Projected Electric Vehicle/Hydrogen Electric Vehicle Employee Demand Methodology Technical Memo

as part of the **Workforce Development** project *for the*

National Renewable Energy Laboratory

March 27, 2025

Introduction

This technical memo details methodology relating to the Workforce Development project, a collaborative effort between the Virginia Department of Rail and Public Transportation (DRPT) and the National Renewable Energy Laboratory (NREL) as a continuation of the Commonwealth of Virginia's transit modernization efforts brought about by HJ 542. This initiative aims to support transit agencies in their workforce development efforts by providing comprehensive guidance, assisting with employee recruitment, retention, and reskilling, and addressing skill gaps such as identifying training needs and supporting the development of new programs.

This technical memo details the methodology relating to the following task of the Workforce Development project:

1. **Employee and Training Demand Analysis**: Project the need for EV and hydrogen fuel cell (HFC) training across VA based on transition goals and other resources.

The methodology herein can be replicated by other interested states or organizations. Engagement with stakeholders including the local Clean Cities and Communities Coalition can account for and/or tailor to address state specific nuances.

Methodology

The Employee and Training Demand Analysis includes four key steps:

1. Forecast Workforce Supply to estimate the anticipated number of newly credentialed workers trained for EV and hydrogen fuel cell-related occupations

2. Forecast Employee Demand to estimate the number of anticipated job opportunities for select EV and hydrogen fuel cell-related occupations based on the overall growth of the overall market for EV and HFC vehicles and infrastructure

3. Forecast Training Demand to understand the gap or surplus between workforce supply and employee demand which reflects unmet or misaligned training demand

4. Synthesize Findings within a final output report

Detailed methodology for each step can be found below.

1. Forecast Workforce Supply: This step includes accessing the Integrated Postsecondary Education Data System (IPEDS), the core postsecondary education data collection program for National Center for Education Statistics (NCES), and Apprenticeships.gov to download historical completions relating to the workforce groups and occupations and projecting those completions through 2035.

Steps taken to forecast training demand include the following:

A. Generate credentials awarded by Occupation and Workforce Groups from IPEDS for years 2012-2013 to 2022-2023 to understand historical completions

1. Generate an initial list of higher education institutions by downloading NCES data[1] on January 16, 2025, using the following criteria:
    a. States: Virginia

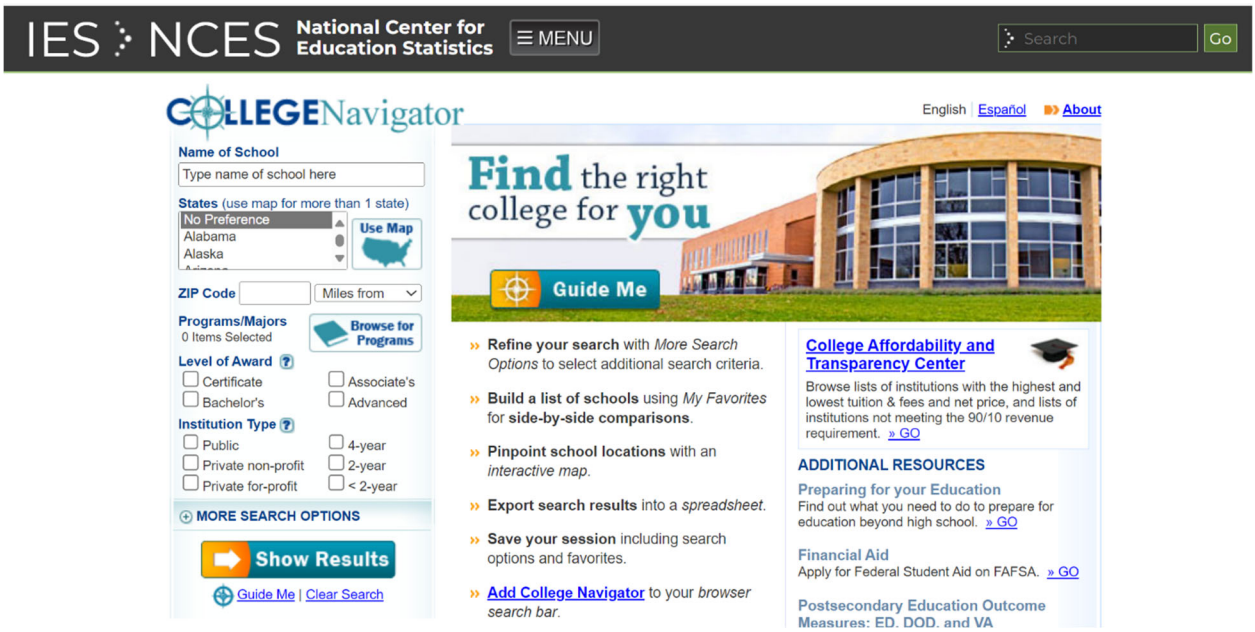

Image: College Navigator

2. Return results with 163 institutions in Virginia from the NCES database.
3. Download Completions for the relevant workforce groups from the list of institutions by accessing Custom Data Files via the Integrated Postsecondary Education Data System (IPEDS) Data System[2]:
    1. Select Institutions
        i. By Names or UnitIDs
        ii. Copy the list of IPEDS ID from the list of 163 institutions in Virginia downloaded from College Navigator
        iii. Paste the IPEDS ID in the 'Institution Name' box and separate each with a comma to search for all the institutions in Virginia[3]

[1] https://nces.ed.gov/collegenavigator/

[2] https://nces.ed.gov/ipeds/datacenter/InstitutionByName.aspx?goToReportId=5&sid=6e7b81bb-d33e-4483-ace6-2910f3482239&rtid=5

[3] This search may return a different number of institutions in IPEDS. This may be due to institutions changing their name, permanently closing or another reason. If there is a discrepancy between the number of institutions returned from the NCES database and IPEDS, further analysis of the missing institutions can verify that the institution list is comprehensive.

iv. Click 'Select'[4]

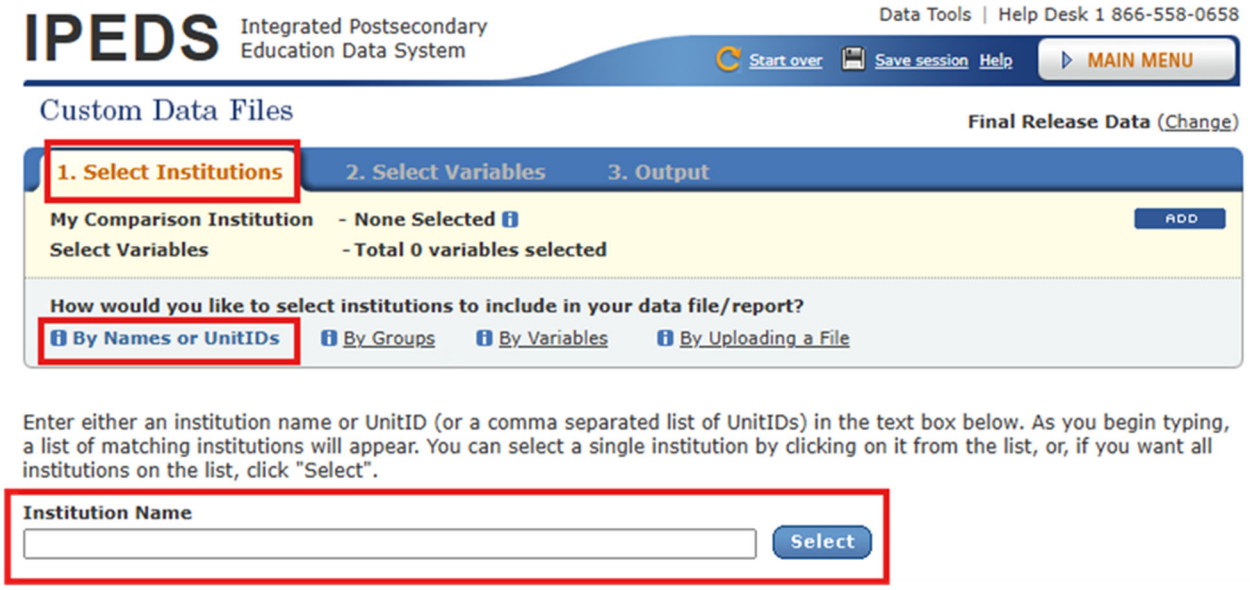

Image: IPEDS Search Institutions

v. Select all of the institutions in Virginia by clicking 'Check All'
vi. Click 'Continue'

