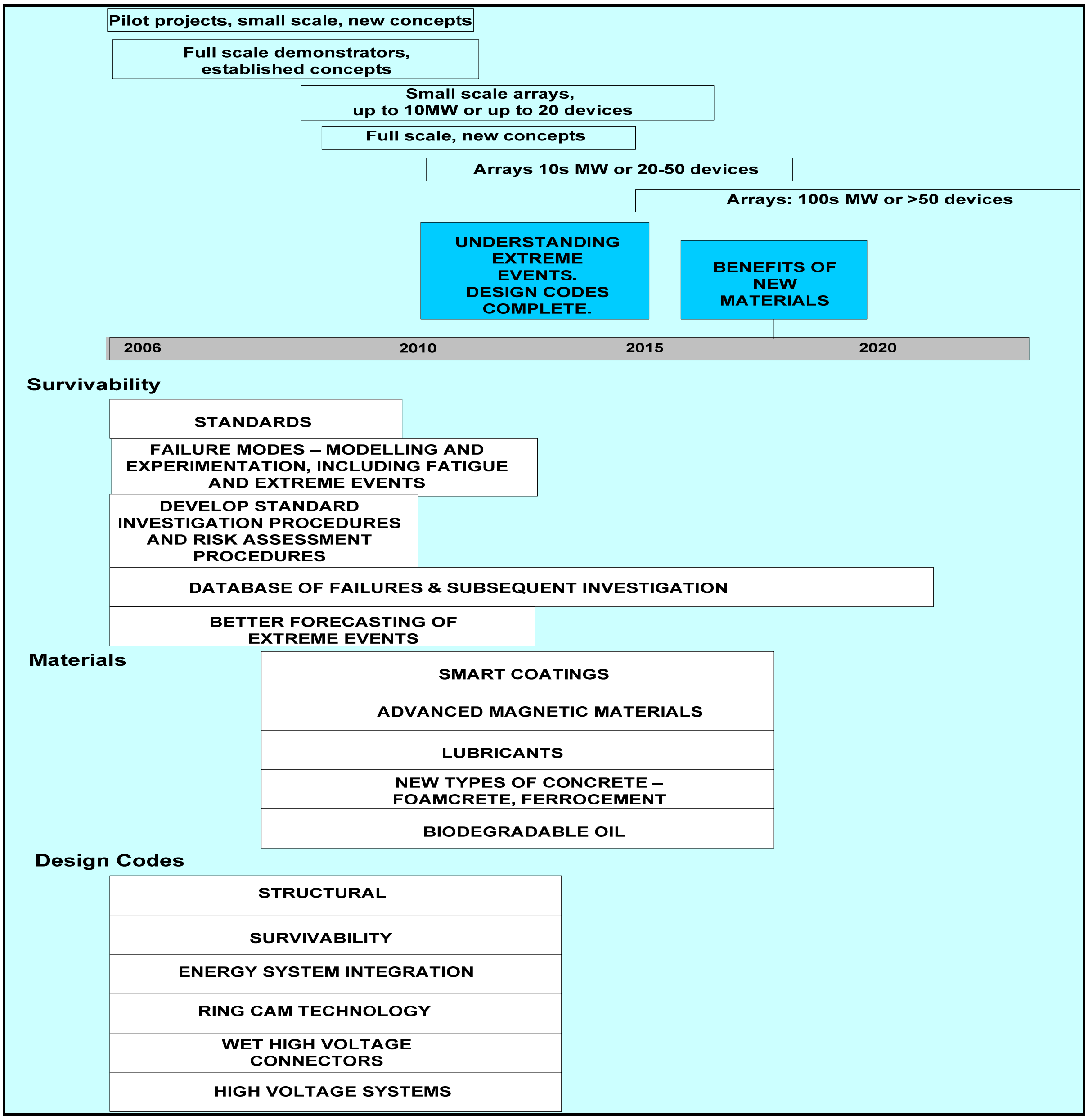

Figure 3G: Engineering Design Timeline

Technical Strategy: Lifecycle & Manufacturing Timeline

- Manufacturing infrastructure is one of the key aspects to meeting the 2020 target, and it should be in place by 2012 for high volume deployment from 2015 onwards.
- High volume manufacture will require device designs to have matured and been finalised.
- Scaling and the economics need to be assessed to determine the optimum production unit, which should be finalised for high volume deployment.
- During testing of small to medium arrays device/array performance should be appraised so that more confidence is gained for operation and costing for larger arrays.
- A generic component database including reliability and cost data will be a useful tool for developers.
- Manufacturing depends upon the engineering design of a device, will influence the installation and operation of a device and clearly cost effective manufacture will be vital for the economics.

