2024 Alaska Electricity Trends Report

An Analysis of Electricity in Alaska, Data Years 2011-2021

Alaska Center for Energy and Power

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Notice

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Chapter 1.

Introduction

An Analysis of Electricity in Alaska, Data Years 2011-2021

Welcome

This interactive report summarizes electricity data gathered from federal, state, and utility sources and presented in the form of a web book. It provides an overview of electricity capacity, generation, consumption, and price trends from 2011 to 2021. A comprehensive report highlighting these trends has not been produced for the state of Alaska since 2013's *Alaska Energy Statistics Report*.

This web book is designed as 'best available' document for the 2011-2021 energy trends data and reports. This website will be updated when updates to the underlying 2011-2021 data or fixes become available. Future year trends reports will be tackled in a different context and reporting structure.

Please explore the data using the chapter navigation links in the left sidebar and the section navigation links in the right sidebar.

1.0.1. How to Cite

Alaska Center for Energy and Power. "2024 Alaska Energy Trends Report Web Book." Accessed `{ojs} currentDate`. https://acep-uaf.github.io/aetr-web-book-2024

```
//| echo: false

// set up today's date
date = new Date();
day = date.getDate();
month = date.toLocaleString('default', { month: 'long' });
year = date.getFullYear();
month_2digit = (date.getMonth() + 1).toString().padStart(2, "0");
day_2digit   = date.getDate().toString().padStart(2, "0");

currentDate = `${month} ${day}, ${year}`

// build a button
button = (blob, filename = 'test.bib', displayname) => {
  const button = DOM.download(
    blob,
    filename,
    `${displayname}`
  );
  return button;
}
```

```
// BibLaTeX content
biblatexContent =
`@online{aetr_web_book_2024,
    author = {{Alaska Center for Energy and Power}},
    title = {{2024 Alaska Electricity Trends Report}},
    year = 2024,
    url = {https://acep-uaf.github.io/aetr-web-book-2024/},
    urldate = {${year}-${month_2digit}-${day_2digit}}
}`

risContent =
`TY  - ELEC
AU  - Alaska Center for Energy and Power
TI  - 2024 Alaska Electricity Trends Report
PY  - 2024
DA  - {${year}-${month_2digit}-${day_2digit}}
UR  - https://acep-uaf.github.io/aetr-web-book-2024/
N1  - Accessed on ${currentDate}
ER  -`

// Create the blobs
biblatex_blob = new Blob([biblatexContent], { type: 'text/plain' });
ris_blob = new Blob([risContent], { type: 'text/plain' });

// Insert blobs into buttons
button(biblatex_blob, 'aetr_web_book_2024.bib', 'BibLaTeX');
button(ris_blob, 'aetr_web_book_2024.ris', 'RIS');
```

Executive Summary

The objective of this work is to provide regulators, legislators, and other energy stakeholders with a holistic look at recent trends in electrical generation. The first impetus for this report is a lack of combined reporting on electricity generation across the state that extends to federally and non-federally regulated electric utilities (most of Alaska's electric utilities do not meet the minimum threshold for federal reporting requirements). The second impetus for this report is to aid in decision-making processes surrounding Alaska's energy future.

With uncertainty in natural gas sources on the Railbelt, technological advancements in generation technology, and improvements in the affordability of technologies, understanding trends in the state's capacity, generation, consumption, and prices is vital to more informed decision-making.

In this report, we present data collected from federal, state, and local sources supplemented by correspondence with utilities. We show trends for capacity, generation, consumption, and prices. The capacity and generation trends include data from 2011 to 2021, and the consumption and prices trends are data limited to 2019. More information on sources and methods are provided in the subsequent sections throughout the report. This report uses data visualizations as the primary mode for presenting the trends. To accommodate this presentation style, we present trends as simplified regions of the state as opposed to the Alaska Energy Authority energy regions.

We emphasize that this report is designed to provide factual information to the best of our ability without providing recommendations or in-depth analysis. However, context is provided for more impactful trends.

Key Takeaways

1.0.1. Capacity

- Generation capacity on average increased across all of Alaska from 2011 to 2021.
- The state saw large increases in renewable energy capacity, storage, and on-demand peaking units.

1.0.2. Generation

- Net generation has remained relatively stable
- The Coastal region generated more power from wind and hydro, but less from oil in 2021 than in 2011.
- The Railbelt region generated more power from wind, hydro, coal, and solar, but less from oil and gas in 2021 than in 2011.
- The Rural Remote region generated more power from wind and solar, but less from oil and hydro in 2021 than in 2011.
- We have seen significant increases in the usage of utility-scale battery storage.

1.0.3. Consumption

- Electricity consumption overall has fallen for all customer classes, with residential customers seeing the most reductions.
- The number of customer accounts have continued to increase throughout the state.
- Per capita consumption for the residential sector is highest in the Coastal region and lowest in the Rural Remote region.

1.0.4. Prices

- Residential electricity rates increased on average across Alaska after adjusting for inflation, the PCE subsidy, and population weighting.
- The region that experienced the least residential rate increase was the Coastal region with a 6% increase.
- The region experiencing the highest residential rate increase was the Railbelt with a 26% increase.
- Commercial and Other customers in the Coastal and Rural Remote regions saw rate decreases where Commercial customers in the Railbelt region saw price increases of about 15%.
- PCE subsidies continue to dampen residential prices in the Coastal and Rural Remote regions.

Chapter 2.

Methods

Data Sources, Region Definitions, and Description of the PCE Program

2.1. Data Sources

The data in this report was collected from a variety of sources that are listed below. Most electric utilities throughout the state are not required to submit annual reports to the federal government due to their size and/or number of customers. Therefore, our data sources encompass federal, state, commercial, and local filings as well as direct communications with utilities and state program managers. Each section of the report pulls data from a variety of these sources. The data was downloaded directly from the original sources and concatenated to develop a dataset for this report. In some cases, a single observation is derived from multiple sources due to reporting limitations.

Below are relevant sources of data for the report.

2.1.1. Federal

- Energy Information Administration
  - EIA-860
  - EIA-861
  - EIA-923
- Federal Energy Regulatory Commission
  - Form 1

2.1.2. State

- Alaska Energy Authority
  - Power Cost Equalization Program Utility Monthly Reports
- Regulatory Authority of Alaska
  - Annual filings

2.1.3. Direct Communications

- Alaska Energy Authority
  - Hydro/Wind Program Managers
  - Village and Powerhouse Assessments
- Electric Utilities

2.1.4. Commercial Sources

- Intelligent Energy Systems

2.1.5. Compilation

Neil McMahon, first at AEA and then at DOWL, an Alaska engineering firm, did the preliminary compilation of data and developed the Excel workbooks that support this report. This step involved careful cross-referencing of assets between the various data sources and error checking by domain experts. At this point, aggregate calculations were created to match the tables found in previous *Alaska Energy Statistics Reports*. Data in this report were derived from those workbooks exported to CSV files; the original workbooks are available via a GitHub repo ak-energy-statistics-2011_2021.

2.2. Regional Summaries

For the purpose of energy planning, AEA has defined eleven energy regions for the State of Alaska. Previous versions of the *Alaska Electric Energy Statistics* reports presented data summarized by those regions. In order to provide visualizations that are easier to understand, we have condensed these eleven regions into three major energy regions: Coastal, Railbelt, and Rural Remote. **?@fig-regions-scheme** shows the diagrammatic relationship between these two classification systems and **?@fig-regions-map** displays this relationship cartographically.

We note that the Coastal and Rural Remote regions include mixtures of Power Cost Equalization (PCE) and non-PCE eligible communities. The Coastal region includes Copper River/Chugach and incorporates all communities served by Copper Valley Electric Association. PCE communities are largely dependent on diesel generation.

```
// build a library
stdlib = require("@observablehq/stdlib")
d3 = require("d3@7")

L = require('leaflet@1.9.4')
html`<link href='${resolve('leaflet@1.2.0/dist/leaflet.css')}' rel='stylesheet' />`

bootstrap=require("bootstrap")
css=html`<link rel="stylesheet" href="https://cdn.jsdelivr.net/npm/bootstrap@5.2.0/dist/css/bootst
```

```
aea_regions = FileAttachment("data/working/regions/aea_regions.geojson").json()
acep_regions = FileAttachment("data/working/regions/acep_regions.geojson").json()

coords_json = FileAttachment("data/working/regions/coordinates.geojson").json()

// coords_csv = FileAttachment("data/working/regions/coordinates_pce.csv").csv({typed: true})
```

```
aea_regions_input = L.geoJSON(aea_regions, {
                        style: function(feature) {
                            switch (feature.properties.NAME) {
                                case 'Aleutians': return {color: "#FF5733"};
                                case 'Bering Straits': return {color: "#FF1493"};
                                case 'Bristol Bay': return {color: "#20B2AA"};
                                case 'Copper River Chugach': return {color: "#7D3C98"};
```

```
                                case 'Kodiak': return {color: "#C70039"};
                                case 'Lower Yukon Kuskokwim': return {color: "#00B4D8"};
                                case 'North Slope': return {color: "#4682B4"};
                                case 'Northwest Arctic': return {color: "#6A5ACD"};
                                case 'Railbelt': return {color: "#228B22"};
                                case 'Southeast': return {color: "#FFC300"};
                                case 'Yukon-Koyukuk Upper Tanana': return {color: "#FF8C00"};
                            }
                          }
                      }).bindTooltip(function (layer) {
                        return layer.feature.properties.NAME;
                        },
                        {
                        sticky: true,
                        offset: [10, 0],
                        direction: "right",
                        opacity: 0.75
                      });


acep_regions_input = L.geoJSON(acep_regions, {
                        style: function(feature) {
                            switch (feature.properties.NAME) {
                                case 'Rural Remote': return {color: "#FF0000"};
                                case 'Coastal': return {color: "#0000FF"};
                                case 'Railbelt': return {color: "#228B22"};
                            }
                          }
                      }).bindTooltip(function (layer) {
                        return layer.feature.properties.NAME;
                        },
                        {
                        sticky: true,
                        offset: [10, 0],
                        direction: "right",
                        opacity: 0.75
                      });
```

```
// Code below builds community location points
points = L.geoJSON(coords_json, {
    pointToLayer: function (feature, latlng) {
        return L.circleMarker(latlng,
          {radius: 5,
          fillColor: "#808080",
          color: "#000",
          weight: 1,
          opacity: 1,
          fillOpacity: 0.8
     });
    }
}).bindTooltip(function (layer) {
                        return layer.feature.properties.name;
                        },
                        {
                        sticky: true,
                        offset: [10, 0],
```

```
                        direction: "right",
                        opacity: 0.75
                      });
```

```
//| label: fig-regions-map
//| fig-cap: "Cartographic Relationship between Energy Regions as defined by AEA and ACEP"

viewof region_input = Inputs.select(new Map([
                ["AEA Regions", aea_regions_input],
                ["ACEP Regions", acep_regions_input]]),
              {value: aea_regions_input, label: "Display below:"}
              );
```

```
// the order of the container calls is important, do first, don't mess with
map = {
    let container = DOM.element('div', { style: `width:${width}px;height:${width/1.2}px` });
    yield container;

    // create map object
    let map = L.map(container).setView([62.945279601222396, -155.5946697727831], 4);

    // add basemap
    var basemap = L.tileLayer('https://basemap.nationalmap.gov/arcgis/rest/services/USGSTopo/MapSe
      maxZoom: 20,
      attribution: 'Tiles courtesy of the <a href="https://usgs.gov/">U.S. Geological Survey</a>'
    });
    basemap.addTo(map);

    // // add dropdown input selection
    region_input.addTo(map);

    // add community points
    points.addTo(map);


}
```

2.3. Power Cost Equalization (PCE)

Alaska is famous for wide expanses of rugged terrain. Towns are often extremely distant from one another, or are separated by inaccessible mountains and glaciers. The utility landscape of Alaska resembles a sea of islands, very different from the interconnected grids of the contiguous United States.

In total, Alaska contains over 100 separate utilities, many of which serve a single, small community. Most rely on diesel generators connected to huge fuel tanks, which receive a barge shipment of fuel in the summer that must last through the winter. If the town runs out of fuel during winter months, additional fuel has to be flown in at extreme expense. Predictably, electricity in these remote towns is extremely expensive.