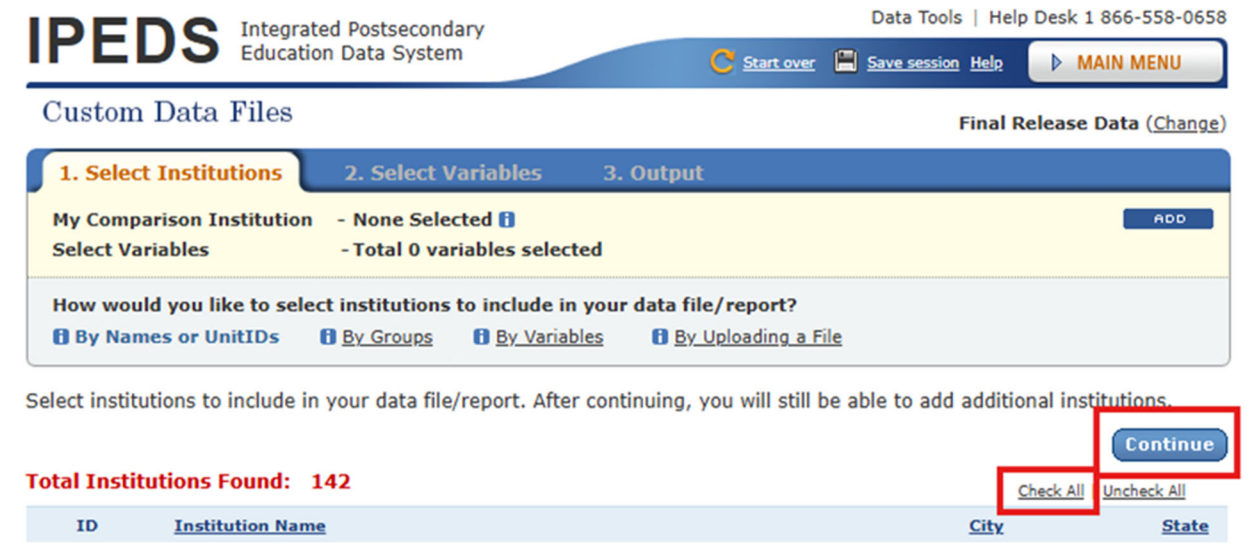

Image: IPEDS Select Institutions

[4] To create a comma-separated list, first, paste the list of IPEDS IDs into an Excel spreadsheet. In an empty cell, enter a TextJoin formula, =TEXTJOIN(" , " , TRUE, A1:A163), then hit 'Enter.' Copy the list and paste it into the IPEDS ID in the 'Institution Name' box.

b. Select Variables
   i. Browse/Search Variables
   ii. Completions

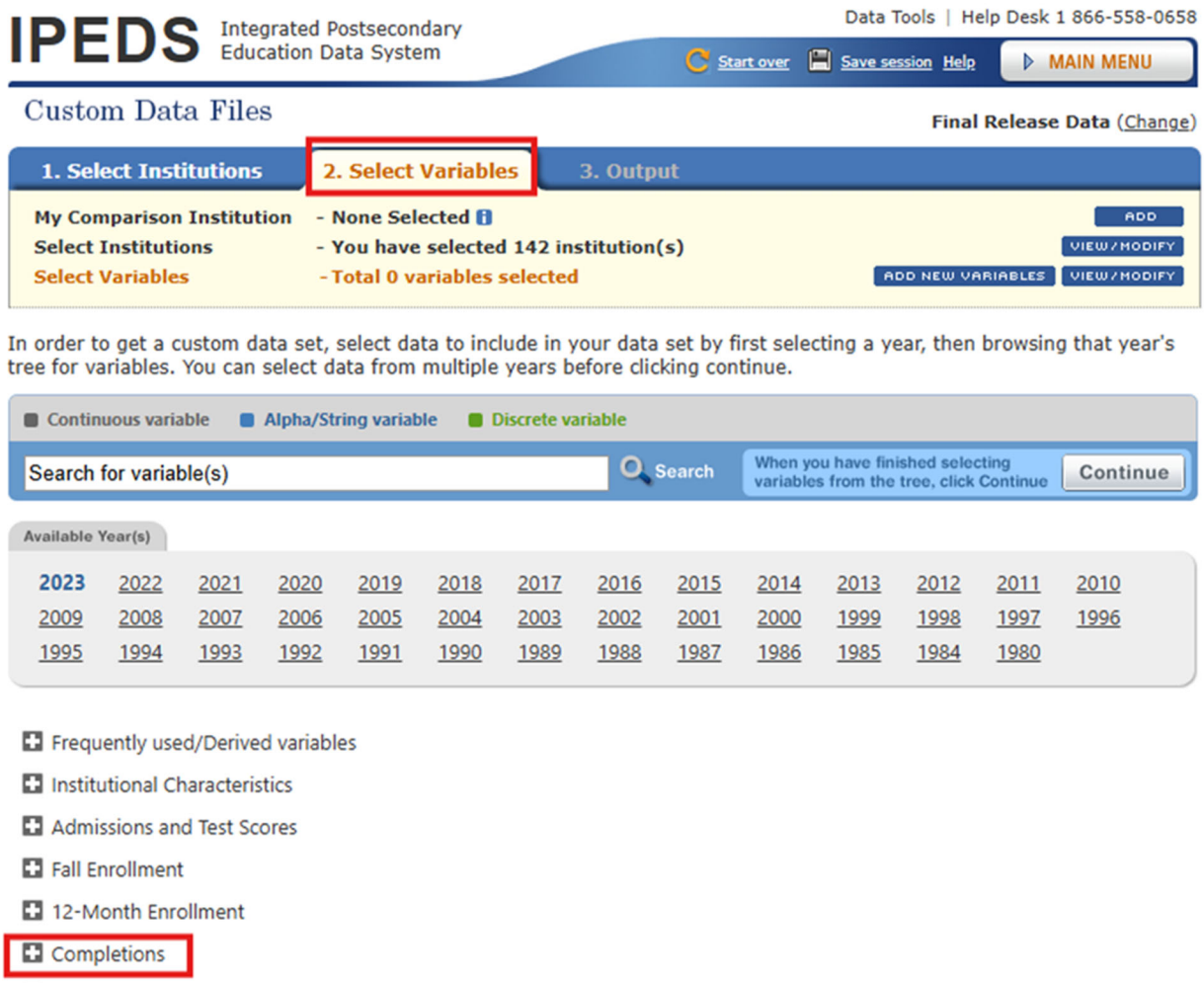

Image: IPEDS Select Variables

i. Using the following list of Workforce Group classification of instruction programs (CIP)[5] codes found in the Appendix related to Electrician and Charging Infrastructure, Hydrogen Fuel Cells, Manufacturing, Automotive Maintenance and Service, and Transit and Facility Management developed in coordination with NREL and VA DRPT, download Completions for 2023:
   a. Available Year(s): 2023

[5] All CIP (2020) can be found here: https://nces.ed.gov/ipeds/cipcode/browse.aspx?y=56. All CIP (2010) can be found here: https://nces.ed.gov/ipeds/cipcode/browse.aspx?y=55. This Crosswalk of CIP codes to Occupations was developed by accessing this resource from IPEDS: https://nces.ed.gov/ipeds/cipcode/post3.aspx?y=56.

b. Completions by CIP 2020
   - Completions
     - Awards/degrees conferred by program (CIP), award level, race/ethnicity, and gender: July 1, 2022, to June 30, 2023
       - Select Qualifying Variable(s)
         - First or Second Major
           - ✓ First major
           - ✓ Second major

           Click Save
         - CIP Code – 2020 Classification

           Review the list of CIP (2020) found in the Appendix and select only the applicable 4-digit CIP Codes. 39 value(s) selected[6]

           Click Save
         - Award level code
           - ✓ Degrees/certificates total

           Click Save
       - Select from the List of Variables
         - ✓ Grand total

c. When you finish selecting variables from the tree according to the steps above, *Click Continue*

[6] Sorting the list of reference CIP codes from smallest to largest first can help with the process of selecting all applicable codes.

