Modelling and Design of an Oscillating Wave Energy Converter

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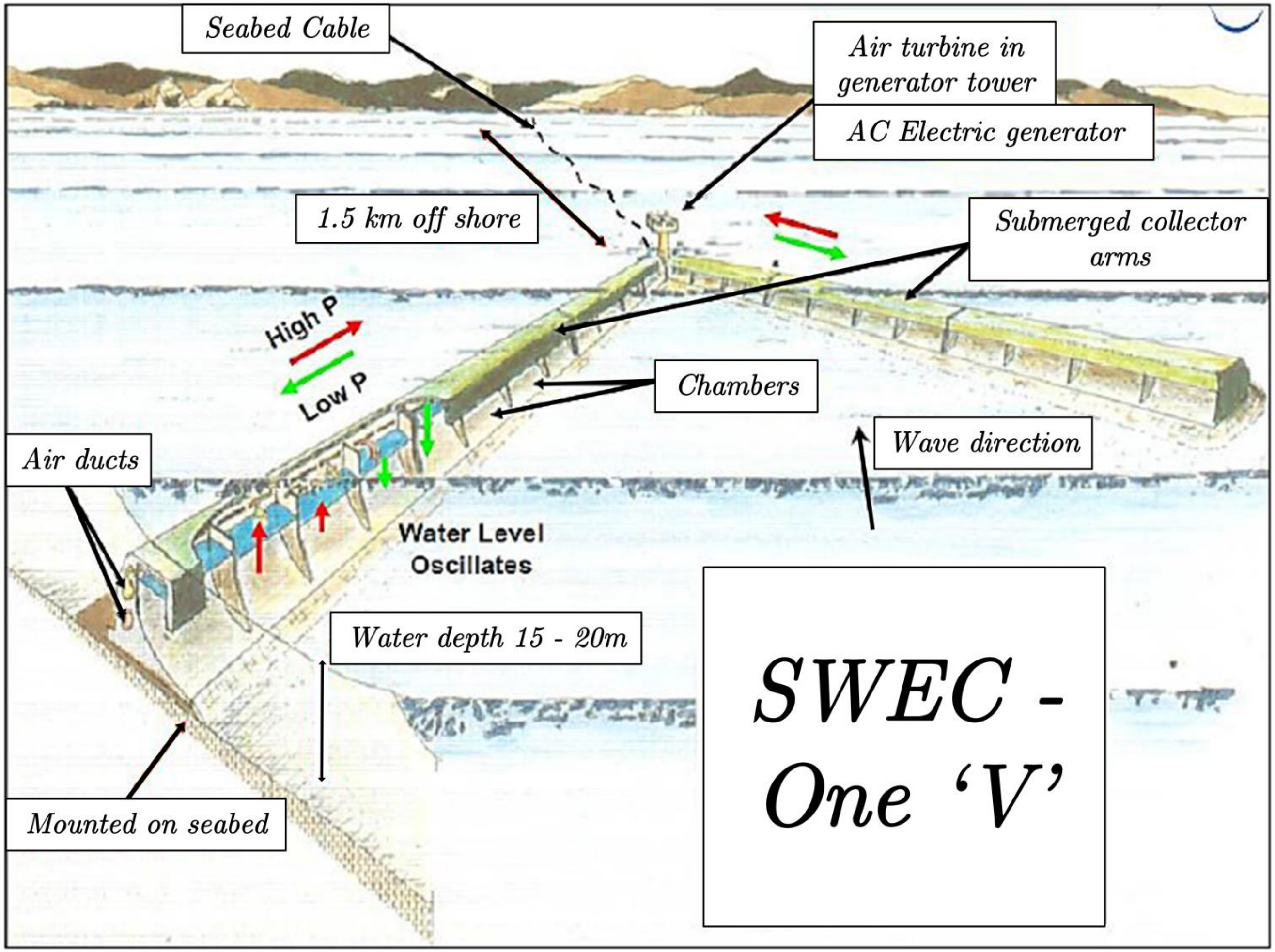
Introduction

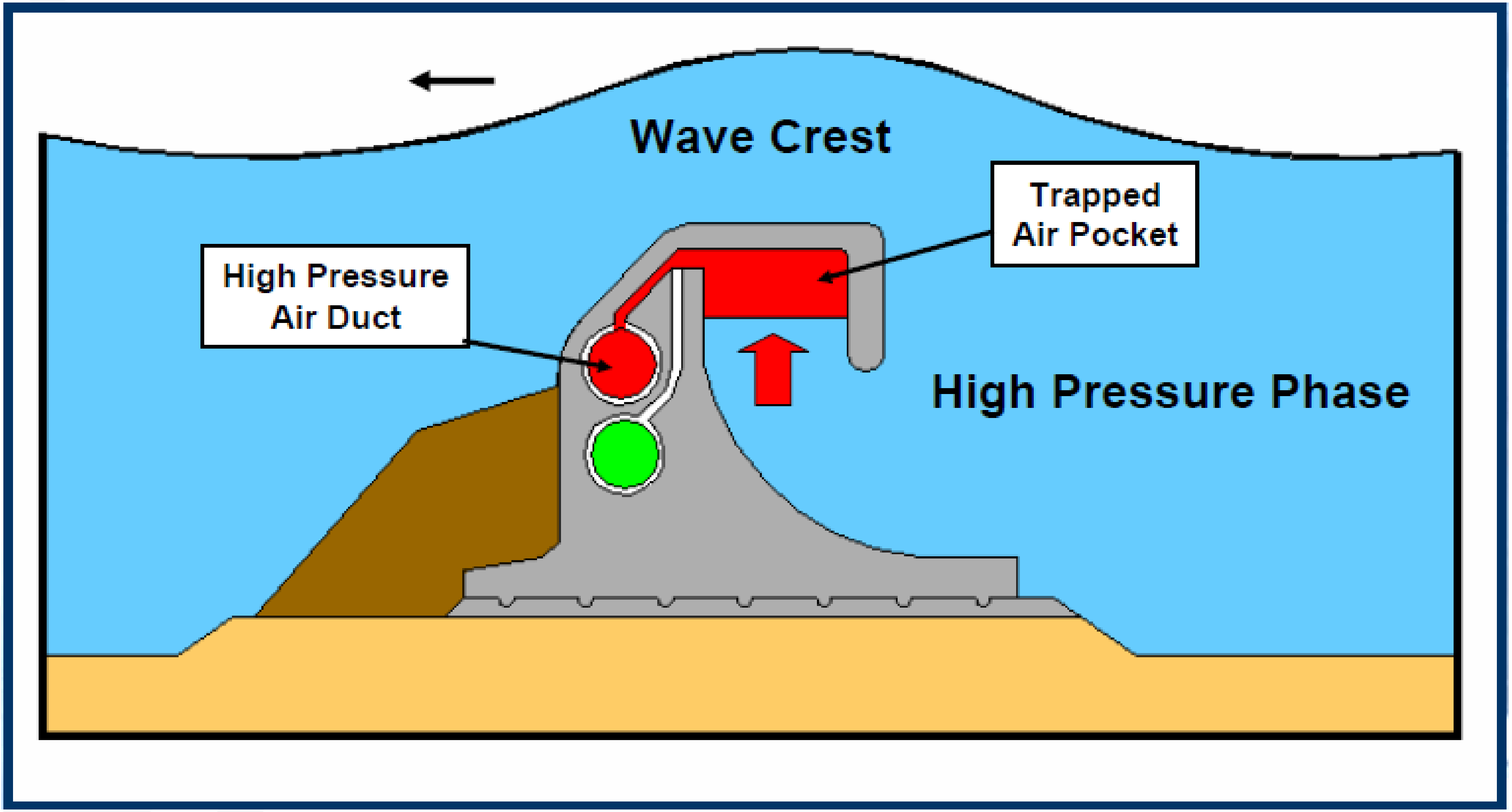
- The SWEC born in 1980's
- Estimate of 25 kW/m along South Africa's West coast 700 km long
- Other WEC's and claimed conversion efficiencies:
  - Archemides Wave Swing - 50% (Fiaz and Salari, 2011)
  - Oscillating surge converter – 60% (Folley, 2004)
  - OWC , *Limpet* – 60% (Wittaker et al., 2004)
  - Over-topping device – 18% (Tedd, 2007)
  - Pelamis – 70% (Yemm et al., 2011)

