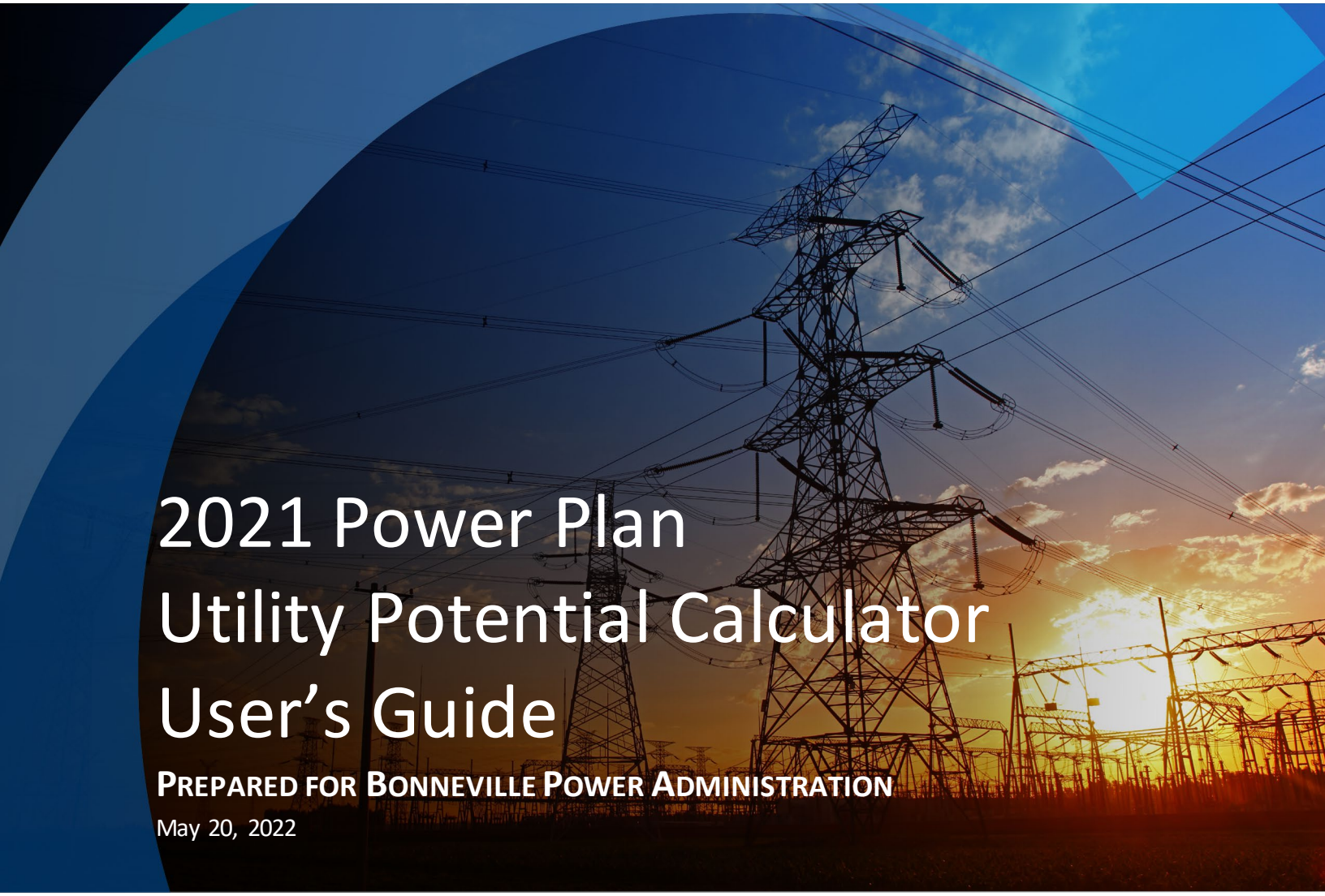
CADMUS



2021 Power Plan Utility Potential Calculator User's Guide

PREPARED FOR BONNEVILLE POWER ADMINISTRATION

May 20, 2022

Bonneville Power Administration
905 NE 11th Avenue
Portland, OR 97232

Prepared by

Cadmus
Aquila Velonis
Masumi Izawa
Andrew Grant
Sophia Spencer

Lighthouse Energy Consulting
Ted Light

CADMUS

Table of Contents

1. Introduction

The objective of this User's Guide is to help utility customers of the Bonneville Power Administration (BPA) better implement, navigate, use, and update the 2021 Power Plan Utility Potential Calculator (UPC). Cadmus and Lighthouse Energy Consulting developed the UPC to provide utilities in BPA's territory a tool to estimate the energy efficiency potential efficiently and economically for their service territory based on a streamlined set of utility-specific inputs.

This user guide describes the features and functions of the UPC. The UPC produces estimates of energy efficiency potential and the associated costs over a 20-year horizon. User inputs influence the level of energy efficiency potential available and can be adjusted based on a utility's customer characteristics. UPC outputs highlight the sectors, end uses, and top measures to inform future utility program and resource planning. For step-by-step instructions on updating the UPC, users should reference the *User Guide Step-by-Step* section.

1.1. System Requirements

The UPC was designed to be used on a standard desktop computer. This section describes the recommended software to use the model. It also provides helpful tips to ensure optimal performance.

1.1.1. Recommended Software

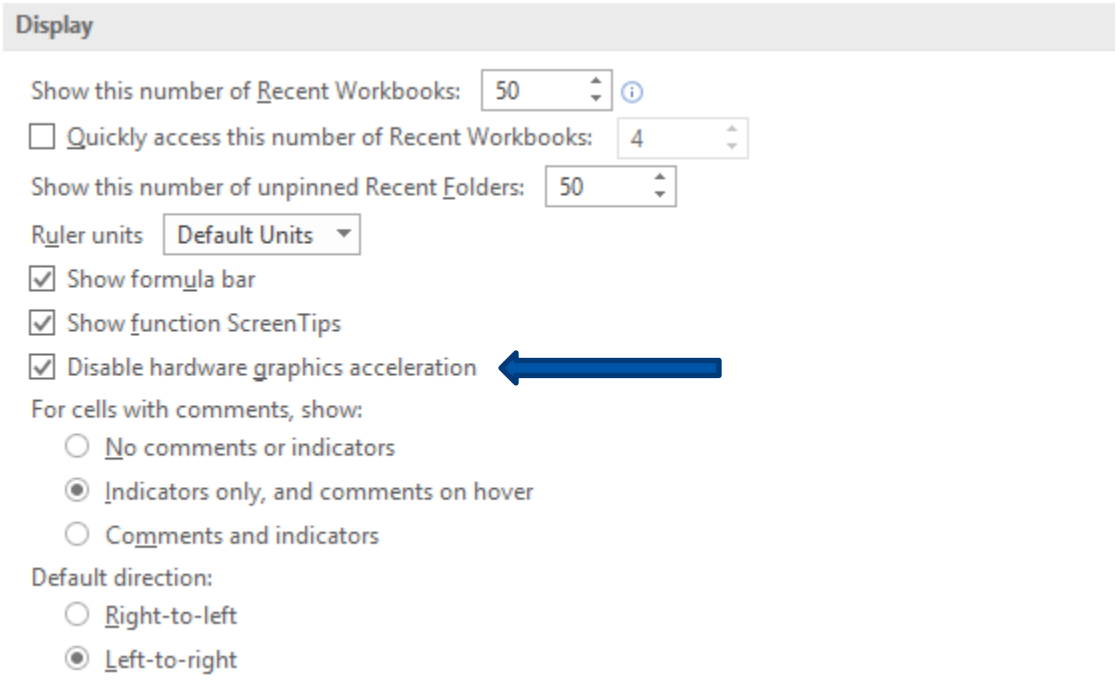
The UPC is supported by Microsoft 365, Excel 2010, Excel 2013, Excel 2016, and Excel 2019. Users may encounter errors if using a different version of Microsoft Excel than those listed.

