



Marine Energy Performance Models

Matt Prilliman
2021 SAM Webinars
August 18th, 2021

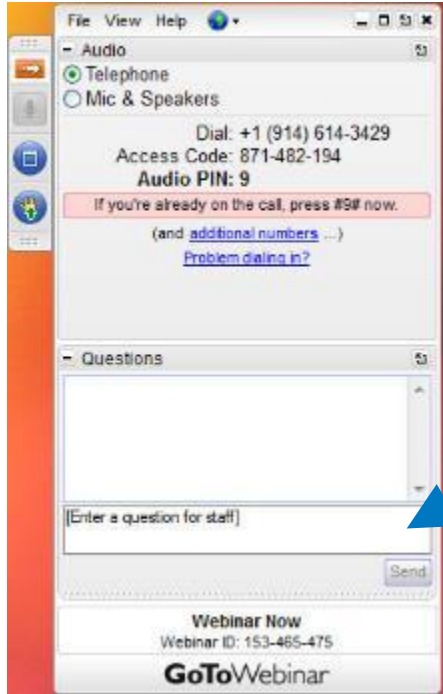
SAM Webinars for 2021

Merchant Plant Financial Model	August 4
Marine Energy Performance Models	August 18
New Battery Model Features	September 1
New Community Solar Financial Model	September 15
Electricity Bill Calculator Updates	September 29

Register for free at: <https://sam.nrel.gov/events.html>

Find webinar recordings at <https://sam.nrel.gov/>

Questions and Answers



Desktop application



Instant Join Viewer

We will either type an answer to your question or answer it at the end of the presentation.

Outline

- 1** What is SAM?
- 2** Wave and Tidal model overview
- 3** Upcoming work
- 4** SAM Live demo
- 5** Discussion of Results
- 6** Questions and Answers

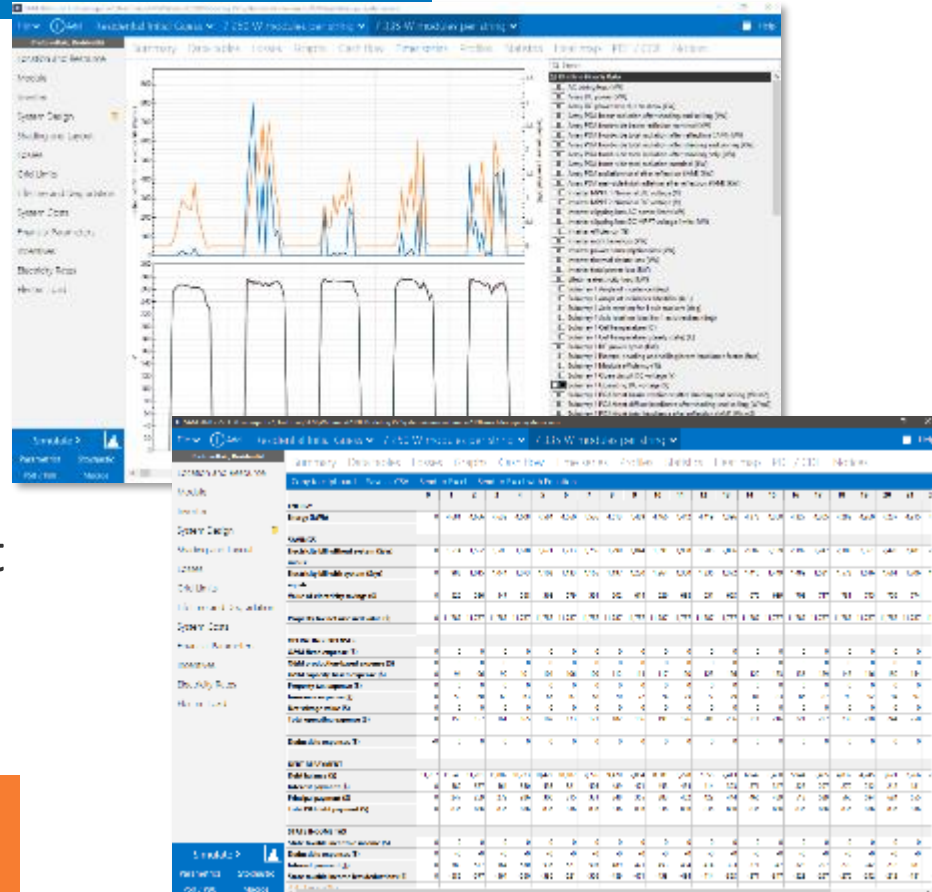
What is SAM?

The System Advisor Model

Free computer software developed and distributed by the U.S. Department of Energy's National Renewable Energy Laboratory

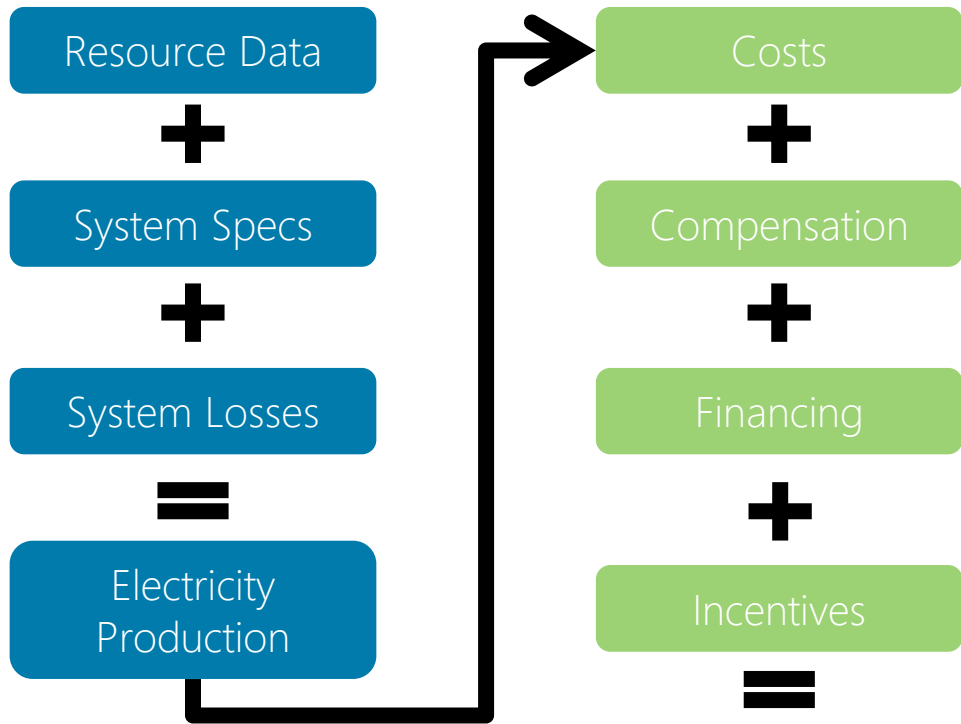
Calculates:

- A power system's energy output over one year
- A power system's economic performance



“Introduction to SAM 2020.2.29”
<https://sam.nrel.gov>

What is SAM?