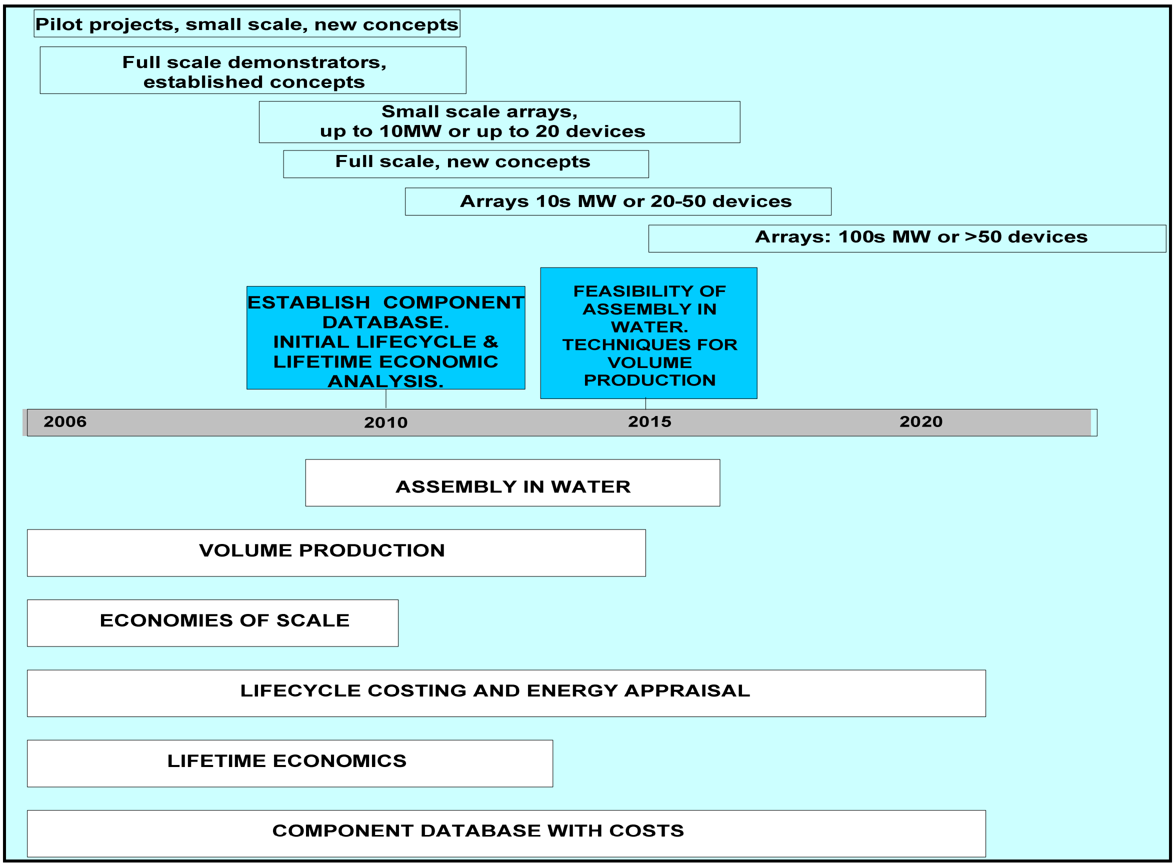

Figure 3H: Lifecycle and Manufacturing Timeline

Technical Strategy: Installation and O&M Timeline

- In order to achieve high volume deployments the community needs to have dedicated installation vessels so that they do not compete with other sectors of the offshore industry.
- Deployment of the small to medium sized arrays will provide experience of installation methods and O&M procedures, particularly in various weather conditions.
- In both aspects, H&S procedures need to be established before even small scale deployments.
- Installation methods should be part of an integrated design procedure forming part of the design optimisation.
- Throughout the deployment phases physical data detailing performance and reliability should be collected for verifying modelling and design tools.
- Intelligent condition monitoring methods need to be demonstrated to assist in O&M.