The SWEC



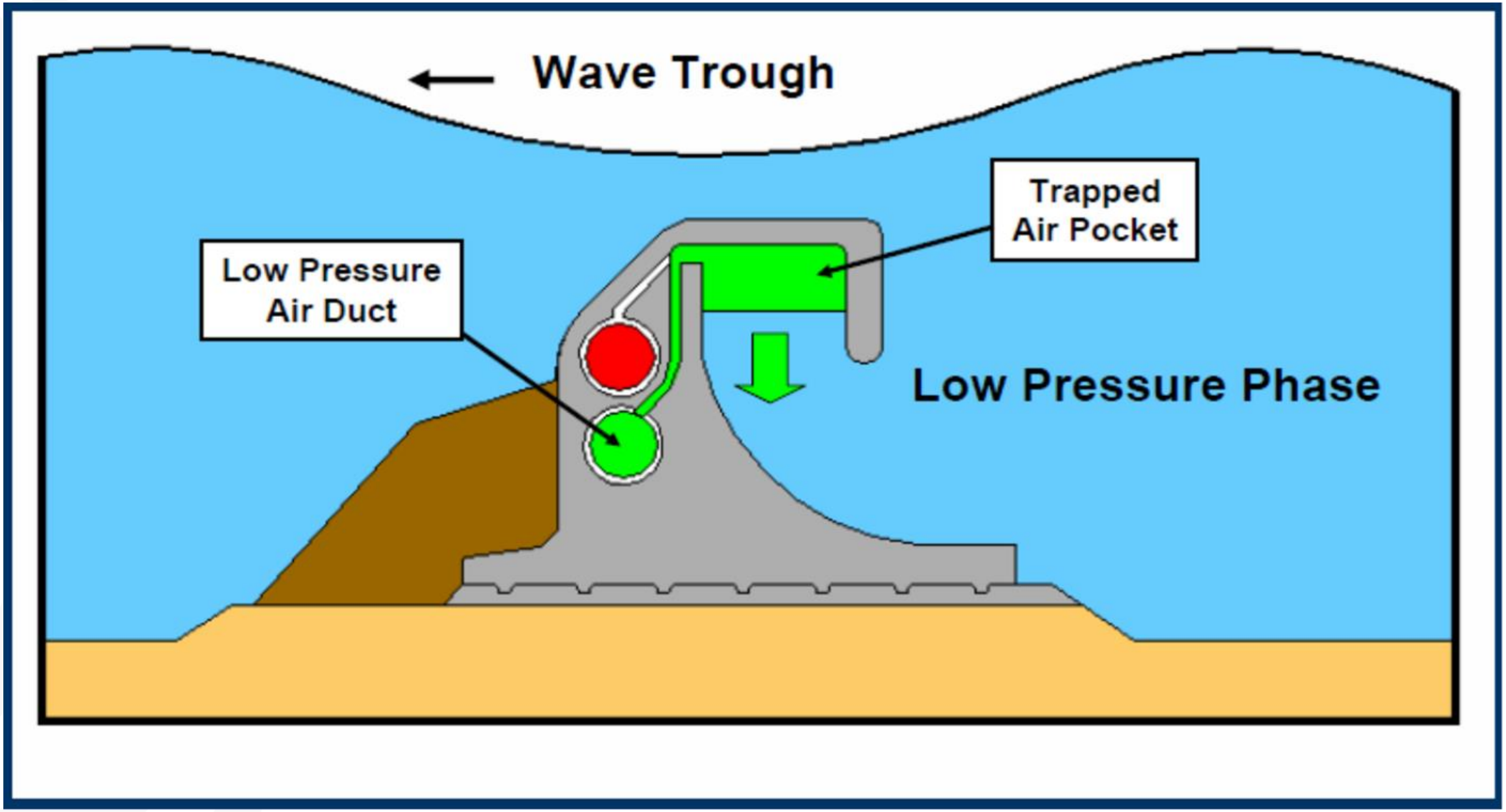
Submerged SWEC 'V' (adapted from Retief et al., 1982)

The SWEC



SWEC during crest of the wave (Bavesh, 2006)

The SWEC



SWEC during trough of the wave (Bavesh, 2006)

Problem Statement

Past studies have not been able to accurately model the SWEC:

- Not able to produce accurate results for high frequency wave inputs
- An unaccounted-for loss variable has often been added