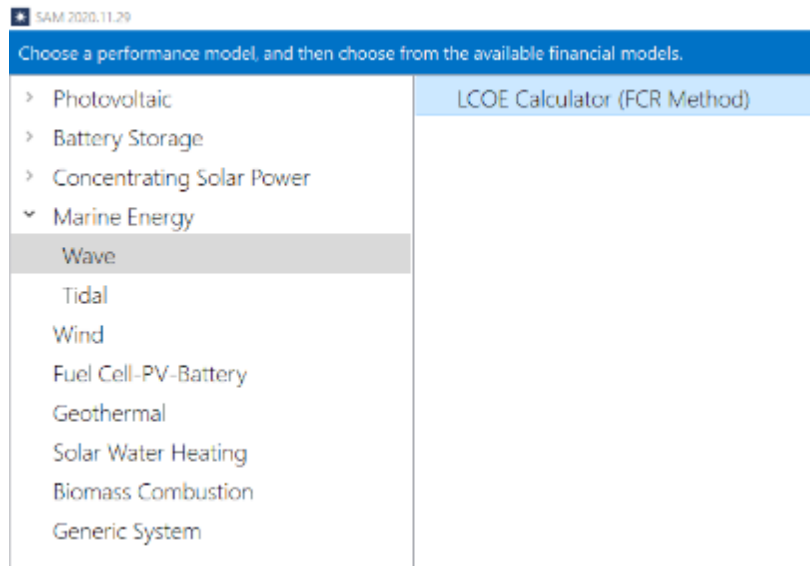
Results

Annual, Monthly, and Hourly Output, Capacity Factor, LCOE, NPV, Payback, Revenue

What is SAM? – Financial Models

SAM's Financial Models

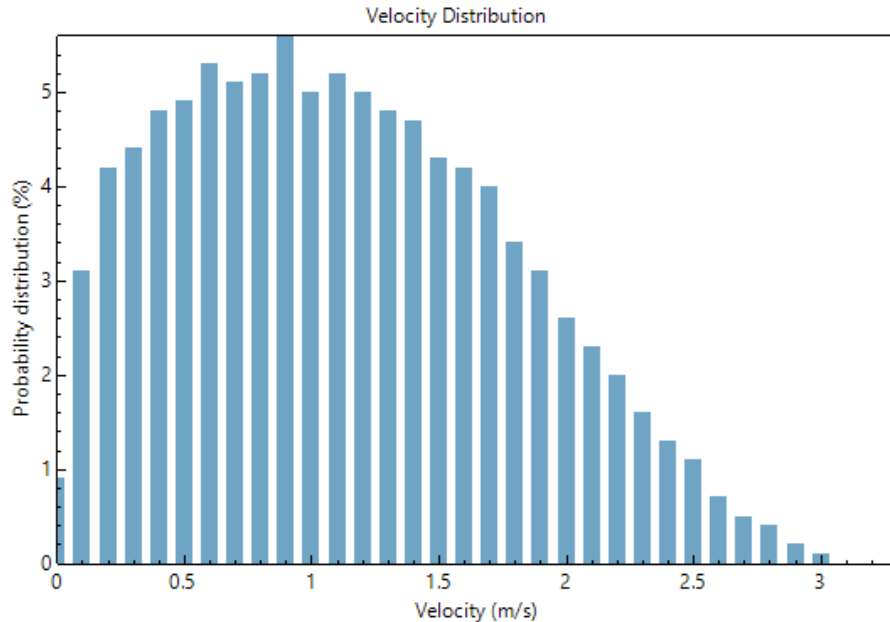
- Residential & Commercial
- Power Purchase Agreement (PPA)
- Third Party Ownership
- LCOE Calculator



<https://sam.nrel.gov/forum/>

Tidal Performance Model - Resource

- Stream velocity with probability distribution fraction
- Can import from csv or copy/paste

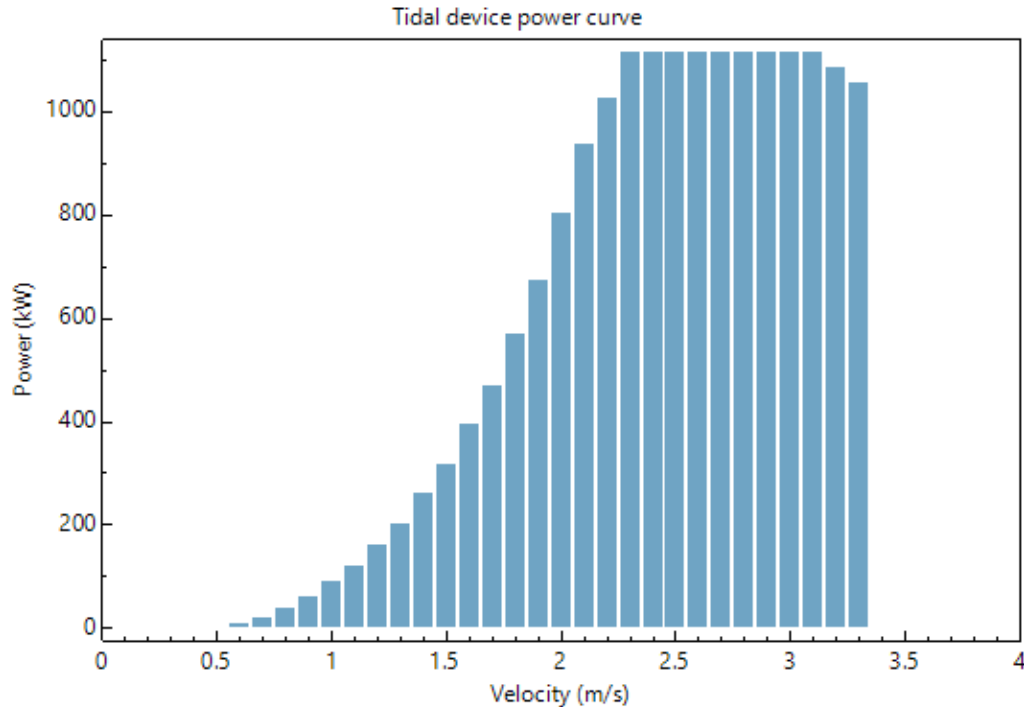


Sum of Probability Distribution Values

Velocity (m/s)	Probability Distribution
0	0.009
0.1	0.031
0.2	0.042
0.3	0.044
0.4	0.048
0.5	0.049
0.6	0.053
0.7	0.051
0.8	0.052
0.9	0.056
1	0.05
1.1	0.052
1.2	0.05
1.3	0.048
1.4	0.047
1.5	0.043
1.6	0.042
1.7	0.04
1.8	0.034
1.9	0.031
2	0.026
2.1	0.023
2.2	0.02
2.3	0.016
2.4	0.013
2.5	0.011
2.6	0.007
2.7	0.005
2.8	0.004
2.9	0.002
3	0.001
3.1	0
3.2	0
3.3	0

Tidal Performance Model - WEC

- Stream velocity with power output in kW
- Can import from csv or copy/paste



Velocity (m/s)	Power (kW)
0	0
0.1	0
0.2	0
0.3	0
0.4	0
0.5	0
0.6	10.4211
0.7	20.8423
0.8	39.9689
0.9	59.0956
1	89.2016
1.1	119.308
1.2	160.886
1.3	202.464
1.4	259.292
1.5	316.12
1.6	392.673
1.7	469.226
1.8	570.306
1.9	671.386
2	802.908
2.1	934.43
2.2	1024.71
2.3	1115
2.4	1115
2.5	1115
2.6	1115
2.7	1115
2.8	1115
2.9	1115
3	1115
3.1	1115
3.2	1085.37
3.3	1055.73

