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Data Types

Household

Attribute	**Data type**	**Nullable**
Email	String	Not Null
SquareFootage	Integer	Not Null
HouseholdType	String	Not Null
PublicUtilites	ArrayList <String>	Null
ThermostatSettingHeating	double	Null
ThermostatSettingCooling	double	Null

Address

Attribute	**Data type**	**Nullable**
PostalCode	String	Not Null
City	String	Not Null
State	String	Not Null
Latitude	double	Not Null
Longitude	double	Not Null

Appliance

Attribute	**Data type**	**Nullable**
ApplianceOrder	Integer	Not Null
ModelName	String	Null
BTURating	Integer	Not Null

Manufacturer

Attribute	**Data type**	**Nullable**
ManufacturerName	String	Not Null

WaterHeater

Attribute	**Data type**	**Nullable**
CapacityInGallons	double	Not Null
Temperature	Integer	Null
EnergySourceWH	String	Not Null

AirHandler

Attribute	**Data type**	**Nullable**
Air conditioner		
EnergyEfficiencyRatio	double	Not Null
Heater		
EnergySourceH	String	Not Null
Heat pump		
SeasonalEnergyEfficiencyRating (SEER)	double	Not Null

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HeatingSeasonalPerformanceFactor (HSPF)	double	Not Null

PowerGenerator

Attribute	**Data type**	**Nullable**
GeneratorOrder	Integer	Not Null
GenerationType	String	Not Null
AverageMonthlyKilowattHours	Integer	Not Null
BatteryStorageCapacity	Integer	Null

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Business Logic Constraints

Enter Household Info

1. Every household must provide a valid email address and it can't be one that already exists in the database

2. Enter an invalid postal code should be rejected.

3. Require a heating/cooling thermostat entry unless the user has indicated they do not have heating or cooling.

View/Add/Delete Appliances

1. While it is unlikely that an appliance will be deleted, if it is, the appliance number should not be re-used.

2. If all appliances are deleted, the user cannot leave this screen until at least one appliance has been added.

Add/Skip Power Generation

1. If a house is "off-the-grid", the user must add power generation.

View/Add/Delete Power Generation

1. While it is unlikely that a generator will be deleted, if it is, its number should not be re-used.

2. If all generators are deleted and the household is "off-the-grid", the user cannot leave this screen until at least one generator has been added.

Report Part

1. Any instances where a NULL value might be returned should be replaced with an empty string, unless otherwise specified in the report definition.

2. If a sort order is not specified as ascending or descending, then ascending order is implied.

3. If a number is rounded, unless otherwise specified, it should follow the 'half rounds up' method that most DBMSes implement.

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Task Decomposition with Abstract Code

Main Menu

Task Decomposition

Lock Types: No communication with the database.

Number of Locks: None

Enabling Conditions: None. It is the first page visited.

Frequency: High. Every householder must visit this page before they enter their household information or query data.

Consistency: Not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract Code

- Show "***Enter My House Info***" and "***View reports/query data***" link.
- Two options:
  - Click on "***Enter My House Info"*** link. Jump to the **Enter Household Info** task.
  - Click on "***View reports/query data"*** link. Jump to the **View Reports/Query Data** task.

Enter Household Info

Task Decomposition

Lock Types: Read from **Address** and write to **Household** table. For each **Household**, we need to look up the email for validation and edit it if it is a new household. A lookup for the postal code from the **Address** is necessary for validation. Edits of the house type (chosen from a

predefined house type array list), square footage, and thermostat settings for each **Household** are also necessary. Additionally, different utility selections should be recorded for the **Household**. In summary, we need to read and write for this lock.

