The IEA CHP and DHC Collaborative

CHP/DC Country Scorecard: India

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Executive Summary

In 2011, India was the world's third largest consumer of energy,[1] and its rapid economic and population growth have driven steady increases in energy demand. The availability of clean and affordable energy and electricity has become a growing concern for the Indian Government, as well as for end users. In order to mitigate the climate effects of increasing demand, in 2009 India set a voluntary target to reduce the greenhouse gas (GHG) emissions intensity of its gross domestic product (GDP) by 20% to 25% over the 2005 levels by 2020.[2] In fact, India's CO_2 intensity has improved already by 7% between 2005 and 2011.[3]

The Indian government has focused its efforts on energy demand management through policy measures to encourage energy efficiency in various sectors. Policymakers in India have an opportunity to assess in more detail the role that combined heat and power (CHP) and district cooling[4] (DC) technologies could play in sustainably meeting energy demand through the efficient use of locally available energy sources to generate power and thermal energy.

India has increased its support for CHP in targeted industries, especially bagasse-based applications in the sugar industry, setting a strong base on which to build future policy opportunities. In 2012, India exceeded by 14% its 1.2 gigawatt (GW) target for additional bagasse-based CHP capacity set by Eleventh Five Year Plan (2007 to 2012), with a total bagasse-CHP installed capacity of 2.3 GW in March 2013. The Indian government continued this strategy, setting a target of 2.0 GW in additional bagasse-based CHP capacity during the Twelfth Five Year Plan (2012 to 2017). However, policy support for non-bagasse CHP is limited, despite significant potential in other applications. One study estimates over 14 GW of industrial CHP potential in a wide range of sectors, with more than 9 GW outside the sugar industry.[5]

Some recent CHP projects have demonstrated the feasibility and benefits of these applications. A natural gas-fired CHP unit in a hospital in New Delhi, for example, supplies power, heating and cooling, achieving 69% overall efficiency, and providing an estimated annual savings of INR 13 million.[6] At present, there are few DC systems in India. A few high-profile DC projects, including those at Gujarat International Finance Tec-City and DLF Cybercity, could raise awareness of the benefits of these integrated systems.

However, comprehensive information on installed capacity of CHP and DC is difficult to obtain due to a lack of centralised data collection, making it difficult to assess in detail the overall potential for further deployment of these technologies in the country. Key actions going forward should include standardising data collection on CHP and DC deployment in India, improving strategic planning for thermal and electricity infrastructure development and taking a wider perspective in CHP promotion to include a broader range of technologies and feedstocks. These actions can contribute to the Indian government's strategic energy goals of providing reliable energy access and improving energy security.

The intent of this report is to summarise the current status of CHP and DC applications in India, to review the impact that government policies have had on CHP and DC uptake, and to offer possible solutions to the barriers identified.

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[1] IEA, 2013c.

[2] Planning Commission, 2011.

[3] IMF, 2013; IEA analysis. GDP data based on PPP (purchasing power parity) valuation of country GDP in billions of 2012 dollars and CO2 emissions calculations from IEA. CO2 emissions are calculated based on the IPCC Tier 1 sectoral approach.

[4] In this report, *district cooling* refers to systems that allow cooling to be distributed among end users within a local network.

[5] Singh, et al., 2013.

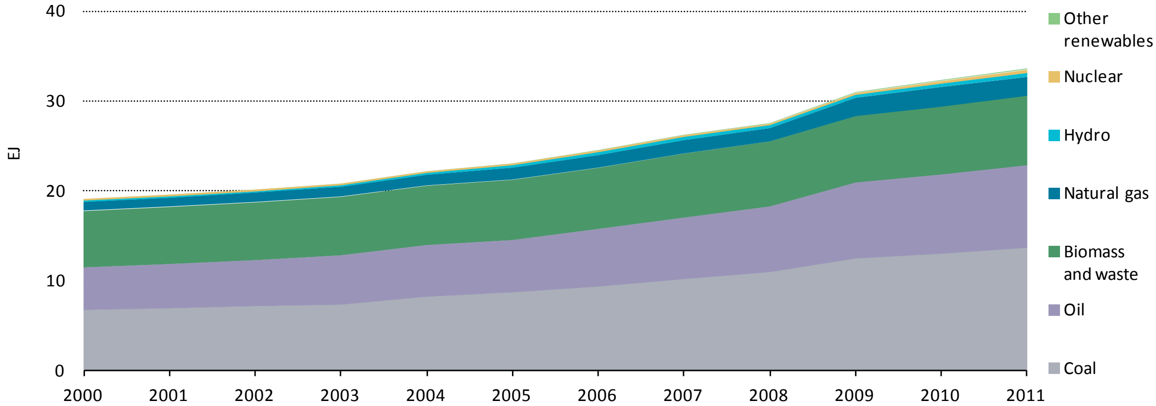
[6] Shukla, 2012.

Energy Overview

Over the decade from 2001 to 2011, India's GDP growth rate was twice the global GDP growth rate,[7] giving rise to increasing energy demand and GHG emissions, though GDP growth in India has fallen dramatically in 2012 and 2013. This rapid growth poses a challenge for India, straining its energy resources and requiring new strategies for sustainably meeting the energy needs of its 1.2 billion people.

As a net importer of fossil fuels, India faces particular challenges with respect to availability, reliability, and price of its fuel supplies. Primary energy demand in India has more than doubled in the last two decades with coal as the largest energy source. Power generation and the steel industry have been the largest consumers of coal, while the rapid growth of the transportation sector has increased demand for oil in recent years. About 25% of India's primary energy needs are met through combustible renewables and waste, used for cooking in almost 800 million Indian households.[8] However, traditional biomass cooking can be highly inefficient and can release hazardous air pollutants into the local atmosphere. India also has significant hydropower potential – currently it represents just 1.5% of total primary energy supply (17% of utility-owned installed power capacity), as environmental and social acceptance barriers have slowed its growth.

Figure 1 • India's total primary energy supply by energy source



Note: Unless otherwise noted, all tables and figures derive from IEA data and analysis.

Source: IEA (2013), *Energy Balances of Non-OECD Countries (2013 Edition)*, OECD/IEA, Paris.

Key message • Coal is India's main source of primary energy.

Currently, the Gas Utilization Policy, which allocates of the limited domestic gas supply in India among the different end-use sectors, prioritises the fertilizer and petrochemical industries above other users, including power plants. It also prioritises existing projects over greenfield projects.[9] The chemicals and petrochemicals industry accounted for only 13% of final industrial energy use[10] in India in 2011.

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[7] From 2001 to 2011, India's GDP grew by 7.4% on a Compound Annual Growth Rate (CAGR) basis, compared to a global average of 3.5%. These growth rates were calculated using GDP data based on PPP (purchasing power parity) valuation of country GDP in billions of 2012 international dollars.

IMF, 2013; IEA analysis.

[8] Central Statistics Office, Government of India, 2014.

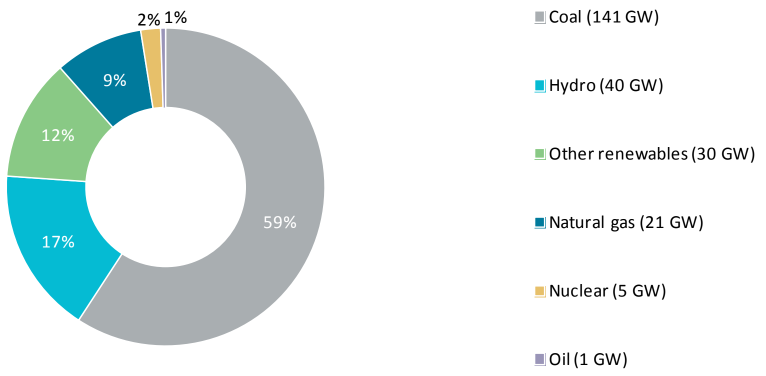
[9] IEA, 2010.

[10] Includes blast furnace and coke oven energy use in iron and steel and energy use as feedstock in petrochemical plants.