Wave Performance Model - Resource

- Wave resource defined as a joint probability distribution (JPD)
- % annual frequency of wave at given significant wave height, wave energy period
- Upcoming: API downloads of WPTO U.S. Wave dataset as JPD or as time series
<https://registry.opendata.aws/wpto-pds-us-wave/>

		Te = wave energy period (s)																				
		0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5
Hs = significant wave height (m)	0.25	0	0	0	0	0	0	0	0.02	0.03	0	0	0	0	0	0	0	0	0	0	0	0
	0.75	0	0	0	0	0.02	0.46	1.49	2.68	1.91	1.1	0.53	0.17	0.02	0	0	0	0	0	0	0	0
	1.25	0	0	0	0	0.01	0.59	4.11	5.56	4.48	2.74	1.28	0.67	0.33	0.07	0.02	0.02	0	0	0	0	0
	1.75	0	0	0	0	0	0.12	3.27	5.14	4.62	3.93	2.11	1.24	0.76	0.31	0.1	0.03	0	0	0	0	0
	2.25	0	0	0	0	0	0	0.92	5.25	3.68	4.14	2.87	1.31	0.84	0.42	0.2	0.08	0.02	0	0	0	0
	2.75	0	0	0	0	0	0	0.14	2.43	2.6	2.82	2.85	1.57	0.8	0.32	0.14	0.06	0.02	0	0	0	0
	3.25	0	0	0	0	0	0	0	0.45	1.54	1.47	1.96	1.42	0.79	0.32	0.11	0.04	0.02	0.01	0.01	0	0
	3.75	0	0	0	0	0	0	0	0.05	0.49	0.63	1.08	1.01	0.63	0.29	0.1	0.05	0.02	0	0	0	0
	4.25	0	0	0	0	0	0	0	0	0.09	0.21	0.45	0.56	0.42	0.21	0.07	0.02	0.02	0	0	0	0
	4.75	0	0	0	0	0	0	0	0	0.02	0.08	0.12	0.26	0.27	0.19	0.07	0.02	0.01	0	0	0	0
	5.25	0	0	0	0	0	0	0	0	0	0.03	0.03	0.11	0.15	0.13	0.07	0.02	0	0	0	0	0
	5.75	0	0	0	0	0	0	0	0	0	0	0	0.02	0.07	0.05	0.05	0.02	0	0	0	0	0
	6.25	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.04	0.02	0.01	0	0	0	0	0
	6.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0.02	0	0	0	0	0	0
	7.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Wave Performance Model - WEC

- Wave energy converters power output defined over same wave height, wave period bins as resource JPD
- Existing: matrices from Reference Model Project, can import own power matrix (<https://energy.sandia.gov/technology-development/reference-model-project-rmp/>)
- Upcoming: can use JPD, or match time series resource data to closest entry in power matrix

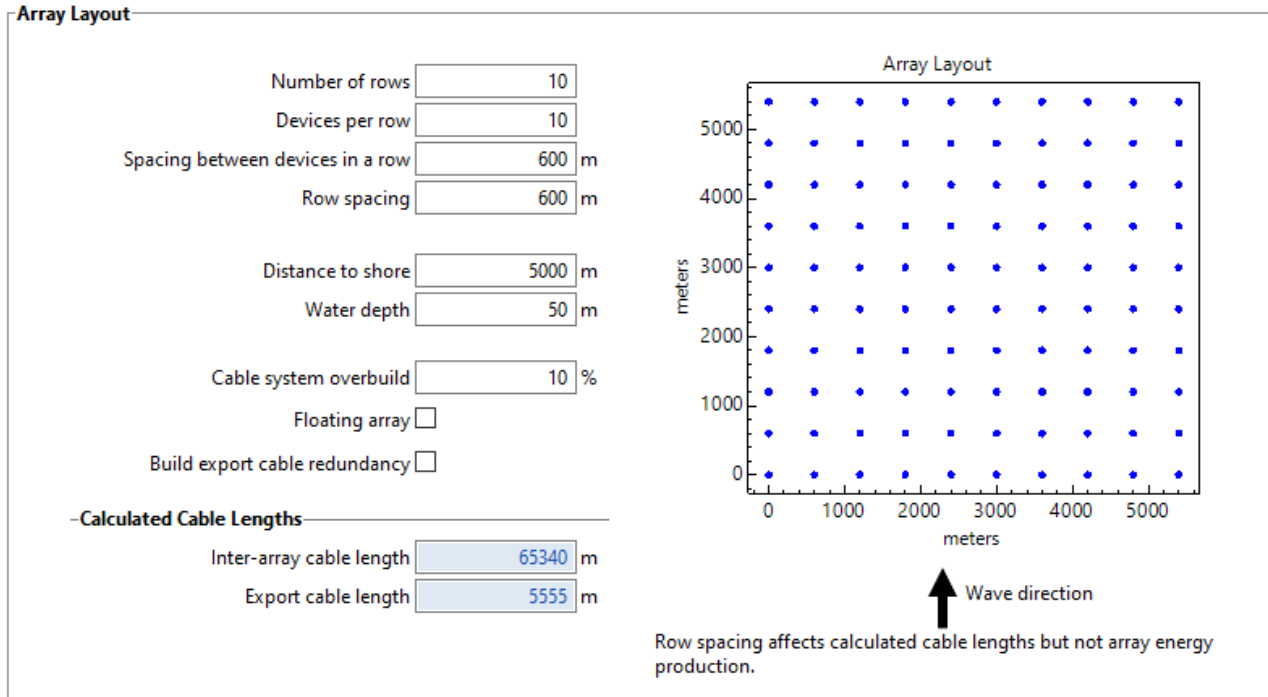
Te = wave energy period (s)

