# Transformational Integrated Greenhouse Gas Emissions Reduction Project Report

Informing the *Oregon Climate Action Roadmap to 2030*

KeepOregonCool
Oregon Global Warming Commission

Prepared by the
Oregon Department of Energy
March 2023

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# ACKNOWLEDGEMENTS

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And the numerous state agency people that helped guide this project along the way.

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## Support

The grant for this work was administered by the Center for the New Energy Economy (CNEE) at Colorado State University. Patrick Cummins, Senior Policy Advisor, was the contract administrator.


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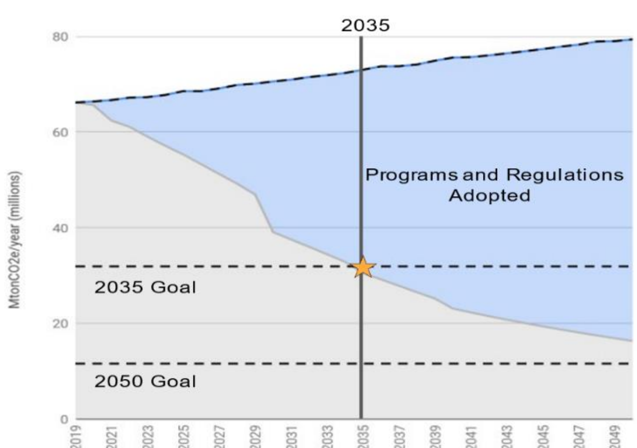
# EXECUTIVE SUMMARY

**Purpose.** The purpose of the Oregon Global Warming Commission's Roadmap to 2035 (now the Roadmap to 2030) was to develop and analyze actions across the economy to achieve Oregon's sector-based greenhouse gas emissions reduction goal of at least 45 percent below 1990 levels by 2035, while continuing to grow Oregon's economy and enhancing equity and quality of life for all Oregonians. The Transformational Integrated Greenhouse Gas Emissions Reduction Project (TIGHGER Project) assessed Oregon's projected progress toward meeting its GHG emission reduction goals and informed the development of the Roadmap for future climate action in Oregon.

**Process.** The Oregon Global Warming Commission oversaw the TIGHGER Project with frequent opportunities for public comment and engagement. In addition, ODOE staff and the OGWC engaged state agencies and the public to identify GHG-reducing actions and review the modeling results. The TIGHGER Project was partially funded by a $252,000 grant from the U.S. Climate Alliance for the modeling. The Oregon Department of Energy selected the consulting firm Sustainability Solutions Group (SSG) to assist with the project. SSG has used its *Energy Systems Simulator* (ESS), an energy, emissions, and finance accounting tool, to evaluate emissions reduction benefits and costs of policy actions for jurisdictions for over 20 years. SSG input Oregon's specific and county level data, and then calibrated the model using observed data and the 2019 Oregon DEQ statewide GHG inventory. SSG then developed a reference case, or Business-As-Usual GHG projection, and modeled the GHG emission reductions anticipated from 15 programs and regulations already in place in Oregon. SSG also modeled two scenarios to meet the 2035 goal in Executive Order 20-04 by 2030.

**2035 Results.** SSG's modeling forecasted that with the continued implementation of the 15 programs and regulations adopted, ***Oregon is on track to meet its 2035 emission reduction goal***. Even though current emission trends are headed in the wrong direction, former Governor Brown's Executive Order 20-04, the Oregon Legislature, and state agencies have put in place the policies and programs to enable Oregon to achieve its goal. Of the programs and regulations adopted in Oregon, two account for most of the emission reductions: HB 2021 (2021) and the Climate Protection Program (CPP). The TIGHGER analysis demonstrates the importance of Oregon's existing climate programs and regulations in reducing GHG emissions. However, Oregon can only achieve the 2035 goal if the programs and regulations adopted operate as planned and are provided the necessary staffing and resources to be successful. The work it will take to fulfill the promise of all these programs and regulations adopted should not be underestimated.




**2030 Results.** With the insight that Oregon is on track to meet the 2035 emission reduction goal with the programs and regulations adopted, the OGWC asked SSG to analyze additional actions Oregon could take to achieve the 2035 goal by 2030, consistent with the best available science from the Intergovernmental Panel on Climate Change (IPCC), federal GHG emission reduction goals, and the more ambitious short-term GHG emission reduction goals of Oregon's west coast neighbors. The TIGHGER analysis demonstrated that it is possible to accelerate and achieve the 2035 GHG emission reduction goal by 2030 by implementing an additional set of actions – the TIGHGER Actions.

Understanding that there are different pathways to achieve the accelerated goal of 2030, two scenarios were developed for modeling: an Electrification Scenario and a Hybrid Scenario. In total, SSG modeled 35 TIGHGER Actions across the two scenarios (23 that were common to both scenarios and 12 were unique to one or the other scenario). The TIGHGER analysis shows that ***ALL*** of the TIGHGER Actions in either scenario will need to be implemented to achieve the accelerated 2030 reduction goal. To advance these actions, the OGWC is recommending the development of Action Implementation Plans for each action. These Action Implementation Plans should include the specifics on who (which agency takes the lead in development), what, where, when, and how the action should be implemented.

**Benefits.** Most climate action plans apply a least-cost method to preferentially implement the most cost-effective actions first and the least cost-effective actions last. Given the multiple benefits of climate action, the OGWC expanded the analysis beyond just cost-effectiveness. Specifically, the OGWC incorporated the co-benefits of climate action like health benefits, equity benefits, and jobs and economic prosperity benefits into its analysis. The OGWC also analyzed the risk and uncertainty associated with the actions. SSG modeling identified significant financial benefits and other co-benefits to Oregonians of advancing the TIGHGER actions, including:

- The net present value of the benefits (savings minus costs) in today's dollars for either the Electrification or Hybrid Scenarios is approximately $47 billion.
- The estimated health benefits to Oregon from the TIGHGER Actions, over time through 2050 and beyond, is over $73 billion – creating a combined total net benefit to Oregon of over $120 billion.
- The TIGHGER Actions could create between 283,000 and 357,000 additional net job-years through 2050, with a peak of 25,000 to 32,000 additional job-years per year in the 2026-2027 time period.

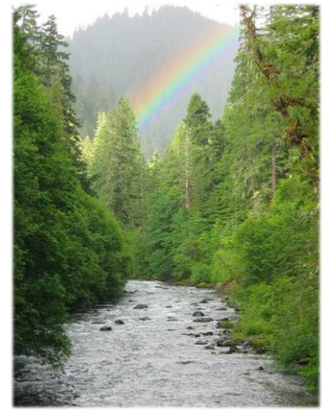
| Cost or Savings Category | Electrification Scenario (Billions $) | Hybrid Scenario (Billions $) |
|---|---|---|
| Capital Investment Costs | **-$83.7** | **-$87.0** |
| Energy Savings | **$108.6** | **$110.4** |
| Operation and Maintenance Savings | **$22.0** | **$23.4** |
| **Net Benefit** | **$46.9** | **$46.8** |
| Oregon Health Benefits | **$75.6** | **$73.5** |
| **Total Net Benefit with Health Benefits** | **$122.5** | **$120.3** |

The OGWC concluded that because it is unlikely Oregon can do all of the TIGHGER Actions all at once, focus should be on prioritizing the actions that offer the biggest reduction in GHG emissions first, followed by cost-effectiveness and co-benefits.

The TIGHGER analysis and OGWC discussions of the findings informed six overarching recommendations and 26 sub-recommendations to inform climate action moving forward. Those recommendations can be found in the Oregon Climate Action Roadmap to 2030.

# INTRODUCTION

The Oregon Global Warming Commission's Oregon Climate Action Roadmap to 2030 developed and analyzed actions across economic sectors to achieve Oregon's sector-based greenhouse gas emission reduction goals for consideration by the Governor, Legislature, and policy makers. The project to develop and model the actions for the Roadmap was called the Transformational Integrated Greenhouse Gas Emissions Reduction Project (TIGHGER Project). This report describes the process and results of the TIGHGER Project analysis.



*In 1990, Oregon's recorded level of greenhouse gases totaled 57.3 million metric tons of CO2 equivalent.*

*By 2021, Oregon's emissions totaled 61.4 million metric tons of CO2 equivalent.*

## Project Background

Oregon is a demonstrated leader on state climate action. In 2007, the Oregon Legislature established the state's first greenhouse gas emission reduction goals:

- By 2010, Oregon will arrest the growth of greenhouse gas emissions and begin to reduce emissions;
- By 2020, Oregon will achieve greenhouse gas levels that are 10 percent below 1990 levels; and
- By 2050, Oregon will achieve greenhouse gas levels that are at least 75 percent below 1990 levels.

In the same year, Oregon created the Oregon Global Warming Commission (OGWC) to steward the state's progress and to advise on mitigation strategies. In the years following, Oregon established one of the nation's first renewable portfolio standards in 2008; doubled the renewable portfolio standard in 2016 to 50 percent; became the first state in the country to legislatively mandate an end to coal in the state's electricity mix; passed the nation's second low carbon fuel standard; and aggressively pursued transportation electrification through rebates, planning, and incentive programs. Despite this progress, by 2020 Oregon was still falling short of its emission reduction goals.

To address this gap, Governor Kate Brown in March 2020 issued Executive Order 20-04. The order directed 16 agencies and commissions to take specific actions to reduce Oregon's GHG emissions, added an interim GHG emission reduction goal of at least a 45 percent reduction by 2035, and updated the 2050 goal from 75 percent to an 80 percent reduction.

The period between 2020 and 2022 marked significant climate policy accomplishments for Oregon. A dozen key programs and regulations were put in place to reduce GHG emissions. Most notably, the Oregon Legislature passed the landmark clean energy law (HB 2021), and the Oregon Environmental Quality Commission adopted the Climate Protection Program (CPP).

The TIGHGER analysis was designed to inform the next stage of climate planning by analyzing sectoral strategies. The goal of the TIGHGER Project was to advise the Governor and Legislature on the near-term actions for achieving Oregon's GHG emission reduction goals, while continuing to grow Oregon's economy and enhancing equity and quality of life for all Oregonians.

In developing the TIGHGER Project, Oregon forecasted our sector-based GHG emissions and then analyzed of the most effective and least-cost decarbonization actions and pathways available in Oregon. Back in 2012 the OGWC commissioned a marginal abatement cost analysis that informed legislative priorities and executive actions on climate for many years. The TIGHGER Project renews that analysis as Oregon embarks on a path toward more ambitious climate goals.

The OGWC was uniquely suited to guide such an effort with assistance from Oregon Department of Energy (ODOE) staff. The OGWC is an independent body that identifies strategies to reduce GHG emissions and recommends policy measures and other actions to be carried out by state and local governments, as well as non-governmental partners. The OGWC includes 25 members: 11 voting and 14 non-voting members. The voting members include six members with specific sector experience and five at-Large members all appointed by the Governor. The non-voting members include: three non-voting members representing state agencies or academic institutions; seven non-voting members who are state agency directors representing specified state agencies; and four Legislators appointed by the Senate President and House Speaker. (Details about OGWC members: https://www.keeporegoncool.org/commission-members).

The OGWC is directed by statute to produce a biennial report to the Governor and Legislature on Oregon's progress toward meeting the state's GHG emission reduction goals. In addition, the OGWC may recommend statutory and administrative changes, policy measures and other recommendations that state and local governments, businesses, nonprofit organizations or residents should undertake to meet the goals. In developing its recommendations, the OGWC is directed to consider economic, environmental, health and social costs, and the risks and benefits of alternative strategies, including least-cost options, and additional policies and programs needed to reduce greenhouse gas emissions.

In 2010, the OGWC developed a set of recommended sector-based actions known as the *Roadmap to 2020*. The TIGHGER Project updated that Roadmap, built upon previous and on-going Oregon and regional studies, and helped create a new Roadmap. The TIGHGER Project used the traditional "biggest bang for the buck" analysis (i.e., marginal abatement cost), augmented with a co-benefits assessment, to identify the transformative sector-based emission reduction actions across sectors of the economy (an integrated strategy) needed to meet Oregon's GHG emission reduction goals. The OGWC acted as the Steering Committee for this project; ODOE provided overall project management expertise, directed the work of consultants, facilitated stakeholder engagement, and provided in-kind technical support to the project.

## TIGHGER Project Scope of Work

The strategy of the TIGHGER Project was to first total all the planned GHG emission reductions from the programs and regulations adopted and already in place in Oregon. By doing so, it was possible to determine whether the amount was sufficient to achieve the 2035 reduction goal. If the analysis showed an emissions gap, the next step would be to identify sufficient actions to fill the gap and achieve the 2035 GHG emission reduction goal. The steps in the process were:

1. Create a Reference Case or Business-As-Usual forecast of GHG emissions.
2. Forecast the GHG emission reductions from Oregon programs and regulations already adopted.
3. Develop a list of potential emission reduction actions (actions).
4. Analyze the cost and GHG reduction amounts of each potential action and develop sector-based Marginal Abatement Cost Curves (MACC) showing the cost-effectiveness of each action.
5. Determine and analyze the co-benefits of each action.

6. Score and rank the actions using agreed upon evaluation criteria.
7. Create a new Roadmap to meet our GHG emission reduction goals with specific action implementation plans for each recommended action.

To help undertake the TIGHGER Project, in May 2020, ODOE secured a $252,000 grant from the U.S. Climate Alliance to hire a consultant to model the actions to determine their cost, their GHG reduction amount, and any interactions among the actions. Sustainability Solutions Group (SSG) was selected in late June 2021 to do the modeling for the TIGHGER Project. SSG was selected in part because they already had a sophisticated and complex sector-based systems model that could easily be adapted for Oregon, and in part because of their extensive modeling experience that was rooted in objective analysis. The OGWC first reviewed the overall project steps and the consultant's scope of work on August 4, 2021.[1] SSG began their work by reviewing dozens of relevant Oregon documents and reports[2] to assess Oregon's climate change landscape.[3]

As part of the second and third steps of the process, the project team met with nine separate Oregon state agencies,[4] held two stakeholder virtual meetings attended by 95 people,[5] and received 75 comments from individuals and organizations through an online portal.[6] The stakeholder comments resulted in ODOE staff adding 20 new actions, revising 40 actions, and consolidating actions to reduce overlap. The most feedback focused on the forestry sector (24 percent of the comments), the buildings sector (23 percent), and the energy sector (17 percent).[7] SSG used this input to create a catalog of potential actions to be used in the modeling.

## The SSG Model

SSG's model is called the *Energy Systems Simulator* (ESS) and is an energy, emissions, and finance accounting tool. SSG has been refining and perfecting their model for the last 20 years. The model incorporates and adapts concepts from the system dynamics approach[8] to complex systems analysis. The model is an economy-wide model that is built up from the details at the county level and then aggregated at the state level.

Because GHG emissions result largely from the use of energy, ESS models energy feedstocks in Oregon (such as renewable resources and conventional fuels) and the equipment that consumes energy in Oregon (such as vehicles, appliances, buildings, etc.). Further, it models the relationships between the energy feedstocks and the equipment that consume that energy.

SSG collaborated extensively with agencies to collect and process Oregon-specific data and to reflect Oregon-specific program goals and forecasted outcomes. A key outcome from the project is a customized model with county-level resolution for Oregon, and a representation of Oregon's unique set of policies and programs, Oregon's specific built environment, and Oregon's demographics. The model can assess the impacts of programs and policies for each county as well as for the state as a whole. ESS

[1] See meeting materials from August 4, 2021.
[2] See the List of Background Documents.
[3] See the TIGHGER Situational Analysis by SSG, October 2021.
[4] See more on the Agency Meetings.
[5] See the meeting presentation slides and meeting recordings for December 7, 2021 and December 8, 2021.
[6] See Stakeholder Comments.
[7] See January 6, 2022 meeting presentation slides.
[8] System Dynamics is a computer-based mathematical modeling approach for strategy development and better decision making in complex systems. This approach uses computer-aided simulation methodology based on feedback systems theory which complements the other Systems Thinking approaches.

was calibrated to observed data specific to Oregon in order to accurately reflect how Oregon's systems operate today. SSG also used the information from the 2019 DEQ GHG Inventory to calibrate the model to be able to replicate Oregon's 2019 sectoral GHG emissions (2019 was the base year for the analysis).

ESS also measures the potential impact of a given set of emissions reduction actions on Oregon's GHG emissions, such as the programs and regulations already adopted in Oregon.[9, 10, 11, 12] The details of these actions were informed through multiple interviews with 9 state agencies, more than 15 OGWC and OGWC committee meetings, and public comments from more than 75 entities. This input served to refine the impact of the actions.

There are four key components of the model's framework: inputting the data, calibrating the model, inputting the actions, and calculating and reporting the model outputs. One of the model's key outputs is how much the set of programs and regulations already adopted would reduce Oregon's emissions. The model also allowed for the exploration of the impacts of new actions on Oregon's emissions. Specifically, for each action the model provides information on its:

- net benefit or cost
- capital investments needed [13]
- energy savings or costs
- price per metric ton reduced (used to create MAC Curves) ($/MTCO2e)

The model also provides outputs that can help evaluate some of the co-benefits[14] of actions. Outputs include:

- social cost of carbon
- overall energy use (per capita for the residential sector and per square foot for the commercial sector)
- overall energy burden reduction for the residential sector
- air pollution and resulting health outcomes and costs
- jobs (created and lost)
- transportation costs

[9] For a detailed explanation of the model, see the TIGHGER Data Methods and Assumptions Manual by SSG.
[10] Also see the Oregon Financial Assumptions by SSG (excel file).
[11] See the SSG modelling deep dive from September 2022.
[12] Also see the TIGHGER Modeling Approach presentation, November 2021.
[13] Capital investments were for only the direct cost to implement the action. This calculation does not include any additional infrastructure needed to enable implementation such as: additional new electric transmission or distribution system investments, pipeline or local distribution system expansion or upgrade investments, or new transportation investments such as EV charging stations.
[14] Co-benefits are the additional benefits attributable to an action beyond the direct GHG reductions, and the financial benefits or the cost of an action. For this project the co-benefits were equity co-benefits, health co-benefits, and jobs and economic prosperity co-benefits.