Electricity generation

In January 2014, the total utility-owned installed electricity generation capacity of India was 234 GW.[11] Almost 55 GW[12] of capacity were added during the Eleventh Five Year Plan (2007 to 2012), falling short of the 79 GW target. Despite various government initiatives designed to reduce the gap between power supply and demand, the country faced an overall power supply deficit of 9% and a peak demand shortage of 9% in fiscal year (FY) 2011-12.[13] As shown in Figure 2, in January 2014, coal was the dominant fuel used for electricity generation in India at 59% of installed capacity. Although the Twelfth Five Year Plan (2012 to 2017) estimates that 59% of the targeted additional capacity of 100 GW will be coal-based, the Indian government has incentivised the use of other fuel sources, primarily due to concerns about growing coal imports [160 megatonnes (Mt) in 2012][14] and sustainability issues. Gas-based power plants account for around 20 GW, or 9% of the total installed capacity in India.[15] The use of gas for electricity generation is limited by insufficient domestic production and high costs of imported gas that cannot be absorbed easily in the power sector. Domestic gas production increased at an average annual rate of 8.4% in the period 2000 to 2010 and suffered a drastic reduction of 9.3% in 2011.[16] Therefore, natural gas is not expected to gain in share of fuel input for electricity generation.[17] Electricity generation capacity from non-hydro new and renewable sources[18] has recently increased significantly; from an installed capacity[19] of 11 GW at the end of FY 2007-08, it has more than doubled by FY 2011-12 to 24 GW, largely driven by wind capacity additions. New policies, such as the Jawaharlal Nehru National Solar Mission (JNNSM), clearly highlight the desire to diversify the fuel inputs for electricity generation beyond conventional sources.[20]

Figure 2 • Fuel mix of utility-owned installed power capacity in India, February 2014



Note: Includes only utility-owned installed power capacity.

Source: Central Electricity Authority, Government of India (2014), *Monthly CEA Report for February 2014,* www.cea.nic.in/reports/monthly/inst_capacity/feb14.pdf.

Key message • Coal continues to dominate the fuel mix for electricity generation.

[11] Central Electricity Authority, Government of India, 2014.

[12] Central Statistics Office, Government of India, 2013.

[13] Central Statistics Office, Government of India, 2013.

[14] IEA, 2013b.

[15] Central Electrical Authority, Government of India, 2014.

[16] Central Statistics Office, Government of India, 2013.

[17] IEA, 2013d.

[18] New and renewable sources includes industrial and urban waste.

[19] Includes utility-owned capacity only. Central Statistics Office, Government of India, 2014.

[20] ESMAP and the World Bank, 2013.

Of total electricity consumption in FY 2011-12, the industrial sector had the largest share (45%), followed by residential (22%), agricultural (17%), commercial (9%) and others (7%).[21] Within the industrial sector, captive power generation[22] plays a key role, providing the necessary infrastructure to end-users who cannot access the electricity grid or are constrained by the grid's unreliable performance. In FY 2011-12, captive generation capacity accounted for 15%[23] of the total installed generation capacity.[24] As of the end of FY 2012-13, the total captive generation capacity was 43 GW.[25]

[21] Central Statistics Office, Government of India, 2013.

[22] The term "captive" refers to generation capacity that provides electrical or thermal energy (or both) primarily for own use, typically meeting on-site demand.

[23] Captive generation capacity includes plants with a capacity greater than 1 MW.

[24] Central Statistics Office, Government of India, 2013.

[25] Central Electricity Authority, Government of India, 2013.

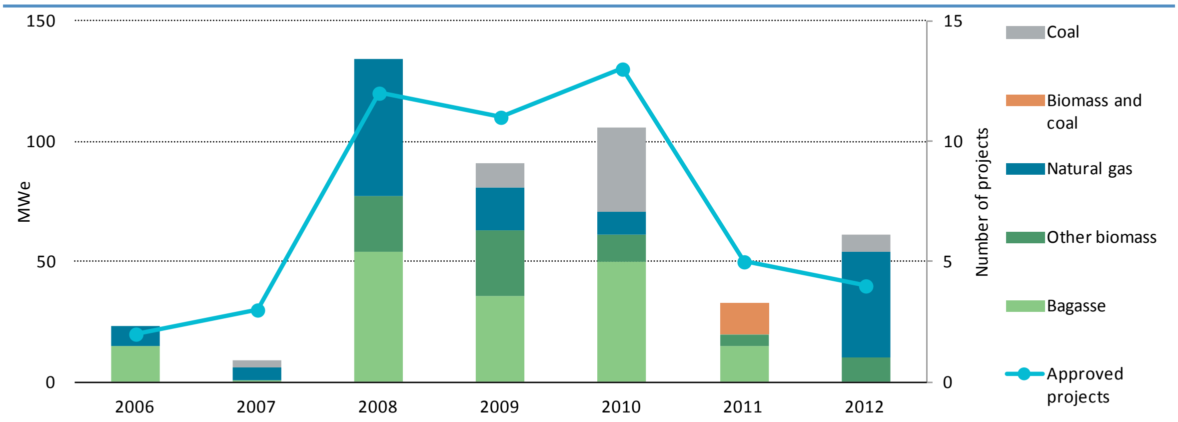
Climate Change Context

In 2011, India's per capita carbon dioxide (CO_2) emissions were 1.4 tonnes of carbon dioxide (tCO_2) compared to 4.5 tCO_2 per capita for the world.[26] India's Ministry of Environment and Forests projects per capita greenhouse gas emissions to rise to 2.1 tonnes of carbon dioxide equivalent (tCO2-eq) in 2020 and 3.5 tCO_2-eq per capita in 2030.[27]

India is a Non Annex-I country and therefore has no binding commitment to reduce its emissions under the Kyoto Protocol regime. However, citing energy security, sustainable development and the advantages of using financial mechanisms under the Kyoto Protocol, the Indian government has announced a goal of reducing the GHG emissions intensity of its GDP by 20% to 25% relative to 2005 levels by 2020.[28]

India has also participated actively in the Clean Development Mechanism (CDM) of the Kyoto Protocol with a total of 1 006 CDM projects registered as of December 2013. Of the registered projects, 50 CHP-based CDM projects have been approved,[29] the majority of which are based on bagasse and other biomass. The total GHG mitigated due to CHP projects registered under the CDM mechanism in India is 2.5 megatonnes of carbon dioxide per year ($MtCO_2$/year).[30] CHP projects under the CDM in the country peaked in 2010 with 13 projects registered, and their numbers declined to 4 projects in 2012 towards the end of the first Kyoto Protocol commitment period (Figure 3). Globally, projects under the CDM have decreased in recent years, mainly due to low Certified Emission Reduction (CER) prices and the uncertainty of future climate negotiations. In February 2014, prices of some CER futures, which as recently as June 2011 reached more than EUR 12/tCO_2-eq, dropped below EUR 0.50/tCO_2-eq due to lack of demand.[31]

Figure 3 • Approved CHP-based CDM projects in India by electrical capacity and fuel, 2006 to 2012



Note: Capacity information was not available for one bagasse-based project in 2011.

Source: National CDM Authority , Government of India (2014), "No. of approved reports", www.cdmindia.gov.in/approved_projects.php?n=1, accessed 4 March 2014.

Key message • Additional CHP-based CDM capacity in India peaked in 2008 and is mostly fuelled by bagasse and other biomass.

[26] IEA, 2013a.

[27] Ministry of Environment and Forests, Government of India, 2009.

[28] Planning Commission, 2011.

[29] National CDM Authority, Government of India, 2014.

[30] These values are calculated according to standard CDM methodology, and reported to the National CDM Authority in India. National CDM Authority, Government of India, 2014; UNFCCC, 2013.

[31] Intercontinental Exchange Group, Inc., 2014.

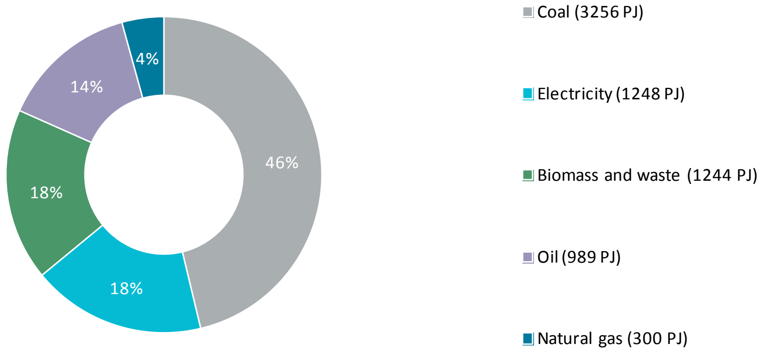
CHP Status: Technology, Applications and Market Activity

Recent studies or estimates of the current total CHP installed capacity in India are not available. The Indian government reported a cumulative CHP capacity of 3.0 GW based on bagasse and non-bagasse biomass by the end of 2013.[32] In a 2008 publication, the IEA estimated a total CHP installed capacity in 2005 of 10 gigawatts electric (GW_e) in India.[33] DC in India is limited to a few existing and proposed projects accounting for 69 MW capacity[34]; though there is potentially scope for much larger application if the necessary framework conditions are established.

