Call format and process

ADDED 17.08.2023

Are we allowed to submit annexes alongside the pre-proposal? If so, any limitations on the number of files or the number of pages in each file? We understand all files should be in PDF and no links are allowed but just want to confirm how many supporting documents are expected from WES.

Separate annexes may be submitted for each question if the combined response (response form + annex) does not exceed the page limit for each question. The content of the response form will be considered first and any part of the accompanying annex which exceeds the total page limit will not be considered.

ADDED 16.08.2023

WES has been informed of an error in the return e-mail address specified in the response form. A new response form has been uploaded to the webpage here. Applicants should ensure that pre-proposal responses are sent to info@waveenergyscotland.co.uk by the deadline of 1200 (BST) on Friday 18th August.

ADDED 14.08.2023

Is the named individual/organisation at the initial application point required to be the Principal Investigator or, as teams are formed, can this be changed before consideration for award?

WES will consider changes between pre-proposal (Part A) and full-proposal (Part B) application stages.

How is the project funded? Is it a grant or subsidy, and therefore what is the claim mechanism for the project?

Proposals will state a required budget up to £50k, which will then be paid as a subsidy. Proposals should present a payment schedule against milestones in up to two instalments.

Is it possible for organisations to be involved in multiple bids?

An organisation can be involved in multiple bids but would need to be able to provide the required resource to all projects if they are successful.

Are you expecting bids from organisations who did not attend, or register for the brokerage event?

The process for pre-proposal is open to all eligible organisations and there could be bids from organisations who did not attend the event. Up to 15 full proposals will be invited by WES.

Is there a criterion for the number of DEG vs DFG designs to make it through to the full proposal stage?

There is no fixed minimum number of DEG (Dielectric Elastomer Generator) or DFG (Dielectric Fluid Generator) designs which need to progress through to the final proposal. Selections are based on merit, as presented in the call guidance document, regardless of the type of technology used.

Given that deliverables include concept designs, is the assessment of proposals based more on team strength?

Full proposals will be evaluated on the questions as presented in the response form. Understanding the challenge and opportunity, project methodology, team and delivery approach will be evaluated.

Objectives and strategy

How does WES strategy intend to use the outcomes of the selected projects?

The call guidance document explains the objectives of the projects and how these will help to develop and drive the WES strategy. The key outcomes that drive strategy will be a vision of a future concept, evaluation of benefits, challenges and feasibility, R&D requirements and the creation of teams to deliver further technology development.

To what extent has this call been influenced by existing projects - are they running in to barriers we should be aware of?

Experiences from existing projects, including the barriers they have identified, have been important factors in the design of this competition. An example is the selection of scope to focus on cell-based or segmented architectures to avoid the scale-up challenges of monolithic DEG architectures. Guidance towards environmental acceptability and compatibility of solutions with low-cost, mass-production processes are other examples, as is the requirement for concepts to be designed based on optimal exploitation of direct generation, electroactive technologies, rather than the retrofit into existing WEC archetypes which misses the real potential.

What is the IP approach?

Terms and Conditions and an example of the IP terms are in the call guidance document. As per previous WES calls, we want participants to exploit and own their own IP while WES maintains permissions to retain the IP in the future if it is not utilised by the participants.

Direct Generation Technologies and Concept Design approaches

ADDED 14.08.2023

Are piezoelectric technologies eligible?

Section 2.4 of the Call Guidance Document identifies Dielectric Elastomer Generators (DEG) and Dielectric Fluid Generators (DFG) as being the primary technologies of interest rather than Piezoelectric technologies which you mentioned during the telephone call. The link to the Call Guidance Document is provided here: https://www.waveenergyscotland.co.uk/media/1481/call-guidance-document_-concept-creation-competition_final.pdf .

ADDED 01.08.2023.

Is there a risk that WES will fund 5 projects which all create similar concepts, influenced by similar input from a small number of direct generation technology specialists? Would it be sensible to run a workshop for all interested parties before the projects so that a range of concepts could be taken forward?

WES carried out some concept design activity to provide inspiration and demonstrate the wide range of solutions that could be envisaged based on today's knowledge of direct generation technology. While an attractive approach, challenges with a group workshop would be the funding mechanism, management of IP preferences and fair selection of participants. An online brokerage

platform has been provided to maximise engagement and interaction of technology specialists to aid the delivery of high-quality, varied proposals and projects.

ADDED 01.08.2023.

A question about Part A. of the initial proposal, specifically the bullet point:

- **The device design, development, integration and demonstration challenges**

Is the answer to this question intended to convey our understanding of the challenges associated with:

1. **the design and developmental path of DEGs/DFGs in general?**
2. **taking any concept using DEGs/GFGs through the stages of the WES project finishing in Jan/Feb 2024?**
3. **taking our specific DEG or DFG concept through the stages of the WES project?**

If the answer is 3., should we be describing a physical device concept at this first stage and, in particular, whether we are intending to use DFG or DEG (or other direct generator)?