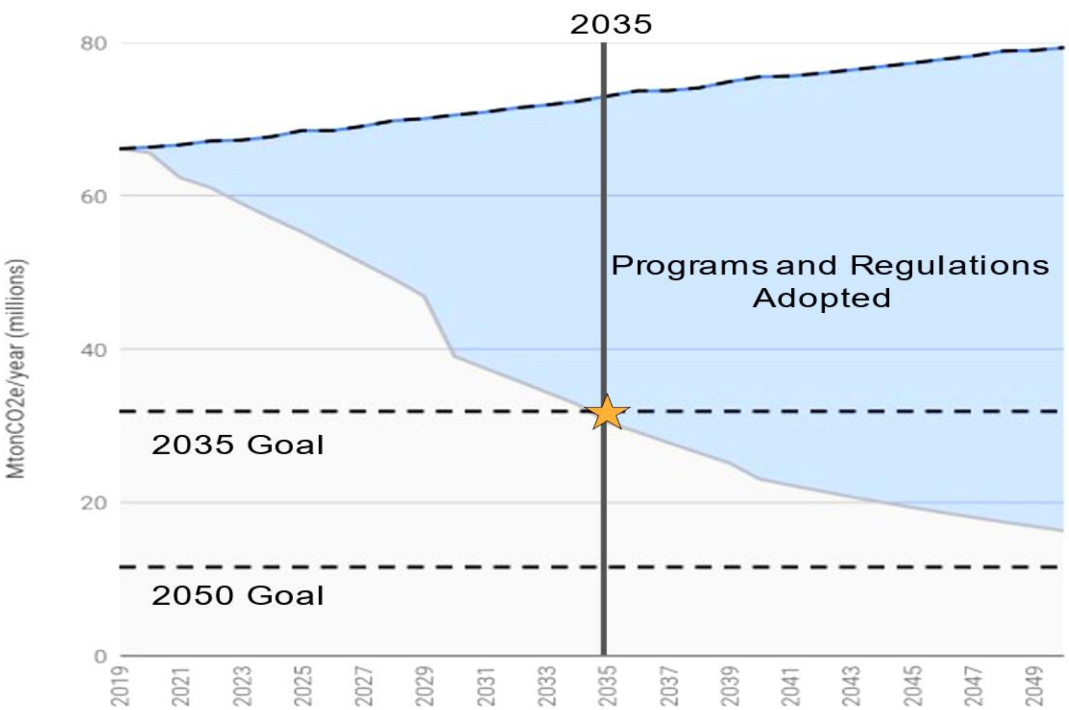
## PROGRAMS AND REGULATIONS ADOPTED

After conducting the modeling analysis that summed up the forecasted reductions from the 15 programs and regulations already adopted, the OGWC found that Oregon is on track to meet its 2035 emission reduction goal. Even though current emission trends are headed in the wrong direction, Governor Brown's EO 20-04, the Legislature, and state agencies have put in place the policy infrastructure to put Oregon on track to achieve its goal. But it will require considerable effort to ensure this policy infrastructure delivers as planned.

**The 15 programs and regulations adopted put Oregon on track to meet its 2035 emission reduction goal.**

In the graph below, the Reference Case forecast, or Business-As-Usual (BAU) forecast, is represented by the dashed line on the top of the graph[15], the forecasted GHG emission reductions from the Programs and Regulations Adopted (PRA) are represented by the blue wedge, and the middle-dashed horizontal line is the current 2035 GHG emission reduction goal amount (45 percent below 1990 emission level). The graph demonstrates that with the programs and regulations adopted Oregon is on track to achieve its EO 20-04 2035 goal (denoted by the gold star). The cumulative total of the reductions required by, or created by, the programs and regulations adopted, will be reducing Oregon's GHG emissions by 42.5 million metric tons of $CO_2e$ per year by the year 2035.

**Figure 1: Emission Reductions from Programs and Regulations Adopted**




[15] The Reference Case, or BAU, starts with the Portland State University population forecast and the Oregon Employment Department's employment growth forecast through 2050; then adds the necessary residential buildings and commercial/industrial buildings to match those forecasts; and assumes the 2012 CAFE standards for fuel efficiency. For a more detailed explanation of how the BAU was developed see the [presentation from the April 18, 2022 OGWC meeting.]

The 15 Oregon Programs and Regulations Adopted,[16] plus one federal program (the CAFE standards for cars and trucks), are listed in the table below in order of their modeled amount of GHG emission reduction.[17] Two of the programs account for most of the emission reductions from electricity and direct use fossil fuels. The first is the Oregon Legislature's clean electricity law (HB 2021) which accounts for over half (nearly 52 percent) of the modeled emission reductions by 2035. It requires investor-owned utilities (Portland General Electric and PacifiCorp) and electricity service suppliers to reduce their GHG emissions associated with electricity sold in Oregon, compared to a 2010-2012 average baseline: 80 percent by 2030, 90 percent by 2035, and 100 percent by 2040 – effectively requiring emission-free electricity by 2040.

The second is Oregon DEQ's Climate Protection Program (CPP). The program establishes a mandatory, declining emissions limit on fossil fuels used throughout the state. The CPP requires fuel suppliers (natural gas utilities and liquid fuel suppliers) to reduce GHG emissions from fossil fuels[18] 50 percent by 2035, and 90 percent by 2050. Certain stationary sources (a very limited set of emission sources, such as certain manufacturing processes, that emit over 25,000 MTCO2e per year) are also covered by the CPP and are required to implement Best Available Emission Reduction (BAER) strategies. The CPP emissions limit applies to fuels used in the transportation sector (the sector that accounts for the most emissions in Oregon) and in other residential, commercial, and industrial applications, such as heating. There are several ways in which these emissions can be reduced including increased use of biofuels, demand response, energy efficiency, electrification, and potential future technologies like hydrogen. The CPP works in concert with multiple DEQ programs that also reduce the use of fossil fuels in the transportation sector; for example, DEQ's Clean Fuels Program, Clean Fuels Program Expansion, Advanced Clean Cars I & II, and Advanced Clean Trucks. The federal CAFE[19] standards also have the effect of reducing transportation related GHG emissions. Together these programs significantly reduce emissions from gasoline and diesel, accounting for another 28 percent of modeled emission reductions by 2035 (they are identified in the table below with a "CPP"). However, these programs do not reduce GHG emissions from non-transportation uses of natural gas or the covered stationary sources. They will need to rely on other yet-to-be-developed specific actions or programs to comply with the CPP reduction requirements. These remaining GHG emission reductions needed to comply with the overall CPP emission reduction requirements (the "Remaining Climate Protection Program" in the table below) represent about 17 percent of the modeled GHG emission reductions (the vast majority of which are attributable to natural gas use). Together, HB 2021 and the CPP (including related programs) account for over 97 percent of the modeled emission reductions by 2035. The other eight listed programs contribute less than 3 percent of the needed emission reductions.

[16] During the development of the TIGHGER project the 15 "Programs and Regulations Adopted" (PRA) were called the "Programs and Regulations Adopted and Under Development" (PRAUD), because two regulations were not yet adopted into rule by the Environmental Quality Commission. Those two were the Clean Fuels Program Expansion and the Advanced Clean Cars II rules. Near the completion of the TIGHGER Project both were adopted, and thus we no longer needed to refer to them as "under development."

[17] See Programs and Regulations Adopted Descriptions.

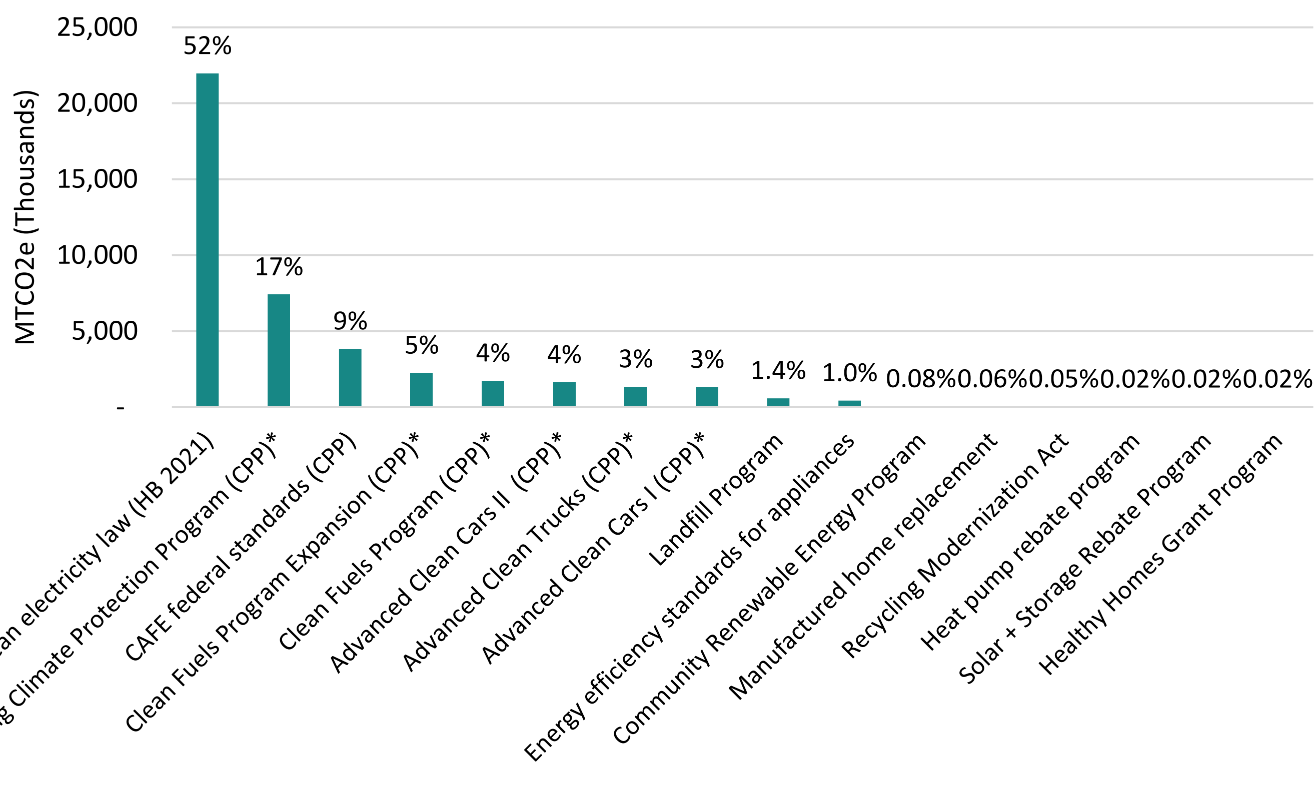
[18] Natural gas, gasoline, diesel, kerosene, and propane.

[19] Corporate Average Fuel Economy, expressed in miles per gallon (MPG), most recently updated in March 2022.

**Table 1: GHG Emission Reductions by 2035 from Programs and Regulations Adopted**

| Rank | Action Title | Annual Emissions Reduced by 2035 (Thousands of MTCO2e) | Percent of Total | Cumulative Percent of Total |
|---|---|---|---|---|
| 1 | Clean electricity law (HB 2021) | 21,962 | 52% | 52% |
| 2 | Remaining Climate Protection Program (CPP)* | 7,402 | 17% | 69% |
| 3 | CAFE federal standards (CPP) | 3,833 | 9% | 78% |
| 4 | Clean Fuels Program Expansion (CPP)* | 2,243 | 5% | 83% |
| 5 | Clean Fuels Program (CPP)* | 1,732 | 4% | 87% |
| 6 | Advanced Clean Cars II (CPP)* | 1,620 | 4% | 91% |
| 7 | Advanced Clean Trucks (CPP)* | 1,335 | 3% | 94% |
| 8 | Advanced Clean Cars I (CPP)* | 1,300 | 3% | 97% |
| 9 | Landfill Program | 581 | 1.4% | 98.76% |
| 10 | Energy efficiency standards for appliances | 424 | 1.0% | 99.76% |
| 11 | Community Renewable Energy Grant Program | 34 | 0.08% | 99.84% |
| 12 | Manufactured home replacement | 26 | 0.06% | 99.90% |
| 13 | Recycling Modernization Act | 21 | 0.05% | 99.95% |
| 14 | Heat pump rebate program | 8 | 0.02% | 99.97% |
| 15 | Solar + Storage Rebate Program | 7 | 0.02% | 99.98% |
| 16 | Healthy Homes Grant Program | 7 | 0.02% | 100.0% |
| **Total** | | **42,535** | **100%** | **100%** |

**Figure 2: Programs and Regulations Adopted by Percent of Total Needed GHG Emission Reductions by 2035**




**Oregon DEQ programs that affect CPP requirements*

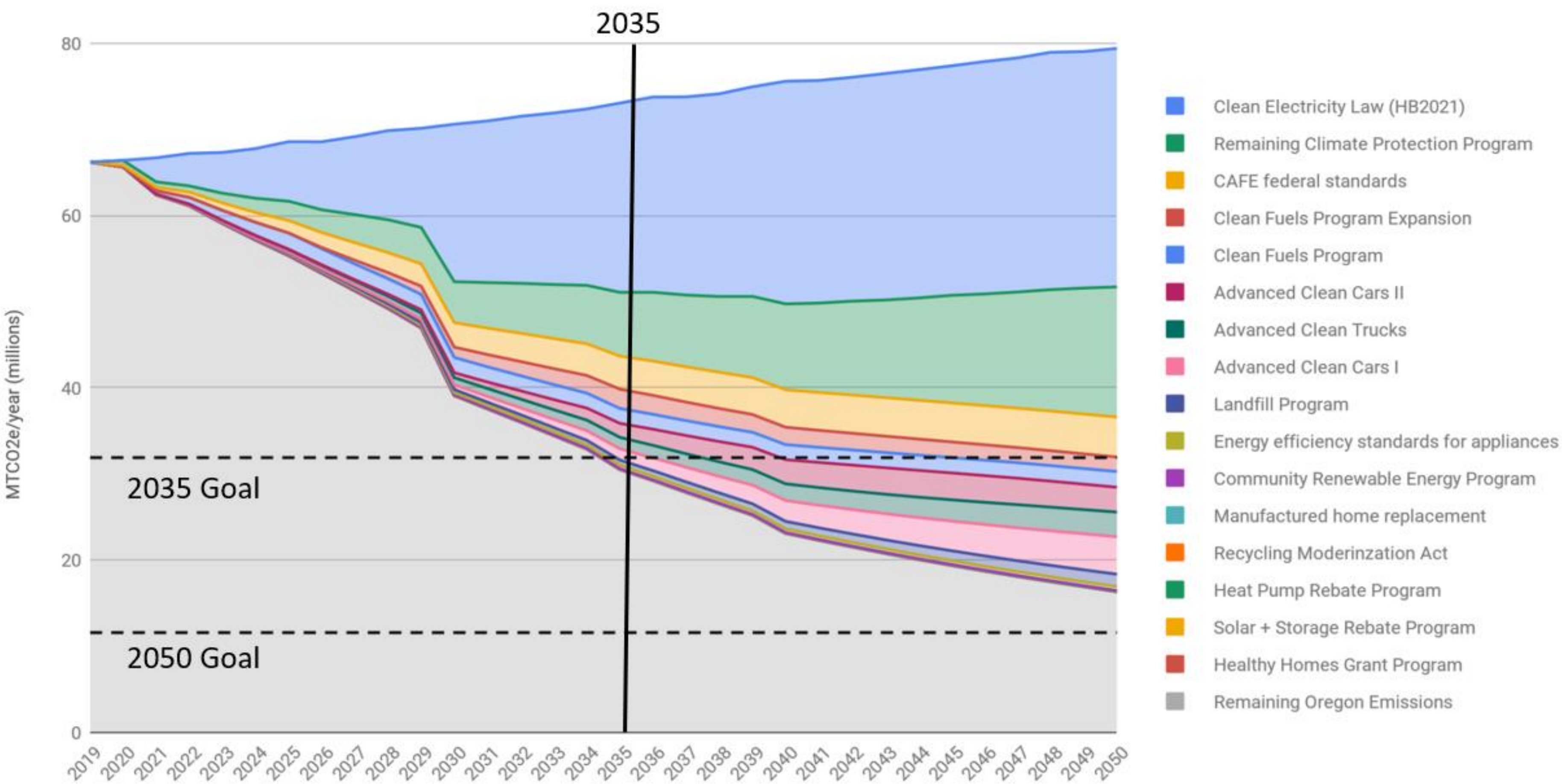
The Clean Fuels Program Expansion was modeled at the originally planned 25 percent increase. The Environmental Quality Commission's decision to increase to 37 percent was made after all the TIGHGER modeling was done, and that increase is not included in this analysis. The overall TIGHGER modeling outcome would likely not change significantly with the higher adopted percent target because fuels are covered under multiple programs. The higher adopted percent target would likely instead redistribute the amount of reductions among these programs, resulting in the Clean Fuels Program Expansion accounting for a higher share of emission reductions.

In addition, there are multiple other agency actions already underway that will create additional sector-based GHG emission reductions for which details were not confirmed or data was not available at the time of modelling. Examples include transportation actions like Every Mile Counts, and land-use actions like Climate-Friendly and Equitable Communities. Some state agencies are focusing on actions that address consumption-based emissions, natural and working lands emissions, and sequestration; these actions were not included in this sector-based analysis.

A recent inventory of the 136 programs and actions being taken by 17 state agencies, boards, and commissions was included in the Oregon Department of Energy's 2022 Biennial Energy Report section *Oregon State Climate Programs and Actions*.

The wedge graph below shows the amount of GHG emission reductions over time from each of the Programs and Regulations Adopted.

