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CS340 - Winter 2019
Group #43

Sustainable Technology Database Project Final Version

Web Application URL

<http://flip3.engr.oregonstate.edu:24505>

Peer Review Feedback - Project Step 6

Project Step 6 Review 1 (Matt):

"DELETE comments:

When I clicked Remove Region in the EnergySource page, it said "Removed from EnergySource-Region relationship". Although this message confirms that something happened in the backend, it wasn't very visually clear how deleting the region affected the db. Similarly, in the EnergyTech page, when I click the Remove EnergySource button, it says "Removed from EnergySource-EnergyTechnology relationship" but there's no visual confirmation that anything actually changed. Similarly, in the Region page, when I click the Remove EnergySource button, it says "Removed from EnergySource-Region relationship" but there's no visual confirmation that anything actually changed.

In the Company page, I clicked Delete Record and successfully saw that the record actually got deleted. Wonderful!

General Strengths: (same comments as Step 5)

1) Overall, good progress on getting your page up and running. We're able to enter records into each of the tables and the layout is each to understand.

2) In the EnergySource page, the Add New Record page handled errors when inputting various types of user data. I was also able to add new records successfully. This field also properly handled negative values. Good work!

General Recommendations: (same comments as Step 5)

1) In EnergySource page, it is difficult to determine what the correct inputs are for Add Region, Add Company, and Remove Region.

2) It would be nice if the webpage design included an upgraded front-end, such as backgrounds, table lines, CSS rounded corners.

3) In EnergyTech, it would be nice if the Search field accepted wildcards.

4) Most of the fields that allow you to enter data need input validation and exception handling. When adding records using the "Add Data" button on each page, it is possible to enter whitespaces and have that be accepted to enter a new record. For fields where you can enter/remove an Id, it's possible to enter random characters and cause the page to crash."

Project Step 6 Review 2 (Matt):

"Hi Matthew.

I was able to remove a company easily, but I'm not sure what it's doing on the other pages. It says something was removed on them, but doesn't look like anything actually happened. Cool site though."

Project Step 6 Review 3 (Thanh):

"Hi Thanh,

The site is really starting to come together nicely!

For all tables, add new record works perfectly and has excellent input validation features.

EnergySource Entity Table:

Add Region, Add Company, and Remove Region all seem to work in that, if I enter an existing id, it takes the input and displays a message saying it was added to or removed from the relationship. Since this data isn't being displayed, I'm unable to see if an update or delete is actually happening. Is this something that will be visible on the front end or will the data change only be visible in your database?

Energy Technology Entity Table:

Add Energy Source and Remove Energy Source both update and delete data from the energy_src_id column without error. I thought your implementation of Update/Delete was spot on here and was a nice reflection of the queries you have in your DDL.

Adding/removing from a column in the webpage table was a helpful feature because it was clear that the updates/deletes were taking place.

Sustainable Product Entity Table:

The page let me enter correct company ids into Add Company field and the button grabbed the data and an appropriate message was displayed. Still, it's hard to know if an actual update is happening b/c the data isn't reflected anywhere on the front end. This could be entirely by design however.

Company Entity Table:

Update and Delete buttons both work perfectly. I was able to update the Solar City entry and then delete it. Add EnergySource and Add Sustainability do not work for all existing sustainable product ids. They redirect to a "This site can't be reached" page. I read the Actions Based on Feedback section from Project Step 4 and this could be due to some features still needing to be implemented. I suppose it could also be due to the id having already been added previously such that, if the id entered is a duplicate of an existing id, it redirects to the error page.

Region Entity Table:

Similar to some of the other tables, the add EnergySource and remove EnergySource buttons both seem to work but it's unclear whether or not anything is actually happening to the data.

Regarding the redirect to "This site can't be reached", a possible fix in the future might be to add some input validation to check whether the energy source actually exists or if it is already present in the table (since duplicates might be throwing errors). The Add/Remove fields seemed to work for most of the correct ids, but they always crashed if the ids didn't exist or were left blank. I think it would be cool to add a message telling the user that the ids are incorrect similar to the input validation you did with the Add New Record functionality.

DDQ and DDL look good and were nicely reflected in the app functionality.

Overall, it looks like you're making some real progress and I think the app is going to be awesome when it's finished! Keep up the good work!"

Project Step 6 Review 4 (Thanh):

"Hey Thanh,

I think Patrick is correct on the issue of pages failing to load upon updating a relation. I tested by adding a new row to various tables and adding that relation (which worked) then failed when using the same data again.