Number of Locks: Several

Enabling Conditions: Enabled by clicking on "***Enter My House Info"*** link from **Main Menu**

Frequency: High

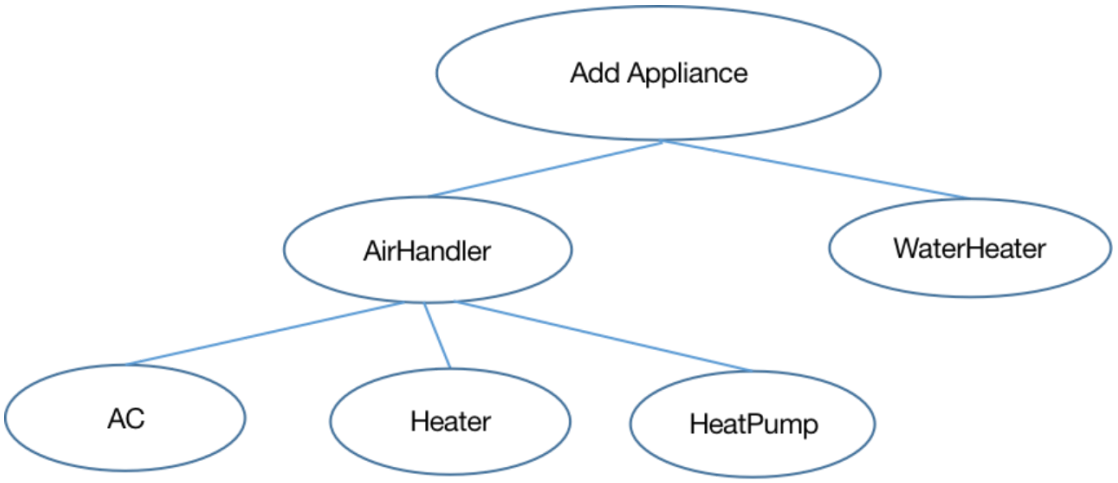
Consistency: Not critical. Order is not critical because we do the validation only when we click ***Next*** button.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract Code

- Each householder enters *email*($Email), *postal code*($PostalCode), *square footage* ($SquareFootage), *thermo heating*($Heating) and *thermo cooling*($Cooling) (in case we uncheck the box *no heating* and *no cooling*) input fields. Each one has to select *home type* ($HouseholdType) and check/uncheck *public utilities* ($Utilities).
- After we fill out all required inputs, click on ***Next*** button:
  - If data validation (no duplicates email or valid postal code from database or no empty string for thermostat setting meanwhile not indicating no heating or no cooling) is successful for both *email*($Email), *postal code*($PostalCode), then:
    - Add Household Information into the database.
    - Jump to **Add Appliance** form.
  - Else:
    - An appropriate error message should be displayed.

Add Appliance



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Task Decomposition

Lock Types: Read from **Manufacturer** and write to **AirHandler**/**AirConditioner**/**Heater**/**HeatPump**/**WaterHeater**. For each **Appliance**, we need to select one type (either air handler or water heater), which is similar to editing the Appliance Type. We also need to look up the manufacturer of the selected appliance type from the database. The ModelName is optional, but we could edit it here. Different appliance types may have different local attributes in addition to some common ones, such as Manufacturer, ModelName, and BTURating. The **AirHandler** and **WaterHeater** will have different layouts and attributes. The **AirHandler** type includes three different types: **AirConditioner**, **Heater**, and **HeatPump**. Essentially, we will have to edit the information for different appliance types. Overall, this lock type will include read and write.

Number of Locks: Many

Enabling Conditions: Triggered after finishing entering household information.

Frequency: High.

Consistency: Consistency is critical. For example, once the ***add*** button is clicked, the newly added appliance with related information (eg. ApplianceOrder) should be immediately updated in the database. Order is critical because we must first select Appliance Type.

Subtasks: Mother task is required to coordinate subtasks. It doesn't matter if we execute **WaterHeater** or **AirHandler** task first.

Abstract Code

- If the user has no appliance to add, *appliance type*($ApplianceType) is equal to Null, then click ***Add.***
  - Jump to the **View Appliances** task.
- Else if *appliance type*($ApplianceType) is equal to 'Water Heater', then Execute **WaterHeater** task:
    - Jump to **WaterHeater** form.
    - Query the **Manufacturer** information for **Appliance.**
    - The user must select *manufacturer* ($Manufacturer), edit *model name*($ModelName) (optionally), *energy source* ($EnergySourceWH), and enter the information for *capacity* ($Capacity), *temperature setting* ($TemperatureSetting) and *BTU Rating* ($BTURating).
    - When ***Add*** button is clicked:
      - If all input fields are valid:
        - That input information will be saved to the database for current **Appliance** for current **Household.**
        - Jump to the **View Appliances** task.
      - Else:
        - Display appropriate error messages.

