Energetic Debates: A proposal for the 2026-2027 High School Policy Topic

A Topic Proposal for the National Federation of High Schools Topic Selection Committee

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Introduction

High school debaters need a topic focused on confronting climate change. Over one third of American high schoolers told pollsters they battle climate anxiety, a whole set of emotions stemming from fears that young people will lose their planet to global warming (Will, 2022). Yet in the last two decades the high school community has not been able to agree on a topic that fits that need, often because of concerns of overlap with college topics. This paper will argue that renewable energy offers the best vehicle to debate the climate change area.

Renewables are a rich controversy area right now. The United States is a net total energy exporter yet only about one fifth of energy consumption comes from renewable sources (U.S. Energy Information Administration, 2024). The Biden Administration's attempts to shape climate policy for years to come, the Inflation Reduction Act, face scrutiny from the new Trump Administration (Fuji-Rajani, 2025). Renewables touch all aspects of the American economy: manufacturing, technology, foreign investment, security, and infrastructure, which provides dynamic advantage and disadvantage ground. Additionally, political disagreements over how America should plot its energy future offer a variety of compelling politics disadvantage links.

We need resolutions that meet three essential criteria. First, can we explain the topic, and its value, to parents and administrators. In an era of budget cuts, teacher retirements, and intense competition between school activities, debate always needs more positive press. Renewables is something that is intuitive, in the news, and easily explained to parents and administrators without legal jargon or extensive context. Second, will the topic capture the excitement of people who are new to debate. People who have been debating for multiple years have already embraced debate but people who are new to debate need to think that they will like policy debate topics, that they can count on the topics being interesting. Renewables taps into their concerns about global warming and is something they already have a rough understanding of. Third, will the topic encourage veteran debaters to dive deep into a literature base that offers in-depth topic debates. Debates have increasingly relied on arguments that are so generic as to be read without change on most topics, partly because negative topic ground has been so sparse or the topics chosen have included such disparate parts. Renewables offers variety while having more unifying factors and its prevalence in current policy discussions offers a more consistent literature base.

Why focus on renewables over other climate topics? Unfortunately the high school debate community seems particularly scared about debating a topic closely related to a college topic. In the 2024-2025 college debate season, the NDT/CEDA topic was Resolved: The United States Federal Government should adopt a clean energy policy for decarbonization in the United States, including a market-based instrument. If the guiding terms of that resolution are understood to be “clean energy policy” and/or “decarbonization,” then those aspects need to be distinct and separate from what we debate if we are to win the hearts and minds of voters. Focusing on “renewable energy” allows high school to have a climate topic without being a college retread.

Potential Topics

First consider relevant past topics:

NFHS 2008-2009
Resolved: The United States federal government should substantially increase alternative energy incentives in the United States.

NFHS 1997-1998
Resolved: That the federal government should establish a policy to substantially increase renewable energy use in the United States.

NFHS 1978-1979
Resolved: That the federal government should establish a comprehensive program to significantly increase the energy independence of the U.S.

2024-2025 NDT/CEDA
Resolved: The United States Federal Government should adopt a clean energy policy for decarbonization in the United States, including a market-based instrument.

2012-2013 NDT/CEDA
Resolved: The United States Federal Government should substantially reduce restrictions on and/or substantially increase financial incentives for energy production in the United States of one or more of the following: coal, crude oil, natural gas, nuclear power, solar power, wind power.

2004-2005 NDT/CEDA
Resolved: The United States Federal Government should establish an energy policy requiring a substantial reduction in the the consumption in the total non-governmental consumption of fossil fuels in the United States.

1989-1990 NDT/CEDA
Resolved: The federal government should adopt an energy policy that substantially reduces nonmilitary consumption of fossil fuels in the United States.

Consider some suggested resolutions, in order of author's preference:

Resolution 1:
The United States federal government should adopt a renewable energy policy, including a market-based instrument.

This topic is directly inspired by the 2024-2025 NDT CEDA topic about clean energy and decarbonization. Several readers of draft 1 suggested that this mechanism would provide more flexibility for the affirmative, particularly in preventing the topic from collapsing into a states counterplan debate, while also providing more uniqueness for both sides as renewable energy subsidies currently dominate the policy sphere. Advantages would be that this is still a very direct, simple, straight forward topic that avoids list creep and potential sectioning of the topic into disparate parts. Hopefully this topic would provide the complexity to sustain dynamic varsity debates while still being able to be explained as the renewable energy topic to novices, parents, administrators, etc. The only concern is that “renewable energy policy” seems to not be a term of art, see Resolutions 2 and 3. Another phrase that could potentially be used is “renewable energy transition” which seems to have a clear brightline.

Resolution 2:
The United States federal government should substantially increase incentives for renewable energy through permitting reform, developing energy infrastructure, and/or fossil fuel subsidy reform.

This topic is inspired by draft 1 readers who suggested that there were policies to encourage or incentivize renewable energy that went beyond subsidies that would likely be both more unique and more strategic for the affirmative to deploy. The first two list items in particular offer several different affirmative areas while the second two are a little narrower but are firmly in the literature base. An earlier draft of this resolution, “The United States federal government should substantially increase incentives for renewable energy by adopting permitting reform, developing energy infrastructure, raising the price of fossil fuels, and/or restricting fossil fuel imports”, was scrapped largely because the verb phrase and policy change were not terms of art, i.e., “adopting permitting reform” produces almost no search results. Additionally, it was challenging to word the subareas, i.e., “developing energy infrastructure” was used instead of “developing electricity infrastructure” or “developing transmission infrastructure” largely because of the previous challenge regarding terms of art. Similarly the third component, intended to capture debates about carbon pricing, carbon tax, and fossil fuel subsidies, originally was two separate areas that were “Raising the price of fossil fuels” and “Restricting fossil fuel imports”, then simplified to “fossil fuel pricing” which does appear in the literature but was not as precise as “fossil fuel subsidy reform.” It should also be acknowledged that there has not been a resolution with “through” in it since 1992-1993 but that is not an integral part of the resolution. Another version of this topic that might be more grammatically palatable and popular for voting could be “The United States federal government should substantially increase renewable energy permitting reform and/or infrastructure.” Advantages to this resolution would be that it avoids the subsidy uniqueness concerns and gets to the heart of essential reforms that could promote renewables. The concerns with this topic is that it is a more specific list topic than usual for high school and one that utilizes different verb phrases. Also, as a list topic it could suffer from the “mini-topics” aspect of other recent list topics that lacked cross-cutting disadvantages or counterplans. Hopefully “incentives for renewable energy” is a unifying enough term to reduce this risk.

Resolution 3:
The United States federal government should adopt a market-based instrument substantially incentivizing renewable energy in the United States.

This topic is an attempt to utilize the market-based instrument approach while getting around that “renewable energy policy” might not be a term of art. Hopefully putting “substantially incentivizing renewable energy” after “adopt a market-based instrument” reduces some of the mixing-burdens topicality concerns that some topics have but that would be one of the main concerns with the phrasing of this topic.

Resolution 4:
The United States federal government should substantially increase renewable energy subsidies in the United States.

This topic was the main suggested topic in draft 1 of the paper. However, several readers expressed concern that a subsidies focused topic would be stale, struggle with uniqueness concerns, and potentially lead to affirmatives with difficulty answering counterplans. Advantages to this resolution would be that it is likely the simplest resolution of the five discussed in this paper and there would be very clear topicality baselines and straightforward disadvantage links. If the committee agrees with the above concerns about subsidies, a suggestion was made by an editor for a topic along the lines of The United States federal government should adopt a renewable energy policy, at least increasing subsidies for renewable energy. This would allow creative affirmatives to be more than just a subsidy so they could access affirmatives that would take resources away from fossil fuels.

Resolution 5:
The United States federal government should substantially increase subsidies for one or more of the following industries: bioenergy, hydroelectricity, geothermal energy, solar energy, wind energy.

This list topic could also be modified to replace subsidies with “market-based instrument”. If there was a desire to cut areas out, bioenergy and geothermal would be the first to go. Otherwise the thought process would be that this is a very similar topic as Resolution 4.

Definitions

Readers can find topicality cards in the Appendix, right before the Works Cited. Light research was utilized to determine the viability of terms and what debaters could reasonably find in their own research. What follows is a brief summary of the findings regarding different terms that are discussed in the Potential Topics section above.

Renewable energy is from “natural sources … that are constantly replenished” and includes solar, wind, hydroelectric, biomass, geothermal, and ocean energy sources (Shinn, 2022). If the topic is ultimately a list of different energies, renewable energy should not be used in addition to the list because that would be repetitive and if the list is used to exclude certain energies to narrow the topic, that would be counter intuitive.

Renewable energy policy is a government guideline or regulation to promote renewable energy sources and encourage the adoption of sustainable energy technology (Science Direct). It was surprisingly difficult to find good definitions for this phrase which might not be a term of art. Reasonable individuals could likely conclude that it would be one limiting factor in a resolution and combined with the other words would have a very specific meaning but it did prompt an exploration into other words and phrases that could be superior.

Incentives for renewable energy can include a whole host of actions including grants, contracts, weatherization assistance, production incentives, loan guarantees, technology transfers, tax credits, and more to increase renewable energy efficiency, capacity, and production (Cunningham). This phrase was explored as an alternative to renewable energy policy. It is considered preferable to incentivizing renewable energy policy because it has less of an appearance of forcing affirmatives to win solvency to prove topicality.

But, incentivizing renewable energy means providing incentives for renewable energy so there should be little difference between these two phrases beyond grammatical preference by the topic committee (Matisoff, 2017).

Renewable energy transition is “a policy focusing on improving energy sustainability and reducing air pollution by replacing non-renewable fossil fuel with renewable clean energy i.e., wind, and solar” (Ai, 2025). This has some concerns with proving solvency to win topicality but it is a little bit more defined in the literature base than some of the other words and phrases.

Alternative energy is sometimes considered in these topic and it includes nonrenewable energies like nuclear power (Britannica). There is little reason to explore this phrase and the topic paper assumes that renewable energy is the operative phrase.

Subsidy is public monies or tax concessions that constitute government assistance to private actors (World Trade Organization). There is little dispute on what subsidies are in most of the literature bases.

Domestic subsidy is geographically limited (International Trade Administration). That phrase could be utilized if there was a concern about which subsidies would be eligible but given that it is a domestic topic it does not seem necessary.

Switching focus to market-based instruments was a move made in this second draft to try to capture complex debates for varsity debaters while providing enough clarity for novices. Market-based instruments are taxes, permits, market creation, and subsidy elimination (Stavins, 1998; Zhang, 2013). Special thanks to Kevin Hirn's college wording paper where the evidence was taken for this phrase.

If the topic lists specific action areas, permit reform and energy infrastructure as key areas. Permitting reform includes streamlining and speeding up the processing of permits to build, operate, store, and transmit renewable energy (Bauer, 2024). This area is probably the most well defined in the literature and must be included.

Energy infrastructure is any facility that produces, transmits, and delivers energy (Clay, 2021). While this area might be less defined, because it is wider ranging and can mean a variety of things, it is still very important.

Fossil fuel subsidies are "financial interventions … provided either to producers or consumers in order to reduce or limit the cost of fossil fuels" (Belgioioso, 2025). Especially given recent developments, this could be an exciting area for affirmatives though it is probably the least of the "must-have" action areas.

Affirmative Ground

General

There are many different ways the affirmative could incentivize renewable energy (Lesser, 2024).

- Production tax credits (PTC) to producers, similar to the Clean Electricity Production Credit, which provides an incentive tied to how much electricity is produced by a specific energy facility (McNamara, 2024). New stipulations could increase the credit itself or decreasing or increasing the amount of power produced to receive the benefit.

- Investment tax credits (ITC) to consumers, like the Residential Clean Energy Credit, which provides an annual flat incentive to individuals who install renewable energy in their homes (Veyon, 2024). New policies could go to different types of consumers beyond homeowners or changing the amount of the incentive, which will apply in all instances and will not be suggested again.
- Incentives for the research or development of new renewable programs, such as the Rural Energy for America Program (REAP), which provides grants and loans to farmers and rural businesses that develop renewable energy production on their properties (Baranowski, 2025). New subsidies could be grants and loans to different industries or geographic distinctions.
- Incentives to get renewable pilot programs off the ground, like the Rural Energy Pilot Program (REPP), which provides assistance for communities that apply to install renewable energy production. Pilots would provide the aff with an interesting tool to invest in programs to test their scalability.
- Incentives for the improvement or rehabilitation of renewable infrastructure, such as the Modified Accelerated Cost Recovery System (MACRS), which allows business owners to recover investment costs over a period of time based on the depreciation of a prior investment (Langone, 2021). New initiatives could change the value formula or the time periods for certain investments.
- Incentives for power plant transitions or storage capacity, like the Innovative Energy Loan Guarantee Program, which gives favorable loans to developers with a reasonable expectation of repaying the loan (McDonald, 2021). Loan guarantees for plant retrofits provide the affirmative with an interesting way to span the greater energy debate.