Objectives

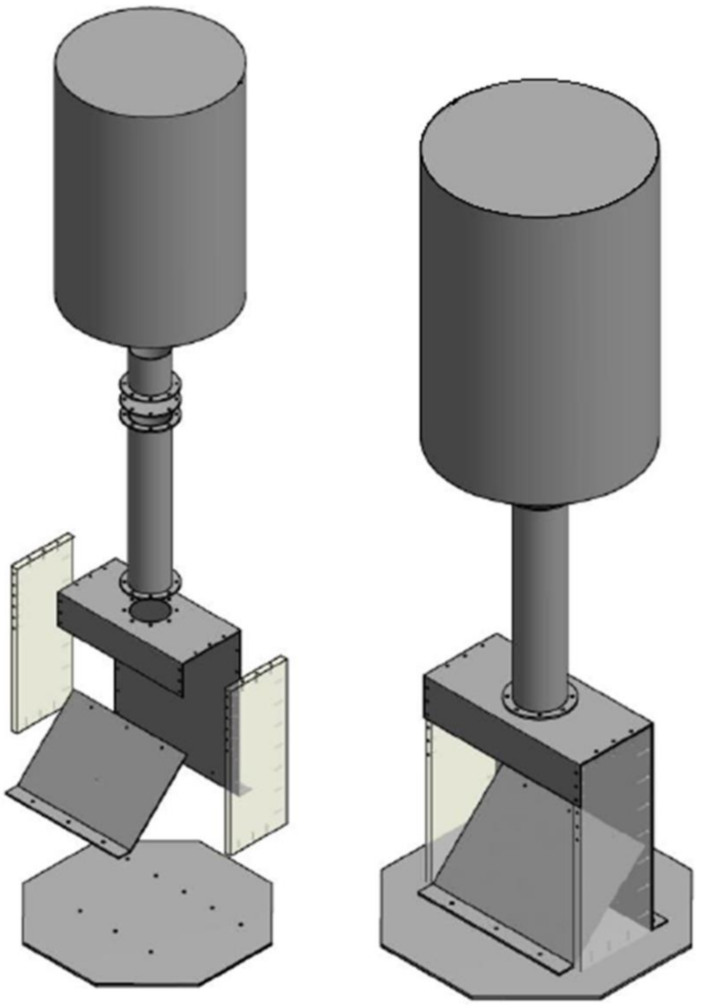
- Extensive experimental testing:
  - Use results to verify simulation models
  - Make conclusions on the viability of the SWEC as a WEC and the affect of orientation angle

- Produce two verified simulation models:
  - Surface SWEC
  - Submerged SWEC
  - Use models to optimise chamber design

Methodology

- Scale model of a single SWEC chamber
- Measurement apparatus:
  - Orifice flow meter – 5 different plate sizes
  - Wave probes
- Test two configurations in Civil engineering wave flume
- Develop simulation models for two configurations
- Verify simulation models
- Optimise chamber
- Draw conclusions

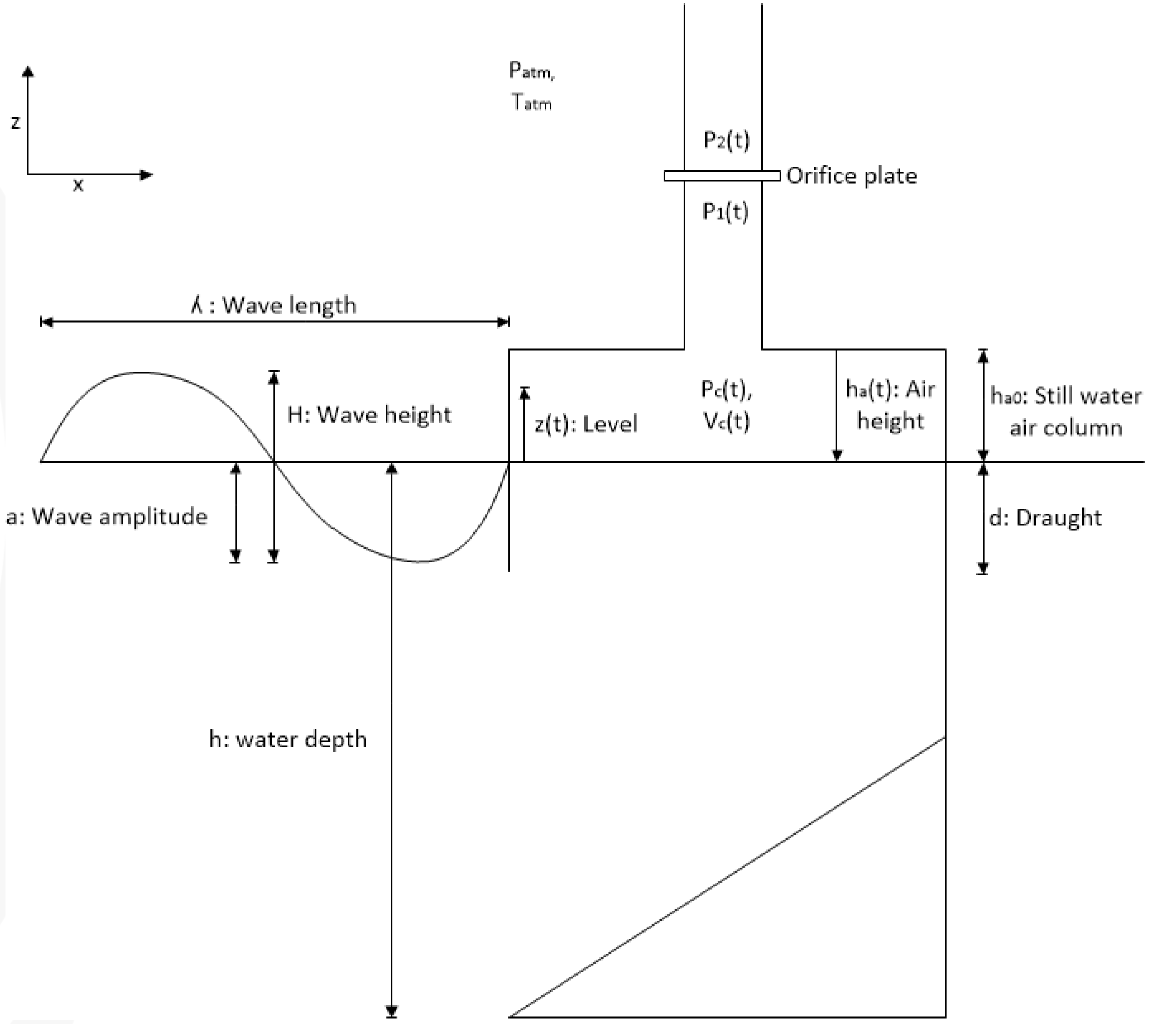
Experimental testing



CAD drawing of model.