➢ Else if appliance *type*($ApplianceType) is equal to 'Air Handler' then Execute **Air**

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Handler task:

◆ Firstly, jump to **AirHandler** form. In this form, the following public attributes and checking box will be displayed:

- *manufacturer* ($Manufacturer), *model name*($ModelName) and *BTU Ratings* ($BTURating).
- three checkbox options for different *air handler types*($AirHandlerType).

◆ Query the **Manufacturer** information for **Appliance.** Then select *manufacturer* ($Manufacturer) and edit *model name*($ModelName) and enter the information for *BTU Ratings*($BTURating).

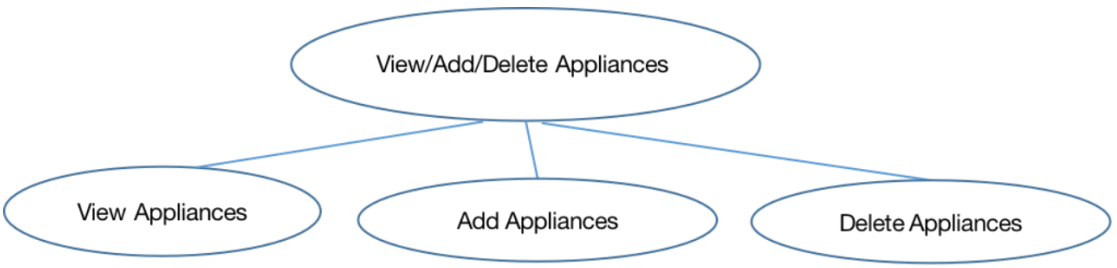
◆ Select *air handler type*($AirHandlerType) in the check box:

- If *the air handler type*($AirHandlerType) check box *Air Condition* is selected, then jump to **AC** task:
  - Display the *Energy Efficiency Ratio* for the text input and then enter the information for *Energy Efficiency Ratio* ($EER).
- If *the air handler type*($AirHandlerType) check box *Heater* is selected, then jump to the **Heater** task:
  - Display *energy source* ($EnergySourceH) box and then select one type of energy source.
- If *air handler type*($AirHandlerType) check box *Heater Pump* is selected, then jump to the **HeaterPump** task:
  - Display *SEER* ($SEER) text box as well as *HSPF* ($HSPF), and enter the information for both of them.

◆ When ***Add*** button is clicked:

- If all input fields are valid:
  - Those inputs information will be saved to the database for current **Appliance** for current **Household.**
  - Jump to the **View Appliances** task.
- Else:
  - Display appropriate error messages (such as 'Invalid data type' or 'Invalid range for SEER').

View/Add/Delete Appliances



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Task Decomposition

Lock Types: Read from AirHandler/AirConditioner/Heater/HeatPump/WaterHeater /Manufacturer and write to AirHandler/AirConditioner/Heater/HeatPump/WaterHeater. For the current Household, the appliance list will provide a summary of appliances with their related information. It will query and look up the information for the related appliances when the **View Appliances** task is run. By running the **Add Appliances** or **Delete Appliances** task, we can insert, delete, and update the appliance information in the database. Overall, this includes write and read lock types.

Number of Locks: Many

Enabling Conditions: View Appliances task is enabled after adding an appliance. The other two are enabled after running **View Appliances** task.

Frequency: Different subtasks have different frequencies. **View Appliances** task is slightly higher than the other two tasks. **Delete Appliances** task has the lower frequency usage than **Add Appliances.**

Consistency: It is critical. For example, once the **Delete Appliances** task is executed, the deleted appliance with related information (eg. ApplianceOrder) should be deleted immediately in the database.