1.1.2. Helpful Tips

The following tips could improve UPC performance and functionality, if you find the file slow to update:

- **Set Microsoft Excel calculations to "Manual"** (Formula -> Calculation -> Calculation Options -> Manual). When calculations are set to manual, press **F9** to calculate all open workbooks and worksheets; the values in each workbook and worksheet will update. **F9** should be pressed after every UPC input is updated to address future dependencies.
- **If the UPC stalls or freezes, try closing other applications:** Other open applications could limit the available memory and affect the UPC's performance.
- **Disabling hardware graphics acceleration may improve performance:** To disable this feature, click **File -> Options -> Advanced.** Under the "Display" section of the advanced menu, check the box that says, "Disable Hardware Graphics Acceleration," as shown in Figure 1.

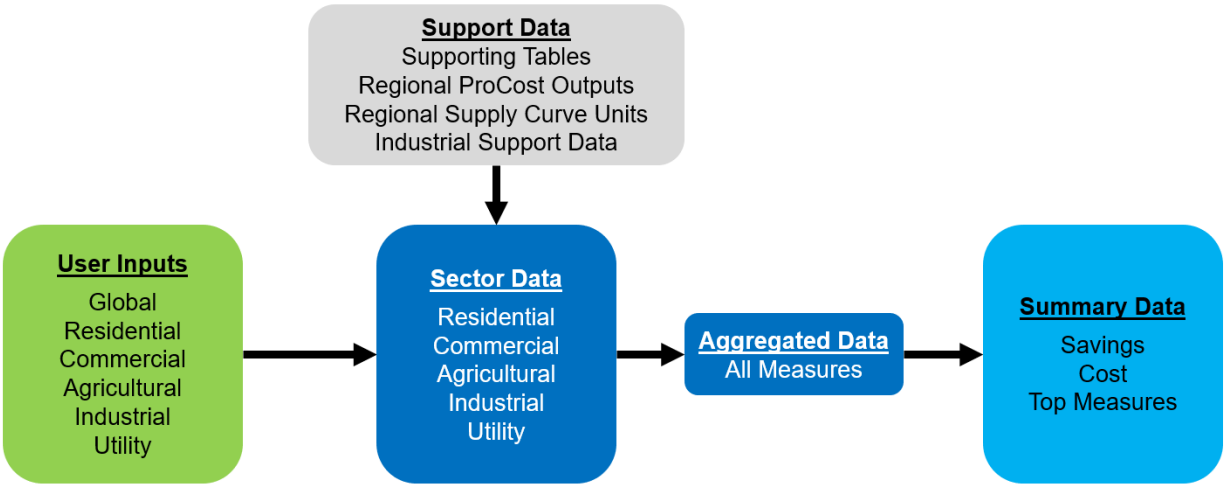
Figure 1. Disabling Hardware Graphics Acceleration



2. Model Overview

The UPC is designed to customize energy efficiency potential estimates to a utility service territory based on user inputs characterizing the customer base. For details on the energy efficiency potential estimation process see the *Energy Efficiency Potential* section. Supporting data from the 2021 Power Plan, 2016 Residential Building Stock Assessment, Regional Technical Forum, and US Energy Information Administration (EIA) is manipulated based on the user inputs to generate estimates of sector level achievable technical units on the corresponding sector tabs. The sector data is combined, and achievable technical potential is calculated on the "All Measures" tab. Finally, savings, cost, and top savings measures are summarized on a collection of summary tabs. Figure 2 shows a schematic of the data relationships in the UPC. Additional detail on each of these workbook tabs is available on the "Read Me" tab of the UPC workbook.

Figure 2. UPC Model Schematic



2.1. Achievable Technical Potential Calculation

The UPC uses the Northwest Power Conservation Council (Council)'s 2021 Power Plan achievable technical potential as the basis for achievable technical potential in a utility's service territory for each of the energy conservation measures. Cadmus and Lighthouse Energy Consulting then scale the achievable technical potential based on the different inputs on the user inputs tabs. The types of variables used to scale potential vary by sector, and Table 1 provides a description of these variables.

Table 1. Scaling Variables

Sector	Variable	Method
Residential	Number of Homes	2021 Power Plan potential is scaled based on the number of residential homes relative to the 2021 Power Plan regional number of homes
	Climate Zone Applicability	Energy conservation measures not in the climate zone applicable to the user's region are excluded
	Equipment Saturations	2021 Power Plan saturations are scaled based on the user input saturations
	State Applicability	Energy conservation measures not applicable to the user's state are excluded
Commercial	Building Square Feet	2021 Power Plan potential is scaled based on the ratio of building floor area, by segment, in the user's service territory relative to the entire region
	Climate Zone Applicability	Energy conservation measures not applicable to the climate zone of the user's service territory are excluded
Agricultural	State Applicability	Energy conservation measures not applicable to the user's state are excluded
	Agricultural Shares	2021 Power Plan potential is scaled based on the ratio of different agricultural types (i.e. farms, dairy, etc.) in the user's service territory relative to the state
Industrial	Industrial Sales	2021 Power Plan potential is scaled based on the ratio of industrial sales, by facility type, in the user's service territory to the entire region
Utility	Utility Sales	2021 Power Plan potential is scaled based on the ratio of utility sales compared to the entire region's sales

Once the achievable technical units have been scaled to reflect the utility's service territory, Cadmus and Lighthouse Energy Consulting apply an adjustment to prevent the 20-year cumulative achievable technical units from exceeding the maximum possible achievable technical units. If the cumulative achievable technical units exceed the maximum achievable technical units in a year, then the cumulative achievable technical units in that year are set to the maximum value and the following years have zero

incremental achievable technical units. This manipulation occurs in columns AU-BN of the "All Measures" tab.

Finally, achievable technical potential is determined by multiplying the achievable technical units by 2021 Power Plan's unit energy savings for each measure.

2.2. Achievable Economic Potential Calculation

Achievable economic potential is determined based on the user selected cost-effectiveness screen described in the *Global User Inputs* section. Each measure is assigned a one or zero value in column Y of the "All Measures" tab based on this selection. Measures that are included are assigned a value of one, and the achievable economic potential is equal to the achievable technical potential. Measures that are not deemed to be cost-effective are assigned a value of zero, and they receive no achievable economic potential.