Industrial applications

The implementation of CHP systems in industrial facilities can provide additional revenues for the industries derived from selling excess power to the grid, providing opportunities to reduce externality costs. In India, CHP in industry has been primarily based on internally produced fuel, industrial residue or waste, such as bagasse in the sugar industry, and on conventional fuels, such as coal. Although specific data on fuel use in industrial CHP is unavailable, 60% of overall industrial energy demand, as shown in Figure 4, is met by coal and oil, and 18% comes from biomass and waste.

Figure 4 • Industrial energy demand by fuel in India, 2011



Source: IEA (2013), *Energy Balances of Non-OECD Countries (2013 Edition)*, OECD/IEA, Paris.

Key message • Almost 20% of industrial energy demand is met by biomass and industrial residue or waste such as bagasse in the sugar industry.

Currently, CHP is most commonly deployed in India in the sugar industry. In FY 2010-11, India was the second largest producer of sugarcane in the world, with 527 working sugar mills crushing around 240 Mt of cane per year and generating 80 Mt of wet bagasse, around 70 Mt of which are used for generating captive heat and power.[35] In March 2013, 213 sugar mills had a combined installed capacity of 2.3 GW of bagasse-based CHP, producing an estimated 4 gigawatt hours (GWh) per megawatt (MW) of capacity annually.[36] However, the sugar industry plays a relatively

[32] MNRE, 2014a.

[33] IEA, 2008.

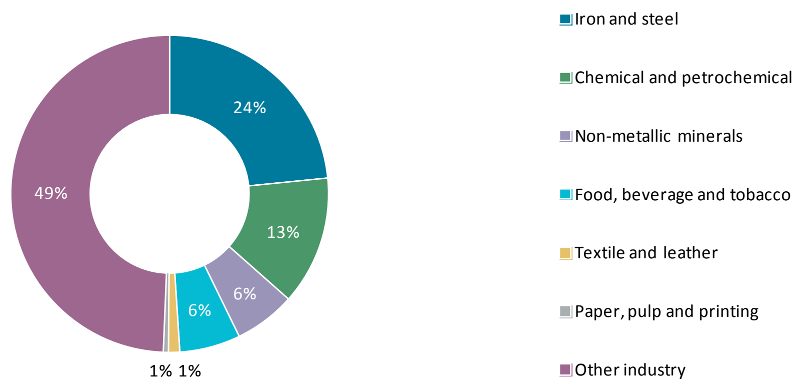
[34] Includes GIFT City and proposed NDMC system; capacity not available for DLF Cybercity.

[35] Press Information Bureau, Government of India, 2012.

[36] Press Information Bureau, Government of India, 2013.

small role in industry in India; in 2011, the food processing, beverages and tobacco sector, of which sugar makes up a large part, accounted for only 6% of total final industrial energy use[37] in India.

Figure 5 • Industrial energy consumption in India by sub-sector, 2011



Source: IEA (2013), *Energy Balances of Non-OECD Countries (2013 Edition)*, OECD/IEA, Paris.

Key message • The chemical and petrochemical sub-sector, which represents 13% of total industrial energy use, has the highest priority for allocation of domestically-produced natural gas.

CHP has also been deployed in other industrial sectors such as the chemicals and textile industries. Because the fertilizers and petrochemicals industrial sectors are given higher priority for allocation of lower-priced domestically produced natural gas from state-owned companies than other industrial sectors and utility-owned power plants,[38] CHP could be more economically feasible in the chemicals industry.

The Indian government also reported a cumulative biomass-based captive CHP capacity of 510 MW as of 2013 - excluding bagasse (Figure 6).

Figure 6 • Captive CHP capacity based on biomass (non-bagasse) in India, 2007 to 2013

Note: Data as of 31 December in each year, except for 2008 (as of 31 January 2009).
Source: MNRE, Government of India (2014a), "Akshay Urja", http://mnre.gov.in/mission-and-vision-2/publications/akshay-urja/.

Key message • Cumulative non-bagasse biomass CHP capacity amounted to 510 MW at the end of 2013.

[37] Includes blast furnace and coke oven energy use in iron and steel and energy use as feedstock in petrochemical plants.
[38] IEA, 2010.

Data on current deployment levels of CHP in energy-intensive industry is limited, which makes assessing the overall status of CHP in industry difficult. CHP deployment has been studied primarily in the sugar industry for bagasse-based plants; visibility of other industrial sub-sectors is limited. However, there are some examples of CHP applications in industry, though more data is needed to gain a fuller understanding of the status of CHP in Indian industry.

Anecdotal examples suggest that CHP deployment has made some progress in industry. Recently, the Director General of the National Council for Cement and Building Materials has reported that about 110 MW of CHP capacity is installed in Indian cement plants to date.[39] Similarly, some reports indicate that CHP has already been widely implemented in industries such as pulp and paper and chemicals, though quantitative analysis on this topic has been limited to date.[40] For example, the Vadodara facility of Gujarat State Fertilizers & Chemicals, Ltd., has achieved substantial energy savings, as well as improving electricity self-sufficiency, after the installation of a combined cycle CHP plant consisting of a 30 MW gas turbine, 125 tonnes per hour (TPH) waste heat recovery boiler and 20 MW steam turbine in 1996.[41]

[39] International Cement Review, 2013.

[40] Malhotra, 2007.

[41] Pandya, 2007.

Box 1 • Case Study 1 – Bagasse CHP projects in Maharashtra cooperative sugar factories

Bagasse-based CHP projects have become widespread in the Indian sugar industry not only for meeting onsite power requirements but also for increasing revenues through exports of excess power. Three such initiatives consisting of bagasse CHP projects in three cooperative sugar mills are located in the state of Maharashtra in India: the Malegaon, Someshwar and YM Krishna Sahakari Shakar Karkhana (SSK) (sugar cooperatives). The CHP projects help the cooperatives to meet growing energy needs due to expansion by replacing high-cost grid power[42] and reducing fuel requirements. All three cooperatives decided to undergo modernisation projects by replacing their existing steam systems with higher-pressure ones [reaching 67 kilograms per square centimetre (kg/cm^2) to 87 kg/cm^2], with the following technology characteristics:

- Malegaon SSK installed boilers rated at 80 tonnes per hour (TPH) and 40 TPH and two steam turbines: one is a 14 MW back-pressure steam turbine and the second is a 7 MW double-extraction condensing turbine.
- The Someshwar SSK installed a boiler of 100 TPH and an 18 MW extraction condensing steam turbine.
- The YM Krishna SSK commissioned a 90 TPH boiler and a 16 MW double-extraction condensing turbine.

The CHP units in the three cooperatives were financed through a mix of debt and equity. The average investment for the three projects was about INR 45 million per MW (USD 736 000 per MW). The Ministry of New and Renewable Energy (MNRE), and various other financial institutions, such as the Sugar Development Fund (SDF) and the National Cooperative Development Corporation (NCDC), provided support to the Maharashtra sugar cooperatives for this project.

During the crop season, while meeting heat demand from the sugar plants, excess power produced along by the CHP units is primarily exported to the grid and sold to distilleries. During the off-season, when heat and power needs at the sugar plants are lower, the CHP installations only provide heat and electricity for self-consumption.

Malegaon SSK exported 67% of the electricity it produced during the milling season, Someshwar SSK exported 68% and YM Krishna SSK, 78%. Because of the higher agreed sale price for exported electricity compared to other mills, and effective management of internal energy use leading to higher volume of electricity exports, YM Krishna SSK is expected to generate greater returns for its farmer members than the other two cooperatives.

