Policy brief

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Indo-German cooperation on electrification of industrial heat

A vision for 2030 and beyond

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Summary

Electrification of low-temperature industrial process heat presents a low-hanging opportunity to advance industrial decarbonisation and competitiveness in both India and Germany. By replacing fossil fuel-based boilers with technologies like electric boilers or industrial heat pumps, micro, small and medium enterprises (MSMEs) can enhance energy security, improve energy efficiency and access cheaper renewable electricity as grids continue to decarbonise. Such a transition can also bring supply-side opportunities for technological innovation and supply chain resilience for clean technology manufacturing industries in both countries.

Strengthening Indo-German cooperation in this area can lead to mutual benefits. India and Germany could work together to improve the uptake of industrial electrification technologies among Indian MSMEs, enable further integration of renewable energy in the Indian power grid and establish a local manufacturing base for industrial heat pumps and their components in India. This can help Indian MSMEs benefit from renewables-based electrification and improved technology access while providing market access and a supply chain alternative to German technology providers looking to expand their production capacity. Such cooperation would also offer opportunities for joint technology innovation, skills transfer and skilled workforce mobility.

Drawing on extensive stakeholder engagement, this paper identifies key barriers and recommendations for future collaboration. Key barriers include: the absence of an industrial heat electrification policy framework in India; low awareness and data availability among Indian MSMEs; high technology and electricity costs; limited access to affordable finance; market-entry bottlenecks for technology providers; and infrastructure challenges, including grid reliability and limited energy storage. Together, these factors weaken the business case for electrification and slow the adoption of electrification technologies. Stakeholders highlighted the following key recommendations for the Indo-German partnership going forward:

1. **Facilitate the uptake of electrification technologies among Indian MSMEs** by addressing technical barriers and providing targeted financial support.
2. **Reinforce the enabling infrastructure for renewables-based electrification**, including by strengthening electricity grids and energy storage.
3. **Cooperate on resilient supply chains for electrification technologies** by identifying and developing joint capabilities in common-interest components.
4. **Support joint innovation in electrification technologies**, targeting efforts to reduce costs and scale adoption across industrial use cases.

To unlock the benefits of cooperation, the 2026 Indo-German Inter-Governmental Consultations should formally recognise industrial heat electrification as a strategic priority within the bilateral partnership and establish a structured multistakeholder dialogue to translate expert recommendations into implementation action.

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Abbreviations

EPC	Engineering, Procurement and Construction
EU	European Union
EUR	Euro
EXI	Export Initiative Environmental Protection
FTA	Free Trade Agreement
GSDP	Green and Sustainable Development Partnership
IGCC	Indo-German Chamber of Commerce
IGCs	Inter-Governmental Consultations
MSME	Micro, Small and Medium Enterprise
MIIM	Make in India-Mittelstand
R&D	Research & Development

1 Introduction: the Indo-German partnership

This paper is part of a series articulating a vision for mutually beneficial Indo-German cooperation on green industrialisation, based on extensive stakeholder engagement. This paper focuses on electrification of low-temperature industrial process heat, while the other two papers in the series address green steel and critical minerals. Although these areas are still emerging within the partnership, they hold significant potential to help advance the shared strategic priorities of India and Germany – climate change mitigation, technological innovation, industrial development and supply chain resilience amidst broader geopolitical uncertainty.

India and Germany share a long-standing bilateral relationship built on decades of cooperation across sectors. Since the establishment of diplomatic ties in 1951, the cooperation has extended to areas like trade, science, technology, energy, climate and development. It has involved a wide range of actors – national and subnational governments, research institutions, businesses and civil society – establishing a strong, trust-based foundation on which the partnership continues to build. In 2022, German Chancellor Scholz and Indian Prime Minister Modi signed the Green and Sustainable Development Partnership (GSDP) with a financial commitment of EUR 10 billion from Germany by 2030, establishing the framework to advance cooperation on the dual imperatives of climate action and sustainable development.