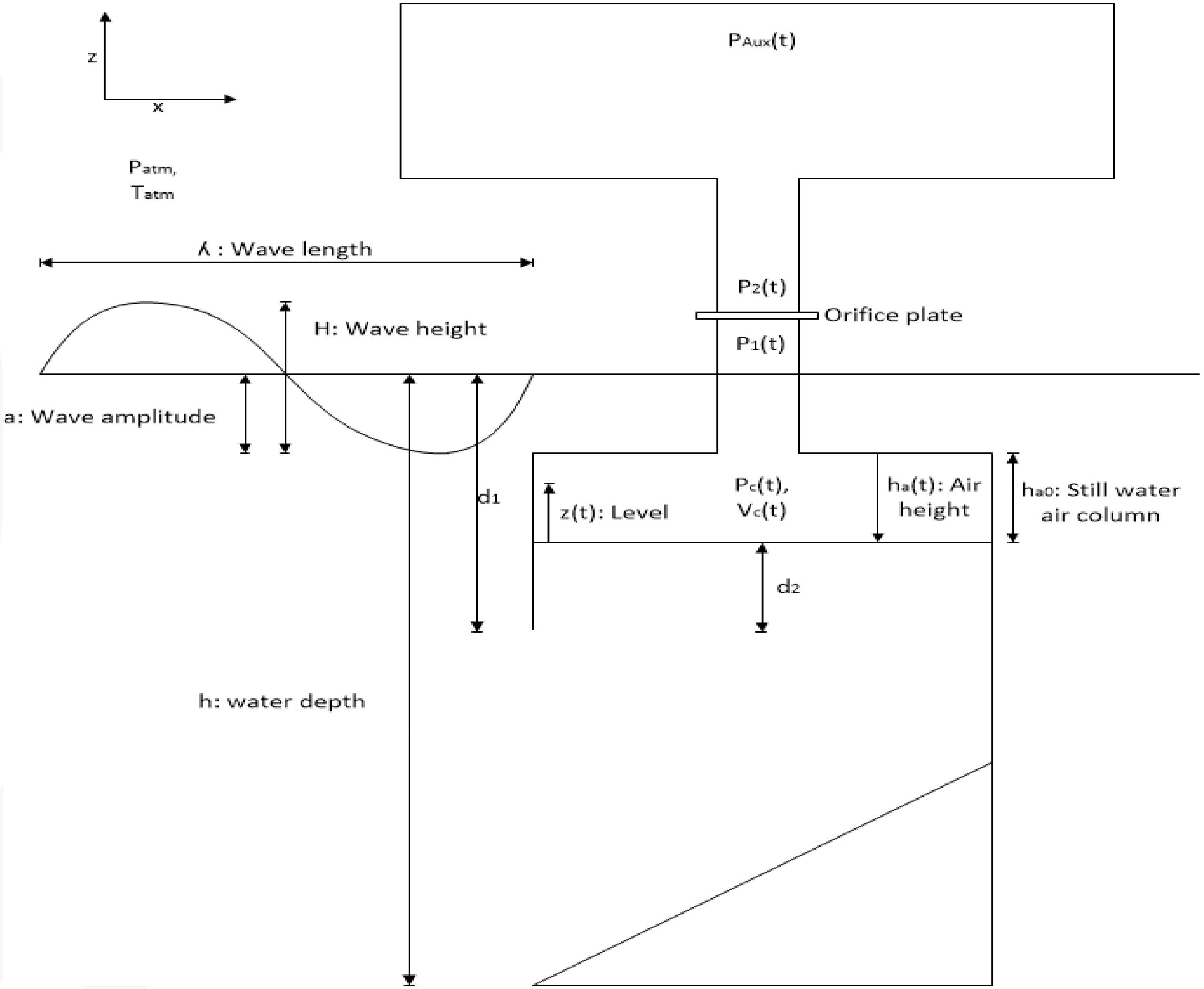
Photo of experimental setup

Surface SWEC configuration



Schematic of Surface SWEC configuration

Submerged SWEC configuration



Schematic of Submerged SWEC configuration

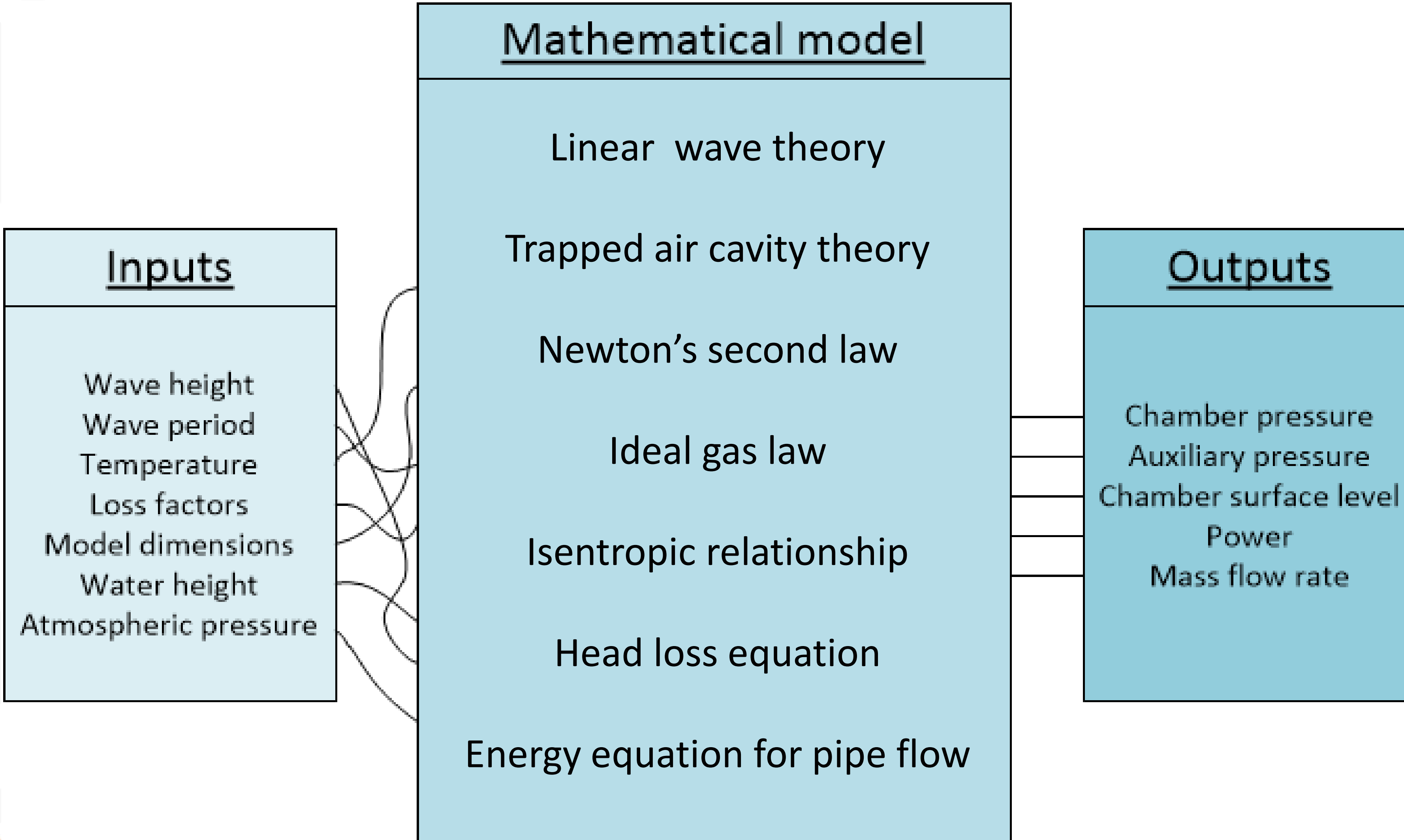
Experimental testing

$$P_{\mathrm{converted}}(t) = \dot{V}(t) \times \Delta p(t)$$ (Zhang et al., 2012)