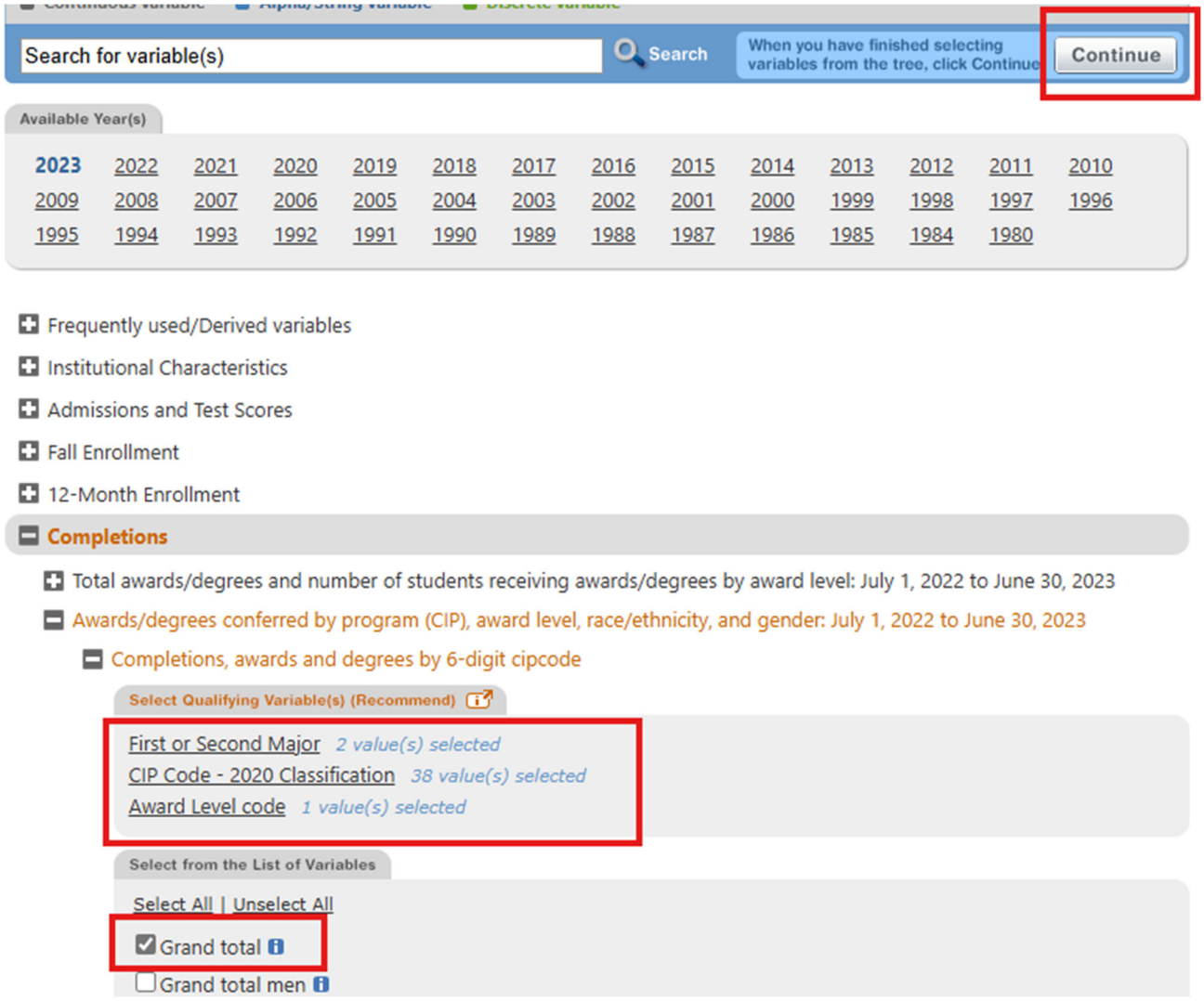

Image: Completions by CIP 2020

c. Output. Download the data by clicking on 'CSV'[7]

[7] Once all completions are generated, review the output to remove any outside of the scope of analysis such as 'Aircraft' related programs under CIP 47.06.

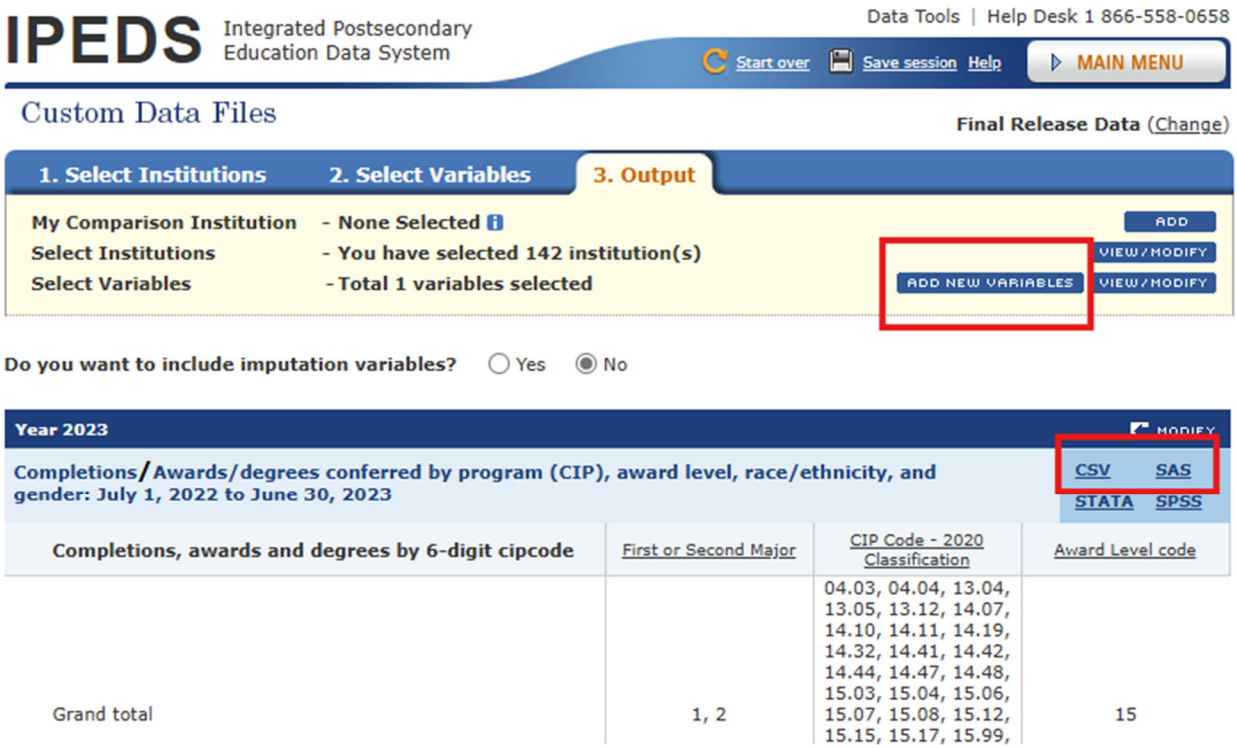

Image: IPEDS Output

5. Once the data has been downloaded, click on 'Add New Variables'
6. Select the next year and repeat Forecast Workforce Supply "Step A3", for each year of data needed
    1. For the purposes of the Employee and Training Demand Analysis, 11 years of data was downloaded (2013 to 2023)
    2. Note that for years 2019 and prior, the 2010 CIP codes should be used (see in the Appendix)

B. Generate relevant completer apprentices from Apprenticeship.gov for fiscal years 2015-2025 to capture an alternative academic pathway of workforce supply

1. Access the Interactive Apprenticeship Data dashboard on Apprenticeship.gov[8]
    a. Click on Apprentices by Program Location
    b. Apprentice Type: Completer Apprentices
    c. Fiscal Year: FY 2015
    d. State: Virginia
    e. Occupation: Select multiple occupations based upon the crosswalk in the Appendix

[8] https://www.apprenticeship.gov/data-and-statistics/apprentices-by-state-dashboard

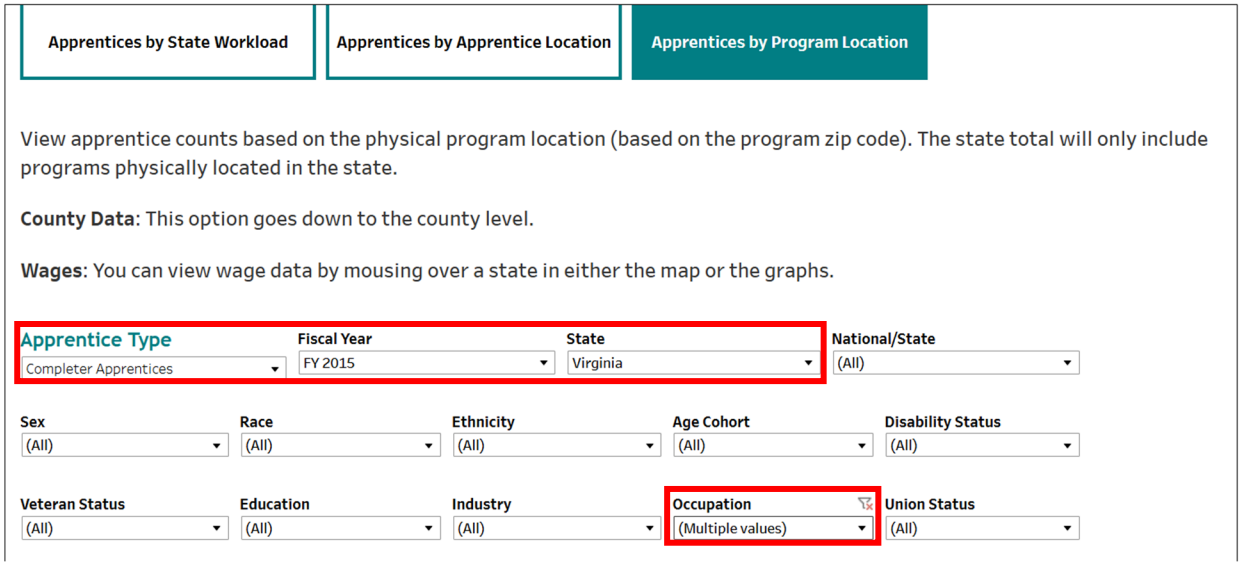

Image: Apprenticeship.gov

f. Breakdown: Occupation

2. Using Excel, noted the number of completer apprentices by Occupation

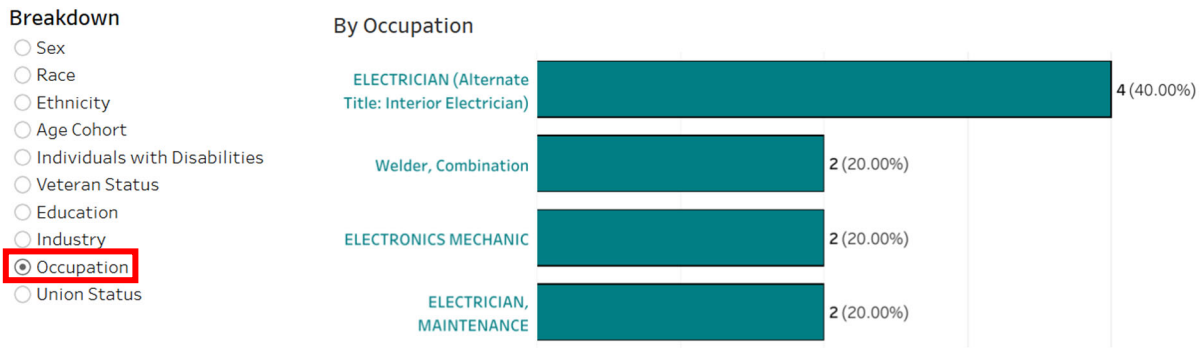

Image: Completer Apprentices by Occupation

3. Map the completer apprentices Occupations for FY 2015 to the Workforce Groups and Occupations listed in the Appendix
4. Repeat Forecast Workforce Supply "Steps B1-3" for FY 2016 – FY 2024