Recent developments underscore the rising significance of this partnership in a rapidly changing geopolitical and economic context. German Chancellor Merz's visit to India in January 2026 concluded with 19 Joint Declarations of Intent and projects worth EUR 1 billion committed under the GSDP, heralding deeper industrial cooperation in areas like renewable energy, green hydrogen, critical minerals and supply chains. Germany's 2024 "Focus on India" strategy also outlines intentions to strengthen trade, technology and research cooperation as well as skilled migration and people-to-people ties. At the same time, developments at the European Union (EU) level – such as the EU-India Free Trade Agreement (FTA), the EU-India Comprehensive Strategic Agenda for 2030 and the ongoing discussions on Horizon Europe association for India – highlight the broader strategic convergence on trade, industry and innovation underpinning the Indo-German relationship.

The 8th Indo-German Inter-Governmental Consultations (IGCs) scheduled for the upcoming winter will provide an opportune moment to define clear, actionable priorities for the next few years. This vision paper series aims to highlight practical pathways to strengthen governmental, industrial and research cooperation on industrial decarbonisation, green technologies and resilient supply chains, building on shared interests and complementary strengths, to realise the vision for an ambitious, strategic and mutually beneficial cooperation until 2030 and beyond.

2 Background: electrification of industrial heat

Industry accounts for about 30% of global energy demand, largely for heat in industrial processes, with over 70% coming from sectors like food, textiles and paper that mainly use low-temperature process heat (below 100°C). These sectors primarily rely on fossil fuels for low-temperature process heat and account for half of global direct industrial energy-related carbon dioxide (CO_2) emissions (IEA, 2025).

Advancing the uptake of electrification technologies for low-temperature industrial process heat, alongside increasing the share of renewable energy in electricity systems, presents a significant low-hanging opportunity to reduce global reliance on fossil fuels, improve industrial energy resilience and efficiency, enable access to cheaper renewable power and mitigate industrial CO_2 emissions.

Electrification technologies like electric boilers and industrial heat pumps are already mature and commercially available for low-temperature heat applications and are more energy efficient than boilers based on thermal combustion of fossil fuels or biomass. Industrial heat pumps, in fact, are ultraefficient, as they can provide more heat output than electricity input in low-temperature ranges (Rosenow *et al.*, 2024) (Rosenow et al., 2024). However, their global adoption remains slow due to barriers such as high upfront costs, expensive electricity relative to fossil fuels, limited grid capacity and insufficient policy support (Rosenow *et al.*, 2024; IEA, 2025).

In India, less than one-fifth of industrial heat demand is electrified (IEA, 2025). Indian manufacturing industries relying on low-temperature process heat – such as textiles and apparel, food processing, automotive equipment and pulp and paper – predominantly feature micro, small and medium enterprises (MSMEs) organised in geographical clusters. MSMEs play a major role in the Indian economy, providing 35% of the total manufacturing output, 50% of total exports and 335 million jobs (MoMSME, 2025). Across clusters, MSMEs typically rely on traditional boilers using coal, biomass or imported fossil gas for low-temperature process heat.

MSMEs' reliance on traditional boilers exposes them to several risks. For example, MSME clusters using imported fossil gas are vulnerable to supply disruptions and price shocks, as seen in the recent Strait of Hormuz crisis. Export-oriented MSME clusters, such as in textiles, pulp and paper and automotives, face increasing pressure to decarbonise their fossil fuel-dependent processes and improve the traceability of biomass input under India's Carbon Credit Trading Scheme or EU importers' sustainability requirements (Ethiraj and Gupta, 2026). Although renewables-based electrification could alleviate such risks and may already be cheaper (Deshpande *et al.*, 2026), MSMEs face various economic, financial and technical challenges in switching to electrification technologies **(see Section 2.1)**.

In Germany, too, electrification of industrial heat has been slow due to structural challenges, such as high electricity-to-gas price ratios, high grid connection costs and low availability of skilled workers (Rosenow et al., 2024; Volt et al., 2025). However, electrification is viewed by German businesses as a key measure to improve their energy security by reducing dependence on imported fossil gas (E3G, 2026). With new and upcoming EU-level policies such as the Electrification Action Plan, the Heating & Cooling Strategy and the Affordable Energy Action Plan, Germany's demand for industrial electrification technologies is likely to increase.

