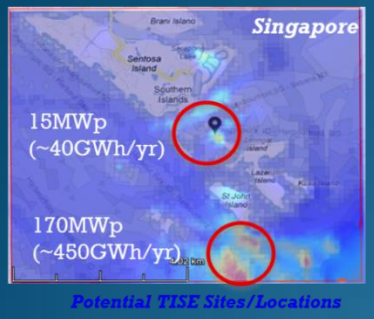
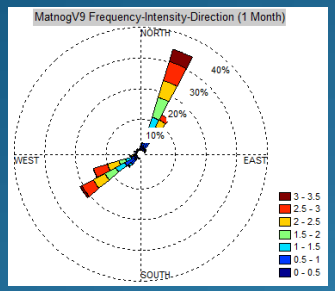
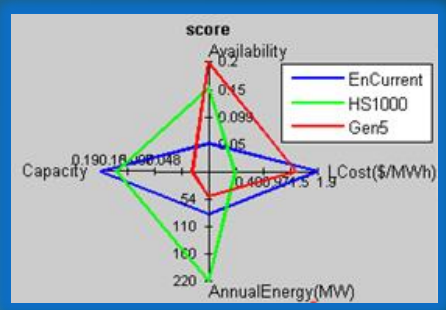
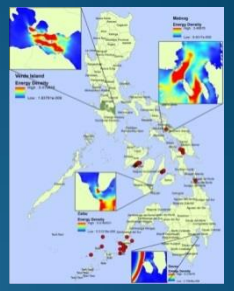


Potential TISE Sites/Locations







Marine Renewable Energy for Island Micro-Grids in South East Asia

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Director

OceanPixel Pte Ltd
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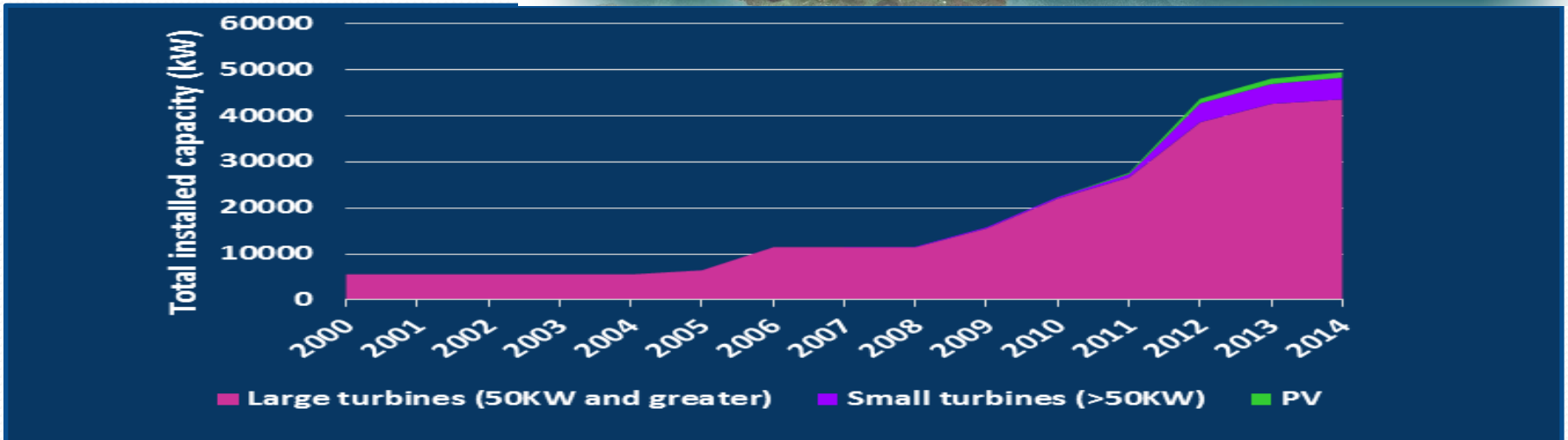
Orkney's renewable energy resources

Total = > 5,000 MW deliverable capacity

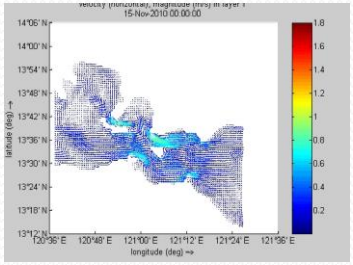
Key		
Onshore wind	40 MW existing/planned	
New onshore wind	100-200 MW	
Wave	500-1000 MW	
Tidal	500-2,500 MW	
Offshore wind	1000 MW	
Wave leases	550 MW	
Tidal leases	500 MW	
Mirco & other	2.5 MW	
Gas & other	20 MW	Dispersed
EMEC sites	5 + 7 MW	Dispersed and

107% of electrical demand in Orkney met by renewables in 2014



South East Asia RD&D

Simulation Studies

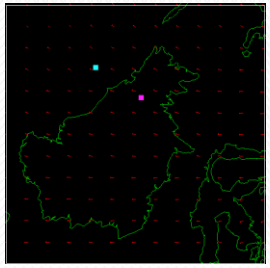


Myanmar
Tidal Barrage

Indonesia
Tidal Current Test

Europe, N. America, Australia

Brunei
Offshore Wind



Vietnam
Tidal Turbine Drive Train

Malaysia
OWC Test

Tow Tanks
(eg UTM, MMU, NTU)