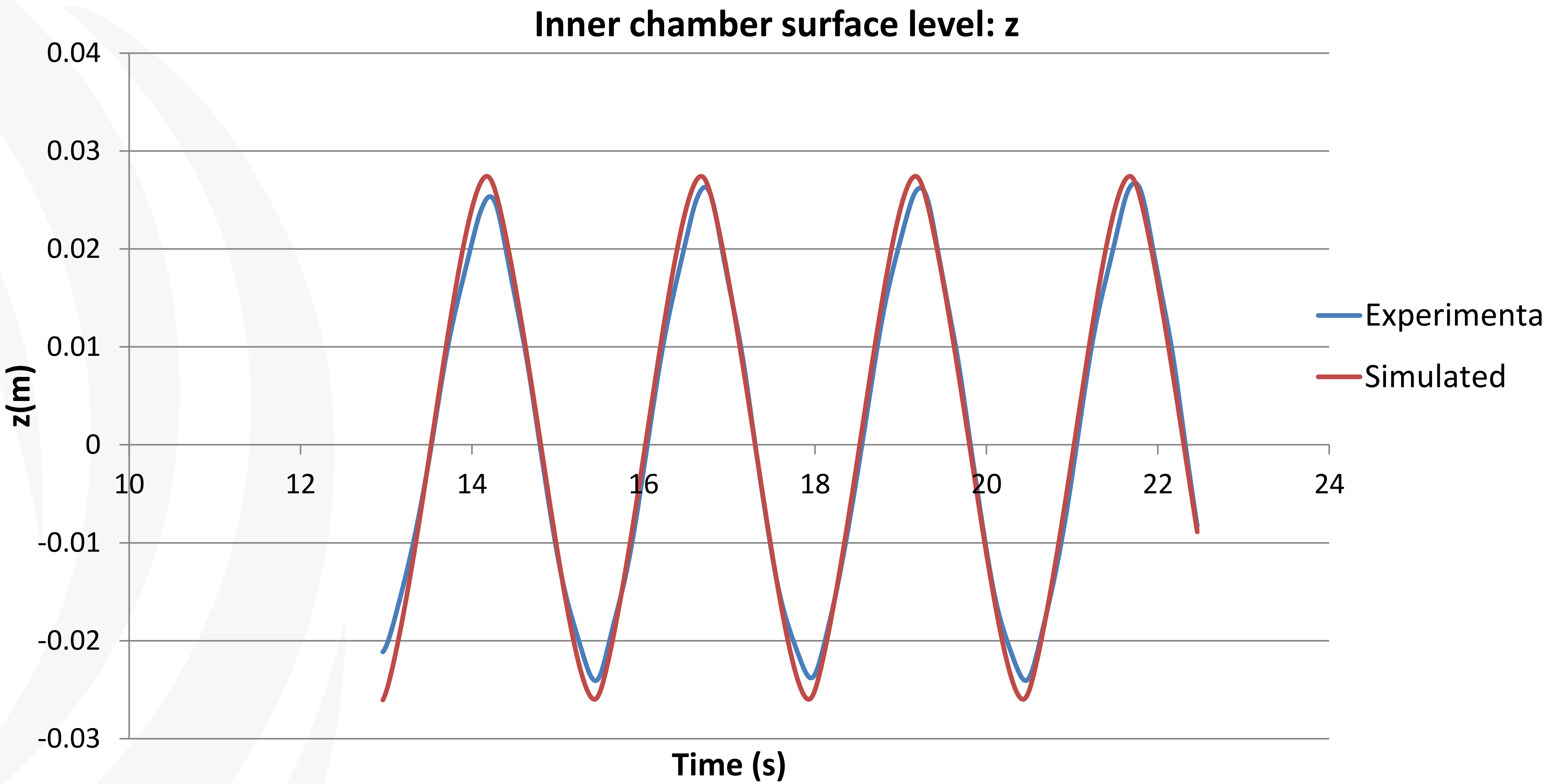
$$P_{\mathrm{wave}} = \frac{\rho g H^2}{8} C_g$$ (McCormick, 1981)

