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UAF UNIVERSITY OF ALASKA FAIRBANKS

ACEP Alaska Center for Energy and Power

PMEC Pacific Marine Energy Center

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

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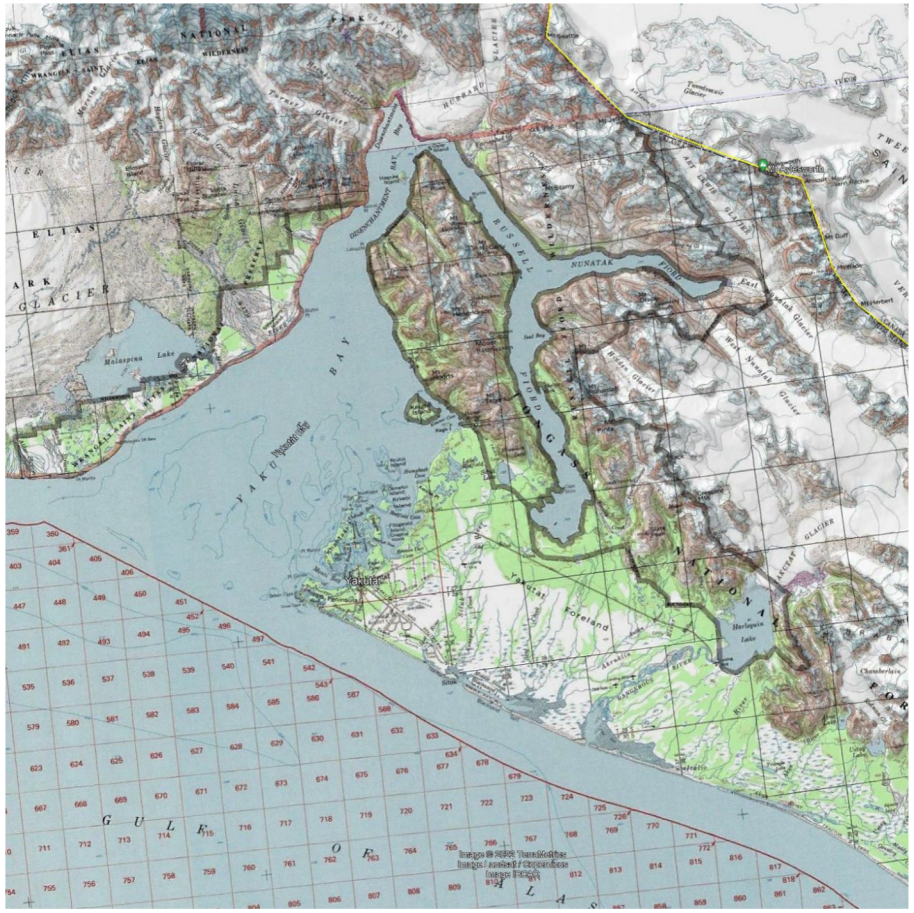
Why Yakutat?

- 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 feasible[1]



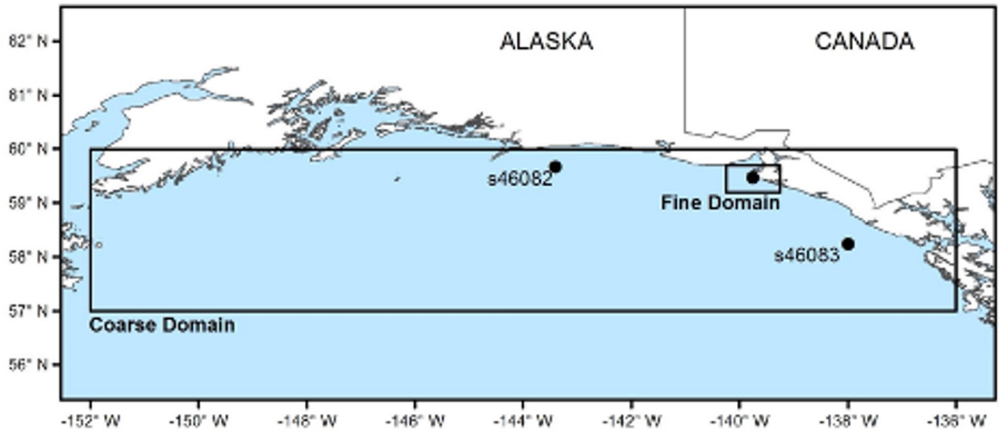
1: Chamberlain, M., 2021, “Techno-economic Investigation and Policy Implications of Renewable Energy Integration into an Islanded Diesel-based Microgrid in Rural Alaska”