**Figure 3: GHG Reduction Wedges from Programs and Regulations Adopted**



The work required to fulfill the promise of all these Programs and Regulations Adopted should not be underestimated. Oregon can only achieve our 2035 goal if the Programs and Regulations Adopted continue to operate as planned and are provided the necessary staffing and resources. A good example of this is the multitude of programs needed to acquire the significant amount of energy efficiency and renewable energy resources (e.g., utility-scale solar, onshore wind, offshore wind, geothermal, hydro, biomass, and marine energy) to comply with the HB 2021 clean electricity requirements by 2040.

**Oregon can only achieve its 2035 goal if the programs and regulations adopted continue to operate as planned and are provided the necessary staffing and resources.**

## TIGHGER SCENARIOS AND ACTIONS TO MEET THE 2035 GOAL IN 2030

With the insight that Oregon is on track to meet the 2035 goal with existing programs and regulations, the OGWC considered a revised goal that is consistent with the best available science from the Intergovernmental Panel on Climate Change (IPCC), federal GHG emission reduction goals, and the GHG emission reduction goal of Oregon's West Coast neighbors that have adopted more ambitious goals than our current 2035 goal. The IPCC indicates that immediate action is necessary to substantially reduce emissions in the near-term to limit average global temperature rise to 1.5 degrees Celsius.[20] The OGWC decided to investigate what additional actions would be necessary to meet an accelerated GHG emission reduction goal in 2030, or five years earlier. This new set of actions would be in addition to all the current and future actions necessary to implement the Programs and Regulations Adopted. These additional actions, or TIGHGER Actions, would need to reduce Oregon's annual emissions by a total of another 8 million metric tons of GHG emissions by 2030.

Understanding that there are different pathways to achieve the accelerated goal of 2030, two pathways or scenarios were developed for modeling. The first scenario was comprised exclusively of electrification actions and the second emphasized alternative fuel actions. While electrification actions with sufficient GHG emission reductions were able to be selected to meet the accelerated goal, there were insufficient alternative fuels actions (i.e., renewable natural gas and renewable clean hydrogen) available to fully meet the accelerated goal. As a result, the alternative fuel actions were supplemented with electrification actions resulting in a new hybrid scenario.

The actions selected for the Electrification and Hybrid Scenarios were winnowed from the initial catalog of potential actions compiled at the beginning of the project. That catalog of potential actions started with 125 ideas, 18 were removed because of a lack of data, leaving 107 actions. Thirty-seven were further removed because they were related to natural and working lands sequestration and embodied carbon from materials that do not reduce sector-based emissions. Thirty-five actions were removed because they were assumed to be implemented as part of the programs and regulations already adopted, leaving a pool of 35 actions to apply to the Electrification and Hybrid Scenarios – the TIGHGER Actions.[21] Twenty-three of the electrification actions were incorporated into the Hybrid Scenario and are

[20] To reduce the risks and impacts of climate change, the parties to the Paris Agreement agreed to take collective action to prevent global temperatures from increasing by more than 2°C above pre-industrial levels, and to strive to prevent global temperatures from increasing above 1.5°C. According to the Intergovernmental Panel on Climate Change (IPCC), limiting warming to 1.5°C would greatly reduce the scale, intensity, and frequency of extreme climate events in comparison to 2°C of warming. To do so, requires immediate action to substantially reduce emissions. Further, given the global nature of the target, developed countries who have contributed more to the emissions problem and have more resources to address the problem (like the United States) should arguably be setting the strongest reduction targets.

[21] See the TIGHGER Final Action List (excel file).

common to both scenarios. Twelve actions were unique to one or the other scenario (five in the Hybrid Scenario and seven in the Electrification Scenario). In the table below, the TIGHGER Actions that are unique to the Electrification Scenario are shaded green and the unique Hybrid Scenario actions are shaded orange, all the non-shaded actions are common to both scenarios.

A list of the TIGHGER Actions shown in the table below are sorted by their cumulative GHG emission reduction amounts for the period of 2022 through 2050 (highest first).[22] Calculated GHG reduction amounts from each action are only the direct emission reductions (scope one emissions) and not the secondary or tertiary emission reductions. Only the GHG emissions reductions from direct energy use reduction or avoided emissions caused by an action were calculated. In addition, the GHG emission reductions of some relevant actions were lowered by varying degrees because part of the action was deemed to be addressed in the programs and regulations required to meet the CPP.

[22] The ranking uses the higher emission reduction amount from either the Electrification or Hybrid Scenario for each action.

### Table 2: TIGHGER Actions by GHG Emission Reduction Amount [23]

| Action Description | Category | Abbreviated Action Title (used in graphs) | Potential Cumulative GHG Emission Reductions (MTCO2e) (2022-2050) |
|---|---|---|---|
| RNG Use at Full Potential by 2050 (47.5 tBTU by 2050, with 10.6 tBTU from Oregon, and 36.5 tBTU from Imports)[24] | RNG | RNG Full Potential by 2050 | 22,617,000 |
| Weatherize 95% of Existing Commercial Building Envelopes by 2040 (to achieve 50% reduction in energy use)[24] | Building Energy Efficiency | Wz 95% Existing Com by 2040 | 21,128,000 |
| Weatherize 95% of Existing Residential Home Envelopes by 2040 (to achieve 50% reduction in energy use)[24] | Building Energy Efficiency | Wz 95% Existing Res by 2040 | 19,578,000 |
| Industrial Renewable Hydrogen Adopted by 70% by 2050[24] | Renewable Hydrogen | Ind RH2 70% by 2050 | 18,863,000 |
| Rooftop Solar 16.3 TWh by 2035 | Renewables | Rooftop Solar | 17,757,000 |
| Improve Energy Efficiency of Existing Non-CPP Covered Industrial Facilities by 50% by 2050[24] | Industrial Energy Efficiency | Non-CPP Ind EE 50% by 2050 | 13,621,000 |
| Implement the Medium and Heavy-Duty Vehicle Zero Emission Plan by 2050 (beyond Advanced Clean Trucks) (Ending fuel shares of: 60% EV, 20% Hydrogen, 20% Biodiesel; and Hybrid has 10% Fuel Cell EVs)[24] | Transportation | MD/HD Zero Emission Plan by 2050 | 12,337,000 |
| Commercial Code Energy Reduction 60% by 2030 | Building Energy Efficiency | Com Code Reduction 60% by 2030 | 11,751,000 |
| 100% Heat Pumps & Water Heaters in New Residential Homes by 2025[25] | Building Energy Efficiency | 100% HP & WH in New Res by 2025 | 10,182,000 |
| Electrification of Industrial Process Loads 70% by 2050[24] | Industrial Electrification | 70% Electrification Ind Process by 2050 | 10,129,000 |

[23] For a list of the TIGHGER actions by modeling number see TIGHGER Actions Table by Modeling Number.

[24] The GHG emission reductions for this action was lowered by a varying degree because part of the action was deemed to be addressed in the programs and regulations required to meet the CPP.

[25] 100% electric in Electrification Scenario, and a 50/50 split electricity/natural gas for the Hybrid Scenario.

| Action Description | Category | Abbreviated Action Title (used in graphs) | Potential Cumulative GHG Emission Reductions (MTCO2e) (2022-2050) |
|---|---|---|---|
| Residential Code Energy Reduction 60% by 2030 | Building Energy Efficiency | Res Code Reduction 60% by 2030 | 8,044,000 |
| Injection of 15% Renewable Hydrogen Into Distribution System by 2035[24] | Renewable Hydrogen | RH2 Injection 15% by 2035 | 6,763,000 |
| Increase Amtrak Ridership | Transportation | Increase Amtrak Ridership | 5,497,000 |
| Carshare Increases in Urban Areas by 2035 | Transportation | Carshare Increases by 2035 | 5,042,000 |
| 100% of Existing Residential Homes retrofitted with Heat Pumps by 2043[24] [25] | Building Energy Efficiency | Existing Res Buildings 100% HP by 2043 | 4,523,000 |
| 100% of Existing Residential Homes retrofitted with Heat Pump Water Heaters by 2043[24] [25] | Building Energy Efficiency | Existing Res Buildings 100% HPWH by 2043 | 4,470,000 |
| 100% Heat Pumps and 50% Water Heaters in New Commercial by 2025[24] [25] | Building Energy Efficiency | 100% HP & 50% WH in New Com by 2025 | 4,366,000 |
| 50% of New Off-road Vehicles Sales (farm, forestry, construction, and recreation) are ZEVs by 2035, 100% by 2050 | Transportation | 50% Off-Road Vehicle Sales ZEVs by 2035 | 3,802,000 |
| 100% of New Transit Buses are ZEVs by 2035[24] | Transportation | 100% New Buses are ZEVs by 2035 | 3,694,000 |
| Implement an Electric Micro-Mobility Strategy, E-Bikes & E-Scooters Gain 10% Mode Share in Portland Metro and Eugene Counties by 2035 | Transportation | 10% Micro-mobility by 2035 | 3,615,000 |
| Fuel Cells in 5% of Residential Homes by 2030[24] [25] | Renewable Hydrogen | Home Fuel Cells 5% by 2030 | 3,409,000 |
| 100% of Existing Commercial Buildings retrofitted with Heat Pumps by 2043[24] [25] | Building Energy Efficiency | Existing Com Buildings 100% HP by 2043 | 3,055,000 |
| Increase Integrated Solar Generation on New Building Facades 4 TWh by 2035 | Renewables | Solar on New Buildings | 2,648,000 |
| Food Waste Program Diverting 50% of Organics and Capturing Methane by 2030 | Waste | Food Waste Program | 2,572,000 |
| Water Systems improve Energy Efficiency 20% by 2035 | Industrial Energy Efficiency | Water Systems EE 20% by 2035 | 2,286,000 |

| Action Description | Category | Abbreviated Action Title (used in graphs) | Potential Cumulative GHG Emission Reductions (MTCO2e) (2022-2050) |
|---|---|---|---|
| Congestion Pricing Achieves a 10% Transport Mode Shift Away From Private Cars to Transit in Multnomah, Lane, and Washington Counties By 2035 | Transportation | Congestion Pricing | 2,078,000 |
| Energy Storage of 14 kWh in 25% of Residential Homes by 2035 | Renewables | Res 25% Energy Storage | 1,900,000 |
| Reduced Residential Floor Area of New Homes | Land-Use | Reduced Res Floor Area | 1,718,000 |
| Higher Residential Density in Urban Areas | Land-Use | Higher Urban Res Density | 1,315,000 |
| 5% of Fuel Share From Pyrolysis of Biomass by 2035 | Biomass | 5% Fuel Share Biomass Pyrolysis by 2035 | 1,161,000 |
| 100% of Existing Commercial Buildings retrofitted with Heat Pump Water Heaters by 2043[24] [25] | Building Energy Efficiency | Existing Com Buildings 100% HPWH by 2043 | 617,000 |
| Transfer 10% of Medium Duty Vehicle Miles Traveled to Light Duty/Electric Micro-Mobility in Urban Counties by 2035[24] | Transportation | 10% Mode Shift MD to LD | 595,000 |
| Diesel Backup Power 100% Conversion to Battery Storage by 2035 | Renewables | Backup Battery Storage | 482,000 |
| 100% New Appliance Sales for Commercial Buildings are Electric by 2035[24] | Building Energy Efficiency | Non-Heating Equip Elec in All Com by 2035 | 103,000 |
| 100% New Appliance Sales for Residential Homes are Electric by 2035[24] | Building Energy Efficiency | Non-Heating Equip Elec in All Res by 2035 | 55,000 |

*TIGHGER Actions that are unique to the Electrification Scenario are shaded green and the unique Hybrid Scenario actions are shaded orange, all the non-shaded actions are common to both scenarios.*

The table below provides an accounting of the number of TIGHGER Actions by category. It is important to recognize that some actions could fit into multiple categories. For example, the Reduced Residential Floor Area of New Homes action is categorized as a Land-Use action, but it also deals with Building Energy Efficiency. As can be seen in the table, the actions span a variety of categories – with the most actions addressing Building Energy Efficiency and Transportation.

**Table 3: Summary of TIGHGER Actions by Category**

| Action Category | # |
|---|---|
| Building Energy Efficiency | 12 |
| Transportation | 8 |
| Renewable Electricity | 4 |
| Renewable Hydrogen | 3 |
| Industrial Energy Efficiency | 2 |
| Land-Use | 2 |
| Biomass | 1 |
| Industrial Electrification | 1 |
| Renewable Natural Gas | 1 |
| Waste | 1 |

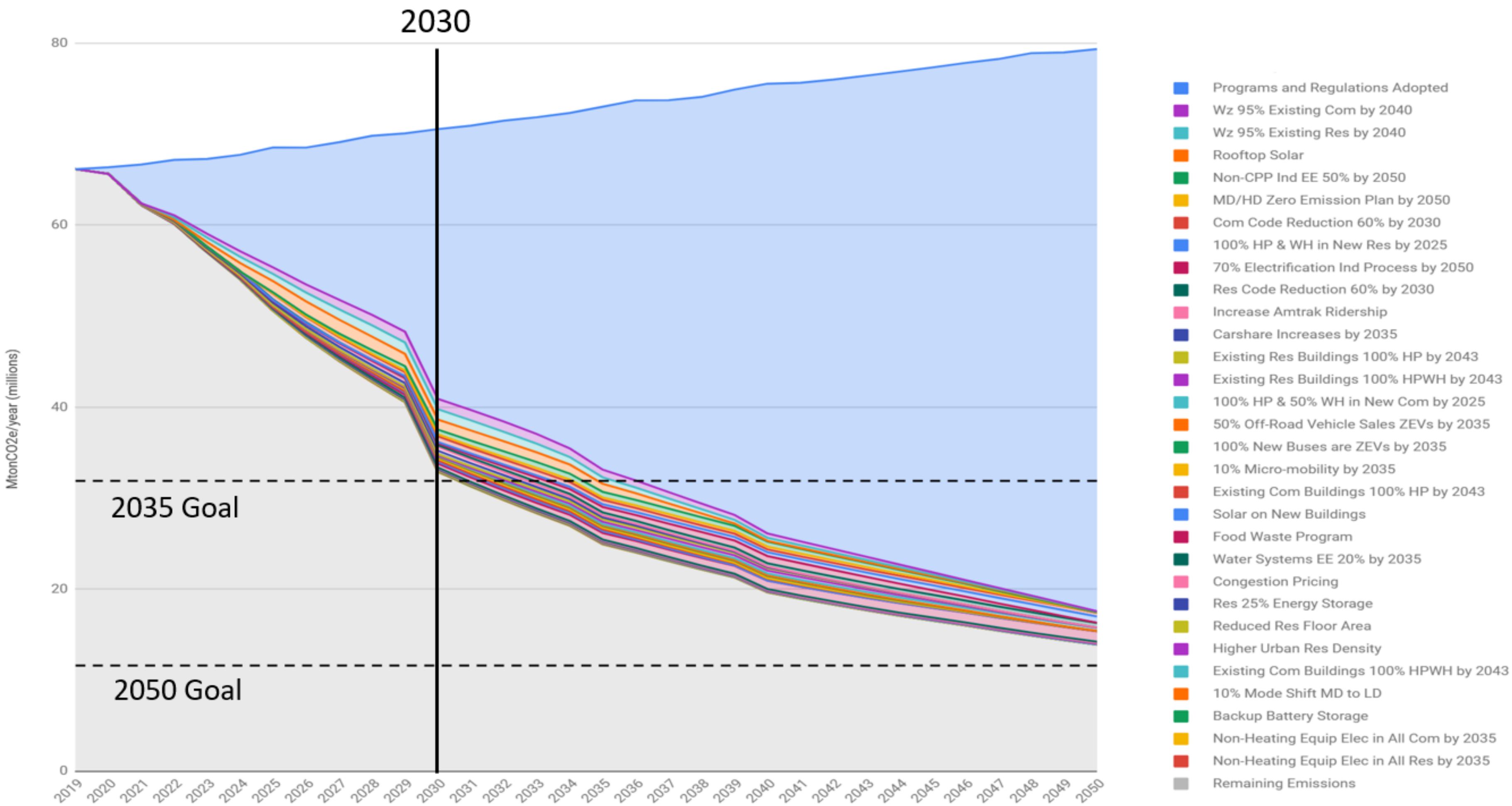
In total, there were 27 Electrification Scenario actions and 25 Hybrid Scenario actions, and ***ALL*** of the TIGHGER Actions in either scenario will need to be implemented for either scenario to achieve the accelerated 2030 reduction goal.

The graphs below show the sets of actions needed for each scenario to meet the accelerated 2030 reduction goal. Each action is represented by a wedge of reductions over time. The Electrification Scenario relies only on electrifications actions, while the Hybrid Scenario relies on many common actions to the Electrification Scenario as well as alternative fuel actions.