$$\eta = \frac{\overline{P}_{\mathrm{converted}}}{P_{\mathrm{wave}}}$$

Mathematical modelling



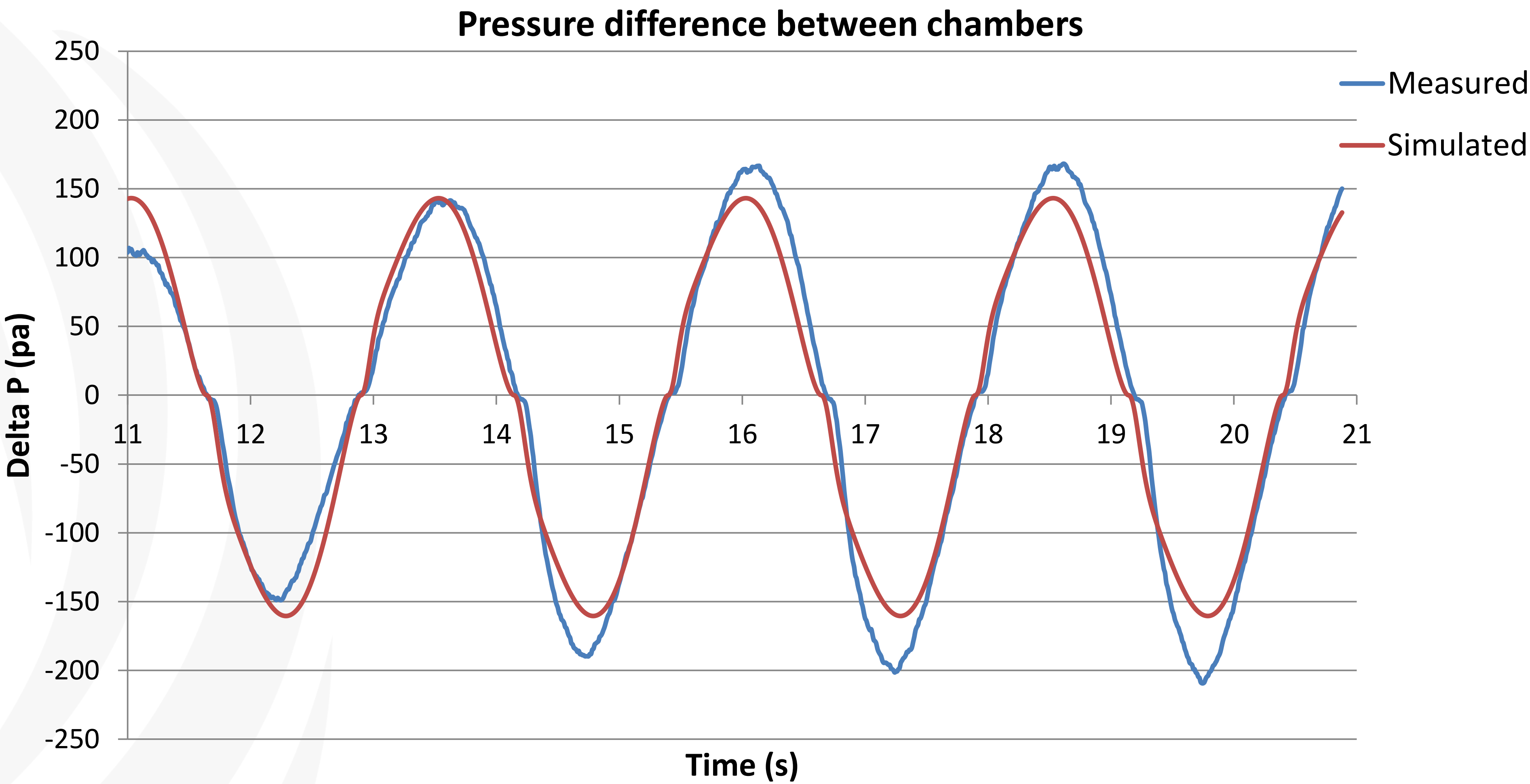
Results – Surface SWEC



H: 0.06m

T: 2.5s

Results – Surface SWEC