This obviously falls into the input validation category, which can be frustrating fixes. My suggestion would be to use a select dropdown to verify only existing rows. Then maybe do a check for a duplicate entry. If you're using handlebars, this is easy with:

```
{{#each (context-name)}}  
    <option value="{{insert-to-db}}">{{column-to-display}}</option>  
{{/each}}
```

Alternatively, the node lecture and github repo from module 8 shows a useful javascript selector function to show an existing row relation. This could solve the issue if you choose to use a dropdown.

```
function selectEntity(id) {  
    $("#data-selector").val(id);  
}
```

as long as the data-selector id is in the dropdown's select tag:

```
<select id="#data-selector">
```

I did look at the js code in the DOM and i don't think the issue is from your html or client*.js files, but from the back-end. Though I could be wrong, it would be a place to start.

Overall, I was able to implement the necessary update and delete functionalities. Great job and I am very impressed with the effort you put into the relation tables. We have

one in my group and was challenging to maintain. Keep on and good luck as you finish up the project.”

Peer Review Feedback - Project Step 5

Project Step 5 Review 1 (Matt):

“Hi Matthew,

I haven't otherwise reviewed your project before, so I'm trying to follow all of your documentation. I kind of agree with a previous reviewer who said following the id's between the pages a bit inconvenient, but I understand making major changes at this stage is probably a no-go.

I see one update feature for companies, which I was able to successfully add/update/delete. I like that the update form shows existing values.

I see some other reviewers have also mentioned this, but styling would be a nice touch. The table headings and alignment within the tables makes them a little hard to follow.”

Project Step 5 Review 2 (Matt):

“Matthew,

The site still looks good and it seems like you put up some more features. I added the duck energy source and everything seems to work well there. Add region did not work as im sure you are aware. I tried my best to mess up the the input in the company table but could not. The site could use a little color or maybe some drop shadows on the tables, it looks a little late 90s at the moment. All in all great job though.”

Project Step 5 Review 3 (Matt):

“UPDATE Comments:

I was able to successfully update records in the Company page, so great job getting it working! When updating records, one minor issue is that I could update the record name to an empty string, so you might want to check user input when updating records. Optionally, one idea to consider but is not totally necessary, it would be nice if the front-end used to update the Company record used Ajax so that the user can update records without a page refresh.

General Strengths:

1) Overall, good progress on getting your page up and running. We're able to enter records into each of the tables and the layout is each to understand.

2) In the EnergySource page, the Add New Record page handled errors when inputting various types of user data. I was also able to add new records successfully. This field also properly handled negative values. Good work!

General Recommendations:

1) In EnergySource page, it is difficult to determine what the correct inputs are for Add Region, Add Company, and Remove Region.

2) It would be nice if the webpage design included an upgraded front-end, such as backgrounds, table lines, CSS rounded corners.

3) In EnergyTech, it would be nice if the Search field accepted wildcards.

4) Most of the fields that allow you to enter data need input validation and exception handling. When adding records using the "Add Data" button on each page, it is possible to enter whitespaces and have that be accepted to enter a new record. For fields where you can enter/remove an Id, it's possible to enter random characters and cause the page to crash."

Peer Review Feedback - Project Step 4

Project Step 4 Review 1 (Matt):

"Great job on getting the front and back ends working together. I could successfully add data to each of the subpages.

For areas of improvement, a nice front end design with CSS, images, and/or webpage effects would be good addition. Then again, I know the website is WIP, so I'm guessing you'll probably add that later. In Energy Technology page, it would be nice if user could input decimal values into Cost/Watt. When I try to enter \$0.15 cost/watt, the webpage says "Please enter a valid value. The nearest two values are 0 and 1."

Project Step 4 Review 2 (Matt):

"Excellent job getting your app working, I'm jealous of what you have already. In the Sustainable Product Entity Table the "Enter Company id" is auto filled in as a placeholder im assuming but it may look better as a header vs needing to delete the text in the field. It is a bit hard to follow which id is related to the other tables. Have you

considered putting all of the tables on one page? All in all I think your app is looking pretty solid from the rubric besides a bit of missing css styling, delete, and a search function.”

Project Step 4 Review 3 (Thanh):

“Website Functionality:

Add EnergySource: I successfully added an energy source to the table and it correctly displayed the new entry. One concern with the single integer input fields is that a user can descend into negative numbers. It rejected my input for a negative number, which is great, but from the front-end the user should not be able to select negative values.