- Reform renewable fuel standards (RFS) regarding volume or the tradable credits (Bracmort, 2023). Regulatory standards could be viable with more liberal topicality interpretations, especially if the regulatory standard can be tied to a permit.
- Carbon disincentives, or actions that reduce the cost of energies that have a lower carbon footprint, functionally making energies and activities with a higher carbon footprint less attractive, like a carbon tax (Miron, 2024). While some authors connect this to renewable subsidies and others do not, it falls squarely in the market-based instrument set of resolutions.
- Incentives for renewable research and development, such as actions that fostered innovation in lithium ion batteries (Wu, 2022). While the negative might seek to limit out these affirmatives, it seems that even research and development would have similar effects on energy prices which is likely the link to many negative positions.
- International treaties and commitments, like the Paris Climate Agreement that encourages renewable energy development or the Agreement on Climate Change, Trade and Sustainability (ACCTS) that discourages fossil fuel subsidies (Tipping, 2024). These affirmatives would most likely access this literature base through advantages instead of solvency mechanisms.

Areas

There are different areas or baskets affirmatives could fall in based on their targeting of a specific renewable energy.

- Biomass incentives could cover a few different aspects of the industry including production and transportation for biomass utilization improvement and production and operating incentives for new biomass development (Lin, 2024).

- Hydropower incentives could cover everything from pumped storage, maintenance, enhancements for existing facilities, and new capacity or new infrastructure (Hayes, 2023).
- Geothermal incentives would cover tax credits and rebates for residential and commercial installation of geothermal heat pumps and grants for the development of new geothermal projects (Barnes, 2023).
- Solar incentives could include grants, low-interest loans, rebates, and tax credits covering different production tax credits to research and development in solar panels for producers, consumers, and specific communities (Bronner, 2024 and Kubis, 2019).
- Wind incentives focus on increasing wind energy production and deployment and usually see to make wind energy price efficient with other sources of energy (Chang, 2022).

Advantages

This will not be an exhaustive list but a brief discussion of a few core advantage areas including global warming, green economy, energy independence, grid security, technology leadership, and manufacturing.

- Global warming is the obvious place to start and federal renewable incentives are an important step to creating a uniform, nationwide, solution to reduce emissions according to the Climate & Community Institute (Ramamurthy, 2023).
- Similarly, affirmatives could argue that their incentives were necessary to the overall green economy, especially in light of Trump Administration rollback and a possible shift back to fossil fuels (Jacoby, 2025).
- Energy independence is an essential component of energy security and affirmatives could argue that renewable energy's sustainable production stability increases U.S. energy independence (Laimon, 2024).

- Affirmatives could also argue that integrating renewable energy systems makes the grid more secure and less prone to blackouts (Stockton, 2018).
- Technology leadership is another strong advantage area where renewables provide the United States the opportunity to lead by example and to close gaps in energy exports (Buchholz, 2019 and Jackson, 2024).
- Affirmatives could build manufacturing advantages around a variety of renewables internal links related to production of batteries and storage technology to chips and panels construction (Turner, 2024).

Negative Ground

Disadvantages

There have been several recent topics that have not had disadvantages that spanned the whole subareas listed but renewables will hopefully be different.

Economy

There will be several flavors of economy disadvantages. The negative could say that renewable energy development reduces business confidence based on past U.S. incentives of renewables and/or other industries and/or a comparison of other countries (Hardi, 2024). There are several articles about renewable incentives reducing inflation, often tied to the Inflation Reduction Act, but the negative could contend that renewable incentives cause inflation, possibly because they shift towards other energy sources that will inevitably cause inflation (Loyola, 2025).

Industry and Energy Prices

There also should be a variety of specific industry based disadvantages, rooted in economists who criticize energy incentives as distorting the market (Texas Policy Research, 2024). While affirmatives may very well make arguments that they decrease energy prices, the negative could go for an energy prices disadvantage as statistical analyses of states with renewable energy incentives compared to states without shows the former pay more for energy (Loyola, 2024). Of course, a likely specific energy prices disadvantage would be the oil disadvantage as a renewable energy shift causes downward pressure on oil prices (Seel, 2021).

Land Use/Environment

The negative also could make environment disadvantages based on how renewable development destroys habitats, displaces animals, and increases mining and other activities that might harm the environment (Moore, 2019 and Sonter, 2020). Just as the negative could say that renewables use land in ways that harm the environment, they could say that renewables use land in ways that harm food production and that a renewables transition correlates with higher food prices (Attilio, 2024).

Politics

Political polarization in how to best address U.S. energy security makes this a ripe area for politics disadvantages (Baker-Bransetter, 2025).

Counterplans

Again this section will spotlight a few of the most likely counterplans negatives could expect on the topic.

- States: In the renewable literature there is a vibrant federal/states federalism debate surrounding regulatory power and land use federalism versus national advantages for capacity and scale (Gerrard, 2022 and Stokes, 2021).
- Agent: The different approaches to renewables from the Biden and Trump administrations showcases the power of executive orders in shaping renewables policy and other overarching energy frameworks (Jones, 2025). Plus, recent Supreme Court cases such as Chevron have called into question a whole array of renewables issues that the court could decide for affirmative or negative ground (Farah, 2024). Whether as a counterplan or as a response to the previous two suggestions, there could also be

debates as to why Congress is best to protect existing incentives and spend on new ones (Reuters, 2025).

- Advantage: The advantages discussed at the end of the affirmative section provides excellent ground for advantage counterplan debates, especially in conjunction with the wide array of renewable incentives disadvantages. Additionally, there will be plenty of counterplans based on market-based instruments that target carbon instead of renewable energy (You, 2025).
- Privatization: Beyond advantage counterplans there could also be counterplans that privatize certain aspects of government renewable infrastructure or counterplans that utilize public private partnerships to smooth the transition (Kang, 2023 and Isarabhakdee, 2024).
- Process: Since it is debate in the 2020's there will of course be more process counterplans than you would ever need. There are a wide variety of regulatory ones, including but not limited to regulatory negotiations (Payne, 2017). There also would be several different impact assessment counterplans like environmental impact assessments and economic impact assessments (Islam, 2024). These counterplans do not need to be encouraged more than they are already but at least those two have some semblance of existing in the topic literature.

Kritiks

Kritiks find a way to link to everything but there are a variety of criticisms of renewables - and energy writ large - with vast literature bases. Economics based kritiks like capitalism and neoliberalism have lots of angles related to criticizing the market economy, government intervention, energy corporatism, commodification of nature, and more (Fearn, 2023). Environment based kritiks like deep ecology and environmental management can explore renewables' complex relationship to human control of the environment or a Heideggerian analysis of renewables (Kahsar, 2020 and Knuth, 2022). The advantage areas will lend themselves to the traditional international relations security based critiques but there is also an interesting debate in the literature about both climate fear mongering contrasted with renewable energy demonization (Slevin, 2024 and Stossel, 2023).

Topic Synopsis

This paper proposes that The United States federal government should substantially increase renewable energy incentives in the United States. Much has changed in energy policy since the last time high school policy debate debated alternative energy. The topic will be immediately intuitive to parents, administrators, and new debaters. New and veteran debaters will be able to enjoy this topic because of the knowledge they bring to the topic and the rich research ground for both affirmative and negative teams. Renewable energy touches many different sectors of the economy and trade which means affirmative and negative teams will have opportunities to innovate with advantages and disadvantages that cover a wide variety. While different energy sources will provide variety and creativity for teams there will still be core topic disadvantages that span all types of energy. Renewable energy is a substantial controversy that provides many different advantage, agent, process, and topic counterplans for the negative while also giving the affirmative unique ways to explain why their policy is best.

Timeliness

Every topic paper in this section always talks about how their topic is in the news, constantly on people's minds, and something that the public at large pays attention to. Energy is all that in spades. News coverage of the Trump administration's energy changes and energy goals receive widespread coverage, especially as the Trump administration looks to chip away at Biden's seminal Inflation Reduction Act. More importantly, renewables are the perfect way to access climate debates and teenagers do have climate on their minds. Furthermore, the issues that are in the news and do receive attention are actually the debates that will likely happen.

Scope/Range/Quality

Renewable energy provides for several engaging debate areas including energy, economy, environment, industry, technology, and more. Energy and global warming's significance in international and domestic policy and public perception will only grow. This means that debaters get to enjoy a dynamic domestic topic that also has wide ranging international ramifications.

The depth of the renewable energy literature, diversity of argumentation, potential for topic disadvantages, provides a wide ranging, high quality topic that will appeal to novice and varsity debaters. Novice affirmatives could be based on specific categories of renewable energy that teenagers already have some information about like solar panels and wind power. Or novice affirmatives could be based on different instruments like taxes, permits, or decreasing subsidies. If necessary, novice case limits could choose three of the five main types of renewable energy. Novice starter negative arguments could include the states counterplan, the federalism disadvantage, the oil disadvantage, and the neoliberalism kritik. Varsity arguments are discussed in more detail above.

The topic education, from the wide diversity of advantages and disadvantages, will provide students with a variety of portable skills and experiences.

Balance

This topic has substantial ground for both sides. Renewable energy has criticisms from both the left and right which means there is a lot of room for debaters' creativity. Additionally, the potential of topic disadvantages that cross all aspects of the topic creates ground equity. A non list topic could provide for topicality debates as well as there is some debate over if nuclear power is renewable energy.

Synopsis for National Ballot

PROBLEM AREA I: ENERGY

High school debaters think about climate change more than most other global problems. Countries around the world are grappling with how to reduce climate change and shift their economies toward environmental sustainability. At the forefront of this shift is energy and how to move from a fossil fuel based economy to a renewable based economy. Climate change – and energy – comes up tangentially in many debates yet has not been the topic focus for almost 20 years. Renewables are a rich controversy area right now, especially as the push and pull of different Biden and Trump administration policies contend to define the era. Renewables touch all aspects of the American economy: manufacturing, technology, foreign investment, security, and infrastructure. This allows the topic to be widely accessible and relatable to debaters of all background and experience levels. More importantly, it is a topic that is intuitive and immediately explainable to parents, teachers, administrators, and new debaters.

On the affirmative, debaters will have the opportunity to explore wind, solar, geothermal, hydro, and/or biomass energy. They can incentivize that shift through taxes, permits, subsidies, or market creation. Advantage areas span climate change, green economy, energy independence, energy security, leadership, and manufacturing.

On the negative, debaters will have the opportunity to research the best agents and instruments to incentivize renewables as well as disadvantages built on economic, industry, energy prices, and environment grounds. Debaters can also critique the economic, managerial, or security approach, to name but a few of the criticisms that could be introduced.

Appendix: Definitions

"renewable energy"
Lora Shinn, National Resource Defense Council, "Renewable Energy: The Clean Facts", NRDC, 6-1-22, https://www.nrdc.org/stories/renewable-energy-clean-facts

Renewable energy, often referred to as clean energy, **comes from natural sources** or processes **that are constantly replenished**. For example, **sunlight** and **wind** keep shining and blowing, even if their availability depends on time and weather.

While renewable energy is often thought of as a new technology, harnessing nature's power has long been **used for heating, transportation, lighting, and more**. Wind has powered boats to sail the seas and windmills to grind grain. The sun has provided warmth during the day and helped kindle fires to last into the evening. But over the past 500 years or so, humans increasingly turned to cheaper, dirtier energy sources, such as coal and fracked gas.

Now that we have innovative and less-expensive ways to capture and retain wind and solar energy, renewables are becoming a more important power source, accounting for more than 12 percent of U.S. energy generation. The expansion in renewables is also happening at scales large and small, from giant offshore wind farms to rooftop solar panels on homes, which can sell power back to the grid. Even entire rural communities (in Alaska, Kansas, and Missouri) are relying on renewable energy for heating and lighting.

As renewable use continues to grow, a key goal will be to modernize America's electricity grid, making it smarter, more secure, and better integrated across regions.

"renewable energy"
Lora Shinn, National Resource Defense Council, "Renewable Energy: The Clean Facts", NRDC, 6-1-22, https://www.nrdc.org/stories/renewable-energy-clean-facts

Types of renewable energy sources

Solar energy

Humans have been harnessing solar energy for thousands of years—to grow crops, stay warm, and dry foods. According to the National Renewable Energy Laboratory, "more energy from the sun falls on the earth in one hour than is used by everyone in the world in one year." Today, we use the sun's rays in many ways—to heat homes and businesses, to warm water, and to power devices.

Solar, or photovoltaic (PV), cells are made from silicon or other materials that transform sunlight directly into electricity. **Distributed solar systems** generate electricity locally for homes and businesses, either through rooftop panels or community projects that power entire neighborhoods. **Solar farms** can generate enough power for thousands of homes, using mirrors to concentrate sunlight across acres of solar cells. Floating solar farms—or "**floatovoltaics**"—can be an effective use of wastewater facilities and bodies of water that aren't ecologically sensitive.

Solar supplies nearly 3 percent of U.S. electricity generation (some sources estimate it will reach nearly 4 percent in 2022). But 46 percent of all new generating capacity came from solar in 2021.

Solar energy systems don't produce air pollutants or greenhouse gases, and as long as they are responsibly sited, most solar panels have few environmental impacts beyond the manufacturing process.

Wind energy

We've come a long way from old-fashioned **windmills**. Today, **turbines** as tall as skyscrapers—with turbines nearly as wide in diameter—stand at attention around the world. Wind energy turns a turbine's blades, which feeds an electric generator and produces electricity. Wind, which accounts for 9.2 percent of U.S. electricity generation, has become one of the cheapest energy sources in the country. Top wind power states include California, Iowa, Kansas, Oklahoma, and Texas, though turbines can be placed anywhere with high wind speeds—such as hilltops and open plains—or **even offshore in open water**.

