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GCAMUSAJobs: An R package for employment projections based on GCAM-USA power sector outcomes

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Software

- Review
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Summary

The `GCAMUSAJobs` R package was developed to post-process electric power projections from GCAM-USA, enabling the estimation of future power sector jobs at the state-level by generation technology and job type. `GCAMUSAJobs` extends GCAM-USA functionality by (1) estimating the capacity levels of different activities – operational capacity, capacity addition, and retirement; and (2) calculating jobs associated with production activities, including those in operation and maintenance (O&M), construction, and decommissioning.

Statement of need

The development of `GCAMUSAJobs` was driven by the need to assess the distributional labor impacts of energy system transition (Hanson, 2023; Mayfield et al., 2023; Raimi, 2021; Xie et al., 2023). While gross employment (Mayfield et al., 2023) and power sector employment (Xie et al., 2023) are expected to grow into the future, over time under both business as usual and decarbonization, Xie et al. (2023) find insignificant differences in power sector jobs between the two scenarios. Other research has also suggested that fossil fuel-intensive states may experience slower job growth or job losses (Hanson, 2023; Mayfield et al., 2023).

Currently, GCAM-USA does not calculate power sector jobs. `GCAMUSAJobs` addresses this gap by providing projected direct power sector jobs based on GCAM-USA output, enhancing the functionality of GCAM-USA for labor impact analysis.

The Journal of Open Source Software

Workflow

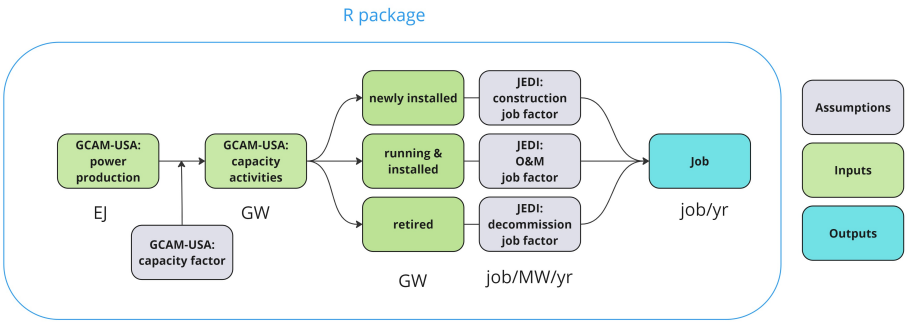

Figure 1: Figure. 1. Package workflow.

GCAMUSAJobs utilizes GCAM-USA annual electricity generation outputs to estimate underlying capacity levels based on assumptions about capacity factors and calculate associated power sector jobs based on employment factors (Fig. 1). The employment factor represents the average number of jobs created per unit of power production activity (e.g., jobs per gigawatt). This method is widely used in the relevant literature (Mayfield et al., 2023; Rutovitz et al., 2015). GCAMUSAJobs adopts employment factors from NREL's Jobs & Economic Development Impacts (JEDI) model (https://www.nrel.gov/analysis/jedi/models.html), which has been broadly used in the literature (Jacobson et al., 2017; Rutovitz et al., 2015; Xie et al., 2023).

Key functions

GCAMUSAJobs::GCAM_EJ queries power generation data (in exajoules, EJ) from the GCAM-USA output database for a single scenario, disaggregating generation from existing plants, newly added plants, and the generation lost from recently retired plants. The output is provided annually, broken down by state and fuel technology. Building on this, GCAMUSAJobs::GCAM_GW, taking the output from GCAMUSAJobs::GCAM_EJ, calculates the average annual capacity levels (in gigawatts, GW) by state and fuel technology for different activities, including operation, addition, and retirement. It supports both the "Total" and "Net" methods. In the "Total" method, all capacity additions and retirements are counted separately. In the "Net" method, premature retirement is offset with capacity addition. The "Total" method is better suited for large states with many facilities, where it is plausible that while one plant is retiring, a facility at a different location in the state is beginning construction. In small states with few facilities, simultaneous retirement and addition may not reflect reality. For example, if only one coal plant exists in a small state and it retires, any new capacity is likely a direct replacement, not a separate project. In this case, the replacement would imply a lower number of jobs needed than if the retirement and addition occurred as separate projects. The two options of user-defined methods ensure that job estimates for capacity expansion and decommissioning remain realistic and regionally appropriate. GCAMUSAJobs::GCAM_JOB then utilizes the output from GCAMUSAJobs::GCAM_GW to estimate the average annual job estimates, broken down by fuel type and job type, including construction (both on-site and construction-related), operations & maintenance, and decommissioning. Users can select between the "Total" or "Net" method, with "Total" used as the default. GCAMUSAJobs also provides a list of functions to visualize the employment factor assumptions, capacity, and job outcomes.

GCAMUSAJobs::GCAM_EJ is compatible with both the GCAM-USA output database as well as a

project data file queried using the R package `rgcam`. Please refer to the package vignette for additional examples and visualizations.

Implementation

For demonstration purposes, we use `GCAMUSAJobs` to post-process the outcome from GCAM v7.1 for a standard reference scenario, estimating the direct job, aggregated over states, associated with U.S. power generation (Fig. 2).

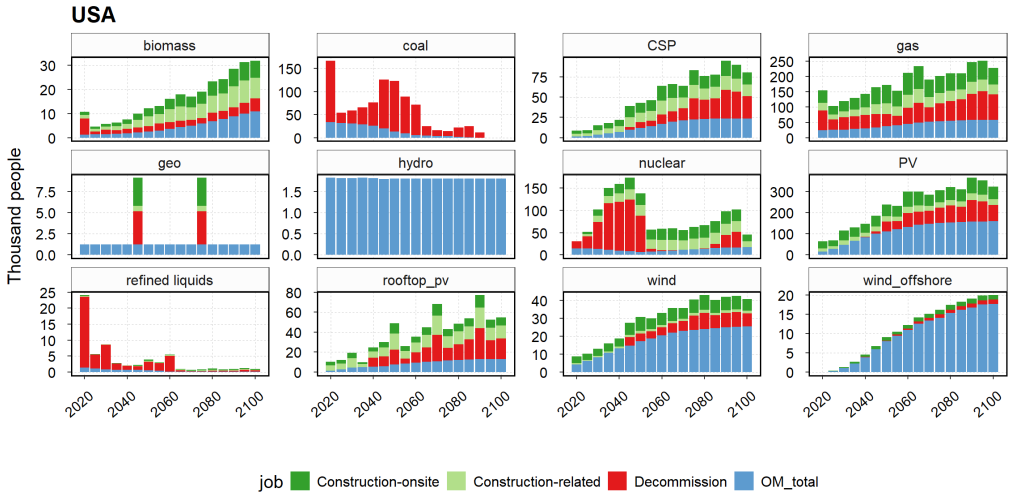

Figure 2: Figure. 2. Annual average power sector jobs by fuel and job types over a 5-year model period. Note that y-axes have different scales.

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Mention

This package is used by researchers at the University of Maryland for a published report on the renewable energy transition in Maryland and its implications (Kennedy et al., 2024). Specifically, the report provides direct job estimates at Maryland's thermal power plants based on facility characteristics (e.g., nameplate capacity, capacity factor, and fuel type) and the employment factors produced by this package.

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