	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	
0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2	0.2	0.2	0.1	0.1	0	0	0
1.25	0	0	0	0	0	0	0	4.3	14.7	19	21.3	18.8	16.2	13	10.1	7.6	5.7	4.2	3.1	0	0	0
1.75	0	0	0	0	0	0.2	35.2	68.4	75.1	70.9	64.1	55.3	46.6	38.3	30.8	24.1	18.9	14.8	11.6	0	0	0
2.25	0	0	0	0	0.1	26.6	128.3	145.6	142	132.2	120	106.1	91.4	76.1	61.2	48.8	39.2	31.4	25.1	0	0	0
2.75	0	0	0	1.6	0.6	121.3	215.7	229	219.9	202.5	182	159.3	137.2	117	90.4	61.5	45.3	32.4	22	0	0	0
3.25	0	0	0	19.8	36.5	212.4	288.1	321.7	305	278.8	250.2	220.9	188.3	159.8	133.6	110.3	93.2	77.3	64.1	0	0	0
3.75	0	0	0	46.3	120.2	212.4	288.1	330.7	350.5	348.6	319.2	278.6	237.8	202.8	170.4	140.7	119.9	101.5	86	0	0	0
4.25	0	0	0	84.7	142.3	212.4	288.1	330.7	350.5	348.6	339.7	337.6	284.8	233.4	196.4	149.2	129.5	112.8	98.3	0	0	0
4.75	0	0	0	114	142.3	212.4	288.1	338.7	350.5	344.8	339.7	349.0	289.4	241.1	196	160.2	137.8	118	101.1	0	0	0
5.25	0	0	0	114	142.3	212.4	288.1	330.7	350.5	344.8	339.7	350.1	309.3	261.9	206.1	172.1	146.6	123.5	104	0	0	0
5.75	0	0	0	114	142.3	212.4	288.1	338.7	350.5	344.8	339.7	350.1	276.1	217.7	216.8	184.8	156	129.2	107	0	0	0
6.25	0	0	0	114	142.3	212.4	288.1	330.7	350.5	344.8	339.7	350.1	276.1	217.7	205.4	189.1	169.8	153.4	145.6	0	0	0
6.75	0	0	0	114	142.3	212.4	288.1	330.7	350.5	344.8	339.7	350.1	276.1	217.7	205.9	193.4	181.1	171.3	165.9	0	0	0
7.25	0	0	0	114	142.3	212.4	288.1	338.7	350.5	344.8	339.7	350.1	276.1	217.7	207.9	198.3	189.8	183.5	180.7	0	0	0
7.75	0	0	0	114	142.3	212.4	288.1	330.7	350.5	344.8	339.7	350.1	276.1	217.7	209.9	202.5	196.3	191.9	190	0	0	0
8.25	0	0	0	114	142.3	212.4	288.1	338.7	350.5	344.8	339.7	350.1	276.1	217.7	211.4	205.7	200.9	197.6	196.2	0	0	0
8.75	0	0	0	114	142.3	212.4	288.1	330.7	350.5	344.8	339.7	350.1	276.1	217.7	212.5	207.8	204	201.4	200.3	0	0	0
9.25	0	0	0	114	142.3	212.4	288.1	330.7	350.5	344.8	339.7	350.1	276.1	217.7	213.2	209.1	205.0	203.5	202.6	0	0	0
9.75	0	0	0	114	142.3	212.4	288.1	338.7	350.5	344.8	339.7	350.1	276.1	217.7	213.4	209.6	206.5	204.4	203.5	0	0	0

Hs = significant wave height (m)

ME Performance Models - Arrays

- Model single device, specify desired capacity, or number of devices
- Cable length calculated based on number of devices, row spacing



ME Performance Models - Losses

- Specify % energy loss based on following categories:
 - Array spacing
 - Resource overprediction
 - Transmission
 - Array/ device downtime
 - Additional losses
- Sum for total % loss
- Defaults
 - 2% transmission loss
 - 5% device downtime

Array Spacing Losses

Losses associated with interactions of devices due to spacing.

Array spacing %

Resource Overprediction Losses

Reduction from resource uncertainty associated with installing the device in waters at a depth or distance outside parameters of resource file (e.g. shallow waters close to shore, large distance from measuring buoy).

Resource overprediction %

Transmission Losses

Related to the efficiency of the electrical infrastructure for the array, such as inter-device cabling, export cabling, substations, and onshore transmission up to grid interconnection.

Transmission losses %

ME Performance Model – Costs

- New to SAM 2020.11.29: Itemized cost inputs based on the Marine Energy Cost Breakdown Structure
- Ability to enter high level or detailed cost inputs
- User decides how detailed to be with their cost inputs for each category

	Input option	Modeled value	User input	Category cost
Structural assembly	Use Cost Breakdown (\$) ▾	\$473,550,400	\$0	\$0
Power take-off system	Enter in \$ ▾	\$60,847,944	0	\$0
Mooring, Found., and Substruc.	Use Modeled Value (\$) ▾	\$71,658,504	0	\$71,658,504
			Total device costs	\$71,658,504

Override cost structure

	Category Totals	Sub-Category Totals
Prime mover	\$0 ⓘ	
	<input type="checkbox"/> Enter detailed costs	
Primary structural assembly		\$0
Buoyancy chambers		\$0
External ballast chambers		\$0
Active structure		\$0
Other prime mover costs		\$0
Additional structural components	\$0 ⓘ	
Marine systems	\$0 ⓘ	
	<input checked="" type="checkbox"/> Enter detailed costs	
Personnel access system		\$0
Ballast system		\$0
Navigation lighting		\$0
Other marine system costs		\$0

ME Performance Model – LCOE

- **Levelized Cost of Energy:** total project lifecycle cost expressed in cents per kilowatt-hour of electricity generated by the system over its life.
- **Fixed Charge Rate:** revenue per amount of investment required to cover the investment cost
 - Alternative to cash flow analysis
- User specifies FCR or calculated based on project period, tax and debt term inputs

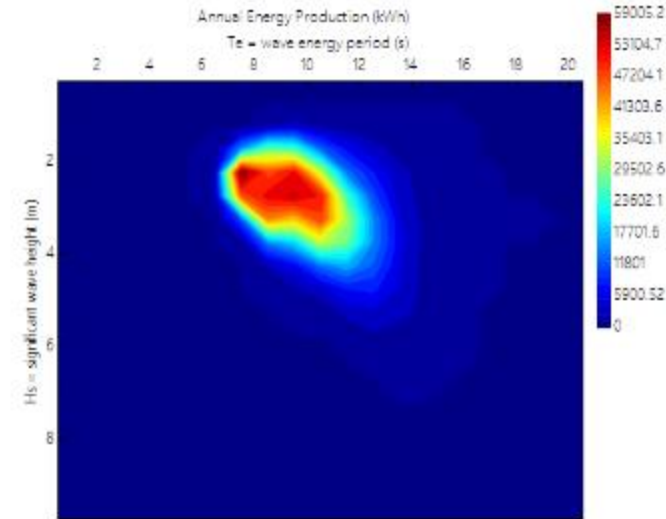
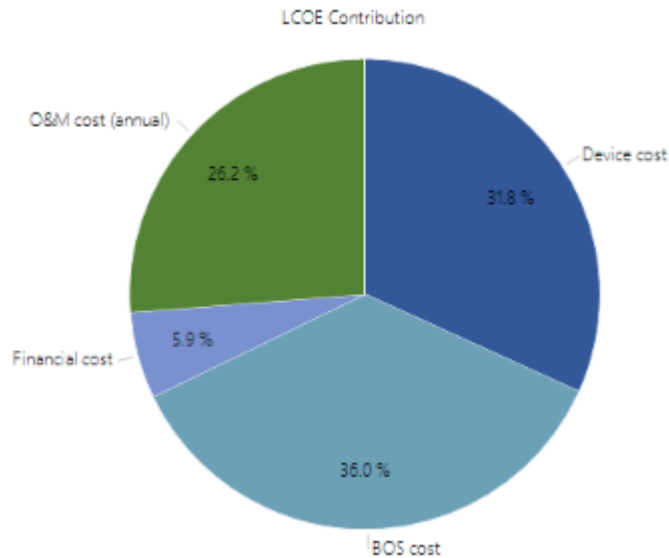
$$\text{LCOE} = \frac{\text{FCR} \times \text{TCC} + \text{FOC}}{\text{AEP}} + \text{VOC}$$

$$\text{FCR} = \text{CRF} \times \text{PFF} \times \text{CFF}$$

- LCOE: Levelized cost of energy
- FCR: Fixed charge rate
- TCC: Total capital cost
- FOC: Fixed operating cost
- AEP: Annual energy production
- VOC: Variable operating cost
- CRF: Capital recovery factor
- PFF: Project financing factor
- CFF: Construction financing factor

ME Performance Model – Results

- Results include Annual energy production, LCOE
- Heatmap of AEP by wave height, wave period