Other alternative energy sources

Hydroelectric power

Hydropower is the largest renewable energy source for electricity in the United States, though wind energy is soon expected to take over the lead. Hydropower relies on water—typically fast-moving water in a large river or rapidly descending water from a high point—and converts the force of that water into electricity by spinning a generator's turbine blades.

Nationally and internationally, large **hydroelectric plants—or mega-dams**—are often considered to be nonrenewable energy. **Mega-dams** divert and reduce natural flows, restricting access for animal and human populations that rely on those rivers. **Small hydroelectric plants** (an installed capacity below about 40 megawatts), carefully managed, do not tend to cause as much environmental damage, as they divert only a fraction of the flow.

Biomass energy

Biomass is organic **material that comes from plants and animals, and includes crops, waste wood, and trees**. When biomass is burned, the chemical energy is released as heat and can generate electricity with a steam turbine.

Biomass is often mistakenly described as a clean, renewable fuel and a greener alternative to coal and other fossil fuels for producing electricity. However, recent science shows that many forms of biomass—especially from forests—produce higher carbon emissions than fossil fuels. There are also negative consequences for biodiversity. Still, some forms of biomass energy could serve as a low-carbon option under the right circumstances. For example, sawdust and chips from sawmills that would otherwise quickly decompose and release carbon can be a low-carbon energy source.

Geothermal energy

If you've ever relaxed in a hot spring, you've used geothermal energy. The earth's core is about as hot as the sun's surface, due to the slow decay of radioactive particles in rocks at the center of the planet. Drilling **deep wells** brings very hot underground water to the surface as a hydrothermal resource, which is then **pumped through a turbine** to create electricity. Geothermal plants typically have low emissions if they pump the steam and water they use back into the reservoir. There are ways to create geothermal plants where there are not underground reservoirs, but there are concerns that they may increase the risk of an earthquake in areas already considered geological hot spots.

Ocean

Tidal and wave energy are still in the developmental phase, but the ocean will always be ruled by the moon's gravity, which makes harnessing its power an attractive option. Some tidal energy approaches may harm wildlife, such as tidal barrages, which work much like dams and are located in an ocean bay or lagoon. Like tidal power, wave power relies on **dam-like structures or ocean floor–anchored devices** on or just below the water's surface.

"renewable energy"
U.S. Energy Information Administration, no date, "Renewable energy explained",
https://www.eia.gov/energyexplained/renewable-sources/
Renewable energy is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible, but they are limited by the availability of the resources.
The major types of renewable energy sources are:
Biomass
Wood and wood waste
Municipal solid waste
Landfill gas and biogas
Biofuels
Hydropower
Geothermal
Wind
Solar

"renewable energy"
Timothy C. Coburn, Abilene Christian University Abilene, Barbara C. Farhar, University of Colorado, "Public Reaction to Renewable Energy Sources and Systems", Encyclopedia of Energy, Volume 5, 2004,
https://www.sciencedirect.com/science/article/pii/B012176480X004629/pdfft
Renewable energy means different things to different people. Although there is little argument as to what energy is, even in its myriad forms, the term renewable energy conjures up a more diverse assortment of images.
In the simplest terms, energy is the capacity of a physical system to do work, or alternatively, to produce heat. Energy is a characteristic of the physics of a system. Renewable, on the other hand, pertains to the origin of the energy; thus, ideas and opinions about renewable energy are often confounded with information (or misinformation) about the source.
Renewable energy is energy that is derived from a supply that is constantly and naturally replenished over a relatively short time. Hence, **any discussion of renewable energy is ultimately reduced to a discussion of renewable resources** as they are **derived from geophysical processes: sunlight, wind, falling water, sustainable biomass, wave motion, tides, and geothermics**. Some entities, such as the Texas Renewable Energy Industries Association, describe all renewable energy as being directly or indirectly derived from the sun or natural movements and mechanisms of the environment. Others—private, commercial, governmental, and international—have their own definitions. One of the more visible characterizations has been provided by the U.S. Department of Energy (DOE), which

segregates renewable energy into six components: bioenergy derived from biomass resources; geothermal energy derived from the earth's own heat-producing processes; hydrogen, hydropower, or hydroelectric power; ocean energy; solar energy; and wind energy.

"renewable energy"
Johns Hopkins University, "Renewable Energy vs Sustainable Energy: What's the Difference?" Renewable Energy vs Sustainable Energy: What's the Difference?" 7-2-21, https://energy.sais.jhu.edu/articles/renewable-energy-vs-sustainable-energy/
Solving the energy crisis is one of the most essential undertakings of the 21st century. Perfect solutions will be hard to come by, due not only to drastic differences in political and public support for sustainable energy throughout the world, but the extensive knowledge required to address the many challenges associated with the global energy landscape.
"Renewable energy" and "sustainable energy" are often used interchangeably, even among industry experts and veterans. There is some overlap between the two, as many sustainable energy sources are also renewable. **However, these two terms are not** exactly **the same.**
A clear understanding of renewable energy versus sustainable energy can help:
What Is Renewable Energy?
Produced from existing resources that naturally sustain or replenish themselves over time, renewable energy can be a much more abiding solution than our current top energy sources. Unlike fossil fuels, renewables are increasingly cost-efficient, and their impact on the environment is far less severe. By taking advantage of the earth's ability to grow and recycle organisms, renewable power sources will theoretically be able to supply our energy needs indefinitely.
Renewable energy is defined by the time it takes to replenish the primary energy resource, compared to the rate at which energy is used. This is why traditional **resources like coal and oil, which take millions of years to form, are not considered renewable.** On the other hand, **solar power can always be replenished**, even though conditions are not always optimal for maximizing production.
Under this definition, **examples of renewable energy sources include**:
Biomass: Organic material that is burned or converted to liquid or gaseous form. Biomass from trees was the leading source of energy in the United States before the mass adoption of fossil fuels. Modern examples of biomass include ethanol and biodiesel, which are collectively referred to as biofuels.
Geothermal: Heat produced by decaying radioactive particles found deep within the earth. Geothermal energy can be used as a direct heat source or to generate electricity.
Hydropower: One of the oldest sources of electricity, requiring not only massive amounts of water but also a formidable amount of force. Hydropower was the largest source of renewable electricity until 2019.
Solar: A favored green alternative, although production requires a large surface area and consistent sunlight. Solar farms should be combined with storage solutions in order to harness the sun's potential. Like geothermal energy, solar power is often used as a direct heat source and electricity generator.

Wind: Utilizes turbines to convert the wind's kinetic energy into mechanical energy, which is then used to accomplish a task like grinding rain. Alternatively, the mechanical energy can be rotated at high speeds to produce electricity.

What Is Sustainable Energy?

Sustainable energy is derived from resources that can maintain current operations without jeopardizing the energy needs or climate of future generations. The most popular sources of sustainable energy, including wind, solar and hydropower, are also renewable. Biofuel is a unique form of renewable energy, as its consumption emits climate-affecting greenhouse gasses, and growing the original plant product uses up other environmental resources. However, biofuel remains a major part of the green revolution. The key challenge with biofuel is finding ways to maximize energy output while minimizing the impact of sourcing biomass and burning the fuel.

Even with resources that are both renewable and sustainable, like wind and solar power, an important question remains: Is sustainable energy the solution to our energy and climate needs?

It is a promising but nuanced option, and the answer isn't as simple as transitioning from so-called "dirty" resources to sustainable ones. In addition to the biomatter conundrum, not all sustainable solutions can be used in every situation. Their efficiency and/or effectiveness depends on factors such as climate and location, and once the energy is generated, collected and stored, it must then be distributed. For instance, wind is produced by temperature changes in the air, which aren't consistent across the planet. In the U.S., this means that the best place to put wind farms is in the Midwest, the Texas region, or offshore. How do we ensure this energy fairly provides for other regions, like the Northeast?

Furthermore, disparities in regulations and target goals can create a problem where the best place to produce energy may not have the public interest or infrastructure necessary to support it. For example, a windy state may struggle to pass legislation for financing the construction of turbines, while its neighbor may be eager for a nearby source of clean energy. How do we navigate such situations in a way that allows consumers to get what they want, no matter where they live?

"renewable energy policy"

ScienceDirect, No Date

https://www.sciencedirect.com/topics/social-sciences/renewable-energy-policy#:~:text=Renewable%20Energy%20Policy%20refers%20to,%2C%20wind%2C%20and%20geothermal%20power.

Renewable Energy Policy refers to the set of guidelines and regulations established by governments to promote the use of renewable energy sources such as solar, wind, and geothermal power. These policies aim to reduce reliance on fossil fuels and encourage the adoption of sustainable energy technologies.

"renewable energy policy"

IEA, October 2018, https://www.iea.org/reports/20-renewable-energy-policy-recommendations

Many renewable electricity technologies have some degree of daily or seasonal variability related to weather factors or time of day. The impact of this variability depends on the characteristics of particular electricity systems, and generally can be managed without problems, especially in the initial stages of deployment. At higher deployment levels, **policy-makers need to introduce measures that encourage system-friendly generation from renewable sources** (wind and PV in particular) **and increase overall system flexibility, including:**

1. **Recognize** (e.g. through differentiated tariff levels) the different locational, time and technological **value of the renewable power plants** and decentralised installations.
2. **Reform electricity market design** to provide accurate pricing at growing shares of VRE.
3. **Provide support for** system flexibility (e.g. demand response, **storage** such as pump storage hydro, batteries or thermal storage).
4. **Ensure that grid connection codes include appropriate requirements** for VRE.
5. Plan for deploying a mix of technologies that bring valuable synergies.

"renewable energy policy"

Piotr Bojek, Energy Analyst - Renewable Energy Markets and Policies @ IEA, 1-30-25, https://www.iea.org/energy-system/renewables

Adjust policy design to integrate variable renewables

Increasingly competitive, renewables – especially solar PV and wind – are rapidly transforming power systems worldwide. However, reforms to power market design and **policy frameworks will be needed to ensure investment at scale both in new renewable capacity and in power system flexibility to integrate high shares of variable renewables in a reliable and cost-effective manner**. As the share of variable renewable energy increases, **policies ensuring investment in all forms of flexibility** become crucial. **Solutions include enhancing power plant flexibility, unlocking demand-side management, supporting energy storage and improving grid infrastructure.**

"incentives for renewable energy"

Lynn J. Cunningham, Senior Research Librarian, and Claire M. Jordan, Research Librarian, 2-10-23, "Renewable Energy and Energy Efficiency Incentives: A Summary of Federal Programs", CRS, https://www.congress.gov/crs-product/R40913

The Department of Energy (**DOE**) **operates** the greatest number of efficiency and **renewable energy incentive programs, including RDD&D grants and contracts, weatherization assistance, production incentives, loan guarantees, and technology transfers**. DOE also provides **grants to states for energy policy development and assists other federal agencies in developing and implementing energy efficient and renewable energy resources**.

The Department of Agriculture (USDA) runs several programs that largely focus on biofuels, such as ethanol and wood energy. Other USDA programs include assistance to rural communities with high energy costs, biomass crop assistance, grants and loans to promote energy efficiency and renewable energy for agricultural producers and rural businesses, assistance to general consumers for rural energy savings, and sustainable agricultural research.

The Department of the Treasury (Treasury) **administers tax credits** and other incentives for energy efficiency and renewable energy. Eligible activities include energy efficient home

improvements, renewable energy production, and business investments in energy efficiency and renewable energy.
Other federal agencies with energy efficiency and renewable energy programs include the following:

- Department of the Interior (DOI), with programs on tribal energy production and use;
- Department of Housing and Urban Development (HUD), with energy efficient mortgages and loan programs;
- Small Business Administration (SBA), with loan programs to help borrowers upgrade their facilities and fund energy efficiency or renewable energy projects;
- Fannie Mae, with a "Green Initiative" loan program;
- Department of Health and Human Services (HHS), which provides energy assistance to low-income households; and
- Department of Veterans Affairs (VA), which provides energy efficient mortgages.

A wide range of entities are eligible for these energy efficiency and renewable incentives, including biofuel producers; state, local, and tribal governments; businesses; schools and universities; research organizations; builders and developers; homeowners; utilities; and veterans. **Eligibility also includes a variety of energy-related technologies, such as advanced batteries, heating and cooling systems, vehicles and biofuels**, appliances, building envelope technologies, **renewable energy production technologies**, lighting, and electricity generation and transmission.

