

## Carnegie Achieves CETO Digital Development Pathway Commercial Target

### *Reducing timeframe to reach commercialisation*

- CETO commercial target achieved through cost and performance improvements
- Economic cost model independently reviewed by BDO Corporate Finance (WA) Pty Ltd
- Step change reduction in CETO cost of energy delivered
- Energy capture up 30% through new product innovations, including Carnegie's proprietary Wave Predictor and Intelligent Controllers
- EuropeWave PCP Programme to validate the improved CETO along defined pathway
- CETO addressable markets projected to expand as learning rates deliver cost reductions
- Achievements anticipated to unlock opportunities with new and existing strategic partners
- Carnegie to release Product Roadmap over coming weeks

### INTRODUCTION

Carnegie Clean Energy Limited (ASX Code: CCE) ("Carnegie" or the "Company") is pleased to advise that the [Digital Development Pathway](#) that commenced in 2019 has achieved its internal commercial target of reducing CETO's cost of energy to a level that puts it on the established industry trajectory. Reaching this target signals the completion of the Digital Development Pathway and escalation of commercialisation activities. The work undertaken has delivered a step change improvement in cost and performance which will place CETO in a strong position on the industry pathway to provide commercially attractive offerings to customers. The work conducted is expected to accelerate the uptake of CETO over the coming years by bringing the technology down the cost curve sooner, making it increasingly attractive to global markets. As the technology progresses along its commercialisation pathway, and as cost of energy decreases further, Carnegie envisages the addressable market for wave energy to expand, creating a growing adoption curve previously seen in the solar PV and offshore wind market expansions.

The current levelised cost of energy for wave power is estimated at USD \$0.30-0.60/kWh.<sup>1</sup> This figure is in line with historical solar PV and wind costs before early commercialisation, achieving economies of scale and innovation bringing costs down. Recent estimations by developers with active projects show that wave energy costs can be reduced to USD \$0.165/kWh by 2030.<sup>1</sup> Costs by 2030 could be even lower, depending on early commercialisation, deployment support and industry learning rates.

The Digital Development Pathway delivered several technical and commercial achievements, including a significant reduction in the range of CETO costs over the previous iteration, as illustrated in Figure 1. The effort and funds used to deliver the Digital Development Pathway enabled Carnegie to accomplish a substantial outcome that now propels CETO forward on its commercialisation pathway and reduces the time and funds required to reach increased revenue generation. This

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<sup>1</sup>IRENA, 'Innovation Outlook Ocean Energy Technologies', 2020 [https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Dec/IRENA\\_Innovation\\_Outlook\\_Ocean\\_Energy\\_2020.pdf](https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Dec/IRENA_Innovation_Outlook_Ocean_Energy_2020.pdf)

commercialisation pathway is comparable to the historical progression of solar PV and offshore wind, whose learning rates and cost reduction curves look similar to the trajectory in Figure 1.