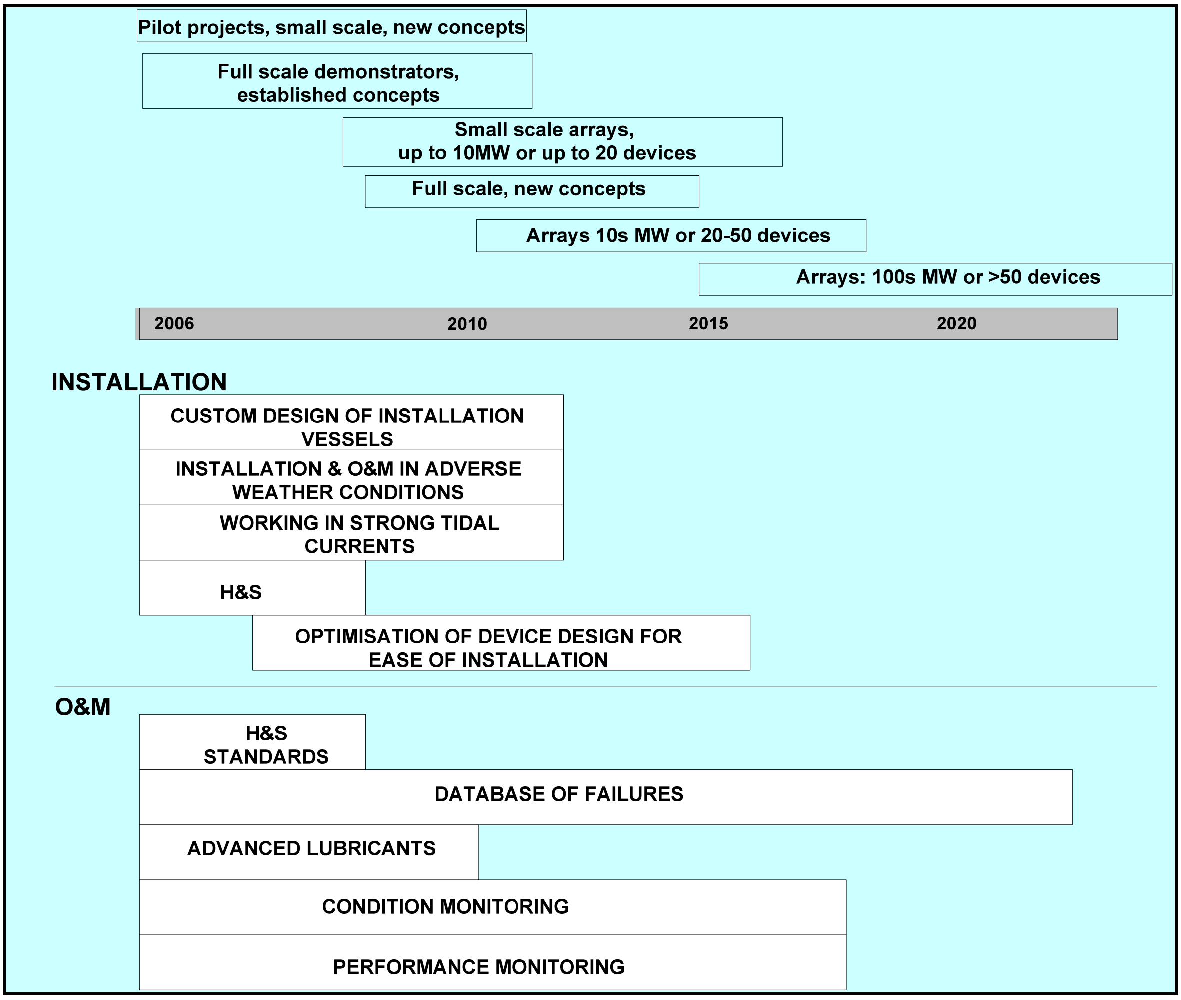

Figure 31: Installation, O&M Timeline

Technical Strategy: Environmental Timeline

- The impact of the devices (installation, operation and decommissioning phases) on the environment and vice versa needs to be monitored throughout the deployment of small to medium arrays.
- “The environment” includes not only marine life, but also the marine geography, eg. the sea-bed and the coastline.
- Physical data collected during the monitoring process will be used to verify environmental modelling, assess the impact of new devices and assist in the planning process for large volume deployments from 2015.
- Environmental monitoring and post-processing of the results is important to solve potential environmental barriers to deployment. This will require close collaboration between the marine environment and marine energy communities.