Some rural towns pay 3 to 5 times the rates of urban Alaska. Urban Alaska has greatly benefited from large state-subsidized energy projects, such as the Bradley Lake Hydroelectric Project, the Four Dam Pool Projects, and the Alaska Intertie. In an effort to confer similar benefits to rural Alaska, the state of Alaska developed the Power Cost Equalization Program (PCE).

The PCE program reimburses rural utilities for credits that have been provided to eligible customers. Eligibility is limited to residential customers and community facilities. The subsidy applies to the first 750 kWh per month of residential consumption. Community facilities are subsidized up to the first 70 kWh per month per resident. The program is administered by the Regulatory Commission of Alaska (RCA) and the Alaska Energy Authority (AEA).

Please visit the Alaska Energy Authority PCE webpage for more information about the Power Cost Equalization program.

2.4. Feedback Regarding Potential Errors

Since these data come from multiple sources, there is potential for errors in its compilation. An integral part of this effort is the creation of a high quality dataset that can constructively contribute to future work. Therefore, any discrepancies or noted errors should be reported using email or GitHub issues via the links in the right hand navigation menu of every page. Alternatively, direct contact information for members of the DCM team is listed in Section D.2.

Chapter 3.

Installed Capacity

Total Installed Capacity by Certified Utilities in Alaska, 2011-2021

3.1. General Overview

Generation capacity represents the maximum amount of electricity that can be generated at any given time dependent on certain conditions. The combination of generation sources is often referred to as the capacity mix. Changes in the capacity mix over time reflect decisions to build and retire generators. These decisions are a result of shifting costs, technological innovations, the normal aging of the generation fleet, and/or stakeholder policies. Due to data limitations, we show capacity levels for calendar years 2011-2013, 2018, and 2021. While we cannot observe year-to-year trends, there are enough years of data to visualize capacity trends from 2011 to 2021.

We begin this section by showcasing the increases in total capacity across the state. In 2011, it is estimated that the total statewide electricity generation capacity was 2,197 MW. We estimate that this has increased to approximately 3,163 MW in 2021 based on best available data. This represents an increase of 966 MW, or 44 percent increase since 2011. To illustrate this example, we show a stacked area chart in **?@fig-capacity-state** that showcases growth over time for various technologies.[1]

```
//| label: fig-capacity-state
//| fig-cap: "Capacity Changes, Statewide"

Plot.plot({
  // Configure the plot
  //title: "Capacity changes, Statewide",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year",
    //domain: [2011,2012,2013,2018,2021]
  },
  // Configure the y-axis
  y: {
    grid: true,
    label: "Capacity (MW)"
```

[1]The PCE data do show powerhouse consumption as a separate data item, which would allow for the computation of "net generation" in PCE communities. However, we have continued to report generation in PCE communities as the gross amount in order to be consistent with previous Alaska Energy Statistics Reports.

```
  },

  // Stacked area plot
  marks: [
    Plot.areaY(cap_data,
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "capacity",
          fill: "Prime Mover",
          order: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Utility Solar","Rooftop Sol
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],

  // Configure the color scheme
  color: {
        domain: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Utility Solar","Rooftop Sola
        range: ["#606571", "#9da7bf", "#00a1b7", "#F79646", "#fad900","#9BBB59","#71346a","#896D0
        legend: true
    }
})
```

3.2. Coastal

For the coastal region, we observe a 121.2 MW increase in generation capacity (an increase of approximately 22.8 percent) between 2011 and 2021. **?@fig-capacity-coastal** shows the change in total installed capacity for each prime mover in the coastal region. This region saw additions of 38.9 MW of fossil turbines, and 28.9 MW of reciprocating engines. The remaining increases were renewable and storage capacity which we look at in more depth in **?@fig-capacity-coastal-renewable**.

```
//| label: fig-capacity-coastal
//| fig-cap: "Coastal Region Capacity"

Plot.plot({
  // Configure the x-axis
  x: {
    tickFormat: "d",
    type: "band",
    label: "Year"
  },
  // Configure the y-axis
  y: {
    grid: true,
    label: "Capacity (MW)"
  },
  // Configure the plot
  //title: "Coastal region capacity",
```

```
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Stacked area plot
  marks: [
    Plot.barY(cap_data.filter((d) => d.acep_region === "Coastal" && d.capacity !== 0.0),
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "capacity",
          fill: "Prime Mover",
          order: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Storage"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],
  // Configure the color scheme
  color: {
        domain: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Storage"],
        range: ["#606571", "#9da7bf", "#00a1b7", "#F79646", "#71346a"],
        legend: true
    }
})
```

Across the 53.45 MW of added renewable and storage capacity , hydropower accounted for the bulk of the capacity additions with 41.95 MW. Storage capacity increased by 7 MW and wind generation capacity increased by 4.5 MW. Between 2013 and 2018, significant hydropower additions were made in the Southeast (19.4 MW), Kodiak (11.3 MW), and the Copper-River/Chugach (6.5 MW) AEA energy regions.

```
//| label: fig-capacity-coastal-renewable
//| fig-cap: "Coastal Region Renewable Capacity"

Plot.plot({
  // Configure the x-axis
  x: {
    tickFormat: "d",
    type: "band",
    label: "Year"
  },
  // Configure the y-axis
  y: {
    grid: true,
    label: "Capacity (MW)"
  },
  // Configure the plot
  //title: "Coastal region renewable capacity",
  insetLeft: 0,
  insetRight: 0,
  width: width,
```

```
  // Stacked area plot
  marks: [
    Plot.barY(cap_data.filter((d) => d.acep_region === "Coastal" && d.capacity !== 0.0 && d.prime_
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "capacity",
          fill: "Prime Mover",
          order: ["Hydro", "Wind","Storage"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],
  // Configure the color scheme
  color: {
        domain: ["Hydro", "Wind","Storage"],
        range: ["#00a1b7", "#F79646", "#71346a"],
        legend: true
    }
})
```

3.3. Railbelt

For the Railbelt region, capacity additions were dominated by more-efficient fossil fuel generating units and new battery storage. These additions are visualized in **?@fig-capacity-railbelt**. There were 761.9 MW of capacity additions between 2011 and 2021. The Railbelt region saw 207.3 MW of reciprocating engine additions and 390.2 MW of fossil fuel turbines. The remaining capacity additions were renewables and storage and are shown in **?@fig-capacity-railbelt-renewable**.

```
//| label: fig-capacity-railbelt
//| fig-cap: "Railbelt Region Capacity."

Plot.plot({
  // Configure the x-axis
  x: {
    tickFormat: "d",
    type: "band",
    label: "Year"
  },
  // Configure the y-axis
  y: {
    grid: true,
    label: "Capacity (MW)"
  },
  // Configure the plot
  //title: "Railbelt region capacity",
  caption: "Figure note: The category of Landfill Gas refers to the 11.5 MW power plant at the Anc
  insetLeft: 0,
  insetRight: 0,
  width: width,
```

```
  // Stacked area plot
  marks: [
    Plot.barY(cap_data.filter((d) => d.acep_region === "Railbelt" && d.capacity !== 0.0),
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "capacity",
          fill: "Prime Mover",
          order: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Utility Solar","Rooftop Sol
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],
  // Configure the color scheme
  color: {
        domain: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Utility Solar","Rooftop Sola
        range: ["#606571", "#9da7bf", "#00a1b7", "#F79646", "#fad900","#9BBB59","#71346a","#896D09
        legend: true
    }
})
```

Total renewable and storage capacity in the Railbelt region increased by 164.41 MW. Notable additions included the commercial commissioning of the 18 MW Fire Island Wind site in September 2012 and the 25 MW Eva Creek Wind site in October 2012. Significant investments in storage capacity have also been made. Since 2011, 89.5 MW of storage, 43.49 MW of wind, 7.09 MW of hydro, 1.9 MW of utility solar, 10.93 MW of rooftop – also known as "behind-the-meter" – solar, and 11.5 MW of landfill gas have been added.

```
//| label: fig-capacity-railbelt-renewable
//| fig-cap: "Railbelt Region Renewable Capacity"

Plot.plot({
  // Configure the x-axis
  x: {
    tickFormat: "d",
    type: "band",
    label: "Year"
  },
  // Configure the y-axis
  y: {
    grid: true,
    label: "Capacity (MW)"
  },
  // Configure the plot
  //title: "Railbelt region renewable capacity",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Stacked area plot
  marks: [
```

```
    Plot.barY(cap_data.filter((d) => d.acep_region === "Railbelt" && d.capacity !== 0.0 && d.prime
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "capacity",
          fill: "Prime Mover",
          order: ["Hydro", "Wind","Utility Solar","Rooftop Solar","Storage","Landfill Gas"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],
  // Configure the color scheme
  color: {
        domain: ["Hydro", "Wind","Utility Solar","Rooftop Solar","Storage","Landfill Gas"],
        range: ["#00a1b7", "#F79646", "#fad900","#9BBB59","#71346a","#896D09"],
        legend: true
    }
})
```

3.4. Rural Remote

The rural remote region saw an increase of 83.1 MW in capacity (a 32.63% increase) (**?@fig-capacity-rural**). Most of the increases in capacity were fossil fuel turbines (25.4 MW added on the North Slope) and reciprocating engines (45.65 MW). Renewable capacity is explored in further detail in the **?@fig-capacity-rural-renewable**.

```
//| label: fig-capacity-rural
//| fig-cap: "Rural Remote Region Capacity"

Plot.plot({
  // Configure the x-axis
  x: {
    tickFormat: "d",
    type: "band",
    label: "Year"
  },
  // Configure the y-axis
  y: {
    grid: true,
    label: "Capacity (MW)"
  },
  // Configure the plot
  //title: "Rural Remote region capacity",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Stacked area plot
  marks: [
    Plot.barY(cap_data.filter((d) => d.acep_region === "Rural Remote" && d.capacity !== 0.0),
```

```
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "capacity",
          fill: "Prime Mover",
          order: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Utility Solar","Storage"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],
  // Configure the color scheme
  color: {
        domain: ["Fossil Turbines", "Recip Engines", "Hydro", "Wind","Utility Solar","Storage"],
        range: ["#606571", "#9da7bf", "#00a1b7", "#F79646", "#fad900","#71346a"],
        legend: true
    }
})
```

This region saw an absolute increase of 12.05 MW of renewable capacity between 2011 to 2021. Over this time period, hydropower generation resources increased by 0.99 MW, wind increased by 6.51 MW, utility-scale solar increased by 1.31 MW and storage increased by 3.25 MW. Between 2018 and 2021, 2 MW of wind was retired in the Bering Straits energy region, 1.2 MW in Kotzebue, and 0.2 MW in the Aleutians, explaining the reduction in wind capacity between the calendar years.

```
//| label: fig-capacity-rural-renewable
//| fig-cap: "Rural Remote Region Renewable Capacity"
//|
Plot.plot({
  // Configure the x-axis
  x: {
    tickFormat: "d",
    type: "band",
    label: "Year"
  },
  // Configure the y-axis
  y: {
    grid: true,
    label: "Capacity (MW)"
  },
  // Configure the plot
  //title: "Rural Remote region renewable capacity",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Stacked area plot
  marks: [
    Plot.barY(cap_data.filter((d) => d.acep_region === "Rural Remote" && d.capacity !== 0.0 && d.p
      Plot.groupX(
        {
          y: "sum"
```

```
        },
        {
          x: "year",
          y: "capacity",
          fill: "Prime Mover",
          order: ["Hydro", "Wind","Utility Solar","Storage"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],
  // Configure the color scheme
  color: {
        domain: ["Hydro", "Wind","Utility Solar","Storage"],
        range: ["#00a1b7", "#F79646", "#fad900","#71346a"],
        legend: true
    }
})
```

```
original_cap_data = FileAttachment("data/working/capacity/capacity_long.csv").csv({ typed: true })
cap_data = original_cap_data.map((d) => ({...d, "Prime Mover": d.prime_mover}))
```

Chapter 4.

