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Advanced ocean wave energy harvesting: current progress and future trends

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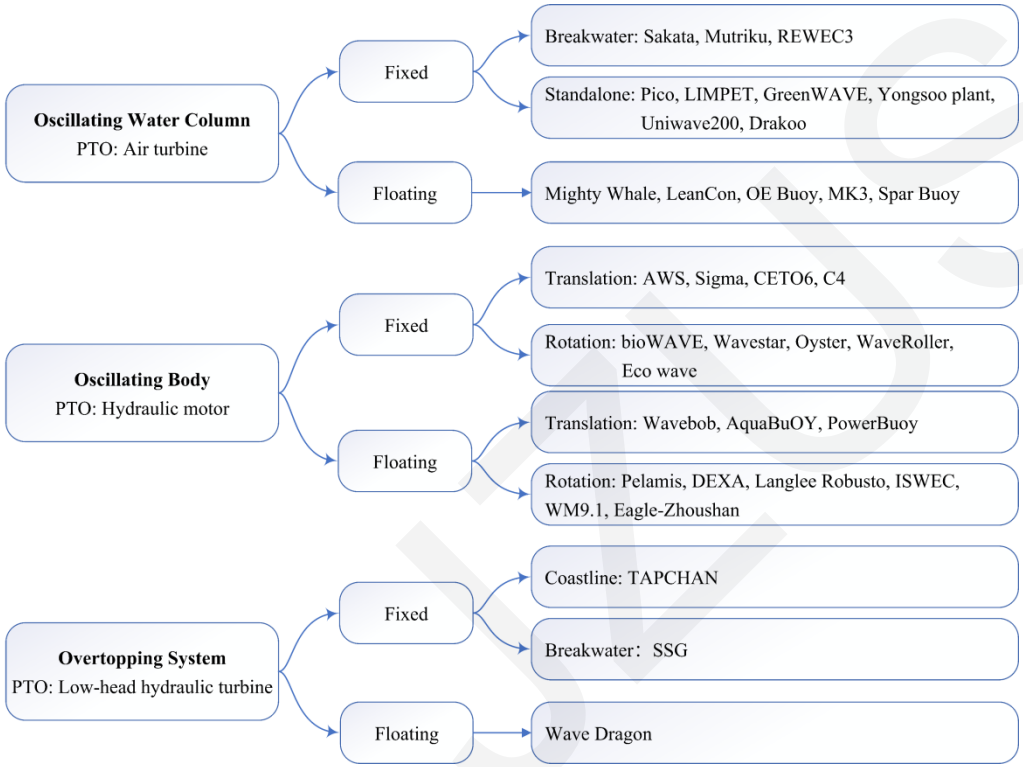
Traditional WECs

- There is a wide variety of WEC concepts, with highly individual manufacturing, transportation installation, and operation costs.



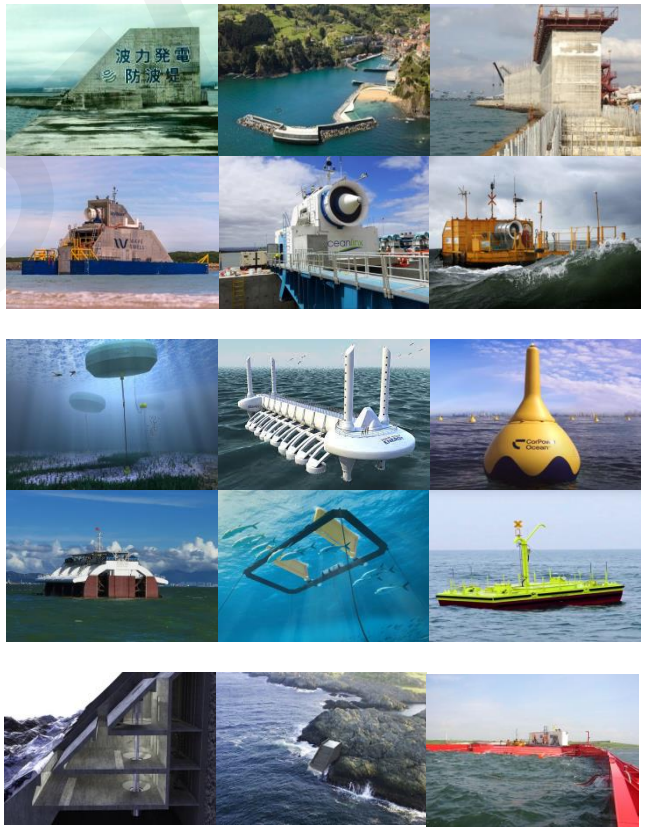


Fig. 1. Classification of WECs. Reprinted from (Falcão, 2010), Copyright 2010, with permission from Elsevier