3. User Guide Step-by-Step

This section walks through the process a utility user can follow to effectively update the UPC for their service territory. In addition to this section, the user can reference the text instructions on each of the user input tabs in the UPC.

If at any time the user believes they have altered underlying formulas in the workbook not outlined in this section, then Cadmus and Lighthouse recommend downloading a new version of the workbook from the BPA website. The workbook link can be found in the *Resources* section of this guide.

3.1. Global User Inputs

The "Global User Inputs" tab is the first tab that a user should update and populate when customizing the UPC. These inputs inform future tabs by defining the geographic boundaries of the service territory. Additionally, utility cost assumptions are outlined in this tab.

3.1.1. Key Definitions

The following input variables are included on the "Global User Inputs" tab:

- **Primary state presence**, the state the utility operates in or the largest energy using state for the utility.
- **Utility**, a drop down to select the utility name that also informs climate zone designations cells D6 and E6.
- **Economic measure set**, one of the two groups of cost-effective measure described in the *Cost-Effectiveness Screening* section.
- **Administrative cost overhead**, administrative costs expressed as a percent of incremental measure cost. By default, the calculator uses 20%, a common regional assumption.
- **Incentive share of total measure cost**, the assumed percentage of the incremental measure cost covered by the utility through incentives by sector. The default values are assumptions used by the Council and Regional Technical Forum.

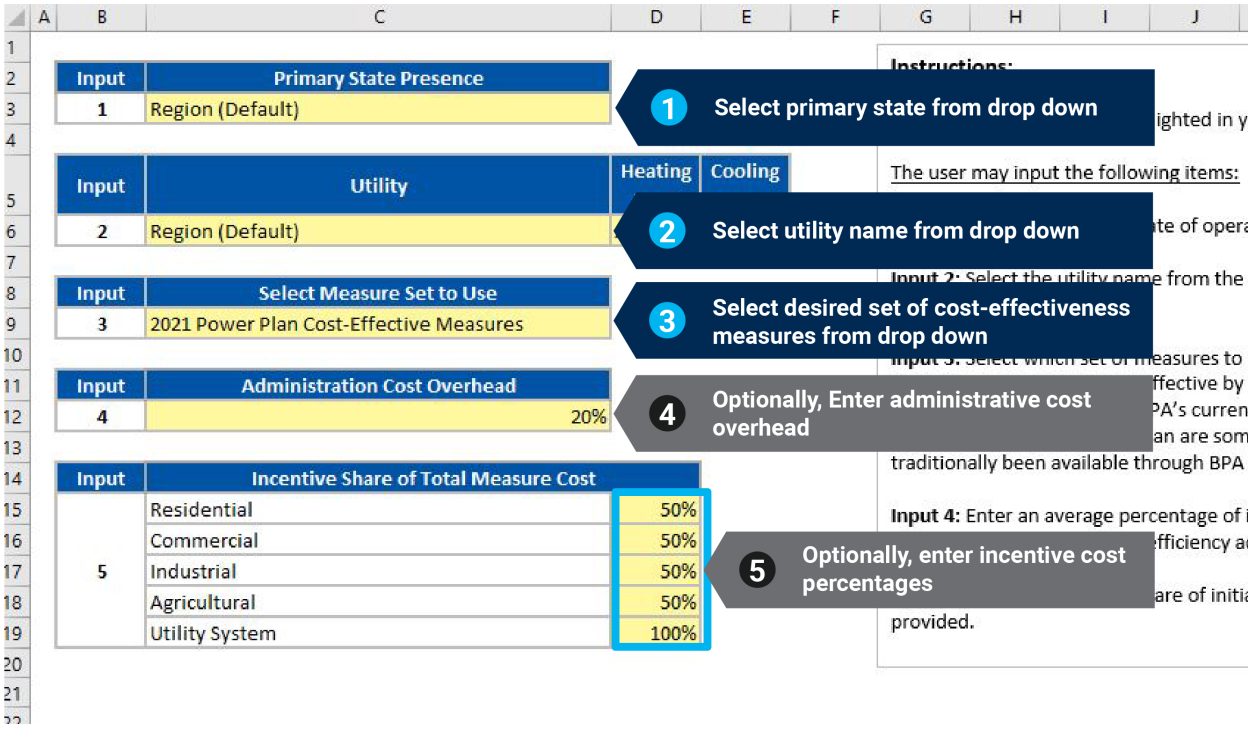
3.1.2. Updating Inputs

The user can follow the following steps to update the inputs:

1. Select primary state from drop down in cell C3.
2. Select utility name from drop down in cell C6.
3. Select desired set of cost-effectiveness measures from drop down in cell C9.
4. Optionally, change the administrative cost overhead in cell C12.
5. Optionally, customized the incentive cost percentages in cells C15:C19.

Figure 3 illustrates where these adjustments can be made on the "Global User Inputs" tab.

Figure 3. Global User Inputs



3.2. Residential User Inputs

The "Residential User Inputs" tab is used to customize the residential potential to the utility's service territory using a utility-entered number of homes as well as HVAC and appliance saturations. Based on user inputs, saturation values are calculated from RBSA data which can subsequently be refined based on utility data or judgement.

3.2.1. Key Definitions

The following input variables are included on the "Residential User Inputs" tab:

- **Region**, the primary portion of the selected state that the utility services. The definition of regions varies depending on the state selected on the "Global User Inputs" tab.
- **Sub-Region**, either the BPA or non-BPA portion of the selected region.
- **2020 Homes in Utility Service Territory**, the number of residential homes (single family, multifamily, or manufactured) included in the selected sub-region for the utility.
- **Electric Heating Share**, the percentage for each of the three customer segments (single family, multifamily, or manufactured) that uses electric heating for their primary heating system.
- **System Saturations**, the saturation (or percentage of customers) that have different types of heating/cooling equipment in the utility service territory by segment.
- **Equipment Saturations,** the saturation (or percentage of customers) that have different types of equipment in the utility service territory by segment. Values greater than 100% imply more than one piece of equipment per home. For example, single family homes often average more than one refrigerator per home.

