Impact Evaluation of Climate Change Mitigation Policies for the Manufacturing Sector in Gujarat

Shanal Pradhan and Deepa Janakiraman

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According to International Energy Agency, the Indian manufacturing sector is the single largest consumer of delivered energy in India and contributed to 26 per cent of the economy-wide CO_2 emissions in 2017.

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The **GHG Platform - India** is a collaborative effort conceptualised by Shakti Sustainable Energy Foundation and Vasudha Foundation. The Platform provides an independent estimation and analysis of India's greenhouse (GHG) emissions across key sectors such as Energy, Waste, Industry, Agriculture, Forest and Other Land Use (AFOLU) sectors. It includes notable institutions such as CEEW, CSTEP, ICLEI South Asia, Vasudha Foundation, and WRI India as platform members. It hosts national and sub-national GHG emissions estimates from 2005 to 2015 on its web portal on an open domain.

This report is an initiative of the platform undertaken by the platform partners and funded by the Shakti Sustainable Energy Foundation. CEEW, CSTEP, ICLEI South Asia, Vasudha Foundation were lead researchers for manufacturing industry, energy, waste, and agriculture sectors respectively with WRI India being the peer reviewer for the analysis. This report evaluates climate mitigation policies for the manufacturing sector in Gujarat from 2005 to 2015. The compiled report covering all-end use economic sectors can be accessed at http://www.ghgplatform-india.org/.

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"As an industrial state, Gujarat has implemented numerous policies on its manufacturing sector with little or no significant impact on greenhouse gas mitigation. Gujarat has the potential to address the dual challenge of meeting its increasing energy demand while reducing emissions. In fact, all states must formulate policy frameworks more supportive to energy transitions in manufacturing sector which will bring down overall energy cost and increase competitiveness. This, though, will only occur if we bring forward low carbon strategies and ensure a proper mix of market-based instruments at national and subnational level."

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"State-level climate action plans are of utmost importance in India's endeavour to realise its climate commitments. High dependency on coal for energy generation plagues the manufacturing sector in Gujarat with most of the natural gas being used as feedstock. Unavailability of data at the state-level remains as a major roadblock for assessment, without which productive policies cannot be designed. Gujarat, a highly industrialised state which is ahead on the industrial development curve, can and should design an industrial decarbonisation roadmap that other states too can learn from."

The manufacturing sector saw a rise in production responding to increased consumer demand, which in turn increased its carbon footprint. Only sustainable industrial growth can decarbonise the sector and help achieve our climate commitments.

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Acronyms

BEE	Bureau of Energy Efficiency
CDM	Clean Development Mechanism
CLCSS	*Credit Linked Capital Subsidy Scheme*
CER	certified emission reduction
CRZ	Coastal regulation zone
DCs	designated consumers
GEDA	Gujarat Energy Development Agency
GERMI	Gujarat Energy Research and Management Institute
GHG	greenhouse gas(es)
GoG	Government of Gujarat
GWP	global warming potential
MoP	Ministry of Power
MoU	Memorandum of understanding
MSME	micro, small, and medium enterprises
Mtoe	Million tonnes of oil equivalent
$MtCO_2e$	Million tonnes of carbon dioxide equivalent
MoP&NG	Ministry of Petroleum and Natural Gas
NOC	No objection certificate
PAT	*Perform, Achieve, and Trade*
PNG	piped natural gas
PPAC	Petroleum Planning & Analysis Cell
RTS	*Rooftop Solar Scheme*
SEC	specific energy consumption
TEQUP	*Technology and Quality Upgradation Programme*
LNG	liquefied natural gas

Gujarat, with a 33 per cent share of manufacturing in its GVA and 16 per cent share in industrial energy use as per our estimates, is among the most industrialised states in India.

Image: iStock

Executive summary

In the last decade, subnational governments in the country have increased their involvement in climate action. This is integral to India achieving its climate goals, as ultimately, state governments are responsible for implementing policies on the ground. It is crucial to assess whether policies implemented at the state level have made a meaningful impact, particularly in terms of their ability to realise the co-benefits from climate action. It is challenging to measure the effects of such policies on greenhouse gas (GHG) emissions, as their pathway is not always direct. Further, such a study would require consistent timeframes of assessment and baseline assumptions. Thus, such assessments generate poor quality data, which in turn leads to greater uncertainty in the results. This study attempts to initiate a process of systematically evaluating the policies impacting industries at the subnational level. As such, this study will add significant value to the literature, as it analyses industrial policies from a GHG mitigation perspective, as well as other indicators such as the delivery of resources to support implementation (input indicators) and policy administration activities (activity indicators).

Polices and mitigation actions are evaluated using a framework that assesses them according to three parameters: input, activity, and GHG impact. The mitigation policies and actions considered in the evaluation are primarily those that directly or indirectly impact GHG emissions. Market-based mechanisms like the *Perform, Achieve and Trade (PAT) Scheme* and the *Clean Development Mechanism* (CDM) have been considered in the assessment, as they have a direct impact on reducing emission intensity in the manufacturing sector. These mechanisms have been categorised as GHG emission mitigation instruments.

The mitigation policies and actions considered in the evaluation are primarily those that directly or indirectly impact GHG emissions

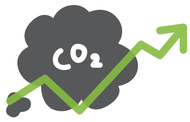
For polices and mitigation actions that are still being implemented, GHG impacts are assessed till 2018. However, cumulative GHG reductions are provided for the period 2005–2015. For instance, the *Rooftop Solar* (RTS) scheme was implemented in 2012, but the cumulative GHG emissions that were reduced as a result of the scheme is estimated only till 2015 to account for the assessment period.

Of the eight polices and mitigation actions assessed, GHG reduction impacts have been estimated for three of them: the RTS scheme, PAT scheme, and voluntary participation of industries under the CDM. Overall, an estimated 13.5 $MtCO_2e$ of GHG emissions were reduced from as a result of these three polices and mitigation actions, as assessed between 2005 and 2015.

The emission reductions are provided for the different time periods in which the schemes were implemented. There was an estimated 0.02 $MtCO_2e$ reduction in emissions because of the industrial RTS scheme, which was implemented in 2012; emission reductions are estimated for 2012–2015. The implementation of PAT scheme cycle 1 (2012–2015) resulted in a nearly 2.28 $MtCO_2e$ reduction in emissions. Further, in 2005–2015, CDM projects from Gujarat contributed to 11.16 $MtCO_2e$ reduction in emissions.

Manufacturing schemes like *Technology and Quality Upgradation* (TEQUP) support to micro, small, and medium enterprises (MSMEs), the *Credit Linked Capital Subsidy Scheme* (CLCSS), and subsidies towards quality certification (ISO 9000) indirectly contributed to GHG mitigation (GoG 2016–2017; PIB 2019). However, due to the unavailability of information, emission savings were not estimated.

Most of the GHG mitigation arises from polices and mitigation actions following 2010. For instance, RTS scheme is assessed till 2015, and the PAT scheme cycle 1 falls between 2012–2015. Hence, despite the rising intensity of emissions from industries in 2005–2011, mitigation actions have effectively reduced the energy intensity of the sector during the latter half.



The carbon intensity in the energy mix indicated a six per cent reduction in 2007–2011 but a seven per cent increase in 2011–15

Coal remained the dominant source of energy while natural gas penetration levels were low in Gujarat even with the introduction of the *LNG Terminal Policy* 2012. The lack of sustained supply of cheap domestic gas has been a serious bottleneck in expanding gas-based production capacities, especially in energy-intensive sectors like iron and steel (Sen 2015). Currently, there are only two operational gas-based production facilities in the country: Essar Steel (Surat Hazira) and JSW (Dolvi and Vijayanagar).

A three-year moving average trend of the emission intensity, energy intensity, and carbon intensity of the energy mix indicates that the energy intensity of the sector increased by 13 per cent in 2007–2011. It subsequently decreased by 7 per cent 2011–2015, which happens to be when most of the policies and mitigation actions were operational. However, the reduction in the energy intensity during the second half of the assessment period (2011–15) was offset by an increase in carbon intensity in the energy mix. This marginally impacted emission intensity levels. The carbon intensity in the energy mix indicated a six per cent reduction in 2007–2011 but a seven per cent increase in 2011–15.

1. Introduction

With the growing debate around the electrification of industrial processes as a means to reduce emissions, schemes such as *Rooftop Solar* need to be more aggressively promoted.

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The study intends to sensitise officials from various line departments in Gujarat, as well as numerous stakeholders from industry, academia, and civil society groups, about the impact of policies and mitigation actions on reducing GHG emission intensity in the manufacturing sector. Along with the emission reduction potential, the contribution of policies towards broader GHG reduction goals—such as reducing the manufacturing sector's energy intensity by adopting energy efficiency measures and utilising cleaner techniques in production processes—is considered in the evaluation. The study also provides concluding remarks on whether ongoing mitigation efforts need to be continued, adjusted, or expanded, or if additional policy measures need to be implemented. This study provides answers to some pertinent questions on the role of polices and mitigation actions in climate mitigation at the subnational level, such as:

- What were the most relevant policies and mitigation actions implemented in Gujarat in 2005–2015 to reduce emissions from industrial operations?
- What was the measurable impact of the policies and mitigation actions? Were there any direct GHG emission mitigations or co-benefits?
- What were the key drivers influencing such policies and mitigation actions? For instance, structural changes in the manufacturing industry, energy efficiency measures, a shift to cleaner fuels, and improved supply infrastructure.
- What are future options to further improve the emission intensity of manufacturing units in Gujarat?