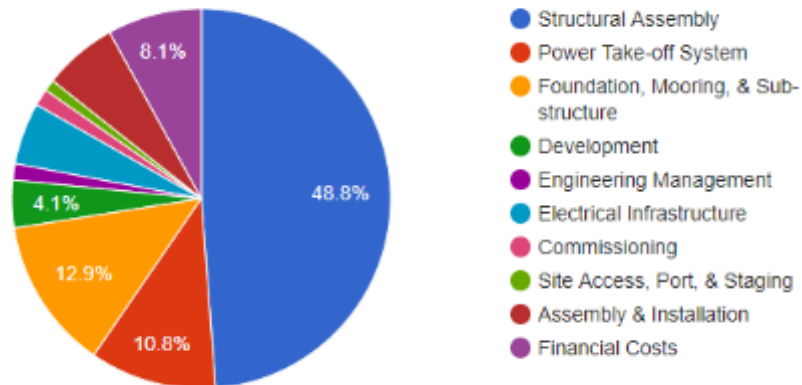


Costs	\$ million	\$/kW	LCOE
Capital cost	166.28 \$mill	4,744 \$/kW	0.19 \$/kWh
- Device cost	71.66 \$mill	2,044 \$/kW	0.08 \$/kWh
- Balance of system cost	81.22 \$mill	2,317 \$/kW	0.09 \$/kWh
- Financial cost	13.40 \$mill	382 \$/kW	0.02 \$/kWh
O&M cost	6.39 \$mill/yr	182 \$/kW/yr	0.07 \$/kWh

ME Wave Report Macro

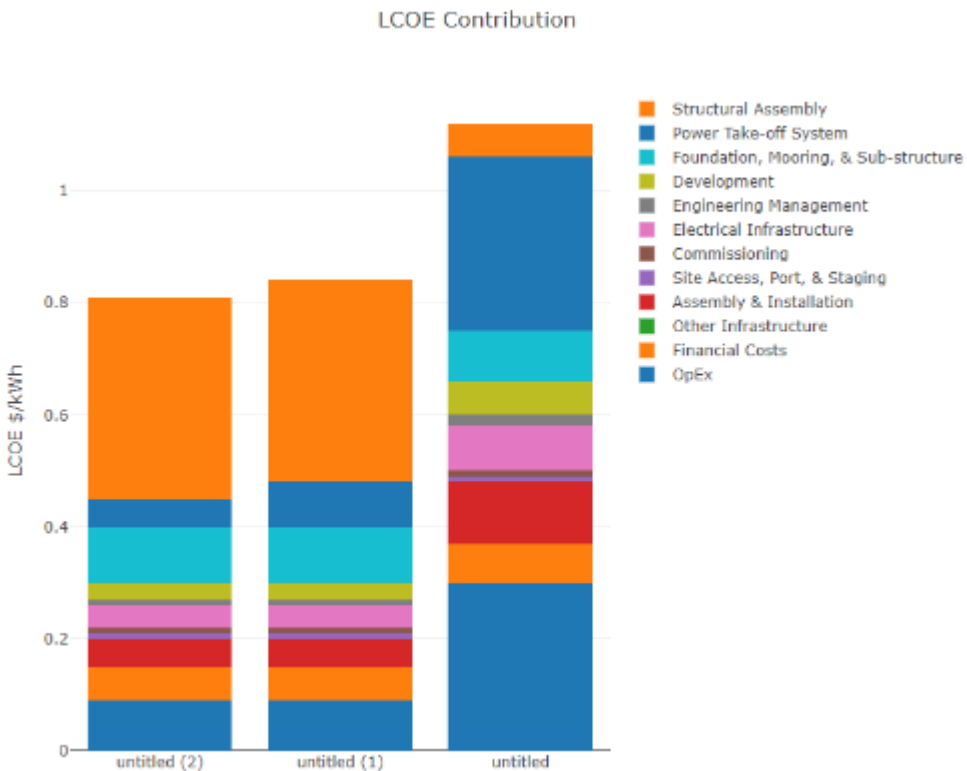
- Generate report based on data in SAM case
- Exports to html
- Interactive plot tools

Capital Expenditures



ME Wave Compare Cases Macro

- Compare costs for two or more cases
- Exports to html
- Interactive plot tools



ME Wave Report Template

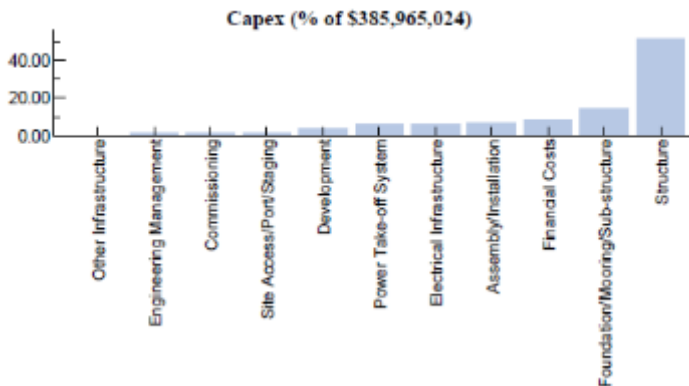
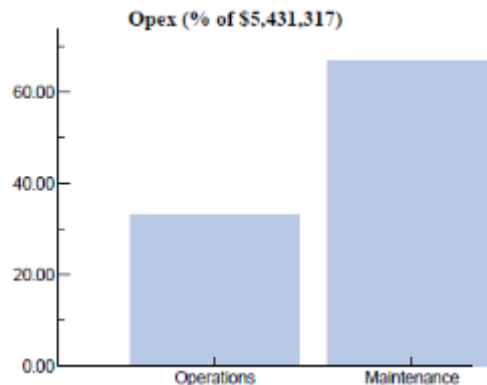
- Pdf report template with performance and cost information from given case

System Costs

	\$	\$/kW	\$/kWh/yr	Value Type
Capital Expenditures				
Marine Energy Converter				
Structural Assembly	198,679,680	6,947	0.36	modeled
Power take-off System	44,014,128	1,539	0.08	modeled
Mooring, Found., & Sub-Struct.	52,549,712	1,837	0.1	modeled
Subtotal	295,243,520			
Balance of System				
Development	16,536,453	578	0.03	modeled
Engineering and Management	5,655,879	198	0.01	modeled
Electrical Infrastructure	21,459,932	750	0.04	modeled
Plant Commissioning	5,832,821	204	0.01	modeled
Site Access, Port & Staging	4,010,065	140	0.01	modeled
Assembly & Installation	25,655,542	897	0.05	modeled
Other Infrastructure	0	0	0	modeled
Subtotal	79,150,688			
Financials				
Project Contingency Budget	18,227,566	637	0.03	modeled
Insurance during Construction	3,645,513	127	0.01	modeled
Reserve Accounts	10,936,540	382	0.02	modeled
Subtotal	32,809,620			
Total Capital Expenditures	407,203,840	14,238	0.74	
Operational Expenditures				
Operations	1,773,032	62	0.03	modeled
Maintenance	3,658,285	128	0.06	modeled
Total Operational Expenditures	5,431,317	190	0.09	

System Performance

Annual Energy Production, kWh	59,434,320
Capacity Factor, %	23.72
Total assumed losses, %	7.00



ME Performance Model – Future Work

- Wave Resource: 3-hour time series data from WPTO US Wave dataset
 - Search by latitude and longitude
 - West Coast, Atlantic coast, and Hawaii datasets (more in the future)
 - 1979-2010
 - Download single year, multi-year range, all ~30 years
- Option to run wave model without financials
- New macros
- Improved report template, output graphs for visualizing results
- Updated electrical infrastructure cost model

ME Performance Model – Future Work

Select dataset: West coast ▾

Enter desired location coordinates: Latitude Longitude

Choose a single year 2010 ▾
 Choose years Start year End year
 Download all years (1979-2010)

Choose download folder: ...