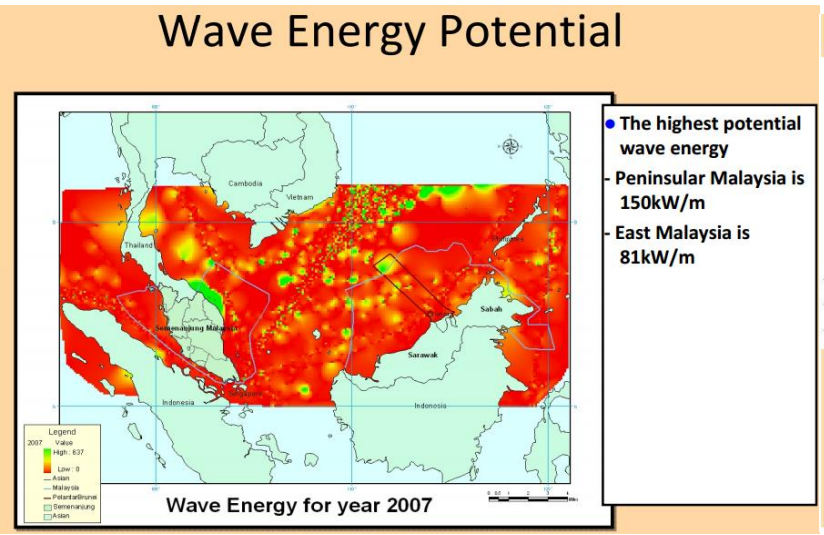
Philippines
Tidal Barrage

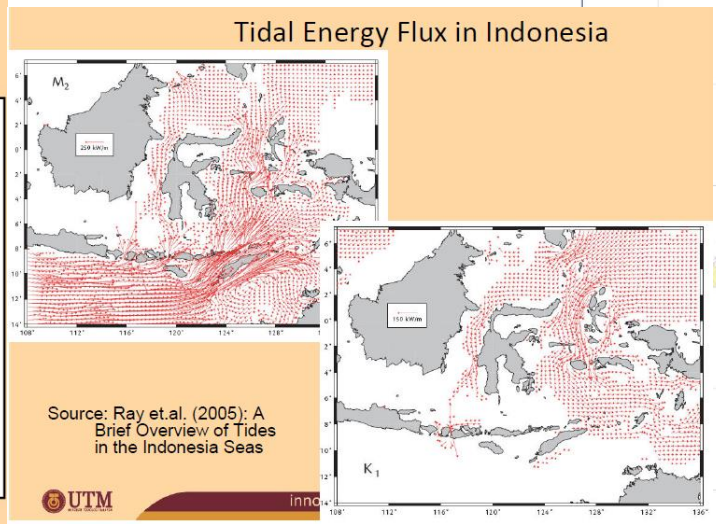
Singapore
Tidal Turbine Testing

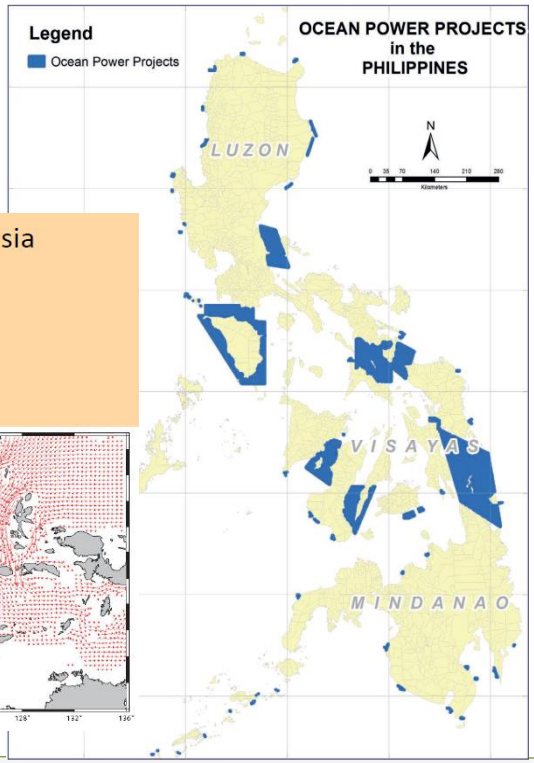
Source: SEAcORE 2013

South East Asia Potential for Ocean RE

- ~30,000 Islands (with great ORE potential)
- Singapore: ~3TWh/yr Tidal In-Stream, Wave ?
- Philippines: 170GW ORE (Phil Dept. of Energy)
- Malaysia (UTM): Wave 150kW/m, Current 14MWh/m^2/yr
- Indonesia: 727GW ORE (INOCEAN)
- Brunei, Myanmar, Thailand, Vietnam

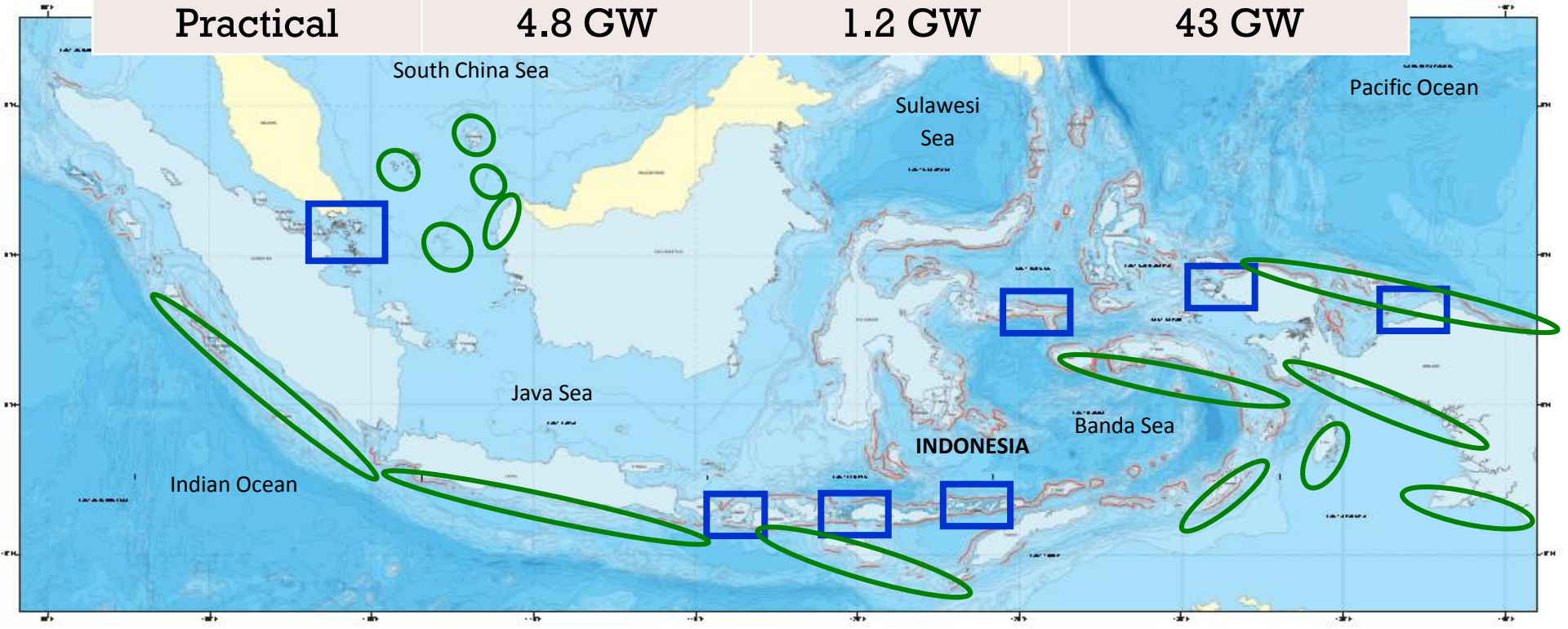






* ORE Potential: Indonesia[1]