"incentives for renewable energy"
U.S. Energy Information Administration, 12-30-22, "Renewable energy explained", https://www.eia.gov/energyexplained/renewable-sources/incentives.php
Renewable energy requirements and **incentives**
Federal, state, and local governments and electric utilities encourage investing in and using renewable energy and, in some cases, require it. T**his is an overview of the major programs and incentives available for renewable energy production and use in the United States**.
The Database of State Incentives for Renewables & Efficiency® (DSIRE) is a comprehensive source of detailed information on government and utility requirements and incentives for renewable energy.
Government financial incentives
Several federal **government tax credits, grants, and loan programs** are available for qualifying renewable energy technologies and projects. The federal tax incentives, or credits, for qualifying renewable energy projects and equipment include the Renewable Electricity **Production Tax Credit (PTC), the Investment Tax Credit (ITC)**, the Residential Energy Credit, and the Modified Accelerated Cost-Recovery System (MACRS). Grant and loan programs may be available from several government agencies, including the U.S. Department of Agriculture, the U.S. Department of Energy (DOE), and the U.S. Department of the Interior. Most states also provide financial incentives to encourage renewable energy production and use.
Renewable portfolio standards or goals
A renewable portfolio standard (RPS) typically requires that a percentage of the electric power sales in a state comes from renewable energy sources. Some states have specific requirements, and some have voluntary goals, within a specified time frame, for the share of

electricity generation or sales in a state that come from renewable energy. Compliance with RPS policies may require or allow utilities to trade renewable energy certificates.
Renewable energy certificates or credits
Financial products are available for sale, purchase, or trade that allow a purchaser to pay for renewable energy production without directly producing or purchasing the renewable energy. The most widely available products are renewable energy certificates, or credits (RECs). These products may also be called green tags, green energy certificates, or tradable renewable certificates, depending on the entity that markets them. Electric utilities can use RECS to comply with state renewable energy portfolio standards. Many companies use RECS or similar products to meet their voluntary targets or goals to reduce greenhouse gas emissions in their operations.
Net metering
Net metering allows electric utility customers to install qualifying renewable energy systems on their properties and to connect them to an electric utility's distribution system (or grid). These mainly state-based programs vary, but in general, electric utilities bill their net metering customers for the net electricity their customers use during a defined period. Net electricity is the customer's total electricity consumption minus the electricity that their renewable energy system generates and delivers to the grid. According to the DSIRE website (as of 12/27/2022), 44 states and the District of Columbia have some form of state net metering policy. Two states (Idaho and Texas) do not have statewide rules, but several utilities in those states allow net metering. Most net metered systems are solar photovoltaic (PV) systems.
Feed-in tariffs (FITs)
Several states and individual electric utilities have established special rates for purchasing electricity from certain types of renewable energy systems. These rates, sometimes known as feed-in tariffs (FITs), are generally higher than electricity rates otherwise available to the generator. FITs are intended to encourage new projects for specific types of renewable energy technologies.

“incentivizing renewable energy”
Sustainability Directory, 4-25-25, “What Policies Accelerate Renewable Energy Transition?”, https://energy.sustainability-directory.com/question/what-policies-accelerate-renewable-energy-transition/
The shift towards Renewable Energy sources is a pressing global imperative driven by the need to mitigate climate change, secure energy independence, and foster sustainable economic growth. **Transitioning from fossil fuels to renewables requires a multifaceted approach, with carefully designed policies** acting as the engine of change.
Policies aimed at accelerating the renewable energy transition can be broadly categorized into several key types. These include:
- **Incentives These policies provide financial benefits or tax breaks to encourage investment in renewable energy projects.**
- Regulations These policies establish standards or mandates that require a certain percentage of electricity to come from renewable sources.
- Carbon Pricing These policies place a cost on carbon emissions, making renewable energy more competitive.

- Research and Development Funding These policies support the development of new and improved renewable energy technologies.
- Grid Modernization These policies upgrade the electrical grid to better accommodate the influx of renewable energy sources.

Each of these policy types plays a distinct yet interconnected role in driving the adoption of renewable energy.

Understanding the fundamental types of policies is just the first step. The effectiveness of these policies depends heavily on their design, implementation, and the specific context in which they are applied.

The Role of Feed-In Tariffs

Feed-In Tariffs (FITs) are a policy mechanism designed to support renewable energy development by guaranteeing a fixed price for electricity generated from renewable sources. This fixed price, usually set above market rates, provides investors with long-term revenue certainty, encouraging investment in renewable energy projects. FITs have been particularly effective in driving the adoption of solar photovoltaic (PV) and wind power in countries like Germany and Denmark.

The structure of FITs can vary. Some FITs offer a single tariff for all renewable energy technologies, while others provide differentiated tariffs based on technology type, project size, or location. Differentiated tariffs can be used to target specific technologies or to encourage development in areas with high renewable energy potential.

Renewable Portfolio Standards

Renewable Portfolio Standards (RPS), also known as renewable energy standards (RES), mandate that a certain percentage of a utility's electricity supply must come from renewable sources. **RPS policies create a market for renewable energy certificates** (RECs), which represent the environmental attributes of renewable energy generation. Utilities can meet their RPS obligations by either generating renewable energy themselves or purchasing RECs from other renewable energy generators.

RPS policies have been widely adopted in the United States at the state level, **and they have been a significant driver of renewable energy deployment.** The specific requirements and design of RPS policies can vary considerably from state to state.

The Significance of Carbon Pricing

Carbon Pricing mechanisms, such as carbon taxes and cap-and-trade systems, put a price on carbon emissions, **making fossil fuels more expensive and renewable energy more competitive.** A carbon tax directly taxes carbon emissions, while a cap-and-trade system sets a limit on overall emissions and allows companies to trade emission allowances.

Carbon pricing can be a powerful tool for driving the renewable energy transition, as it internalizes the environmental costs of fossil fuels. However, the effectiveness of carbon pricing depends on the level of the carbon price, as well as the design of the policy and its interaction with other energy policies.

Grid Modernization Policies

The electrical grid was originally designed to transmit electricity from large, centralized power plants to consumers. The integration of distributed renewable energy sources, such as rooftop solar PV, requires a more flexible and resilient grid. Grid Modernization Policies aim to upgrade

the grid to better accommodate renewable energy, improve grid reliability, and enable new grid services.
Grid modernization can involve a range of investments, including:
- Smart Grids that use sensors, communication technologies, and advanced control systems to optimize grid performance.
- Energy Storage systems that can store excess renewable energy and release it when needed.
- Expanded Transmission Capacity to transmit renewable energy from remote areas to population centers.

The Impact of Direct Subsidies

Direct subsidies, such as grants, rebates, and tax credits, can help to lower the upfront cost of renewable energy projects, making them more financially attractive. **Subsidies can be particularly effective in promoting the adoption of renewable energy technologies** by households and small businesses.

Subsidies can be designed to target specific technologies or to encourage development in certain geographic areas. They can also be used to support specific stages of project development, such as feasibility studies or construction.

Building upon the fundamental policy mechanisms discussed, **a deeper examination reveals the intricacies and challenges associated with accelerating the renewable energy transition.** The real-world effectiveness of any policy depends on a complex interplay of economic, social, and technological factors.

For instance, simply implementing a feed-in tariff doesn't guarantee success. **The tariff level must be carefully calibrated to provide adequate incentive for investment** without creating excessive costs for consumers.

Analyzing Policy Interactions

No single policy exists in a vacuum. **The interaction between different policies can either amplify or diminish their individual effectiveness. For example, a carbon tax combined with an RPS can create a synergistic effect, further incentivizing renewable energy development**.

Conversely, poorly designed policies can create unintended consequences. A generous feed-in tariff, without adequate cost controls, might lead to a boom in renewable energy development that outstrips grid capacity, resulting in curtailment and wasted resources.

"incentivize renewable energy"

Daniel C. Matisoff, School of Public Policy Georgia Institute of Technology, Erik P. Johnson, Department of Economics, Carthage College, "The comparative effectiveness of residential solar incentives", Energy Policy, Volume 108, September 2017, Pages 44-54
https://www.sciencedirect.com/science/article/abs/pii/S0301421517303166

Concerns about local and global environmental damages from fossil fuel combustion for electricity generation **have led governments to incentivize renewable electricity generation**. A number of reasons might motivate policymakers to incentivize renewable energy production including the desire to drive down costs of new technologies through market transformation; concerns about pollution from fossil fuel based electricity production; and the price volatility of fossil fuels, among others. In addition, policy makers may simply seek to signal constituents that they have strong environmental values. As a result of these policy efforts, **a significant amount**

of incentives has been directed at the installation of small-scale, distributed generation such as rooftop solar photovoltaic (PV) panels. Due to the varied types of incentives and the ability of multiple tiers of governments and electricity companies that offer incentives for new PV installations, little peer reviewed empirical work has comprehensively examined the comparative effectiveness of these incentives.1 If some types of incentives are more likely to stimulate investment in distributed generation than others, governments can design policies to take advantage of these policy characteristics. Moreover, other incentives may be scaled back or eliminated if they are being paid to investments that would have been made without incentives. Local and state **governments** and electric power companies **provide a wide array of incentives** for households and business to install new residential rooftop solar photovoltaic panels in addition to federal programs **such as the Solar Investment Tax Credit**. Among the state and local incentives are **Renewable Portfolio Standards** (RPSs), **tax credits, property tax easements, and direct cash incentives**. In this paper, we use a net present value calculation to standardize the value of nearly all state and local solar incentives offered in the United States from 2002 to 2012. We also measure several policy indicators that might serve as enablers: net metering and government subsidized financing availability may facilitate other incentives. We combine these incentives data with state-level data on residential PV installations to estimate the response of homeowners to different types and magnitudes of solar incentives.2

Installing solar panels require households to make a large up-front investment with variable and uncertain returns, potentially dependent on the design of particular solar incentives. **RPSs, for example, award Renewable Energy Credits** (RECs) **to producers of solar electricity that can be sold for an uncertain future value**, dependent upon the demand for RECs and the performance of the PV panels. In contrast, other policies such as **cash rebates provide fixed financial incentives for households to install PV panels**. These programs may provide a payment that is tied to the capacity of PV panels (rather than the performance) and provide certainty about the net costs of the PV installations by providing cash transfers, tax credits, or low interest loans. In many jurisdictions, households qualify for a mix of fixed financial incentives and performance incentives.

“renewable energy transition”

Hongshan Ai, School of Economics and Trade, Hunan University, Changsha, et. al., “Renewable energy transition and sustainable development: Evidence from China”, Energy Economics, Volume 143, March 2025, 108232,
https://www.sciencedirect.com/science/article/abs/pii/S0140988325000556

It is essential to distinguish between renewable energy and clean energy. Clean energy includes electricity and natural gas (Huang and Zou, 2020), which produce virtually no pollution during utilization. However, not all clean energy is renewable. **Renewable energy sources encompass hydropower, biomass gasification, biofuels, geothermal, wind, solar, and marine energy** (Goldemberg, 2008). These energy sources are described as **“sustainable in perpetuity”, because their utilization does not diminish the underlying resource volume** (Brundtland, 1987). **Renewable energy transition is a typical environmental policy, focusing on improving energy sustainability and reducing air pollution by replacing non-renewable fossil fuel with renewable clean energy** (i.e., wind, and solar). **The ultimate**

goal of renewable energy transition is to reduce air pollution. The clean energy transition requires a change in the structure of energy supply and the way we consume energy. The government regulates the utilization rate and usage rate of clean energy. Additionally, the central and local governments force the closure of heavily polluting coal-fired power plants.

“renewable energy transition”
Hongshan Ai, School of Economics and Trade, Hunan University, Changsha, et. al., “Renewable energy transition and sustainable development: Evidence from China”, Energy Economics, Volume 143, March 2025, 108232,
https://www.sciencedirect.com/science/article/abs/pii/S0140988325000556
On the one hand, previous research has revealed that **the transition to renewable energy effectively enhances energy efficiency and reduces reliance on depleting fossil fuels** (Dong et al., 2021; Zhao et al., 2021), further **decreasing air pollution and carbon emissions and contributing to environmental sustainability** (Zhang and Chen, 2022; Bashir et al., 2023). Therefore, the renewable energy transition may promote economic growth while improving sustainability and further can contribute to the long-term sustainable development. On the other hand, **the renewable energy transition requires government financial suppor**t to compensate for the high costs of facilities and infrastructures in the short term. Therefore, there may exist a crowding-out effect on investment in research and innovation, which is the foundation for technological advancements. Technological advancement is a pivotal driving force of sustainable development. Insufficient support for technological progress may temporarily impede sustainable development. Considering that the impact of the renewable energy transition on sustainable development is the basis for assessing the costs and benefits of the relevant environmental policies and strategies, we aim to examine the causal impact of policy-induced energy transitions on sustainable development. We also focus on exploring the underlying mechanisms behind the effects of the energy transition on sustainable development. Our empirical investigation develops our understanding of environmental policies and offers theoretical and practical insights and implications for the synergy between economic development and environmental protection.
We first choose a comprehensive measurement of sustainable development. Green total factor productivity (GTFP) captures the capability of maximizing the desirable output (e.g., economic growth) and minimizing the undesirable output (e.g., air pollution and carbon emission) with given inputs, qualifying as a measure of social welfare, economic productivity, and sustainability (Tian and Lin, 2017; Cheng et al., 2020; Liu et al., 2023a). Next, we select a specific environmental policy on renewable energy transition. In October 2018, China launched the Plan on Clean Energy Accommodation (2018–2020) (PCEA),1 which aims to promote a green energy transition characterized by a low-carbon and efficient energy system. This policy is an important environmental policy with clean energy utilization targets and installation requirements for clean energy facilities, further integrating environmental protection with socioeconomic development. By leveraging a differences-in-differences (DID) design, we examine the causal effects of the implementation of the PCEA on GTFP. Our DID estimates show that the PCEA leads to a pronounced reduction in GTFP, indicating that the PCEA hampers prefectures' sustainable development. This decrease is mainly attributable to technical efficiency. These findings remain reliable after conducting various robustness tests. Our analyses of the

underlying mechanisms suggest that the impact of energy transition might differ between the short and long term. In the short term, **infrastructure development for renewable energy transition, including energy storage systems and transmission networks, requires substantial government investment**, further crowding out the expenditure on science and technology (S&T) and hindering innovation (Huang et al., 2019; Wei et al., 2023). This, in turn, impedes sustainable development (Zhao et al., 2022b). In the long term, however, the reduction in dependence on fossil fuels and improvements in energy consumption and carbon intensity jointly enhance sustainability (Gao et al., 2021). Once the infrastructure investment is completed, improvements in energy structure and carbon intensity can promote sustainable development. Furthermore, heterogeneity analyses reveal that southern cities, resources-based cities, and cities with lower stock of human capital temporarily experience a larger decline in GTFP.