This bullet point relates to the applicant's *understanding of the challenges/opportunities* associated with the *design, development, integration and demonstration* of a direct generation wave energy converter device, during and beyond the present competition. Part of that includes the *challenges/opportunities* associated with the integration of the direct generation material, metamaterial or module into that wave energy converter device, but it is more broadly related to the complete technology development path of the wave energy converter as a whole.

Presentation of a specific wave energy converter device concept and selection of a specific type of direct generation technology (DEG or DFG) is not required at this stage - those are outcomes of the project itself. The questions in the full proposal focus on the intended process for *creation of a direct generation wave energy concept* design and the intended process for the *delivery of detailed analysis of the concept's feasibility, risk and benefit.*

How much detail is required on the design of the chosen DEG or DFG technology?

The objective of these projects is not to design direct generation technologies, rather to create wave energy converter concepts designed specifically to exploit the physical and functional characteristics of such technologies. This will require consideration of those characteristics and selection of the types of solution that could deliver those characteristics, but not the design of such.

What might the notional size of a cell be? What is the optimum cell structure?

The design space from small cell-based solutions, through larger segmented designs, up to large monolithic DEG architectures is an optimisation challenge to be solved. The key questions relate to complexity of the architecture, electrical connection of electrodes, control of individual or banks of cells, redundancy/survivability, impact of defects and manufacturability/scale-up. There is a strong interplay between the functional characteristics of the cell-based solution and the function operation of the device.

Are these design concepts based on the assumption that the material is available in the future?

Wave Energy Converter Concepts should be based upon a solid understanding of the functional characteristics of a feasible Direct Generation technology and then projects should define the areas

of R&D they believe are required to make those enabling technologies a reality. So, yes, but they should also support the WES strategy to make those materials available in the future.

Are DEG/DFG specialists required within the team?

A strong team would have access to suitable knowledge in these areas to help drive the concept creation using understanding of existing and potential functional characteristics. This could be achieved by including the skills in team or through associated positions such as advisory or guidance roles**.**

How is the Techno-economic analysis performed against existing devices? Is there a specific technology to be compared against for LCOE? Is WES providing the values for these?

WES will share a high-level LCOE tool, showing a typical cost breakdown of a conventional WEC. Projects should compare a simplified Direct Generation concept design against this including discussion and justification of the numbers being used.

Wave energy history is littered by Wave Energy Converter concepts - how do we prevent that happening again? How to address the longer term TRL when considering these early-stage concepts?

The objective of the project is to provide a vision for the future, demonstrate potential benefits and help drive the enabling R&D required to make it a reality. Projects will include evaluation of risks, feasibility and R&D requirements to allow a wider understanding of the potential and achievability of future direct generation WEC solutions.

Is there a possibility of hitting a developmental hurdle such as instability phenomena in the membrane material?

Such is an example of identifying a risk, R&D requirement and helping to drive future enabling R&D, with a balance of technical requirements with achievability, which is a key outcome of these projects.

Technical background

The brokerage event led to numerous questions about the in-scope direct generation technologies, Dielectric Elastomer Generators and Dielectric Fluid Generators. Below is a short list of scientific papers for potential participants looking to expand their knowledge:

- Collins, I., Hossain, M., Dettmer, W., & Masters, I. (2021). Flexible membrane structures for wave energy harvesting: A review of the developments, materials and computational modelling approaches. Renewable and Sustainable Energy Reviews, 151, p. 111478.
- Duranti, Mattia et al (2017). A new class of variable capacitance generators based on the dielectric fluid transducer. Smart Mater. Struct. 26 115014
- Moretti, G., Rosset, S., Vertechy, R., Anderson, I. and Fontana, M. (2020), A Review of Dielectric Elastomer Generator Systems. Adv. Intell. Syst., 2: 2000125.

Do you have an understanding for what the stretch ratio is during the wave energy application?

This is one of the challenges to be addressed. Hundreds of percent stretch can be applied, which can lead to major fatigue challenges. Existing WEC design is typically below 100%, however this call will allow for innovations above this value. Extreme deformation can lead to instability and material breakdown.

Do material defects influence the instability behaviour of a membrane material?

Yes, a defect could result in a premature instability due to localised material softening occurring in the location of the defect.

When do you apply the charge during the DEG cycle? Does the amount of charge applied influence the response of the device?

The charge can be applied at any point during the stretching phase; however, one should note that a greater amount of stretch will result in a larger capacitance change and therefore more energy harvested. The amount of charge applied does not directly influence the deformation of the membrane. However, it does influence the amount of mechanical energy which can be transferred to electrical energy. A DEG can only work within certain charge and stretch boundaries, otherwise you risk deleterious effects such as dielectric breakdown and electromechanical instabilities. Therefore, it is important to consider the optimum charge and stretch values in a DEG cycle.

Is there an estimate for cost per kilogram for these materials?

See academic literature – due to the potential to greatly simplify the architecture of a wave energy converter and avoidance of high-cost materials and mature technologies, direct generation concepts have the potential to be very cheap compared to traditional WECs that utilise steel, generators, power electronics etc.