EWEB

Rely on us.

Planning for long-term carbon reduction goals in the IRP

EWEB's Integrated Resource Planning will help with the selection of resources for the next 20 years.

EWEB's Integrated Resource Plan (IRP) is the periodic result of a long-term planning process to evaluate the community's future electricity needs and determine which energy resource options might be the best fit within the context of our organizational values. The IRP combines analysis and modeling results with Board guidance and public involvement to inform the timing of resource acquisition needs and identify lowest-cost alternatives for EWEB's future power portfolio over a 20-year time horizon. The results of the IRP will guide the utility as we make strategic decisions about our energy supply.

EWEB included small modular nuclear reactors (SMR) as an option in its IRP to represent a zero-carbon firm resource (see sidebar). In both the initial reference case and subsequent sensitivity analysis, the modeling suggested a need for these resource characteristics at some point in the next 20 years. Although EWEB is not actively pursuing acquisition of SMR or other zero-carbon, firm resources at this time, there will be a need for a resource with these characteristics in our future.

In this briefing, we will examine:

- Why are zero-carbon, firm energy resources necessary for deep decarbonization?
- Why did EWEB's IRP modeling select small modular nuclear reactors?
- What is a small modular nuclear and what are its tradeoffs?

What is a firm resource?

A firm resource is one that we can rely on to deliver power on demand for extended periods of time. These resources typically have two primary characteristics, which are:

- Dispatchability – the power output can be controlled by operators as needed.
- Consistent fuel supply – they have a fuel source that is predictable and lasts for days to weeks (or even years).

Historically, fossil fuel generation like natural gas and coal plants have fulfilled the role of 'firm' generation, but with oncoming carbon reduction goals, a new type of resource will be needed to fill this function. In the Northwest, most of our non-emitting firm energy currently comes from hydropower and nuclear generators.

Why are zero-carbon, firm energy resources necessary for deep decarbonization?

Today, EWEB relies on hydropower for the bulk of our electricity. This hydropower – produced by large dams on the Columbia River System and sold to EWEB by the Bonneville Power Administration, a federal agency – can produce enormous amounts of zero-carbon energy essentially on demand. This hydropower is what makes EWEB's electricity so clean.

But the future won't resemble the past. The federal hydro system is fully allocated, and new generation will be needed to meet local and state carbon polices that put obligations on EWEB and other regional utilities to further reduce carbon emissions. Additionally, demand for electricity is expected to grow as

EWEB customers switch to electric vehicles and electric heating systems. For EWEB, our Board Policy SD15 commits the utility to procure 95% carbon-free power on a planning basis by 2030. Other statutes such as Washington's Clean Energy Transformation Act[1] and Oregon's House Bill 2021[2] will impact the regional energy mix, though they do not place specific obligations on EWEB.

Even though EWEB does not currently have a 100% carbon-free obligation, any carbon in our portfolio will impact our ability to engage with other utilities in our interconnected electric system. Additionally, because EWEB is assigned carbon emissions from market purchases we make to provide reliable, cost-effective power, there is little room in our portfolio for resources that generate emissions on their own.

What is the Challenge?