Net/Gross Generation

Generation by Fuel Type in Alaska, 2011-2021

4.1. General Overview

This section outlines the trends in generation by fuel type for each region. Generation in our context has two separate definitions. Data collected through the Energy Information Administration (EIA) records "net" generation, which excludes electricity use for power plant operations. However, data collected from the Alaska Energy Authority's (AEA) Power Cost Equalization (PCE) program is presented as "gross" generation, which does not make this exclusion.[1]

?@fig-generation-by-region provides a visual representation of yearly electricity generation for the Coastal, Railbelt, and Rural Remote regions. All regions produced a relatively consistent amount of electricity between 2011 and 2021. Across this time period, the Railbelt generated an average of 4,772 GWh, the Coastal region generated an average of 1,131 GWh, and the Rural Remote region generated an average of 509 GWh. Between 2011 and 2021, the average yearly growth rate for generation was 1.62% in the Coastal region, -0.31% in the Railbelt region, and 2.43% in Rural Remote communities.[2] The Coastal and Rural Remote trends are in line with improvements in rural electrification, as well as modest population growth. Of the regions, the Railbelt is the only one that consistently saw decreases in generation across the years. Total statewide generation increased at an average annual growth rate of 0.22%.

```
//| echo: false
import {tidy, groupBy, rename, summarize, sum, mutate, select, n, nDistinct, mean, filter, pivotWi

// Import the long-form generation data
gen_data = FileAttachment("data/working/generation/net_generation_long.csv").csv({ typed: true })

// Convert MWh to GWh
gen_data_gwh = tidy(gen_data, mutate({
  generation: (d) => d.generation / 1000
})).map((d) => ({...d, "Fuel Type": d.fuel_type})).map((d) => ({...d, "ACEP Region": d.acep_regior

//gen_data_gwh = gen_data_gwh_.map((d) => ({...d, "ACEP Region": d.acep_region},{...d, "Fuel Type'
```

[1] The PCE data do show powerhouse consumption as a separate data item, which would allow for the computation of "net generation" in PCE communities. However, we have continued to report generation in PCE communities as the gross amount in order to be consistent with previous Alaska Energy Statistics Reports.

[2] Calculated with the compound average growth rate: $CAGR = \left(\left(\frac{gen_{2021}}{gen_{2011}} \right)^{\frac{1}{2021-2011}} - 1 \right)$

```
//| label: fig-generation-by-region
//| fig-cap: "Electricity Generation by Region"

// Plotting total generation by region and year//|
Plot.plot({

  // Configure the plot
  //title: " Electricity generation by region",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year"
  },

  // Configure the y-axis
  y: {
    grid: true,
    label: "Generation (GWh)"
  },

  // Plotting the series
  marks: [
    Plot.barY(
      gen_data_gwh,
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "generation",
          fill: "ACEP Region",
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],

  // Legend
  color: {
    domain: ["Coastal","Railbelt","Rural Remote"],
    range: ["#8cbbda","#97cd93","#f28d8c"],
    legend: true
  }
})
```

While generation did not change significantly during the observed time period, the resources from which generation occurred, did. **?@fig-generation-changes-by-region** shows how the mix of generation fuels changed between 2011 and 2021.[3]

[3] Oil consists of generators whose primary fuel source is diesel/distillate, naphtha, or jet fuel. Gas consists of natural or landfill gas. Hydro refers to conventional hydroelectric turbines. Wind and solar are both

```
//| echo: false

// Establish the figure caption for generation mix charts
caption_gen_mix = "Note: Storage is not included here due since net generation is negative."

// Creating a modified version of the data
share_data = tidy(
  gen_data,
  groupBy(
    ['year','acep_region','fuel_type'],
    [
      summarize({
        generation: sum('generation')
      })
    ]
  )
)

// Creating total generation data from each region and year
total_gen = tidy(share_data, groupBy(['year','acep_region'], summarize({total_generation: sum('gen


// Creating a joined table from the above two
join = tidy(share_data, fullJoin(total_gen, {by: ['year','acep_region']}))

// Creating a column with shares
join_shares = tidy(join.filter((d) => d.fuel_type !== "Storage"),
  mutate({generation_share: (d) => (d.generation / d.total_generation)*100})
).map((d) => ({...d, "Fuel Type": d.fuel_type})).map((d) => ({...d, "ACEP Region": d.acep_region})

// Table for just the 2011 and 2021 generation mix comparison
gen_mix_diff = tidy(
  join_shares.filter((d) => d.year === 2011 || d.year === 2021),
  groupBy(
    ['ACEP Region','Fuel Type'],
    mutateWithSummary({
        generation_share_2011: lag('generation_share', {default: 0})
    })
  ),
  mutate({
    delta: (d) => d.generation_share - d.generation_share_2011
  }),
  filter(
    (d)  => d.year === 2021
  )
)
```

```
//| label: fig-generation-changes-by-region
//| fig-cap: "Regional Changes in Net Generation"

// Plotting the deltas
Plot.plot({
  //title: "Regional changes in net generation",
  caption: "Percentage point differences in generation mix between 2021 and 2011",
  insetLeft: 15,
```

utility-scale (excluding behind-the-meter solar). Storage is not included in these calculations.

```
  insetRight: 15,
  marginRight: 70,
  height: 600,
  width: width,

  x: {
    label: "Percentage Point Change",
    labelAnchor: "center"
  },

  y: {
    grid: true,
    domain: ["Coal","Oil","Gas","Hydro","Wind","Solar"],
    label: ""
  },

  facet: {
    data: gen_mix_diff,
    y: (d) => d.acep_region
  },

  marks: [
    Plot.frame(),
    Plot.barX(gen_mix_diff, {
        x: "delta",
        y: "Fuel Type",
        fill: "Fuel Type",
        order: ["Coal","Oil","Gas","Hydro","Wind","Solar"],
        tip: {
          format: {
            x: (d) => `${(d).toLocaleString(undefined, {maximumFractionDigits: 2})}%`,
            y: false,
            fy: false
          }
        }
      }
    ),
    Plot.ruleX([0])
  ],

  color: {
    domain: ["Coal","Oil","Gas","Hydro","Wind","Solar"],
    range: ["#7f7f7f","#BFBFBF","#DCD9C5","#96B3DF","#F79646","#F5C243"],
    legend: true
  }
})
```

We show that for these resources, the Coastal region displaced oil generation with hydro and wind generation. The Railbelt displaced gas and oil generation with coal, hydro, and solar generation. Finally, the Rural Remote region of the state displaced coal and a small amount of hydro with gas, solar, and wind generation.

This figure does not include trends in storage or the other category. Storage net generation is always negative due to the efficiency of current battery systems where more energy is sent to storage than can be recovered. The "other" category was not included in this figure as net generation was zero in 2011 and 2021 (but not throughout the series, which we show in the subsequent sections).

4.2. Coastal

In 2011, the Coastal region generated 89% of its electricity from hydro, 10% from oil, and the remainder from wind.[4] In 2021, the region generated 92% of electricity from hydro, 6% from oil, and 2% from wind. In addition, storage played a role in generation, albeit the net result is negative due to efficiencies. **?@fig-generation-fuel-coastal** shows how this generation mix has changed over the years.

```
//| label: fig-generation-fuel-coastal
//| fig-cap: "Share of Net Generation by Fuel Type, Coastal Region"

// Plotting the shares for the coastal region
Plot.plot({

  // Configure the plot
  //title: "Share of net generation by fuel type, Coastal region",
  caption: caption_gen_mix,
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year"
  },

  // Configure the y-axis
  y: {
    grid: true,
    label: "Share of electricity generation"
  },

  marks: [
    Plot.areaY(
      join_shares.filter((d) => d.acep_region === "Coastal"),
      {
        x:"year",
        y:"generation_share",
        fill: "Fuel Type",
        order: ["Oil","Hydro","Wind"],
        tip: {format: {x: "d", y: (d) => `${(d).toLocaleString(undefined, {maximumFractionDigits:
      }
    ),
    Plot.ruleY([0])
  ],

  // Legend
  color: {
    domain: ["Oil","Hydro","Wind"],
    range: ["#BFBFBF","#96B3DF","#F79646"],
    legend: true
}
})
```

[4]Net generation from storage facilities are not included in these calculations.

Generation grew at an average annual growth rate of 1.62% from 2011 to 2021. **?@fig-generation-coastal** highlights the yearly trends in generation by fuel source.

```
//| label: fig-generation-coastal
//| fig-cap: "Electricity Generation, Coastal Region"

// Plotting total generation by region and year
Plot.plot({

  // Configure the plot
  //title: "Coastal region electricity generation",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year"
  },

  // Configure the y-axis
  y: {
    grid: true,
    label: "Generation (GWh)"
  },

  // Plotting the series
  marks: [
    Plot.barY(
      gen_data_gwh.filter(d => d.acep_region === "Coastal" && d.generation !== null),
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "generation",
          fill: "Fuel Type",
          order: ["Oil","Hydro","Wind"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],

  // Legend
  color: {
    domain: ["Oil","Hydro","Wind"],
    range: ["#BFBFBF","#96B3DF","#F79646"],
    legend: true
  }
})
```

4.3. Railbelt

Railbelt generation has seen notable changes in how it generates electricity between 2011 and 2021. In 2011, the Railbelt region generated 73% of electricity from gas, 8% from coal, 8% from hydro, and 11% from oil. Additionally, a small amount of wind generation was present. In 2021, the region generated 61% of electricity from gas, 15% from coal, 12% from hydro, 10% from oil, and 2% from wind. Additionally, a small amount of solar generation was present. In addition, storage played a role in generation, albeit the net result is negative due to non-perfect efficiencies. **?@fig-generation-fuel-railbelt** shows how this generation mix has changed over the years.

```
//| label: fig-generation-fuel-railbelt
//| fig-cap: "Share of Net Generation by Fuel Type, Railbelt Region"

Plot.plot({//|

  // Configure the plot
  //title: "Share of net generation by fuel type, Railbelt region",
  caption: caption_gen_mix,
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year"
  },

  // Configure the y-axis
  y: {
    grid: true,
    label: "Share of electricity generation"
  },

  marks: [
    Plot.areaY(
      join_shares.filter((d) => d.acep_region === "Railbelt"),
      {
        x:"year",
        y:"generation_share",
        fill: "Fuel Type",
        order: ["Coal","Oil","Gas","Hydro","Wind","Solar"],
        tip: {format: {x: "d", y: (d) => `${(d).toLocaleString(undefined, {maximumFractionDigits:
      }
    ),
    Plot.ruleY([0])
  ],

  // Legend
  color: {
    domain: ["Coal","Oil","Gas","Hydro","Wind","Solar"],
    range: ["#7f7f7f","#BFBFBF","#DCD9C5","#96B3DF","#F79646","#F5C243"],
    legend: true
  },
})
```

Generation from 2011 to 2021 saw an average annual growth rate of -0.31%. **?@fig-generation-**

railbelt highlights the yearly trends in generation by fuel source.

```
//| label: fig-generation-railbelt
//| fig-cap: "Electricity Generation, Railbelt Region"

// Plotting total generation by region and year
Plot.plot({

  // Configure the plot
  //title: "Railbelt region electricity generation",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year"
  },

  // Configure the y-axis
  y: {
    grid: true,
    label: "Generation (GWh)"
  },

  // Plotting the series
  marks: [
    Plot.barY(
      gen_data_gwh.filter(d => d.acep_region === "Railbelt"),
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "generation",
          fill: "Fuel Type",
          order: ["Coal","Oil","Gas","Hydro","Wind","Solar"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],

  // Legend
  color: {
    domain: ["Coal","Oil","Gas","Hydro","Wind","Solar"],
    range: ["#7f7f7f","#BFBFBF","#DCD9C5","#96B3DF","#F79646","#F5C243"],
    legend: true
  }
})
```

4.4. Rural Remote

The Rural Remote region has seen notable changes between 2011 and 2021 in how it generates electricity. In 2011, the region generated 84% of electricity from oil, 12% from gas, 2% from hydro, and 2% from wind. In 2021, the region generated 77% of electricity from oil (mostly diesel), 19% from gas, 1% from hydro, and 3% from wind. Additionally, a small amount of solar generation was present. **?@fig-generation-fuel-rural** shows how this generation mix has changed over the years.

```
//| label: fig-generation-fuel-rural
//| fig-cap: "Share of Net Generation by Fuel Type, Rural Remote Region"

// Plotting the shares for the coastal region
Plot.plot({

  // Configure the plot
  //title: "Share of net generation by fuel type, Rural Remote region",
  caption: caption_gen_mix,
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year"
  },

  // Configure the y-axis
  y: {
    grid: true,
    label: "Share of electricity generation"
  },

  marks: [
    Plot.areaY(
      join_shares.filter((d) => d.acep_region === "Rural Remote"),
      {
        x:"year",
        y:"generation_share",
        fill: "Fuel Type",
        order: ["Oil","Gas","Hydro","Wind","Solar","Other"],
        tip: {format: {x: "d", y: (d) => `${(d).toLocaleString(undefined, {maximumFractionDigits:
      }
    ),
    Plot.ruleY([0])
  ],

  // Legend
  color: {
    domain: ["Oil","Gas","Hydro","Wind","Solar","Other"],
    range: ["#BFBFBF","#DCD9C5","#96B3DF","#F79646","#F5C243","#C0504D"],
    legend: true
}
})
```