Growing demand for electrification presents opportunities and challenges for Germany's heat pump manufacturing sector. There are around 300 heat pump and component manufacturing sites in Europe, many in Germany, providing around 170,000 direct jobs (EHPA, 2025). This strategically important sector has been struggling in the face of competition from China and the United States, particularly in the residential and commercial heat pump segments. Non-EU imports of residential heat pumps rose sharply in the aftermath of the 2022 energy crisis, as EU manufacturing capacity was insufficient to meet rising demand. While the EU's industrial heat pump segment is still self-sufficient, limited production capacity means it may have to rely on imports in the future to meet increasing European demand for industrial heat electrification (Volt *et al.*, 2025). The EU industrial heat pump industry may need to strengthen supply chain partnerships to secure cost-effective inputs to expand production capacity and retain its leadership position.

2.1 Key barriers to a deepening partnership

Strengthening Indo-German cooperation on electrification of low-temperature industrial process heat can help achieve both countries' climate and industrial priorities. India and Germany can work together to improve the uptake of industrial electrification technologies among Indian MSMEs, enable further integration of renewable energy in the Indian power grid and establish a local manufacturing base of industrial heat pumps and their components in India. This can help Indian MSMEs benefit from renewables-based electrification and improved technology access while providing market access and a supply chain alternative to German technology providers looking to expand their production capacity. Deeper cooperation would also offer opportunities for joint technology innovation, skills transfer and skilled workforce mobility **(see Section 3)**.

Despite the potential for a win-win cooperation, renewables-based electrification of industrial process heat has not featured extensively in Indo-German cooperation so far. Renewable energy and its grid integration have been a major focal point for cooperation, for example through the Green Energy Corridor and the recently launched India-Germany Platform for Investments in Renewable Energy Worldwide. Industrial energy efficiency has received attention under the Indo-German Energy Forum, mainly via knowledge sharing and institutional capacity building activities in

the pulp and paper industry (GIZ, 2024). However, deeper cooperation on industrial electrification technologies is limited. Key barriers to further cooperation are identified below, based on input from stakeholder consultations and workshops.

First, there is **no industrial heat electrification policy framework** in India clearly signalling it as a strategic priority (Ethiraj and Gupta, 2026). While the country has made strides in renewable energy owing to favourable policies, a similar framework setting targets, mandates, benchmarks or incentives for industrial electrification is not in place. This means neither Indian MSMEs nor the Indo-German partnership has a policy-driven reason to focus on industrial heat electrification.

Further, **low awareness and data availability** among MSMEs in India limit technology uptake. A lack of baseline thermal energy consumption data among MSMEs hides the magnitude of boiler efficiency losses and the corresponding benefits of electrification (Ethiraj and Gupta, 2026). This also prevents an accurate assessment of the relative costs and benefits of available technology options mapped across MSME clusters and use cases. In addition, there are **not enough technology demonstration projects** in MSME clusters proving technoeconomic viability to increase MSME confidence (Ethiraj and Gupta, 2026).

Electrification technologies also often face **unfavourable economics** compared to traditional alternatives (Shankar *et al.*, 2025). MSMEs currently relying on coal or biomass boilers to meet their heat demand have access to cheap and abundant feedstock. Electrification through industrial heat pumps, however, can require high upfront investments due to high equipment costs and customised design and installation needs. In some states, they may also have high operating costs due to high electricity tariffs, which affect the long-term energy cost savings potential, and in turn, the business case for investing in energy-efficient technologies. Even in cases where the economics work, MSMEs lack **access to low-cost finance** due to their lack of collateral and high-risk perception among financial institutions.

Further, **supply side bottlenecks** prevent widespread availability of industrial electrification technologies in India. Industrial heat pump manufacturers in Germany encounter regulatory or administrative barriers in entering the Indian market, such as navigating licensing requirements or identifying suitable local partners. The lack of demand-side studies estimating market size also creates business uncertainty, possibly limiting the number of domestic and international technology providers catering to India's industrial heat market (Shankar *et al.*, 2025).

Finally, there are significant **infrastructural barriers** to electrification in India. India's power system and grid infrastructure face limitations in accommodating large-scale renewables-based electrification of industrial process heat demand. Some regions are affected by grid unreliability and frequent outages, which may impact the continuity of MSME industrial operations and lead to increased dependence on diesel generators for backup power. Energy storage is also not widely deployed, making it challenging to integrate higher shares of cheaper variable renewables into the grid (GGGI, 2025).