Traditional WECs

- **A comprehensive evaluation of the performance of various existing WECs will help significantly in converging on a predominant model for WECs and focus further in-depth research**

Capture width ratio | Environment effects | Local adaptation | Control strategies | ~~~

Table. 1. Mean capture width ratio (CWR) and main issues for each type of WEC

Type of WEC	PTO	CWR	Main Issues	
Oscillating water column	Air turbine	29%	Multiple chambers; air compression; efficiency of air turbine	Integration; array layout optimization; mooring system; control strategy local adaptation; environmental implications
Oscillating body	Hydraulic motor	16% (translation); 37% (rotation)	Reliability; multiple degrees of freedom	
Overtopping system	Low-head hydraulic turbine	17%	Design of sloping access and reservoir; parameter optimization of outlet pipe and PTO	

Advanced ocean wave energy harvesting

Application paradigms of AI in OWEH

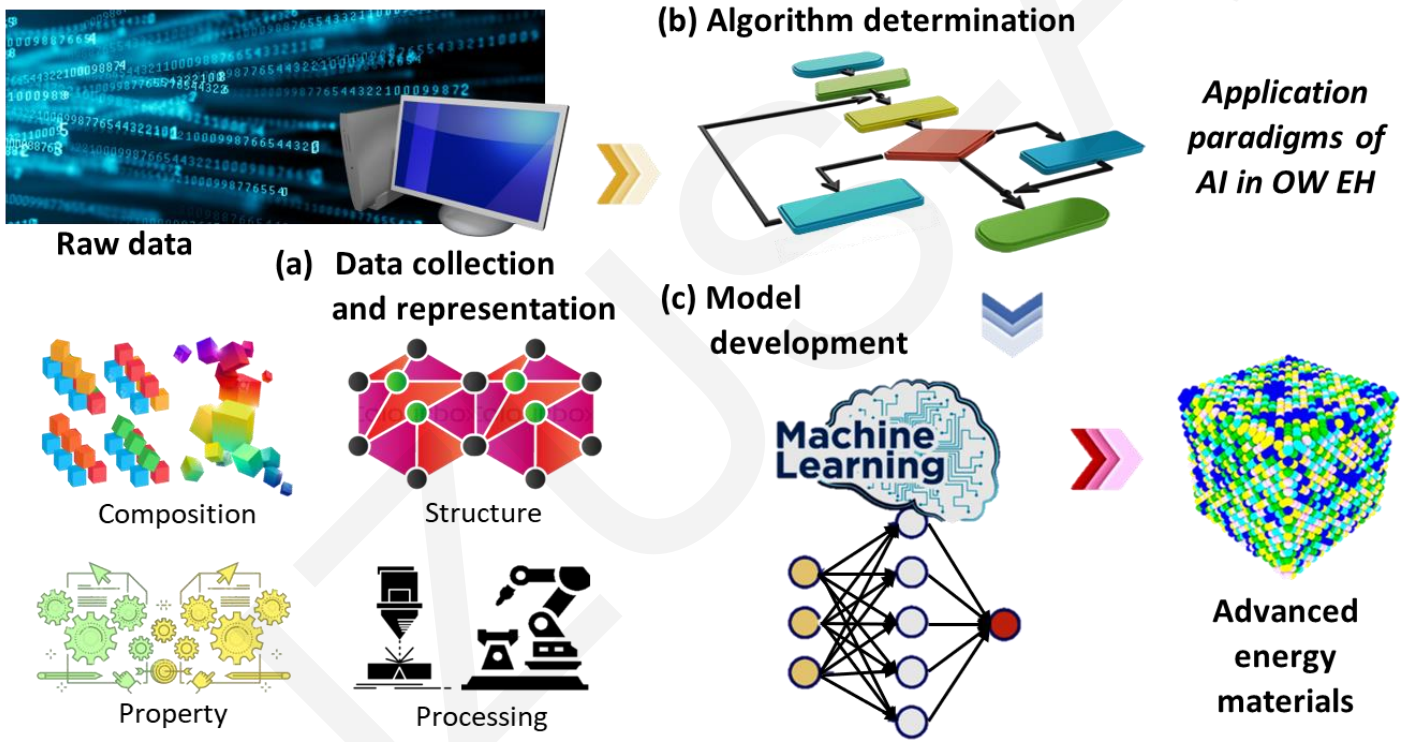


Fig. 5. Application paradigms of AI in advanced energy materials: (a) data collection and representation; (b) algorithm de-termination; (c) model development. OWEH: ocean wave energy

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■Data-driven design and optimization of energy devices

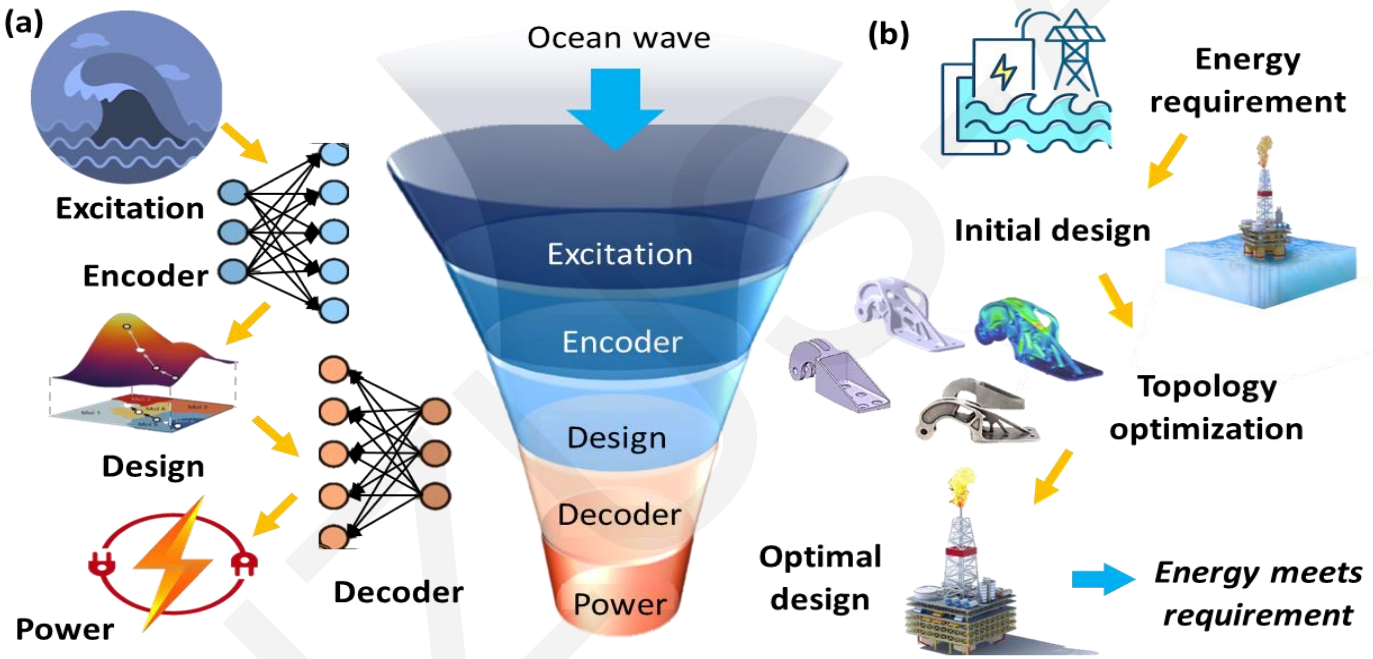

Fig. 6. Data-driven design and optimization of energy devices: (a) structural design to assist in efficiently triggering energy materials in response to ocean waves; (b) illustration of AI-enabled inverse design of energy devices in ocean wave energy harvesting