NREL Wave Toolkit data is only available for locations in the continental United States. Each weather file contains wave resource data for a single year.

[See Help for details.](#)

Source	Location ID	Jurisdiction	Latitude	Longitude	Time Zone	Local Time Zone	Distance to Shore
DOE-WPTC	479519	b'Federal'	44.5682	-124.228	0	-8	12353.165
Year	Month	Day	Hour	Minute	Significant Wave Height	Energy Period	
2010	1	1	0	0	3.769469976	8.788399696	
2010	1	1	3	0	3.687020063	8.916899681	
2010	1	1	6	0	3.429470062	9.237400055	
2010	1	1	9	0	3.469340086	8.975099564	
2010	1	1	12	0	3.537899971	8.97729969	
2010	1	1	15	0	3.833400011	8.659999847	
2010	1	1	18	0	4.90571022	9.579099655	
2010	1	1	21	0	5.703320026	11.20189953	
2010	1	2	0	0	5.70566988	11.7954998	
2010	1	2	3	0	5.351449966	12.0145998	

SAM Walkthrough and Example

SAM Demo

Thank you!

www.nrel.gov

SAM questions: Matthew.Prilliman@nrel.gov

ME questions: Elena.Baca@nrel.gov



Extra Slides

SAM Demo

System Advisor 2017

The Welcome page displays news from the software development team at NREL, and is where you start your work in SAM

Start a new project >

Open a project file

New script

Open s...

Announcements

The National Renewable Energy Laboratory (NREL) Solar Technical Assistance Team (STAT) Network is hosting a one-day training for state decision-makers on how to use NREL's portfolio of solar tools, including SAM, to inform decisions. See the [NREL State](#)

Start a new project or open an existing one. Projects are stored as .sam files. Scripts are .lk files that store scripts for advanced analysis.

Would you like to meet the SAM team? This [webinar](#) is free. These 30-minute online sessions are held on Mountain time (GMT-6) -- all you need is an internet connection.

The latest version is SAM 2017.1.17 r4, SSC 174. To see complete version information for your SAM installation, click **About** in the lower left corner of this window.

Check here for updates, to open SAM's Help system, and to see Version number and registration information.

Quick start for new users >

Help contents

Check for updates...

Registration

About

Quit

C:\Users\gaobo\Desktop\Temp\tod factor test.sam

C:\Users\gaobo\Desktop\Temp\Marcou Mesa Project (200MW) - Disgen.sam

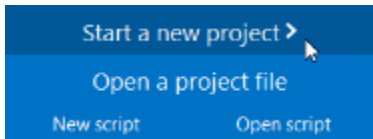
C:\Users\gaobo\Desktop\Temp\...

C:\Users\gaobo\Desktop\Temp\...

List of recent files: Double-click to open a file.

C:\Users\gaobo\Desktop\Temp\SAM Barksdale thin fix 20 080217.sam

C:\Users\gaobo\Desktop\Temp\test shading.sam



To create a new project, click Start a new project in the Welcome window, and then choose a performance model and financial model for your analysis.

Choose a performance model, and then choose from the available financial models.

- > Photovoltaic
- > Battery Storage
- > Concentrating Solar Power
- ▼ Marine Energy
 - Wave
 - Tidal
 - Wind
 - Fuel Cell-PV-Battery

List of performance models

- Biomass Combustion
- Generic System

LCOE Calculator (FCR Method)

Financial models

SAM 2010.11.29

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Marine Wave, LCOE Calculator

Wave Resource

Wave Energy Converter

Array

Losses

Capital Costs: Device

Capital Costs: BOS

Capital Costs: Financial

O&M Costs

Financial Parameters

The Main window is where you do your work in SAM.

Wave Energy Resource Library

Click a name in the list

Filter: Name

Name	City	State	Country	Latitude	Longitude	Nearby Busy Number	Average Power Flux	Bathymetry	Sea Bed	Time Zone	Data Source	Note
CalWave Central Coast South	Lompoc	California	United States	34.321	-120.689	NDBC 46218	39.9	Gently Sloping	Sandy	-7	Sandia; SAND2015-7963	Offsh
Humboldt Bay - DOE Reference	Eureka	California	United States	40.8418	-124.249	NDBC 46212	32.2	Gently Sloping	Sand and Clay	-7	Sandia; SAND2014-9440	
Jennette's Pier	Magee Head	North Carolina	United States	35.9123	-75.5063	NDBC 44395	6.08	Gently Sloping	Sandy	-4	Sandia; SAND2015-7463	Pacific
PacWave North	Nearport	Oregon	United States	44.6099	-124.135	NDBC 46094	37	Gently Sloping	Soft Sand	7	Sandia; SAND2015-7463	Pacific
PacWave South	Nearport	Oregon	United States	44.567	-124.229	NDBC 46094		Gently Sloping	Soft Sand	7	Sandia; SAND2015-7463	Pacific
USACE FRF	Duck	North Carolina	United States	36.1858	-75.7486	NDBC 44035		Gently Sloping	Soft Sand	7	Sandia; SAND2015-7963	U.S.A
U.S. Navy Wave Energy Test Site	Kanaloa	Hawaii	United States	21.47	157.75	NDBC 51207		Gently Sloping	Soft Sand	7	Sandia; SAND2015-7963	

Wave resource file name from library: C:\SAM\2020.11.29\release\wave_resource\Humboldt_California_Wave Resource Library

Annual Frequency of Occurrence of Sea States from Library

$T_s = \text{wave energy period (s)}$

	3.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5
3.25	0	0	0	0	0	0	0	0
3.75	0	0	0	0	0	0	0	0
4.25	0	0	0	0	0	0	0	0
4.75	0	0	0	0	0	0	0	0
5.25	0	0	0	0	0	0	0	0
5.75	0	0	0	0	0	0	0	0

Use these buttons to show different input pages. The highlight indicates we are now looking at the System Design input page.

Use these buttons to run simulations, view results, or for advanced simulation options.

Probability of dominant wave: 5.5% Dominant wave height: 1.23 m Dominant wave period: 7.5 s Frequency sum: 99.89 %

Wave Energy Resource File

Choose wave energy resource file instead of choosing from library

Check the box and click Browse to choose a .zer file stored on your computer without adding it to the wave resource library. Note that the matrix data above shows data from files in the library, not from the file you choose here. See Help for details.

File Add untyped untyped (1)

Marine Wave, LCOE Calculator Device Costs (Capital)

Wave
Wave
Array
Losses

Capital Costs pages. On this page, you can enter a capital cost as a single value, or choose from a list of values.

