Cost Modeling of Marine Energy Converters (MEC)

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Background

- The demand of renewable energy production has risen drastically, and Marine Energy Converters are being highly consider for power generation to support costal and blue economies.
- Marine Energy can vary in geographic location and their physical properties change with the different hydrokinetic energies they encounter.
- By collecting data and reviewing experimental results the key cost driving factors can construct an in-depth cost analysis of Marine Energy Conversion Systems.
- The main Reference Models being looked at include Tidal Energy Converter and River Current Turbine.

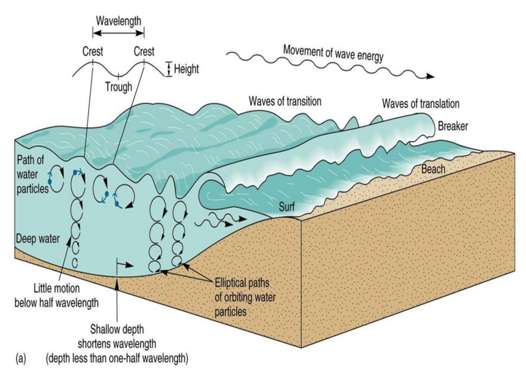

Figure 1. Physical Properties of wave and deep-water currents

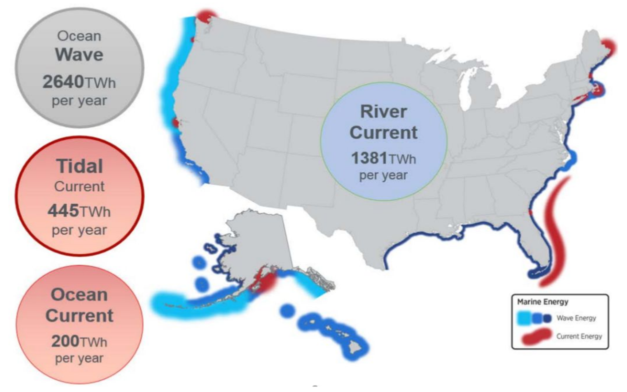

Figure 2. Expected Marine and River Energy Potential in U.S.A

Understanding the Design

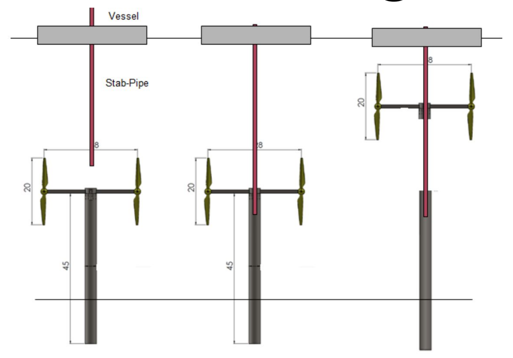

Figure 3. Structural Design of Variable-Speed Variable-Pitch Axial-Flow Tidal Turbine

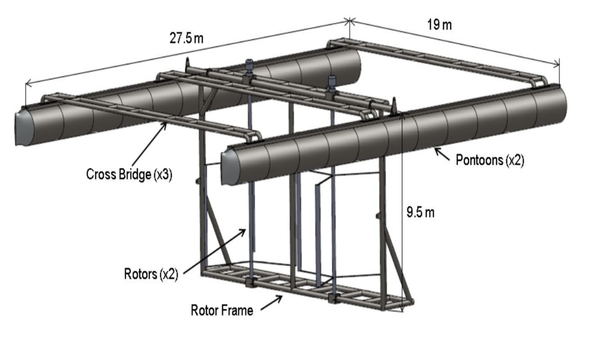

Figure 4. Structural Design of Variable-Speed Dual-Rotor Cross-Flow River Turbine