C. *Identify average annual change in completions and completer apprentices over the last 10 years and 3 years and create a smoothed regression model to determine a projected average annual growth rate of completions into the future*

1. Combine each year's data into one spreadsheet from Forecast Workforce Supply "Step A"
2. Map the CIP codes to the associated Workforce Groups and Occupations using the list of CIP (2020) and CIP (2010) codes in the Appendix
3. Create a PivotTable[9] to summarize completions by Occupations for the 10-year period
4. Add the completer apprentices data from FY 2015 - FY 2024 from Forecast Workforce Supply "Step B" to the completions by Occupations from Forecast Workforce Supply "Step C3"
5. Using the data from Forecast Workforce Supply "Step C4", identify average annual change in completions over the last 10 years and 3 years to determine a projected average annual growth rate in completions
    a. First, identify the 10-year growth rate for each Occupation
        i. Using Excel, subtract the earliest year's value for the first Occupation from the most recent year's value, and divide it by the earliest year's value (e.g., 2023 – 2013 / 2013)
        ii. Copy the formula for each Occupation
    b. Next, identify the 10-year average annual growth rate
        i. Create a formula to divide the first Occupation's growth rate established in C5a by 10 and copy that formula for each Occupation
    c. Then, identify the 3-year growth rate for each Occupation
        i. Create a formula to subtract the 2020 value (3 years prior) for the first Occupation from the 2023 value (most recent) and divide that value by the 2020 value (e.g., 2023 – 2020 / 2020)
        ii. Copy that formula for each Occupation
    d. Finally, identify the 3-year average annual growth rate
        i. Create a formula to divide the first Occupation's 3-year growth rate established by Forecast Workforce Supply "Step C5c" by 3 and copy that formula for each Occupation
6. [Optional] Visualize the year 2023 completions in PowerBI or another data visualization tool by county for each Workforce Group to identify regions with high/low preparedness for training demand based upon a heat map of completions[10]. Users can still analyze regional preparedness using Excel tables if access to or the use of Power-BI is not feasible. This can be accomplished by mapping each institution to a region (e.g., county) and developing a count of completions per region within Excel.

[9] Create a PivotTable to analyze worksheet data: https://support.microsoft.com/en-us/office/create-a-pivottable-to-analyze-worksheet-data-a9a84538-bfe9-40a9-a8e9-f99134456576

[10] https://learn.microsoft.com/en-us/power-bi/visuals/power-bi-visualizations-arcgis

D. Apply the projected average annual growth rate to project credentials (plus completer apprentices) by Occupation and Workforce Group to 2035

1. Using the data from Forecast Workforce Supply "Step C", calculated a smooth regression annual growth rate for each Occupation
    a. Calculate the average between the 10-year average annual growth rate from Forecast Workforce Supply "Step C5b" and the 3-year average annual growth rate from Forecast Workforce Supply "Step C5d" for one Occupation
    b. Repeat Forecast Workforce Supply "Step D1a" for each Occupation
2. Using the smooth regression annual growth rate, projected completions by Occupation for years 2024 – 2035
    a. Using the previous year's completions for one Occupation, multiply the smooth regression annual growth rate by the previous year's completions and add the previous year's completions (e.g., 2023 * smooth regression annual growth rate + 2023)
    b. Repeat Forecast Workforce Supply "Step D2a" for years 2025 – 2035
3. Map the resultant table of completion projections for each Occupation to its corresponding Workforce Group according to the Appendix to summarize the completions by Workforce Group

2. Forecast Employee Demand: This step includes accessing Projection Central and the BLS to download employment data relating to the Workforce Groups and Occupations and projecting employment to 2035 based on scenarios.

Steps taken to forecast employee demand includes the following:

A. Generate number of jobs and average annual openings by Occupation and Workforce Group from Projections Central for years 2022 to 2032

1. Download Long-Term Occupation Projections (2022-2032) from Projection Central[11]
    a. Search and Select State: Virginia
    b. *Click 'Continue to Occupation Selection'*

[11] Projection Central by the Projections Managing Partnership (PMP) is an integrated, nationwide program of state and local projections. The PMP helps projections customers make informed decisions based on the most reliable and relevant occupational and industry outlook information. Funding for the PMP is provided by the U.S. Department of Labor, Employment & Training Administration, with technical support from the Bureau of Labor Statistics and other entities across the country. https://projectionscentral.org/longterm

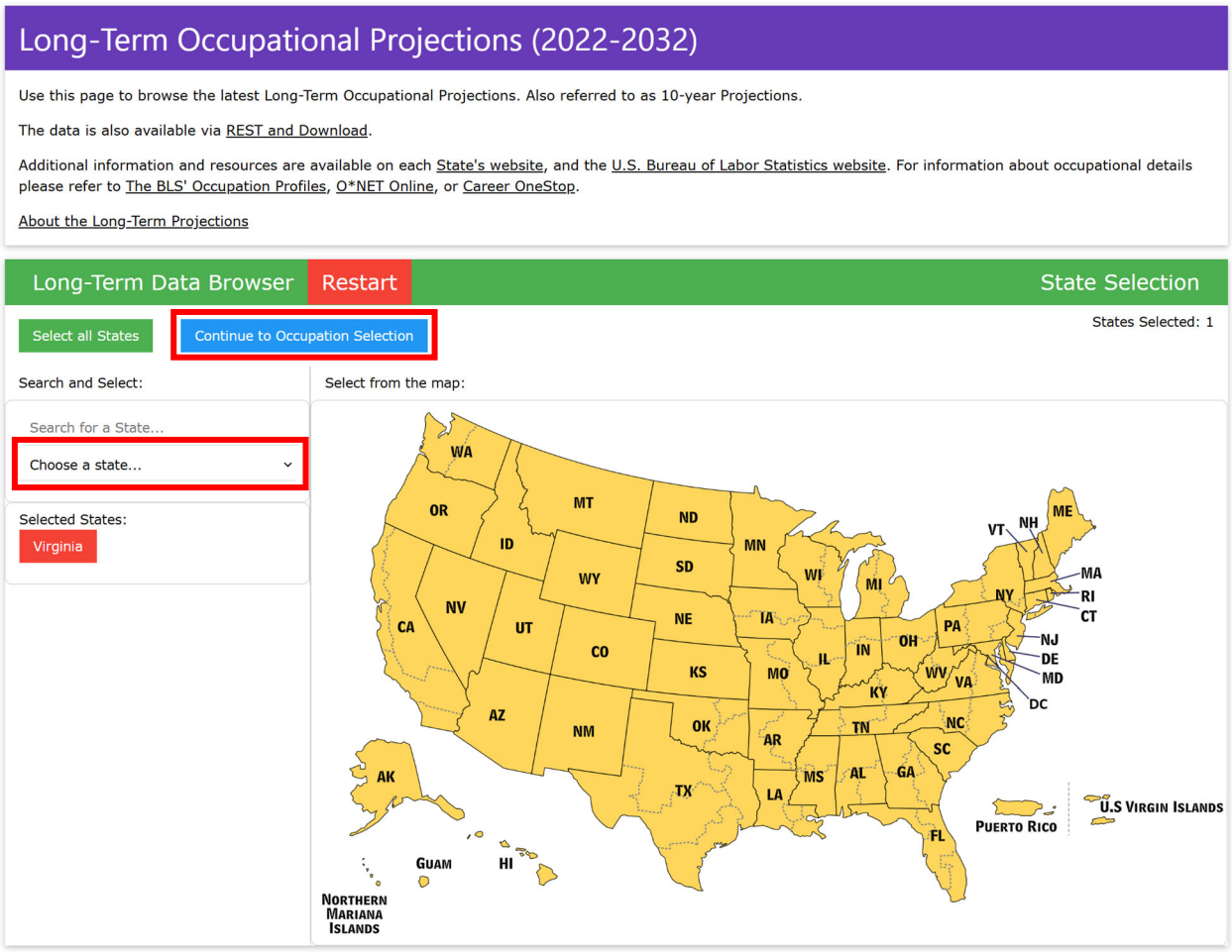

Image: Long-Term Occupation Projections (2022-2032)

c. Select the SOCs (2018) noted in the Appendix (38 occupations selected)
d. *Click 'Continue to Results'*

