In collaboration with Accenture

WORLD ECONOMIC FORUM

Transitioning Industrial Clusters towards Net Zero: National Policy Enablement for Industrial Decarbonization

WHITE PAPER

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Images: Getty Images

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Foreword

If industrial clusters win, we all win.

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We recognize that decarbonization of the hardest-to-abate industrial sectors must come through public-private collaboration at a scale rarely seen anywhere on the globe. International legislative bodies are leaning into the examples of one another to craft policy and financial enablers intended to rapidly mature markets for technologies unheard of in the mainstream only years ago.

In March 2021, Accenture, in collaboration with the World Economic Forum, published its first major point of view on the industrial cluster approach. We have been thrilled to see the approach expand and mature with great success.

In the wake of welcoming our ninth signatory industrial cluster to the initiative, we are pleased to share the work our team at the Transitioning Industrial Clusters Towards Net Zero initiative has been aggregating over the past year to illuminate a concise view of what several regional and federal governments are doing to drive industrial decarbonization through the lens of our approach.

More detail is provided in this white paper on why we pursue holistic, system value creation alongside collaborative, highly-localized industrial decarbonization. This approach is increasingly supported by regional and federal policies – many of which are outlaid herein – and demonstrates successful delivery of economic, environmental and social wins for the communities housing industrial clusters.

Thank you to all of those participating in research and policy analyses for their time and contributions to this white paper and the continued development of a roadmap to decarbonize heavy industry.

Executive summary

Federal governments around the globe are awakening to the criticality of their role in catalysing the decarbonization of industry with the industrial clusters approach core to global legislation.

As nations worldwide continue to develop and industrialize at a pace never before seen, the demand for products like cement, chemicals, coal, oil and gas, and steel – or their substitutes – is rapidly growing. Often these hard-to-abate sectors are geographically co-located in so-called industrial clusters, hubs or zones. To address an urgent need for scaled decarbonization in these industries, strong policy support is needed with a particular focus on the transition of these CO_2-emitting industrial areas across all nations, independent of industry mix or development stage.

Industrial segments including cement, chemicals, coal, oil and gas, and steel represent 80% of global industrial emissions

This white paper reviews the legislated policies driving industrial decarbonization in a selection of ten nations across the Americas, Europe and Asia-Pacific, as well as the enabling mechanisms to promote a collaborative, market-oriented industrial clusters approach. Across these policies, analysis has shown that:

1. Enablement for decarbonization is typically manifested through **target setting, industry-influencing public sector regulations and funding packages** – grants, loans, tax or direct pay incentives.

2. The most common appearance of the Transitioning Industrial Clusters approach in these nations' legislation is in the form of **mandated private collaboration** across co-located industrials towards **process efficiency and circularity innovation and maturation**. Private corporations must collaborate to develop and scale not only clean technologies and processes themselves but also their markets.

3. A selection of reviewed nations have legislated targets for – and often fund – the **development of clean hydrogen and carbon capture, utilization and storage (CCUS) demonstration projects** in industrial contexts. These demonstration projects de-risk the uncertainty in nascent technologies and build a strong foundation for private investors' security.

4. In many nations' industrial decarbonization legislation, a holistic system value approach to decarbonization is presented, **balancing environmental benefits with the social (health, workforce) and economic (gross value added (GVA), market leadership, foreign direct investment (FDI)) benefits** to uplift the core and drive towards net zero in the hardest-to-abate sectors.

Nations reviewed: Canada, United States of America, Germany, Spain, Netherlands, United Kingdom, Australia, Indonesia, China, Singapore.

The analysis presented in this white paper underlines the necessity of creating a secure environment for not only investors to trust the transition, but also for the employees and communities that exist in and around these industrial clusters and stand to benefit the most from this industrial transformation.

TABLE 1 | **National investment in key decarbonization technologies**

	Hydrogen	Carbon capture, utilization and sequestration	Systemic efficiency and circularity	Direct electrification and industrial heat
	Federal funding and support measures			
Canada	Investing	Investing	Investing	Investing
United States	Investing	Investing	Investing	Investing
Spain	Exploring	Interest expressed	Investing	Seeding
Germany	Investing	Investing	Investing	Investing
Netherlands	Exploring	Exploring	Exploring	Exploring
United Kingdom	Seeding	Investing	Seeding	Investing
Australia	Exploring	Exploring	Exploring	Exploring
Indonesia	None	Interest expressed	Stated ambition	Stated ambition
China	Investing	Investing	Investing	Investing
Singapore	Exploring	Exploring	Exploring	Stated ambition

Exploring – <$200 million **Seeding** – $500 million-$1 billion **Investing** – >$1 billion

Scope of work and research approach

BOX 1 **Transitioning Industrial Clusters towards Net Zero initiative approach**

The World Economic Forum, in collaboration with Accenture and EPRI, launched the "Transitioning Industrial Clusters towards Net Zero" global initiative at COP26 in Scotland, to accelerate the transition of industrial clusters globally towards net-zero emissions. This initiative promotes and enables industries to realize the benefits of co-location and take an integrated approach to transitioning towards net zero. Industrial clusters are where sector-specific decarbonization efforts and clean energy technology deployment efforts converge to enable a systemic approach towards industrial decarbonization.

To this end, carefully developing a strategic approach tailored to each cluster lays the groundwork for collaborative investment de-risking, clean energy market creation and cluster-based decarbonization. The initiative prompts both signatories and prospective clusters alike to explore:

- Partnerships: How can we build trust between competing companies both on the supply and demand side?
- Policy: Have enabling policies been developed to accelerate net zero industrial clusters?
- Financing: What innovative options exist for public and private financing?
- Technology: While the initiative is technology neutral, what are the logical technology pathways which converge a diversity of levers and apply to all clusters?

The initiative convenes industrial players at all stages of ambition development in an impartial forum to collaboratively shape strategies and share lessons learned. Since its launch, the initiative has developed thought leadership and on-the-ground strategy and concept coaching to grow and incubate best practices for both signatory and prospective clusters.

This paper supports the Transitioning Industrial Clusters towards Net Zero initiative, which aims to accelerate decarbonization within industrial hubs. Selective policy reviews were pursued in three initial geographic swaths:

- Americas
- Europe
- Asia-Pacific

Nations selected for review within these geographies were driven both by the community interest and the availability of deep content knowledge within Accenture and World Economic Forum teams. As the initiative's platform continues to expand, so will the policy reviews undertaken and released for public consumption.

All policy packs, and thereby this summary white paper, were developed through thorough review of national and collaboration-of-nations' legislation and other federal, public documentation. In this review, the team identified national guidance and legislation, which was met with strong interest, high use and/or increases in industrial decarbonization investment. Further, in a subset of geographies, local experts were interviewed, or additional desktop research was executed to understand the partnership, policy, finance and technology strategies of "flagship" industrial clusters.

A summary of both this policy review and flagship industrial cluster profiling is presented herein.

More detail on Transitioning Industrial Clusters' signatory members is available here.

1 Americas

1.1 Canada

Canada has pledged over CAD 8 billion towards the decarbonization of the largest industrial emitters in the race toward its 2030 goal of 40% greenhouse gas emissions reductions from 2005 levels.

As part of its climate plan, the Government of Canada has set ambitious targets of reducing greenhouse gas (GHG) emissions by 40% of 2005 levels by 2030, transitioning to net-zero electricity by 2035, and achieving overall net-zero emissions by 2050. To meet these goals, heavy industry must decarbonize by 39% of 2005 levels by 2030.[1]

To fuel the transition, the Government of Canada has implemented a variety of strategies and funding mechanisms aimed at decarbonizing large emitters, most notably the commitment of CAD 8 billion[2] through the Strategic Innovation Fund – Net Zero Accelerator,[3] to encourage the adoption of clean technologies.

Meanwhile, provincial governments are taking independent steps towards the development of their own climate change policies, ranging from the government of Quebec's plan to achieve carbon neutrality by 2050,[4] to the government of Ontario's plan to reduce GHG emissions by 30% by 2030, when compared to 2005 baseline.[5]

FIGURE 1 **Industrial cluster challenges and opportunities in Canada**

37% vs 18%

Percentage of GHG emissions produced by the industrial sector vs percentage of the industrial sector's nominal GDP contribution

CAD 46 billion

Cost of a carbon tax for the industrial sector in 2030 if output levels are unchanged

190 $MtCO_2e$*

Possible annual GHG reduction by 2050 through scaled hydrogen sector

* Megatonnes of carbon dioxide equivalent

Sources: Government of Canada; Clean Energy Canada

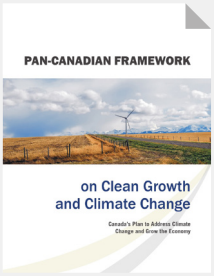
Canada's approach to industrial decarbonization

Canada's clean energy policy development
The Canadian government's Environment and Climate Change department has published three notable policies since 2020, with the expectation that two additional pieces of impactful policy are brought within the next year. With an apparent focus on hydrogen, carbon capture, utilization and storage (CCUS), and developing a battery supply chain across the nation, Canada has demonstrated great willingness to commit capital to accelerate these markets' development.

FIGURE 2 **Relevant Canadian policy**

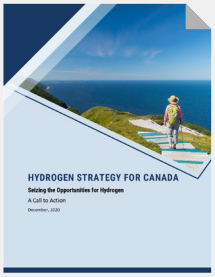
Canada

Canadian legislation empowering industrial decarbonization

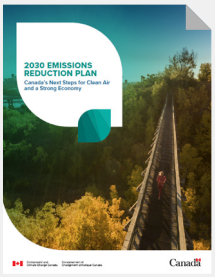


Pan-Canadian Framework on Clean Growth and Climate Change (2016)

A Healthy Environment and a Healthy Economy (2020)

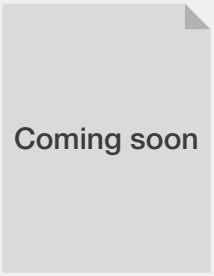


Hydrogen Strategy for Canada (December 2020)



2030 Emissions Reduction Plan (March 2022)

Canada's National Adaptation Strategy (Expected end of 2022)



Canada's strategy for carbon capture, utilization and storage (TBD – in progress)

Sources: Government of Canada; Environment and Climate Change Canada

2020 legislation: Canada's strengthened climate plan and *Hydrogen Strategy for Canada*[6]

The *Hydrogen Strategy for Canada* presents an ambitious framework for actions intended to cement hydrogen as a tool to achieve Canada's goal of net-zero emissions by 2050.

Canada's strengthened climate plan sets forth the nation's latest course for climate action across five key pillars, one of which focuses on decarbonizing industry, and allocates billions of dollars in funding to actualize the pathway described. Most notable funding allocations include CAD 1 billion to advance renewable energy – wind, solar and storage – and grid modernization projects, CAD 1.5 billion into the Low-carbon and Zero-emissions Fuels Fund (e.g. hydrogen, renewable natural gas), and CAD 8 billion in Net Zero Accelerator fund to expedite decarbonization of large emitters (oil and gas, cement, iron and steel), support clean tech in aerospace and automobiles and support battery innovation.

The most notable pillars of the climate plan in the context of industrial clusters include:

- Expediting decarbonization projects with large industrial emitters and supporting their transition to net zero by 2050.
- Building on current carbon pricing by increasing the price by CAD 15/tonne starting in 2023 to reach CAD 170/tonne by 2030.[7]

This climate plan was further augmented in December of 2020 with the publication of the *Hydrogen Strategy for Canada*. This presents an ambitious framework for actions intended to cement hydrogen as a tool to achieve Canada's goal of net-zero emissions by 2050, and position Canada as a global, industrial leader of clean, renewable fuels.[8]

BOX 2 | **Funding spotlight: Net Zero Accelerator**

The Strategic Innovation Fund's (SIF) Net Zero Accelerator initiative (NZA)[9] has a clear purpose: to target key industrial sectors across the country to drive industrial transition and secure significant GHG emission reductions on a scale consistent with achieving Canada's climate goals. So far, CAD 8 billion has been committed to support two decarbonization "paths":

- Path one: Near-term proposals that will significantly reduce existing annual GHG emissions in Canada within the next decade.
- Path two: High-value, transformative decarbonization proposals that could support an industry-wide shift to net zero by 2050.

