



The Economic and Energy Feasibility of Installing Wave Energy Converters in Yakutat, AK (Spring 2019-Spring 2021)

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Why Yakutat?

- Fossil fuel based power generation only
- 3 diesel gensets, 2x 900kW, 1300kW
- Max load: 1100kW (September)
- \$2.65/gal fuel (2020)
- 470,000 gal/year
 - Must be barged in
 - \$1,250,000 fuel cost per year
- High wave energy density in the Gulf of Alaska during winter
- Solar resource during summer

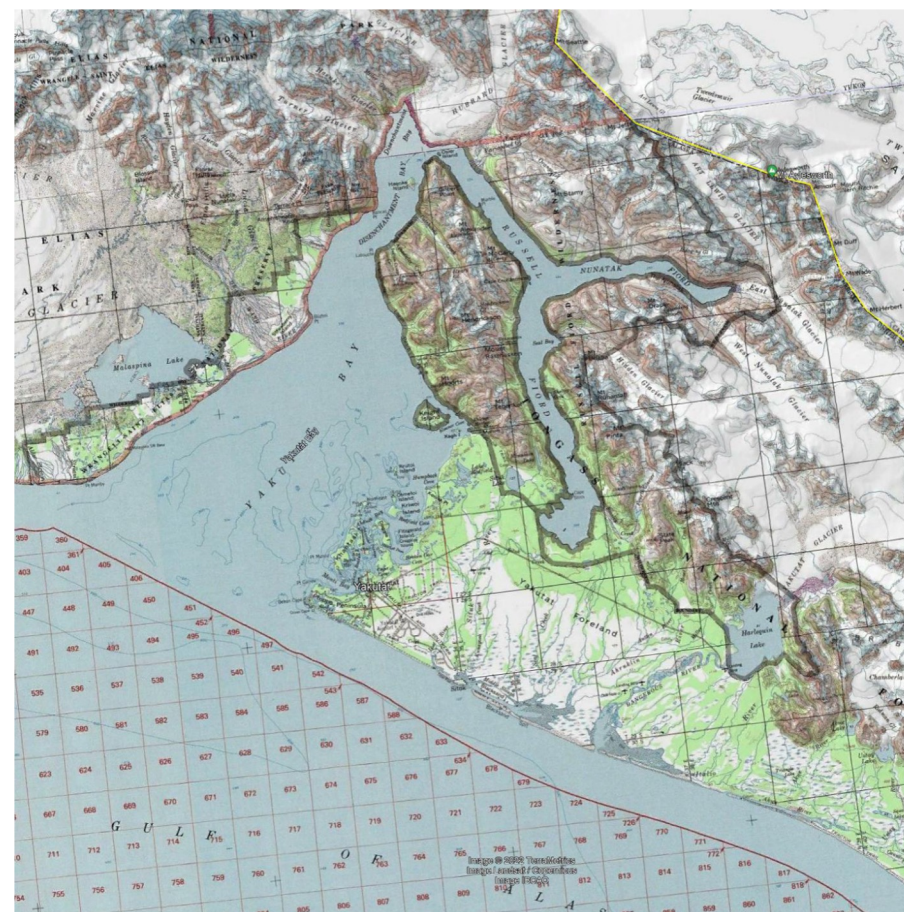


<https://kcaw-org.s3.amazonaws.com/wp-content/uploads/2014/12/Yakutat.jpg?x26178>



Why use wave power?

- Diesel-only is \$\$\$
- Local topography prevents hydro
- Turbulent winds prevent wind usage
- Renewable energy technologies (RE) are expected to become economically feasible¹