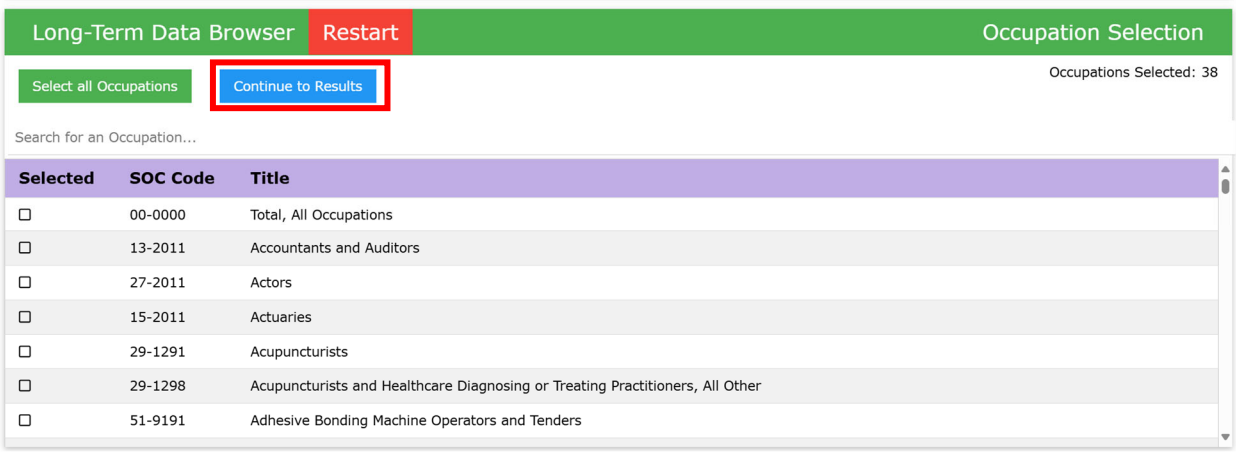

Image: Projection Central Select Occupations

e. Download all results as a .xlsx

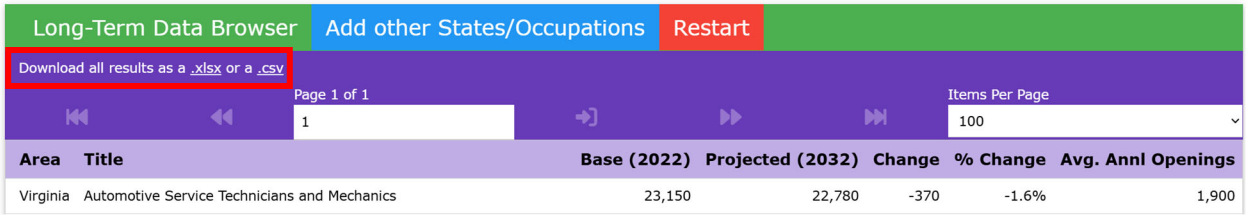

Image: Download Results

f. Map the Titles within the Excel containing the results to the list of Occupations according to the Appendix
g. Create a PivotTable from the results of Forecast Employee Demand "Step A1f" to summarize the Base Year (2022), Projected (2032), Change, and Average Annual Openings for the Occupations
h. Copy this output into a new sheet within Excel to calculate a new Percent Change (e.g., (Projected 2032 – Base Year 2022) / Base Year 2022) for each Occupation

B. *Identify average annual percent change in employment to identify projected 2025 and projected 2035 employment using BLS projected estimates which reflect recent levels of investment in EVs, HFCEVs, related charging infrastructure and workforce*

1. Using the data from Forecast Employee Demand "Step A", identify average annual percent change in total employment
    a. First, create a formula to divide the new Percent Change developed from Forecast Employee Demand "Step A1h" by 10 (e.g., Percent Change / 10)
    b. Copy the formula for each Occupation
2. Identify projected 2023-2025 and projected 2033-2035 employment
    a. To identify projected 2023 employment, create a formula to multiply the average annual percent change in total employment by the Base Year 2022 employment and add the Base Year 2022 employment (e.g., Average Annual Percent Change * Base Year 2022 + Base Year 2022)
    b. Copy the formula for each Occupation
    c. Repeat Forecast Employee Demand "Step B2a-b" for projected 2024-2025 employment
    d. To identify projected 2033 employment, create a formula to multiply the average annual percent change in total employment by the Projected Year 2032 employment and add the Projected Year 2032 employment (e.g., Average Annual Percent Change * Projected Year 2032 + Projected Year 2032)
    e. Copy the formula for each Occupation
    f. Repeat Forecast Employee Demand "Step B2d-e" for projected 2034-2035 employment
    g. A 10% confidence interval can be established per statistics standard practices by multiplying 10% by each projected employment value and adding and subtracting the resulting value to create an employment range

3. Map the resultant table of employment projections for each Occupation to its corresponding Workforce Group according to the Appendix to summarize the average annual openings, projected 2025, and projected 2035 employment by Workforce Group

C. *Define a range in projected 2035 employment based upon historical job growth and scenarios*[12]

1. Estimate a 2035 employment projection based upon moderated federal and state investment in EVs, HFCEVs, related charging infrastructure and workforce
    a. Access BLS employment data via the Occupational Employment and Wage Statistics (OEWS) tables[13] and download State employment data for May 2022 (XLS)

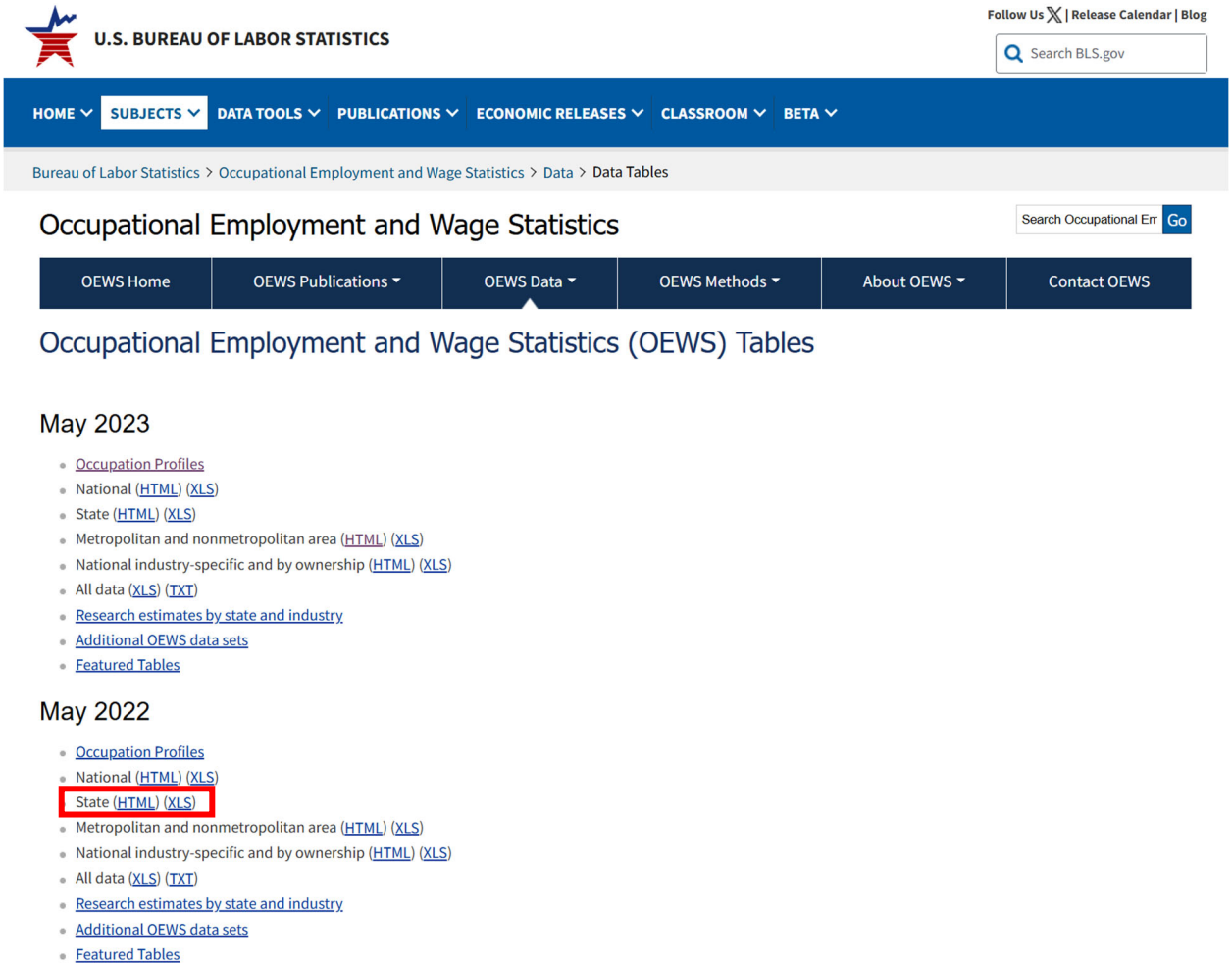

Image: BLS OEWS Tables

[12] See Assumptions and Notes within the Appendix
[13] https://www.bls.gov/oes/tables.htm

b. Filter the State XLS for the state of analysis (Virginia) and the Workforce Group SOCs of the Occupations listed in the Appendix and All Occupations in Virginia
c. Repeat Forecast Employee Demand "Steps C1a-b" for years 2018-2021