Potential	Tidal Current	Ocean Wave	Ocean Thermal
Theoretical	160 GW	510 GW	57 GW
Practical	4.8 GW	1.2 GW	43 GW



Tidal Current Energy Reserves

Wave Energy Reserves

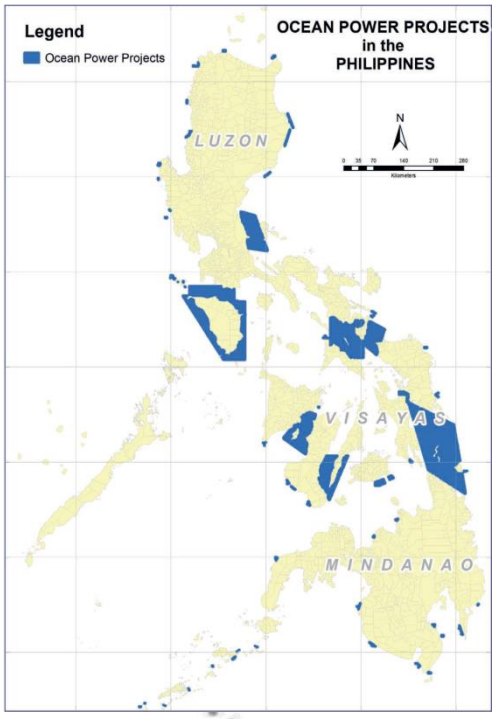
Contour showing water depth having > 20 ℃ Temp. Gradient

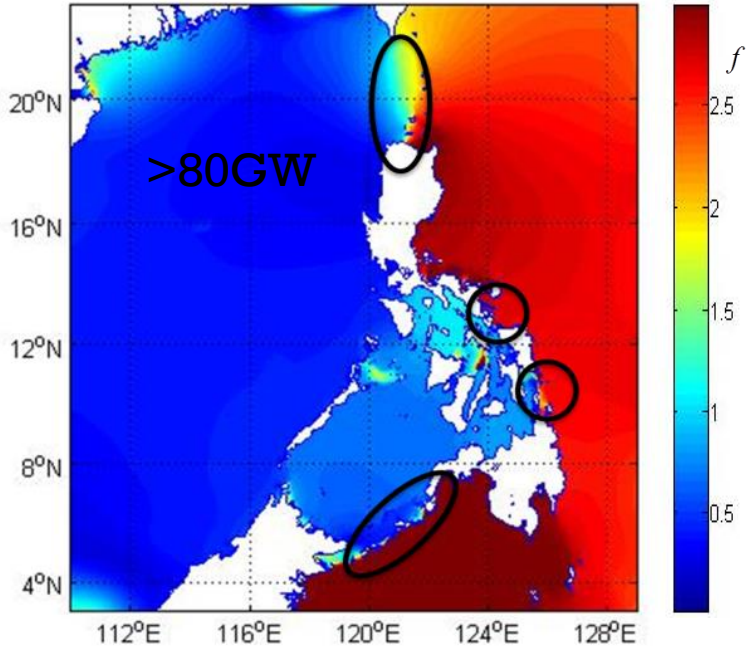
[1]INOCEAN 2013

Wave Energy: Albatern's WaveNET

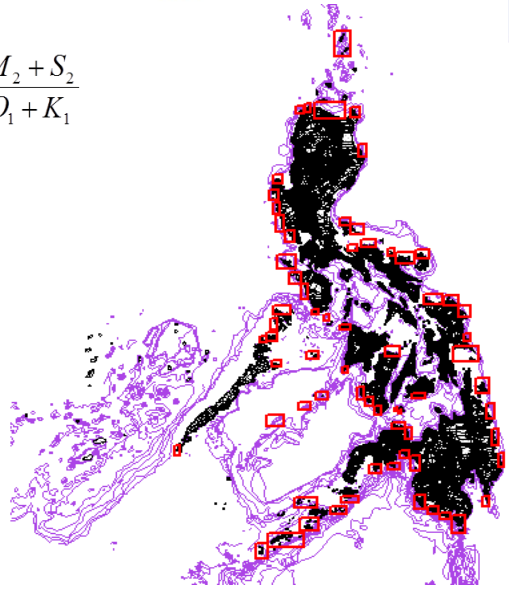
* ORE Potential: Philippines (170 GW)