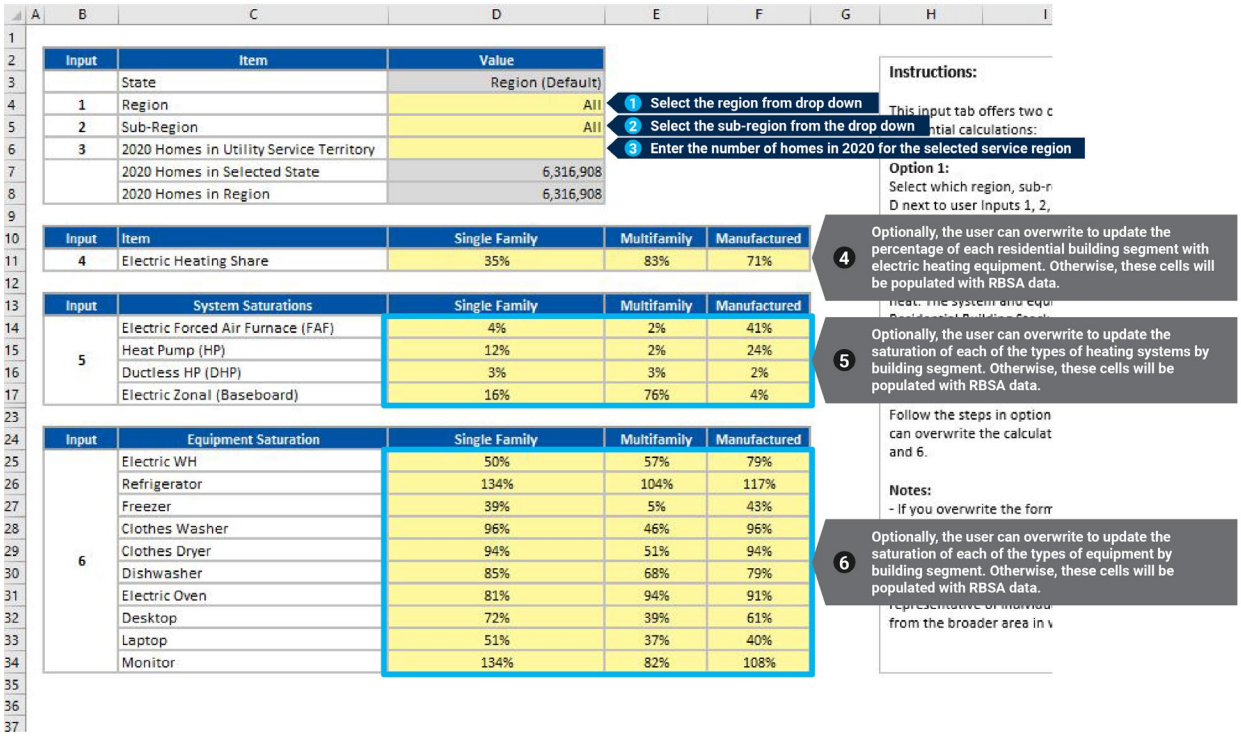
3.2.2. Updating Inputs

The residential user inputs require a few manual entries with the option to provide more utility-specific saturation and fuel share data or have that data be populated using the RBSA. Figure 4 outlines how the user can tailor these inputs to their service region through the following steps:

1. Select the region in cell D4 from the drop down.
2. Select the sub-region from the drop down in cell D5.
3. Enter the number of homes in 2020 for the selected service region in cell D6.
4. Optionally, the user can overwrite the formulas in cells D11:F11 to update the percentage of each residential building segment with electric heating equipment. Otherwise, these cells will be automatically populated with RBSA data based on the selected region and sub-region.
5. Optionally, the user can overwrite the formulas in cells D14:F17 to update the saturation of each of the types of heating systems by building segment. Otherwise, these cells will be automatically populated with RBSA data.
6. Optionally, the user can overwrite the formulas in cells D25:F34 to update the saturation of each of the types of equipment by building segment. Otherwise, these cells will be automatically populated with RBSA data.

Note that RBSA equipment saturations calculated from utility inputs are calculated based on the broad sub-region areas and may not be representative of individual utilities with space and water heating fuel shares that vary from the broader area in which they reside.

Figure 4. Residential User Inputs



3.3. Commercial User Inputs

The "Commercial User Inputs" tab provides an opportunity for the user to enter their specific 2018 sales, but it also offers an option for this field to be auto populated using 2018 EIA data from Form 861[1]. This informs the building square footage estimates by segment.

3.3.1. Key Definitions

There is only one user input on this tab, the 2018 commercial sales. This value pre-populates based on the utility selected on the "Global User Inputs" tab and US Energy Information Administration (EIA) Form 861 data. This field can be over-written if utilities have updated information.

- **2018 Commercial sales**, all commercial customer sales, in megawatt-hours, in 2018.

3.3.2. Updating Inputs

To update the commercial sales, users can enter any value in cell C3 to represent their 2018 commercial sales. Figure 5 shows where to enter this data.

Figure 5. Commercial User Inputs

Utility	Region (Default)
Commercial Sales in MWh (in 2018)	54,773,407
Commercial Share of Region	100.0%

Optional – Enter 2018 commercial sales

Commercial Segment	Existing Million Square Feet in 2022	New Million Square Feet in 2022	Regional Existing Million Square Feet in 2022	Regional New Million Square Feet in 2022	Existing Ratio of Total Sqft to Region	New Ratio of Total Sqft to Region
Large Off	396.20	5.63	396	6	100.0%	100.0%
Medium Off	203.00	4.20	203	4	100.0%	100.0%
Small Off	187.32	1.35	187	1	100.0%	100.0%
XLarge Ret	141.78	1.16	142	1	100.0%	100.0%
Large Ret	212.76	1.06	213	1	100.0%	100.0%
Medium Ret	100.40	1.47	100	1	100.0%	100.0%
Small Ret	111.75	0.71	112	1	100.0%	100.0%
School K-12	272.12	1.88	272	2	100.0%	100.0%
University	133.39	0.74	133	1	100.0%	100.0%
Warehouse	489.95	3.06	490	3	100.0%	100.0%
Supermarket	52.01	0.45	52	0	100.0%	100.0%
MiniMart	23.60	0.12	24	0	100.0%	100.0%
Restaurant	51.84	0.87	52	1	100.0%	100.0%
Lodging	184.62	1.70	185	2	100.0%	100.0%
Hospital	113.50	3.40	114	3	100.0%	100.0%
Residential Care	139.33	2.94	139	3	100.0%	100.0%
Assembly	374.08	4.37	374	4	100.0%	100.0%
Other	368.65	6.06	369	6	100.0%	100.0%

[1] https://www.eia.gov/electricity/data/eia861/

3.4. Industrial User Inputs

The "Industrial User Inputs" tab contains the inputs necessary to populate the "Industrial" tab and inform the industrial potential estimate. The inputs require knowledge of industrial sales by industrial facility type, so that the potential estimates can be calculated for each industrial facility type based on the ratio of utility sales to regional sales.

3.4.1. Key Definitions

The input in the section is for:

- **Estimated 2022 Industrial Sales**, industrial sales in megawatt-hours, estimated for 2022 for each of the industrial facility types considered in the 2021 Power Plan.

3.4.2. Updating Inputs

Users will be required to populate cells D3:D23. Figure 6 shows where to enter this data.