Add EnergyTechnology: Successfully added a technology and displayed the change.

Add Sustainability Product: Successfully added a sustainability product and displayed the change.

Add Company: Successfully added a company and displayed the change.

The CREATE and READ functionality is all there and works. I do have a few suggestions for improving the usability of each page:

The Add- buttons for each relation that are next to the displayed table should remove the placeholder when the user clicks the input field. As of now, the placeholder text remains. Also, you could add a <label> tag before each input field so that you can title each input field rather than the "Add (attribute)" button.

Also, the input fields could use a SELECT query to get each **existing** entry. Then you could convert your input field to a select dropdown rather than a text input field. That could be your input validation that is clear to the user.

A small detail in the html design--you may want to put the entity table inside of a div so your formatting will be easier. Looks like every section of the page is wrapped inside a div except for the display entity table. It may also help when you begin to format the column spacing.

Overall, it works fine and I was impressed by the functionality of the Add-(relation) buttons. It looks like it works given the constraints in the DDQ file. I'm excited to see how it looks after some front-end tweaks. Good work.”

Project Step 4 Review 4 (Thanh):

"Hi Thanh,

Nice job on the website!

I was able to successfully add values to each table. It also correctly validated my input.

The data I added was correctly displayed on the page.

The Add buttons next to the tables would only occasionally work. Sometimes I would get 404 errors or it wouldn't be able to reach the page. This could be an issue with flip or possibly an issue on my end but I thought I would bring it up.

Other than that, I think the requirements for this step were clearly met. Create and Read functionality seems to be working great.

Something to nitpick about:

The table headings are not all aligned with the table data. All of the data below the headers is left-justified but the headings are sometimes centered and sometimes left-justified making it just a little bit difficult to follow. This may be a design decision but it makes the front-end a little less user friendly in my opinion.

Anyway, I think you guys are doing a great job and your app is coming along great!"

Peer Review Feedback - Project Step 3

Project Step 3 Review 1 (Matt):

"Highlights:

1) Your project idea was really interesting, unique, and educational for me. I've never heard of molten salt towers and many other things related to energy. I can see this type of project being useful for many energy companies in real life.

2) For EnergyTechnology, I like how you thought of including development_stage. Well thought out!

Recommendations:

1) Good job on the initial design of the front-end. It seems that the front-end is currently an interface for the database at this time, providing interfaces to insert, delete, and whatnot. Despite it's simplicity at this time, it is clean, organized, and user-friendly. You could easily re-organize the webpage with the current buttons and labels to something more practical in later project steps.

2) The SQL manipulation file, DDQ.sql, looks pretty solid. You'll probably need to filter your SELECT statements using a WHERE clause in many cases, such as when you query for Sustainable Products.

3) Just something to consider but I think it's possible to have a M-M relationship between EnergyTechnology and Company. Your ERD does not show a relationship between EnergyTechnology and Company. However, your schema technically shows that EnergyTechnology is linked to Energy_Company. If you add the composite table EnergyTechnology_Energy_Company, you could have a M-M relationship between the two tables.

4) In your Energy_Region and Energy_Company tables, you have the energy_id attribute. The naming of the attribute confused me. Is energy_id a reference to energy_source.id? If so, you might want to consider renaming this attribute to Energy_Region.energy_source_id and Energy_Company.energy_source_id.”

Project Step 3 Review 2 (Thanh):

“Hi Thanh,

I think your project is going to be great! Reading through your responses to the draft 2 feedback, I feel as if I have a better understanding of the realized application.

Here's my review of each section in the third draft.

Actions Based on Feedback:

I thought it was a good design decision to use a varchar over a string variable.

Adding more attributes to the region entity was a good idea because it could help “atomize” the database attributes which is a fundamental characteristic of relational databases. Also, rewording the description was a wise choice given the feedback. The most important aspect of this application is that the users understand what it is supposed to do before they use it.

DDL:

I imported your DDQ file into phpmyadmin. The create queries all worked without errors. I liked the way you included constraints directly in the create tables. It was a little different than the way my group did it. We used update/delete cascades to prevent the dreaded foreign key reference errors but your way avoided it as well which I feel helped me develop a better understanding of the different ways you can develop a create statement with foreign keys.