(a) Tidal Current (b) Ocean Thermal (c) Wave





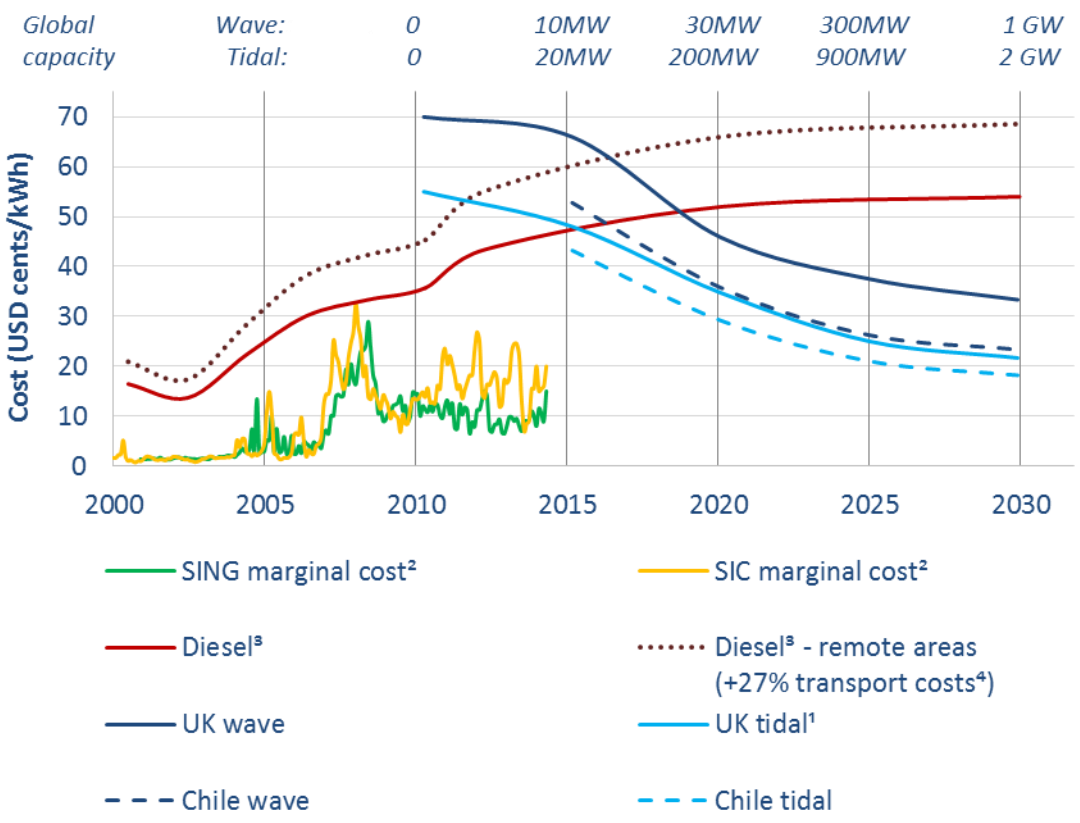
Tidal In-Stream Energy Potential Sites



Wave Energy Potential Sites

OTEC Route to Grid Parity

Wave and tidal



Sources: [1]Carbon Trust; [2]CNE; [3]World Bank/Bloomberg; [4]Chilean Ministry of Energy

Marine energy markets:

LONG TERM
Grid electricity

MEDIUM TERM
Diesel replacement; water pumping and desalination (mines)

SHORT TERM
Remote diesel replacement

Some Costs in South East Asia

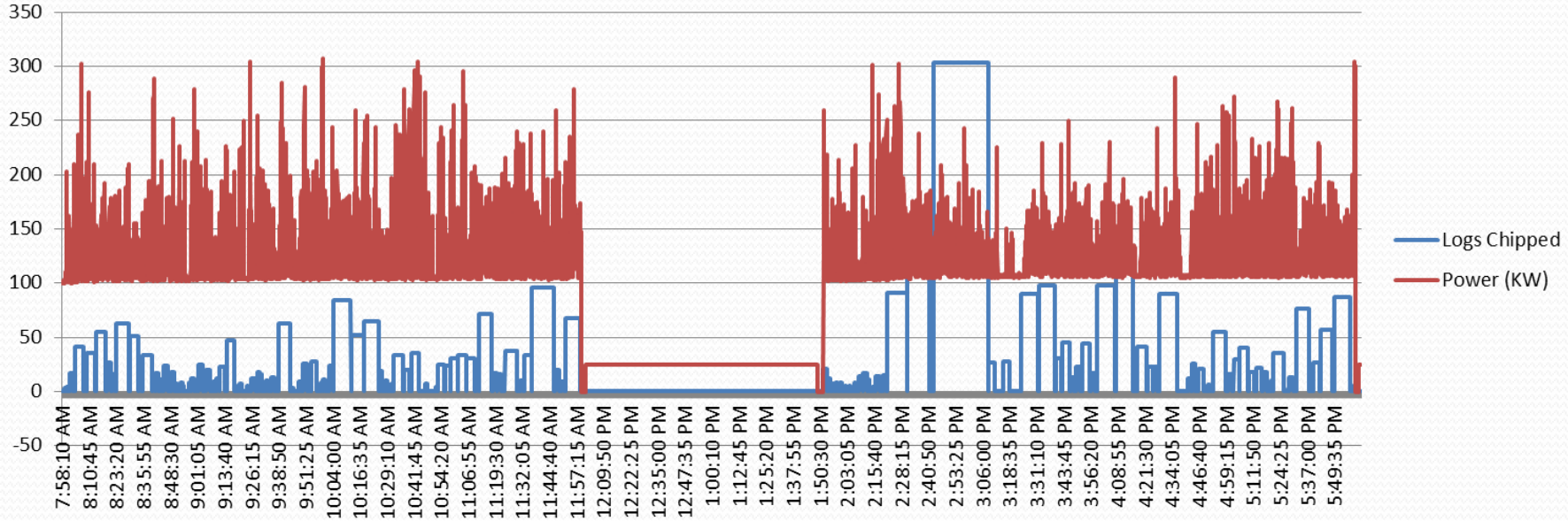
- Sinkers: $500 to $1k / ton → $100/ton
- Surveys (ADCP Transect + Seabed-mounted): $100k → $30k-$50k
- Barge-Based Floating Support System: $250k → $50k to $100k
- Tug boats / Survey Vessels: ~$10k/day → $1k - $5k/day
- Feasibility Studies: $500k-600k/site → $150k - $300k/site
  - Environment Compliance Certificate (5MW to <100MW): $50k-$100k
- Deployed 2m Diameter Tidal Turbine
  - Support Structure(Floating)+Mooring+Installation = $60k
- Piling, Crane Barges, Cabling…