Figure 6. Industrial User Inputs

Input	2021 Plan Facility Type Name	Estimated 2022 Sales by Facility Type (MWh)	Regional 2022 Total Sales by Facility Type (MWh)	Ratio of Total Sales to Region
1	Cement	2,070,482	2,070,482	100.0%
	Chemical	4,882,292	4,882,292	100.0%
	ColdStorage	934,285	934,285	100.0%
	ElecFab	4,148,451	4,148,451	100.0%
	Foundries	456,333	456,333	100.0%
	FrozenFood	2,295,990	2,295,990	100.0%
	FruitStorage	1,662,283	1,662,283	100.0%
	KraftPulp	2,945,325	2,945,325	100.0%
	Lumber	1,552,851	1,552,851	100.0%
	MechPulp	2,950,713	2,950,713	100.0%
	MetalFab	1,247,723	1,247,723	100.0%
	MiscManf	974,344	974,344	100.0%
	OtherFood	3,140,913	3,140,913	100.0%
	Panel	548,975		
	Paper	523,751		
	Refinery	2,409,559		
	Silicon	402,880		
	Transportation	2,800,070	2,800,070	100.0%
	Wastewater	1,052,610	1,052,610	100.0%
	WaterSupply	1,032,790	1,032,790	100.0%
	Wood	3,049,346	3,049,346	100.0%
	Total	**41,081,965**	**41,081,965**	**100.0%**

Instructions:

Enter estimated sales in MWh by facility type for t

See the user guide for further descriptions of these

Enter estimated 2022 sales for each facility type

Further definition for the industrial facility types is provided in Table 2.

Table 2. Industrial Facility Type Descriptions

2021 Plan Facility Type Name	Description
Cement	Cement, concrete, and other similar aggregate products
Chemical	Production of chemicals
ColdStorage	Storage of refrigerated and frozen foods
ElecFab	Fabrication of electrical equipment, excluding silicon-based products
Foundries	Production of metals through melting and casting
FrozenFood	Production of frozen food products
FruitStorage	Storage of fruit requiring controlled atmosphere conditions
KraftPulp	Production of pulp and paper through the kraft pulp process
Lumber	Production of dimensional lumber
MechPulp	Production of pulp and paper through the mechanical pulping process
MetalFab	Fabrication of metal products through cutting, bending, assembling, etc.
MiscManf	Manufacturing operations not fitting into the other categories
OtherFood	Production of food products that are not frozen foods
Panel	Production of panel goods (e.g., plywood, OSB, particle board, etc.)
Paper	Conversion of raw paper to finished paper and paperboard goods
Refinery	Refining of raw materials into other finished products (e.g., petroleum)
Silicon	Production of silicon-based materials for computer chips, solar PV, etc.
Transportation	Production of equipment for transportation and other purposes (e.g., cars, planes, etc.)
Wastewater	Treatment of wastewater
WaterSupply	Treatment of water for municipal supply purposes
Wood	Other wood products that are not lumber or panel goods (e.g., furniture)

3.5. Agricultural User Inputs

The inputs in the "Agricultural User Inputs" tab are necessary to populate the "Agricultural" tab and develop the estimate of utility-specific agricultural potential. The inputs inform the make-up of agricultural activity in the utility service territory compared to the statewide make-up.

3.5.1. Key Definitions

There are four different variables the user needs to enter to effectively estimate agricultural potential:

- **Share of statewide farms**, the number of farms in the utility service territory, expressed as a percent of the statewide total (based on the state selected in the "Global User Inputs" tab).
- **Share of statewide dairy production**, the number of dairy cows in the utility service territory, expressed as a percent of the statewide total (based on the state selected in the "Global User Inputs" tab).
- **Share of statewide irrigated land**, the number of irrigated acres in the utility service territory, expressed as a percent of the statewide total (based on the state selected in the "Global User Inputs" tab).
- **Share of statewide irrigated alfalfa**, the number of acres of irrigated alfalfa in the utility service territory, expressed as a percent of the statewide total (based on the state selected in the "Global User Inputs" tab).

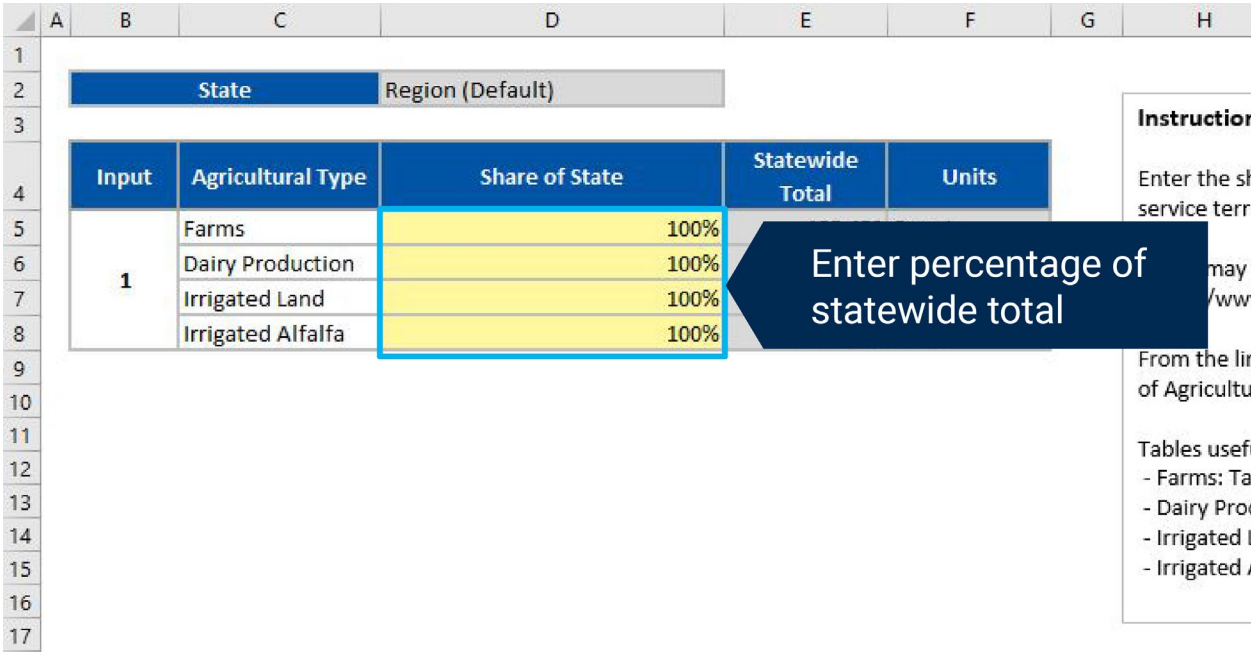
To determine these inputs, the user may need to reference the US Department of Agriculture's Census of Agriculture[2]. The tables listed below can be used to estimate utility-specific shares of statewide totals from the county-level reports.

- Farms: Table 1
- Dairy Production: Table 11
- Irrigated Land: Table 10
- Irrigated Alfalfa: Table 26

3.5.2. Updating Inputs

To update the inputs mentioned above, the user should enter a 0%-100% value in cells D5:D8. Figure 7 shows where to enter this data.

Figure 7. Agricultural User Inputs



3.6. Utility Sector User Inputs

The final user input tab is the "Utility Sector User Input" tab. Utilities have the option to enter their sales from 2018, otherwise the sales will be automatically populated with 2018 EIA data from Form 861 based on the utility selected in the "Global User Inputs" tab.