Monitoring and evaluation of policies provides sound evidence of what works and what needs course correction. This assists state governments in effective implementation and decision making.

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2. Methodology

Defining the various parameters for measuring the impact of policies and mitigation actions is the initial step. This is followed by identifying relevant parameters to compare and assess policies. Subsequently, the impact of individual policies and mitigation actions is demonstrated using an evidence-based framework; the analysis is further supported by qualitative and quantitative assessments. The results are collectively analysed to assess the cumulative impact of policies and mitigation actions, from baseline emissions to estimating the overall effect throughout the monitored period. The key economic sectors that are considered are the manufacturing sector and renewables. This assessment employs the framework illustrated in Figure 1.

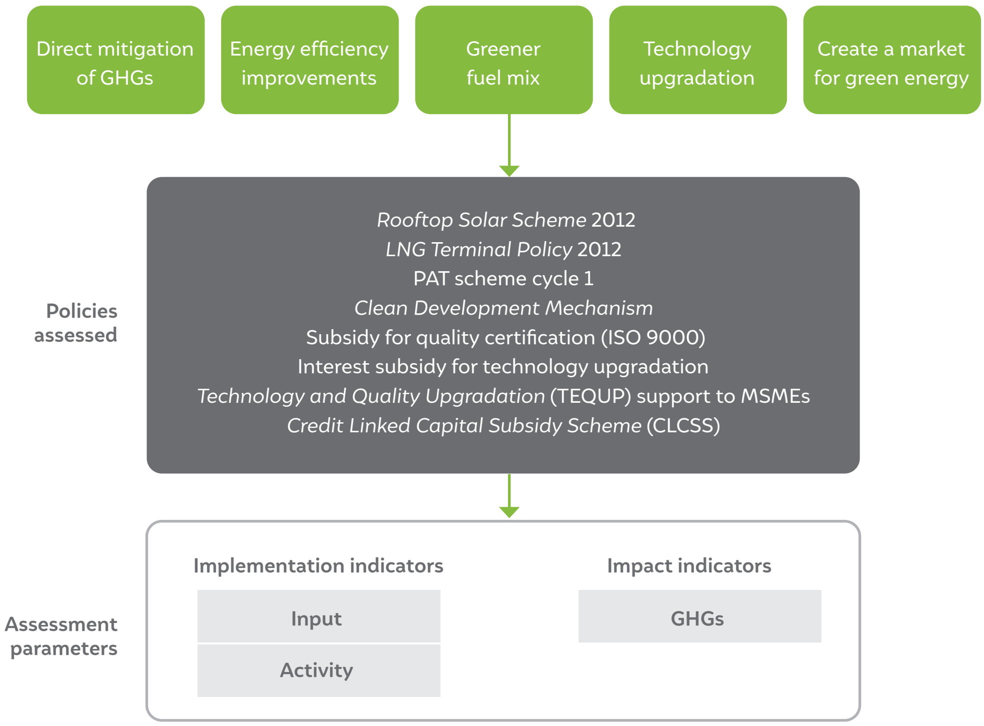


Figure 1
Assessment framework for polices and mitigation actions used in this study

Source: Authors' adaptation from Rich, et al. (2014).

Gujarat is among the country's leading industrialised states; it has demonstrated strong economic growth in recent decades. Gross domestic product (GDP) for the state (at current prices), grew by 14 per cent between 2011–12 and 2016–17 (RBI 2019)—this was higher than the national GDP growth rate of 12 per cent (RBI 2019a; RBI 2019c). The manufacturing sector accounted for a 32.6 per cent share in Gujarat's net state value added in 2016–17 (RBI 2019c). A combination of factors spurred this swift growth; relevant policy support, coupled with effective institutional arrangements and funding mechanisms for policy design and implementation, has played a key role in facilitating these developments. Gujarat contributes about 6 per cent to the country's total gas production (E&PD 2017). The city gas distribution network in the state is extensive, with 4,551 industrial connections to piped natural gas (PNG) as of April 2018 (PPAC 2019a). The state has the single-largest share in industrial PNG connections, comprising 60 per cent of the country's total industrial connections.

Nonetheless, high levels of industrial activity are associated with harmful emissions, as the burning of fossil fuels is a major source of industrial GHG emissions. Thus, Gujarat, as a highly industrialised state with several implemented policies, and as one of the few states with a large number of industrial DCs (designated consumers) allotted in PAT cycle 1 (37), is ideal for policy evaluation.

3. Coverage and period

The pulp and paper industry uses high amounts of coal for energy. It needs to transition to cleaner fuels like natural gas to reduce its emissions footprint.

Image: iStock

This assessment covers polices and mitigation actions undertaken in Gujarat's manufacturing sector (see Table 1). Additionally, cross-sectoral policies—such as the RTS scheme 2012, which plays a major role in emissions mitigation—have been analysed in the study. Market-based mechanisms, such as PAT and CDM, have been considered in the assessment, as they have a direct impact on reducing emission intensity in the manufacturing sector. Although the CDM scheme is primarily implemented by non-state actors, it is essential to record the mitigation results in the state. However, the CDM consists of cross-sectoral interventions. Moreover, only schemes that focus solely on fuel switching or energy-efficient processes are considered in the assessment. These schemes have been assessed across 11 industrial sub-sectors in 2005–2015. Due to the unavailability of reliable information, petroleum refinery, mining and quarrying, construction, manufacture of solid fuels, and other energy industries have been excluded from the assessment.

The energy and emission estimates comprise both, the primary and secondary forms of energy that industries consume, including energy consumed for on-site energy transformation. Emission estimates include CO_2, CH_4, and N_2O, and GWP (global warming potential) values, which have been converted to CO_2 equivalents. These three gases collectively account for a large share of the emissions from India. The Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines mention other gases, such as hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride (collectively known as F-gases), which have high GWP levels. This study does not cover these F-gases, because their total contribution in India for the period under investigation is known to be negligible (or unmeasured).

Table 1 Eight industrial policy instruments are analysed in this study

Policies and mitigation actions in Gujarat	Policy/scheme initiated during/ before 2005	Initiation year (if after 2005)	Year(s) for which Information was available
LNG Terminal Policy 2012	No	2012 (ongoing)	Not available
RTS scheme 2012	No	2012 (ongoing)	2014 onwards
PAT scheme cycle 1	No	2012–2015	2012–2015
Clean Development Mechanism (CDM)	Yes	2004 (ongoing)	2004–2005 onwards
Interest subsidy for technology upgradation	Yes	2004 (ongoing)	2004–2005 to 2014–2015
Subsidy for quality certification (ISO 9000)	Yes	2004 (ongoing)	2004–2005 to 2014–2015
Technology and Quality Upgradation (TEQUP) support to MSMEs	No	2010 (ongoing)	2010–2011 onwards
Credit Linked Capital Subsidy Scheme (CLCSS)	Yes	2000 (ongoing)	2011–2012 to 2014–2015

Source: Authors' compilation

4. The evaluation framework

Three parameters were identified to measure the effectiveness of policies and mitigation actions in reducing GHG emissions. These indicators include qualitative and quantitative elements that provide a sense of the impacts, as well as explain processes and interventions that drive policy outcomes. Table 2 presents a comprehensive picture of the assessment parameters and sub-parameters on which the polices and mitigation actions are assessed.

Table 2 Assessment parameters used for evaluating policies and mitigation actions

	Input	Activities	GHG effects
Definition	Resources (financial, human, or organisational) necessary to implement policies and mitigation actions	Activities involved in implementing policies and mitigation actions, such as permitting licensing procurement or compliance and enforcement	Changes in GHG emissions by sources or removals by sinks, which result from the polices and mitigation actions
Parameter	- Funds allocated/disbursed - Low-interest loans - Tax rebates - Subsidies issued - Budget - Manpower employed - Skill of manpower - Collective pooling of funds (National Clean Energy Fund NCEF) - Distribution of equipment - Institutes for assistance and promotion of industry (MSMEs)	- Audits - Workshops/seminars - Training - Awards - Pilot projects - Memorandums of understanding (MoUs) - Joint ventures - Rankings - Index - Regulatory body - Research and development (R&D) - Investment in infrastructure - Compliance and enforcement activities - Power purchase agreement (PPA) - Certification - Dissemination and awareness	- Reduced GHG emissions as a result of switching to cleaner energy sources, such as renewable energy (RE) and natural gas - Changes in emissions due to changes in energy consumption trends - Changes in emissions because of the use of efficient technologies

Source: Authors' compilation

The tables that follow provide details about the analysed policies and the identified indicators. Various inputs, such as budgetary allocation, financial incentives, and human resources, which have gone towards implementing the policies, are shown in Table 3. Impact indicators comprise of measuring the GHG impact of relevant policies; they are listed in Table 1 in Annexure 1.

