

### **BOARD OF DIRECTORS & CEO**

Non-Exec Chairman - Terry Stinson Non-Exec Director - Grant Mooney Non-Exec Director - Michael Fitzpatrick Non-Exec Director - Anthony Shields Chief Exec Officer - Jonathan Fievez

#### CONTACT DETAILS

www.carnegiece.com enquiries@carnegiece.com

21 North Mole Drive North Fremantle WA 6159 +61 8 6168 8400

PO Box 39 North Fremantle WA 6159

### **QUARTER HIGHLIGHTS**

- Achieved first two CETO Digital Development Pathway milestones
- Developed Wave Predictor capable of accurately predicting waves 30 seconds into the future
- Completed generator market study for new electric power take-off (PTO)
- Funding awarded to CREATE Project in which Carnegie is a participant

Over the quarter, the Carnegie team maintained its focus on CETO development, achieving the first two milestones on the Digital Development Pathway and advancing its collaborative research projects, whilst also continuing to operate its Garden Island Microgrid asset.



# CETO DEVELOPMENT

During the quarter, Carnegie achieved the first milestones of the CETO Digital Development Pathway:

- Developed the machine learning based Wave Predictor capable of predicting the characteristics of waves that will reach the CETO Unit up to 30 seconds in the future. This is the first product in Carnegie's suite of intelligent control products which will be capable of increasing the energy captured by a CETO Unit and also has potential as a standalone commercial product.
- Completed a comprehensive landscaping and market study on potential generator technologies and suppliers further enabling the development of CETO's new, fully electric PTO. The PTO converts the wave-driven motion of the CETO buoy directly into electricity without the intermediate hydraulic step that was present in previous designs.

The first milestone on Carnegie's CETO Digital Development Pathway, as outlined to shareholders in Carnegie's July 2019 Prospectus, is complete. The plan aims to optimise the design of the CETO technology to significantly improve performance and reduce cost via the development and integration of several innovations.



Carnegie's Digital Development Pathway – First Milestones Completed



## Achieving Intelligent Wave Energy Control: Wave Predictor Development

One of the key innovations in the Digital Development Pathway targets the development of an intelligent wave energy controller that makes use of machine learning, a form of artificial intelligence, to increase the amount of energy captured from the waves and thereby increase the over-all electric power yield of a CETO Unit. The Wave Predictor enhances the potential commercial viability of CETO and further enables the development of Carnegie's new intelligent controller, the Wave Controller.

The data analysis team has now successfully delivered a Wave Predictor which achieves excellent accuracy, with wave height prediction errors averaging around 4% and no greater than 7% of the significant wave height, and orbital velocity prediction errors averaging around 3% and no greater than 6%. Carnegie's Wave Predictor has been validated and tested on numerical data, in sea states ranging up to 5 m.



Carnegie's wave predictor results showing close correlation of the surface height elevation prediction 30 seconds ahead ('forecast (30 s)') to the actual data ('test set')

Digitally validating the Wave Predictor marks the achievement of Carnegie's first key milestone in the plan and enhances Carnegie's suite of intelligent control products which enable the CETO technology to respond to wave conditions in a manner that optimises power production. The Carnegie Wave Predictor innovation will further contribute to achieving CETO's commercial viability in renewable energy markets.

Carnegie is also exploring the Wave Predictor's potential technical and commercial applications in the marine industry. Offshore operations such as crew transfer, refuelling,



vessel manoeuvring and others, may be made safer and more efficient using Carnegie's Wave Predictor.

The next step is to empirically validate Carnegie's Wave Predictor using physical wave data. To this end, Carnegie had planned to undertake the tank testing validation at a wave tank in Spain early May 2020. Unfortunately, this will now be delayed due to the COVID-19 pandemic. Carnegie is working to minimise the impact of this delay and continues progressing with other aspects of the intelligent control work. The impact to the overall plan is difficult to predict at this time due to the uncertainty relating to COVID-19. Carnegie will provide regular updates to ensure that shareholders and stakeholders are fully informed.

# Innovating a fully electric Power Take Off (PTO): Electrical Generator Development

Carnegie has canvassed the latest electrical drive technology from around the world and widely engaged with potential generator suppliers from a number of industries including, wind power, machine tools and various Electric Vehicle (EV) platforms including marine, trucks and automobiles. The engagement with several leading suppliers in the EV market shows promise and may provide Carnegie with the opportunity to leverage significant volume/cost benefits that can be realised from the increasing EV uptake worldwide. Carnegie has consolidated information gathered from various markets and potential suppliers into a comprehensive electrical generator product landscaping and market study. The applications vary in size and power providing Carnegie with the opportunity to scale the PTO to support different sizes of CETO device and identify the best size/power/cost configurations. Adopting existing electrical generator products and technologies is part of Carnegie's roadmap to compete with existing energy sources and achieve commercial success.