This paper contributes to the existing literature in three key ways. First, it deepens the understanding of the association between energy transition and sustainable development. A growing body of literature has examined the economic and environmental effects of energy transition. **The energy transition reduces the dependence on fossil fuels** (Chen et al., 2022), thereby lowering carbon emissions and air pollution (Zhang and Chen, 2022; Tauseef Hassan et al., 2023). Meanwhile, the energy transition also alleviates energy poverty and prompts economic growth (Zhao et al., 2022a; Rehman et al., 2022). However, these studies primarily address specific aspects of sustainable development, while evidence for overall sustainability is insufficient. This paper offers a comprehensive analysis of the impact of energy transitions on sustainability, enriching the evaluation of policy-driven renewable energy adoption.

Second, our findings provide valuable environmental policy implications for developing countries. Although a large body of literature has focused on the effects and implications of stringent environmental policies in developed countries (Hassan et al., 2024; Rehman et al., 2024), relatively little is known about developing countries (Mohsin et al., 2021; Dai and Du, 2023; Ma et al., 2023a; Wang et al., 2023b). Due to different cultural backgrounds and political systems, the implementation process and the effects of environmental policies vary in different contexts. The experience of developed countries cannot be directly applied to developing countries. This paper finds that infrastructure investment in renewable energy transition induced by the implementation of PCEA might crowd out government expenditure on S&T in the short term, but it indeed improves environmental efficiency in energy consumption. In the long term, the energy transition is conducive to sustainable development. Therefore, governments should expand their funding sources (e.g., the involvement of private capital). This paper extends the findings that the increasing environmental policy stringency has long-term positive impact on developed countries' productivity (Feng et al., 2021). Moreover, the central government should provide policy and financial support to regions that are more vulnerable to energy transition, helping them adopt renewable energy more effectively.

Third, this paper contributes to the understanding of environmental policies. **Renewable energy transition is an important part of environmental regulation policies because of high clean energy usage targets and strict requirements for the installation of clean energy facilitie**s. The existing literature has shown the reduction in carbon emission and ecological footprint driven by the energy transition (Zhang and Chen, 2022; Bashir et al., 2023). Indeed, sustainable development emphasizes green development. We promote economic growth while reducing environmental damage. The existing literature primarily focuses on short-term and contemporaneous economic and environmental effects of different stringent environmental policies. Strict environmental policies may be not conducive to industrial productivity and economic development due to the increased cost of environmental protection in the short term (Ma et al., 2019; Tang et al., 2019). We find that the transition to renewable energy has negative effects on sustainable development in the short term. The synergy between environmental policies and economic strategies has played an important role in sustainable development. Environmental protection and economic development principles should be integrated into all strategies and policies to emphasize the transition to sustainable development. Meanwhile, policymakers should recognize that energy transition may not yield immediate positive effects. Environmental policies and other related strategies should account for the necessary investments, carefully balancing costs and benefits to maximize efficiency in achieving sustainable development in the long term.

"alternative energy"
Britannica, no date, "Alternative energy",
https://www.britannica.com/procon/alternative-energy-debate
Whether alternative energy can meet energy demands effectively enough to phase out finite fossil fuels (such as coal, oil, and natural gas) is hotly debated. **Alternative energies include renewable sources—such as solar, tidal, wind, biofuel, hydroelectric, and geothermal—and nonrenewable nuclear power (considered alternative but not renewable because it relies on uranium, a finite resource not easily replenished**).

"alternative energy"
Council on Foreign Relations, 7-25-23, "Sources of Energy: A Comparison",
https://education.cfr.org/learn/reading/sources-energy-comparison
Renewable and Alternative Energy: Wind Power, Solar Power, Hydropower, Nuclear Energy, and Biofuels
Forms of energy not derived from fossil fuels include both renewable and alternative energy, terms that are sometimes used interchangeably but do not mean the same thing. **Alternative energy broadly refers to any energy that is not extracted from a fossil fuel, but not necessarily only from a renewable source**. For example, nuclear power generation most commonly uses uranium, an abundant but not technically renewable fuel. **Renewable energy, on the other hand, includes sources such as sun and wind that occur naturally and continuously.**
There are five main renewable and alternative fuels.
* Wind power is created when wind spins a turbine, or a windmill, which can be located on land or offshore.
* Solar power harnesses the sun's energy in two ways: by converting the sun's light directly into electricity when the sun is out (think solar panels), or solar thermal energy, which uses the sun's heat to create electricity, a method that works even when the sun is down.
* Hydropower is created when rapidly flowing water turns turbines inside a dam, generating electricity.

* Nuclear energy is produced at power plants by the process of nuclear fission. The energy created during nuclear reactions is harnessed to produce electricity.
* Biofuels, also referred to as biomass, are produced using organic materials (wood, agricultural crops and waste, food waste, and animal manure) that contain stored energy from the sun. Humans have used biomass since they discovered how to burn wood to make fire. Liquid biofuels, such as ethanol, also release chemical energy in the form of heat.

Renewable and alternative energy sources are often categorized as clean energy because they produce significantly less carbon emissions compared to fossil fuels. But they are not without an environmental footprint.

Hydropower generation, for example, releases lower carbon emissions than fossil fuel plants do. However, damming water to build reservoirs for hydropower floods valleys, disrupting local ecosystems and livelihoods. In another case, biofuels are renewable but are cultivated on huge swaths of land and sometimes generate more carbon emissions than fossil fuels do.

Other considerations such as safety also matter. The likelihood of a meltdown at a nuclear facility is exceedingly small, but if one were to occur, the results would be catastrophic. In fact, concerns about the dangers associated with operating nuclear power plants have limited the expansion of nuclear energy.

"alternative energy"

Dictionary.com, no date, "Alternative energy",
https://www.dictionary.com/browse/alternative-energy

energy, as solar, wind, or nuclear energy, that can replace or supplement traditional fossil-fuel sources, as coal, oil, and natural gas.

"subsidy"

World Trade Organization, "World Trade Report", 2006,
https://www.wto.org/english/res_e/booksp_e/anrep_e/wtr06-2b_e.pdf

1. The Definition of Subsidies: Conceptual Issues

Although the term "subsidy" is widely used in economics, it is rarely defined. often it is used as an antonym to a tax, i.e. a government transfer of money to an entity in the private sector. this seems, for instance, to be the case in the oxford online dictionary2 where **a subsidy is defined as: "a sum of money granted from public funds to help an industry or business keep the price of a commodity or service low**".3 **But many would argue that tax concessions are also a form of subsidization.** Indeed, for the relevant recipients it may not make much difference whether they are made better off by receiving money or through the reduction of their tax bill. **Both forms of "assistance" also represent financial transfers by the government**. Border protection, e.g. **tariffs, on the other hand does not result in any such financial transfer from the government,** and instead results in fiscal revenue. Yet it could be argued that the imposition of a tariff represents a form of subsidization for the import-competing sectors that are thereby protected from foreign competition. to define subsidies in terms of government transfers or fiscal expenditure is thus not necessarily complete. an alternative approach is to consider that **a "subsidy" arises any time a government programme benefits private actors**. the main difficulty with this approach is that recipients of, for instance, a cash transfer or a tax concession, are not necessarily the ultimate beneficiaries of the policy. for example,

housing allowances, such as the German “eigenheimzulage”, consist in transfers or tax concessions to consumers who build a house. In their ultimate effect, however, they are not unlike direct payments to construction companies. Similarly, the main beneficiaries of subsidized intermediate goods may not be the recipients of the subsidies, but rather downstream firms utilizing these products as inputs in their own production. Such indirect effects may or may not be intended by the government. the more specifically designed a programme, the more likely it is that the intended beneficiary (objective) and the actual beneficiary (effect) coincide. But it is not necessarily easy to design well targeted programs. the literature provides numerous examples of subsidy programmes that have unintended side effects. adams (2000), for instance, examines the possibility that owing to improper targeting of inferior goods in the case of food subsidies to assist the poor, part may be leaked to high-income people, where they free up funds for other uses. devarajan and Swaroop (1998) illustrate how official development assistance (oda), even though targeted at a specific project, may indirectly finance other activities in cases where the government would have implemented the relevant project anyway and oda has the effect of releasing government resources that can be spent elsewhere.
Another drawback of defining subsidies purely in terms of “benefits” is that such a definition should in principle take into account the other side of the ledger – the numerous government programmes that impose costs on those same “actors”, either in the form of taxes or regulations that pose a burden on private activity.4 Many governmental services, such as road infrastructure, are tax-financed by users, in this case through such levies as excise duties on cars and road tolls. the provision of road infrastructure should thus not be seen as a subsidy in its entirety, but it may contain an element of subsidization that is in most cases difficult to measure. Some subsidy programs even appear to be designed in order to counterbalance distortions created through other government interventions. In many countries, for instance, savings beneath a certain threshold are exempt from taxes. Such tax concessions serve in part to redress the discrimination of saving vis-à-vis consumption, which may explain why the German Government in its periodic subsidy reports excludes such tax exemptions from its subsidy calculation.5
The previous paragraphs illustrate some of the difficulties in defining the concept of subsidies. although there appears to be agreement that **subsidization involves the government and results in benefits for somebody**, approaches differ when it comes to the details. Indeed, the relevant literature is full of references to the difficulties of defining the term “subsidy”, as reflected in the frequently quoted statement by Hendrik S. Houthakker: “My own starting point was also an attempt to define subsidies. But in the course of doing so, I came to the conclusion that the concept of a subsidy is just too elusive”.6 what Houthakker wrote several decades ago still holds today. rather than trying to pin down one specific definition of subsidies, this Section therefore discusses a range of characteristics of subsidy definitions used in the literature or in policy documents and analyses how different subsidy definitions make reference to these characteristics.
Depending on the context, **a large number of government programmes may be considered subsidies.** for simplicity, these programmes can be grouped into at least three categories: firstly, **the government may transfer funds to producers or consumers, resulting in direct or potential budgetary expenditure**, or use its power to instruct private entities to make a transfer. direct transfers, like re-training grants or child allowances, would fall into this category.

an example of potential expenditure is the provision of loan guarantees.7 the latter may or may not lead to actual disbursements, but even if they do not, an official guarantee artificially lowers default risks of potential buyers and stimulates consumption that otherwise would not take place. If a government instructs a private bank to provide loans at preferential interest rates to certain private entities, this would not result in government expenditure. Yet this can be considered to be a government transfer as it would not have taken place without the intervention of the government and as it has the same effect as if the government itself had provided the loan at preferential rates.

Secondly, **the government may provide goods or services at no cost or below market price**, such as university education, public transport or food stamps. **Such transfers also involve expenses for the government,** with the difference being that beneficiaries receive in-kind contributions as opposed to funds they can freely dispose of.8

Thirdly, **regulatory policies may be seen as subsidies, if they create transfers from one group to another**. Border protection, for example, allows for price discrimination and pooling of revenues to producers that are implicitly financed by domestic consumers (Schluep and de Gorter, 2000).9 In this context, Cadot et al. (2004) point out that regulatory instruments can circumvent forms of direct subsidization, leading to the same effects but at higher welfare costs. the authors demonstrate that preferential rules of origin amount to export subsidies for intermediate goods industries in the preference-providing country. this category of transfers caused but not paid for by the government may also comprise implicit subsidies arising from the failure by governments to internalize externalities, such as air pollution by industry, or rents associated with untaxed exploitation by private parties of publicly-owned or managed resources.10

3. The Definition of Subsidies in the WTO

World Trade Organization, "World Trade Report", 2006, https://www.wto.org/english/res_e/booksp_e/anrep_e/wtr06-2b_e.pdf

Neither the Gatt nor the tokyo round Subsidies Code contained a definition of the term "subsidy". this changed when the wto SCM agreement came into being. SCM article 1 is entitled "**definition of a Subsidy**" and spells out the conditions under which a subsidy is deemed to exist. first of all, **there must be a "financial contribution by a government** or any public body" (SCM article 1.1(a)(1).22 the different forms of financial transfers that were mentioned above are listed explicitly, namely (i) **direct transfers of funds**, including potential transfers, **such as loan guarantees**, (ii) **foregone revenues that are otherwise due** and (iii) **goods and services provided by the government other than general infrastructure**. Under the last point, government purchases are also mentioned. article 1.1.(a)(1)(iv) specifies that subsidies are also deemed to exist if a government makes payments to a funding mechanism, or entrusts or directs a private body to carry out one or more of the type of functions illustrated under (i) to (iii). In addition to financial contributions by a government within the meaning of article 1.1(a)(1), SCM article 1.1(a)(2) mentions **any form of income or price support** in the sense of article XVI of Gatt 1994, i.e. support which operates directly or indirectly to increase exports of any product from, or reduce imports into, a Member's territory. SCM article 1.1(b) stipulates that **any**

