**The Guideline of Using the UH-Switch Model**

This document is prepared to explain how to use the UH-SWITCH model. The document first provides the list of input files and modules used in the UH-SWITCH model. Then, it explains the basic structure of the model. After that, the steps and the commands to run the model are provided. By using them, users can create an input profile, run the model, and generate the output files.

The UH-Switch model is a micro-grid Switch model. The underlying structure of the model is the Switch model, the energy planning model developed by Matthias Fripp. The UH-SWITCH model is supposed to find the most economical way to serve electricity and a path to achieve the renewable transformation plan of the University of Hawaii at Manoa.

1. **List of input files**

The UH-SWITCH model uses multiple input files. This section provides the list of input files and explains each input files

* + carbon\_prices.csv
    - Contains the price of carbon dioxide
    - Currently carbon price is set to 15 dollars per tons of CO2
  + demand\_charge\_period.csv
    - Provides the demand charge
    - The demand charge is the part of non-energy charge from HECO
    - It is based on demand (MW) not consumption (MWh)
    - unit: dollar/MW
  + financials.csv
    - Provides a based year, interest and discount rate
  + fuel\_cost.csv
    - Contains the prices of fossil fuels
  + fuels.csv
    - Contains the list of fossil fuels used in the system
    - Natural gas and oil are included for the UH-SWITCH system as a fossil fuel
    - CO2 intensity rate and eligibility of RPS are also included
  + gen\_build\_costs.csv
    - Contains the costs of building each generation project
  + gen\_build\_predetermined.csv
    - Provides the information of existing facilities
    - Capacity, built year
  + gen\_take\_or\_pay\_cost.csv
    - Provides the price of PPA for PV
  + generation\_projects.info.csv
    - Contains the detailed information of each power project
  + load\_zones.csv
    - Set the name of zone to serve electricity
  + loads.csv
    - Contains the information of electricity demand of the UH
    - The unit of time is 15 minutes
  + modules.txt
    - Provides the list of modules considered in the model
    - The number and list of modules used in the analysis depend on the selected scenarios
    - The detailed information of each module will be provided in the following section
  + non\_fuel\_energy\_sourcs.csv
    - Provides the list of renewable energy sources (PV, wind) considered
  + nonenergy\_price\_timepoint.csv
    - Contains the price of nonenergy charge
    - The unit of the nonenergy charge is dollar/MWh
  + periods.csv
    - This file indicates the investment periods
    - The investment periods are currently set at 2020, 2025, 2030, 2035
  + power\_price\_timepoint.csv
    - Contains the energy charge from HECO
    - The unit of the energy charge is dollar/MWh
  + timepoints.csv
    - Presents each time point when the system is optimized
    - The UH-Switch model is set to be optimized in 15-min basis
  + timeserices.csv
    - Provides the information of time series (daily basis)
    - Contains the weight of each day
    - The weight of each day depends on the number of sample days in each month
  + variable\_capacity\_factors.csv
    - Provides the rate of electricity generation in each PV project
    - If the future PV project is assigned that its generation is variable, then the capacity factor for the PV project should be included.

1. **List of python files creating input files**

To make easy to handle input files, multiple python codes are created. This section provides the list of python scripts and explains the role of each script.

* prepare\_purchase\_power\_price.py (check this out)
  + - This generates “power\_price\_timepoint.csv” by using estimated energy charge. The energy charge of HECO is closely associated with the global oil prices. This script creates the csv file by using the results of projecting future energy prices.
* set\_ppa\_project\_price.py
  + - Generating PPA price input for PV project with PPA. Currently, the model considers only one PPA project, Rooftop\_PV-2020\_PPA.
* create\_input\_folder.py
  + - This python script creates a set of input profiles that can be used in the UH-SWITCH model. The way to use it will be explained in Section 4.

1. **The Structure of Scenarios**

This section explains scenarios used in the UH-SWITCH model. The UH-SWITCH model can create more than a thousand different scenarios. Each scenario contains eight options, and each option provides three or four choices. This section provides a brief explanation of each option and the choices under each option.

* 1. HECO’s Renewable Transition Plan:

The first option that the UH-SWITCH model provides is the HECO’s renewable energy plan. Two different choices are provided under this option. The first choice is the transition plan based on HECO’s Power Supply Improvement Plan (PSIP), and the second choice is based on the optimized results by using the Oahu-SWITCH model.

* + - EM0: Based on the plan in PSIP 2016
    - EM1: Based on the results of optimized plan from the Oahu-Switch model
  1. Electricity demand (L):

The second option is about the UH’s electricity demand. The data used in this option is the UH’s 15-min electricity demand. Total four different choices are created based on the UH’s energy efficiency improvement plan: 0%, 10%, 20%, and 30% energy efficiency improvement. These different plans indicate the UH’s 15-min electricity demand will consistently decrease from 2020 to 2039. As a result, the UH’s 15-min electricity demand in 2039 will be 10% (or assigned percent) lower than the demand in 2020.

* + - 00L: 0% energy efficiency improvement
    - 10L: 10% energy efficiency improvement
    - 20L: 20% energy efficiency improvement
    - 30L: 30% energy efficiency improvement
  1. Energy charge (EC)

EC indicates the energy charge from HECO, which is the same as the energy charge recovery factor (ECRF). The ECRF is highly correlated to global crude oil prices. To reflect this relationship, the UH-SWITCH model uses three different options such as high, middle, and low global oil prices.