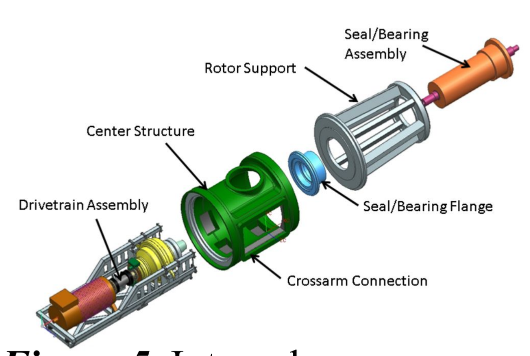

Figure 5. Internal Components of Nacelle

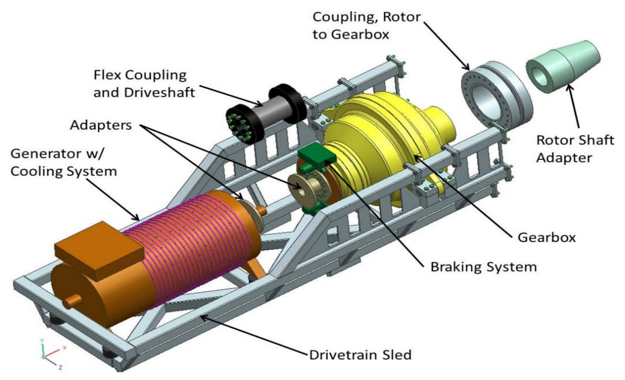

Figure 6. Power Conversion Chain Key Cost Driver of Nacelle

Results

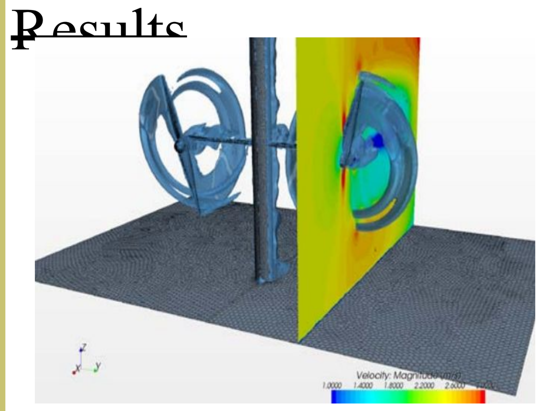

Figure 7. Fixed Point Tidal Turbine Configuration

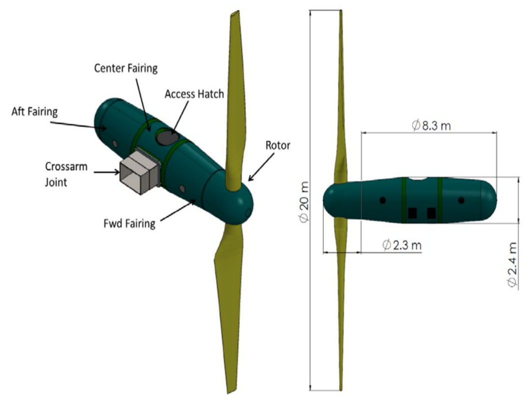