Subtasks: Mother Task is required to coordinate subtasks. We must first execute **View Appliances** task before we edit current appliances.

Abstract Code

- After we finished **Add Appliance** from the last part, firstly run **View Appliances** task:
  - It will query and summarize the basic information (eg. Appliance order#, Type, Manufacturer, Model, etc.) into a table with appropriate layout of ***Delete*** and ***Add Another Appliance*** button.
- Secondly, it will enable us to edit the current appliances. We will have two cases below:
  - If we click on ***Delete*** button, it will run **Delete Appliances** task:
    - Delete and remove the current selected Appliance with its order number and related information for this Household.
    - Execute **View Appliances** task.
    - If all appliances are deleted, jump back to the **Add Appliance** form.
  - If we click on ***Add Another Appliance*** button, it will run **Add Appliance** task:
    - Jump to the **Add Appliance** form.
- When ready, the user can click ***Next*** button to jump to **Power Generation Edit** form.

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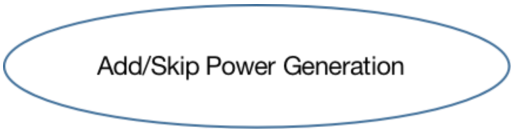
Add/Skip Power Generation



Task Decomposition

Lock Types: Read from Utilities of **Household** and write to **Generator**. For the current **Household**, it will query the database to determine if the householder is "off-the-grid". The user has the option to skip the screen if they are not "off-the-grid". If the current **Household** does not use the skip option, the GenerationType for the **Generator** must be selected from a predefined array list. Additionally, the BatteryStorageCapacity and AverageMonthlyKilowattHours for the **Generator** are required to be filled out, which also relate to the insert type. In summary, we have a write lock type here.

Number of Locks: 2

Enabling Conditions: Trigger by clicking ***Next*** button from Appliances List.

Frequency: The number of households with the additional power generator might be relatively low. The frequency of adding power generation will be lower than skipping it.

Consistency: Consistency is critical. For example, once the ***add*** button is clicked, the newly added generator with related information (eg. GeneratorOrder) should be immediately updated in the database.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract Code

- After clicking ***Next*** button from Appliance list, jump to **Power Generation Edit** form.
- If the house is "on-the-grid", then ***Skip*** button is enabled. There are two options for us to choose:
  - If we click on ***Skip*** button, run **Skip Power Generation** task:
    - No generator for this **Household** will be saved to the database.
    - Execute **View Power Generation** task.
  - Else:
    - Go to step **Add power Generation Info** task to enter power generation Information.
- Else, the house is "off-the-grid", then ***Skip*** button is disabled, and go to step **Add power Generation Info** task to enter power generation Information.
- For **Add power Generation Info** task:

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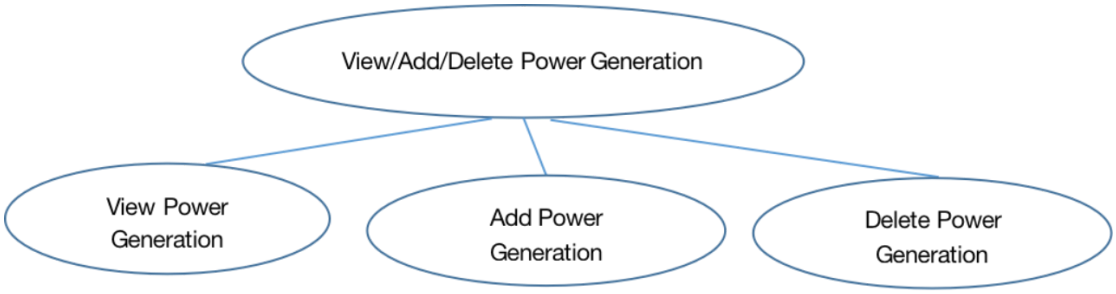
- Select one *generation type*($GenerationType) from the dropdown box.
- Enter the information for *Monthly kwh*($AverageMonthlyKiliwattHours) and *Storage kwh*($BatteryStorageCapacity)
- Finally, after making sure everything is correct. Click on ***Add*** button:
    - If all input fields are valid:
        - The information will be passed and saved in the database.
        - Execute **View Power Generation** task.
    - Else:
        - Display appropriate error messages.