All applications must meet one of three criteria:

- Encouraging the adoption of clean technologies and processes that will dramatically reduce the GHG footprint of the nation's largest emitters.
- Supporting the green transformation of key industrial sectors, such as automotive, aerospace, agriculture and agri-food.
- Having a positive impact on the creation of a domestic Canadian battery supply chain (e.g. anode/cathode manufacturing, cell manufacturing, electric vehicles (EVs).

Source: Government of Canada

2030 Emissions Reduction Plan

Introduced in 2022, Canada's *2030 Emissions Reduction Plan*[10] further leans into the foundation set by 2020's legislation with an achievable roadmap that outlines a sector-by-sector path for Canada to reach its emissions reduction target of 40% below 2005 levels by 2030 and net-zero emissions by 2050.

Sectors among those highlighted in the current state analysis and roadmap to 2030 include buildings, electricity, heavy industry, oil and gas, transport, agriculture, waste, nature-based solutions, sustainable finance, and sustainable jobs and skills.

FIGURE 3 | **Canada's legislative support for key technologies**

Systemic efficiency and circularity

- Implement a greening government strategy to reduce GHG emissions from federal facilities and conventional fleets by 40% below 2005 levels by 2030, through actions such as green procurement based on life cycle assessments.
- Provide CAD 183.1 million over five years (starting 2022-2023) to reduce plastic waste and increase circularity by developing regulatory measures and conducting scientific research to inform policy-making.
- Develop a national strategy to encourage remanufacturing and other value-retention processes (VRPs).
- Examine options to reprocess and repurpose mine wastes, including via by-product opportunities to valorize wastes and applications to repurpose wastes.

Direct electrification and renewable heat

- Invest over CAD 1 billion in clean energy and clean technologies that reduce reliance on fossil fuel generation and encourage renewables, through programmes including the Strategic Innovation Fund and Smart Renewables and Electrification Pathways.
- Work via the Canada Infrastructure Bank with large private and public sector real estate owners to modernize and improve the energy efficiency of existing buildings. This initiative is part of a commitment to invest CAD 2 billion to finance the upfront capital costs of building retrofits, using the long-term savings from efficiencies and operating cost savings as a repayment source.
- Extend the 50% reduction of the general corporate and small business income tax rates for zero-emission technology manufacturers to include manufacturers of air-source heat pumps to support buildings' emissions reduction.

Carbon capture, utilization and storage (CCUS)

- Develop a comprehensive CCUS strategy and explore other opportunities to help keep Canada globally competitive in this growing industry.
- From 2022-2030, introduce an investment tax credit of up to 60% for capital invested in CCUS projects, with the goal of reducing emissions by at least 15 $MtCO_2e$ annually.
- Provide CAD 319 million over seven years, with CAD 1.5 million in remaining amortization, to Natural Resources Canada to support research, development and demonstration that would improve the commercial viability of CCUS technologies.

Hydrogen

- Drive towards the federal hydrogen strategy, which highlights hydrogen's potential to deliver up to 30% of Canada's energy in 2050 and acts as a key enabler to reach net-zero emissions by 2050, contributing up to 190 $MtCO_2e$ reductions per year by 2050.
- Increase the production and use of low-carbon fuels (e.g. hydrogen, biocrude, renewable natural gas and diesel, cellulosic ethanol) through CAD 1.5 billion in a Low-carbon and Zero-emissions Fuels Fund.
- Develop clean fuel standard regulations to require suppliers of liquid fuels to reduce carbon-intensity of liquid fuels by 12% by 2030 starting 2022, and establish a compliance credits market and regulations.

Source: Government of Canada

1.2 United States of America

The United States has legislated the deployment of $65 billion by 2026 to accelerate industrial decarbonization towards net zero by 2050.

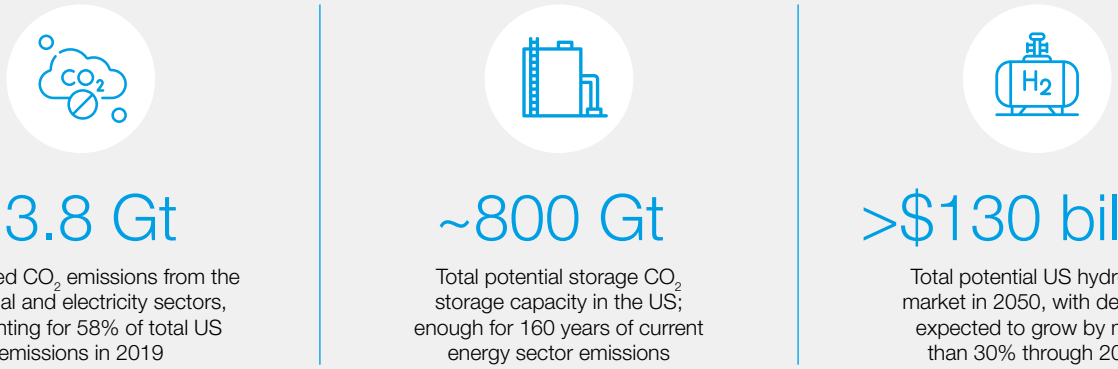
The United States boasts 60% of the globe's carbon sequestration capacity.

Despite more than 3.8 gigatonnes (Gt) of combined CO_2 emissions and 92 terawatts of electricity demand from industrial and electrical sectors, the United States is uniquely positioned to participate in emerging clean energy markets.[11] The nation boasts 60%[12] of the globe's carbon sequestration capacity and, with the introduction of recent legislation, is already seeing increased market participation in the clean hydrogen market, estimated to grow to $130 billion by 2050.[13]

The approach of decarbonizing industrial clusters presents sizeable economic opportunities to drive the US towards achieving national targets. An analysis of 2020 Environmental Protection Agency (EPA) GHG data indicates the presence of 51[14] industrial sectors across the US – a vast variety in comparison to other nations – prompting exploration of strategic decarbonization around regional competitive advantages.

Concentrated areas with high industrial emissions, such as the Gulf Coast, Central Florida and Southern California, present opportunities for pioneer industrial clusters combining CCUS,[15] hydrogen and electrification to reduce emissions with additional opportunities coming from industrial clusters that are in close proximity to existing natural gas or hazardous materials pipelines, as well as rail lines for transport opportunities. There are a number of CCUS projects in progress in the US already, with state-by-state permitting to take ownership over the most compelling geography picking up ahead of federal funding opportunities to support CCUS at scale.[16]

FIGURE 4 **Industrial cluster challenges and opportunities in the United States**



Sources: International Energy Agency (IEA); Forbes; Energy Information Administration (EIA); EPA

United States' approach to industrial decarbonization

United States' clean energy policy development
Over the last few years, six policy mechanisms have been critical to enabling continued investment in decarbonization technologies; with the 45A tax credit and 45X production tax credit (PTC), the *Energy Act of 2020* and the *Infrastructure Investment and Jobs Act* driving the most compelling value cases for corporate participation.

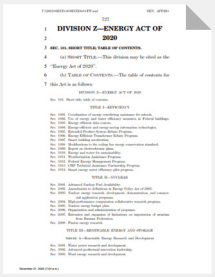
FIGURE 5 | **Relevant US policy**

US legislation empowering industrial decarbonization

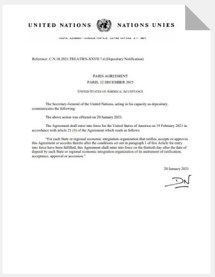

PUBLIC LAW 115–123—FEB. 9, 2018

BIPARTISAN BUDGET ACT OF 2018

45Q Tax Credit reform under *Bipartisan Budget Act of 2018* (2018)

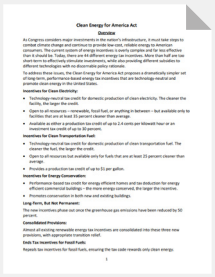

DIVISION Z—ENERGY ACT OF 2020

Energy Act of 2020 (December 2020)


UNITED NATIONS NATIONS UNIES

PARIS AGREEMENT

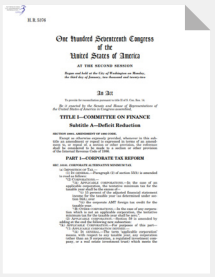
Re-enters *Paris Climate Agreement* (February 2021)


Clean Energy for America Act

Clean Energy for America Act (April 2021)


PUBLIC LAW 117–58—NOV. 15, 2021

Infrastructure Investment and Jobs Act (November 2021)


One Hundred Seventeenth Congress of the United States of America

TITLE I—COMMITTEE ON FINANCE

Subtitle A—Deficit Reduction

Inflation Reduction Act (August 2022)

Sources: whitehouse.gov; energy.gov; rules.house.gov; AIP; Techcrunch

Section 45 and 48 tax credits

Federal tax code sections 45 and 48[17] provision credits for end users or manufacturers investing in a variety of clean energy and emissions reduction technologies. These vary from the tax credits for the installation of geothermal, biomass, selected hydropower, solar and wind facilities to clean landfill and trash services. Two of great relevance to the topic of industrial decarbonization include:

- 45Q tax credits provide industrial manufacturers with credits for each megatonnes (Mt) of CO_2 stored or used. The *Bipartisan Budget Act of 2018* lays out modification plans to incrementally increase the 45Q tax credit through 2034.
- 45X clean hydrogen PTC is a twelve-year tax credit for the production of clean hydrogen after 31 December 2021. The credit rate is $3/kg multiplied by an applicable percentage per kilogram of hydrogen (100% if the life cycle greenhouse gas emissions rate is <0.45 kg CO_2e).

Two additional credits – 45Y clean energy production tax credit and 48E clean energy investment credit – were added in 2022's *Inflation Reduction Act* to catalyse the development of carbon neutral or carbon negative electricity generation facilities in-service in 2025 or thereafter.

Energy Act of 2020

The *Energy Act of 2020*[18] laid out several large investments into energy efficiency and storage. This includes, among others:

- $1 billion over five years in investment into energy storage research, development and demonstration, and incorporated distributed storage into Department of Energy (DOE) loan programmes.
- $6.2 billion in funding to research and deploy CCUS over five years.
- $500 million in funding for industrial emissions reduction technology development programme over five years.

Infrastructure Investment and Jobs Act (2021)

The $1.2 trillion *Infrastructure Investment and Jobs Act*[19] was an initial down payment in capital to rebuild infrastructure from transportation and water to energy, broadband and the resilience and rehabilitation of natural resources. This bill was followed by the 2022 *Inflation Reduction Act*, a narrower version of the proposed 2021 *Build Back Better Act*.

The *Inflation Reduction Act* includes significant investments in energy security, climate change and healthcare offset by tax increases, additional Internal Revenue Service (IRS) funding and prescription drug pricing reform.

The *Infrastructure Investment and Jobs Act* package includes (not exhaustive): from the $73 billion total allocated to power infrastructure, $9.5 billion for clean hydrogen (including $8 billion for at least four clean hydrogen hubs) and around $12 billion for CCUS (including $3.5 billion for four carbon removal hubs). $7.5 billion was allocated to EV infrastructure and $21 billion to environmental remediation.

This act was substantially augmented by the subsequent *Inflation Reduction Act*,[20] which expanded tax credit support for clean energy, as described above, with limited additional grant funding for the same.

BOX 3 **Policy spotlight: US *Infrastructure Investment and Jobs Act*'s hydrogen hub funding[21]**

The Department of Energy has made $8 billion[22] available to fund the establishment of no less than four clean, regional hydrogen hubs across the United States. These hubs closely align with the initiative's definition of an industrial cluster and prompt many of the same holistic evaluation techniques advocated for in this paper. The Loan Programs Office,[23] managing the disbursement of these funds, has stipulated that grants will be awarded based, in part, on the following criteria:

- Grants will be awarded to a single lead entity, with funds being distributed to sub-recipient partners.
- Six to ten hubs will be initially selected to receive, at minimum, $400-500 million with a minimum production of 50-100 Mt/day.
- The DOE will make note of which hubs have established community benefits agreements with local communities.

Source: White House Facts Sheet; Accenture analysis

FIGURE 6 **United States' legislative support for key technologies**

Systemic efficiency and circularity

- $65 billion investment in power infrastructure including funding for energy efficiency projects for small- and medium-sized manufacturers.
- Industrial emissions reduction technology development programme to be established, supporting demonstration projects with funding of $500 million over five years.
- $719 million funds for projects that support research and development on energy efficiency and renewable energy technologies, with $94.6 million for advanced manufacturing.