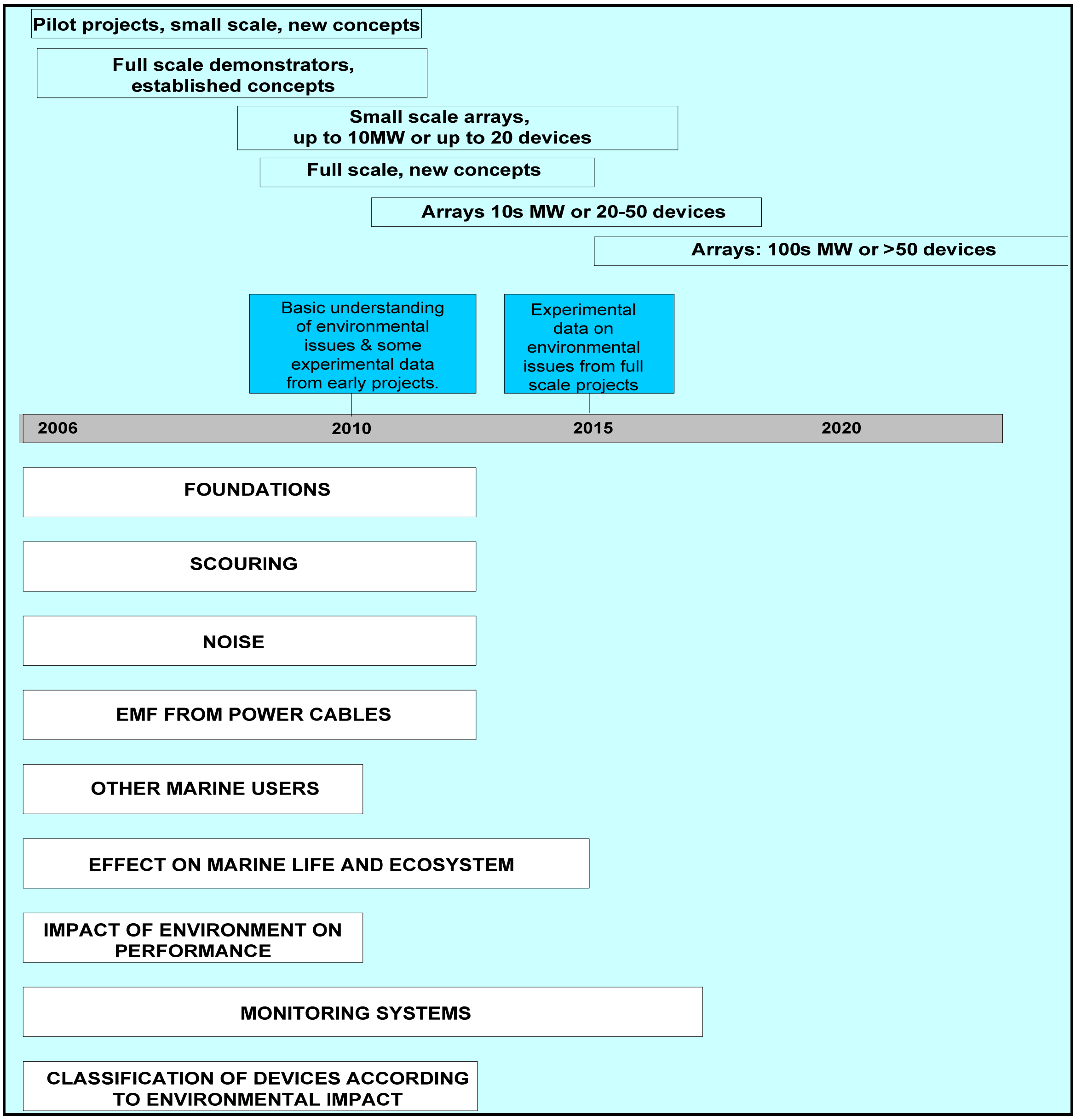

Figure 3J: Environmental Timeline

Technical Strategy: Standards Timeline

- Guidelines and best practice should be established before full standards to ensure that new concepts are not locked out.
- Results from all deployments – single prototypes to arrays – should be used to establish guidelines. Continued deployment will enable these guidelines to be verified leading to the establishment of standards.
- Standards should be reviewed at regular intervals to take into account advances in the technology and new knowledge of the environment.
- Having to meet standards gives device and project developers, policy makers and potential investors more confidence in the capabilities of the technology.