Table 3 **Various input indicators identified for each policy and mitigation action**

Policy/ mitigation action	Input indicator	Responsible organisation	Indicator
Budgetary allocation support/Expenditure on schemes (manufacturing sector)			
LNG Terminal Policy 2012	Investment to build up the LNG Terminal	Energy and Petrochemicals Department	The LNG Terminal was developed with an investment of INR 5,041 crore (USD 730 million), funded through a combination of debt and equity financing (GoG 2012). The project received INR 3,528 crore (USD 560 million) in funding from 11 Indian banks in April 2015 (Hydrocarbons Technology 2020)
CDM	Finances allocated to CDM projects on a national scale as of 2012	National Clean Development Mechanism Authority (NCDMA)	The 3,000 projects implemented in the country since 2012 represent an estimated investment of over INR 160, 000 crore since the inception of CDM in 2004 (NCDMA 2015)
CLCSS	Total expenditure in lakh INR till December 2017 (national-level figures only)	Small Industries Development Bank of India (SIDBI)/ National Bank for Agriculture and Rural Development (NABARD)	At the national level, a total expenditure of INR 283,444.16 lakh was reported until December 2017. Disaggregated data at the state level could not be found (MoMSME 2018)
TEQUP	Amount sanctioned and expense incurred by the scheme	Direct Benefit Transfer (DBT) system	The sanctioned amount was INR 157,500, and the total expenses incurred was INR 107,370 for the scheme in Gujarat in 2016–2017 (MoMSME 2017)
Financial incentive (subsidy/tax/loan) (manufacturing sector)			
PAT scheme cycle 1 (2012–2015)	ESCerts (Energy Savings Certificates) are financial incentives for DCs who surpass their energy efficiency target	Administrator (BEE) Registration (POSOCO) Trading Platform (PXIL, IEX)	According to the monitoring and verification report (MRV) submitted under the PAT scheme cycle 1 in Gujarat, 551,669.6 ESCerts have been generated by 40 DCs in the state (GoG 2020b)
CDM	Certified Emission Reduction (CER) credits[1] can be earned from CDM projects and trades/ sales to meet emission reduction targets	NCDMA	The state has earned INR 12.63 crore CER credits (GoG 2020a)
Interest subsidy for technology upgradation	Interest subsidy for technology upgradation	Industries and Mines Department	The interest subsidy amounts to INR 140,708.22 lakh for 79,314 units between 2004–2005 and 2014–2015 (GoG 2014) (Industries Commissionerate 2017)
Subsidy for quality certification (ISO 9000)	Subsidy for quality certification	Industries and Mines Department	Subsidy amounts to INR 10,385.84 lakh for 4,489 units between 2004–2005 and 2014–2015 (GoG 2014) (Industries Commissionerate 2017)
CLCSS	Subsidy provided for CLCSS in Gujarat	NABARD/ SIDBI	In Gujarat, a total subsidy of INR 42,847.3 lakh provided for 7,571 units from 2011–2012 to 2014–15 (PIB 2015)

1 Equal to one tonne of CO_2.

Policy/ mitigation action	Input indicator	Responsible organisation	Indicator
TEQUP	Reimbursement of national/international product certifications	DBT	The total sanctioned amount sanctioned was INR 80 lakh in 2012–2013 and INR 25 lakh in 2014–2015 (MSME-DI 2013); the total disbursed amount was INR 75 lakh in 2012–2013, and INR 24 lakh in 2014–2015 (MSME-DI 2015)
LNG Terminal Policy 2012	Subsidies provided under the policy	Energy and Petrochemicals Department	No data found for this specific indicator.
Financial incentive (subsidy/tax/loan) (renewable sector)			
RTS scheme 2012	Tax rebate for supporting rooftop solar	Gujarat Energy Development Agency (GEDA)	Tax rebates on the accelerated depreciation of 40 per cent for RTS systems in the industrial sector (Trivedi, et al. 2018)
RTS scheme 2012	Low-cost loan scheme for grid-connected RTS	Indian Renewable Energy Development Agency (IREDA)	In July 2015, IREDA launched a low-cost loan scheme for grid-connected RTS with a loan interest rate of 9.90–10.75 per cent per annum. Although this data is from Surat Municipal Corporation, the rate is presumed to apply to the whole of Gujarat (SMC 2016)
Human resources (manufacturing sector)			
PAT scheme cycle 1 (2012–2015)	Human resources input in the scheme (national-level figures only)	BEE	Capacity building on a national level (state-level figures were unavailable): 13,718 energy auditors and managers were certified; 219 energy auditors were accredited; and 53 accredited energy auditors were empanelled. Capacity building took place for over 5,000 engineers and operators (Samal, Pravatanalini 2020) (BEE n.d.)
TEQUP	Number of beneficiaries under the TEQUP scheme in Gujarat	DBT	Number of product certification units in MSME Development Institute (MSME-DI), Ahmedabad, was 173 from 2010–2011 to 2015–2016 (MSME-DI n.d.)
TEQUP	Number of participants in TEQUP programmes	DBT	156 participants (2012–2013) (MSME-DI n.d.)204 participants (2014–2015) (MSME-DI 2015) 234 participants (2016–2017) (MSME-DI 2017)
CLCSS	Number of beneficiaries till December 2017 (national-level figures only)	NABARD/ SIDBI	There were 4,081 beneficiaries till December 2017. The benefit was provided in cash (MoMSME 2018)

Source: Authors' compilation

The activity indicators, such as licensing or permitting, information collection and tracking, compliance and workshops, to implement the policies are listed in Table 4.

Table 4 Various activity indicators identified for each policy and mitigation action

Policy/ mitigation action	Activity indicator	Responsible organisation	Indicator
Licensing, permitting, and procurement functions (manufacturing sector)			
PAT scheme cycle 1 (2012–2015)	Registration system; registration fee	POSOCO and BEE	Interested DCs who have been issued ESCerts by the Ministry of Power (MoP) must register themselves with the 'Registry' (POSOCO) to become eligible (BEE 2017). There is a one-time registration fee of INR 15,000 per eligible entity for the transaction of ESCerts (CERC 2017)
PAT scheme cycle 1 (2012–2015)	Certification	BEE	Once issued, ESCerts can be traded. According to the M&V report submitted under PAT cycle 1 in Gujarat, around 551,669.6 ESCerts have been generated by 40 DCs in the state (CCD 2020)
CDM	Registration of CDM projects	MoEFCC	Registration of projects is done by the CDM executive board. About 239 projects were registered in Gujarat since inception of CDM till data was available (1 October 2018) in the UNEP database (Fenhann 2018)
LNG Terminal Policy 2012	Licensing agreement	Energy and Petrochemicals Department	In February 2015, construction firm BAM Infraconsult signed a licensing agreement with Adani Ports and Special Economic Zone (APSEZ) to install Xbloc breakwater armour units on the reclaimed land in order to protect the Mundra LNG Terminal (Hydrocarbons Technology 2020)
LNG Terminal Policy 2012	MoUs and joint ventures	Energy and Petrochemicals Department	Gujarat State Petrochemicals Corporation Limited and Adani signed an MoU to set up the Gujarat LNG Terminal during the Vibrant Gujarat Global Investors' Summit in 2007. Both of them subsequently formed a joint venture to build the LNG import terminal in Pipavav; the GoG approved this in August 2011 (Hydrocarbons Technology 2020)
PAT cycle 1 (2012–2015)	MoU in the petrochemical sector	BEE	An MoU was signed with Engineers India Limited under the PAT scheme to implement energy efficiency in the petrochemical sector (BEE 2018)
Information collection and tracking (renewable sector)			
RTS scheme 2012	Approval time for RTS PV (photovoltaic) systems	GEDA	Approximately 200 MW (megawatt) RTS PV were installed across municipal corporations and municipalities under the 12th Plan (Joshi 2012) It takes around four months to get approval for an RTS system (GoG 2016a)
Information collection and tracking (manufacturing sector)			
PAT scheme cycle 1 (2012–2015)	Documentation and verification of DCs; web portal	BEE/GEDA	Documents like PAN, TAN, and CIN are required for verification. BEE developed the PATNet portal for DCs, on which they upload forms; additionally, ESCerts can be electronically issued on the portal (BEE 2017)
Compliance and enforcement (manufacturing sector)			
PAT scheme cycle 1 (2012–2015)	Performance assessment document to be submitted; mandatory energy audit (MEA); M&V process; amount of money collected in fines for non-compliance	BEE/GEDA	DCs have to submit the performance assessment document within four months of the conclusion of the target year, specifying compliance with energy consumption norms and standards. The MEA is a compulsory energy audit conducted by DCs in their plant premises within 18 months of the notification date (BEE n.d.). The M&V is carried out after the completion of a PAT cycle to assess energy savings. The first PAT cycle ended on 31 April 2015 and 48 of the 52 DCs in Gujarat have submitted their target achievement reports. Eight of the industries have been issued 'show cause notice' for non-compliance (CCD 2020). DCs are liable to a penalty of INR 10 lakh for non-compliance with provisions (BEE 2012)

Policy/ mitigation action	Activity indicator	Responsible organisation	Indicator
LNG Terminal Policy 2012	MoEFCC and CRZ (coastal regulation zone) compliance report; No Objection Certificate (NOC) from the Gujarat Pollution Control Board; environmental impact assessment	Energy and Petrochemical Department	The Mundra LNG Terminal received environmental and CRZ clearance from the MoEFCC in 2013 (Hazira LNG Private Ltd 2017). An NOC from the Gujarat Pollution Control Board (GPCB) was complied and an EIA study was carried out for the Hazira terminal (NEERI 2012)
Workshops, symposia, and seminars (manufacturing sector)			
TEQUP support to MSMEs	Number of awareness programmes conducted (national-level figures)	DBT	A total 382 of awareness programmes have been conducted since the inception of TEQUP in 2010–2011 (MoMSME n.d.)