Figure 8. Design of Tidal Turbine Nacelle

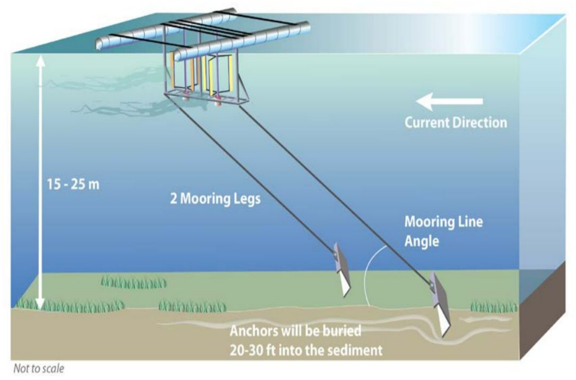

Figure 9 River Current Turbine Mooring Configuration

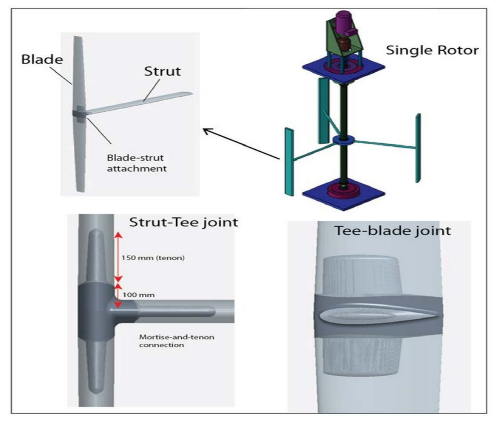

Figure 10. Blade-strut Design of River Current Turbine

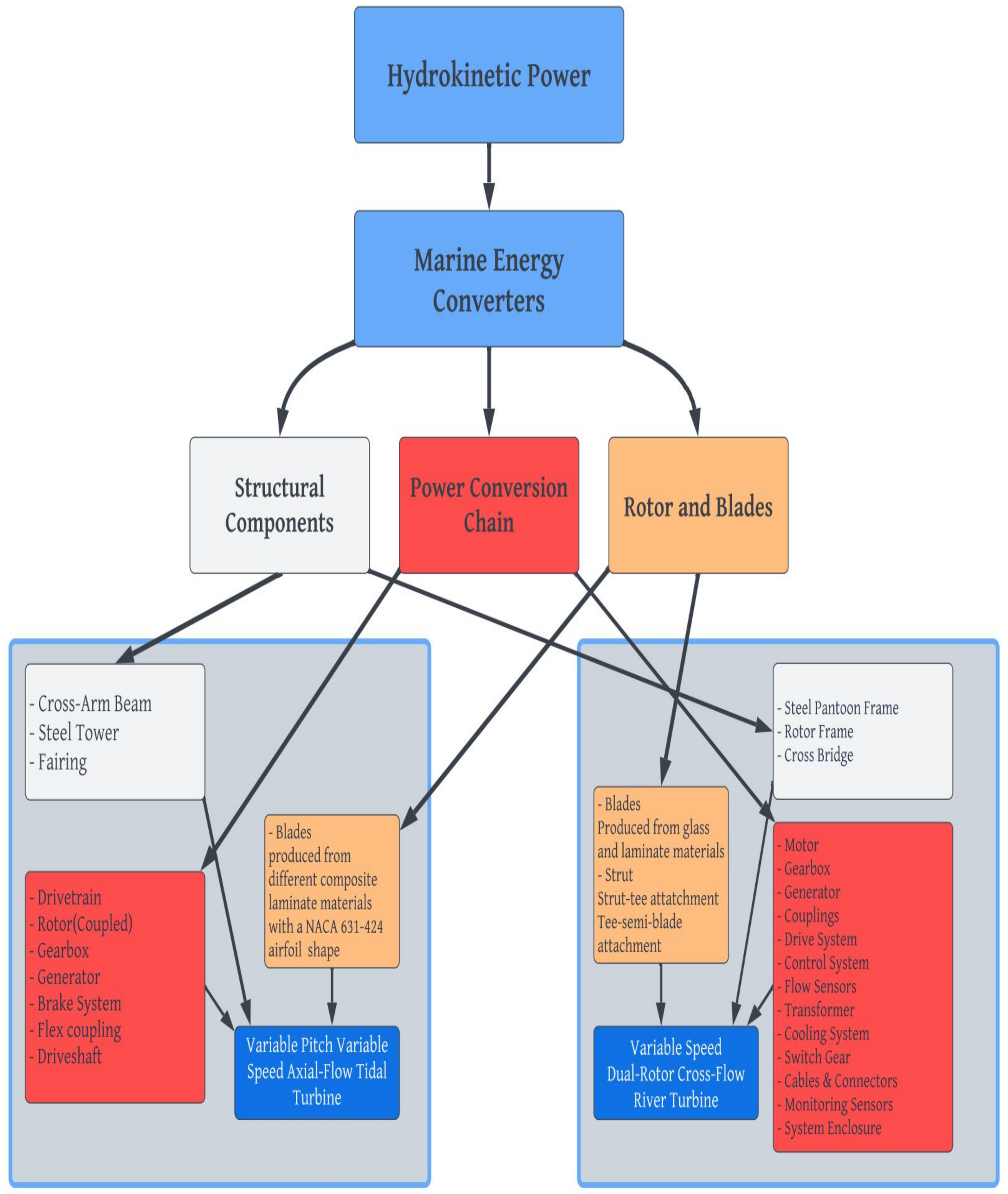

Figure 11. Modeling of Key Driving Costs Structural Components and Power Conversion Chain