DDQ:

Regarding the DDQ file, everything seemed to work well. I tested the updates and deletes and they worked with the single row data that was inserted from the initial insert statements in the DDL. I was wondering if you were planning to use joins between tables. Are you going to cross-reference tables to look for relationships? If so, the select queries would result in redundant data without using join statements.

Website:

I thought the basic design of the website was done well and the forms on each page made sense.

I did have a question about one of the forms. At the bottom of the EnergySource Entity table, there are only three fields to insert a new data record. Was there supposed to be an annual growth field as well? Your insert queries show four attributes: name, percent global power, annual growth, and cost per kWh.

Anyway, very well done! I look forward to the final product!"

Project Step 3 Review 3 (Thanh):

"Thanh, I really like the changes made from the previous step.

Outline:

Excellent detail to the actions based on feedback. You provide reason for each change and have done research. And i'm happy to see the introduction was edited. It's more clear and defined.

Webpage:

EnergySource - No input field for annual growth.

Company - for the Update record (UPDATE) button, if it uses the same form as the Add data (INSERT) button, i recommend moving it next to or below the form. Same could be said for DELETE button.

DDL:

Looks great!

DDQ:

Regarding the "Select *" queries for populating the table data, (and this may be a design decision, so feel free to ignore) the id column will be displayed. Unless the user needs

to visualize each id value, i'd recommend removing it. Just call the SELECT query for each value you need to display. You can adjust the parameter order to customize the layout, too.

Great work!"

Peer Review Feedback - Project Step 2

Project Step 2 Review 1 (Matt):

"Hi Matthew.

I love your idea, an easy way to compare renewable and sustainable energy technologies is very needed. It does seem hard to implement though, since they are so different. I like your ERD and Schema, but I would make a few changes. For EnergyTechnology, there should be an average startup cost and a running cost. In the long run some are better than others, but they'll cost more to get into. Another thing I'm not sure about is the one-to-many relationship between Company and EnergySource. I would think that some companies would be involved in several different energy sources, but I haven't done any research into that so maybe I'm wrong. And for Region I would use a foreign key for countries so that you don't get misspellings or abbreviations. This would help when filtering and comparing the data."

Project Step 2 Review 2 (Thanh):

"Database Outline

All four entities contain an attribute for name that uses a string with a maximum of 20 characters. I'm going to pass on the suggestion that I received for doing the same thing which was to be more specific and use a VARCHAR of length 20 instead. Also regarding the length of the VARCHAR, unless you used abbreviations, it seems like 20 characters might be too small for some of the Sustainable Product names (like "batteries for renewable energy storage"). It might be better to go with a 100 character VARCHAR in this instance.

Regarding the development_stage attribute of Energy Technology entity, is there a default stage? I'm assuming that the default would probably be the theoretical stage but it might be good to mention it.

Regarding the Region entity, since the examples of regions show states as well as countries, it seems like it might be a good idea to include more specificity via attributes in the entity table. For example, you could have an attribute for state/province/territory, an attribute for country, and an attribute for continent. I imagine that it might help to narrow down the region more and provide a stronger cross-reference. Of course, I'm not an expert in this topic so I could be totally off base here.

Entity Relationship Diagrams (ERD)

I thought the ERDs were very well done. The crows foot diagrams fit exactly as described in the previous section. I did notice that the composite entity tables in the Schema were left out of the ERD (for Company_Product and Energy_Region). I might be wrong, but I thought we were supposed to include those in the ERD so we could show the relationships between the each composite entity and their parent entities (which was discussed in Ch. 4 of the textbook)

Project Step 2 Review 3 (Thanh):

Project and Database Outline:

Project description could be more concise, but I do understand the premise. An example of a sustainable technology or renewable energy in the description would help the reader before he/she moves on to the entities. As for editing, the first and second sentences mean the same thing; I recommend removing the first sentence all together or combine and edit the two. It's not drastically important, but I do think it would help overall.

Entities:

- EnergySource: For the attributes percent_global_power, annual_growth, and cost_per_kWh--any reason for why these fields can be blank? Are these values not required for a newer energy source, but will be added once data is collected?
- EnergyTechnology: Same as above for cost_per_unit, development_stage, and energy_source.
- Region: Since California and Germany are included in the examples listed, I recommend adding more specificity to the entity. The continent attribute makes sense, but adding a Country and State (optional) would create a more accurate demographic if you ever needed to create a map of this data."