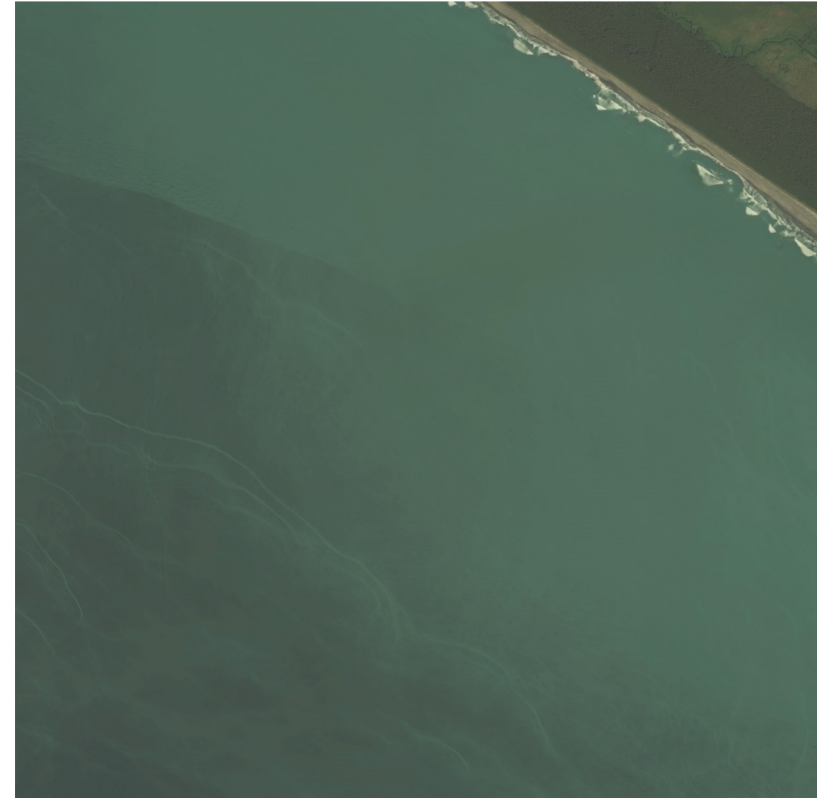


1: Chamberlain, M., 2021, "Techno-economic Investigation and Policy Implications of Renewable Energy Integration into an Islanded Diesel-based Microgrid in Rural Alaska"



Limitations

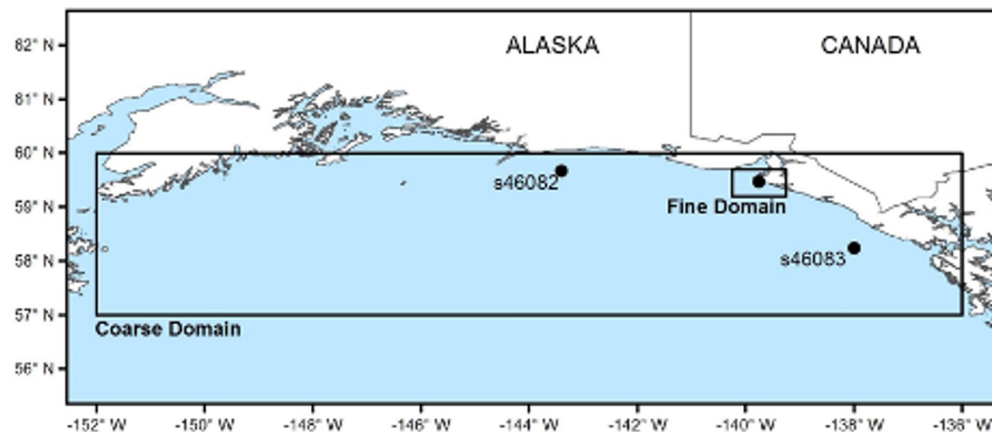
- Transient responses are unknown
 - Possible electrical ripple from WECs¹
- Power surfaces of WECs are simulated
- Wave simulations tend to underestimate wave energy
- WECs are still very much in development
- Wave simulation/forecasting under 5 mins has problems
- Environmental risks are unknown e.g. sediment transport & marine life



1: Chamberlain, M., 2021, "Techno-economic Investigation and Policy Implications of Renewable Energy Integration into an Islanded Diesel-based Microgrid in Rural Alaska"