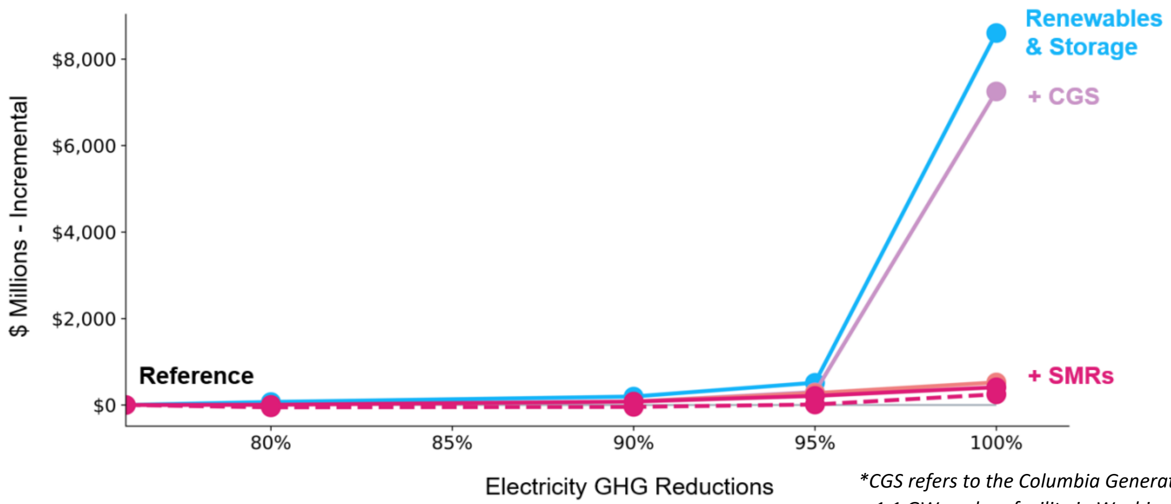
The challenge with decarbonizing the electric grid is moving away from on-demand generating resources we have relied on in the past. At present, EWEB and all other regional utilities are facing the same issue – the coal plants that have provided firm generation for decades are now retiring for regulatory and economic reasons. By 2040, it is expected that all of the current coal plants operating in the West will close. How this firm energy will be replaced is still a question to be wrestled with.

In contrast to the coal and natural gas plants being retired, many low and zero-carbon resources, like wind and solar, are intermittent, and not necessarily available on demand. Batteries and other storage technologies are filling the gaps, but technology and cost barriers remain. In EWEB's case, the Northwest has long-duration winter events that require resources with sustainable peaking capability. These events are not conducive to solar and/or wind plus storage.

Leading studies show that as the electric grid becomes cleaner, the challenge and cost of removing GHG emissions with only renewables plus storage increases exponentially[3] (see Figure 1 below). These studies also show that as we move towards 100% carbon-free, a mix of resources with different attributes will be needed, including low/zero-carbon firm resources we can rely on 24/7. However, the list of firm resources that are commercially available today or in the near future is limited. Broadly supported solutions for low-carbon, firm resources have not been identified. For instance, Portland General Electric's most recent IRP found that while they could meet 2030 carbon goals with existing technologies such as wind, solar and batteries, the 100% carbon-free goal in 2040 would require something new[4].

[1] Clean Energy Transformation Act - Washington State Department of Commerce
[2] External memo (oregon.gov)
[3] E3_Resource_Adequacy_in_the_Pacific-Northwest_March_2019.pdf (ethree.com)
[4] Integrated Resource Planning and Clean Energy Planning | PGE (portlandgeneral.com)

Figure 1: E3 Zero Emitting Resources Study: Cost of reaching 100% carbon-free



**CGS refers to the Columbia Generating Station, a 1.1 GW nuclear facility in Washington.*

EWEB's existing hydro-dominated portfolio already places us on the leading edge of low-carbon resource planning. However, with the challenges mentioned above, we still have a difficult path ahead to reach our carbon reduction goals. Reliability is paramount, and the cost impacts of portfolio decisions need to be managed to both prevent harm to those who cannot afford to pay more for their electricity, and to support customers who choose to electrify their homes and vehicles as a way to reduce overall societal GHG emissions.

Considerations for EWEB's future portfolio include:

1. Getting to and maintaining 95% or higher carbon-free power can be exponentially more expensive and challenging than tackling the first 80-90% of decarbonization.
2. We will need a variety of resources, some of which are not currently commercially or technologically viable, to meet these goals.

How do we build a reliable, low-carbon power portfolio?

Balancing EWEB's resource characteristics and optimizing a resource's strengths, while minimizing its weaknesses, will be essential for providing reliable, cost-effective, low-carbon power. Studies have shown that three broad resource types will be needed to achieve these goals[5]. Eliminating or excluding a resource category as an option in power system modeling consistently results in higher costs, higher emissions, and/or reduced reliability. These three categories are not meant to be exhaustive or perfectly capture every resource, but they do represent the vast majority of resources that will be available to us.

