WECC

# Year 20 Foundational Case

April 2024

## Executive Summary

WECC works to understand and help mitigate risks to the reliability of the bulk power system in the Western Interconnection. As part of this work, WECC assesses system performance under a range of future scenarios related to reliability risks. Through its assessment work, WECC has studied potential risks in the Year 10 time frame. Drivers of change like energy policies and clean energy goals are being planned beyond 10 years, with many policies setting targets near the middle of the century. In addition, planning and building or updating system elements can take a long time, in some cases more than a decade. To ensure critical elements are built or updated by the time they are needed, they must be planned long in advance. To account for these factors, in 2023, WECC began developing its capability to assess risks in a Year 20 time frame. This allows WECC to evaluate the implications of potential, long-term risks and help the industry better prepare to respond.

The Year 20 Foundational Case (Y20 FC) described in this report is the baseline for all WECC's 20-year assessments. The Y20 FC represents a business-as-usual future scenario set in the year 2042. To build the Y20 FC, WECC started with its 2032 Anchor Data Set Production Cost Model (2032 ADS), which is a stakeholder-vetted compilation of load, resource, and transmission forecasts for 2032. From there, WECC extended the load and resource forecasts to reflect 10 more years of business-as-usual growth, arriving at the load and resource assumptions for the Y20 FC. Not all case elements were updated, such as future technologies, transmission, and pricing. Model components and assumptions not updated in the Y20 FC remained the same as the 2032 ADS.

WECC used the Y20 FC as the baseline for three Year 20 studies in the 2023 WECC Study Program:

- Extreme Heat Event—examines system performance under an extreme, protracted heat event in 2042, with data extrapolated from the August 2020 heat event to 2042.
- Extreme Cold Event—examines system performance under and extreme, protracted cold event in 2042, with data extrapolated from the December 2022 cold weather event.
- Compound Load Impacts—examines system performance given changes in load resulting from differing amounts of electrification as well as possible demand response programs.

The purpose of the Y20 FC was to create a basis to run other assessments. WECC did not use the case to test the system or understand how it might operate under certain conditions. While the Y20 FC work was not meant to draw conclusions about future risks, there are observations worth noting:

- There was no unserved load seen in this case during any hour of the year.
- Overall, there is a significant reliance on renewable and natural gas resources.
- The most heavily used transmission paths were in Southern California, the northern subregions of Canada and Montana, and the California-Oregon Intertie (COI).

## Challenges and Next Steps

The creation of the Y20 FC posed some analytical and modeling challenges and provided learning opportunities that WECC will use to improve future versions of the Y20 FC.

**Challenge 1:** The lack of a capacity expansion plan proved a challenge in building the Y20 FC.

> **Next Step:** As it does in its process for building the Anchor Data Set, WECC is considering asking Balancing Authorities (BA) to submit their own Year 20 forecasts to help build the Y20 FC. In any case, entities should begin building their capability to develop 20-year forecasts and planning processes.

**Challenge 2:** The optimization parameters in the GridView modeling software created unusual results.

> **Next Step:** WECC will work with production cost model (PCM) vendor to update energy storage modeling so that it can optimize charging and discharging beyond a 24-hour period to reflect how energy storage could be used in the future.

**Challenge 3:** WECC could only focus on a limited number of elements in developing this version of the Y20 FC.

> **Next Step:** WECC will consider adding elements to future Y20 FCs, including renewable hourly profiles, emissions pricing, fuel pricing, additional plant retirements, transmission topology, renewable incentive updates, new technologies, and policy changes.

WECC conducts its study work in partnership with stakeholders and would like to thank all the stakeholders who participated in this study.

# Technical Summary

## Load

WECC based the load shapes in the Y20 FC on the actual demand shapes of 2018. From there, WECC used a forecast linear progression starting with the Year 10 forecasts provided by BAs to create the Y20 FC load magnitudes. The linear growth rates of the loads were evaluated for years 2025–2032, then the loads were grown at those rates through 2042. Finally, to check the reasonableness of the 2042 load shapes, WECC compared the 2042 load forecasts to other Year 20 industry datasets.

## Energy Profiles

The Y20 FC hourly energy profiles are based on actual production during 2018 with the magnitudes and distributions varied by area and technology type. WECC developed the resources through a multistep process.

- Existing resource retirement dates in the 2032 ADS were honored, and no retirements were expedited or added.

- Resource additions were limited to wind, solar, and energy storage in accordance with known decarbonization goals in the Western Interconnection.
- Additional resource capacity was added to balance the loads by first adding and distributing resources similarly to the EIA Annual Energy Outlook, meaning the amounts of each resource type in each subregion. The EIA Annual Energy Outlook explores long-term energy trends in the United States and comes from the EIA, the primary federal authority on energy statistics and analysis. WECC adjusted and distributed the additional resources to achieve similar planning capacity margins as the 2032 ADS. WECC tuned the resource mix by comparing it to other industry reports, datasets, and state planning goals.
- The Y20 FC Loads and Resources, to validate their alignment with the industry perspective, were compared to industry cases such as the National Renewable Energy Laboratory (NREL) 2022 Standard Scenarios, a suite of forward-looking scenarios of the U.S. power sector updated annually to support and inform energy analysis.

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## Introduction

Historically, WECC has studied potential risks in the 10-year time frame. In recent years, it has become clear that the risks facing the Western Interconnection extend beyond the 10-year horizon. Drivers of change like energy policies and goals are being planned beyond 10 years, with many policies setting targets near the middle of the century. In addition, planning and building or updating system elements can take a long time, in some cases more than a decade. To ensure critical elements are built or updated by the time they are needed, they must be planned long in advance. To account for these factors, in 2023, WECC began developing its capability to assess risks in a Year 20 time frame.[1] This new capability allows WECC to evaluate the implications of potential long-term risks and help better prepare the industry to respond.

The first step in building WECC's capability to assess long-term risks was to develop the Year 20 Foundational Case (Y20 FC). The Y20 FC provides a reasonable set of business-as-usual assumptions as an analytical baseline against which WECC can test different scenarios and sensitivities. For the 2023 Study Program, WECC analyzed three scenarios:

- Year 20 Extreme Cold Weather Event,
- Year 20 Extreme Hot Weather Event, and
- Year 20 Compound Load Impacts.