Actions Based on Feedback

Project Step 6

Review 1 stated that when a many-to-many relationship was added or deleted, while a message was displayed notifying the user that the addition or deletion was successful, there was no other associated visual cue displayed by the web application. As the web application does not actually fulfill any function related to many-to-many relationships besides storing them, no other visual actions associated with the many-to-many relationships are warranted. The other comments/suggestions of Review 1 are the same as those of Review 3 described below for Project Step 5 as they were made by the same reviewer.

Review 2 thought that the relationship removal buttons were actually record deletion buttons when in fact they only modify the many-to-many relationship tables and display a message to the user, so no action is needed in this case.

Reviews 3 and 4 stated that errors preventing the web application from being displayed arose when entering values in the many-to-many relationship addition fields that would cause a duplicate key error or a non-numeric value that would be unable to be interpreted correctly by the SQL expressions. This issue was fixed by adding logic in the back-end JavaScript that handles these types of errors by re-rendering the page from which the relationship addition form was sent with a message added to the bottom of the table that describes the error and how to avoid it through correct data input. Additionally, Review 3 mentioned that there was no visual display besides a message printed on the webpage for the user when many-to-many relationships are added or deleted. As previously stated, the web application only functions in storing the many-to-many relationships, so no other visual operations are necessary.

Project Step 5

Review 1 felt that displaying the ids on the web application is unnecessary and potentially confusing, but this design decision is being kept as a means of identifying each record. Review 1 also commented that the web application could benefit from styling improvements which will be implemented upon submittal of the final version.

Review 2 stated that the Add Region button was not working, but the button works upon being tested. Review 2 recommended the use of CSS which was added.

Review 3 suggested further input validation, the use of AJAX requests to handle the UPDATE operations, the acceptance of wildcards in the search field, and the use of CSS. As stated above, CSS was added to the application, and input validation for the many-to-many relationship fields was implemented to handle SQL errors arising due to duplicate ids or non-numeric input. The other suggestions were not acted upon due to time/complexity constraints. The review also suggested that the specifications for accepted inputs be displayed on the webpages. The specifications for INSERT query inputs are displayed on the webpages if a user enters a value that violates one or more data constraints.

Project Step 4

Review 1 suggested that the cost_per_watt variable of the EnergyTechnology entity be converted from an integer to a float to allow cent values to be supported in the data. This suggestion was implemented. The review also stated that style modifications through CSS would be important to carry out, which will be done before submittal of the final project.

Review 2 questioned whether the entity tables of the project would look better one a single webpage versus one webpage for each of the tables. The approach was considered but not chosen.

Review 3 noted that the numeric inputs for our website allowed users to input negative values which would not make sense given the context of our project. As such, we edited our HTML files to prevent end users from inputting negative values into the numeric fields. Review 3 also suggested that the placeholder values present in some of the input fields be converted from the “value” html attribute type to the “placeholder” type so that the values would not have to be manually deleted upon form entry. This modification was made. Additionally, Review 3 suggested that all entity tables be put inside their own div to allow for easier style formatting, which was also done. The final suggestion of Review 3 to use a SELECT query to populate a drop-down menu for each form input field was not acted upon due to the complexity involved with the implementation.

Review 4 stated that some of the buttons in the webpages returned 404 errors when they were pressed, which was because not all the features of the web application had yet been implemented. This issue has been resolved. Review 4 also conveyed that the uniformity of the table layouts should be improved, which will be completed during the addition of CSS to the webpages.

Project Step 3

Review 1 suggested that WHERE clauses be added to the SELECT queries for entities to allow more specific display of data. It was decided that this functionality may be entered into the database at a later time, but it will be foregone in the initial development of the database in the interest of reducing complexity. The review also suggested that another many-to-many relationship table could be added that links the EnergyTechnology entity with the Energy_Company relationship table in order to establish a relationship between all three entities. As depicted in the schema for the project, both the EnergyTechnology entity and the Energy_Company relationship table contain a foreign key that references the id attribute of the EnergySource entity, but EnergyTechnology and Company are not directly linked. Again, for the purpose of reducing complexity in the development of the database, it was decided that the table addition would not be made at this time. Finally, the review suggested that the energy_id attribute in the Energy_Region and Energy_Company tables be replaced with the more specific name of energy_source_id. The attribute name was changed to energy_src_id in accordance with the suggestion.

Review 2 had inquired if we would use JOINS to relate our tables and information together and at the moment, we do not have plans to.