Direct electrification and renewable heat

- $65 billion investment in power infrastructure, including funding for industrial emission demonstration projects and renewable energy projects.
- $719 million funding in projects that support research and development on renewable energy technologies.
- $1.3 billion in BUILD programme funds for infrastructure projects with a focus on port infrastructure projects from the Department of Transportation.

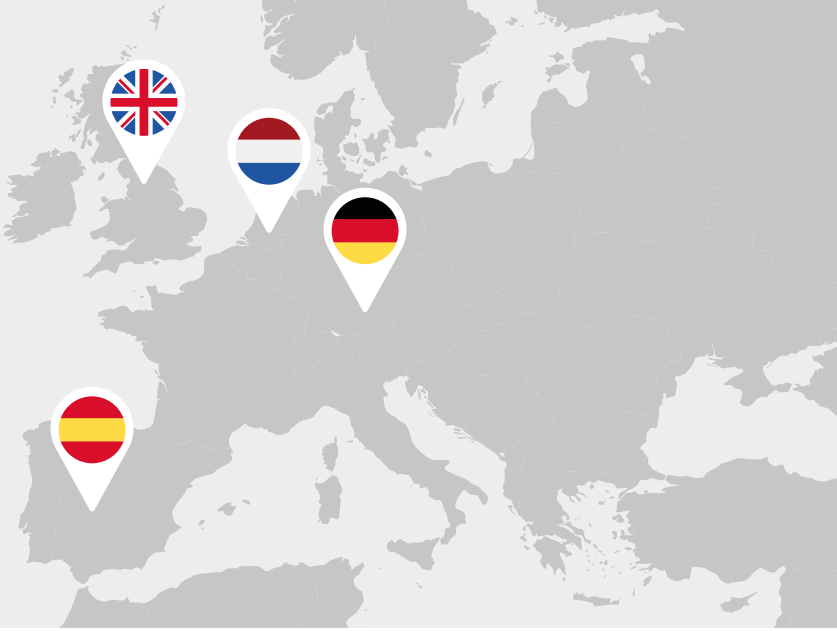
Carbon capture, utilization and storage (CCUS)

- $2.5 billion to expand DOE's Carbon Storage Validation and Testing programme, $3.5 billion for direct air capture projects to establish four regional hubs, $900 million in loans for CO_2 transport infrastructure projects.
- *Energy Act of 2020* grants $6.2 billion to deploy CCUS (partly authorized under the *Infrastructure Investment and Jobs Act*).
- 45Q tax credits provide industrial manufacturers with credits for each tonne of CO_2 stored or used, with the tax credit rising to $50/t$CO_2$ for geological storage and $35/t$CO_2$ for CO_2 enhanced oil recovery in 2026.

Hydrogen

- *Infrastructure Investment and Jobs Act* includes $8 billion for the establishment of at least four regional clean hydrogen hubs, $1 billion for green hydrogen, $500 million for R&D into manufacturing and recycling among other incentives and funds.
- $2.9 billion for the Advanced Research Projects Agency-Energy (ARPA-E) programme to help scaling of new energy technologies.
- $72 million made available for hydrogen projects under the H2@Scale programme under the Office of Energy Efficiency and Renewable Energy (EERE).

Source: whitehouse.gov; energy.gov; rules.house.gov; AIP; Techcrunch



2 Europe

2.1 Germany

Germany advocates for a centralized industrial clusters approach to decarbonize heavy industry through demonstrated support from both federal and state governments.

As both the largest emitter and nation with the highest GDP in the EU, Germany faces a significant challenge on the path towards carbon neutrality by 2045.[24] Despite a 181 tCO_2e[25] (5%) increase in GHG emissions in 2021, the German state recognizes the value of large-scale transformation to sustainable energy, anticipating significant job creation and economic expansion through it.[26]

Germany already shows promise in their effort towards a more sustainable future. In 2021, the industrial sector accounted for 28%[27] of final energy consumption, a 14% decrease from 2020. In support of further decreasing industrial emissions, the German government has pledged €9 billion[28] to promote green hydrogen campaigns with the anticipation that between 300,000-400,000 green jobs[29] will be created by scaling the industry. Although only 20%[30] of energy consumed today is generated from renewable sources, the federal and state German governments have indicated that they believe significant investment will rapidly increase this proportion.

FIGURE 7 **Industrial cluster challenges and opportunities in Germany**

~55-60%

Volume of oil and gas imports that came from autocratic states in 2020

88%

GHG reduction goal by 2040 compared to 1990 levels

>300,000

Incremental green job creation by 2030 from hydrogen, additional to ~3 million driven by industry investment

Sources: Clean Energy Project, International Energy Agency, Handelsblatt

Germany's approach to industrial decarbonization

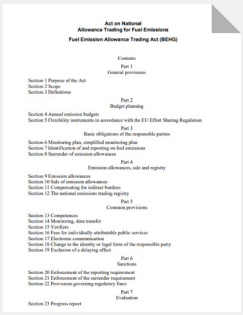
Germany's clean energy policy development
From the nation's historic 2021 ruling that current efforts to stave off climate change do not adequately protect the freedom of youth and future generations, Germany has since launched significant decarbonization programmes with increasing ambition and absolute decarbonization goals. Included among this is €200 billion[31] earmarked to transform the economy, society and the state, anticipated to drive increased energy independence, accelerated hydrogen market maturation and expanded EV charging networks.

> **One generation must not be allowed to consume large portions of the CO_2 budget while bearing a relatively minor share of the reduction effort if this would involve leaving subsequent generations with a drastic reduction burden and expose their lives to comprehensive losses of freedom.**
>
> German Federal Constitutional Court[32]

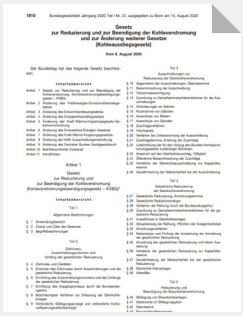
FIGURE 8 **Relevant German policy**

Die Bundesregierung

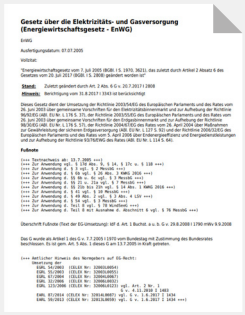
German legislation empowering industrial decarbonization



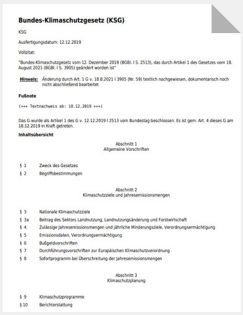
Fuel Emissions Trading Act (December 2019)



Coal phase-out law (August 2020)



Energy Industry Act (last version 2021)



Federal Climate Change Act (2021)

Renewable Energy Sources Act (2021)

Sources: Koalitionsvertrag; Federal Ministry of Transport and Digital Infrastructure (BMVi); Association of German Chambers of Industry and Commerce (DIHK); Umweltbundesamt; German Institute for Economic Research (DIW)

German Development and Resilience Plan (DARP), 1.1 decarbonization

In the wake of the market instability caused by COVID-19, the German government set forth a roadmap to sustainable, green economic recovery referred to as "DARP", or the *Development and Resilience Plan*.[33] This policy was legislated in three components: 1.1 decarbonization, 1.2 climate-friendly mobility, and 1.3 climate-friendly sanitation and construction summing to a total capital infusion of €11.5 billion.[34]

Component 1.1 decarbonization – representing ~30% of allocated capital – provisioned funds primarily for the scaling of green hydrogen initiatives, which are deemed "Important Projects of Common European Interest" (IPCEI)[35] or contributing to the development of the full hydrogen value chain from production, storage, transmission and distribution to end use in industrial offtake.

Federal Climate Change Act (2021)

The *Federal Climate Change Act*[36] codified GHG reduction targets to achieve net zero by 2045 through the incremental elimination of emissions on a per-sector, annual reduction target basis. With this, the federal government also legislated an additional €8 billion to the Federal Ministry for Economic Affairs and Climate Action in support of decarbonization in transit, energy, industry and built infrastructure.

2022's Easter package[37]

Germany's landmark energy policy revision delivered early in 2022 – notably just after Russia's invasion of Ukraine – seeks to accelerate the development of clean energy sources and decrease reliance on imported fossil fuels. Specific measures included in the package include:

- Publication of the ambitious goal that, by 2030, 80% of electrical generation is from renewable sources.
- Increased land allocations for empowered local government participation in the renewable expansion (onshore wind, commercial solar and rooftop solar were highlighted).
- Removal of complex surcharge on electricity that subsidizes renewable energy development in order to simplify access to the self-produced energy market.

BOX 4 **Industrial cluster spotlight: Atmosfair's Fairfuel[38]**

Key industries: aviation, chemicals, refining

Siemens, Ineratec, EWE, Lufthansa, DHL and TÜV have collaborated to develop the world's first carbon-neutral jet fuel supply chain. Beginning with carbon capture on-site at local energy generation and biogas facilities, in addition to direct air capture, the collaborative produces a fossil fuel-free crude kerosene equivalent, which is then processed to provide Jet A-1 kerosene. The fuel is currently made available for use at Hamburg airport; the collaborative intends to scale its production processes worldwide.

Source: Atmosfair

FIGURE 9 **Germany's legislative support for key technologies**

Systemic efficiency and circularity

- Plan to share financial incentives to reduce demand for raw materials. Linking industrial subsidies to improvements in energy efficiency is also intended to create incentives to reduce energy demand in the industrial sector.
- Government intends to push for the introduction of an EU-wide quota for recycling, recyclates and secondary raw materials. Other planned measures include the introduction of a recycling label as well as reusable, return and deposit systems and digital product passports.

Direct electrification and renewable heat

- Government has initiated various programmes to support a faster transition, including subsidies for purchasing purely electric vehicles, investments in the charging infrastructure and funding for electric buses in public transport. €5.6 billion will become available for the development of electromobility, including the expansion of the charging infrastructure.
- Federal Ministry of Economics and Climate Protection (BMWK) supports with investments of €16.9 billion for energy efficiency and renewable energies in the building sector, the use of new heating systems, the optimization of existing heating systems, measures on the building envelope and the use of optimized system technology.

Carbon capture, utilization and storage (CCUS)

- Coalition agreement mentions the need for technical negative emissions and plans a long-term strategy for dealing with the approximate 5% of unavoidable residual emissions.

Hydrogen

- The national hydrogen strategy details goals, implementation steps and expected outcomes of increasing the hydrogen economy's play in Germany.
- The development of the hydrogen industry is being funded with a total of €4 billion.
- KfW Bankengruppe (the German funding bank) actively supports companies focused on energy transition and hydrogen by investing in relevant projects, with investments of up to €25 million per project.
- The German Ministry of Economics and Climate Protection supports international measures to scale the deployment of green hydrogen. The focus is on producing, storing and transporting hydrogen as well as fundamental research on this topic.

Source: Koalitionsvertrag; Federal Ministry of Transport and Digital Infrastructure (BMVi); Association of German Chambers of Industry and Commerce (DIHK); Umweltbundesamt; German Institute for Economic Research (DIW)

2.2 Spain

Spain has made considerable progress towards its net zero by 2050 goal, but there is still need for strong policy to support national decarbonization initiatives and incentivize further private investment.