3 Cooperation opportunities and the case for a strengthened partnership

Cooperating on renewables-based industrial heat electrification in India can bring mutual benefits to India and Germany, such as industrial competitiveness, supply chain resilience, technological innovation and skills and job creation. This section presents potential cooperation opportunities and mutual benefits **(Table 1)**.

First, India and Germany could work together to **support renewables-based electrification of low-temperature industrial process heat in India** through highly efficient and commercially available technologies like industrial heat pumps. Germany can provide technical and financial support to address the barriers preventing electrification technology uptake among Indian MSMEs and support grid infrastructure reinforcements to enable renewables-based electrification. This would help Indian MSMEs become more energy efficient, access cheap renewable power and replace reliance on imported fossil gas, thus improving their competitiveness (GGGI, 2025). At the same time, it could potentially boost local demand for German electrification technologies like industrial heat pumps, providing the immediate impetus for expanding its own manufacturing capacity.

Second, there is an opportunity to jointly expand **clean technology and component manufacturing** in India, particularly of industrial heat pumps and their key components, to the benefit of both countries. German technology providers could cooperate with Indian counterparts to manufacture industrial heat pump components (e.g. compressors, semiconductors, sustainable refrigerants) locally. Such supply chain cooperation would be in line with the existing Joint Declarations of Intent between Germany and India and the EU and India on semiconductors (EC, 2023; MEA, 2026). Cooperating with India on the full industrial heat pump supply chain could help secure and diversify supply of cost-effective inputs to expand German production capacity, while also enabling its technology providers to gain access to a sizable market through better local competitiveness. At the same time, it would help India scale its heat pump and component manufacturing base, improving local manufacturing, job creation and the availability and affordability of technology.

Third, there is scope to jointly accelerate **innovation and technology co-development** for electrification technologies through Research and Development (R&D) cooperation between German and Indian industries and research institutions. For example, the heat pump industry in the EU is at the forefront of innovation but is quickly losing its leadership position to China (Volt *et al.*, 2025). India, too, has built up strong innovation capacity and consistently overperforms on innovation

benchmarks relative to its development level across indicators measured by the Global Innovation Index (WIPO, 2025). Collaboration between German and Indian companies and research institutions can potentially lead to the development of standardised and cost-effective solutions adapted for Indian industrial activities where Germany has less experience, for example textiles manufacturing. India and Germany could also work together on cutting-edge solutions, for example electrothermal energy storage or more efficient industrial heat pumps reaching higher temperature ranges, supporting wider market uptake through reduced technology costs. Both countries would benefit from such avenues for technology innovation and market competitiveness.

Finally, cooperation can help scale up **green skills and jobs** in both countries. One of the key challenges to industrial heat pump deployment in India is the lack of providers with the specialised knowhow to design and integrate customised solutions in existing factories (Shankar et al., 2025). Similarly, in the EU, the shortage of a skilled workforce and high internal competition for labour among clean technology sectors also impacts the rate of adoption of industrial heat pumps (Volt et al., 2025). Experienced German engineering, procurement and construction (EPC) firms could partner with Indian counterparts to establish a local presence, employ local workers and offer skilling programmes on designing and installing industrial heat pump solutions adapted for the Indian market. This would support India's national skill development objectives and address its high levels of educated unemployment. It would also support the international business interests of German EPCs, while potentially addressing Germany's skilled labour shortage through associated skilled labour mobility programmes, in line with the goals of the Indo-German Migration and Mobility Partnership Agreement (MEA, 2024).

Table 1: Overview of cooperation opportunities in electrification of industrial heat and their mutual benefits

Opportunity	Description	Benefits to India	Benefits to Germany and the EU
Renewables-based industrial process heat electrification	Supporting the uptake of renewables-based electrification among Indian MSMEs	– Reduces MSME energy consumption, imports and bills	– Potentially creates demand for German electrification technologies in India
Clean technology and component manufacturing	Expanding technology (e.g. industrial heat pump) and component (e.g. compressor, semiconductor) manufacturing in India	– Boosts availability and affordability of technology – Boosts local manufacturing and job creation	– Provides market access for German technology providers – Secures and diversifies supply of cost-effective inputs for expanded production
Innovation and technology co-development	Jointly innovating on cutting-edge or standardised technologies, including for Indian context	– Creates opportunity for technology co-development and market scale-up	– Provides access to new avenues for potential cost reductions and market scale-up
Green skills and jobs	Creating jobs and offering skilling programmes through EPC cooperation in India on design and system integration of electrification solutions	– Leads to local skill development and job creation	– Supports international business interests of German EPCs – Could address labour shortage through skilled labour mobility programmes

4 Recommendations for leveraging the cooperation toolkit

This section provides recommendations for how Indian and German actors can deploy tools in the existing cooperation toolkit – technical assistance, finance and investment and R&D support – to support mutually beneficial cooperation on electrification of low-temperature industrial process heat **(see Section 3)**.

