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Accelerate reliable grid decarbonization efforts to support ZEROgrid Initiative

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Acronyms

ACE	Affordable Clean Energy
CAISO	California ISO
CARB	California Air Resources Board
CEBA	Clean Energy Buyers Association
CES	Clean Energy Standard
CPP	Clean Power Plan
DOE	Department of Energy
EPA	Environmental Protection Agency
ESG	Environmental, Social, and Governance
EU	European Union
EV	Electric Vehicles
FERC	Federal Energy Regulatory Commission
GHG	Greenhouse Gas
GM	General Motors
IIJA	Infrastructure Investment and Jobs Act
IRA	Inflation Reduction Act
ISO	Independent System Operators
NGO	Non-governmental organization
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NREL	National Renewable Energy Laboratory
NYISO	New York ISO
PG&E	Pacific Gas and Electric Company
RE	Renewable Electricity
RMI	Rocky Mountain Institute
RPS	Renewable Portfolio Standards
RTO	Regional Transmission Organizations
TSO	Transmission System Operator
UK	United Kingdom
VP3	Virtual Power Plant Partnership
ZGI	ZeroGrid Initiative

I. Introduction

As the world struggles to confront climate change on an urgent basis, with global temperatures rising and extreme weather events becoming more frequent and severe, switching to a sustainable energy system has become critical. The reduction of greenhouse gas emissions associated with the generation of electricity, or the decarbonization of the grid, is a fundamental element of this change. In light of the urgency of the situation, research indicates that if emissions are not significantly reduced, global temperatures may rise by over 2 degrees Celsius above pre-industrial levels by the end of the century, with disastrous effects on ecosystems, economies, and public health.[1]

A change toward renewable energy sources and a greater focus on carbon neutrality are hallmarks of the current global energy landscape. The grid, which supports contemporary economies and societies, must be decarbonized in order to facilitate this shift. One of the most important areas for mitigation efforts is electricity generation, which contributes significantly to global carbon emissions. A mere 20% of final energy consumption is in the form of electricity; however, the generation of electricity alone accounts for over 40% of all energy-related emissions. Worldwide emissions of carbon dioxide (CO2) from burning fossil fuels total about 34 billion tonnes (Gt) per year, with approximately 45% stemming from coal, 35% from oil, and 20% from gas.[2]

Decarbonizing the electrical grid becomes a critical undertaking in the worldwide effort to combat carbon emissions, especially in the coming ten years. Not only does a switch to a carbon-free grid eliminate one of the biggest contributors to emissions, but it also provides a critical platform for tackling emissions in other high-impact areas like transportation and industrial operations.

In order to propel grid decarbonization efforts forward as quickly as possible in the near future, it is essential to broaden the scope and provide incentives for businesses to go beyond the traditional strategy of merely obtaining renewable energy when it is easily accessible.

[1] The Regulatory Assistance Project. Decarbonize the Grid. Retrieved from https://www.raponline.org/what-we-do/decarbonize-the-grid/

[2] World Nuclear Association. Carbon Dioxide Emissions from Electricity. World Nuclear Association. Retrieved from https://world-nuclear.org/information-library/energy-and-the-environment/carbon-dioxide-emissions-from-electricity#:~:text=Just%2020%25%20of%20final%20energy,tonnes%20(Gt)%20per%20year.

Businesses can take the lead in promoting comprehensive decarbonization along with improved affordability and reliability by interacting with regulators and grid operators and participating in interconnected systems.

Leading businesses like GM, Meta, Prologis, Salesforce, Walmart, and others are partnering with RMI to launch the Zero-Emissions Reliability Optimized Grid Initiative, or ZEROgrid, in recognition of this opportunity and urgency.[3] Having partnered with RMI, GM is aware of the importance of grid decarbonization in achieving its sustainability goals. GM intends to use its influence to accelerate the transition to a low-carbon grid by introducing initiatives such as the ZGI. GM plans to invest in renewable energy technologies in order to support legislative changes that will enable a transition to net-zero emissions.

The purpose of this report is to examine the efforts of GM within the broader context of the ZGI, which aims to promote grid decarbonization and facilitate the transition to a sustainable energy system. By analyzing GM's specific tactics, initiatives, and contributions within the framework of the ZGI, this study seeks to provide valuable insights into practical pathways toward achieving a future with net-zero emissions. Additionally, the report will explore how the ZGI supports corporate actions beyond traditional renewable procurement processes, fostering a more resilient and sustainable energy landscape. Through actionable recommendations and the highlighting of successful strategies, this report aims to inform and inspire further progress towards realizing a net-zero emissions future.

II. Corporate actions for ZEROgrid Initiative and grid decarbonization

A. The Urgency of Grid Decarbonization

Making up 25% of all emissions, the power sector is the second-largest source of greenhouse gas emissions in the U.S.[4] Decarbonization of the power sector can play a leading role in

[3] ZEROgrid. Retrieved from https://zerogrid.org/

[4] Resources for the Future. (2020). Pathways Toward Grid Decarbonization: Impacts and Opportunities for Energy Customers from Several US Decarbonization Approaches. https://www.rff.org/publications/reports/pathways-toward-grid-decarbonization-impacts-and-opportunities-for-energy-customers-from-several-us-decarbonization-approaches/

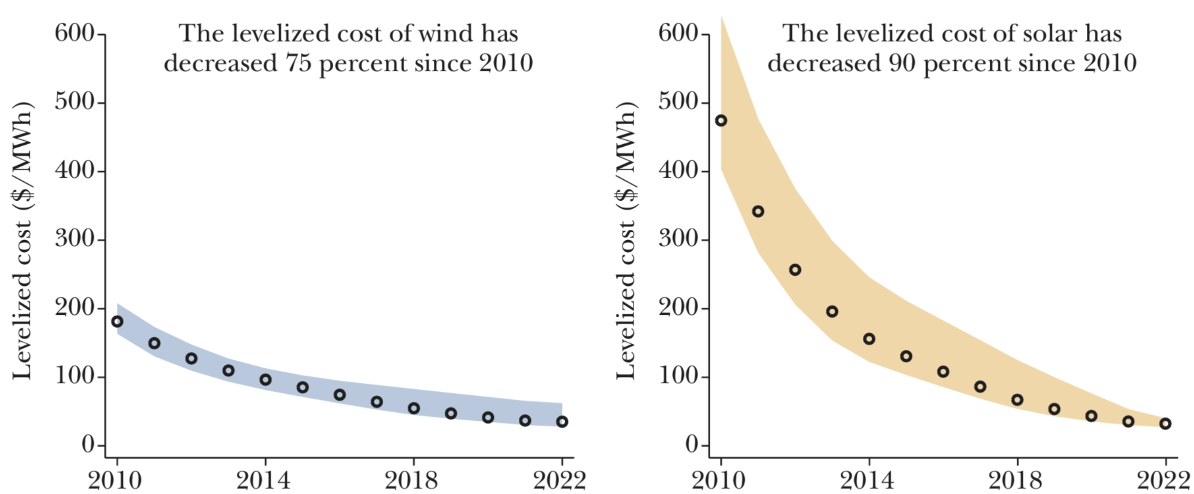
cost-effective, economy-wide emissions reductions. Electrification is anticipated to be the most economical way to decarbonize many energy-using activities.

In every scenario that aims to move economies away from fossil fuels and toward a net-zero carbon future, renewable electricity generation is essential. The ramifications of this change for electricity system investments are substantial. The price of grid-scale wind and solar power has dropped dramatically in the last ten years. Improvements in manufacturing processes, economies of scale, and supply chain efficiency have all contributed to this decline. For example, cost reductions in solar photovoltaic have been driven by small improvements in manufacturing processes, while wind power has benefited from the adoption of larger turbines.

Between 2010 and 2022, the costs of wind and solar generation dropped by 75% and 90%, respectively.[5] Presently, wind and solar energy are cost-competitive with or even cheaper than fossil fuels on a levelized cost basis. This trend underscores the feasibility and economic viability of transitioning to renewable energy sources [Fig 1].

Fig 1.[6]

Decreasing Cost of Grid-Scale Renewables



[5] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[6] *Ibid.*

Even with tremendous advancements, natural gas and coal continue to dominate the U.S. electricity generation market, with wind and solar energy making up a negligible portion of total electricity generation. Thirty states have set targets for increasing the use of renewable energy through the implementation of renewable portfolio standards, which aim to accelerate the shift towards renewables. This dedication is demonstrated by the high standards set by states like California, which aim for 60% renewables by 2030 and 100% by 2045.[7] But there is an urgent need for a significant increase in renewable energy capacity to meet the growing demand for electricity brought on by widespread electrification. Research suggests that in order to meet decarbonization targets by 2030 and beyond, considerable increases in renewable capacity and generation are required.