* + - EC1: Middle price scenario (based on futures prices of Brent crude oil)
    - EC2: High price scenario (based on EIA’s crude oil forecast)
    - EC3: Low price scenario (based on 1 SD lower than futures price)
  1. Non-energy charge (NEC)

NEC includes the non-energy charge which includes RBA, PPAC, and demand charges. The rate of non-energy charge is highly related to the overall electricity consumption. The UH-SWITCH model considers two different assumptions of future electricity demand in Oahu. The first assumption is that the electricity consumption in Oahu will be the same as the current level. In other words, there is no grid defection. The second assumption is that the electricity consumption in Oahu will be defected by 30% until 2039.

* + - NEC0: No grid defection
    - NEC1: 30% grid defection
  1. PV installation without PPA (PV)

This option considers the PV installation plan of the UH without purchase power agreement (PPA) with HECO. Thus, the UH is expected to pay for installation and maintenance costs for PV. The maximum capacity of PV is set to 15 MW. Due to the loop repairment, the PV installation is set to follow a certain schedule. The user can choose to either include or exclude this PV installation.

* + - PV0: without any PV installation on campus
    - PV1: with 15MW installation plan on campus
  1. PV installation with PPA (PPA)

This option considers the PV installation plan of the UH. This plan does not consider a purchase power agreement (PPA) with HECO. Thus, the UH will pay for both installation and maintenance costs for PV. In this plan, the maximum capacity of PV is set to 15 MW. Due to the loop repairment, the PV installation will follow a specific installation schedule. The user can choose to either include or exclude this PV installation.

* + - PPA0: No PPA contract with HECO
    - PPA1: 17 cents per kW
    - PPA2: 15 cents per kW
    - PPA3: 19 cents per kW
  1. Cogeneration power plant project (CG)

The UH-SWITCH model has an option to build a cogeneration power plant (CPP). The model provides five different ways to install a cogeneration power plant. The specific description of each choice is provided below.

* + - CG0: the UH won’t build a CPP
    - CG1: the UH will build a CPP without PPA
    - CG2: the UH will build a CPP without PPA. The CPP will serve only the BIOMED chiller demand.
    - CG3: the UH will build a CPP with PPA
    - CG4: the UH will build a CPP with PPA. The CPP will serve only the BIOMED chiller demand.
  1. Green Tariff in West Oahu (WO)

WO indicates the 10 PV installation plan in West Oahu under the green tariff with HECO. The user can choose whether to include or exclude the WO in the model.

* + - WO0: without PV project in West Oahu
    - WO1: with PV project in West Oahu
  1. Battery:

The capacity of the battery installation will be determined by model.

* 1. How to read scenarios in input folder

Example:

* + - Input\_EM1\_00L\_EC0\_NEC0\_PV1\_PPA1\_CG1\_WO0:
* HECO’s renewable energy plant is based on the results of the optimization plan
* UH’s energy efficiency improvement will be zero
* Energy charge is projected based on global Brent crude oil futures prices
* Non-energy charge is projected without grid defection
* 10MW PV construction plan on campus is included
* 5MW PV project with 15 cents/kWh PPA is included
* Cogeneration power plant will be installed
* 10MW PV project in West Oahu is excluded

1. **Steps to run the model**

This section explains how to run the UH-Switch model step-by-step. To run the model, you can use a terminal (for Mac) or a conda prompt (for Window). The original switch model and python should be installed before running the model.

* 1. Create an input folder

To create a folder containing all of input files, go to ‘inputs\_outputs’ folder and run a following command

*python create\_input\_folder.py “name\_of\_scenario”*

ex) python create\_input\_folder.py EM0\_00L\_EC1\_NEC0\_PV0\_PPA0\_CG0\_WO0\_VRM0

This command line will generate input folder named as

*input\_“name\_of\_scenario”*

in the current directory

* 1. Run the UH-Switch model

After creating the input folder, you can run the UH-switch model. Go to the directory that contains the input folder that you would like to run. Run the model by using the following command.

*‘switch solve --inputs-dir name\_of\_input\_folder --out-dir name\_of\_output\_folder’*

ex) ‘switch solve –inputs-dir Input\_EM0\_00L\_EC1\_NEC0\_PV0\_PPA0\_CG0\_WO0\_VRM0

–output-dir EM0\_00L\_EC1\_NEC0\_PV0\_PPA0\_CG0\_WO0\_VRM0’

This command will run the UH-SWITCH model by using the assigned input folder. Then, the model will create an output folder to store all of the outputs.

* 1. Generate the final results and figures

The following command will compute the monthly UH’s electricity bill during the study period. The model also creates figures presenting UH's future monthly bill, hourly load balance, and the percentage of each source used for annual electricity generation.

*‘python prepare\_final\_results.py name\_of\_scenario’*

ex) python prepare\_final\_results.py EM1\_00L\_EC0\_NEC0\_PV1\_PPA1\_CG1\_WO0

* 1. Run all models all at once

If you like to run all scenarios all at once, please, use the following command.

*‘python run\_multiple\_scenarios.py’*

Last updated: April 19, 22