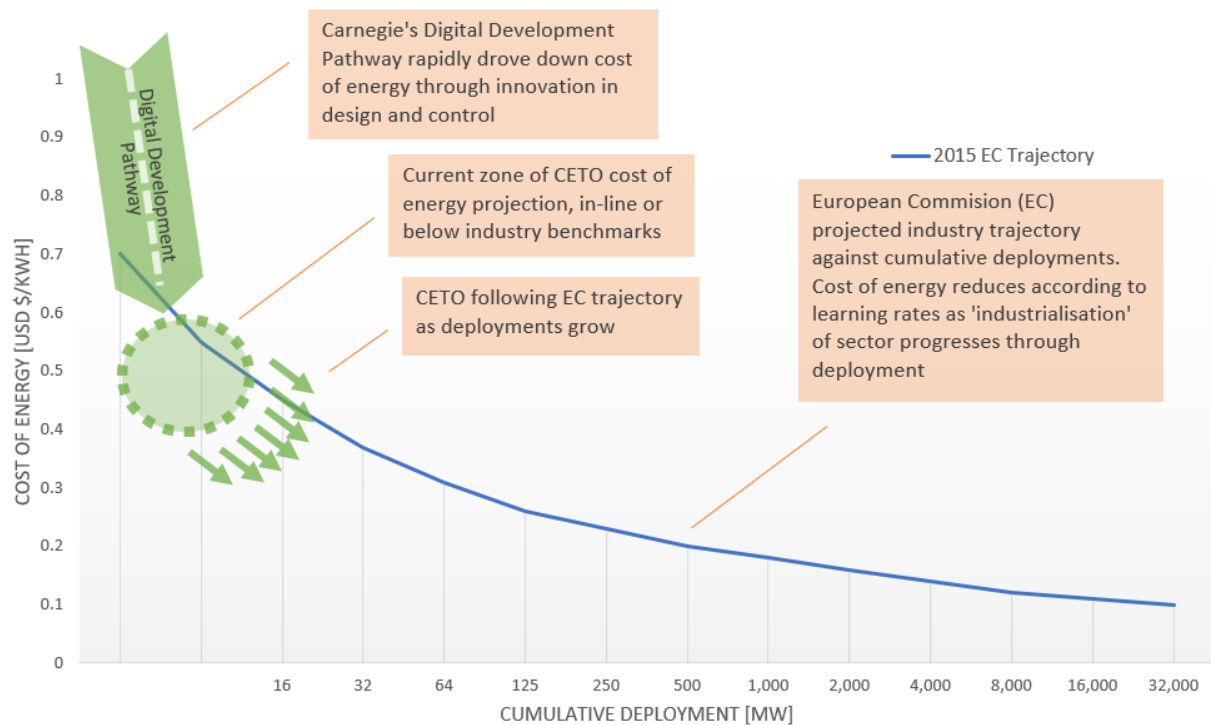


Figure 1- Cost of energy vs deployment relationship for wave industry (as per 2015 EC trajectory) and CETO (using outputs from models). This demonstrates the Digital Development Pathway delivered significant value by unlocking a path to greater commercial opportunities.

Carnegie utilised its in-house cost model to evaluate the impact of the Digital Development Pathway innovations and track progress towards its commercial target. The model draws upon a variety of sub models that simulate power capture and analyse CAPEX and OPEX together with uncertain but reasonable assumptions around learning rates, discount rates and the market support to drive growing deployment. Given the importance of this modelling, Carnegie engaged advisory services firm, BDO Corporate Finance (WA) Pty Ltd to provide a third-party review. The results of the modelling reinforce the business plan of the Company to further advance the CETO technology.

**Carnegie's CEO, Mr Jonathan Fiévez, commented:** "We are extremely pleased to have met our internal cost and performance target, delivering a step change reduction in the projected CETO cost of energy since the introduction of our Digital Development Pathway two years ago.

"In addition to capital cost reductions, the team at Carnegie has been able to deliver up to a 30% increase in simulated energy capture performance, alongside projected improvements in reliability and

*operational efficiency. Joining forces with industry partners such as HPE has been mutually beneficial and helped to deliver beyond our expectations.*

*“This achievement is a key milestone to showcase how wave energy can become a commercially competitive and widely adopted technology and follow a similar trajectory to other comparable marine renewables, such as offshore wind. As we continue to progress on our commercialisation pathway, and now with multiple complementary product offerings in MoorPower and Wave Predictor, our addressable market will progressively expand to make wave energy attractive in an increasing number of global markets. We are also aware that providing a commercially attractive CETO offering is not just about cost but is also driven by the growing recognition of the additional value and services provided by wave energy.*

*“The improvements made in CETO’s performance are reflected in our success in entering the EuropeWave PCP Programme which aligns with our plans to validate the technology and its commercial viability.”*

## **DIGITAL DEVELOPMENT PATHWAY ACHIEVEMENTS**

Over the past 2 years, Carnegie has been laser focused on driving key cost centres down and making design choices to achieve commercial competitiveness. The combination of system optimisation, incorporation of industrially proven components and leveraging advances in Artificial Intelligence (AI) to deliver intelligent control have been instrumental in these improvements.

To realise substantial performance improvements, Carnegie has applied advances in control theory and AI that optimise power generation in a broad array of sea states to dramatically increase the amount of energy extracted from each wave. The Company’s suite of proprietary software and codes has grown considerably in the past 18 months to include a machine learning based Wave Predictor technology and a variety of controllers based on model predictive control and reinforcement learning. These tools have delivered up to a 30% rise in energy capture performance over previous iterations. Additionally, the new controllers are providing low cost or no cost solutions to extreme wave scenarios by ensuring smart responses that avoid damaging forces, typically a major cost driver for wave energy converters. Carnegie’s partnerships in this space with leaders such as Hewlett Packard Enterprise (HPE), Pawsey Supercomputing Centre and the University of Adelaide are delivering significant gains while also being very economical and mutually beneficial.