The industrial sector was, in 2020, responsible for 25%[39] of Spain's total CO_2 emissions. The nation has taken critical steps in its decarbonization journey by closing coal mines, adjusting gas and electricity tariffs and placing decarbonization and climate change as a top priority on the national agenda. The country is tracking to meet the European Union's targets and remain in line with the requirements of the Paris Agreement (2015).[40]

To meet Spain's own net zero by 2050 goal, the nation aims to have renewable energies provide 100% of the electricity by 2050, with an intermediate target of 74% by 2030.[41] In the near term, the country will focus on energy efficiency, electrification and renewables deployment, with a growing interest in developing a strong green hydrogen market and positioning the country as pioneers in the nascent technology. It is estimated that these efforts will result in significant job creation – up to 348,000 annual incremental jobs through 2030 – and economic benefit – €67.3 billion in savings by 2030 – through the replacement of fossil fuel imports with renewable energy production.[42]

FIGURE 10 **Industrial cluster challenges and opportunities in Spain**

~72 $MtCO_2$*

Industrial sector emissions in 2020, representing 25% of Spain's CO_2 emissions

* Megatonnes of carbon dioxide

€67.3 billion

Potential savings by 2030 through replacement of fossil fuel imports for renewable energy production

100%

Renewables contribution to the electricity mix by 2050

Sources: IADE; Consumo de Energia Final; Ministry for the Ecological Transition and the Demographic Challenge (MITECO); National Integrated Energy and Climate Plan (PNIEC)

Spain's approach to industrial decarbonization

Spain's clean energy policy development

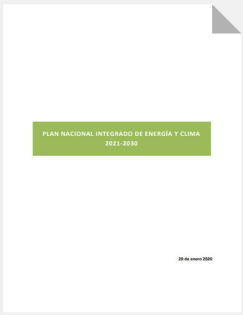
The Spanish government has indicated an understanding of the urgency to create enabling policies that will support momentum building in the private and public sectors to catalyse the joint path to net zero. The *National Integrated Energy and Climate Plan* (PNIEC) acts as the central document informing policy direction and supporting the implementation of different sustainable initiatives to reach, and surpass, the 2050 European Green Deal goals.[43]

FIGURE 11 | **Relevant Spanish policy**

GOBIERNO DE ESPAÑA

Spanish legislation empowering industrial decarbonization

National Strategy for Fair Transition (Feb 2019)



National Integrated Energy and Climate Plan (PNIEC) (Jan 2020)

Hydrogen Strategy (Oct 2020)

Recovery, Transformation and Resilience Plan (Apr 2021)

Climate Change and Energy Transition Law (May 2021)

Sources: Ministry for the Ecological Transition and the Demographic Challenge; Spanish Government

Recovery, Transformation and Resilience Plan (RRTP)

Spain's post-COVID-19 recovery plan[44] is built on four pillars set to provide a holistic backbone for national economic transformation. These pillars include the ecological transition, digital transformation, gender equality, and social and territorial cohesion.

Industrial cluster development will benefit from this policy as it is focused on seeding a decarbonized, competitive and efficient energy sector that will enable the mobilization of significant private investment. Further, the legislation will provide a secure regulatory framework for Spain's renewable potential and value chains to strengthen competitiveness in domestic and export markets including, for instance, €6.39 billion of public investment in energy transition.

BOX 5 | ***National Integrated Energy and Climate Plan*** **(PNIEC) 2021-2030**

Spain's PNIEC legislation[45] lays the groundwork for national achievement of the 2050 European Green Deal goals. Total investments to achieve the PNIEC goal reach €241 million between 2021-2030. The private sector will be the major contributor (80% of total) of funds focused primarily on renewable energies, electrification and transport. The remaining 20% will be funded by the public sector, in energy saving and efficiency measures and in actions associated with the promotion of sustainable mobility.

Following the structure established in Regulation 2018/1999, the PNIEC is divided into two blocks: the tendency scenario and the objective scenario, where global strategic dimensions established by the Energy Union model varying metrics surrounding decarbonization, energy efficiency, energy security, internal energy market and research, innovation and competitiveness.

With the implementation of this plan, Spain will see by 2030:

- 74% of electricity generation produced from renewable energies.
- €16.5 to €25.7 million incremental increase in Spain's GDP.
- 253,000 to 358,000 jobs.

FIGURE 12 | **Spain's legislative support for key technologies**

Systemic efficiency and circularity

- Develop a consumption system based on dynamic pricing; implementing a legal framework and eliminating bureaucratic barriers.
- €1.36 billion public investment towards the digitalization of the energy grid to meet future distribution requirements.
- €929 million public investment for agricultural machinery efficiency improvement.
- €3.9 billion public investment for industrial heat efficiency improvement.

Direct electrification and renewable heat

- Estimated investments associated with electricity infrastructures foreseen for the decade are €4,554 million, with an average annual investment volume of €759 million.
- Developing legal framework to encourage use of energy storage.
- National strategy oversees and rewards individual's and corporation's energy consumption and introduction of renewable self-consumption systems in public buildings.
- Promote high-efficiency cogeneration of electricity that aims for a total of 1,200 MW.

Carbon capture, utilization and storage (CCUS)

- Regulation of carbon offset.
- Pilot programme for the use of blockchain for carbon emission tracking.

Hydrogen

- Regulatory framework, aid and tax benefit programmes focused on supporting alternative fuel implementation that will enable the following goals: Production of 100% renewable hydrogen and infrastructure for its use for storage, installation of 4 GW of electrolyser plants by 2030. 100-150 public access hydrogen stations by 2030 and 5,000-7,500 light and heavy-duty fuel cell vehicles for freight transport by 2030.
- Diverse mechanisms that will act as enablers for hydrogen innovation projects:
  - **Proyectos CIEN:** Requested budget should be between €5-€20 million. This aid will fund up to 85% of the approved budget.
  - **Misiones Ciencia e Innovacion:** Supporting large R&D initiatives with a budget of €70 million.
  - **Plan MOVES II:** €100 million grants for projects that contribute to the goal of decarbonizing the transport industry.

Sources: Ministry for the Ecological Transition and the Demographic Challenge; Spanish Government

BOX 6

Industrial cluster spotlight: Basque Net Zero Industrial Supercluster[46,47]

Key industries: steel, cement, pulp and paper, oil refining, foundry

Transitioning Industrial Clusters' initiative signatory, the Basque Net Zero Industrial Supercluster, aims to develop initiatives to promote private companies' engagement and commitment to net zero by 2050; fostering collaboration on circularity and systemic efficiency. The cluster will support the maintenance of 204,000 direct and indirect industrial jobs impacted by the cluster while increasing competitiveness through decreased carbon footprint of finished and semi-finished products of corporates participating. More broadly, it is the cluster's goal to position the Basque Country as a global pioneer in decarbonizing an industrial region, boosting technology and business development and attracting further foreign investment into the Basque Country.

Highlighted emissions reduction initiative

With the focus on accelerating the implementation of direct electrification and promoting energy efficiency, Iberdrola is working on replacing fossil-fuelled furnaces with energy-efficient electric furnaces for industrial processes, which is helping reduce CO_2 emissions. Additionally, Iberdrola has installed on-site renewables and/or renewable power purchase agreements (PPAs) to help reduce the carbon footprint and further electrify industrial processes of hard-to-abate industries.

2.3 Netherlands

Netherlands' federal government has long demonstrated a commitment to accelerating clean industrial operations in the sector, which represents 50% of the nation's final energy consumption.

The Netherlands has long been established as a climate-conscious leader in the European Union. From the 2020 ban on single-use plastics,[48] strong national focus on circularity and a reuse-centric supply chain, to the nation's advocation for and financial support of five key industrial clusters, the Netherlands demonstrates various policy support mechanisms to empower market-creation and collaboration across hard-to-abate industries.[49]

The nation's emissions have materially decreased since the early 2010s[50] emphasis on decarbonization appeared in policy. The Netherlands has decreased industrial emissions by 36% from 1990-2019, while still representing nearly half of total final energy consumption in 2018. The federal government has legislated the target of further reducing emissions across nine key industrial sectors through 2030 by nearly 20 $MtCO_2e$.

Supported by multi-billion euro funding packages, the nation has emphasized hydrogen and sustainable heating in its roadmap to net zero by 2050 setting targets to develop 3-4 gigawatts (GW) of electrolyser capacity and decrease emissions from heating by 5.3 $MtCO_2e$ ahead of 2030.[51]

FIGURE 13 **Industrial cluster challenges and opportunities in the Netherlands**

~50%

The industrial sector accounted for almost half of total final energy consumption in 2018

~54.5 $MtCO_2e$

Emissions from industry in 2019, equating to just over 25% of the nation's GHG emissions – a decrease of 36% on 1990 levels

55% by 2030

Netherlands has committed to raising its GHG reduction target from 1990 levels to 55%, in line with the EU ambition

Sources: International Energy Agency; Klimaatakkoord; ISPT Europe

Netherlands' approach to industrial decarbonization

Netherlands' clean energy policy development
The Dutch government has introduced strong legislation in recent years to promote the industrial clusters approach and industry-wide carbon abatement well beyond the standards stipulated by the European Union. With significant subsidies and grant programmes to accelerate growth in CCUS, clean hydrogen and electrification of industrial heat, the Netherlands is moving quickly towards cost-effective CO_2 reduction demonstrations involving these key technologies.

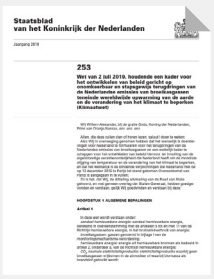
FIGURE 14 | **Relevant Dutch policy**

Rijksoverheid

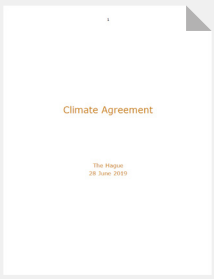
Dutch legislation empowering industrial decarbonization

The Energy Agreement (2013)

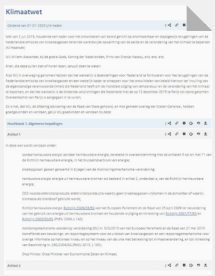
Nederland Circulair 2050 (2016)



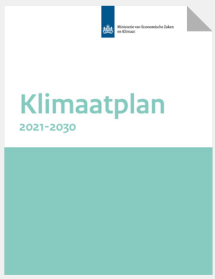
Climate law (Klimaatwet) (2019)



Climate Agreement (Klimaat-akkoord) (2019)



Climate law (Klimaatwet) (2020)



Climate plan 2021-2030 (2020)

Sources: The Social and Economic Council (SER); Ministry of Infrastructure and the Environment and Ministry of Economic Affairs; Rijksoverheid; Overheid.nl; Ministry of Economic Affairs and Climate Policy

> **Banning the use of coal in electricity generation and compensation for the losses by scaling renewable generation sources and setting guidelines for the reduction of non-renewable generation emissions caps.**

Climate Agreement (2019)

The Dutch *Climate Agreement*[52] was created through collaborative climate roundtables, where representatives from government, non-government and commercial organizations across five key sectors (electricity, mobility, industry, built environment and agriculture), negotiated and agreed upon the measures. Four key areas of impact, directly empowering the industrial clusters approach to decarbonization, are as follows:[53]

- **Clusters:** Provisioning coordination support for five key industrial clusters with regional energy strategies and mandating the contribution of the "big twelve" industrial players to long-term industrial improvement programmes within them.
- **Hydrogen:** Laying the groundwork for 3-4 GW of hydrogen electrolyser capacity and 65% reduction in electrolyser investment costs by 2030.
- **Electricity:** Banning the use of coal in electricity generation and compensation for the losses by scaling renewable generation sources and setting guidelines for the reduction of non-renewable generation emissions caps.
- **Carbon capture:** Including selected CCUS technologies in existing federal subsidies (with a roadmap to increase inclusion by 2035) and implementing new cost-sharing mechanisms for CCUS development.

Integrated National Energy and Climate Plan 2021-2030 and Sustainable Energy Production and Climate Transition Incentive Scheme (SDE++)

In compliance with the European Union mandate that all member states propose a GHG reduction plan across five core dimensions contributing to climate change (decarbonization, energy efficiency, energy security, internal energy markets and research, innovation and competitiveness), the Netherlands published their *Integrated National Energy and Climate Plan 2021-2030*[54] laying out the incremental targets to meet EU and national GHG reduction goals across these dimensions.

The legislation introduces a CO_2 tax to begin in 2021 at a rate determined on the basis of European benchmarks. This tax was signed into law at the beginning of 2021 at €30/tCO_2e with annual increases until 2030's rate of €125/tCO_2e. The legislation also opens the door to increased investment in hydrogen and biofuel production through the Sustainable Energy Production and Climate Transition Incentive Scheme (SDE++).