Note: USD 1 = INR 61.11
Source: MNRE and UNDP, 2010.

[42]According to a study by the PHD (Progress Harmony Development) Chamber of Commerce and Industry, electricity tariffs in Maharashtra are among the highest in India. For industrial and commercial users (*non-domestic users*), In FY 2011-12, the average peak tariff was the third highest of the 26 states studied, at INR 8.10/kWh, and increased by almost 35% to INR 10.90/kWh in FY 2012-13, becoming the highest tariff in any of the 26 states studied.

PHD Chamber of Commerce and Industry, 2013.

Table 1 • Case study 1 – Power distribution of the Maharashtra sugar cooperatives

Cooperative	CHP capacity (MW)	Crop season				Off season	
		CHP auxiliary consumption (MW)	Power to sugar plant (MW)	Power sold to distillery (MW)	Power exported to grid (MW)	CHP auxiliary consumption (MW)	Power to sugar plant (MW)
Malegaon SSK	21.0	6.3	0.8	13.1	0.9	0.8	5.1
Someshwar SSK	18.0	1.8	4.0	0.3	11.9	1.8	0.3
YM Krishna SSK	16.0*	1.5	4.0	11.0	1.5	0.6	14.0

*The YM Krishna SSK has future plans to expand to 30 MW.

Source: MNRE, Government of India and UNDP (United Nations Development Programme) (2010), "Comparative analysis of co-operative owned cogeneration units in Maharashtra", *Bioenergy India*, Issue 5, pp. 10-15.

Small–scale CHP applications

The use of CHP-based space cooling has been increasing in commercial buildings aiming to achieve higher efficiencies and operation cost reductions. IEA estimated 164 petajoules (PJ) of energy consumption for space cooling in India in 2011, up from 60 PJ in 2000. Some of this demand was likely served by chilled water-based central systems – a target market for CHP-based space cooling based applications.

Some large project developers have taken up CHP projects as measures to secure reliable power supply and reduce electrical load for air conditioning. For example, DLF Limited, the largest commercial real estate company in India, has installed a gas-based CHP unit at its Infinity Tower project. Recovered flue gases from the CHP unit are used to run vapour absorption machines (VAMs) reducing the electrical load of the building to 10 megawatts electric (MW_e) and saving 1 gigawatt hour (GWh) annually. By 2010, DLF had installed 200 MW of CHP capacity in commercial and residential applications and plans to deploy about 500 MW additional capacity by 2015.[43]

[43] Vashishtha, S., 2010.

Box 2 • Case Study 2 – CHP project in Jai Prakash Narain Apex Trauma Center, All India Institute for Medical Sciences (AIIMS), New Delhi

This project is part of the Indo-German Trigen Project jointly implemented by the Bureau of Energy Efficiency (BEE) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation) (GIZ) under the Indo-German Energy Programme (IGEN). New Delhi has ambient temperatures of over 40°C during summer, which increases the air conditioning load during the day. In addition, the city frequently experiences power shortages. The objective of the project is to demonstrate the efficient generation of electricity, heating and cooling by setting up a CHP based plant at Jai Prakash Narayan Apex Trauma Centre, AIIMS, a government hospital in New Delhi. The project, which was commissioned in May 2012, provides electricity, cooling from vapour absorption machines (VAMs) and warm water to the hospital.

Figure 7 • Jai Prakash Narain Apex Trauma Center, AIIMS, New Delhi

A natural gas-fired CHP unit with 347 kilowatts electric (kW_e) of capacity is sufficient to meet the facility's power requirements. The hospital's cooling capacity of 1.3 megawatts thermal (MW_{th}) is met by the VAM, and the heating capacity for warm water supply for the kitchen and laundry is equivalent to 20 kW_e.

The project has an estimated payback period of just over 3 years, and the annual savings in avoided grid power purchases is about INR 13 million (USD 0.21 million). The Indo-German Trigen project aims to demonstrate the economic and technical feasibility of CHP-based power, heating and cooling generation, and increase experience with this technology in India. It also aims to raise awareness among decision makers in the public and private sectors of the energy security, environmental impact and energy reliability advantages of CHP, and encourages Indian suppliers to assess this technology as a market opportunity.

Note: USD 1 = INR 61.11
Source: Shukla, A., 2012.

Table 2 • Case study 2 – Energy performance of the CHP unit at the Jai Prakash Narain Apex Trauma Center (AIIMS)

	Fuel/Use	TJ	% of Input
Input	Natural Gas *	28.4	-
Output	Electricity	10.5	37%
	Cooling	8.9	31%
	Heating	0.2	1%
Overall efficiency			**69%**

* A natural gas pipeline was constructed to the hospital to make gas available for this project.

Sources: Shukla, A. (2012), "Trigeneration: Energy efficiency in the Indian building sector", Indo-German Energy Programme (IGEN), May 2012, www.emt-india.net/Presentations2012/Indo-GermanSymposium2-3May2012/Session1_Anant.pdf; Shukla, A. (n.d.), "Indo-German Trigeneration Project", www.giz.de/en/worldwide/15856.html.

District cooling applications

District cooling systems allow cooling to be produced, either from heat via absorption or from natural cooling from atmospheric and water-based sources, and then distributed among end-users within a local network. Efficiently operated DC can have significant energy and environmental benefits over conventional cooling. These systems are well-suited to areas of high population density, and can be especially useful when integrated with district heating networks, locally available thermal energy sources, such as renewable sources or industrial surplus heat, and efficient generation technologies, such as CHP. Global deployment is currently limited, though some regions have successfully reached high levels of penetration. In many regions, a few major barriers, including high up-front costs of building new infrastructure or renovating old equipment, combined with lack of data and strategic planning for thermal energy needs, have limited investment in DC systems.

In India, high capital costs, lack of government incentives and inexperience with district cooling technology are some of the main reasons for its limited deployment. Work is underway on the Gujarat International Finance Tec-City (GIFT City), which will have the country's first public DC system with 35 MW of cooling capacity.[44] Similarly, the DLF Cybercity Special Economic Zone (SEZ) in Gurgaon provides a DC system that is distributed to all buildings within the district, through central underground vents.[45] The New Delhi Municipal Council (NDMC) is also considering installing a DC system in a central commercial district, which would integrate a 16 MW CHP unit with 34 MW of cooling capacity based on VAMs and electrical chillers.[46]

[44] GIFT City, 2011.

[45] DLF Cybercity, n.d.

[46] GIZ, 2010.

Government CHP and DC Promotion Policies

There are several federal and state level policies and regulations that could positively impact the deployment of CHP and DC systems. Table 3 provides a timeline of the more recent main policy and regulatory developments related to these technologies including the policy programmes that explicitly promote CHP deployment. DC applications could potentially benefit from energy efficiency policies, but have not been specifically promoted at the national level.

Central government CHP promotion policies

The Ministry of New and Renewable Energy (MNRE) of India actively promotes the deployment of captive CHP through bagasse and biomass (non-bagasse) specific programmes. The federal government also provides capital subsidies for bagasse-based CHP in the private sector or in sugar mill cooperatives, through the Central Financial Assistance (CFA) scheme of the Bagasse Cogeneration Programme of 2005.

The Indian Renewable Energy Development Agency (IREDA) provides loans for setting up biomass power and bagasse CHP projects. Additionally, the central government has several innovative market-based mechanisms such as the Perform, Achieve and Trade (PAT) programme under the National Mission for Enhanced Energy Efficiency (NMEEE) and the Renewable Energy Certification scheme. PAT, which identifies CHP implementation in industries as an important measure for reducing the energy intensity of industry, is based on mandated reductions in specific energy consumption in energy-intensive industries that can be met with tradable energy reduction certificates. Similarly, the Renewable Energy Certification programme, which in some states includes biomass cogeneration, allows the Renewable Purchase Obligation (RPO) to be met through tradable certificates.

Within the Biomass Power and Bagasse Cogeneration programme, various federal-level fiscal incentives are available to biomass projects, including 80% accelerated depreciation on certain equipment required for biomass projects, concessional import and excise duties and 10-year tax exemptions.

Additionally, economic reforms have made India's foreign investment policy conducive to foreign companies entering Indian market for CHP projects. Foreign direct investment is freely allowed and industrial licenses are not required for development of cogeneration and trigeneration projects in India.[47]

[47] GIZ, 2010.