**All of the TIGHGER Actions in either scenario will need to be implemented for either scenario to achieve the accelerated 2030 reduction goal.**

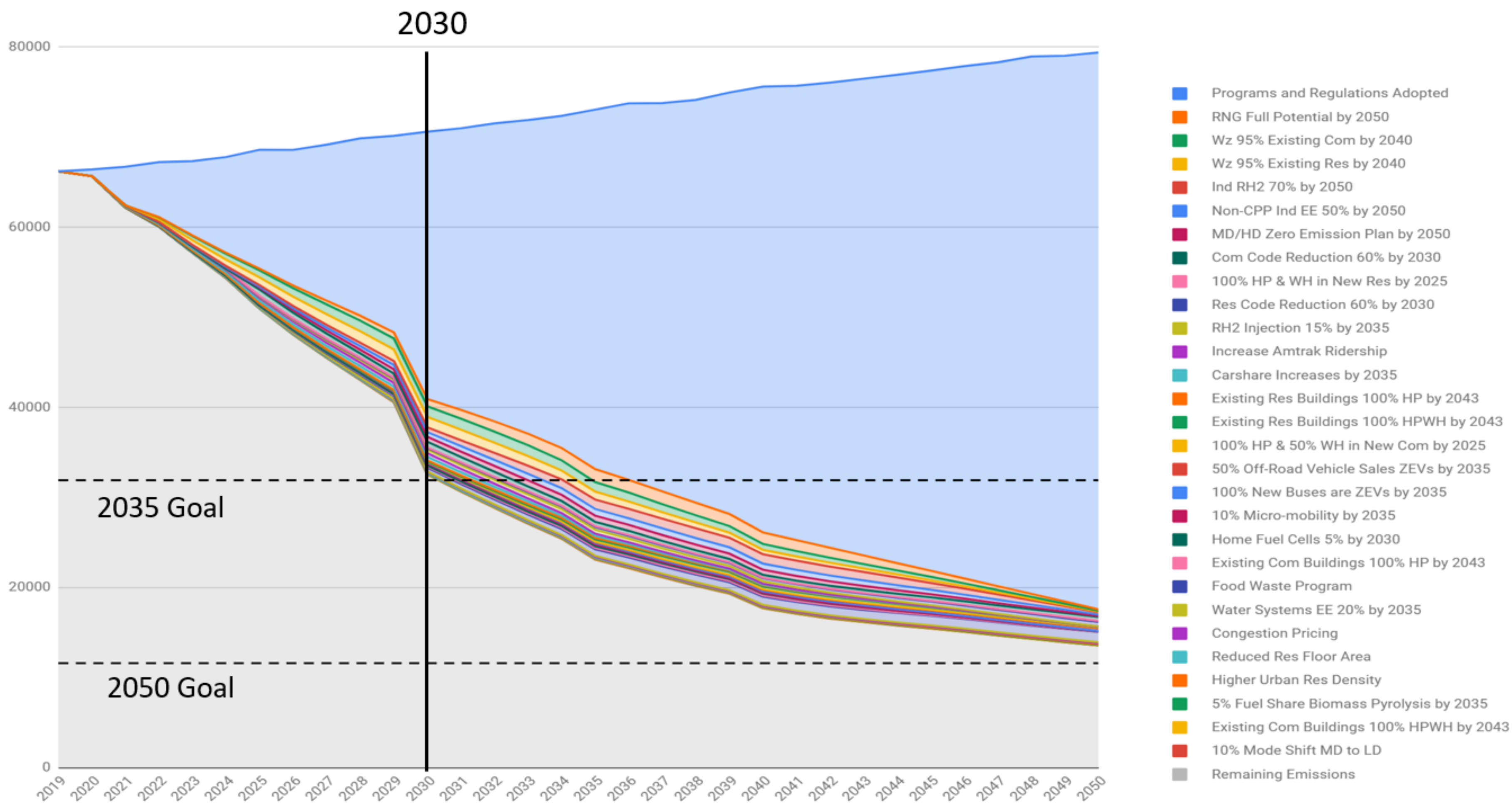
The graph below shows the wedges associated with the Electrification Scenario actions. Note that none of the actions act as "big-lever" actions, they all contribute relatively equal smaller amounts of GHG emission reductions.

**Figure 4: Electrification Scenario Actions Wedges**



The graph below shows the wedges associated with the Hybrid Scenario actions. As with the Electrification actions, none of the actions act as "big-lever" actions, they all contribute relatively equal smaller amounts of GHG emission reductions.

**Figure 5: Hybrid Scenario Actions Wedges**



## ACTION IMPLEMENTATION PLANS

To facilitate advancement of these actions, an Action Implementation Plan (AIP) should be developed for each action. AIPs should include the specifics on who (which agency takes the lead in development), what, where, when, and how the action could be implemented. Some of the actions build on existing programs and regulations, while others may require new authority or direction. In addition, there may be enabling conditions that can help maximize implementation of an action or multiple actions (e.g., more compact land-use supporting a number of the transportation actions). The AIPs will need to: include discussion of the items above, identify funding needs and suggest funding sources (as practicable), and provide enough specific details for agency approval or legislative authorization. In addition, the action's program design should maximize the co-benefits identified by the OGWC. Actions that either do not have an existing delivery pathway, or their delivery mechanism or technology is uncertain or underdeveloped will need particular attention. The OGWC also identified higher risk and uncertainty surrounding some of the actions which should be further considered in developing AIPs for those actions. Development of these AIPs is a large undertaking that will need focused attention and additional ODOE staff resources to support OGWC coordination efforts with other agencies. Other state agencies may also need additional resources to develop the individual AIPs.

## MARGINAL ABATEMENT COST CURVES (MACC)

The marginal abatement cost curve (MACC) is another output from SSG's ESS model. MACCs were developed in 2007 by the consulting firm McKinsey & Company, in collaboration with the Swedish utility Vattenfall. The MACC is used to illustrate opportunities for GHG emission reductions. The marginal abatement cost (MAC) of an action is the cost of avoiding a metric ton of GHG emissions, discounted to present dollars.

MACCs are graphs that essentially show, along the vertical Y-axis, the cost-effectiveness of actions in dollars per metric ton of carbon reduced, or $/MTCO2e. Actions that create savings extend below the x-axis, and those that have a cost extend above the x-axis. If the MAC value is positive that indicates the action creates a net cost, and if the value is negative, it indicates a net savings from the action. The width of the bar illustrates the quantity of GHG emission reductions resulting from each action. Simply put, actions that reduce a large amount of emissions have wider bars, and actions that reduce fewer emissions have narrower bars. A deep and wide bar extending below the x-axis indicates an action that is cost-effective and reduces a great deal of GHG emissions.[26] For policy makers, MACCs can inform several important policy questions:

- Which actions create savings, and which have a cost?
- Which actions save both money and reduce or avoid the most GHG emissions?
- Which actions have a financial profile that is likely to be of interest to the private sector, (e.g., potentially the most cost-effective actions that create substantial savings and thus potential profit for a private-sector company)?
- Are there opportunities to combine or package higher-cost actions with actions that create savings to achieve greater GHG emission reductions, while avoiding lost opportunities (e.g.,

[26] For a more in-depth explanation of the process used to create the MACCs see the Approach to Marginal Abatement Cost Curves developed by SSG for the TIGHGER Project. The Net Present Value of each MAC in the TIGHGER Project is calculated using a 3% discount rate.

requiring actions that have a cost to be done along with actions that have savings to balance the overall cost-effectiveness of the package of actions)?

- Which actions should be considered for investments by governments to reduce the costs through supporting innovation or by providing subsidies?

An important limitation of MACCs to consider is that they do not illustrate the feedback between different actions. Removing an action with a high cost, may for example, decrease the GHG reduction associated from another cost-effective action.

The two graphs below show the MACCs for the Electrification Scenario actions and the Hybrid Scenario actions. Again, the actions on the left side of the graph have the lowest cost and the actions with the widest bars have the largest GHG emission reduction amounts. The actions listed in the legends on the left side of the graph create a net savings, while the actions listed in the legends on the right side of the graph have a net cost.

**Figure 6: Electrification Scenario Marginal Abatement Cost Curve**

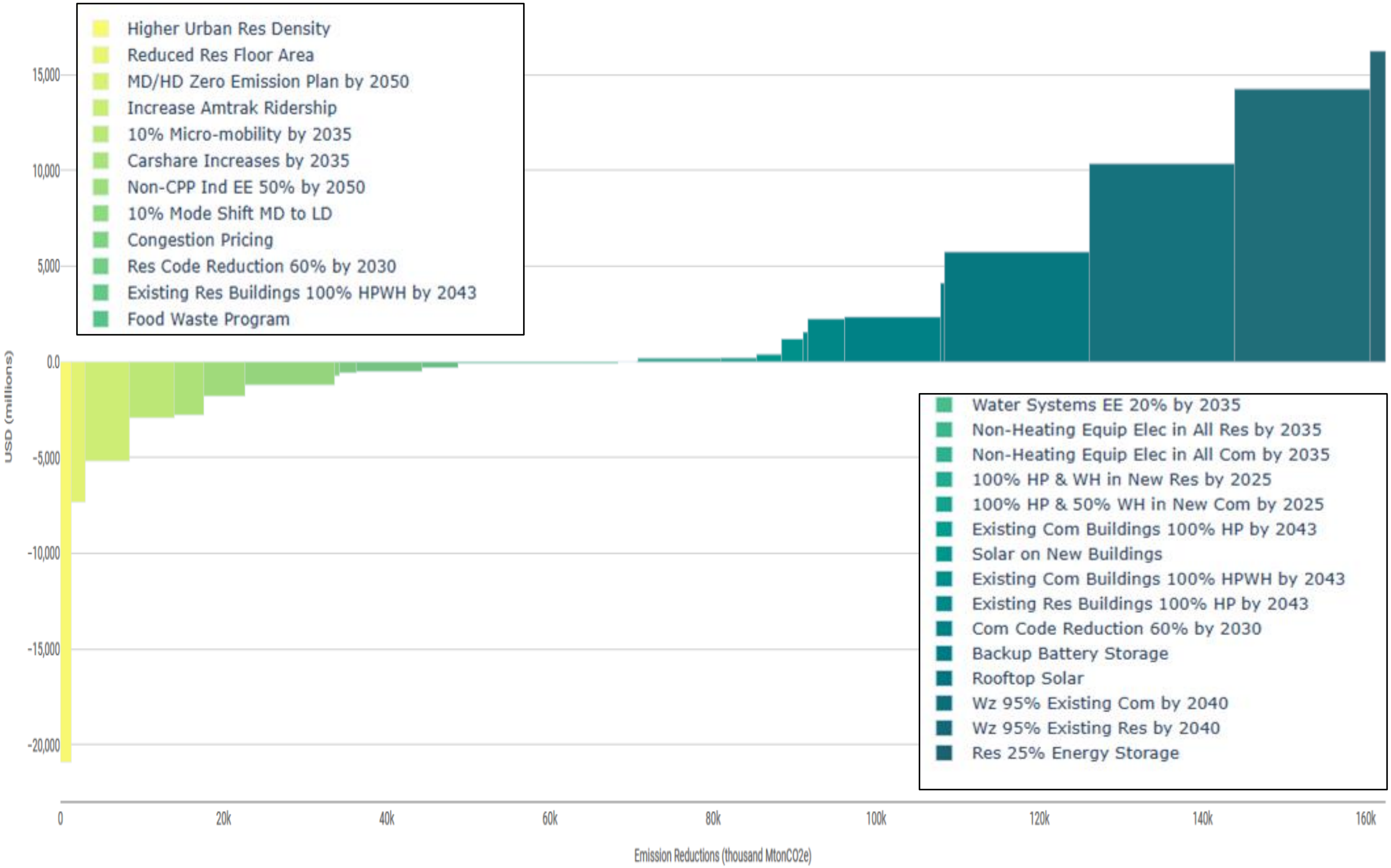
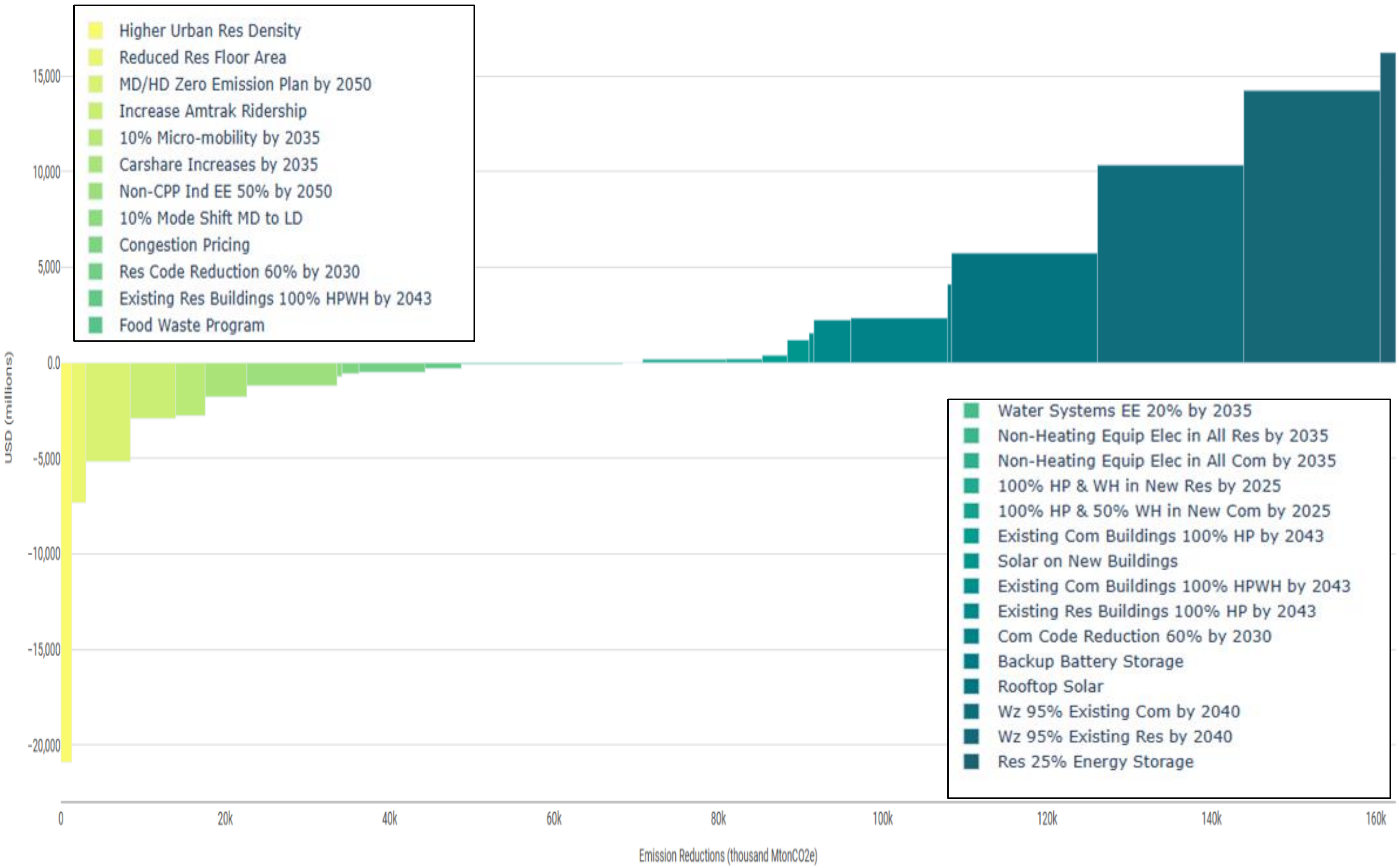


**Figure 7: Hybrid Scenario Marginal Abatement Cost Curve**



## NET FINANCIAL BENEFITS FROM THE TIGHGER ACTIONS

SSG's ESS model calculates annual emission reductions (in MTCO2e/year), capital investments (in $/year)[27], energy savings (in $/year), and operation & maintenance savings (in $/year) for the life of each action. The model starts in 2019, adds actions beginning in 2022, and reports outputs annually for each action. The annual costs or benefits from each action are summed to create an overall annual cost or benefit for the entire scenario. SSG's ESS model uses the summation of annual costs or benefits from 2022 to 2050 (and beyond for some operational costs and benefits that occur after 2050) to calculate the net present value (NPV) for the series of annual cash flows (in 2022$), using a 3 percent discount rate. The NPV represents the amount of money one would need to be given today to be equal in value to the series of annual cash flows. The NPV amount would therefore make one indifferent to taking either the NPV amount today or the series of cash flows – they are equal in value.

The tables below show the NPV of each scenario. The SSG model calculates the NPV of all the capital costs through 2050 necessary to fund the implementation of all the actions in each scenario. This number is a cost, and is depicted in the table below as a negative number in red. The NPV of the Electrification Scenario capital investments is a negative $83.7 billion (a cost), and a negative $87.0 billion for the Hybrid Scenario.[28] The NPV of the savings associated with reduced direct energy use for the two scenarios is a positive $109 billion for the Electrification Scenario (a savings) and $110 billion for the Hybrid Scenario. The NPV of the savings from reduced operation and maintenance (O&M) is a positive $22 billion and $23 billion, respectively. The overall net benefit (savings minus costs) in today's dollars for both the Electrification and Hybrid Scenarios is approximately $47 billion. This finding indicates that after taking into consideration all costs and savings, Oregon would be $47 billion better off having implemented the TIGHGER Actions, making the investments in the TIGHGER Actions a net benefit to Oregon and not a net cost.

The MAC for the combined actions in each scenario is a negative $115/MTCO2e for the Electrification Scenario and a negative $105/MTCO2e for the Hybrid Scenario. Again, a negative MAC number means that there is an overall net savings from implementing these sets of actions (a positive MAC number would indicate a net cost).

**Oregon would be $47 billion better off having implemented the TIGHGER Actions – a net benefit for the state.**

**Table 4: Net Benefits from TIGHGER Actions by Scenario**

| Cost or Savings Category | Electrification Scenario (Billions $) | Hybrid Scenario (Billions $) |
|---|---|---|
| Capital Investment Costs | **-$83.7** | **-$87.0** |
| Energy Savings | **$108.6** | **$110.4** |
| Operation and Maintenance Savings | **$22.0** | **$23.4** |
| **Net Benefit** | **$46.9** | **$46.8** |
| Marginal Abatement Cost ($/MTCO2e) | **-$115** | **-$105** |

[27] Capital investments are only the direct cost of enabling the action; and does not include the cost of any additional infrastructure needed for implementation, such as: electric transmission and distribution upgrade investments, natural gas pipeline and local distribution upgrade investments, or transportation infrastructure investments.

[28] The potential incentive amounts from the federal Inflation Reduction Act (IRA) are not included in this analysis as they were approved after the completion of the financial modeling, and will not be fully developed until late 2023 or early 2024. These potential federal incentives will be included in the next round of analysis for the TIGHGER Project.