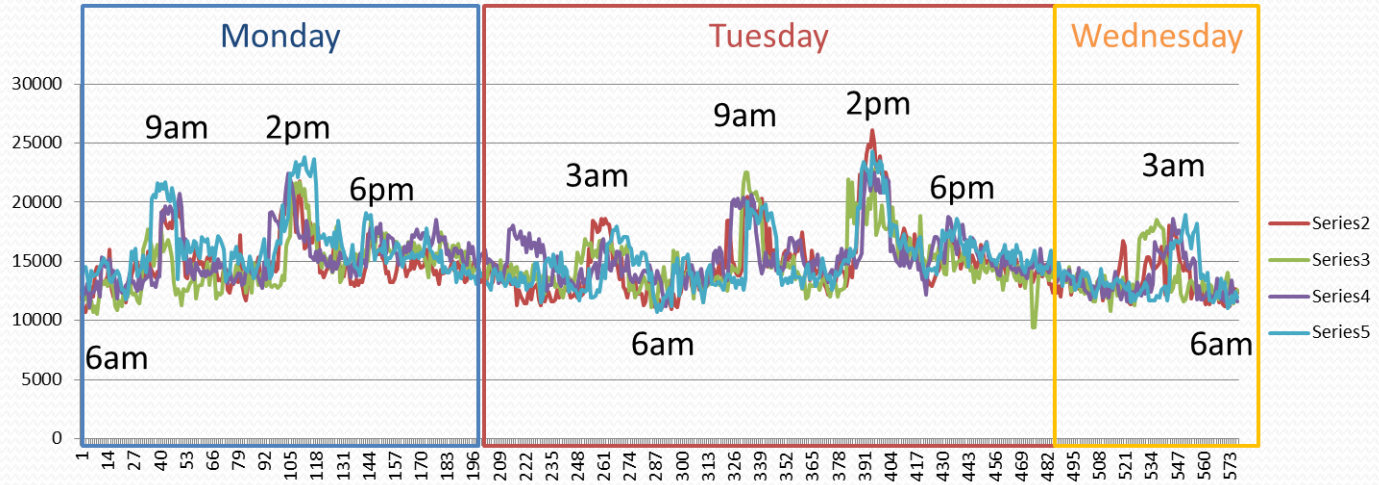
SEA Case Study: Island with Industry

The BUMWI Micro-Grid

SHIP LOADING
BC-15
BC-14
BC-12A
TOWER HOIST CRANE
INDUSTRY
CHIP YARD
GENSET
NEW WORKSHOP
GENERAL OFFICE
WATER PUMP
WAREHOUSE
SPORTS FIELD
DORM
BADMINTON
BATHROOM
MOSQUE
YOU ARE HERE
FUEL WAREHOUSE
1
2
3
4
5
6
7
8
BUMWI
Main & Sub-Main Plan