The transformational change cannot be attained by lower technology costs alone. In order to fully decarbonize the power sector, NREL identifies four key obstacles that must be overcome[8]. These include developing emerging technologies, expanding infrastructure, manufacturing clean energy, and accelerating electrification. Resolving these issues is essential to achieving the goal of a net-zero grid by 2035. Achieving a net-zero grid may be hampered if these issues are not resolved.

B. The Creation of ZGI

The ZGI, led by major corporations like Akamai, GM, Meta, Prologis, Salesforce, and Walmart, in partnership with RMI, aims to accelerate the transition to a reliable and affordable zero-emissions electric grid. Even with increasingly robust climate policy and a range of corporate action, they are collectively not on track to realize the decarbonized grid of the future. In order to put the US electrical grid on a net zero trajectory by 2030, a 1.3 gigaton CO2e gap needs to be closed.[9]

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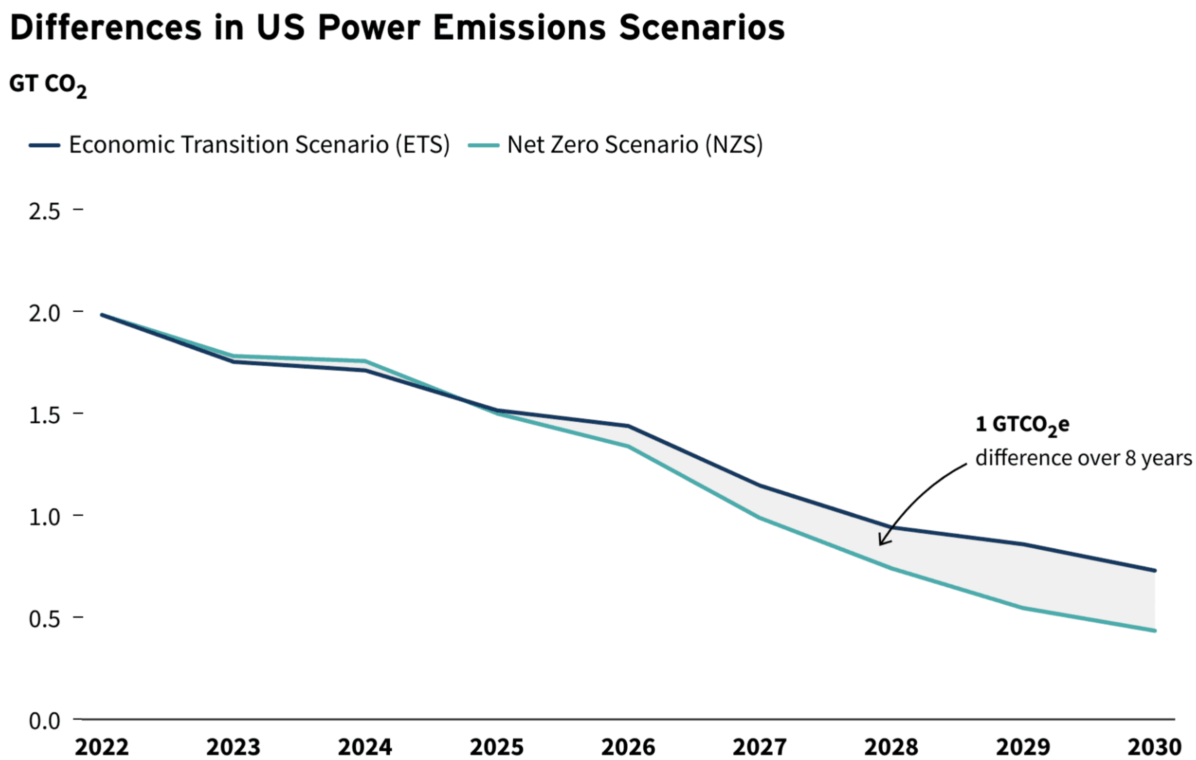
[7] *Ibid*.

[8] U.S. Department of Energy. (n.d.). NREL Study Identifies Opportunities and Challenges in Achieving U.S. Transformational Goal. Energy.gov. Retrieved apr 3, 2024, from https://www.energy.gov/eere/articles/nrel-study-identifies-opportunities-and-challenges-achieving-us-transformational-goal

[9] ZEROgrid. (n.d.). Retrieved from https://zerogrid.org/

Fig 2[7]:



Building on successful efforts previously incubated by RMI, such as the Clean Energy Buyers Association and the Virtual Power Plant Partnership, ZGI focuses on maximizing grid reliability and emissions reduction through corporate action across clean energy procurement, policy, investment, research and development, and operations.[10]

Unlike traditional approaches, ZGI's unique strategy involves engaging corporations in system-wide strategies rather than solely direct renewable energy purchases.[11] By collaborating with grid operators, the initiative aims to identify how corporations can support system-level reliability and cost-effectiveness, ensuring a decarbonized grid is accessible for businesses of all sizes.[12] This approach emphasizes a holistic framework that prioritizes grid reliability, affordability, and decarbonization.[13]

[10] ZEROgrid. (n.d.). Retrieved from https://zerogrid.org/.
[11] *Ibid.*
[12] *Ibid.*
[13] *Ibid.*

The initiative's first phase involves assessing best practices with grid operators and organizations, defining the role of corporations in clean policy advocacy, clean tech investments, research and development, and operational changes that enhance energy efficiency and grid resilience.[14] This work will shape ZGI's interventions and activation plan, aiming to develop a comprehensive methodology to incentivize corporate climate investments and move toward a truly zero-emissions grid.[15]

C. GM's involvement within ZGI and objectives

Plans for decarbonization are essential for companies hoping to thrive in the changing economy because they require drastic adjustments and flexibility at every stage of the supply chain. Businesses can save energy, comply with ESG investor demands, and develop strategic supplier partnerships by adopting sustainability.[16] Establishing sustainability goals as part of decarbonization plans enables businesses to show stakeholders that they are committed to their mission, take decisive action, and efficiently manage priorities. In the end, carrying out these plans improves reputation and competitiveness in a market that is socially and environmentally conscious.

GM exemplifies this commitment to sustainability and innovation through its active involvement in initiatives like the ZGI. Being one of the biggest automakers in the world, GM is actively looking for ways to lessen its environmental impact because it understands how much transportation affects emissions. GM collaborates with other top businesses in the ZGI, utilizing its electrification experience to speed up the shift to a cleaner, more dependable energy infrastructure.[17] In line with its long-term goals and core values, GM is positioned to play a significant role in influencing the development of sustainable transportation and energy systems through cooperative efforts centered on clean energy procurement, policy advocacy, and technological innovation. Through collaboration with other corporations, utilities, and grid operators, GM aims to drive meaningful change and contribute to a more reliable, optimized, and zero-emissions future for the electricity grid.

[14]ZEROgrid. Retrieved from https://zerogrid.org/
[15] *Ibid.*
[16] Net0. Decarbonization. Retrieved from https://net0.com/blog/decarbonization
[17] GM Annual Report 2022.

D. Integration of decarbonization into corporate strategy

As a leading player in the automotive industry, GM recognizes the importance of integrating decarbonization into its corporate strategy. This involves investing in new transmission infrastructure to connect renewable energy sources, deploying grid-enhancing technologies to improve reliability, and integrating EVs into the grid as a flexible resource. GM is committed to collaborating with utilities and grid operators to explore innovative ways for its expanding fleet of EVs to contribute to grid reliability and decarbonization.[18] Through initiatives like the Emissions First partnership, GM advocates for sophisticated methods to maximize the carbon-reduction impact.[19] The company is also working with grid operators like PJM to integrate carbon-emissions signals into its renewable energy procurements, with the long-term goal of leveraging EVs to store and discharge renewable energy when needed most.[20] Additionally, public policy and advocacy play pivotal roles in nurturing a resilient, carbon-free energy ecosystem, and GM is actively involved in legislative endeavors that propel grid decarbonization forward. Alongside other companies in the ZGI, GM's contributions are accelerating the transition to a clean energy future.