Table 3 • Summary of policy and regulatory environment for CHP in India

Year	Policy
2005	**Programme of Biomass Energy and Cogeneration (non-bagasse) in Industry** • Provides capital subsidies of 5% to 25 % of project cost for biomass and waste-based power projects • Encourages the deployment of biomass energy systems in industry • Promotes decentralised power generation with at least 50% of power of captive use, and a provision for the surplus power to be exported to the grid • Promotes medium to large-scale biomass technologies (such as biomass gasifiers and non-bagasse biomass cogeneration), in industries like pulp and paper, textiles, fertilizers, petroleum, petrochemicals and food processing • Covers installation of cogeneration projects based on conventional fuels and industrial waste
2005	**Biomass Power and Bagasse Cogeneration Programme** • Provides financial assistance to bagasse cogeneration projects and associated boiler upgrades using the Build, Own, Operate and Transfer (BOOT) model in cooperative sugar mills. (Box 1) • Provides central financial assistance in the form of capacity grants (Table 4) • Provides fiscal incentives to biomass projects, including tax benefits for certain equipment
2008	**Central Electricity Regulatory Commission (CERC) discussion paper on "Promotion of Cogeneration and Generation of Electricity from Renewable Sources of Energy"** • Advises states to provide preferential treatment (exemption from inter-state open access charges for transmission, wheeling, standby power, grid connection, and scheduling) for renewable energy sources for arranging inter-state transmission when open access is used • Advises states to promote cogeneration and generation of electricity from renewable sources of energy to State Electricity Regulatory Commissions (SERCs) by providing suitable measures for connectivity with the grid
2008	**National Action Plan on Climate Change (NAPCC)** • Released by the Prime Minister's Office, the national strategy to combat climate change includes eight national missions, the National Mission for Enhanced Energy Efficiency provides incentives for energy efficiency projects
2011	**Perform, Achieve and Trade (PAT) of the Bureau of Energy Efficiency (BEE)** • As a new initiative under the National Mission for Enhanced Energy Efficiency, PAT mandates reductions in specific energy consumption in energy-intensive industries, with a system for companies to trade energy-savings certificates
2012	**CERC Renewable Energy Tariff Regulations** • Annually provides non-binding guidelines for the calculation of feed-in tariffs for renewable energy technologies, including non-fossil fuel-based co-generation facilities • Advises SERCs on methodology for calculating technology-specific tariffs, based on financial and technical parameters
2013	**Sugar Industry, Cogeneration and Distillery Promotion Policy, 2013 (Uttar Pradesh State)** • Promotes cogeneration in new or existing sugar mills and distilleries and provides tax exemptions and concessions over a five-year period • Provides 5% reimbursement on loans for plant construction and capital costs. • Provides exemptions from stamp duty and land registration fee for purchased lands to be used for cogeneration • Provides exemptions from the administrative charge on molasses for cogeneration units on new or existing sugar mills
-	**State-level Incentives from State Electricity Regulatory Commissions (SERCs)** • Some SERCs provide incentives in the form of fixed feed-in tariffs for biomass-based CHP projects, which vary by state (Table 5) • Some states impose a Renewable Purchase Obligation (RPO), which mandates that state utilities purchase a set percentage of electricity from renewable sources (including biomass CHP) (Table 5)

Sources: MNRE, Government of India (2013), Annual Report 2012-2013, http://mnre.gov.in/mission-and-vision-2/publications/annual-report-2/; CERC (Central Electricity Regulatory Commission) (2012), "Petition No. 243/SM/2012 (Suo-Motu)", www.cercind.gov.in/2012/orders/243_SM_2012%20dated%2025.10.pdf; CERC (2008), "Promotion of co-generation and generation of electricity from renewable sources of energy", Discussion paper, www.cercind.gov.in/09012008/Comments-invited-on16-05-2008.pdf; Prime Minister's Council on Climate Change, Government of India (2008), National Action Plan on Climate Change, http://pmindia.nic.in/climate_change.php; Ministry of Power, Government of India (2012), PAT: Perform Achieve and Trade, http://beeindia.in/content.php?page=schemes/schemes.php?id=8; Department of Infrastructure and Industrial Development, Government of Uttar Pradesh (2013), "Sugar industry, co-generation and distillery promotion policy, 2013", http://udyogbandhu.com/DataFiles/CMS/file/sugar_policy_english.pdf.

Table 4 • Central financial assistance for bagasse cogeneration projects in India

Project Type	Category	Capital subsidy
Bagasse cogeneration in private sugar mills	Special category states*	INR 1.8 million x (Capacity in MW)^0.646
	All other states	INR 1.5 million x (Capacity in MW)^0.646 (special category states)*
Bagasse cogeneration projects in cooperative/public sector sugar mills**	40 bar to 60 bar	INR 4 million per MW of surplus power
	60 bar to 80 bar	INR 5 million per MW of surplus power
	80 bar & above	INR 6 million per MW of surplus power

*North East Regions, Sikkim, Jammu & Kashmir, Himachal Pradesh and Uttaranchal

**Maximum support INR 80 million per project. For new sugar mills and existing employing incidental, seasonal, backpressure route cogeneration and exporting surplus power to the grid, subsidies shall be one-half of the level shown.

Note: USD 1 = INR 61.11

Source: MNRE, Government of India (2014), "Biomass Power and Cogeneration Programme", www.mnre.gov.in/schemes/grid-connected/biomass-powercogen/.

State government CHP promotion policies

As India is a federal republic, with 28 states and 7 union territories, state and territory governments play a major role in energy policy and technology promotion. Therefore it is difficult to compile a comprehensive list of all the relevant state-level policies. In the power sector, State Electricity Regulatory Commissions (SERCs) play a major role, and in energy efficiency, State Designated Agencies (SDAs) and MNRE nodal agencies are also important.

The State of Uttar Pradesh, one of the largest Indian states, uses the Sugar Industry, Cogeneration and Distillery Promotion Policy of 2013 to encourage private capital investment in sugar and distillery industries and cogeneration. The policy provides fiscal exemptions and concessions over a five-year period for new or existing sugar mills and distilleries. Other SERCs also provide incentives in the form of fixed feed-in tariffs for biomass-based CHP projects, which vary by state. Some also impose a Renewable Purchase Obligation (RPO), which mandates that state utilities purchase a set percentage of electricity from renewable sources. While the RPO is set for each type of renewable-based technology, biomass-based CHP also has separate RPOs in some of the states, as shown in Table 5.[48]

[48] MNRE, 2014b.

Table 5 • Summary of biomass power and cogeneration tariffs across states

State	Tariff fixed by SERC (INR per kWh)	RP0 %
Andhra Pradesh	4.28 (biomass) 3.48 (cogeneration)	Min. 3.75%
Bihar	4.17 (biomass) 4.25 (existing cogeneration projects) 4.46 (new cogeneration projects)	1.5%
Chhattisgarh	3.93 (biomass)	5%
Gujarat	4.40 (biomass) – accelerated depreciation 4.55 (cogeneration) – accelerated depreciation for first 10 years	10%
Haryana	4.00 (biomass) 3.74 (cogeneration) 3% escalation, base year 2007-08	1%
Jharkhand	5.53 (air cooled) 5.31 (water cooled) 3% escalation variable cost, base year 2011-12	-
Karnataka	3.66 (PPA signing date) 4.13 (10th year) (biomass) 3.59 (PPA signing date), 4.14 (10th year) (cogeneration)	Min.10%
Kerala	2.80 (biomass) 5% escalation for five years, base year 2000-01	3%
Maharashtra	4.98 (biomass) 4.79 (cogeneration) – commercial year	6%
Madhya Pradesh	3.33 to 5.14 3 to 8 paise/year escalation for 20 years	0.8%
Odisha	4.87 3% escalation variable cost, base year 2011-12	
Punjab	5.12 (biomass) 4.80 (cogeneration) 5% escalation, base year 2011-12	Min. 3%
Rajasthan	4.72 (water cooled) 5.17 (air cooled)	1.75%
Tamil Nadu	4.50 to 4.74 (biomass) 4.37 to 4.49 (cogeneration) 2% escalation, base year 2010-11	Min. 13%
Uttarakhand	3.06 (biomass) 3.12 (new cogeneration projects)	9%
Uttar Pradesh	4.29 (existing projects) 4.38 (new projects) 4 paise/year escalation, base year 2006	4%
West Bengal	4.36 (biomass) Fixed for 10 years	4%

Note: USD 1 = INR 61.11

Source: MNRE, Government of India (2013), *Annual Report 2012-2013*, http://mnre.gov.in/mission-and-vision-2/publications/annual-report-2/.