d. Using the BLS employment data from 2018-2022, create a linear least squares regression model using R version 4.2.3, a statistical analysis software, to project employment to estimate employment values for every year to 2035 for each Occupation, along with lower and upper bounds. The lower bound is determined by the model to be the lowest possible value for a given year and the upper bound is determined by the model to be the greatest possible value for a given year, based on historical values of 2018-2022 employment. These projections are applied to the year of 2034, to predict an employment outcome of 2035, as well as upper and lower bounds.
    i. Follow the steps to writing the regression model in R:
        1. Create an Excel file for the roles of the analysis where the first column is Year, and the second column is Jobs. There should be a year and jobs value for 2018-2022. Title the Excel BLS_Stats.
        2. Download R here: https://www.r-project.org/
        3. Install the necessary packages by writing into the R prompt *install.packages("stats") install.packages("readxl")*
        4. Load the BLS 2018-2022 Data: *read_excel("BL:S_Stas.xlsx", sheet_name = "Sheet1")* where the name of the excel file is BLS_Stats
        5. Extract the data from the Excel file using the df function: *df <- read_excel("BLS_Stats.xlsx", sheet_name = "Sheet1")*
        6. Create a linear model using the lm() function: *model <- lm(jobs ~ year, data = data)* where year is the column for the year of BLS data and jobs is the jobs value for the associated year and occupation
        7. Set the year 2035 for the future prediction*: future_year <- data.frame(year=2035)*
        8. Make predictions on future jobs for 2035: *predictions <- predict(model, newdata = future_year)*
        9. Display predictions: *predictions*
        10. Find the upper and lower bound of the predicted model: *summary(model)*

    e. Map the resultant table of employment projections for each Occupation to its corresponding Workforce Group according to the Appendix to summarize the upper and lower bound of predicted 2035 employment by Workforce Group

2. Estimate a 2035 employment projection based upon moderated federal and current state investment in EVs, HFCEVs, related charging infrastructure and workforce
    a. Within a new Excel sheet, copy the the BLS OEWS employment figures for years 2018 and 2022 that were downloaded in Forecast Employee Demand "Step C2" for the Workforce Group SOCs of the Occupations listed in the Appendix and All Occupations in Virginia
    b. First, identify the 4-year growth rate for All Occupation in Virginia and the Occupations that are not classified as Clean Energy Jobs as indicated in the Appendix (Automotive, Bus and Truck Technicians and Mechanics; and Industrial Engineering Technologists and Technicians)
        i. Using Excel, subtract the earliest year's value from the most recent year's value, and divide it by the earliest year's value (e.g., 2022 – 2018 / 2018)
    c. Next, identify the average annual growth rate for All Occupation; Automotive, Bus and Truck Technicians and Mechanics; and Industrial Engineering Technologists and Technicians
        i. Create a formula to divide the 4-year growth rate established in Forecast Employee Demand "Step C2b" by 4
    d. Then, identify the average annual growth rate based on the assumptions detailed in the Appendix that Clean Energy Jobs grow 3.5 times faster year-over-year than overall employment in the Commonwealth
        i. Create a formula to divide the 4-year growth rate for All Occupations by 4 and multiply 3.5 (e.g., 4-Year Growth Rate / 4 * 3.5)
        ii. Apply this formula for all Occupations classified as Clean Energy Jobs in the Appendix
    e. To identify projected 2023 employment, create a formula to multiply the average

1. Conduct interviews with entities such as Public Transit and fleet operators, Public Charging Station Operators, Utilities, Chambers of Commerce[14], Foundations/ Unions/ and Trade Groups, Automotive Service Groups, Original Equipment Manufacturers, and Others including several VA agencies and asked questions to understand current and future demand for workers to support EV and HFCEV sector growth and new business development efforts that will increase employee demand. These interview takeaways validate and inform the employee demand predictions and assumptions based upon current market conditions. See the Appendix for sample interview questions.

3. Forecast Training Demand: This step includes identifying the forecasted training demand gap or surplus between workforce supply and employee demand for the workforce groups.

Steps taken to forecast training demand includes the following:

A. *Identify the gap between current and future workforce supply and employee demand (annual openings) by Occupation and Workforce Group (2025 and 2035) to identify training demand across Virginia*
   1. Calculate training demand for each Workforce Group by first copying the supply 2025 figure calculated in Forecast Workforce Supply "Step D" and pasting it alongside the average annual opening figure calculated in Forecast Employee Demand "Step A1"
   2. Calculate training demand by subtracting the average annual opening figure from the supply 2025 figure (e.g., Supply 2025 – Average Annual Openings)
   3. Copy the formula for each Workforce Group
   4. Calculate training demand for each Workforce Group by first copying the supply 2035 figure calculated in Forecast Workforce Supply "Step D2" and pasting it alongside the average annual opening figure calculated in Forecast Employee Demand "Step A1"
   5. Calculate training demand gap or surplus by subtracting the average annual opening figure from the supply 2035 figure (e.g., Supply 2035 – Average Annual Openings)
   6. Copy the formula for each Workforce Group
   7. Repeat Forecast Training Demand "Steps A1-6" for the Occupations

B. *Collect qualitative input on specific skills, training programs, and capacity needed to support the growth of the Workforce Groups*
   1. Conduct interviews with the entities identified in Forecast Employee Demand "Step D1"
   2. Ask questions to understand specific skills, training programs, and capacity needed to support the growth of the Occupations and Workforce Groups

[14] Note, economic development organizations may be unable to meet for an interview or provide specific insights due to non-disclosure agreements with companies engaged in business location, retention, and expansion discussions. Workforce development organizations such as workforce boards can often provide similar perspectives into workforce needs from the perspective of employers.

C. *Collect qualitative input on EV and HFCEV Employee Demand, clear air goals, and transit agency low/no bus transition goals to identify long term training demand (2035-2050)*
    1. Conduct interviews with the entities identified in Forecast Employee Demand "Step D1"

4. Synthesize Findings: Compile all quantitative and qualitative analysis within a report. NREL may provide the Virginia report as an example.

Steps taken to synthesize findings includes the following:

A. *Detail all quantitative and qualitative analysis within a report according to the following outline:*
    1. Workforce Supply
        a. Table of historical completions and completer apprentices by Occupation and Workforce Group for years 2013-2023
        b. Table of Workforce Supply projections for years 2025 and 2035
    2. Employee Demand
        a. Table of Historical job growth by Occupation and Workforce Group for years 2018-2022
        b. Table of the number of jobs and average annual openings by Occupation and Workforce Group for years 2022-2032
        c. Tables of Employee Demand Projections according to scenarios for year 2035
        d. Qualitative input on employee demand gathered during interviews
    3. Training Demand
        a. Table of training demand gap or surplus by Occupation and Workforce Group for years 2025 and 2035
        b. Qualitative input on training demand
    4. Regional Analysis
        a. Maps visualizing high and low completions for year 2023
        b. Qualitative input on regions with workforce shortages

Appendix

Workforce Group CIPs

Workforce Group	Occupation	CIP (2020)	CIP (2010)
Electrician and Charging Infrastructure	Electrical Engineers	14.10 - Electrical, Electronics, and Communications Engineering 14.47 - Electrical and Computer Engineering[15]	14.10 - Electrical, Electronics and Communications Engineering
	Electrical and Electronics Engineering Technologists and Technicians	15.03 - Electrical/Electronic Engineering Technologies/Technicians 15.04 - Electromechanical Technologies/Technicians 15.12 - Computer Engineering Technologies/Technicians 15.99 - Engineering/Engineering-Related Technologies/Technicians, Other 47.01 - Electrical/Electronics Maintenance and Repair Technologies/Technicians	15.03 - Electrical Engineering Technologies/Technicians 15.04 - Electromechanical Instrumentation and Maintenance Technologies/Technicians 15.12 - Computer Engineering Technologies/Technicians 15.99 - Engineering Technologies/Technicians, Other 47.01 - Electrical/Electronics Maintenance and Repair Technology
	Electricians	46.03 - Electrical and Power Transmission Installers	46.03 - Electrical and Power Transmission Installers
	Plant Maintenance	15.17 - Energy Systems Technologies/Technicians 14.48 - Energy Systems Engineering[15] 46.04 - Building/Construction Finishing, Management, and Inspection	46.04 - Building/Construction Finishing, Management, and Inspection

[15] Note, there were no completions in Virginia for this CIP during the period of analysis.