SDE++ opened during the summer of 2021 and now includes subsidies for investments in green hydrogen facilities connected to solar and wind electrical generation facilities, industrial electrification leveraging hybrid glass furnaces, CCUS and photovoltaic (PV) projects. The 2022 budget for the programme sits at €13 billion.[55]

BOX 7 | **Policy spotlight: Energy Investment Allowance**

The Dutch government publishes an annual "energy list" that includes all energy-efficient and sustainable energy technologies in which a business can invest to receive a tax burden reduction (on average 11%) through the Energy Investment Allowance (EIA).[56] With a 2022 budget of €149 million, the EIA allows businesses to deduct up to 45.5% of investment costs in technologies such as high-efficiency lighting, insulation and cooling, as well as solar panels and their grid interconnects, geothermal heat systems, CCUS and hydrogen production, and transmission and distribution equipment.

Source: Netherlands Enterprise Agency

FIGURE 15 | **Netherlands' legislative support for key technologies**

Systemic efficiency and circularity

- Climate and Energy Innovation Demonstration Scheme (DEI+) provides €76 million to support pilot and demonstration projects that contribute to the cost-effective reduction of CO_2 emissions by 2030, including circular use of materials.
- Mission-driven Research, Development and Innovation (MOOI) scheme provides €25,000 minimum subsidy to each of the three participants for research and feasibility studies for renewable energy, decarbonization of industry and circularity.

Direct electrification and renewable heat

- €30 billion of SDE++ funding expanded to include the deployment of solutions for the electrification of industrial heat.
- *Environmental Management Act* requires companies with large energy use (annual electricity use of over 50,000 kWh or natural gas use of over 25,000 m^3) to put in place carbon-saving measures with a payback period of fewer than five years.
- MOOI scheme provides €25,000 minimum subsidy to each of the three participants for research and feasibility studies for renewable energy, decarbonization of industry and circularity.

Carbon capture, utilization and storage (CCUS)

- Renewable Energy Transition (HER+) to provide €30 million to innovation across a number of renewable energy transition tools including CCUS.
- DEI+ provides €76 million to support pilot and demonstration projects that contribute to the cost-effective reduction of CO_2 emissions by 2030, including CCUS.
- €30 billion of SDE++ funding expanded to include CCUS.

Hydrogen

- HER+ to provide €30 million to innovation across a number of renewable energy transition tools including hydrogen.
- DEI+ provides €76 million to support pilot and demonstration projects that contribute to the cost-effective reduction of CO_2 emissions by 2030, including hydrogen.
- €30 billion of SDE++ funding expanded to include hydrogen.

Sources: Klimaatakkoord; IEA; European Commission

2.4 United Kingdom

The industrial sector accounts for 25% of total energy consumption, with six industrial clusters in the UK alone accounting for 10% of the total CO_2 emissions.

Industrial clusters are key hubs of economic activity in the UK and have been identified as paramount to ushering in the nation's clean economy. Currently, industry accounts for a quarter of the UK's GHG emissions with energy use accounting for 80-90%,[57] largely reliant on fossil fuels.

To meet net zero by 2050 and achieve an interim target of a 78%[58] reduction in GHG emissions from 1990 levels by 2035, the UK government has issued ambitious targets for industrial clusters. These targets include 10 GW of hydrogen production by 2030, with at least 5 GW coming from electrolytic hydrogen, 20-30 Mt annually[59] of CO_2 captured by 2030 and four low-carbon industrial clusters by 2030, with at least one net zero industrial cluster by 2040.[60] To achieve these targets, enabling policies have been launched, along with new CCUS and hydrogen business models, new funding mechanisms for carbon transport and storage, and a new emissions trading scheme.

The investment in low-carbon technologies within industrial clusters presents sizable social and economic opportunities, with the potential to secure 1.5 million jobs, generate £320 billion in exports, reduce CO_2 by 30% and save between £2.9 billion and £4.2 billion per year through avoided CO_2 penalties.[61]

FIGURE 16 **Industrial cluster challenges and opportunities in the UK**

~25%

The industrial sector accounted for 25% of total final energy consumption in 2017

2/3

A 2/3 reduction in GHG emissions from 1990 levels is required by 2035 to stay on track for net zero and meet the carbon budget

1.5 million

Jobs secured through the development of the UK's industrial clusters

Sources: UK Government, UK Department for Business, Energy and Industrial Strategy (BEIS)

United Kingdom's approach to industrial decarbonization

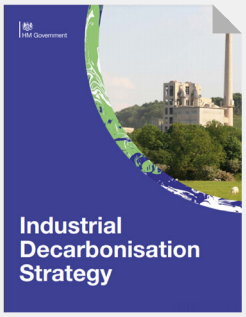
United Kingdom's clean energy policy development

The UK government has placed great emphasis on the role of industrial clusters, issuing a "levelling up" agenda to ensure the economic prosperity of industrial regions, and creating "super places" in areas such as the North East, the Humber, North West, Scotland and Wales to exploit geological and geographical advantages to implement low-carbon technologies such as CCS and hydrogen. Further, the UK Department for Business, Energy and Industrial Strategy (BEIS) has developed a series of initiatives to support industrial clusters through policies that target an element of the country's *Ten Point Plan for a Green Industrial Revolution*.[62]

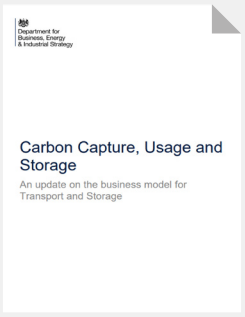
GOV.UK UK legislation empowering industrial decarbonization

The Ten Point Plan for a Green Industrial Revolution (November 2020)

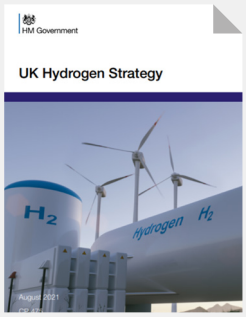
Powering our Net Zero Future (December 2020)



Industrial Decarbonisation Strategy (March 2021)



CCUS business model (May 2021)



UK Hydrogen Strategy (August 2021)

Sources: GOV.UK; UK Research and Innovation

UK Ten Point Plan

The Ten Point Plan for a Green Industrial Revolution[63] sets out the approach the UK government will take to build back better, support green jobs and accelerate the country's path to net zero. This plan will mobilize £12 billion of government investment, and together with the net zero strategy and energy security strategy, could potentially generate £100 billion of private sector investment, to create and support up to 480,000 green jobs by 2030.

Selected growth areas with industrial implications among those listed in the plan, included updated, more ambitious targets outlined in the more recent energy security strategy, including:

- **Advancing offshore wind:** Produce enough offshore wind to power every home and achieve 50 GW by 2030, supporting up to 60,000 jobs.
- **Driving the growth of low-carbon hydrogen:** Generate 10 GW of hydrogen production capacity by 2030, with at least 5 GW of this coming from electrolytic hydrogen, and develop the first town heated entirely by hydrogen by 2030.
- **Delivering new and advanced nuclear power:** Advance nuclear as a clean energy source by developing the next generation of small and advanced reactors, so that by 2050, up to 25% of the power consumed in the UK is from nuclear.
- **"Jet zero" and green ships:** Support difficult-to-decarbonize industries to become greener through research projects for zero-emissions planes and ships, with targets for domestic flights to reach net zero by 2040 and net zero UK aviation emissions by 2050.
- **Investing in CCUS:** Become a world leader in CCS technology with a target to remove 20-30 $MtCO_2$ by 2030.
- **Green finance and innovation:** Develop cutting-edge technology that can support outlined ambitions and make the City of London the global centre of green finance.

> "This plan will mobilize £12 billion of government investment and could potentially generate £100 billion of private sector investment, to create and support up to 480,000 green jobs by 2030.

CCUS business model

With the aim to support "Investing in CCUS"[64] from the *Ten Point Plan*, the CCUS business model policy provides both capital expenditure (CapEx) and operating expense (OpEx) support for projects within industrial clusters. There are three business models to support CCS development:

- **Power CCS**
  There will be a Dispatchable Power Agreement with two parts, an availability payment that is paid monthly and a variable payment that is paid daily, per MWh of electricity generated.

- **CO_2 transport and storage**
  This is a Regulated Asset Base (RAB) model – an allowed revenue model with a regulated return (similar to transmission assets) based on the charging of transport and storage fees and an allowed revenue component if the return cannot be made up from the charging of the fees. Importantly there is also protection against specified high-impact low-probability risks that the private sector cannot efficiently bear, like CO_2 leakage from the store and stranded assets.

- **ICC contract and capital grant co-funding**
  This industrial carbon capture legislation has two parts: 1) a private law contract of up to 15 years (the "ICC contract") that provides the emitter with a payment per tonne of captured CO_2, which is intended to cover operational expenses, and transport and storage fees and repayment of, and a rate of return on, capital investment in carbon capture equipment, and 2) capital grant co-funding for a portion of the capital cost of capture projects, which will be available for initial projects only and is intended to mitigate against certain risks associated with first projects.

FIGURE 18 **The UK's legislative support for key technologies**

Systemic efficiency and circularity

- £315 million Industrial Energy Transformation Fund (IETF) supports energy intensive business investing in efficiency technology.
- The resources and waste strategy sets out circularity goals. This included a £30 million UK Research and Innovation circular economy research programme.
- £200-300 million per annum climate change agreements supporting industrial businesses to achieve energy and carbon savings through energy efficiency improvements.
- £66 million funds under the transforming foundation industries challenge, aiming to bring businesses together to work on common resource and energy efficiency opportunities.

Direct electrification and renewable heat

- £470 million per annum package of compensation and exemptions from electricity policy costs for eligible industrial users.
- The £684 million per annum renewable heat incentive provides financial incentives with the aims of increasing the uptake and installation of renewable heat technologies throughout industry and reducing the reliance on fossil fuels.

Carbon capture, utilization and storage (CCUS)

- £1 billion through the Carbon Capture and Storage Infrastructure Fund to support four industrial clusters.
- £100 million for industry and CCUS from the Energy Innovation Programme.
- £37.5 million to fund the largest government programme of greenhouse gas removal methods for cement (innovation and scaling projects).
- £100 million of new research and development funding to help develop direct air capture technologies in the UK.

Hydrogen

- £240 million per annum through the Net Zero Hydrogen Fund to support a 5 GW by 2030 target. Hydrogen strategy, including national roadmap and parallel request for private perspectives on fund allocation and business model optimization issued.
- £170 million Industrial Decarbonisation Challenge (IDC) supports low-carbon technology, specifically hydrogen and CCUS.
- Industrial Fuel Switching Competition (IFSC) allocated £20 million switching technology.

Source: GOV.UK

BOX 8

Industrial cluster spotlight: HyNet North West

Key industries: refining, cement, energy from waste, biofuel, biogas production, power stations, glass manufacturers, steel

Transitioning Industrial Clusters' initiative signatory, HyNet will support the decarbonization of the North West of England and North Wales.[65] The cluster created a demand-driven landscape with 19 memoranda of understanding (MoUs) signed with prime emitters and more than 25 MoUs signed with hydrogen customers, all led by regional demand.

The cluster is made up of several different elements:

- CO_2 transport and storage infrastructure – repurposing existing oil and gas infrastructure.
- Facilities to capture CO_2 emissions from new and existing industry with storing capacity of 190 Mt of CO_2.
- Low-carbon hydrogen production plants, with CO_2 capture, with attached distribution and storage.

HyNet will build new – and upgrade and re-purpose existing – infrastructure to transport hydrogen and captured CO_2 emissions. This industrial cluster is being developed following funding from BEIS, under their industrial decarbonization strategy, in addition to private investment from the consortium partners like Eni, Essar and Cadent.

Highlighted emissions reduction initiative[66]

It is the cluster's ambition to increase to 10 Mt each year the transport and storage capacity of CO_2. This expansion will broaden the range of capture sources as well as increase the low-carbon hydrogen production to 3.8 GW each year. HyNet has 1.3 terawatt-hours (TWh) of underground hydrogen storage under development and is planning to build a network of new-build pipelines distributing low-carbon hydrogen across the region.

3 Asia-Pacific

3.1 Australia

In 2020, mining and manufacturing contributed to 17.5% of the Australian economy, however, industrial process and product use accounted for 6% of the 499 $MtCO_2$ emissions.

Australia has a suite of climate targets and projections: the Paris commitment, the government's projection, the Australian Labor Party's target and various interest group suggestions. In order to limit the planet's warming to 1.5°C, it is crucial that nations invest in careful planning and mitigation strategies in hard-to-abate industrial sectors to achieve the net zero goals.