Stakeholders

Government

Ministry of Power

The Ministry of Power (MoP) is responsible for strategic planning, policymaking, monitoring of the implementation of power projects, human resource development and the administration and regulation of thermal and hydro power generation, transmission and distribution. The MoP oversees many of the central government's incentive programmes related to CHP and DC. In particular, the MoP is responsible for the implementation of the National Mission for Enhanced Energy Efficiency as part of the National Action Plan on Climate Change (NAPCC), including the PAT programme.

Bureau of Energy Efficiency

The Bureau of Energy Efficiency (BEE) is a statutory organisation under the Ministry of Power. Its role is to implement policies to reduce the energy intensity of the Indian economy within the framework of the Energy Conservation Act of 2001, and to create policy and regulatory frameworks for energy efficiency activities and programmes. BEE is also responsible for implementation of the Perform, Achieve and Trade (PAT) programme.

Energy Efficiency Services Limited

Energy Efficiency Services Limited (EESL) is a joint venture of several state-owned corporations [National Thermal Power Corporation (NTPC) Limited, Power Finance Corporation (PFC) Limited, Rural Electrification Corporation (REC) Limited and PowerGrid Corporation of India (PowerGrid) Limited] under the Ministry of Power. It is designed to create and support energy efficiency markets in India, to promote private investment in energy efficiency projects, to develop a viable ESCO industry in India and to assist the central and state governments in implementation of energy efficiency programmes. It is also involved in the development of energy efficiency projects through advisory services to state governments, electricity utilities, local municipal bodies and building owners. EESL can help CHP project developers to overcome market bottlenecks by, for example, assisting in conducting feasibility studies and partnering with firms to share the risk burden.

Ministry of New and Renewable Energy

The Ministry of New and Renewable Energy (MNRE) is responsible for defining policy and providing support for the development of renewable energy in industrial and commercial applications. The MNRE has formulated policies for all types of renewable energy, including biomass for CHP. It has enacted various fiscal incentives and regulations to incentivise the use of CHP, especially in the sugar industry. The MNRE also collects data on renewable energy capacity and generation, both grid-connected and off-grid, including bagasse-based and non-bagasse biomass-based co-generation.

Indian Renewable Energy Development Agency

The Indian Renewable Energy Development Agency (IREDA) is a government financial institution established to extend financial assistance to specific new and renewable energy projects and conserving energy through energy efficiency. IREDA supports both biomass and non-biomass CHP projects.

State/local government

Each state has jurisdiction over its own renewable energy and CHP policies. Some State Electricity Regulatory Commissions (SERCs), which are responsible for electricity market policymaking and regulation at the state level, also provide incentives for renewable and CHP/DC utilisation. The State Designated Agencies (SDAs), typically part of or under state energy departments, which were designated under the Energy Conservation Act of 2001, are nodal agencies that coordinate with BEE to implement the energy efficiency programmes. There are also state nodal agencies that work in collaboration with the Ministry of New and Renewable Energy (MNRE), and in many cases, these agencies collaborate with both MoP and MNRE.

Industry

There are several industry players utilising CHP and/or developing projects. These include, among others: BHEL, Capstone Turbines, Rolls Royce, Siemens, Areva, Turbomach, Thermax Power, Wartsilla and Caterpillar. The Cogeneration Association of India (CAI), a non-profit trade association for parties interested in cogeneration in India, also actively promotes CHP and provides a platform for knowledge sharing. In 2013, CAI organised workshops and trainings to promote various CHP technologies, as well as acting as a communications platform for stakeholders in CHP. Additionally, CAI has advocated on behalf of CHP projects to government regulatory bodies.

Non-governmental organisations

Currently, there are a small number of organisations, including The Energy and Resources Institute (TERI) and researchers at academic institutions, conduct research and promotes CHP/DC. TERI and the World Alliance for Decentralized Energy (WADE) also work with industry and government to advance deployment of clean and efficient decentralised technologies, including CHP and DC.

CHP/DC Challenges

Lack of reliable power supply, the need to reduce fuel costs and policy support have driven the deployment of some additional CHP capacity in India. However, important barriers still exist to achieving a significant uptake of CHP and DC technologies in the country.

Economic and financial constraints

High capital cost of CHP equipment and DC infrastructure presents a challenge for further deployment of these technologies, particularly as policies benefit mainly biomass and bagasse CHP projects, and incentives for CHP and efficient DC using conventional fuels are limited. The sale of surplus power from CHP units to the grid is also currently expensive due to high surcharges and multiple transmission charges. The lack of research and data on financing needs for CHP and DC in India makes coordinated policy and financial planning to address these challenges at the national level difficult.

Complex pricing policies for natural gas produced domestically, as well as high prices for imported natural gas, create a significant barrier to gas-based CHP units. Regional allocation of natural gas, and prioritisation of certain end-users over others for low-priced gas produced by state-owned companies can also create challenges for deployment of natural gas-based CHP.[49]

Legislative and policy constraints

In India, the term CHP is often understood as being limited to bagasse-based CHP. There is an overall lack of centralised data on CHP/DC systems installed in India - information such as installed capacity, distribution of this capacity in the various sectors, types of fuel used, power and heat/cooling generated. Consequently, there has not been a comprehensive study of India's CHP and DC potential that could help in prioritising required efforts to support a substantial deployment of these technologies.

Additionally, many cities lack available pipeline networks, and regulations regarding new distribution infrastructure can be extremely complex. This limits the potential for DC deployment in the short term.

The environmental and economic benefits of efficient and integrated DC networks are still little-known in India. There is also a lack of a standardised methodology for calculating CO_2 emission reductions from CHP and DC applications in India, preventing understanding of the potential for GHG reductions from these technologies in comparison to other CO_2 emissions mitigation options.

CHP promotion policies focus primarily on biomass- and bagasse-based CHP projects, and do not appropriately reward energy efficiency improvements from CHP based on conventional fuels and CHP implemented in other industrial sectors, failing to make the overall benefits of CHP visible. Similarly, efficient DC systems are not widely recognised in policy as useful options for improving energy efficiency.

[49] IEA, 2010.

The Gas Utilization Policy, which prioritises the fertilizer and petrochemicals sectors over other industrial sectors and power plants for domestic natural gas supply, could create barriers to utility-owned CHP/DC, new CHP/DC projects, and CHP in other industrial sectors. These other industrial sectors, aside from chemicals and petrochemicals, account for 87% of total industrial energy use[50] in India, and there is likely also significant potential for utility CHP.

Technological constraints

As only a small group of engineering companies have extensive expertise in designing and providing CHP packages in India, new and more complex CHP and DC solutions provide a technological challenge for project developers which in turn impacts overall project engineering costs.[51]

[50] Includes blast furnace and coke oven energy use in iron and steel and energy use as feedstock in petrochemical plants.

[51] Singh, 2010.