## Approach

The Y20 FC represents a business-as-usual future scenario set in 2042. WECC started with its 2032 Anchor Data Set (2032 ADS) Production Cost Model (PCM) , which is a stakeholder-vetted compilation of load, resource, and transmission forecasts for 2032. From there, WECC extended the load and resource forecasts to reflect 10 more years of business-as-usual growth, meaning growth without any major changes or course corrections. The resulting assumptions in the Y20 FC reflect a future in which no major action is taken beyond 2032 to affect or account for load and resource growth, i.e., growth would proceed linearly toward 2042. This means the transmission infrastructure, technology types, and pricing assumptions are the same in the Y20 FC as the 2032 ADS. The Y20 FC does not represent the Western Interconnection's expected future. It represents a resource-balanced starting point for studies that are performed in the Year 20 time frame.

WECC made limited changes from the 2032 ADS to help ensure the Y20 FC represented a business-as-usual situation. The changes WECC *did* make included:

- Load magnitude was grown linearly from the load magnitude in the 2032 ADS.

[1] "Year 20" refers to a single year, 2042, which is 20 years from the current study year. It does not include the intervening years.

- Resource retirements as of 2032 were included. Although some state policies aim to achieve more aggressive retirement schedules, WECC only included those retirements accounted for in the 2032 ADS.
- Resource additions were limited to wind, solar, and battery assumptions received from the California ISO, as it is one of the only entities with available 20-year resource plans. New resources had the same profiles as similar resources in the 2032 ADS. New resources were placed near load centers so new transmission was not needed. No new transmission was added beyond what was included in the 2032 ADS.

## Creating Year 20 Forecasts

Creating a Year 20 forecast of the entire Western Interconnection is a major undertaking, complicated by the fact that many entities do not develop forecasts that far out, leading to gaps in the dataset. Those entities that perform long-term forecasts typically include hypothetical resources to meet extrapolated load assumptions. This can lead to overly optimistic assumptions in the baseline case. WECC could not build the Year 20 case from industry forecasts in the same way it builds the 2032 ADS using 10-year forecasts. To ensure the Y20 FC is a meaningful baseline for long-term assessments, WECC designed it to be a reasonable, business-as-usual representation of 2042, extrapolated from information known as of 2032 (the last year of the 10-year forecast information).

Rather than build a Year 20 dataset from the ground up, WECC used the 2032 ADS (version 2.3.2)[2] as the starting point. The 2032 ADS combines forecast load and resource data WECC receives from Balancing Authorities (BA), transmission topology from the heavy summer power flow case, and additional assumptions provided by the Production Cost Data Subcommittee.[3]

## Adjusting the 2032 ADS

WECC adjusted inputs in the 2032 ADS to create a plausible 2042 scenario (see the Key Assumptions section). In this first iteration of the Y20 FC, WECC focused on the forecasts and assumptions deemed most critical to the accuracy of a future scenario. WECC extended the load and resource forecasts to reflect 10 more years of business-as-usual growth, arriving at the load and resource assumptions for the Y20 FC. Not all case elements—such as future technologies, transmission, and pricing—were updated. Model components and assumptions not updated in the Y20 FC stayed the same as the 2032 ADS.

This report outlines opportunities for improving future Y20 FCs based on WECC's observations in this process.

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[2] See WECC's Data Development and Validation Manual for the assumptions and inputs in the 2032 ADS.

[3] WECC's Production Cost Data Subcommittee reviews inputs and assumptions in the Anchor Data Set to help ensure stakeholder information is accurately reflected.

## Benchmarking

Once WECC created a Y20 FC draft case, it benchmarked the case against available industry information in the 2040-to-2045 time frame to test its reasonableness. The benchmark information included reports and datasets. This helped ensure the Y20 FC reasonably approximated likely 2042 conditions when compared to other industry sources. WECC used the following publicly available reports and datasets in its benchmarking:

- National Renewable Energy Laboratory (NREL) 2022 Standard Scenarios
    - Mid-Case—"central estimates for inputs such as technology costs, fuel prices, and demand growth. No nascent technologies. Electric sector policies as they existed in September 2022. IRA's PTC and ITC are assumed to not phase out."
    - Mid-Case nascent techs, current policies,
    - NREL EFS, Base-Case Ref,
    - NREL EFS, Base-Case Medium Electrification,
    - NREL Mid Case nascent techs, 95% decarb by 2050 2042 (Standard Scenarios 2022),
    - NREL Mid Case nascent techs, current policies 2042 (Standard Scenarios 2022),
    - NREL 2045 Mid Case (Cambium 2022) without tax credit expiration,
    - NREL 2040 Mid Case (Cambium 2022) without tax credit expiration.
- EIA Annual Energy Outlook (AEO2032)
    - Reference Case—"Assess how U.S. and world energy markets would operate through 2050 under current laws and regulations as of November 2022 under evolutionary technological growth assumptions."
- WECC Long-Duration Energy Storage Assessment
    - "Built on the 2040 CES case (80% clean energy) with several adjustments. The 2040 CES case used the 2030 ADS as a starting point for existing transmission and generation. In this case, loads were derived using models from the NREL EFS. New candidate generation resources were derived from NREL's Annual Technology Baseline (ATB) for 2040 and resources with proxy representation of an emerging clean technology were added."

A comparison of the total loads and resource capacity in the Y20 FC with the industry sources demonstrated the reasonableness of Y20 FC. Figures 1 and 2 show the comparisons. The NREL cases do not include the portions of Canada and Mexico in the Western Interconnection, so the loads and resources for the 2042 FC are shown respectively (U.S. only, and Interconnection-wide) for the comparison. Though the load energies are similar between the cases, the load profiles differ. The NREL load profiles tend to fluctuate more than the WECC load profiles.