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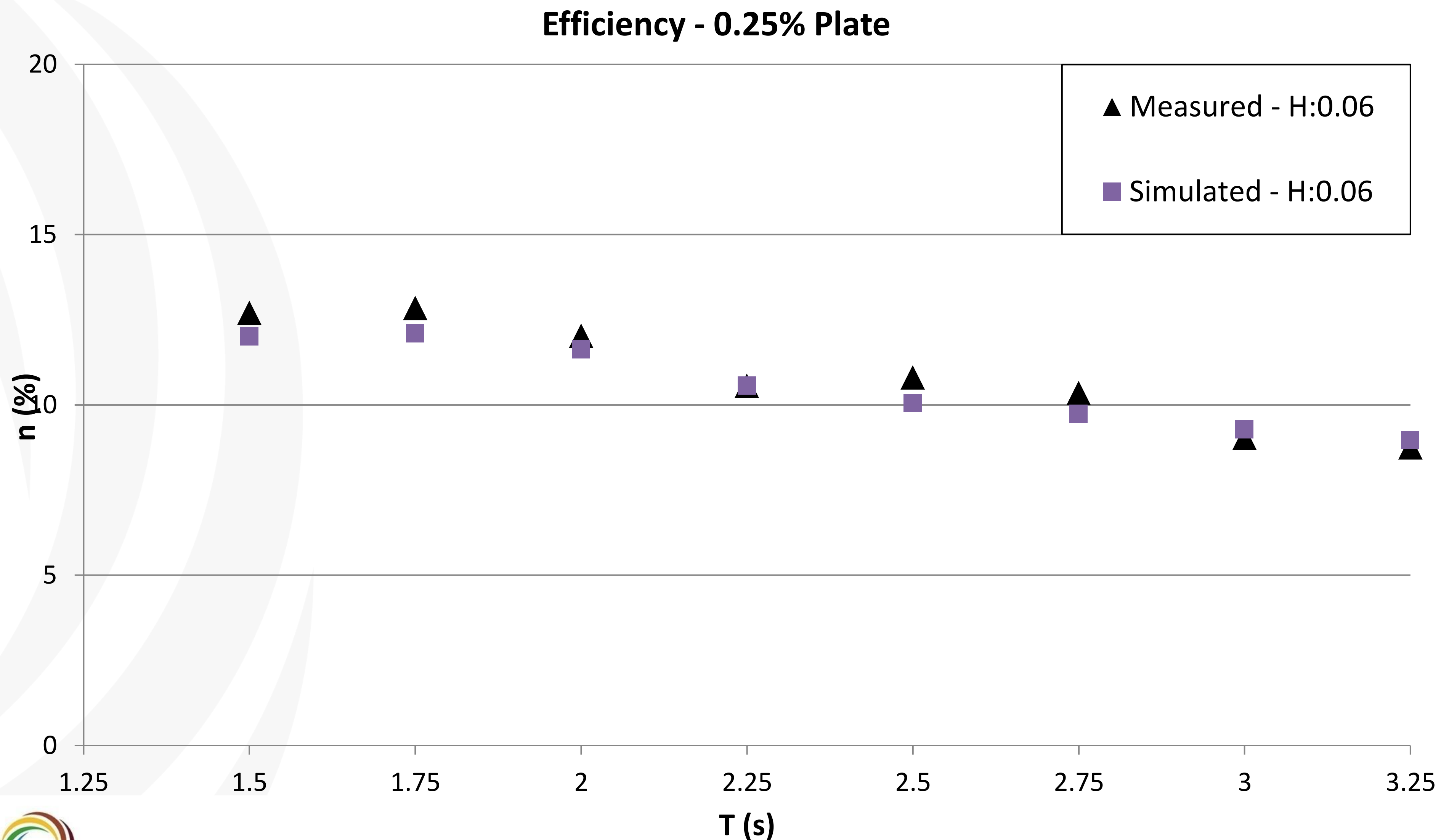
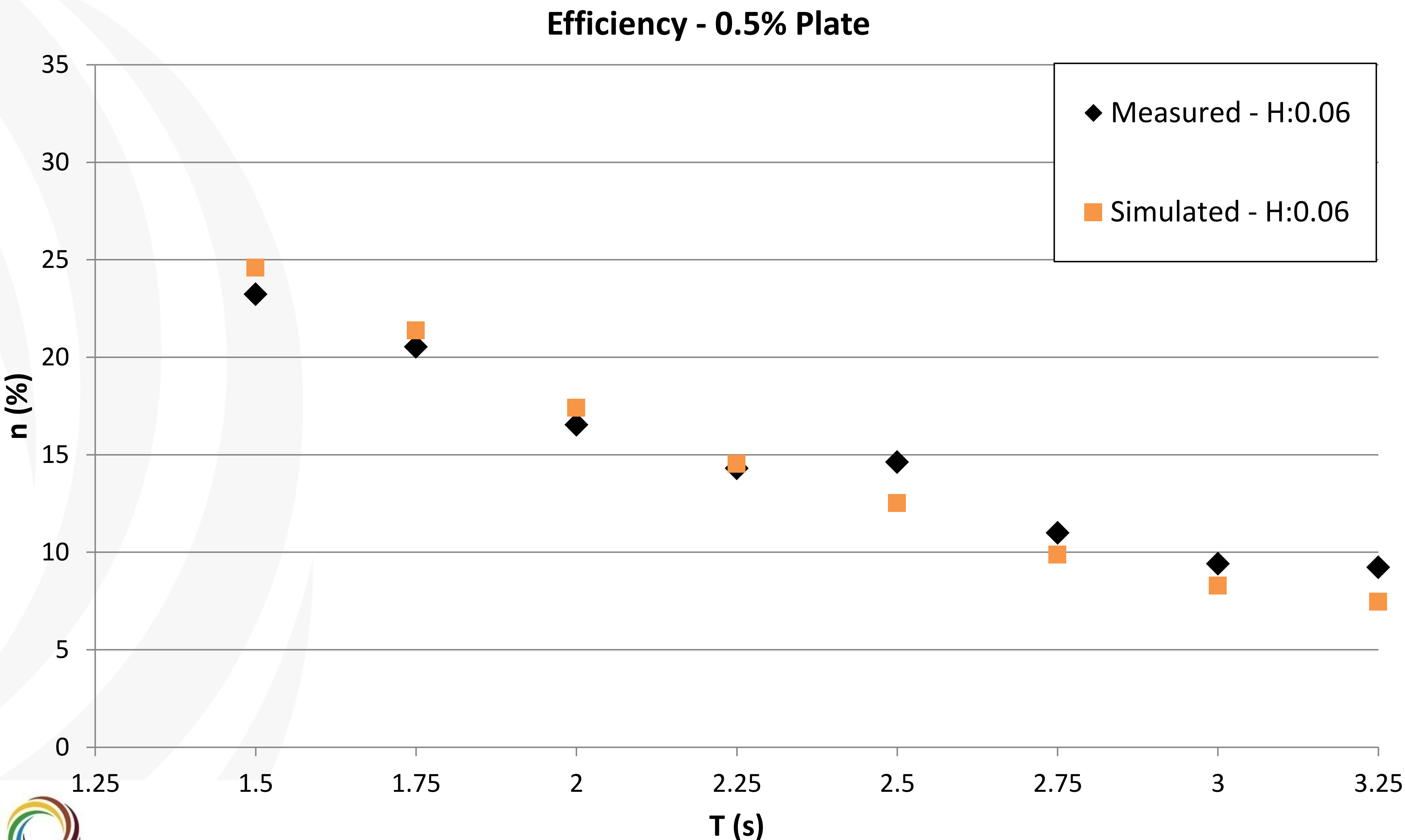
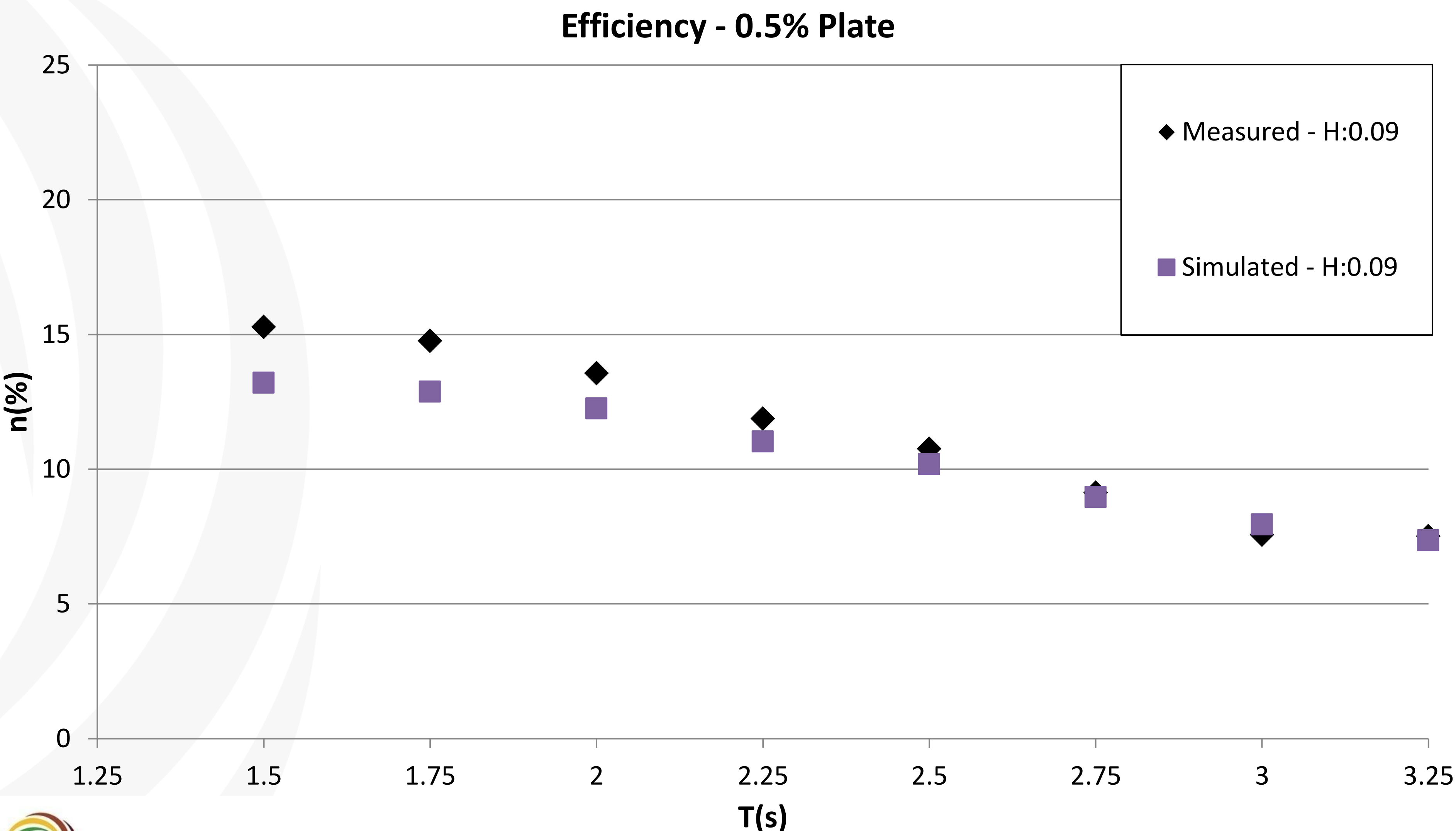
Results – Surface SWEC