## HEALTH BENEFITS FROM THE TIGHGER ACTIONS

SSG's ESS model also calculated the health benefits to Oregon that would result from implementing the TIGHGER Actions. The health benefits are calculated using the USEPA's COBRA model that calculates the avoided health-related cost resulting from reduced air pollution. More specifically, it calculates the health savings that accrue from the resulting reduced mortality, heart attacks, hospital admissions, emergency room visits, and work losses. These health benefits are *in addition to* the $47 billion net benefit calculated above for the two scenarios. The table below shows the estimated health benefits to Oregon, over time through 2050 and beyond from the TIGHGER Actions, are almost $76 billion for the Electrification Scenario and almost $74 billion for the Hybrid Scenario. The combined total net benefit to Oregonians over time would be over $120 billion from implementing the TIGHGER Actions.

**TIGHGER Actions add between $74-76 Billion in health benefits for Oregon.**

**Table 5: Health Benefits from the TIGHGER Actions**

| Cost or Savings Category | Electrification Scenario (Billions $) | Hybrid Scenario (Billions $) |
|---|---|---|
| Oregon Health Benefits | **$75.6** | **$73.5** |
| **Total Net Benefit with Health Benefits** | **$122.5** | **$120.3** |

## THE SOCIAL COST OF CARBON FROM THE TIGHGER ACTIONS

The Social Cost of Carbon (SCC) is another output modeled. SCC represents the NPV of the economic damages associated with emitting one ton of greenhouse gases or carbon dioxide. Calculating the SCC involves translating GHG emissions into changes in atmospheric greenhouse gas concentrations, and then in turn translating atmospheric concentrations into changes in temperature, temperature changes into other climate hazards, and climate hazards into economic damages. In economic terms, the negative effects of emitting GHG emissions represent an "externality," meaning that the prices of "goods and services" that cause GHG emissions do not incorporate the cost of these harms on society. SCC is used by the federal government and states to evaluate the costs and benefits of implementing actions that either increase or decrease carbon emissions. However, the SCC represents the value of the avoided damages (using a 3 percent discount rate) beyond Oregon's borders and represents a *global value of avoided damage*. So, a good portion of the SCC's value does not accrue directly to Oregon. Notwithstanding this caveat, the table below shows that the TIGHGER Actions create an additional SCC avoided harm of between $65 and $69 billion.[29]

**Table 6: Social Cost of Carbon from the TIGHGER Actions**

| Cost or Savings Category | Electrification Scenario (Billions $) | Hybrid Scenario (Billions $) |
|---|---|---|
| Global Social Cost of Carbon | **$68.7** | **$65.1** |

[29] See ODOE's primer on the Social Cost of Carbon for more information.

## YEAR-OVER-YEAR RESULTS

As was mentioned above, SSG's ESS model calculates the annual capital expenditures needed statewide to implement the TIGHGER Actions, as well as their annual energy and operation and maintenance savings. The graphs below show the aggregate annual statewide capital expenditures (blue bars), the annual energy savings (yellow bars), and the annual operations and maintence savings (red bars) starting in 2022 on the left and going to 2050 on the right. The black line shows the cumulative net cost or benefit over time. The graphs show that while there is the usual upfront cost associated with implementation of the TIGHGER Actions, after nine years Oregon would start to see a net benefit, and that net benefit would continue and grow through 2050 and beyond — creating significant net benefit to Oregonians over time.

**Figure 8: Electrification Scenario**
**Year-Over-Year Investments and Returns**

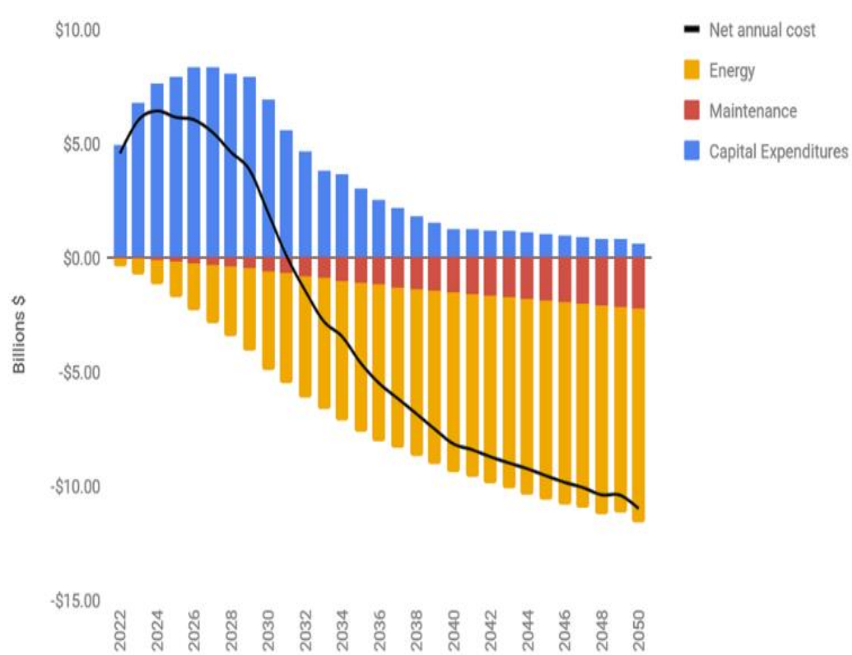
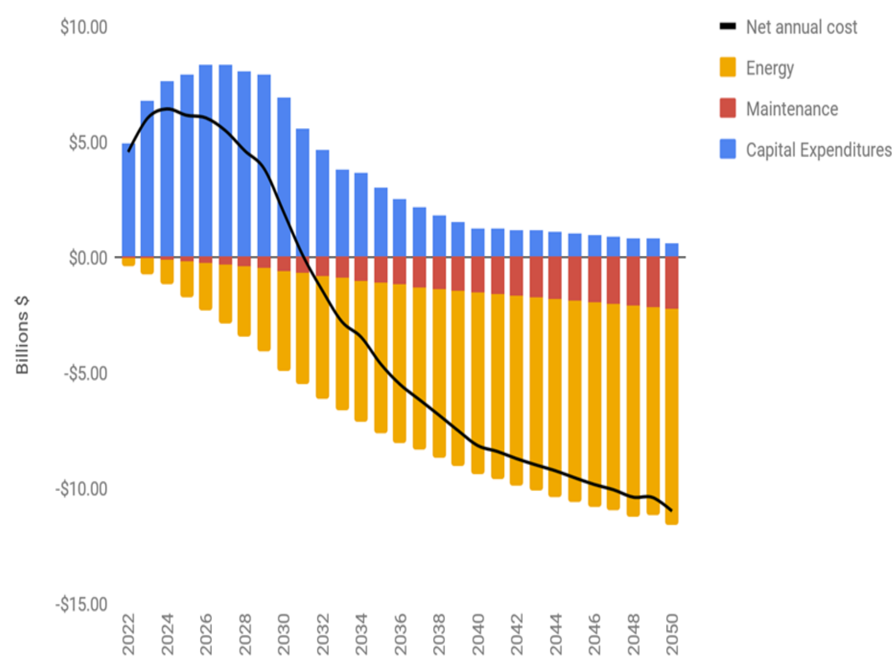



**Figure 9: Hybrid Scenario**
**Year-Over-Year Investments and Returns**



The graphs below start with the graphs above and add the annual statewide health benefits (green bars) to the graph. Because the statewide health benefits accrue over time, they add significant net benefits to Oregonians in the later years.

**Figure 10: Electrification Scenario**
**Year-Over-Year Investments and Returns with Health Benefits**

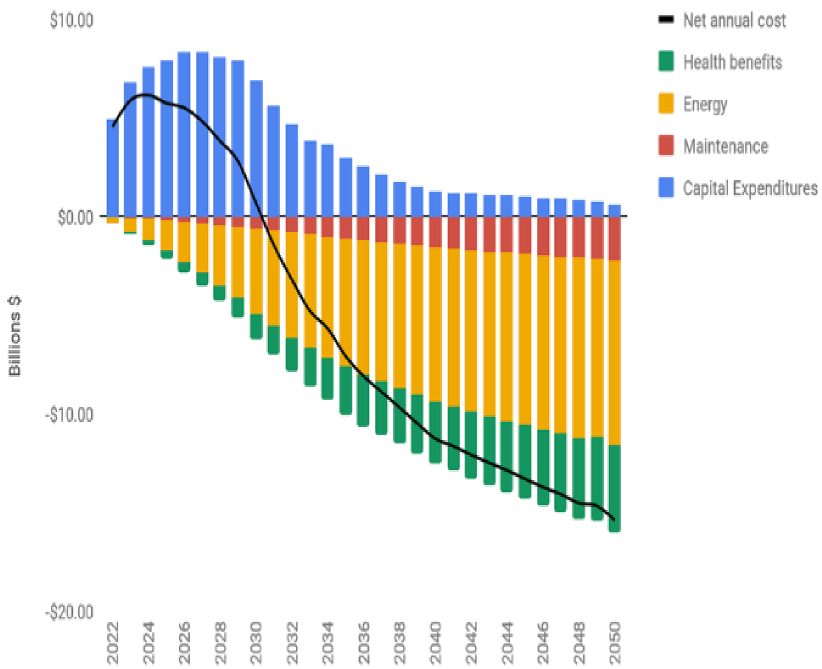
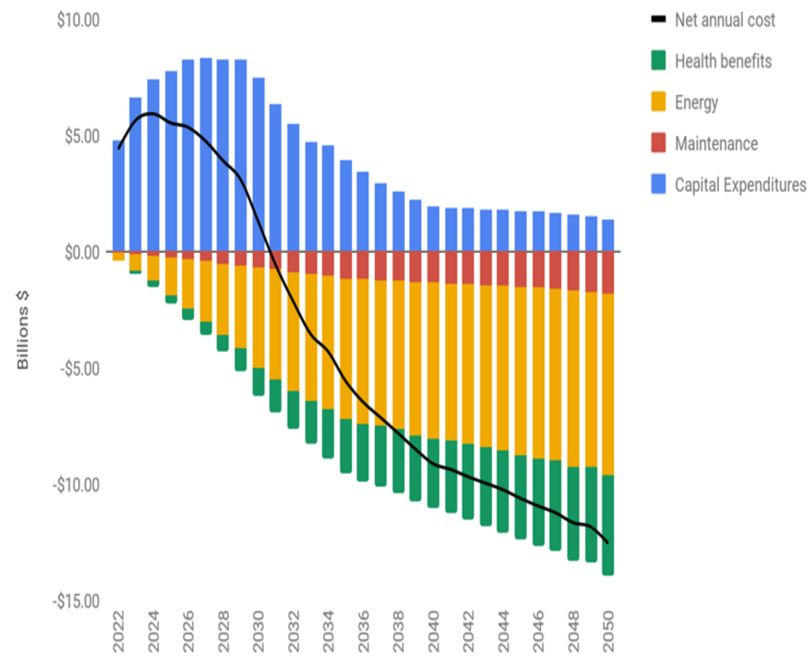



**Figure 11: Hybrid Scenario**
**Year-Over-Year Investments and Returns with Health Benefits**



Since SSG's ESS model is built by inputting data at the county level and then aggregating the county data up to get the total for the state, the model is able to show the health savings at the county level. The graphs below show the 2050 per capita ($ per person) annual health savings for each county in Oregon. It should be noted that all counties in Oregon see health benefits. The yellow counties will see the highest per capita savings ($1,000-$1,200 per person), and the purple counties will see lower health savings (less than $200 per person). Health savings are directly related to the reduction in air pollution, which is why the biggest savings occur in the counties with the highest population and the biggest opportunity to reduce air pollution. Therefore, the Portland metro area sees the biggest health savings while the relatively low populated areas in the east of the state with less air pollution will see lower amounts of health savings.

**Figure 12: Electrification Scenario 2050 Health Benefits by County ($ per person)**

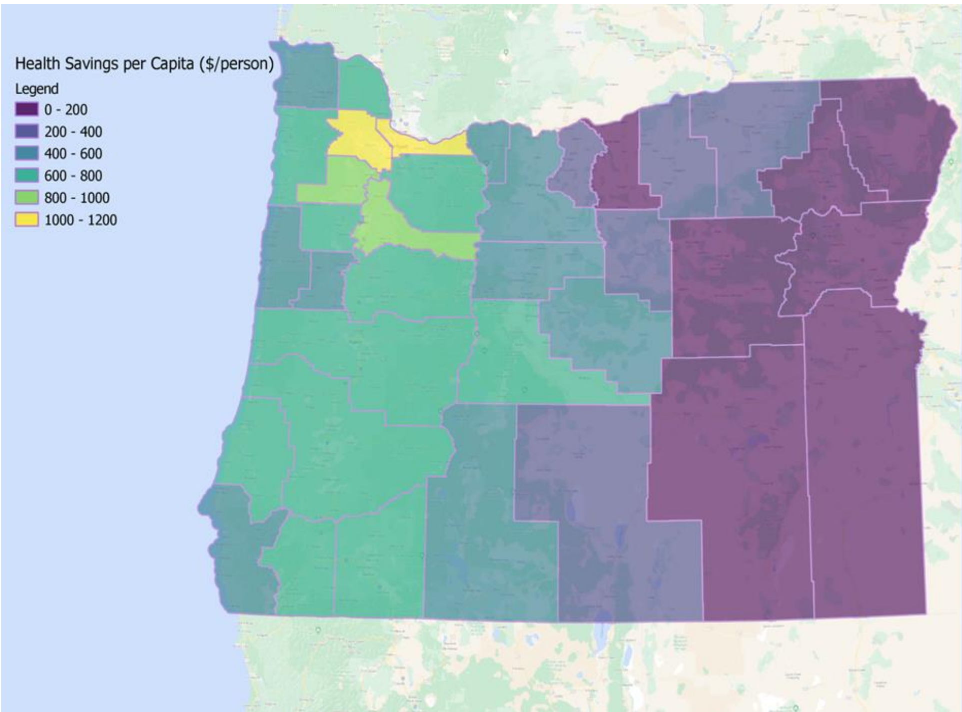
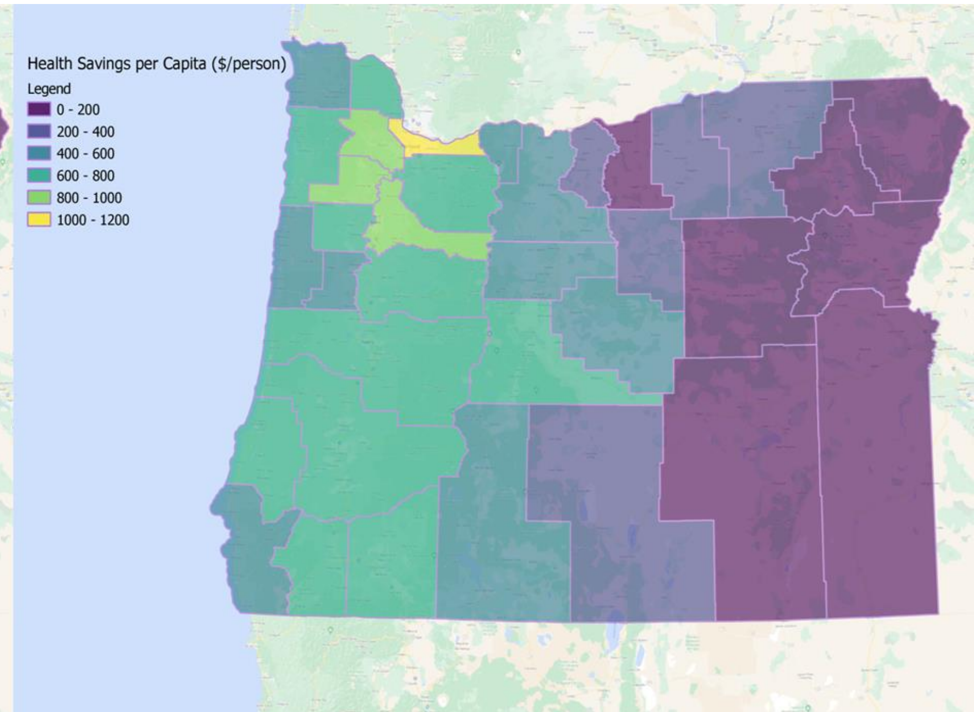



**Figure 13: Hybrid Scenario 2050 Health Benefits by County ($ per person)**



Another output of the SSG model is the job-years created by the actions. The graphs below show the annual net job-years created from the TIGHGER Actions. A job-year is equivalent to one fulltime job for one year. The analysis shows that the Electrification Scenario will create an additional 357,000 net job-years through 2050, and the Hybrid Scenario will create an additional 283,000 net job-years. The peak years for job creation are in 2026-2027 with more than 32,000 additional job-years per year in the Electrification Scenario and more than 25,000 in the Hybrid Scenario.