Source: Authors' compilation

Table 5 lists sector-wise manufacturing policies and important parameters assessed, such as GHGs covered, time period and key performance indicators for each policy.

Table 5 Key performance indicators identified for each policy and mitigation action

Sector	Policy/ mitigation action	Coverage (GHG)	Period	Relevant national action plan	Key performance indicator
Renewables	*RTS scheme 2012*	CO_2, CH_4, and N_2O emissions reduced by easing the burden on local power grids	2014–2018	*Jawaharlal Nehru National Solar Mission*	Energy (in MW) installed and generated by industrial RTS systems
Manufacturing	*PAT scheme cycle 1* (2012–2015)	CO_2, CH_4, and N_2O emissions avoided through a reduction in specific energy consumption	2012–2015	*National Mission for Enhanced Energy Efficiency* (NMEEE)	Reduction in specific energy consumption
Manufacturing	*CDM*	CO_2, CH_4, and N_2O emissions; some projects also account for reductions in NO_x and SO_x emissions	2005–2015	*CDM* (United Nations Framework Convention on Climate Change mandate)	Emissions avoided
Manufacturing	*LNG Terminal Policy 2012*	CO_2, CH_4, and N_2O carbon emissions lower per unit of energy combusted	2012 (ongoing)		Percentage of gas uptake by industries (reducing the carbon intensity in the energy mix)
Manufacturing	*Interest subsidy for technology upgradation*	CO_2, CH_4, and N_2O emissions avoided by reducing levels of energy consumption or fuel switching to cleaner energy	2004–2005 to 2013–2014	*Gujarat Industrial Policy, 2003*	Number of industrial units covered under the scheme by type of project (energy efficiency improvement vs. fuel switching); energy efficiency savings achieved; amount of subsidy disbursed

Sector	Policy/ mitigation action	Coverage (GHG)	Period	Relevant national action plan	Key performance indicator
Manufacturing	*ISO 9000*	CO_2, CH_4, and N_2O emissions avoided through reduced levels of energy consumption or fuel switching to cleaner energy	2004–2005 to 2013–2014	*Gujarat Industrial Policy, 2003*	Number of industrial units covered under the scheme; amount of subsidy disbursed
Manufacturing	*TEQUP support to MSMEs*	CO_2, CH_4, and N_2O emissions saved through reduced levels of energy consumption or fuel switching to cleaner energy	2010 (ongoing)	*National Manufacturing Competitiveness Programme* (NMCP)	Energy efficiency savings achieved; list of beneficiaries under the TEQUP scheme
Manufacturing	*CLCSS*	CO_2, CH_4, and N_2O emissions saved through modernisation	2001 (ongoing)	*Infrastructure development programme*	Total number of beneficiaries; total expenditure under the scheme

Source: Authors' analysis

5. Analytical discussion for a few key policies

This section presents a detailed analysis for few of the policies analysed and the methodology applied for estimating its GHG impact.

I. Rooftop Solar (RTS)

The increase in RTS installation is a recent phenomenon. The industrial sector seems to have responded particularly well, as shown in the analysis (refer to Table 6). The sector witnessed a steep rise in installations, with a 98 MW net increase in capacity installed between 2017 and 2018, amounting to an estimated reduction of 0.113 $MtCO_2e$ (BTI 2018). This could be attributed to the supporting instruments introduced around 2016 such as the *Net Metering Rooftop Solar PV Grid Interactive Systems Regulations* in 2016, which aimed to encourage RTS. Within the same year, the Gujarat state government rolled out guidelines prescribing a timeline for the speedier installation of RTS plants. It set a timeline of approximately four months for system setup, right from the registration process to the issuance of the commissioning certificate (GoG 2016). Industries have an advantageous position when it comes to meeting the high upfront costs of installation (approximately INR 48,300 per kWp) (kilowatt peak) (SMC 2016). The manufacturing sector contributed to around 0.316 $MtCO_2e$ of emission reduction in 2014–2018, which is higher than the amount reduced by residential and governmental buildings (0.183 $MtCO_2e$) and commercial buildings (0.114 $MtCO_2e$) (refer to Table 6).

Table 6 Estimated emission reduction from rooftop solar in Gujarat was found to be around 0.025 $MtCO_2e$

Year	Industry capacity installed (MW)	Industry estimated CO_2 reduction (MtCO$_2$e)	Commercial capacity installed (MW)	Commercial estimated CO_2 reduction (MtCO$_2$e)	Residential & govt capacity installed (MW)	Residential & govt estimated CO_2 reduction (MtCO$_2$e)
As of 31 October, 2014	9.8	0.013	12	0.016	15.1	0.020
As of 31 October, 2015	19	0.025	12	0.016	13	0.017
As of 30 September, 2016	21	0.027	17	0.022	31	0.041
As of 30 September, 2017	48	0.062	19	0.025	36	0.047
As of 30 September, 2018	146	0.189	28	0.036	46	0.059
Total est. CO_2 reduction	Total →	0.316	Total →	0.114	Total →	0.183
Estimated reduction (as of 2015)	$MtCO_2e$	0.025				

Source: Authors' analysis

II. *Perform Achieve and Trade* (2012–2015) *scheme*

For the PAT 1 cycle, around 37 DCs were identified for Gujarat excluding the power sector (MoP 2012) and covering six industrial sectors, viz., iron and steel, cement, fertiliser, pulp and paper, textile, chlor-alkali. In total, they consume about 6 million toe of energy. The iron and steel sector consume around 36 per cent of the energy, followed by the cement and fertiliser sectors, which consume 32 and 20 per cent, respectively. The total savings in energy were estimated at around 0.50 million toe, leading to an equivalent emission reduction of 2.28 million tonnes of CO_2 in Phase 1 for Gujarat (refer to Table 7).

Table 7 Estimated emission reduction was around 2.28 $MtCO_2e$ from PAT 1 scheme (2012-2015)

PAT CYCLE I – GUJARAT (2012-2015)					
Six sectors	**No. of identified DCs**	**Energy (million toe)**	**Share consumption (%)**	**Energy reduction (million toe)**	**Emissions reduction ($MtCO_2e$)**
Iron and steel	4	2.16	36.11	0.184	0.97
Cement	8	1.90	31.86	0.150	0.64
Fertiliser	4	1.18	19.71	0.101	0.32
Pulp and paper	2	0.13	2.13	0.009	0.05
Textile	12	0.27	4.59	0.025	0.13
Chlor-alkali	7	0.36	6.07	0.035	0.17
Total	**37**	**6**	**100**	**0.504**	**2.28**

Source: Authors' analysis

In terms of sector-specific energy consumption (SEC), the textile industry had the highest targeted energy reduction—around 0.10 toe per unit tonne of product (refer to Table 8). However, the median of the targeted SEC of the textile industries in the state is still significantly high compared to the national targets. This is also true for cement manufacturing plants. For the remaining sectors, the state-level targets are either at par with or lower than the national targets. There is significant potential in further increasing the targets for the textile and cement industries, in order to bring their SECs closer to the national targets. Further, benchmarking the sectoral SECs based on international best practices for similar production processes will unlock higher mitigation potential.