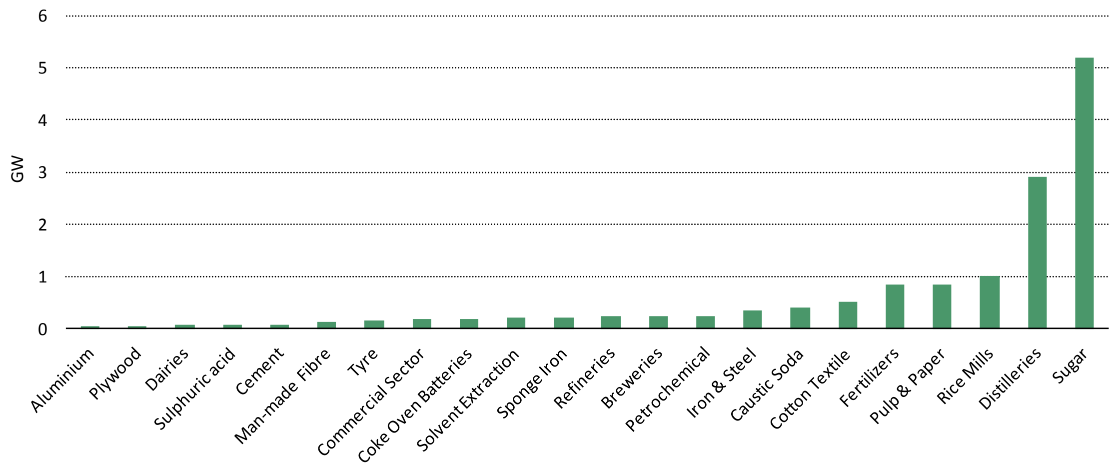
CHP/DC Potential and Benefits

Industrial CHP applications

India has an estimated industrial CHP potential of 14 GW with the largest potentials identified in the sugar (5.2 GW) and distillery (2.9 GW) industries[52] (Figure 8), and both receive substantial incentives from the central government. In recent years, bagasse-based CHP has gained popularity and matured quickly due to the continued government support. In line with the programme on renewable energy capacity addition, the Eleventh Five Year Plan targeted 1.2 GW of bagasse-based CHP capacity. By the end of March 2012, India had installed almost 1.4 GW, surpassing the target. The Twelfth Five Year Plan targets an additional 2.0 GW of capacity by the end of 2017. In order to achieve this, new policies are being developed at both the federal and the state level, including the 2013 policy in the State of Uttar Pradesh promoting biomass CHP in the sugar industry, as well as the Indian government's 2012 Biomass Cogeneration Programme.

In some industries, CHP projects are often implemented to ensure a reliable power supply rather than for economic and environmental benefits. Many industries in India have potential to deploy CHP technologies (Figure 8), but no other industry receives the level of government support that the sugar and distillery industries do. The food processing, beverage and tobacco sector accounts for only a small portion of industrial energy use in India, and more potential for CHP in other industrial sectors could likely be exploited given the right incentives.

Figure 8 • Potential for industrial CHP deployment



Source: Singh, M., B. Singh and S.K. Mahla (2013), "Combined Heat and Power Scenario in Commercial Sector," *International Journal on Emerging Technologies*, Vol. 4, No. 1, pp. 81-87.

Key message • India has a total estimated industrial CHP potential of 14 GW.

[52] Singh, et al., 2013.

Each sub-sector's potential is related to its level of deployment in the Indian industrial structure as well as its specific process requirements in terms of simultaneous production of heat and electricity. Some food and beverage industries, the pulp and paper sector, fertilizer production and some textile industries have some of the highest potential levels for implementing CHP after the sugar industry. For example, the textile sector with its steady simultaneous demand for heat and electricity has a significant potential for CHP. One study of CHP systems in Indian textile mills suggests that installing CHP units at textile mills can be economically feasible, with a payback period of two to three years.[53]

Small–scale CHP applications

In 2010, GIZ estimated a potential of about 6 GW for additional gas-based CHP capacity integrated with heating and cooling systems in the buildings sector in India.[54] Recent improvements in natural gas infrastructure in India, as shown in Figure 9, represent a first positive step towards more fully exploiting the potential, but last-mile connectivity remains a challenge. To allow gas-based CHP to develop its full potential to provide a reliable alternative source of electricity, heat and cooling for commercial and residential end-users, issues of shortage of natural gas supply and pricing issues also need to be addressed.

District cooling applications

India's economic development has given rise to the construction of diverse residential and commercial complexes, and in the baseline scenario, IEA estimates growth of 68% in demand for energy for space cooling in India by 2020 over 2011, from 164 PJ to 277 PJ. Electric chillers and cooling systems normally account for a large portion of the electricity demand of these complexes. DC systems can provide cost savings through energy efficiency, by benefitting from locally available energy sources, such as waste and biomass, surplus heat from industrial facilities and natural cooling, and efficient generation technologies. Capital investment required for additional power generation, transmission and distribution infrastructure can also be reduced. An assessment report published by researchers at five U.S. Department of Energy's National Laboratories identified utilising DC for space cooling in malls and developing energy service companies (ESCOs) to support deployment of DC as two possible areas of opportunity for clean energy deployment in India.[55] Several projects, including the GIFT City and the DLF Cybercity, are taking advantage of DC as a highly energy efficient system to provide cooling services. Other infrastructure projects could incorporate DC systems, though more data is needed to understand the full extent of the potential in this area.

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[53] Gohul, et al., 2012.

[54] Potential based on areas with existing or proposed gas grid access, of which 3.8 GW has existing gas grid access. More detailed analysis on urban density is needed to determine the shares of the potential that could be more efficiently met by small-scale CHP for individual end users and CHP coupled with a district cooling system linked to different end users.

[55] Akhil, et al., 2010.

Figure 9• Existing and proposed gas pipelines in India

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Key message • Planned natural gas pipeline improvements could encourage gas-based CHP projects.

Summary Policy Recommendations

Different stakeholders have taken steps to recognise some of the benefits of CHP and DC projects in India. However, a wider perspective of the role that these technologies could play in the overall energy system is needed to realise their full cost-effective potential. Below are some specific policy recommendations for promoting the development and deployment of CHP/DC in India.

Central and state government support

- Increase and standardise data collection on CHP and DC deployment and make data widely available. Comprehensive information about the level of deployment, technology choices, fuel inputs, and locations of projects could encourage investment and help policymakers focus their efforts.
- Develop a national database of guidelines and information for CHP/DC stakeholders, including relevant policies and regulatory requirements on central and state level. This should include development of a standardised measurement and verification protocol and methodology for energy savings calculations.
- Build on the technical and policy databases to assess cost-effective potentials for CHP and DC technologies in India to help prioritise and stimulate stakeholders' actions in those sectors and regions with greatest growth opportunities.
- Promote strategic planning on commercial and residential complexes and industrial parks that assesses the viability of CHP/DC projects at the development and primary land allotment stage considering their integration with the locally available energy sources and energy end-users.
- Consider the energy efficiency and environmental benefits of non-bagasse and non-biomass CHP technologies in policy strategies. Consider the benefits of co-firing of biomass and waste fuels with conventional fuels on CHP systems, as a means of maximising the utilisation of locally available fuels without jeopardising plant availability, in case of fuel sourcing limitations or seasonality of fuels.
- Consider allowing CHP units that meet specific performance criteria to export surplus power to the grid without excessive surcharges.
- Emphasise the importance of CHP/DC as energy-saving technologies through existing energy efficiency policies, such as the PAT programme and supportive implementation programmes, such as those under EESL.
- Enhance coordination with and support from central government to state energy development agencies to more effectively promote CHP and DC projects.

Private sector initiatives

- Establish a framework for data collection and technology assessment. Industry associations, such as the Cogeneration Association of India (CAI) partnering with others, can take a lead in establishing such a framework, and can also help in disseminating information about CHP and DC technology to small and medium enterprises.

- Create a platform for knowledge and information exchange between the private sector, government and potential customers. Training, workshops and awareness campaigns could improve understanding of the benefits to different stakeholders and support the development of financing strategies.

Enhanced cooperation

- Increase cooperation between the public sector and the private sector, in order to encourage streamlined and effective regulatory frameworks and policy support. Public-private partnerships could also improve information sharing, data collection and visibility of the status and potential of efficient technologies and systems.
- Partner with countries that have successful CHP/DC deployment strategies. Through international cooperation, policymakers and project developers can learn from other countries' experiences and best practices, as government and private sector participants in the Clean Energy Ministerial CHP and Efficient DHC Working Group have. India is an active participant in the international dialogue on energy and the environment. However, there are very few international cooperative activities targeting CHP/DC.

The IEA CHP and DHC Collaborative and IEA-supported Related Initiatives

The IEA CHP and DHC Collaborative was initiated in 2007 to accelerate deployment of cost-effective, clean cogeneration and efficient DHC technologies, leading to reduced CO_2 emissions and increased overall efficiency of energy systems through increased use of waste heat and low-carbon renewable energy resources. The Collaborative also seeks to provide a platform for stakeholders to share best practices, policies, experiences and applied solutions with regard to these technologies. Collaborators include governments, international organisations, regional industrial associations and private-sector collaborators, including equipment suppliers and utility companies.