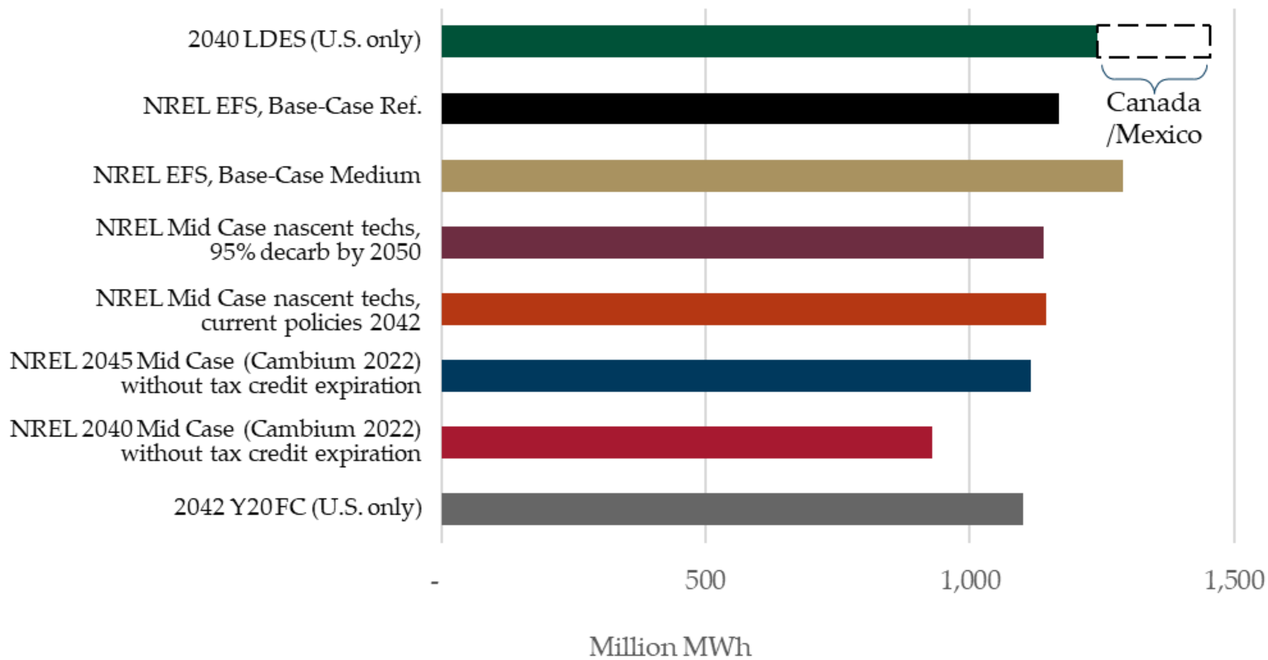


**Figure 1: Comparison of Future Load Forecasts by Study**

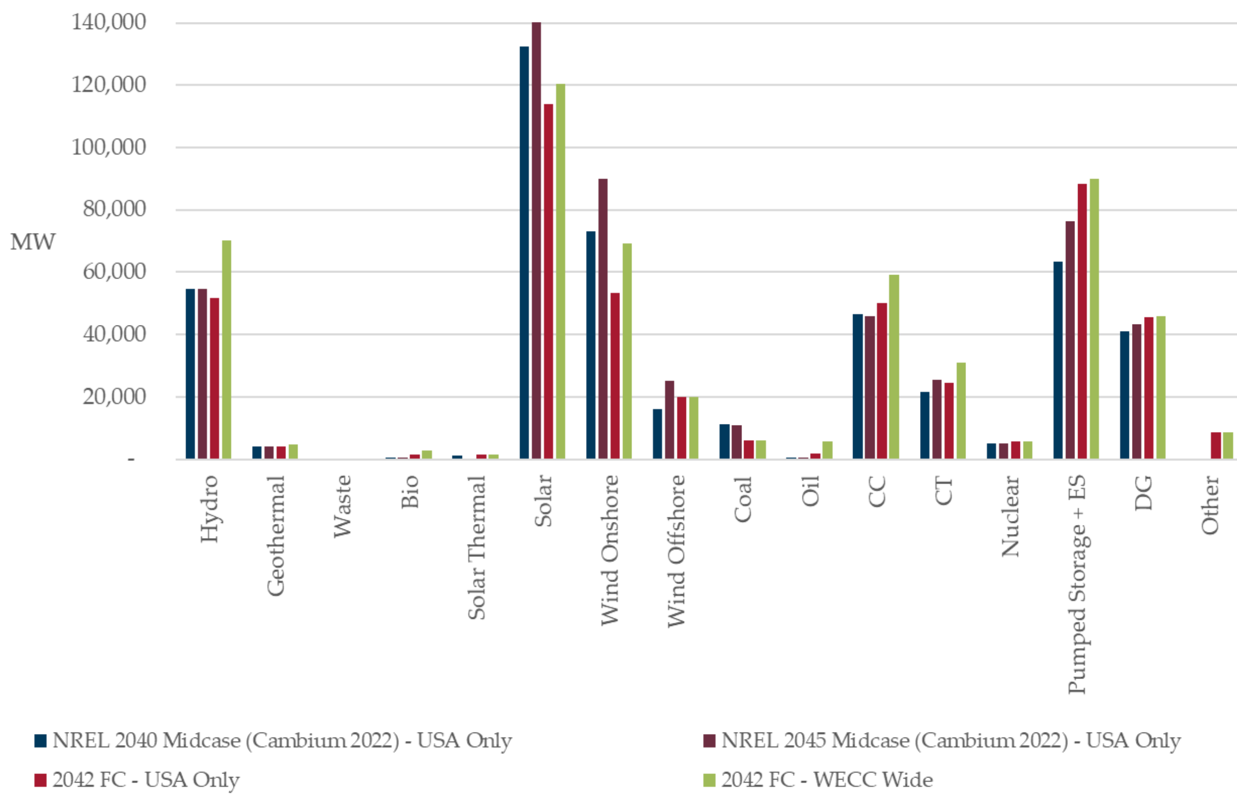


**Figure 2: Comparison of Future Resource Type Capacities by Study**

## Key Assumptions

The changes from the 2032 ADS to the Y20 FC were limited to the defensible changes in the 2032-to-2042 time frame in a business-as-usual situation. (See Table 1.)