Review 2 and 3 noted that on our webpage, for the EnergySource entity page, we were missing the annual_growth attribute in the section where a user could insert a new row into the table. We added the attribute so users could specify this value when inserting new data into this entity.

Review 3 also suggested that the `id` primary key attributes of each table be omitted from the SELECT queries used to display the tables on the website, because the user would not need this information. However, the `id` attributes are still needed by the client-side JavaScript functions we will use to allow UPDATE and DELETE queries for a particular table row to be made in the database, so this attribute was kept. Lastly, Review 3 suggested that we adjust the position of our UPDATE/DELETE buttons for clarity. Previously, they were simply placed in the middle of the HTML page, but we have since adjusted their position to be near the generated table of data to make their function more clear to the end user. Users then understand that the UPDATE/DELETE buttons will be associated to each row of the table to edit/remove.

Project Step 2

Review 1 suggested that two additional attributes, average startup cost and running cost, should be incorporated into the EnergyTechnology entity. However, the values associated with these attributes would vary depending on the size of the energy system associated with them, meaning that they would not be able to be successfully incorporated into the database using the design that has been selected.

Review 1 also suggested that the one-to-many relationship between the Company and EnergySource entities be made into a many-to-many relationship, because particular companies could provide access to multiple energy sources. During initial creation of the outline, it was thought that most companies specialized in one particular energy type, which led to the classification of a one-to-many relationship between the Company and EnergySource entities. Upon further research, however, it was discovered that some companies, such as General Electric and Siemens, specialize in marketing more than one type of renewable energy resource. Due to this, the original one-to-many relationship will be converted to a many-to-many relationship.

Additionally, it was suggested in Review 1 that a foreign key should be used for the country attribute in the Region entity to prevent misspellings and abbreviations from occurring. Because this would require the creation of an additional table within the database that assigns a key to the country attribute, it was decided that countries would be kept as a varchar attribute so that further complexity would not be needed.

Review 2 suggested the use of the varchar variable over the initial use of the string variable. It was decided that this would be a good idea as the use of the varchar variable is more specific. Additionally, it was noted that it would be helpful if the development_stage attribute of the EnergyTechnology entity specified a default value. We found that to be a helpful suggestion and as such, set a default value of "theoretical" for this attribute.

It was also suggested in Review 2 that additional attributes be added to the Region entity so as to allow for the location to be defined less broadly and the use of location data in potential

mapping efforts. The review stated that it could be beneficial to add attributes for the state, province, or territory of the region in addition to the country to which it belonged. While a country attribute was added to the design, it was decided that an attribute listing the state, province, or territory of the region was not necessary. This is due to the fact that the entity will already be characterized on a state/province/territory basis due to the nature of how energy resource data is commonly quantified. This will be accomplished by holding the state/province/territory associated with the region in the name attribute. Lastly, for this review, we confirmed that we did not need to add the composite / relationship tables to our ERD. It was determined that it would be sufficient to only include those in the schema.

Review 3 noted that the project description could be reworded to be more concise. As such, we revised our project description with the intent to reduce redundancy to allow readers to quickly understand the nature of our database. It was also suggested that some examples could be listed for environmentally sustainable technology or energy but we felt that our clear and categorized examples in the entities section was sufficient enough for readers.

Review 3 also questioned whether it was acceptable for some attributes in the EnergySource and EnergyTechnology attributes to be blank. The decision to allow attributes to be blank in these cases was due to the potential for data pertaining to certain energy sources and technologies to be unavailable. Similarly to Review 2, Review 3 also suggested that more attributes be added to the Region entity to allow for locations to be defined more accurately. As described above, this was determined to be a beneficial suggestion and was adopted in the design.

From TA grading

We received feedback from our TA that our ERD should list attributes. Because ours previously didn't, we took the time to add the attributes to make it more clear to the reader.

Upgrades to Draft Version

Project Step 4

It was decided that the handlebars templating system would be used instead of pure client-side JavaScript to render webpages using data retrieved by the server from the database and allow for CREATE/INSERT/UPDATE/DELETE functionality. The static html files presented in Project Step 3 were replaced with a handlebars view for each of the five entity webpages.

Additionally, it was decided that the option to remove from the SustainableProduct-Company and EnergySource-Company many-to-many relationships would not be implemented in the web application to reduce the complexity of both the server-side JavaScript functions and the visual layout of the webpages. The option to remove from the EnergySource-Region many-to-many

relationship will still be implemented, meaning that the assignment requirements associated with many-to-many relationships will still be met.