Table 8 Comparison of sectoral targets (median) between state and national level found that textile industry had the highest targeted energy reduction of around 0.10 toe per unit tonne of product in Gujarat

	PAT cycle 1 median targets – Gujarat			PAT cycle 1 median targets – national		
Industry type	**Baseline SEC (toe/tonne)**	**Target SEC (toe/tonne)**	**Target reduction to be achieved (toe/tonne)**	**Baseline SEC (toe/tonne)**	**Target SEC (toe/tonne)**	**Target reduction to be achieved (toe/tonne)**
Iron and steel	0.59	0.56	0.03	0.66	0.62	0.04
Cement	0.11	0.11	0.01	0.09	0.08	0.00
Fertiliser	0.37	0.36	0.01	0.53	0.37	0.17
Pulp and paper	0.61	0.58	0.03	0.66	0.63	0.03
Textile	2.22	2.12	0.10	0.70	0.66	0.04
Chlor-alkali	0.29	0.27	0.02	0.31	0.30	0.02

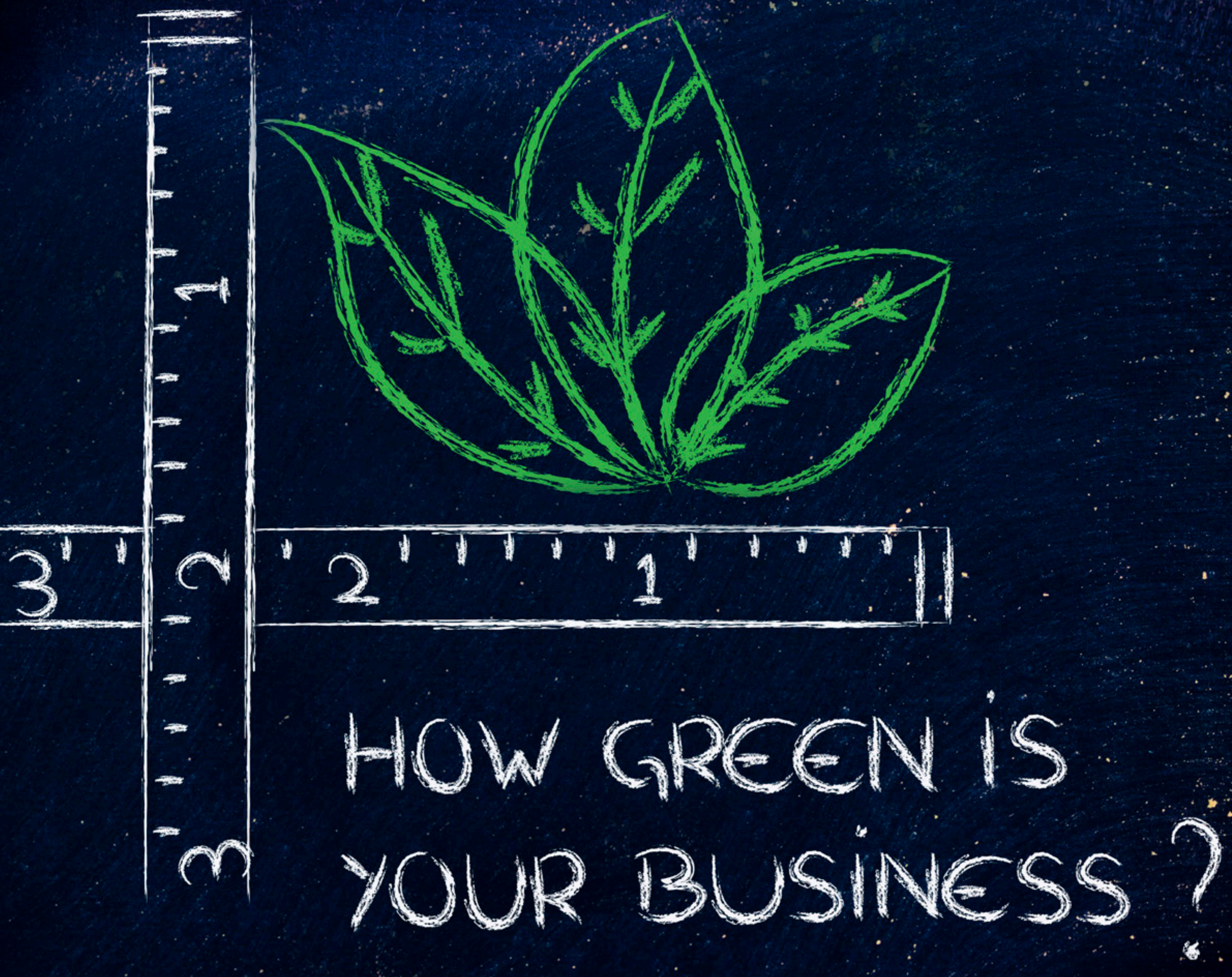
Source: Ministry of Power 2012 (b)

III. *LNG Terminal Policy 2012*

Gujarat introduced its *LNG Terminal Policy* 2012 with the particular mandate of meeting the rising demand for natural gas by developing infrastructure and expanding the natural gas market to provide clean and cheap fuel for industrial purposes (GoG 2012 (a)). Key demand drivers for gas, particularly from industries, have arisen because of its perceived benefits over other fossil fuels such as with lower carbon emissions and environmental pollution per unit of energy consumed. There has been an increasing uptake of gas over the years in the chemical and fertiliser industries where it is primarily used as a feedstock rather than the fuel. However, the majority of the manufacturing industry sectors (iron and steel, machinery, non-ferrous metals, non-metallic minerals, textile and leather) indicated an increasing trend of natural gas consumption till 2010. One can plausibly attribute this trend to higher production (hence higher availability to non-priority sectors) of domestic natural gas during the period.

IV. Other industrial policies and measures

Other industrial policies, such as the *ISO (9000) certification scheme*, interest subsidy for technology upgradation, TEQUP, and CLCSS provide assistance and subsidies for the uptake of energy-efficient technologies. This is evident from the state's budgetary support towards the industrial sector. Amongst the major industrialised states, Gujarat has the third-largest expenditure toward the industrial sector (after Tamil Nadu and Maharashtra) and second-largest expenditure toward the MSME sector (after Tamil Nadu) (Biswas, Sharma, and Ganesan 2018). However, due to the unavailability of data, the impact on emissions could not be estimated.



While regulations are important for implementation and drafting framework for policies, acceptance, and enforcement of these policies require incentives to combat the capital costs that the regulations carry.

Image: iStock

6. Key findings

This section provides the methodological assumptions undertaken to estimate GHGs and the its outcomes are shown in table 9.

Table 9 Various methodological assumptions are followed for estimation of GHG reduction for three policies and mitigation actions, whereas lack of datapoints for other policies led to inability of GHG estimation reductions

RTS scheme 2012	
Objective	To promote the development of distributed RTS PV projects.
Methodological assumption	To estimate CO_2 reduction as a result of RTS, the initial step was to convert the installed RTS capacity into energy generated by applying the formula given below, and then multiplying the energy generated with the yearly grid factor. Where: Installed capacity = installed RTS capacity Capacity utilisation factor (CUF) = 18 per cent Actual number of plant operating days = 365 Actual number of operating hours = 24 Grid factor ($kgCO_2$/kWh) = (2014 = 0.83; 2015 = 0.82; 2016 = 0.83; 2017 = 0.82; 2018 = 0.82)
Analysis	As of 30 September 2018, the manufacturing industry contributed 0.316 $MtCO_2e$ reduction in CO_2 emissions; it was 0.025 by 2015. Due to the non-availability of authentic data, emission reduction has been calculated only for the period between October 2014 and September 2018.
PAT scheme cycle 1 (2012–2015)	
Objective	To mandate specific energy efficiency improvements for energy-intensive industries by setting targets and using tradable energy-saving certificates.
Methodological assumption	Where: Specific Energy Consumption (SEC) - base year: baseline energy consumption per unit of product for the baseline year (average of three years) SEC target year: SEC for the target year 2014–2015 as per the scheme Product output: physical output (average of three years) DCs include six manufacturing sectors (cement, chlor-alkali, fertiliser, iron and steel, pulp and paper, and textile); thermal power plants are excluded from the assessment. Due to the lack of data on the specific energy consumption achieved in the target year (2015), all the DCs in Gujarat are presumed to have achieved their specific energy consumption targets. The emission reduction is estimated as the average over three years. The carbon intensity of six sectors is calculated for 2015, which is the latest available data.
Analysis	Overall, this assessment estimates a reduction of 2.28 million tonnes of CO_2 and energy savings of 0.34 Mtoe (on average over three years) from 37 DCs in Gujarat.