4.1 Facilitate the uptake of electrification technologies among Indian MSMEs

Technical assistance

→ Development agencies can work with research institutes to produce **technoeconomic studies at the MSME cluster level** to build the business case for electrification. Such studies could include:

- Quantification of MSME process heat demand to establish a consumption baseline;
- mapping of relevant parameters across MSME units such as age of existing boiler stock, fuel supply dependencies, state electricity tariff structures, export-orientation and exposure to external policy shocks; and
- mapping of the relative costs and benefits of electrification technologies across use cases and MSME clusters, based on their baseline heat consumption and other parameters.

Such technoeconomic analysis can be turned into accessible decision-support tools, both to help MSMEs make informed investments and to help technology suppliers identify potential first-mover MSME clusters or units with the strongest business case for electrification.

→ Development agencies and Ministries can jointly organise **knowledge exchanges on demand creation policies** for industrial heat electrification. India and Germany can exchange experiences and best practices on integrating industrial and energy policy, setting sectoral electrification targets, establishing green lead markets and industrial product benchmarks, setting mandates for industrial energy audits to establish consumption baseline and promote energy efficient practices and creating preferential green energy tariffs for MSMEs to facilitate their access to renewable power.

→ Development agencies can work with industry actors to organise **training and capacity-building programmes** for workers on both the supply and demand sides. On the technology supply side, German EPC firms wishing to enter the

Indian market can help train local workers on designing, installing and optimally integrating industrial heat pumps into factory systems. On the MSME demand side, EPC firms can help train factory staff on understanding process heat consumption and on operating and maintaining industrial heat pump systems to improve confidence in new technologies.

Finance and investment

- Development finance institutions or philanthropies can provide **targeted financial support for pilot projects** in identified first-mover MSME clusters with the strongest business case for electrification – for example export-oriented clusters reliant on imported fossil gas operating in states with favourable industrial electricity tariffs (Ethiraj and Gupta, 2026). Successful demonstration projects can help prove technoeconomic viability of electrification for specific use cases and build confidence for further adoption by other MSME units in the cluster.
- Private companies, particularly large corporations and global brands with sustainability targets and supply chains in India, can **directly invest in greening the supply chain** and support low-hanging electrification opportunities in Indian MSME clusters like textiles, chemicals or automotive engineering.
- Development finance institutions, philanthropies or green venture capital funds can **support companies providing turnkey solutions and business models** that reduce upfront costs for MSMEs. These models aggregate demand across MSME units, establish shared infrastructure and provide heat-as-a-service or asset leasing arrangements, such that MSMEs do not face high upfront capital costs but only pay an energy service fee based on their consumption. This makes electrification more accessible and financially viable for MSMEs.

4.2 Reinforce the enabling infrastructure for renewables-based electrification

Technical assistance

- Development agencies can work with grid development authorities in India to conduct **grid assessment studies**, identifying what is needed to enable large-scale renewables-based grid electrification of industrial process heat. Such studies can identify technical gaps in the current grid infrastructure, estimate investment needs for the required reinforcements and establish the potential for grid flexibility measures like demand side management or electrothermal energy storage with technologies like industrial heat pumps.
- Development agencies can work with grid development authorities in India to organise **policy and technical capacity building programmes** on preparing the power system for large-scale renewables-based electrification. Topics can range from best practices for flexibly managing a renewables-dominated grid,

for example, through utility-led demand side management programmes, to reforming the grid code and electricity tariff structures to remove disincentives for electrification.

Finance and investment

→ Development finance institutions can provide **de-risking support for grid infrastructure investments** identified as critical for enabling large-scale industrial process heat electrification and for greater renewables integration into the grid.