Australia's government has proposed plans to build industrial clusters around renewable energy industrial zones (REIZ) and integrate them with renewables exports. Further, a network of 13 industrial clusters has been identified by National Energy Resources Australia (NERA) to drive hydrogen market activation, establishing a global identity and recognizable brand in the emerging hydrogen industry.[67]

FIGURE 19 **Industrial cluster challenges and opportunities in Australia**

499 $MtCO_2$

Australia's total carbon emissions in 2020

~85%

Potential emissions reduction from industrial supply chains using existing and emerging technologies

1.8 million

Jobs created over the next five years through renewable and low emission technology growth

Sources: Australia Department of Climate Change, Energy, the Environment and Water; Climateworks Centre; Beyond Zero Emissions Australia

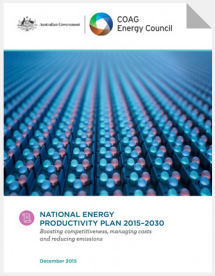
Australia's approach to industrial decarbonization

Australia's clean energy policy development
The Australian government has released a succession of low emissions and clean energy policy documents on a national level that support the development and maturation of industrial clusters. Individual states and territories, such as Western Australia, have additionally released their own policies, building upon the national direction.

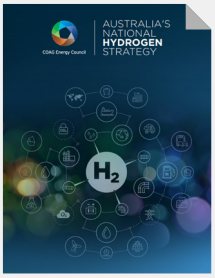
FIGURE 20 **Relevant Australian policy**

Australian Government

Australian legislation empowering industrial decarbonization



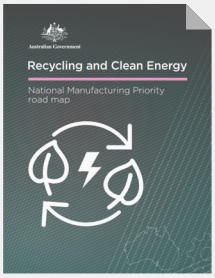
National Energy Productivity Plan (December 2015)



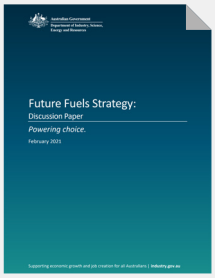
Hydrogen Strategy (November 2019)

Technology Investment Roadmap Discussion Paper (May 2020)

First Low Emissions Technology Statement (September 2020)



Recycling and Clean Energy Manufacturing Roadmap (2021)



Future Fuels Strategy (February 2021)

Sources: Department of Industry, Science, Energy and Resources; Department of Climate Change, Energy, the Environment and Water; IEA; Climate Council; Beyond Zero Emissions; Climateworks Centre; European Commission

First Low Emissions Technology Statement

The Clean Energy Finance Corporation (CEFC) is pursuing large-scale investment opportunities through its AUD 300 million Advancing Hydrogen Fund.

The *First Low Emissions Technology Statement*[68] identifies clean hydrogen, energy storage and low-carbon materials (steel and aluminium) as priority technologies in industry's decarbonization. As part of this policy, the Clean Energy Finance Corporation (CEFC) is pursuing large-scale investment opportunities through its AUD 300 million (Australian dollar) Advancing Hydrogen Fund while the commonwealth plans to invest AUD 18 billion in low emissions technology over the decade, to drive AUD 50-100 billion of private investment. These enablers will support different technology targets such as:

- Getting clean hydrogen under AUD 2/kg cost to produce to be competitive with alternatives in large-scale deployment.
- Reaching <AUD 100/MWh for long-duration energy storage (6-8 hours or more) to be dispatched as part of the *Technology Investment Roadmap*.
- Reaching <AUD 900/t for low emissions steel production, and low emissions aluminium under AUD 2,700/t.
- Reaching <AUD 20/t of CO_2 using CCS – CO_2 compression, hub transport and storage.

Western Australia's regional policy

In November 2020, Western Australia released their climate policy plan following a series of documents all supporting the state's net-zero target for 2050.[69] These documents included policies supporting clean manufacturing and future industries, transforming energy generation and use, storing carbon and caring for landscapes, lower carbon transport, resilient cities and regions, and government leadership.

Western Australia's regional policy includes significant investments in low-carbon initiatives, namely: AUD 21 million for the Electric Vehicle Strategy; AUD 100 million for the 100 megawatts (MW) big battery; AUD 15 million for the Carbon Farming Strategy and Land Restoration Program; AUD 15 million Renewable Hydrogen Fund; and AUD 60 million Green Jobs Plan, among other incentives.

FIGURE 21 | **Australia's legislative support for key technologies**

Systemic efficiency and circularity

- Achieving 80% average recovery rate from all waste streams by 2030 and increase use of recycled content by governments and industry.
- AUD 43 million to assist large energy users to undertake studies to identify opportunities to lower energy costs and reduce emissions.

Direct electrification and renewable heat

- Fund projects aligned to investment priorities to support industrial emissions reduction under the Australian Renewable Energy Agency's (ARENA) Advancing Renewables Program. Outcomes include:
  - Informing target sectors and industries on pathways to a renewable energy future particularly for process heat.
  - Increasing collaboration between local and international industry, equipment providers and institutions supporting industrial transition to renewable energy.

Carbon capture, utilization and storage (CCUS)

- Investigating the potential for establishing a large-scale, multi-user carbon capture and storage network in the Latrobe Valley of Victoria.
- AUD 100 million funded by the Clean Energy Initiative and the Victorian government for feasibility studies. A further AUD 2.3 million was awarded by the State of Victoria under the Department of Primary Industries, who manage the project.

Hydrogen

- AUD 275.5 million to accelerate development of four additional clean hydrogen hubs and implement clean hydrogen certification scheme.
- Priority stretch goal of producing clean hydrogen under AUD 2/kg under government's 2020 *First Low Emissions Technology Statement*.
- Partnering internationally for Australia to attract investment, build supply chain and advance research and development – ultimately to be a major hydrogen exporter.
- Various state governments have declared their own hydrogen strategies including Western Australia and New South Wales.

Sources: Department of Industry, Science, Energy and Resources; Department of Climate Change, Energy, the Environment and Water; IEA; Climate Council; Beyond Zero Emissions; Climateworks Centre; European Commission

BOX 9

Industrial cluster spotlight: Kwinana Industrial Area

Key industries: petroleum and minerals refineries, power generation, chemicals, cement

Transitioning Industrial Clusters' initiative signatory, Kwinana Industrial Area was established with the operationalization of the BP Kwinana Oil Refinery in 1955 and now houses concentrated heavy industry on Australia's western coast with more than 150 examples of circularity, intermediate product and utility exchanges within the industrial cluster.[70]

Today, members including Alcoa, BHP, BP, Tianqi Lithium and the Fremantle Ports drive sustainable innovation in the area.

Highlighted emissions reduction initiative

Pilot Energy has anchored the development of the South West Blue Hydrogen and CCS Project as Australia's first CCS trial project. The project aims to use petroleum exploration wells to sequester the industrial area's captured carbon to repurpose oil and gas assets, and expertise, in the clean energy transition.[71]

Sources: Pilot Energy; Kwinana Industries Council

3.2 Indonesia

Despite being the largest economy by GDP in South-East Asia, Indonesia recorded 568.27 Mt of CO_2 emissions in 2020 with an annual growth of 6.1%, which is among the lowest in the G20.

The archipelagic country has 119 existing industrial areas, including 107 industrial parks and 12 industry special economic zones established by the Indonesian government.[72] With Indonesia's ambition to accelerate the competitiveness of its industrial sector, further emissions growth is expected in the next few years.[73]

The recent job creation law passed by the parliament in 2020[74] aims to attract investment, create new jobs and stimulate the economy by, among other things, simplifying the licensing process and harmonizing various laws and regulations, and making policy decisions faster for the central government. Foreign direct investment is expected to be boosted, while the ease of doing business in Indonesia should increase.

To counteract this, Indonesia has committed to reducing greenhouse gas emissions and achieving net zero by 2060.[75] Through its *National Energy Policy*, the country has declared a primary energy mix target by 2025 consisting of at least 23% new and renewable energy, 30% coal, 22% gas and the highlighted role of oil should be less than 25%.[76] The Indonesian government has put several regulations in place to create a path for the country to shift from its dependency on fossil fuels to renewable energy.

FIGURE 22 **Industrial cluster challenges and opportunities in Indonesia**

85%

Percentage of Indonesia's power generation that still comes from conventional sources, despite high and diverse renewables potential

3

Number of leading state-owned enterprises (SOEs), namely Perusahaan Listrik Negara, Pertamina and Pupuk Indonesia, who are currently developing green industrial clusters using green hydrogen and ammonia

74,000 acres

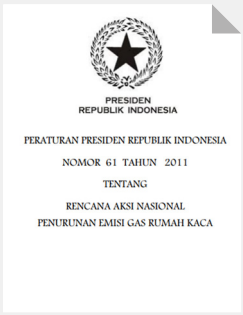
Size of land for the new green industrial park in North Kalimantan that will operate fully using hydropower and solar power, indicating growing commitment to decarbonization in the region

Source: World Economic Forum; Pertamina; ASEAN Briefing

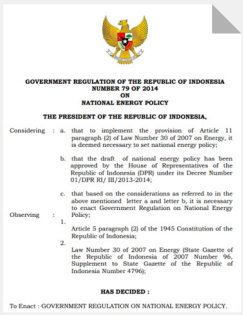
Indonesia's approach to industrial decarbonization

Indonesia's clean energy policy development
Alongside the *Electricity Procurement Plan* (RUPTL) that is reviewed by state utility Perusahaan Listrik Negara (PLN), the Indonesian government has also set in place regulations to ensure it meets nationally determined contribution targets for 2030 and the net zero target by 2060 through a series of legislation beginning in 2011 with the *National Action Plan for Reducing GHG Emissions*.

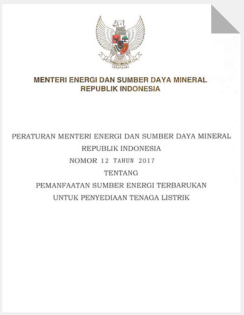
Indonesian legislation empowering industrial decarbonization



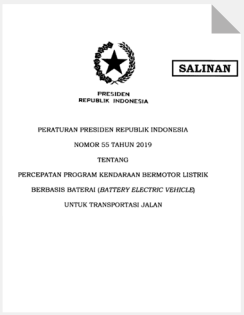
[National Action Plan for Reducing GHG Emissions](#) (2011)



[National Energy Policy](#) (2014)



[Utilization of Renewable Energy for the Provision of Power Supply](#) (2017)



[Promotion of Battery-Powered Electric Vehicles](#) (2019)

[Long-Term Strategy for Low Carbon and Climate Resilience 2050](#) (2021)

Sources: The Audit Board of the Republic of Indonesia; UNFCCC

National Energy Policy

The *National Energy Policy* (NEP) (Regulation 79/2014)[77] is an energy management framework that upholds the principles of justice and sustainability to address national energy security and serves as the guiding principle for future regulations surrounding the energy industry. This document targets a primary energy mix of at least 23% new and renewable energy, 55% coal, 22% gas, with oil contributing less than 25% to the overall energy mix. The policy is aimed at supporting energy availability, development and establishment of reserves.

Within the same year, Indonesian President, Joko Widodo, announced the removal of subsidies on premium gasoline as part of Indonesia's 2015 budget and introduced a fixed subsidy on solar diesel (resulting in solar diesel being priced at IDR 1,000 (Indonesian rupiah) below market value. The removal of the subsidies resulted in $15.6 billion (IDR 211 trillion) savings or 10% of the Indonesian government's expenditure (IDR 2,039.5 trillion) in 2015.[78]

Utilization of Renewable Energy for the Provision of Power Supply

"PLN must now prioritize the purchase of electricity from all renewable energy independent power producers.

This policy (Regulation 50/2017)[79] sets more competitive tariffs for renewable energy sources (solar, wind, hydro, biomass, biogas, city waste to energy and geothermal power plants), thus increasing their rate of inclusion into the national energy mix. It also stipulates that PLN must purchase all the power produced by renewable projects with less than 10 MW capacity, further incentivizing small-scale renewable project owners.

In 2020, this policy was amended via Regulation 4/2020,[80] which revoked the requirement on PPAs to develop on-grid renewable projects exclusively under the build, own, operate and transfer (BOOT) scheme. Additionally, PLN must now prioritize the purchase of electricity from all renewable energy independent power producers (IPPs), based on the must-run regime without any restrictions on the generation capacity of these plants. All these are notable developments for the renewables sector and a positive signal to investors and financiers.