__such financial contribution__ or income or price support pursuant to article 1.1(a) **__must confer a benefit to the recipient if it is to be considered a subsidy__** in the sense of the agreement.23 Thus, in terms of the terminology used above, the SCM agreement **__appears to exclude from its subsidy definition__** transfers falling into the third category (i.e. **__regulatory policies__**), but seems to take a rather inclusive approach with respect to the forms transfers can take within the other two categories.24 the panel in USExport Restraints, for instance, concluded that export restraints did not constitute a subsidy, as they did not represent a financial contribution by the government. Moreover, export restraints could not be considered to represent a financial contribution in the sense of article 1.1.(a)(1)(iv) of the SCM agreement.25 the panel report stressed that government entrustment or direction was "different from the situation in which the government intervenes in the market in some way, which may or may not have a particular result simply based on the given factual circumstances and the exercise of free choice by the actors in that market".26 Using a hypothetical example, the panel illustrated that a "tariff" could not constitute a financial contribution, even if it conferred a benefit to specific downstream producers. It added that if the concept of financial contribution were about the effects, rather than the nature of a government action, this concept would effectively be eliminated, leaving "benefit" and "specificity" as the sole determinants of the scope of the agreement.27

"subsidy"
The Law Dictionary, no date, "Subsidy", https://thelawdictionary.org/subsidy/
Subsidy
Definition and Citations:
In English law. **__An aid, tax, or tribute__** granted by parliament to the king for the urgent occasions of the kingdom, to be levied on every subject of ability, according to the value of his lands or goods. Jacob. In American law. **__A grant of money made by government in aid of the promoters of any enterprise, work, or improvement in which the government desires to participate, or which is considered a proper subject for state aid__**, because likely to be of benefit to the public. In international law. The assistance given in money by one nation to another to enable it the better to carry on a war. when such nation does not join directly in the war. Vattel, bk. 3,

"subsidy"
International Trade Administration, The Department of Commerce, "Trade Guide: WTO Subsidies Agreement", https://www.trade.gov/trade-guide-wto-subsidies
__A subsidy has a very particular meaning under the Subsidies Agreement and U.S. law__ (Title VII of the Tariff Act of 1930). **__A subsidy is defined as a "financial contribution" by a government which provides a benefit__**. The forms that a subsidy can take include:
* **__a direct transfer of funds__** (e.g., **a grant, loan**, or infusion of equity);
* **__a potential transfer of funds or liabilities__** (e.g., **a loan guarantee**);
* **__foregone government revenue__** (e.g., **a tax credit**); or
* **__the purchase of goods__**, or the provision of goods or services (other than general infrastructure).
Under the Agreement, actions can only be taken against subsidies that are "specific." A specific subsidy is one that is only given to one company, or to a special group of companies.

"domestic subsidy"
International Trade Administration, The Department of Commerce, No date, "Get Relief from Unfair Trade," https://www.trade.gov/subsidy-allegation
Financial Contribution:
A financial contribution may involve direct funding by a foreign government or public entity to a producer or exporter, or the indirect transfer of funds through a funding mechanism or a private party. Examples include:
A direct transfer of funds (e.g., grants, loans, equity infusions) or the potential direct transfer of funds or liabilities (e.g., loan guarantees);
Foregoing or not collecting revenue that is otherwise due (e.g., tax credits, deductions from taxable income, import duties);
Providing goods or services for less than adequate remuneration, other than general infrastructure; and
Purchasing goods for more than adequate remuneration.
Benefit: A benefit generally exists to the extent that the subsidy recipient receives assistance on terms more favorable than what is available on the market or would normally apply or pays less or receives more than the recipient otherwise would in the marketplace, absent the financial contribution.
Specificity: There are three basic categories of subsidies that are "specific": (1) export subsidies, (2) import substitution subsidies, and (3) domestic subsidies.
Export subsidies and import substitution subsidies are automatically deemed to be "specific." Domestic subsidies may be either de jure (in law) or de facto (in fact) specific.
An export subsidy is a subsidy that is contingent upon export performance, alone or as one of two or more conditions.
An import substitution subsidy is a subsidy that is contingent upon the use of domestic over imported goods, alone or as one of two or more conditions.
A domestic subsidy that is de jure specific **is one where the authority providing the subsidy expressly limits the subsidy to an enterprise or industry or group of enterprises or industries**. De jure specificity also exists where a subsidy is **limited to designated geographical regions within the jurisdiction of the granting authority**.
Even though a subsidy may appear to be generally available to all companies and industries, the actual distribution of benefits is also examined to determine if it may be de facto specific. De facto specificity exists where one or more of the following factors exist:
The number of actual subsidy recipients is limited.
Certain enterprises or industries are predominant users of the subsidy program or receive disproportionate benefits under the subsidy program.
The authority providing the subsidy uses discretion to favor certain enterprises or industries over other industries.

MBI's exclude performance standards (e.g. RFS, CAFO's, etc) command-and-control, and subsidies. There are four topical areas: taxes, TPS (tradeable permits), market creation, and eliminating subsidies.

Stavins ’98 [Robert; September 22; Albert Pratt Professor of Business and Government, and Faculty Chair, Environment and Natural Resources Program, John F. Kennedy School of Government, Harvard University; Public Policies for Environmental Protection, “Market-Based Environmental Policies,” ed. Portney and Stavins, Harvard University Resources for the Future]
**Kevin Hirn

1. **WHAT ARE MARKET-BASED POLICY INSTRUMENTS?**

Nearly all environmental policies consist of two components, either explicitly or implicitly: the identification of an overall goal (either general or specific, such as a degree of air quality or an upper limit on emission rates) and some means to achieve that goal. In practice, these two components are often linked within the political process, because both the choice of a goal, and the mechanism for achieving that goal, have important political ramifications.1 This chapter focuses exclusively on the second component, the means — the “instruments” — of environmental policy, and considers, in particular, economic-incentive or market-based policy instruments.

1.1 A **Definition**

Market-based instruments are regulations that encourage behavior through market signals rather than through explicit directives regarding pollution control levels or methods.2 These policy instruments, such as tradable permits or pollution charges, are often described as “harnessing market forces”3 because if they are well designed and implemented, they encourage firms (and/or individuals) to undertake pollution control efforts that both are in those firms’ (or individuals’) interests and that collectively meet policy goals.

By way of contrast, conventional approaches to regulating the environment are often referred to as “command-and-control” regulations since they allow relatively little flexibility in the means of achieving goals.
EarlyenvironmentalpolicIes,suchastheCleanAirActof1970andtheCleanWaterActof1972, relied almost exclusively on these approaches.4

In general, command-and-control regulations tend to force firms to shoulder similar shares of the pollution-control burden, regardless of the relative costs to them of this burden.5
Command-and-control regulations do this by setting uniform standards for firms, the most prevalent of which are technology-based and performance-based standards. Technology-based standards specify the method, and sometimes the actual equipment, that firms must use to comply with a particular regulation. For example, all electric utilities might be required to employaspecifictypeofscrubbertoremoveparticulates. A performance standard sets a uniform control target for firms, while allowing some latitude in how this target is met. For example, a regulation might limit the number of allowable units of a pollutant released in a given time period, but might not dictate the means by which this is achieved.

Holding all firms to the same target can be expensive and, in some circumstances, counterproductive. While standards may effectively limit emissions of pollutants, they typically exact relatively high costs in the process, by forcing some firms to resort to unduly expensive means of controlling pollution. Because the costs of controlling emissions may vary greatly among firms, and even among sources within the same firm, the appropriate technology in one situation may be inappropriate in another. Thus, control costs can vary enormously due to a firm’s production design, physical configuration, age of its assets, or other factors. One survey of eight empirical studies of air pollution control found that the ratio of actual, aggregate costs of the conventional, command-and-control approach to the aggregate costs of least-cost benchmarks ranged from 1.07 for sulfate emissions in the Los Angeles area to 22.0 for hydrocarbon emissions at all domestic DuPont plants.6

Furthermore, command-and-control regulations tend to freeze the development of technologies that might otherwise result in greater levels of control. Little or no financial incentive exists for businesses to exceed their control targets, and both technology-based and performance-based standards discourage adoption of new technologies. A business that adopts a new technology may be "rewarded" by being held to a higher standard of performance, but is not given the opportunity to benefit financially from its investment, except to the extent its competitors have even more difficulty reaching the new standard.

1.2 Characteristics of Market-Based Policy Instruments

The two most notable advantages that market-based instruments offer over traditional command- and-control approaches are cost effectiveness and dynamic incentives for technology innovation and diffusion.

In theory, if properly designed and implemented, market-based instruments allow any desired level of pollution cleanup to be realized at the lowest possible overall cost to society, by providing incentives for the greatest reductions in pollution by those firms that can achieve these reductions most cheaply.7 Rather than equalizing pollution levels among firms (as with uniform emission standards), market-based instruments equalize the incremental amount that firms spend to reduce pollution (their marginal cost).8

It is important to recognize that command-and-control approaches could — theoretically — achieve this cost-effective solution, but this would require that different standards be set for each pollution source, and, consequently, that policy makers obtain detailed information about the compliance costs each firmfaces. Such information is simply not available to government. By contrast, market-based instruments provide for a cost-effective allocation of the pollution control burden among sources without requiring the government to have this information.

In contrast to command-and-control regulations, market-based instruments have the potential to provide powerful incentives for companies to adopt cheaper and better pollution-control technologies. This is because with market-based instruments, it always pays firms to clean up a bit more if a sufficiently low- cost method (technology or process) of doing so can be identified and adopted.9

1.3 **Categories of Market-Based Instruments**

Market-based instruments can be considered within four major categories: pollution charges; tradable permits; market barrier reductions; and government subsidy reductions.10

Pollution charge systems assess a fee or tax11 on the amount of pollution that a firm or source generates.12 Consequently, it is worthwhile for the firm to reduce emissions to the point where its marginal abatement cost is equal to the tax rate. Firms will thus control pollution to differing degrees, with high-cost controllers controlling less, and low-cost controllers controlling more. A challenge with charge systems is identifying the appropriate tax rate. Ideally, it should be set equal to the benefits of cleanup at the efficient level of cleanup, but policy makers are more likely to think in terms of a desired level of cleanup, and they do not know beforehand how firms will respond to a given level of taxation.

A special case of pollution charges is a deposit refund system , where consumers pay a surcharge when purchasing potentially polluting products, and receive a refund when returning the product to an approved center (for recycling or disposal). A number of states have implemented this approach through "bottle bills," to control litter from beverage containers and to reduce the flow of solid waste to landfills, and the concept has also been applied to lead-acid batteries.13

Tradable permits can achieve the same cost-minimizing allocation of the control burden as a charge system, while avoiding the problem of uncertain responses by firms.14 **Under a tradable permit system, an allowable overall level of pollution is established and allocated among firms in the form of permits**.15 Firms that keep their emission levels below their allotted level may sell their surplus permits to other firms or use them to offset excess emissions in other parts of their facilities.

Market barrier reductions can also serve as market-based policy instruments. In such cases, substantial gains can be made in environmental protection simply by removing existing explicit or implicit barriers to market activity. Three types of market barrier reductions stand out: (1) **market creation**, as with measures that facilitate the voluntary exchange of water rights and thus promote more efficient allocation and use of scarce water supplies; (2) **liability rules** that encourage firms to consider the potential environmental damages of their decisions; and (3) **information programs, such as energy-efficiency product labeling requirements.**

Government subsidy reductions are the fourth and final category of market-based instruments. Subsidies, of course, are the mirror image of taxes and, in theory, can provide incentives to address environmental problems. In practice, however, many subsidies promote economically inefficient and environmentally unsound practices. This market distortion received much attention in the 104th Congress under the rubric of "corporate welfare," an example of which is the below-cost sale of timber by the U.S. Forest Service.

In the simplest models, pollution taxes and tradeable permits are symmetric, but that symmetry begins to break down in actual implementation.16 First, permits fix the level of pollution control while charges fix the costs of pollution control. Second, in the presence of technological change and without additional government intervention, permits freeze the level of pollution control while charges increase it. Third, with permit systems as typically adopted, resource transfers are private-to-private, while they are private-to-public with ordinary pollution charges. Fourth, while both charges and permits increase costs on industry and consumers, charge systems tend to make those costs more obvious to both groups. Fifth, permits adjust automatically for inflation, while some types of charges do not. Sixth, permit systems may be more susceptible to strategic behavior.17 Seventh, significant transaction costs can drive up the total costs of compliance, having a negative effect under either system, but particularly with tradeable permits.18 Eighth and finally, in the presence of uncertainty, either permits or charges can be more efficient, depending upon the relative slopes of the marginal benefit and marginal cost functions19 and any correlation between them.20

The degree of abatement achieved by a pollution tax and the tax's effect on the economy will depend — in part — on what is done with the tax revenue. There is widespread agreement that revenue recycling (that is, using pollution tax revenues to lower other taxes) can significantly lower the costs of a pollutiontax21. Some researchers have suggested, further, that all of the abatement costs associated with a pollution tax can be eliminated through revenue recycling in the form of cuts in taxes on labor.22 But pollution taxes can exacerbate distortions associated with remaining taxes on investment or labor. There is now common recognition that environmental taxes impose their own distortions that are at least as great as those from labor taxes.23 Using revenues from an environmental tax (or from the auction of pollution permits24) to reduce labor taxes can reduce the efficiency costs of the environmental tax, but — in most cases — the substitution of an environmental tax for an investment or labor tax will reduce welfare, apart from the potentially beneficial environmental consequences of the tax. Thus, the primary justification for environmental taxes should be their environmental benefits, not reform of the tax system per se.