[2] https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Census_by_State/index.php

3.6.1. Key Definitions

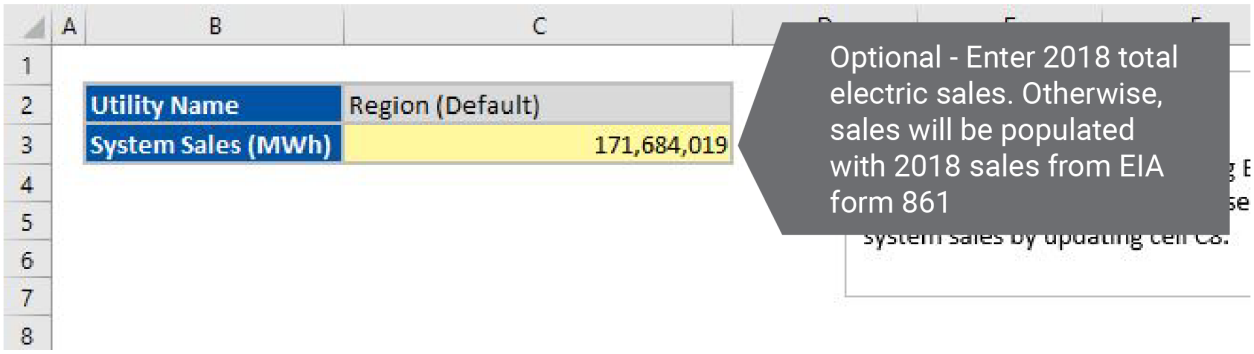
The only input in the section is for:

- **2018 System Sales**, utility electric energy sales in megawatt-hours in 2018.

3.6.2. Updating Inputs

Users will be required to populate cell C3. Figure 8 shows where to enter this data.

Figure 8. Enter Utility Sector Data



3.7. Output Data

Once the user has populated the input tabs and allowed the workbook to calculate, output data tabs will be populated with estimates of potential savings and cost information. The UPC generates multiple views of the savings potential estimates including summaries at the sector, end use, and measure level. This section provides descriptions of the different output data tabs.

3.7.1. Savings Output

The UPC includes a high-level summary of the estimated savings potential on the "Savings Summary" tab. This tab summarizes both achievable economic energy (columns B-F) and demand savings (columns I-M) in cumulative average megawatts (aMW) and megawatts (MW), respectively. The first tables and graphics summarize 2-, 4-, 10-, and 20-year cumulative potential at the sector level. The following tables and graphics summarize 2-, 4-, 10-, and 20-year cumulative end use savings potential for each sector.

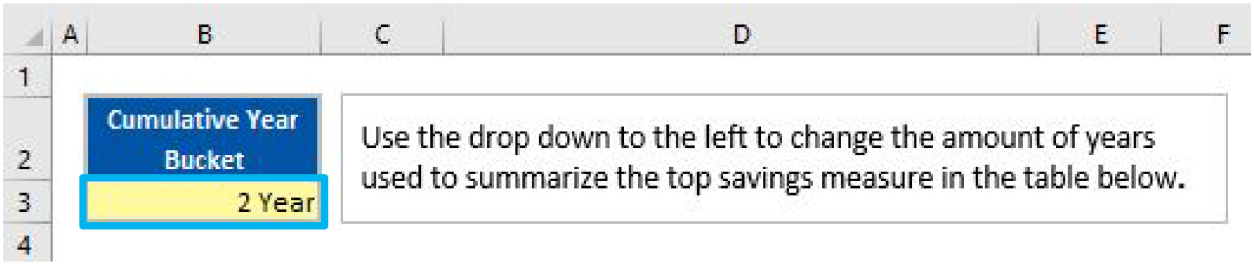
3.7.2. Cost Output

The costs associated with the achievable economic savings potential are summarized on the "Cost Summary" tab. This tab contains four tables which summarize the cost by sector over 2-, 4-, 10-, and 20-year cumulative timeframes. In addition, costs are summarized from two different perspectives. In rows 2-9, costs are summarized according to the utility cost perspective, including only program administrative and incentive costs. Rows 11-18 summarize the costs using the Total Resource Cost perspective, which includes all program and measure costs. Cost amounts are provided in total amounts (dollars) as well as the cost per unit of first year savings ($/MWh). Note that the cost per first year savings do *not* reflect the measure life of individual measures and are not comparable to levelized costs of other resources.

3.7.3. Top Measures

The "Top Measures" tab provides tables for the top 20 measure categories in each sector and the cost-effective energy savings associated with the measure category. The cumulative achievable economic potential can be summarized over a 2-, 4-, 10-, or 20-year timeframe based on the user's selection. Figure 9 shows where the user can make this selection in cell B3.

Figure 9. Top Measures User Input



3.7.4. Detailed Output

The "All Measures" tab of the workbook provides the most detailed output in the UPC. Each row on the "All Measures" tab is unique by the sector, segment, resource type, and measure name combination. There are over one hundred columns on this tab for the following information.

- **BPA Sector (Column B)**, the sector definition using BPA taxonomy.
- **BPA End Use (Column C)**, the measure end use definition using BPA taxonomy.
- **BPA Category (Column D)**, a sub-category of BPA end use for the measure using BPA taxonomy.
- **BPA Technology/Activity/Practice (Column E)**, a sub-group of BPA category for the measure using BPA taxonomy.
- **BPA UES Measure (Column F)**, a flag indicating whether BPA has a similar UES measure in its energy efficiency program offerings
- **Sector (Column G)**, the building type sector definition using the 2021 Power Plan taxonomy.
- **Segment (Column H)**, the building type definition using the 2021 Power Plan taxonomy.
- **Measure Category (Column I)**, a sub-category of end use for the measure from the 2021 Power Plan.
- **Resource Type (New, NR, or Retrofit) (Column J)**, a flag identifying if the measure is:
    - **New:** A measure installed in a new construction building
    - **NR (Natural Replacement):** A measure installed in an existing building when the existing equipment reaches the end of its life and needs to be replaced
    - **Retrofit:** A measure that can be installed in an existing building at any time
- **2021 Plan Workbook (Column K)**, the workbook from the 2021 Power Plan where the measure originates from. The Resources section provides the location of the workbooks.
- **Cleaned Measure Name (Column L)**, the name of the measure from the 2021 Power Plan adjusted for more clarity in the UPC.
- **Measure Index Name (Column M)**, the sector, measure category, resource type combination for a measure. This is used for summarizing data.