BOX 10 | **Policy spotlight: *Long-Term Strategy for Low Carbon and Climate Resilience 2050* (2021)**

Indonesia's *Long-Term Strategy for Low Carbon and Climate Resilience 2050* (LTS-LCCR)[81] provides decarbonization solutions across sectors while striking a balance with economic development. As the coal industry contributes significantly to the local economy, the country aims to rely on CCUS implementation rather than a near-term coal phaseout. This document proposed to equip 76% of coal-fired capacity with CCUS facilities to curb emissions by 2050. It also estimated that by 2050, coal would contribute to 40% of the country's total power demand, with three-quarters of this 40% capacity retrofitted with CCUS facilities. Additionally, biomass-coal co-firing with CCUS is also encouraged.

Overall, the LTS-LCCR 2050 provides long-term national policy direction on climate change while allowing adjustment over time to keep pace with national and global dynamics. It also complements the country's national vision (Visi Indonesia 2045) goal of countering the adverse effects of climate change and reducing the country's GHG emissions.

FIGURE 24 | **Indonesia's legislative support for key technologies**

Systemic efficiency and circularity

- On top of the fiscal and non-fiscal incentives from establishing businesses in industrial parks and special economic zones (SEZs) formed by the government, electricity generation assets can now supply end consumers within business areas despite being outside such business areas.

Direct electrification and renewable heat

- As outlined in Regulation 12/2017's *Utilization of Renewable Energy for the Provision of Power Supply*, this increases the rate of inclusion in the national energy mix. This policy has also been updated across the years since its enactment.

Carbon capture, utilization and storage (CCUS)

- While the Indonesian government has yet to develop a regulatory framework for carbon extraction, the government has established the National Center of Excellence for CCS and CCUS to coordinate R&D efforts on CO_2 extraction in the country. CCUS solutions are also emphasized in the country's *Long-Term Strategy for Low Carbon and Climate Resilience 2050*.
- **Private sector initiatives**
  - Pertamina: Study of CCS and CCUS technologies in three oil and gas fields with ExxonMobil
  - Pertamina: Joint study agreement on commercialization of CCUS in central Sumatra with Mitsui
  - Repsol: Building a CCUS facility in Sakakemang, South Sumatra – 2027
  - BP: Building two CCUS facilities in Ubadari field and Vorwata – 2025

Hydrogen

- Hydrogen development in Indonesia is still in the research and piloting stage. Commercial projects are not yet available. The Indonesian government has also not drafted or issued anything on hydrogen policies.

Sources: Reuters; Pertamina; New Energy and Industrial Technology Development Organization

3.3 China

China has legislated its intention to peak carbon emissions by 2030 to achieve carbon neutrality by 2060.

China is the world's largest emitter and is responsible for about one-quarter of global greenhouse gas emissions. The country's announcement of its net zero goal sets the pace for the industrial sector and its corporate decarbonization roadmaps. There is a growing need for industrial corporates to address the gaps in carbon management and expertise.

The industrial sector accounted for about 70% of the total final energy consumption and industrial clusters accounted for about 31% of the nation's CO_2 emissions in 2020.[82] To stay on track to China's net zero goals, industrial clusters must eliminate at least 28% of their CO_2 emissions by 2035.[83]

China has the ambitious goal of peaking CO_2 emissions by 2030 and reaching carbon neutrality by 2060. To meet this goal, the government is actively supporting decarbonization through different initiatives, roadmaps and policy tools made available to industrial corporates. One of these to be reviewed here is the creation of 52[84] low-carbon industrial clusters.

FIGURE 25 **Industrial cluster challenges and opportunities in China**

70%

The industrial sector accounted for about 70% of total final energy consumption in 2020

25%

Consumption of non-fossil energy must be raised to 25% by 2030 from 2005 values

~$11 trillion

Cumulative investment in renewable energy in industrial clusters from 2020 to 2050

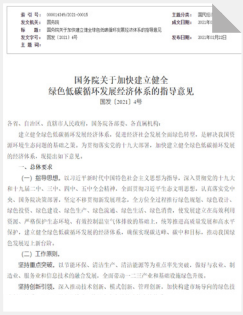
Source: Accenture; State Council China; People's Republic of China

China's approach to industrial decarbonization

China's clean energy policy development
A series of actions and plans issued by the Chinese government strongly promote low-carbon and green initiatives, laying the path to net zero. These plans unlock enabling measures to decrease emissions post-2030 and propose action plans to meet both 2030 and 2050 targets. Decarbonizing industrial clusters (or "parks") has become a top priority to enable heavy industries' ability to meet China's emissions reduction targets.

Chinese legislation empowering industrial decarbonization

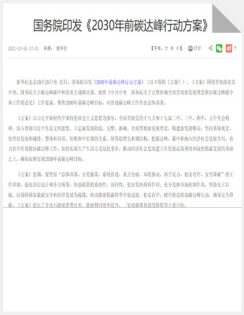
14th Five-Year Plan and 2035 Strategic Vision Goals (March 2021)



Guides on establishment of low-carbon circular economy system (April 2021)

Opinions on new development to realize carbon peak and neutrality (August 2021)

Trading Guidelines of Carbon Emission Rights (September 2021)



Action Plan for Peak CO_2 Emission 2030 (October 2021)

Sources: State Council of the People's Republic of China; National Development and Reform Commission (NDRC)

14th Five-Year Plan and 2035 Strategic Vision Goals (2021)

The *14th Five-Year Plan and 2035 Strategic Vision Goals*[85] outline the detailed objectives and execution plans for the development of industrial clusters across China. As of August 2021, 400 of China's 2,300-plus industrial clusters have successfully adapted to align to one of the five target cluster types:

- **Circularity transformation pilot clusters** focus on constructing circular economies by maximizing the efficiency of resources and therefore, reducing energy costs and controlling emissions.
- **Eco-industrial clusters** focus on building a complete energy consumption environment within the cluster and meeting stipulated green production requirements.
- **Low-carbon industrial clusters** aim to reduce the intensity and total amount of greenhouse gas emissions, which eventually lead to the application of developed knowledge and processes to the low-carbon transformation of traditional industrial clusters. Since 2013, China has been developing a pilot project for low-carbon industrial clusters. The project has included 52 industrial clusters, of which Suzhou Industrial Park was among the first wave.
- **Green clusters** focus on energy-saving and environmental protection equipment manufacturing, green transformation services and green production while optimizing the related services.
- **Near-zero carbon emission pilot zones** intend to develop knowledge and technologies to accelerate the goal of carbon neutrality by embracing digital intelligence in daily operations. As part of the *13th Five Year Plan for Controlling Greenhouse Gas Emissions*, China has highlighted near-zero-carbon zones as one of the key enablers to achieve reductions, including a specific call for 50 near-zero-carbon zones by 2050.

The legislation goes on to allocate up to CNY 200 million (Chinese yuan) to construct hydrogen fueling stations in all types of clusters, of all defined types and CNY 2.5 billion to biomass projects.

China has highlighted near-zero-carbon zones as one of the key enablers to achieve reductions, including a specific call for 50 near-zero-carbon zones by 2050.

Opinions on new development to realize carbon peak and neutrality[86]

Published only a month after the National Development and Reform Council's 14th Five-Year Plan, the Chinese State Council's opinions on new development to realize carbon peak and neutrality stated that, by 2025:[87]

- Energy consumption of GDP per capita should drop by 13.5% (baseline 2020)
- CNY emission of GDP per capita should drop by 18% (baseline 2020)
- Forest coverage should reach 18 billion cubic meters.

FIGURE 27 **China's legislative support for key technologies**

Systemic efficiency and circularity

- As required by guides on the establishment of low-carbon circular economy systems, all clusters at the provincial level and above must modify operations to fit criteria of "circularity clusters".
- Under guidance from the National Energy Bureau (NEB), more than CNY 100 million are funded to assist in clusters' circularity transformations in more than 20 provinces nationwide.
- Tax exemptions for 15-30% of CapEx may be granted to clusters that have gone through circularity transformations.

Direct electrification and renewable heat

- Per the *14th Five-Year Plan and 2035 Strategic Vision Goals*, CNY 2.5 billion was funded to biomass projects during 2020 nationwide.
- Up to CNY 100,000 is subsidized by the State Council and respective municipal governments to clusters' electrification projects of fossil fuel boilers.
- In 2020, the State Council stipulated that hot water supplied in clusters by renewable energy should meet or exceed 10% of the total hot water consumption.

Carbon capture, utilization and storage (CCUS)

- Per the opinions on new development to realize carbon peak and neutrality, 10-25% of CapEx funding may be deployed by provincial governments to accelerate the construction of CCUS sites.
- Proposed by the 2022 Chinese People's Political Consultative Conference (CPPCC) national committee, up to 60% of low-interest loans should be granted to encourage both publicly- and privately-invested CCUS projects*.

Hydrogen

- According to the *14th Five-Year Plan and 2035 Strategic Vision Goals*, up to CNY 200 million will be funded to construct hydrogen fueling stations in clusters, of all defined types, nationwide.
- Up to CNY 80,000 in production grants will be funded to hydrogen-powered vehicle manufacturers.
- Defined by the 2035 Strategic Vision and Scheme, public funds will be made available: up to CNY 5 million one-time seed granting, tax exemptions of up to 30% of CapEx and CNY 2/kg OpEx granting** to clusters' hydrogen production projects.

Notes: *The funding is only available to those hydrogen production site with daily production higher than 500kg and hydrogen sales price less than CNY 40/kg; funding is accessible for up to three years.
**Projects are subjected to certain criteria; for example, the carbon capture capacity should be 100-300 million tonnes/year.

Sources: State Council of the People's Republic of China; National Development and Reform Commission (NDRC)

BOX 11 **Industrial cluster spotlight: Suzhou Industrial Park**

Key industries: electronics, equipment manufacturing, medicine, nanotechnology

Suzhou Industrial Park (SIP)[88] is pursuing steps to achieve carbon neutrality through systemic efficiency and shared energy and resource infrastructure. China's Suzhou Industrial Park was established in April 1994 as a collaboration between China and Singapore with four key project areas: circularity of industrial by-products and waste, distributed clean energy microgrid, ubiquitous Internet of Things (IoT) service platform and integrated green transport system.

While total energy consumption has been increasing, energy consumption – and emissions intensity – per unit of GDP has dropped by 10.3% over the past four years.

Highlighted emissions reduction initiative
Suzhou Industrial Park's "six-in-one" distributed clean energy microgrid currently provides up to 10% of the industrial cluster's energy consumption. The project currently includes two clean energy centres, ten microgrid systems, and 100 distributed energy systems, including 25 MW photovoltaic generation, 50 MW wind generation, 22 MW storage capacity and 1,000 EVs, forming a clean energy system over 1 gigawatt-hour (GWh).

The microgrid system will continue to scale with a goal of a 40% decrease in energy consumption and accompanying more than 50% emissions reduction.

Source: National Development and Reform Commission; State Council of China; Ministry of Ecology and Environment; Accenture analysis

3.4 Singapore

The industrial sector is the largest source of greenhouse gas emissions for the advanced city-state, accounting for 45% of emissions.

The city-state, which contains the world's second largest port, aims to achieve climate neutrality by 2050[89] and has implemented strong policies to safeguard its climate-resilient future. Singapore has an export-oriented economy and remains focused on the need to implement energy efficiency measures that will allow the country to continue growth while reducing its GHG emissions.

Within the city-state, the industrial sector represented 23 $MtCO_2$ emissions in 2019 and 41.5% of the total energy consumed in the country.[90] While decarbonizing industries face several challenges in Singapore – a 36%[91] reduction in emissions intensity from 2005 levels is required to stay on track for its net zero goals – there are sizeable government-supported social and economic opportunities from investments in low-carbon technologies.

The country foresees an optimistic future as the government takes action to support sustainable, green technologies that will accelerate the transition. Singapore has set targets in the solar energy, CCUS and green infrastructure markets to promote its rapid development, augmented by incentives for corporates to invest in these markets' growth.

