



## Challenge #8

### It's A'boat Time We Build an Electric Marina

**Due Tuesday, May 5**

### Congratulations!

You have been chosen to help design a new solar boat marina in Southern California.

The developers are excited to lead innovation in recreational boating and plan to design their marina for electric boats. They also want to install a solar system to support the electric boat (EB) charging needs.

In this challenge you will:

- Create a diagram of your marina design
- Assess the possibility of setting up a solar system to support the EB charging stations
- Analyze the benefit of electric vs. combustion engine boats.

**Complete the plan and attached worksheet and send it to *Julie Miller Kalbacher* at [jamiller@mwdh2o.com](mailto:jamiller@mwdh2o.com). Make sure to include your name and school name on your responses.**

***This activity is worth 100 points.***

***You will earn points based on completing each question with detail, creativity and accuracy.***

## Designing the Marina

To complete this challenge, review the design criteria below and diagram a site plan for your marina. Here are some samples of a top down marina site plan: [Sample 1](#), [Sample 2](#), [Sample 3](#). Your diagram can be completed as a paper drawing, computer drawing, or physical model, just make sure that you can submit a clear picture of your model to receive credit. If you are interested in computer models, consider creating your diagram on a Google Slide, or using the drawing function in Google Docs. You may also consider setting up a free account with [SketchUp](#) - an online computer automated design tool. [Canva](#) is another free platform for digital drawing.

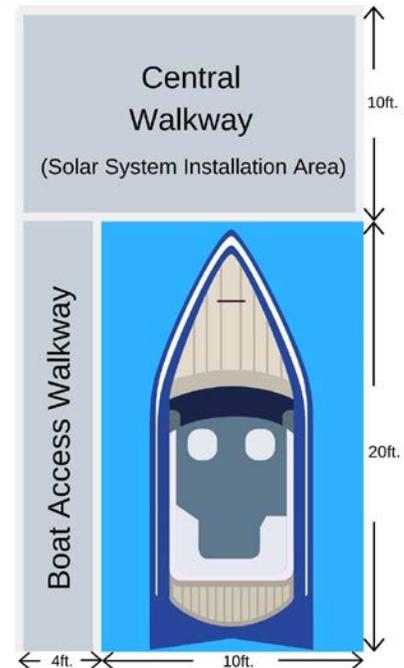
### Part 1 - Dock Design

Dock Design & Constraints - Your design must include the following components.

- 30 boat spots
- Each Duffy Boat<sup>1</sup> is approximately 20ft.x10ft. Use these specs to design your dock(s)
- The central walkway on your dock needs to be at least 10ft. wide
- The boat access walkways need to be at least 4 ft wide

1. What is the minimum total area needed to host all 30 Duffy Boats, dock walkways, and boat access walkways? Use the visual on the right-hand side to assist your calculations.

2. Given your total area, how many docks do you want to include in your design? Diagram your docks.



### Part 2 - Design Your Solar PV Systems

Solar PV Criteria & Constraints - Your design must include the following components.

- Build solar system to provide energy to your EB chargers
- Solar panels can only be installed on the central dock walkway (i.e. design a covered dock with roof space for your panels)

<sup>1</sup> <https://www.duffyboats.com>

See italic text for example calculations from an EB solar charging system.

1. What is the total area available for solar installation on your dock(s)? *If you have one dock that is 30ft. Long and a 10ft. Main walkway, your total solar area = 10ft.x30ft. = 300sq. ft.*
2. What is the maximum number of solar panels that can fit on the usable area of your covered dock(s)? *1 panel = 5ft.x4ft. Max system: 300 sq. ft. usable dock area/ 20 sq. ft. panel area = 15 panels*
3. How much daily power can your maximum number of solar panels produce? Assume each panel produces 330 watts (W). *15 panels x 330 W = 4,950 W = 4.95 kW*
4. Solar panels only produce about 76% of their rated capacity. How much actual power does your system produce? *4.95 kW x 0.76 = 3.76 kW actual solar power potential*
5. How much energy can your maximum number of solar panels produce? Assume full sun for 7 hours a day. *Energy = Power x Time = 3.76 kW X 7 hrs. = 26.33 kWh*
6. Add your maximum number of solar panels to your marina diagram.

### Part 3 - Installing EB Charging Systems

EB Charging Criteria & Constraints - Your design must include the following components.

- EB chargers, (36 Volts, 21 Amperes)
  - At least 1 EB charging station per 10 EB's. Each dock will host Duffy Boats with a 17.5-mile range on average<sup>1</sup>.
1. Can the solar system meet the power demand of the EB chargers? Assume each EB charger requires approximately 1 kW of power. *For example, one 1kW EB charger can be powered by our 3.76 kW solar system.*
  2. If each EB needs one full charge per week and every charge takes about 3.5 hours, can your charging stations fully charge all boats without backup?
    - a. What is the charging time required for all EB's in the marina? *Assuming 4 boats and 3.5 hours of charging each: 4 boats x 3.5 hours charge time = 14 hours required charge time per week*
    - b. How many hours per week of charging can your chargers provide? Assume you are installing on demand chargers without battery backup, so boat users can only charge during the day. The panels get 7 hours of full sun per day. *1 charger x 7 hours per day x 7 days per week = 49 hours available charge time*

<sup>1</sup> <https://www.duffyboats.com/faqs/>

- c. Can your charging stations fully charge all boats every week? *14 hours per week are required and 49 hours per week are actually produced, so the chargers can fully charge all boats every week.*
  
- d. If the answer to c is no, what strategies, or ideas, could you use to make sure all EBs can be charged every week? Make these changes in your diagram. For example, add marina buildings with rooftop space or a vehicle parking lot with solar carports. If the answer to c is yes, skip this question.

#### **Part 4 - Analyze the Benefit of Electric vs. Combustion Engine Boats**

1. What are some of the costs and benefits in your marina design? (Hint: think of environmental costs, maintenance, efficiency etc.)
  
2. What are the benefits to driving an electric boat and charging with solar?