Non-dispatchable, intermittent, low/zero-carbon (e.g. renewables like wind and solar)

[5] The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation: Joule (cell.com)

These resources provide zero-marginal-cost, carbon-free energy. These can be used to offset the fuel consumption for higher-cost resources and reduce total variable costs for the energy system.

Dispatchable, short-duration, low/zero-carbon (e.g. batteries and demand response)

These resources help shape energy supply or demand to meet or reduce peak demand and help balance the electric system as usage fluctuates throughout the day. Because these resources are energy-limited, they provide limited benefits during prolonged load events.

Dispatchable, long-duration, low/zero-carbon, (e.g. small modular nuclear, geothermal, biomass)

These firm resources can be turned on as needed and have sufficient fuel to run for days or weeks at a time.

This briefing is focused on the last category: firm, low/zero-carbon resources. These resources typically have higher upfront costs or operating costs, and they are often emerging technologies. These resources most closely mirror the capabilities of existing fossil fuel plants, and they can provide a variety of services to maintain a reliable grid.

At present, what are the options for dispatchable, long-duration, low/zero-carbon resources?

The list of firm, low-carbon resources is fairly short. These include:

- Geothermal
- Nuclear, including small modular reactors (SMR)
- Biomass/biogas
- Natural gas or coal + carbon capture and storage
- Hydrogen from electrolysis using power from renewable sources

Of these, the IRP included small modular nuclear (SMR), and 'generic' biomass as resource options. These were included because they are based on existing or proven technologies and are currently operating, or expected to begin operating, over the next decade. Geothermal was not included due to the site-specific nature of the resource, but it could be evaluated in the future. Carbon capture and storage technologies are under development and could also be included pending technology or cost changes. Hydrogen electrolysis is a developed technology, but the pathways for it to be effectively used as a zero-carbon resource in the electric sector remain uncertain.

Why did EWEB's IRP modeling select small modular nuclear reactors?

In EWEB's IRP modeling, small modular nuclear was selected as part of EWEB's portfolio in both the reference case and sensitivity analysis. Given that nuclear facilities have not been constructed in the Northwest in over 40 years, why were SMRs selected, and what exactly are they?

Why were SMRs selected in the IRP modeling?

SMRs were selected for the reasons identified above: they are a zero-carbon, firm resource that provides substantial benefits for system reliability. SMRs represent a fraction of the overall portfolio makeup in the IRP, as hydro, wind, and batteries were selected to provide the majority of EWEB's energy needs. This combination of resources aligns with the balanced portfolio requirements described above, with wind providing low-cost carbon free energy, batteries providing energy shifting and short-duration peaking, and SMRs providing firm, dispatchable zero-carbon energy. Hydro provides both low-carbon energy and peaking capacity, depending on storage capability.

The primary characteristics that influenced whether SMRs were selected are:

- Cost (fixed and marginal)
- Carbon emissions
- Transmission cost/constraints
- Flexibility/dispatchability/peaking ability

In the IRP model, the SMR resource had higher costs than many other resources, but its other characteristics meant that it provided value to EWEB and helped meet other constraints. The chart below (Figure 2) comes from the U.S. Department of Energy and is intended to show how nuclear compares to other resource types. In particular, the chart shows that nuclear generation has many positive attributes for the electric system, but there is still substantial cost uncertainty for SMR development. The chart also does not address safety risk or fuel disposal, which are discussed in further detail below.