Generation from 2011 to 2021 saw an average annual growth rate of 2.43%. **?@fig-generation-**

rural highlights the yearly trends in generation by fuel source. From 2013 to 2014, a large increase in gas generation is observed due to operations on the North Slope - specifically in the Barrow Utilities & Electric Cooperative, Inc. (BUECI), Deadhorse, and Nuiqsut service regions.

```
//| label: fig-generation-rural
//| fig-cap: "Electricity Generation, Rural Remote Region"

// Plotting total generation by region and year
Plot.plot({

  // Configure the plot
  //title: "Rural remote region electricity generation",
  insetLeft: 0,
  insetRight: 0,
  width: width,

  // Configure the x-axis
  x: {
    tickFormat: "d",
    label: "Year"
  },

  // Configure the y-axis
  y: {
    grid: true,
    label: "Generation (GWh)"
  },

  // Plotting the series
  marks: [
    Plot.barY(
      gen_data_gwh.filter(d => d.acep_region === "Rural Remote"),
      Plot.groupX(
        {
          y: "sum"
        },
        {
          x: "year",
          y: "generation",
          fill: "Fuel Type",
          order: ["Oil","Gas","Hydro","Wind","Solar","Other"],
          tip: {format: {x: "d"}}
        }
      )
    ),
    Plot.ruleY([0])
  ],

  // Legend
  color: {
    domain: ["Oil","Gas","Hydro","Wind","Solar","Other"],
    range: ["#BFBFBF","#DCD9C5","#96B3DF","#F79646","#F5C243","#C0504D"],
    legend: true
  }
})
```

Chapter 5.

Consumption and Sales

Electricity Sales in Alaska, 2011-2019

5.1. General Overview

The data presented in this section is from calendar years 2011 to 2019. More recent data has been omitted due to issues with data completeness and validity.

Across the state, electricity sales (herein referred to as consumption), has fallen when comparing the 2011 and 2019 calendar years. To visualize this trend, we look at the percentage changes from 2011 to 2019 in electricity consumption by customer class (**?@fig-change-customer-sales**). We highlight the following customer class definitions:

- **Residential**: Residential electric customers
- **Commercial**: Commercial electric customers
- **Other**: For EIA reported data, the Other group includes industrial and transportation customers. For PCE reported data, it includes community and government accounts. No industrial accounts were reported in the PCE data.

Statewide electricity consumption growth for the residential sector was -10.86% from 2,141 GWh in 2011 to 1,909 GWh in 2019. The commercial sector growth was -6.34% from 2,758 GWh in 2011 to 2,583 GWh in 2019. Finally, Statewide electricity consumption growth for the 'Other' customer class was -7.46% from 1,378 GWh in 2011 to 1,275 GWh in 2019.

```
// Import required libraries (condense later)
import {tidy, groupBy, rename, summarize, sum, mutate, select, n, nDistinct, mean, filter, pivotWi

// Import the consumption data
consumption_data = FileAttachment("data/working/consumption/consumption_long.csv").csv({ typed: tr

// Condense the data for regional plotting
regional_consumption_data = tidy(
  consumption_data,
  groupBy([
    "acep_region", "year", "class"
  ],
  [
    summarize({
      revenue: sum('revenue'),
      sales: sum('sales'),
      customers: sum('customers')
    })
  ])
).map((d) => ({...d, "Customer Class": d.class})).map((d) => ({...d, "ACEP Region": d.acep_region]
```

```
// Change in statewide totals
statewide_delta = tidy(
  consumption_data,
  groupBy(
    ["year","class"],
    summarize({
      revenue: sum("revenue"),
      sales: sum("sales"),
      customers: sum("customers")
    })
  ),
  filter((d) => (d.year === 2011 || d.year === 2019) && d.class !== "Total"),
  arrange(["year", asc("year")]),
  groupBy(
    ["class"],
    mutateWithSummary({
      sales_2011: lag("sales", {default: 0}),
      customers_2011: lag("customers", {default: 0}),
    })
  ),
  mutate({
    sales_delta: (d) => (d.sales - d.sales_2011)  / d.sales_2011,
    customers_delta: (d) => (d.customers - d.customers_2011) / d.customers_2011,
  }),
  filter((d) => d.year === 2019)
).map((d) => ({...d, "Customer Class": d.class}))
```

```
//| label: fig-change-customer-sales
//| fig-cap: "Change in Sales by Customer Class, Statewide, from 2011 to 2019"

Plot.plot({

  //title: "Change in sales by customer class, statewide, from 2011 to 2019",
  height: 500,
  marginLeft: 70,
  width: width,

  y: {
    label:"",
    grid: true,
    domain: ["Residential","Commercial","Other"]
  },

  x: {
    transform: (d) => d * 100,
    domain: [-12,0],
    label:"Percent Change"
  },

  marks: [
    Plot.frame(),
    Plot.ruleX([0]),
    Plot.barX(statewide_delta,
      {
        x: "sales_delta",
        y: "Customer Class",
```

```
        fill: "Customer Class",
        tip: {
          format: {
            x: (d) => `${(d).toLocaleString(undefined, {maximumFractionDigits: 2})}%`,
            y: false
          }
        }
      }
    )
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
        legend: true
    }
})
```

We also examine the change in the number of customer accounts across the state. The total number of customer accounts in the state increased 6.15% from approximately 326,402 to 346,476. We plot the percentage increases in customer accounts by category in **?@fig-change-customer-accounts**. Residential accounts across the state increased 5.22% from approximately 275,473 to 289,843. The number of commercial accounts across the state increased 11.77% from 46,411 to 51,875. Finally, the number of other accounts across the state has increased 14.87% from approximately 4,518 to 5,190.

```
//| label: fig-change-customer-accounts
//| fig-cap: "Change in Customer Accounts by Class, Statewide, from 2011 to 2019"
Plot.plot({

  //title: "Change in customer accounts by class, statewide, 2011 to 2019",
  height: 500,
  marginLeft: 70,
  width: width,

  y: {
    label:"",
    grid: true,
    domain: ["Residential","Commercial","Other"]
  },

  x: {
    transform: (d) => d * 100,
    domain: [0, 16],
    label:"Percent Change"
  },

  marks: [
    Plot.frame(),
    Plot.ruleX([0]),
    Plot.barX(statewide_delta,
      {
        x: "customers_delta",
        y: "Customer Class",
        fill: "Customer Class",
        tip: {
```

```
          format: {
            x: (d) => `${(d).toLocaleString(undefined, {maximumFractionDigits: 2})}%`,
            y: false
          }
        }
      }
    )
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
        legend: true
    }
})
```

?@fig-sales__per__capita shows the average annual electricity consumption for each of the regions. The Coastal region led the state in consumption per capita, with an average of 8,980 kWh per customer per year. This was followed by the Railbelt region with 7,118 kWh per capita and the Rural Remote region with 4,868 kWh per capita. Overall, each region has seen reductions in consumption per capita, which may reflect improvements in energy efficient technologies and energy efficiency/conservation behaviors.

```
sales_per_capita_data = tidy(regional_consumption_data.filter((d) => d.class === "Residential"),
  groupBy(
    ['ACEP Region','year'],
    [
      mutate({
        sales_per_capita: (d) => (d.sales / d.customers) * 1000
      })
    ]
  )
)
```

```
//| label: fig-sales_per_capita
//| fig-cap: "Average Residential Sales per Customer"
//caption_include = "Note: For EIA reported data, the Other customer class includes industrial and

Plot.plot({

  // Plot setup
  //title: "Average Residential Sales per Customer",

  // Configure the x-axis
    x: {
      domain: [2011, 2019],
      tickFormat: "d",
      label: "Year",
      grid: true
    },

    // Configure the y-axis
    y: {
      domain: [3000, 10000],
      ticks: 6,
      label: "kWh",
```

```
      grid: true
    },

  width: width,

  marks: [
    Plot.line(sales_per_capita_data, {
        x: "year",
        y: "sales_per_capita",
        stroke: "ACEP Region",
        strokeWidth: 5,
        tip: {format: {x: "d"}}
      }
    ),
    Plot.ruleY([3000])
  ],

  color: {
        domain: ["Coastal", "Railbelt", "Rural Remote"],
        range: ["#8CBBDA", "#97CD93", "#F28D8C"],
        legend: true
    }
})
```

5.2. Coastal

To estimate the average yearly growth rate in each customer class, we calculate the cumulative compound average growth rate (CAGR). From 2011 to 2019, the coastal region saw an average yearly growth rate of -0.56% for residential sales, -0.63% for commercial sales, and -0.76% for all other sales. **?@fig-delivered-by-class-coastal** shows these sales in GWh for each year.

```
//| label: fig-delivered-by-class-coastal
//| fig-cap: "Delivered Electricity by Customer Class, Coastal region"
Plot.plot({//|

  // Plot setup
  //title: "Delivered electricity by customer class, Coastal Region",
  //caption: caption_include,

  // Configure the x-axis
    x: {
      tickFormat: "d",
      label: "Year"
    },

    // Configure the y-axis
    y: {
      transform: (y) => y / 1000,
      domain: [0, 1200],
      label: "GWh",
      grid: true
    },

  width: width,
```

```
  marks: [
    Plot.barY(regional_consumption_data.filter((d) => d.class !== "Total" && d.acep_region == "Coa
      {
        x: "year",
        y: "sales",
        fill: "Customer Class",
        tip: {format: {x: "d"}}
      }
    ),
    Plot.ruleY([0])
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
        legend: true
    }
})
```

While customer sales fell overall, customer accounts in the Coastal region increased for all customer classes. **?@fig-accounts-coastal** shows the trend in customer accounts by class for the Coastal region. The average yearly growth rate in customer accounts was 0.55% for the residential class, 1.43% for the commercial class, and 0.73% for the other class.

```
//| label: fig-accounts-coastal
//| fig-cap: "Number of Customer Accounts, Coastal region"
Plot.plot({

  // Plot setup
  //title: "Number of customer accounts, Coastal region",
  //caption: caption_include,

  // Configure the x-axis
    x: {
      tickFormat: "d",
      label: "Year"
    },

    // Configure the y-axis
    y: {
      label: "Accounts",
      domain: [0, 60000],
      grid: true
    },

  width: width,

  marks: [
    Plot.barY(regional_consumption_data.filter((d) => d.class !== "Total" && d.acep_region == "Coa
      {
        x: "year",
        y: "customers",
        fill: "Customer Class",
        tip: {format: {x: "d"}}
      }
    ),
```

```
    Plot.ruleY([0])
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
        legend: true
    }
})
```

5.3. Railbelt

From 2011 to 2019, the Railbelt region saw an average yearly growth rate of -1.71% for residential sales, -1.27% for commercial sales, and -1.31% for all other sales. **?@fig-delivered-by-class-railbelt** shows these sales in GWh for each year.

```
//| label: fig-delivered-by-class-railbelt
//| fig-cap: "Delivered Electricity by Customer Class, Railbelt Region"
Plot.plot({//|

  // Plot setup
  //title: "Delivered electricity by customer class, Railbelt region",
  //caption: caption_include,

  // Configure the x-axis
    x: {
      tickFormat: "d",
      label: "Year"
    },

    // Configure the y-axis
    y: {
      transform: (y) => y / 1000,
      domain: [0, 5000],
      label: "GWh",
      grid: true
    },

  width: width,

  marks: [
    Plot.barY(regional_consumption_data.filter((d) => d.class !== "Total" && d.acep_region == "Rai
      {
        x: "year",
        y: "sales",
        fill: "Customer Class",
        tip: {format: {x: "d"}}
      }
    ),
    Plot.ruleY([0])
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
```

```
        legend: true
    }
})
```