Advanced ocean wave energy harvesting

■Data-driven integrated ocean wave energy harvesting systems

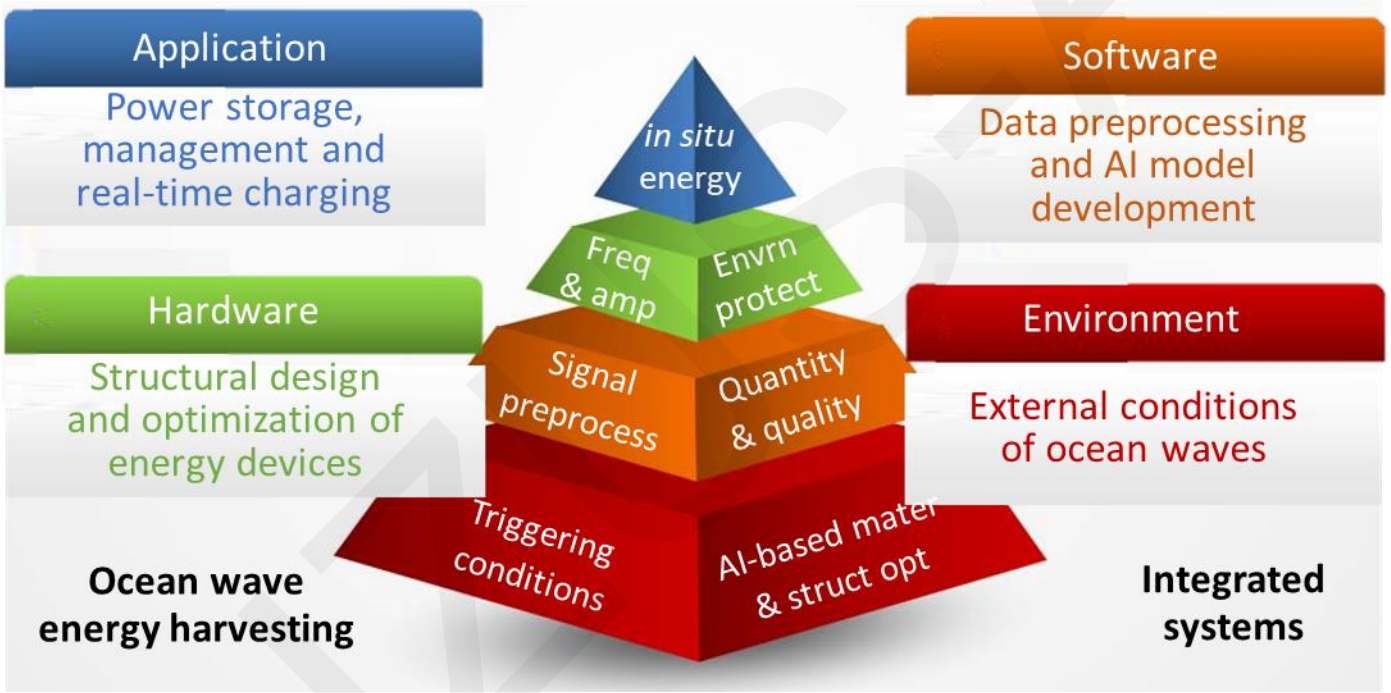

Fig. 7. Data-driven integrated ocean wave energy harvesting systems: (a) environmental, software, hardware and application layers; (b) extended functions in energy platforms and networks. Note: freq: frequency; amp: amplitude; envrn: environment

Advanced ocean wave energy harvesting

■Vision for OWEH in the fields of ocean engineering and ocean technology in intelligent ocean

Fig. 8. Vision for ocean wave energy harvesting in intelligent ocean, including the applications of self-powering ocean structural health monitoring systems in the field of ocean engineering and the applications of maintaining the functionality of various marine equipment and devices in the field of ocean technology.

Conclusions

- A comprehensive evaluation of the performance of various existing WECs will help significantly in converging on a predominant model for WECs and focus further in-depth research.
- It must be acknowledged that traditional wave energy harvesting is not yet fully mature and needs a breakthrough that would enable it to handle the essential characteristics of sea conditions.
- Advanced materials and technologies (e.g., data-driven structural optimization and multifunctional energy materials) provide potential solutions for the future development of ocean wave energy harvesting .
- Ocean wave energy harvesting is envisioned for the applications in intelligent ocean from the perspectives of ocean engineering and ocean technology.