**Table 1: 2042 Foundational Case Assumptions Overview**

<table>
<tr><th>System Component</th><th>Assumptions</th></tr>
<tr><td>Loads</td><td><ul><li>Magnitude<ul><li>2032 ADS grown out linearly to 2042</li></ul></li><li>Shape(s)<ul><li>No change from 2032 ADS, based on 2018</li></ul></li></ul></td></tr>
<tr><td>Resources</td><td><ul><li>Capacity<ul><li>2032 ADS retirements honored</li><li>Additional resources were added to 2032 ADS and distributed by area<ul><li>Wind</li><li>Solar</li><li>Batteries<ul><li>Small, short duration (4 hr.)</li></ul></li></ul></li></ul></li><li>Shape(s)<ul><li>No change from 2032 ADS, based on 2018</li></ul></li></ul></td></tr>
<tr><td>Pricing</td><td><ul><li>No change from 2032 ADS</li><li>Production Tax Credits (PTC)<ul><li>PTCs continue for existing, eligible facilities</li><li>New builds of wind and solar assumed to include PTCs</li></ul></li></ul></td></tr>
<tr><td>Transmission</td><td><ul><li>No change from 2032 ADS</li><li>Path ratings opened, when necessary, to assess anticipated line flows</li><li>No-loss model required by software for resource distribution</li></ul></td></tr>
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### 2042 Loads

The load forecast in the Y20 FC consists of two major components: magnitude and hourly shape. To create the load magnitudes for 2042, WECC started with the 2032 ADS load, used a linear annual growth rate from years 2025 through 2032, and projected the annual growth rate to 2042 for each hour of each defined area modeled in GridView. There was no change in the hourly load shape between the 2032 ADS and the Y20 FC; both use the 2018 actual load shape for the respective area. WECC compared the Y20 FC loads to industry benchmarking cases. (See Figure 3.)

## 2042 Resources

### *Resource Retirements*

In the Y20 FC, WECC honored existing retirement dates from the 2032 ADS. (See Figure 3.) Although some states or subregions hope to achieve more aggressive retirement schedules, WECC did not include additional retirements of resources or resource types in this iteration of the Y20 FC.

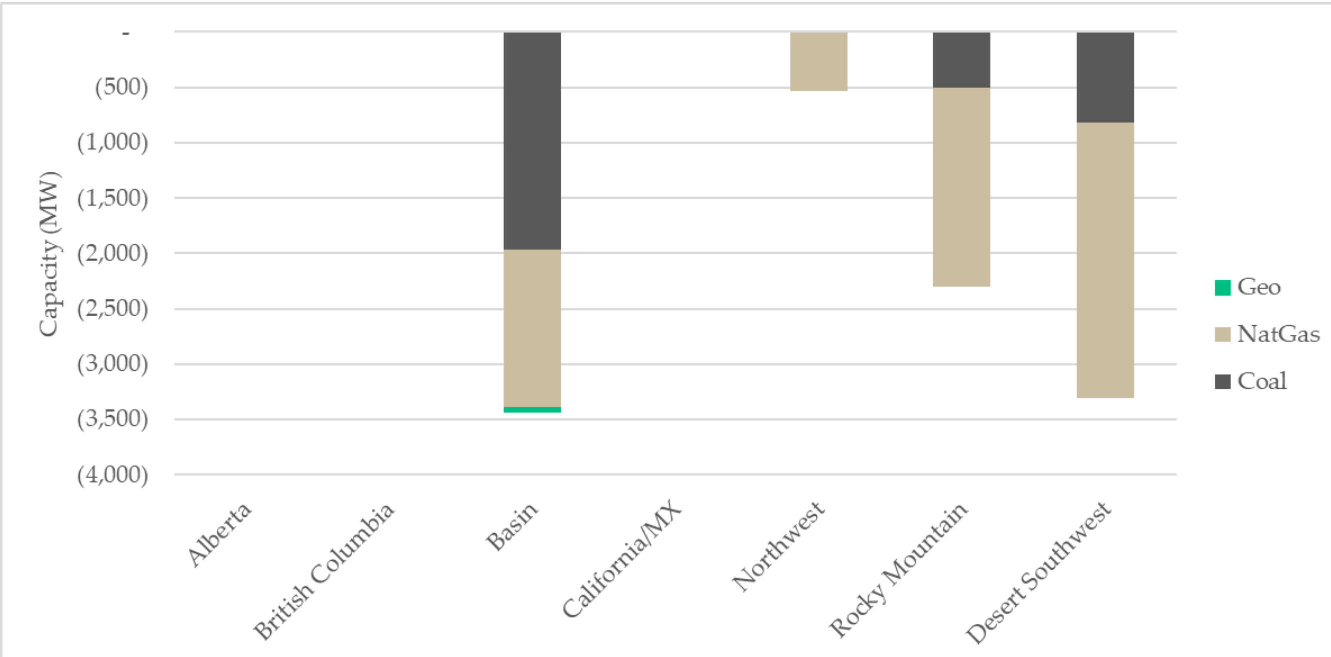


**Figure 3: Retired Thermal Capacity between 2032 ADS and 2042 FC**

### *Resource Additions*

The resource additions in the 2042 FC were limited to wind, solar, and batteries. (See Figure 4.) WECC modeled the wind and solar additions after modeling existing resources and distributed them by individual subregions. This way, wind and solar additions were not represented in the model as being attached to a single bus. The wind and solar resources had the same profiles as in the 2032 ADS (also based on 2018 actuals).