Workforce Group	Occupation	CIP (2020)	CIP (2010)
Hydrogen Fuel Cell	Chemical Engineer	14.07 - Chemical Engineering 14.32 - Polymer/Plastics Engineering 14.44 - Engineering Chemistry[15] 41.03 - Physical Science Technologies/Technicians	14.07 - Chemical Engineering 14.32 - Polymer/Plastics Engineering 14.44 - Engineering Chemistry[15] 41.03 - Physical Science Technologies/Technicians
	Chemists	40.05 - Chemistry	40.05 - Chemistry
Manufacturing	Industrial Engineering Technologists and Technicians	15.06 - Industrial Production Technologies/Technicians 15.07 - Quality Control and Safety Technologies/Technicians[16]	15.07 - Quality Control and Safety Technologies/Technicians[16]
	Mechanical and Mechatronics Engineers[17]	14.11 - Engineering Mechanics 14.19 - Mechanical Engineering 14.41 - Electromechanical Engineering[16] 15.08 - Mechanical Engineering Related Technologies/Technicians 14.42 - Mechatronics, Robotics, and Automation Engineering[16]	14.11 - Engineering Mechanics 14.19 - Mechanical Engineering 14.41 - Electromechanical Engineering[16] 15.08 - Mechanical Engineering Related Technologies/Technicians 14.42 - Mechatronics, Robotics, and Automation Engineering[16]
	Welding Technologists and Technicians	48.05 - Precision Metal Working	48.05 - Precision Metal Working
Automotive Maintenance and Service	Automotive, Bus and Truck Technicians and Mechanics	47.06 - Vehicle Maintenance and Repair Technologies/Technicians	47.06 - Vehicle Maintenance and Repair Technologies

[16] Note, there were no completions in Virginia for this CIP during the period of analysis.
[17] Mechanical Engineers and Mechatronics Engineers are merged due to the lack of completions for CIP 14.42 which aligns to Mechatronics Engineers.

Workforce Group	Occupation	CIP (2020)	CIP (2010)
Transit and Facility Management[18]	Facilities Managers	15.15 - Engineering-Related Fields 19.06 - Housing and Human Environments[16] 46.04 - Building/Construction Finishing, Management, and Inspection 52.02 - Business Administration, Management and Operations	15.15 - Engineering-Related Fields 19.06 - Housing and Human Environments[16] 46.04 - Building/Construction Finishing, Management, and Inspection 52.02 - Business Administration, Management and Operations
	Vehicle Operations	49.02 - Ground Transportation	49.02 - Ground Transportation
	Vehicle Operations Support	52.04 - Business Operations Support and Assistant Services	52.04 - Business Operations Support and Assistant Services
	Transportation Planners	04.03 - City/Urban, Community, and Regional Planning 04.04 - Environmental Design[19] 44.04 - Public Administration 44.05 - Public Policy Analysis	04.03 - City/Urban, Community, and Regional Planning 04.04 - Environmental Design[19] 44.04 - Public Administration 44.05 - Public Policy Analysis
	Training and Development Specialists	13.04 - Education Administration and Supervision 13.05 - Educational/Instructional Media Design 13.12 - Teacher Education and Professional Development, Specific Levels and Methods	13.04 - Education Administration and Supervision 13.05 - Educational/Instructional Media Design 13.12 - Teacher Education and Professional Development, Specific Levels and Methods

[18] Additional occupations may be relevant for Transit agencies and can be considered for future analyses including Accountants and Auditors, Managers, Cost Estimators, Secretaries and Administrative Assistants, Receptionists and Information Clerks, Advertising and Promotions Managers, Public Relations Specialists and Compliance Officers.

[19] Note, there were no completions in Virginia for this CIP during the period of analysis.

Workforce Group	Occupation	CIP (2020)	CIP (2010)
		52.10 - Human Resources Management and Services	52.10 - Human Resources Management and Services

Workforce Group Apprenticeships[20]

Workforce Group	Occupation	Apprenticeship Occupation
Electrician and Charging Infrastructure	Electrical Engineers	N/A
	Electrical and Electronics Engineering Technologists and Technicians	Control Equip Elec-Tech Drafter, Electrical Electric Power Generator Technician Electrical Technician Electromechanical Technician Electronic Mechanic Electronics Technician Instrumentation & Controls Technician
	Electricians	Electrician (Including Interior Electrician) Electrician, Maintenance Electrician, Substation Line Installer-Repairer Line Maintainer (Including High Voltage Electrician)
	Plant Maintenance	Building Maintenance Building Maintenance Repairer Electric Meter Tester Industrial Maintenance Repairer Machine Repairer, Maintenance Maint Mechanic Maintenance Mechanic Maintenance Machinist Maintenance Production Technician Maintenance Repair, Industrial Millwright Operating Engineer

[20] This list may not be inclusive of all relevant apprenticeship occupations due to variations in state apprenticeship programs. Each state should evaluate which Registered Apprenticeship Programs should be included in the analysis.

Workforce Group	Occupation	Apprenticeship Occupation
		Power-Plant Operator Set-Up Technician Substation Operator
Hydrogen Fuel Cell	Chemical Engineer	N/A
	Chemists	N/A
Manufacturing	Industrial Engineering Technologists and Technicians	Engineering Technicians Field Service Engineer Industrial Engineering Technician Industrial Manufacturing Technicians Inspectors and Testers Inspector, Metal Fabricate Machinist (Including Precision Machinist) Machinist, Experimental Maker Professional (Including Machine Operator 1)
	Mechanical and Mechatronics Engineers	Engineering Technicians Mechanical Engineering Technician Mechatronics Technician
	Welding Technologists and Technicians	Metal Fabricator Production Welder Sheet Metal Worker Welder, Arc Welder, Combination Welding Technician
Automotive Maintenance and Service	Automotive, Bus and Truck Technicians and Mechanics	Automobile Mechanic (Including Light-Wheel Vehicle Mechanic) Automotive Mechanic Automotive Technician Specialist Maint Mechanic (Const; Petrol)

Workforce Group	Occupation	Apprenticeship Occupation
	Training and Development Specialists	Education & Training Human Resource Assistant Human Resources Associate Teacher Aide I Trade/Industry Instructor Workforce Development Specialist

Workforce Group SOCs

Workforce Group	Occupation	SOC (2018)	SOC (2010)
Electrician and Charging Infrastructure	Electrical Engineers	17-2071 - Electrical Engineers 17-2072 - Electronics Engineers, Except Computer	17-2071 - Electrical Engineers 17-2072 - Electronics Engineers, Except Computer
	Electrical and Electronics Engineering Technologists and Technicians	17-3023 - Electrical and Electronics Engineering Technologists and Technicians 17-3024 - Electro-Mechanical and Mechatronics Technologists and Technicians 51-2028 - Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	17-3023 - Electrical and Electronics Engineering Technicians 17-3024 - Electro-Mechanical and Mechatronics Technicians 51-2022 - Electrical and Electronic Equipment Assemblers 51-2023 - Electromechanical Equipment Assemblers

Workforce Group	Occupation	SOC (2018)	SOC (2010)
	Electricians	47-2111 - Electricians 47-3013 - Helpers--Electricians 49-2092 - Electric Motor, Power Tool, and Related Repairers 49-2093 - Electrical and Electronics Installers and Repairers, Transportation Equipment 49-2095 - Electrical and Electronics Repairers, Powerhouse, Substation, and Relay	47-2111 - Electricians 47-3013 - Helpers--Electricians 49-2092 - Electric Motor, Power Tool, and Related Repairers 49-2093 - Electrical and Electronics Installers and Repairers, Transportation Equipment 49-2095 - Electrical and Electronics Repairers, Powerhouse, Substation, and Relay
	Plant Maintenance	51-8013 - Power Plant Operators 49-9071 - Maintenance and Repair Workers, General 49-9041 - Industrial Machinery Mechanics	51-8013 - Power Plant Operators 49-9071 - Maintenance and Repair Workers, General 49-9041 - Industrial Machinery Mechanics
Hydrogen Fuel Cell	Chemical Engineer	17-2041 - Chemical Engineers	17-2041 - Chemical Engineers
	Chemists	19-2031 - Chemists 19-2041 - Environmental Scientists and Specialists, Including Health	19-2031 - Chemists 19-2041 - Environmental Scientists and Specialists, Including Health
Manufacturing	Industrial Engineering Technologists and Technicians	17-3026 - Industrial Engineering Technologists and Technicians 51-4031 - Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic 17-3029 - Engineering Technologists and Technicians, Except Drafters, All Other 51-9061 - Inspectors, Testers, Sorters, Samplers, and Weighers	17-3026 - Industrial Engineering Technologists and Technicians 51-4031 - Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic 17-3029 - Engineering Technologists and Technicians, Except Drafters, All Other 51-9061 - Inspectors, Testers, Sorters, Samplers, and Weighers

Workforce Group	Occupation	SOC (2018)	SOC (2010)
	Mechanical and Mechatronics Engineers	17-2141 - Mechanical Engineers 17-2199 - Engineers, All Other	17-2141 - Mechanical Engineers 17-2199 - Engineers, All Other
	Welding Technologists and Technicians	51-4121 - Welders, Cutters, Solderers, and Brazers	51-4121 - Welders, Cutters, Solderers, and Brazers
Automotive Maintenance and Service	Automotive, Bus and Truck Technicians and Mechanics	49-2096 - Electronic Equipment Installers and Repairers, Motor Vehicles 49-3023 - Automotive Service Technicians and Mechanics 49-3031 - Bus and Truck Mechanics and Diesel Engine Specialists	49-2096 - Electronic Equipment Installers and Repairers, Motor Vehicles 49-3023 - Automotive Service Technicians and Mechanics 49-3031 - Bus and Truck Mechanics and Diesel Engine Specialists
Transit and Facility Management	Facilities Managers	11-3013 - Facilities Managers 11-3051 - Industrial Production Managers	11-3011 - Administrative Services Managers 11-3051 - Industrial Production Managers
	Vehicle Operations	53-3032 - Heavy and Tractor-Trailer Truck Drivers 53-3051 - Bus Drivers, School 53-3052 - Bus Drivers, Transit and Interagency 53-3053 - Shuttle Drivers and Chauffeurs	53-3032 - Heavy and Tractor-Trailer Truck Drivers 53-3021 - Bus Drivers, Transit and Interagency 53-3022 - Bus Drivers, School or Special Client
	Vehicle Operations Support	43-5032 - Dispatchers, Except Police, Fire, and Ambulance 53-1047 - First Line Supervisors of Transportation & Material Moving Workers, Exc Aircraft Cargo Handling Supervisor 53-6061 - Passenger Attendants	43-5032 - Dispatchers, Except Police, Fire, and Ambulance 53-1031 - First-Line Supervisors of Transportation and Material-Moving Machine and Vehicle Operators 53-6061 - Transportation Attendants, Except Flight Attendants

Workforce Group	Occupation	SOC (2018)	SOC (2010)
	Transportation Planners	19-3099.01 - Transportation Planners	19-3099.01 - Transportation Planners
	Training and Development Specialists	13-1151 - Training and Development Specialists 11-3131 - Training and Development Managers	13-1151 - Training and Development Specialists 11-3131 - Training and Development Managers

Sample Interview Questions

The sample interview questions below aimed at transit agencies can be used in the development of custom interview guides for each type of interview (e.g., transit agencies, charging operators, manufacturers).