The trends in the number of customer accounts by class are visualized in **?@fig-accounts-railbelt**. The average yearly growth rate in customer accounts on the Railbelt was 0.6% for the residential class, 1.37% for the commercial class, and -1.64% for the other class.

```
//| label: fig-accounts-railbelt
//| fig-cap: "Number of Customer Accounts, Railbelt Region"
Plot.plot({

  // Plot setup
  //title: "Number of customer accounts, Railbelt region",
  //caption: caption_include,

  // Configure the x-axis
    x: {
      tickFormat: "d",
      label: "Year"
    },

    // Configure the y-axis
    y: {
      transform: (y) => y / 1000,
      label: "Accounts (000s)",
      domain: [0, 260],
      grid: true
    },

  width: width,

  marks: [
    Plot.barY(regional_consumption_data.filter((d) => d.class !== "Total" && d.acep_region == "Rai
      {
        x: "year",
        y: "customers",
        fill: "Customer Class",
        tip: {format: {
            x: "d",
            y: (y) => `${(y).toLocaleString(undefined, {maximumFractionDigits: 2})}`
          }}
      }
    ),
    Plot.ruleY([0])
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
        legend: true
    }
})
```

5.4. Rural Remote

From 2011 to 2019, the Rural Remote region saw an average yearly growth rate of -0.43% for residential sales, 2.88% for commercial sales, and 2.7% for all other sales. Positive growth rates for the commercial and other customer classes are unique to the rural remote energy region as all other regions saw average yearly declines in sales. **?@fig-delivered-by-class-rural** shows these sales in GWh for each year.

```
//| label: fig-delivered-by-class-rural
//| fig-cap: "Delivered Electricity by Customer Class, Rural Remote Region"
//| fig-cap-location: top
Plot.plot({

  // Plot setup
  //title: "Delivered electricity by customer class, Rural Remote region",
  //caption: caption_include,

  // Configure the x-axis
    x: {
      tickFormat: "d",
      label: "Year"
    },

    // Configure the y-axis
    y: {
      transform: (y) => y / 1000,
      domain: [0, 500],
      label: "GWh",
      grid: true
    },

  width: width,

  marks: [
    Plot.barY(regional_consumption_data.filter((d) => d.class !== "Total" && d.acep_region == "Rur
      {
        x: "year",
        y: "sales",
        fill: "Customer Class",
        tip: {format: {x: "d"}}
      }
    ),
    Plot.ruleY([0])
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
        legend: true
    }
})
```

The trends in the number of customer accounts by class are visualized in **?@fig-accounts-rural**. The average yearly growth rate in customer accounts in the Rural Remote region was 1.14% for the residential class, 1.52% for the commercial class, and 2.79% for the other class.

```
//| label: fig-accounts-rural
//| fig-cap: "Number of Customer Accounts, Rural Remote Region"
Plot.plot({

  // Plot setup
  //title: "Number of customer accounts, Rural Remote region",
  //caption: caption_include,

  // Configure the x-axis
    x: {
      tickFormat: "d",
      label: "Year"
    },

    // Configure the y-axis
    y: {
      //transform: (y) => y / 1000,
      label: "Accounts",
      domain: [0, 37500],
      grid: true
    },

  width: width,

  marks: [
    Plot.barY(regional_consumption_data.filter((d) => d.class !== "Total" && d.acep_region == "Rur
      {
        x: "year",
        y: "customers",
        fill: "Customer Class",
        tip: {format: {
            x: "d",
            y: (y) => `${(y).toLocaleString(undefined, {maximumFractionDigits: 2})}`
          }}
      }
    ),
    Plot.ruleY([0])
  ],

  color: {
        domain: ["Residential","Commercial","Other"],
        range: ["#0084c1","#e29617","#fad900"],
        legend: true
    }
})
```

Chapter 6.

Price of Electricity

Electricity Prices for the Residential, Commercial, and Industrial Customer Classes, 2011-2019

6.1. General Overview

Utilities in Alaska serve multiple customers, namely residential, commercial, industrial, government/municipal, and community customer classes. Each customer class experiences a different set of costs such as per kWh charge as well as monthly customer charges. In this section, we aim to highlight trends in electricity prices for the residential, commercial, and other customer classes across the Coastal, Railbelt, and Rural Remote regions. We again restrict the data years in this section to 2011 to 2019 due to concerns with data validity for 2020-21.

In rural areas, many communities are eligible to participate in the PCE program (described in Section 2.3). It is important to note that the prices presented here reflect the post-PCE adjustment and are annualized averages based on the calendar year. Yearly average effective rates listed here reflect the calendar year and not the fiscal year, which will make them different from those reported in the AEA's annual reports. We also note that for PCE communities, the rates are reported in the original data. For data sourced from the EIA, rates were calculated by dividing total revenue by total kWh sold in each customer class - this may overestimate the rate as this would include revenue from customer charges.

Note that all prices in this section have been adjusted for inflation over time to 2021 dollars using the Bureau of Labor Statistics (BLS) Consumer Price Index (CPI) for all items in urban Alaska (BLS CUUSA427SA0). To our knowledge, there is no CPI that properly accounts for price changes over time in rural Alaska. However, the general trend shows that customer account-weighted prices have been relatively stagnant across all regions of the state.

6.1.1. Regional Overview

?@fig-price-regions-classes shows the distribution of prices across a selected customer class. The three classes used in this analysis can be selected from the dropdown menu. Hover your pointer over the dot to display utility information.

Most notably, the dramatic effects of the PCE subsidy can be seen by comparing the price distribution of the residential customer class against the price distribution of the commercial/other customer classes in the Rural Remote and Coastal regions.

```
// active inputs

viewof dimension = Inputs.select(new Map([
                ["Residential", 'residential_price'],
                ["Commercial", 'commercial_price'],
                ["Other", 'other_price']]),
              {value: "Residential", label: "Customer Class:"}
              );
```

```
// viewof flipCoords = Inputs.toggle({ label: 'Flip', value: false })

// Inputs.table(customers_pivot)
```

```
// hardcoded inputs here

// viewof thresholds = Inputs.select([10, 20, 60], { label: 'Bins', value: 60 })
thresholds = 40

// viewof seed = Inputs.range([1, 100], { step: 1, label: 'Raw Data Seed', value: 1 })
seed = 1

// viewof rawDataSize = Inputs.range([10, 100], { value: 40, step: 10, label: 'Raw Data Size (%)'
rawDataSize = 20

// viewof rawDataOffset = Inputs.range([0, 50], { value: 5, step: 5, label: 'Raw Data Offset (%)'
rawDataOffset = 5
```

```
//| label: fig-price-regions-classes
//| fig-cap: "Prices by Region and Customer Class"
//| class: raincloud-custom
Plot.plot(rainCloudX)
```

```
rainCloudX = ({
  grid: true,
  label: null,
  width: width,
  marks: [
    Plot.ruleX([0]),
    halfViolinX,
    rawDataX
  ],
  facet: {
    data: data,
    y: 'acep_energy_region',
    marginRight: 80
  },
  x: {
    label: "Cents per Kilowatt Hour"
  },
  y: {
    ticks: 0,
    tickFormat: d => d < 0 ? '' : d
  },
  color: {
      domain: ["Coastal", "Railbelt", "Rural Remote"],
      range: ["#8CBBDA", "#97CD93", "#F28D8C"]
  }
})
```

```
halfViolinX = Plot.areaY(
  data,
  Plot.binX(
    {
```

```
      y: 'count'
    },
    {
      x: dimension,
      fill: 'acep_energy_region',
      thresholds: thresholds,
      curve: 'basis'
    }
  )
)
```

```
rawDataX = Plot.dot(
  data,
  {
      x: dimension,
    y: jitter(data, seed),
    fill: 'acep_energy_region',
    r: 1.5,
    channels: {Name: "reporting_name", Year: "year"},
    tip: {format: {fill: false,
                  fy: false,
                  y: false
                  }}

  }
)

// tip = Plot.tip(
//   data, Plot.pointer(
//   {
//   x: dimension,
//   y: 'acep_energy_region',
//   format: {
//     year: true,
//     reporting_name: true,
//     dimension: true,
//     filter: (d) => d.reporting_name,
//     title: (d) => [d.reporting_name, d.year].join("\n\n")
//     stroke: false
//   }
//   }
// )
// )
```

```
//| echo: false
// appendix

jitter = (data, seed) => {
  const rng = seedrandom(seed);
  return data.map(() => -(rng() * rawDataSize + rawDataOffset) * maxTotal / 100);
}

maxTotal = d3.max(
  Array.from(
    d3
    .group(data, d => d.aea_energy_region)
```

```
    .values()
  )
  .flatMap(g => bins(g.map(d => d[dimension])))
  .map(bin => bin.length)
)

bins = d3
  .bin()
  .domain(d3.extent(data, d => d[dimension]))
  .thresholds(thresholds)


seedrandom = require('seedrandom')
```

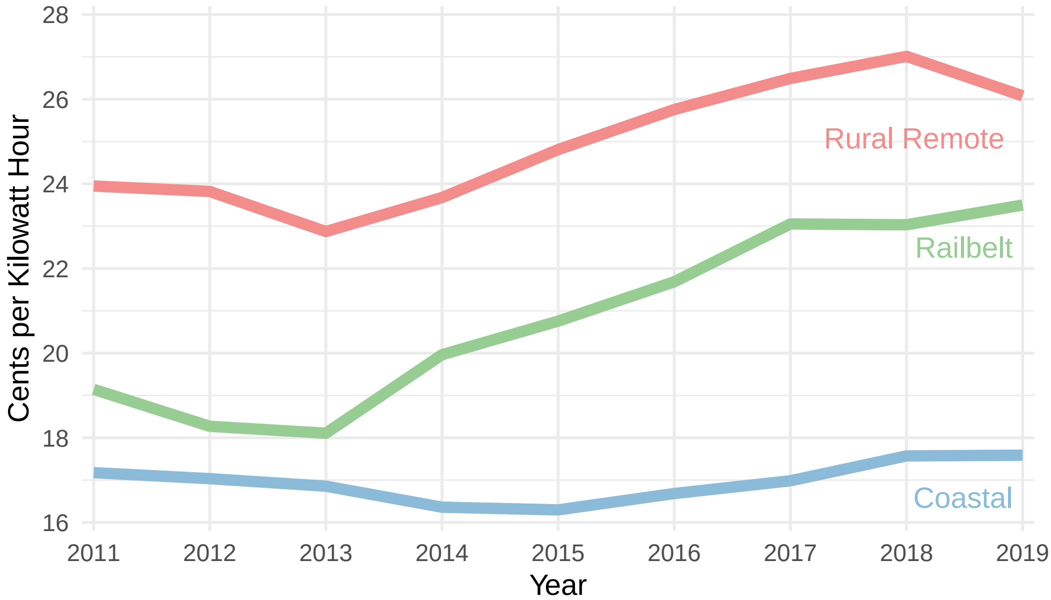
```
prices_tidy = tidy(
  prices,
    rename({
      'residential_price_kwh_2021_dollars': 'residential_price',
      'commercial_price_kwh_2021_dollars': 'commercial_price',
      'other_price_kwh_2021_dollars': 'other_price',
    }),
    // pivotLonger({
    //   cols: ['residential', 'commercial', 'other'],
    //   namesTo: 'sector',
    //   valuesTo: 'price'
    // }),
    select([
      'year',
      'reporting_name',
      'acep_energy_region',
      'residential_price',
      'commercial_price',
      'other_price'
    ])
)

customers_pivot = tidy(
  prices,
    rename({
      'residential_price_kwh_2021_dollars': 'residential_price',
      'commercial_price_kwh_2021_dollars': 'commercial_price',
      'other_price_kwh_2021_dollars': 'other_price',
    }),
    rename({
      'residential_customers': 'residential',
      'commercial_customers': 'commercial',
      'other_customers': 'other',
    }),
    pivotLonger({
      cols: ['residential', 'commercial', 'other'],
      namesTo: 'sector',
      valuesTo: 'customers'
    }),
    select([
      'year',
      'reporting_name',
```

```
      'acep_energy_region',
      'residential_price',
      'commercial_price',
      'other_price',
      'customers',
      'total_customers'
    ])
)

// prices_customers_long = tidy(
//   prices_pivot,
//     leftJoin(customers_pivot,
//       { by: ['year', 'aea_sales_reporting_id', 'reporting_name', 'sector'] }),
//     select([
//       'year',
//       'reporting_name',
//       'acep_energy_region',
//       'sector',
//       'price',
//       'customers',
//       'total_customers'
//     ])
// )

data = tidy(
  prices_tidy,
  mutate({
    residential_price: (d) => d.residential_price === 0 ? null : d.residential_price,
    commercial_price: (d) => d.commercial_price === 0 ? null : d.commercial_price,
    other_price: (d) => d.other_price === 0 ? null : d.other_price,
  }),
  filter((d) => d.year < 2020),
  filter((d) => d.reporting_name != "Lime Village"),
  filter((d) => d.reporting_name != "Healy Lake")
);
```

6.1.2. Regional Averages

Due to the wide range of electricity prices in Alaska, it is difficult to accurately summarize the data. Because of this, we determined that averages were best calculated using a customer account weighted average. Population is roughly correlated to price, with small communities experiencing higher rates than larger communities. The average number of customer accounts for the year was used to calculate the weighted arithmetic mean price for each year and region. **?@fig-price-over-time** is a graph of residential customer prices over time after weighting for the number of customer accounts.