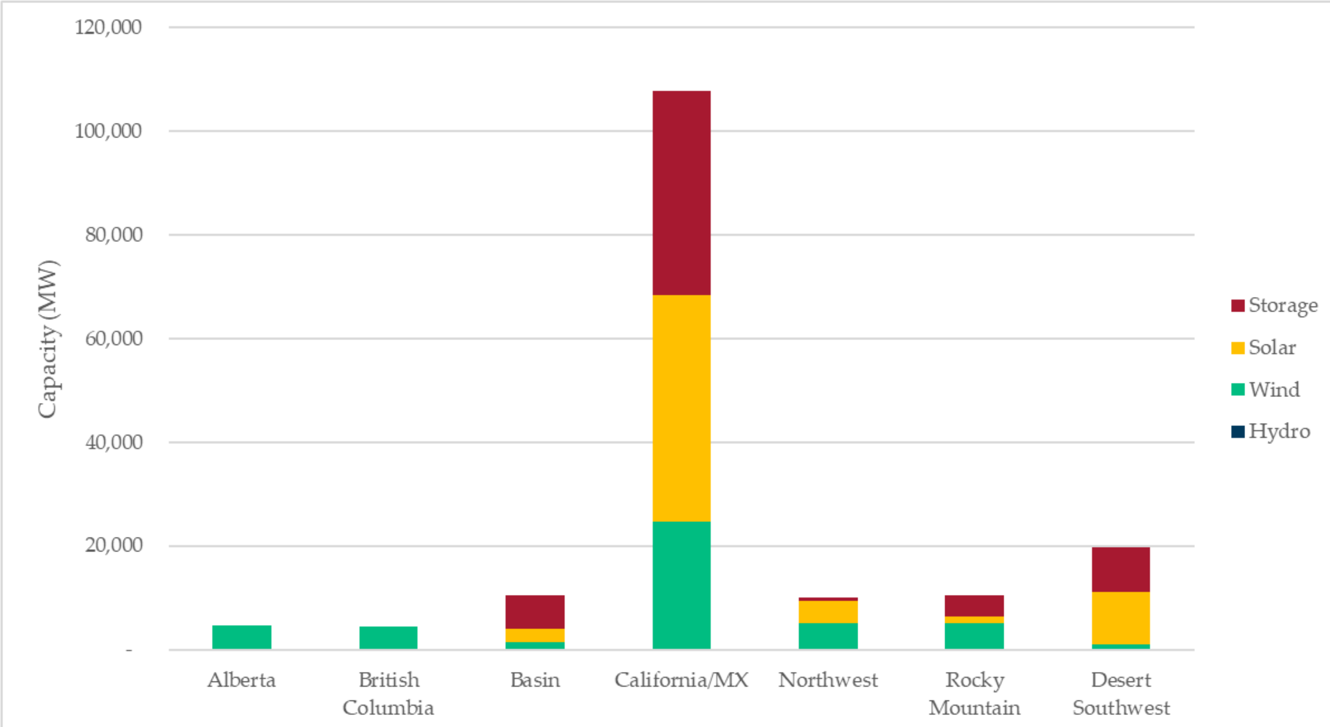


**Figure 4: Net Change in Renewable Capacity between 2032 ADS and 2042 FC (Retirements and Additions)**

The PCM WECC used limited the energy storage added to the system to a 4-hour duration and optimized them over each 24-hour period (i.e., charging and discharging occurred in each 24-hour period). Figure 5 shows a breakdown of the total capacity in the 2042 FC by type and subregion.

Without an explicit capacity expansion plan, WECC added new resources to meet the business-as-usual future capacity needs by combining elements of three methods:

- Industry benchmark: WECC compared the capacity for each subregion to industry sources to test the 2042 assumptions for reasonableness. (See Benchmarking section.)
- Targeted planning capacity margin: WECC tuned the addition of resources by type to get a similar planning capacity margin for each BA, like what is in the 2032 ADS.
- Incorporation of CAISO 20-year capacity plan: As part of the advisory group, CAISO requested that WECC incorporate the 2023 CAISO 20-year capacity plan. The CAISO capacity forecast differs from the other BAs, since it is not a business-as-usual expectation, and increased loads were already considered.

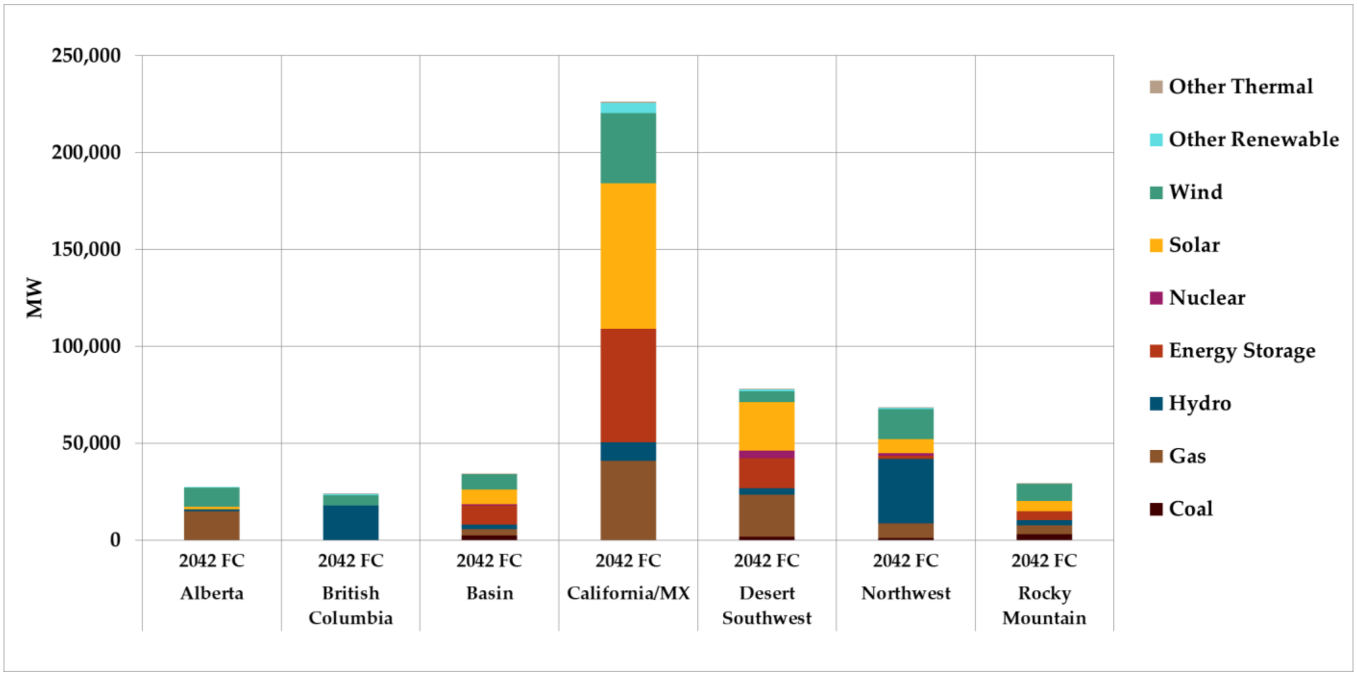


**Figure 5: Total Capacity by Type and Subregion**

### 2042 Pricing

Since the focus of this case is to identify reliability concerns, WECC made no changes to the 2032 ADS in terms of pricing assumptions for the Y20 FC.