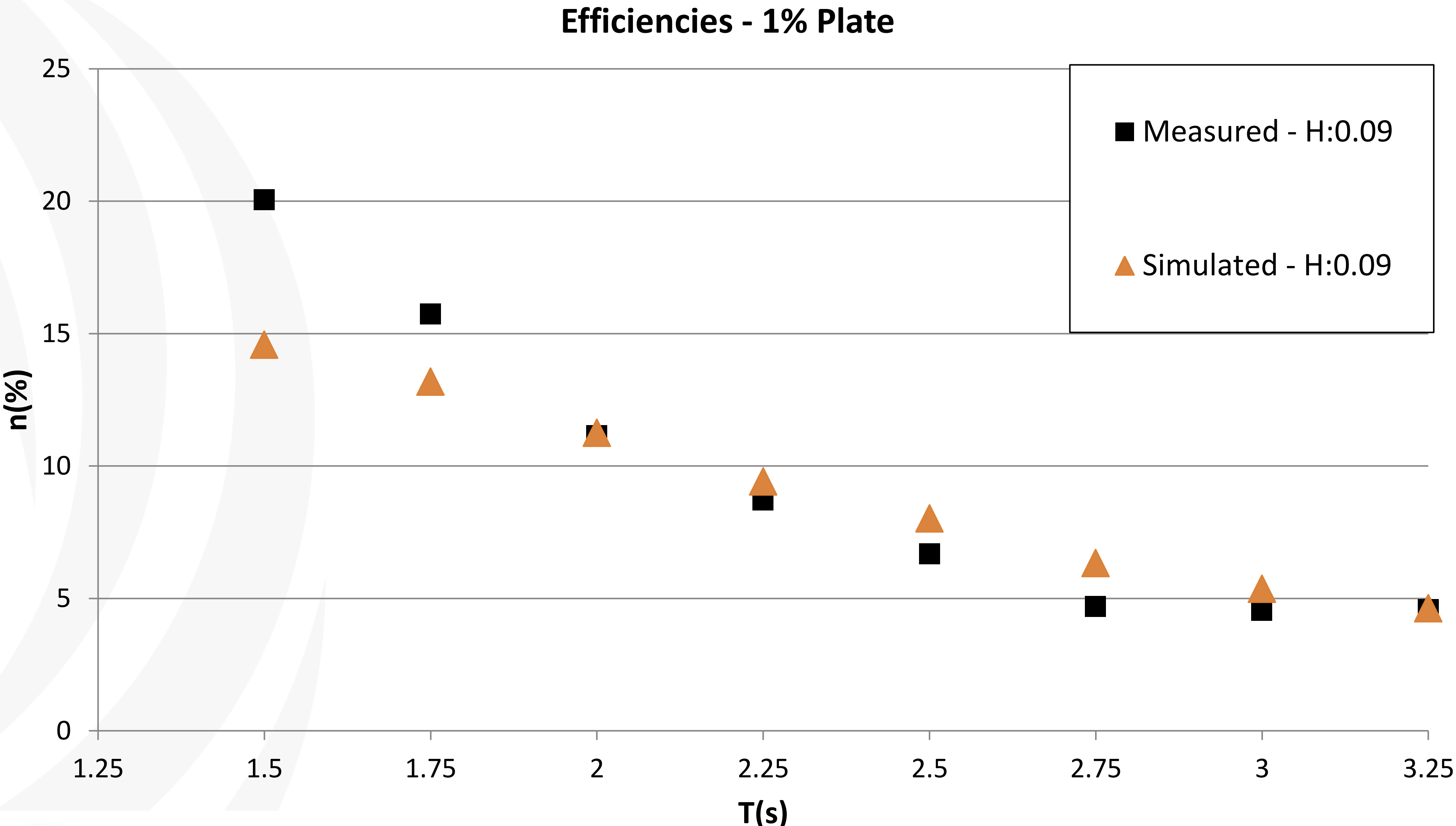
Results – Surface SWEC



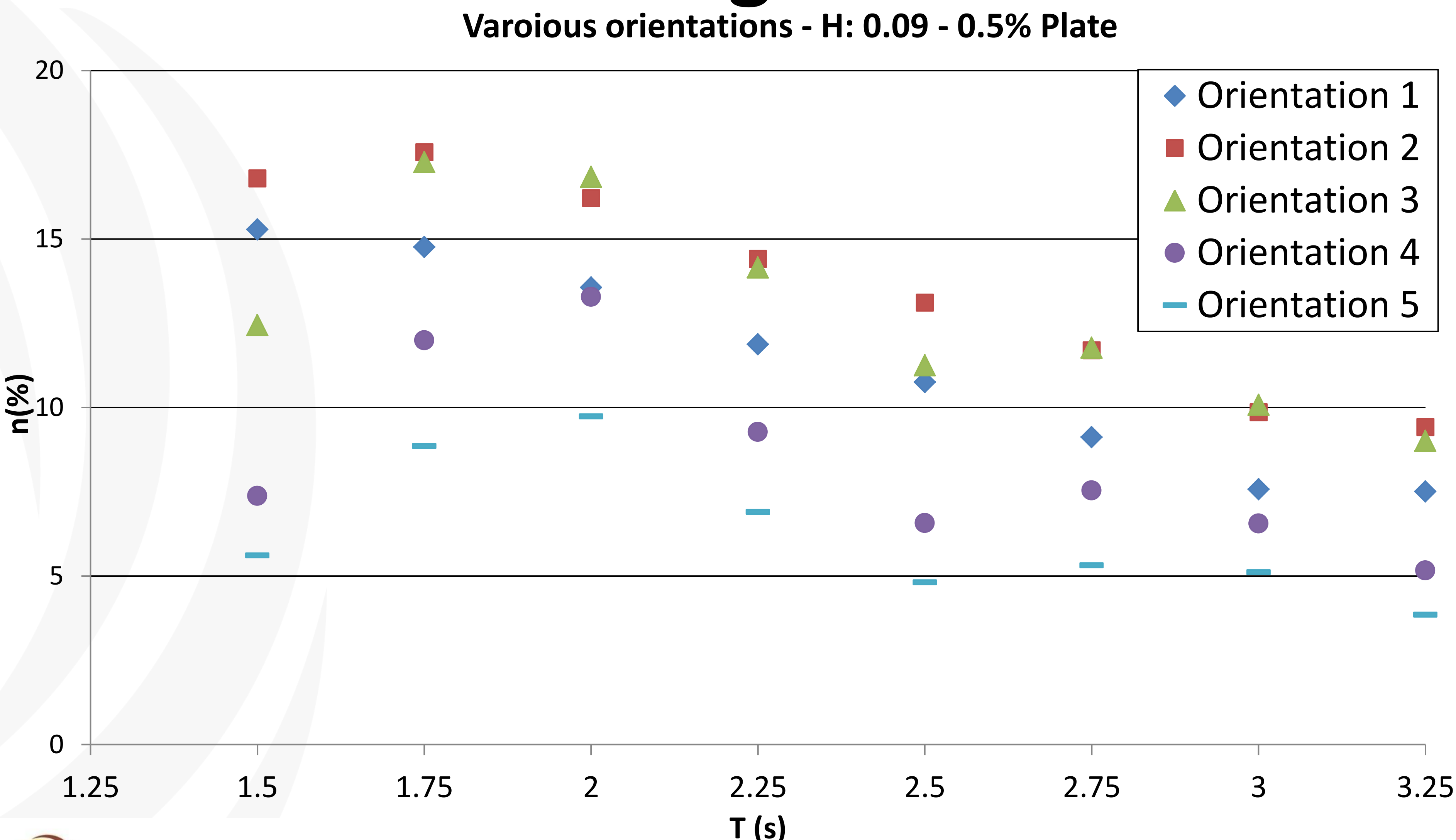
Results – Submerged SWEC



Results – Submerged SWEC



Results – Submerged SWEC



Conclusions

- Experimental results show maximum conversion efficiency of 15% and 13% at operating conditions
- Reaching up to 17% orientation 2 not at operating conditions
- Both models predict conversion efficiency with +- 2% average error
- Optimisation still to be carried out

Thanks