E. Current corporate action effort of ZGI's members

Company	Actions
GM[21]	● Collaborates closely with organizations like the Clean Energy Buyers Association, American Clean Power, and the Renewable Thermal Collaborative. ● Partners with universities globally to facilitate market changes supporting affordable energy target attainment. ● Secured agreements ensuring all U.S. sites transition to entirely renewable sources by 2025, 25 years ahead of the initial 2050 target. ● Joined the ZGI for a dependable, cost-effective, and decarbonized grid. ● Announced 17 renewable energy sourcing agreements in October 2022, spanning 10 states, effectively meeting its 2025 target. ● Actively monitors carbon emissions from electricity use across 35

[18] GM Annual Report 2022.
[19] John, J. St. (2024, April 23). *Big companies seek new paths to deep grid decarbonization*. Canary Media. https://www.canarymedia.com/articles/corporate-procurement/big-companies-seek-new-paths-to-deep-grid-decarbonization
[20] *Ibid.*
[21] GM 2023 Sustainability Report: Journey to Zero

	GM sites in collaboration with PJM. ● Invested in Wind Catching Systems (WCS), a Norway-based offshore wind company, in 2022. ● Foundational Funders of the Beyond the Megawatt initiative through the Clean Energy Buyers Institute (CEBI). ● Plays a key role in the Clean Energy Buyers Alliance (CEBA), aiming for a 90% carbon-free U.S. electricity system. ● Prioritizes decarbonization across operations through the Emissions First Partnership, focusing on quantified emissions impact of electricity consumption and generation.
Meta[22]	● Partners with major U.S. utilities to integrate renewable energy into their systems. ● Invested $14.2 billion in renewable energy infrastructure, supporting over 10,000 MW of projects. ● Advocates for updates to GHG emissions accounting systems through the Emissions First partnership. ● Pursues carbon removal projects to achieve net-zero emissions goal by 2030. ● Supports a diverse portfolio of natural and technological solutions for climate impact. ● Prioritizes significant emission reductions and collaborates with data center partners.
Prologis[23]	● Aiming for net-zero emissions across operations by 2030 and across their value chain by 2040. ● Focuses on operating facilities efficiently, providing sustainability, renewable energy, and mobility solutions. ● Surpassed 400 MW of solar generating capacity by the end of 2022, securing the #2 spot for onsite solar in the U.S. ● Actively involved in MIT's Climate & Sustainability Consortium and exploring partnerships for innovation. ● Considering off-site renewable energy purchases to meet growing energy demand. ● Offers Energy + Sustainability solutions, including SolarSmart, StorageSmart, and LED Essentials. ● Issued green bonds and private placements to fund sustainability projects.
Akamai[24]	● Intensified efforts to reduce carbon footprint through investments in renewable energy and energy efficiency measures. ● Aims to power global operations with 100% renewable energy by 2030. ● Collaborates with data center partners to increase renewable energy

22 2023 Meta Sustainability Report.
23 Prologis 2022 - 2023 ESG Report.
24 Akamai Sustainability Report 2023.

	footprint. ● In partnership with CEBA, Akamai has prioritized integrating environmental considerations into the strategic planning process for Akamai Connected Cloud. Akamai helped to create a guide of best practices for corporate colocation and cloud procurement and calls for their colocation providers to follow the same principles. ● Adopted Locational Marginal Emissions (LMEs) to track emissions abatement. ● Prioritizes decarbonization across operations through the Emissions First Partnership.

III. Advocacy Campaigns and Policy Influence

GM engages in policy advocacy on many different fronts in relation to energy regulation. Alongside pledges that follow the orders and regulations of organizations such as the EPA, or even the Biden Administration, the company has also made commitments to support long-term U.S. market goals.[25] GM's stance on energy regulation policy, and decarbonization in general, carries a lot of influence in the policy advocacy space as it is a large corporation that many others are turning to as the push towards decarbonization and clean energy policy becomes increasingly relevant.

In January of 2021, GM was officially the leading US automobile manufacturer that set 2035 as the target date to eliminate all tailpipe emissions from all of its new light-duty vehicles within the U.S.[26] This public support paves the way for other companies within the ZGI, but more specifically other stakeholders in the EVs industry, to also work towards decarbonization in the automotive industry. Later, in August 2021, GM also showed official public support for the environmental benefits of the EPA's August 2021 GHG regulation proposal, which includes multiplier incentives for advanced technology vehicles such as electric vehicles. An extension of these incentives would assist in commercializing light-duty vehicles and align with the EPA's goals of little to zero GHG emissions long-term. The resulting economic benefits would be evident in areas such as environmental justice when discussing the issue of climate change and the level of GHG emissions nationwide. Another form of GM's policy advocacy, in August 2021, was its participation in the administration

[25] General Motors. 2023, December. *2023 Sustainability Advocacy Report.* General Motors. https://investor.gm.com/static-files/210fa676-989e-4703-a4a5-8ff5bc5599a3
[26] Ibid.

event for Executive order 14037—a goal of 50% EV share by 2030 alongside a goal of 60% GHG reduction between 2020 and 2030[27].

Along with GM's support of EPA, GHG regulations, and the Biden administration's executive order, it has also made a stand against critics, when it filed a motion with the Alliance for Automotive Innovation in March 2022 against petitioners who challenged proposed regulations.

Majority of GM's policy advocacy actions have centered around support and commitment to the proposed goals and regulations of organizations such as the EPA, the presidential administration, and general U.S. market goals. For instance, in September 2022, GM made another commitment to supporting market standards that aim to have 50% EVs by 2030. Within this commitment, GM has coordinated with the Environmental Defense Fund, and continues to demonstrate support for regulation under Biden's Exec. order 14037, and the following of U.S. market standards is modeled after the IIJA as well as the IRA[28].

In 2023, GM continued to advocate for clean energy solutions and decarbonization, supporting the coordination between federal and state agencies such as the EPA, NHTSA, DOE, and CARB, in order to ensure compliance with all of these organizations' clean energy and low pollutant standards in the transition towards decarbonization. Some of these standards include the aforementioned EPA GHG emissions program, CARB's GHG regulations, and NHTSA's criteria for light and medium duty vehicles. Coordination between the U.S. federal government and agencies such as CARB best ensure that all industry and consumer stakeholders can successfully achieve this decarbonization within the next decade.[29] GM continues to advocate for the enactment of the production tax credits, as this would support domestic critical mineral processing and EV battery production. The company is a proponent of grants to support the transition of auto manufacturing facilities to EV production. All of these actions would innately help the transition towards decarbonization in

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27 General Motors. 2023, December. *2023 Sustainability Advocacy Report.* General Motors. https://investor.gm.com/static-files/210fa676-989e-4703-a4a5-8ff5bc5599a3

28 *Ibid.*

29 *Ibid.*

the transportation sector, as they support the commercialization and industrialization of clean energy vehicles.

In addition to the company's public support of clean energy and decarbonization goals and proposals in the policy space, GM has also created a "Leadership Pathway"—a regulatory path for other companies to follow to speed up the development of EVs deployment.[30] This pathway lays the groundwork for a smoother transition to decarbonization, and supplies companies with a framework to better work towards following current state and federal regulations.

In terms of policy advocacy on a nonprofit level, GM contributes to nonprofit coalitions with specific policy goals (i.e. infrastructure work through Build Together, federal battery investment work through CALSTART's EV Battery Leadership Initiative, etc).[31] Moreover, GM cultivates connections with nonprofit environmental advocates. For example, as previously indicated, the company collaborated with the Environmental Defense Fund to develop their national EV vision and to support the provisions for electric vehicles in the IIJA and IRA. In order to deepen its understanding and create inclusive policies, GM also collaborates with NGOs that offer insightful perspectives on diversity, inclusion, and environmental justice.[32] The Company has joined the Ellen MacArthur Foundation Network in an effort to advance the ideas of a circular economy based on renewable energy and sustainability.[33]

IV. Regulatory and Standards Landscape

The transition to a zero-carbon energy grid is a critical component of global efforts to mitigate climate change. At both federal and state levels in the U.S., regulatory frameworks are being developed and refined to accelerate the decarbonization of the electric grid. These frameworks encompass a variety of policies, incentives, and mandates aimed at reducing GHG emissions, promoting renewable energy sources, and modernizing grid infrastructure.

[30] *General Motors. 2023, December. 2023 Sustainability Advocacy Report. General Motors. https://investor.gm.com/static-files/210fa676-989e-4703-a4a5-8ff5bc5599a3*
[31] *Ibid.*
[32] *Ibid.*
[33] *Ibid.*

At the federal level, agencies such as the EPA and DOE play key roles in shaping policies related to grid decarbonization. Initiatives like the CPP and CES have been proposed to set targets for emissions reductions and promote the adoption of renewable energy sources. Additionally, federal tax credits and grants are often utilized to incentivize investment in clean energy technologies and grid modernization projects.[34]

CPP was a set of regulations introduced by the EPA in 2015 under the Obama administration. It aimed to regulate CO2 emissions from existing fossil fuel-fired power plants in the U.S., primarily coal-fired power plants, which are among the largest sources of greenhouse gas emissions in the country.[35] The plan was developed in response to the growing urgency of addressing climate change and aimed to accelerate the transition to cleaner energy sources while reducing reliance on coal for electricity generation. The Plan established individualized CO2 emission reduction goals for each state, based on factors such as their current energy mix, emissions levels, and potential for renewable energy deployment. States were given flexibility in how they could achieve these targets, allowing them to develop their own compliance plans tailored to their unique circumstances. The CPP encouraged states to invest in renewable energy sources such as wind, solar, and hydroelectric power, as well as energy efficiency measures, to reduce emissions from the power sector.[36] By incentivizing the adoption of cleaner technologies and practices, the plan aimed to drive innovation and stimulate economic growth in the clean energy sector. However, the implementation of the CPP faced legal challenges from industry groups and some states, leading to a series of legal battles that ultimately resulted in the plan being put on hold by the Supreme Court in 2016.[37] Subsequently, the Trump administration announced its intention to repeal and replace the CPP with the ACE, which offered more limited emissions reductions and greater flexibility for coal-fired power plants.[38]