### 2042 Transmission

WECC made no change from the 2032 ADS to the transmission topology or projects for the Y20 FC. An important note: because new resources were distributed by subregion, the GridView software requires the model to be run as a no-loss model, which does not account for transmission losses. Without accounting for transmission losses, the generation needed to serve the system may be underestimated.

## Observations

The primary purpose of the Y20 FC is to provide a baseline to which WECC's other 20-year studies can be compared. Building and running the model provides useful insights into how it represents a business-as-usual 2042 scenario and gives important context for comparing the results of WECC's other analyses.

### Load and Generation

The Y20 FC experienced no unserved load during any of the 8,760 hours of the year. There was a large contribution from renewable resources and a dependency on gas resources. (See Figure 6.)

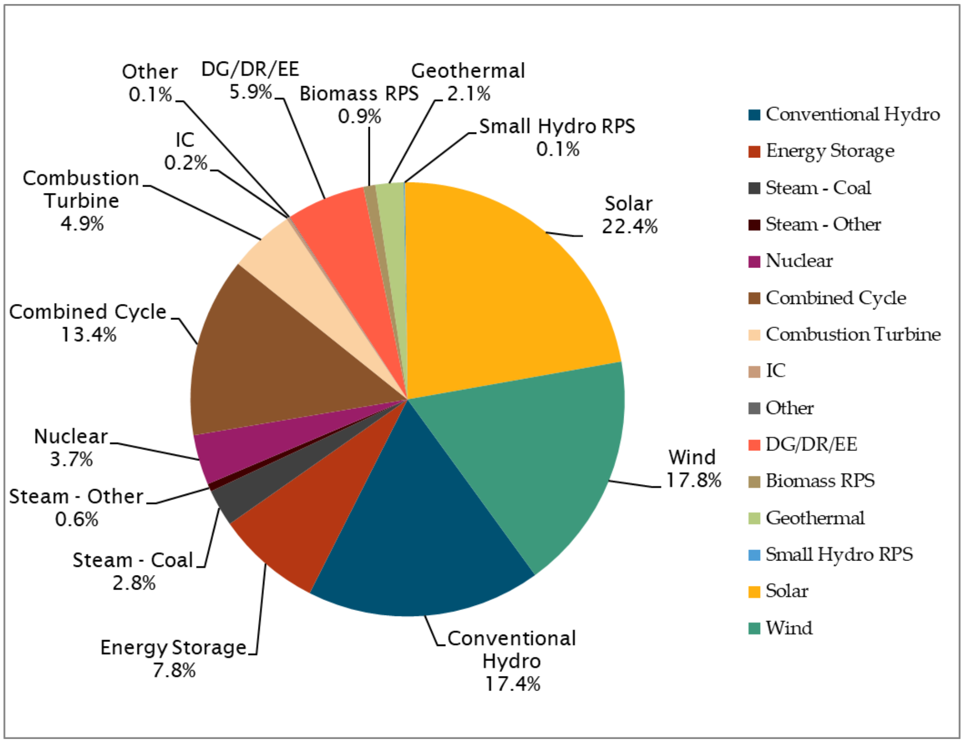


**Figure 6: Total Annual Energy in 2042 FC by Resource Type**

The CAMX subregion used the most energy. (See Figure 7.)