View/Add/Delete Power Generation



Task Decomposition

Lock Types: Read from utilities of **Household**/**Generator** and write to **Generator**. The power generation list for the current **Household** will provide a summary of power generators with their related information. When the **View Power Generation** task is executed, it will query and look up the related generator information. The **Add Power Generation** or **Delete Power Generation** tasks will insert, delete, or update the appliance information in the database. Overall, this involves read and write lock types.

Number of Locks: Several

Enabling Conditions: View Power Generation task is enabled after adding a generator from the last task decomposition. The other two are enabled after running **View Power Generation** task.

Frequency: Different subtasks have different frequencies. **View Power Generation** task is slightly higher than the other two tasks. **Delete Power Generation** tasks have the lower frequency usage than **Add Power Generation**.

Consistency: It is critical. For example, once the **Delete Power Generation** task is executed, the deleted generator with related information (eg. GeneratorOrder) should be deleted immediately in the database.

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Subtasks: Mother Task is required to coordinate subtasks. We must first execute the **View Power Generations** task before we edit current generators.

Abstract Code

- After finishing **Power Generation Edit** form, **View Power Generation** task will be firstly executed:
  - It will query and summarize the basic information (e.g. Generator order#, Type, Monthly kWh, Battery kWh, etc.) into a table with appropriate layout of ***Delete*** and ***Add More Generator*** button.
- Secondly, it will enable us to edit the current generators. We will have two scenarios below:
  - If we click on ***Delete*** button, it will run **Delete Power Generations** task:
    - Delete and remove the current selected **Generator** with its order number and related information for this **Household.**
    - Execute **View Power Generations** task.
    - If all power generators are deleted, jump to the **Power Generation Edit** form.
  - If we click on ***Add More Generator*** button, it will run **Add Power Generation** task:
    - Jump to the **Power Generation Edit** form.
- When ready, the user can click ***Finish*** button to jump to **Wrapping up** form.

Wrapping Up

Task Decomposition

Lock Types: No communication with the database.

Number of Locks: None

Enabling Conditions: Enabled after click ***Finish*** button from power generation list.

Frequency: High. We may want to return to the main menu after finishing entering the information.

Consistency: Not critical.

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Subtasks: Mother Task is not needed. No decomposition needed.

Abstract Code

- Show "***Return to The Main Menu***" link.
- One option:
  - Click on "***Return to The Main Menu"*** link. Jump to the **Main Menu** form.

View Report/Query Data

Task Decomposition

Lock Types: No communication with the database.

Number of Locks: None

Enabling Conditions: Enabled after clicking the "***View reports/query data"*** link from **Main Menu** form.

Frequency: High

Consistency: Not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract Code

- After clicking "***View reports/query data"*** link from **Main Menu** form, it will jump to and then run the **View Reports/Query Data** task:
  - Display Report Links List with "***List Top 25 Popular Manufacturers"*** link, "***Search Manufacturers/Model"*** link, "***Report Heating/Cooling Method"*** link, "***Report Water Heater Statistics by State"*** link, "***Create off-the-grid Household Dashboard"*** link and "***Report Household averages by Radius"*** link***.***
  - Then we have many options to choose:
    - Click the "***List Top 25 Popular Manufacturers"*** link. Jump to the **List Top 25 Popular Manufacturers** task.
    - Click the "***Search Manufacturers/Model"*** link. Jump to the **Search Manufacturers/Model** task.
    - Click the "***Report Heating/Cooling Method"*** link. Jump to the **Report Heating/Cooling Method** task.
    - Click the "***Report Water Heater Statistics by State"*** link. Jump to the

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Report Water Heater Statistics by State task.

◆ Click the "***Create off-the-grid Household Dashboard"*** link. Jump to the **Create off-the-grid Household Dashboard** task.