MBI's use one of four market signals: taxes, permits, subsidy reduction, or market creation.

Zhang '13 [Bei; June 20; Chinese Journal of Population Resources and Environment, "Market-based solutions: An appropriate approach to resolve environmental problems," Volume 11] **Kevin Hirn

Definition of the market-based solutions

In the eyes of the economists, the environmental factor is valuable and should not be cost free. **When consumers buy products, the price they pay includes a certain amount of money for the environmental consideration, such as environmental harm and any recycling process. Market-based instruments should offer the environmental factor** a proper price in the production and consumption process and present flexibility and distinction at the same time. This kind of economic method stops people undertaking a monetary burden regarding pollution. "**Market-based instruments are regulations that encourage behavior through market signals rather than through explicit directives regarding pollution control levels or methods**" (Stavins Citation1998).

A different approach to work out the environmental problem is a traditional method called "command-and-control theory" approach. This approach compels all the companies to implement similar pollution control strategies, irrespective of the relative cost (Hahn and Stavins Citation1992). Companies and individuals are informed how much pollution they may let out, the kind of technology to apply, and even the certain manufacturing procedures to follow. However, **compelling all companies and individuals to obey the same rules or use the same technology or facilities may be costly**. In addition, there will be fewer motives for companies to go further than the regulations and laws require them to follow.

Advantages of market-based solutions

In terms of the market-based instruments, which provide great flexibility and financial incentives, they can spur producers to adopt the new technologies and facilities to pursue better results in order to solve the environmental problems. From the definitions of market-based instruments and command-and-control instruments, we can figure out the comparative advantages of the market-based solutions: cost effectiveness and motivation for technology innovation.

In a theoretical view, if well-designed and carried out properly, market-based policies "allow any desired level of pollution cleanup to be realized at the lowest overall cost to society, by providing incentives for the greatest reductions in pollution by those firms that can achieve these reductions most cheaply" (Stavins Citation2003). Compared with the command-and-control measures, which set the same criterion for all companies, market-based policies equate the increased amount which companies use for reducing pollution. More specifically, it offers a motive for companies to equate abatement costs at the margin, thereby reaching the fixed standard of environmental quality in a cost-effective way.

What the command and control measures ignore is that the costs of dealing with environmental problems vary greatly according to the production, labor force, technology, the quality of equipment and other factors among different firms in the various industries. The way of setting uniform standards for all the firms may be inappropriate and costly in fact. In addition, it leaves little flexibility for companies to pursue better pollution reduction solutions.

As mentioned above, market-based solutions give the companies a greater incentive to use the new technologies and equipment. **Incentives which will influence the individual's behavior to a considerable extent.** **People will accept a policy more easily if either the benefits increase or the cost decreases**. One may pour their wastes to a close-by river if they do not need to pay for that. This can be regarded as a result of "tragedy of the commons" which means that if people can use valuable resources such as the water or fishery industry without restriction, the resources will be damaged or exhausted by people who want to share its value (Anderson and Leal Citation2001), because there is no incentive to stop gaining benefits in such an easy and cheap way. That is what market-based solutions try to change in the environmental protection process. **Market-based solutions connect the "incentive" with "economy" and show that making use of an environmental protective incentive in an appropriate way could finally achieve a cost-efficient process. This is how the market-based solutions operate, they connect the environmental missions with the financial incentives.** Because of this factor, the market-based solution often "pays firms to clean up a bit more if the sufficiently low-cost method (technology or process) of doing so can be identified and adopted" (Stavins 2003). Moreover, this kind of incentive drives companies to try and develop better technologies in their own interests and, ultimately, achieve a way to reduce pollution.

Major categories of market-based solutions

In terms of the different categories of market-based solutions, four major ways should be taken into account: "Pollution charges; tradable permits; market barrier reductions; and government subsidy reductions" (Stavins 2003).

Pollution charge

Pollution charge systems "assess a fee or tax on the amount of pollution that a firm or source generates" (Stavins Citation2001). The companies are willing to reduce the pollution to the level when the marginal abatement cost can equate the fee they pay.

The deposit refund system, which is regarded as a special case within the pollution charges, is widely used among many countries. The deposit refund system asks individuals to pay a deposit for the bottles when they buy the products and pay back the money to them when the bottles are returned. Many countries have carried out this method through "bottle bills" (Menell Citation1990).

In Norway, more than 90% of beer and soft drink bottles which have deposits are re-cycled; however, only 70% of wine bottles are recycled. The similar phenomenon is found in car hulks. In Sweden, the effect of the car hulks project tends to be limited due to its cheap deposit. While in Norway, with a deposit more than three times than that in Sweden, over 90% are re-cycled (Wrobel Citation1990). To some extent, a higher deposit always brings greater responses.

Furthermore, the deposit refund system can be used in other similar cases, such as tires and diapers, where disposal expense is very high if individuals throw them away randomly.
There are many issues concerning tire recycling in many countries. In Canada, Ontario holds a US$5 fee deposit for each tire bought. If the buyer returns the used tire to the re-cycle station, the deposit will be returned, then the station will pay for dealing with the used tires in a proper way (Wrobel 1990). This kind of charge for the environment not only brings money to the re-cycling process, but also encourages people to choose environmentally protective ways. To take the disposable diapers as an example, people prefer to use them because of their convenience and cheap price compared with other choices like diaper services. However, a large amount of used diapers become a big problem for the dump sites. In this way, people should be charged certain sales tax when they buy the products for the rubbish they make. Life can be easier and cheaper, but people should benefit the environment as well. Furthermore, this policy also encourages people to turn to choices which are more environmentally protective (NRDC 1997).
These daily cases show that individuals play important roles in the market-based solutions. This kind of tax which brings money for the reproduction or the environmental management and governance, increase the price for the dirty products and reduce the price for cleaner ones. In this case, individuals will have an incentive to use environmental protection in their daily lives.

Tradable permits

Tradable permits could "achieve the same cost-minimizing allocation of the control burden as a charge system, while avoiding the problem of uncertain responses by firms" (Stavins 1998). After the mission (the total amount of pollution within allowance) is fixed, firms will get certain permits which allow them to share the amount in freely distributed or auction way. To use the permits effectively, companies which manage to maintain their emission below the allocated standard will either sell the extra permits or put them into their other products to neutralize the emission which surpasses the standard. Meanwhile, companies which have excess emissions could buy emission reductions from other companies to meet their own demand. Thus, companies driven by the financial benefits will decrease their emissions as much as they can.
Tradable permits as an effective market-based solution are widely used in the US (US Environmental Protection Agency 1992). Several major federal markets permit solutions that contribute a lot to the environmental problems discussed below.

Lead trading

The lead trading strategy started during the 1980s with the aim of offering gasoline refiners a more flexible way to achieve emission criterion by reducing the lead content of petrol by 10% of its earlier standard. The Environmental Protection Agency (EPA) then ratified the lead credits transaction within the refinery and originated a project to let refineries to save their lead credits in the bank which achieved good effects (Hahn and Hester Citation1989). Though the gains of the marketing process are hard to estimate, the strategy seems to be a comparatively cost-effective solution. The transactions among companies became more frequent than that in previous environmental trading. EPA assessed that the lead trading project was 20% more cost effective than other programs, approximately $250 million per year (Schwartz et al. Citation1985.).

CFC trading

Another application of the marketable permits, called CFC Trading in US, is designed to promote the Montreal Protocol, an international agreement to protect the ozone layer. The agreement aims to reduce the use of CFCs, one of the most detrimental chemical gases in ozone depletion. The market formulates restrictions on the production and consumption processes of CFCs and distributes an allowance which restricts such activities (Stavins 2003). Due to the fact that various kinds of CFCs lead to various influences on ozone depletion, each CFC is allocated specific weight according to its depletion potential (Hahn and McGartland Citation1989). In this way, companies have to get the allowance first to produce a certain content of CFCs. The market-based solution which set a tax on CFCs provides great flexibility to the issue of the CFCs. Although the total benefits in the CFC market are hard to calculate due to lacking of statistics involving these issues, the comparatively cheap trade costs connected with trading is regarded as a cost-effective way compared with other approaches (Stavins 1998).

Market barrier reductions

Market barrier reductions have great influence on eliminating the existing frictions in market activity in order to archive the benefits in the environmental protective issues. By creating a market in water rights, this solution promotes voluntary market-based exchange of water rights and therefore facilitating more effective distribution and makes better use of water resources among competing users.

In the United States, an agreement was achieved that farmers in the Imperial Irrigation District (IID) supplied 100,000 acre-feet of water each year to the Metropolitan Water District (MWD) with increasing urban requirement for water (Willy, Citation1988). This program resolved the imbalance between supply and demand of a scarce water resource. For urban government and individuals, the water bill for the same quantity of water would be reduced to a certain degree.

Another effective way to eliminate the market barriers is to promote environmental issues by offering more information to people in order to influence their choices in the consumption process. At the same time, **it creates incentives for environmental protection among firms**. The "dolphin-safe" labels on canned tuna lets consumers know that the tuna are captured without injuring the dolphins. This solution delivers information to buyers that labeled tuna will contribute to the environment protection and therefore achieve a better sales volume, which will optimize the tuna capture process in the long run (Roe and Sheldon Citation2007.).

Government subsidy reductions

From the theoretical view, "**since subsidies are the mirror image of taxes", they can provide incentives** to address environmental problems; while **in practice, many subsidies are thought to "promote economically inefficient and environmentally unsound practices**" (Stavins 1998).

The US government allocates many subsidies into energy areas such as fossil fuels which draw a lot of attention due to the climate change issues. An EPA research shows that reducing these subsidies may contribute a lot to CO2 emission reduction (Shelby et al. Citation1997). Another study shows that because of the government's involvement in energy areas via tax and other individual projects, US$17 billion was paid by the Federal government every year (Koplow Citation1993). In this way, a multiple share of the subsidies and projects will eliminate the dependence on fossil fuels to a considerate extent. In fact, traditional technologies take up 90% of the subsidies and even within fossil fuels, natural gas, which is regarded as the new energy most friendly to the environment, gets merely around 20% of the subsidies (Stavins

1998). Luckily, as time passes by, renewable energy gains more and more attention and governments will support the project for renewable energy sources and energy efficiency.

"permitting reform"
Citizens Climate Lobby, No Date, "Let's Reform America's Clean Energy Permitting Process", https://citizensclimatelobby.org/our-climate-solutions/clean-energy-permitting-reform/#:~:text=What%20has%20Congress%20done%20on,permitting%20reform%20discussions%20ramped%20up.
Clean Energy Permitting Reform 101: What is permitting reform?
Just like you need a building permit to expand your home, big **energy projects must get written approval from local, state, and/or federal authorities to start construction. Permitting is important, but it adds hefty time and expense to projects of all kinds. Permitting reform is critical if we're going to make the clean energy transition happen fast enough to meet our climate targets.**
There are three key parts to successful energy permitting reform:
1. **Siting/building clean energy projects**
Right now, it takes an average of 4.5 years for federal agencies just to complete environmental impact statements for major energy projects. These are important assessments, but we need them to move faster and speed up the pace with which we build new clean energy projects.
2. **Transmitting that clean energy across the country**
In the past decade, the U.S. has expanded our electricity transmission infrastructure just 1% per year. Why so little? Well, right now, it takes over a decade on average to build a new transmission line. We've got to speed up that pace and triple our current capacity to transmit clean electricity by 2050.
3. **Involving local communities**
Better permitting allows local communities to give their input on energy projects early in the process and choose good projects over bad ones. Good projects should be approved faster, harmful projects should be rejected faster, and all new projects should safeguard the lives and health of people living nearby.

"permitting reform"
Lori Bird, Director, US Energy Program, World Resources Institute, and Katrina McLaughlin, Clean Energy Associate, US Energy Program, World Resources Institute, 2-9-23, "US Clean Energy Goals Hinge on Faster Permitting", https://www.wri.org/insights/clean-energy-permitting-reform-us#:~:text=Congress%20and%20the%20administration%20are,FERC%20can%20issue%20the%20permit.&text=There%20is%20not%20a%20single,site%2C%20subject%20to%20relevant%20ordinances.
Given the challenges to building interstate transmission, **further federal action** and collaboration across jurisdictional scales **is needed**. The most visible Congressional effort to date is the stalled Manchin **permitting reform** proposal. This bill **would have created a streamlined permitting system for energy assets, including renewable energy projects and natural gas and fossil projects, and would have authorized specific projects** like the Mountain Valley gas pipeline. **The proposal also would have allowed the U.S. Department of Energy (DOE) to designate transmission lines in the national interest and enable FERC to**

allocate the costs of these projects to ratepayers across the region who would benefit from them. While the bill contained controversial provisions and ultimately stalled, transmission issues are a critical topic for federal policymakers to address. Debates on this issue are expected to continue in the 118th Congress.
Meanwhile, administrative actions by agencies or the administration may be viable to address some elements of needed permitting reform, such as setting clear or expedited timelines and improving coordination across agencies, although such actions can be changed or reversed by future administrations.