**Figure 14: Electrification Scenario Net Annual Job-Years of Employment**

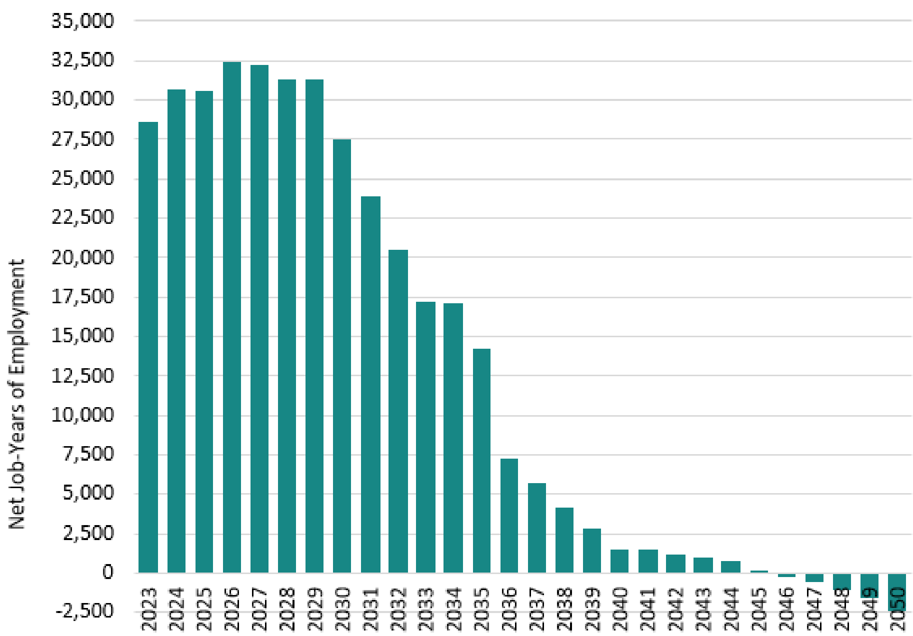
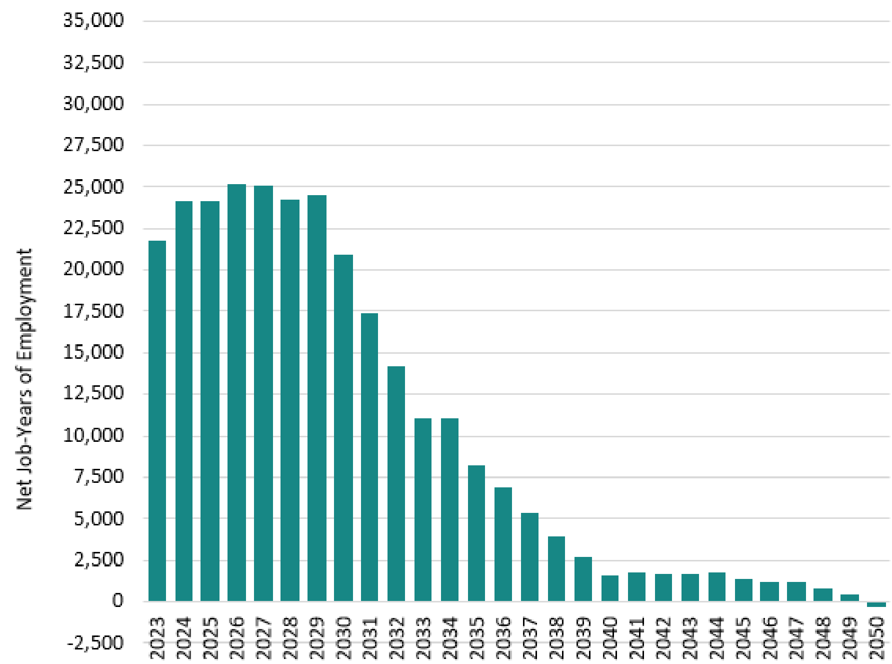



**Figure 15: Hybrid Scenario Net Annual Job-Years of Employment**



The maps below show the amount of total job-years employment increase by 2050 at the county level:

**Figure 16: Electrification Scenario 2050 Job-Year Creation by County**

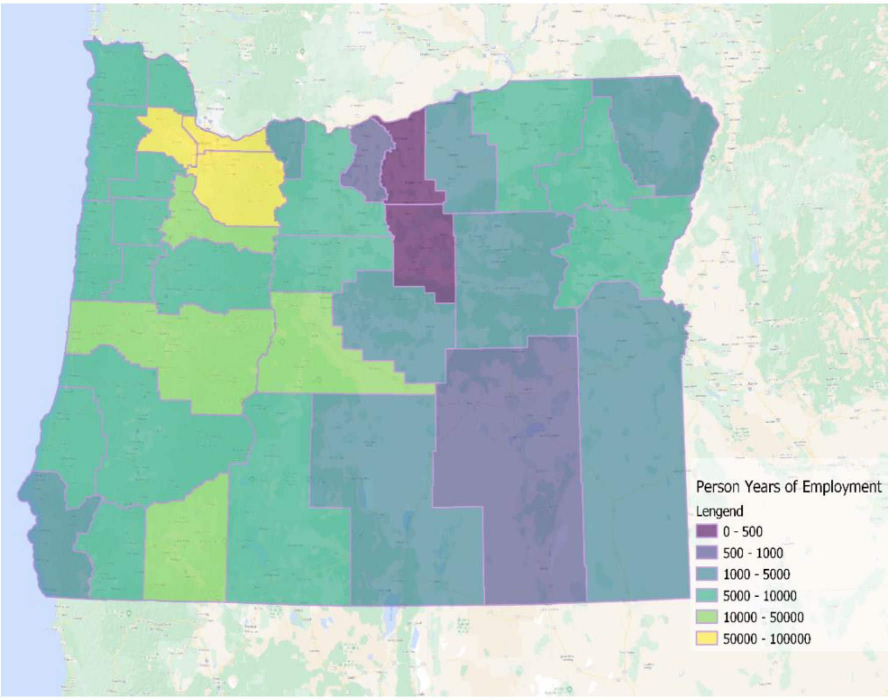
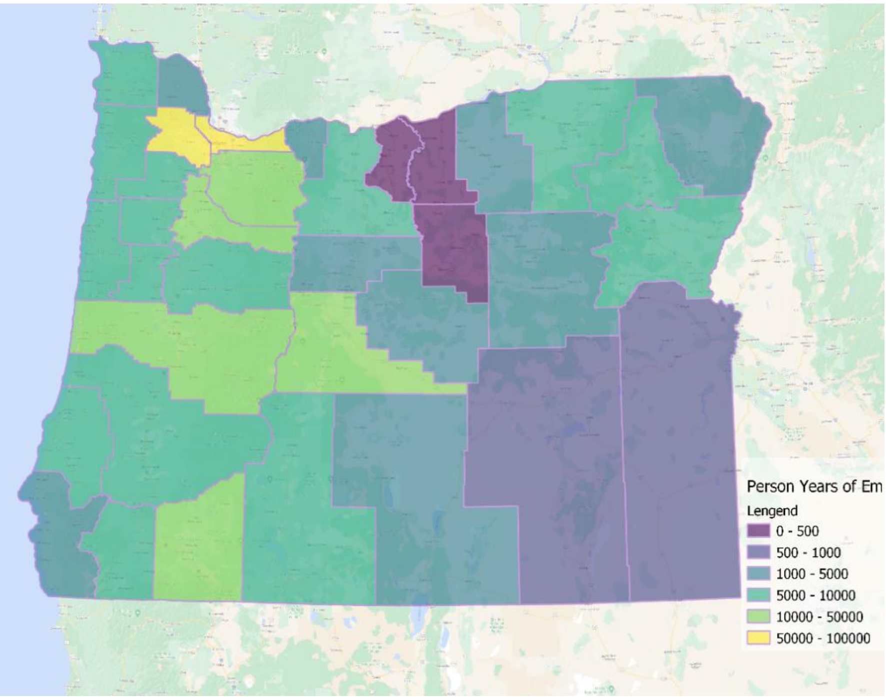



**Figure 17: Hybrid Scenario 2050 Job-Year Creation by County**



## INCLUDING CO-BENEFITS

Most climate action plans apply a least-cost method to preferentially implement the most cost-effective actions first and the least cost-effective actions last. Given the multiple benefits of climate action, the OGWC wanted to expand the analysis beyond just cost-effectiveness. Specifically, the OGWC has incorporated co-benefits of climate action like health benefits, equity benefits, and job and economic prosperity benefits, and incorporated the risk and uncertainty associated with the actions into the analysis.

### Evaluation Criteria

To incorporate co-benefits, OGWC and ODOE developed a methodology to allow for the evaluation of actions based on multiple evaluation criteria, and not just cost-effectiveness. Some of the agreed upon evaluation criteria were quantitative outputs from the modelling and some would need to be evaluated qualitatively. The OGWC weighted each of the evaluation criteria which were then used to evaluate each action and calculate its overall numerical score which identified which actions perform best against the multiple criteria.

The following table shows the six agreed upon evaluation criteria, their weightings, and their descriptions. The weighting was based on a total of 100 points which were allocated among the six evaluation criteria.[30]

**Table 7: Evaluation Criteria**

| Evaluation Criteria | Weighting | Description |
|---|---|---|
| GHG Emission Reduction Amount | 29 | Relative amount of GHG emissions reduced (MTCO2e). |
| Cost-Effectiveness | 15 | Relative net cost/benefit of emissions reductions, “bang for your buck” ($/MTCO2e). |
| Equity Co-Benefit | 16 | Relative level at which the action can serve environmental justice communities by reducing air pollution, addressing health inequities, and alleviating energy burden. |
| Health Co-Benefit | 15 | Potential to improve public health by avoiding health impact of air pollution and reducing other health risks. |
| Jobs and Economic Prosperity Co-Benefit | 14 | Potential to create jobs and reduce energy and transportation costs for households and businesses. |
| Risk and Uncertainty | 11 | Likelihood the cost-effectiveness, GHG emission reductions, and co-benefits from the action will actually materialize. Risks and uncertainties are assessed by technical feasibility, political feasibility, and implementation timing. |

[30] See Evaluation Criteria & Scoring Detail.

## Scoring and Ranking

The *Scoring and Ranking Spreadsheet* was developed to assist in the scoring task.[31] The purpose of the scoring was to use the weighted evaluation criteria to distinguish the actions in a scenario from one another. Actions were sorted based on how well they meet each criterion. The best performing action scored the highest, the lowest performing action scored the lowest, and the rest of the actions were scored between the high and low scores relative to how well they met the criteria. By doing this systematically with each criterion and sub-criterion, a total score was calculated for each action. Future iterations of this scoring exercise should be more robust with more available and tracked quantitative data for analyzing co-benefits, more available funding, and more public engagement.

There were four actions that did not have sufficient cost data to be included in the scoring and ranking analysis and they will need further investigation as part of developing AIPs for those actions:

- Electrification of Industry 70% by 2050
- 50% of New Off-road Vehicles Sales (farm, forestry, construction, and recreation) are ZEVs by 2035
- 100% of New Transit Buses are ZEVs by 2035
- 5% of Fuels By Share From Pyrolysis of Biomass by 2035

The following graphs show the TIGHGER Actions ranked by their total evaluation criteria score (out of total of 100 possible points) for each scenario.[32]

[31] For a detailed explanation of how the scoring was conducted, see the Guide to the TIGHGER Scoring and Ranking Spreadsheets

[32] See the Detailed Electrification Scoring and Ranking Spreadsheet and Detailed Hybrid Scoring and Ranking Spreadsheet (excel files).

**Figure 18: Actions Ranked by Total Evaluation Criteria Score - Electrification Scenario**

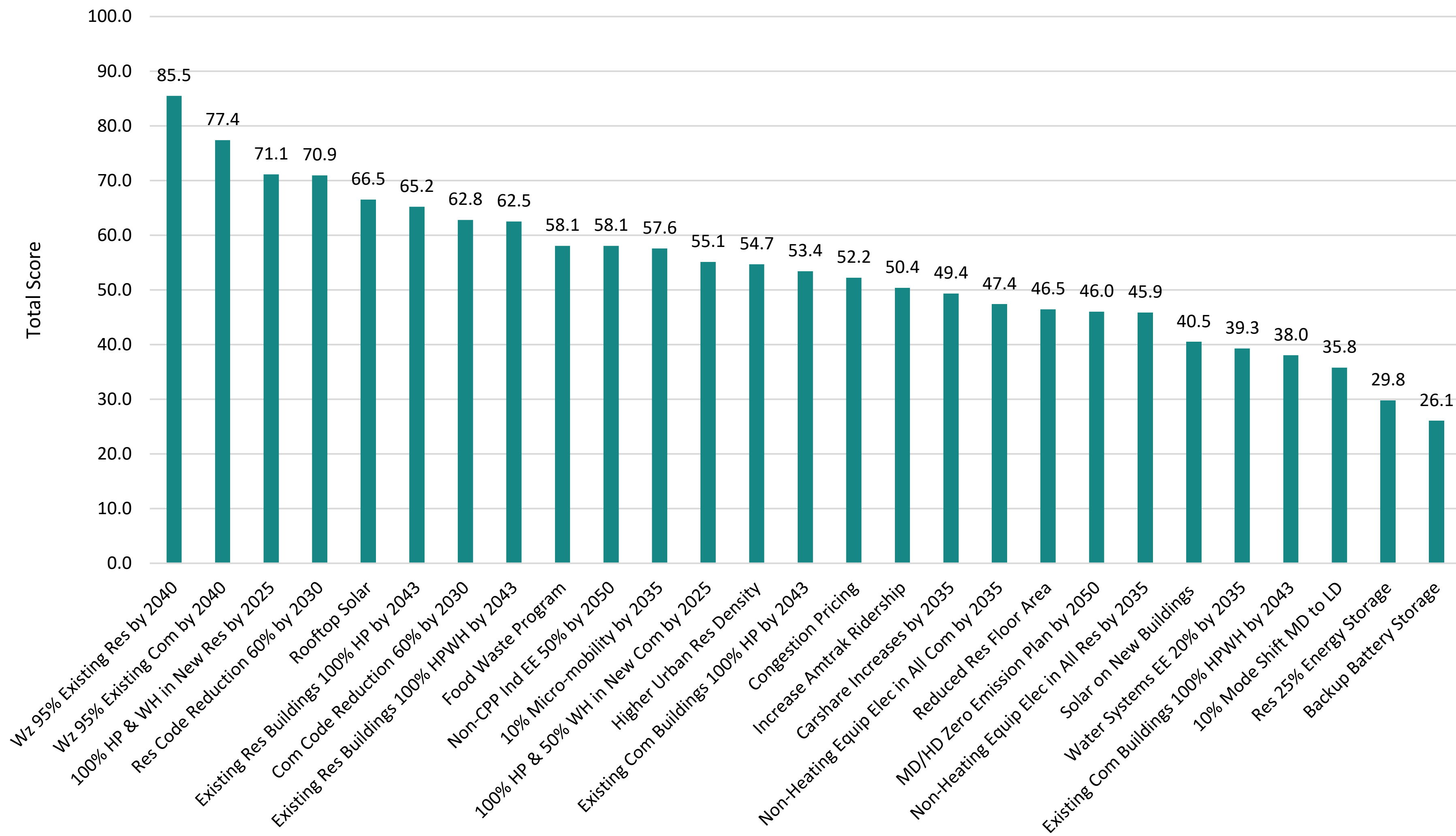
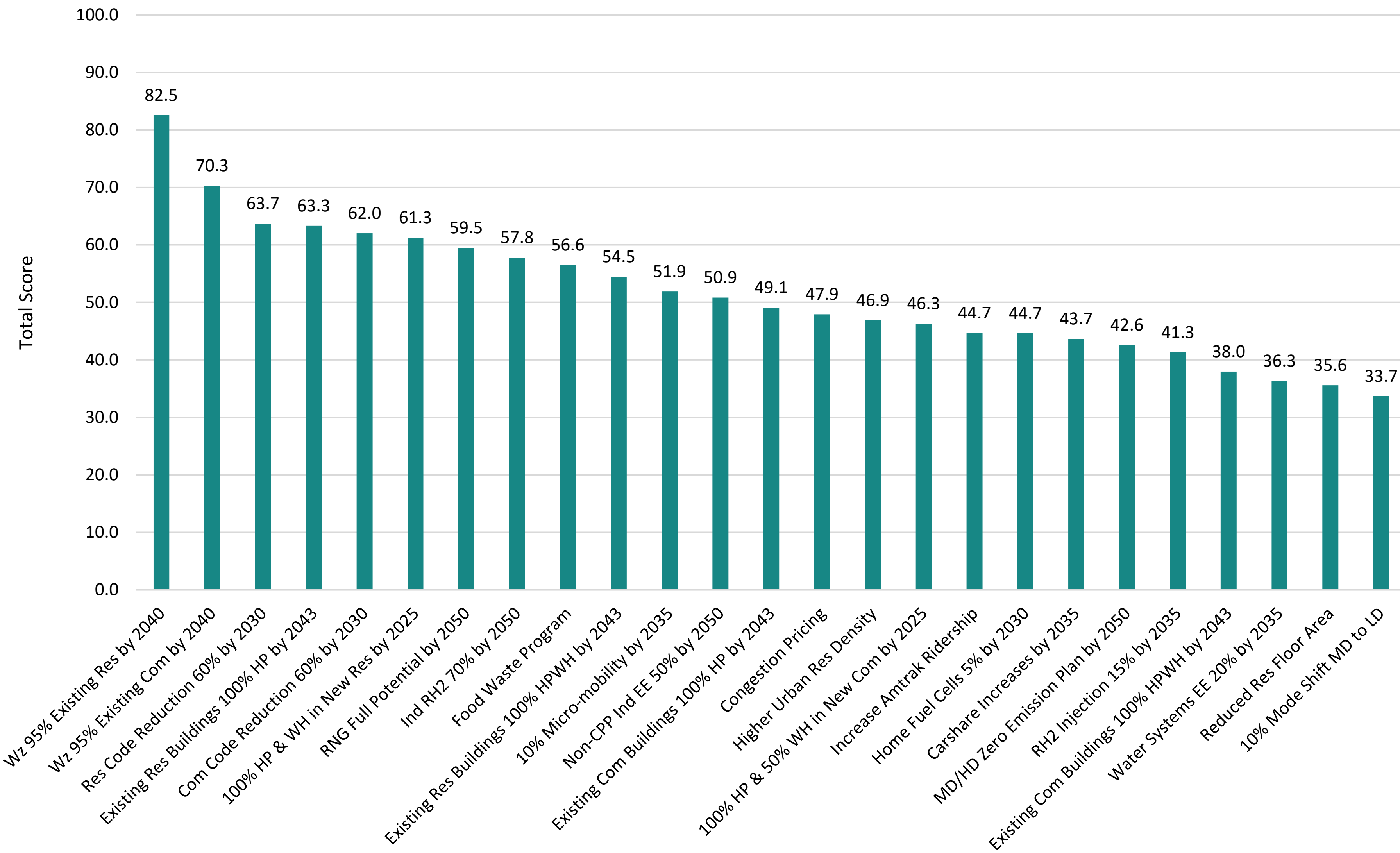


**Figure 19: Actions Ranked by Total Evaluation Criteria Score - Hybrid Scenario**



## RANKING AND LENSES

While it is necessary to implement ***ALL*** of the actions identified in either scenario to meet the 2030 accelerated goal, limited human, political, and financial resources make it unlikely that all of the 35 actions could be implemented at the same time. Ranking the actions provides additional information helpful for decision-makers as they look to prioritize actions.