[34] MIT. 2022. The Future of Energy Storage. An Interdisciplinary MIT Study. Cambridge, MA: Massachusetts Institute of Technology.
[35] California Air Resources Board. U.S. EPA Clean Power Plan | California Air Resources Board. (n.d.). https://ww2.arb.ca.gov/our-work/programs/clean-power-plan/about
[36] CPP-EPA-DOE-FERC. Federal Energy Regulatory Commission. (2020a, December 9). https://www.ferc.gov/media/cpp-epa-doe-ferc
[37]Clean Power Plan: Legal Background and Pending Litigation in West Virginia v. EPA. Retrieved from https://crsreports.congress.gov/product/pdf/R/R44480
[38] Environmental Protection Agency. (2019, June 19). EPA Finalizes Affordable Clean Energy Rule, Ensuring Reliable, Diversified Energy Resources while Protecting our Environment. EPA. https://www.epa.gov/newsreleases/epa-finalizes-affordable-clean-energy-rule-ensuring-reliable-diversified-energy#:~:text=WASHINGTON%20(June%2019%2C%202019),to%20reduce%20emissions%20while%20providing

The CES is technology-neutral portfolio standard that requires that a certain percentage of utility sales be met through "clean" zero- or low-carbon resources, such as renewables, nuclear energy, coal or natural gas fitted with carbon capture, and other technologies.[39] The primary goal of a CES is to reduce greenhouse gas emissions from the power sector, mitigate climate change, and promote energy independence and security. The specific design and implementation of a CES can vary depending on factors such as political priorities, economic considerations, energy market dynamics, and available resources. Some states in the U.S. have already implemented CES policies, while others are considering or exploring the feasibility of adopting such standards to accelerate the transition to clean energy and reduce reliance on fossil fuels.[40]

At the federal level, proposals for a nationwide CES have been introduced in Congress as part of broader efforts to address climate change and promote renewable energy development. Political polarization and shifts in administration can impede federal regulation creation, causing uncertainty. This uncertainty has resulted in the reversal of specific policies enacted by prior administrations.[41] Moreover, the lack of comprehensive federal laws dedicated to grid decarbonization may result in regulatory gaps and inconsistencies, thereby obstructing long-term planning and investment certainty.

Not only at the federal level, states also have substantial authority in regulating their own energy markets, leading to a diverse array of approaches to grid decarbonization across the country. In most cases, a CES policy will include an RPS as part of the requirement,[42] which mandates that a certain percentage of electricity sold within the state must come from renewable sources by a specified date.[43] Others have established ambitious emissions reduction goals or joined regional carbon pricing initiatives to incentivize the transition away from fossil fuels [Fig 3]. However, variability in state-level policies can create challenges for interstate coordination and the development of regional energy markets. Some states may

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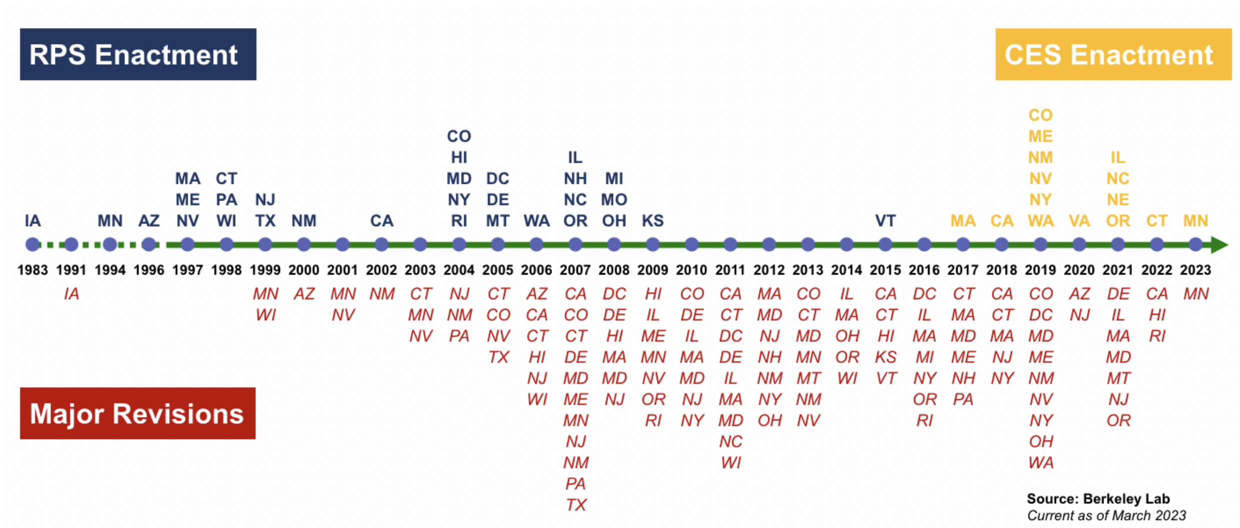
[39] Clean Energy Standards. (n.d.). Retrieved from https://www.rff.org/publications/issue-briefs/clean-energy-standards/
[40] Barbose, Galen L. 2023. U.S. Renewables Portfolio Standards: 2023 Status Update. Berkeley, CA: Lawrence Berkeley National Laboratory.
[41] *Ibid.*
[42] Brief state renewable portfolio standards and goals. (n.d.). Retrieved from https://www.ncsl.org/energy/state-renewable-portfolio-standards-and-goals#:~:text=For%20example%2C%20California%20enacted%20its,from%20renewable%20sources%20by%202030.
[43] Barbose, Galen L. 2023. U.S. Renewables Portfolio Standards: 2023 Status Update. Berkeley, CA: Lawrence Berkeley National Laboratory.

face resistance from entrenched fossil fuel interests or encounter legal and institutional barriers that impede the implementation of more aggressive decarbonization measures.

Fig. 3[44]:



V. Impact Assessment of GM's Efforts

A. Evaluation of GM's contributions to grid decarbonization

Overall, GM's efforts encompass a range of activities, from internal transitions to renewable energy procurement and active participation in industry initiatives, demonstrating a holistic approach to contribute to grid decarbonization.

However, while GM has made significant commitments towards carbon neutrality, there is still much to be done. Although GM has committed to sourcing all of its renewable energy within the United States by 2025 nationally and 2035 globally,[45] a standardized framework that other companies—especially those not within ZGI—can implement to accelerate decarbonization is yet to be created. While GM does work with state agencies and

[44] Barbose, Galen L. 2023. U.S. Renewables Portfolio Standards: 2023 Status Update. Berkeley, CA: Lawrence Berkeley National Laboratory.
[45] General Motors. 2023, December. 2023 Sustainability Advocacy Report. General Motors. https://investor.gm.com/static-files/210fa676-989e-4703-a4a5-8ff5bc5599a3

independent research organizations to analyze infrastructure needs,[46] increased corporate responsibility contributing towards decarbonization and a clean electric grid across the energy industry is essential for greater change. GM's internal shift towards clean energy procurement is commendable, but its partnership with initiatives such as ZGI, VP3, and the Emissions First Partnership (EFP)[47], must be strengthened.

B. Analysis of the effectiveness of GM's initiatives and advocacy campaign

It is crucial to find and implement a comprehensive carbon-free energy system, particularly concerning infrastructure and battery technologies. GM has provided grant funding to support RMI research regarding electric grid planning, which serves as a stepping stone towards creating grid planning tools to aid utility companies in their transition to a carbon-neutral grid. However, more research needs to be completed in order to find comprehensive strategies to ensure that the path to decarbonization is equitable and accessible to a wide range of communities.[48]

Another area in which GM could expand its contributions towards grid decarbonization efforts is in its collaboration with utility companies. As of 2022, GM partnered with PG&E to test and eventually implement bi-directional charging technologies to provide a backup power option for homes, which would improve electric resiliency and reliability.[49]

VI. Challenges and Opportunities

A. Identification of challenges faced by GM in promoting grid decarbonization

GM faces several challenges in its efforts to promote grid decarbonization. Firstly, the company needs to address infrastructure development issues. This includes building new transmission lines, energy storage facilities, and charging infrastructure for EVs to support

[46] General Motors. 2023, December. 2023 Sustainability Advocacy Report. General Motors. https://investor.gm.com/static-files/210fa676-989e-4703-a4a5-8ff5bc5599a3

[47] Our renewable energy journey: General Motors. Our Renewable Energy Journey | General Motors. (n.d.). https://www.gm.com/stories/renewable-energy-sustainable-strategy#:~:text=Focus%20first%20on%20energy%20efficiency,efficiency%20and%20power%20demand%20projects.