Figure 2: Residential Price Over Time



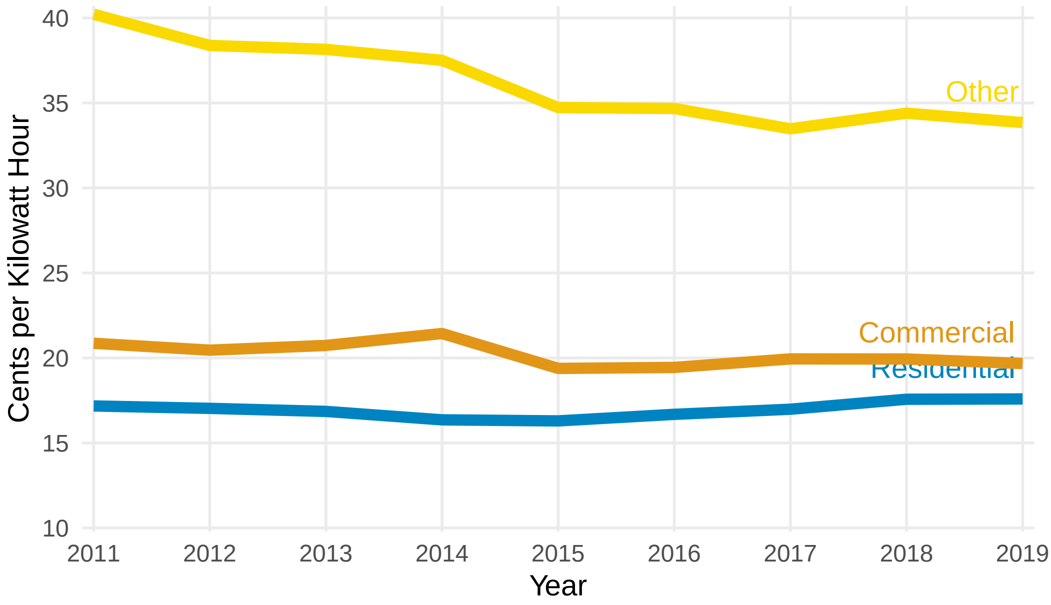
6.2. Coastal

?@fig-price-sector-coastal shows the average price of electricity in the Coastal region for each customer class and year. Between 2011 and 2019, the region experienced decreasing prices for Commercial and Other customers, while Residential customers have seen a slight increase in price.

The average real price (in 2021 dollars) of electricity for Residential customers in the Coastal region rose `{ojs} coastal_res_change`% from `{ojs} coastal_res_2011` cents/kWh in 2011 to `{ojs} coastal_res_2019` cents/kWh in 2019. The average price of electricity for Commercial customers in the Coastal region fell `{ojs} coastal_com_change`% from `{ojs} coastal_com_2011` cents/kWh in 2011 to `{ojs} coastal_com_2019` cents/kWh in 2019. Finally, the average price of electricity for Other customers in the Coastal region fell `{ojs} coastal_other_change`% from `{ojs} coastal_other_2011` cents/kWh in 2011 to `{ojs} coastal_other_2019` cents/kWh in 2019.

Residential customers in the Coastal region saw increases in the price of electricity while commercial and other customers saw decreases. However, the residential customer class continues to pay the lowest per kWh in the region due to a combination of low prices in high population areas and PCE subsidies in eligible communities.

Figure 3: Sector Price Over Time, Coastal Region



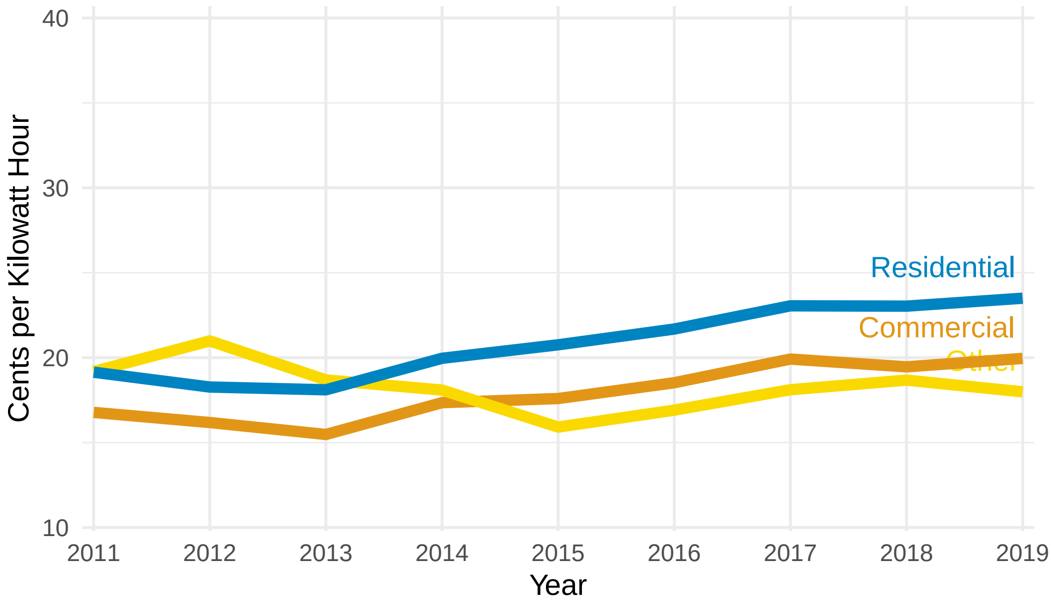
6.3. Railbelt

?@fig-price-sector-railbelt shows the average price of electricity in the Railbelt region for each customer class and each year of the report. Between 2011 and 2019, Other customers saw a large decrease in price, followed by a gradual increase. Residential and Commercial customers experienced slight decreases in price until 2013 when prices reversed and rose dramatically.

The average real price of electricity for Residential customers in the Railbelt rose `{ojs} railbelt_res_change`% from `{ojs} railbelt_res_2011` cents/kWh in 2011 to `{ojs} railbelt_res_2019` cents/kWh in 2019. The average price of electricity for Commercial customers in the Railbelt rose `{ojs} railbelt_com_change`% from `{ojs} railbelt_com_2011` cents/kWh in 2011 to `{ojs} railbelt_com_2019` cents/kWh in 2019. Finally, the average price of electricity for Other customers in the Railbelt fell `{ojs} railbelt_other_change`% from `{ojs} railbelt_other_2011` cents/kWh in 2011 to `{ojs} railbelt_other_2019` cents/kWh in 2019.

This region differs significantly from the Coastal and Rural Remote regions in that residential customers pay more for electricity than the Commercial or Other customer classes.

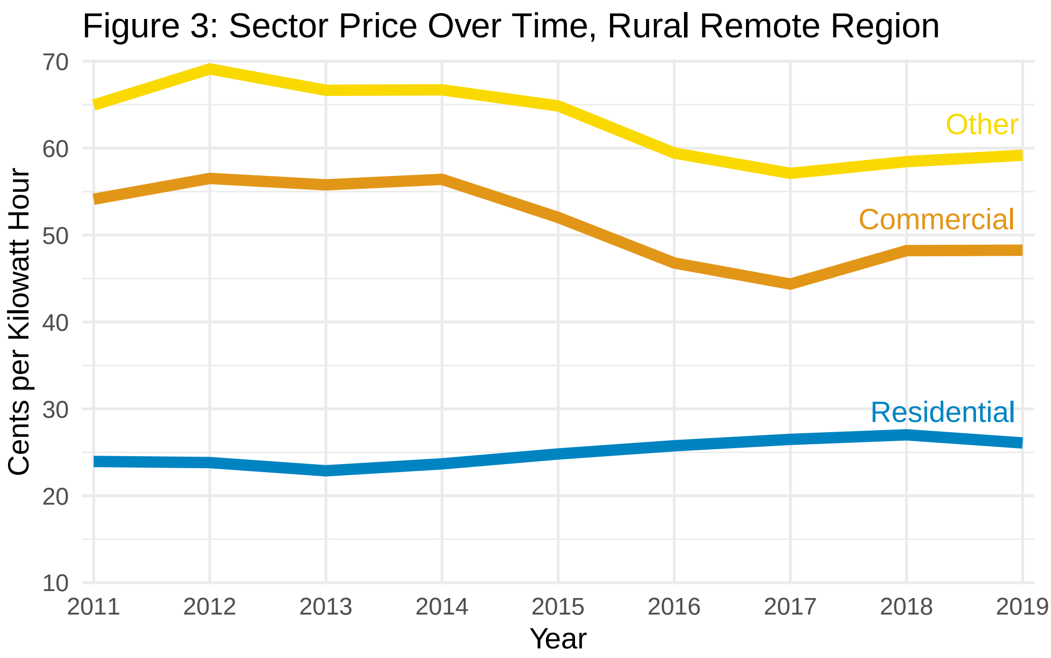
Figure 3: Sector Price Over Time, Railbelt Region



6.4. Rural Remote

?@fig-price-sector-rural shows the average price of electricity in the Rural Remote region for each customer class and year of the report. Between 2011 and 2019, Residential customers experienced a gradual increase in rates, while Commercial and Other customers experienced a gradual decrease in rates.

The average price of electricity for the Residential customers in the Rural Remote region rose `{ojs} rural_res_change`% from `{ojs} rural_res_2011` cents/kWh in 2011 to `{ojs} rural_res_2019` cents/kWh in 2019. The average price of electricity for Commercial customers in the Rural Remote region fell `{ojs} rural_com_change`% from `{ojs} rural_com_2011` cents/kWh in 2011 to `{ojs} rural_com_2019` cents/kWh in 2019. Finally, the average price of electricity for Other customers in the Rural Remote region fell `{ojs} rural_other_change`% from `{ojs} rural_other_2011` cents/kWh in 2011 to `{ojs} rural_other_2019` cents/kWh in 2019.




```
// price extraction function

function extract_price(region, year, sector) {
  const filteredData = weighted_prices.filter(
    d => d.year === year &&
    d.sector === sector &&
    d.acep_energy_region === region);

  const extractedPrice = Math.round(filteredData.map(d => d.weighted_price));

  return extractedPrice;
};
```

```
// percentage function

function percent_change(region, start_year, end_year, sector){
  const start_price = extract_price(region, start_year, sector);
  const end_price = extract_price(region, end_year, sector);

  const rawPercent = (((start_price - end_price)/start_price) * 100);
  const percent = Math.abs(Math.round(rawPercent));

  return percent;
}
```

```
// starting prices

rural_res_2011 = extract_price("Rural Remote", 2011, 'residential');
railbelt_res_2011 = extract_price("Railbelt", 2011, 'residential');
coastal_res_2011 = extract_price("Coastal", 2011, 'residential');

rural_com_2011 = extract_price("Rural Remote", 2011, 'commercial');
railbelt_com_2011 = extract_price("Railbelt", 2011, 'commercial');
coastal_com_2011 = extract_price("Coastal", 2011, 'commercial');
```

```
rural_other_2011 = extract_price("Rural Remote", 2011, 'other');
railbelt_other_2011 = extract_price("Railbelt", 2011, 'other');
coastal_other_2011 = extract_price("Coastal", 2011, 'other');
```

```
// ending prices

rural_res_2019 = extract_price("Rural Remote", 2019, 'residential');
railbelt_res_2019 = extract_price("Railbelt", 2019, 'residential');
coastal_res_2019 = extract_price("Coastal", 2019, 'residential');

rural_com_2019 = extract_price("Rural Remote", 2019, 'commercial');
railbelt_com_2019 = extract_price("Railbelt", 2019, 'commercial');
coastal_com_2019 = extract_price("Coastal", 2019, 'commercial');

rural_other_2019 = extract_price("Rural Remote", 2019, 'other');
railbelt_other_2019 = extract_price("Railbelt", 2019, 'other');
coastal_other_2019 = extract_price("Coastal", 2019, 'other');
```

```
// percent changes

coastal_res_change = percent_change("Coastal", 2011, 2019, 'residential');
coastal_com_change = percent_change("Coastal", 2011, 2019, 'commercial');
coastal_other_change = percent_change("Coastal", 2011, 2019, 'other');

railbelt_res_change = percent_change("Railbelt", 2011, 2019, 'residential');
railbelt_com_change = percent_change("Railbelt", 2011, 2019, 'commercial');
railbelt_other_change = percent_change("Railbelt", 2011, 2019, 'other');

rural_res_change = percent_change("Rural Remote", 2011, 2019, 'residential');
rural_com_change = percent_change("Rural Remote", 2011, 2019, 'commercial');
rural_other_change = percent_change("Rural Remote", 2011, 2019, 'other');
```

```
// load libraries
stdlib = require("@observablehq/stdlib")
d3 = require("d3@7")
import {tidy, groupBy, rename, summarize, sum, mutate, select, n, nDistinct, mean, filter, pivotWi

// load data
prices = FileAttachment("data/working/prices/prices.csv").csv({typed: true});
weighted_prices = FileAttachment("data/working/prices/weighted_prices.csv").csv({typed: true});
```

Chapter 7.