CDM	
Objective	To assist countries in fulfilling their commitments to reduce emissions and achieve sustainable development.
Methodological assumption	Around 22 CDM registered projects that specifically relate to energy efficiency and fuel switching activities have been identified (UNEP DTU 2019). For each project, the estimate of annual emission reduction in tonnes of CO_2e is extracted from individual project design documents available on the CDM web portal. Project documents provide a description of project activities along with an estimate of annual emission reduction. The total estimated carbon reductions for each project are calculated for the crediting years (2005–2015). See Annexure 2 for the annual estimations.
Analysis	Around 11.16 $MtCO_2e$ in emissions from 22 projects were avoided. However, this is only an estimate of the amount of emissions reduced during the project's crediting years. It is difficult to measure the actual GHG reduction, as this amount is given in the monitoring reports of individual projects, which are available only for a few years and quite irregularly. As such, this approach was not feasible. This is a major limitation associated with calculating actual GHG emission reductions from CDM projects.
LNG Terminal Policy 2012	
Objective	To provide cleaner and cheaper energy for industrial purposes, and to encourage investments in infrastructure that are suitable for the reception and re-gasification of LNG.
Methodological assumption	GHG impacts from use of natural gas could not be assessed because of the unavailability of the required data. The gas infrastructure in the state—including production and utilisation—has been assessed along with the gas consumption trend within the fuel mix in industries. As of April 2018, there are 4,551 industrial PNG connections (PPAC 2019b). There are three LNG terminals—Hazira LNG Terminal with a capacity of 5 MMTPA (million metric tonnes per annum), Dahej LNG Terminal (15 MMTPA), and Mundra LNG Terminal (5 MMTPA). Our analysis from the Annual Survey of Industries (ASI) database indicates that there has been an increase in gas uptake in the chemicals and fertiliser sector.
Analysis	We observed that the share of natural gas in the energy mix has increased for some industries, such as petrochemical and refining and chemicals and fertilisers. However, natural gas is primarily used as feedstock in the fertiliser sector. The share of natural gas in the industrial energy mix was marginal during the analysis period (2005–2015).
Interest subsidy for technology upgradation	
Objective	Provide subsidies to enable industries to improve their energy efficiency.
Methodological assumption	Estimating the GHG impact—for instance, energy savings—is not possible because the data required are not available in the public domain. Thus, information on the number of units that availed of the subsidy and the subsidy amounts is provided from 2004–2005 to 2013–2014. Further data on the types of technologies implemented were not available.
Analysis	Data for Gujarat are available from 2004–2005 to 2014–2015 for Gujarat. Overall, INR 140,708.22 lakh in interest subsidy were paid to 79,314 units between 2004–2005 and 2014–2015.
ISO 9000	
Objective	To assist in establishing and maintaining an effective quality system while adhering to statutory and regulatory requirements.
Methodological assumption	ISO 9000 certification deals with quality management systems that help organisations to establish and maintain an effective quality system while adhering to statutory and regulatory requirements. Estimating the GHG impact—for instance, energy savings—is not possible because the data required are not available. Thus, other parameters are assessed, such as the subsidy amount disbursed in the state.
Analysis	Data are provided for between 2004–2005 and 2014–2015; a total of INR 10,385.84 lakh in subsidy were provided for the quality certification (ISO 9000) of 4,489 units.

TEQUP support to MSMEs	
Objective	To encourage the use of energy-efficient technologies in MSMEs in order to reduce production costs and emissions.
Methodological assumption	Estimating the GHG impact—for instance, energy savings as a result of the uptake of energy-efficient technologies—is not possible because the data points required are not available. Thus, other parameters have been assessed, such as the number of TEQUP programmes conducted and the number of participants. Information on reimbursement of national/international product certification is available with total amounts sanctioned and disbursed.
Analysis	Overall, the number of product certification units under the MSME-DI in Ahmedabad was 173, from 2010–2011 to 2015–2016.
CLCSS	
Objective	To facilitate technology upgradation by providing 15 per cent upfront capital subsidy up to a maximum of INR 15 lakh to the micro and small-scale (MSE) units.
Methodological assumption	Estimating the GHG impact—such as improvements in energy consumption levels or fuel switching in the process of modernisation or capacity expansion—is not possible since the data required were not available.
Analysis	Subsidy of INR 42,847 lakh provided for 7,571 units from 2011–2012 to 2014–15 (up to 28 February 2015) in Gujarat.

Source: Authors' analysis

The study indicated a total emission reduction of about 13.5 $MtCO_2e$ as a result of the three polices and mitigation actions (11.16 from CDM, 2.28 from PAT 1, and 0.02 from RTS; refer Annexure 3). During the analysis period, the emission intensity of industrial output from the manufacturing sector in Gujarat marginally increased with a CAGR of 1 per cent. At the subsectoral level, the chemical and fertiliser and iron and steel industries showed an increase in emission intensity—a CAGR of 3 per cent and 9 per cent, respectively. On the other hand, non-ferrous metals, non-metallic, and machinery industries showed decreasing emission intensity trends with a negative CAGR of 8 per cent, 2 per cent, and 4 per cent, respectively (refer to Annexure 5).

Further, in our analysis, we tried to evaluate the factors influencing the emission intensity of the manufacturing sector in Gujarat, namely, the structural composition, energy intensity, and carbon intensity of the energy mix. The structural composition of the manufacturing sector, represented by the gross value-added (GVA) by the subsectors to overall manufacturing, is presented in Table 10. It can be seen that during the period, high-energy-intensive industries—iron and steel, chemicals and fertilisers, textile and leather, and non-metallic minerals (primarily cement)—showed a marginal decrease in their GVA contribution. This indicates a structural transition away from energy-intensive manufacturing. However, an increase in economic contribution can be observed from the transport equipment and machinery sectors (to some extent). However, considering the significant economic contribution (about 42 per cent) of the high-energy-intensive sectors in Gujarat, any change in the energy intensity of production or fuel switches would affect the emission intensity of the overall manufacturing sector.

Table 10 **Trends in subsectoral GVA shares in the overall manufacturing sector from 2005 to 2015**

Industry	2005 (%)	2006 (%)	2007 (%)	2008 (%)	2009 (%)	2010 (%)	2011 (%)	2012 (%)	2013 (%)	2014 (%)	2015 (%)
Chemical and fertiliser	17	15	14	16	16	15	16	16	16	17	15
Food processing, beverages, and tobacco	12	11	13	13	10%	11	12	10	11	10	11
Iron and steel	14	14	14	12	14	13	13	10	10	11	11
Machinery	17	18	20	20	20	20	21	21	20	19	18
Non-ferrous metals	3	3	3	2	3	3	2	2	2	2	2
Non-metallic minerals	5	5	6	7	5	5	5	6	5	6	7
Non-specified industry	5	5	5	6	9	7	6	6	8	7	7
Pulp, paper, and print	2	2	2	2	2	2	2	2	2	2	2
Textile and leather	12	14	12	12	10	10	10	11	13	12	10
Transport equipment	13	12	10	10	11	13	12	14	12	15	17
Wood and wood products	0	0	0	0	0	0	0	0	0	0	0

Source: Authors' analysis

Energy intensity showed a similar trend to emission intensity even at the subnational levels. At the aggregated level, it increased with a CAGR of about 1 per cent. The non-ferrous metals, machinery, and non-metallic industries (primarily cement manufacturing) showed a decreasing trend in energy intensity with a negative CAGR of 8 per cent, 8 per cent, and 2 per cent, respectively. However, the chemical and fertiliser, and iron and steel industry showed an increase in their energy intensity levels—a CAGR of about 4 per cent and 10 per cent, respectively (refer to Annexure 6).

The carbon intensity of the energy mix (also referred to as carbon intensity) across the industrial sector showed a consistent decrease until 2010 and increased to the initial levels thereafter (see Annexure 7). Figure 2 compares the carbon intensity trends of the Gujarat manufacturing sector across the two time periods—2007 to 2011 (referred to as the first period) and 2011 to 2015 (referred to as the second period).

The carbon intensity of the energy mix across the industrial sector showed a consistent decrease until 2010

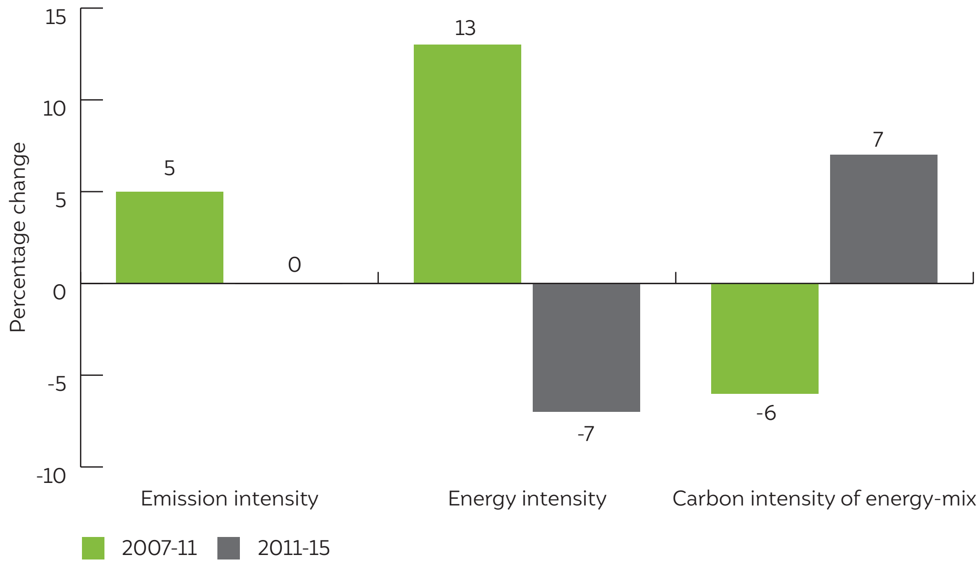


Figure 2
Intensity trends compared between 2007–2011 and 2011–2015 shows improvement in emission and energy intensity in the second period (2011-2015), implying the impact of major policies during this period, whereas carbon intensity of the energy mix shows an increasing trend

Source: Authors' analysis

It can be seen that in the first period, the emission intensity increased by 5 per cent, which was driven by a 13 per cent increase in energy intensity and a 6 per cent reduction in the carbon intensity of the energy mix. In the second period, there was no observed change in emission intensity levels. However, unlike in the previous period, the energy intensity of production showed a decrease, indicating the implementation of policy interventions. This implies that the majority of the policies enacted, such as PAT scheme cycle I, RTS scheme, and CDM, reaped GHG reduction benefits over the second half of the assessed period. However, these benefits achieved through energy efficiency improvements have been offset by the increasing carbon intensity of the energy mix. The energy mix was primarily dominated by coal with interim peaks in natural gas consumption between 2008 and 2009.