- **End Use (Column N)**, the measure end use definition from the 2021 Power Plan.
- **Lost Opportunity Flag (Column O)**, a true/false flag indicating if a measure is a lost opportunity. A lost opportunity measure can only be installed when existing equipment burns out or in new construction, as opposed to retrofit measure which can be installed at any time.
- **Building Vintage (Column P)**, a variable set to new or existing depending on if the measure is for an existing building or a new construction building.
- **Levelized Cost mills/kWh (Column Q)**, the levelized cost of the equipment as determined by the 2021 Power Plan.
- **Total Sponsor Levelized Cost (Column R)**, the levelized cost based on the cost to utility sponsors, including BPA and utility programs
- **Initial Capital Cost (Column S)**, the upfront cost of installing the energy efficiency measure, based on the 2021 Power Plan.
- **Bulk Energy (kWh/unit) (Column T)**, first-year energy savings per unit, relative to the measure baseline from the 2021 Power Plan used to determine achievable technical potential.
- **Bulk Demand (kW/unit) (Column U)**, first-year demand savings per unit, relative to the measure baseline from the 2021 Power Plan used to determine achievable technical potential.
- **Measure Life (Column V)**, the 2021 Power Plan effective useful life for the measure.
- **Total Regional B/C Ratio (Column W)**, the total resource cost test ratio for the measure based on the 2021 Power Plan analysis.
- **Include in BPA Expanded Measure Set (Column X)**, a 1 or 0 flag indicating if the measure is included in the BPA expanded set of measure to include in the achievable economic potential.
- **CE Screen (Column Y)**, a 1 or 0 flag indicating if the measure should be included in the achievable economic potential based on the user's selection of the cost-effective measure set on the "Global User Inputs" tab.
- **2022-2041 Achievable Technical Units (Column Z:AS)**, the incremental, annual number of achievable technical units based on the 2021 Power Plan with adjustments for user input.
- **Max Achievable Technical Units (Column AT)**, the maximum 20-year number of achievable technical units for a measure based on the 2021 Power Plan with adjustments for user input.
- **2022-2041 Achievable Technical Units (Max Adjusted) (Column AU:BN)**, the annual, incremental number of achievable technical units adjusted so that the 20-year cumulative units does not exceed the maximum achievable technical units. This calculation is described in the Achievable Technical Potential Calculation section.
- **2022-2041 Incremental Achievable Technical Potential aMW (Column BO:CH)**, the annual, incremental achievable technical energy savings potential based on the maximum adjusted achievable technical units and the 2021 Power Plan energy savings per unit.
- **2022-2041 Incremental Achievable Technical Demand (MW) (Column CI:DB)**, the annual, incremental achievable technical demand savings potential based on the maximum adjusted achievable technical units and the 2021 Power Plan demand savings per unit.
- **2-, 4-, 10-, 20-Year Achievable Technical Potential (aMW) (Column DC:DF)**, the cumulative achievable technical savings potential summaries for a measure in 2-, 4-, 10-, and 20-year increments.

- **2-, 4-, 10-, 20-Year Achievable Technical Demand Potential (MW) (Column DG:DJ)**, the cumulative achievable technical demand savings potential summaries for a measure in 2-, 4-, 10-, and 20-year increments.
- **2-, 4-, 10-, 20-Year Achievable Economic Potential (aMW) (Column DK:DN)**, the cumulative achievable economic savings potential summaries for a measure in 2-, 4-, 10-, and 20-year increments.
- **2-, 4-, 10-, 20-Year Achievable Economic Demand Potential (MW) (Column DO:DR)**, the cumulative achievable economic demand savings potential summaries for a measure in 2-, 4-, 10-, and 20-year increments.
- **2022-2041 First Cost (Column DS:EL),** the 2021 Power Plan capital cost and the user input administrative cost percentage on the "Global User Inputs" tab.
- **2-, 4-, 10-, 20-Year First Cost (Column EM:EP)**, the cumulative 2-, 4-, 10-, and 20-year summaries of first-year capital and administrative cost associated with a measure.

3.8. Troubleshooting

There are three primary causes of errors when altering the UPC:

1. **Not updating user inputs in the correct order.** The UPC is designed under the assumption that users will first modify the "Global User Inputs" tab following the steps outlined in the *Global User Inputs* section, then move on to the sector-specific user input sections. This is because the state selected on the "Global User Inputs" tab informs the potential list of utilities and regions that the user will have to select from in future steps. For example, if a user selects Idaho as their primary state, then selects a utility in Idaho, they will encounter an error if they change the state to Washington because the selected utility is not in Washington.
2. **Overwriting cells on input tabs with pre-existing formulae.** On each of the user inputs tabs there is pre-populated data that is not intended to be edited. If the user overwrites any pre-populated data, then we recommend downloading a new copy of the UPC. Note that in certain tabs, such as the "Residential User Input" tab, users can alter certain pre-populated data with utility specific data, but any formulas overwritten will be permanently lost.
3. **Entering data in the incorrect unit.** When entering data ensure that the units align with the unit described in the workbook. Since the development of utility-specific energy efficiency savings potential is primarily based on scaling factors to regional totals, it is important that both the regional data and the utility-specific data are in the same unit.

4. Energy Efficiency Potential

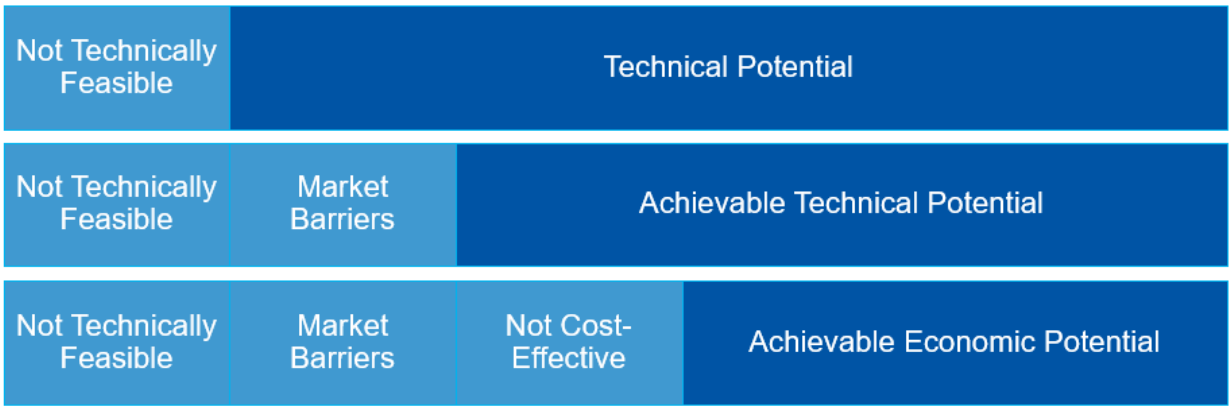
Energy efficiency potential is an estimate of the amount of future energy efficiency savings available for a given geographic region or service territory. Calculating energy efficiency potential can inform utility resource and program planning. Energy efficiency potential does not consider how it is acquired. For example, savings may be acquired through utility programs, improved codes and standards, and market transformation.

There are three different types of energy efficiency potential relevant to the UPC:

- ***Technical potential*** assumes that all technically feasible resource opportunities may be captured, regardless of their costs or other market barriers. It represents the total potential in a utility's service territory, after accounting for purely technical constraints.
- ***Achievable technical potential*** is the portion of technical potential that is assumed to be achievable over the study period, regardless of cost.
- ***Achievable economic potential*** is the portion of achievable technical portion determined to be cost-effective.

Achievable technical and achievable economic potential can be found in the UPC, but the UPC does not include technical potential. We include a description here because technical potential informs both achievable technical and achievable economic potential. Figure 10 shows how each of the potential types relate to each other.

Figure 10. Types of Potential



The following sections detail how each of these types of potential is calculated and where the data can be found in the UPC.