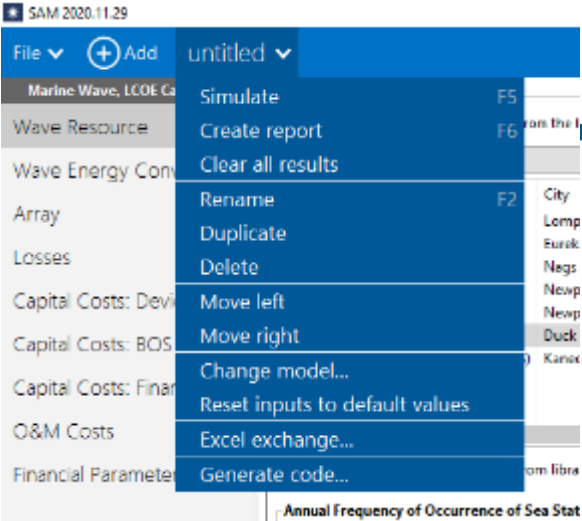
Capital Costs: Device
Capital Costs: BOS
Capital Costs: Financial
O&M Costs
Financial Parameters

Blue inputs are values that you cannot change on this input page. They either come from other pages, or are calculated by SAM. For example, the Modeled Structural assembly cost value is calculated based on work from the Reference Model Project

	Input options	Modeled value	User input	Category cost
Structural assembly	Use Modeled Value (\$) <input type="button" value="v"/>	\$198,679,680	<input type="text" value="0"/>	\$198,679,680
Power take-off system	Use Modeled Value (\$) <input type="button" value="v"/>	\$44,014,128	<input type="text" value="0"/>	\$44,014,128
Mooring, Found., and Substruc.	Use Modeled Value (\$) <input type="button" value="v"/>	\$52,549,712	<input type="text" value="0"/>	\$52,549,712
Total device costs				\$295,243,520

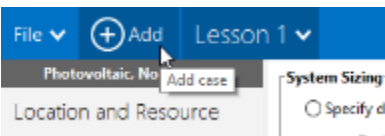
“Greyed out” inputs are inactive. In this case the User input value for the Mooring, Foundation, and Substructure Costs is inactive because the Use Modeled Value option is selected.

- + Structural Assembly Cost Breakdown
- + Power Take-off System Cost Breakdown
- + Mooring, Foundation, and Substructure Cost Breakdown

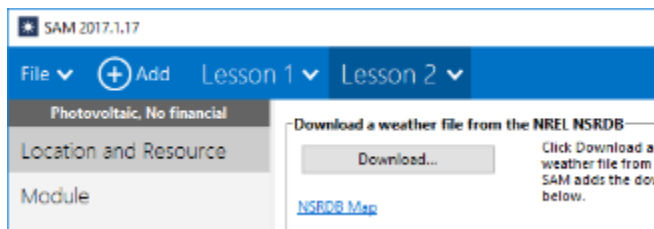


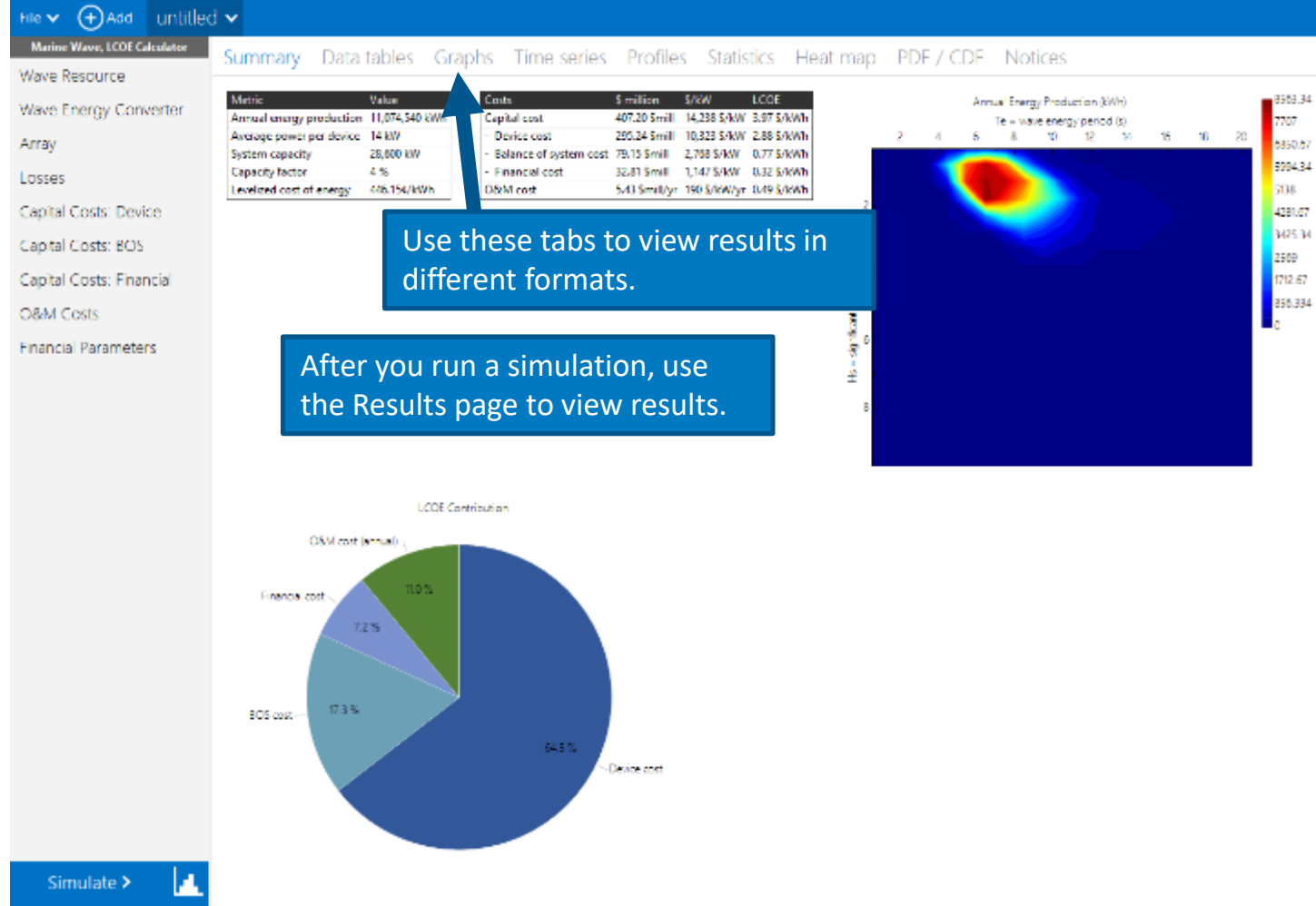
The Case menu lists commands for the current case. Click v to see the menu.



A case is like a worksheet in an Excel workbook, it is a complete set of inputs and results. A project can have one or more cases.




Click Add to add a case to your project. You can use multiple cases for comparison or to model a complex system.



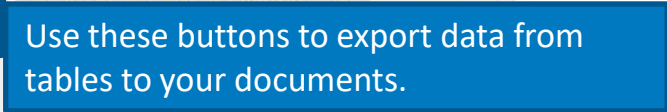


 Search **Single Values**


- Annual energy production of array (MWh)
- Average power production of a single array (kW)
- BOS cost (%)
- Balance of system costs per unit annual energy (¢/kWh)
- Capacity Factor (%)
- Capital cost as percentage of overall system cost
- Capital costs per unit annual energy (¢/kWh)
- Device cost (%)
- Device costs per unit annual energy (¢/kWh)
- Distance to shore (kW/m)
- Financial cost (%)

Single Values 

BOS cost (%)	17.3009
Device cost (%)	64.535
Financial cost (%)	7.1716
O&M cost (annual) (%)	10.9925
Levelized cost of energy (\$/kWh)	4.46152



Use these buttons to export data from tables to your documents.