[48] Fedex and General Motors support RMI Research to accelerate transportation electrification. RMI. (2023, June 7). https://rmi.org/press-release/fedex-and-general-motors-support-rmi-research-to-accelerate-transportation-electrification/

[49] PG&E and General Motors collaborate on pilot to reimagine use of electric vehicles as backup power sources for customers. GM Corporate Newsroom. (n.d.). https://news.gm.com/newsroom.detail.html/Pages/news/us/en/2022/mar/0308-pge.html

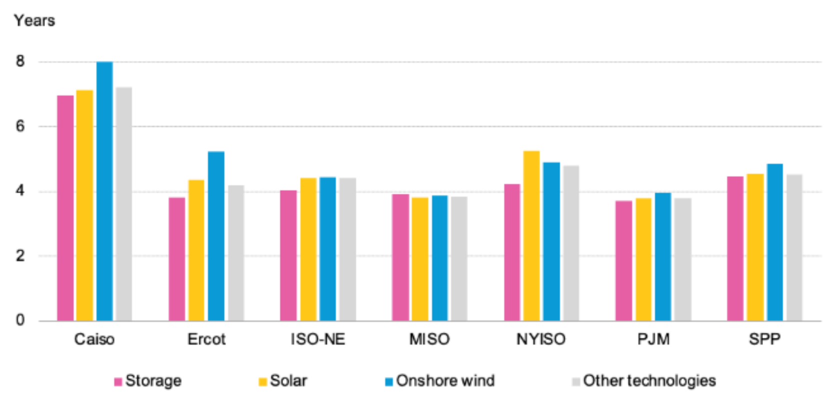
the widespread adoption of renewable energy sources. The lack of adequate infrastructure can slow down the transition to a decarbonized grid and hinder GM's efforts.

Secondly, regulatory barriers may impede GM's progress at the local, state, or federal level. Outdated regulations, permitting challenges, or policies that favor conventional energy sources over renewables could pose significant challenges for GM's initiatives. Currently, the backlog for transmission projects is 4-5 years [Fig 5].

Fig 5[50]

Average age of projects in the queue that applied for interconnection before 2020 as of Jan 2024 (years)

ISO/RTO	Solar	Onshore wind	Offshore wind	Storage	Other technologies
Caiso	7,1	8,0	3,8	7,0	7,2
Ercot	4,3	5,2		3,8	4,2
ISO-NE	4,4	4,4	4,8	4,0	4,4
MISO	3,8	3,9		3,9	3,8
NYISO	5,2	4,9	5,0	4,2	4,8
PJM	3,8	3,9	4,3	3,7	3,8
SPP	4,6	4,9		4,5	4,5
All	**4,5**	**5,2**	**4,6**	**4,9**	**4,7**



Local siting and permitting challenges often hinder construction. Long-distance transmission projects require permission from numerous landowners, and convincing them to allow construction can be uncertain, expensive, and time-consuming. Landowners may oppose high-voltage transmission lines due to concerns about visual impacts, health effects, site preservation, and other issues. Additionally, numerous federal, state, county, municipal, and tribal agencies are involved in the permitting process, and laws such as the Clean Water Act, Endangered Species Act, and National Historic Preservation Act may apply. Local opposition

[50] BloombergNEF. (2024). (rep.). *US Grid Applications Status 2024: Much Work Pending*. BloombergNEF.

to energy projects can significantly increase costs and delays. Resolving tensions between the broader public good and local land use concerns remains a key barrier to faster growth in energy infrastructure. Benefits of energy infrastructure are often dispersed widely, while land use concerns are highly localized, making it challenging to achieve consensus.

Even after obtaining approval from relevant stakeholders, the construction of transmission lines remains a significant challenge. These projects require substantial capital investments, with high-capacity long-distance transmission lines costing $3 million or more per mile.[51] Unlike the costs for grid-scale renewables, there is little evidence of a decline in transmission line costs over time. In fact, recent projects have had much higher costs per mile compared to those in the early 2000s.[52] While renewables have benefited from economies of scale and learning-by-doing, the technology for electricity transmission has remained largely unchanged for decades.

Another concern is whether transmission lines will be utilized enough to justify the capital costs. Unlike fossil fuel or nuclear power plants, where transmission can be sized to ensure close to full capacity utilization 24/7, this is not the case for renewables. For example, a transmission line connecting a solar-rich area to the grid may only be operational 30 percent of the time. This capacity factor issue implies that electricity systems relying on renewables generally require more total transmission capacity compared to fossil fuel-based systems.[53]

Another challenge is the intermittency and reliability of renewable energy sources. Solar and wind energy, which are key components of GM's renewable energy strategy, are intermittent and not available 24/7. The output of wind and solar power plants varies significantly due to factors such as changes in wind speeds, wind directions, and solar irradiation, rather than being controlled by economic dispatch instructions from the system operator.[54] To reduce the costs associated with wind and solar energy generation, it is essential to utilize these resources across larger geographic areas to take advantage of the diversity in demand and supply within bulk power systems. For instance, while the sun sets at 7:00 PM in Michigan,

[51] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[52] *Ibid.*
[53] *Ibid*.
[54] Joskow, Paul L., 2019, "Challenges for Wholesale Electricity Markets with Intermittent Generation at Scale: The U.S. Experience," *Oxford Review of Economic Policy,* 35(2), 291-331.

it may set an hour later in Nevada. Solar generators in Nevada can meet demand in Michigan initially and continue to supply power to Nevada after sunset, thereby increasing capacity and lowering costs. Expanding transmission capacity not only provides access to more favorable wind and solar sites but also helps reduce overall electricity demand and increase generator load factors by combining demands across larger geographic areas, thus exploiting diversity. However, this requires more than just increasing transmission capacity. It also involves expanding the geographic footprint of wholesale market and dispatch areas or implementing measures to enhance the coupling of neighboring market areas.

GM must address challenges related to the variability of renewable generation and ensure grid reliability as they transition their operations to rely entirely on renewable sources. Conventional electricity generation sources can be located near population centers with fuel transported to the plants. In contrast, renewable energy sources like wind and solar must be sited where those resources are naturally available. The cost-effectiveness of wind and solar power depends on their location in areas with favorable conditions, which are not evenly distributed across the U.S. The best wind resources are found in the central part of the country, such as in Nebraska, Kansas, and Oklahoma, where wind turbines achieve capacity factors of 40 percent or more.[55] This means they produce 40 percent of their maximum capacity throughout the year. Investments in wind generation have mainly focused on states with the best wind resources, with Texas alone accounting for 26 percent of U.S. wind generation.[56] Similarly, the best solar resources are concentrated in the Southwest and Southeast regions. States like Arizona and California have solar capacity factors nearly twice as high as northern states. Investments in solar generation have been concentrated in states with the best solar resources, with California leading the way. California is to solar what Texas is to wind, with 27 percent of U.S. grid-scale solar, almost as much as three states combined (Texas, North Carolina, and Florida).[57] This uneven distribution of renewable resources highlights the importance of electricity transmission. Renewable generation potential varies across states, and even within states with good potential, the best locations are often far from major population centers and existing transmission infrastructure.

[55] *See* Lawrence Berkeley National Laboratory (2022) for wind capacity factors by state. For maps of US wind and solar resources, see NREL (2023a) and NREL (2023b), respectively.
[56] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[57] *Ibid.*

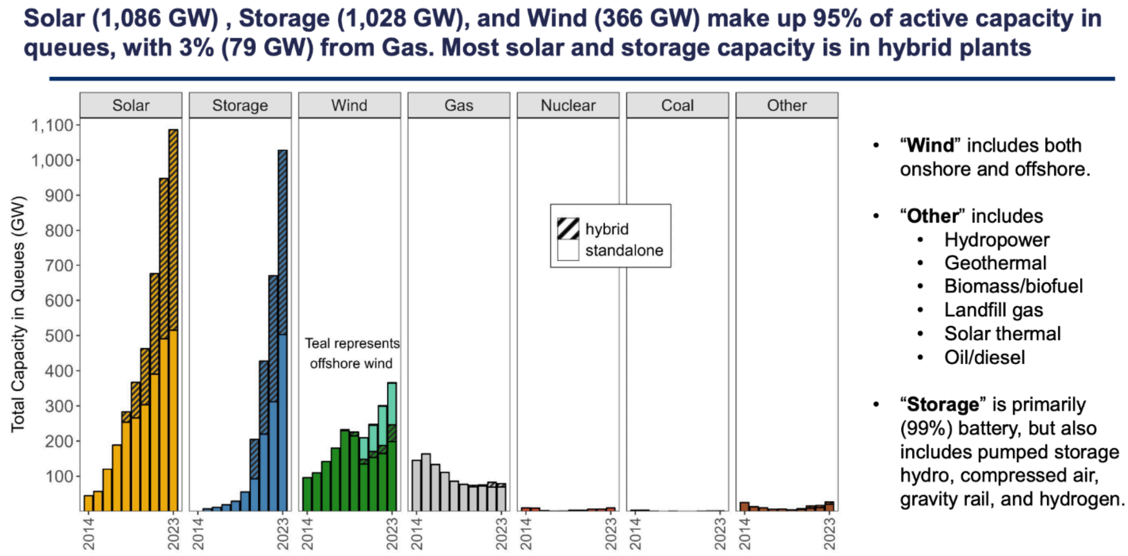
This leads to grid integration challenges. Integrating renewable energy into the grid requires coordination with utility companies and grid operators. Technical challenges related to grid compatibility, stability, and the need for upgrades to accommodate higher levels of renewable energy penetration must be overcome. The historical development of the U.S. electric grid has led to inherent limitations in its capacity for long-distance power transmission. There is almost no capacity to move electricity between the three main interconnections in the continental U.S.—the Eastern, Western, and Texas grids.[58] This lack of interconnection persists despite evidence showing that the benefits of such connections would far outweigh the costs.[59] Except for a handful of older high-capacity lines designed to transport hydro power to distant customers through interconnections, there is minimal capability to transfer electricity, particularly during peak periods when these connections would be most beneficial.