Project Step 3

After the initial html files were created to display the CRUD functionalities on the website, the layout and content of some html elements were revised so that the elements would be in a more readable configuration and better suited to allow the corresponding queries to be made. Specifically, this consisted of placing the forms and buttons associated with the UPDATE, DELETE, and relationship add/remove queries in the table of each webpage and reducing the text displayed for each form and button.

Project Step 2

It was decided that the attribute `cost_per_unit` contained within the `EnergyTechnology` entity would be switched to `cost_per_watt` to allow for standardized cost comparisons to be made between various energy technologies that do not directly depend on system size.

Revised Outline

Project Description

This database will hold information related to renewable energy and environmentally sustainable technology such as the varying types of renewable energy resources and the major companies associated with the supply and manufacturing of environmentally sustainable products. Additionally, specific regions of the world will be contained in the database where certain renewable energy resources are plentiful. There are many different examples of sustainable technology currently being developed, and each product contains unique characteristics that set it apart from others. A well-constructed database will help synthesize and draw relationships among the wide range of information available pertaining to renewable energy and sustainable technology.

Entities

- **EnergySource** (e.g. wind, solar, geothermal, wave, tidal, nuclear)
 - **id**: An auto-incrementing integer serving as the primary key that is automatically assigned to each new energy source added to the database.
 - **name**: A varchar with a maximum of 20 characters representing a renewable energy source. This attribute cannot be blank, and no default attribute will exist.
 - **percent_global_power**: An integer representing the percentage of global power supply that the energy source provides. This attribute must have a value between 0 and 100 or be blank.

- **annual_growth**: An integer representing the annual growth percentage exhibited by the energy source. This attribute must have a value between zero and 100 or be blank.
- **cost_per_kWh**: An integer representing the cost in U.S. cents per kilowatt hour (kWh) of electricity supplied from the energy source. This attribute must have a value greater than zero or be blank.
- **EnergyTechnology** (e.g. wind turbine, photovoltaic array, molten salt tower, dry steam plant, wave surge converter)
 - **id**: An auto-incrementing integer serving as the primary key that is automatically assigned to each new technology added to the database.
 - **name**: A varchar with a maximum of 100 characters representing a renewable energy technology used to harness a particular renewable energy source. This attribute cannot be blank, and no default attribute value will exist.
 - **cost_per_watt**: A float representing the cost in U.S. dollars per watt of power generated by the renewable energy technology (e.g. the cost of one wind turbine). This attribute must have a value greater than zero or be blank.
 - **development_stage**: A varchar with a max of 20 characters representing the stage of development of the energy technology. This attribute will be constrained to one of the following terms: "theoretical", "experimental", "pilot-stage", "commercial", "utility-scale". This attribute cannot be blank, and the default value will be set to "theoretical".
 - **energy_source**: An integer that holds the id of the energy source that is associated with the particular energy technology used to harness it.
- **Company** (e.g. Tesla, SolarCity, Vestas, Siemens, AWS Ocean Energy)
 - **id**: An auto-incrementing integer serving as the primary key that is automatically assigned to each new company added to the database.
 - **name**: A varchar with a maximum of 20 characters representing a company associated with the supply or manufacture of renewable energy or other sustainable technology. This attribute cannot be blank, and no default attribute value will exist.
 - **annual_revenue**: Amount of money a given company makes in a year given as an int. The value of this attribute must be greater than or equal to zero or be blank.
 - **annual_growth**: An integer that represents the annual growth percentage of the revenue generated by the business. There are no constraints for this attribute.
- **SustainableProduct** (e.g. electric cars, energy efficient lighting, energy efficiency software, solar ovens, batteries for renewable energy storage)
 - **id**: An auto-incrementing integer serving as the primary key that is automatically assigned to each new product added to the database.