Conclusions

Description of Results and Conclusions

From 2011 to 2019/21, there have been significant developments in the electricity generation landscape in Alaska. In this report, we highlight trends across installed capacity, net/gross generation, consumption by customer class, and price per kWh. There are several key takeaways from each of these areas that we reiterate in this conclusion.

7.0.1. Capacity

There has been continued development in the installation and availability of electric generation capacity (Section 3.1) across the state. Throughout every region, installed capacity increased. Of particular note are the installation of peaking and/or backup engines, renewable energy facilities (hydro, wind, and solar expansions), and storage. If trends continue, we can expect to see further increases in resilience and reliability-focused capacity.

7.0.2. Generation

Net/gross generation (Section 4.1) throughout the state remained relatively stable across observed years with each region having notable trends. In the Coastal region, we observed more hydroelectric and wind generation on average in 2021 than in 2011. This was coupled with reductions in generation from oil-based units. On the Railbelt, we observed more generation from wind, hydroelectric, coal, and solar resources in 2021 than in 2011. This was coupled with less oil and natural gas generation. Finally, in the Rural Remote region, we observed more generation from wind and solar resources in 2021 than in 2011. We also note the increase in use of utility-scale battery storage throughout the state.

7.0.3. Consumption

Electricity consumption (Section 5.1) throughout the state fell on average. The residential customer class saw the largest reductions, while the number of customer accounts increased across all categories. We also note that the Rural Remote region saw increases in consumption for the commercial and industrial customer classes. Finally, we observed that the Coastal region had the highest per capita consumption for residential customers, followed by the Railbelt and then the Rural Remote regions.

7.0.4. Prices

Electricity prices (Section 6.1) across the state were variable but trended upward. After adjusting for inflation, PCE subsidies, and including a population weight, the average residential electricity price across the state increased. The largest residential rate increases from 2011 to 2019 were observed in the Railbelt region (26%), and the smallest were observed in the Coastal region (6%). Throughout the Coastal and Rural Remote regions, commercial and other customer classes saw rate decreases. Rate decreases were also observed on the Railbelt for commercial customers. We also observed that PCE subsidies were paramount to mitigating the cost of electricity for residential and community customers in the Rural Remote and Coastal regions.

7.1. Future Plans

The results of this trends report highlight the direction that installed capacity, net/gross generation, consumption, and prices took from 2011-2019/21. We emphasize the importance of continuing to collate electricity data from federal, state, regional, and local sources so that it may be analyzed on a more consistent basis. Our hope is to continue producing trends reports with updated data to better inform the public and decision makers regarding Alaska's energy future.

Chapter 8.

Data Portal

Download the Data Used in the Report's Figures

8.1. Data Overview

The data used in this web-book is derived from federal, state, commercial, and local sources, as well as direct communications with utilities and state program managers. More information about data sources can be found on the methods page of this web-book.

8.2. Download Individual Tables

Individual tables can be downloaded here as text files (CSV, comma-separated values). Once downloaded to your local machine, these files can be opened graphically using Microsoft Excel, or programmatically using R or Python.

8.2.1. Capacity

`{ojs} capacity_wide_description`

```
capacity_wide_description = metadata.resources[0].description;
capacity_wide_raw = FileAttachment("data/working/capacity/capacity_wide.csv").csv({typed: true});

capacity_wide = tidy(capacity_wide_raw,
                  filter((d) => d.year < 2020))

capacity_wide_path = metadata.resources[0].path;
capacity_wide_metadata = metadata.resources[0].schema.fields;


viewof capacity_input = Inputs.select(new Map([
                ["Capacity Metadata", capacity_wide_metadata],
                ["Capacity", capacity_wide]]),
              {value: capacity_wide_metadata, label: "Preview:"}
              );

Inputs.table(capacity_input);
```

Download

Download

```
button(capacity_wide_metadata, 'capacity_metadata.csv', `Capacity Metadata`)
button(capacity_wide, `capacity.csv`, `Capacity`)
```

8.2.2. Net Generation

{ojs} net_generation_wide_description

```
net_generation_wide_description = metadata.resources[2].description
net_generation_wide_raw = FileAttachment("data/working/generation/net_generation_wide.csv").csv({t

net_generation_wide = tidy(net_generation_wide_raw,
                  filter((d) => d.year < 2020))

net_generation_wide_path = metadata.resources[2].path
net_generation_wide_metadata = metadata.resources[2].schema.fields

viewof generation_input = Inputs.select(new Map([["Generation Metadata", net_generation_wide_metad
              ["Generation", net_generation_wide]]),
              {value: net_generation_wide_metadata, label: "Preview:"}
              );
Inputs.table(generation_input);
```

Download

Download

```
button(net_generation_wide_metadata, 'net_generation_wide_metadata.csv', `Generation Metadata`)
button(net_generation_wide, `net_generation_wide.csv`, `Net Generation`)
```

8.2.3. Consumption and Sales

{ojs} consumption_wide_description

```
consumption_wide_description = metadata.resources[4].description
consumption_wide_raw = FileAttachment("data/working/consumption/consumption_wide.csv").csv({typed:

consumption_wide = tidy(consumption_wide_raw,
                  filter((d) => d.year < 2020))

consumption_wide_path = metadata.resources[4].path
consumption_wide_metadata = metadata.resources[4].schema.fields

viewof consumption_input = Inputs.select(new Map([["Consumption Metadata", consumption_wide_metada
              ["Consumption", consumption_wide]]),
              {value: consumption_wide_metadata, label: "Preview:"}
              );
Inputs.table(consumption_input);
```

Download

Download

```
button(consumption_wide_metadata, 'consumption_wide_metadata.csv', `Consumption Metadata`)
button(consumption_wide, `consumption_wide.csv`, `Consumption`)
```

8.2.4. Prices

{ojs} prices_description

```
prices_description = metadata.resources[6].description;
prices_raw = FileAttachment("data/working/prices/prices.csv").csv({typed: true});

prices = tidy(prices_raw,
            filter((d) => d.year < 2020))

prices_path = metadata.resources[6].path;
prices_metadata = metadata.resources[6].schema.fields;


viewof prices_input = Inputs.select(new Map([["Prices Metadata", prices_metadata],
              ["Prices", prices]]),
              {value: prices_metadata, label: "Preview:"}
              );

Inputs.table(prices_input);
```

Download

Download

```
button(prices_metadata, `prices_metadata.csv`, `Metadata`);
button(prices, `prices.csv`, `Prices`);
```

8.2.5. Population-Weighted Average Prices

{ojs} weighted_prices_description

```
weighted_prices_description = metadata.resources[7].description;
weighted_prices_raw = FileAttachment("data/working/prices/weighted_prices.csv").csv({typed: true})

weighted_prices = tidy(weighted_prices_raw,
                    filter((d) => d.year < 2020))

weighted_prices_path = metadata.resources[7].path;
weighted_prices_metadata = metadata.resources[7].schema.fields;

viewof weighted_prices_input = Inputs.select(new Map([["Weighted Prices Metadata", weighted_prices
              ["Weighted Prices", weighted_prices]]),
```

```
              {value: weighted_prices_metadata, label: "Preview:"}
              );

Inputs.table(weighted_prices_input);
```

Download

Download

```
button(weighted_prices_metadata, `weighted_prices_metadata.csv`, `Metadata`);
button(weighted_prices, `weighted_prices.csv`, `Weighted Prices`)
```

```
// load libraries
stdlib = require("@observablehq/stdlib")
d3 = require("d3@7")
import {tidy, groupBy, rename, summarize, sum, mutate, select, n, nDistinct, mean, filter, pivotWi

// load metadata
metadata = FileAttachment("data/metadata.json").json();
```

```
// download button function
button = (data, filename = 'data.csv', displayname) => {
  const downloadData = new Blob([d3.csvFormat(data)], { type: "text/csv" });

  const size = (downloadData.size / 1024).toFixed(1);
  const button = DOM.download(
    downloadData,
    filename,
    `${displayname} (${size} KB)`
  );
  return button;
}
```

```
//| eval: false
// DEPRECATED
// THIS CHUNK DOES NOT RUN (eval: false)

// fancy dropdown database viewing tool

// connect to database
db = FileAttachment("data/working/aetr.db").sqlite()

viewof dbTable = Inputs.select((await db.describe()).value.map(d => d.name),
                    { label: "" })

database = db.query(`SELECT * FROM ${dbTable}`)


Inputs.table(database)

db_button = (database, filename = 'data.csv') => {
  const downloadData = new Blob([d3.csvFormat(database)], { type: "text/csv" });
```

```
  const size = (downloadData.size / 1024).toFixed(1);
  const button = DOM.download(
    downloadData,
    filename,
    `Download ${filename} (${size} KB)`
  );
  return button;
}

db_button(database, `${dbTable}`)
```

Appendix A.

About this Report

Description of the 2024 Alaska Electricity Trends Report Web Book

A.1. General Overview

This Alaska Electrical Trends Report (AETR) Web Book has been produced by the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks (UAF). It is designed to be interactive and dynamically updated when new data becomes available.

Throughout the years, several agencies have prepared and published reports and data compilations on energy use in Alaska. AETR is complementary to those prior reports, but is not presented in a comparable format.

A.2. Historical Timeline of Prior Reports

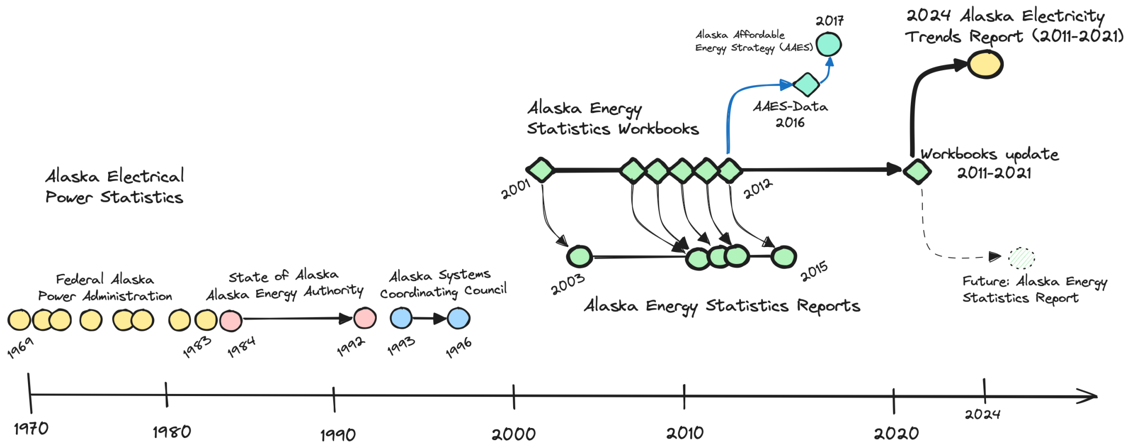


Figure A.1.: Timeline of Energy Reports

Starting in 1969, the first Electric Power Trends report was published by the Alaska Power Administration. During this time, the Alaska Power Administration was a federal agency housed within the U.S. Department of the Interior. Their first publication was known as the “First Annual Report” and covered data from the 1968 fiscal year. However, this became the “Alaska Electric Power Statistics Report” in 1971 and examined data from the 1960-1969 data years. The APA continued to produce intermittent reports until 1983 when the State of Alaska established the Alaska Power Authority (APA), which later became the Alaska Energy Authority (AEA).