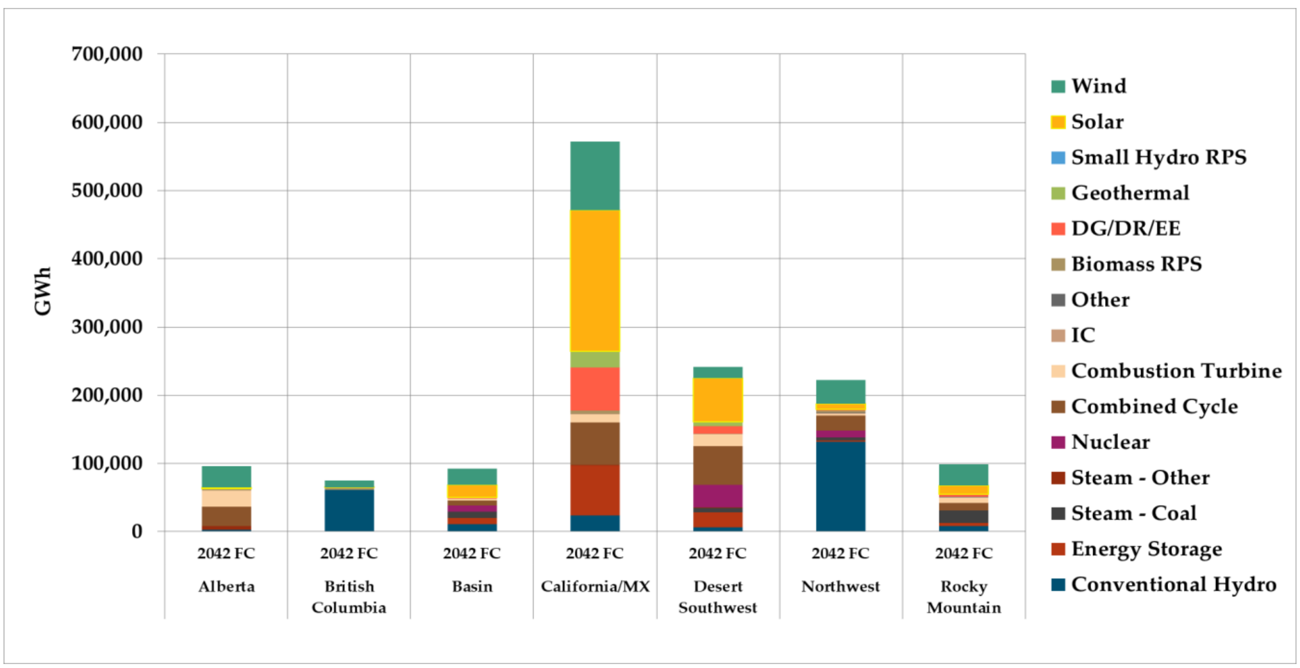


**Figure 7: Annual Energy Consumption in 2042 FC by Subregion and Resource Type**

WECC saw an expected curtailment, or dumped energy, in the Y20 FC. With the addition of more renewable resources such as solar and wind in the Year 20 time frame, there were times when the outputs from these resources did not match perfectly with the load times. For instance, solar panels produce the most energy when the sun is shining, but the highest load time in the day is near the evening peak. Therefore, there are times when the solar panels are producing more power than the system can use, and the excess energy must be dumped. The results below support this. (See Figure 8.)

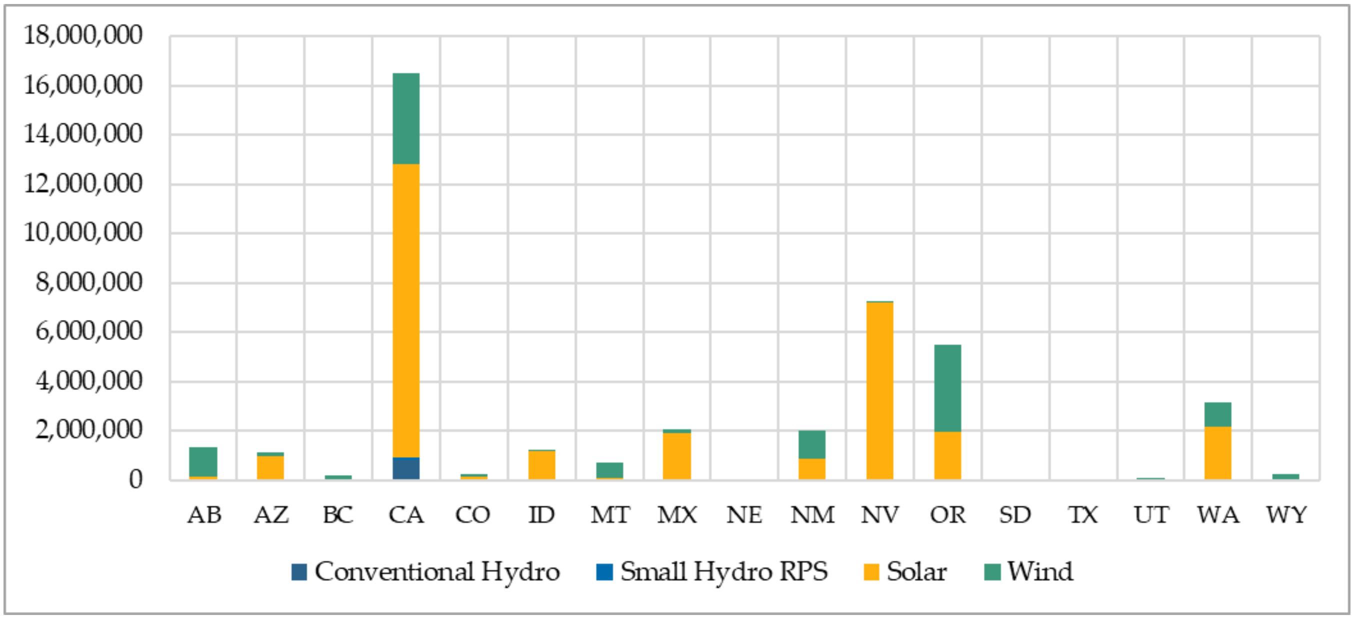


**Figure 8: Total Dumped Energy by State and Resource Type**

## Transmission

WECC measures transmission use with the U99, U90, and U75 designations, which indicate the percentage of hours that a line or path is above the respective amount of its rating (e.g., U75 measures the amount of time that the line is used at 75% or more of its rating in either direction). In the Y20 FC, the most heavily used transmission paths were in Southern California, the northern subregion around Canada and Montana, and the California-Oregon Intertie (COI). (See Figure 9.)