This initiative has already completed several publications that provide a vision of cogeneration and DHC energy potential, along with an overview of policy best practices and recommendations of options to consider when implementing these policies. The Collaborative results have also highlighted the benefits of an integrated energy system approach that uses cogeneration technologies to assist in balancing electricity production from variable renewables. For more information about the Collaborative, please visit www.iea.org/chp.

In addition, the Implementing Agreement for a Programme of RD&D on District Heating and Cooling, including the Integration of Combined Heat and Power (DHC IA), is a multilateral technology initiative supported by the IEA. The nine member countries of the DHC IA deal with the design, performance and operation of distribution systems and consumer installations. In operation since 1983, the DHC IA is dedicated to helping make DHC and cogeneration powerful tools for energy conservation and the reduction of environmental impacts of supplying heat. For more information, please visit www.iea-dhc.org.

Annex: India CHP and DC Background Data

Table 6 • Approved CHP-based CDM Projects

No.	Year	Project Developer	Electrical Capacity (MW_e)	Fuel Input	GHG Savings ($ktCO_2$-eq/year)
1	2006	RBNS Sugar Mills Ltd.	15	Bagasse	10
2	2006	Sintex Industries Limited	8	Natural Gas	25
3	2007	Dankuni Steel Limited	5	Natural Gas	40
4	2007	OGC and Sugar Company Ltd.	1	Bagasse	37
5	2007	Scan Steels Ltd.	3	Coal/lignite	13
6	2008	Bala Murugan Chemicals Private Limited. Tuticorin, Tamilnadu	2	Biomass	36
7	2008	Suyash Chemical and Fertilizer Private Limited	3	Biomass	54
8	2008	LANXESS India Private Limited	5	Natural Gas	17
9	2008	Gujarat Narmada Valley Fertilizers Company Limited(GNFC)	33	Natural Gas	235
10	2008	Yashwantrao Mohite Krishna SSK Limited, Maharashtra, India	16	Bagasse	12
11	2008	Sanjog Sugars & Eco-Power Private Limited	10	Biomass	52
12	2008	Lanxess India Pvt Limited	4	Biomass	101
13	2008	Shree Someshwar Sahakari Sakhar Karkhana Limited	18	Bagasse	86
14	2008	Ambika Solvex Limited	3	Biomass	47
15	2008	S Kumars Nationwide Limited	19	Natural Gas	46
16	2008	Shri Shankar Sahakari Sakhar Karkhana Ltd.	20	Bagasse	17
17	2008	Ihsedu Speciality Chemicals Private Limited	1	Biomass	141
18	2009	Vikas Sahakari Sakhar Karkhana Limited	18	Bagasse	25
19	2009	Maruti Suzuki India limited	18	Natural Gas	40
20	2009	Ihsedu Agrochem Pvt. Ltd., Gujarat, India	3	Biomass	62
21	2009	Sunstar Overseas Limited(SOL), Amritsar	3	Biomass	39
22	2009	Usher Eco Power Limited, Chhata, Uttar Pradesh, India	16	Biomass	89
23	2009	Amir Chand Jagdish Kumar Exports Limited	1	Biomass	40
24	2009	Vikas S.S.K. Ltd. India	18	Bagasse	25

25	2009	Varrsana Ispat Ltd	10	Coal/lignite	49
26	2009	MAC OIL PALM LIMITED	1	Biomass	4
27	2009	Sunstar Overseas Ltd	2	Biomass	46
28	2009	Dev Kiran Paper Mills (P) Ltd	1	Biomass	31
29	2010	Gujarat Gas Company Limited (GGCL), India*	9	Natural Gas	16
30	2010	Mallikarjun Agro, West Bengal, India	0.8	Biomass	31
31	2010	Bhagwati Vintrade Pvt ltd, Ramgarh, Jharkhand	1	Biomass	32
32	2010	Siddheshwari Paper Udyog Limited	6	Biomass	37
33	2010	Goel International Pvt. Ltd	3	Biomass	64
34	2010	Co-operative Sugar mills in Fazilka, Punjab, India	15	Bagasse	71
35	2010	Co-operative Sugar mills in Nakodar, Punjab, India	15	Bagasse	71
36	2010	Co-operative Sugar mills in Morinda, Punjab, India	15	Bagasse	67
37	2010	Sterling Agro Industries Ltd	0.5	Biomass	72
38	2010	KIC Metaliks Limited	5	Coal/lignite	24
39	2010	Sesa Goa Limited (SGL)	30	Coal/lignite	167
40	2010	Ponni Sugars (Erode) Limited	5	Bagasse	38
41	2010	United Spirits Limited, Nashik	0.1	Biomass	33
42	2011	Manali Sugars Limited, Karnataka	15	Bagasse	56
43	2011	Nawanshahr Co-operative Sugar Mills Ltd	Not available	Bagasse	62
44	2011	Shakti Bhog Foods Ltd , Karnal	4	Biomass	18
45	2011	Siddhi Vinayak Agro Industries Pvt. Ltd	1	Biomass	44
46	2011	Satia Industries Limited	13	Biomass and coal	49
47	2012	DLF Utilities Limited	18	Natural Gas	19
48	2012	Malanpur Captive Power Ltd (Trigen)	26	Natural Gas	50
49	2012	Dharwad Bioenergy Private Limited	10	Biomass	50
50	2012	Ambuja Cement , Rajasthan	7	Coal/lignite	61

*Aggregate capacity and emissions reduction for five cogeneration systems installed in various industrial applications, including chemicals, paper, textiles, and other industry.

Note: Capacity values have been rounded to the nearest 1 MW_e, except for projects with total electrical capacity below 1 MW_e.

Source: National CDM Authority, Government of India (2014), "No. of approved reports", www.cdmindia.gov.in/approved_projects.php?n=1, accessed 4 March 2014.

Acronyms, Abbreviations and Units of Measure

Acronyms and abbreviations

AIIMS	All India Institute for Medical Studies
AIT	Asian Institute of Technology
BEE	Bureau of Energy Efficiency
CAGR	Compound annual growth rate
CAI	Cogeneration Association of India
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CERC	Central Electricity Regulatory Commission
CFA	Central Financial Assistance
CHP	Combined heat and power
DC	District cooling
DHC	District heating and cooling
EESL	Energy Efficiency Services, Limited
ESCO	Energy service company
FY	Fiscal year
GDP	Gross domestic product
GHG	Greenhouse gas
GIFT City	Gujarat International Finance Tec-City
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation)
IEA	International Energy Agency
IGEN	Indo-German Energy Programme
IREDA	Indian Renewable Energy Development Agency
JNNSM	Jawaharlal Nehru National Solar Mission
MNRE	Ministry of New and Renewable Energy
MoP	Ministry of Power
NAPCC	National Action Plan for Climate Change
NCDC	National Cooperative Development Corporation
NDMC	New Delhi Municipal Council
NMEEE	National Mission for Enhanced Energy Efficiency
PAT	Perform, Achieve and Trade
PPA	Power Purchase Agreement
RPO	Renewable Purchase Obligation
SDA	State Designated Agency
SDF	Sugar Development Fund
SERC	State Electricity Regulatory Commission
SEZ	Special economic zone
SSK	Sahakari Shakar Karkhana (cooperative sugar factory)
TERI	The Energy and Resources Institute
VAM	Vapour absorption machine
WADE	World Alliance for Decentralized Energy

Units of measure

°C	degree Celsius
CO_2	carbon dioxide
EJ	exajoule
EUR	Euro
GW	gigawatt
GW_e	gigawatt electric
GWh	gigawatt-hour
INR	Indian rupee
kg/cm^2	kilograms per square centimetre
$ktCO_2$	kilotonne of carbon dioxide
kW	kilowatt
kW_e	kilowatt electric
kWh	kilowatt hour
Mt	megatonne
$MtCO_2$	megatonne of carbon dioxide
MW	megawatt
MW_e	megawatt electric
MWh	megawatt hour
MW_{th}	megawatt thermal
PJ	petajoule
tCO_2	tonne of carbon dioxide
tCO_2-eq	tonne of carbon dioxide equivalent
tCO_2/year	tonnes of carbon dioxide per year
TJ	terajoule
TPH	tonnes per hour
USD	United States dollar

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