FIGURE 28 **Industrial cluster challenges and opportunities in Singapore**

41.5%

Proportion of total energy consumed by the industrial sector in 2019

SGD 35 billion

(Singaporean dollars)

Value of green bonds made available by the public sector through 2030 to fund green infrastructure projects

40,000-60,000

Incremental job creation through 2030 resulting from sustainable development

Sources: Ministry of Foreign Affairs Singapore; Monetary Authority of Singapore; The Straits Times

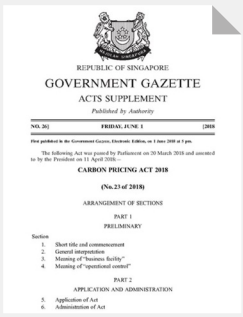
Singapore's approach to industrial decarbonization

Singapore's clean energy policy development
The Singaporean government has coordinated multi-ministry efforts to develop a series of policies and initiatives to support industrial decarbonization and, more broadly, the energy transition. Figure 29 shows five of the main policies that support the country's strategy to reduce GHG emissions and fulfil its Paris Agreement pledge. Focused on both long- and short-term ambitions and through a diversity of strategies, these policies support Singapore's industrial decarbonization priorities. Industrial clusters will play a key role in supporting these priorities as a primary enabler of energy efficiency improvements and the development of low-carbon alternatives.

FIGURE 29 | **Relevant Singaporean policy**

Singaporean legislation empowering industrial decarbonization

Climate Action Plan
(July 2016)


REPUBLIC OF SINGAPORE
GOVERNMENT GAZETTE
ACTS SUPPLEMENT
Published by Authority
NO. 26] FRIDAY, JUNE 1 [2018
CARBON PRICING ACT 2018
(No. 23 of 2018)
ARRANGEMENT OF SECTIONS
PART 1
PRELIMINARY
PART 2
APPLICATION AND ADMINISTRATION

Carbon Pricing Act
(March 2018)

Long-Term Low-Emissions Development Strategy (LEDS)
(April 2020)

Sustainable Jurong Island
(November 2021)

Singapore Green Bond Framework
(June 2022)

Sources: National Climate Change Secretariat; Republic of Singapore; Singapore Economic Development Board; Monetary Authority of Singapore

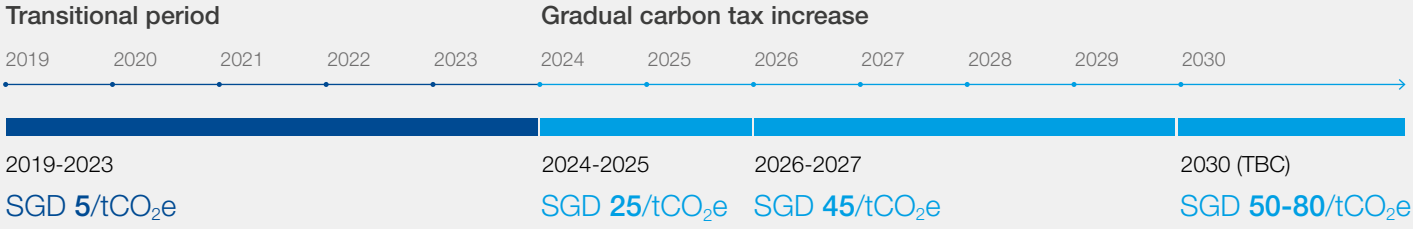
Carbon Pricing Act

The *Carbon Pricing Act*[92] of 2018 established an incrementally increasing carbon tax policy to provide clear price signals for industries to plan their carbon abatement strategies while also stimulating demand growth in the nation's carbon credit market.

The period between 2019 and 2023 has been legislated as the transitional period during which emitters should adjust operations. During this time, industrial companies need to quickly align their environmental, social and governance (ESG) strategies with those of the nation and develop action plans to drive effective carbon abatement in core business activities. Sustainability-themed start-ups can tap into government funds to kick-start operations and develop first-mover advantages.

The baseline carbon tax will increase every two years during 2024-2030, as a continued signal prompting companies to modify emitting operations. This is intended to prompt companies to continuously invest in carbon capture and carbon abatement technologies, using prevailing carbon tax rates to baseline investment decisions. Companies can also employ the growing carbon credit market to offset these costs, tapping into low-cost solution offerings within the ASEAN region.

FIGURE 30 | **Carbon tax structure**



Sources: *Carbon Pricing Act*; Singapore Statutes Online

Regional power grid and imported electricity

Singapore is importing up to 100 MW of hydro energy from Lao PDR and channelling it via existing interconnections through Thailand and Malaysia.

Due to land scarcity in Singapore, the nation lacks viable sources of renewable energy to completely transition from carbon-based fuels. In recognition of that, Singapore has identified the potential of an ASEAN regional power grid as part of its future energy switch. Through this regional power grid, Singapore aims to draw on the abundance of hydro and renewable sources from its neighbour nations and import renewable energy to supplement its supply of electricity.[93]

Efforts to import electricity from neighbouring countries have shown early signs of success. In June 2022, Singapore signed a multilateral cross-border electricity trade agreement involving three other ASEAN countries: Lao People's Democratic Republic (Lao PDR), Malaysia and Thailand. Under the Lao PDR-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP), Singapore is importing up to 100 MW of hydro energy from Lao PDR and channelling it via existing interconnections through Thailand and Malaysia.

Other similar efforts include importing solar energy from Pulau Bulan, Indonesia, and a 4,200km[94] undersea cable to draw solar energy from Northern Australia.

Sustainable Jurong Island plan[95]

The *Sustainable Jurong Island* plan, as part of the Singapore Green Plan 2030, outlines Jurong Island's targets and key initiatives to drive its transformation journey into a sustainable energy and chemicals (E&C) park.

By 2030, Jurong Island aspires to increase sustainable products output by 1.5 times 2019 levels, improve energy efficiency in refineries and crackers to be in the top quartile globally, and achieve 2 Mt of carbon capture. In addition, by 2050, the island's aim is to increase sustainable products output by four times 2019 levels and achieve more than 6 Mt of annual carbon abatement from low-carbon solutions.

This plan lays the shared infrastructure and sustainability ambitions for Jurong Island and defines in detail policies and programmes to incentivize industry to reduce emissions (via the Resource Efficiency Grant for Energy and Investment Allowance for Emissions Reduction) and drive R&D projects in CCUS and low-carbon hydrogen via the Low-Carbon Energy Research Funding Initiative and the Jurong Island Innovation Challenge.

BOX 12

Industrial cluster spotlight: Jurong Island

Key industries: refining, power generation, petrochemicals

Jurong Island will play a key role in enabling Singapore to meet its 2050 emission targets, with 60% of the nation's total emissions coming from the aggregation of seven islands representing a gross value added (GVA) of more than SGD 100 billion annually and 100 corporations.[96] As the key Singaporean geography for carbon abatement legislation, the federal government has legislated that 2030 will be the peak emissions year at approximately 65 Mt of CO_2e with the rapid decarbonization ambition of halving that volume by 2050.

This will not be possible without the full support of industrial multinationals like Shell, ExxonMobil, Keppel, Evonik and Sembcorp with facilities on the island.

Highlighted emissions reduction initiative
One of Sembcorp's sustainability initiatives on the island recovers approximately 280,000 tonnes of waste annually for system reuse through steam production in energy-from-waste plants and woodchip boilers. Woodchip boilers, accounting for approximately 25% of recovery, capture around 36% of all Singaporean construction and demolition woodchip waste.

Source: Sembcorp

FIGURE 31 | **Singapore's legislative support for key technologies**

Systemic efficiency and circularity

- Drive industry initiatives towards achieving higher energy efficiency and promote improved waste recycling and management systems through various grants.
- SGD 19 million public investment for industrial facilities' energy efficiency improvement.
- SGD 6 million public investment for test-bedding waste-to-energy technologies.

Direct electrification and renewable heat

- Innovation call to test-bed innovative energy solutions, including renewable energy technologies, energy storage systems and low-carbon solutions.
- Programmes to drive adoption of solar energy technologies.

Carbon capture, utilization and storage (CCUS)

- Carbon tax framework to drive carbon credit demand and promote investment into CCUS technology.
- SGD 55 million public investment for funding research initiatives into CCUS technologies for decarbonization of the power and industry sectors.

Hydrogen

- Regulatory policies enabling investments into solutions for the production, storage, and distribution of green hydrogen.
- SGD 55 million public investment for funding research initiatives into increasing hydrogen-related process efficiencies for decarbonization of the power and industry sectors.

Sources: National Climate Change Secretariat; Republic of Singapore; Singapore Economic Development Board; Monetary Authority of Singapore

Conclusion

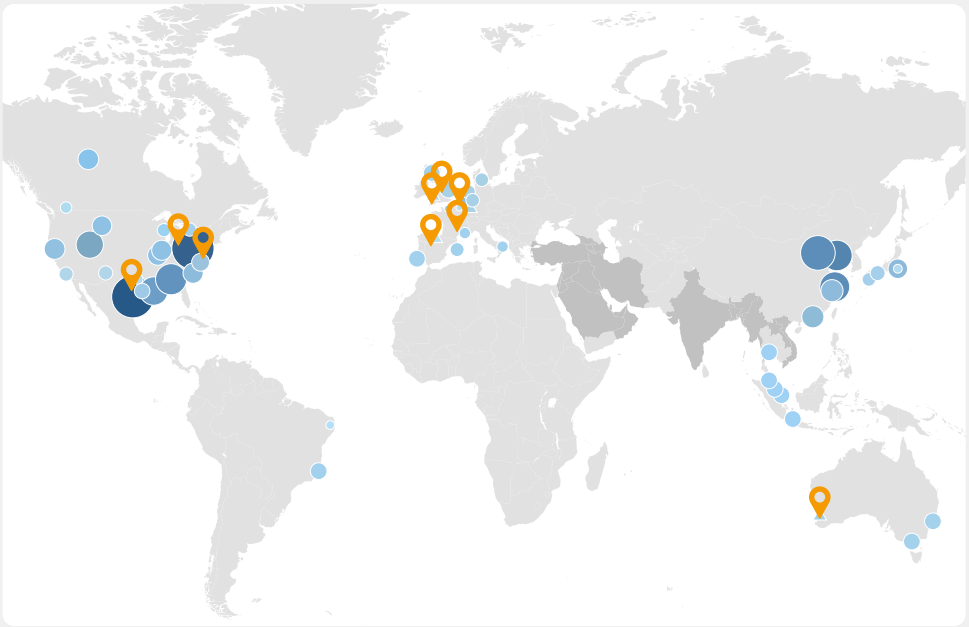
The public sector must continue to act decisively to remove barriers to scaling clean resource markets across the value chain.

Federal, state and municipal governments on every continent are recognizing the necessity of decreasing dependence on fossil fuels and facilitate a collaborative landscape which catalyses private investment in clean technologies, infrastructure and social preparedness for the shift. Four key themes emerge in considering how to accelerate this shift:

- Collaboration within and across nations with increased emphasis on public-private partnerships has consistently demonstrated itself as a strong catalyst. It is necessary that the public sector learns from global best practices, adjusting successful policies and mechanisms for their local environment.
- Enabling policy must be regarded as a seed to de-risk private investment in building clean resource markets. Leaders should seek to understand where they are and where they're aiming on a maturity curve for financing and policy enablement in the context of clean resource markets.
- From seed financing to scaled capital investment in clean resources markets, public-private collaboration and portfolio blending are required to balance investment priorities and ensure holistic and sustainable long-term growth.
- Both public and private collaborators must prioritize building clean resource landscapes which support the development of a market for clean resource technologies, processes and supporting enablers rather than disparate projects and demonstrations.

FIGURE 32 **Impact of decarbonizing one hundred industrial clusters**

With greater than 10,000 industrial clusters globally, this map highlights a subset of around 100 clusters in target markets where the initiative is positioned to have the greatest impact.



100 Clusters' Impact

1.6 billion
Metric tonnes of CO_2
↳ **5%** of total global CO_2 emissions
↳ **15%** of global CO_2 industrial emissions

17.8 million
Total direct jobs

$2.5 trillion
Total GDP contribution

Industrial Clusters signatory | Potential | MMT* CO_2e 2.50 — 72.50

*Million metric tonnes

Notes: Additional analysis forthcoming on shaded geographies.

Sources: Accenture Strategy Analysis

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