◆ Click the "***Report Household averages by Radius"*** link. Jump to the **Report Household averages by Radius** task.

View Top 25 popular manufactures

Task Decomposition

Lock Types:
Read from **AirHandler**/**AirConditioner**/**Heater**/**HeatPump**/**WaterHeater**. Read lookups and query information from appliance manufacturers, including all air handler and water heater manufacturers. Air handler is divided into air conditioner, heater and heat pump appliance type. Overall, this lock type will be read.

Number of Locks: Several

Enabling conditions: Trigger by clicking on "***Top 25 popular manufactures"*** link.

Frequency: High. We may want to click the link when users need to generate the report.

Consistency (ACID): not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract code

- Run the view **List Top 25 popular manufacturers** task: Query for information about the household information and appliances listing from the HTTP Session/Cookie.
- If there is no information returned:
  - Display message with 'Nothing is found'.
- Else:
  - Display one table list top twenty-five manufacturers with the most appliances in the database,
    - ◆ One column for each manufacturer along with a ***manufacturer drilldown*** button; another column for the raw count of appliances for that manufacturer; Table ordered by count descending.

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- If clicking on ***manufacturer drilldown*** button:
  - List the manufacturer name at the top, then a table is displayed:
  - One column for each appliance type; another column with the raw count of appliances of that type for that manufacturer (integer); Ordered by count ascending.

Manufacturer/model search

Task Decomposition

Lock Types: Read from AirHandler/AirConditioner/Heater/HeatPump/WaterHeater. Read lookups and query information from appliance manufacturers and models, enter any string to match any part of a manufacturer name or model name from the database. Appliances include all air handlers and water heaters. Air handler is divided into air conditioner, heater and heat pump appliance type. Overall, this lock type will be read.

Number of Locks: Several

Enabling conditions: Trigger by clicking on "***Manufacturer/model search"*** link.

Frequency: High. We may want to click the link when users need to generate the report.

Consistency (ACID): not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract code

- Run **Search Manufacturers/Model** task:
  - Display a *search row* ($ManuModel) with ***Search*** button next to it. Enter the information for the search row and click on ***Search*** button:
  - If the information is not found:
    - Display message with 'Nothing is found'.
  - Else:
    - Return a list of distinct results where entered string matches any part of a manufacturer name or model name.
- The table content is shown as below:
  - Columns for the manufacturer name and model name; ordered by manufacturer name ascending and model name ascending.
  - The cell with manufacturer name, model name (or both) that matched the

search string must be highlighted with a light green background.

Heating/cooling method detail

Task Decomposition

Lock Types: Read from **AirHandler**/**AirConditioner**/**Heater**/**HeatPump**/**Household**. Read lookups and query households' appliance air handler information. Read information from air handler BTU rating and attributes of air conditioner/heater/heat pump, grouped by household type information from household's attribute. Overall, this lock type will be read.

Number of Locks: Several

Enabling conditions: Trigger by clicking on "***Heating/cooling method details"*** link.

Frequency: High. We may want to click the link when users need to generate the report.

Consistency (ACID): not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract code

- Run **Report Heating/Cooling Method** task:
  - Display three tables grouped by air handler heating/cooling method:
- The table content is described below:
  - Table one: each column for the count of air conditioners, average air conditioner BTUs, and average EER
  - Table two: each column for the count of heaters, average heater BTUs, and the most common energy source
  - Table three: each column for the count of heater pumps, average heat pump BTUs, and the average SEER and the average HSPF

Water heater statistics by state

Task Decomposition

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Lock Types: Read from **Address**/**WaterHeater** table. Read lookups of address and appliance water heater's attribute. Read state's abbreviation from address and other attributes from the water heater entity. Overall, this lock type will be read.

Number of Locks: 2

Enabling conditions: Trigger by clicking on "***Water heater statistics by state"*** link.

Frequency: High. We may want to click the link when users need to generate the report.