Electric transmission system operators (ISOs, RTOs, or utilities) require projects aiming to connect to the grid to undergo a series of impact studies before they can proceed. This process determines what new transmission equipment or upgrades may be necessary before a project can connect to the system and assigns the costs of that equipment. These lists of projects in the process are referred to as "interconnection queues."[60]

The amount of new electric capacity in these queues is growing significantly, with nearly 2,600 gigawatts (GW) of total generation and storage capacity now seeking connection to the grid, over 95% of which is for zero-carbon resources such as solar, wind, and battery storage. [Fig 4][61] In total, over 1,480 GW of zero-carbon generating capacity is currently seeking transmission access. Solar (1,086 GW) accounts for the largest share of generation capacity in the queues [Fig 4]. Substantial wind (366 GW) capacity is also seeking interconnection, 1/3 of which is for offshore projects (120 GW). [Fig 6][62]

Fig 6.

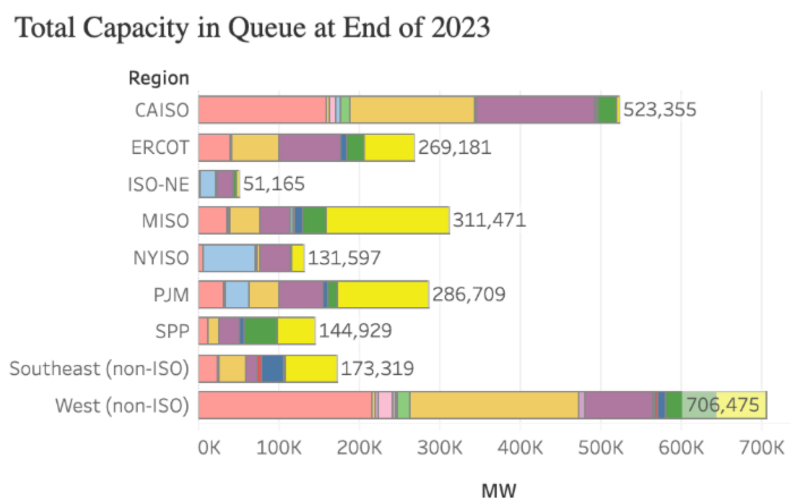
[58] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, “Transmission Impossible? Prospects for Decarbonizing the US Grid,” *Journal of Economic Perspectives,* 37(4), 155-180..
[59] *Ibid.*
[60] Joseph, Rand, Nick Manderlink, Will Gorman, Ryan H. Wiser, Joachim Seel, Julie Mulvaney Kemp, Seongeun Jeong, and Fritz Kahrl (n.d.). (rep.). Retrieved 2024, from https://emp.lbl.gov/publications/queued-2024-edition-characteristics.
[61] *Ibid.*
[62] *Ibid.*



However, most projects that apply for interconnection are eventually withdrawn, and those that are constructed are taking longer on average to complete the required studies and become operational. Only 19% of the projects (representing 14% of capacity) seeking connection from 2000 to 2018 being constructed as of the end of 2023 and the typical duration from connection request to commercial operation rising from less than two years for projects built in 2000-2007 to over four years for those built in 2018-2023, with a median of five years for projects completed in 2023. [Fig 7][63]

[63] *Ibid.*

Fig 7.



Furthermore, GM's efforts may be affected by supply chain sustainability issues. Sourcing renewable materials for manufacturing EV batteries and other components while ensuring ethical and environmentally responsible practices throughout the supply chain can be complex.

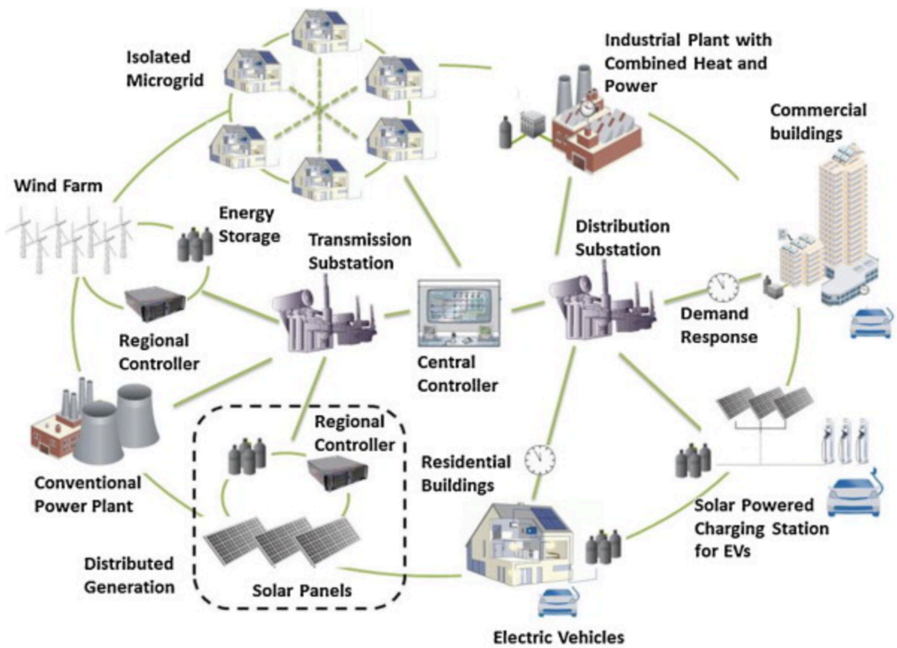
Addressing these challenges will require collaboration with stakeholders across the energy sector, innovative solutions, and continued advocacy for policies that support renewable energy deployment and grid decarbonization.

B. Opportunities for GM to enhance its efforts and achieve greater impact

The current electric grid infrastructure, designed for one-way electricity flow from large power plants to consumers, is increasingly recognized as a constraint to progress due to technological advancements, security threats, and climate concerns. The adoption of a "smart grid" is proposed as a solution to modernize the electricity infrastructure, integrating various resources like distributed renewables, energy storage, and electric vehicles. Smart grids enable two-way communication between utilities and consumers, promoting higher power quality, system security, and efficiency through dynamic pricing and demand management.

Smart grid deployment varies across countries, with the U.S., EU, UK, Japan, Korea, and China each pursuing different strategies. However, evidence suggests that widespread adoption of smart grid technologies requires supportive policies to address interoperability, standardization, and cybersecurity issues.

Fig 8.[64]



The following are some ways that GM can contribute to improving the smart grid:

a. **Allocating Capital for Smart Grid Technologies:** Invest in and allocate resources to the implementation of smart grid technologies, including demand response systems, automation of distribution, and sophisticated metering infrastructure.

b. **Collaboration and Advocacy for Policies:** Take part in state and federal policy advocacy campaigns to advance laws that will facilitate the implementation of smart grids. Work together to address interoperability, standardization, and cybersecurity challenges with industry stakeholders, legislators, and regulatory agencies.

c. **Integration of Renewable Energy Sources:** Make use of smart grid capabilities to make it easier for GM's electrical grid to incorporate renewable energy sources like wind and

[64] https://cepl.gatech.edu/projects/sgp/policies

solar power. Examine the possibilities for energy storage, distributed generation, and infrastructure for charging electric cars.

d. **Data Analytics and Optimization:** To improve energy efficiency, reduce carbon emissions, and optimize grid operations, make use of cutting-edge data analytics and optimization tools. To guarantee the dependability and durability of General Motors' grid infrastructure, employ predictive maintenance tactics.

e. **Employee Training and Stakeholder Engagement:** To improve GM employees' comprehension of smart grid technologies and their part in grid decarbonization, offer training courses and awareness campaigns. Interact with consumers, local communities, and other interested parties to encourage backing for smart grid projects.