- Wave Resource
- Wave Energy Converter 
- Array
- Losses
- Capital Costs:
- Capital Costs:
- Capital Costs: Financial
- O&M Costs
- Financial Parameters

Wave Energy Converter

Filter:

Name	Technology Type	PTO Type
RM3	Heaving Buoy	Hydraulic Drive
RM5	Oscillating Surge Wave Converter	Hydraulic Drive
	Oscillating Water Column	Wells Air Turbin...

Notes

Power matrix from new WEC prototype

To remove a note, delete all of the text (including spaces) in the note box.

The yellow icon indicates there is a note for this page.

Add notes to pages you want to make notes for yourself or colleagues.

Simulate >

Parametrics Stochastic

P50 / P90 Macros

Power matrix (kW)

Te = wave energy period (s)

	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	
0.25	0	0	0	0	0.4	0.6	0.8	1	1.1	1.1	1	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0	
0.75	0	0	0	0	3.2	5.3	7.4	9.1	9.8	9.5	8.6	7.4	6.2	5.1	4.1	3.4	2.8	2.3	1.9	1.6	0	
1.25	0	0	0	0	9	14.8	20.5	25	26.8	25.9	23.3	20	16.8	13.8	11.3	9.2	7.6	6.3	5.2	4.3	0	
1.75	0	0	0	0	17.6	28.9	39.9	48.3	51.6	49.7	44.7	38.4	32.2	26.5	21.7	17.8	14.6	12.1	10	8.4	0	
2.25	0	0	0	0	29	47.5	65.4	78.8	83.8	80.6	72.4	62.3	52.2	43	35.3	28.9	23.8	19.7	16.3	13.7	0	
2.75	0	0	0	0	43.2	70.7	97	116.3	123.1	118.1	106.1	91.3	76.5	63.2	51.9	42.5	35	28.9	24.1	20.1	0	
3.25	0	0	0	0	60.2	98.3	134.5	160.5	169.3	162.1	145.5	125.2	105	86.8	71.3	58.5	48.2	39.9	33.2	27.8	0	
3.75	0	0	0	0	79.9	130.4	177.8	211.2	222	212.2	190.4	164	137.6	113.8	93.6	76.9	63.3	52.5	43.7	36.6	0	
4.25	0	0	0	0	102.4	166.7	226.7	268.3	281.1	268.2	240.5	207.2	174.1	144.1	118.5	97.4	80.3	66.6	55.5	46.5	0	
4.75	0	0	0	0	127.6	207.4	281.2	286	286	286	286	286	255	214.3	177.5	146.1	120.2	99.2	82.2	68.6	57.6	0
5.25	0	0	0	0	155.4	252.4	286	286	286	286	286	286	286	258.2	214	176.3	145.1	119.8	99.4	83	69.7	0
5.75	0	0	0	0	186	286	286	286	286	286	286	286	286	286	253.6	209	172.2	142.2	118.1	98.6	82.8	0
6.25	0	0	0	0	219.2	286	286	286	286	286	286	286	286	286	244.2	201.2	166.4	138.2	115.5	97.1	0	0
6.75	0	0	0	0	255	286	286	286	286	286	286	286	286	286	281.9	232.4	192.2	159.7	133.5	112.3	0	0
7.25	0	0	0	0	286	286	286	286	286	286	286	286	286	286	286	265.6	219.8	182.8	152.9	128.7	0	0
7.75	0	0	0	0	286	286	286	286	286	286	286	286	286	286	286	286	249	207.2	173.4	146	0	0

File Add untyped Help

System Advisor Model Help

Back Home Web site Forum Email support Release notes About Close

Click Help, or press the F1 key to display help.

Wave Energy Converter

System Design
Shading and Layout
Losses
Results

PVWatts
System Design
Results

Concentrating Photovoltaic
Module
Inverter
Array
System Costs
Results

Battery Storage

Behind the Meter (BTM)
Battery Dispatch BTM
Front of Meter (FOM)
Battery Dispatch FOM
Results

Wind

Wind Resource
Wind Turbine
Wind Farm
Losses
Uncertainties
System Costs

Marine Energy Wave

Wave Resource
Wave Energy Converter

SAM's wave energy converter (WEC) model uses an electrical power capture matrix to characterize the performance of the converter. This matrix can be generated by a time-domain numerical simulation model such as the open source [WEC-Sim](#) (Wave Energy Converter Simulation) MATLAB/SIMULINK model. The matrix maps electrical power capture to the significant wave height and peak period in the wave resource scatter diagram on the [Wave Resource](#) page and should use the same bin size. The WEC modeling approach is consistent with the method described in LaBonte, A. et al. (2013). [Standardized cost and performance reporting for marine and hydrokinetic technologies](#). 11 pp. Proceedings of 1st Marine Energy Technology Symposium, Washington DC.

Unlike SAM's other performance models, the wave energy converter model does not perform a time series simulation of the system's performance so it does not generate hourly or subhourly time series results over the year like the other models.

You can either choose a wave power matrix from the wave energy converter library, or you can import the data from a text file or other program.

WEC Library

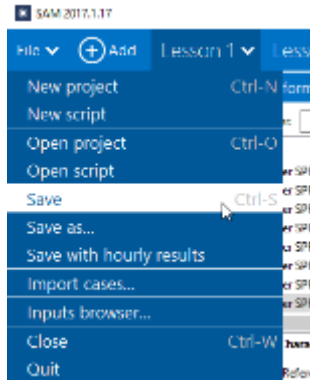
SAM's wave energy converter library stores power matrix data and some descriptive information for different types of WECs.

WECs included in the library are based on open-source marine energy point designs as part of the Reference Model Project (RMP), sponsored by the U.S. Department of Energy (DOE). The included reference models are:

- Reference Model 3: Wave Point Absorber
- Reference Model 5: Oscillating Flap
- Reference Model 6: Oscillating Water Column

Related studies and supporting documentation for each reference model is located on the [DOE Reference Model Project website](#).

To choose an WEC from the library:



Use the File menu to save your project files as .sam files.

If your project has more than one case, use the inputs browser to compare inputs.

A screenshot of the SAM System Advisor Model Help window. The window title is "System Advisor Model Help". It has a navigation bar with links: Back, Home, Web site, Forum, Email support, Release notes, Scripting reference, About, and Close. A left sidebar contains a table of contents with categories like "Models and Databases", "Getting Started", "Reference", and "User Manuals". The main content area is titled "File Menu" and contains text explaining the File menu's purpose and listing several menu items with their keyboard shortcuts: New project (Ctrl-N), New script, Open project (Ctrl-O), Open script, Save, Save as..., Save with hourly results, Import cases..., Inputs browser..., Close (Ctrl-W), and Quit. A blue callout box is overlaid on the right side of the help page.

System Advisor Model Help

Back Home Web site Forum Email support Release notes Scripting reference About Close

File Menu

SAM's File menu provides access to commands for managing projects and scripts, and opening the inputs browser.

New project
Create a new project file using default input values. SAM opens a project with a single case and no results.

New script
Open the script editor for a new new [.tk](#) script.

Open project
Open an existing SAM project file (.sam) file.

Save with hourly results
Save the project as a SAM (.sam) file in its current location, and include hourly results.
Use this option if you want hourly data to be available on

See the "Getting Started" and "Reference" topics in Help for more details about SAM's user interface.