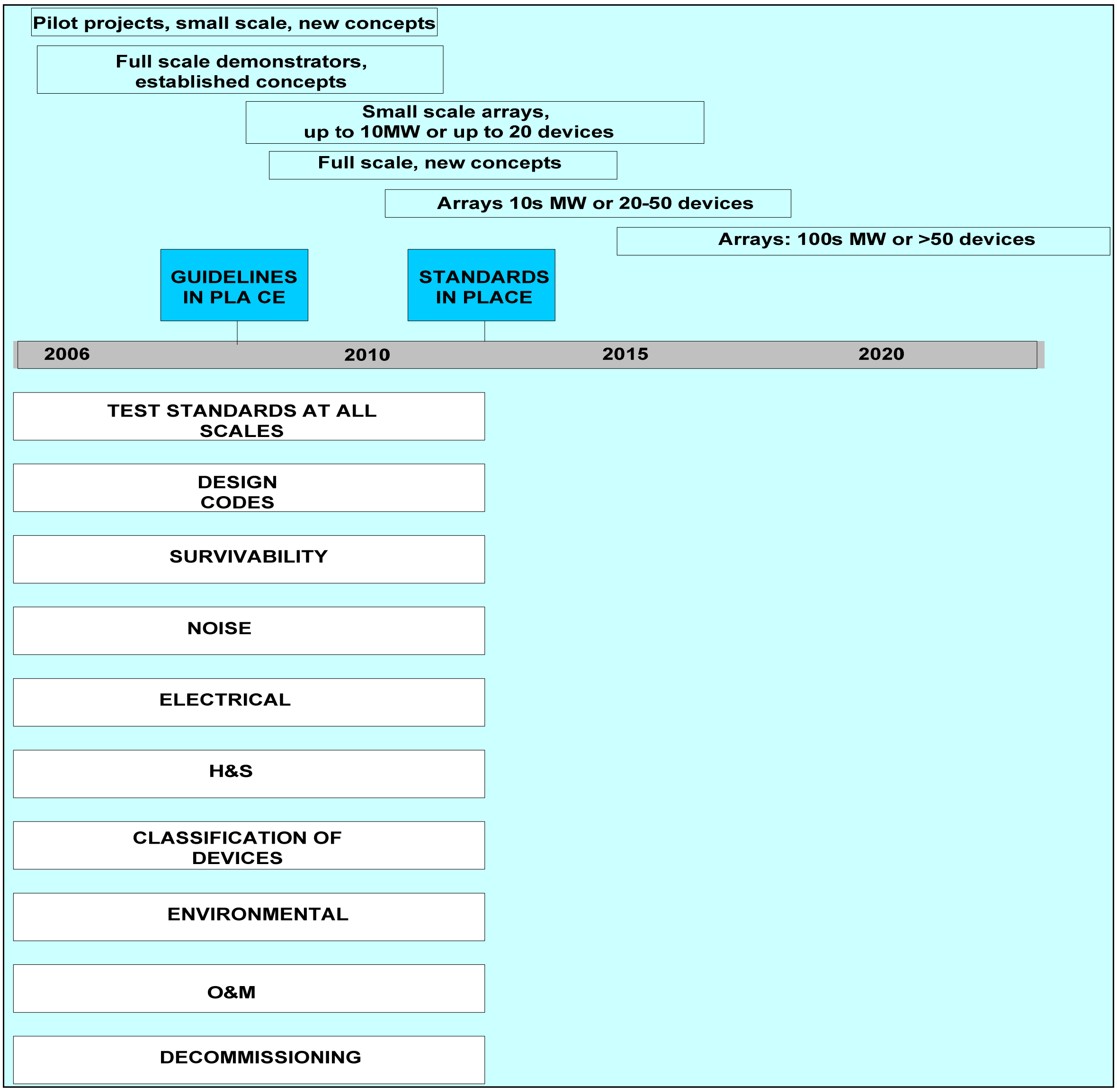

Figure 3K: Standards Timeline

5 Challenges and Summary

The following section highlights the key challenges to achieve the proposed deployment strategy. They have been categorised and summarised below, and provide a justification for the commercial and technical strategies.

Challenge	Priority / Required advances
Predictability Understanding the resource and device interaction such that it delivers predicted design performance.	Better resource analysis and weather forecasting; Better hydrodynamic and primary power conversion modelling; Better understand of floating-, founded-wave and tidal current device array effects; Better modelling of combined waves and currents.
Manufacturability from a concept that can be manufactured within a prescribed cost using existing or new technology.	Understand consequences of increasing scale from 1/100th to full size; Address turbulence and cavitation effects; Develop direct drive and hydraulic power take-offs, control and storage;
Installability and installed at site in the marine and environmental conditions prevailing using existing or new facilities.	Establish fabrication, transport and installation infrastructure; Develop cost effective foundations, moorings and anchorages; Develop electrical connectors, submarine cabling networks, improve network integration.
Operability thereafter to be controlled, operated and maintained for the necessary service periods determined by weather access.	Improve offshore access, operation and maintenance; Understand biofouling and interaction with marine environment.
Survivability and conceived and constructed to survive predicted and surprise extremes in wind, wave and tidal current conditions in any combination.	Better statistical analysis and short term prediction of extremes; Design for cost-effective survival; Establish standards, testing, proving and certification methods and operate to them.
Reliability while continuing to operate reliably over its predicted lifetime, maintained as planned.	Improve coating, sealing, monitoring, reliability in marine environment; establish component reliability statistical database.
Affordability at a lifetime cost that ensures market access and return on investment in the prevailing economic climate.	Develop equitable means of lifetime costing and performance appraisal; understand cost:survival:performance relationships.