Limitations

- Transient responses are unknown
  - Possible electrical ripple from WECs[1]
- 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

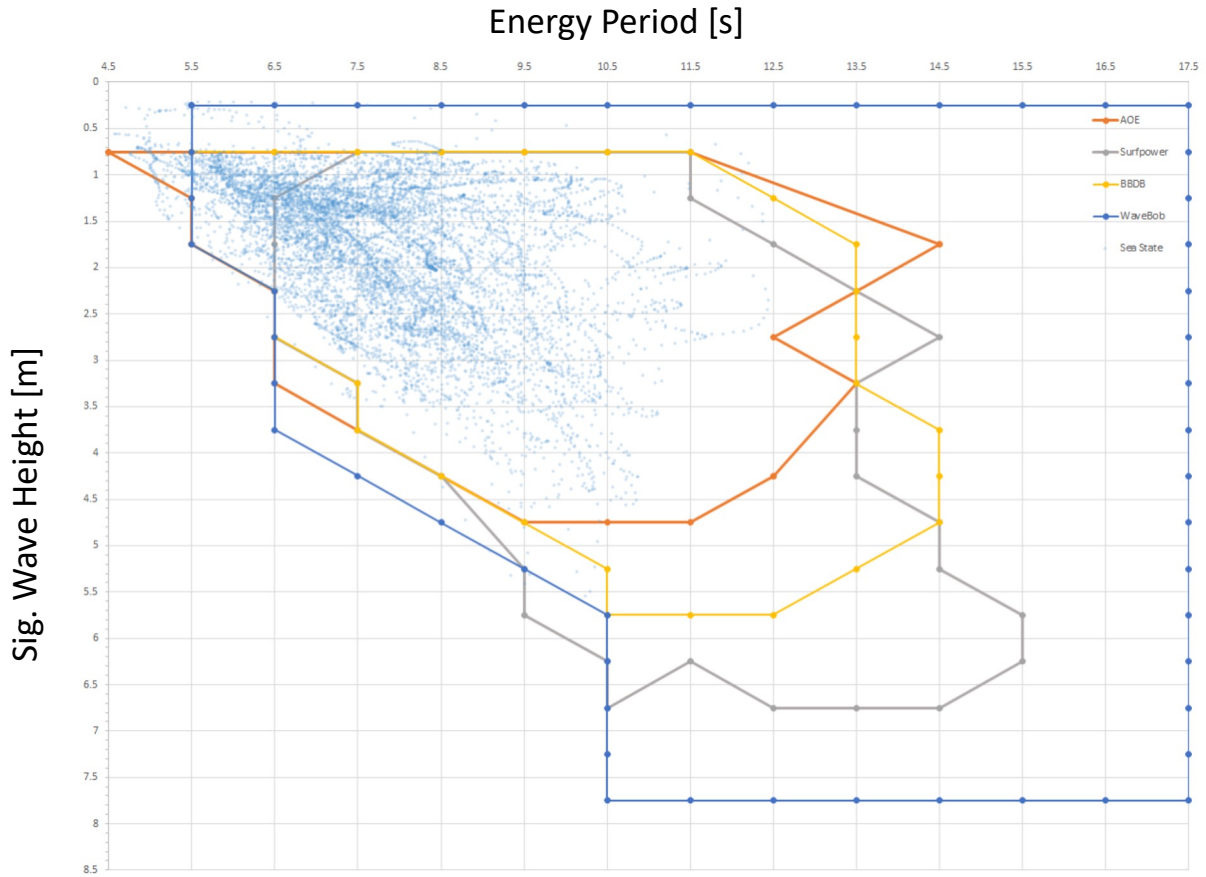
1: Chamberlain, M., 2021, “Techno-economic Investigation and Policy Implications of Renewable Energy Integration into an Islanded Diesel-based Microgrid in Rural Alaska”