The chemical and fertiliser industry showed a consistent increase in the share of gas (3 per cent in 2005 to 23 per cent in 2015) and a decrease in the share of coal (68 per cent in 2005 to 52 per cent in 2015). This indicates a move towards adopting cleaner fuels. On the other hand, the iron and steel sector showed an increase in the utilisation of coal (48 per cent in 2005 to 83 per cent in 2015), except for 2008 and 2009 as gas consumption peaked to represent a share in the energy mix by 56 per cent and 48 per cent respectively. In the non-metallic minerals sector, coal and grid electricity have replaced petroleum fuels in the energy mix during the period. One common trend across the majority of the sectors was the sudden increase in gas consumption between 2008 and 2009. One can possibly attribute this to increased levels of domestic gas production during that period (MoP&NG 2017).

The chemical and fertiliser industry showed a consistent increase in the use of gas and a decrease in the use of coal

Overall, the majority of the fuel share is still met by coal (54 per cent in 2015); therefore, a shift towards cleaner fuels can help reduce specific energy consumption, especially by energy-intensive industries in the state. For instance, sectors like iron and steel, non-metallic minerals, paper, pulp and print, and textiles have continued to heavily rely on coal, while showing marginal uptake of natural gas.

CLEANING IN PROGRESS

Gujarat shows ambition by piloting a first-of-its-kind emission trading scheme for particulate matter. Nonetheless, the inclusion of GHG is vital for mitigation.

7. Conclusion

Although we have been able to quantify the emission reduction resulting from polices and mitigation actions, the impact on the entire manufacturing sector was not discernible. For instance, mandatory energy-saving targets like the PAT scheme have been successful in mitigating GHG emissions, but its coverage was limited to large energy consumers, as identified under the Energy Conservation Act of 2010 (Amendment). The cumulative emissions avoided from PAT scheme cycle 1 represented only about 1 per cent of the cumulative emissions for the period. Table 11 provides a snapshot of the policies and mitigation actions that have been assessed.

Policy or mitigation action	Impact—GHG emission reduction
Rooftop Solar (2012) scheme	0.025 $MtCO_2e$
PAT scheme cycle 1	2.28 $MtCO_2e$
Clean Development Mechanism	11.16 $MtCO_2e$
LNG Terminal Policy 2012	Not estimated due to lack of data
Interest subsidy for technology upgradation	Not estimated due to lack of data
Subsidy for quality certification (ISO 9000)	Not estimated due to lack of data
Technology and Quality Upgradation (TEQUP) *support to MSMEs*	Not estimated due to lack of data
Credit Linked Capital Subsidy Scheme (CLCSS)	Not estimated due to lack of data
Total GHG emission reduction	**13.5 $MtCO_2e$**

Table 11
A total of 13.5 $MtCO_2e$ was mitigated by the policies and mitigation actions assessed

Source: Authors' analysis

Reducing the existing thresholds by 30–40 per cent will unlock further potential in improving energy efficiency while avoiding a significant rise in transaction costs per unit of energy targeted (Biswas, Janakiraman, and Ganesan 2019). However, its impact on emission intensity may not be proportional, as already identified by the study. Even if energy-intensive sectors like iron and steel, cement, ammonia, and petrochemicals achieve best-in-class energy efficiency levels within the next 10 years, the cumulative emissions from these sectors between 2010 and 2050 would represent 13 per cent of the global carbon budget under the 2 degrees scenario (Biswas, Ganesan, and Ghosh 2019). Thus, this highlights the need for policy actions that aim for deep decarbonisation of the industrial sector.

RTS trends indicated a rapid deployment in the industrial sector, especially between 2017 and 2018, supported by net-metering regulations and revised guidelines on installation timelines. The fact that about 23 per cent of the energy demand of the industrial sector is met by electricity indicates the considerable potential for GHG mitigation under the RTS scheme.

Incentivising a transition to low-carbon energy sources will unlock greater emission reduction potential alongside reduced air pollution. However, coal remains the primary fuel, catering to the majority of the manufacturing sector's energy needs, and uptake of natural gas in the sector has largely been limited to two sectors—chemical and fertiliser and petroleum refineries (including petrochemicals). One of the major concerns for industries is the poor availability of a cheap and sustained supply of natural gas. In order to incentivise a transition to a cleaner energy mix, the prices of fuels need to reflect the true cost of their environmental impact. One such intervention could be levying a lower tax or rebate on natural gas and increasing the tax on polluting fuels in order to ensure no additional burden on the state exchequer.

One of the major concerns for industries is the poor availability of a cheap and sustained supply of natural gas

Of all the policies and mitigation instruments evaluated, CDM has been able to achieve the largest emission reduction. This clearly reiterates the potential of a carbon market to reduce the emission footprint of the manufacturing sector. However, we have to inculcate key learnings from the CDM and the PAT scheme to design an effective market-based programme eliminating some of the known bottlenecks like target setting to incentivise continual improvement and the high transaction costs associated with project validation and M&V.

Recently, the Gujarat Pollution Control Board even piloted an emission trading scheme to control particulate matter pollution in a selected industry cluster in the Surat region by allotting permits. Within this scheme, the industries can trade with one another to settle their allotted permit balance (GPCB 2020). Gujarat is the first state in the country to pilot such a scheme; it would further benefit the state to extend the scheme to cover GHG emissions as well. This presents an opportunity for Gujarat to be the leading industrialised state in India, both in terms of economic output and sustainable manufacturing practices.

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Annexures

Annexure 1
Impact indicator

Table 1
Estimation methods of GHG impact adopted for each policies and mitigation actions assessed

Source: Authors' analysis

Policy/ mitigation action	Impact indicator	Period	Calculation method
RTS 2012 scheme	Manufacturing industry generated energy; GHG emissions avoided from the captive generation of power.	31 October 2014 to 30 September 2018	Emissions reduction = energy generated * grid emission factor (BTI 2019)
PAT scheme cycle 1 (2012–2015)	The carbon intensity of each sector; emission reductions in each sector; energy savings; energy consumption; number of ESCerts issued.	2012-2015	First, the energy savings for each sector is calculated. Then, carbon intensity is estimated individually for each of the six sectors. Finally, emission reduction is estimated. (MoP 2012)
Clean Development Mechanism (CDM)	Amount of GHG emissions saved from CDM projects; number of CERS issued.	2005–2015	Around 22 CDM registered projects that are specifically related to energy efficiency and fuel switching activities were identified (UNEP DTU 2019). For each project, the annual estimation of emission reductions in tonnes of CO_2e is extracted from individual project design documents available from the CDM web portal. Total estimated carbon reductions are calculated for the crediting period from 2005 to 2015 (UNEP DTU 2019).
LNG Terminal Policy 2012	Unable to estimate emissions due to data limitations, hence: gas production data and consumption in industries is estimated.	2012–present	This analysis found a declining trend in the share of gas production in the state, from 3,773 million cu m to 1,403 million cu m, and a further dip to 389 million cu m in 2018. Overall, the gas consumption by the industries did not significantly rise (increasing from 1.060 Mtoe in 2005 to 2.794 Mtoe in 2015) (PPAC 2019).
Interest subsidy for technology upgradation/ subsidy for quality certification (ISO 9000)/ TEQUP/CLCSS	The GHG impact of these schemes was not discernible as the data such as energy savings achieved from these schemes is not available.	2004–2005 to 2014–2015	Parameters such as the number of subsidies provided to units, total amount sanctioned and disbursed, awareness programmes, and participants are given.