Figure 2: Resource Attribute Matrix from US Department of Energy Liftoff Report

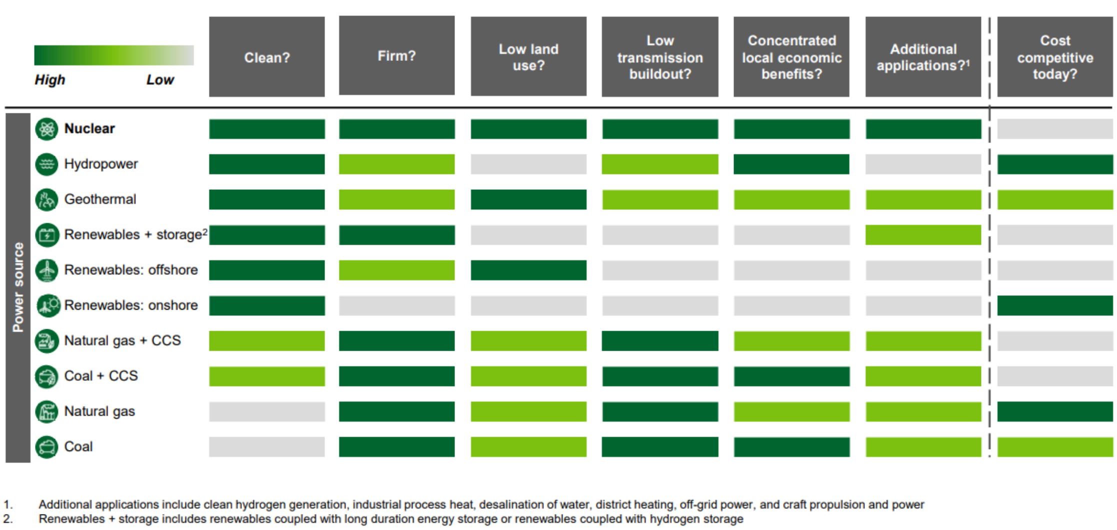


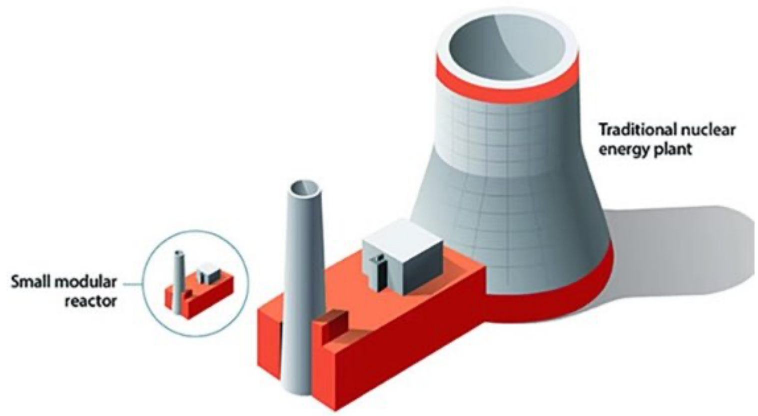
Figure 5: Select elements of nuclear's value proposition as compared to other power sources [6]

[6] Pathways to Commercial Liftoff - Advanced Nuclear - Mar 20 UPDATED (energy.gov)

What is a small modular nuclear and what are its tradeoffs?

Small modular nuclear reactors use nuclear fission (separating atoms) to generate heat. That heat is used to turn water into steam, which drives a generator turbine. There are no carbon emissions from power generation, and nuclear has one of the lowest lifetime carbon emission rates of any energy resource[7]. To address some of the past challenges with traditional nuclear, SMRs have additional design attributes and features. Some of these differences include:

- **Smaller scale**
- **Enhanced and/or passive safety features**
- **Modular design**
- **Increased operating flexibility**
- **Reduced safety radius**
- **Multi-year on-site fuel supply**



These changes are meant to improve upon areas such as cost, safety, location/placement, and ability to follow load, among others.

1) **Cost:** Cost has been major obstacle for generating support for new nuclear facilities. Historically, nuclear facilities have experienced significant cost overruns and manufacturing delays. In the Northwest, the failed construction of multiple nuclear plants resulted in one of the largest public debt defaults in our history[8]. SMRs hope to address cost concerns by using modular designs and smaller scale so that major parts can be manufactured in a controlled, off-site location. The smaller scale also allows manufacturers to learn through repetition, standardize equipment and processes, and stimulate a dependable supply chain.
2) **Safety:** Small modular reactors have updated safety features compared to traditional units. These include either (a) passive safety that allows the plant to shut down and self-cool indefinitely with no operator action, additional water, or power supply[9], or (b) a fuel supply that cannot melt down[10], among other precautions. This means that the risk of meltdown or radiation leakage due to natural disaster or other unforeseen complication is effectively mitigated. EWEB supports the principle that SMR facilities should follow Nuclear Regulatory Commission (NRC) and other regulatory guidelines for safety.