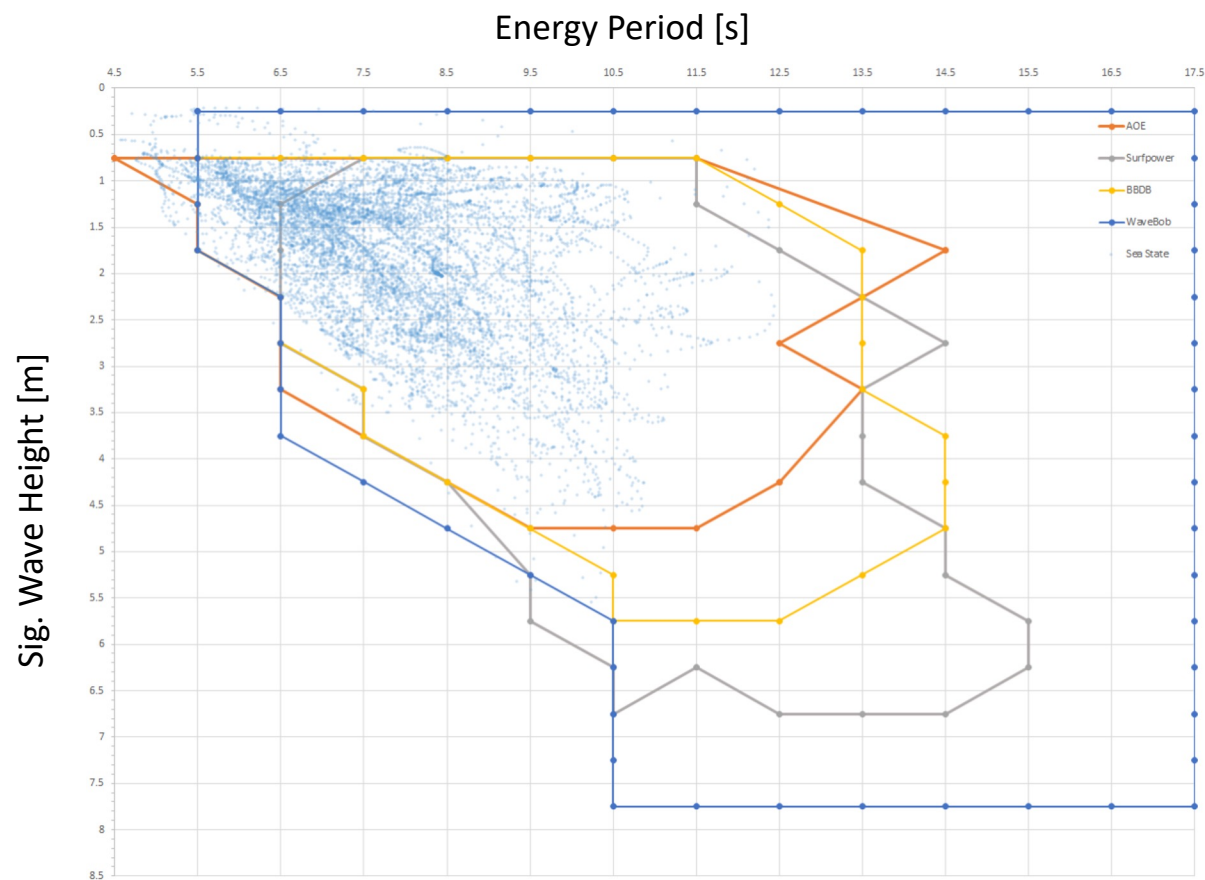
Methodology: Simulating WAves Nearshore (SWAN)



- 2 domains: coarse & fine
- Starts from calm sea, simulates over 10 years, 2010-2020
- Pierson-Muskowitz spectrum (steady state)
- Wind & S. wave boundary data sourced from ECMRWF ERA5 reanalysis



Sea states vs WEC boundaries @ 40m





Methodology: HOMER

- Exhaustive search for the most economical system in terms of LCOE
- Energy balance only
- Artificially matched LCOE of solar to WECs
 - Optimizes towards diesel offset
- Lifetime: 20 years
- Solar cells, battery banks, WECs
- Observed: Solar resource, elec. load
- Simulated: wave resource