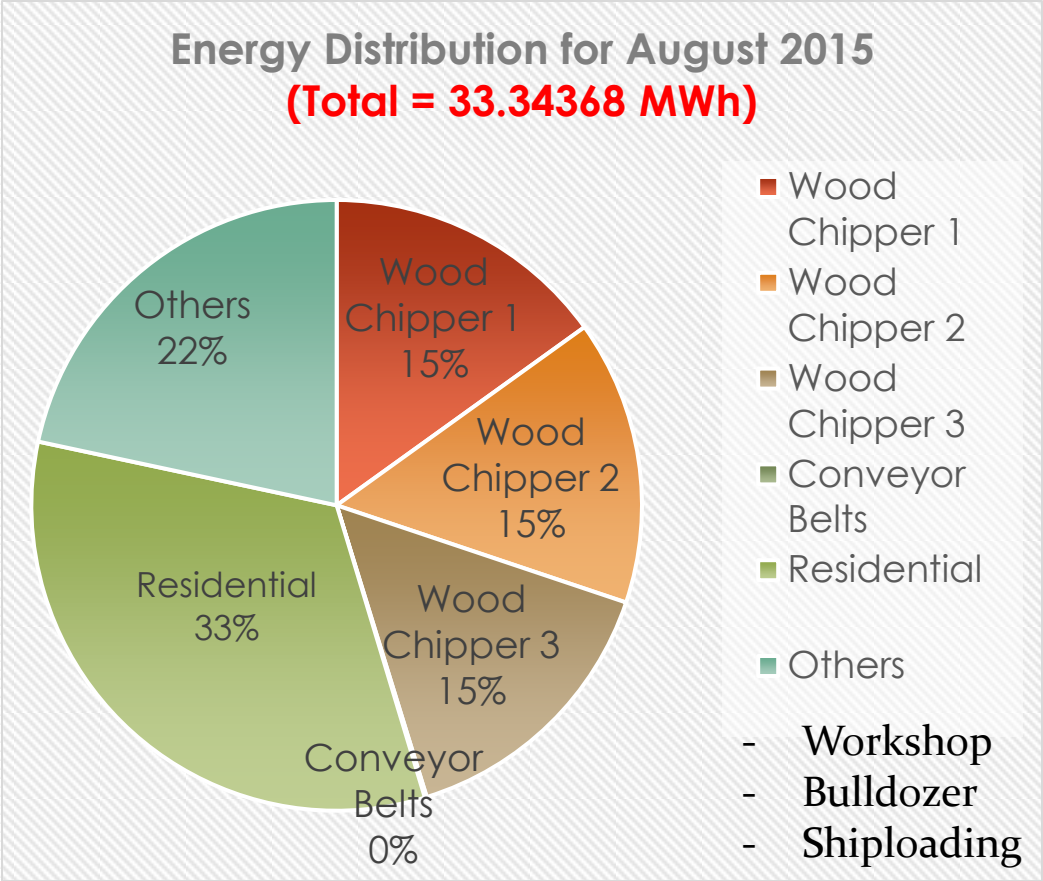
Industrial Island Energy Use



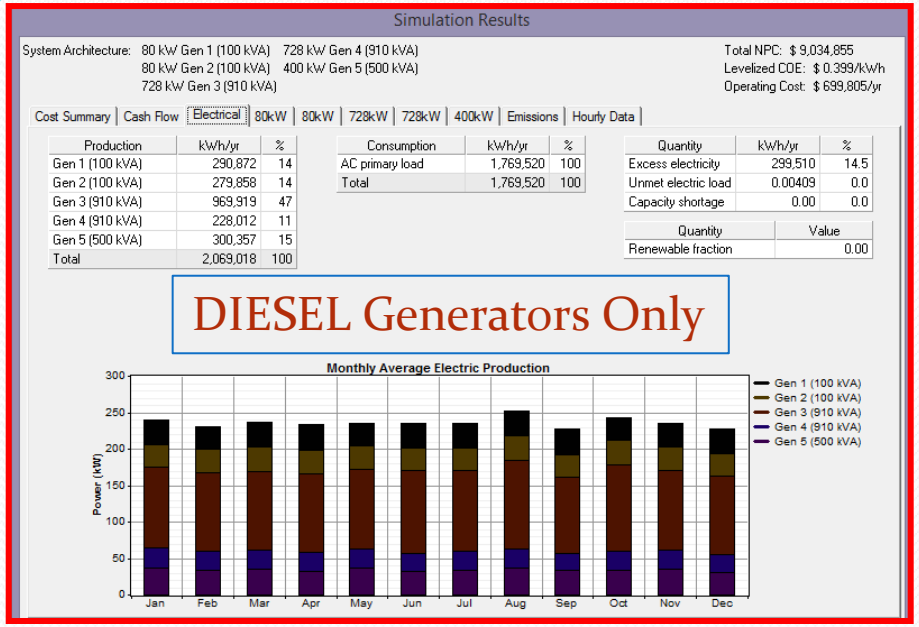


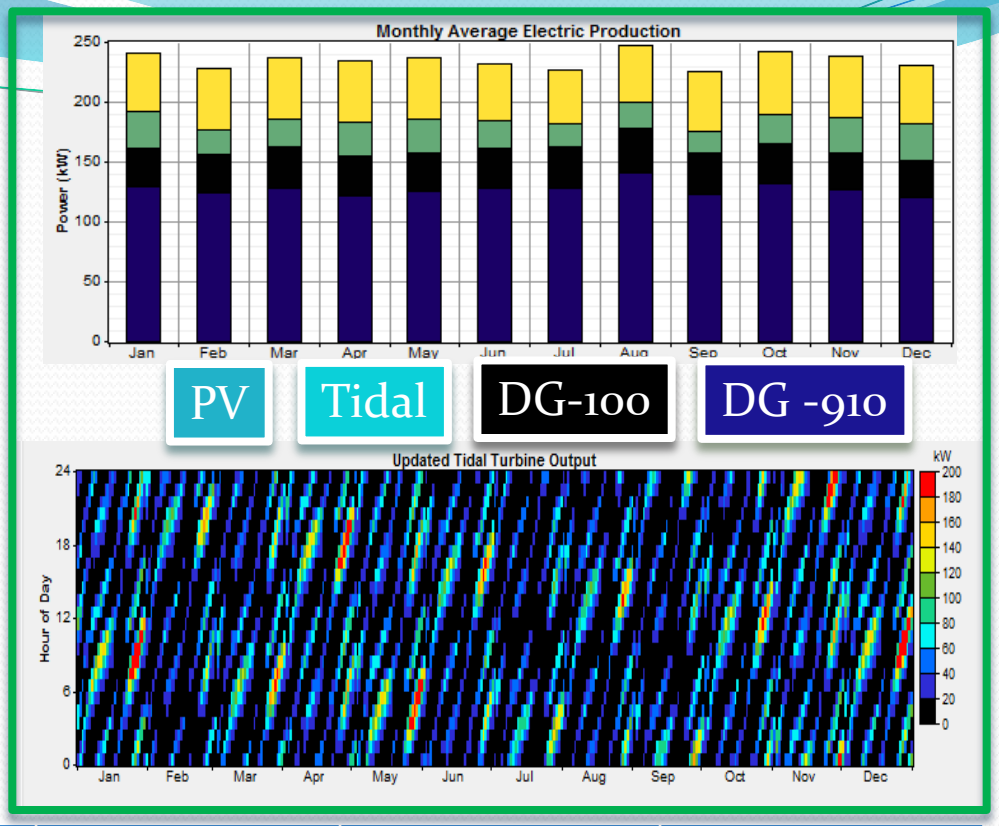
Summary of Energy Statistics

- **Diesel Cost (Aug)**
  - 18,800li x $0.89/li
  - $16,732
- **Eff. Electricity Rate:**
  - $0.5/kWh
- **Electricity Costs**
  - ~$7,563 Industry
  - ~$5,502 Residential
  - ~$3,667 Others
- **Electricity Cost/Log:** $0.045
  - Logs/Month:~165k
  - 21 x 7,870 logs/day