VII. Recommendations

A. Actionable recommendations for GM to further accelerate grid decarbonization

1) Unified National Comprehensive Decarbonization Policy in the U.S.

The U.S. lacks a national decarbonization policy, but many states have set ambitious goals for reducing carbon emissions in their electricity supplies. However, some states oppose such efforts, leading to conflicts in multi-state ISOs and certain planning regions. GM certainly can influence states to work together.

CAISO and NYISO, single-state ISOs in California and New York with aggressive decarbonization goals, integrate these goals into their transmission planning processes. They rely on competitive procurement of transmission projects to support decarbonization commitments, with costs recovered through regulated transmission charges, incorporating cost containment and performance incentives. The absence of a national decarbonization policy complicates transmission planning, but decarbonization benefits can still be considered in TSOs' planning processes. In contrast, the EU has committed to net-zero carbon emissions by 2050, with interim goals for 2030.[65] A unified

[65] Joskow, Paul L., 2019, "Challenges for Wholesale Electricity Markets with Intermittent Generation at Scale: The U.S. Experience," *Oxford Review of Economic Policy,* 35(2), 291-331.

EU policy reduces conflicts between member states and their TSOs, with policies to expand interconnectors and an emissions trading system.[66]

Without a national decarbonization policy, expanding transmission capacity to access low-carbon resources remains challenging and requires careful consideration for identification, development, permitting, and financing.

2) Wider Adoption of RPS

The increase in renewable energy generation is remarkable, but to achieve decarbonization goals, significantly more progress is needed. As of 2022, natural gas and coal still remained the two primary sources of electricity generation in the United States. To accelerate the transition to renewables, 30 states have implemented RPS. For instance, California aims to reach 60 percent renewable energy by 2030 and 100 percent by 2045.[67] Although state-level standards often include geothermal, hydroelectric, and sometimes nuclear energy, the majority of new renewable capacity from 2020 to 2050 is expected to come from wind and solar sources due to the declining cost of capital.

GM can influence states in which GM has operations to continue to refine and revise their RPS policies, by adopting higher renewable energy policies. Among the 29 states plus DC with an RPS, 16 states have RPS targets of at least 50% of retail sales, and 17 states have a 100% Clean Energy Standard or RPS target.[68] By having a higher RPS policy, the impacts on renewable energy development are monumental. Roughly half of all growth in U.S. RE generation and capacity since 2000 is associated with state RPS requirements, though that percentage has declined in recent years, representing 30% of all U.S. RE capacity additions in 2022.[69] Within some regions, particularly the Northeast and Mid-Atlantic, RPS policies play a more central role in motivating RE growth.[70]

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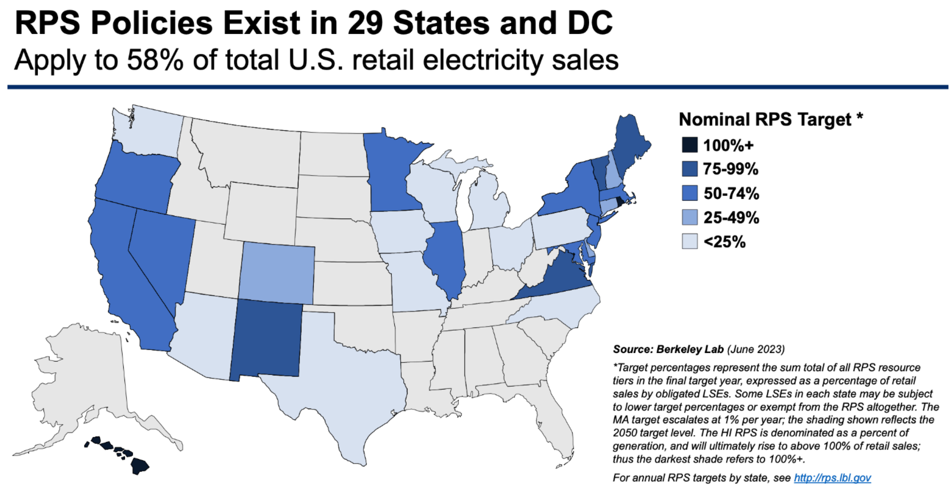
[66] *Ibid.*
[67] *California Energy Commission. (n.d.). Developing renewable energy. https://www.energy.ca.gov/about/core-responsibility-fact-sheets/developing-renewable-energy*
[68] Barbose, Galen L. 2023. U.S. Renewables Portfolio Standards: 2023 Status Update. Berkeley, CA: Lawrence Berkeley National Laboratory.
[69] *Ibid.*
[70] *Ibid.*

Fig 9[71]:



In the Northeast and Mid-Atlantic regions, the demand for renewable energy has surpassed the actual growth in renewable energy sources, leading to a deficit that is partly met by imports.[72] This indicates that RPS have been a significant driver of non-hydro renewable energy growth in these areas.[73] In the West, the growth of renewable energy has exceeded RPS requirements, primarily due to the proliferation of net metered solar photovoltaic (PV) systems, with around 33 terawatt-hours (TWh), most of which is not utilized for RPS compliance.[74] Conversely, in Texas and the Midwest, renewable energy growth has far exceeded RPS needs, mainly driven by the attractive economics of wind energy.[75] In the Southeast, there is negligible regional RPS demand, particularly in North Carolina, although some renewable energy growth serves RPS demand in the PJM Interconnection.[76]

3) Enhanced federal authority for siting and permitting new and upgraded transmission lines

The current approval process for electricity transmission projects involves multiple federal, state, and local agencies.[77] However, GM can argue that the public benefits of

[71] *Ibid.*
[72] Barbose, Galen L. 2023. U.S. Renewables Portfolio Standards: 2023 Status Update. Berkeley, CA: Lawrence Berkeley National Laboratory.
[73] *Ibid.*
[74] *Ibid.*
[75] *Ibid.*
[76] *Ibid.*
[77] *See* https://emp.lbl.gov/state-distribution-planning-requirements for complete summary of legislative and regulatory requirements for regulated electric utilities to file some type of distribution system plan in 20 U.S. jurisdictions.

these projects argue for greater centralization of decision-making.[78] Increased transmission capacity generates economic benefits that spread across states, which a federal agency can better consider compared to individual states or utilities. Historically, FERC has been the central authority for siting natural gas pipelines, and a similar approach could be taken for electricity transmission. Interstate transmission lines are critical for decarbonization of the U.S., but they are frequently rejected by state authorities due to the high local costs. Natural gas pipelines have similar cost-benefit tradeoffs, but they are permitted much faster due to FERC's existing siting authority over them.[79] MIT suggests that enhanced authority should focus on interstate transmission lines due to the significant coordination challenges they present.[80] FERC could also ensure that interstate transmission lines allocate a fair fraction of their capacity to the states and communities through which they pass, thereby increasing local support for transmission and more equitably distributing its benefits.[81]

Recent instances have highlighted the challenges that interstate transmission lines encounter at the state level. A notable example is the Grain Belt Express transmission line in Missouri, which was initially denied by the state Public Service Commission in 2015.[82] Despite eventual approval in 2019 and the granting of eminent domain powers, the state legislature has repeatedly sought to restrict or eliminate this authority, potentially halting the project.[83]

Strengthening federal authority for siting will be challenging. Recent legislation like the Bipartisan Infrastructure Law of 2021 and the Inflation Reduction Act of 2022 have taken steps in this direction, such as updating FERC's existing authority for transmission lines by clarifying its role under "backstop authority"—that is, allowing FERC to override state opposition to the construction of transmission infrastructure if a given project takes longer than a year and is located in a DOE-declared National Interest Electric

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[78] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[79] Sud, R., Patnaik, S., & Glicksman, R. (n.d.). (issue brief). *Reforming Federal Permitting to Accelerate Clean Energy Infrastructure*.
[80] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[81] Sud, R., Patnaik, S., & Glicksman, R. (n.d.). (issue brief). *Reforming Federal Permitting to Accelerate Clean Energy Infrastructure*.
[82] *Ibid.*
[83] *Ibid.*

Transmission Corridor.[84] However, it remains uncertain to what extent FERC will use this new authority. Proposed legislation by Senators Chuck Schumer and Joe Manchin aimed to address barriers including improved cost allocation, enhanced federal permitting authority, simplified National Environmental Policy Act procedures, and streamlined multi-agency coordination.[85] However, this legislation encountered political obstacles and did not pass.

4) Upgrading existing transmission lines

Opportunities exist to shift new transmission investments away from greenfield locations and towards upgrading existing transmission corridors. Instead of focusing solely on new projects, emphasis could be placed on upgrading existing high-voltage lines to expand capacity. For example, lines could be upgraded from 230kV to 345kV.[86] Another option is to increase capacity by converting existing high-voltage alternating current (HVAC) lines to high-voltage direct current (HVDC) or hybrid AC/DC lines.[87] GM can advocate for grid upgrade and also monitor the implementation of this initiative.