The exact generator selected will depend on the outcome of the scale study currently ongoing as part of the CETO Architecture deliverable due by the end of Q3 2020. However, it is likely that Direct-Drive Permanent Magnet Generator (DD-PMG) technology will be preferred. This technology is heavily utilised in the wind industry and has found particular application for in-wheel motors in the EV market. Furthermore, a strong and competitive supply base exists serving the marine propulsion, machine tool and industrial market, where Carnegie can potentially leverage volume and cost benefits from existing markets. DD-PMGs generally lend themselves to high torque, low speed applications, aligned with operation of most wave energy converters. The generator technologies and products identified can be designed and built to be highly energy efficient across a broad operational range that can be complimentary to the motion created by waves. Carnegie has developed strong parametric cost models for this technology, allowing exploration of the optimal CETO scale in relation to required generator size.

More broadly, within the PTO innovation stream, development work continues on other subsystems such as the translation and tensioning systems which convert the buoy motion from linear to rotary and maintain mooring tension respectively. Carnegie has engaged with a number of parties for development of the translation system and continues to explore



possibilities for jointly funded developments in this area. Furthermore, tensioner work has continued utilising local engineering expertise. This work has advanced the design level of the tensioner, with an expected design program throughout 2020 into testing in 2021.

## **CETO Collaborations**

During the quarter, Carnegie continued to progress its external research collaborations which feed into the CETO technical and commercial development, including via direct collaborations with suppliers and academic research partners; funded research projects; and industry associations such as the Australian Ocean Energy Group (AOEG).

Another Project in which Carnegie is participating to develop non-core technologies was recently awarded grant funding. Wave Energy Scotland (WES) awarded funding to Arup's CREATE Project, a project exploring the potential for the use of reinforced concrete to reduce the cost of wave energy converters. This Project utilises Carnegie's CETO device as a case study and Carnegie is a paid participant.

This is the second project in which Carnegie is participating that has been awarded funding by WES recently. At the end of the previous quarter, WES awarded funding to Subsea Riser Product's (SRP) Rocksteady WEC Mooring and Electrical Connection Project which aims to demonstrate the feasibility of a variant of one of Subsea Riser Products' connector for wave energy converters. SRP previously supplied connectors for the CETO 5 array.

In parallel to the significant progress made by Carnegie on the core technology development such as the Wave Predictor and PTO as outlined above, Carnegie continues to advance the non-core subsystems of the CETO unit via a suite of strong collaborations. The advances on the PTO, a core component, are important as this is the most critical of the CETO subsystems and demands a high level of Carnegie resources. However, the team is not losing sight of the need to continue progressing the broader CETO system; as such, existing and new collaborations on non-core subsystems also play an important role in Carnegie's future commercial success.

The company has learned from the past and evolved. The current Digital Development Pathway focuses on Carnegie's technological strengths and aims to maximise return on the funds that shareholders invested to breathe new life back into Carnegie. The Pathway also aims to minimise future calls for capital by shifting the business model towards developing and licensing a product for customers and working with those customers and partners to leverage their investment in larger scale deployments to deliver CETO to the market. Carnegie believes this model will generate future return for shareholders, stakeholders, customers and partners.

## GARDEN ISLAND MICROGRID

The Garden Island Microgrid continued operations over the quarter, selling renewable solar energy to the Department of Defence (Defence). The base-wide electrical system upgrade on Garden Island is still underway and in the final phases of work. During this quarter, Defence's upgrade works have caused some disruptions to the operations of the Garden Island Microgrid causing reduced production.

In the next, final phase of Defence's upgrades, the Garden Island Microgrid will have increased downtime as new connection works are undertaken. Carnegie continues working with Defence and its contractors to minimise disruption to the system. Once completed, Defence's upgraded electrical system will be able to support more streamlined operations of the Garden Island Microgrid.





# CORPORATE ACTIVITIES

Security Transfer Australia, Carnegie's provider for share registry services, was acquired by Automic Group who took over provision of services effective 20 January 2020. An announcement to this effect was issued on the same day. Shareholders wanting to make enquiries regarding their shareholding should contact Automic:

1300 288 664 (within Australia) +61 (0) 2 9698 5414 (International) www.automicgroup.com.au

During the quarter, the Carnegie team adapted to the changes and restrictions required by COVID-19 and continues to diligently progress the CETO digital development pathway. It is fortunate that due to our new digital development approach, internal activities are largely unaffected by the need to self-isolate. However, parts of the development work are being impacted due to limitations with communications and travel including the wave tank testing (which was due to be undertaken in Spain) and recruitment of personnel with unique technical skills required to advance the technology.

Carnegie has adapted to the new environment and is working to minimise any potential delays to the delivery of the digital development pathway. As the development road map milestones and activities are impacted, rescheduled and/or adjusted, Carnegie will provide an update to Shareholders.

At the end of the Quarter, the Company had approximately \$4 million in cash reserves.

### Note 6 to Appendix 4C:

Payments to related parties of the entity and their associates were made during the quarter. In total, approximately \$57,000 was paid to Directors and associates for salaries, superannuation and contracted services.