Methodology: Simulating WAves Nearshore (SWAN)



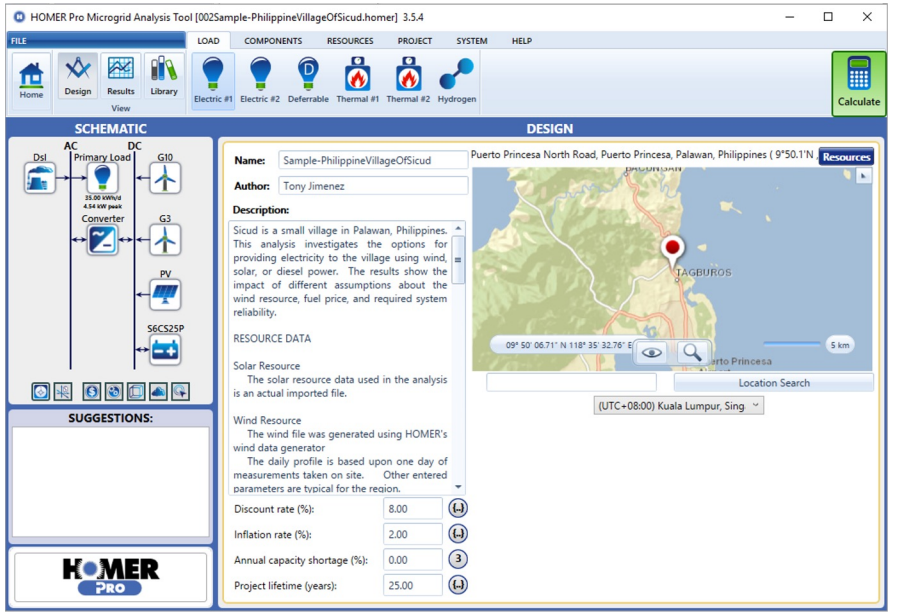
- 2 domains: coarse & fine
- Starts from calm sea, simulates over 10 years, 2010-2020
- Pierson-Muskowitz spectrum (steady state)
- Wind & S. wave boundary data sourced from ECMRWF ERA5 reanalysis