"permitting reform"
Lauren Bauer, Wendy Edelberg, Cameron Greene, Olivia Howard, and Linsie Zou, 5-22-24, "Eight facts about permitting and the clean energy transition", Brookings, https://www.brookings.edu/articles/eight-facts-about-permitting-and-the-clean-energy-transition/#:~:text=Although%20there%20are%20fewer%20reported,;%20Manitius%2C%20Cavert%2C%20and%20Kelly
During the 2021 Leaders Summit on Climate, President Biden pledged that, on the road to economy-wide net zero emissions in 2050, the U.S. power sector would be carbon pollution free by 2035 (White House 2021). Meeting these goals requires building clean energy infrastructure at an unprecedented speed. **Permitting reform**—that **is, changing the processes for obtaining government approval to build and operate energy generating, energy transmitting, and energy storage systems**—has attracted notice because permitting-related bottlenecks have stymied both the speed and the scale of the clean energy transition. In this set of facts, The Hamilton Project highlights key economic facts about the state of permitting reform and where attention should be focused to accelerate building out clean energy infrastructure.

"energy infrastructure"
U.S. Department of Energy, No Date, https://www.energy.gov/lpo/title-17-energy-infrastructure-reinvestment-eir-financing
Energy Infrastructure is defined as a facility, and associated equipment, used for (1) the generation or transmission of electric energy; or (2) the production, processing, and delivery of fossil fuels, fuels derived from petroleum, or petrochemical feedstocks.
This definition encompasses a wide variety of facilities and sites, including, but not limited to, decommissioned or operating power plants, related transmission interconnections, oil and gas infrastructure including pipelines, refineries, and gas stations or refueling terminals.

"energy infrastructure"
Karen B. Clay, Teresa and H. John Heinz III Professor of Economics and Public Policy at Carnegie Mellon University's Heinz College of Information Systems and Public Policy, and Akshaya Jha, Assistant Professor of Economics and Public Policy, Carnegie Mellon University, Heinz College of Information Systems and Public Policy, 7-6-21, "Heinz Experts Eye Future of U.S. Energy Infrastructure", https://www.cmu.edu/news/stories/archives/2021/july/energy-infrastructure.html
Q: Just to define the term, **what is the energy infrastructure** and what are its main components?

Akshaya Jha: So, when we think about the energy infrastructure, what we're really talking about is **the means by which different forms of energy — be it electrical or otherwise — are produced, transported, and delivered**.
Karen Clay: Right. Typically, we consider generation, transportation, storage and distribution to be the main categories of that infrastructure, or the steps that need to be taken. For instance, solar energy to be absorbed into a photovoltaic panel to someone miles away turning on their television. In addition to electricity, the main components of energy infrastructure also include petroleum products and natural gas, and **the main categories of transportation and distribution include high voltage transmission lines, pipelines, and long- and short-distance transportation** via truck, rail, barges and ships. Additionally, as I mentioned, **the energy infrastructure also encompasses storage methods, such as batteries, underground and above ground storage** of petroleum and natural gas, and hydroelectric storage methods.
Jha: I would like to add that **one new aspec**t that more and more people are also talking about **is electric vehicle charging infrastructure**. Having these charging stations so that electric vehicles can go from point A to point B, possibly achieving longer-distance rides than what's feasibly occurring today. Which is to say that as technologies change and evolve, what is considered energy infrastructure can also change and evolve.

"energy infrastructure"
Cybersecurity & Infrastructure Security Agency, U.S. Department of Homeland Security, No Date,
https://www.cisa.gov/topics/critical-infrastructure-security-and-resilience/critical-infrastructure-sectors/energy-sector
The **energy infrastructure is divided into three interrelated segments: electricity, oil, and natural gas. The U.S. electricity segment contains more than 6,413 power plants** (this includes 3,273 traditional **electric utilities** and 1,738 nonutility power producers) with approximately 1,075 gigawatts of installed generation. Approximately 48 percent of electricity is produced by combusting coal (primarily transported by rail), 20 percent in nuclear power plants, and 22 percent by combusting natural gas. The remaining generation is provided by hydroelectric plants (6 percent), oil (1 percent), and renewable sources (solar, wind, and geothermal) (3 percent). The heavy reliance on pipelines to distribute products across the nation highlights the interdependencies between the Energy and Transportation Systems Sector.

"energy-related infrastructure"
Janea Scott, Counselor to the Assistant Secretary, Land and Minerals Management, U.S. Department of the Interior, 11-16-21, Hearing on "Plugging in Public Lands: Transmission Infrastructure for Renewable Energy",
https://www.doi.gov/ocl/renewable-energy-transmission-infrastructure
As the largest Federal land manager in the West, the BLM plays a key role in planning critical energy corridors and siting transmission facilities. Each year, the BLM processes thousands of applications for ROW grants on public lands – authorizations to use public lands in support of infrastructure projects across the country. The BLM permits and administers electrical transmission across public lands that involve everything from small residential electricity lines, to

interstate, bulk-energy transmission from generation sources to major population demand centers. These include renewable energy projects, electric transmission lines, communication sites, broadband deployment, highways, trails, railroads, canals, pipelines, and other facilities or systems which are in the public interest. Over half (59,000) of the total 118,000 ROW grants the BLM manages are for **energy-related infrastructure** and facilities. **Increasing transmission capacity is essential for providing access to high-quality renewable energy resources and furthering efforts to meet state and Federal mandates to expand the country's renewable energy portfolio.**

Major **transmission lines have the capability to unlock numerous opportunities for renewable energy project siting**. The BLM is actively working on several large-scale bulk-energy transmission projects, such as Ten West Link between Arizona and California, connecting over 4,000 MW of solar plus energy storage projects to load centers once this line is constructed. Another project the BLM is actively processing, the Greenlink West Transmission project in Nevada, will unlock new potential opportunities for the siting of renewable energy along its pathway. Currently, seven new utility-scale solar project applications have been received by the BLM, all of which are sited near the Esmeralda substation in Nevada, that would connect to the Greenlink West Transmission project. A project the BLM has permitted but is not yet built, the Southwest Intertie Project (SWIP North), is part of a 1,000 MW transmission pathway from Idaho to California that will provide access for utility-scale wind and solar projects and deliver energy to several states. Several other large-scale bulk-electricity transmission projects on Federal lands include the Greenlink North project in Nevada and projects that span state boundaries including Sunzia, Boardman to Hemingway, Gateway West, Gateway South, and Transwest Express.

"fossil fuel subsidies"

Margherita Belgioioso, Associate Professor of Quantitative International Relations, School of Politics and International Studies, University of Leeds, UK, and Edward Newman, Professor of International Security, School of Politics and International Studies, University of Leeds, UK, January 2025, "Fossil fuel subsidy reform, distributive justice and civil unrest", https://www.sciencedirect.com/science/article/pii/S2214629624004596#:~:text=The%20reduction%20or%20reform%20of,and%20encouraging%20renewable%20energy%20use.

In this article **fossil fuel subsidies are defined as financial interventions in energy markets which are provided either to producers or consumers in order to reduce or limit the cost of fossil fuels used for domestic cooking, heating and lighting, and for operating vehicles**. It is widely believed that these subsidies obstruct efforts to meet climate change reduction targets, in addition to contributing to other social and economic ills [[1], [2], [3], [4], [5], [6]]. **Subsidies shield consumers from the true cost of energy since they are paying below the market value, which encourages consumption**. They also represent a fiscal burden on many countries, absorbing public resources which could be used for other purposes, and obstruct the development and take-up of renewable energy sources since the financial competitiveness of renewable energy is dampened by the availability of subsidized fossil fuel products. It is generally the fiscal problems associated with large fossil fuel subsidies which lead governments to attempt to reform or reduce subsidies, rather than the ecological benefits,

although the latter attract significant attention given their relevance to the political challenges of addressing climate change.
Two different methodologies are used to measure and define subsidies [[7], [8], [9]] and as a result of this assessments of their value vary widely. Firstly, the measurement of **<u>explicit subsidies</u>** – which is used in this article – **<u>is based on the absolute value of financial interventions and the 'price gap' that this generates between production and consumption costs.</u>** **<u>These interventions can include fixing prices or capping price increases, exemptions from taxes, assistance for specific groups of consumers, and support for energy companies</u>** [10]. Secondly, an alternative definition includes the wider impacts and costs of fossil fuel use which are exacerbated by subsidies – such as the public health consequences of pollution – which are counted as externalities and thus regarded as the 'true costs' of subsidies. The IMF [10] describes these broader costs as 'implicit subsidies', since they include the wider impacts of subsidizing fossil fuels as well as the price gap between production and retail values. Although these are presented as alternative 'definitions', they represent fundamentally different understandings of fuel subsidies and their impact. By including externalities, the IMF approach involves a far wider range of impacts and costs linked to carbon emissions, given that these are inflated by subsidies. Therefore, defining subsidies — especially the implicit approach — and their impact is not without controversy [11].
Using the wider definition, the IMF [10] finds that fossil fuel subsidies were US$7 trillion globally in 2022, which represents 7.1 % of GDP. Existing work [[12], [13], [14]] demonstrates the broad impact of undercharging for fossil fuels using this definition, which includes a range of externalities and side-effects. In contrast, the International Energy Agency (IEA) [15], using the narrow price-gap definition, found that global fossil fuel consumption subsidies were US$1 trillion in 2022, an all-time high and double the previous year. This was in large part due to the war in Ukraine and cuts in Russia's fuel supplies to some regions, which had a sharp inflationary impact on energy prices. Higher subsidies were a response to this on the part of many governments, and they are expected to decline in the shorter term. Nevertheless, the longer-term trajectory – to 2030 – is expected to reflect an increase beyond the 2022 peak, due to the share of fuel consumption in emerging markets continuing to increase [10]. The value of subsidies also fluctuates, depending on demand and energy production and supply costs; thus, global subsidy values declined during the Covid-19 pandemic in 2020, and increased during the energy crisis of 2022. Subsidy reform is particularly sensitive – and often stalled or reversed [16] – in times of soaring international energy prices as national authorities seek to cushion the impact of this upon consumers.

"fossil fuel subsidy reforms"
Nils Droste, Department of Political Science and Centre for Innovation Research, Lund University, Benjamin Chatterton, Department of Economic History, Lund University, Jakob Skovgaard, Department of Political Science, Lund University, 6-27-24, "A political economy theory of fossil fuel subsidy reforms in OECD countries",
https://pmc.ncbi.nlm.nih.gov/articles/PMC11211386/
Specifically, our theory consists of four interconnected mechanisms: i) **<u>a market-power mechanism that captures the effects of competition between energy sectors, and where larger renewable energy shares decrease the role of fossil fuels and thereby ease the</u>**

reform of fossil fuel subsidies (see the causal arrow from renewables' market share to fossil fuel subsidy reform in Fig. 2); ii) **a policy mechanism where reforms lead to lower overall fossil fuel subsidy levels** (see the causal arrow from fossil fuel subsidy reform to fossil fuel subsidy levels in Fig. 2); iii) a polity mechanism that captures the effects of institutional quality on the effectiveness of the market and policy mechanisms (e.g. government effectiveness, corruption control) (see the moderating causal arrow from quality of institutions to the causal arrows of mechanisms i and ii in Fig. 2); and iv) **a feedback mechanism where lock-ins into fossil fuel dependent pathways affect the effectiveness of the market mechanism** (see the causal arrow back from fossil fuel subsidy levels to renewable market share). The mechanisms in our theory include energy markets, political and institutional (feedback) factors, similarly to other theoretical frameworks that include techno-economic, socio-technical and political factors to study e.g. energy transitions63. Next, we introduce these mechanisms, present the corresponding causal hypothesis inspired by both our inductive approach to the data and our deductive engagement with the literature. To test the developed hypotheses, we present results of two-way fixed effects regressions that measure within country variations64 and account for moderating effects65 of mechanisms iii and iv (see Methods).

"fossil fuel subsidy reforms"
Nils Droste, Department of Political Science and Centre for Innovation Research, Lund University, Benjamin Chatterton, Department of Economic History, Lund University, Jakob Skovgaard, Department of Political Science, Lund University, 6-27-24, "A political economy theory of fossil fuel subsidy reforms in OECD countries", https://pmc.ncbi.nlm.nih.gov/articles/PMC11211386/
When considering different subsidies, we first identify which fuel or energy source is targeted. In general, these subsidies are specific to a certain type of fuel e.g., reduced tax rates on diesel for agricultural use. Electricity where it is directly subsidized, for example consumption subsidies for households or reduced taxation for high energy industry, have also been considered as a potential fossil fuel subsidy. Generation is however, often achieved at least partly through renewables. **Reforms to these subsidies have only been considered fossil fuel subsidy reforms when generation was primarily achieved by burning fossil fuels. We utilize a cut-off point of at least 60% of generation coming from fossil fuels for electricity subsidies to be considered fossil fuel subsidies. This percentage was set as it ensured that we could identify reforms to subsidies that primarily and consistently benefitted fossil fuels.** Setting at the 50% line was avoided as fluctuations in generation year on year would mean subsides often benefited renewables more. Those subsidies that seek to subsidize

certain types of electricity generation (hydropower, natural gas etc.) are not subject to this 60% constraint as they are considered a subsidy for the utilized fuel, not the electricity.

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