Consistency (ACID): not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract code

- Run **Report Water Heater Statistics by State** task:
  - Firstly, Displayed a table with water heater statistics for each state.
  - The table content is shown as below:
    - Each column for the state's abbreviation along with ***state abbreviation*** button, the average water heater capacity, the average water heater BTUs, the average water heater temperature setting, the count of water heaters where a temperature setting has been provided, the count of water heaters where no temperature setting has been provided, sorted by state abbreviation ascending.
    - If there are no water heaters and/or households for a state, display zeroes for all statistical columns.
  - After clicking each ***state abbreviation*** button, jump to state water heater reports table:
    - Display the state as a header or report title.
    - For the table content, display a column for each energy source, grouped by energy source; Display a column of the minimum water heater capacity; Display a column of the average water heater capacity; Display a column of the maximum water heater capacity; Display a column of the minimum temperature setting; Display a column of the average temperature setting; Display a column of the max temperature setting; Display the row ordered by energy source in ascending order.

Off-the-grid household dashboard

Task Decomposition

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Lock Types: Read from Utilities of Household/Address/Generator/AirHandler/ AirConditioner/Heater/HeatPump/WaterHeater. Read-only lookups of household, address, appliance, and power generation information. This lock type will be read.

Number of Locks: Several

Enabling conditions: Trigger by clicking on "***Off-the-grid household dashboard"*** link.

Frequency: High. We may want to click the link when users need to generate the report.

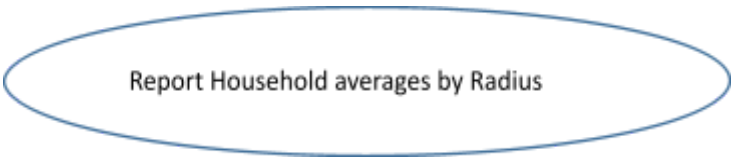
Consistency (ACID): Not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract code

- Run **Create off-the-grid Household Dashboard** task, display the following tables:
  - First table: one column listed the state with the most "off-the-grid" households, one column displayed the count of its households.
  - Display the average battery storage capacity.
  - Second table: two columns for the percentages for each power generation type (solar-electric, wind or mixed).
  - Third table: one column for "off-the-grid"/ "on-the-grid" household category, one column for the average water heater gallon capacity.
  - Fourth table: columns for the minimum, average and maximum BTUs for all "off-the-grid" households' appliances will be displayed, grouped by appliance type.

Household averages by radius



Task Decomposition

Lock Types: Read from Address/Household/Generator. Read lookups and query from the whole household, household utilities, address and power generation information. Insert the postal code and radius to query data. Overall, this lock type will be read.

Number of Locks: Several

Enabling conditions: Trigger by clicking on "***Household averages by radius"*** link.

Frequency: High. We may want to click the link when users need to generate the report.

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Consistency (ACID): not critical. Order is not critical as well.

Subtasks: Mother Task is not needed. No decomposition needed.

Abstract code

- Run **Report Household averages by Radius** task:
  - Display two input fields: postal code to center the search on, and the search radius with ***Search*** button on the side.
  - Enter two input fields.
  - After clicking on ***Search*** button:
    - If the input postal code and radius are valid:
      - Display the postal code, the search radius and the count of households.
      - Display a table: a column for the household types, another column for the count of households for each household type.
      - Display average square footage, average heating temperature, average cooling temperature, which public utilities are used (displayed in a single cell, separated by commas), the count of "off-the-grid" homes, the count of homes with power generation, the most common generation method, average monthly power generation and the count of the households with battery storage.
    - Else:
      - Display appropriate error messages.

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Appendix

Markups	Examples
Bold Underline: Form	**Water Heater** form
Bold Italics: Buttons	***Enter My House Info*** button
Bold: Task	**Enter Household Info** task
Italics: Form input fields (checkbox or free-form text)	*Energy Source, Energy Efficiency Ratio, etc.*
"Bold Italics with quotation marks": Form link	"***View reports/query data***" link
$String: input field in UI	$ApplianceType input in UI
'Single Quote': Message	'Nothing is found'
Bold highlighted in Blue: Entity in ER	**Household**

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