4.1. Technical Potential

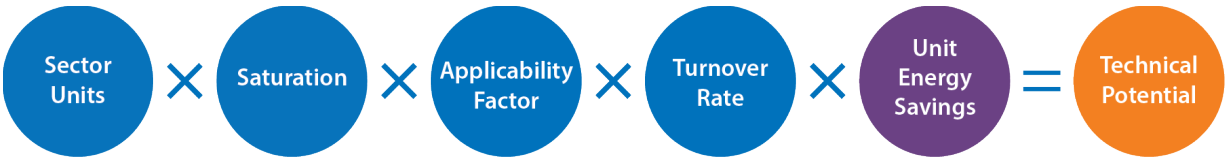
Technical potential is not included in the UPC, but it is the basis for calculating achievable technical potential. Cadmus and Lighthouse Energy Consulting used the Council's 2021 Power Plan technical potential calculations to determine achievable technical potential in the UPC.

To calculate annual technical potential for a piece of equipment, the Council relies on the variables shown in the equation in Figure 11. The components that make up the measure unit calculation (in blue) are:

- **Sector units** are the number of homes, commercial square feet, industrial load, or shipments of applicable equipment
- **Saturation** is the percentage of the sector units that have that equipment
- **Applicability factor** reflects the share of units where the measure is technically feasible and where the measure has not already been installed
- **Turnover rate** is the rate at which the equipment burns out and needs replacement, this is typically one divided by the measure life

The number of units is multiplied by the per unit energy savings to determine the technical potential.

Figure 11. Technical Potential Equation



4.2. Achievable Technical Potential

Achievable technical unit counts and savings potential can both be found in the UPC at the measure level on the "All Measures" tab columns AU-BN and BO-CH, respectively. Achievable technical potential equals the product of a unit forecast, the equipment unit energy savings, the maximum achievability factor, and ramp rate factors (Figure 12). Blue components are a part of the unit forecast calculation. The blue, purple, and orange components make up the achievable technical potential calculation described above.

Figure 12. Equation for Estimating Achievable Technical Potential

As illustrated in Figure 12, achievable technical potential is the product of technical potential and both the maximum achievability factor and the ramp rate. The UPC uses maximum achievability factors and ramp rates from the Council's 2021 Power Plan.

4.3. Achievable Economic Potential

The UPC includes summaries of achievable economic (or cost-effective) potential by sector and end use on the "Savings Summary" tab. The achievable economic potential is the achievable technical potential

for only those measures that are cost-effective based on the cost-effectiveness selection criteria selected by the user in cell C9 of the "Global User Inputs" tab.

4.3.1. Cost-Effectiveness Screening

To determine achievable economic potential, a cost-effectiveness analysis is typically done. The most common metrics used for cost-effectiveness screens are benefit-cost ratios and levelized costs. In each of these calculations, measure benefits and costs are quantified and the measures that do not meet the levelized cost or benefit-cost criteria are excluded from the achievable economic potential. The benefits, costs, and screening criteria can vary by utility preference and regional requirements.

The UPC offers two different sets of measures for consideration in achievable economic potential:

- **2021 Power Plan Cost-Effective Measures**, these are the measures deemed to be cost-effective based on the results of the 2021 Power Plan.
- **Expanded BPA Measures**, these are the measures deemed cost-effective under the 2021 Power Plan and measures that did not meet the Council's cost-effectiveness criteria described above but have been typically included in BPA's energy efficiency programs. There are no specific criteria for the additional measures included. They were selected on a case-by-case basis.

5. Resources

Important links:

- **Northwest Power and Conservation Council's 2021 Power Plan:** https://www.nwcouncil.org/2021-northwest-power-plan
- **Northwest Power and Conservation Council's 2021 Power Plan Supply Curves:** https://nwcouncil.app.box.com/s/u0dgjxkoxoj2tttym81uka3wrjcy6bo6
- **Northwest Power and Conservation Council's 2021 Power Plan CBSA Updated Supply Curves[3]:** https://nwcouncil.app.box.com/s/b5udjan8fh71w9wuuzhrg1hxhueyr5wa
- **Main UPC Host Site:** https://www.bpa.gov/energy-and-services/efficiency/utility-toolkit

Appendix A. BPA End Uses and Measure Categories

Table 3. Residential End Use and Measure Categories

BPA End Use	Measure Category
Electronics	Advanced Power Strips
	Air Cleaner
	Clothes Dryer
	Computer
	EV Supply Equip
	UHD TV
Food Preparation	Electric Oven
	Microwave
HVAC	Air Conditioning
	ASHP
	Cellular Shades
	DHP
	Duct Sealing
	Fans
	GSHP
	Heat Recovery Ventilation
	Pumps
	ResWx
	Smart Thermostats

[3] Following the release of the final 2021 Power Plan supply curve workbooks, the Council made updates to certain commercial supply curve workbooks to incorporate the 2019 Commercial Building Stock Assessment (CBSA) data. The UPC includes the CBSA updated supply curve data.

Lighting	Lighting
Other	Pumps
Refrigeration	Freezer
	Refrigerator
Water Heating	Aerator
	Clothes Washer
	Dishwasher
	HPWH
	Pumps
	Showerheads
	TSRV
	WasteWater Heat Recovery
	WH Pipe insulation
Whole Bldg/Meter Level	Behavior

Table 4. Commercial End Use and Measure Categories

BPA End Use	Measure Category
Compressed Air	Compressed Air
Electronics	Advanced Power Strips
	Computer
	Servers and Power Supplies
Food Preparation	Cooking Equipment
HVAC	Air Conditioning
	ARC
	Chiller
	DHP
	Glass
	Heat Pumps
	PTHP
	Pumps
	Secondary Glazing Systems
	Smart Thermostats
	VHE-DOAS
	VRF-DOAS
Lighting	Bi-Level Stairwell Lighting
	Exterior Building Lighting
	LEC Exit Sign
	Lighting
	Street and Roadway Lighting

Motors/Drives	Fans
	Pumps
Process Loads	Block Heater
	Elevator
Refrigeration	Grocery Refrigeration Bundle
	Ice and Vending
	Refrigerator/Freezer
	Water Cooler Controls
Water Heating	HPWH
	Pre-Rinse Spray Valve
	Pumps
	Showerheads
	Washer
Whole Bldg/Meter Level	Commercial EM

Table 5. Agricultural End Use and Measure Categories

BPA End Use	Measure Category
HVAC	Dairy
Irrigation	Irrigation Hardware
	Irrigation Motor
Lighting	Dairy
	Lighting
Motors/Drives	Dairy
	Irrigation Motor
Process Loads	Block Heater
	Stock Tanks
Refrigeration	Dairy

Table 6. Industrial End Use and Measure Categories

BPA End Use	Measure Category
Compressed Air	Compressed Air
HVAC	HVAC
Lighting	Lighting
Motors/Drives	Motors
Other	Water/Wastewater
Process Loads	Fans
	Food Storage
	Fork Lift Charger

	Hi-Tech
	Metals
	Paper
	Pulp
	Pumps
	Water/Wastewater
	Wood Products
Refrigeration	Refrigeration Retrofit
	Refrigeration Tuneup
Whole Bldg/Meter Level	Energy Management

Table 7. Utility End Use and Measure Categories

BPA End Use	Measure Category
Utility Transmission System	Distribution System Efficiency