When possible, GM can also provide funding for grid upgrade, because capacity expansion projects still require significant capital investment. Grid upgrades may be easier in terms of local siting concerns. New transmission projects can also be placed along existing public infrastructure corridors such as waterways, railroads, and highways. This approach can be simpler than negotiating right-of-way permissions with numerous individual landowners and has the potential to reduce local siting concerns significantly compared to projects that involve breaking new ground.

5) Dynamic Pricing

Another potential alternative to electricity transmission is dynamic pricing. Currently, most electricity customers face fixed prices that do not effectively reflect real-time

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[84] Office of Congresswoman Katie Porter. (n.d.). (rep.). *Refocusing Our Energy: Permitting Reform That Promotes Electrical Transmission*.
[85] Goggin, Michael, and Rob Gramlich. 2022. Emissions Reductions from Electricity Transmission Provisions in Energy Permitting Legislation. Bethesda, MD: Grid Strategies LLC. and Davis, Lucas, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[86] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[87] *Ibid.*

changes in market conditions.[88] Under dynamic pricing, customers would pay higher prices during peak periods, leading to reduced electricity demand during those times. This would lessen the need for large investments in generation and transmission capacity, which are typically driven by peak demand rather than average demand.

However, dynamic pricing is not widely implemented, especially in residential settings. Consumer groups often oppose dynamic pricing due to concerns that customers may not understand complex pricing structures or be able to adjust quickly to price changes. Additionally, there are worries that some customers would end up paying more under dynamic pricing models.[89] Furthermore, dynamic pricing can increase the overall variability of electricity bills, which can be particularly challenging for low-income households with limited financial stability.[90]

GM can help advocate the implementation of dynamic pricing. Economists have advocated for decades that electricity markets could operate more efficiently with dynamic pricing.[91] Moreover, numerous empirical studies have shown reductions in electricity demand in response to dynamic pricing across both residential and nonresidential sectors.[92] As communication technology, particularly automation, continues to advance, consumers are increasingly capable of responding to real-time price changes.[93] This pricing mechanism would be supported with a smart grid.

B. Investments and policy recommendations to accelerate grid decarbonization[94]

1. Electric Transmission and Distribution Infrastructure
    - By working with utility partners to support the development of transmission lines connecting regions rich in renewable resources to high-demand areas, GM can invest in the expansion of high-voltage electric grid infrastructure.

[88] Borenstein, Severin, and Stephen Holland. 2005. "On the Efficiency of Competitive Electricity Markets with Time-Invariant Retail Prices." *RAND Journal of Economics* 36 (3): 469–93.
[89] Davis, Lucas W., Catherine Hausman, and Nancy L. Rose, 2023, "Transmission Impossible? Prospects for Decarbonizing the US Grid," *Journal of Economic Perspectives,* 37(4), 155-180.
[90] *Ibid*.
[91] *Ibid*.
[92] *Ibid*.
[93] *Ibid*.
[94] Accelerating decarbonization of the U.S. Energy System. (n.d.-b). https://www.cmu.edu/traffic21/research-and-policy-papers/25932.pdf

- The business can push for federal policy modifications, like a revision to the Federal Power Act, to make it easier to plan and implement the transmission infrastructure that decarbonization requires.
- In order to improve grid reliability and meet the growing demand from electric vehicles (EVs) and renewable energy sources, GM can also help develop and implement automation and control technologies on distribution systems.

2. Electric Vehicle Charging Infrastructure
   - As a top producer of electric cars, General Motors (GM) can contribute significantly to the development of EV charging infrastructure by collaborating with utilities and charging station operators to place charging stations in key areas.
   - The business can push for federal financing and incentives to help expand the infrastructure for EV charging, including programs to close gaps in interstate charging and facilitate charging in low-income areas.
   - In order to ensure compatibility and user-friendliness for EV drivers, GM can work with standards organizations such as the National Institute of Standards and Technology (NIST) to develop interoperability standards for EV charging infrastructure.
   - Invest more research into bidirectional EV charging infrastructure that can be used to provide backup electricity generation for homes.

By actively participating in these activities, GM can contribute to the acceleration of decarbonization efforts, facilitate the widespread adoption of electric vehicles, and support the transition to a net-zero energy economy.

C. Suggestions for collaboration and partnership within the ZGI

1. Partnership with Clean Energy Advocacy Groups

GM's dedication to decarbonization is evident through its participation in groups such as the Emissions First Partnership and the Clean Energy Buyers Alliance. Through cooperation with these organizations within the ZGI, GM can promote legislative and regulatory adjustments that facilitate the implementation of sustainable energy technologies and efforts to modernize the grid.

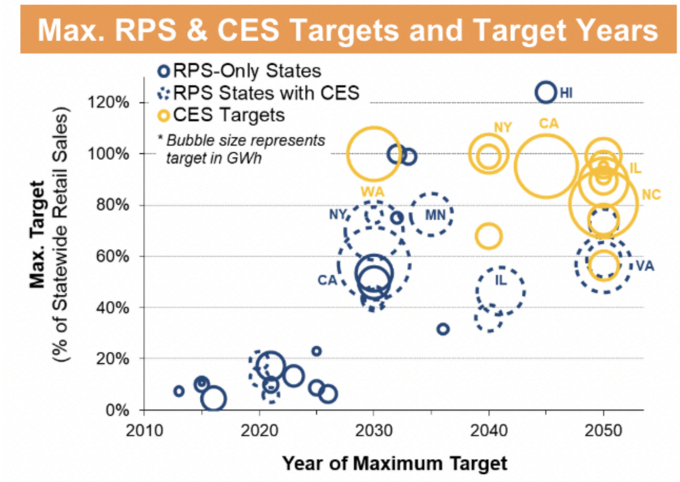
To contribute to regulation making, GM can actively engage with policymakers, regulatory agencies, industry associations, and advocacy groups to advocate for policies and standards that support grid decarbonization. This can involve participating in public hearings, submitting comments on proposed regulations, and building coalitions with other stakeholders to influence decision-making processes.

2. Engagement with Research Institutions

GM has partnered with universities all over the world, demonstrating its interest in promoting market adjustments that enable the achievement of the affordable energy target. GM can work with academic institutions to investigate cutting-edge grid decarbonization solutions through the ZGI, including sophisticated energy storage technologies, grid optimization algorithms, and strategies for integrating renewable energy sources.

GM can collaborate with other stakeholders, including utilities, technology providers, research institutions, and non-profit organizations, to develop and deploy innovative solutions for grid decarbonization. By pooling resources and expertise, companies can accelerate the adoption of clean energy technologies in accordance with CPP, CES, and RPS [Fig 4].

Fig 4[95]:



D. Creation of Broader Regulatory Frameworks

GM has created the Leadership Pathway, which other companies can follow to streamline their process of EVs development. To expand on this, GM can create a broader regulatory framework for companies to follow to navigate the overall transition to decarbonization through a multi-faceted approach, not just EVs deployment technologies. This framework could take different factors into consideration, including facilitating conversations and collaborations between utility companies and other stakeholders in the energy industry.

VIII. Conclusion

The report examines GM's efforts within the context of the ZEROgrid Initiative, focusing on promoting grid decarbonization and transitioning to a sustainable energy system. It identifies challenges faced by GM in promoting grid decarbonization, such as infrastructure development issues, and highlights opportunities for GM to enhance its efforts. The report provides actionable recommendations for GM to accelerate grid decarbonization, including the need for a unified national comprehensive decarbonization policy in the U.S. and wider adoption of renewable portfolio standards.

[95] Barbose, Galen L. 2023. U.S. Renewables Portfolio Standards: 2023 Status Update. Berkeley, CA: Lawrence Berkeley National Laboratory.

GM has been actively involved in promoting grid decarbonization through initiatives such as the ZGI. The company has invested in renewable energy technologies and collaborated with research institutions to explore cutting-edge grid decarbonization solutions. GM has also participated in groups like the Emissions First Partnership and the Clean Energy Buyers Alliance to promote legislative and regulatory adjustments that facilitate the implementation of sustainable energy technologies and efforts to modernize the grid. Additionally, GM has partnered with utility companies to test and implement bi-directional charging technologies to provide a backup power option for homes, addressing accessibility issues in charging deserts.

Continued efforts towards a net-zero emissions future are crucial for addressing climate concerns and promoting a sustainable energy landscape. Collaboration with stakeholders across the energy sector, innovative solutions, and advocacy for policies that support renewable energy deployment and grid decarbonization are essential. GM's commitment to integrating decarbonization into its corporate strategy, investing in new transmission infrastructure, and collaborating with utilities and grid operators demonstrates the importance of corporate leadership in advancing grid decarbonization efforts. It is imperative for companies like GM to continue their efforts and contribute to a more reliable, optimized, and zero-emissions future for the electricity grid.