Table 1: Main Challenges to Deployment

6 Conclusion

- This document presents a marine renewable energy technology roadmap applicable to both wave and tidal current energy. It is based on evidence gathered from workshops and interviews with the main players in the marine community.
- A deployment scenario has been proposed supported by a commercial strategy and a technical strategy.
- Timeline diagrams of both the commercial and technical strategies have been overlayed onto the deployment scenario to indicate the necessary cross links required to achieve the goal of 2GW installed capacity by 2020 as outlined in the vision statement.
- The major challenges facing the marine energy technology are summarised in Table 1 and related directly to the deployment scenario: *predictability, manufacturability, installability, operability, survivability, reliability & affordability.*
- Each of these challenges is addressed in more detail in the commercial and technical strategies, in which activities have been prioritised to meet the deployment scenario.
- The challenges listed relate very much to the technolog, but industrial infrastructure is a major challenge facing the sector, which includes electrical, manufacturing, supply chain and human resource.
- Policy has an important role to play in the meeting the 2020 vision in the vision statement, but it is of utmost importance that the technology roadmap is used to inform the development of policy as the two are interdependent.
- The timelines in the document represent a list of prioritised recommendations and actions developed in consultation with the marine community, and it should therefore be possible for funding bodies to allocate funds accordingly
- An assessment of the status of the marine energy landscape with respect to the technology roadmap, including UK capabilities, fundamental and applied R&D providers, funding, technology status and current policy and funding mechanisms, has been made in a more detailed Marine Technology Roadmap document, which is nearing completion.

- Finally, it should be remembered that the roadmap is a living document and will be updated on an annual basis to reflect the changes in policy and the advancement of the technology.

Appendix: 1

The commercial strategy (displayed in Figure 2) required to fulfil the deployment strategy consists of the 15 themes covering all aspects of the RDD&D chain for an emerging technology such as marine renewables. An expansion of these sub themes found in the following section

1. **Research & Development**
   - R&D includes fundamental and applied to meet generic and the more specific challenges associated with the technology.
   - The R&D priorities have been identified and form the basis of the Technical Strategy, which is presented in Section 4.
   - Output from the UKERC Marine Renewable Landscape feeds into this theme in terms of identifying the gaps in expertise and the technical barriers to be overcome, so that investment and resource can be focussed in the most appropriate places.
   - IP generation is the main commercialisation output from this theme.
   - R&D is a continuous theme throughout the deployment scenario to 2020 and beyond.
2. **Capacity Building**
   - The sector requires personnel from all backgrounds covering a range of qualifications who have the right skills to meet the vision and 2020 goal.
   - It is important to emphasise that vocational are just as important as degree qualifications.
   - Academia, further education colleges and industry need to work together here to ensure that future students are working to fill gaps in expertise and developing the right skills in other areas.
   - Industry can assist this by helping to sponsor students and degree programmes.
   - Wavetrain, an EU funded Marie Curie network is a good example of an initiative that needs to be continually supported build up skills, encourage international mobility and collaboration.
   - Linking into the supply chain and the potential for knowledge transfer from other industries has a role to play in capacity building.

3. Infrastructure

This theme applies to the physical aspects of the sector and is broken down into 6 sub-groups:

a. Test Facilities

- Wet test facilities are available at all scales from 1/100th model scale to sea trials of near full scale prototypes.
- Model scale facilities tend to be found in academic institutions.
- NaREC offer 1/10th scale wave test facilities and a ¼ ?? scale tidal test facility.
- EMEC offer both wave and tidal current sea test facilities.
- WAVEHUB will provide wave test facilities for small arrays.
- It is currently not possible to test at model scale in both waves and currents – this is a priority in the technical strategy.
- As well as wet test facilities, electro-mechanical test facilities will assist in the development of power take off and control systems.
- A component testing facility is of benefit in terms of enabling technology developers to choose the most appropriate and reliable components.
- All test facilities are closely linked to standards and certification.

b. Manufacturing

- The required infrastructure needs to be in place to meet UK and global demand.
- By 2012, the sector needs to be able to build 1 unit per week, ramping up to 4 per week by 2015 to meet the large volumes required for the 2020 goal.
- High volume manufacture requires design consensus of devices within individual companies.