Under state direction, the APA/AEA continued to publish intermittent reports on electric power statistics until their final publication in 1992 which covered data years 1960 to 1991. To address the reporting gap, the Alaska Systems Coordinating Council in collaboration with the State of Alaska, Department of Community and Regional Affairs, Division of Energy continued generating reports until 1996 with their final report covering data years 1960 to 1995. Finally, the University of Alaska Anchorage, Institute of Social and Economic Research produced several reports with their last covering 1960 to 2012. Since then, there have been no electric power statistical reports.

The Table A.1 provides a summary of this timeline. This report serves to supplement the reporting gap in electric power statistics for the State of Alaska.

Table A.1.: Historical Timeline of Reports

Year Published	Institution	Data Coverage
1971 to 1983	Alaska Power Administration	1960 to 1982
1984 to 1988	Alaska Power Authority	1960 to 1987
1989 to 1992	Alaska Energy Authority	1960 to 1991
1992 to 1996	Alaska Systems Coordinating Council; State of Alaska	1960 to 1995
2003, 2011 to 2015	University of Alaska Anchorage, Institute of Social and Economic Research	1960 to 2012

For a table of links to these historic reports, please refer to Table B.1.

A.3. Technical Details

The book is formatted using Quarto, an open-source scientific and technical publishing system. The template was developed by the Openscapes project, as part of their Quarto Website Tutorial.

The markdown files that make up the book reside in the aetr-web-book GitHub repository. The generation process is publicly accessible. Errors in the document can be flagged using GitHub issues where they can be tracked and addressed by the DCM team.

The book also integrates R code for data processing and figure generation. When data files are updated, manually triggering the Quarto render will update the figures automatically.

Appendix B.

Historical Electric Power Statistics Reports

Links to Previous Reports, Data Years 1960-2012

B.1. Historical Electric Power Reports

For an overall description of previous reports that have examined electric power trends in Alaska, please see Section A.2. Below is an exhaustive list of links to these reports over time. Notably, we omit reports that include projections such as the State of Alaska Energy Reports/Plans.

Table B.1.: Links to Historical Reports

Publication Year	Data Years	Data Year Type	Authoring Institution	Publication Title	Type	Persistent Links
1969	1968	Fiscal	United States Department of the Interior, Alaska Power Administration	First Annual Report	Report	First Annual Report
1971	1960-1969	Calendar	United States Department of the Interior, Alaska Power Administration	Alaska Electric Power Statistics 1960 - 1969	Report	Alaska Electric Power Statistics 1960 - 1969
1972	1960-1970	Calendar	United States Department of the Interior, Alaska Power Administration	Alaska Electric Power Statistics 1960 - 1970	Report	Alaska Electric Power Statistics 1960 - 1970
1974	1960-1973	Calendar	United States Department of the Interior, Alaska Power Administration	Alaska Electric Power Statistics 1960 - 1973	Report	Alaska Electric Power Statistics 1960 - 1973
1976	1960-1975	Calendar	United States Department of the Interior, Alaska Power Administration	Alaska Electric Power Statistics 1960 - 1975	Report	Alaska Electric Power Statistics 1960 - 1975
1977	1960-1976	Calendar	United States Department of the Interior, Alaska Power Administration	Alaska Electric Power Statistics 1960 - 1976	Report	Alaska Electric Power Statistics 1960 - 1976
1981	1960-1980	Calendar	United States Department of Energy, Alaska Power Administration	Alaska Electric Power Statistics 1960 - 1980	Report	Alaska Electric Power Statistics 1960 - 1980

Publication Year	Data Years	Data Year Type	Authoring Institution	Publication Title	Type	Persistent Links
1983	1960-1982	Calendar	United States Department of Energy, Alaska Power Administration	Alaska Electric Power Statistics 1960 - 1982	Report	Alaska Electric Power Statistics 1960 - 1982
1984	1960-1983	Calendar	State of Alaska, Alaska Power Authority	Alaska Electric Power Statistics 1960 - 1983	Report	Alaska Electric Power Statistics 1960 - 1983
1985	1960-1984	Calendar	State of Alaska, Alaska Power Authority	Alaska Electric Power Statistics 1960 - 1984	Report	Alaska Electric Power Statistics 1960 - 1984
1986	1960-1985	Calendar	State of Alaska, Alaska Power Authority	Alaska Electric Power Statistics 1960 - 1985	Report	Alaska Electric Power Statistics 1960 - 1985
1987	1960-1986	Calendar	State of Alaska, Alaska Power Authority	Alaska Electric Power Statistics 1960 - 1986	Report	Alaska Electric Power Statistics 1960 - 1986
1988	1960-1987	Calendar	State of Alaska, Alaska Power Authority	Alaska Electric Power Statistics 1960 - 1987	Report	Alaska Electric Power Statistics 1960 - 1987
1989	1960-1988	Calendar	State of Alaska, Alaska Energy Authority	Alaska Electric Power Statistics 1960 - 1988	Report	Alaska Electric Power Statistics 1960 - 1988
1990	1960-1989	Calendar	State of Alaska, Alaska Energy Authority	Alaska Electric Power Statistics 1960 - 1989	Report	Alaska Electric Power Statistics 1960 - 1989
1991	1960-1990	Calendar	State of Alaska, Alaska Energy Authority	Alaska Electric Power Statistics 1960 - 1990	Report	Alaska Electric Power Statistics 1960 - 1990
1992	1960-1991	Calendar	State of Alaska, Alaska Energy Authority	Alaska Electric Power Statistics 1960 - 1991	Report	Alaska Electric Power Statistics 1960 - 1991
1993	1960-1992	Calendar	Alaska Systems Coordinating Council; State of Alaska, Department of Community and Regional Affairs, Division of Energy	Alaska Electric Power Statistics 1960 - 1992	Report	Alaska Electric Power Statistics 1960 - 1992
1994	1960-1993	Calendar	Alaska Systems Coordinating Council; State of Alaska, Department of Community and Regional Affairs, Division of Energy	Alaska Electric Power Statistics 1960 - 1993	Report	Alaska Electric Power Statistics 1960 - 1993

Publication Year	Data Years	Data Year Type	Authoring Institution	Publication Title	Type	Persistent Links
1995	1960-1994	Calendar	Alaska Systems Coordinating Council; State of Alaska, Department of Community and Regional Affairs, Division of Energy	Alaska Electric Power Statistics 1960 - 1994	Report	Alaska Electric Power Statistics 1960 - 1994
1996	1960-1995	Calendar	Alaska Systems Coordinating Council; State of Alaska, Department of Community and Regional Affairs, Division of Energy	Alaska Electric Power Statistics 1960 - 1995	Report	Alaska Electric Power Statistics 1960 - 1995
2003	1960-2001	Calendar	University of Alaska Anchorage, Institute of Social and Economic Research	Alaska Electric Power Statistics (with Alaska Energy Balance) 1960 - 2001	Report	Alaska Electric Power Statistics (with Alaska Energy Balance) 1960 - 2001
2011	1960-2008	Calendar	University of Alaska Anchorage, Institute of Social and Economic Research	Alaska Energy Statistics 1960 - 2008	Report, Excel Workbook	Alaska Energy Statistics 1960 - 2008
2011	1960-2009	Calendar	University of Alaska Anchorage, Institute of Social and Economic Research	Alaska Energy Statistics 1960 - 2009	Report, Excel Workbook	Alaska Energy Statistics 1960 - 2009
2012	1960-2010	Calendar	University of Alaska Anchorage, Institute of Social and Economic Research	Alaska Energy Statistics 1960 - 2010 Final Report	Report, Excel Workbook	Alaska Energy Statistics 1960 - 2010 Final Report
2013	1960-2011	Calendar	University of Alaska Anchorage, Institute of Social and Economic Research	Alaska Energy Statistics 1960 - 2011 Final Report	Report, Excel Workbook	Alaska Energy Statistics 1960 - 2011 Final Report
2015	2012	Calendar	State of Alaska, Alaska Energy Authority	2012 Alaska Energy Statistics Final Report	Report	2012 Alaska Energy Statistics Final Report

Appendix C.

Acronym Definitions

Acronyms Commonly used in the Report

C.1. Acronyms

These abbreviations are used throughout this report

- ACEP: Alaska Center for Energy and Power, UAF
- AEA: Alaska Energy Authority
- BUECI: Barrow Utilities & Electric Cooperative, Inc.
- DCM: the Data and Cyberinfrastructure Management team at ACEP, UAF
- PCE: Power Cost Equalization
- EIA: Energy Information Administration
- ETI: Energy Transitions Initiative, ACEP
- FERC: Federal Energy Regulatory Commission
- CAGR: Compound Annual Growth Rate
- kW: Kilowatt
- kWh: Kilowatt-hour
- MW: Megawatt
- MWh: Megawatt-hour
- GW: Gigawatts
- GWh: Gigawatt-hour
- UAF: University of Alaska Fairbanks

Appendix D.

Acknowledgements and Roles

About the Team that Created the 2024 Alaska Electricity Trends Report

D.1. Acknowledgements

D.1.1. Funding

Funding support for this team was provided by leveraging support from multiple partners that include:

- Office of Naval Research's (ONR) Alaska Regional Collaboration for Technology Innovation and Commercialization (ARCTIC) program (award #N00014-19-1-2235)
- Denali Commission - Alaska Energy Project Partnerships (award #1659)
- State of Alaska

Note: Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the funding supporters.

D.1.2. Partners

- Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks (UAF)
- Institute of Social and Economic Research (ISER) at the University of Alaska Anchorage (UAA)
- Alaska Energy Authority (AEA)
- DOWL Engineering (DOWL)

Data used in the energy workbooks comes from a variety of sources and partners, but special thanks to the Alaska Energy Authority for partnering with the team to make the base line power cost equalization datasets available. Without this openness, this report would not be possible. We would also like to thank the utilities who responded directly when we had questions. A full list of these organizations has been complied in Section 2.1.

D.2. Credits and Roles

The Alaska Electrical Trends web book has been produced by the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks (UAF). It is a collaboration between data scientists, researchers, and policy experts. Roles here are described by Contributor Roles Taxonomy (CRediT).

- Jesse Kaczmarski1
  - Roles: data curation, formal analysis, project administration, software, validation, visualization, writing – original draft

- Ian MacDougall1
  - Roles: data curation, formal analysis, software, validation, visualization, writing – original draft
- Steve Colt2
  - Roles: data curation, formal analysis, investigation, validation, writing – review & editing
- Elizabeth (Liz) Dobbins1
  - Roles: software, project administration, resources, supervision, writing – review & editing
- Neil McMahon3
  - Roles: data curation, investigation, validation
- Sara Fisher-Goad4
  - Roles: conceptualization, validation, writing – review & editing
- Brittany Smart2
  - Roles: project administration, writing – review & editing
- Dayne Broderson1
  - Roles: conceptualization, funding acquisition
- Gwen Holdmann2
  - Roles: conceptualization, funding acquisition
- Shivani Mathur2
  - Roles: validation, writing – review & editing
- Erika Boice2
  - Roles: writing – review & editing

D.2.1. Affiliations

ACEP's Data and Cyberinfrastructure Management (DCM) Team includes software developers, mathematicians, spatial analysts, economists, open science enthusiasts, and experts in information security and the deployment of computer infrastructure. ACEP's Energy Transition Initiative (ETI) is a group of experts that respond quickly to informational requests about Alaska energy. These teams together maintain a reliable pathway for data from collection to distribution.