Step-change reductions in cost have been achieved through the adoption of a direct electrical conversion architecture for the power take-off (PTO) which also avoids conversion losses seen in previous hydraulic designs. The number of components or ‘part count’ is reduced, contributing to lower costs and higher reliability. The electrical hardware is also similar to what is used in electric vehicles and industrial process electrification and therefore benefits from the existing economies of scale and growing supply chain competition. This is also the case for other components such as foundations, mooring connectors and dynamic cables. Other ocean technologies such as offshore wind, tidal energy and those supporting oil and gas developments are driving innovation and cost reduction for these common components and services.

Lastly, the operation and maintenance methodologies have been tuned to minimise cost and maximise speed to return the system to full capacity. The philosophy behind the design has been built on Carnegie's unique experience in the sector of deploying, operating and maintaining an array of devices in the open ocean. This includes a design for operations perspective which is considered in all design decisions and optimisations.

### **INDEPENDENT THIRD-PARTY REVIEW**

Carnegie's economic modelling of its CETO technology, as part of the Digital Development Pathway, has been subjected to an independent review by Advisory Services firm, BDO Corporate Finance (WA) Pty Ltd.

BDO has considered the mathematical integrity of the model and the logic of the calculations, and as a result of the work conducted nothing came to BDO's attention which would lead them to believe the model was materially incorrect. BDO has not undertaken procedures on the underlying data sources obtained by the Company that support the model or the sub models that calculate inputs into the economic model.

The results of the economic modelling reinforce Carnegie's business plan in further advancing the CETO technology and demonstrate the value delivered by the Digital Development Pathway.

### **RECENT INDUSTRY TRENDS DEMONSTRATE A ROBUST PATHWAY AND GROWING SUPPORT**

Carnegie's team have determined that the CETO wave energy technology is poised for commercialisation following the example of offshore wind, solar and other emerging technologies. Over the last 20 years, the investment in wave energy technologies has increased markedly but still sits well behind other forms of renewables at comparable stages of development. With recent industry trends this looks set to change.

Advancing from a few small projects in the early days, offshore wind today is experiencing exponential uptake around the world, with 6 GW installed each year in recent years, to reach a total of more than 35 GW today (see Figure 2)<sup>2</sup>.

The state of Victoria also recently announced the plan to accelerate the rollout of offshore wind energy generation projects in the state, setting rolling targets of 2GW installed by 2030, 4GW by 2035, and 9GW by 2040. The state has legislated a target for a 50% renewable energy powered electricity grid by 2030 and is the first state in Australia to have an offshore wind project proposed off its coast. Studies have shown Victoria has the potential to support 13GW of capacity from coastal regions by 2050 – five times the state's current renewable energy generation<sup>3</sup>.

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<sup>2</sup> GWEC (Global Wind Energy Council), 'Global Offshore Wind Report 2021', <https://gwec.net/wp-content/uploads/2021/09/GWEC-offshore-wind-2021-updated-1.pdf>

<sup>3</sup> Renew Economy 'Victoria sets "game changing" offshore wind target of 9GW to replace coal', March 2022

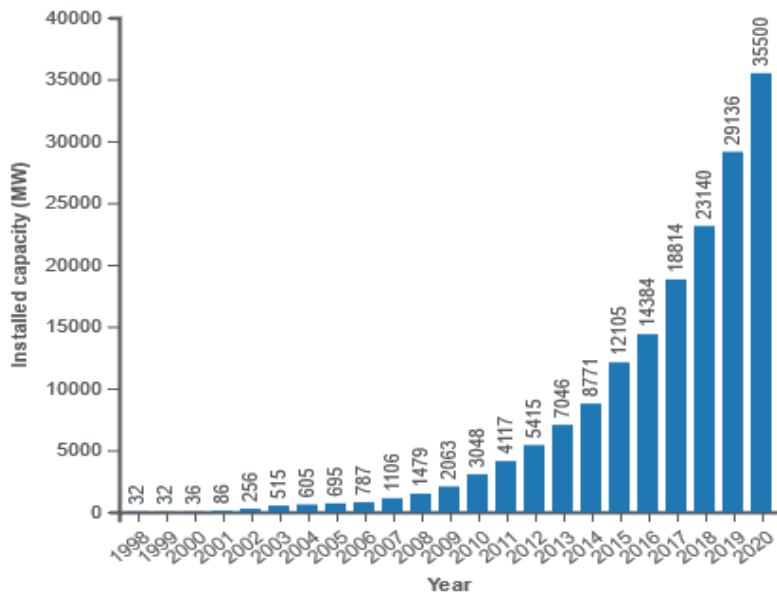


Figure 2 –Global cumulative offshore wind capacity (MW)