4.3 Cooperate on resilient supply chains for electrification technologies

Technical assistance

→ Development agencies can work with industrial heat pump associations to produce **supply chain diagnostic studies** in both Germany and India to identify common (current or future) dependencies, import vulnerabilities and manufacturing gaps on both sides to support joint investment decisions in supply chain resilience.

→ Established platforms – such as the Indo-German Chamber of Commerce (IGCC), Make in India-Mittelstand (MIIM) and SME export initiatives like German Energy Solutions and Export Initiative Environmental Protection (EXI) – and new mechanisms under the EU-India FTA can facilitate **industry-level exchanges** between German and Indian heat pump manufacturers and EPCs, addressing administrative or network-related barriers to supply chain cooperation.

Finance and investment

→ Development finance institutions can provide **de-risking support for supply chain investments in India** for components identified as common vulnerabilities in the industrial heat pump supply chain.

R&D support

→ Standard-setting bodies in India and Germany can cooperate on **harmonising standards** for industrial heat pumps and their components in both countries to enable joint supply chain investments.

→ German and Indian industrial heat pump manufacturers can cooperate on **joint R&D and corresponding supply chain investments**, for example to tailor German technology to local conditions or to produce low-cost sustainable refrigerants.

4.4 Support joint innovation in electrification technologies

R&D support

→ Indian and German Ministries can **jointly fund "2+2" R&D configurations** involving both Indian and German research or academic institutes and industrial players, for example through the Indo-German Science & Technology Centre's annual funding calls or by establishing dedicated Centres of Excellence on electrification of industrial heat. Joint R&D efforts can target cost reductions by exploring potential standardisation of industrial heat pump solutions in sectors that offer scale, such as textiles manufacturing in India. They can also aim for market scalability by advancing innovation in cutting-edge technologies, such as high-temperature heat pumps, thermal energy storage and next-generation sustainable refrigerants.

By cooperating closely on these recommendations **(see Table 2)**, India and Germany can capitalise on a significant opportunity to advance mutual economic, industrial and climate objectives. To unlock the mutual benefits of cooperation, the 2026 Inter-Governmental Consultations should **formally recognise industrial heat electrification as a strategic priority** within the bilateral partnership and **establish a structured multistakeholder dialogue** to translate expert recommendations into coordinated implementation action.

Table 2: Summary of recommendations across the cooperation toolkit.

Recommendation	Technical assistance	Finance and investment	R&D support
Facilitate the uptake of electrification technologies among Indian MSMEs	– Development agencies and research institutes can produce MSME cluster-level technoeconomic studies to build the business case for electrification and identify potential first-movers – Development agencies and Ministries can organise knowledge exchanges on demand creation policies – Development agencies and industry actors can organise workforce skilling programmes on both the technology supplier and MSME consumer sides	– Development finance institutions (DFIs) can provide targeted financial support for pilot projects in identified first-mover MSME clusters – Large private companies (e.g. retail brands) can directly invest in electrification in MSME clusters through green supply chain initiatives – DFIs, philanthropies or venture capital funds can support turnkey solution providers or demand aggregators offering solutions for MSMEs	– N/A
Reinforce the enabling infrastructure for renewables-based electrification	– Development agencies and grid development authorities can conduct grid assessment studies to identify the technical gaps and investment needs for renewables-based electrification – Development agencies and grid development authorities can organise capacity building programmes on preparing the power system for large-scale renewables-based electrification	– DFIs can provide de-risking support for critical grid infrastructure investments for large-scale renewables-based electrification	– N/A
Cooperate on resilient supply chains for electrification technologies	– Development agencies and industrial heat pump associations can produce supply chain diagnostic studies in both countries to identify common interests and support joints investment decisions – IGCC, MIIM, SME export initiatives or EU-IN FTA related platforms can facilitate business-to-business exchanges to address administrative or network-related barriers to cooperation	– DFIs can provide de-risking support for supply chain investments in India for common-interest component manufacture	– Standard-setting bodies can cooperate on harmonising standards of industrial heat pump and their components to enable joint supply chain investments – German and Indian manufacturers can cooperate on joint R&D to adapt German technology to the Indian market, and link to joint manufacturing investment decisions
Support joint innovation in electrification technologies	– N/A	– N/A	– Indian and German governments can jointly fund R&D in “2+2” configurations through IGSTC’s funding calls or Centres of Excellence on standardised and cutting-edge industrial heat pump solutions

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