The *Scoring and Ranking Spreadsheet* allows for the ranking results to be viewed using different evaluation criteria. For example, actions can be ranked based on a single evaluation criterion or multiple criteria. The various criteria we use to rank the actions act as different lenses to view the results. The lenses, or criteria, that were used to rank the scenario actions included:

1. The amount of GHG emissions each action reduces (MTCO2e)
2. The cost-effectiveness of each action ($/MTCO2e)
3. The three co-benefits of each action (equity, health, and jobs and economic prosperity co-benefits)
4. The total evaluation criteria score of each action

The analysis shows that the ranking of the actions was different for each of these lenses. The final recommended ranking of the actions depends on which of the lenses is deemed most important.

### OGWC Discussion on Approach to Using the Lenses

At the December 16, 2022 OGWC meeting, the OGWC had a robust discussion on the preferred way of using the lenses to come up with a recommendation to prioritize the actions. Commissioners brought up the point that because we cannot do all of the actions at once, focus should be on the actions that offer the biggest reduction in GHG emissions first to allow us to demonstrate a path forward with early actions that have the greatest impact, followed by cost-effectiveness and co-benefits.

Accordingly, the two graphs below show the actions ranked in the order of the **GHG Reduction Amount** for the Electrification and Hybrid Scenarios, respectively. The height of the bar reflects the amount of GHG emissions reduced. The bars with the highest GHG Reduction Amount are colored green for identification in this and subsequent graphs.

**Figure 20: Electrification Scenario Actions Ranked by GHG Reduction Amount**

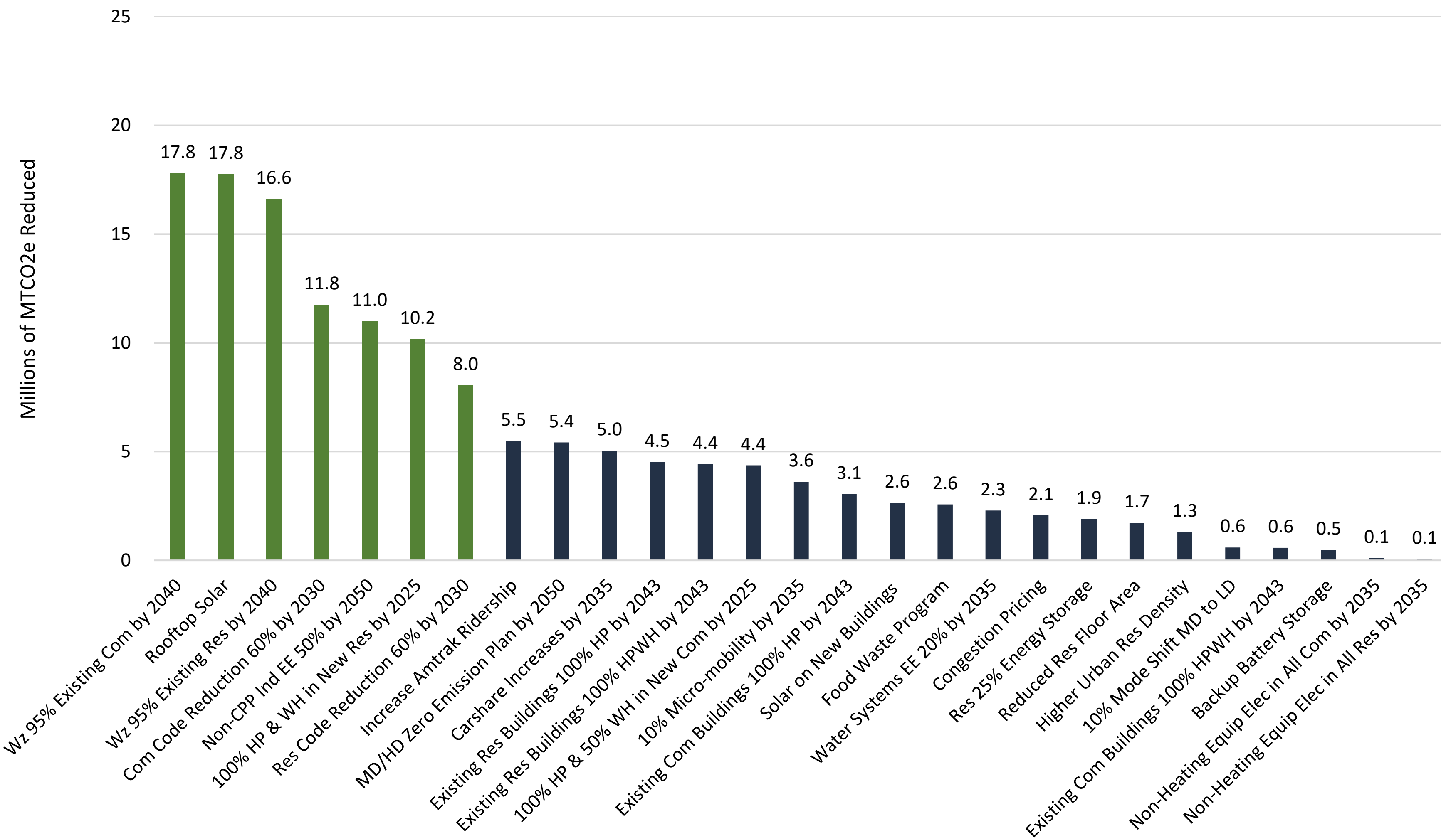
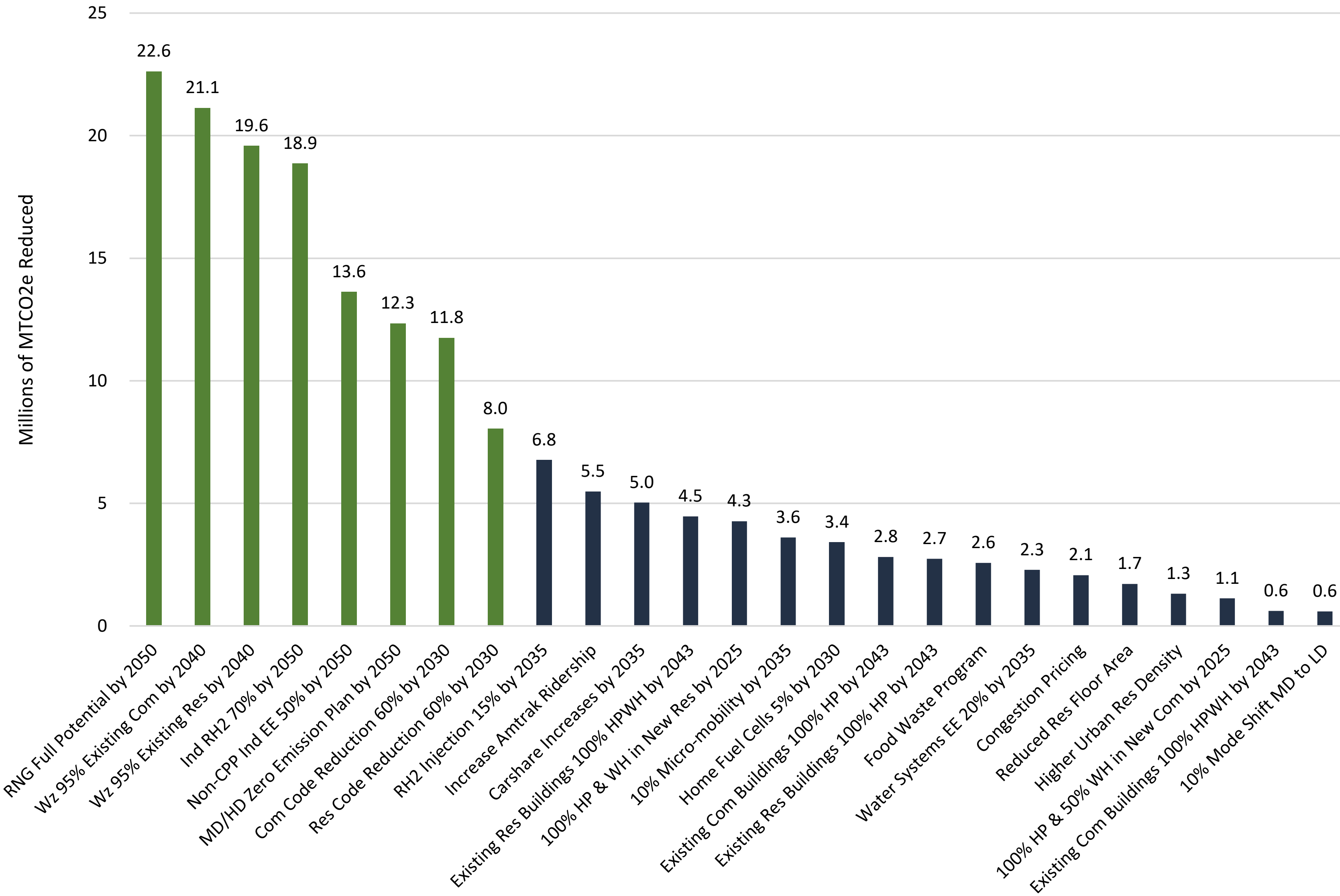


**Figure 21: Hybrid Scenario Actions Ranked by GHG Reduction Amount**



The two graphs below show the above graphs resorted by their **Cost-Effectiveness** ranking (while maintaining the heights of the bars indicating the GHG Reduction Amount). The actions with the highest Cost-Effectiveness ranking are on the left side of the graph and the actions with the lowest Cost-Effectiveness ranking are on the right side of the graph. It is clear from the graphs that when we look through the Cost-Effectiveness lens for ranking, some of the most cost-effective actions are not the actions with the highest GHG Reduction Amount. In fact, some of the actions with the highest GHG Reduction Amounts (the green bars) are toward the least cost-effective right side of the graph.

**Figure 22: Electrification Scenario Actions Ranked by Cost-Effectiveness**

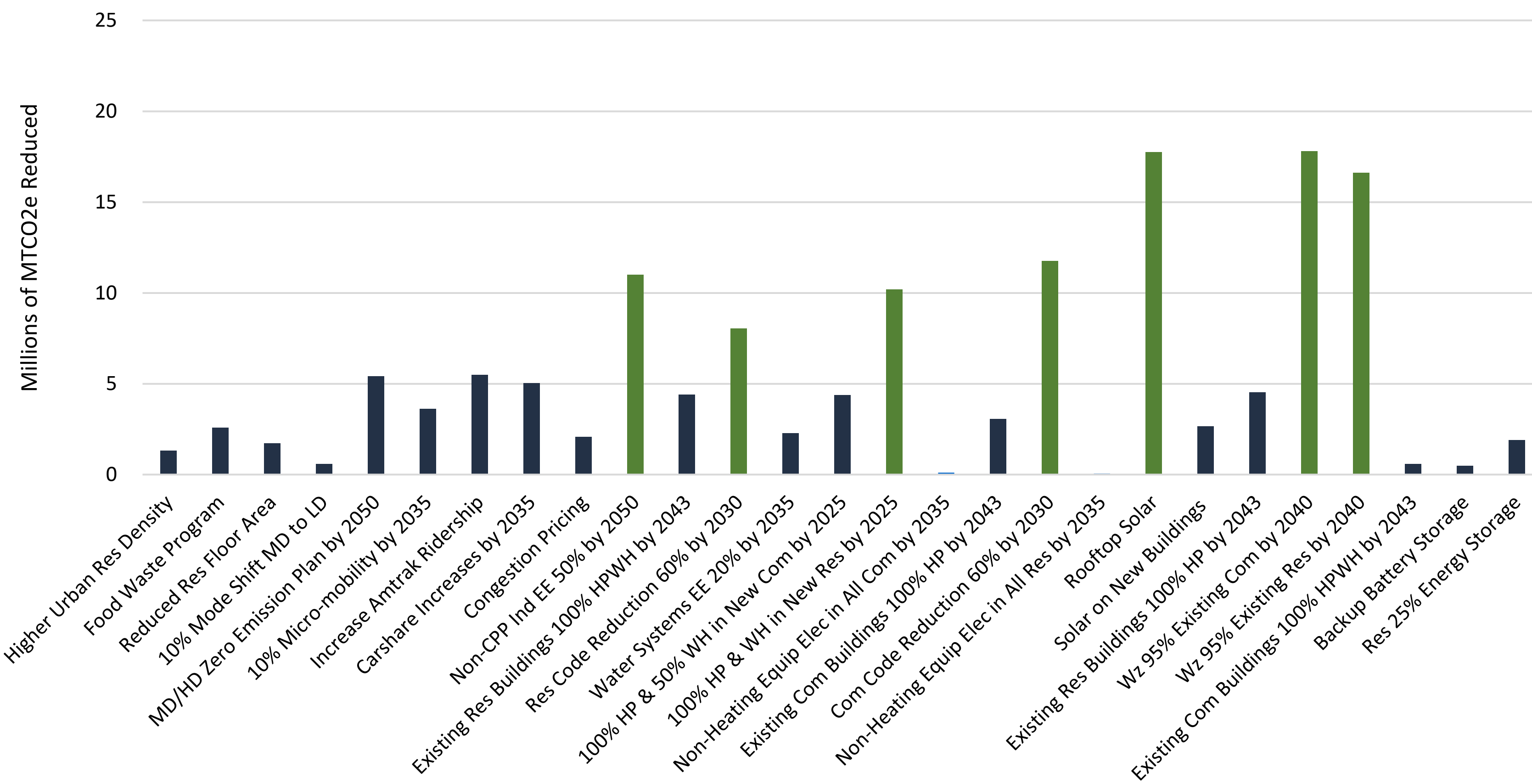
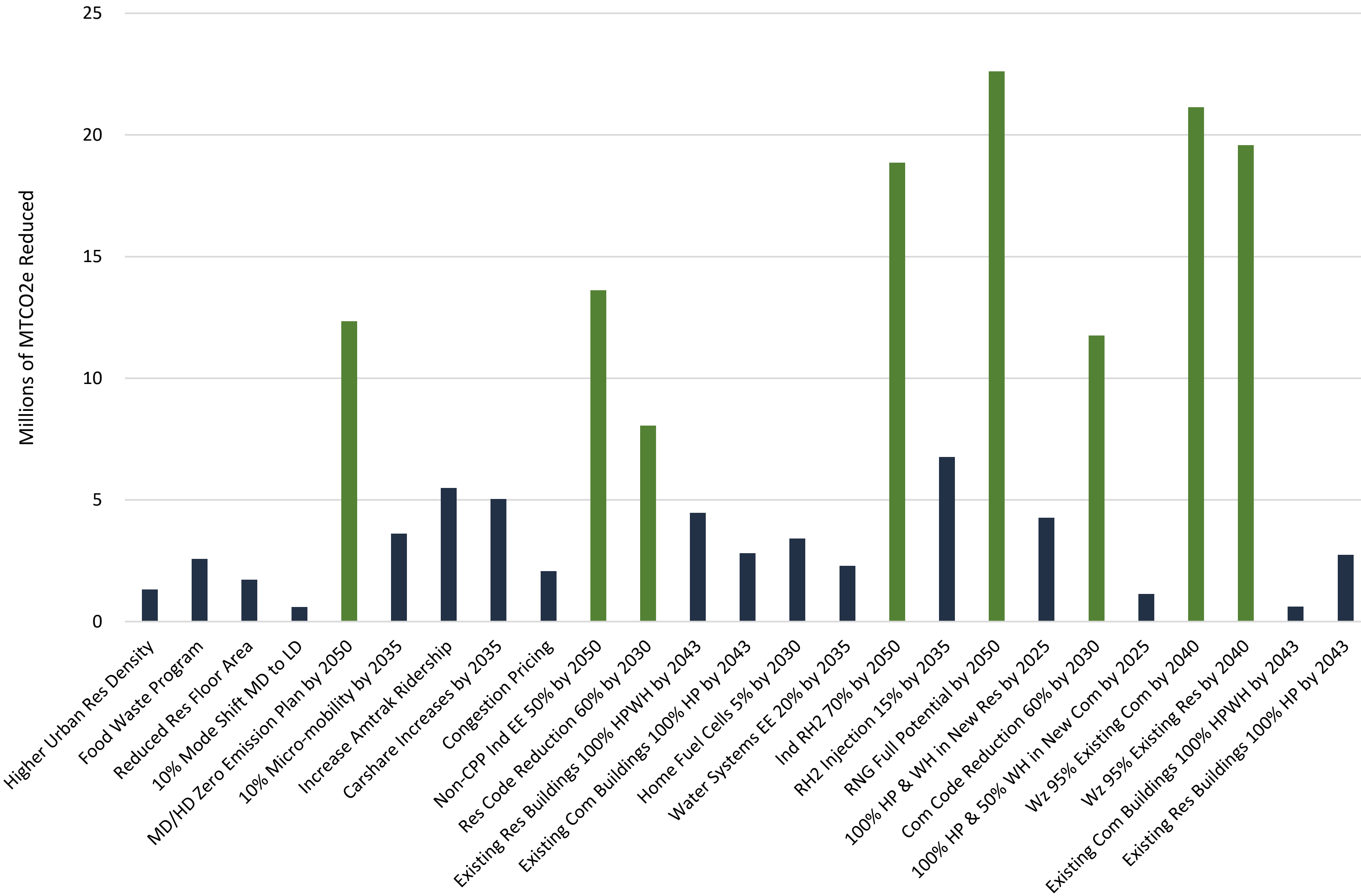


**Figure 23: Hybrid Scenario Actions Ranked by Cost-Effectiveness**



The two graphs below show the actions resorted by their score of the **Three Co-Benefits Score** (while maintaining the heights of the bars indicating the amount of GHG Reduction Amount). Again, the three Co-Benefits were equity, health, and jobs and economic prosperity. The actions with the highest Three Co-Benefits Scores are on the left side of the graph and the actions with the lowest Three Co-Benefits Scores are on the right side of the graph. Looking through the Three Co-Benefits Score lens the actions with the highest GHG Reduction Amounts would be scattered across the graph.