EV and HEV Demand

1. How would you characterize the current Virginia market demand for all EVs and HFCEVs and how do you see this evolving over the next decade?
    - What factors will drive this demand in the short term?
    - Looking beyond 2035, what are the most important factors that will drive demand?
2. Can you share more about your organization's transition to a low/no emissions fleet and any workforce (employee and training demand) implications?

Employee Demand

3. What specific roles and skills are critical for your organization's deployment of low/no emission vehicles?
4. What challenges has your organization faced with recruiting and retaining EV and HFCEV skilled workers?
5. What strategies are being implemented by your organization to meet the growing demand for EV and HFCEV skilled workers? If there were no constraints, what ideal strategies would your organization take on to meet employee demand?

Training Demand

6. How has your organization approached upskilling and re-skilling workers on skills relating to EVs and HEFCVs?
7. How do you observe training providers reacting to the increase in training demand? What new training programs have been offered in response to the increase in training demand?
8. Does your organization have any partnerships with bus manufacturers for ongoing technical support and training?

Investment and Collaboration

9. From your perspective, how can state government and educational institutions collaborate differently to address the technical training needs of the EV and HFCEV sectors?
10. From your perspective, what new federal or state policies should be considered to enhance training capabilities in the EV and HFCEV sectors?

Wrap Up/ Conclusion

11. Is there any additional information you would like to share that we have not discussed today?
12. Do you have any questions for our team?

Assumptions and Limitations

The academic pathway and state registered apprenticeships was the focus of the workforce supply forecast and other pathways to employment (i.e., non-registered apprenticeships and career technical education) is not represented.

It is possible that a CIP may map to multiple Workforce Groups. However, for the purposes of this Task, there are no instances of the same CIP mapping to multiple Workforce Groups.

The BLS[21] accounts for the effects of EVs, HFCEVs, and related infrastructure in its employment forecasts, based on the following methodology listed on their website[22]:

- *The overall pace of technological change will be consistent with past experience*

- *Existing laws and policies with significant impacts on economic trends are assumed to hold throughout the projection period*

Employee demand and training demand projections can be made until 2035 using historical employment data, long-term projections, and market research.

This effort explored three employee demand scenarios co-created with Virginia Clean Cities and validated by NREL and DRPT:

1. *Recent levels of investment in EVs, HFCEVs, related charging infrastructure and workforce.* This scenario is based on the employment estimates provided by Projection Central and assumes that existing laws and policies with significant impacts on economic trends to

(RGGI)[26]. Based on differences in rates of change from 2018-2022, upper and lower bounds of predicted outcomes are created through the regression analysis and applied to 2035 to find a lower and upper projected employment.

3. *Moderated federal and current state investment in EVs, HFCEVs, related charging infrastructure and workforce*. To complete this scenario, research is conducted to understand the effects of recently implemented state policy (the Virginia Clean Economy Act) had on employment. An analysis conducted by E2 on data from the 2022 U.S. Energy and Employment Report (USEER)[27] estimates that Virginia's clean energy jobs grew more than 3.5 times faster year-over-year than overall employment in the Commonwealth. A multiplier of 3.5 is applied to the VA employment growth rate as estimated by scenario 2 to identify a new employment growth rate for clean energy jobs (see table on next page). This growth rate assumes continued high state investment in workforce development associated with clean energy jobs. This growth rate projects employment for the Workforce Groups and Occupations to 2035.

Clean Energy Jobs

The following table classifies the Occupations as clean energy jobs according to Virginia Clean Cities based upon time prevalence of the occupation to clean economy. This segmentation was validated by NREL and DRPT.

Occupations	Clean Energy Job (Yes/No)	Notes
Automotive, Bus and Truck Technicians and Mechanics	No	Skills are changing for this role due to clean energy innovation and upskilling and reskilling workers in this occupation will be required to work across traditional combustion engines and low and no emission vehicles. Existing work on traditional combustion engines will continue, therefore, employee demand for this occupation is not expected to rise.
Chemical Engineer	Yes	Research work for this occupation may be growing in the areas of rare earth metals and hydrogen fuel cells/sodium ion battery innovation. Therefore, employee demand for this occupation is expected to rise.
Chemists	Yes	Research work for this occupation may be growing in the areas of rare earth metals and hydrogen fuel cells/sodium ion battery innovation. Therefore,

[26] https://www.governor.virginia.gov/newsroom/news-releases/2023/june/name-1005558-en.html
[27] E2-FS-Clean-Jobs-VA-2022-23-04-C_03.pdf

Occupations	Clean Energy Job (Yes/No)	Notes
		employee demand for this occupation is expected to rise.
Electrical and Electronics Engineering Technologists and Technicians	Yes	Employee demand for this occupation may increase due to the growth of charging infrastructure installation and maintenance.
Electrical Engineers	Yes	This occupation may be increasingly responsible for innovation with batteries and charging infrastructure building/ replacement/ and movement. Therefore, employee demand for this occupation is expected to rise.
Electricians	Yes	This occupation may be increasingly responsible for innovation with batteries and charging infrastructure building/ replacement/ and movement. Therefore, employee demand for this occupation is expected to rise.
Facilities Managers	Yes	This occupation will oversee new facilities associated with clean energy both at transit agencies and utilities. Therefore, employee demand for this occupation is expected to rise.
Industrial Engineering Technologists and Technicians	No	Net new growth is not expected for this occupation. However, the work of this occupation will evolve with the transition to clean energy.
Mechanical and Mechatronics Engineering	Yes	This occupation supports the manufacturing of infrastructure associated with clean energy (e.g., solar, wind, hydrogen). Therefore, employee demand for this occupation is expected to rise.
Plant Maintenance	Yes	This occupation may grow due to the additional plant facilities required for clean energy. Therefore, employee demand for this occupation is expected to rise.
Training and Development Specialists	Yes	As clean energy grows, employee demand for this occupation is expected to rise to instruct workers on skills associated with clean energy technology.
Vehicle Operations	Yes	As low and no emission vehicles are deployed and transit operations expand, employee demand for this occupation is expected to rise.

Occupations	Clean Energy Job (Yes/No)	Notes
Vehicle Operations Support	Yes	Initially, employee demand for this occupation may rise alongside the changes in operations from the deployment of low and no emission vehicles.
Transportation Planners	Yes	The employee demand for this occupation is expected to rise due to the addition of new routes, interconnected routes, and longer schedules from the deployment of low and no emission vehicles.
Welding Technologists and Technicians	Yes	This occupation supports welding activities associated with clean energy infrastructure (e.g., hydrogen pipelines). Therefore, employee demand for this occupation is expected to rise.

Notes

Projecting employee demand required research and analysis on the current climate at the state and federal level around EVs, HFCEVs, related charging infrastructure, and workforce development:

- Within Virginia, there are several key policies at the state level that are impacting employee demand for Clean Energy Jobs such as the Virginia Clean Economy Act of 2020 and the complexities surrounding the Regional Greenhouse Gas Initiative (RGGI) regulation. Furthermore, work by DRPT has revealed that several transit agencies have goals/milestones to transition fleets to low- or no-emissions vehicles. For this reason, our assumption is that Virginia is moving towards a net-zero economy by the year 2050.

- At the federal level, there have been many investments impacting employee demand including the National Electric Vehicle Infrastructure (NEVI) Formula Program which is part of the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA). Based on guidance issued in the 'Unleashing American Energy' Executive Order[28] the future of NEVI remains unclear at the time of this report's development.

When states conduct this analysis and tailor the methodology, they will need to assess the current federal and state regulatory and funding environment. Research should be conducted on the impact of policies like these on employee demand to date to project employee demand. There are numerous national and regional organizational that provide state level analysis on the implication of policy decisions on workforce. States replicating this study should seek out these reports to inform modeling estimates. For example, the Energy Systems and Infrastructure

[28] https://www.whitehouse.gov/presidential-actions/2025/01/unleashing-american-energy/

Analysis tool[29], Jobs EVSE, provided by Argonne National Laboratory can estimate employee demand with specific scenarios.

[29] https://www.anl.gov/esia/jobs-evse