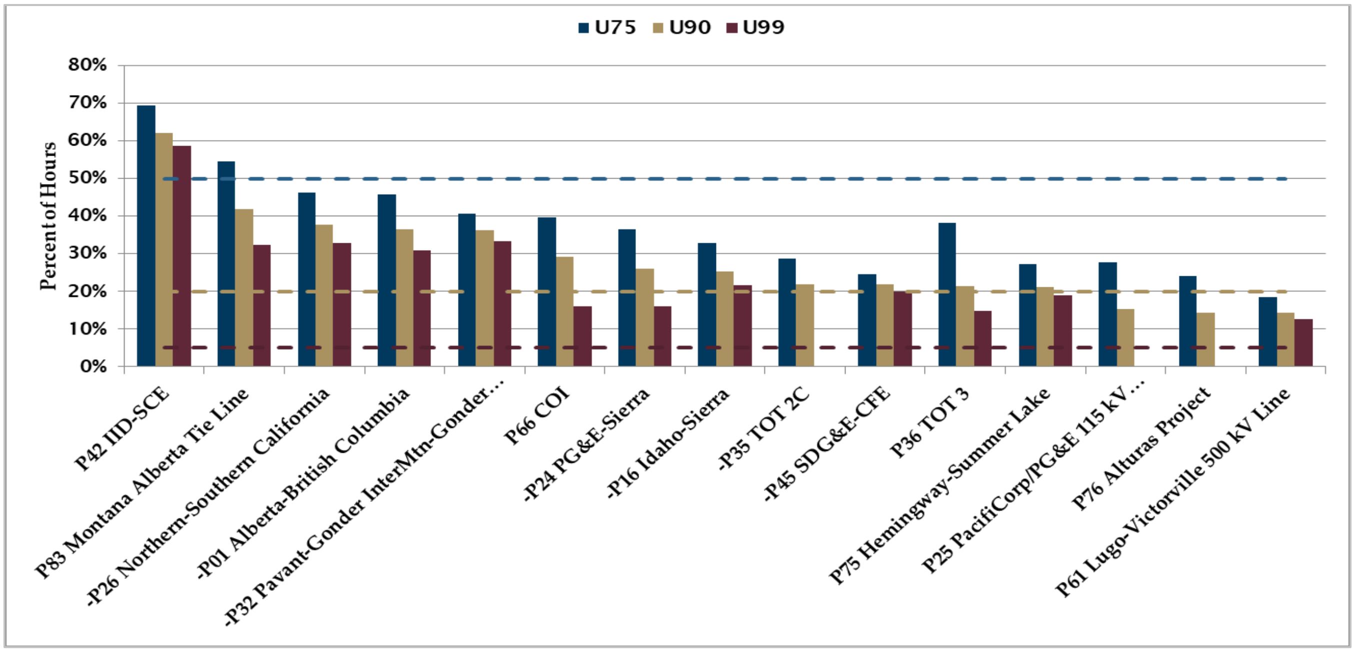


**Figure 9: Transmission Path Utilization for 2042 FC**

Although California produces a substantial amount of energy to serve its demand, it also imports a significant amount of energy. Therefore, California is expected to be a net importer, whereas other areas produce more energy than they consume and are expected to be net exporters (e.g., Northwest and Basin subregions). The Y20 FC results support this. (See Figure 10.)

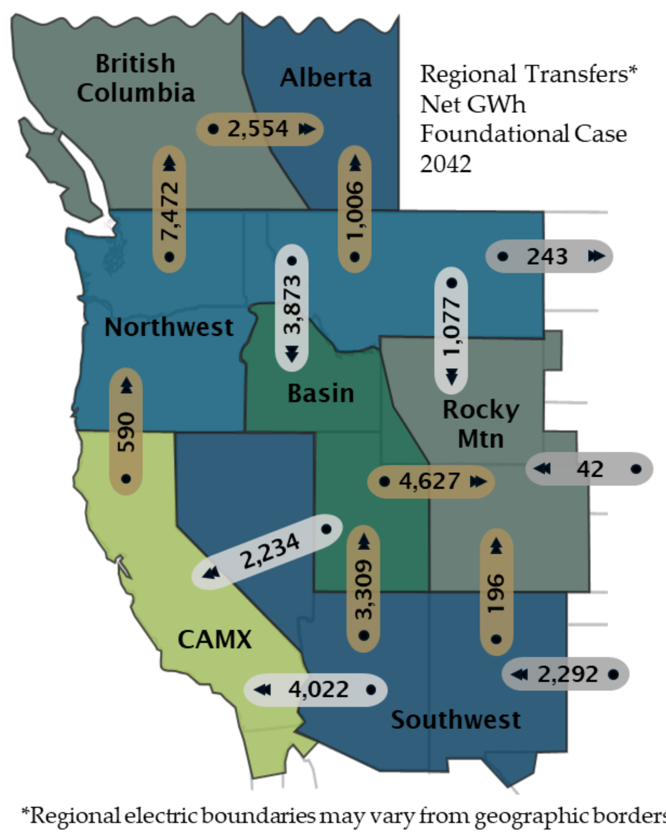


**Figure 10: Net Subregional Transfers for 2042 FC**

## Challenges and Next Steps

The creation of the Y20 FC posed some analytical and modeling challenges. WECC will use the lessons learned from this iteration of the Y20 FC to improve future versions.

**Challenge 1:** The lack of a capacity expansion plan was a challenge in building the Y20 FC. In lieu of a plan, WECC had to weave together insights from several sources, creating a useable but simplified capacity expansion dataset.

> **Next Step**: As it does in its process for building the Anchor Data Set, WECC is considering asking BAs to submit their own Year 20 forecasts to help build the Y20 FC. In any case, entities should begin building their capability to develop 20-year forecasts and planning processes.

**Challenge 2:** WECC experienced challenges growing the system to the Year 20 time frame because its expanded WECC's modeling requirements and pushed the limits of the software.

While adding the 2042 loads and resources, the software experienced errors or provided unintended results. Many of these issues were resolved with a new software version. However, WECC continued to see some unexpected results due to GridView's system optimization calculation, including energy storage optimization. Because the Y20 FC and other Year 20 studies were run using the same version of the GridView PCM, WECC expects the unusual results to have little effect on the comparison between the cases.

> **Next Step:** WECC will work with production cost model (PCM) vendor to update energy storage modeling so that it can optimize charging and discharging beyond a 24-hour period to reflect how energy storage could be used in the future.

**Challenge 3:** WECC focused only on the most critical factors in transforming the 2032 ADS to the Y20 FC: load magnitude and resource capacity. Throughout the process, WECC identified a number of additional elements to consider in future Y20 FC builds.

> **Next Step:** WECC will consider adding elements to future Y20 FCs, including:

- Renewable hourly profiles
  - Consider different hourly profile assumptions for future renewable resources as loads change.
- Emissions pricing
  - Some states charge for the production of specific emissions. It might be reasonable to assume additional BAs will adopt similar regulations, which could change the flow of power.
- Fuel pricing
  - Consider fuel price assumption changes to see how the model alters the resource dispatch priority, which could affect transmission flows.

- Plant retirements
  - Study more aggressive plant retirement schedules to see how this affects resource adequacy.
- Transmission topology
  - Include proposed or anticipated transmission additions that are not included in the ADS.
- Production Tax Credit/Investment Tax Credit updates
  - Analyze which existing and future renewables will have PTC/ITCs or extensions of current incentives.
- Capacity expansion plans
  - Request Year 20 capacity expansion plans from BAs, where available, or build a Year 20 capacity expansion plan.
- New technologies
  - Consider new technologies including carbon capture, modular nuclear units, and long-duration energy storage.
- Policy
  - How to incorporate speculative or changing government or state policies and goals such as state subsidies or Renewable Portfolio Standard goals.