Sources: [GWEC](#) (2011–2020) and [EWEA](#) (1998–2010)

The wave energy industry is expected to follow a similar commercial pathway as offshore wind as the world strives to decarbonise the global energy system which is currently only 5.7% renewable.<sup>4</sup>

Europe is leading the way to catalyse the wave energy opportunity with growing sector targets and corresponding investments. Over the coming years, Carnegie expects that there will be a resurgence in targeted support for the ocean energy industry. The recent £20m ringfenced funding for tidal energy in the UK’s contract for difference scheme (AR4) is an indication of this rising support and enthusiasm for the future of ocean energy. The EuropeWave PCP Programme is another example of funding targeted at accelerating emerging technologies such as CETO and other marine renewables to advance to commercialisation.

## OUTLOOK

The CETO technology, currently being progressed via Phase 1 of the competitive EuropeWave PCP Programme, benefits greatly from the step change design and cost improvements delivered under the Digital Development Pathway and recent design efforts. The improved CETO technology will be validated with a tank testing campaign undertaken in Spain in June 2022 as part of Phase 1. If successful in being selected for future phases of the EuropeWave PCP competition, this will lead to the deployment of a CETO prototype in Europe. This next CETO prototype will enable real world validation of the significant improvements delivered by the Digital Development Pathway and demonstrate to strategic partners that the technology is ready for its next major strides down the commercialisation pathway.

<sup>4</sup> BP Statistical Review of World Energy, 2021

Carnegie will continue to advance its full suite of products over the coming years, including MoorPower and Wave Predictor, whilst seeking to establish long term commercial partnerships. There are many common elements to these technologies and simultaneous development will be mutually beneficial.

In the coming weeks, the team will be releasing a new Product Roadmap outlining the product targets and milestones to be progressed over the next 18-24 months. The EuropeWave PCP program and the MoorPower project will form the basis of Carnegie's roadmap. The Company's future plans have been developed with the goals of validating our technologies, building strategic partnerships and bringing forward revenue streams from our products.

This announcement has been authorised by the Chairman and CEO.

**For more information**

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## ABOUT CARNEGIE

Carnegie Clean Energy (ASX: CCE) is a technology developer focused on delivering ocean energy technologies to make the world more sustainable. CETO Wave Energy Ireland is a wholly owned subsidiary of Carnegie Clean Energy. Carnegie is the owner and developer of the CETO® and MoorPower™ technologies, which capture energy from ocean waves and convert it into electricity. Using the latest advances in artificial intelligence and electric machines, Carnegie can optimally control our technologies and generate electricity in the most efficient way possible. The Wave Predictor technology developed by Carnegie uses a proprietary machine learning algorithm to improve the performance of our wave technologies and has additional applications beyond the wave energy industry. The company has a long history in ocean energy with a track record of world leading developments.

<https://www.carnegiece.com/>

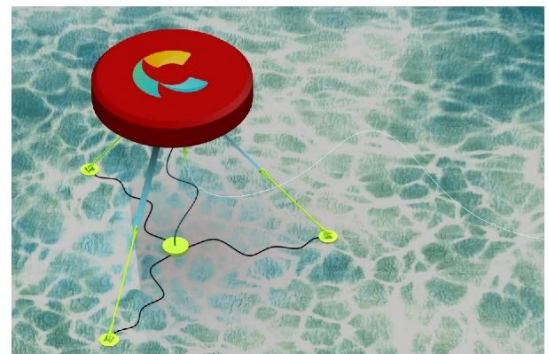
## ABOUT EUROPEWAVE PCP

With almost €20 million in funding for the 3 phases of the programme, which runs from 2022 to 2026, the EuropeWave PCP is a collaboration between Wave Energy Scotland (WES), a subsidiary of the Scottish Government's Highlands and Islands Enterprise, and the Basque Energy Agency (EVE).



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<https://www.europewave.eu/>



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