[7] Life Cycle Assessment Harmonization | Energy Analysis | NREL
[8] Nuclear Implosions: The Rise and Fall of the Washington Public Power Supply System. By Daniel Pope. (Cambridge: Cambridge University Press, 2008. xx, 282 pp. $85.00, ISBN 978-0-521-40253-8.) | Journal of American History | Oxford Academic (oup.com)
[9] VOYGR SMR Plants | NuScale Power
[10] TRISO-X — TRISO Particle Fuel For Advanced Nuclear Reactors — X-energy

3) **Location:** Traditional nuclear plants are very large and must maintain a robust Emergency Planning Zone. New SMR designs are smaller facilities, and because they are deemed safe from meltdown, they are not required to have the same emergency perimeter. This means SMRs could potentially be located closer to major load centers, reducing the need for additional transmission infrastructure.

- **Flexibility:** SMR reactors are being developed with the understanding that renewable energy will play a large role in our future energy system. This means that their designs incorporate features that will allow them to quickly ramp energy production up and down to meet variations in system energy needs. However, SMRs have high capital costs and low variable costs, so the economics of operating below peak capacity for extended periods of time may be unfavorable.
- **Waste disposal:** Like traditional nuclear, SMRs will generate radioactive spent fuel. Because there is not currently a national repository for nuclear waste, it is kept in containment casks. These casks can be stored onsite or transported elsewhere. The total volume of spent fuel is small compared to the amount of energy generated. In the case of the Columbia Generating Station in Washington, a 1,100 aMW nuclear plant, the total spent fuel from the past 40 years occupies an area the size of several football fields[11]. It is anticipated that managing or recycling radioactive waste will evolve as SMRs become commissioned.

Columbia Generating Station Fuel Waste

What is the actual development and/or deployment of SMR?

SMR facilities are not yet operating in the U.S. or most other places in the world. This means that while many SMR designs are based on proven technology, there is still uncertainty around how much they will cost, and how prevalent the technology will become as a major energy source in the future. In the U.S., the Nuclear Regulatory Commission (NRC) provides substantial licensing and regulatory oversight for any nuclear generation. This oversight means that developing new nuclear technology takes years to decades and presents substantial obstacles for new options to become available. Currently, several companies in the U.S., including NuScale and XEnergy, have passed numerous NRC requirements and are expected to have operational plants within the next decade. In addition, the federal government acknowledges the cost concerns of SMR technology and is actively exploring ways to mitigate risk for future investment.

Can EWEB purchase nuclear power?

[11] Used Nuclear Fuel Storage (energy-northwest.com)

Oregon statute section 469.595 states that new nuclear facilities must be approved by popular vote and cannot be sited in Oregon until there is a national nuclear waste repository[12]. Since there is not currently a national repository, SMR facilities cannot yet be built in Oregon. Despite these siting restrictions, EWEB can purchase the output of nuclear power from facilities in other states. Currently, EWEB receives nuclear energy through our Bonneville Power Administration contract.

What's next?

The IRP identified resource needs over the coming years as existing contracts expire, and we recognize that the utility will likely need to explore new resource options over the coming decade. However, EWEB is not actively pursuing contracts with SMR or other new generating resources. We hope to use the IRP as a springboard to identify where further analysis and research is needed. We want to understand the ability of different resources to meet our needs, and to not preemptively exclude options we might want in the future.

Locally and regionally, in pursuing a deeply decarbonized electric sector, we are tackling something big that represents a unique and new challenge. EWEB wants to provide the best information we can and have an informed conversation about our community's diverse interests and the tradeoffs between different approaches to meeting our energy needs.

[12] https://www.oregonlegislature.gov/bills_laws/ors/ors469.html