**Figure 24: Electrification Scenario Actions Ranked by the Three Co-Benefits Score**

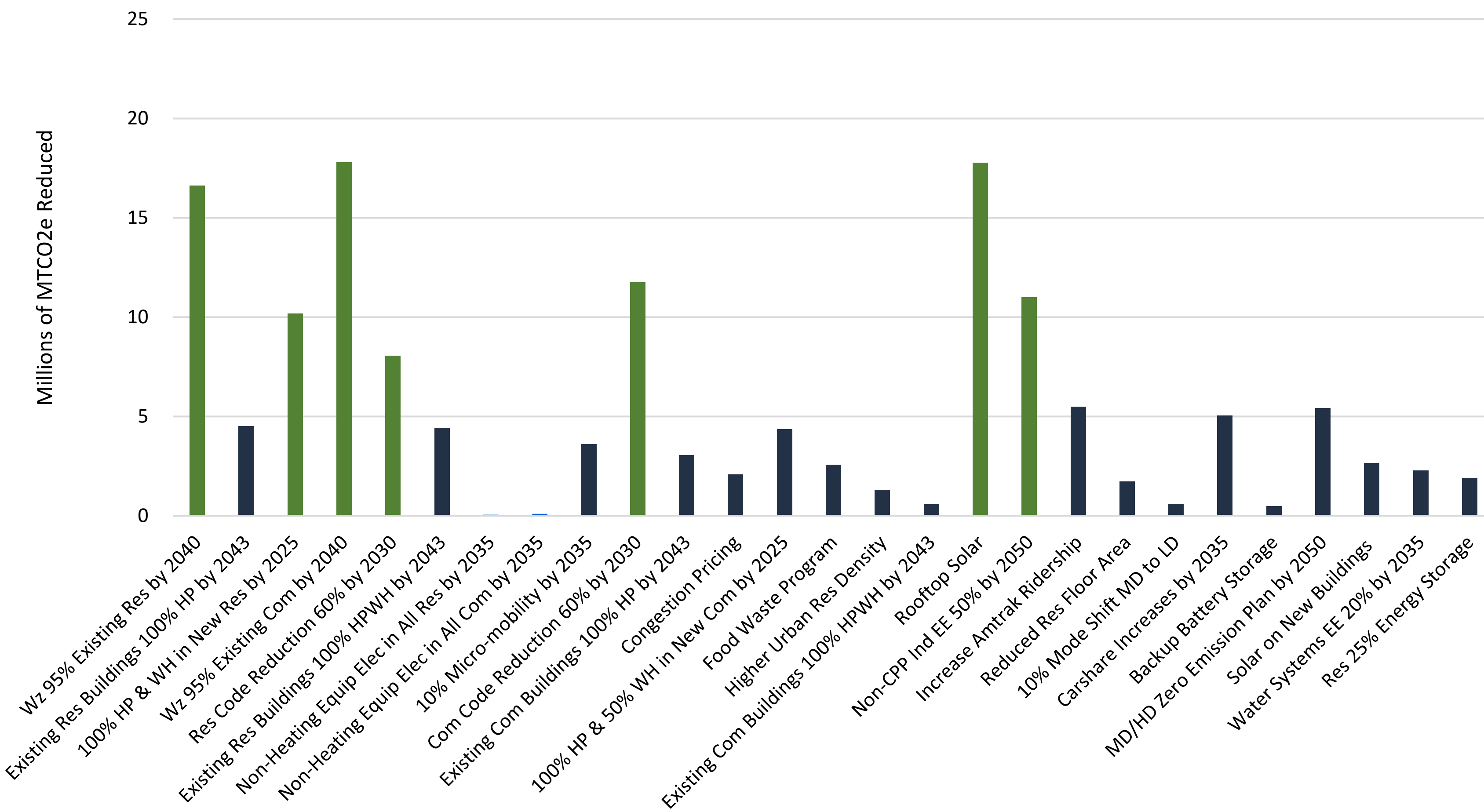
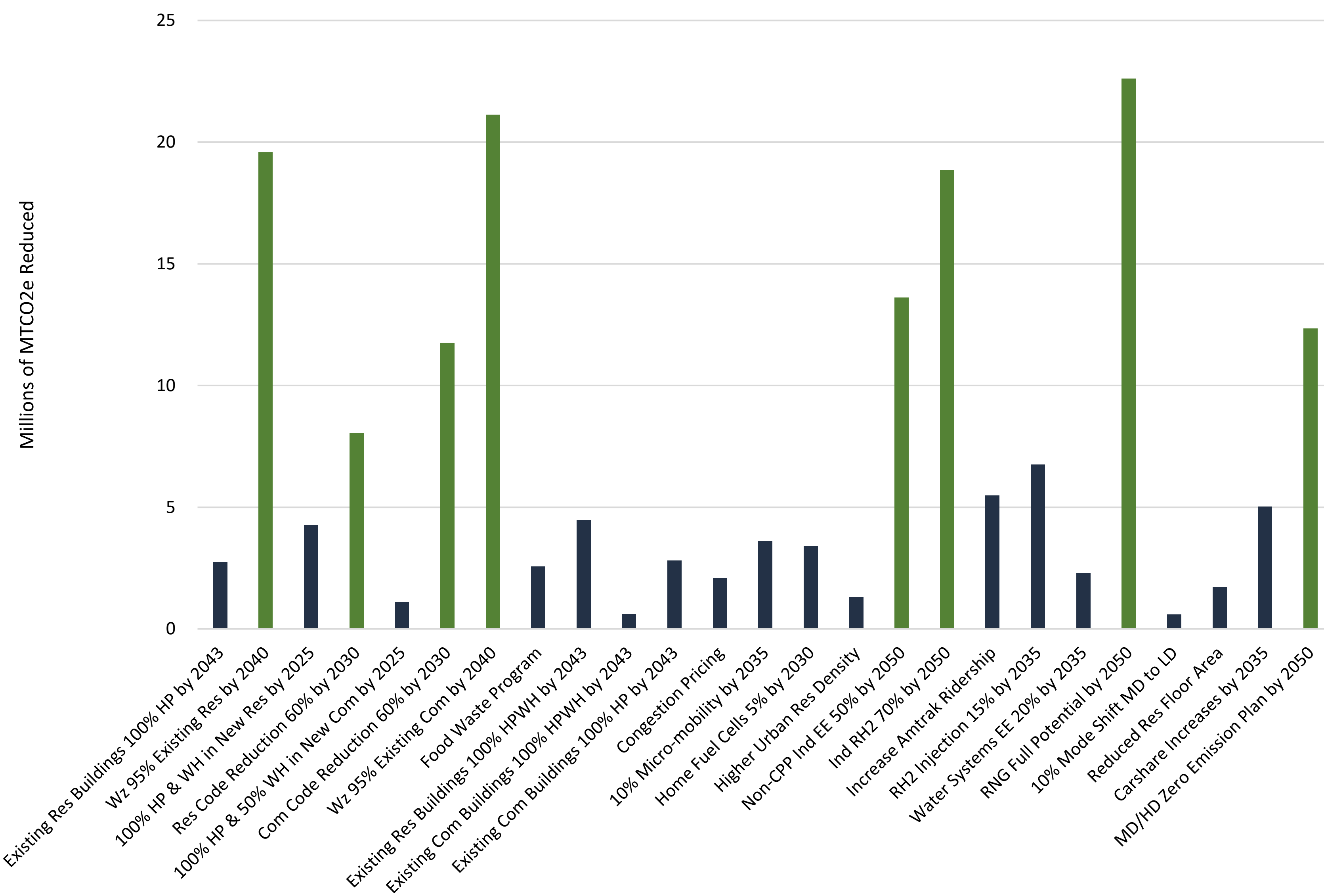


**Figure 25: Hybrid Scenario Actions Ranked by the Three Co-Benefits Score**



The two graphs below show the actions resorted by their **Total Evaluation Criteria Score** ranking (while maintaining the heights of the bars indicating the amount of GHG Reduction Amount). The actions with the highest Total Evaluation Criteria Score are on the left side of the graph and the actions with the lowest Total Evaluation Criteria Score are on the right side of the graph. Looking through the Total Evaluation Criteria Score lens would preserve many of the high-ranking GHG Reduction Amount actions (shown with green bars) as priority actions.

**Figure 26: Electrification Scenario Actions Ranked by Total Evaluation Criteria Score**

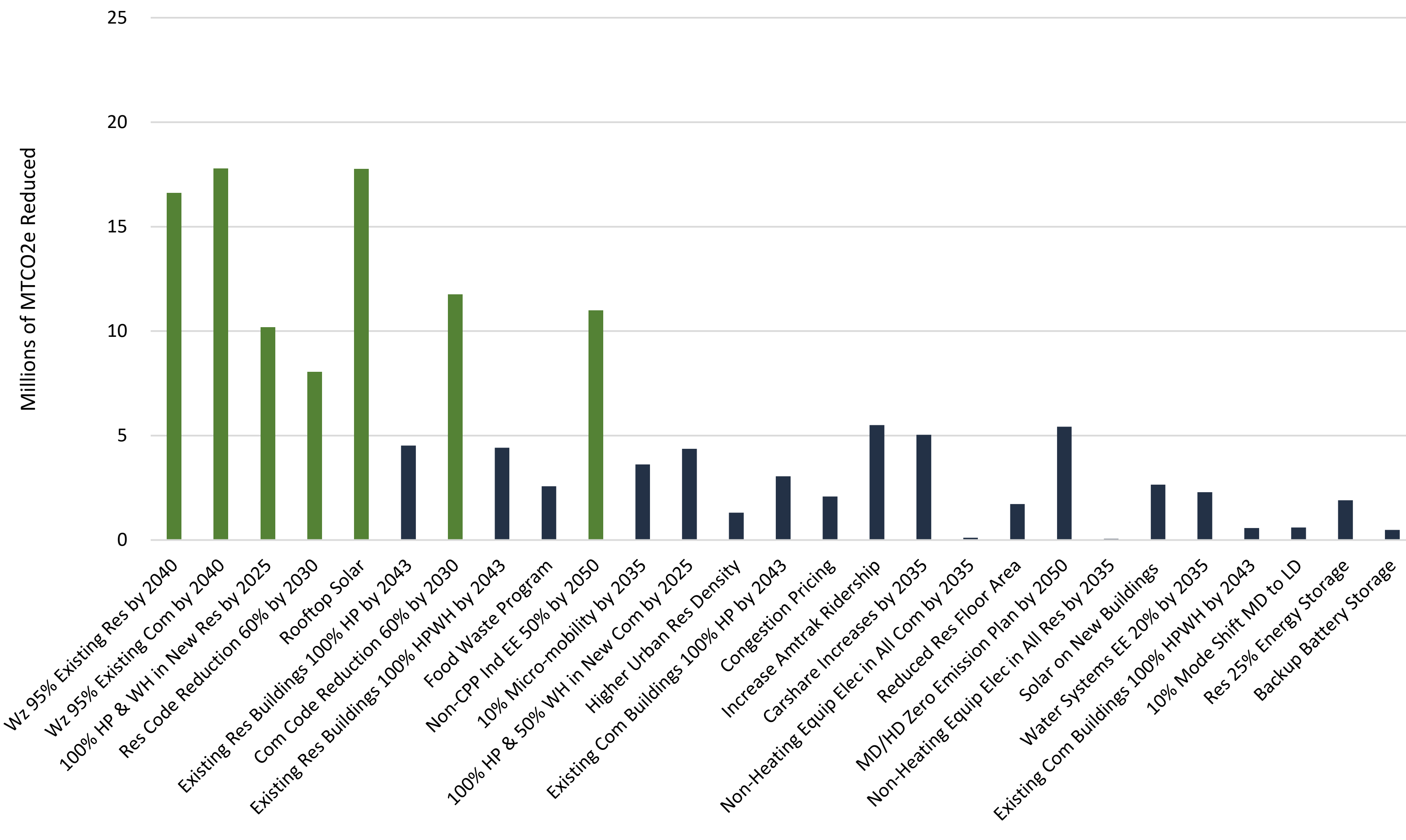
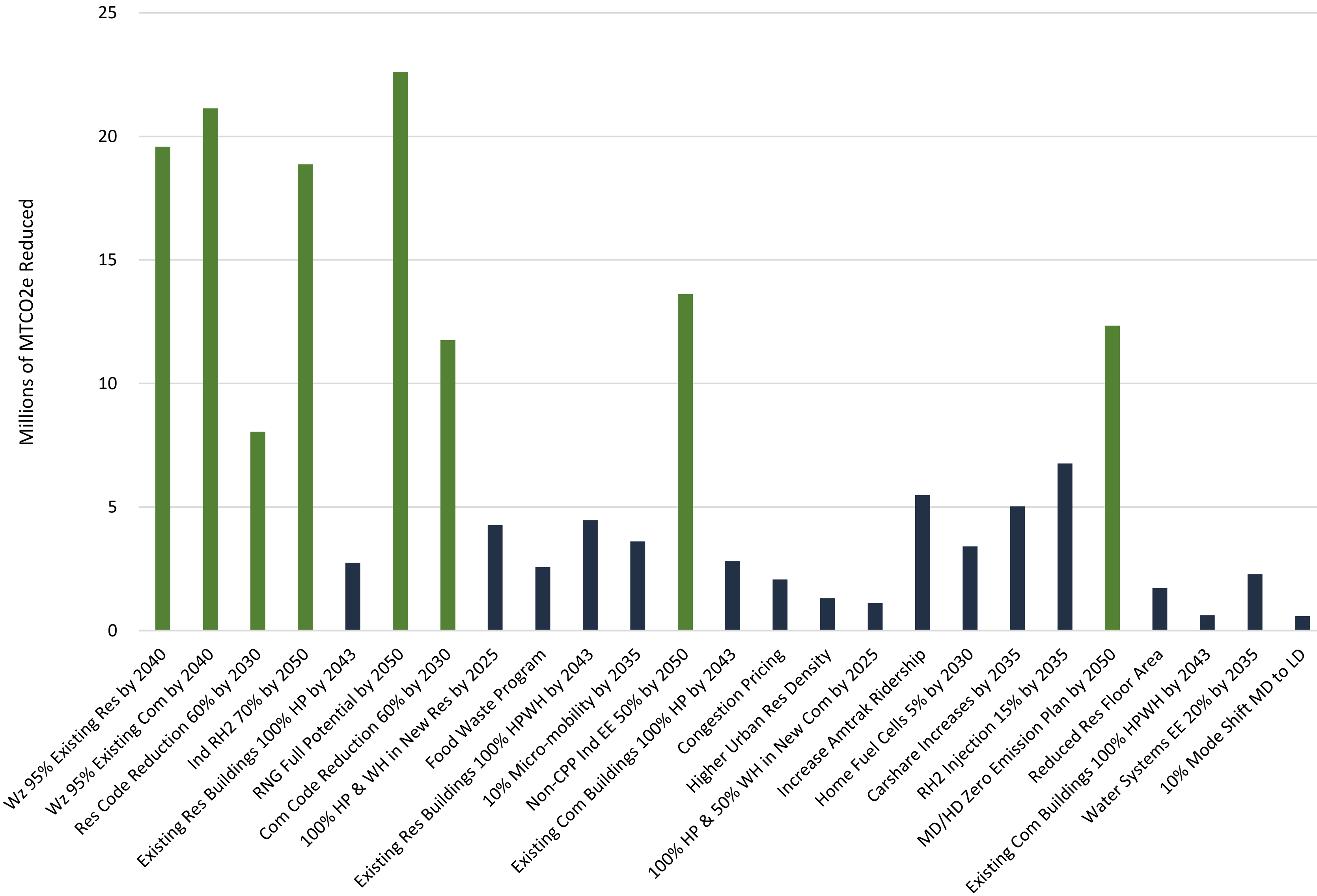


**Figure 27: Hybrid Scenario Actions Ranked by Total Evaluation Criteria Score**



This analysis of the different ranking lenses demonstrates that depending on which ranking lens one chooses to look through, one can see significantly different rankings or prioritizations of the actions. However, given the OGWC's focus on actions that offer the biggest reduction in GHG emissions there are six TIGHGER Actions that are common to both scenarios, that are among the largest GHG emission-reducing actions, and already have pathways or mechanisms for implementation through existing programs and regulations. These actions are:

- Weatherize 95% of Existing Commercial Building Envelopes by 2040
- Weatherize 95% of Existing Residential Home Envelopes by 2040
- Improve Energy Efficiency of Existing Non-CPP Covered Industrial Facilities by 50% by 2050
- Commercial Code Energy Reduction 60% by 2030
- 100% Heat Pumps & Water Heaters in New Residential Homes by 2025
- Residential Code Energy Reduction 60% by 2030

## CONCLUSION

The TIGHGER analysis demonstrates the importance of the state's existing climate programs and regulations in reducing GHG emissions. The TIGHGER analysis specifically analyzed the 15 Oregon climate Programs and Regulations Adopted. Oregon can only achieve its 2035 goal if these programs and regulations are provided the necessary staffing and resources so they can continue to operate as planned. The work it will take to fulfill the promise of all the Programs and Regulations Adopted should not be underestimated.

The TIGHGER analysis also shows that achieving an accelerated 2030 GHG emission reduction goal is achievable, but it will require implementation of ***ALL*** of the TIGHGER Actions identified for either scenario. The analysis also showed that implementation of the TIGHGER Actions will result in significant financial and co-benefits to Oregonians – over $120 billion by 2050.

The TIGHGER analysis and OGWC discussions regarding the findings informed a set of six overarching recommendations and 26 sub-recommendations to inform climate action moving forward. Those recommendations can be found in the Oregon Climate Action Roadmap to 2030 Recommendations.