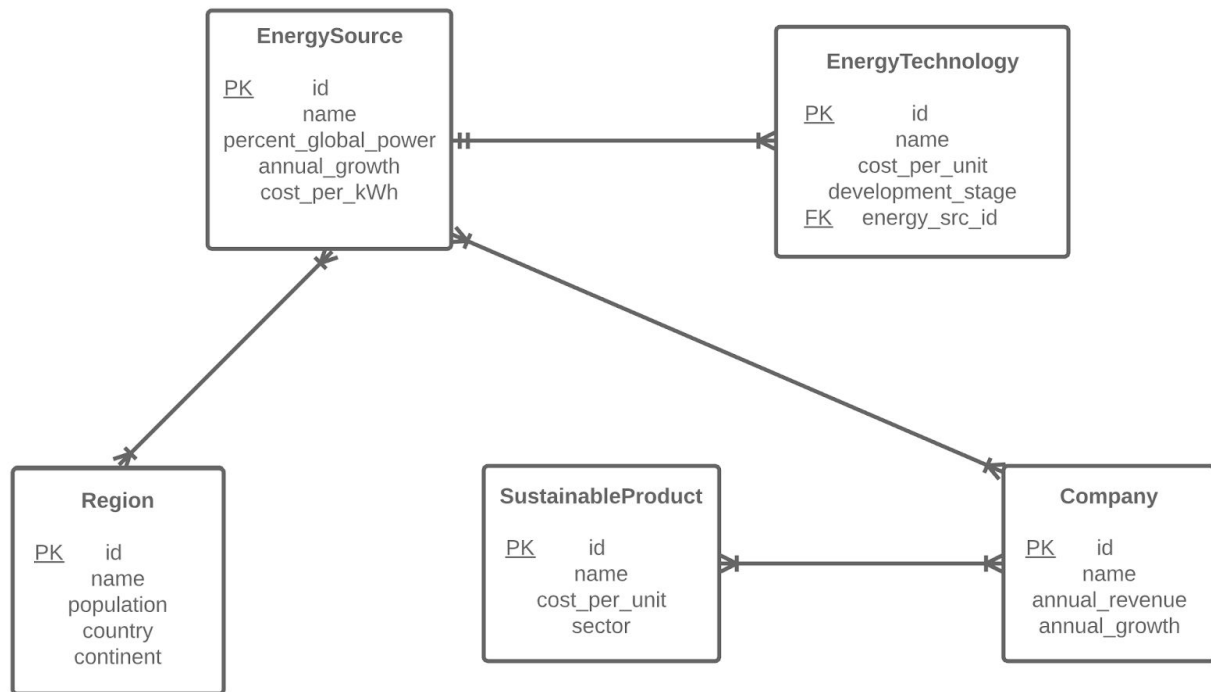
- **name:** A varchar with a maximum of 100 characters representing a sustainable product used to harness a particular renewable energy source. This variable cannot be blank, and no default variable will exist.
- **cost_per_unit:** An integer representing the cost in U.S. dollars per unit of the product. This attribute must have a value greater than zero or be blank.
- **sector:** A varchar with a maximum of 50 characters used to represent the economic market sector to which this product belongs (e.g. household consumer product, transportation, industrial, software). There are no constraints for this attribute.
- **Region** (e.g. California, Texas, China, Germany, Denmark)
 - **id:** An auto-incrementing integer serving as the primary key that is automatically assigned to each new product added to the database.
 - **name:** A varchar with a maximum of 20 characters representing the state, province, or territory associated with the region. The variable cannot be blank, and no default variable will exist.
 - **population:** An integer that represents the human population of the region. There are no constraints for this attribute.
 - **country:** A varchar with a maximum of 50 characters representing the country on which the region is found. This variable cannot be blank, and no default variable will exist.
 - **continent:** A varchar with a max of 20 characters that represents the continent on which the region is found. This attribute will be constrained to one of the following terms: "Africa", "Antarctica", "Asia", "Australia", "Europe", "North America", "Oceania", "South America".

Relationships

- **(EnergySource to EnergyTechnology)** Energy sources are harnessed using particular technologies. This is a *one-to-many* relationship: an energy source can be harnessed by multiple technologies, but any one technology only corresponds with one energy source.
- **(EnergySource to Company)** Various companies are associated with the supply of renewable energy sources. This is a *many-to-many* relationship: some companies specialize in the utilization of one particular energy source, but others are involved in the supply of multiple energy sources. Additionally, a single energy source can be supplied by multiple companies.
- **(SustainableProduct to Company)** Companies provide a range of sustainable technology for purchase. This a *many-to-many* relationship: individual sustainability companies often provide more than one product, and the same product can be marketed by more than one company.

- **(EnergySource to Region)** Energy sources are plentiful in various regions of the world. This is a *many-to-many* relationship: an energy source can be present in multiple regions, and a single region can contain multiple energy sources.

Entity Relationship Diagram



Schema