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

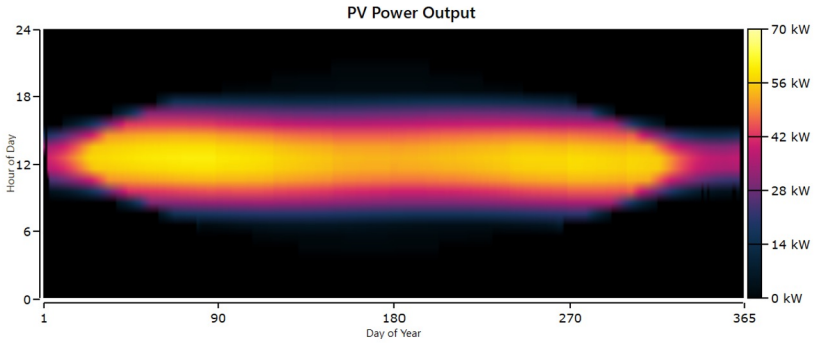


Results

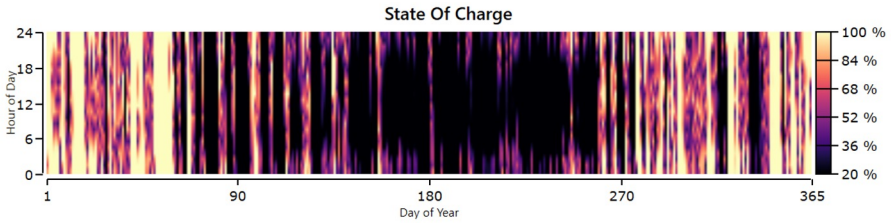
	Base	Solar		Wavebob		Surf		All REs	
		Battery	No battery	Battery	No battery	Battery	No battery	Battery	No battery
Power sources & storage	3 Gensets	25kW solar 300kWh bat.	25kW solar	6 Bob 600kWh bat.	2 Bob	2 Surf 900kWh bat.	2 Surf	75kW solar 2 Surf 2 Bob 900kWh bat.	25kW solar 2 Surf 2 Bob
LCOE $/kWh	$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

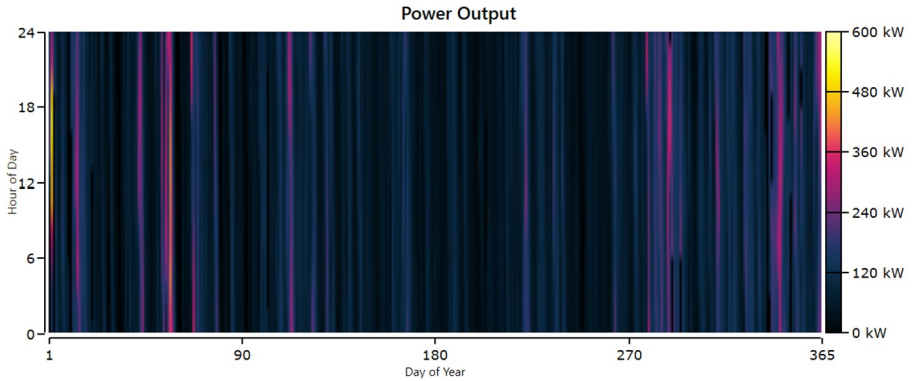
Solar



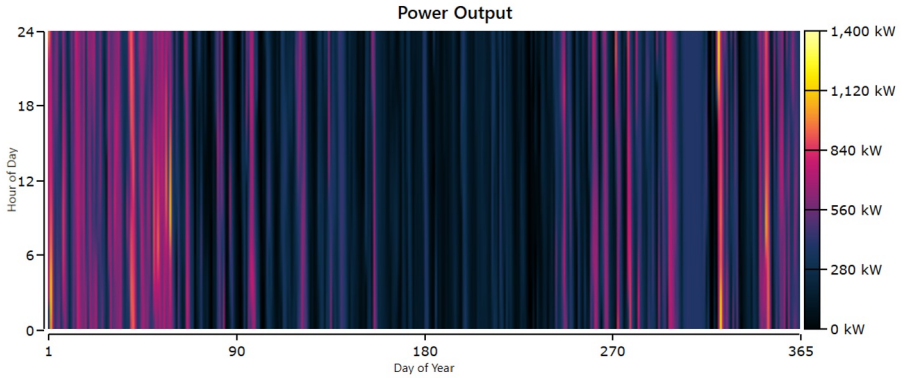
Battery



Wavebob

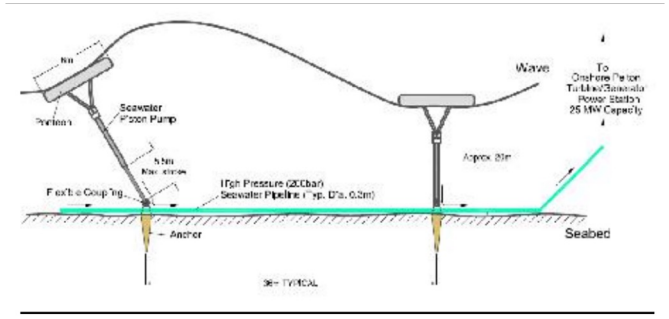


Surfpower



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

ECMWF

NREL
Transforming ENERGY

SWAN
Simulating WAves Nearshore

NOAA
National Centers for Environmental Information

MHKiT

MATLAB®

python™

Chris Pike &
Michelle Wilbur

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