c. Electrical Grid

- The sector needs to work with the utilities to ensure the grid infrastructure is in place for the best sites that will be exploited first to meet the 2020 target.
- The sector needs to work with the government, the regulator and planners to ensure that all potential barriers to development of the necessary grid infrastructure are overcome before large scale deployment in 2015.
- This theme should also consider both onshore and offshore grid issues.

d. Installation & Deployment

- Infrastructure is required to facilitate large volume deployments, so that the sector does not have to compete with other offshore sectors principally the oil & gas sector.

e. Operation & Maintenance

- O&M is closely linked to the infrastructure required for deployment.
- O&M procedures developed will be specific to particular devices.
- A failure database covering all aspects of the technology will be useful to inform future developers, and enable the supply chain to improve component reliability.

f. Supply chain

- The role of the supply chain needs to exceed that of basic component supplier to one of collaborating with developers to ensure that components are designed fit for purpose.
- Establish a supply chain network in order to transfer knowledge and experience between the two.
- A supply chain landscape analysis will provide the sector with knowledge of cluster locations, and potential weaknesses/gaps in the chain.

4. Environment & Community

a. Site & Resource Assessment

- Survey seabed conditions, grid infrastructure, shipping lanes, leisure usage for all the best sites most likely to be exploited first.
- Provide standardised resource data for all the best sites to be exploited first.
- Include this information in a GIS.
- Expand on the DTI wave and tidal current database.

b. Environmental Impact

- Exploitation of the marine resource requires a full understanding of the potential impact on marine life right through the food chain.
- The SEA should be extended to the whole of the British Isles (i.e. including Ireland).

c. Community Outreach

- The sector will work with all communities who may be affected by a high volume deployment of marine renewable energy devices.

- This will include marine leisure users, fishing industry, communities affected by electrical grid infrastructure expansions, and communities affected by the development of industrial infrastructure.

5. **Planning**
   - The sector needs to work with UK government, the Crown Estates and planners (both at sea and on land) to develop a standard planning procedure for all sites in UK waters.
   - The marine sector needs to learn from the experiences of the wind industry in both onshore and offshore developments.
6. **Standards**
   - Best practice guidelines will be developed initially to ensure that innovation is not stifled so that new devices with high potential can be exploited.
   - Standards will then evolve from the best practice guidelines once large volume deployment is underway in 2015.
   - Existing standards from other sectors, such as wind could be used as a starting point where relevant, such as in electrical infrastructure for example.
   - EMEC are involved in the development of marine standards and have published the following documents (http://www.emec.org.uk/emec_documents.asp):
     - Performance Assessment for Wave Energy Conversion Systems
     - EMEC Environmental Impact Assessment Guidance
   - EMEC are preparing other documentation in cooperation with the marine community.
7. **Market**
   - Non-large utility niche electricity markets, such as island generation, need to be assessed as a way of increasing deployment.
   - Markets other than electricity need to be assessed – such as the desalination market – thereby increasing deployment.
   - The sector needs to analyse the routes to market and hence identify potential barriers, which may require technical or policy based solutions.
8. **Policy**
   - The sector will work with policy groups to advise government bodies on the recommendations of the roadmap and how they can be used to inform policy on targets, planning, grid infrastructure and R&D funding for example.
   - The sector needs to either form a policy group or extend the BWEA Marine Group to lobby government on its behalf.

9. Finance

- The sector must work with funding bodies (private and public) and investors to provide continuous and the most appropriate funding mechanisms at relevant points on the RDD&D curve.
- Successful small and medium scale deployments will strengthen investor confidence for high volume deployment from 2015.

10. Knowledge Transfer

- Many of the solutions required to overcome technical and non-technical barriers will be obtained from other industrial sectors.
- Paths need to be established to ensure effective and timely movement of knowledge into the marine sector from other sectors in both the industrial and academic arenas.
- Knowledge transfer is closely linked with the supply chain.