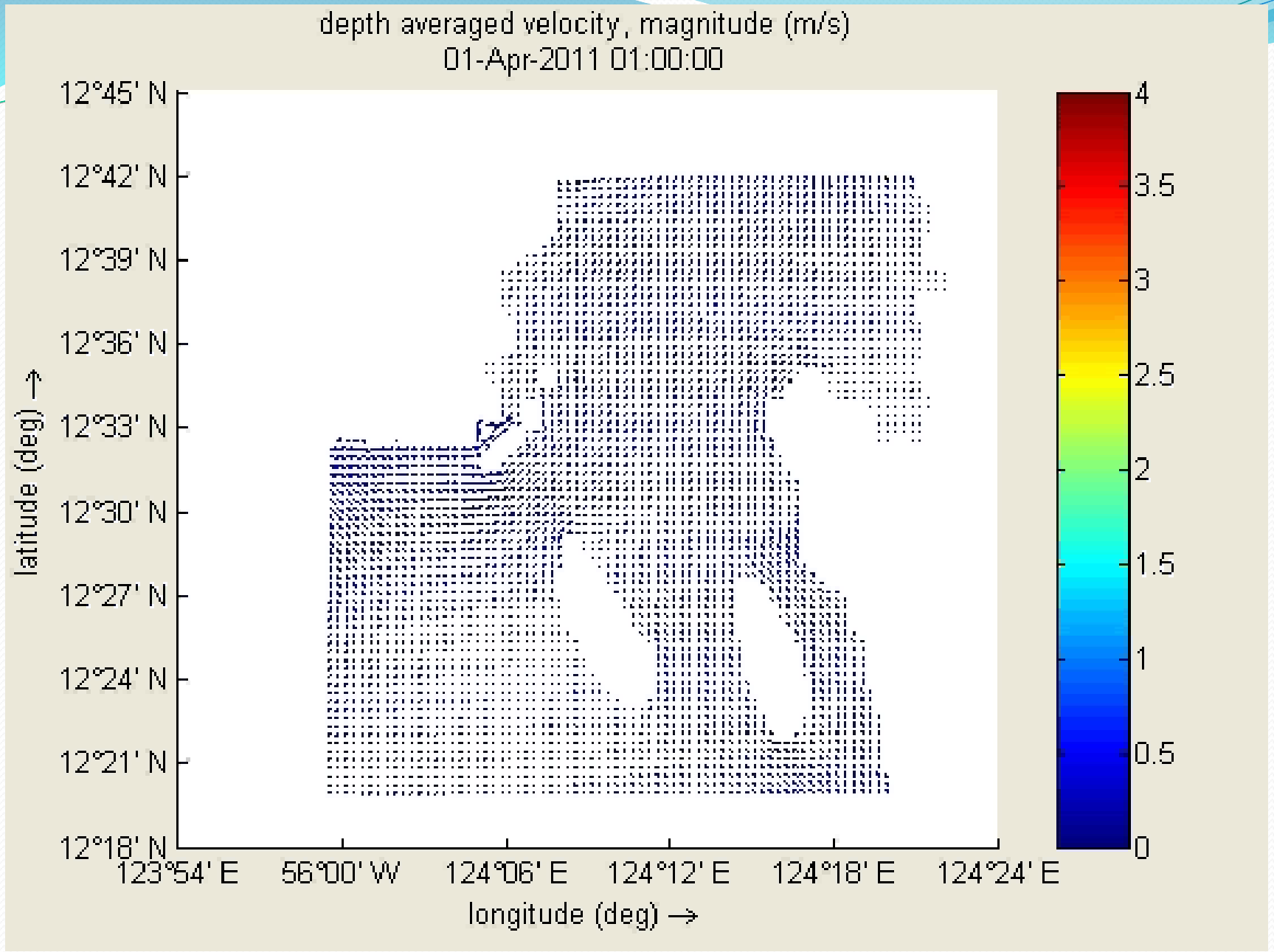


Case Study: Hybrid System for an Island Micro-Grids

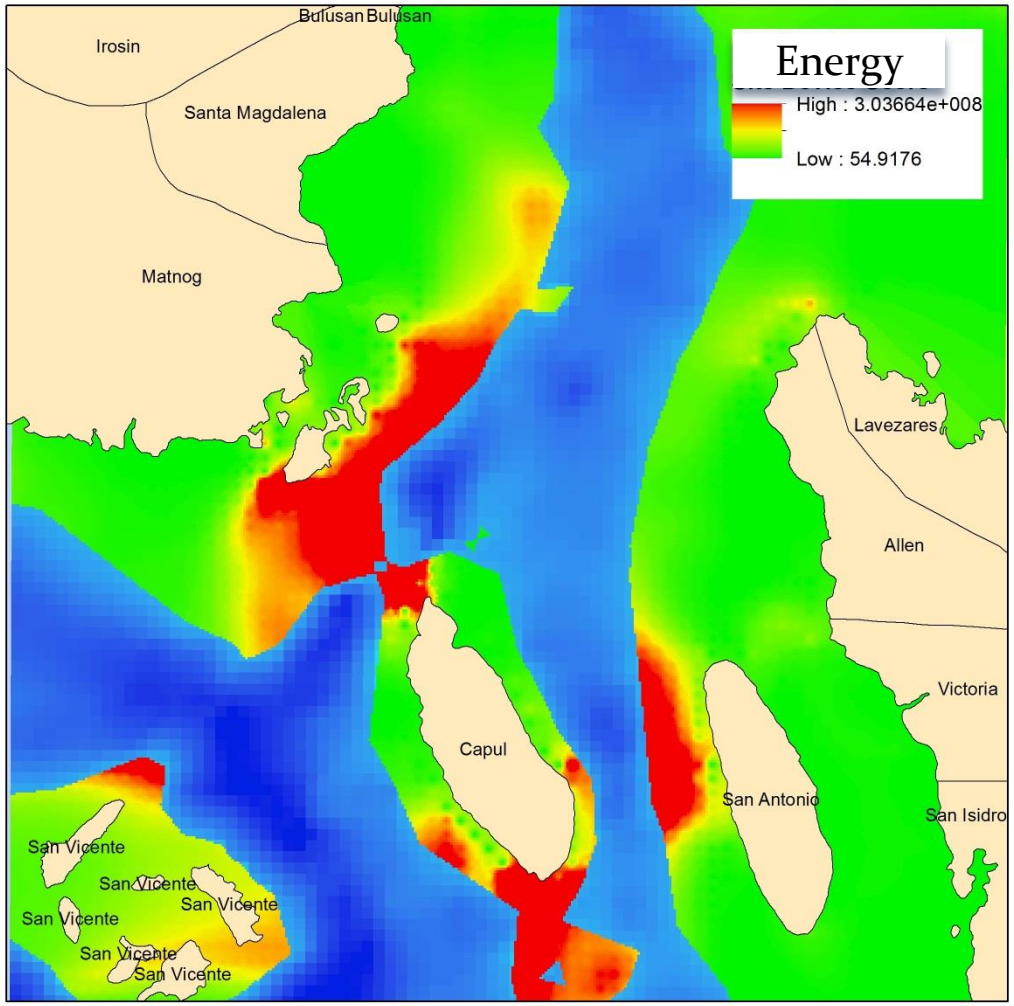


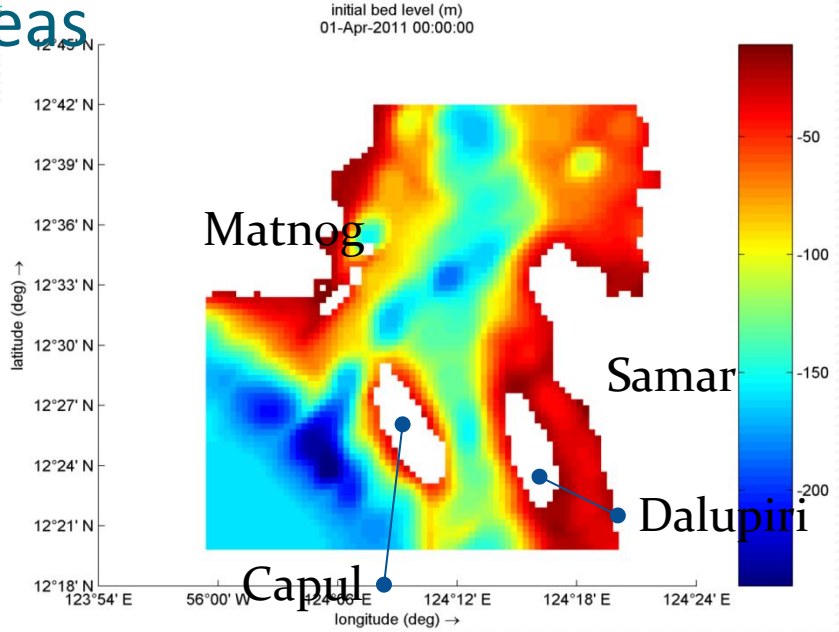


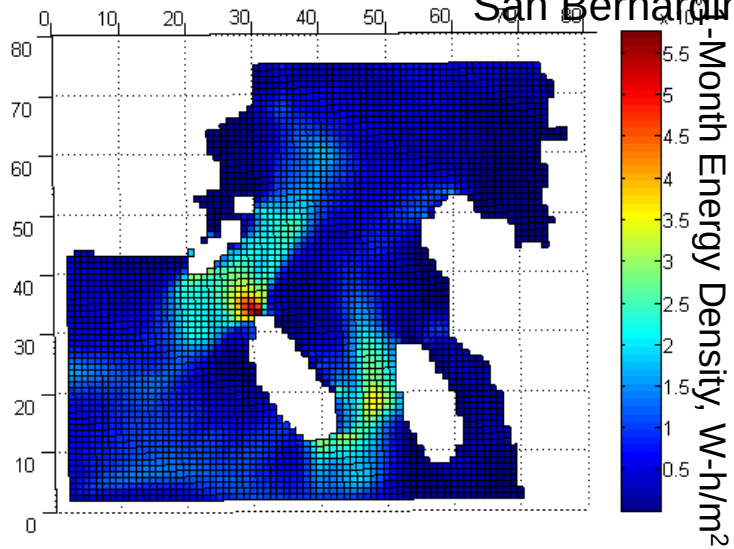
Power System Config.	RE Fraction	Excess Electricity	LCOE (USD/kWh)
Diesel GenSets (910, 100 kVA) + Batt (576kWh) + Solar (300kWp) + Tidal (300kWp)	**31.6%**	**12.6%**	**0.368**
Diesel GenSets (910kVA, 100 kVA) + Batt (720kWh) + Solar (600kWp)	38.6%	20.1%	0.386
Diesel GenSets (910kVA, 100 kVA)+Batt.(1440kWh)	0.0 %	2.47%	0.456
Diesel GenSets (2x 910, 500, 100 kVA)	0.0 %	14.5%	**0.50**