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Structure of Nacelle Cost($/kW): $792960.000000

Fairing Cost($/kW): $51600.000000

Powertrain System Cost($/kW): $251000.000000

Rotor Cost($/kW): $144170.961642

Support Sructure Cost($/kW): $1760640.000000

Operations and Maintenance Expenditure Cost($/kW): $725000.000000

Environmental Capital Expenditures($/kW): $1450000.000000

Installation Cost($/kW): $8627585.000000

Post Installation Monitoring Cost($/kW): $12500.000000

Total CapEx Cost($/kW): 13077955.961642

Total MEC Cost($/kW): $13815455.961642

Levelized Cost of Energy(cents/kW): 241.666667
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Figure 12. Code Output for Tidal Turbine Cost Model

How do you plan to apply what you have learned?

There is potential for renewable energy technologies to satisfy a large portion of the energy demand. Marine energy converters are a good way to satisfy that demand. But to make MEC accessible, the associated cost of energy(ACOE) must be reduced. Finding solutions to reduce the ACOE can be formulated through the cost models of the system bringing insight into the key cost drivers. Knowing the driving forces of the system allows for the reduction of ACOE while maintaining the performance of the MEC.

Discussion/Next Steps

- **Code Refinement**
  - Reference model's specification may change due to new technologies and research findings, meaning the code will need to be able to scale each key driving cost appropriately.
- **Data Analysis**
  - Analyzing data and formulating new methods to decrease the ACOE and LCOE of Marine Energy Resources.
  - Understanding the data and research will allow the appropriate placement of Marine Energy Converters, optimizing their Annual Energy Production and life spans.
- **Array Design Formulation**
  - The most cost-effective option for manufacturing will be making array configurations of MECs and capturing the energy of 100 or more converters at once.

Conclusions

The resource potential of MECs in the United States is estimated to total more than 66% of its annual generated electricity. Capturing this energy could cut carbon emissions and allow for more independent energy production practices across the world. To help understand the costs of MECs, the Key Cost Driving Factors must be identified. The factors of the MECs referenced include Structural Components shown in Figure 3 and Figure 4 and the Power Conversion Chain is shown in Figure 6. Scaling the system's Key Cost Driving Factors is crucial to mitigating erroneous and costly MEC designs. The future of MECs will depend on improving and developing the KCDFs and finding new technologies and materials to reduce the LCOE.

What benefits did you get from your SURE experience?

The SURE research program allowed me to be immersed with hard-working individuals who were passionate about their jobs and engineering. I was not sure what to expect when starting the SURE program but with the great leadership of Dr. Herber and Athul I had a clear understanding of my responsibilities and goals for the research. I was lucky enough to have worked at the Powerhouse Energy Institute and got to see all the groundbreaking research being done there. The work being done within the Powerhouse and at CSU is inspirational for aspiring engineers. It is possible to change the world and this experience has shown me there is a diverse group of people at CSU ready to team up and find solutions to new problems. I want to thank the Scott Undergraduate Research Experience and Susan Benzel for this opportunity.

References & Acknowledgements

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[2] Segura, Eva, Rafael Morales, and José A. Somolinos. "Cost assessment methodology and economic viability of tidal energy projects." *Energies* 10.11 (2017): 1806.

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[4]Bir, Gunjit S., Michael J. Lawson, and Ye Li. "Structural design of a horizontal-axis tidal current turbine composite blade." *International Conference on Offshore Mechanics and Arctic Engineering*. Vol. 44373. 2011.

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