The screenshot displays the HOMER Pro Microgrid Analysis Tool interface. The main window is titled "HOMER Pro Microgrid Analysis Tool [002Sample-PhilippineVillageOfSicud.homer] 3.5.4". The interface is divided into several sections:

- FILE**: Home, Design, Results, Library.
- LOAD**: Electric #1, Electric #2, Deferrable, Thermal #1, Thermal #2, Hydrogen.
- COMPONENTS**: A toolbar with icons for various components.
- DESIGN**: A central area showing a schematic diagram of a microgrid system. The schematic includes a Diesel generator (Dsl), a Primary Load, a Converter, a Grid (G10), a Generator (G3), a PV panel, and a battery bank (S6CS25P).
- DESCRIPTION**: A text area containing project details:
 - Name**: Sample-PhilippineVillageOfSicud
 - Author**: Tony Jimenez
 - Description**: Sicud is a small village in Palawan, Philippines. This analysis investigates the options for providing electricity to the village using wind, solar, or diesel power. The results show the impact of different assumptions about the wind resource, fuel price, and required system reliability.
- RESOURCE DATA**: A table of resource parameters:

Parameter	Value	Unit
Discount rate (%)	8.00	(%)
Inflation rate (%)	2.00	(%)
Annual capacity shortage (%)	0.00	(%)
Project lifetime (years)	25.00	(years)
- MAP**: A map showing the location of the project in Puerto Princesa, Palawan, Philippines (9°50.1'N, 118°35'32.76"E).



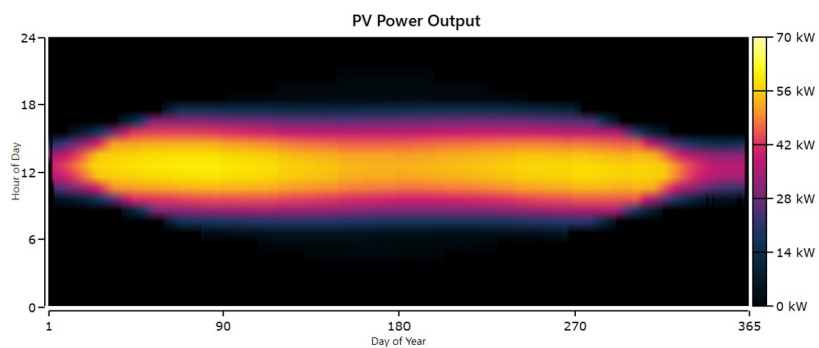
Results

	Base	Solar		Wavebob		Surf		All REs	
		Battery	No battery	Battery	No battery	Battery	No battery	Battery	No battery
Power sources & storage	3 Gensets	25kW solar 300kWh bat.	25kW solar	6 Bob 600kWh bat.	2 Bob	2 Surf 900kWh bat.	2 Surf	75kW solar 2 Surf 2 Bob 900kWh bat.	25kW solar 2 Surf 2 Bob
LCOE \$/kWh	\$0.438	\$0.439	\$0.438	\$0.436	\$0.437	\$0.433	\$0.450	\$0.432	\$0.455
Renewable Energy Fraction	0%	1%	1%	37%	13%	45%	37%	58%	46%