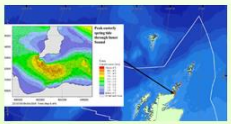
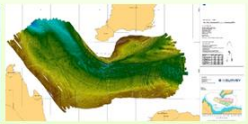

depth averaged velocity, magnitude (m/s)
01-Apr-2011 01:00:00
12°45' N
12°42' N
12°39' N
12°36' N
12°33' N
12°30' N
12°27' N
12°24' N
12°21' N
12°18' N
latitude (deg) →
123°54' E
56°00' W
124°06' E
124°12' E
124°18' E
124°24' E
longitude (deg) →
4
3.5
3
2.5
2
1.5
1
0.5
0

Potential Feasible Installation Areas (Applied Depth-Mask of <100m)







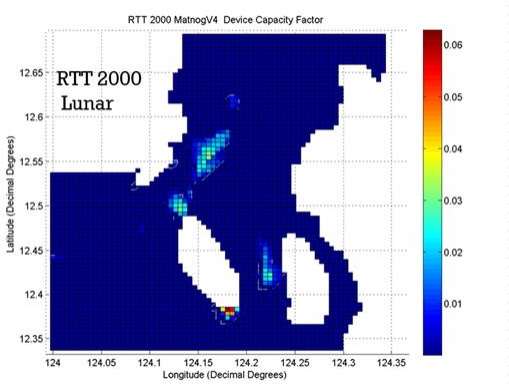




OceanPixel

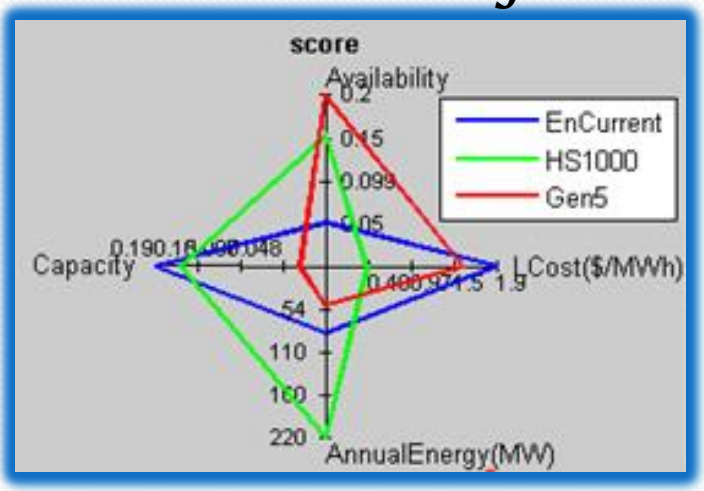
Data Analytics, Intelligence, Suitability, Decision Support

Multi-Site, Multi-Device, Multi-Criteria Geographic Information System

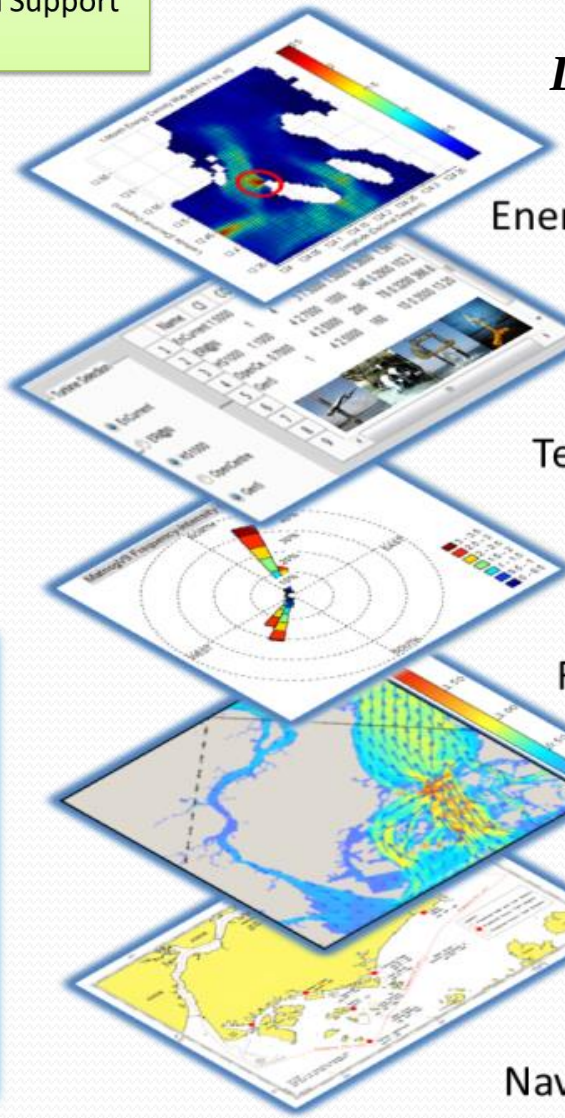
Suitability Maps



Multi-Metric Scoring Tools



Data Analytics



- Energy Density
- Project Dev't Planning
- Environmental Scores
- Technology Library
- Distance-to-Shore
- Resource Analysis
- Cost Ranging
- Resource Data
- Decision Support Maps
- Navigation & Shipping Considerations

Summary / Conclusions

- There are Marine Renewable Energy Resources in SEA
- Unique ecosystem in SEA will (hopefully) increase the uptake of marine renewables in the region
- Need for actual projects beyond R&D in SEA…
- Project Pathways may take different forms: from community-scale to commercial grid-connected projects.
- Progressive Development of Sites (Phased Approach) seems to be an attractive strategy for developers

Thank you.

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Fluid. Intelligence.

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southeast asian collaboration for ocean renewable energy