Annexure 2
Estimated annual reduction from CDM scheme

Years	Annual estimation of emission reduction in tonnes of CO_2e
2005	1,95,958.30
2006	5,33,096.17
2007	924,890.47
2008	10,49,632.72
2009	10,99,330.72
2010	11,15,663.52
2011	14,28,880.02
2012	14,35,146.27
2013	13,29,686.02
2014	10,46,790.52
2015	10,04,607.82
Total (tCO_2e) →	1,11,63,682.55
Total ($MtCO_2e$) →	11.16

Table 2
The 22 projects assessed shows an estimated emission reduction of 11.16 $MtCO_2e$ from 2005 to 2015 (with 5 $MtCO_2e$ reduced from 2005-2010 and 6 $MtCO_2e$ from 2011-2015)

Source: Authors' analysis

Annexure 3 Cumulative policy impact

Table 3 Cumulative GHG reduction of 13.5 $MtCO_2e$ is estimated from three relevant policies

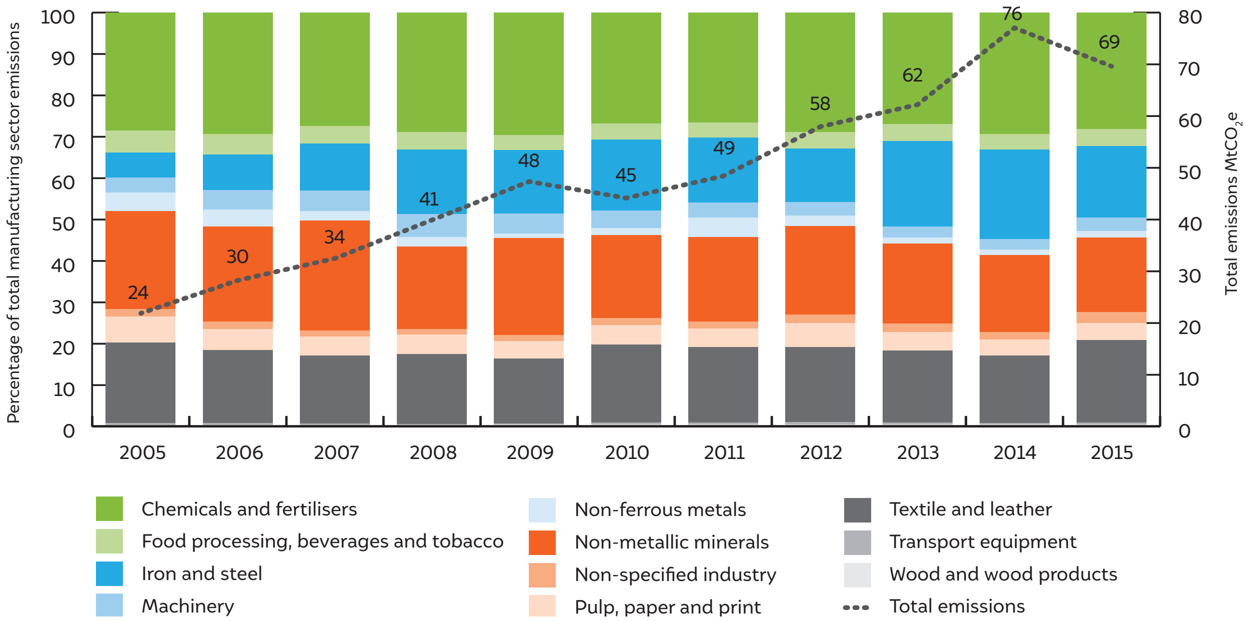
Cumulative GHG reduction from schemes												
Years assessed	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Emissions reduction ($MtCO_2e$)
Rooftop Solar scheme												0.025
PAT scheme cycle 1												2.28
CDM												11.16
Total reduction from schemes →												13.5

Source: Authors' analysis

Annexure 4
Manufacturing sector energy consumption and related emission intensity trends

The total industrial energy consumption in Gujarat increased from 5 Mtoe in 2005 to 13 Mtoe in 2015 with a CAGR of 11 per cent—higher than the national energy use emission growth rate. The chemical and fertiliser sector is the single-largest consumer of energy, roughly representing 32 per cent of the total industrial energy consumption in 2015, Followed by non-metallic minerals and textiles, both representing about 19 per cent of the total energy consumption. With a 17 per cent consumption in 2015, the iron and steel sector showed the highest growth rate (24 per cent CAGR) in energy consumption between 2005 and 2015.

Figure 1 **Emission trends of industries in Gujarat increased from 24 to 69 $MtCO_2e$ in 2005–2015**



Source: Authors' analysis

The associated energy-derived emissions increased from 24 $MtCO_2e$ to 69 $MtCO_2e$, increasing by a CAGR of 11 per cent during the period 2005–2015 (refer to Figure 1). Sectors like chemicals and fertilisers, non-metallic minerals, textile and leather, and iron and steel contributed around 84 per cent of the share of emissions during 2015, and these sectors have also shown a significant increase in emissions. Emissions from the chemical and fertiliser sector increased from 7 $MtCO_2e$ to 19 $MtCO_2e$ between 2005 and 2015, with a CAGR of 11 per cent during this period; on the other hand, iron and steel showed a 12-fold increase in emissions, from 1 $MtCO_2e$ to 12 $MtCO_2e$, with CAGR of 24 per cent in the same time period. Textiles, which is an important industry in Gujarat (it contributes to a significant share in the exports), has shown a three-fold increase from 5 $MtCO_2e$ to 14 $MtCO_2e$. The non-metallic mineral sector doubled its emissions over this period, with an increase in CAGR of 8 per cent.

Annexure 5

Emission intensity trends in Industries in Gujarat (tCO_2e/million INR production output) from 2007-2015

Industry	2007	2008	2009	2010	2011	2012	2013	2014	2015
Non-metallic minerals	90.35	90.97	92.44	82.69	79.02	75.49	78.83	85.37	79.98
Pulp, paper and print	39.54	38.05	36.27	36.54	36.73	40.39	42.79	45.19	41.05
Textile and leather	32.14	32.22	32.43	32.25	31.23	30.33	30.28	32.24	33.31
Iron and steel	17.17	23.03	32.63	36.37	33.86	29.66	32.94	37.01	34.65
Chemicals and fertilisers	12.95	14.27	15.37	15.31	14.68	14.55	15.24	17.56	16.77
Non-ferrous metals	12.12	9.53	7.45	7.29	9.70	11.63	11.61	8.27	6.37
Wood and wood products	5.46	6.33	7.52	8.32	8.43	8.42	9.08	11.79	13.50
Food processing, beverages and tobacco	6.13	5.52	5.12	5.07	5.22	5.47	5.75	6.28	6.11
Machinery	5.51	6.01	6.19	5.96	5.04	4.29	4.03	3.99	3.84
Transport equipment	2.70	2.61	2.36	2.42	2.73	3.76	4.60	5.67	5.98
Non-specified industry	4.41	4.37	4.05	3.76	3.38	3.26	3.30	3.00	3.05

Source: Authors' analysis

Emissions intensity
2.36 – 92.44

Annexure 6

Energy intensity trends in industries in Gujarat (toe/million INR) from 2007-2015

Industry	2007	2008	2009	2010	2011	2012	2013	2014	2015
Non-metallic minerals	19.97	20.13	21.05	18.97	17.89	16.68	17.28	18.64	17.12
Pulp, paper and print	8.40	8.14	7.81	7.86	7.83	8.52	8.95	9.41	8.50
Iron and steel	3.11	4.74	7.77	9.11	8.27	6.22	6.53	7.33	6.85
Textile and leather	6.20	6.38	6.76	6.91	6.67	6.24	6.04	6.33	6.47
Chemicals and fertilisers	2.79	3.29	3.70	3.68	3.36	3.06	3.25	3.99	3.88
Non-ferrous metals	2.65	2.07	1.63	1.69	2.27	2.67	2.64	1.79	1.32
Wood and wood products	0.70	0.83	1.10	1.30	1.39	1.37	1.39	1.65	1.75
Food processing, beverages and tobacco	1.09	1.00	0.93	0.91	0.90	0.92	0.97	1.07	1.02
Machinery	0.95	1.11	1.20	1.15	0.89	0.65	0.56	0.53	0.49
Transport equipment	0.35	0.32	0.29	0.30	0.35	0.47	0.56	0.64	0.64
Non-specified industry	0.40	0.44	0.47	0.47	0.40	0.34	0.34	0.32	0.33

Source: Authors' analysis

Energy intensity
0.29 – 21.05

Annexure 7
Carbon intensity trends in industries in Gujarat (tCO_2e/toe) from 2007-2015

Industry	2007	2008	2009	2010	2011	2012	2013	2014	2015
Non-specified industry	11.00	10.04	8.84	8.05	8.69	9.73	9.77	9.50	9.16
Transport equipment	7.79	8.28	8.25	8.15	7.75	7.94	8.15	8.85	9.36
Wood and wood products	7.81	7.69	7.20	6.53	6.10	6.15	6.57	7.09	7.71
Machinery	5.80	5.49	5.22	5.30	5.93	6.66	7.18	7.62	7.89
Food processing, beverages and tobacco	5.60	5.53	5.51	5.60	5.81	5.95	5.93	5.88	5.99
Textile and leather	5.18	5.06	4.83	4.67	4.69	4.86	5.01	5.09	5.15
Iron and steel	5.50	5.12	4.52	4.05	4.26	4.86	5.08	5.09	5.17
Pulp, paper and print	4.71	4.67	4.64	4.65	4.69	4.73	4.78	4.81	4.83
Non-ferrous metals	4.75	4.73	4.63	4.31	4.26	4.38	4.48	4.66	4.83
Non-metallic minerals	4.52	4.51	4.39	4.37	4.44	4.53	4.56	4.58	4.69
Chemicals and fertilisers	4.67	4.35	4.19	4.19	4.45	4.75	4.70	4.45	4.36

Source: Authors' analysis

Carbon intensity
4.05 – 11.00

For Gujarat, there is an inherent need to rethink, reassess and redesign strategies to decarbonise the manufacturing sector without compromising on its economic development.

Image: iStock

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