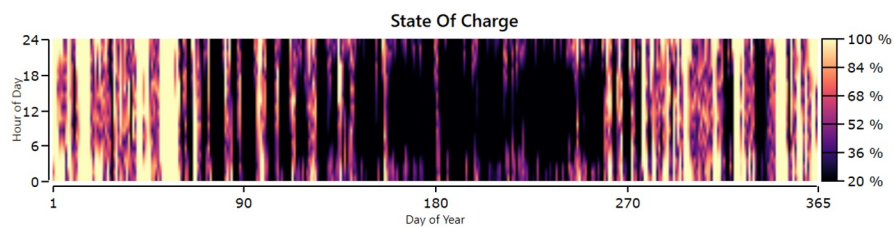


Discussion: RE output

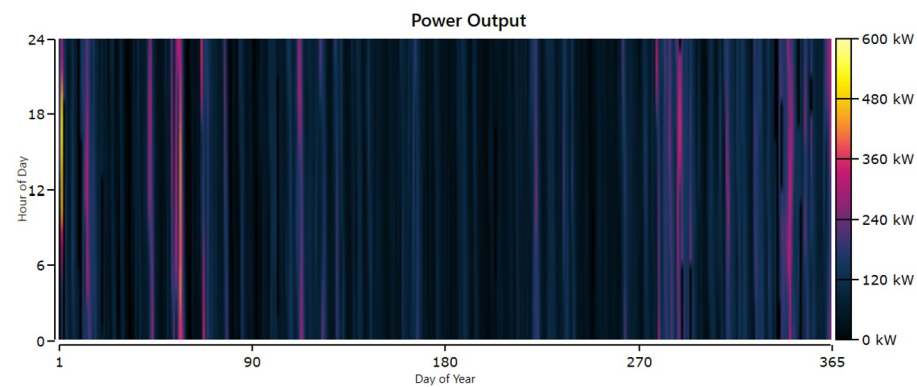
Solar



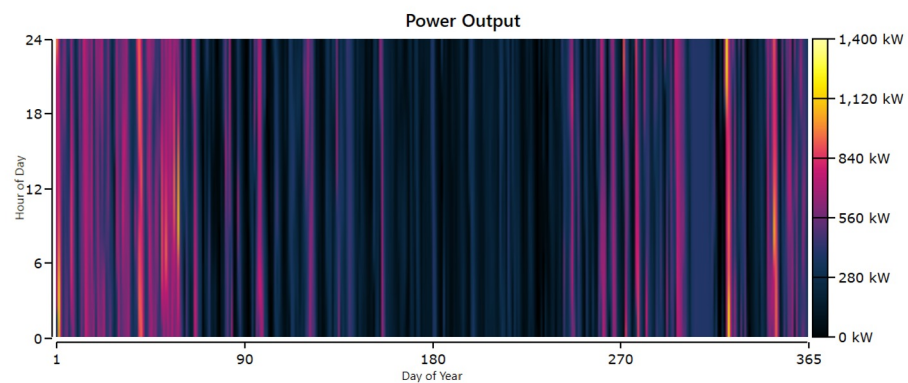
Battery



Wavebob



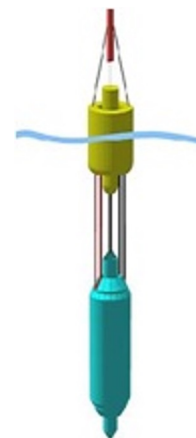
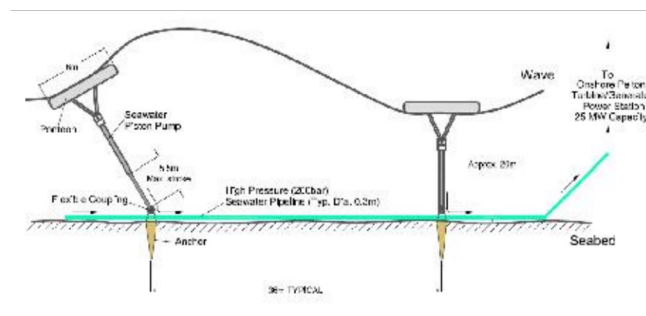
Surfpower





Discussion

- Wavebob & Surfpower are best suited for Yakutat
- Batteries tend to determine feasibility of system
- Synergy exists
- WEC power surfaces & spectrum response non-trivial





Conclusion

- The energy is there
 - Batteries are very important
- No singular source can offset the most diesel
- Differing WEC designs might offer the best full spectrum response
- Different WECs might be needed in other wave environments
- Remember limitations





Data Sources & Tools



National Centers for
Environmental
Information



Chris Pike &
Michelle Wilbur



Acknowledgements

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OSU**





Fin.